SYSTEMS DEVELOPMENT OF DATA RETRIEVAL FOR AN ENGINEERING COMPANY'S AFTER-SALES SERVICE

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SUMMARY

The first case study raised a number of questions about the process of, and management's involvement in, computer systems analysis and development:

- how are systems selected for 'computerisation'?
- how are system requirements defined?
- how effective are the practical systems approaches?
- what is the influence of technological change?

A second case study, a literature survey and detailed analysis were carried out in support of the investigation of these issues.

The main conclusion is that the increasing level of technological capability has changed the problem of systems development to emphasise the requirement for corporate planning and a systemic view at the expense of the lower level design effort.

The case study evidence is that the company's management did not adopt the corporate and systemic view necessary to support the development of integrated systems. Since modern computer technology can be the basis of new ways of working and of extensions to a company's business activities it should be an element of planning at the highest level.

The prevalent management attitude is appropriate for the earlier level of technology and development of isolated systems. It is not suitable for the development of integrated systems using current and future computer technology which requires the adoption of a systemic view and development of the role of systems integrator.

The research has contributed to the body of knowledge about management's role in systems analysis and development by identifying the implications of technological advance for one company, highlighting the shortcomings of its current situation and setting the scene for further research.

Such further work should be directed toward broadening this study to generalise the results, considering the organisational impact of integrated systems, evaluating the alternative models for computer usage and developing the role of the systems integrator.

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KEYWORDS MANAGEMENT COMPUTING SYSTEMS-ANALYSIS INTEGRATION

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LIST OF ABBREVIATIONS

Throughout this work the following abbreviations have been employed whenever convenient.

A.C.D. - Air Cooling Division

A.S.D. - After Sales Division

B.S.D. - Business System Design

C.S.D. - Computer System Design

G.A. - General Arrangement

I.H.D. - The Interdisciplinary Higher Degrees Scheme

M.C.C. - Materials Control Clerk

M. of M.S. - Manager of Management Services

M.P.F. - Master Parts File

M.S. - Management Services

P.D. - Production Control

P.P.L. - Production Parts List

S.A. - Systems Analysis

S.E.C.D. - Small Engine Cooler Division

S.H.T. - Serck Heat Transfer

S.T. - Sales Technician

W.O. - Works Order

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CHAPTER I INTRODUCTION

SUMMARY This Chapter introduces the I.H.D. Scheme of Aston University and the sponsoring organisation, the Serck Group of Companies. The course of the project work is explained and the layout of the thesis described.

SECTIONS

I.1 Introduction to the I.H.D. Scheme and the Serck Group

The I.H.D. Scheme of Aston University brings together academic research and industry through postgraduate students undertaking project work as employees of an industrial organisation. The sponsoring organisation has the opportunity of establishing close links with the University whilst benefitting from the impact of the University's resources upon the content and result of the project.

This thesis reports the work carried out between October of 1975 and September of 1978 under the I.H.D. scheme in conjunction with the Serck Group of Companies.

Serck is a group of engineering companies whose products serve a wide range of industries throughout the world. Manufacturing takes place in eight countries with the base in the United Kingdom. The company started business in 1907 as one of the original manufacturers of car radiators. It went public in 1919 and since then has expanded steadily. By 1975 it had seven principal activities, listed here in descending order of size:

1. Industrial valves through Serck Audio Valves International.
2. Heat Transfer Equipment through Serck Heat Transfer.
3. Exchange parts for motor vehicles through Serck Services.
4. Tubes in non-ferrous metals through Serck Tubes.
5. Supervisory Control Systems through Serck Controls.
6. Environmental control equipment & systems through Serck Visco.

7. Water & Waste Water Treatment through Serck Water Processing.

The project work was carried out on the Birmingham site of Serck Heat Transfer. This section is the second largest of the group's companies, employing between its three sites in Birmingham, Manchester and Hamburg, some 1,600 people and £10m capital. All subsequent references to S.H.T. or 'the company' should be taken to mean the collection of manufacturing operations on the Birmingham site.

I.2 The Structure of the Work

During the three years of the practical work two separate projects were considered. But for reasons quite unconnected with this work, neither could be completed. Despite this, the conclusions outlined in the Summary have been drawn.

The first project under which work began in 1975 was entitled:

"The Application of Computers to Production Control within an Engineering Company".

Its purpose was to examine the existing computer-based production control systems within one of the company's manufacturing divisions, then recommend and implement improvements. During the first eight months this work had proceeded well and an analysis of existing practice made. But in June of 1976 the company retained an external firm of business consultants to make broad-based recommendations on a company-wide stock-accounting system. Intrinsic in this was the need to review the production control routines in each of the divisions, an operation which cut directly across this first project.

Therefore, the first project was curtailed and was replaced by a second project entitled:

"Systems Development of Data Retrieval for an Engineering Company's After Sales Service".

The focus of the work was the After Sales Division of the company which had only been formed at the beginning of 1976 and was the spares and repairs facility for the three major manufacturing divisions. The management of this division was keen for it to expand and wanted to improve the speed with which the spare parts could be identified, thereby offering a faster service to the customer.

A detailed analysis was made of the spares and repairs supply function and resulted in a significant re-definition of the requirements of the data retrieval system. Before the design work could be started however, it was necessary for the divisional management to take some decisions about the future organisation of the division. But these decisions were never taken, because in the early summer of 1978 the company decided to drastically cut down the After Sales Division by returning the responsibility for spares supply to the manufacturing divisions.

This meant that the second practical project came to an end.

I.3 The Layout of the Thesis

The thesis follows the chronology of the practical work in describing the first project and then the second project, because the conclusions are derived from ideas which developed as a result of influences experienced during the three years.

This section describes how the chapters of the thesis support the evolution of the ideas.

Chapter II presents the background to the company and the description of the product range enables the right 'pictures' to be formed when the detailed operations of the After Sales division are being discussed. Existing use of the computer characterises the role which automation of clerical procedures plays within the company.

Chapter III establishes the starting point of the first project, in terms of both the researcher's and the division's expectations.

Although the theory and practice described in Chapter IV and V respectively were researched concurrently, they are presented in this particular order so as to provide a structure on to which the division's operating procedures can be analysed.

The first project was concluded at the end of the work described in Chapter V. However, Chapter VI is an abstraction of the underlying problems of the division's production control routines and as such outlines the doubts raised about the efficacy of the system analysis and development processes that created such routines.

This leads on naturally to Chapter VII; a survey of the theory of the process of systems analysis and design which concludes that the procedures within S.H.T. are typical of the practical analysis and design work being done throughout industry.

Chapter VIII describes the detailed analysis made of the requirements and operations of the After Sales Division during the second project. It leads to a modification of the initial statement of the project, as made by the divisional management, and this revision gives rise to significant implications.

Chapter IX states the efforts made to examine and resolve these implications by means of the system model. It is the reaction of the divisional management to this model which prompts the main conclusion of the thesis.

In Chapter X the further analysis undertaken, while the future of A.S.D. was being resolved, is described. It was directed toward speeding the course of the anticipated system design work by investigating circumstances outside the immediate concern of A.S.D. but necessary to support the proposed data retrieval system.

In the event, this second project was terminated when the division was cut-back and Chapter XI reviews the practical work done and brings together the lessons that can be derived from it.

The evidence of Chapters VI and XI is that a common shortcoming of management's role in the system specification and design process is the lack of a corporate approach.

Chapter XII examines the existing body of knowledge on this subject and in the final chapter the implications of the practical work and the conclusions are derived and substantiated.

CHAPTER II BACKGROUND

SUMMARY The divisions and product range of Serck Heat Transfer (SHT) are described and the company's use of computing is reviewed.

SECTIONS

II.1 Description of S.H.T.

This project was carried out in Serck Heat Transfer, the second largest of the companies in the Serck Group, employing between its three sites in Birmingham, Manchester and Hamburg, some 1,600 people and £10 million capital. Any subsequent reference to S.H.T. or "The Company" should be taken to mean the collection of manufacturing operations on the Birmingham site alone, the location of the project.

S.H.T. is a medium size engineering company manufacturing heat exchangers, these being defined as devices for passing heat from one medium to another, be it for cooling or heating. However, within this broad definition there exist readily identifiable classes of units and as of December, 1975, S.H.T. was divided into four divisions, each of which was concerned with the manufacture of one such category of heat exchanger.

These divisions are:-

a.	Tubular Cooling Division	(TCD)
b.	Air Cooling Division	(ACD)
c.	Small Engine Cooler Division	(SECD)
d.	Aircraft Equipment Division	(AED)

II.2 The Product Range

AED manufactures the high quality, high reliability units required to meet the stringent demands of the various airworthiness authorities and employs specialised techniques and materials. Because of the rigour of these external inspectors it is almost completely independent of the other divisions and it plays no part in the project, only being mentioned here for the sake of completeness.

TCD is principally concerned with the classic Serck shell and tube liquid to liquid heat exchanger. This type of unit is used for a variety of applications primarily on large diesel engines, e.g. to cool engine oil, transmission oil, quenching oil, jacket water cooling, etc.

The underlying principle is that the medium to be cooled is passed through a tube over which the cooling medium runs. (See Figure 2.1). Heat is transferred from the hot liquid through the walls of the surrounding tube to the covering medium. To effect an adequate exchange of heat, many tubes are used and they are formed into a single bundle bound together by end plates, this whole being termed the tubestack, again see Figure 2.1.

Some means of guiding the cooling medium over the tubes is needed, typically a cylindrical shell with suitable holes for the entry and exit of the liquid. Obviously the casing needs to be a sound fit around the tubestack end plates so as to prevent

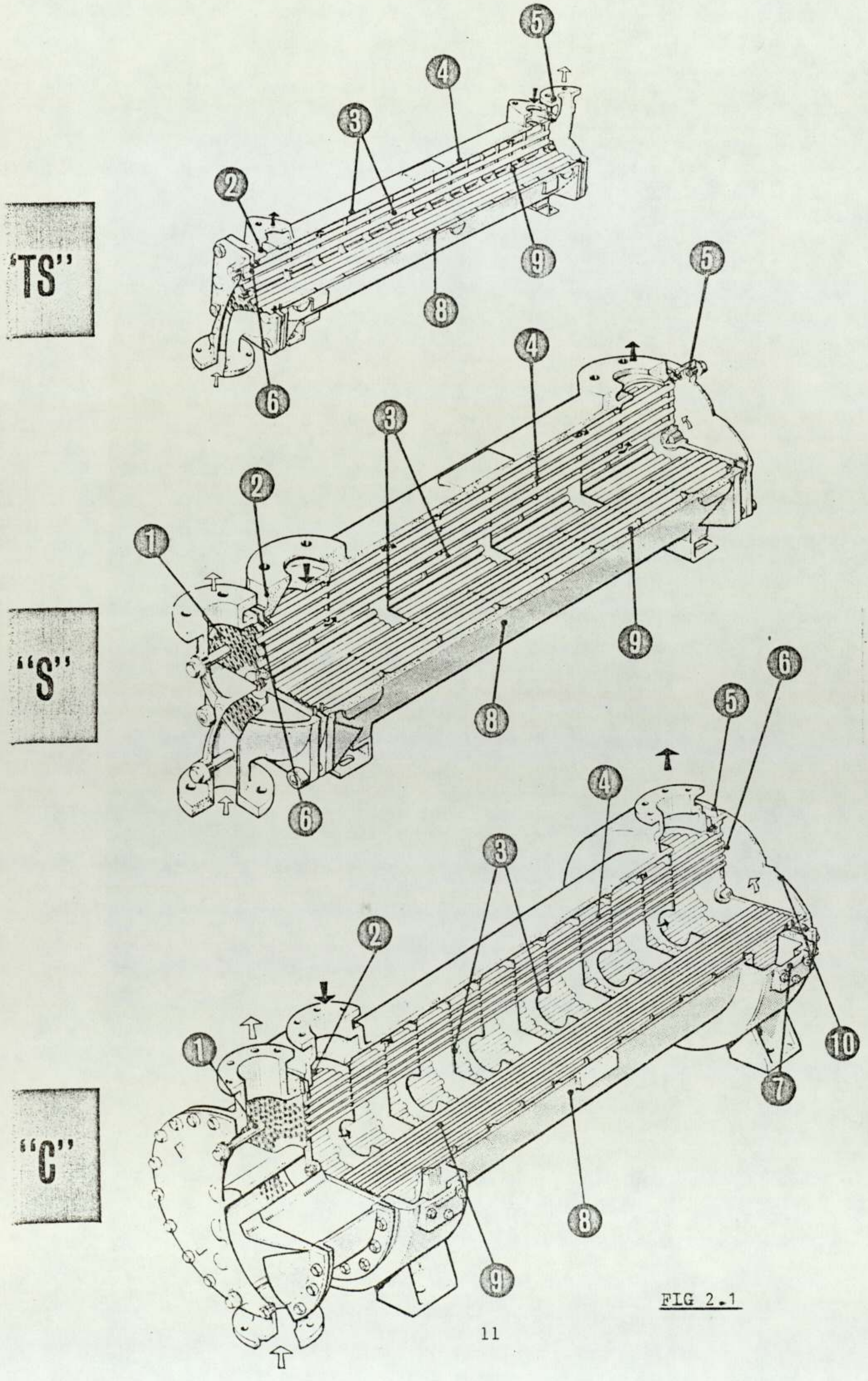


FIG 2.1

1 Corrosion resistors.

2 No hidden joints in any part of construction.

3 Radial flow circular baffles, affording maximum efficiency with minimum pressure loss.

4 Removable and interchangeable tube stack.

5 Safety expansion ring and double joint, permitting expansion of the entire stack whilst preventing interleakage between the fluid media.

FEATURES

6 Tubes expanded and bonded to tube plates as a double insurance against leakage.

7 Surface inspection door.

8 Accurately bored and machined cylinder.

9 Removable straight tubes — easy to clean.

10 Removable covers, enabling cleaning and inspection of raw water side without disturbance of pipe joints.

leakage. Further, the cooled medium needs to be brought to and from the cooler. This interface between the user's pipework and the tubestack is achieved using boxes. In the simplest case, a box is a cylindrical, biscuit-tin-like device, closed across one flat, bolted to the casing and having branches suitable for bolting to the adjacent pipework. This is the primary product of TCD; the concept is very simple, but during the 80 years since the original patent, a considerable degree of sophistication has been introduced to the practice. Further details will be explained as appropriate throughout the remainder of this work; suffice to say at this stage that the vast range of designs, each having different heat transfer properties, which are realised in a large number of materials according to the situation, requires the maintenance of a large technical support section of designers, metallurgists, corrosion and heat transfer engineers to ensure that the customer receives a unit suitable for the job in hand.

Whereas TCD deals with the cooling of liquids by liquids, ACD is involved in the design and manufacture of units which use air as either the cooling or cooled medium, there being two main categories of device, namely radiators and the pressure charge air coolers. The radiators, which operate on the same principle as ordinary car radiators, although far larger, consist of heat transfer elements (known as sections), bolted to appropriate header tanks with general ducting and supporting ironmongery. See Figure 2.2. There may be fan and motor units to force the

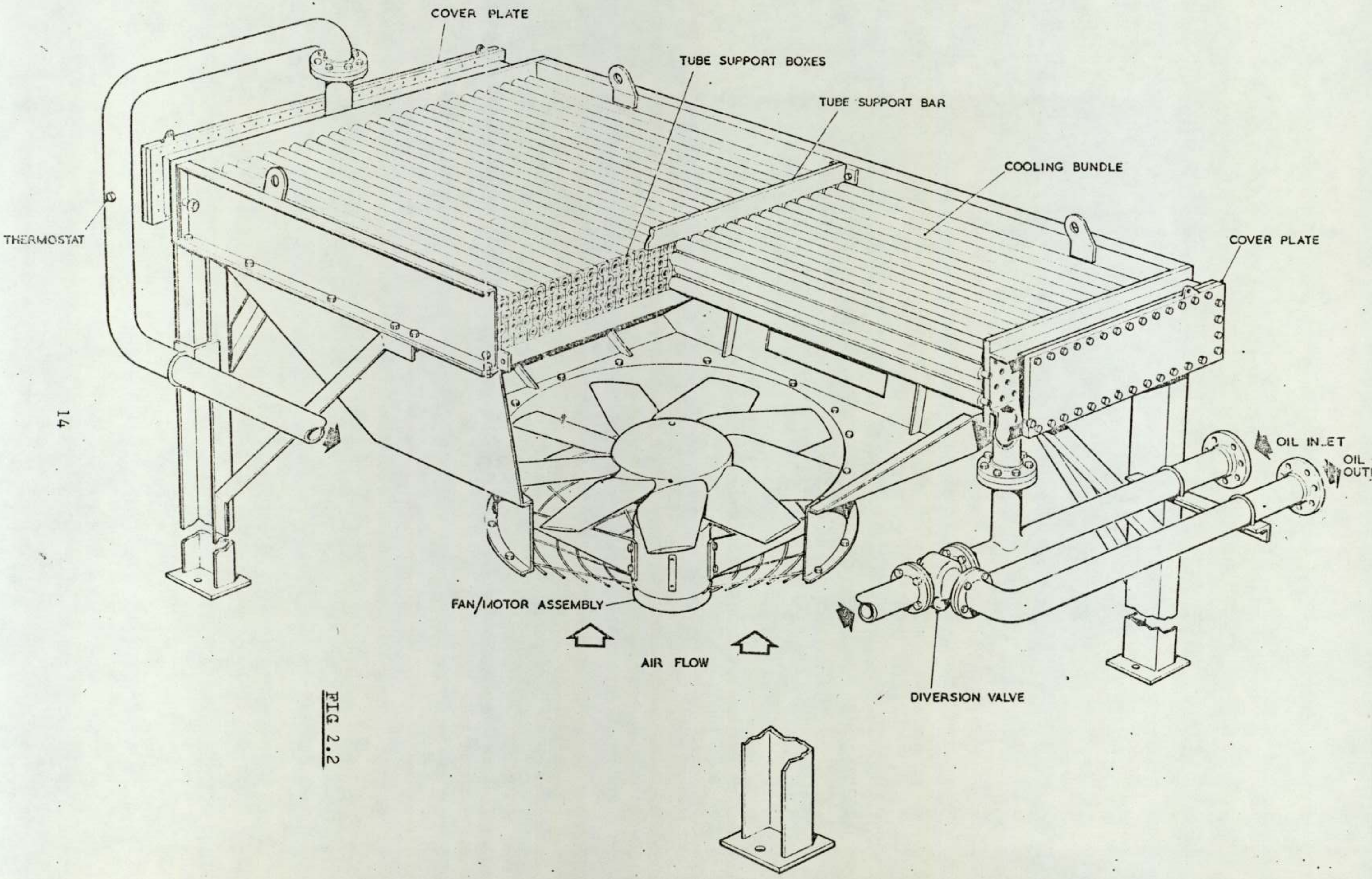
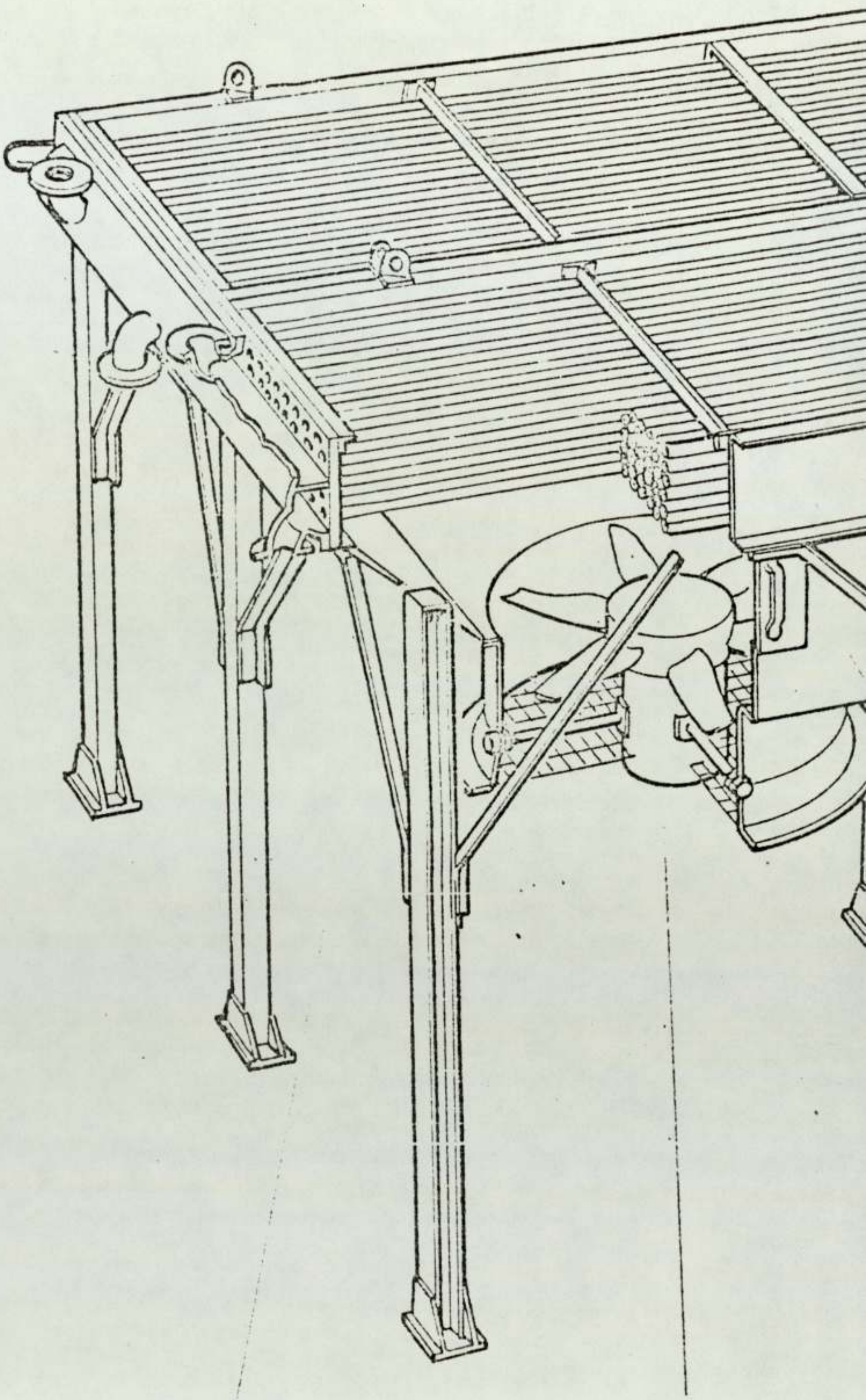

COVER PLATE
TUBE SUPPORT BOXES
TUBE SUPPORT BAR
COOLING BUNDLE
COVER PLATE
THERMOSTAT
OIL INLET
OIL OUT
FAN/MOTOR ASSEMBLY
AIR FLOW
DIVERSION VALVE

FIG 2.2

FEATURES



HEADERS

Bonnet, removable cover and plug type headers are available, in some cases fabricated from carbon steel but cast iron or fabrications in other materials may be considered where applicable. Headers may be designed to any of the recognised international Pressure Vessel Code requirements. Vent and drain connections are fitted where necessary.

HEAT TRANSFER SURFACE

The heat transfer surface generally comprises ribbon fin tubes but other specialised forms of surface are used depending upon the application. All forms of surface are of a robust construction and are rigidly supported to prevent sag and vibration.

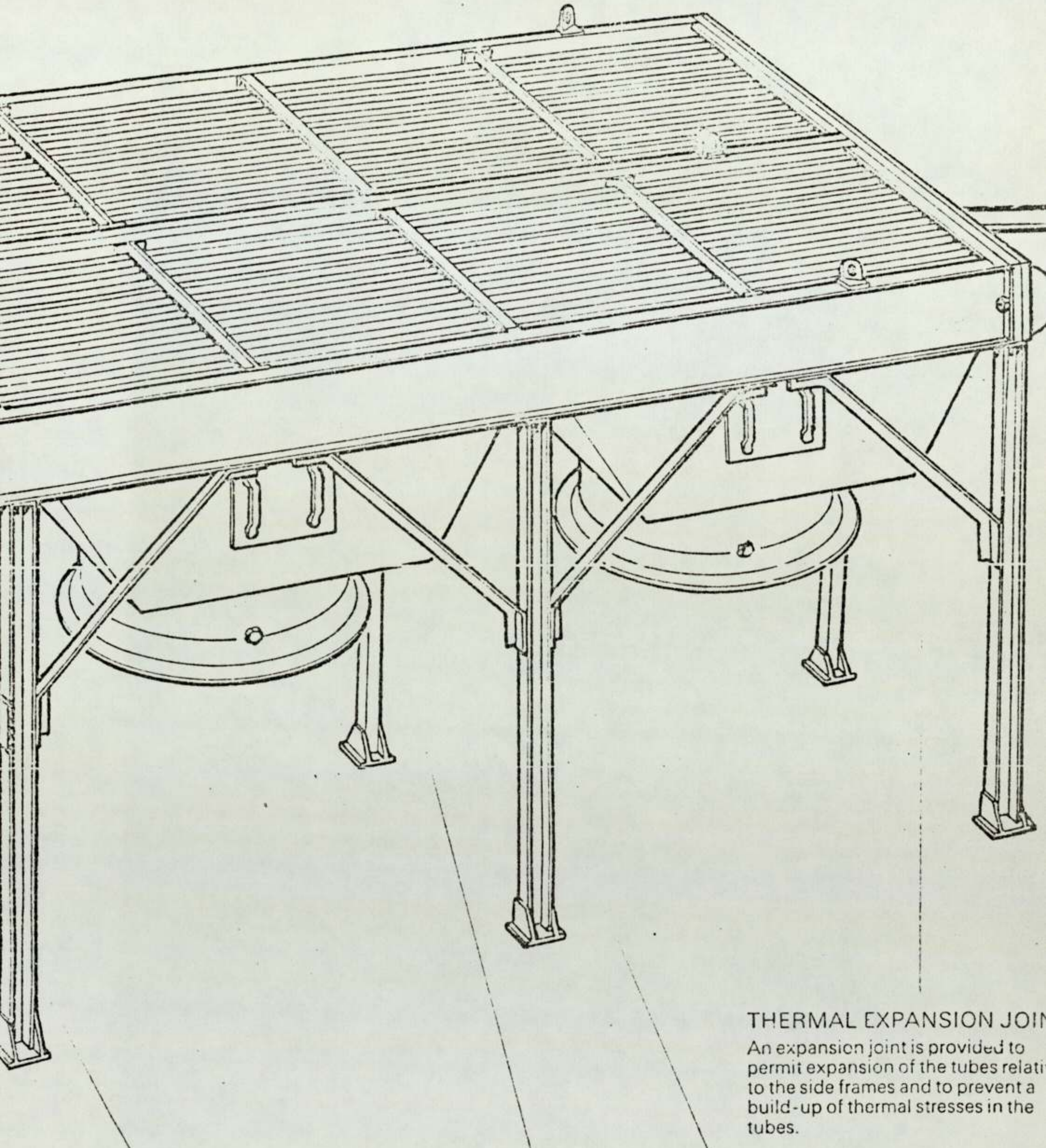
FANS

Fans are normally supplied with aerofoil-type blades cast in alumini and driven by a direct coupled elect motor.

Larger and slower speed fans can b supplied driven by a plinth-mounte gear box and electric motor, or alternatively vee-belts and electric motor.

Electric motors can be provided tot enclosed weatherproofed, or flameproof, single or dual speed winding, and generally to custome specification.

FIG 2.3



THERMAL EXPANSION JOIN

An expansion joint is provided to permit expansion of the tubes relati to the side frames and to prevent a build-up of thermal stresses in the tubes.

PLENUM CHAMBER

Each fan is provided with a plenum chamber which ensures uniform air distribution over the heat transfer surface and minimises air recirculation and leakage. The chambers are made from heavy gauge steel sheet protected against corrosion and incorporate manholes for access to fan and cooling surface.

SIDE PLATES

Each tube bundle is contained within substantial steel side plates adequately protected against corrosion. The side plates also carry the transverse bundle supports. Lifting of the complete bundle (which may be 30 feet long and weigh 10 tons) is facilitated by means of robust lifting lugs.

FRAMEWORK

A sturdy steel framework carries the horizontally arranged tube bundles can be designed to withstand the m severe climatic and seismic conditio specified.

All steel components are pre-drilled for easy erection in the field by unskilled labour. Adequate clearanc under the units provides easy access fan motors and ancillary equipment such as pumps, etc., as necessary.

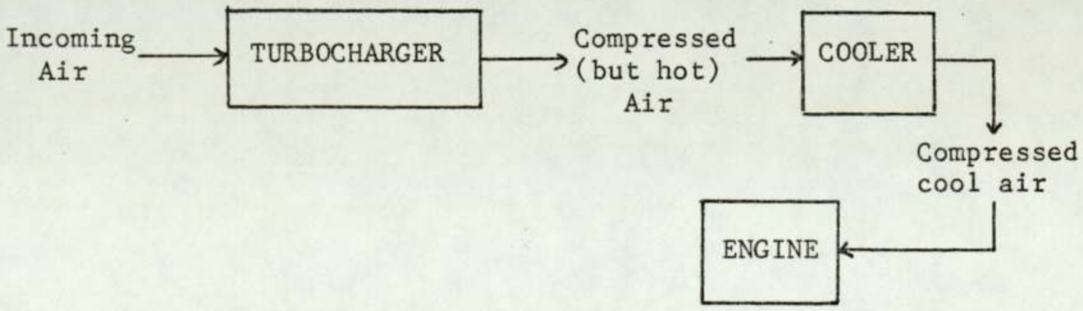
Accessory Equipment: Louvres, walkways, ladders, motor starters, surge tanks, etc., can be supplied as extras.

cooling air over the heat exchange elements carrying the cooled medium.

The larger of these coolers form free standing structures up to 15 feet high, 30 feet long, and weighing some 10 tons, of which a typical application would be as a power station engine water cooler or process cooler. (See Figure 2.3).

In the interest of efficiency, modern large diesel engines are frequently turbocharged. This is a process in which the energy of the exhaust gases from the engine is used to pressurise the air on the induction side of the engine, thus compressing it to enable a larger quantity to enter the combustion chambers and resulting in greater power from the engine.

However, compressing the induction air causes it to get hotter and expand. Such expansion naturally offsets the gain received from the turbocharger. So a cooler is inserted between the engine and the turbocharger, and the following process results; the air is compressed and heated in the turbocharger, then cooled down in the cooling unit so that high pressure but low temperature air reaches the combustion chambers.



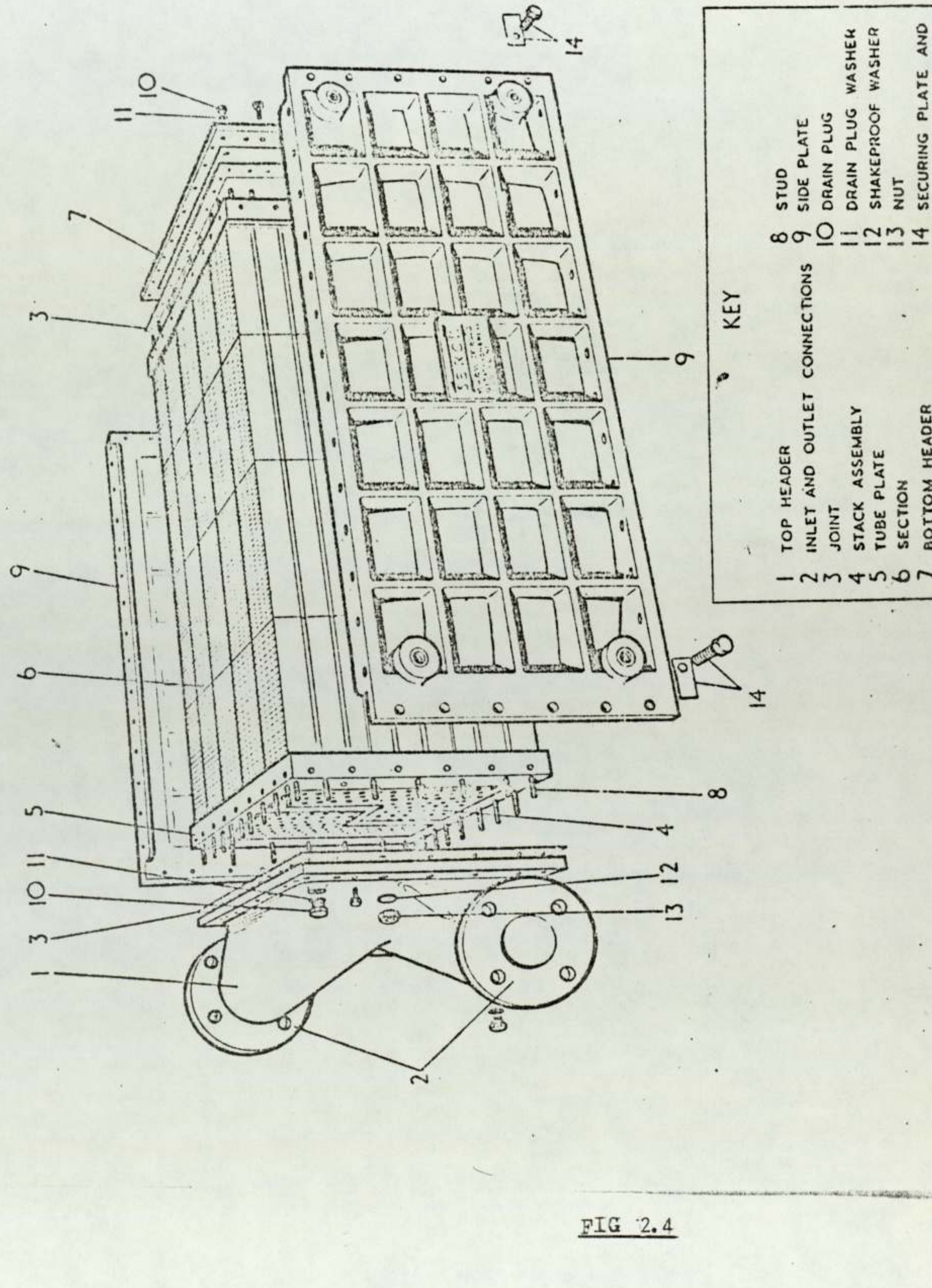
Such a cooler is termed an intercooler or pressure charge air cooler and an example is shown in Figure 2.4.

Because the pressures involved are high, these coolers are mounted in a heavy machined casing. But the principle of operation is similar to that of the radiator, in that the charge air is passed over finning bonded to the tubes through which the cooling liquid is pumped.

As for the product of TCD, a simple idea has been made progressively more sophisticated, and this quick introduction merely points out the extensive range and the considerable new design facilities that are available.

The fourth division is SECD which manufactures coolers for the small-diesel engine market. Such engines would be those in lorries, trucks and small boats, so the physical size of the product is smaller than those of TCD and ACD. In concept, these coolers are scaled down versions of the shell and tube ones already discussed, although their small size enables different techniques and materials to be used. (e.g. the stack may be bonded to the boxes which may be of rubber). The capital cost of these coolers is small and there are fewer ranges of design than for the other divisions. Figure 2.5 shows a typical unit.

The divisions of the company frequently liaise with a user to



KEY

1	TOP HEADER
2	INLET AND OUTLET CONNECTIONS
3	JOINT
4	STACK ASSEMBLY
5	TUBE PLATE
6	SECTION
7	BOTTOM HEADER
8	STUD
9	SIDE PLATE
10	DRAIN PLUG
11	DRAIN PLUG WASHER
12	SHAKEPROOF WASHER
13	NUT
14	SECURING PLATE AND

FIG 2.4

ILLUSTRATION & NOMENCLATURE

E.S. VOLUME	2
SECTION	2
PART	1
CODE	PAGE
AM.10	2.1

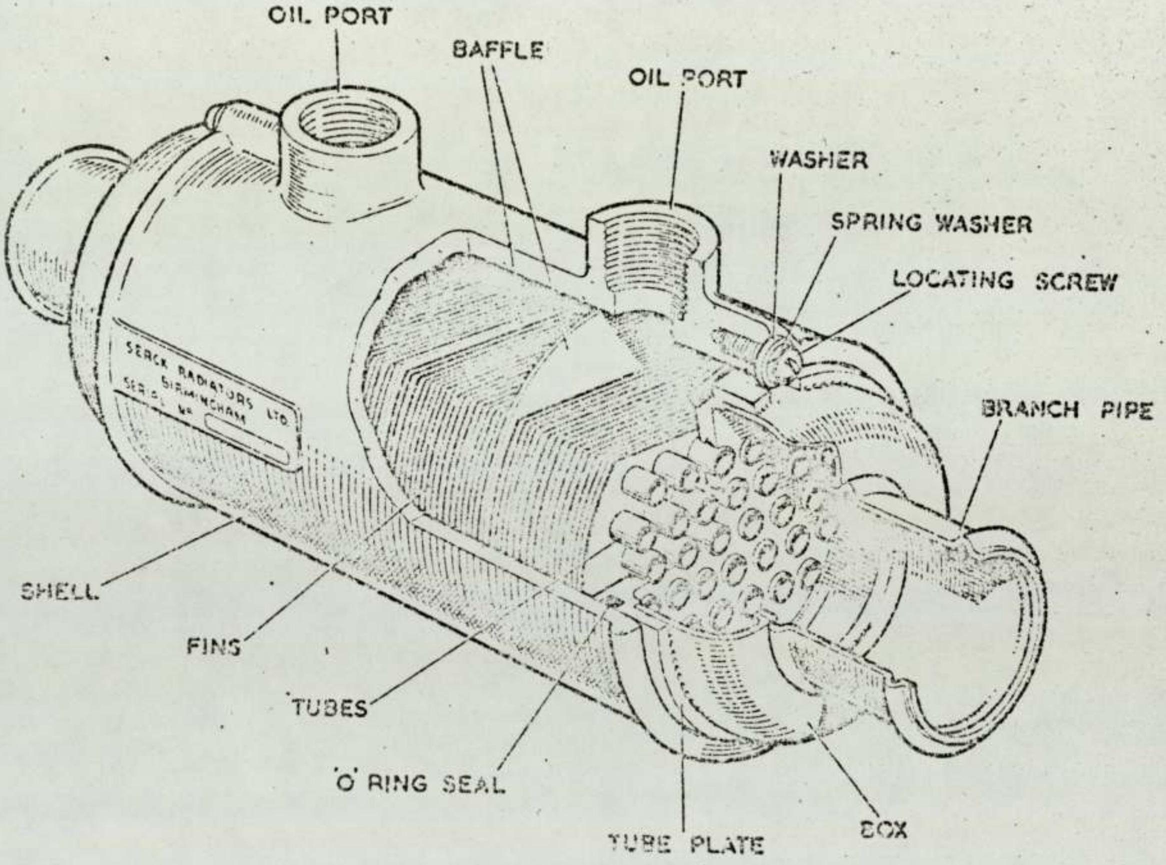


FIG 2.5

1.5

produce a cooler specific to his requirements, be it the production of a special casting to enable the unit to fit an engine housing, development of a new material, or ,the most common request, producing a cooler with a particular thermal performance for given rates of flow of the media. Thus, each division supports a team of heat transfer engineers and design staff who provide the general investigative and prescriptive service for any installation. With one notable exception, efforts are made to supply an existing design if possible, with the obvious concomitant savings of time and money.

Thus, the phrase "manufacturersof heat exchangers" covers a broad range of products having a common function, but executing this function in highly varied ways, using a wide range of production methods and selling in different markets.

II.3 Computer Usage in S.H.T.

S.H.T. bought its first computer for business data processing in 1969 and from the outset adopted a policy of employing specialist staff to design and develop systems tailored to the company's requirements. The alternative approach of purchasing a commercially available package was rejected on the grounds that such applications software would be either too simple or too complex. If too simple, a considerable number of program additions and modifications would be required to convert the package to S.H.T's requirements. It would be better to design and produce such program suites from scratch than attempt these conversions. Conversely, a package which provides facilities for all situations is highly complex, hence it is difficult to understand and modify. Although the supplier will usually provide support, there exist well-documented instances where such support has proved inadequate and the consequences have been disastrous for the customer. To make this approach work calls for skilled personnel to be available so as to modify and maintain the package. If sufficiently high calibre staff are needed, one might as well, runs the argument, employ them to develop one's own systems.

The view that self-sufficiency was superior to relying on external assistance was strongly reinforced by one of S.H.T's few exceptions to the rule. In the early 1970's a production control package supplied by I.C.L. called PROMPT generated so much confusion when installed in S.E.C.D. that it was quickly removed and a considerable sum of money was written off.

The company's second computer was installed in 1975. This was an I.C.L 1901T mainframe with 32K of core and run in batch mode. It supported four E.D.S. 30 disc packs, four tape decks, a line printer and card reader. The major reason for changing to this new machine was that it enabled the higher speed access data storage medium of discs to be employed in place of the earlier tapes, although in 1975 the transition from tape to disc was not yet complete.

Punched cards were the primary data input medium and two eight hour shifts per working day proved just adequate to meet the current level of the company's data processing needs.

Broadly the usage was slanted toward the commercial and financial aspects of the business at the expense of production and engineering. The research and development engineers used another computer not on the S.H.T. site for a small number of technical routines, but the divisional engineers had very little dealing with either computers.

There are three main reasons which can be advanced in support of this bias. These reasons reflect neatly the nature of the problems facing a company which is still in the phase where business computing is not yet an accepted part of the company's activities.

A manufacturing division can be considered as possessing two aspects, the first of which, production and product engineering, looks inward to the division and does not significantly affect the other parts of the company. The second, sales, purchasing and financial accounting looks outward to the central departments of the company, the accounts office, the buying office and so on.

If, as happened in S.H.T, the decision to buy a computer is taken centrally and the new department created to run it (Management Services) is made responsible to the Financial Director, the obvious aspects to consider 'computerising' first are precisely those with the highest degree of commonality between the manufacturing divisions, namely the commercial and financial routines. Further, since these areas are central to the task of maintaining the financial control of the business they tend to be the most well-defined and regulated. This too enhances their suitability to being implemented on computer.

Therefore the central areas form the natural starting point due to the high degree of commonality. They are the most well defined of the routines, they can be implemented from the centre of the business and the company does not have to rely upon the divisional management bringing the change about.

By 1975 the four manufacturing divisions were all using the

following systems:-
- sales ledger
- purchase ledger
- payroll
- cost and accounting ledger
- plant register
- cost of sales
- order book
- master parts file

These systems ran reliably and effectively so that they were well integrated into the day-to-day running of the business. However further extensions to the computer's usage encroach on areas specific to each division. Two sections of the company, S.E.C.D and a part of A.C.D known as the Block Shop, had been provided with Production Breakdown and Stock and Order Monitoring routines. These two areas were selected due to the high batch quantities involved and their small size in comparison with T.C.D and A.C.D. Apart from the previously mentioned exercise with PROMPT, the systems had been developed in house by Management Services and had provided an extensive grounding in this new area.

Steps had been made to extend the Production Breakdown routines to T.C.D and A.C.D, but due to lack of enthusiasm within the divisions the parts files and structure files were still incomplete and required a considerable amount of work to make them useful.

CHAPTER III THE FIRST PROJECT

SUMMARY The starting point of the First Project is described and some background provided. A methodology for this work is proposed and discussed.

SECTIONS

III.1 Initial Statement of the First Project

The title of the first project was:

> "The Application of Computers to Production Control within an Engineering Company".

The brief was to identify the shortcomings of the production control systems of one division, Small Engine Cooler Division, then design and implement improvements. The researcher was responsible to the General Manager of S.E.C.D. and the Manager of Management Services for the day to day activities of the practical work and to the project steering committee for the broader issues of the I.H.D. project.

The starting point was purposely general, so as to impose minimal restrictions upon the course of the project. However, the 'constraints' of the work were:

- S.E.C.D.
- production control systems.

III.2 Project Specific Background

During the previous year Management Services had completed the implementation of a production control system which had been designed completely in-house. This task had required the department to solve a considerable number of data processing and administrative problems, the experience of which was now to be employed in extending the use of the computer into the production areas of the other manufacturing divisions. Although S.E.C.D. was the most straightforward candidate for this development work among the divisions, by virtue of its simpler product and smaller size, it had received an amount of Management Services effort out of proportion to the division's importance within S.H.T. For this reason the bulk of the department's resources was to be employed away from S.E.C.D., but applying the lessons learnt there.

This meant that the production control system of S.E.C.D. was to receive no further attention under the short-term Management Services plan. But the General Manager was keen to progress, now that the major problems of the initial implementation and the acceptance of the computer had been overcome. Management Service's budget did not allow for any further staff to be taken on, thus the opportunity arose for this I.H.D. project to continue the development of the division's production control systems.

III.3 Methodology for the First Project

The first step was to establish some methodological structure for the practical work and following due consideration Fig. 3.1 was drawn up. The boxes represent separate stages within the project and the complete sequence is intended to overcome the researcher's lack of experience of both the engineering industry in general and production control in particular.

STAGE 1 There is an extensive literature of Production Control representing the distillation of a great deal of practical experience. An initial review of this provides ideas for structuring the subsequent work, as well as supporting an analysis of the existing manufacturing and production control methods within the division. This analysis phase should be sufficiently protracted and detailed to enable the researcher to understand precisely what is going on in the division.

STAGE 2 The outcome of this analysis will be a list and description of the problems and shortcomings of the existing production control system as viewed by the operational staff of S.E.C.D. The purpose of the subsequent stages is to overcome these problems and eliminate the shortcomings.

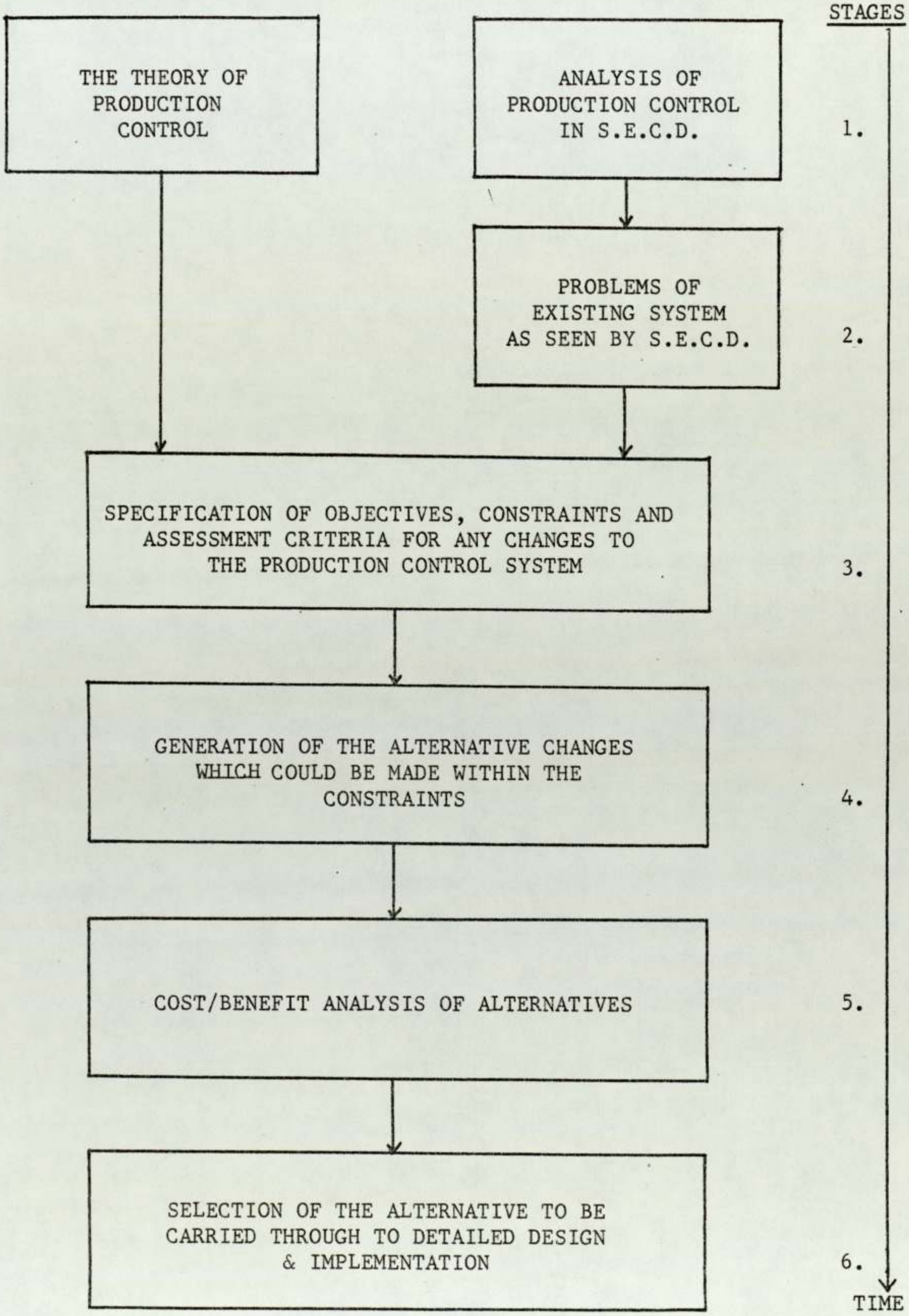

STAGES
THE THEORY OF PRODUCTION CONTROL
ANALYSIS OF PRODUCTION CONTROL IN S.E.C.D.
1.
PROBLEMS OF EXISTING SYSTEM AS SEEN BY S.E.C.D.
2.
SPECIFICATION OF OBJECTIVES, CONSTRAINTS AND ASSESSMENT CRITERIA FOR ANY CHANGES TO THE PRODUCTION CONTROL SYSTEM
3.
GENERATION OF THE ALTERNATIVE CHANGES WHICH COULD BE MADE WITHIN THE CONSTRAINTS
4.
COST/BENEFIT ANALYSIS OF ALTERNATIVES
5.
SELECTION OF THE ALTERNATIVE TO BE CARRIED THROUGH TO DETAILED DESIGN & IMPLEMENTATION
6.
TIME

FIGURE 3.1

STAGE 3 The elements of the prior work - the theory, practice and problems-are the groundwork on which is based the setting of objectives, targets, constraints and assessment criteria for any changes to the production control system which might be proposed. The objectives arise from the theory as applied to S.E.C.D., the problems as seen by the people within the company and the policy the division adopts to production control. These objectives are the broad statement of desired achievements. Examples might be, "to increase the accuracy of delivery date forecastings," or "to optimise the overall machine usage". These objectives are likely to be conflicting on occasions. (Indeed it would be unusual were this not the case.) However, each, individually, is a statement of desirability.

They can now be made more useful by evolving targets. These are quantified statements of the objectives and are intended as realistic figures which could be achieved. Targets are set through discussion, not with the people who operate the system but with those people who are affected by a failure to meet targets.

If the objective is to increase the accuracy of delivery date forecasting it is likely to be the customer liaison/progress chasing department which suffers when the quoted delivery date is not met and the customer complains. This department should quantify the obvious objective, "increase accuracy of delivery date forecasting" to a figure appropriate to their needs. If customers tolerate a delay of 3 days, then this stands as a plausible target.

Assessment of a change requires some relative weights to be given to the individual targets. The overall assessment will require that the relative merits of conflicting targets be judged. If possible, this should be done prior to having any ideas to discuss so as to obtain an unbiased view.

STAGE 4 This generates the alternative improvements which might be effected within the gross constraints. Both the theory of production control and the listing of practical problems encountered by the operational staff will play a role in this. Some changes can be small, others large, however associated with each will be a cost and a level of benefit derived through improved performance. The generation of the outline designs, necessary to estimate costs and benefits, is a function of this stage of the methodology.

STAGE 5 A standard cost/benefit analysis is carried out to have some basis for comparing alternative schemes. But in some instances the allocation of a cost and a measure of benefit are difficult. Should the cost of missing an opportunity be considered? What is the measure of benefit derived from improved customer relations? It is not necessarily straightforward to produce a ranking of these alternatives in cost/benefit order, but to genuinely compare the options it needs to be done.

STAGE 6 Having generated the ranking and selected the improvements, a plan of action for the detailed design and implementation could be drawn up. The method shown in Fig. 3.1 seemed to provide a reasonable way in which to approach the work and was adopted in November of 1975 at the commencement of the project.

III.4 Sources of Information for the Analysis

The practical investigation into, and analysis of, the production control systems of S.E.C.D. was based upon frequent and extensive interviews with the divisional staff, supported by a detailed examination of the physical records maintained.

The senior managers could only be interviewed by appointment, usually in a meeting of specified duration. However, with the operational staff of the division an effort was made to eliminate the formal aspects of the interview.

This was done for four reasons:-

(1) by becoming 'part of the furniture' the researcher could witness events as they occurred rather than having to ask questions to prompt appropriate answers;

(2) informality avoids any overtones of 'checking up' on the members of staff which naturally occur when talking about their work;

(3) a formal interview might constrain the interviewee to discussion of the formal system, rather than the informal one that might be in operation;

(4) it is a far better way of maintaining a necessary relationship over a considerable period of time, than its alternative.

Where the production control systems extend to areas outside the division it was necessary to pursue the investigation. Thus the cost office, management services, accountants, product design and sales staff were included in the work.

CHAPTER IV A SURVEY OF THE THEORY OF PRODUCTION CONTROL

SUMMARY Production Control is defined and its elements described. The techniques and tools of the discipline are reviewed with particular reference to the role of the computer.

SECTIONS

IV.1 Definition

The literature of Production Control is in agreement on a general definition of the subject. The quoted examples are from Burbidge J. L. (1971) and Corke D. K. (1969);

> "Production Control is the function of management which plans directs and controls the materials supply and processing activities of an enterprise, so that the specified products are produced by specified methods to meet an approved sales programme; these activities being carried out in such a manner that the labour plant and capital available are used to the best advantage".

> "Production Control is management of the execution of orders. Its objectives are to enable good delivery dates to be offered and to get customers' orders completed on time, consistent with keeping stocks and working progress at an acceptably low level and the utilisation of plant, management and materials at an acceptably high level".

These similar definitions are intended to cover Production Control in all types of manufacturing organisations. For the sake of brevity the following discussion is restricted to those aspects of Production Control relevant to production within S.E.C.D., namely the control of batched-flow production of multi-component products using the techniques of general engineering.

IV. 2 Functions

(i) to liaise between the sales and manufacturing areas to provide realistic quotations of delivery date whilst maintaining as much flexibility to meet changing requirements as possible. Obviously the Sales department has to negotiate delivery times with customers. This cannot be done if the manufacturing area supplies quotations which are unrealistic. Equally, the manufacturing area cannot tolerate being requested to perform the impossible. The medium through which these two parties reconcile their frequently conflicting objectives is Production Control.

(ii) to specify the work to be done in the manufacturing areas through the issue of appropriate instructions, then to monitor the progress of that work.

(iii) to identify impending production problems and to offset their effect as far as possible.

(iv) to optimise the usage of equipment and resources available within the manufacturing process.

(v) to provide information to other departments and to management about the manafacturing operation.

(vi) to maintain the minimum stock holding consistent with the desired level of manufacturing performance.

(vii) to ensure the availability of the items necessary to support production, such as drawings of components, tools, jigs and fixtures, material and people. Since it is Production Control who decides when an activity will occur in the manufacturing area, it is their responsibility to synchronise the arrival of these essential elements from the disparate sections of the company.

From the above list it is apparent that the Production Control section has to fit into precisely that functional area of the company's spectrum of activities not covered by any other section. Although the very business of a manufacturing company such as S.H.T. is the construction of heat exchanges, the majority of departments within the company are not directly concerned with the routine production.

Consider
- Product Design and Development, orientated to customer requirements and product specification.
- Production Engineering, deals with methods of manufacture, how to make a product, but not with the repetitive and continuing production.
- Factory Management and Maintenance, covers the provision and upkeep of the manufacturing facilities.
- Sales Department, orientated to the customer and trying to mould production to suit the everchanging customer requirements.

- Stores, controlling the flow of Stock to and from the various repositories.
- Purchasing, converts an internal need into an external order.
- Finance/Accounting, monitors the flow of money around the company.

These and other departments can be visualised as a set of interlocking activities combining to constitute the company, yet none of them is actually responsible for "getting the product out of the door". Each is operating to some measure of success other than the quantity of items dispatched during a given period. They can all work in the most efficient manner imaginable, yet the business could still become a commercial disaster due to shortcomings in that area precisely identifiable as the heart of the business - Production Control.

Accountants can present an accurate picture of financial disaster, salesmen can report a huge order book which is not being built, the products can be excellent, they can be brilliantly engineered and the modern plant immaculately maintained. All these are necessary for the success of the business but they are insufficient if the P.C. function fails to discharge the tasks listed at the beginning of this section.

IV. 3 The Main Elements

The three elements of Production Control are INITIAL PLANNING, PRE-PRODUCTION PLANNING and CONTROL OF MANUFACTURING. (The terminology follows CORKE (1969), but BURBIDGE (1971), MAGEE & BOODMAN (1967) and OFFORD (1967) say much the same things.)

INITIAL PLANNING involves P.C. interacting with the product designers and production engineers to agree an operation layout. This specifies how a product is to be made, the sequence of manufacturing, determines the time allowable for the stage and the precise material requirements. Such data are permanent, in that they will remain the same every time that product is manufactured, unless some alterations are implemented.

The specialised equipment necessary to do the work, such as press tools, jigs, and punched tapes to control automatic machines will also be specified and obtained during the phase.

In practice initial planning occurs continually. There are always changes to design, manufacturing methods and materials taking place, so it cannot be viewed as a once-off exercise.

PRE-PRODUCTION PLANNING is intended to ensure that realistic order completion dates are supplied to the sales department. Any manufacturing operation has a maximum capacity. It is not possible to produce more components on a single machine than there can be machine cycles. Therefore it is possible to place a greater demand upon the works than can physically be fulfilled. Capacity planning is the name of the process where demand is forecast at the earliest possible time and factory capacity varied to accommodate this demand.

Its counterpart is termed Order Intake Control and deals with the process where the intake of orders is modulated to levels which the factory can fulfil.

Four causes of late delivery can be itemised:

(i) insufficient manufacturing capacity
(ii) non-availability of materials, tools, specifications, instructions, etc.
(iii) unplanned occurrences such as machine failure, absenteeism and rejects
(iv) failure to process work in the best sequence.

Item (i) should in theory, be catered for by some combination of Order Intake Control and Capacity Planning. Item (ii) is in part met by the initial planning stage. However, the aspect not covered by initial planning is the important one of ordering, see Fig. 4.1.

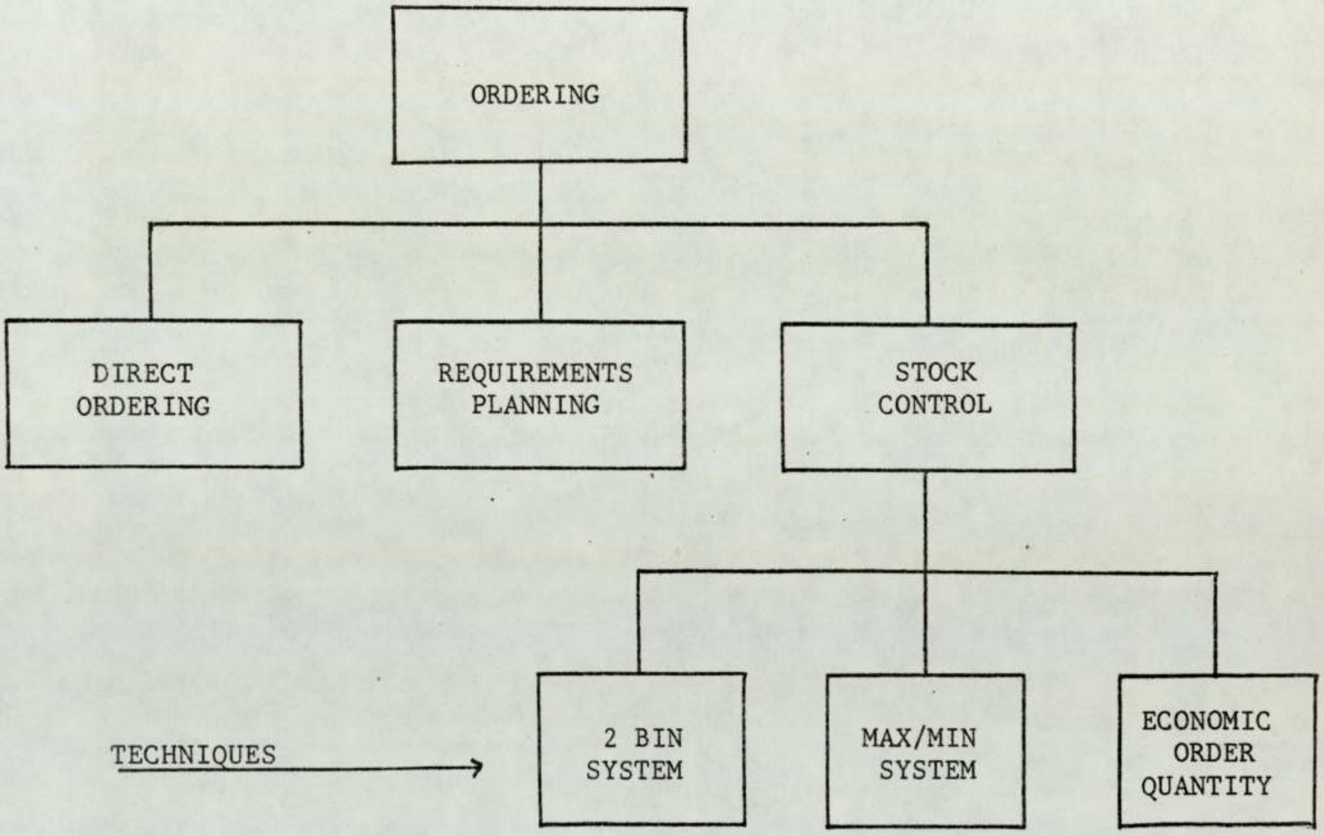

ORDERING
DIRECT ORDERING
REQUIREMENTS PLANNING
STOCK CONTROL
TECHNIQUES
2 BIN SYSTEM
MAX/MIN SYSTEM
ECONOMIC ORDER QUANTITY

FIGURE 4.1

Ordering is the function which specifies what is to be bought in or made during the manufacturing period in question. An order will specify a quantity and a delivery date. Direct ordering is for those items needed for a specific job and for no other. The nuts and bolts used in several different products would not be ordered directly, whereas the quantity of a special metal needed for a one-off job would be. Requirements planning is an activity which has been considerably aided by the advent of computer usage in P.C. and refers to the collation of needs for standard components across different works orders.

Since the overwhelming preponderance of companies employs the principle of the closed-stores to which goods can only be added or removed by means of a stores requisition, the flow of material into the manufacturing area is through the stores. Hence ordering is not just a matter of knowing from the requirements planning which components are needed, it is necessary to know what is already in stock. This justifies the presence of Stock Control, and the many specific techniques for effecting it, in Fig. 4.1.

As with the initial planning stage, pre-production planning is a continuous operation vital to support the next stage, control of manufacturing.

CONTROL OF MANUFACTURING covers the scheduling of operations in which specific starting and completion times for jobs are issued to the manufacturing sections, shop loading where individual sections are given the maximum amount of work that can be achieved in the period but in line with the overall production plan, shortage control, delay anticipation and the maintenance of progress records.

"Scheduling is mainly concerned with finding the optimum start and finish times for each task in relation to attainment of a plan. Loading is concerned with the effective utilisation of capacity and the determination of reliable delivery dates."

(from Burbidge J.L. (1971))

Although the pre-production planning stage has considered the capacity of the manufacturing area, it is not intended to provide specific instructions as to order-processing sequence in every section of the factory. Scheduling and loading requires P.C. to issue instructions to each section saying what should be made by when. This is possibly the essence of P.C. and mistakes here cannot be compensated by extreme efficiency elsewhere. The maintenance of progress records, in any one of a number of ways to be discussed later, provides the means of knowing what is going on within the factory without having to leave an office to find out. It is also the basis of much of the information supplied to the sales department in particular, usually in response to questions such as "When will job number 1234 be finished?"

The remaining points - shortage control and delay anticipation, are accepted as being extremely difficult to organise since their timing and effect are by definition unexpected.

Successful action requires a great deal of knowledge about the products, manufacturing methods and the factory to be allied to valid information about the current state of affairs in the factory, particularly work loads on the separate sections, the tightness of the delivery schedule and the status of individual orders. The popular image of a harassed production controller stems from the difficult nature of his job. He is required to accommodate unforeseen changes to the plan by manipulating schedules and operation sequences, usually whilst having to strike compromises between offending one or other of the sections of the company with whichhe is forced to negotiate.

IV. 4 TECHNIQUES & TOOLS

Most of the departments of a company listed earlier in this Chapter have techniques and tools whichare used to improve the efficiency with which they do their job. Accountants have Discounted Cash Flow calculations, Standard and Marginal Costing, balance sheets and budgets to enable them to compare the worth of projects and record the flow of money around a company. Sales Departments maintain sales ledgers and employ seasonally weighted sales forecasts.

Management have 'Return on Capital Employed' ratios, Management by Objectives, Group technology and the use of profit centres to act as measures of success and principles upon which to base action.

Although many of these ideas have become enshrined as 'the way to do things', indeed in some cases have become statutory requirements, they all began as techniques, designed to make the job, of controlling the particular function, easier. Some have spawned tools which are used to automate or simplify the practice of the techniques - the D.C.F. tables used by the accountant, the computer programs used to maintain the sales ledger, the organisation chart on the General Manager's wall. These tools can be systems, such as the weekly sales review meetings, the monthly management - union discussion and so on.

By far the majority of techniques used by Production Controllers is in the area of inventory control. This is a subsection of the ordering function and the problem is to hold just enough stock to support an unknown and variable demand. The application of methods from Operational Research has produced ways of forecasting short term demand, varying in complexity from the use of the previous periods demand figure to Bayesian forecasting. Lewis (1970); (1) and (2) demonstrates how sophisticated such mathematical techniques have become.

Given a reasonable demand forecast, the next aspect of inventory control benefitting from Operational Research is the Inventory Model. A model aids decisions on how much to order or manufacture and when to do so. The criterion for assessing performance in this is the cost of maintaining the inventory.

Components of cost include:

- the cost of obtaining goods
- the cost of holding goods
- the cost of shortages

The models aggregate the individual costs (which are probable functions of quantity, size and usage) and then through suitable statistical techniques, minimise the cost with respect to some variable. In this way Economic Order Quantities are calculated i.e. the most suitable levels for reorder are deduced.

Ordering techniques can be divided into two distinct groups according to one or other of the following principles:-

- Maintain a fixed order quantity and vary the interval between orders.
- Maintain a fixed order cycle, but vary the order quantity.

Although each has had its proponent, many hybrid systems combining their better elements have been developed to suit specific requirements, see Greene (1970), MaGee & Boodman (1967), or Plossl & Wight (1967) for details.

All these techniques fall into the area of pre-production planning and are essentially mathematical abstractions from the real world processes.

In contrast the technique for production scheduling and control is less of a technique than an organised method of monitoring and controlling the progress of work. These activities are usually carried out either by means of a version of the Loading Box system or by some form of Gantt charting. The essence of each of these is given in the accompanying exhibits and details are available from Corke (1969), Burbidge (1971) or Radford & Richardson (1968).

EXHIBIT 1

The Loading Box System for Scheduling and Loading

Fig. 4.2 shows the layout for the system. The fixed information for each part number created during the Initial Planning Stage covers operation sequence, machine type, standard times and the specification of the materials required.

When an order is received for a part, two master cards are raised. The constant master lists the fixed data and the variable master holds the data specific to the order such as delivery date and quantity. From these masters are generated:

- Progress Card. This is held centrally and is used to record what operations have been carried out on the batch and when.
- a material requirement card-lists the materials, including raw, bought in or subcomponent, needed at every stage.
- a route card that gives the sequence of operations
- job cards - each operation in the complete sequence has its own job card.

These are distributed as shown in Fig. 4.2.

At a preset time before each individual operation is commenced, the material requisition is put through shortage control procedure to check material availability. These cards and the job card for the next operation are sent to the supervisor of the shop in question for the work to be started. Upon completion this fact is recorded on the progress record card and the job card for the subsequent operation, waiting in its box.

Since job cards are removed from the loading box on completion, the balance in the box is the total on that section for this period. It can be compared with the capacity figure, this being the basis of the weekly reports on loading for each section.

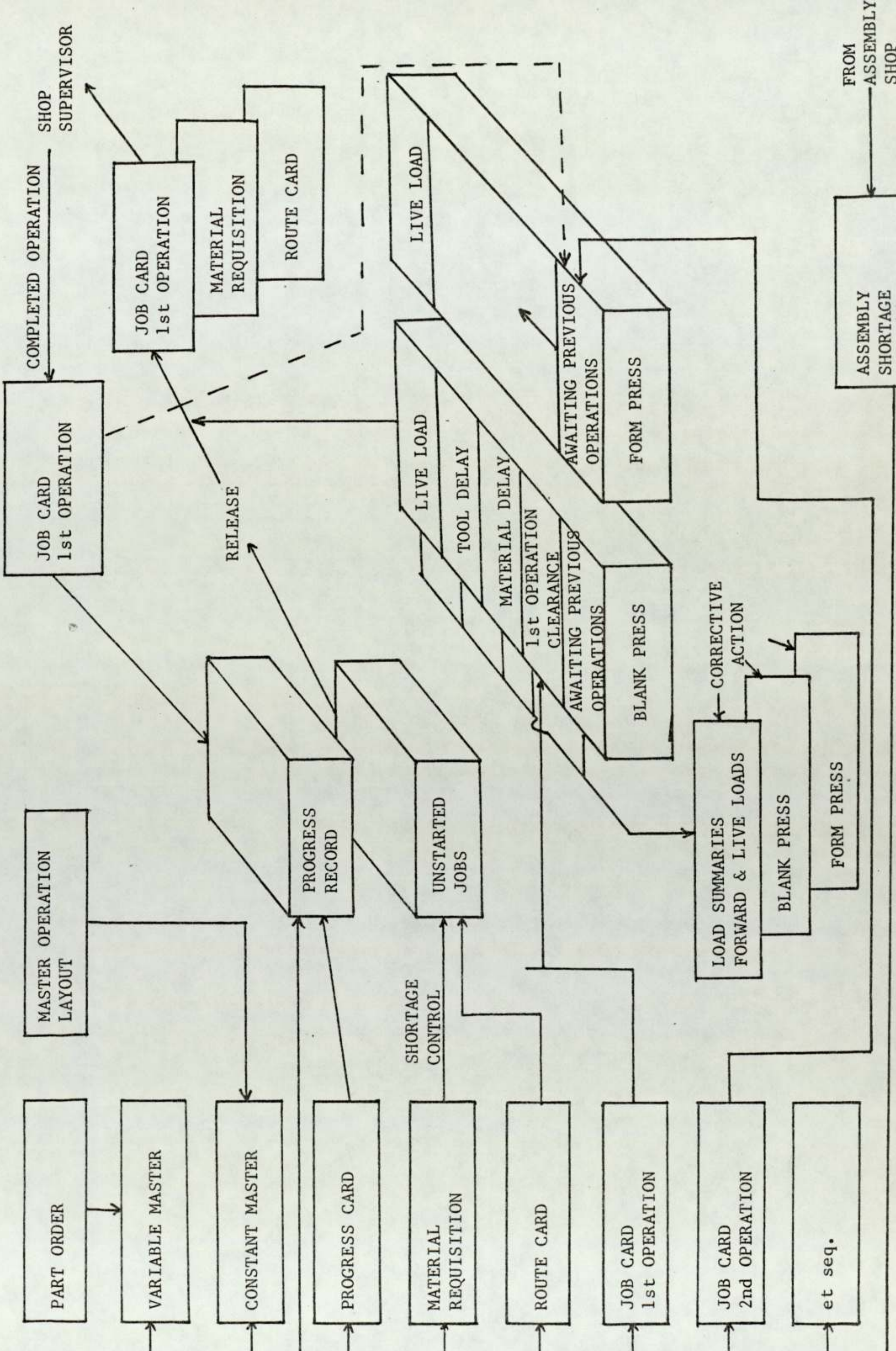

PART ORDER
VARIABLE MASTER
CONSTANT MASTER
PROGRESS CARD
MATERIAL REQUISITION
ROUTE CARD
JOB CARD 1st OPERATION
JOB CARD 2nd OPERATION
et seq.
MASTER OPERATION LAYOUT
SHORTAGE CONTROL
PROGRESS RECORD
UNSTARTED JOBS
JOB CARD 1st OPERATION
COMPLETED OPERATION
SHOP SUPERVISOR
JOB CARD 1st OPERATION
MATERIAL REQUISITION
ROUTE CARD
RELEASE
LIVE LOAD
LIVE LOAD
TOOL DELAY
MATERIAL DELAY
1st OPERATION CLEARANCE
AWAITING PREVIOUS OPERATIONS
BLANK PRESS
AWAITING PREVIOUS OPERATIONS
FORM PRESS
LOAD SUMMARIES FORWARD & LIVE LOADS
BLANK PRESS
FORM PRESS
CORRECTIVE ACTION
ASSEMBLY SHORTAGE
FROM ASSEMBLY SHOP

FIGURE 4.2

EXHIBIT 2

The Gantt Chart for planning and controlling a project (see Fig. 4.3) lists the major stages in the complete manufacturing tasks and plots them against time by means of a simple bar. Progress can easily be monitored, but the practice can be criticised on the following grounds:

- it cannot show the dependency of one operation on another
- identification of 'initial' activities cannot be done
- manpower and resource allocations are now shown
- it cannot collate work across orders.

To overcome these deficiencies other types of charting have been developed. Most work on the same principle as the Gantt Chart, namely listing the elements of manufacturing, but the horizontal axis indicates capacity instead of time. The total length of the line represents the amount of work which can be done during the period by that section. As jobs arrive the amount of capacity each needs is blocked off on the line. Scheduling can be achieved by the simple expedient of inter-changing blocks along the line. (see Fig. 4.4)

THE GANTT CHART

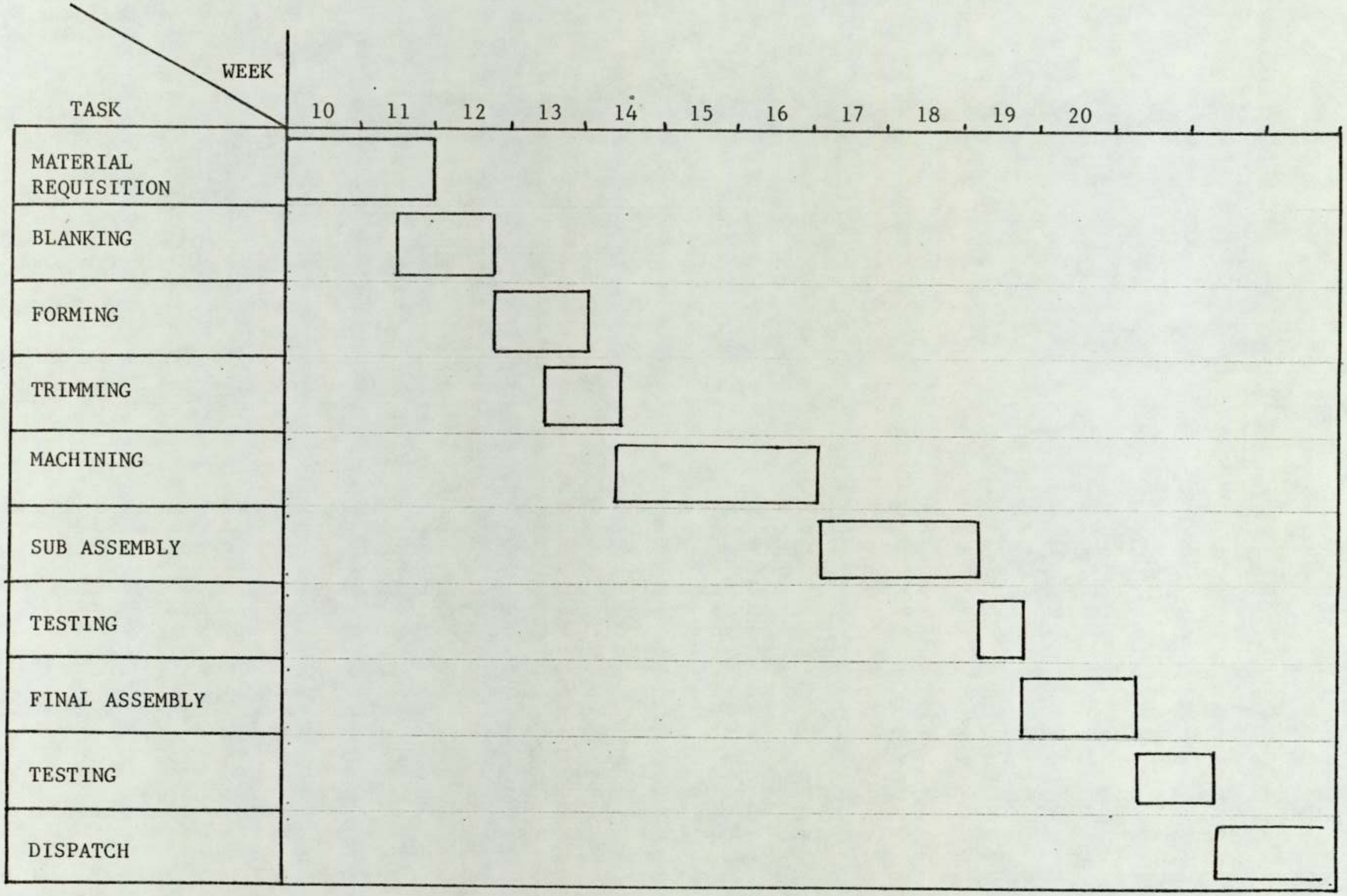


FIGURE 4.3

MACHINE CAPACITY CHART

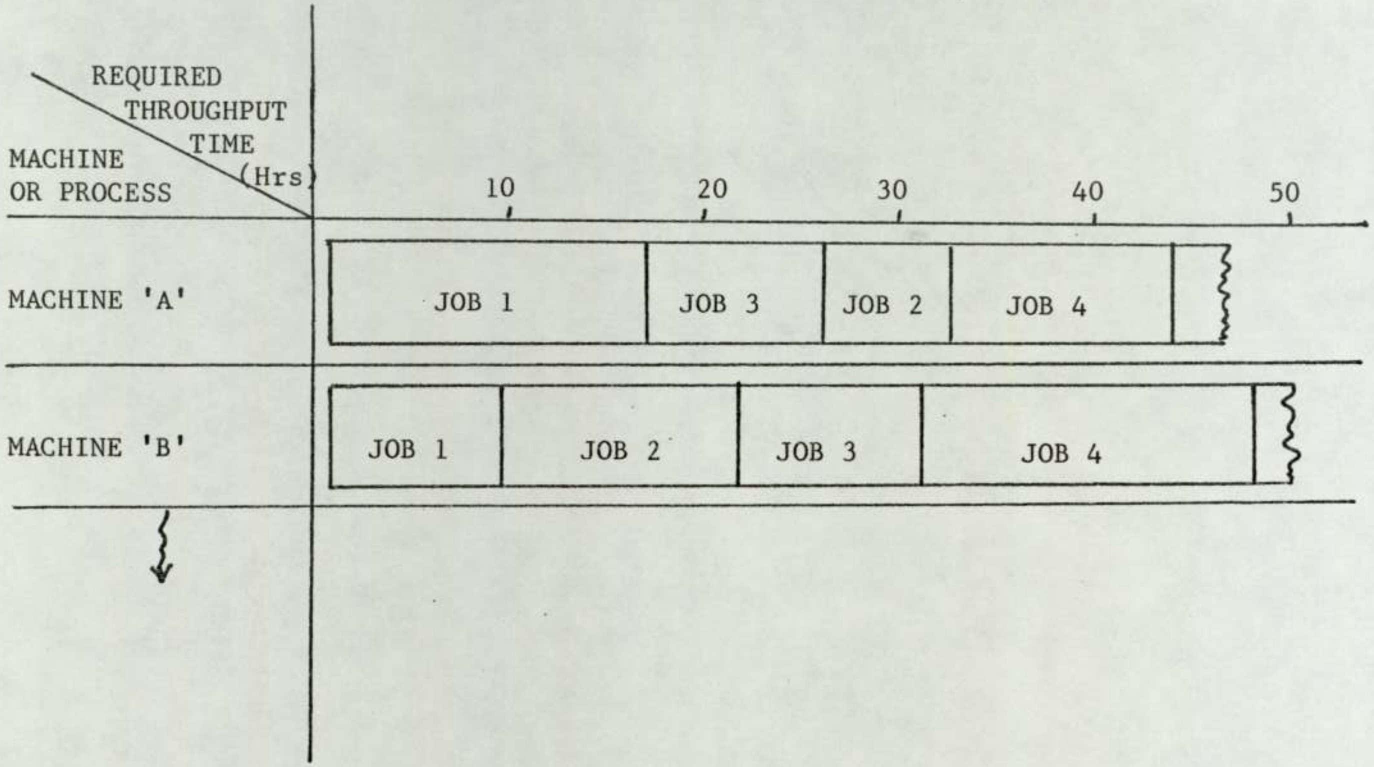


FIGURE 4.4

EXHIBIT 3

PROJECT NETWORKS Since the late 1950's a host of very similar planning techniques based on network analysis have been developed to overcome the Gantt Chart's inability to deal with operation interaction.

e.g.
- PERT - program evaluation and routine technique
- CPM - critical path method
- PRISM - program reliability information system for management
- PEP - program evaluation procedure
- IMPACT - integrated management planning and control technique
- SCAN - scheduling and control by automatic networks systems.

The starting point of such techniques is to draw up a network, such as Fig. 4.5.

Each event carries an earliest and latest time at which it might be completed, determined by its relation to other events. The slack is the difference in these two times. The float for any activity is the latest finish time minus the earliest start time minus the duration of the activity and is a measure of the latitude of this event's timing.

The longest route through the network is called the critical path and it is identified by those activities having zero total float. Any delay on this path will cause the project completion date to be put back.

THE SEQUENCED GANTT CHART

Having calculated the critical path, the sequenced events, and the free float, these may now be presented on a 'sequenced Gantt chart' which is a more useful form of Gantt chart than that described previously. Details of these are given in WILD (1975) or OFFORD (1967) and Fig. 4.6 shows a typical chart for 10 activities A to J, its use being an identification of critical tasks.

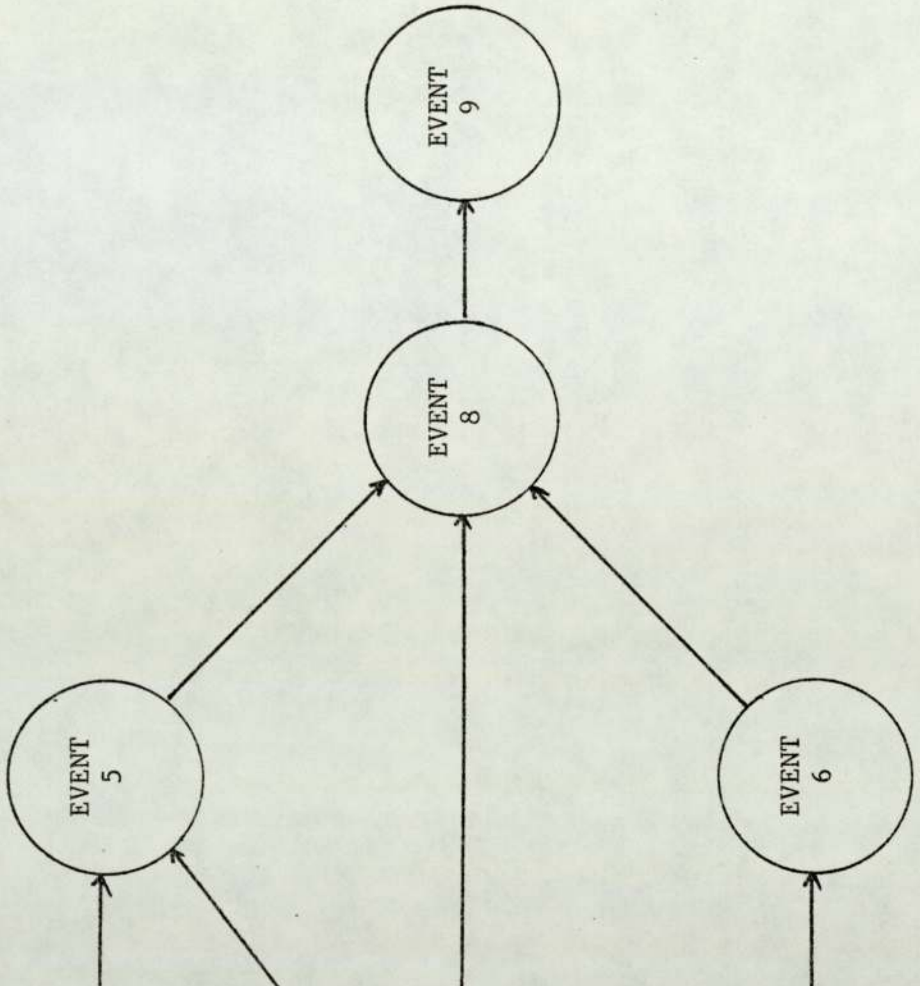


FIGURE 4.5

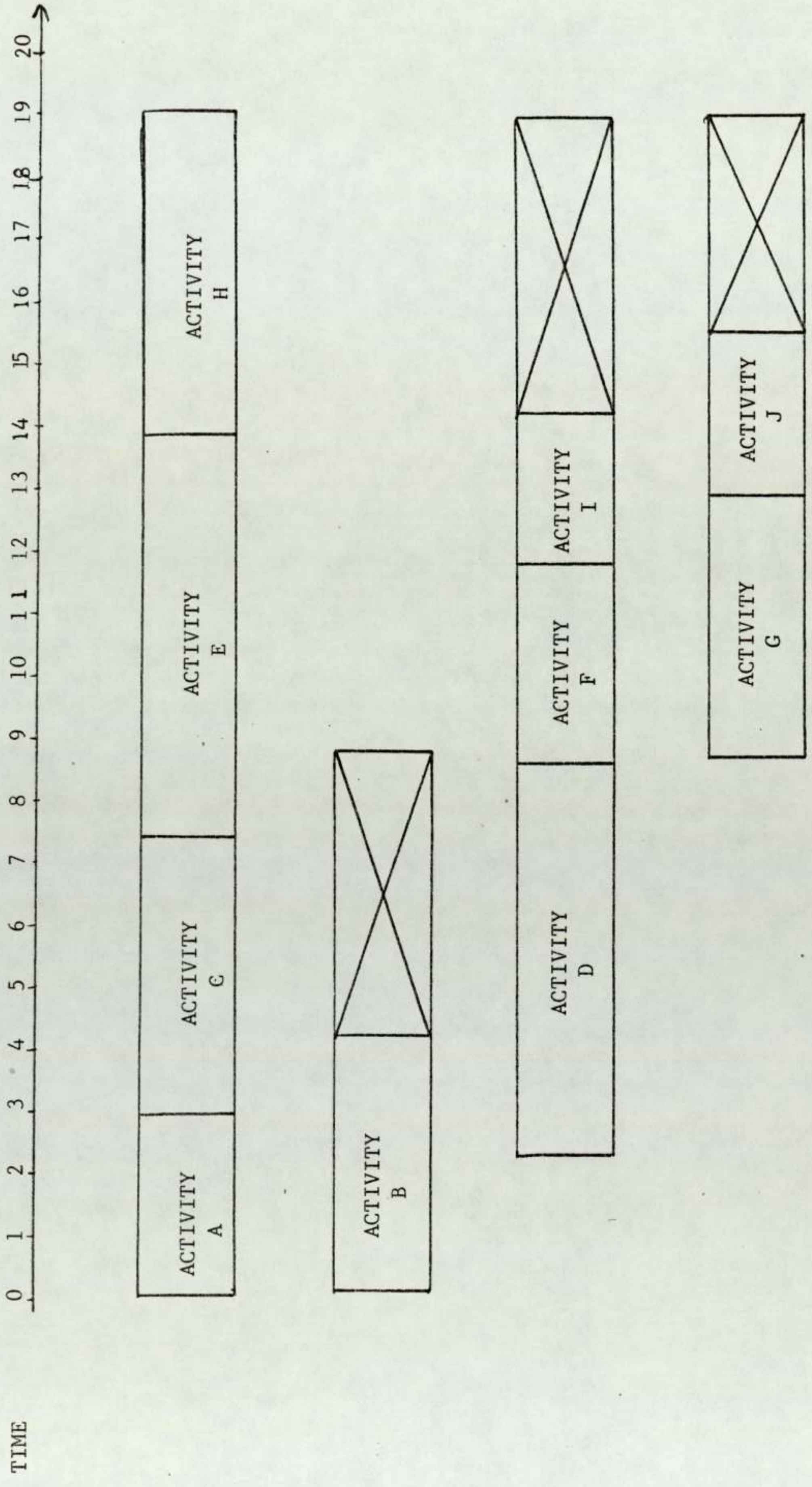

TIME
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
ACTIVITY A
ACTIVITY C
ACTIVITY E
ACTIVITY H
ACTIVITY B
ACTIVITY D
ACTIVITY F
ACTIVITY I
ACTIVITY G
ACTIVITY J

FIG. 4.6

The final technique to be mentioned is another highly mathematical one, that of sequencing jobs through a manufacturing process.

The 'sequencing' or 'dispatching' problem is one encountered frequently where a large number of jobs requires numerous operations to be performed on several machines. The question to be answered is - in what order or sequence should jobs be assigned to machines?

Although many complex and vigorous sequencing heuristics are available based on priority rules, no complete solution has yet been devised for the general practical problem.

It is important to distinguish between two classes of problem. Firstly, the <u>static</u> case, in which all jobs to be processed are known and are available and in which no additional jobs join the queue during the exercise; secondly, the <u>dynamic</u> case which allows for the continuous arrival of jobs into the queue. Associated with these two cases are certain objectives. In the static case, the problem is merely to sequence a queue of jobs through a given number of machines, each job passing through the machines in the requisite order and spending the necessary amount of time at each. The objective in this case is usually to minimise the total time required to process all jobs - i.e. the <u>throughput</u> time. In the dynamic case, the objective might be to minimise machine idle time, minimise work-in-progress or to achieve the requisite completion or 'due-dates' for each job.

An optimum solution to the case where n Jobs are to be processed through 2 machines is available, this being Johnson's algorithm (Johnson 1954).

To process n jobs through m machines has no general solution yet, but the branch and bound algorithms developed by Ignall and Schrage (1965) provide acceptable results, as does the more recent work of Campbell, Dudek & Smith (1970).

When the 'dynamic' situation arises the sequencing problem described previously becomes rather more complex. Not only do jobs continuously arrive in the queue, but the sequence in which operations are performed will vary and machines will be liable to break down. In this situation the problem is not normally approached by looking for a complete job sequence but by considering it in simpler 'dispatching' terms, that is by considering each job on a daily or weekly basis, etc., and, according to the criteria, loading the machines for that time period only.

The principal method of job dispatching is by means of priority rules. Moreover, whereas the objective of the static problem is to minimise total throughput time, the criteria for dynamic situations are normally different.

e.g. (1) Due date Criteria - average lateness, number of jobs late, etc.

(2) Time Criteria - mean throughput time, average idle time, etc.

Examples of simple priority rules in common use in manufacturing industries are (Conway, 1965):

i. First come first served.

ii. The job with the earliest due date is done first.

iii. The job with the shortest processing time is done first.

iv. The job with the highest value is done first.

However, many other rules based on the calculation of a <u>priority index</u> have also been developed as a result of research using simulation techniques or practical experimentation.

e.g. Priority index $= \dfrac{(t_i - x_i) - f_i}{N \pm b}$

where ti = present date.

xi = scheduled start date for operation*.

fi = a delay or contingency allowance.

b = empirically derived constant.

N = number of remaining operations.

* Due date minus total processing time,

The simulations used to test priority rules are usually simplified by making assumptions such as the following:-

- The operation times (including set-up times) for all jobs are known and are independent of the order in which jobs are processed on machines.
- Operations once started must be completed.
- No machine may process more than one job at a time.
- Transport time of jobs between machines is neglected.
- Each job must be processed on machines in a given

predetermined order.

- Machines do not break down.
- Machines and labour resources are available in known quantities.
- The 'splitting' of batches is not permitted.

IV. 5 Computer Usage

So far, this brief review has concentrated on manual techniques, however the tool having the largest single impact upon production control is the computer. By the mid 1970's the computer was becoming an accepted part of the production scene in medium and large companies although the high cost of the equipment debarred its use in smaller companies.

The role of the computer in production control can be summarised as:

(a) Analysis of data.
(b) Recording of information and updating files.
(c) Making quantitative decisions i.e. decisions based on mathematical logic.
(d) Provision of management information.

Some of the more specific areas of production control where computers have been successfully introduced are described in Exhibit 4 and the major benefits claimed are listed in Exhibit 5.

EXHIBIT 4 EXAMPLES OF COMPUTER USAGE

Order Analysis. Details of all orders for a company's products can be retained in a memory store accessible by the computer on demand. The commonest file types for this purpose are magnetic disc and magnetic tapes. The data may be analysed in various ways enabling the available information to be presented in different forms according to the particular problem on which a decision is required. For example, the computer can be programmed to group orders into different categories and to determine demand trends for each category; from these, it can forecast what the future demand for each product category is likely to be, assuming that the current trend patterns continue into the future. Such an analysis not only assists in the development of the short-term production programme, it also enables the sales forecast to be 'monitored in advance', indicating to the sales department which product groups are likely to result in a shortfall in sales, compared with the sales forecast, and for which product groups demand is likely to exceed production capacity. This assists sales management in determining where the sales effort would most beneficially be applied.

Monitoring also indicates to production managment where and when increases or decreases in capacity are likely to be required enabling appropriate action to be taken in advance, e.g. extra shifts etc. A further advantage is that it provides an opportunity for the management accountant to warn production departments that variances are to be expected in those budget areas affected by a change in expected demand.

EXHIBIT 4 (cont'd)

Past orders can also be analysed under different headings such as profitability, geographical location of customers, value of orders per salesman etc. While such information may not be directly related to production control, it is useful management information which is often required.

Operations Planning and Bills of Materials. Details of the raw materials, purchased items, jigs and tools required to make a finished product together with the set-up or changeover times for each manufacturing operation may be retained in a 'parts file' held in a magnetic memory store.

This information can be used to determine dates by which purchased materials should be obtained and manufacturing operations should commence in order that a customer's requirements can be satisfied by a given date. For complex products the computer may employ a network planning technique such as critical path analysis or, for batches to be delivered at different points in time, the line of balance method could be employed. Cost data, either included in tabular form on other files, allow the computer to be programmed so that it can calculate the standard cost of manufacture for each stage and compare with actual cost information being fed back from the shop floor.

Bills of materials or parts list files are fundamentally lists of parts and/or sub-assemblies which go into the manufacture of a final assembly or another sub-assembly. The computer may either

EXIBIT 4 (cont'd)

analyse the product in order to calculate the net requirements for parts or assemblies or may synthesise information to produce a where used list.

Capacity Loading. The computer can be programmed to load orders onto the manufacturing facilities for several weeks ahead, perhaps with reference to some particular criterion which management desires to optimise, such as minimisation of a particular product mix, or reduction of overtime working.

Data on load and capacity may be used to estimate realistic delivery times for individual orders, and also to assess such factors as the efficiency of manufacturing departments.

Scheduling and Sequencing. Computer-aided scheduling and sequencing of jobs in production control is a problem which has only been approached in more recent years and, mainly for this reason, its application is still fairly limited.

For some types of manufacturing operations, the computer can produce and up-date schedules reasonablyaccurately using linear programming, line of balance, branch and bound techniques etc. However, the general problem is an extremely complex one involving a large number of jobs, operations and machines and, although various algorithms and heuristic programs for scheduling and sequencing have been developed, the majority suffer from the disadvantage of being concerned with the optimisation of only one

EXHIBIT 4 (cont'd)

or two criteria such as minimisation of idle time, overdue orders etc. In practice, however, there are many conflicting criteria which all have some importance and should be considered.

Stock Control. In its simplest form, the computer can be used for simple stock recording and for ordering when the stock level for an item falls below a predetermined re-order point. A more sophisticated system could include demand forecasting techniques based on an analysis of past demand, which can be used for automatic calculation of re-order levels, buffer stocks, re-order quantities etc. Systems could be applied to finished products, brought out and manufactured stock items, raw and consumable materials.

Work-in-progress is a special aspect of stock control which is suited to computer application using fast feedback of shop floor data. This aspect is closely connected to job progress recording.

Works Order Documentation. Computers can be programmed to produce complete works documentation, either as a master from which copies will be produced, or as a multi-copy printout.

EXHIBIT 5

The Benefits of Computerised Production Control

The benefits claimed from computerised production control can be summarised as:

- reduced work in progress and buffer stocks.
- more accurate information updated as and when required.
- better communication.
- foremen enabled to plan ahead.
- progress chasers shown what and where to chase.
- reduced paperwork in circulation.
- over and under loading of facilities highlighted.
- long term effects of management decisions shown.
- improved management performance.
- management statistics provided.

Practical Implementation of Computerised Production Control

A survey carried out by Rizwi (1971) into production planning and control by computer investigated practical applications in some ninety-three companies of which sixteen per cent were jobbing type, seventy-four per cent batch, and ten per cent continuous or flow production.

Computing time within these companies was, on average, split as follows: thirty-four per cent on accounting, ten per cent on payroll, thirty-two per cent on production control and twenty-four per cent on other activities.

Although a computerised production control system should be considered as a complete entity, various functions can be regarded as separate subsystems and for the purpose of the survey nine such subsystems were identified which broadly speaking relate to the areas of application described previously. A company's progress towards an integrated system may be measured by its success in developing and linking the subsystems together.. Its attitudes with respect to the effectiveness of the computer for production control appear to depend on which subsystems the particular company has in operation

The nine subsystems which were considered are briefly described below:

Sales Forecasting Subsystem provides the means whereby past demand data may be analysed in a regular and routine manner to provide forecasts of demand in future periods. These data are fundamental to the whole planning process and together with sales order data form the principal input to the production control system.

Sales Order Processing Subsystem has the primary function of recording customer orders, issuing shipping advice and invoices for orders which can be supplied from stock, initiating production planning for orders which require manufacture, and compiling order backlog and delivery statistics for management information and action.

Purchasing Subsystem initiates the purchase orders, monitors delivery, progress, goods inwards and quality control. It may also record and evaluate supplier performance in terms of price, quality and delivery.

Capacity Planning Subsystems operate on two planning levels.

(1) Long term - to determine the future resource requirements so that the long term production plans may be accomplished.

(2) Short term - to determine what temporary additional capacity, such as overtime working and subcontracting, should be used to accommodate short term variations in demand.

Requirements Planning Subsystem with reference to the materials and parts file, breaks down the sales orders into individual assemblies, sub-assemblies and component parts, and grosses up the total requirements of each. Requirements planning, by reference to stocks, delivery and manufacturing lead times, enables materials and parts to be available at the right time and in the right quantities.

Inventory Management Subsystem maintains the inventory master file, updating it when items are received or issued and signalling when replenishment is necessary and the amount required.

Engineering Data Control Subsystem concerned with the recording, maintenance and updating of the materials and parts files, the manufacturing instructions for each component, assembly and product, and all other engineering information necessary for production.

Operational Loading Subsystem concerned with the actual loading of the work on the production work centres and provides the detailed schedule of when and where each aspect of the work is to be performed.

Shop Floor Control Subsystem provides all the data such as detailed manufacturing instructions, routing and progress information which are necessary for the undertaking and progressing production on the shop floor. The subsystem, by information feedback from the shop floor, maintains data on the status and location of all work-in-progress and issues situation reports for control purposes.

The percentage of companies routinely operating each of these computer subsystems is shown below.

	% of companies using subsystem	% of companies using standard package
Sales forecasting	31	2
Sales order processing	68	1
Purchasing	39	2
Capacity Planning	40	9
Requirements Planning	59	13
Inventory Management	76	10
Engineering Data Control	47	20
Operational Loading	44	17
Shop Floor Control	46	7

It is perhaps to be expected that inventory management figures most prominently, but a surprising fact is the low percentage of companies using a sales forecasting system.

The most significant use of standard packages is for engineering data control, operations loading, and requirements planning. The percentage of companies using standard packages for the various subsystems is, as indicated in the table, generally small. Thirty-four per cent of the companies did in fact use standard packages for one or more of the subsystems, and ninety percent of these made modifications to the packages to suit their own particular requirements.

The N.C.C. (National Computing Centre) publish a series of FACTFINDER booklets which provide a comprehensive list of sytems being offered in a particular area, such as accounting, payroll etc. No.13 (1973) covers Production Control and EXHIBIT 6 is a list of some of the major computer companies' products.

EXHIBIT 6

Computer Company	Package Name	Description
I.B.M.	CLASS	Shoploading and scheduling including network analysis.
I.B.M.	MINCOS	Inventory Control.
I.C.L.	PROMPT	An integrated P.C. package including requirements calculations, stock control, shoploading and scheduling, progress control.
I.C.L.	PLUTO	Bill of Materials package with provision for parts explosion and implosion.
I.C.L.	POWER	Another integrated P.C. package, as for PROMPT but with network analysis and purchase control.
HONEYWELL	FICS	Sales Forecasting and Inventory Control System.
HONEYWELL	TABS	A bill of materials package supporting parts explosion.
HONEYWELL	FACTOR	An integrated P.C. package including FICS and TAB, plus sales order processing, production scheduling and progress control.
N.C.R.	AIMS	Stock control and ordering, including parts implosion and explosion.
I.B.M.	KRAUS	Job scheduling.

EXHIBIT 6 (cont'd)

Computer Company	Package Name	Description
I.B.M.	B.O.M.P.	A bill of materials package supporting parts explosion and implosion and gross requirements planning.
I.B.M.	P.I.C.S.	An integrated P.C. package including B.O.M.P., inventory management, capacity planning shoploading and scheduling, progress and purchase control.
I.B.M.	CAPOSS	Machine loading and scheduling.
UNIVAC	UNIS	Shop scheduling.

EXHIBIT 7 TECHNICAL ADVANCES

Knight (1966) gives an interesting analysis of the impact of computer processing speed upon the simulation of machine shoploading. An average machine shop was considered, having:

- 20 machines in 14 groups by type
- 60 operators working in 3 shifts
- 12 part numbers being worked on
- 120 batches being processed per year
- each batch needs 40 machine operations
- £2 MILLION output annually
- £1 MILLION value of work in progress.

The time and cost of simulating such an operation was broken down by computer type as an indication of the rate of technological progress.

COMPUTER	YEAR	COMPUTER OPERATIONS PER SECOND	COST PER MINUTE	TIME TO SIMULATE 2 YRS. PRODUCTION	COST
IBM 704	1956	1.07×10^4	£5.7	6 hours 30 mins	£2200
IBM 7090	1959	0.98×10^5	£7.7	43 minutes	£ 330
IBM 7094	1962	1.76×10^5	£8.5	24 minutes	£ 205
IBM 360/65	1966	1.38×10^6	£5.4	3 minutes	£ 16

The figures quoted by Knight (1966) shown in EXHIBIT 7 demonstrate just how the significance of the computer as tool for mathematical simulation is increasing. The effect of cost reductions of this order is to suddenly provide production management with a means of radically changing the very basis of their task. Before the possibility of computing existed, the prevalent techniques were designed around the available resources - the production controller's brain, which although supported by various aids and distillations of previous experience (rules of thumb),has severe limitations when it comes to running a significant simulation. The whole organisation is then geared to the capability of this link. To quote GALBRAITH (1973):-

> "(If) a sales department knows the scheduler cannot solve the complex scheduling problem, as a result, they quote to customers delivery times which are sufficiently long that the complex scheduling problem does not arise. The organisations can remain competitive because they compete with other job shops facing scheduling problems that are identically complex. Their competitive market interaction determines a standard delivery time the same way that it establishes a price."

A similar point is made by POUNDS in MUTH & THOMPSON (1963).

But the advent of relatively low cost computing in the 1970's has brought a new dimension to this situation. The competitive balance is regained at a higher level of production performance because of the sophisticated techniques whichcan be employed on this new tool, the computer. Instead of comparison between producing organisations being a function of the controllers' brains, it can now be a function of the quality of the Operational Research staff who developed the models around which the company's routines are built.

A similar argument applies to the non-mathematical uses of the computer within production, the data recording and information routines. The computer represents a step jump in the capability of management to organise, monitor and control production and one facet of a successful manufacturing company now has to be effective use of a computer.

Despite the technical arguments in favour of using computers in production control the rate at which they have been adopted depends upon a considerable number of other factors. Computers in general have been given a bad image as a result of well publicised but poor early application.

Although subsequent analysis will reveal that it is the way in which the machine is harnessed, rather that the machine itself, which is at fault, the legacy of a bad application is an enduring mistrust of computing. Since production is central to a business, companies are, quite reasonably, highly sceptical of any gimmicks or fads that appear to provide short term benefits but might end up absorbing resources and signally failing to provide the improvements expected of them. Further, companies are highly diverse in the details of their manufacturing operations, which renders the development of a package having sufficient generality a difficult task. Since computer manufacturers and software houses are only prepared to invest such time and effort if the cost can be retrieved, the initial applications of computing to production control were in those larger companies capable of affording the high cost of the work.

But, as the cost of computing falls, so it may be expected to become more of an accepted part of a modern production operation, as the present barriers of non computing tradition are eroded.

CHAPTER V ANALYSIS OF PRODUCTION CONTROL IN S.E.C.D.

SUMMARY The components and manufacturing methods of S.E.C.D. product are described and the production quantified. The elements of the organisation and control systems are analysed according to the terminology of Chapter IV. Finally, the problems of the production control system are described.

SECTIONS

V.1 The Operation Sequence

S.E.C.D. manufactures the small shell and tube heat exchangers used on lorry and small marine diesel engines, such as are shown in Fig. 2.5 and whose principle of operation is described in Chapter II, Section 2.

Variations between separate products are in terms of dimensions and materials rather than overall design, so Fig. 5.1 is put forward as a typical breakdown of the components of a unit.

The manufacturing facilities available in the division are of a general engineering nature, including machining, presswork, soldering and manual assembly. Nine stages may be necessary to construct the unit in Fig. 5.1 as shown in Exhibit 1. In a typical cooler there will be 50 tubes, 80 fins, 5 baffles, 2 headers, one casing, screws, washers, sealing rings, and the solder used to bond the whole thing together.

Naturally, the operations are performed in parallel wherever possible, so that at any time each of the processes 1 to 9 is under way.

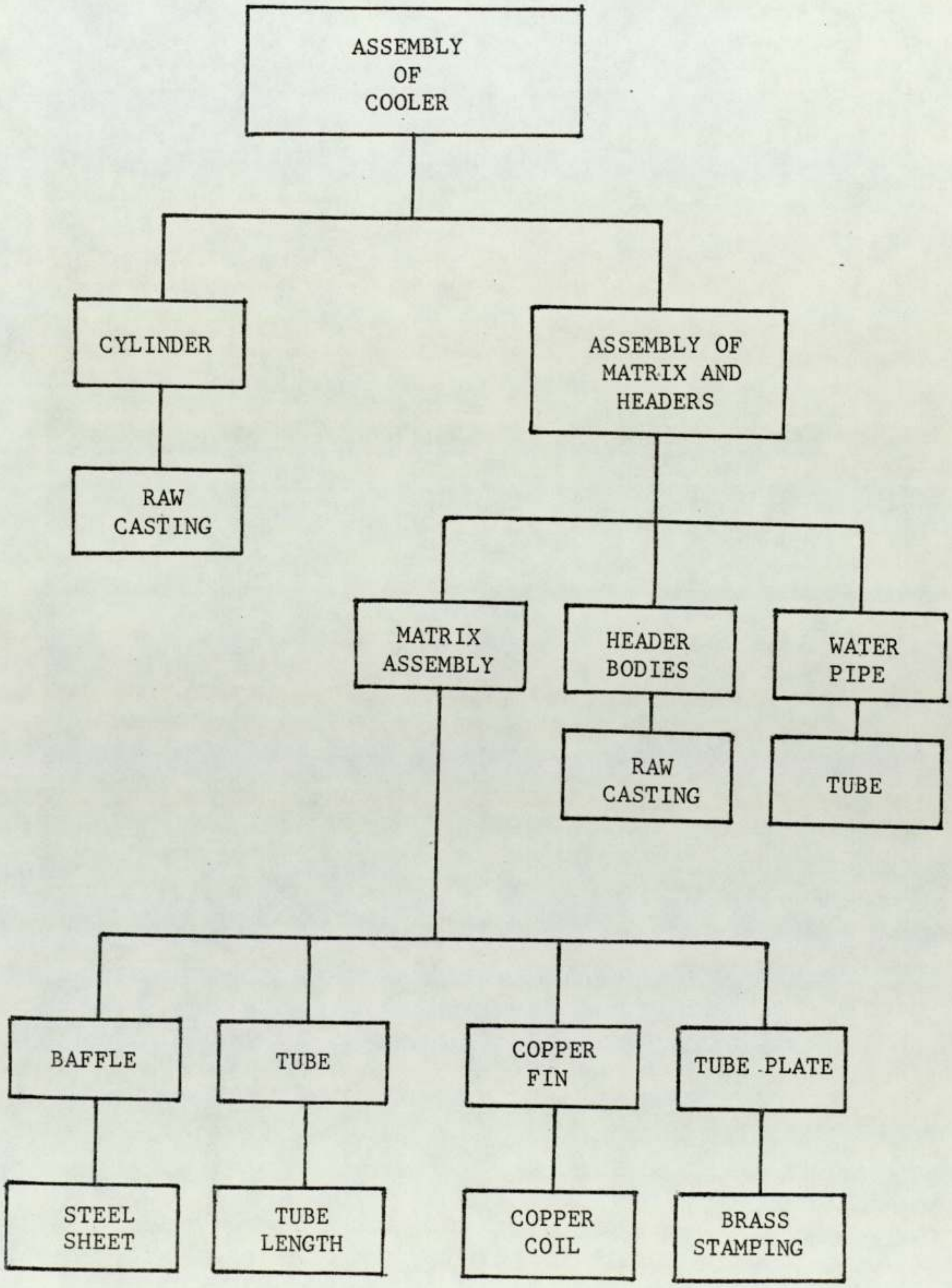

ASSEMBLY OF COOLER
CYLINDER
RAW CASTING
ASSEMBLY OF MATRIX AND HEADERS
MATRIX ASSEMBLY
HEADER BODIES
WATER PIPE
RAW CASTING
TUBE
BAFFLE
TUBE
COPPER FIN
TUBE PLATE
STEEL SHEET
TUBE LENGTH
COPPER COIL
BRASS STAMPING

FIGURE 5.1

EXHIBIT 1

1. Baffles. Requisition steel sheet from the stores. Cut it into strips, pierce holes and blank out from the strip. Inspect and degrease prior to sending to the stores.
2. Tubes. Requisition the long lengths of tube from the stores. Cut to length, degrease and return to the stores.
3. Copper Fins. Requisition copper coil, pierce, plunge and crop. Inspect and return to stores.
4. Tube plate. Brass stampings are bought in from an external supplier. These are bored and faced on the inner side and faced on the top. The outside diameter is turned. Holes to support the tubes are pierced and the proud scurf is flattened. The holes are reamed and countersunk, then the whole is bright dipped, inspected and sent to the stores.
5. Matrix Assembly. The previous 4 items are taken from stores. The fins and baffles are fitted to the tube skeleton. The remaining tubes are fitted and their ends expanded by a drift. The unit is cleaned, soldered and then turned down to its finished o/d.
6. Headers. The raw castings are taken from stores, pierced, plunged and stress relieved. Following cleaning and bright dipping they are returned to the stores.
7. Assembly of Matrix & Headers. The headers and matrix are requisitioned from stores, assembled, soldered and tested for leaks, then returned to stores.
8. Cylinder. The raw castings are drilled, the ports chamfered, bored and faced to length, the header mounting holes are drilled and tapped, the whole is degreased and returned to stores.
9. Final Assembly. The cylinder, matrix/header assembly, screws, washers and seals are taken from stores. The matrix is assembled to the case and tested. A part number and date code are stamped on the casing, the unit is flow tested, plugs are fitted to keep dirt out and passed to dispatch.

V.2 Divisional Statistics

The Division offers 6 main designs of product which form convenient groups for reference throughout manufacture. But the complexity arises in the large range of variations offered for each design. One particular design has 37 variations of length, tube number and diameter, casing size etc,.

On average 10,000 coolers were made per month although this figure includes spare tubestacks, so 9,000 is a more realistic estimate. The value of this output was- £150,000.

Naturally, the bulk of S E C D's business was the supply of coolers to engine manufacturers. Although the division maintained a list of 150 customers, one accounted for 33% of output and the major 6 customers took 80% of the production by value. These large customers ordered regularly by means of a monthly call-off or schedule. Thus to speak of the number of orders outstanding on the division at any time does not reflect the true picture. However, works orders were raised for each batch of identical coolers and an analysis of the number of new works orders issued over a 4 month period revealed an average of 55 issued per month.

Month	Number of Works Orders Issued
7	47
8	53
9	65
10	57

The Sales Department reckoned on 95% of orders being supplied on time. The remaining 5% are predominantly low volume orders for standard products from infrequent customers.

Standard delivery times were around 6 - 12 weeks because, as a rule of thumb, there were 3 main operational stages to be gone through and the volume of work dictated that 2 - 4 weeks were taken up over each one. In weeks 2 - 4 the raw materials and bought out components were obtained. In weeks 3 - 8 the raw materials and castings were machined and sub assemblies built. The remaining time was devoted to the final assembly, testing and dispatch.

Fig. 5.2 shows the broad organisation of the division with the General Manager responsible to the Operations Director of S.H.T and in turn delegating responsibility to the three major operational managers.

Because the General Manager's performance is judged by the balance sheet for his division, he has considerable discretion over its organisation subject to the gross financial constraints.

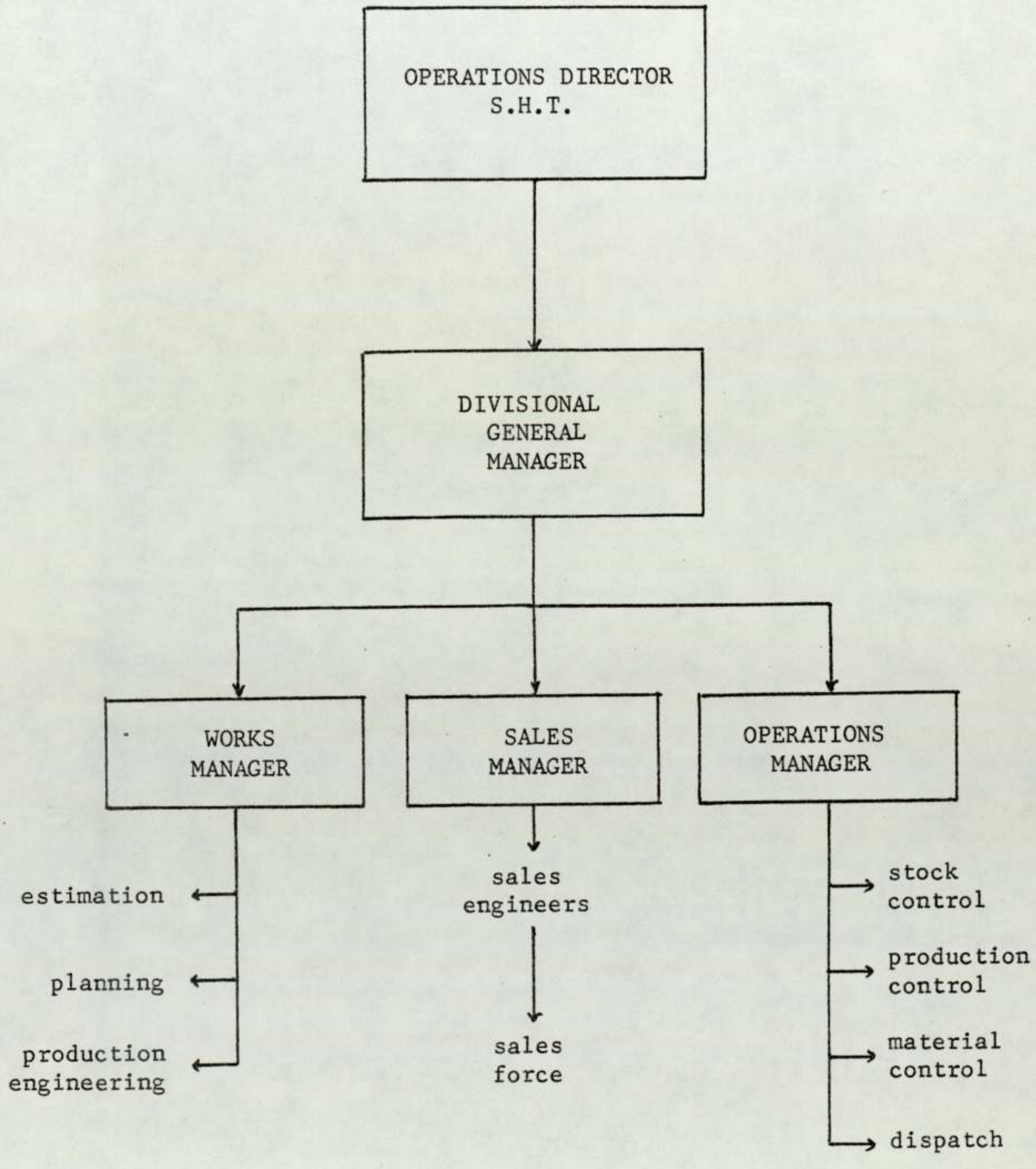

OPERATIONS DIRECTOR
S.H.T.
DIVISIONAL
GENERAL
MANAGER
WORKS
MANAGER
SALES
MANAGER
OPERATIONS
MANAGER
estimation
planning
production
engineering
sales
engineers
sales
force
stock
control
production
control
material
control
dispatch

FIGURE 5.2

V. 3 Initial Planning Following the terminology of CORKE (1969) as introduced in Chapter IV, the starting point of a production control system is the information about the product and manufacturing processes which remains fixed throughout the product's life.

S.H.T. made use of product codes, a 3 figure number allocated to a product group. The purpose was to enable costs to be allocated across the site, but because the product code 540 covered everything dealt with by SECD, the production area made no reference to product codes.

The second centralised classification system was that of the Brisch part numbering. Under this scheme a 9 digit part number is allocated to every separate component used in the company, with the first digit signifying the broad class of the part (1 implies raw material, 2 is commercially available items such as nuts, and bolts, and so on.)

A central department Classification and coding is responsible for the association of part numbers to new components and products, which it does by classifying the items into groups which are then given identifying numbers. In principle it should be possible to recognise a part simply from its Brisch number, However, this feat requires considerable exposure to the classification system and the divisional staff associate numbers directly with designs, rather than through the intermediary of the classification system.

The complete list of all current part numbers is termed the Master Parts File (M.P.F.) and is maintained as a computer file.

A complementary computer file is the relations file, or structure file. The purpose of this is to list the component parts of any assembly or sub-assembly. Part identification is by Brisch number and for any assembly, a breakdown is available of the part numbers and the quantities necessary to build one assembly. The reverse of such a file is a 'used-on' listing, where the applications of piece parts are listed out in the order of the part numbers of the assemblies upon which they appear.

When a new part is designed the works planning department of SECD is responsible for the production engineering. This requires them to liaise with the heat transfer engineers who are product designers and also to determine just how the part is to be made. The physical summary of this is a collection of sheets of paper termed the operations layout. It shows the stages in production, the dimensions to be worked to at each stage, the machines to be used, the tooling which will be required and a standard time for the jobs. These layouts take a long time to produce but are subsequently adequate to support the actual manufacture.

The other document produced at this time is the Production Parts List (P.P.L.). This specifies for any assembly the components in that assembly and it is from the P.P.L. that the data are input to the computer based relations file.

Annually an extensive update is carried out to incorporate the latest manufacturing times into the standard job times.

V. 4 Pre-Production Planning

The Order Intake Phase It was stated earlier that the majority of orders were from large customers having a monthly requirement. Thus few physical orders are received through the post.

An order arriving in the post is first sent to the central function of credit control where a new customer is checked out for credit worthiness. It then passes to the divisional product engineers who check that the demand is for a valid product. If the order is for a special item the engineer initiates a Not Drawn (N/D) routine which promptsthe estimating department to prepare a cost and the production engineers to ensure it can be made. This ensures that by the time the order reaches the Orders Clerks the paperwork necessary to support production is prepared (costings, P.P.L's. etc.). The Orders Clerk allocates the next available works order number and raises the works order. (see Fig. 5.3).

The works order is passed to the Data Control section of Management Services where it is manually validated as being suitable for preparation to be entered onto the computer. Seven copies of the order are taken and distributed as shown in Fig. 5.3.

The copy sent to the drawing office prompts a check that the drawings

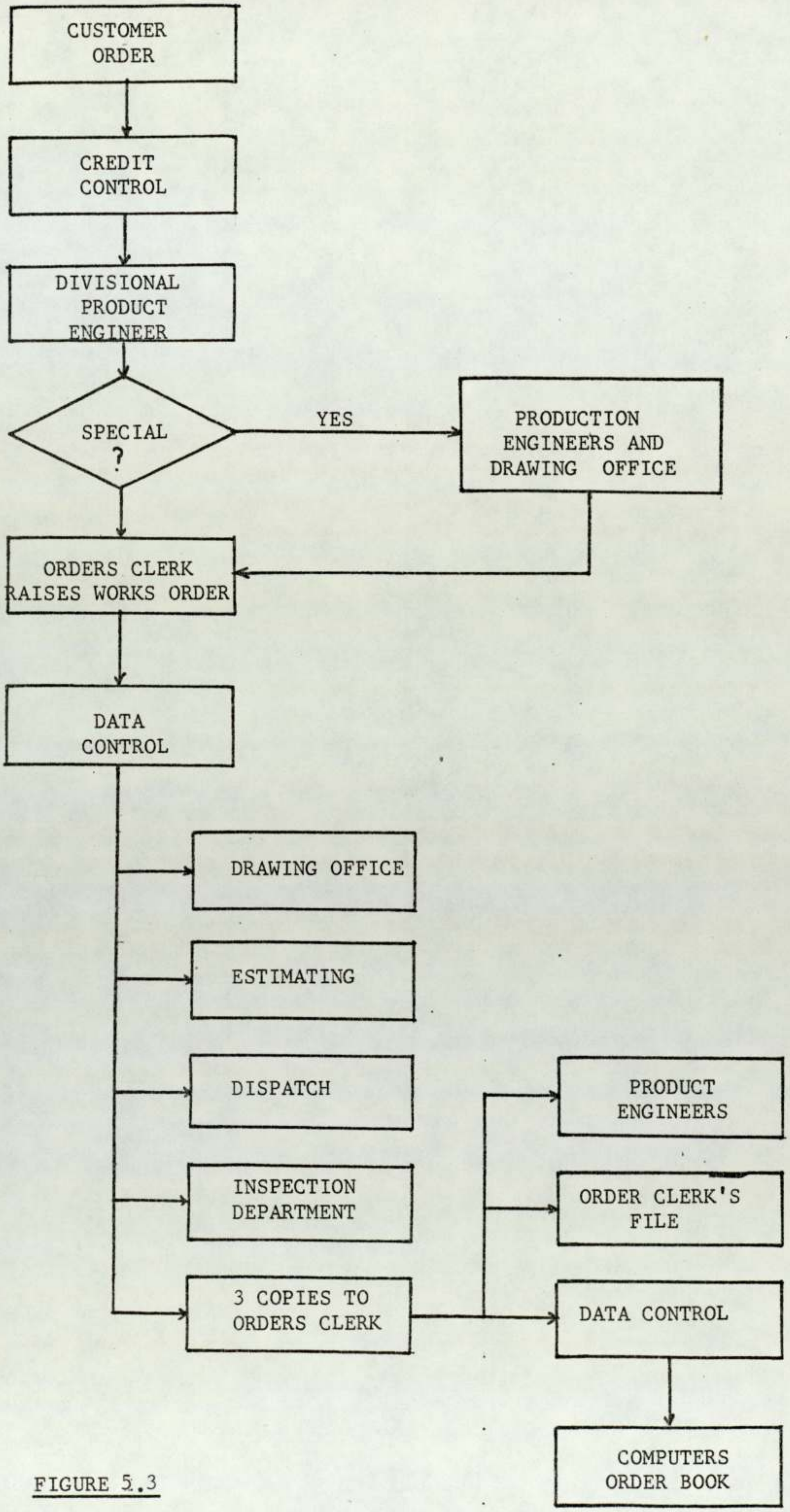

CUSTOMER ORDER
CREDIT CONTROL
DIVISIONAL PRODUCT ENGINEER
SPECIAL ?
YES
PRODUCTION ENGINEERS AND DRAWING OFFICE
ORDERS CLERK RAISES WORKS ORDER
DATA CONTROL
DRAWING OFFICE
ESTIMATING
DISPATCH
INSPECTION DEPARTMENT
3 COPIES TO ORDERS CLERK
PRODUCT ENGINEERS
ORDER CLERK'S FILE
DATA CONTROL
COMPUTERS ORDER BOOK

FIGURE 5.3

exist. The dispatch section maintain a list of works orders against which the dispatches can be checked. The inspectors need to know if any specially rigorous inspection or test procedure is called for. Of the 3 copies returned to the orders clerk, the master is filed, and 1 copy is sent to Data Control to act as input document for the computer, after having been extended to show the costing details. One other copy is passed to the engineers with the costing details to be retained as a record of that quotation. The final copy is filed by the orders clerk to await receipt of an invoice signifying the successful dispatch of the order.

The large customers who produce a requirements schedule send in the schedule monthly, usually by the 20th of the month for inclusion in the subsequent month's programme. The orders clerks raise works orders for these requirements. Some W.O's will have new numbers, but in the case of frequently demanded products an uncompleted W.O. for the same product will be re-used merely by adding an extra element to the quantity needed and due date. The Orders Clerks are proud of their abilities in keeping one W.O. number extant for literally years by this expedient.

Every week the computer produces a listing of all the works orders outstanding on the division. Three of these are used simply as order intake progress guides but the 4th in the month becomes the basis of the next stage in the pre-production planning phase.

Orders are only removed from the orders file on receipt of an invoice indicating dispatch of the completed batch or on receipt of a special order cancellation form. (The former is never received in the case of the 'everlasting' works orders for large customers).

The Production Plan

On the last Thursday in a 4 week manufacturing period the Operations Manager and Chief Production Control Clerk sit down together to raise the Production Plan (P.P.) for the next period. They have the latest version of the Orders file and a sheaf of papers covering those details not yet included on the orders file, namely invoices for goods dispatched and the latest works orders.

Since the Orders File is listed in part number order the two men go through line by line, deciding what is to be built during the next period. (Orders may be on the books for 6 months in advance if they call for special materials to be bought in). (See Fig. 5.4).

Following this exercise the Chief Production Clerk raises the Programme Requirements Input Sheets which are passed to Data Control for validation and thence to be put onto punched cards.

By Friday afternoon the computer has processed the Requirements and returned a number of listings: the first is the Requirements/ Dispatches listing which is a list of the assemblies and sub-assemblies required in date of completion sequence. The Chief

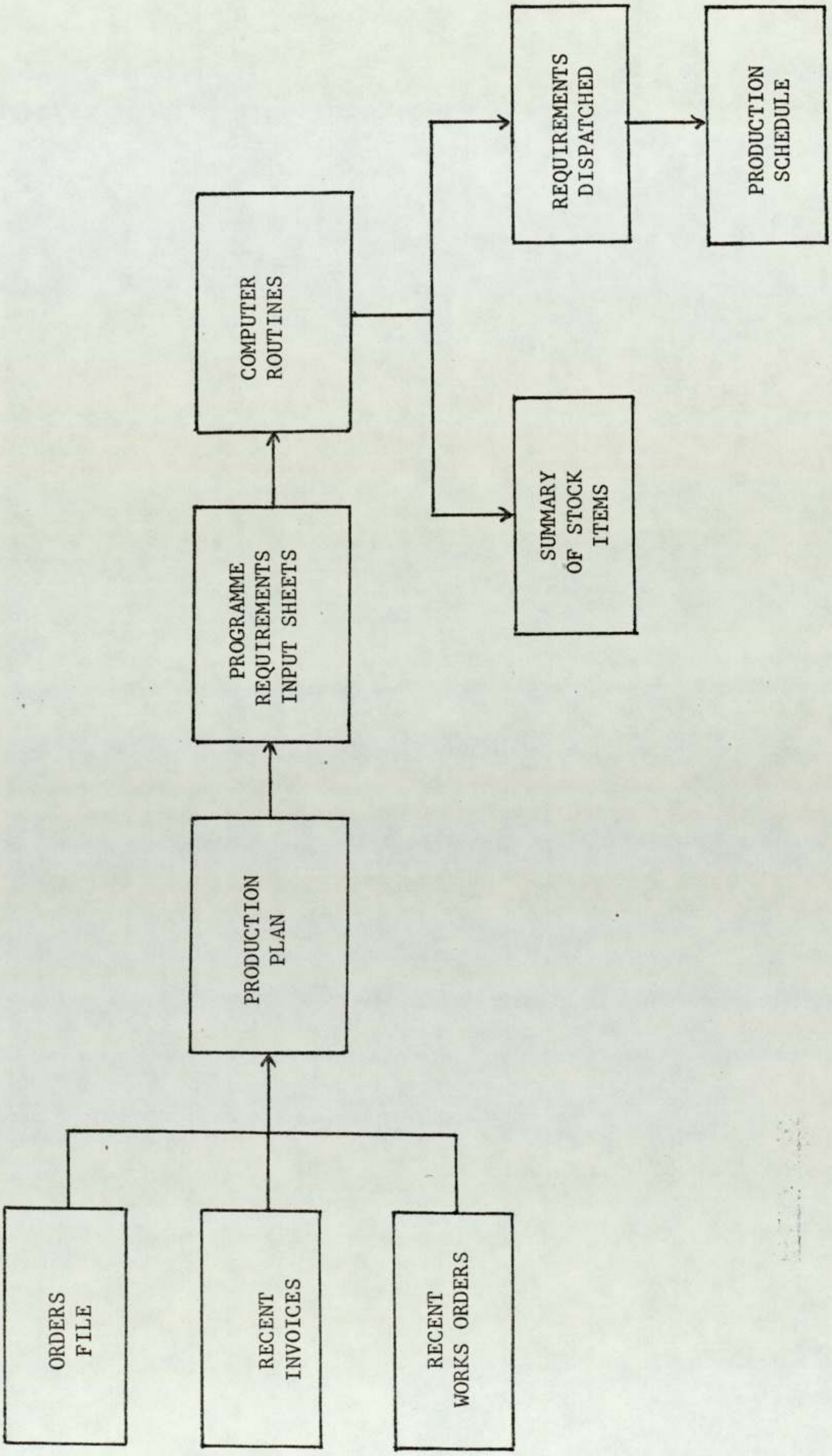

ORDERS FILE
RECENT INVOICES
RECENT WORKS ORDERS
PRODUCTION PLAN
PROGRAMME REQUIREMENTS INPUT SHEETS
COMPUTER ROUTINES
SUMMARY OF STOCK ITEMS
REQUIREMENTS DISPATCHED
PRODUCTION SCHEDULE

FIGURE 5.4

Production Clerk transfers these to preprinted sheets termed the Production Schedule, a task which is completed by midday the following Monday. These schedule sheets become the central reference document for those staff involved in production control.

The second listing produced by the computer is called the Summary of Stock Items. This is a list in 4 parts which shows what quantities of each part number will be required in each of the following categories - piece parts

- assemblies
- bought out items
- raw materials

The computer produces this listing as shown in Fig. 5.5. The requirements list is effectively multiplied with the relations file to give a gross listing of all the components in the total requirements listing. This gross breakdown (termed a parts explosion) is sorted into the 4 categories above and printed out.

Two materials control clerks (MCC I & MCC II) are employed to carry out the next stage in the operation, This involves netting the gross requirements as listed in the S.O.S.I. with the stock and Work In Progress (WIP) to produce a list of the items needed to be bought in, or made this period, that are new from last period.

MCCI deals with the raw materials and bought out items. He has a

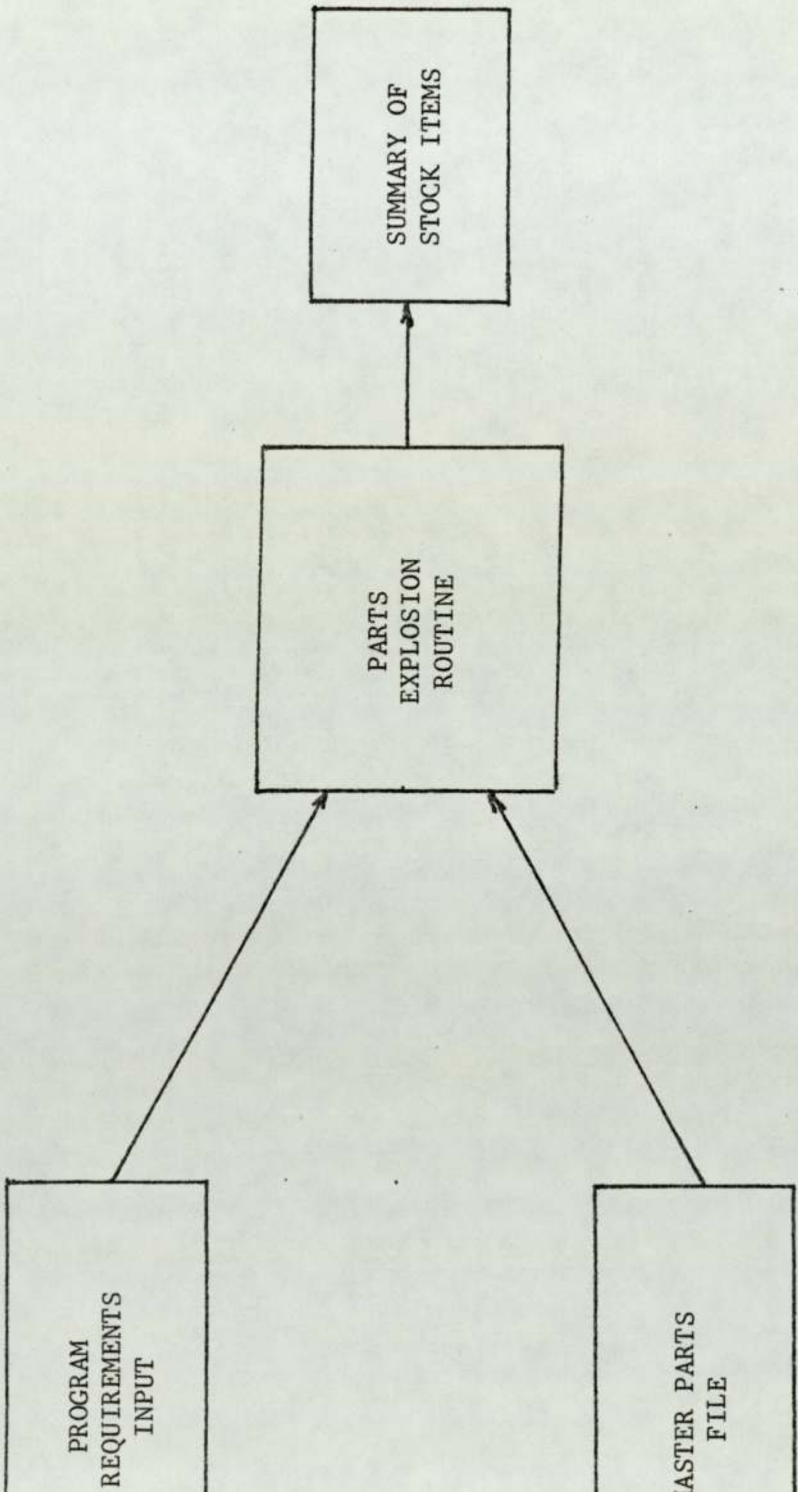

SUMMARY OF STOCK ITEMS
PARTS EXPLOSION ROUTINE
PROGRAM REQUIREMENTS INPUT
MASTER PARTS FILE

FIGURE 5.5

computer listing of the Stock holding which is produced every other day but takes 2 days to produce, consequently it becomes outdated quickly. To update this listing the MCCI maintains a record of Goods Received Notes (GRN's) indicating the items received into the store between the closing time for changes to be sent to the computer to produce the revised stock listing and the actual issue of the listing. He also has a computer listing of the purchase orders placed with external suppliers which have not yet been fulfilled.

From these 3 listings, all of which are conveniently arranged in part number sequence, the MCCI can identify what has to be bought in over the period. He goes through the S.O.S.I. line by line and subtracts the stock quantity which is needed. Purchase requisitions are drawn up to be passed to the Central Buying Office to be converted into external orders. In the instance of commonly used parts, MCCI raises a supply schedule rather than individual requisitions. This requires extensive liaison with the suppliers so that in the majority of cases the submission of a Purchase Requisition to the Buying Office merely initiates the formal authorisation of an informal agreement which has in fact already been arranged.

MCCI has no other data on which to work and he alone is responsible for coping with the ever changing demands for bought out items which last minute modifications to plan confer upon his job.

MCCII has a similar task to MCCI in that he is carrying out a netting operation and issuing orders to supply the balance. However, his domain of interest is products made internally. This includes all the assembly work and the machining of raw castings. If the S.O.S.I. calls for finished coolers to be available by a particular time, this implies that 10 cylinders must be completed by an earlier date, which in turn implies the raw castings must be bought in. Provided MCCI has done his job the latter will have been done and it is up to MCCII to issue instructions to the machine shop to convert the raw castings into finished ones. This is done by means of the batch card set which also determines the scheduling and for this reason is dealt with under the section 'Control of Manufacturing'. At this point it is enough to state that MCCII works with the S.O.S.I. & a list of all orders, his annotated prior version, a few unofficial records and a strong link with the foremen of the manufacturing departments.

Stock The overriding point is that there is no stocking policy, according to the General Manager. Although an average £½ MILLION of Stock is held,no efforts to structure re-ordering or issue are made. The reason for this are:

- the materials control clerks are given an inadequate forecast of requirements and to cover themselves against stock-outs naturally tend to err on the side of large quantity purchases. Such rounding will be mopped-up in time, rendering the mistake invisible except as a legacy on the balance sheet.
- the Operations Manager is under greater pressure to fulfil delivery schedule than to minimise stock. The effect of failing to meet a delivery date is more obvious than a 10%

overstocking. Certainly the stock surplus makes his job run more smoothly.

The mechanics of the system start from the 6 monthly stocktaking. Having counted precisely what is in the stores, anything entering the stores prompts the raising of a GRN, if supplied from outside, or a Receipt to Stores note, if from the works. Materials can only leave the stores on the strength of a Requisition. At the end of every day all these copies are passed by the Storeman to the Chief Production Control Clerk who collates them and passes them to the Data Control section. Following validation the information is transferred to punched cards and used to update the computer files. The batch mode of computer use dictates that any stock listing must be between 1 & 2 days behind real events.

The sophistications to cover reject components, incomplete deliveries and scrap do not affect the essence of this process and will not be detailed.

V.5 The Control of Manufacturing

MCCII is responsible for the issuing of instructions to cover the internal manufacturing operations. These instructions are in the form of the batch card set and Requisitions from the stores.

With reference to Fig. 5.6 for any operation, 5 cards are

OPERATIONS

(1) The set of 5 batch cards (b.c.) and the Requisition from stores are raised.
White b.c. → computer to update orders file then returned to W.B.O. and filed.
Grey b.c. and req. are sent to the stores and filed.
Remaining 3 b.c.s go to the relevant foreman and filed.

(2) Foreman decides to implement the job. He sends Blue b.c. from set to the stores and Yellow b.c. to inspection.

(3) The Storeman, on receipt of Blue b.c. matches it up with the req., issues kit of parts to production area with Blue b.c. and sends issue note detailing actual quantities sent, to Prod. Control.

(4) Prod. Control batches the issue notes and sends to the computer to update stock file.

(5) Production Area carries out operations on material. The b.c. may cover several operations. At the end of each operation 2 things occur:

  (i) Foreman updates his Green progress card.
  (ii) Information that the op'n. is complete goes to W.B.O. who update the White b.c. accordingly.

When the final op'n. has been done, W.B.O. is informed and the decision has to be made as to whether the materials are inspected or not. If not, the goods are left on the shop floor with their Blue b.c. awaiting collection by the next production section. If they are to be inspected, the whole is sent off to INSPECTION with the Blue b.c.

(6) W.B.O. transcribes progress of op'ns. onto White b.c. After last op'n is complete, the White cards are made available to Prod. Control.

(7) Production Control batches the cards up and sends to computer to cancel order on orders file.

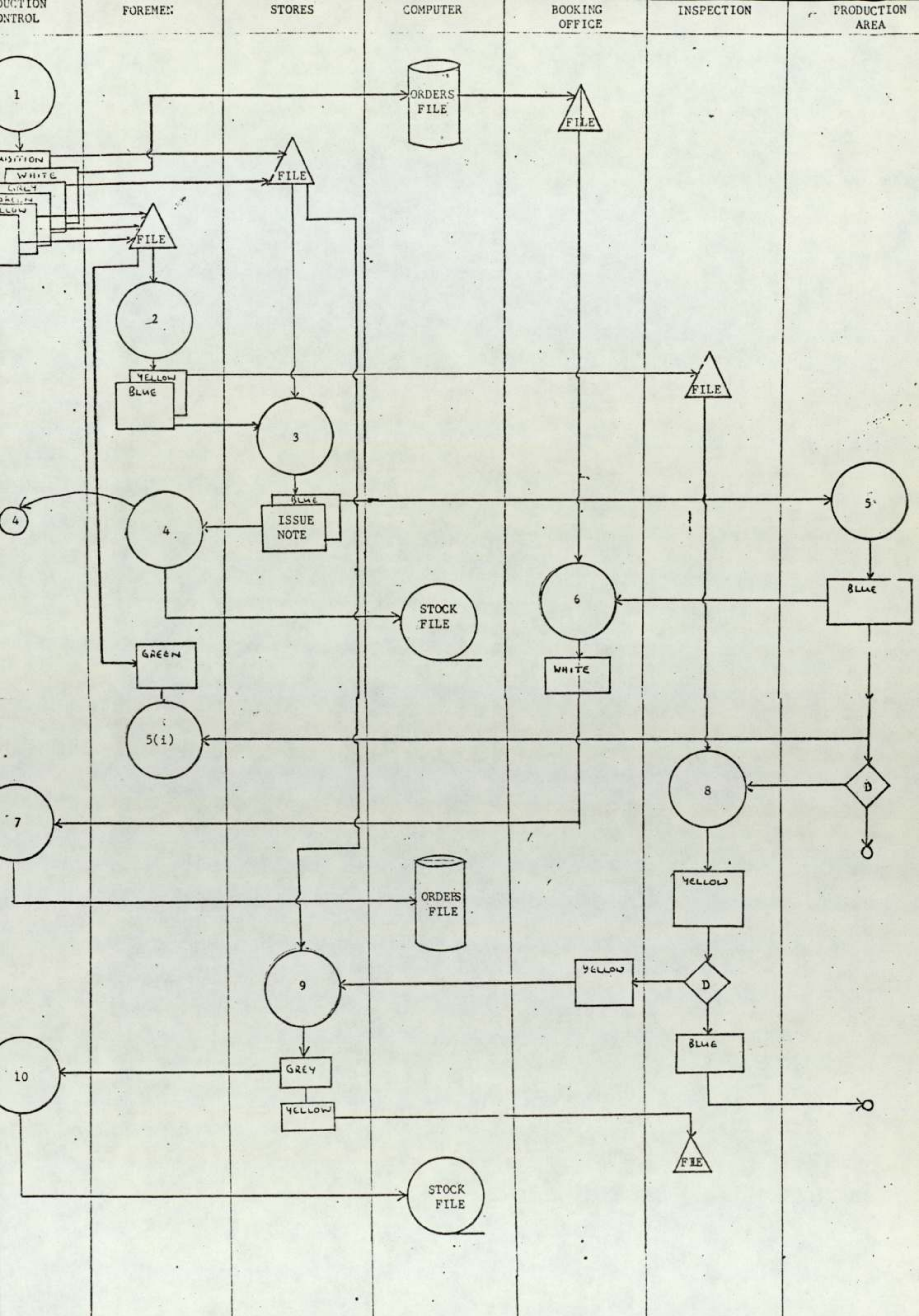
(8) Inspector examines goods. Fills out Yellow b.c. from his file.

He can either (i) send the goods to stores
or (ii) send them directly to the next production section.

In the first case he simply sends them off with the Yellow card.

(9) Storeman checks quantity received with that on Yellow b.c. card books into stores by filling out Grey b.c. from his files. These are sent off to Production Control at the end of each day. (The Yellow b.c. is returned to the inspector who files it).

(10) Production Control batches the grey cards up and sends to the computer to update the stock file.


UCTION
NTROL
FOREMEN
STORES
COMPUTER
BOOKING OFFICE
INSPECTION
PRODUCTION AREA
1
ISITION
WHITE
GREY
GREEN
LLOW
ORDERS FILE
FILE
FILE
FILE
2
YELLOW
BLUE
FILE
3
BLUE
ISSUE NOTE
4
4
5
6
BLUE
STOCK FILE
GREEN
WHITE
5(i)
8
D
7
ORDERS FILE
YELLOW
9
YELLOW
D
BLUE
10
GREY
YELLOW
FILE
STOCK FILE

photocopied from M.P.F. The grey copy and the requisition are sent to the stores and filed. The white copy is sent to the Data Control Section, is validated and acts as the source of data for the punching of the cards for computer input. It is then returned to the Wages Booking Office in SECD and filed.

The remaining 3 copies go to the foreman of the relevant section.

When the foreman decides to start the job, he sends the blue batch card to the stores and the yellow to inspection department.

On receiving the blue card, the storeman matches it up with requisition and issue the list of parts to the appropriate manufacturing area with the blue card. An issue note detailing what parts are taken from the stores is sent to Production Control. These issue notes are batched and sent to the computer to update the stock file.

The manufacturing area carries out the operations on the material as specified by the batch card. On completion of the operations, the foreman should update his green progress card, but in practice he does not. The Wages Booking Office updates its white card from the figures the workers take there, and if the finished goods are to be inspected they are sent to the inspection department under the blue batch card.

In theory, the system as designed requires all goods to be sent to the stores after an operation is completed, but this does not happen! After inspection the inspector should complete his yellow card and send the goods to the stores with the card. If there is no inspection they should go direct. But in the majority of cases the parts are simply left in their stillages and a word of mouth message between foremen prompts the next department to come and collect the parts.

If the storeman does receive the parts, he updates his grey card with data from the blue card, then at the end of each day collates the grey cards and sends them to Production Control. These are batched and sent via Data Control to the computer to update the stock file.

The white cards in the wages booking office are also passed to production control on completion. They are batched and sent to the computer to update the orders file.

Shop floor level organisation. There are 3 separate sections to the manufacturing area:

- machine shop
- sub-assembly
- final assembly.

For each section there is a foreman whose responsibilities are to encourage the operators and to provide them with a steady flow of work.

The foremen report to the Works Superintendent who is in turn responsible to the Operations Manager.

These people meet formally three times per month and informally very often to discuss and decide on scheduling priorities. The basis for this task is the Production Schedule as raised monthly by the Chief Production Control Clerk. This is the nominal list of the work to be done that period and the first question to be considered is that of the availability of the materials. During the production meetings, when such questions are posed, some can be answered by asking the relevant Materials Control Clerk. But frequently a foreman is sent out to find the job on the shop floor. This arises because the 'formal' system as assessed by MCCI and MCCII is only aware that the job has been issued to the floor. . Whether it has been started, finished or is somewhere in between is information that the formal system simply does not possess.

Every evening when production finishes, the dispatch section makes up a list of those units dispatched during the day and a list of units likely to be sent out the next day. These are passed to Production Control and used to update the Production Schedule before being summarised and passed to the General Manager as a daily measure of output.

The problems of controlling production arise from the variability of the demand on the division. If the production schedule were to remain fixed then matters would be simpler. But although the division retains the right to refuse to accept changes to orders, in practice it very rarely does so, in the interest of customer relations. Throughout the life of a schedule the essential 'front-end' changes which cannot be accommodated in a later period are sent to the Operations Manager who has then to try and initiate production. This might require the urgent acquisition of parts from external suppliers, in which case MCCI is encouraged to extract a favour from his contact with that supplier and arrange rapid delivery. Suitable parts might be 'stolen' from a similar, but less critical job. To this end MCCII maintains a private list of, in particular, the castings so as to know precisely what raw, part machined and finished castings are on the shop floor. This is done every few days and enables a castings shortage list to be manually raised.

The staff involved in controlling production are the foremen, works superintendent, materials control clerk II, Chief Production Control Clerk and the Operations Manager.

The foremen and Works Superintendent try to build the Production Schedule and organise themselves to overcome the smaller scale problems which arise, such as absenteeism, machine breakdowns and rejects. If the magnitude of these problems is such as to threaten the attainment of the plan, the Operations Manager is involved. Similarly he introduces changes to the plan from the Orders reception and sales departments.

MCCII and the Chief Production Control Clerk support the scheduling function by deriving the information about what is going on in the division. Further, all the data sent to the computer to maintain the various files are routed through the Chief Production Control Clerk. As the repository for the latest 'formal' information, he is much in demand.

DISPATCH SECTION

The Dispatch Clerk is working to the Works Dispatch Schedule produced from the Production Programme and the amendments usually transmitted by word of mouth from the Operations Manager.

When a batch arrives in Dispatch, the relevant Works Order is matched up with the blue batch card and an invoice set is made out. This comprises an original and 8 copies. 2 copies go with the driver, one to be retained by the customer, the other to be signed and returned and filed with a 3rd copy in dispatch.

The remainder are sent to the orders processing section. Here the relevant works order is extracted and details such as delivery balance outstanding are updated. Terms of payment, price and copper content are added to the invoice. One copy is filed for reference, one is sent to Data Control to be used to update the orders file on the computer and cancel the order if it is fulfilled. The remainder are passed to the Cost Office.

V.6 Problems of the System

The complete set of problems and shortcomings can be divided into three groups according to the cause of the problem. This section is a description of these three groups with a summary of the evidence supporting their classification as problems.

Group 1 There are three ways in which the system as designed is not being followed in practice.

The foreman no longer maintains a record of the progress of each batch on his batch progress cards. This is because batches get split up, the work is done in separate groups and to fill out the progress card requires the foreman to tie together a considerable number of loose ends. Since the card has no facility for recording these partial completions, it is easier for the foreman to gloss over the need to record each part completion and this has gradually extended to the point where no progress cards are maintained. One direct consequence is that the internal orders file reflects poorly the real status of jobs in the division because it is the foreman's batch card which is used to update the orders file.

A second discrepancy between the designed and the 'worked-to' systems is the considerable alteration of the production schedule which takes place throughout its life. In principle it should remain fixed, but in the interests of customer service this never happens. This causes considerable problems in accommodating the changes, since the complete production effort is geared up to a monthly timetable and short term changes call for short term ordering and scheduling.

The final way in which the practice falls short of its specification is that of booking batches into stores on completion of a particular operation or convenient group of operations. The purpose of this is to signal progress to the control system, much as for the foreman's batch cards. But, naturally, when a job is urgently needed it is unreasonable to expect it to be taken to the stores, booked in and immediately booked out again. It is far simpler to move it direct from one area to the next. The consequence is that the formal system (the internal orders file) has a poor knowledge of the progress of batches around the works. This has led to the materials control clerks manually compiling lists of the progress of castings by walking around looking into stillages, to the dispatch area having to raise daily a listing of what has been sent out and what should be sent the following day, to the need for frequent trips to the shop floor during production meetings to establish the precise state of affairs, to problems of physically losing pallet-loads of components because no-one knows where they should be and can't find out what to look for because they do not know . the last operation done on them. In short, the lack of W.I.P. knowledge leads to considerable confusion.

Group 2 This group of problems is caused by the design of the system falling short of the real requirements of the division. The first of these is evidenced by the need for the maintenance of manual records more up to date than are available on the computer. Even when the stock recording system is working, precisely as specified, the stock listings which arrive every other day are always 24 hours out of date. Thus the Materials Control Clerk I has to ensure that he receives a copy of the issue notes indicating what has left the stores in the interim period. On occasions when this informal system fails to work, insufficient materials are ordered. The difficulty associated with using such a manual system is having to rely upon Material Control Clerk I's ability to remember that he has an issue note for a particular part number.

The stock recording system is a burden rather than an aid when the periodic need arises to buy in some materials at very short notice. Such circumstances occur either when a purchase order is not placed or fulfilled for some reason (infrequent) or when the machining of a set of castings revealed some as being porous. (The internal quality of the material being inadequate). Then, in the interests of meeting the batch delivery date and being able to do all the machining in one go, some replacement raw castings have to be acquired quickly.

Although the items might have been collected from the supplier and passed straight to the machine shop on arrival at the plant, it is necessary to raise the appropriate paper work under which they are booked into the stores and allocated out to the works. In the event of this not being done, the records fail to balance, weeks later, when being analysed by the cost office and give rise to an investigation to establish the cause of the discrepancy. At any time there are usually several sets of paperwork being processed some considerable time after the actual event.

The purchase order record also suffers from inaccuracy due to being returned at least 24 hours after the raw datahave been compiled. The MCCI has to maintain a second clip containing the purchase orders he has placed between times.

Group 3 The final category of problems are those that are insufficiently awkward for a manual bypass to have evolved, but are nevertheless not ideal.

The task of raising the Production Programme from the divisional Order Book should in principle be straightforward. However, because the latter reflects poorly the orders on the division (because it is updated weekly and invariably there are new orders, modifications to existing ones and recent invoices to be considered), the Chief Production Clerk has frequently to refer to one or other of the foremen to establish what is the progress on the shop floor. The task of raising the Production Programme takes the majority of a day during which the participants, who are the key people in the production control department, are effectively unavailable to assist the other production staff.

There is no machine loading apart from that which the foremen can do at the lowest level. The simplest improvement would be to group like machining operations so that production runs could be as long as is possible. But whilst this remains the reponsibility of the foreman, who is in a bad position to identify such commonality, it cannot be done effectively. The foreman would welcome such a feature because he is under pressure at every month-end and considerable time is wasted due to the need to repeat setting-up operations where it could have been avoided.

Another inconvenience of the computer system is the fact that the netting operation to substract stock and quantity already on order from the gross requirements is done manually. Within a few hours the gross breakdown of requirements is derived from the production programme by the computer. The Materials Control Clerks then go through it line by line over the next four weeks to do the netting operation. Although they are able to structure this work slightly by knowing which items take longest to arrive and also which need to be used first during manufacturing, the time taken to do this job is in marked contrast to the preliminary stage of producing the breakdown. It gives rise to problems subsequently, when material has not arrived at the expected time. If orders could be placed earlier, there is a greater chance of delivery being met.

The nature of the task performed by the Materials Control Clerks is one of approximation. Due to the high degree of commonality of components across the several product lines, many items are ordered every month, so any shortfall or surplus one month will be made up the next. No information is derived to enable the judgement of the clerks to be assessed and the 'mopping-up' nature of the frequent reordering naturally covers any errors. Because no stocking policy is in operation and minimal attention is paid to the notion of Economic Order Quantity, the Clerks have a routine of ordering a reasonable base figure, say 10,000 copper tubes per month and modulating this figure up or down relative to the stock holding. There has been no analysis to indicate that the stock holding is necessarily a valid statement of probable production requirement, it just happens that the Material Control Clerks use it as a base figure which is seen to be adequate.

So this manual netting procedure is itself a source of approximation and error. The Clerks bring to it considerable experience of the division's operations which enables the procedure to run reasonably smoothly. But there is no formal means to monitor the efficiency with which they discharge their duty.

The final difficulty encountered by the Production Control Staff is that of knowing when a particular job is going to be finished. Queries are frequently passed on from customers by the Sales Department and the best that the production people can do in the absence of any formal scheduling is to physically check on progress on the shop floor. Another facetof this lack of scheduling is the difficulty of getting early warnings of impending failure to meet a deadline. At a month-end there are always panics caused by needing to get more jobs through the final stages of manufacture than there is capacity so to do.

This inconvenience of not being able to identify future circumstances is accepted by the division as a consequence of the existing control methods, but it is certainly an important area for improvement.

CHAPTER VI REVIEW

SUMMARY Causes of the problems of V.6 are suggested which leads to questions about the process of Systems Analysis and Development. The practice of these operations within S.H.T. is reviewed.

SECTIONS

VI.1 Suggested reasons of the problems of V.6

In the previous chapter three classes of shortcoming in the existing Production Control System of S.E.C.D were isolated. These were categorised as :-

- ways in which the designed system was unworkable
- " " " " " " " " inconvenient
- " " " " " " " fell short of the real requirements of the division.

These will now be discussed in order of decreasing generality.

Two points in the last of these categories, the 'outdated' stock and purchase order listings and the high inertia stock recording routines, are consequences attributable to the computer being used in batch processing mode. The chain of transactions occurringcontinually in real time is broken at an arbitrary point and transactions on either side of the break are grouped for processing through the relevant computer routines. The temporal break point is determined by an inflexible schedule set up when the system is instigated and takes no account of the implications of fixing the break at that particular time for an individual set of circumstances. Hence the processed group of transactions is not necessarily an accurate reflection of real world conditions, but an historical statistic which may be inadequate for the Materials Control Clerks to use as a basis for the netting process. To overcome this deficiency the informal system of maintaining a list of issue notes and requisitions has had to be evolved. Now this is not bad system design in the sense that the system is not internally effective. It is bad in the sense that the designed system, when performing precisely as intended, is not meeting the real demands placed upon it. This mismatch is a consequence of the technical constraint that SHT's computer operates in batch processing mode and its magnitude is a function of the frequency at which the system's processing occurs.

The 'inconveniences' of the Materials Control Clerks doing the netting procedure manually, of there being no machine loading facility despite the availability of the raw data in the form of setting and job times, the manual raising of the Production Programme and no stocking policy are caused by limitations in the specification to which the system was designed. Each of these points was delibrately excluded from the original brief and has resulted in the phenomena given in Chapter V.

The first category of problems described in V.1 is the direct outcome of the System Design process. Working to the original specification the design team has selected the procedures as the 'best' way of achieving the required performance within the constraints. However it is seen that the procedures for monitoring progress on internal orders, of incorporating changes to the Schedule and the idea of the interprocess stores are not workable. The responsibility for these ideas lies with the systems design team, because although the principle of each is sound, the particular method adopted is not adequate.

VI.2 Questions about the Analysis & Development of S.E.C.D's Production Control System.

An accepted technique for improving future performance is to recognise and make use of the lesson derived from prior experience. The answers to the following list of questions which should be levelled at the process of analysis and development carried out on the production control system in SECD will provide considerable assistance when considering any future systems project of similar complexity. The general tenor of this section is not one of seeking to ascribe 'blame', but of critically examining the work so as to extract the benefits of the experience gathered.

The questions follow the 3 broad categories into which the problems of the system were analysed in V.6

ie: GROUP I - the present routines are unworkable
GROUP II - the design falls short of the real needs
GROUP III - the system generates inconveniences

GROUP I

1. What was the broad sequence of stages in the analysis and development procedure?

2. To what extent were alternative means of achieving the system specification considered?

3. How much opportunity did the users of the system have to comment upon these alternatives?

4. Did the users have any demonstration of the designed system prior to implementation?

5. How were the users defined? (e.g. Divisional Management, Production Staff, Foremen?)

6. Was the specification ever modified in the light of the findings of the detailed analysis and design work? Was that facility ever required?

UP 2

By whom was the system specification produced?

How was it produced?

What were the main influences upon it? (e.g. Experience, external advice, invention?)

To what extent were the divisional users involved in generating the brief against which the system was designed?

How were the boundaries of the work determined? (e.g. Why was machine loading excluded?)

Was the work aimed specifically at S.E.C.D. or with the needs of the other divisions in mind?

What was the basis for comparing alternative suggested systems?

Does the installed system meet the specification?

Having implemented a system and seen the results, how, with hindsight, should the exercise have been conducted?

. Is the implemented system considered to be a success?

GROUP 3

1. What was the role of I.C.L. (the computer manufacturers) in determining the specification of the computer installed in S.H.T.?

2. Was the machine purchased with the requirements of the Production Control routines in mind?

3. How did the provision of software facilities on the machine affect the design of the P.C. routines?

4. Were the implications of employing batch processing known from the outset and made explicit to the divisional users?

VI.3 Narrative

The termination of this first project for the reason given in Chapter I meant that the next stage of the work was not started. This would have been an analysis of the development procedure that had resulted in the production control system design.

The conclusions derived from the first project are five-fold.

1. The process of systems analysis and design does not always produce good results.

2. The performance of a computer system is a function of the technical capability of the computer. For S.E.C.D. the batch processing mode generated problems.

3. Management do not necessarily specify the requirements of the system correctly which gives rise to boundary definitions which are not optimal.

4. The analyst cannot rely upon always being provided with exhaustive or correct information during an investigation.

5. Users of a computer system will evolve manual routines to overcome shortcomings with the designed system. They will not necessarily seek to change the computer system.

VI.4 Systems Analysis and Design in S.H.T.

The structure and number of staff of the central department of S.H.T., Management Services, (MS) in June of 1976 are given in Fig. 6.1.

The Manager reports directly to the company's Financial Director but has responsibility for running the computer installation. In turn, he delegates operational responsibility to the Chief Systems Designer, Chief Programmer and the Computer Operations Controller.

The majority of the staff, and certainly the two top tiers, are long established members of the company who have developed their careers with the increasing computer usage. The department attempts to pursue a policy of internal promotion and the traditional promotion route of computer operator, through programmer to systems analyst is prevalent.

Chapter II, Section 3 lists the routines in regular use across the site and the operation and maintenance of these remain the primary responsibility of the department. Secondary functions are the modification of existing systems and the design and programming of entirely new ones.

Requests for this work are received from Board members and senior divisional management and criteria have been evolved for assessing

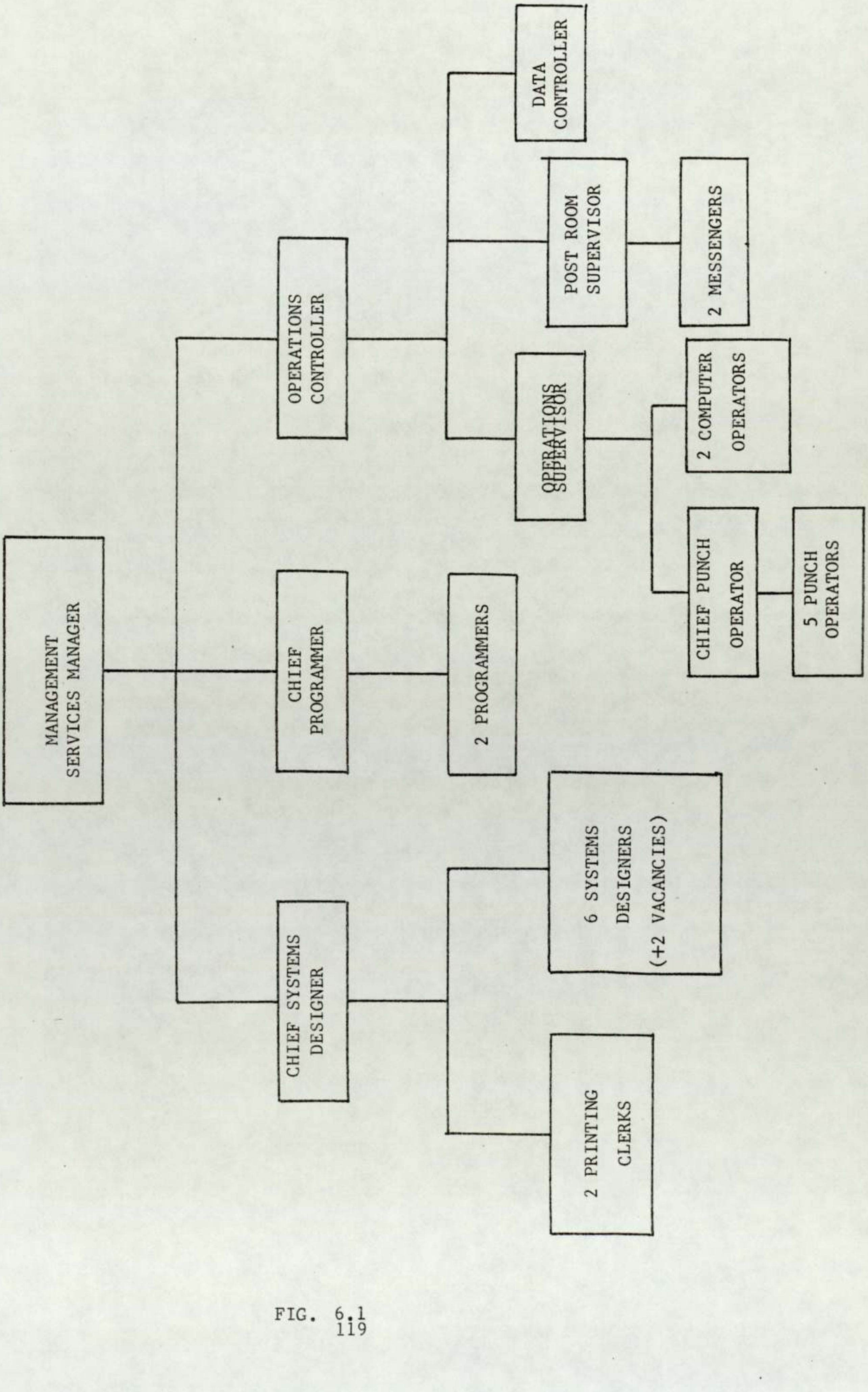

MANAGEMENT SERVICES MANAGER
CHIEF SYSTEMS DESIGNER
CHIEF PROGRAMMER
OPERATIONS CONTROLLER
2 PRINTING CLERKS
6 SYSTEMS DESIGNERS (+2 VACANCIES)
2 PROGRAMMERS
OPERATIONS SUPERVISOR
POST ROOM SUPERVISOR
DATA CONTROLLER
CHIEF PUNCH OPERATOR
5 PUNCH OPERATORS
2 COMPUTER OPERATORS
2 MESSENGERS

FIG. 6.1

the priority allocated to such requests.

Short term work is that estimated at requiring less than three man months' involvement to complete. This covers the maintenance and most of the modifications requested by users. The Chief Systems Designer is responsible for accepting, organising and completing work in this category without reference to the Manager of the department.

But any larger pieces of work are categorised as long term projects whichdo not fall into the classification of maintenance and modifications. Such projects need to be authorised by the Manager and are assessed against the department's five year plan which is the broad scheme under which resources are allocated. The current plan was drawn up in 1974 and covered the period 1975 to 1979. The central features were:

- the completion of the transfer from tape to disc based systems, made possible by the installation of the 1901T,
- the extension of computer based production control routines to the divisions not currently using them,
- linking these extended routines into the existing accounting systems,
- to move into on-line working by means of a revised order book system whichwill support direct interrogation, a facility requested by the Sales departments of the major divisions.

This plan combined new system development with enhancement and extension of existing routines, the former providing considerable interest for the systems staff and the latter a solid background of conventional work. However, one event unforeseen when the plan was drawn up was the creation of the After Sales Division in January of 1976. This had provided the Department with considerable work in modifying the existing routines to incorporate the new division. For this reason the level of 'new' systems development had reached a low point.

Since the majority of the work was maintenance and modification rather than invention of new systems, the work of the systems designers was oriented toward the technical aspect, the computer, rather than toward the 'system' aspect of the user and his requirements. Given a background of computer operations and programming, the analysts were in the process of generalising their skills and experience away from a strongly technical base. This was of no consequence provided that care was taken to supervise the work of these analysts and ensure that an appropriate amount of user consideration and system design was injected, the tasks of the Chief Systems Designer and the Departmental Manager. These two people played a central role in liaising with users at a project's outset, to ensure that the work of the designers was directed and constrained by a valid specification. Thus the title Systems Designers is misleading and perhaps Systems Producers is more appropriate, with the Chief Systems Designer now being termed the Chief Systems Designer and Specifier.

An example of a typical piece of Systems Production work is given by the following 7 page memorandum. It summarises the work done by a contract analyst-programmer who had been brought in for a short period in 1977 to alleviate a short term, but acute shortage of Systems Designers. The researcher had been involved, because of the same staff shortage, in some work for Air Cooling Division. The task was a simple one of developing a Shop Loading System based upon the standard manufacturing times for each part number. This involved analysing the work load on a particular section of A.C.D. called the Block Shop in each of three operation areas, numbered 220, 230 and 241. A forecast of workload would assist the operations planners in determining the resources to be allocated to each of the areas during the coming period. The researcher discussed this with the user, built up a listing of standard times on the Honeywell D.M.S. on-line service and determined the form of the desired outputs. The contract analyst-programmer was employed to develop the system for use on S.H.T's mainframe, the 1901T. The memorandum details his analysis and design work resulting in a technical description of the finished system design. It is typical of the type of work being undertaken by S.H.T. Systems Designers and demonstrates its technical orientation at the expense of user involvement and consideration. The Designers take over once their work has been defined and so cannot be held responsible for any failing in the overall direction of a project.

The policy and strategy decisions are taken by the Manager of M.S.

Serck Heat Transfer

WARWICK ROAD. BIRMINGHAM. B11 2QY

MLT/JMS
10th November, 1977

TO: S. Bennett
R. Clay
P. Johnson

Requirements for ICL 1900 Version of ACD Shop Loading System

The aim of this paper is to set out my understanding of the requirements for the above system, and the input and output layouts thus far defined. I would greatly appreciate it if the recipients of this paper could confirm its acceptability in writing; or, if any disagreements exist, I would ask that I am informed in writing at the earliest possible moment.

Takeon

The overall flow of the initial takeon of Honeywell data is as shown on the appended system flow diagram.

On the first run of program FL81, the existing punched paper tape database will be read in, paired off and validated. Valid records will generate records on the SHOPLOADBASE file, one per pair of OVRL and DTAL records (see appended copy of ACD Shoploading Input Document from Honeywell System for format of paper tape records).

Invalid paper tape records will be reported as such on the Takeon Validation Report (appended) and will not generate records on SHOPLOADBASE.

Validation criteria are as follows:-

The sequence of the file must be OVRL, DTAL, OVRL, DTAL..........

The Part Number field must be in the shape 99999-9999.

The Record Number (i.e. Dependant Number) must be numeric.

The Date should be in the form DD/MM/YY, and day, month and year should be valid as to range.

The "hours" fields; 220, 230 and 241, should be numeric, as should the "No. of sections" field.

All fields should be of lengths as shown on the copy document, and should be terminated by commas or 'end of record'.

As there will presumably be some errors thrown up in the input of around a thousand records, the facility will exist to run FL81 a second and subsequent times, accepting card input punched in the same format as the paper tape, and appending valid output to the end of the SHOPLOADBASE file. By this means it will be possible for all errors to be corrected before continuing through to file creation.

Con't...

TO: S. Bennett
R. Clay
P. Johnson

When the relevant parties are entirely satisfied with the validity and content of the SHOPLOADBASE file, program FL82 will be run. This program will sort the SHOPLOADBASE records into ascending sequence on Date within Part Number, and will then concatenate all records for the same Part Number into one record for output to SHOPLOADTEMP.

As a part of the concatenation process, averages will be calculated for the No.s of hours in 220, 230, and 241; by the process of taking the arithmetical mean of the relevant fields in each dependant record. The Number of Sections, however, will be derived by a slightly more sophisticated method, in that only non-zero fields will be averaged. This prevents the value being corrupted by failure of some input records to carry a value in this field. The average Number of Sections thus calculated will depend for its accuracy upon the degree of inaccuracy and variation in the input, but will in any case be amendable in the bi-monthly processing cycle (q.v.).

As the SHOPLOADTEMP file is being created, a File Creation report (appended) will be produced showing the entire contents of each record. At the finish of the program run, the relevant parties will need to check this report and give the go-ahead, before a standard utility program is used to load the SHOPLOADTEMP file to the Indexed-Sequential SHOPLOADFILE.

In the event of drastic problems, it would be possible to re-run the entire sequence of events, using card input exclusively, to arrive at an acceptable Shoploading database. Please note that all records on the Database will have a Process Number of 1 at this stage.

Bi-Monthly Processing

The expected frequency for the main update/report cycle is once every two months, and file sizes have been predicted on this expectation.

Each separate occurrance of a passing through shops of a specific Part Number will be recorded on one line of the new A.C.D. Shoploading Movements document (appended). Fields to be entered are as follows:-

Part Number in form 99999-9999.

Insertion Indicator, blank if existing process for existing Part Number;
"1" if new process (since last computer run) for Part No.
"2" if new Part Number (since last computer run)

No. of Sections: Must be numeric on new process or new part;
May be blank or numeric non-zero if Insert indicator is blank.

Date:- Must be in YYMMDD form, and valid as to range and combination.

Hours 220:- No. of hours in 220 shop, numeric (may be zero).

Hours 230:- No. of hours in 230 shop, numeric (may be zero).

Hours 241:- No. of hours in 241 shop, numeric (may be zero).

Con't...

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Remaining fields are to allow for re-organisation of ACD into Works Centres, and will be left blank at present.

In addition to input of new and updating data as outlined above, there is the facility to "delete" a part from the database. This is achieved by entry of a Part Number with an Insert Indicator value of "D" and the remainder of the line blank. The actual effect of this is to suppress printing of the latest process for this Part Number. Thus the information will not be dropped from the database, and will be accessible on specifying a "full" averages report at program FL85 (q.v.). Due to limitations on disc storage space, it may prove necessary at some point to drop these obsolete records from the file by means of a disc re-organisation; but this should not be done without the agreement of the relevant parties.

After the data entered on the Shoploading Movements forms has been punched onto cards, it will be read in by program FL84, which will sort the data into ascending sequence on Date within Part Number, and will validate it according to the criteria listed above, with the following additions:-

Card type must = "FL".

Part Number must be on file if Insert indicator ≠ 2.

Part Number must not be on file if Insert indicator = 2.

All records for a Part Number must have the same value of Insertion Indicator.

The date of a record must exceed the highest date previously recorded for the Part Number unless it is equal to a previously recorded date, in which case the input record will overwrite the matching item.

Each No. of hours field should be within a standard variance based on the existing average for that shop or Work Centre. 75% to 150% of the existing average is suggested. This error may be treated as a caution if so desired.

No. of Sections must be same on all new part or new process records for a part.

Invalid records will be reported on the Validation Report (appended) and will not generate output records. Valid records, however, will generate movement records on SHOPLOADMVTS file, and will be reported as accepted activities. The following accepted activities are possible:-

Update of existing process (i.e. latest process for part number has not been "deleted" at any time, and is matched by movements with Insertion indicator blank). Existing process record is to be amended.

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New Process (i.e. Part Number exists; movements have Insertion indicator = 1) New Part number record to be generated with Process number one greater than previous highest Process Number. The highest previous Process record to be set as "obsolete".

New Part (i.e. Insertion indicator = 2, and Part number not already present). New part number record to be generated with Process number of one.

Update of obsolete Part (Insertion indicator blank, Part no. exists on file but all process records for it are flagged as "obsolete"). The latest process record is to be updated, but will not change its status and will remain obsolete.

Deletion (i.e. Insertion indicator = "D", Part number exists on file, latest process is not obsolete yet). Mark latest process number record as "obsolete".

At the end of run of program FL84, there will be a file SHOPLOADMVTS containing valid movements, and a validation report which will be in the same sequence as the original File Creation report and each subsequent bi-monthly averages report. It should thus be a simple matter for the relevant parties to check off the results of the validation and determine the causes of errors, and the correctness of accepted data. Errors will be corrected by pulling the respective data cards and re-punching them, and the program FL84 will be re-run, inputting all valid data again, together with the re-punched cards. With an average volume of 500 cards in a run this should not cause problems.

Please note that the facility has been incorporated (see validation of date input, above) to amend previously-input information by matching on Part Number and Date. This implies that Part number and Date constitute a unique key in the system, and thus that no part will ever be recorded twice with the same date.

When the decision is taken to go ahead with the update and Averages Report, program FL85 will be run. This program will action the SHOPLOADMVTS records against the SHOPLOADFILE database, serially, and concurrently it will print the Averages Report (appended). This will either print the non-obsolete records on SHOPLOADFILE, or the relevant parties may optionally specify a full print of all process records on file. The activities carried out will be as follows:-

Updating

A deletion will be actioned by setting the "obsolete" flag in the Part/Process record specified by FL84.

Con't...

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R. Clay
P. Johnson

A new Process Record or a new Part record will be actioned by generating a new record on SHOPLOADFILE for the required Part Number, with a Process Number one greater than the previous highest (which will also be set "obsolete") in the former case, and a Process Number of 1 in the latter case.

An update will be actioned to an existing Part by accessing the highest Process Number for that Part (as specified by FL84). The number of Sections field, if non-blank on input, will be taken from each SHOPLOADMVTS record for the Part Number and used to overwrite the Number of Sections held on the SHOPLOADFILE record; thus the latest dated input record with a non-blank No. of Sections field will determine the final value of the No. of Sections held on file. Each input record will create an additional set of Shop Hours figures on the Part record, until there are twenty such sets held; at this point the earliest sets are overwritten progressively until all new inputs have been stored in the Part record. This does not apply to inputs with dates matching previously-recorded dates, which will be used to overwrite the matching items rather than filling up the array or overwriting the earliest items.
At this point, an arithmetical mean average is calculated for each Shop or Work Centre, by adding together all those figures which are present, and dividing by the number of sets present. At present, only the first three columns will be utilised, representing 220 Shop, 230 Shop and 241 Shop respectively. The remaining five columns will be left blank on the Averages Report until there is significant data to report.

Reporting

If the relevant parties have so specified, the program will report on all Part/Process records on file, irrespective of currency or obsolescence. Otherwise, only those Part/Process records not being marked as "obsolete" will be reported. This includes only the latest Process for each part, and not necessarily every part number will be reported.

Below the main report line for a part, all the sets of figures held on record are listed out. This will hopefully provide a complete check as to the correctness of the database at all times.

Con't...

TO: S. Bennett
R. Clay
P. Johnson

Security Aspects

I recommend that the SHOPLOADTEMP file be retained as security for the SHOPLOADFILE until the Bi-monthly processing cycle has been operating successfully for some time. Additionally, and as a regular part of the processing cycle, an XPJW file dump should be made from the SHOPLOADFILE prior to the first run of FL84 in each period. Should later enhancements be embarked upon, such as on-line random interrogation of the SHOPLOADFILE, then more extensive security may be called for.

Enclosures

Proposed ACD Shoploading System - flow diagram.

ACD Shoploading input document - (Honeywell System) copy.

Proposed ACD Shoploading Movements - input document.

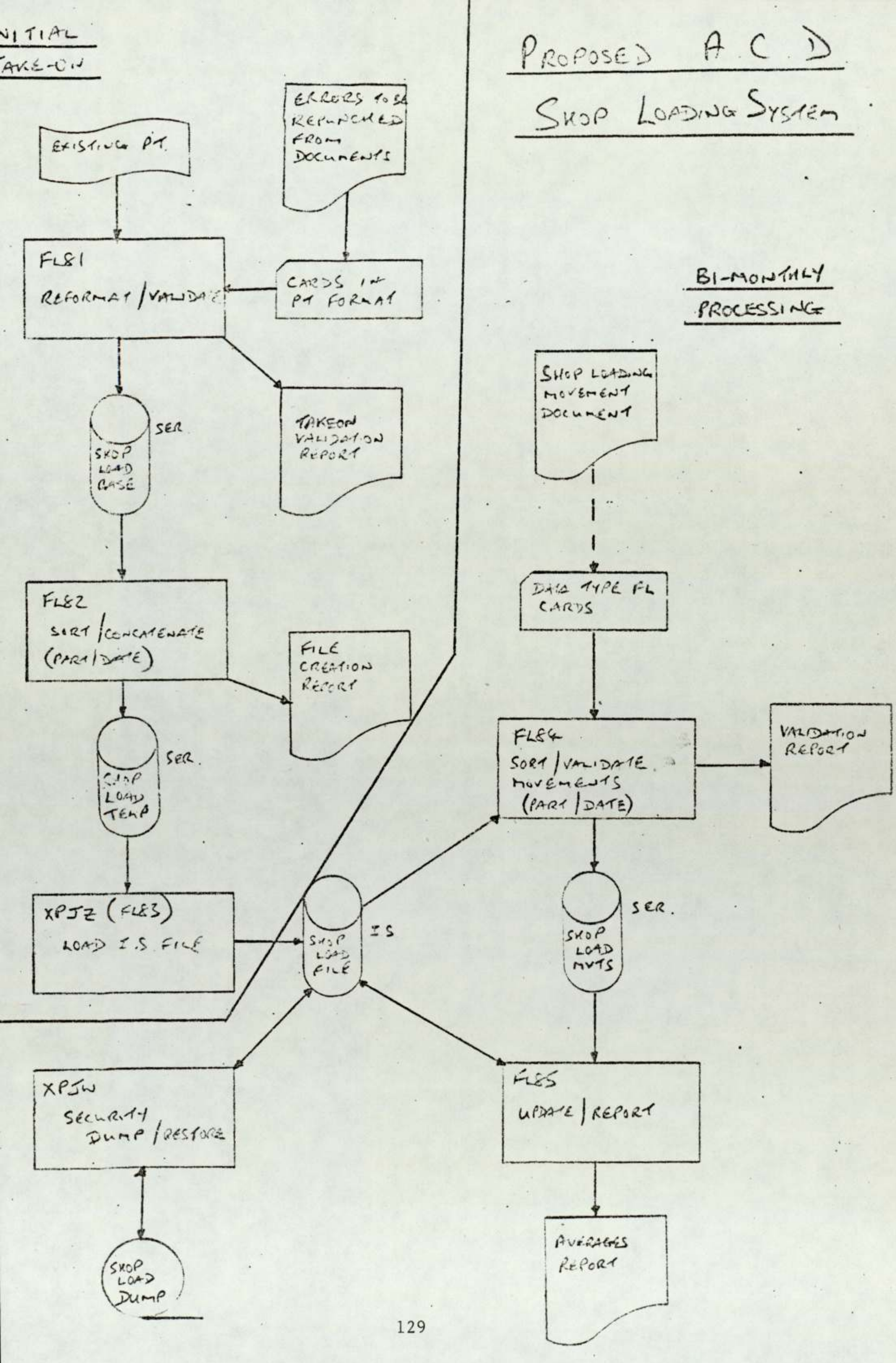
Proposed TAKEON VALIDATION REPORT Layout.

Proposed FILE CREATION REPORT Layout.

Proposed VALIDATION REPORT Layout.

Proposed AVERAGES REPORT Layout.

M.L. TURNER


NITIAL
AKE-ON
PROPOSED A C D
SHOP LOADING SYSTEM
EXISTING PT.
ERRORS TO BE REPUNCHED FROM DOCUMENTS
FL81
REFORMAT / VALIDATE
CARDS IN PT FORMAT
SER
SHOP LOAD BASE
TAKEON VALIDATION REPORT
FL82
SORT / CONCATENATE (PART / DATE)
FILE CREATION REPORT
SER.
SHOP LOAD TEMP
XPJZ (FL83)
LOAD I.S. FILE
I S
SHOP LOAD FILE
XPJW
SECURITY DUMP / RESTORE
SHOP LOAD DUMP
BI-MONTHLY PROCESSING
SHOP LOADING MOVEMENT DOCUMENT
DATA TYPE FL CARDS
FL84
SORT / VALIDATE MOVEMENTS (PART / DATE)
VALIDATION REPORT
SER.
SHOP LOAD MVTS
FL85
UPDATE / REPORT
AVERAGES REPORT

and the Chief Systems Designer. The influences on the former are the Board and the Computer Users Steering Committee and this has resulted in the generation of the five year plan. The influences on the latter have a greater technical bias since it is his responsibility to ensure the integrity and practicability of any design work carried out.

In conclusion the complete systems definition and development programme has two main aspects. The higher of these is the policy and project definition phase performed by the Manager and Chief Systems Designer in conjunction with user management. This results in a system specification which is the basis of working of the second aspect - the System Design. Design includes the tasks of detailed information gathering, document design, data preparation, processing and output specification and is the responsibility of the Systems Designers. This phase involves the user in agreeing the details of the input/output considerations, but is rigidly defined by the overall specification.

CHAPTER VII A SURVEY OF THE THEORY OF SYSTEMS ANALYSIS AND DEVELOPMENT

SUMMARY

The need for the discipline and its development are described. The aspects of modern practice are discussed and a working definition of its limitations proposed.

SECTIONS

VII.1 The History of Systems Analysis

Systems Analysis had not been isolated as a separate function when computers were first used for commercial purposes in the 1950's. The development of the subject has to be understood in the context of the changing technology and the experience of early applications which brought about the need for analysis.

The First Generation of Business Computers: These were machines installed between 1955 and 1960 which had been developed from those used in scientific work and were characterised by the use of vacuum tube technology. Processing speeds were slow, the internal memory highly restricted and only a single job could be processed at any one time. The mass storage medium was magnetic tape, which has the disadvantage of being serial access, or magnetic drums (although the latter were considerably less frequently used).

To make such a machine operate was a highly technical task performed by specialist computer programmers. These people were completely machine oriented by training and inclination.

Thus the very earliest business applications were direct automations of existing manual systems. It was enough to duplicate current activities precisely and rely upon the inherent speed and accuracy of the computer to provide the benefit. The machine performed straightforward calculations supported by limited data storage and handling.

A typical application would be the payroll. The payroll clerks would multiply hours worked by hourly rate for each employee and make appropriate deductions for tax. By specifying the calculations to be done the requirement of the computer programs is determined. This is suitable for the programmers to turn into a computer routine.

The Second Generation of computer were available between 1960 and 1965. Transistors were used in place of valves and the machines were considerably smaller, more reliable and less expensive to run than the earlier ones. Magnetic discs became commonplace as mass storage media and a larger internal memory were employed. Increased business confidence was leading to more widespread use of computers,(both in that there were more users and a larger range of applications had been developed).

It was during this period that systems analysis was isolated as a separate function in the complete computer system design and development task. This came about as a consequence of the realisation that a gulf was opening up between the technical programmers who made the computers work, and the users of the systems, the business management and staff.

Because the task of designing and writing programs was at this stage highly complex, the programmers naturally sought to keep the specification of the systems as simple as possible. If the requirement was complex, the problems of meeting it and ensuring the validity of the programs were immense. Therefore, if the decision was left to the programmers, the system would be pared down to the minimum workable.

For this reason stock control systems were designed which could not cater for scrap, or for rejects. Order book routines were developed without the facility for an order quantity to be changed. Such systems failed to meet the needs of the business since there were invariably excellent reasons for the manual systems being as complicated as they were.

If the system was small and could be completely specified by the user, the method of using programmers directly was seen to work. However, as confidence grew and bigger systems were being tackled, it became apparent that the programmers with their technical stance were in a poor position to communicate with the users. They in turn did not necessarily understand the computer and so could not describe what was needed in computing terms.

Acrimony arose between the two parties because:

"the (computing) tail was wagging the (business) dog"

Firnberg (1975).

Systems analysis evolved precisely in response to this perceived need for better communication.

It reflected the nature of business computing in the early 1960's by dealing with the automation (or computerisation) of existing manual routines.

Prominent in sponsoring this development were the computer manufacturers. The role was forced upon them by the adverse comment engendered by the few disastrous computer installations of that period. If the concensus of opinion was for companies to reject the new business tool on the grounds that it was not effective, the manufacturers would naturally lose out.

Exhibit 1 is taken from an early I.C.T. Ltd. training manual and defines the role of the systems analyst as seen then.

It shows that early systems analysis involved the detailed investigation of existing practice, deducing how the computer could be used to duplicate this and generating a system design which interfaces the user and the technical programmer. The programmer has to ensure that his program meets the specification and the analyst in turn is responsible for ensuring that the specification reflects the business requirement.

The Third Generation of computers was introduced in 1965 and featured an interrupt facility. This meant that computers could now process more than one program at a time, (although in reality

EXHIBIT 1

(from Techniques of Computer Management, Vol.2, 1966)

"The Systems Analyst;

(a) investigates and records the working of the existing system

(b) analyses the results of this investigation to help determine the requirements of a new system

(c) designs a new system that is practical and efficient

(d) assists in the implementation of the new system and its maintenance thereafter".

they process small parts of each program in rapid succession). This principle lies at the heart of the sophisticated operating systems which have drastically reduced the housekeeping tasks involved in operating a computer installation. Before the advent of operating systems, it was necessary to load and run programs manually, to the extent of specifying where in the computer memory the program would be stored, when the data would be held and so on. An operating system is a complicated program that effectively runs an installation in response to instructions input by the operators. It organises the internal environment of the computer and automatically optimises its operations. Under an operating system more than one program can be run at a time, with control being passed from one program to another without the need for operator intervention. This can be done because the speed of the central processing unit is quicker than that of peripherals such as tape readers, disc drives and printer. The computer can thus run two programs at a time, working on one whilst the other is waiting for a peripheral to complete its action and vice versa.

The same principle enabled on-line working to be introduced, where one or more users are in direct communication with the computer, which appears to respond directly to requests. The airlines' seat reservation systems adopt this technique, but the high cost of developing these systems restricted their early use to such prestige areas.

By the mid 1960's the technical capability of computers was sufficiently advanced to support the next development of systems analysis. Earlier work came mainly under the heading - 'automation of existing procedures' - the mechanistic approach. But the increasing performance and ease of use of batch processing computers on one hand and the new opportunities opened by on-line working on the other, gave rise to the possibility of using the computer in tasks having no exact manual counterpart.

The conventional mechanistic approach was inadequate as a method of producing such systems, because:

> "What we are really observing is the automation of human limitation. We are enshrining in steel, glass and semi-conductor the very limitations of hand, eye and brain that the computer was invented precisely to transcend".
>
> Beer (1966)

To overcome this problem a number of 'systems approaches' was originated by the independent consulting houses. These approaches are characterised by their systematic nature and provide a checklist of the phases of a successful project. In this sense they serve the same purpose as the step-by-step dismantling and assembly instructions found in car repair manuals. The home mechanic need not understand why he should start with the wheel cylinder furthest from the master cylinder when bleeding his car's brakes. Provided the instructions are rigorously followed the correct result - well bled brakes - will be obtained.

Similarly, the approaches are the distillation of considerable practical experience on the part of the consulting houses. The results are offered as a means of tackling any project of systems analysis and design.

A review of these approaches is contained in Bally (1977).

Exhibit 2 is an extract from a typical approach, in this instance originated by the Honeywell Corporation, computer manufacturers. It is termed B.I.S.A.D. (an acronym for Business Information Systems Analysis and Design). The suggested sequence of stages is laid out with a brief description of the activities to be carried out in each stage.

The common theme of all the approaches is stated clearly in the opening sentences of the Exhibit.

Systems Analysis and Design may be broken down into a set of logical steps and these steps form a general problem solving methodology.

These approaches were developed at a time of rapid expansion of business computing, when technical advances were reducing costs, and making the benefits available to a wider set of companies. Naturally a considerable quantity of analysts and 'computer-people' were needed comparatively quickly to support such expansion. Since few of the right sort of technical people existed,

EXHIBIT 2 (B.I.S.A.D.)

THE STEPS OF SYSTEMS ANALYSIS AND DESIGN

Systems analysis and design may be broken down into logical steps. These steps represent a methodology which may be applied to obtain a solution to any problem. They are:

1. Background Analysis
2. Functional Analysis
3. Designing the System Prototype
4. Designing the Working System
5. Operational Planning
6. System Specifications
7. Implementation and Control

In essence, we may summarize each of these stages as follows:

1. Background Analysis

This is the foundation of accurate problem definition upon which we build our future systems work.

2. Functional Analysis

Here we break down the total operation into logical groups of tasks with required information which must be available for those tasks to be carried out. This is done regardless of the way they may have been performed in the past or how they may be done in the future - we concern ourselves solely with what must be done. Generally speaking, a logical group of tasks is called a function and each task therein is an activity.

3. System Prototype Design

In this step we progress from what must be done, to how it is to be done in terms of basic data processing operations only, (e.g. classifying, recording, calculating, sorting, communications and summarizing). In other words, we develop a model of the business system without regard to the media which could, should, or even would be used to perform those data processing operations required by our system prototype, although we would certainly have some ideas on the subject at this stage. These ideas must include both manual and machine operations if the prototype system is to be of "closed loop" design.

4. Working System Design
Once the persons authorizing the study have approved the model, we can then concern ourselves with the design detail necessary to convert our prototype to a working model, with both the sequence and the media involved.

5. Operational Planning
Much of the problem historically associated with systems work was that many systems (good and bad) were never implemented for lack of a plan to get the system operational. No system is complete without an operational plan detailing implementation criteria, (i.e. tasks, resources schedules, etc.).

6. System Specifications
This is a collation of documentation resulting from the previous steps which define the business system, the working system, their advantages over other systems and a plan for implementation.

7. Implementation and Control
In this stage we are concerned with making the system operational and controlling the implementation effort.

(i.e. those with a computer background), it was necessary to recruit from existing business staff. This turned out not to be a drawback because S.A. was evolving away from the technicalities of computing toward understanding of the business as the basis for action.

Exhibit 3 is taken from Ward (1975) and shows the characteristics considered desirable in an analyst. They are general rather than technical and show that this new crop of analysts had to be given some grounding in how to use computers. The prevalent climate of opinion was that systems approaches provided the best method of working and so formed the basis of much of that training.

Naturally in the period since then these people have developed their careers and moved up organisational hierarchies. Their ideas of how computer systems should be designed have undoubtedly been modified by practical experience, but the systems approaches have become firmly established as a standard method of working.

The advent during the 1970's of communications networks and the increasing use of on-line facilities have not changed this mode of working. Instead, additional techniques have been introduced to enlarge the job of systems analysis. In designing a real time system there will a need for such mathematical techniques as probability theory, queuing theory and the comparison of terminal network configurations. But the evidence, according to authorities such as the N.C.C. (1978), Yourdon (1972) and Tebbs & Collins (1977)

EXHIBIT 3

The Desirable Characteristics of a Systems Analyst

" - the required intelligence to understand the fundamental logic of the system
- a high degree of perception combined with a refusal to jump to conclusions
- persistance in overcoming difficulties to maintain a planned course of action
- strength of character combined with a sense of purpose
- a broad, flexible outlook with an orderly mind, a disciplined approach to, and logical neatness in, his work
- the possession of higher than average social skills to develop the essential cooperation to bring about change."

is that the impact of these techniques upon the gross structure of systems design work is small. The techniques are slotted into the box marked 'design' in the systematic approach flowchart.

The conclusion of this section is that the Systems Approaches with their systematic, problem solving orientation form the basis of the majority of practical systems work done since the mid 1960's. Further, they have moulded the attitudes of both user and analyst in defining where and how computers should be employed in a business.

VII.2 Current Practice

To develop a list and description of the elements of current S.A. practice two sources were examined. The first was the activities of the analysts within S.H.T. The second was an analysis of the literature on the subject. The wide range of books available cover varying levels of sophistication of the subject from the straightforward description of techniques through to texts on network design and queuing theory.

The following list is offered as a concensus of the tasks subsumed under the heading of systems analysis. Although there will be some analysts in industry and commerce pursuing activities not mentioned in the list, they form only a small percentage of the total.

The tasks are divided into four categories reflecting the broad sequence of a typical analysis project.

Analysis of Requirements

1. Establishing system objectives.
2. Specifying the boundaries of a system.
3. Defining system performance targets.
4. Identifying constraints (cost, resources etc.)

This sets the scene for the subsequent work and is carried out by the analyst in conjunction with the 'owner' of the system in question.

Analysis of Existing System

1. Detail the flows of information around the system.

2. Identify the inputs, outputs and processing rules in operation.

3. Construct detailed flow charts and decision tables to describe the system.

4. Establish some measures of system performance against which to compare design ideas.

The literature pays a considerable amount of attention to the personal interviewing techniques and flowcharting procedures found in this process.

System Design

1. General system configuration selection.
2. Hardware choice.
3. Software choice.
4. Processing routine design.
5. File structure design.
6. Clerical system design.
7. Documentation of the designed system.
8. Form design.
9. The specification of security and data integrity routines.
10. Feasibility Studies to choose between alternative systems.

11. Estimation of performance and costs.
12. Development planning and resource allocation.
13. Producing program specifications.

Implementation

1. Project Control.
2. Reporting of progress to senior management.
3. User training.
4. File creation.
5. System Testing.
6. Change-over supervision.
7. Performance monitoring.

These generalised statements are offered as broad guidelines to the tasks of S.A. They will involve different operational details depending upon the nature of the technicalities of the computing system.

Consider the security and integrity aspects, for example. With an on-line system, security may involve the specification of user identifiers and passwords, of varying levels of access and the need to sign-on at regular intervals. Integrity requires continual checks to be made on the data, a transaction file to be maintained and provision made for system failure and restart.

In contrast a batch processing system will have fewer security needs and the integrity checks cover data format, file generation and batch totals. Failure can be catered for by re-creating the start conditions and repeating the processing.

The bibliography contains the list of texts consulted and reference can be made to these for description of specific points.

VII.3 Database

There have been few areas of computer technology which have developed as radically as the methods of storing and handling data. Early computers had a main memory of a few thousand words and a backing store of a few tens of thousands of words. Modern computers now store many millions of words, each of which may be accessed very rapidly, on a single unit, and new techniques are needed to control and access such vast quantities of data.

The concept of the file was introduced to data processing to cope with larger quantities of data. Early files were simply images of paper files which had been held in filing cabinets in offices, or perhaps on punched cards, and this approach, together with techniques of sorting merging etc., which had been developed for punched card tabulator machines,were perfectly adequate for early commercial applications of data processing. Three factors placed a limit on the usefulness of the approach and on the extent to which it could be developed.

- The development of a number of applications led to a need for storage of the same information in a number of different files (one for each application in extreme cases). This tended to lead to problems in keeping all copies of the data up-to-date.

- In cases where the applications were such that the data could all be stored in one file (or a few files) a different problem arose: a change to any one of the applications could lead to a change in the format of one of the common files and the need to amend and update all the programs.

- The advent of communication systems called for high volume random access to large collections of data: new methods of organising and storing the data were needed to meet these requirements.

The technique which was developed in response to this need is that of database. The fundamental principle is the collection of all the facts about the business into a single bank. Application programs then access this bank - or database - to extract the relevant information.

The distinction between this and the earlier stand-alone systems is that in the former it is usual to have to define what data are necessary and then define the procedures for deriving them. With database the data have already been derived and are available. It is only necessary to decide what is required by the application program.

A database management system (D.B.M.S) is a sophisticated and expensive piece of software which is used to manage, maintain and retrieve data from the database. It organises data elements into a structure determined by the relation between the elements. In doing so it eliminates redundant (i.e. duplicate) data and provides a natural access to that data through paths determined by the organisation of the database.

Although the first commercial system (the Honeywell I.D.S.) was available as early as 1966, it was not until the mid 1970's that the falling costs of computer hardware made database a plausible proposition for any but the largest companies.

Database has resulted in a redefinition of the technical boundaries to the analyst's job. With the stand-alone program suites the analyst is responsible for laying out the broad design of the suite, specifying what data need to be derived and designing the manual/clerical routines for achieving this.

Under database the analysis finishes with a statement of the data which will be required in the application programs.

The analyst's lost area of responsibility is usually subsumed under the function titled database administrator. These people are primarily concerned with the integrity, security and efficient storage of data in the database. They will probably also be responsible for database design and the administration of the data dictionary which serves as a focal point for all data definitions.

The 'statement of data required by the application program' which is the end point of the application analysts design is a logical model of the data required. There is a number of concepts for this logical model but the most widely used is that it is a set of 'relations' plus 'constraints'. This relational model was introduced by Codd (1970) and is described by Wiederhold (1977), Date (1977) and Benci (1976). Alternatives, such as the entity relationship model proposed by Chen (1976) or the network model Codasyl (1971) have found less favour.

Despite the fact that considerable use is made of database throughout modern business computing, it has been the target of a number of criticisms. Beer (1972) has argued from an information theoretic view that a database to hold all the relevant facts about a business must be infinitely large. Since infinitely large computer memories do not exist some selection must necessarily have taken place in order to set up the database. This process of selection necessarily contradicts the fundamental principle of database.

Alter (1976) and Appleton (1977) have observed that database fails to provide effective information for the higher levels of management, probably because the selection criteria for data to be included in the database do not adequately reflect the information needs of management.

But despite these objections, database is a technique that is finding increasing application, as the cost of computing hardware falls and expertise in D.B.M.S. software increases. Its impact upon Systems Analysis has been to separate the analyst from the computer still further by the need to interpose computer database technicians between the statement of the business requirements and the specification for the application program.

VII.4 A Working Definition of Systems Analysis

Systems Analysis is the means through which general business management bring about computer based systems.

It involves:

- communication with the machine-technical staff, e.g. programmers and database administrators, so as to provide them with a statement of the technical requirements of a system.
- communication with the prospective system users and management to define and agree the scope and requirement of the business system
- the design and development of the computer and associated manual procedures necessary to fulfill the business requirement
- the control and co-ordination of this design and development work.

CHAPTER VIII The ASD Data Retrieval Project - System Analysis

SUMMARY

This Chapter describes the practical work undertaken in analysing the activities of the ASD Sales Technicians, starting with an outline of the division's business and structure, the details of the existing data retrieval routines and the role which job knowledge plays in this process. In the light of this work the requirements for the data retrieval system can be restated.

SECTIONS

VIII 1. The Formation of ASD

As has been mentioned, S.H.T. was divided into four divisions, each of which maintained a spares and repairs operation to deal with its own product. However, in January of 1976 the AFTER SALES DIVISION (ASD) was created, largely as a result of considerable pressure by a single director. The purpose of this move was to centralise the organisation of the fragmented spares/repairs facilities in the interests of raising the level of service offered to customers by the company. (Due to the stringent quality controls required for AED products, ASD was concerned with the other three divisions only).

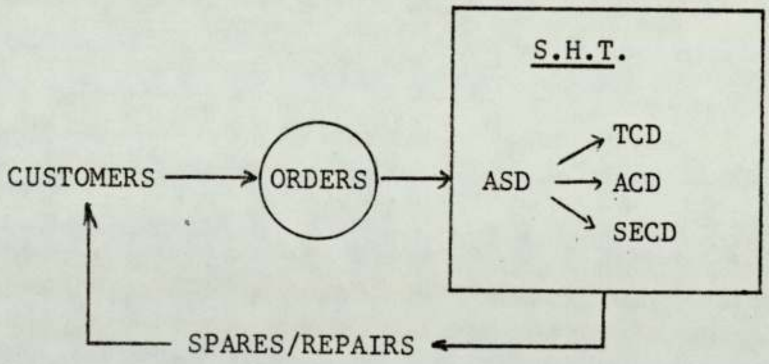
Previously the manufacturing divisions had dealt only with such After Sales work as came their way and due to the priority accorded to the production of original equipment, this service was not very good. If ASD could brighten up the company's image in this area, there were two significant benefits to be achieved:-

(a) The after sales market was investigated and found to be very large. This comes about because the number of new coolers on which the manufacturing division can take a profit every year is very small compared to the total number of units in service. Of this total number a significant proportion will require maintenance in any year, thus ASD has a potentially larger number of coolers on which to make money.

(b) A customer who has received prompt and efficient

> servicing of his coolers is more likely to purchase new ones from Serck at a later date, than if he has to go elsewhere to have his coolers maintained. Thus an efficient after market service should be reflected in enhanced sales of original equipment.

So ASD was established in order to actively pursue spares and repairs business. The manufacturing divisions would still physically produce the goods, but ASD would act as the interface between them and the customers.



ASD accepts the order, processes it and issues an internal works order to the relevant division who invoices the customer upon dispatch.

In the aftermarket, customers are frequently more concerned with the speed of delivery than in the price of the part. Ships could be laid up in port paying some vast sum for the privilege, whilst waiting for a relatively trivial cooler to be repaired. Under such conditions customers are prepared to pay for a good level of service. This service requires prompt manufacture to meet orders and the concomitant flexibility of production conflicts with the optimal arrangements for original equipment manufacture, namely lengthy production runs and minimal tooling changes. According to A.S.D's General Manager, before the advent of A.S.D. the company was in arrears on spares/repairs to the value of £400,000. Hence the need for improvement.

But initially, A.S.D's role was to present a new face of the company to the customer and provide speedy acknowledgement of orders, quotations and realistic delivery promises. Implicit in this need was the problem of spares identification. Briefly, each physical unit is identified by a serial number stamped on the stack and the casing. Records are maintained from which the parts list for any serial number may be retrieved. However, there are numerous reasons why this process is more complex than simply looking up a record, in fact it can take several days to identify the actual part required by the potential customer. Such a delay is the anathema of the A.S.D. service concept, and this led to the idea of computerised data retrieval. If all the information was stored in the machine it could readily be accessed and thus cut down the quotation time. This was the problem on which work started in September of 1976.

The initial statement of the project provided by the Service Director of A.S.D.was:- the identification of the numbers of parts required as spares is taking too long. Therefore investigate a computer based data retrieval system to speed it up.

VIII.2 The Approach to the Practical Work

At the outset the A.S.D. data retrieval project appeared to be a self-contained and straightforward piece of analysis and design work. The Service Director stated very clearly the requirement as he saw it, and the content of the project seemed appropriate for the practical systematic approach described in Chapter VII.

Fig. 8.1 shows the broad sequence of stages in the project. The three numbered points are those at which a major phase is completed by a decision or by agreement of a specification. Certain stages are linked by a loop indicating the iterative nature of these particular elements.

The starting point is the initial statement of the project given at the end of the previous section in this chapter. This determines the boundaries of the first part of the work, to undertake a detailed analysis of the operations of A.S.D. with particular emphasis upon the central aspect, the data retrieval process. This will throw up a revised list of requirements based upon the results of the analysis. The initial statement may be confirmed, or extra requirements might be introduced, but the significant outcome of the discussion and review phase is to agree with A.S.D's management the requirement against which the subsequent design work will be done. This is point 1 in the diagram.

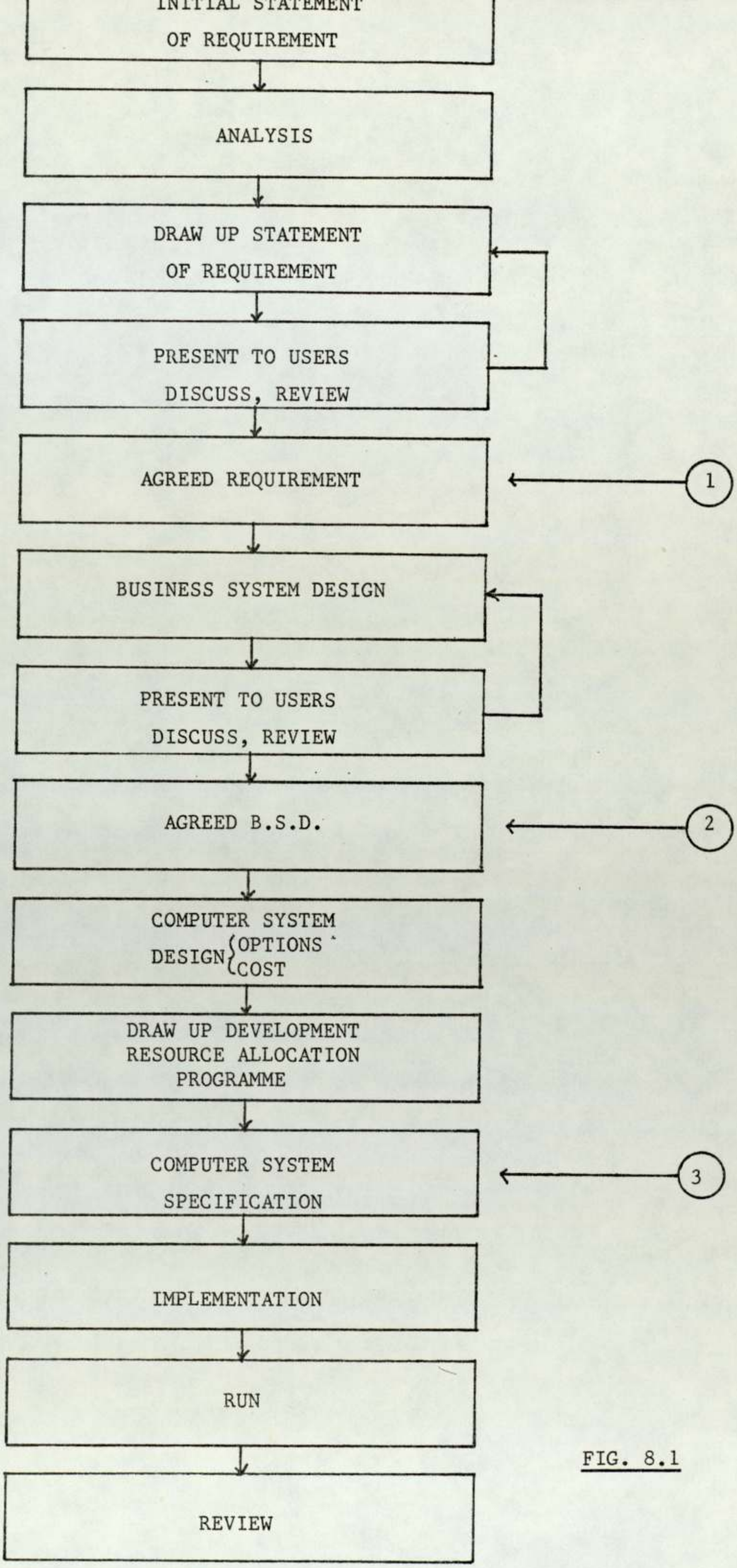

INITIAL STATEMENT
OF REQUIREMENT
ANALYSIS
DRAW UP STATEMENT
OF REQUIREMENT
PRESENT TO USERS
DISCUSS, REVIEW
AGREED REQUIREMENT
1
BUSINESS SYSTEM DESIGN
PRESENT TO USERS
DISCUSS, REVIEW
AGREED B.S.D.
2
COMPUTER SYSTEM
DESIGN OPTIONS
COST
DRAW UP DEVELOPMENT
RESOURCE ALLOCATION
PROGRAMME
COMPUTER SYSTEM
SPECIFICATION
3
IMPLEMENTATION
RUN
REVIEW

FIG. 8.1

The next stage is to expand this list of requirements into a Business System Design. By evolving this B.S.D. the performance criteria, inputs, outputs and processing aspects of the system need to be resolved. The general principle is one of suggesting possible formats and routines to the users and modifying them until the required result of an acceptable system is achieved. This is the end user's opportunity to influence the design of the system whose consequences he will have to face. The B.S.D. acts as a focus for discussion and is a critical phase in ensuring that the way is prepared for a successful computer system design.

Exhibit 1 lists examples of the questions to which answers are necessary in order to characterise the B.S.D. Point 2 in the diagram represents the conclusion of this phase when the design is agreed between the analyst, the users and the user management.

Up to this point all the efforts have been directed toward ensuring that the finished computer system will be an adequate reflection of the real world requirements. Subsequent stages of computer system design and implementation are intended to optimise the technical side of the system within the constraints of meeting the B.S.D.

C.S.D. involves both selection of hardware and specification of software. The 'best' solution is taken in the light of a range of influences other than the purely technical. For example,

EXHIBIT 1

Typical questions whose answers characterise the B.S.D.

1. What is the maximum time delay on a retrieval?
2. How many terminals will be necessary?
3. At the projected rate of divisional growth, plus a contingency allowance, what is the necessary access frequency?
4. How will the users access the data retrieval?
5. Who has responsibility for maintaining the validity of the data on file?
6. How is new information to be captured and entered? Who is responsible?
7. What should be the frequency and timing of updates to the database?
8. What data items are required on any of the returned screens?

A.S.D. could install its own computer purely for the task of data retrieval, but if it cannot be maintained by the company's existing programmers, extra staff will be needed. Further, the Manager of Management Services might be prepared to sanction the installation of a considerably more powerful company mainframe if that was an effective way of meeting the needs of both A.S.D. and the remainder of the company. Obviously such a decision is quite complex involving factors outside the scope of the analysis work.

The first stage of the C.S.D. is to identify the options available and to quantify them in terms of both performance and cost. This involves sufficient design work to support this analysis and leads to the third major decision point marked on Fig. 8.1. The broad hard- and software decisions have been made and a development resource allocation plan drawn up.

Should the project be continued?

Implementation covers the time span from the end of C.S.D. to completion of the system installation. It will be broken down into sub-phases which run concurrently, such as Programming, Clerical Procedure design and File Conversion. The details of this breakdown can be drawn up when the form of the system is known during the C.S.D. stage.

This methodology was adopted at the outset of the project and the description of the practical work is couched in these terms.

VIII.3 The Business of ASD

When ASD began trading in January of 1976 its principal functions were in four categories;

- hydraulics
- repairs
- direct (factored) sales
- spares sales

Hydraulics is the supply of components usually peripheral to S.H.T.'s main business of heat transfer equipment and merits no further attention since it falls outside the scope of this project.

Factored spares or direct spares are those items which are in no way worked on by S.H.T. These would be the low cost, high volume sundries such as the sealing joints,which fit between the castings on a cooler, plugs, cleaning and maintenance kits, studs, nuts and tubes. The manufacturing divisions bought in these components either for internal use or to sell out directly as spares. But ASD took over the latter function and established a small stores in which to hold its own stock. The divisions undertook the laborious process of requisitioning each item individually, so that if an overhaul kit comprised four seals, a set of tools, new studs and nuts, the order had to specify them all. ASD intended from the outset to rationalise this process by having a single part number for a complete overhaul kit. ASD ordered its stock through the central buying office. Any item not in the stores when requested could be obtained in this way. Two people were adequate to staff this function, one Sales Technician (ST) and an apprentice. Their role was to handle orders and enquiries from whatever source, convert them into either requisitions from the stores, or orders to the buying office, and to liaise with the customers as necessary.

The repairs section was a largely self contained unit within ASD which catered for the repair of heat exchangers from any manufacturer, not only Serck. The intention was to establish a resource capable of effecting a repair to anything. A small workshop and reception/ despatch area were set up on the site with four Sales Technicians on hand in the main ASD administration area to deal with customer/ works liaison. Although the usual practice was to try and mend a broken part, in many instances a replacement was the only answer. In these cases the repairs ST's liaised with the ST's dealing with manufactured spares to arrange the purchase of suitable parts from the manufacturing divisions. To accommodate the non-Serck manufactured items certain extensions to the paperwork systems were necessary and a drawing office had been established to produce specifications and drawings for parts not on the Serck list. But the bulk of the work of the repair ST's lay in dealing with customer queries and orders, progressing the works, invoicing and collating costs.

In fact the turnover of ASD is only the sum of these three elements - hydraulics, repairs and factored spares. The remainder of the spares work, to be discussed shortly, is invoiced by the manufacturing divisions, which accounts for the distinction made in Fig. 8.2 - the estimates of turnover made when ASD was established.

This project is mainly concerned with the final aspect of ASD's work, the organisation of the sales of manufactured spares. ASD derives no income from this, but its role is the extremely important one, discussed previously, of rapidly acknowledging, processing and progressing spares orders and enquiries.

Sales of manufactured spares are divided into three areas, to deal with the three divisions concerned, namely TCD, ACD and SECD. SECD, the smallest of them, is the responsibility of a single ST whose job is perhaps simpler than that of his colleagues in that the capital cost of SECD units is low enough to allow the supply of complete units rather than spares in many instances. However this renders him little more than a production chaser when trying to arrange delivery; so, in that respect, his job proves difficult.

The ACD Sales Technician, and the two working for TCD, between them bring in the bulk of the divisional turnover (see attached budget sheets, Figure 8.2). Their job is to receive orders and enquiries,

£'000's

ESTIMATED ORDER INTAKE

	1976/77		1977/78		1978/79		1979/80		1980/81	
Repairs	415		500		550		600		670	
Factored	200		220		230		240		250	
Hydraulics	175		150		150		150		180	
TOTAL - A.S.D.	790		870		930		990		1,100	
S.E.C.D.	60	2,375	70	2,820	70	3,270	90	3,520	100	3,90
A.C.D.	1,110		1,350		1,550		1,630		1,800	
T.C.D. (inc.Admiralty)	1,205		1,400		1,650		1,800		2,000	
TOTAL	3,165		3,690		4,200		4,510		5,000	

Plus Serck GmbH

FIG. 8.2

process them into the language appropriate for Serck's internal use, receive approval from the customer and then issue the Works Order to the manufacturing divisions for production. In this sense ASD spares office acts as a clearing house, providing spares orders and taking the necessary commercial and clerical functions up to the invoicing stage. This gives to spares sales the necessary priority and urgency which had previously been lacking when the divisions were dealing with after-sales work. A specialised customer liaison officer was given the task of keeping abreast of progress on each job so as to be able to deal effectively with customer queries, complaints and demands for progress statements.

VIII .4 The Structure of ASD

Fig. 8.3 gives the organisation chart of ASD when the project started in September of 1976.

The Sales Manager and Works Manager were the senior operational managers responsible for the day-to-day running of their individual sections as shown. The Works Manager dealt with the repairs side and all associated aspects, whereas the Sales Manager covered the administration, contracts sections and the Sales Technicians.

That ASD was a small organisation is illustrated by Fig. 8.4 which

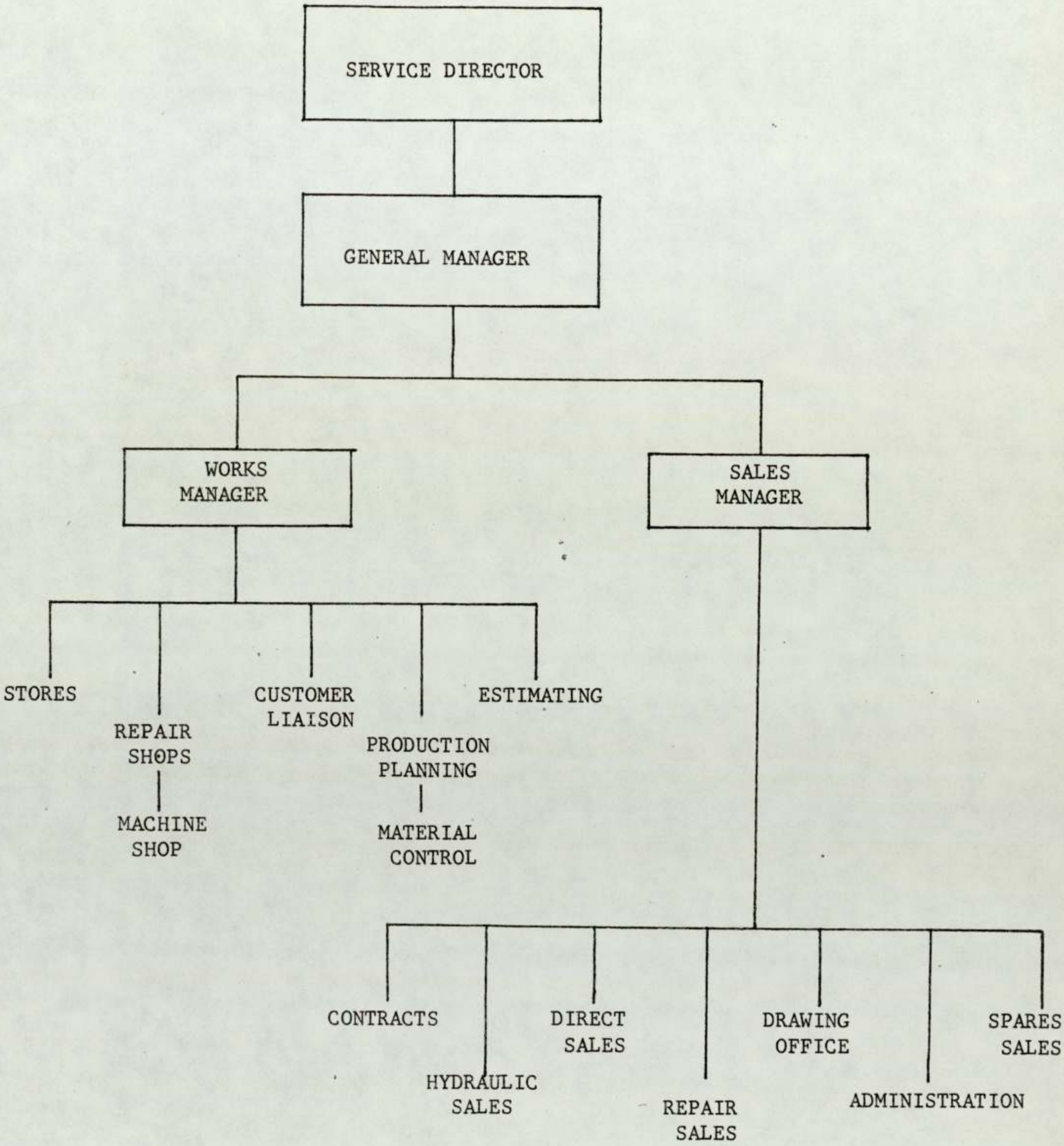

SERVICE DIRECTOR
GENERAL MANAGER
WORKS MANAGER
SALES MANAGER
STORES
REPAIR SHOPS
MACHINE SHOP
CUSTOMER LIAISON
PRODUCTION PLANNING
MATERIAL CONTROL
ESTIMATING
CONTRACTS
HYDRAULIC SALES
DIRECT SALES
REPAIR SALES
DRAWING OFFICE
ADMINISTRATION
SPARES SALES

FIG. 8.3

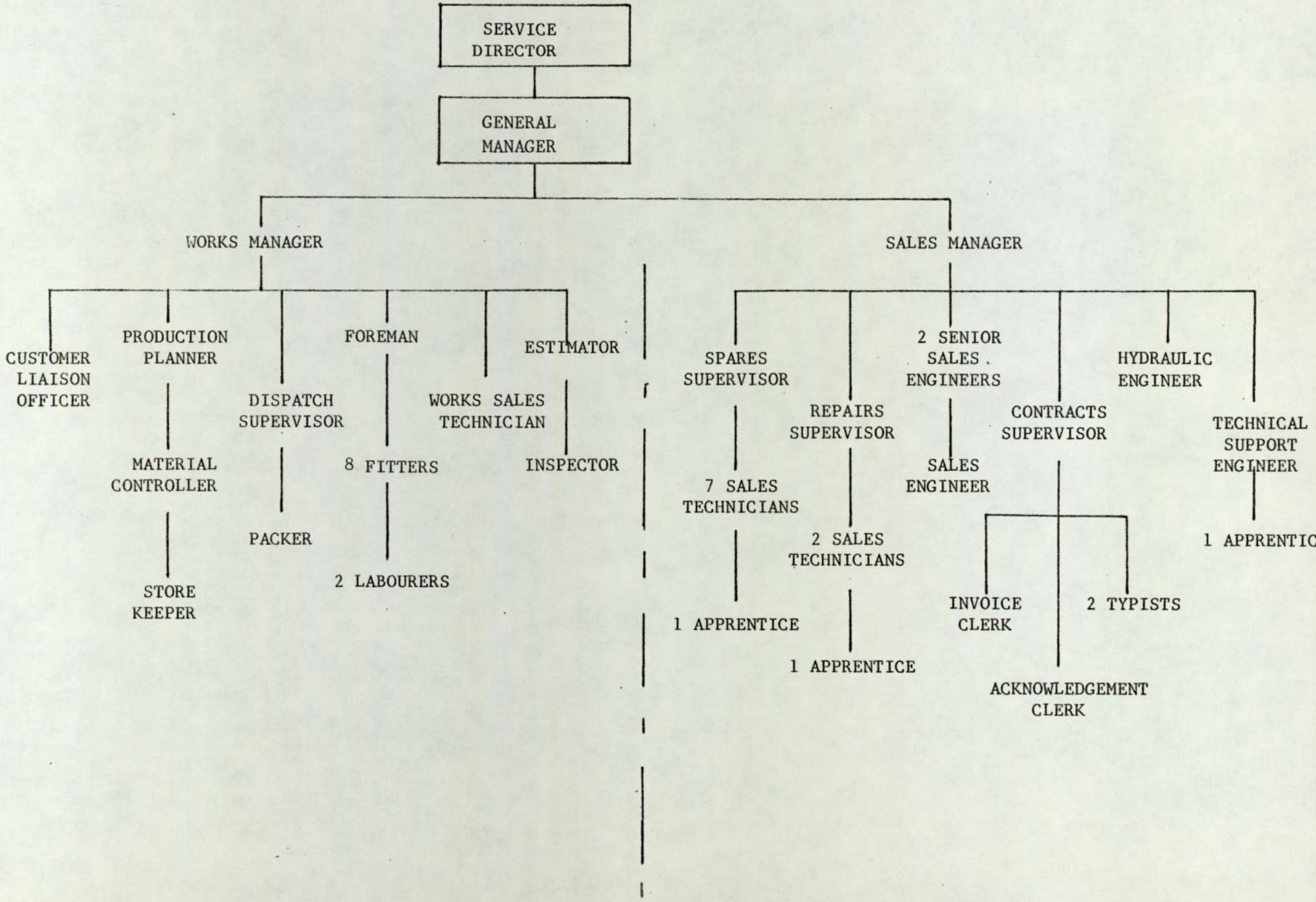

SERVICE DIRECTOR
GENERAL MANAGER
WORKS MANAGER
SALES MANAGER
CUSTOMER LIAISON OFFICER
PRODUCTION PLANNER
MATERIAL CONTROLLER
STORE KEEPER
DISPATCH SUPERVISOR
PACKER
FOREMAN
8 FITTERS
2 LABOURERS
WORKS SALES TECHNICIAN
ESTIMATOR
INSPECTOR
SPARES SUPERVISOR
7 SALES TECHNICIANS
1 APPRENTICE
REPAIRS SUPERVISOR
2 SALES TECHNICIANS
1 APPRENTICE
2 SENIOR SALES ENGINEERS
SALES ENGINEER
CONTRACTS SUPERVISOR
INVOICE CLERK
ACKNOWLEDGEMENT CLERK
2 TYPISTS
HYDRAULIC ENGINEER
TECHNICAL SUPPORT ENGINEER
1 APPRENTIC

FIG. 8.4

gives a more detailed breakdown and includes all the members of the divisional staff.

VIII.5 The Paperwork Systems

A customer might prompt action by placing an order with the ST over the 'phone, by telex or else send in a formal order by letter. The treatment of these is slightly different. Consider the formal order first, the one that arrives by post.
[This next section should be read in conjunction with the flowchart of Fig. 8.5.]

The customer order is received in the post room, opened and stamped with the date and time of receipt. Credit control mark it with a customer code, (a unique reference for each customer) and vet it for credit worthiness before passing it on to the contracts department of ASD via the Sales Manager.

The contracts Supervisor allocates the order a product code (a three digit numeric code which identifies the class of article involved) and an assistant enters details on to the customer orders log and the order number book, so that the order is now identified by a number of the form:-

304/1234

Product Code Sequential identifier

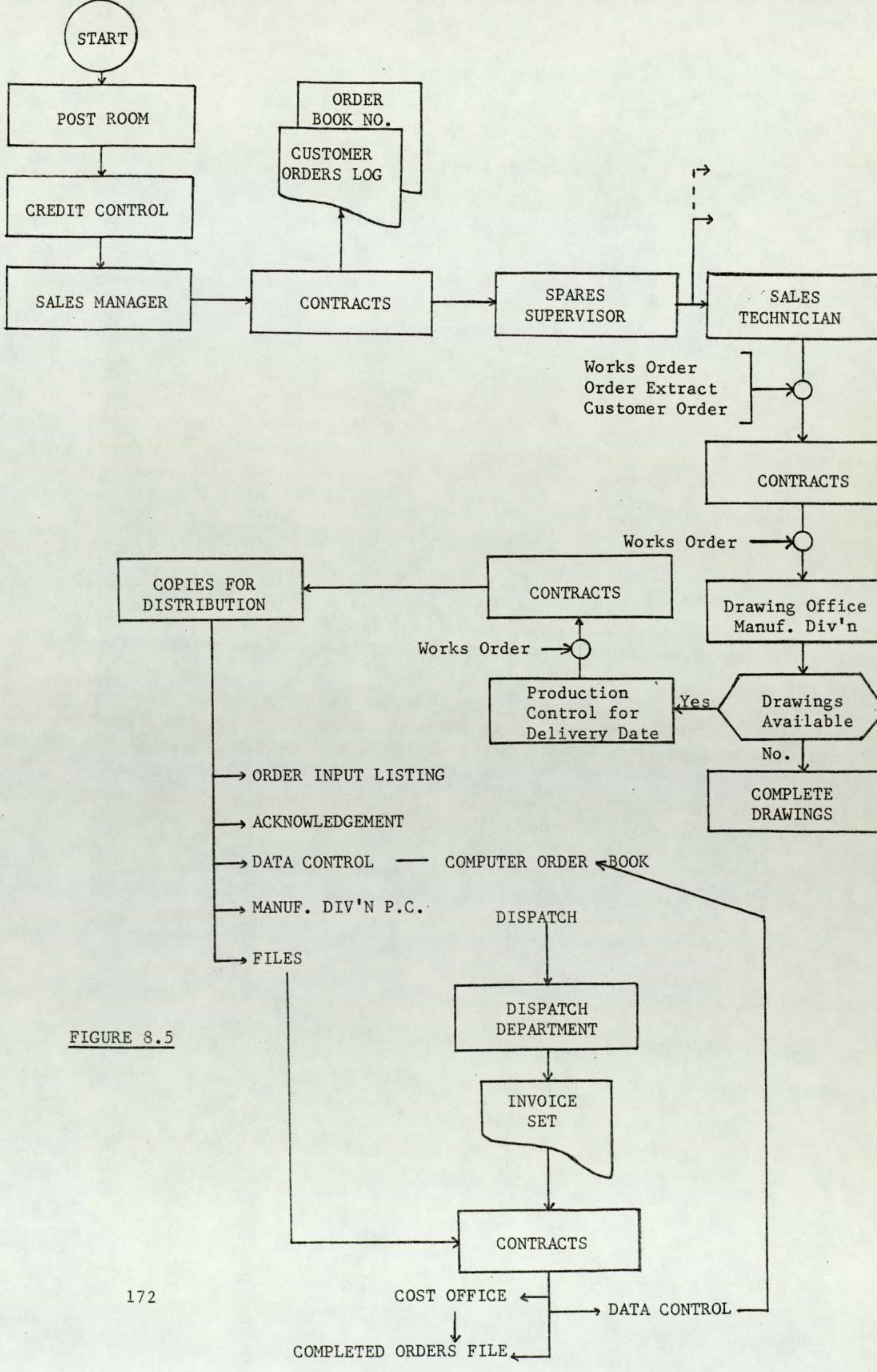
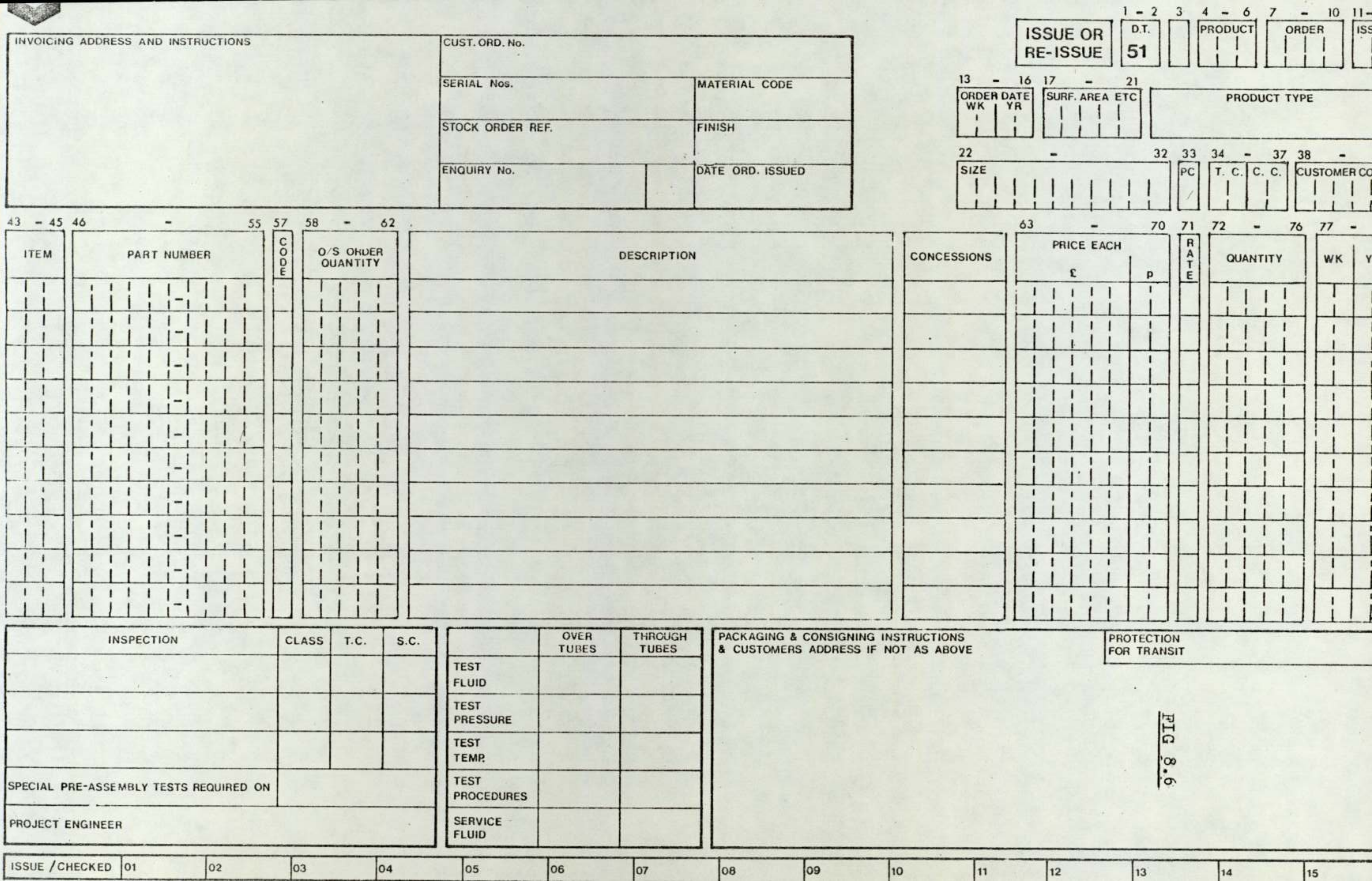

START
POST ROOM
CREDIT CONTROL
SALES MANAGER
ORDER BOOK NO.
CUSTOMER ORDERS LOG
CONTRACTS
SPARES SUPERVISOR
SALES TECHNICIAN
Works Order
Order Extract
Customer Order
CONTRACTS
Works Order
Drawing Office Manuf. Div'n
Drawings Available
Yes
No.
COMPLETE DRAWINGS
Production Control for Delivery Date
Works Order
CONTRACTS
COPIES FOR DISTRIBUTION
ORDER INPUT LISTING
ACKNOWLEDGEMENT
DATA CONTROL
COMPUTER ORDER BOOK
MANUF. DIV'N P.C.
FILES
DISPATCH
DISPATCH DEPARTMENT
INVOICE SET
CONTRACTS
COST OFFICE
DATA CONTROL
COMPLETED ORDERS FILE

FIGURE 8.5

(The product code is a system which allows costs within the company to be allocated to the appropriate department).

For factored spares a streamlined paperwork system has been adopted in which the ST himself performs the above.

The spares supervisor then distributes the orders to the appropriate ST, who carries out the possibly extensive task of identification and makes out the Works Order (WO) and the Order Extract Form (of which copies are enclosed, Figures 8.6 and 8.7), then returns them to contracts with the customer order. This master WO is passed to the Drawing Office of the division concerned in order to ensure that all parts being called up are in fact valid. If they are not, the DO does any drawings which are necessary. The WO is then passed to the Production Department of the division for confirmation of delivery date, from where it is returned to contracts to be matched up against the customer order and OE. The master is then photocopied and distributed according to the table shown below. In the event of an urgent enquiry, or order from a customer, the STs shortcircuit the above protracted method by personally arranging a delivery date with production control. In this instance, they do the photocopying themselves and return the Master WO plus two copies to the contracts section with the customer order and the Order Extract.



1 - 2 3 4 - 6 7 - 10 11-

ISSUE OR RE-ISSUE

D.T. 51

PRODUCT

ORDER

ISS

13 - 16 17 - 21

ORDER DATE WK YR

SURF. AREA ETC

PRODUCT TYPE

22 - 32 33 34 - 37 38 -

SIZE

PC

T. C.

C. C.

CUSTOMER CO

INVOICING ADDRESS AND INSTRUCTIONS

CUST. ORD. No.

SERIAL Nos.

MATERIAL CODE

STOCK ORDER REF.

FINISH

ENQUIRY No.

DATE ORD. ISSUED

43 - 45 46 - 55 57 58 - 62 63 - 70 71 72 - 76 77 -

ITEM	PART NUMBER	CODE	O/S ORDER QUANTITY	DESCRIPTION	CONCESSIONS	PRICE EACH £	p	RATE	QUANTITY	WK	Y

INSPECTION	CLASS	T.C.	S.C.
SPECIAL PRE-ASSEMBLY TESTS REQUIRED ON			
PROJECT ENGINEER			

	OVER TUBES	THROUGH TUBES
TEST FLUID		
TEST PRESSURE		
TEST TEMP.		
TEST PROCEDURES		
SERVICE FLUID		

PACKAGING & CONSIGNING INSTRUCTIONS & CUSTOMERS ADDRESS IF NOT AS ABOVE

PROTECTION FOR TRANSIT

ISSUE / CHECKED 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15

FIG 8.6

AFTER SALES DIVISION

ORDER EXTRACT

FOR SALES OFFICE USE ONLY

W.O. No.

Enquiry No.

PRICE MAKE-UP

Basic W/C		£
Cu. Basis	@	£
Zn. Basis	@	£
Ni. Basis	@	£
Total W/C		£
PROFIT		£
Nett S/P		£
TOTAL EXTRAS		£
GROSS S/P		£

Source of W/C: PL/EST/

Extras

FOB/Freight	£
Survey	£
Other Charges	£
Premiums	£
Commission	£
Discount	£
= TOTAL EXTRAS	£

INVOICE INSTRUCTIONS

Delivery	CPNS/EX.WORKS/FOB/C&F/CIF/
Price	Variable/Fixed Until /CPA
Payment	28 Days/ % Down Payment/CAD/LofC/
Agent Commission	Of % to
Discount	Of % to
Survey/Inspection by	Included/Extra
V.A.T.	Applicable/Zero rated/to be checked

Special Invoice Arrangements :

PACKING AT COST.

Metal Price Variations	
Cu./£10	
Zn./£10	
Ni./£10	

WORKS ORDER PRICE:-

Item No		Price Each	
		£	p
	Total	£	

SECTION DATE SIGNED

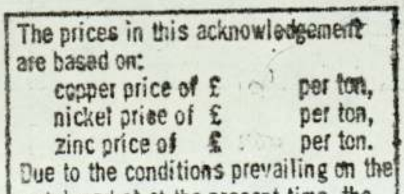
FIG 8.7

	ASD (6)	SECD/ASD (8)	TCD/ASD (8)	ACD/ASD (10)
Contracts	M + 2	M + 4	M + 2	M + 3
Prod. Control	1	1	1	2
D.O.		1	1	1
Estimating		1	1	1
Despatch	1		1	1
Inspection	1	1	1	1
Repair	1		1	1

In contracts, the copies of the WO are priced from the OE and one copy is sent to Data Control for details to be entered on to the computer. Terms of payment and price are added to a second copy and details written to the order input listing, a manual file showing:-

CUSTOMER NAME/W.O. NUMBER/DESCRIPTION/TOTAL VALUE/PROFIT

Receipt of the order is then acknowledged to the customer, a document which contains the copper clause, the stamp being self explanatory.



The prices in this acknowledgement
are based on:
copper price of £ per ton,
nickel price of £ per ton,
zinc price of £ per ton.
Due to the conditions prevailing on the metal market at the present time, the prices will be subject to adjustment should the copper, nickel or zinc price rise or fall more than £10 per ton.

Now the copy of the works order and the order extract are filed as an open order, and the customer order is filed in the customer file with a copy of the acknowledgement. (On repair jobs, the price cannot be calculated until the hours from the workshop are known. In this case the computer copy of the W.O. cannot be sent and it is retained in the "priceless" file until the price is known. When details are entered, the copy goes to the computer and the procedure continues as above.)

The above presumes the arrival of the customer's formal order, but frequently the ST's receive an order over the 'phone with the formal notification to follow. They make out a telephone enquiry sheet and allocate themselves the next product code and order number from the appropriate book. The procedure continues as above for the W.O. system with the acknowledgements being suitably marked to indicate the informal nature of the order. When eventually the customer order arrives, it joins the acknowledgement in the customer file.

A copy of the W.O. is sent to production control of the manufacturing division and the actual work is done,be it the production of a spare or doing the repair, and on being sent out to the customer an invoice set is raised which consists of five copies.

Invoice Copy	Destination
white	customer
yellow	cost office
green	credit control
pink	ASD file
blue	computer

However, the factored spares function operates differently. Since there is no need for the production control to be involved, it is either a case of simply requisitioning from the stores or of arranging purchase through the Buying Office. The simplified W.O. goes only to the supplying division. These orders are not raised on to the computer and the ST maintains a manual listing of the order quantities and values in the form of a customer card file. For the factored spares the blue copy of the invoice is redundant and is simply torn off and thrown away.

When the invoice set is received by contracts, the appropriate W.O. is hunted out from the open order file or the "priceless" file. For those repairs still not priced, the bundle is returned to the "priceless" file. When a price is known, the payment terms, issue number and price are typed on to the invoice and the VAT rate for that destination is added. The W.O. is stamped "completed" and the invoice number entered on to it, then it is filed in the completed orders file, the blue invoice is sent to the computer via data control and the remaining invoice slips are passed to the cost office. Eventually the pink copy is returned from credit control and is filed with the customer order.

For factored spares, the invoice is matched with its W.O. from the ST's file and priced. The invoice number is written on the W.O., typing is done and the procedure is subsequently as above.

The purpose of the contracts section is to maintain files appropriate to the various stages of maturing of the order and to act as the clearing house for the other elements of the complete company system.

VIII. 6 Volume of Work & Projected Order Intake

One phrase in the previous section was;

> "The spares supervisor then distributes the orders to the appropriate ST, who carries out the possibly extensive task of identification ...."

This glibly includes the complete data retrieval problem as seen by ASD's management, a view prompted by the well-publicised stories where an ST had taken two days to identify the part.

Subsequent sections will describe the details of the ST's task, but this section quantifies their job and its projected expansion over the next few years.

Some customers submit orders directly to ASD but more usually these are preceded by an enquiry either by letter,telephone or telex. An enquiry register is maintained and was analysed over a six month period to reveal the following distribution;

Telephone	25%
Telex	41%
Letter	28%
Not given	6%

Since the ST's are obliged to provide a valid answer to each enquiry, in terms of the proposed data retrieval system, enquiries are equivalent to orders. The starting point of the analysis was to determine the volume of work anticipated.

The ST's for each manufacturing division were requested to record the number of order/enquiries they dealt with weekly and to comment upon their workload.

The ST for ACD averaged 20 orders and 25 enquiries for his £1.2 million annual turnover. The associated data retrievals, form filling and other activities filled his 38 hour week although he was not unduly pressed.

The 2 TCD ST's dealt with some 25 orders and 50 enquiries between them, again for an annual turnover of £1.2 Million. They took longer to process each enquiry than the ACD ST so each was kept busy to the extent that every other month they worked some overtime to clear the backlog of non-urgent jobs.

For factored spares, 30 orders and 75 enquiries were received weekly. These figures are higher than for manufactured spares because a lot of Serck cooler users carry out their own maintenance for which they buy in the sundries. Due to the simplified paperwork system the ST and apprentice could cope with this volume adequately.

Finally, the SECD ST collected 10 orders and 25 enquiries per week. Since the bulk of these resulted in a complete new cooler being supplied, he filled his time by dealing with chargeable repairs, the work done by ASD to fix some prior faulty workmanship by the manufacturing divisions.

Fig. 8.2 gives the estimated order intake for 5 years analysed by division. In order to achieve this projected expansion, the order and enquiry volumes will be as given in Fig. 8.8. This table would require 1 ST for ACD, 1 for SECD and 2 for TCD to be employed in addition to existing staff by 1980/81. In the light of these figures management was asked to comment on the significance of the proposed data retrieval. Their justifications for considering any involvement in on-line data retrieval were:

	1976/77		1980/81	
	ORDERS	ENQUIRIES	ORDERS	ENQUIRIES
ACD	20	25	33	41
TCD	25	50	42	84
FACTORED	30	75	35	94
SECD	10	25	20	42

FIG. 8.8

- it would enable current staff levels to support the greater workload with obvious cost savings.

- it would speed up the time taken for ASD to react to an order/enquiry with the advantage in customer service discussed earlier.

- it would make an excellent selling point.

VIII. 7 Customer Identification of Coolers

Prospective customers identify their cooler to the ST in a number of ways and an analysis of orders and enquiries over a 2 month period revealed the distribution of Fig. 8.9.

Since the whole purpose of the initial section of the ST's job is to identify a Brisch number for the ordered part, in 4% of instances this job is already done for him. Yet he still has to look for any discrepancy between the description of the part and its number,eg, if the customer wants a fixed end cover, part number 43861 - 1009, the ST will readily see that either the number or the description is wrong and will contact the customer to clarify the matter.

But in nearly 80% of all enquiries and orders the ST is given a serial number to work from.

MEANS OF IDENTIFICATION	%
SERIAL NUMBER	78
GENERAL ARRANGEMENT NUMBER	13
PART NUMBER (BRISCH)	4
(OLD)	3
ORIGINAL W.O. NUMBER	2
DESIGN NUMBER	
COOLER TYPE	
ENGINE NUMBER	
DESCRIPTION OF COOLER	

FIG. 8.9

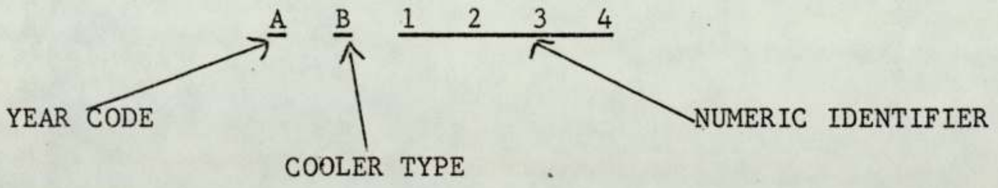
Exhibit 2 contains details of the various serial numbering systems which have been used and the reasons for incorrect numbers being quoted.

Both TCD and ACD maintain two types of log book in which their output is recorded. The serial number log book for each year is divided into sections for each cooler type. An entry gives simply the W.O. number carrying that serial number. The W.O. log book carries details extracted from the W.O., one page per W.O. and in addition, major items of information such as the parts list, the G.A. number and inspection details. Unfortunately there is minimal uniformity since the books have been compiled by many different people down the years.

EXHIBIT 2 SERIAL NUMBERS

Since the 1920's, whenever Serck despatch a cooler, a unique number is stamped on to a thin metal plate which is fastened to the body of the cooler. These numbers are recorded in the serial number log books.

To begin with a 4 digit number was used, with a 5th digit introduced in 1940. By 1950 it was realised that duplication of serial numbers would have awkward consequences for spares supply and the format of the number was changed to;



In 1975 the year code letters were exhausted and a second series was started for 1976, as above but prefixed by a 2.

eg, 2 A B 1 2 3 4

Unfortunately this serial number system fell short of its desired accuracy. During the course of a coolers life it is subjected to a number of events that obscure the lettering on the plate:-

eg,
- painting over
- a blow will flatten the characters
- general grime and filth fill the grooves
- the plate can easily be prised from its rivets.

EXHIBIT 2 (continued)

Several of the engine manufacturers remove the serial number plates from any coolers they use, thus forcing their customers to buy spare parts through them. It is surprising that as many as 80% of the orders/enquiries quote a serial number and wholly unremarkable that 5 - 10 % of these turn out to be incorrect. An examination of the means whereby the serial number was fastened to the cooler revealed that the number was stamped on to the plate with a hammer and hand punch. If the punch is not struck squarely a 7 reads like a 1 and several of the new coolers awaiting despatch suffered precisely this ambiguity.

The ST looks up the serial number he is given in the log book, finds the W.O. number and then seeks out the appropriate entry in the W.O. log book. He is seeking a means of identifying the part number he needs to supply. If the log book contains the parts list, he might find the part number direct.

Frequently the only number quoted is the General Arrangement, or G.A. number. Exhibit 3 outlines the need for,and purpose of, G.A.s.

For each cooler designed or built since 1971 there exists a Production Parts List (PPL). This lists the components of any G.A.

If the ST's examination of the log books reveals a Brisched G.A. number, he can find the desired part number from the PPL's.

If the G.A. is not Brisched and no parts list is given he has to obtain the G.A. drawing from the drawing stores to find the parts list.

If the G.A. is not Brisched and the parts list gives the non-Brisch number he wants,he can move to the stage of converting the old number to a Brisch one.

EXHIBIT 3 G. A. NUMBERS

The complete assembly of a Serck cooler is termed a General Arrangement or G.A. Each separate assembly carries a unique number. Post 1971 this will be Brisched, but earlier numbers can work on any one of some 18 alternative numbering systems to be discussed later. The need for a G.A. number stems from the fact that some sets of components may be assembled into as many as sixteen different arrangements. It is important to know which configuration is which so that an identical unit could be supplied if requested by a customer.

VIII. 8 Part Numbering, History and Procedures

The Brisch part numbering system was introduced in 1971 at which time a set of 50,000 of the existing part numbers were 'translated', leaving an estimated 100,000 as they were. Between 1971 and 1976 Classification and Coding (C & C) estimated they have introduced a further 15,000 numbers, making a total of 65,000 on the company Master Parts File. The manufacturing divisions are primarily concerned with selling new units and the only time they need to convert old numbers would be when a customer requests another cooler to an old design. But ASD are left with the legacy of the part number conversion and have to deal frequently with the old numbers.

C & C are alone responsible for the allocation of Brisch numbers, both for new designs and repeat manufacture of old ones. Strictly speaking the manufacturing division can only work to Brisch numbers, which is why it is necessary for the ST's to have old numbers translated into the 'language' the divisions can understand. Since C & C want to keep the numbering system uncluttered, Brisch numbers are only allocated when absolutely necessary. This means that if a ST is dealing with a cooler with none of its parts having Brisch numbers, instead of converting every part, C & C will allocate Brisch numbers only to those bits required as spares. This policy has resulted in a patchwork effect.If all the old numbers are listed so as to cover one enormous sheet of paper and those for which a modern equivalent exists are crossed out, the effect will be to mark some 3/5ths of the complete set, but in a completely haphazard fashion. Lists are maintained of the conversion both ways (from old to new and vice-versa) which the STs consult frequently.

One particular old numbering system causes many problems - the MZ compound system. In this instance a single MZ number can refer to many physically different items;

eg, MZ1234 will be a water box with branches, but the branches will be shown dotted on the drawing, which should be interpreted as; "there are branches on this water box, but each G.A. will show where they are in any instance".

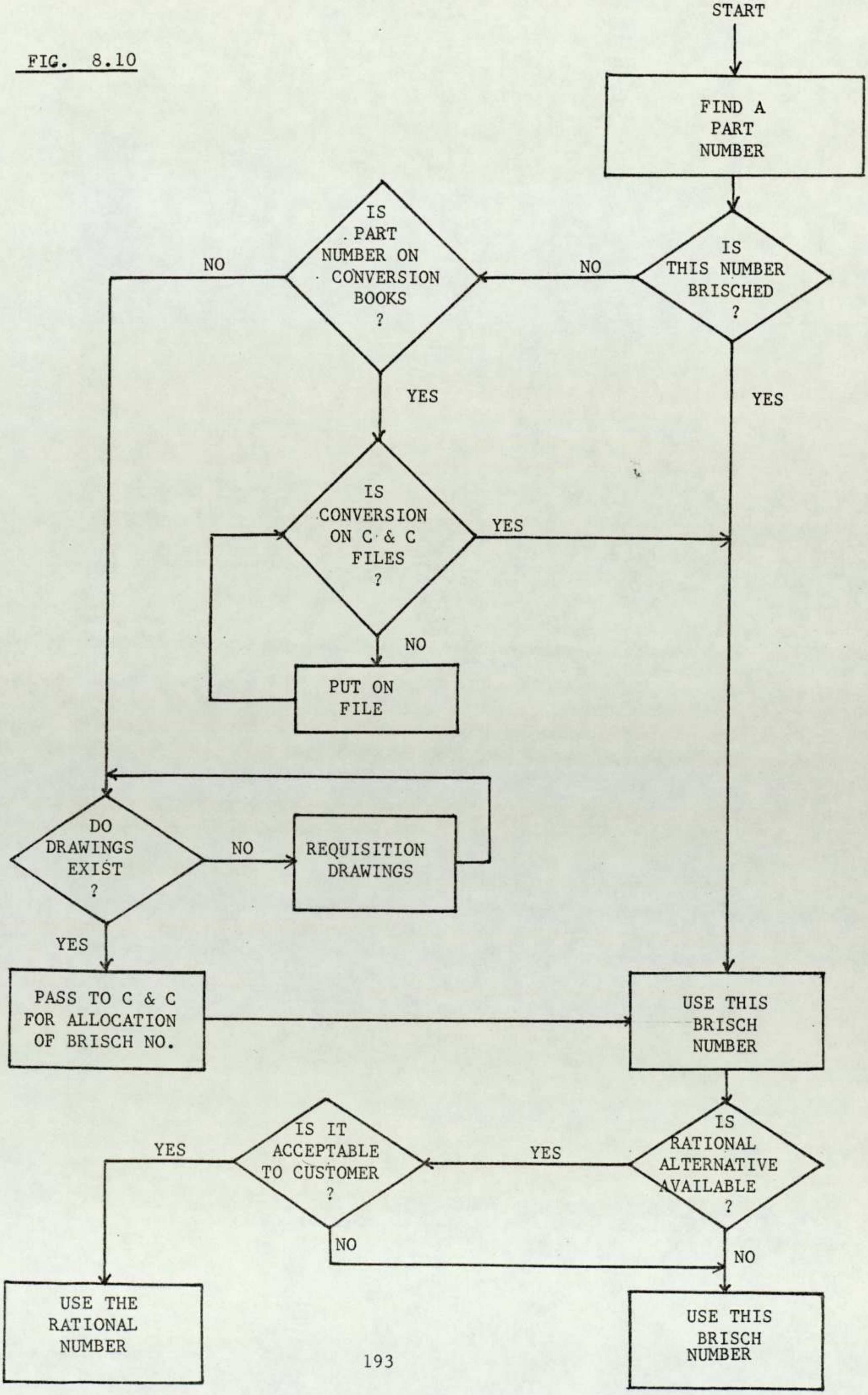
So the ST gets out the drawing for MZ1234 and then has to refer to the G.A. drawing. It is not possible beforehand to know whether this particular version of MZ1234 has been converted, so the whole set of paperwork is submitted to C & C, who after carrying out a conversion might find that it had already been done. However if there is any ambiguity of classification then a duplicate number will be allocated to the one part because C & C cannot find out the first number they have allocated.

Fig. 8.10 shows the procedure the STs follow to obtain the Brisch part number they need in order to move on to the next phase of their task. Four points within there need to be explained, metrication and drawing leadtime, quotation without Brisch number, rationalisation and drawing legibility.

Some problems and delays are caused because certain of Serck's suppliers have gone metric. ACD mount their fans, for forced cooling, onto a fanplate having an equal diameter to the fan. Since all fans are now metric, a request for a replacement imperial fan can only be fulfilled by designing and building a suitable metric fanplate on to which the metric fan will fit. The ACD drawing office is geared to the long lead time of new product design and can rarely produce the desired drawing in under four weeks. The loop in Fig. 8.10 where the drawings are requisitioned can seriously delay the spare's supply. This further gives rise to an unfortunate 'deadly embrace' situation. In the case of the fanplate, C & C cannot allocate a Brisch number without a detailed drawing of the part. But the Drawing Office in turn require a Brisch number against which to book the drawing time. Which they can't have until C & C have allocated the number ....
In practice the ASD ST's have to get around this by cajoling the D.O. into doing the work on 'credit' and booking it later.

Another, and more serious, 'deadly embrace' arises as follows. If a customer needs a spare for which there is no Brisch number,

FIG. 8.10


START
FIND A PART NUMBER
IS THIS NUMBER BRISCHED ?
NO
YES
IS PART NUMBER ON CONVERSION BOOKS ?
NO
YES
IS CONVERSION ON C & C FILES ?
YES
NO
PUT ON FILE
DO DRAWINGS EXIST ?
NO
REQUISITION DRAWINGS
YES
PASS TO C & C FOR ALLOCATION OF BRISCH NO.
USE THIS BRISCH NUMBER
IS RATIONAL ALTERNATIVE AVAILABLE ?
YES
IS IT ACCEPTABLE TO CUSTOMER ?
YES
NO
NO
USE THE RATIONAL NUMBER
USE THIS BRISCH NUMBER

then quite reasonably, he would like to know the cost and delivery date before placing an order. To obtain these, the ST needs to provide the manufacturing division with a Brisch number to quote against. But C & C work to the edict that states they cannot issue a Brisch number without there being a firm order for it, in the interests of not cluttering the M.P.F. Thus the ST cannot get the order without the quote, and cannot get the quote without the order! This is resolved either by - the ST obtaining an 'unofficial' quote from the personal contact network

or - getting C & C to bend their rule and issue a 'temporary' number to be taken up if the order is placed.

Both methods are awkward in that they introduce the possibility of error and growing confusion.

The next point is the issue of rationalisation. Over the years, it has been realised there has been unnecessary duplication of parts. Where one existing part could have been used, another has been designed and produced. The manufacturing divisions have undergone an exercise in rationalisation and stated that certain of the parts are what is termed 'preferred'. These preferred parts are to be offered whenever possible and carry a markedly shorter leadtime than the non-preferred items. However ASD reserve the right to supply the customer with an identical item to his previous one if he so chooses. Further, the STs are not always made aware that a rational part exists and they prescribe the original with its long lead time when a marginally different part could be supplied far quicker, if indeed the works are prepared to make the original item at all. This has led to some unfortunate recrimination in instances where ASD were chivvying the manufacturing division for delivery, only to be told that the equivalent preferred part was available from stock!

The final matter to clarify on Fig.8.10 again refers to the drawings. Of the vast number of drawings in the store (~ 150,000) 10% are indistinct. Roughly half of these can be rendered legible by using alternate light and dark background techniques, but in a few instances the ST has been completly unable to derive any information from the drawing.

VIII.9 Price Determination

This previous stage has enabled the ST to obtain a Brisch number of the part in question. The next stage is to establish a price and delivery date.

Both TCD and ACD produce lists of prices for standard components. A standard component is one that the division would expect to make during the course of its original equipment manufacturing. Standard parts from some 50 - 60% of the demand are simply dealt with by looking the price up in the lists.

Special items are costed by the estimators. A file of all estimates is maintained by each set of STs, but the tendency is not to use them unless the job is very urgent. It is more trouble to look through a pile of perhaps 80 - 100 papers than to send the drawings and estimate request form away to the divisional estimators. The rule on re-issuing estimates is to only use those less than a year old. However the Sales Manager suspected that some quotations were going out for less than the real cost to SHT because they were re-issues of a re-issue.

The process of estimation runs as follows. Buying Office annually produces a listing of raw materials costs and since a lot of units have a considerable copper content, the price of which fluctuates wildly, the estimator determines the proportion of copper in the unit so that the copper price variation can be included at the time of selling. The overhead cost is issued on a fixed charge per job from the list of overheads supplied by the Accounts Office. Labour is the final constituent and there exists a history of job times for the various items of work so the labour cost is compiled from the job's duration and the prevalent piece work rate. However, the estimators insist that their job is not precise, in that a deal of experience is used in each instance.

The turn round time for estimating is usually one day, the STs expecting an answer the day following submission of the documents. This can be modified by special circumstances, such as an urgent enquiry, by the ST telephoning the estimator and encouraging him to allocate a higher priority to that particular job. Alternatively when the estimators are busy on work for their 'owners' the manufacturing division, the turn round time can stretch to three or more days.

VIII.10 Delivery Dates

The ascertainment of delivery times is similar to pricing in that standard items are quoted from lists provided by the manufacturing divisions. These figures are met in some 98% of cases, according to the General Manager of A.S.D. Special items need to be referred to the production control department of the manufacturing division and can cause severe problems because the divisional staff may have, first, to decide how to make the part, and second, schedule this work around the remainder of the division's production so as to arrive at a delivery date. This matter will be referred to later on, so at the moment it is enough to state that the protracted nature of this quotation phase causes considerable problems to the A.S.D. ST's. On one side the customer is clamouring for an answer to his query, on the other the division is moaning about disruption of schedules and eventually quotes a delivery of say, 6 weeks. When the customer is given this information he may be forced to seek a solution elsewhere because he simply cannot wait that long. The shortest time in which the ST could expect to receive a delivery quote from the division is normally a day but as for the estimating process, this can be hurried along. Alternatively the quotation time might stretch out to several days and even a week, if either the production control staff are particularly pressured at that time, or if the manufacturing data to support their work are inadequate.

VIII.11 The Importance of Job Knowledge

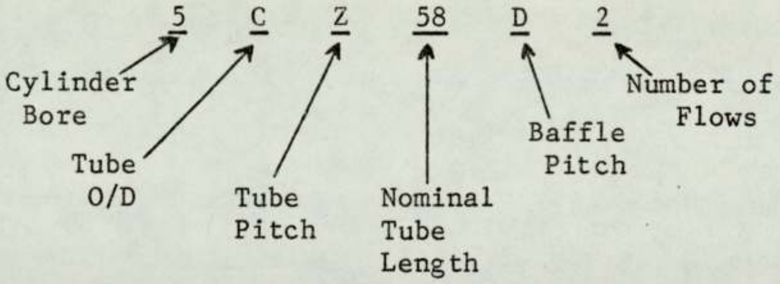
So far the major elements of the ST's job have been described, from finding the relevant part number to establishing the price and delivery date. However, there are a number of ways in which the task is not as straightforward as it may sound. At all stages of the data retrieval process the ST needs to cross check the information being derived to ensure internal consistency. Some 5 - 10% of all serial numbers provided by customers prove to be wrong.

Frequently, the person who sends in the order / enquiry has never seen the cooler in question. When the ST discovers some contradiction (the unit might be described as an oil cooler, but the log books might term it a jacket water cooler) and contacts the customer, it is not always possible for him to ask questions about the cooler and receive instant answers. In these cases he has to ask a question whose answer, when eventually relayed back, will unambiguously resolve the immediate query. This calls for some experience of the product and an appreciation of the significant variations between apparently similar coolers.

Exhibits 4 and 5 describe two of the major aids, the ST has for this process, the Size Designation and Materials Code respectively.

EXHIBIT 4 - SIZE DESIGNATION

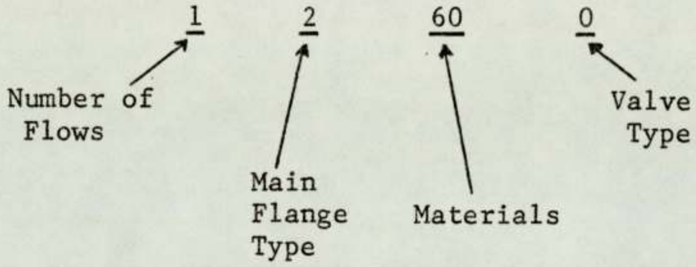
This is a convenient shorthand way of characterising a cooler and takes the form of a nine character alphanumeric sequence employing fixed significance. Although these codes are produced for all SHT products they are only used regularly in ASD by the TCD ST's. A typical code would be:



The cylinder bore is a code for a particular diameter of the cylinder, 5 is equivalent to 12⅝". (They range from 4" to 52"). The tube length is marginally less than the overall length of the cooler, so these two figures give a S.T. an idea of the units overall size.

EXHIBIT 5 - MATERIALS CODE

This is an unfortunate name since only two of the five digits in this code refer to materials. A typical example is:



It is usually, but not always, recorded in the W.O. log book.

Having derived the designation (usually recorded in the W.O. log book) the S.T. can usually find some evidence from the order to demonstrate that he has found the correct data.

The materials code enables the S.T. to further corroborate his work, because he now knows more about the unit referred to by the recorded data. If an alum/brass tubestack is being ordered, but the original was cupro/nickel, then it is worthwhile to check some other point, and ensure the customer is ordering what he really needs.

On certain coolers the expansion end water box will, in fact, fit at both ends, whereas the fixed end box will only fit at one. The experienced S.T. automatically despatches the former, irrespective of the order because he knows that some 5% of customers get confused over the terminology of fixed and expansion ends.

In other cases there may be a short term expedient spare that can be sent out to tide a customer over until the 'real' component can be made. Since some of the S.T's have been 30 years in the company they know that certain customers always have a particular type of cooler, one S.T. even has a private list of components that can be used on other coolers at a pinch.

The important point resulting from this analysis is that the S.T's bring to their job an understanding and critical faculty that enables them to detect inconsistencies in the data due to mistakes by the customer, the data recorders or themselves. There will continue to be a small incidence of customers ringing up who cannot identify their cooler except by description and approximate age. The S.T's treat such occurrences as opportunities to demonstrate their detective skills and can rapidly narrow a search down to just a few possibilities. Any data retrieval system which eliminates the opportunity for the S.T's to exert their job knowledge will prove inadequate because the scope for error in the complete process is considerable, and it is only the redundant additional informationwhich enables the S.T's to check up on themselves.

VIII.12 Examples of the S.T's job

The section details six examples of data retrievalwhich actually took place during this investigation phase. They range from the straightforward to the complex and illustrate the practical blend of all the elements, including job knowledge,which the S.T. has to possess to discharge his duties.

Example 1 - A standard T.C.D. enquiry

The customer telephoned in an enquiry, quoting a 1967 Serial Number, which the S.T. promptly looked up in the appropriate serial number log book. This gave a Works Order number and an examination of the Works Order revealed no list of major parts, only an old G.A. number.

The S.T. checked to see if this number had been converted to a Brisch one from the conversion books. It had been converted and he was able to extract the relevant P.P.L. which gave him the list of new part numbers, including that for the desired spare, the tubestack.

He then ran a check on this number as follows. From the conversion books he found the old equivalent to the tubestack's Brisch number. Since he had been with S.H.T. for many years he recognised this old number as being a standard one, so he consulted a list drawn up in 1971 of old standard numbers to corresponding Brisch ones. The number thus derived was the same as the first tubestack number found, indicating that there had been no design modification in between times.

As this was not a rushed job the price and delivery time were found from the standard listings and he telexed this information back to the client.

Total time from receipt of phone-call to quotation was 6½ minutes, composed of walking around the large office and thumbing through log books and listings.

Example 2 - A non-standard T.C.D. enquiry

The customer telexed in an enquiry quoting a 1954 serial number. A search through the log books revealed the Works Order which quoted the G.A. and also the number of the desired spare, a fixed end water box. This latter number was in the compound MZ series, so the S.T. fetched prints of the G.A. and part drawing from the stores and passed these to C & C who were able to issue him with a Brisch number within the hour. The drawings and estimate request form were sent off to the Estimators via the internal post. They passed it on to the Production Control department subsequently and the results were returned to the S.T. the next morning.

The S.T. then telexed the price and delivery date to the customer, 22 hours after receiving the initial enquiry.

Example 3 - A difficult A.C.D. enquiry

The A.C.D. S.T. received a letter in which the cooler was identified as being a Series 7 unit with sweated-on headers in gun metal. Since there are many thousands of Series 7 G.A's, the value of the Brisch system becomes apparent as C & C were able to produce a complete set of 54 coolers that met the above specifications.

The S.T. rang the customer and entered into a protracted question and answer session that eliminated all but one of the possibilities.

The relevant P.P.L. was extracted which gave the Brisch number of the required spare. Being standard, price and delivery were taken from the listings.

The letter arrived on a Tuesday morning, was dealt with on Wednesday morning, C & C had the list of 50 possibilities by Thursday morning and the quotation was telexed Thursday afternoon.

Example 4 - A.C.D.

A forced air cooler in Botswana needed a new fan 36" in diameter. The fan manufacturers only make metric fans now, so a 1 metre fan would have to be bought and a new fan plate designed and built.

The S.T. had realised this within 30 minutes of first considering the enquiry and consulting the log books, so sought from the A.C.D. drawing office a date when the new fan plate could be designed, and from the production area the manufacturing lead time. This information was sent to the customer by letter 3 days after receiving the enquiry, the delay being composed of ½ day waiting on the drawing office, 1½ days on the production control department, and ½ day waiting for the letter to be typed.

Example 5 - T.C.D.

A marine engine builder rang for an urgent replacement tubestack, but he could only identify the unit by the engine's design number. T.C.D. maintainsfiles of these numbers, so the S.T. hunted out the relevant paperwork referring to the original design process. This quoted an estimate number, which in turn gave the old G.A. number.

The S.T. looked this up in the conversion books and found the new Brisch number. He then rang the Estimator and Production Control to explain it was urgent, could he have the quotes rapidly, and how quickly could it be manufactured? This was at 10:30 in the morning. After lunch the Estimator rang back with the cost, but the Production Control department were busy with some end-of-month problems. The customer rang back twice during the afternoon, but it was not until mid-morning the next day that a delivery date was supplied. The S.T. rang the customer straight off with the information, but the delivery time of 3 - 5 weeks was far too long and the customer chose not to place an order.

Example 6 - T.C.D.

As will be described later, an analysis of orders was carried out to determine an appropriate level of stock-holding. During this work it was found that, during the previous month, one of the T.C.D. S.T's had made out a works order for a part numbered 36157-1052 and the other S.T. had made out an order for 36157-1051.

Under the Brisch numbering system these two parts are essentially identical, so why was one preferred to the other in each case?

These numbers refer to end covers, which are flat, circular gunmetal pieces which bolt on to the ends of a cooler. The only difference lies in the drilling of the bosses, the raised cylindrical lumps on the external face. On the blank casting from which both parts are made there are three bosses in line across the plate. These bosses are drilled and plugged so as to enable the cooler to be drained by removing the plug. If the cooler is mounted vertically then only the central boss needs to be drilled. But if the cooler is mounted horizontally then the two outer ones need to be drilled.

There is a rational alternative 36157-1056, which has all three bosses ready drilled and comes supplied with three plugs. This can readily be configured to suit either installation.

The production lead time on the rational part is one week, but on the two covers actually sold is three weeks.

VIII.13 Restatement of the Project

A.S.D. management initially stated that the retrieval of structural information about the coolers was the key to rapid identification and quotation.

The analysis of the Sales Technician's job has revealed that this is not so.

The incidence of cases where retrieval of structural data causes significant delay is low. They arise when the parts in question are non-standard, have been changed, or when the unit is very old. To establish a computer based retrieval system covering these instances would require a vast amount of work to be done in converting old part numbers to the Brisch system and in identifying which parts have been subject to a design change. Since the majority of this work is unlikely ever to be needed, the exercise is unjustified.

The real information requirements of the Sales Technician are;

- structural data
- price
- delivery time

The design for the business system should be directed toward providing the Sales Technician with these 3 categories of information for modern standard coolers. Once this is achieved extensions can be considered to the non-standard and the older products.

EXHIBIT 6 is a succinct statement of this requirement.

EXHIBIT 6 - SYSTEM REQUIREMENTS

In order to supply customers with quotations and make out works orders the Sales Technicians need to establish three main items of information.

1. The Brisch part number of the item required as a spare.
2. A price for this part.
3. A delivery lead time for this part.

Standard components constitute around 60% of all those dealt with by the Sales Technicians and the above information is currently stored in lists around the office so that it can be found within several minutes. Whilst this is no problem for the S.T. it is still too long for the majority of customers to wait on the telephone.

The main requirement is a system whichwill enable the Sales Technician to access these three categories of information within 1 - 2 minutes.

The second requirement is to identify the part number of a non-standard item whilst the customer is on the telephone. Extra information must be presented to the Sales Technician to enable him to check that the customer has correctly identified the heat exchanger. The incidence of wrong spares being despatched will be reduced.

Non standard parts have price and delivery lead time estimated by the relevant manufacturing division.

VIII.14 Age Distribution of Coolers Dealt with by A.S.D.

A further important statistic to derive is the age distribution of coolers with which A.S.D. is concerned. The S.T.s had mentioned that occasionally they had supplied spares to coolers originally sold in the 1920's and 1930's. If every week there were ten such enquiries then the data retrieval system should go back that far. Alternatively if 95% of all coolers dealt with are those built since 1960, there is little need to go back any further when setting up the data bank.

Three sources of information on this were used as described in Exhibit 7 . The conclusion is 75% of current orders and enquiries would be dealt with by a system going back only 12 years.

EXHIBIT 7 - AGE DISTRIBUTION ANALYSES

ANALYSIS 1 When A.S.D. was being originally discussed the S.H.T. marketing department produced an estimate of the life of the company's products. This is given in Fig. 8.11 and indicates that the 'half-life' is 12 years.

The distribution can be multiplied by the annual production total for the period to generate Fig. 8.12 which gives the value of coolers still in service. Unfortunately, the means by which value was incorporated is not made explicit in the report and a more useful measure might be the number of coolers estimated as still in use.

ANALYSIS 2 This was produced by A.S.D. Sales Manager in 1972 when first taking up a job in the spares/repairs department. He analysed all the units returned for repair during a year into the three categories of A.C.D. products, the 710 and 720 product groups for T.C.D. and generated the block graphs of Fig. 8.13, 8.14 and 8.15 respectively. These show the original production figures and the hope was to identify any correlation between the quantity returned for repair and the number 'in the field' for any year.

The sample is small and the attempted visual correlation with the original production figures is inconclusive. But the results are that 75% of all coolers returned for repair are less than 6 years old for A.C.D., 9 years old for 720 and 12 years old for 710's.

ANALYSIS 3 The orders and enquiries for November and December were analysed and an age listing for all 710 coolers mentioned was produced, a total of 60.

EXHIBIT 7 Cont'd....

Fig. 8.16 shows the cumulative age distribution curve for this sample.
The conclusion which may be drawn is that in the worst case of the long lived 710 product group, 75% of demand is for coolers less than 12 years old.
If a data retrieval system were established in 1978 for 12 years of history, then the following table shows how its use would increase annually.

YEAR	% of ORDERS/ENQUIRIES COVERED BY SYSTEM
1978	75
1979	78
1980	80
1981	83
1982	85

ESTIMATED PERCENTAGE OF EQUIPMENT STILL IN SERVICE AFTER BEING SOLD BY SERCK HEAT TRANSFER DURING THE LAST FIFTY YEARS

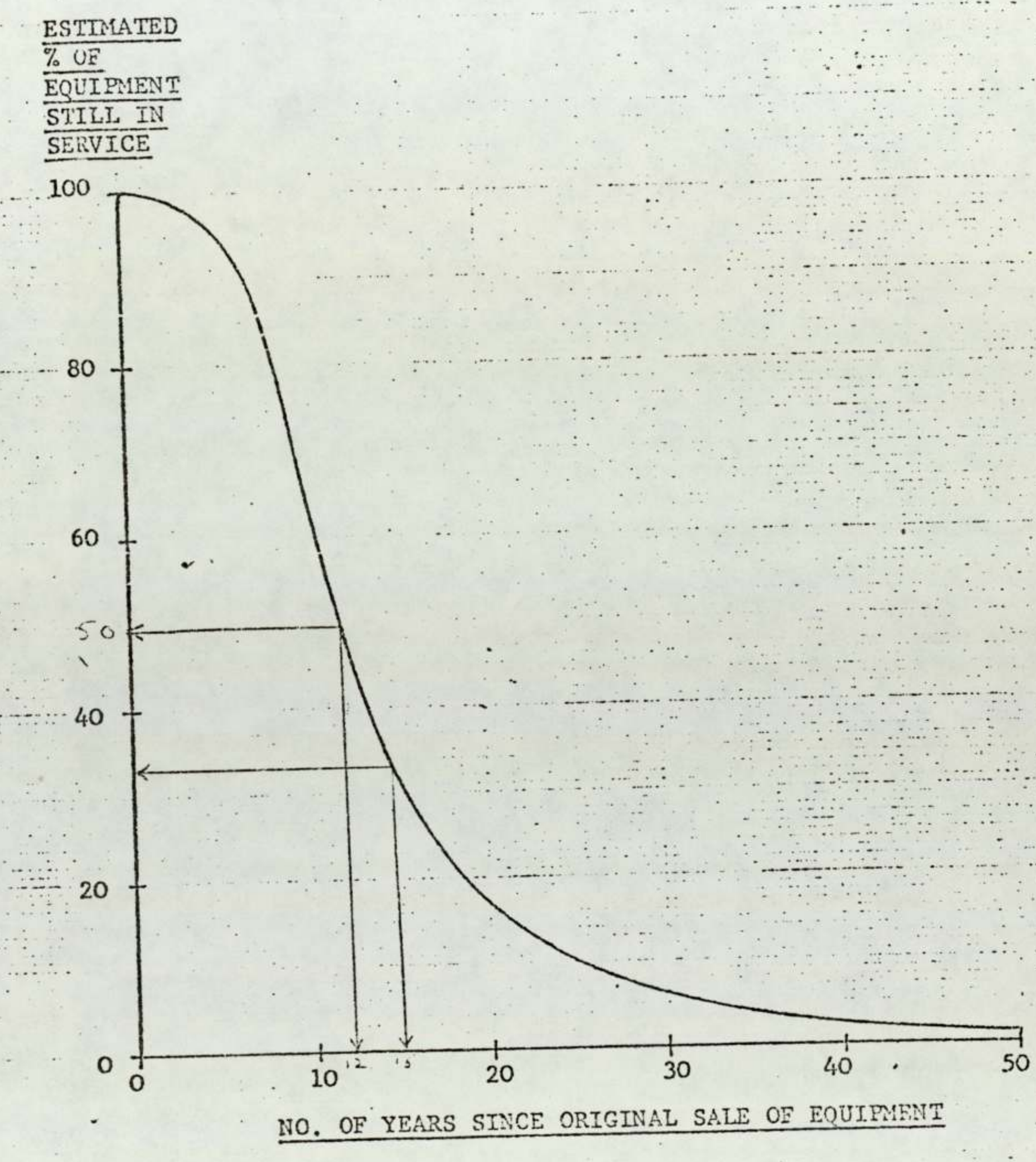
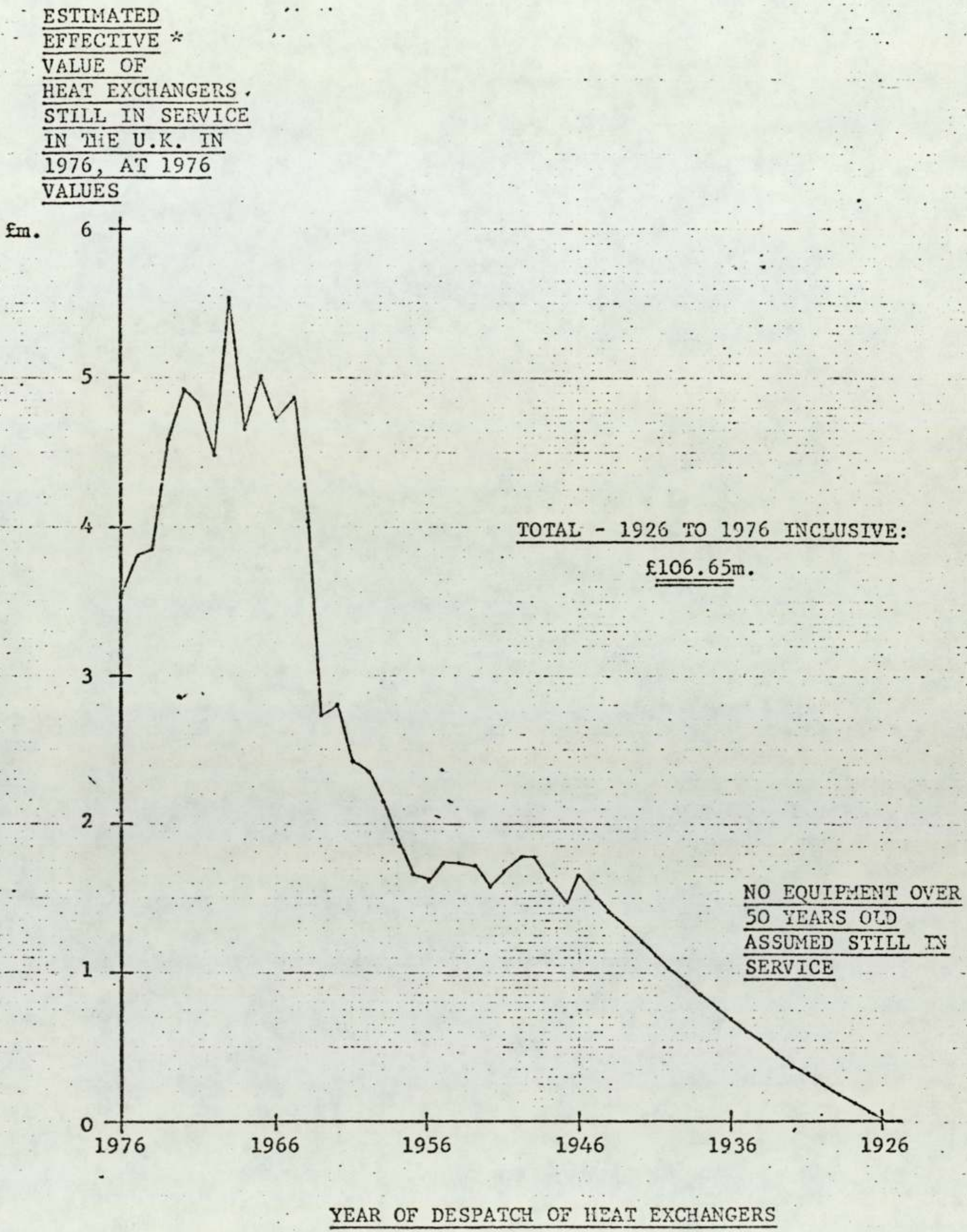


FIG 8.11

VALUE OF SERCK HEAT TRANSFER
HEAT EXCHANGERS STILL IN SERVICE



*The "effective" value is the real value inflated in the case of products sold more than 25 years ago to allow for the higher prices charged by After Sales Divn. for spares for these older products.

FIG 8.12

RETURNS ANALYSIS 1971 : AIR COOLING DIVISION.

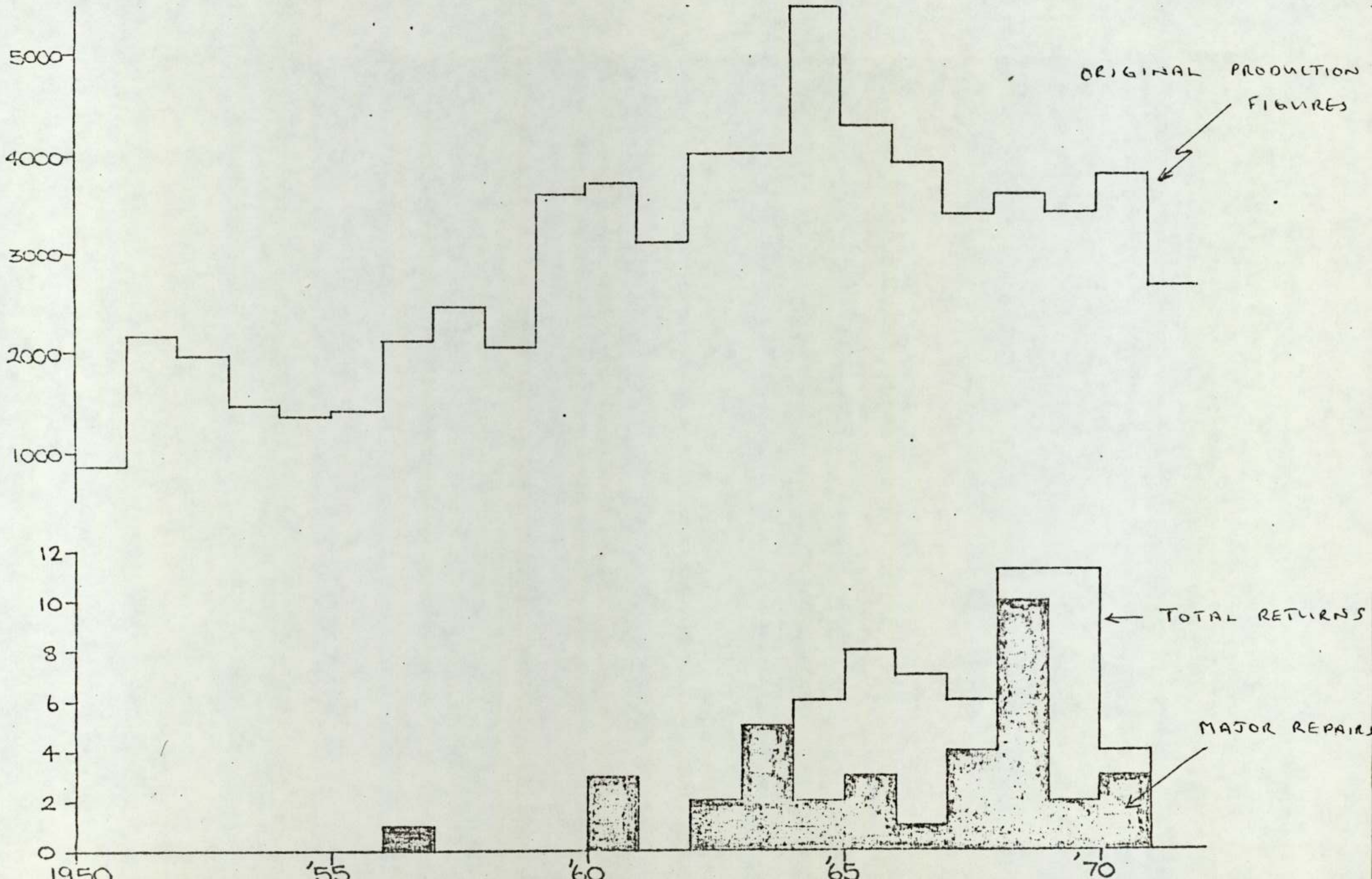


FIG 8.13

RETURNS ANALYSIS 1971 : 720 COOLERS.

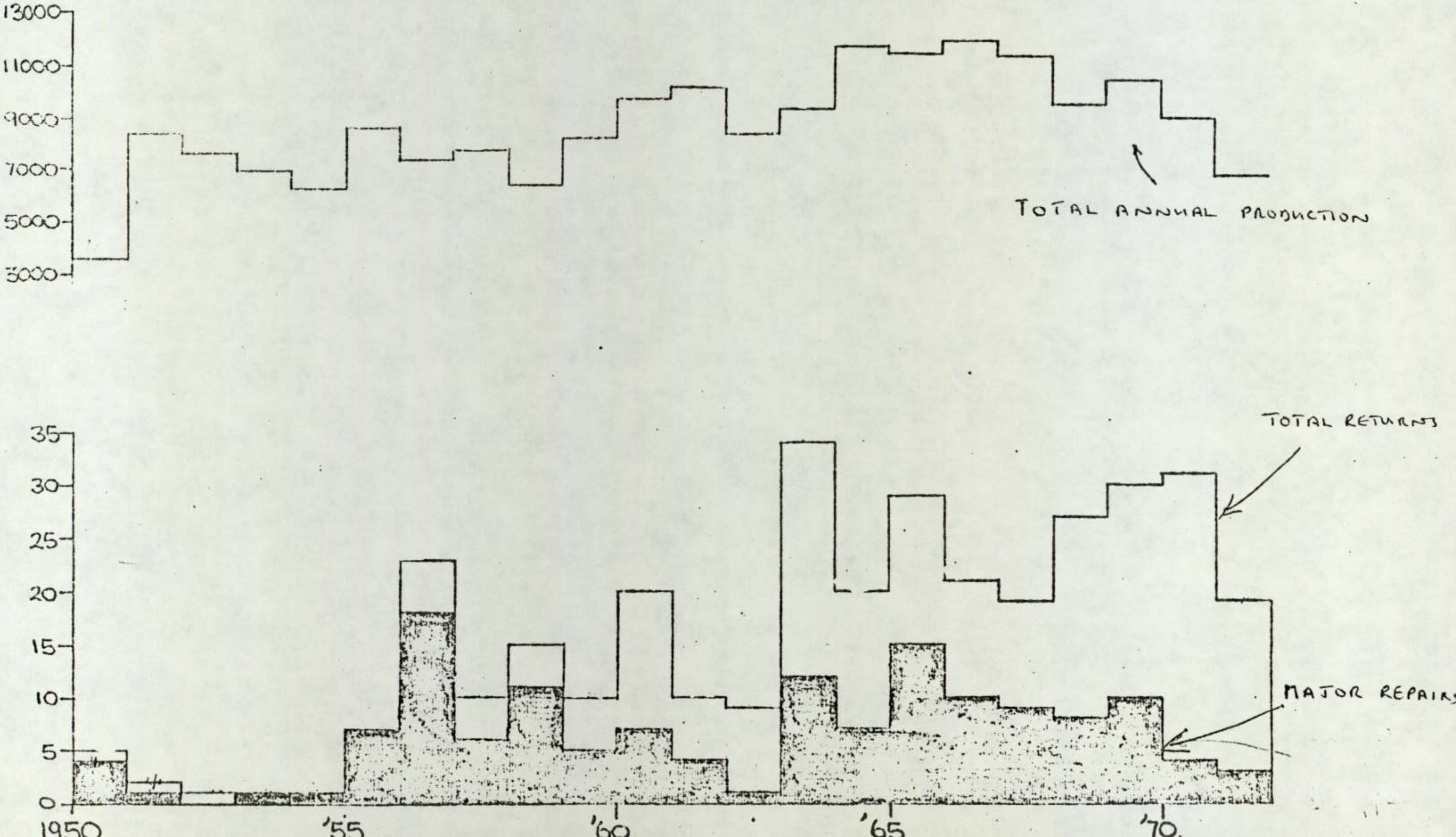


FIG 8.14

RETURNS ANALYSIS 1971 : 710 COOLERS.

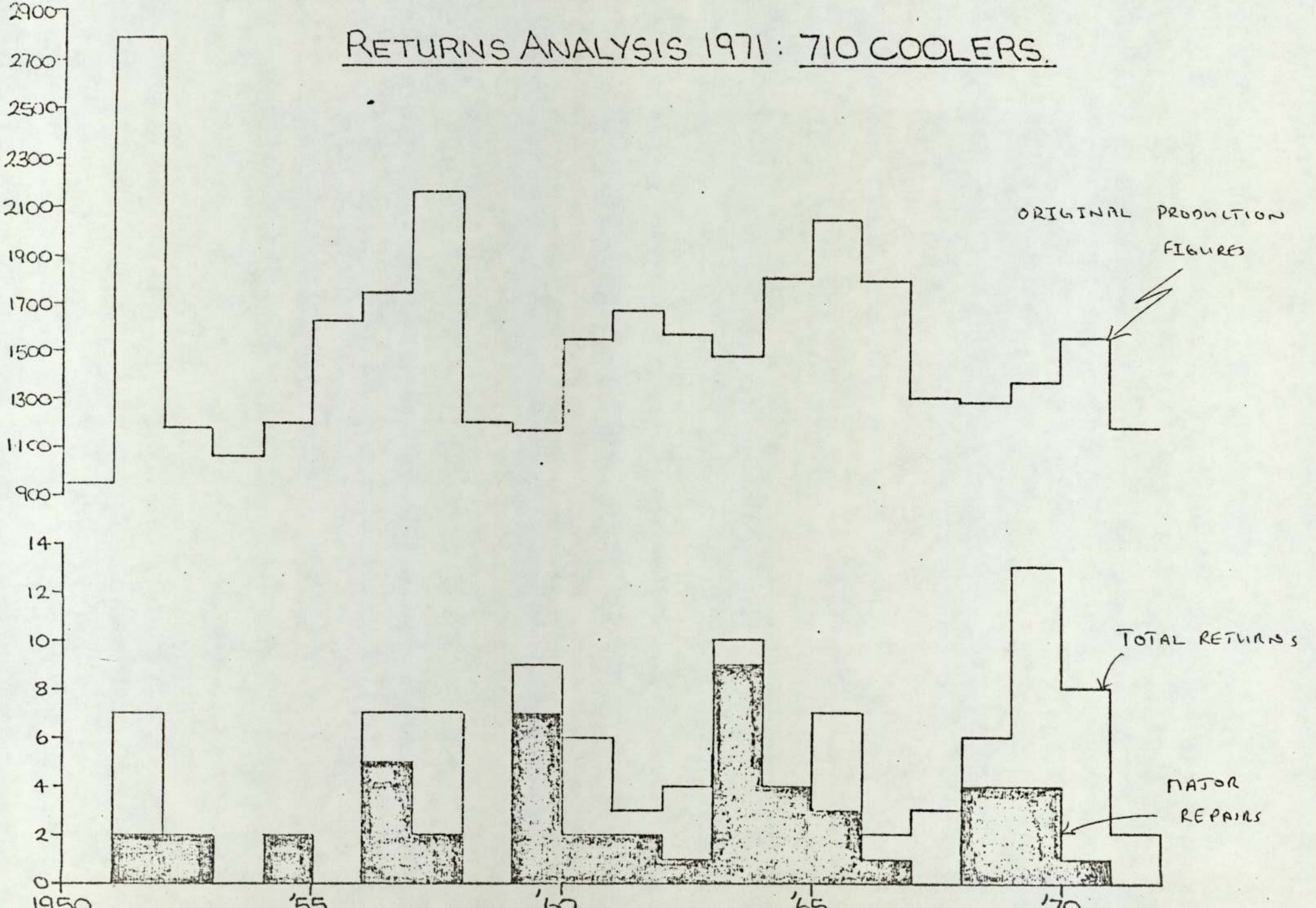
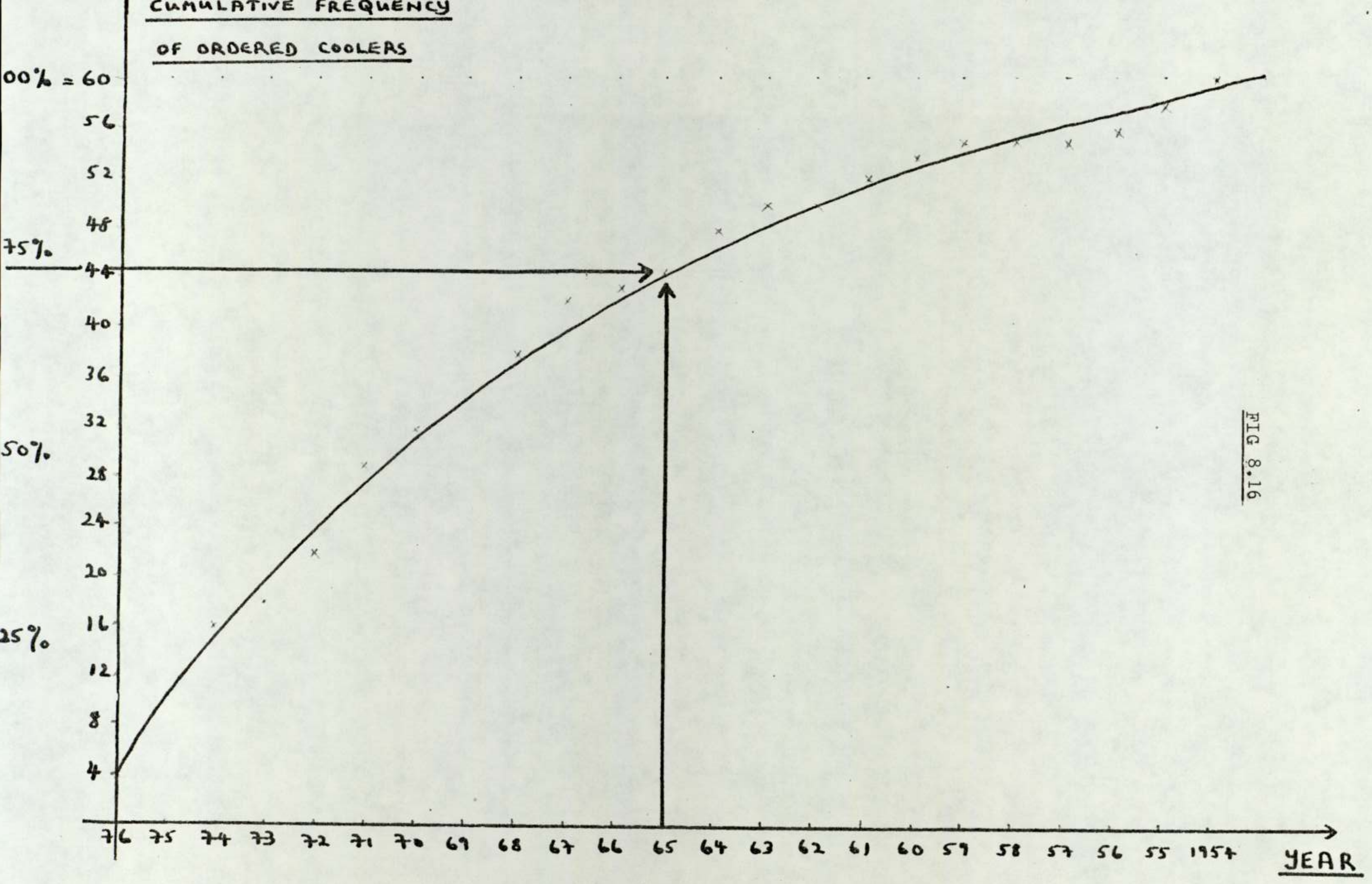


FIG 8.15

FIG 8.16


CUMULATIVE FREQUENCY
OF ORDERED COOLERS
00% = 60
56
52
48
75%
44
40
36
32
50%
28
24
20
16
25%
12
8
4
76
75
74
73
72
71
70
69
68
67
66
65
64
63
62
61
60
59
58
57
56
55
1954
YEAR

VIII.15 Wider Aspects of A.S.D.

During early 1977, as the analysis was being concluded, the Service Director stated publically for the first time his intention to move A.S.D. away from the main S.H.T. site and significantly change the nature of its links with the remainder of the company.

This fact was important to the design of the proposed retrieval system because the work done to date had presumed A.S.D's remaining within its existing environment, namely on the S.H.T. site with its central resources and the manufacturing division close at hand. If these circumstances were to alter, then the methods of supplying information to the data retrieval system would change. The next stage of the project, see Fig 8.1, is the Business System Design, during which the sources of the desired information and the procedures for deriving it will be considered.

Although the system requirement does not change, the mechanism supporting it does.

The reason behind the Service Director's wanting to move was the severe difficulty which the Spares S.T's were encountering with the production control departments of the manufacturing divisions and the damage that this caused to A.S.D's desired image of prompt service.

Briefly, the problem was this; the manufacturing divisions' primary objective was to manufacture and sell heat exchangers in the most efficient manner possible.

Intrinsic in this was the need to minimise the amount of machine setting-up by ensuring that production runs were as long as possible. One means of achieving this is to collect like jobs across works orders and do all the machining in a single run. This requires that the division maintains control over, and some flexibility in, its production schedule. A well organised schedule is like a house of cards in that it is finely balanced and has taken considerable effort to organise. (See Chapter IV)

Unfortunately for the manufacturing divisions, A.S.D's requirements were equivalent to wanting rapid delivery of a card from the base of the house. Spares orders are low volume, usually for 1-offs, and are invariably required extremely quickly. Since all A.S.D's work was done by the manufacturing divisions the Production Controllers found themselves being squeezed between two opposing requirements. On one hand A.S.D. were screaming for a fast delivery and immediate quotation, on the other the operational management of the divisions wanted to optimise divisional efficiency. To satisfy one party was to antagonise the other and to compromise was to satisfy neither.

This was the main reason for the Service Director wanting to move

A.S.D But if this change came about, further benefits might accrue to A.S.D. in the wake of the changed links with the manufacturing divisions. The first of these was that of deciding who took the profit on spares sales. At that time A.S.D. was selling a spare costing, say £500 to make, for between £1000 and £1500 depending upon the urgency with which delivery was requested. However it was not in A.S.D's interest to charge the highest price because the profit gained went to the manufacturing division. Now, if A.S.D moved from the site and set up a stock of commonly ordered parts, this could be replenished by means of regular orders on the divisions. But A.S.D. could take the profit on sales, besides increasing the level of service through having items immediately to hand.

The second proposal was that A.S.D. set up its own limited machining facility. There are many instances where a single raw casting could be machined in any of several different ways to produce different part numbers. If A.S.D. were to carry a stock of the raw castings and support a machining facility, it would be equivalent to a much larger stockholding of the machined parts.

Not surprisingly, the immediate reaction of the manufacturing division was to oppose each of these proposals. The Engineering Union also decided against the ideas on the grounds that if the small A.S.D. staff were working overtime on the machining jobs which 'belonged' to the staff of the manufacturing division who were on standard hours working, then that was not acceptable.

Thus the immediate impact of the Service Director's announcement was to introduce an extra dimension into the design of the Business System. However the announcement constituted neither concensus amongst the divisions, nor a declaration of action. This matter became the subject of extensive discussion amongst the senior management, but no firm decisions were taken for nearly 12 months. During this protracted period of uncertainty morale amongst the Staff of A.S.D. declined considerably due entirely to the complete absence of assurance about the future. This climate was not conducive to active discussion or the proposed retrieval system.

CHAPTER IX Business System Design and The System Model

SUMMARY

This Chapter summarises the major features resulting from the analysis, the reasons for and detailed description of the computer model which was developed to demonstrate the suggested business system design. It concludes with a discussion of the reactions of both the Sales Technicians and the management to the demonstration.

SECTIONS

IX.1 Summary of Results from Analysis

The requirement is to provide the S.T. with information on structure, price and delivery time to enable enquiries to be answered directly, with the S.T. not having to leave his desk.

It has been shown that nearly 95% of all the orders and enquiries are initially identified by either:

- serial number
- G.A. number
- part number

and that it is precisely these that are most easily accommodated in a retrieval system. The remainder would require a vast amount of work to be done in rendering them compatible with any retrieval system. Such work is unjustified since a large proportion of it would not be used.

A.S.D. is bound to the manufacturing divisions which implies that the Brisch numbering system has to be complied with and imposes certain disciplines upon the work of the S.T's.

To be optimally effective the S.T's need to be given the redundant information, such as size designation and materials code which enables them to cross-check the accuracy of both the retrieved data and the customer's initial identification of his unit.

Three completely separate categories of data can be identified from the point of view of compiling the data-base of the retrieval system. These are the data recorded for

- future production
- those coolers built between 1971 & 1976
- those coolers built prior to 1971

Future Production With this category, a system can be established to record whatever data is felt necessary for the purposes of A.S.D. It is possible to set up routines to derive and store any information direct from the manufacturing process.

1971-1976 This category was constructed under the Brisch system and means the only conversion that is necessary to render it compatible with current operations is rationalisation and updating to cover design improvement.

However, there is one notable constraint; the only data available to the database are what is already recorded around the site. It is not justified to compile any new information since the bulk will not be used. Thus the task in compilation is one of transcribing the data from its present physical form to a medium that can be accessed through the computer. Obviously, any mistakes in this process will corrupt the database and the resultant work of the S.T's.

Fig. 8.16 shows the rate at which such data would be accessed. If available in 1978 it would cover some 50% of all enquiries and orders and this number would increase each year in line with Fig. 8.16.

Prior to 1971 The final category, those made before 1971, will overlap the 2nd category to an unknown extent. This overlap is created by repeat orders for new units or spares enquiries that have prompted the part number conversion process. Alternatively, the old number could have been a member of the initial sample of 50,000 originally converted by C & C. It has been demonstrated that the incidence of the old numbers is low enough to render any further large scale conversion unnecessary, particularly since the significance of this category will diminish with time in accordance with Fig. 8.16.

The priority in bringing these categories of heat exchanger into any retrieval system should be reversed-chronology. The future production should be catered for initially. When that works adequately the 1971-1976 units should be compiled. If that mammoth exercise is ever completed, it may then be decided whether there is any point continuing further back. Fig. 8.16 suggests that such a move would be highly unlikely.

IX.2 Alternatives in the Business System Design

The data recorded to support the structure retrieval system do not permit significant alternatives. Details of serial numbers, customers, G.A's and parts lists will be recorded by the manufacturing divisions as new coolers are built and accessed by the retrieval system.

The historical data will be reviewed and assessed, (see Chapter X) but can be compiled into a suitable form for the use of the retrieval system. Provided that enough 'redundant' data is included to enable the S.T. to continue with his continual checking and cross-referencing, the task of the S.T. will remain much as before, but easier.

It is the matter of ascertaining a delivery lead time that gives rise to a range of alternatives. As of early 1977 the S.T's quoted deliveries of 2 - 4 weeks (at best) on standard items supplied by the manufacturing divisions. Urgent and non-standard items would have their delivery lead time arranged by the S.T. personally contacting the appropriate Production Control department. The data retrieval system could, trivially, duplicate this feature for the non-urgent standard heat exchangers, but could not in any way interfere in the personal contact part for urgent and non-standard items.

As described in Chapter VIII Section 15, the possibility of A.S.D.

moving away from the main S.H.T. site and supplying from stock was being discussed. This would reduce the lead time on standard items from weeks to ex-stock at the cost of holding the stock.

If, as the A.S.D. management were confident, this came about, the S.T. would need to interrogate the stock listing once he had established which spare to provide.

But the question to be resolved before any computer system design could be started was, what information could or should be derived to support the S.T. in instances where the stock has expired?

Alternative 1 The retrieval system will deal exclusively with standard enquiries for standard items, at least to begin with. If A.S.D. is to maintain a stock of commonly ordered items, a stock recording routine can be implemented to support the on-line interrogation demanded by the S.T. A straightforward system which simply quotes the stock quantity will be inadequate because instances will arise when more than one S.T. 'sell' the same physical spare. It is necessary to have some system for allocating items to orders, as the orders are taken. This is the simplest system and is included in the following alternatives.

Alternative 2 A.S.D. would submit regular orders to the manufacturing divisions to replenish the stock held. These orders would be prompted probably by a minimum re-order level determined by usage. But there will be occasions when, due to the fluctuating demand, all the stock physically present will be allocated and the replenishment order has not yet been fulfilled. To quote a lead time on delivery to the customer, the S.T. will need to know the due date of the replenishment order on the manufacturing division. This implies that in addition to the stock recording system of the previous alternative, an order monitoring facility is necessary to input data to the retrieval system.

Alternative 3 It was also being discussed whether or not A.S.D. would establish its own machining and limited production facility. If this was to happen there would be two possibilities for the input of information to the retrieval system. The first of these involves the machining of a single raw casting into any one of a number of finished items. The idea would be to hold the unmachined part in stock thereby effectively enlarging the range of stock items held but at minimum cost. To use this facility effectively the S.T.s need to know what the machining possibilities are and then whether the suitable raw components are in stock. This would require a list of alternatives to be compiled and maintained in a means compatible with the retrieval system.

The second possibility regards the ascertainment of a delivery lead time on such items. If the S.T. is being pressed for an urgent delivery and establishes that a suitable raw casting, say, is in stock and needs to be machined prior to dispatch to the customer, he needs to know when the casting can be ready. A.S.D's internal production control could answer the question, in principle, but if some form of machine loading or capacity planning is used, this could act as an input to the retrieval system. As the machine shop accepts 'orders' for work, the load on each machine is increased appropriately. Provided there is no queue jumping, the S.T. could look at the length of this queue and quote a lead time to the customer. If accepted the S.T. can reserve the capacity to meet that delivery date.

Such a facility is in line with the stated objective of the retrieval system, to provide answers to enquiries and orders as quickly as possible.

Alternative 4 What will be the link between the A.S.D. S.T's and the manufacturing divisions? The retrieval system is set up to cater for standard parts, identified in a standard manner. This should deal with 38% of orders/enquiries to begin with.

> [the customer quotes a Serial Number, G.A. or part number in 95% of order and enquiries. The stock analysis (see Ch.X, Section 3) suggests that 40% of all orders can be fulfilled from the initial stock holding.
>
> 95% x 40% = 38% of all orders/enquiries]

This leaves 62% which the S.T. has to refer to the manufacturing division.

Either the S.T's can issue works orders into the divisions as now, or A.S.D. can act as just another external customer to the division. In each case the S.T. will need some contact with the production control department to establish delivery lead times.

IX.3 Reasons for Building a Model

Before any business system specification can be agreed and the detailed design of the computer system started, it is crucial to ensure that all the parties involved in using the final system have had the opportunity to thoroughly discuss and influence the final shape of the specification. A computer model of the system provides an ideal focus for this discussion.

Developing a model will provide valuable experience of on-line computer working which did not exist in the company in 1977.

Although A.S.D's management was still enthusiastic about the project, the manufacturing divisions were not enthusiastic about A.S.D. The proposed retrieval system would have an impact on the manufacturing divisions and in the early summer of 1977 it was felt by A.S.D. management not to be a politically sound move to discuss these matters overtly yet. Developing a model would fill the time until it was appropriate to involve the manufacturing divisions.

Implicit in this was the need to have a better understanding of the consequences of the retrieval system prior to the discussion phase.

If the model is an accurate representation of the proposed system then the S.T's can comment upon the detailed information content and its means of presentation. Further, the model will highlight the need for several decisions that would need to be taken by A.S.D. management before the detailed design can commence.

For these reasons the development of a computer based model has significant advantages over the alternative approach of trying to get a specification agreed on paper.

IX.4 Technical aspects of the Model

The two main considerations in designing the model were:-

- that it should appear to the user just as the real system would
- it should be straightforward to program.

These implied that the structure of the model was less important than the way it looked and hence the technical task of writing the programs could be simplified.

The Management Services Department had recently purchased a V.D.U.

and the question as to which programming language to employ was being examined. Although no decisions had yet been made, the Manager of M.S. suggested that the system model make use of the recently introduced I.C.L. language, Applications Manager. S.H.T. used I.C.L. equipment predominantly and strong links had been established between the two companies. Thus it should be possible to borrow the software long enough to at least demonstrate the model, even if S.H.T. did not subsequently buy it. There was the further advantage that if an unskilled programmer such as the researcher could use the language successfully, then that augured well for the remainder of the department's staff being able to quickly become conversant with it.

The starting point was to design the screen layout and information content required by the S.T's. The standard video screen layout sheets could be used, see Fig. 9.1.. It is important to ensure that no item of data could be longer than the field allocated for it on the screen. Three screens were seen to be adequate for the job and this implied using three individual data files. It is easier in Applications Management to write a program to access a single file than it is to access multiple files. Thus each screen could be the result of a single file access.

The three files implied the use of six programs, one to create and one to interrogate for each of the files. These programs were labelled PSON, PSTW, PSTH, PSFO, PSFI and PSSI where PS stands for Parameter Set, ON for ONE, TW for TWO and so on up to SI for six.

For each program in the suite a logic planning sheet as per Exhibit 1 was produced from which the Parameter Sets could be written.

The actual programs and details of their operation are given in Appendix : PSON, PSTW and PSTH are the interrogation programs for the Customer, Structure and Supply files respectively. PSFO, PSFI, and PSSI are the creation and maintenance programs.

The maintenance routines worked as follows. When a program was called an initial screen was displayed into which the user enters the appropriate data to be added to the file. On completion the "SEND" key was pressed, the data was written to the file and overwrites any record stored under the same key. To ensure that this process was correctly performed, the program then read the record it had just written and displayed it back on the screen of the V.D.U. This enabled the operator to check that the data had been stored correctly.

Several problems were encountered in trying to make the equipment perform as intended because it was the first occasion S.H.T. had used remote terminals. The checking facility built into the maintenance routine proved useful in showing up some of the file addressing faults.

However, these were overcome and in August of 1977 the model was successfully demonstrated. The only technical problem which

APPLICATIONS MANAGER - LOGIC PLANNING SHEET

for parameter set PSFI

LEVEL 1 LEVEL KEY 0

MAJOR CONDITION		ACTION	MINOR CONDITION	
FIRST TIME	Z1	Output clear screen and initial screen.		
		Transfer 0 to line counter		
NOT FIRST TIME	Z2	Input record F1:1 from disc. Overlay with screen data Input from disc record F1:1.		
		Output clear screen and error messages.	Record Missing	Z3
NOT FIRST TIME AND RECORD FOUND.	Z5	Transfer initial value of cursor position to P3 and output "Read from disc" statement.	1st time round loop	Z6
		Output cursor position and first field.	Loop counter not equal to 12	Z7
		Calculate new value of P3		Z7
		Output cursor position and second field.		Z7
		Calculate new value of P3		Z7
		Add one to line counter.		Z7
FIRST TIME	Z1	Set not first indicator.		

EXHIBIT 1

remained was that of response time. The computer was being used for its day to day batch processing work in addition to the on-line working and frequently the delay in servicing calls from the terminal was as much as 20 seconds. This was composed of a short time, at most two seconds, to actually retrieve and display the data and a longer time queuing for enough of the computer to become free to enable the on-line programs to run. This time is independent of the amount of data being stored in the on-line database, but indicates that consideration would have to be given to the hardware necessary to support the data retrieval system.

IX.5 The Appearance of the Model to the User

In the interests of simplicity the programs in the suite were not connected, so at the end of one program, the next one had to be called up. Data could not be transferred or 'chained' between programs, which called for a pen and paper to be used to jot down notes at suitable points in the procedure.

A typical retrieval would begin with the customer quoting a serial number. The operator calls up the serial number routine and the screen of the terminal shows Fig. 9.1. This requests the operator to type in a serial number and press the "SEND" key. The program then reads the entry on the customer file against that serial number and returns the screen shown in Fig. 9.2.

If the record is not found, the error screen of Fig. 9.3 is returned which requests a further serial number to be entered.

The purpose of the screen in Fig. 9.2 is primarily to quote the G.A. number of the cooler for which the serial number has been quoted, but secondarily to provide the S.T. with further information which can be used to corroborate the serial number:-

- is the current customer the original owner of the cooler, or is it likely he could have become so?
- does the date of supply match up with the serial number quoted and the estimated age of the cooler?
- do the application code, size designation and description tie in with the customer's description of the application?
- is the designation consistent with the customer's description of the cooler?

If all these points are in order the S.T. can be confident that the customer's cooler is the one referred to by the returned data. If not then some further work needs to be done in checking the serial number's validity.

In the event of the data appearing consistent, the S.T. notes down the G.A. number and calls up the program to interrogate the structure file. This returns Fig. 9.4 into which the G.A. number is entered.

If the customer has quoted a G.A. directly, the S.T. can jump straight to this routine.

On pressing the "SEND" key the screen as in Fig. 9.5 is displayed. This is a list of the descriptions and quantities of the significant part numbers at the first level of breakdown. By entering the part number of, say, the tubestack into the field at the base of this screen, a breakdown of the tubestack into its components is returned, and so on, until the S.T. has the part number in which he is interested.

This number is noted and the third program called up which returns Fig. 9.7. The part number is entered, "SEND" pressed and Fig. 9.8 is returned.

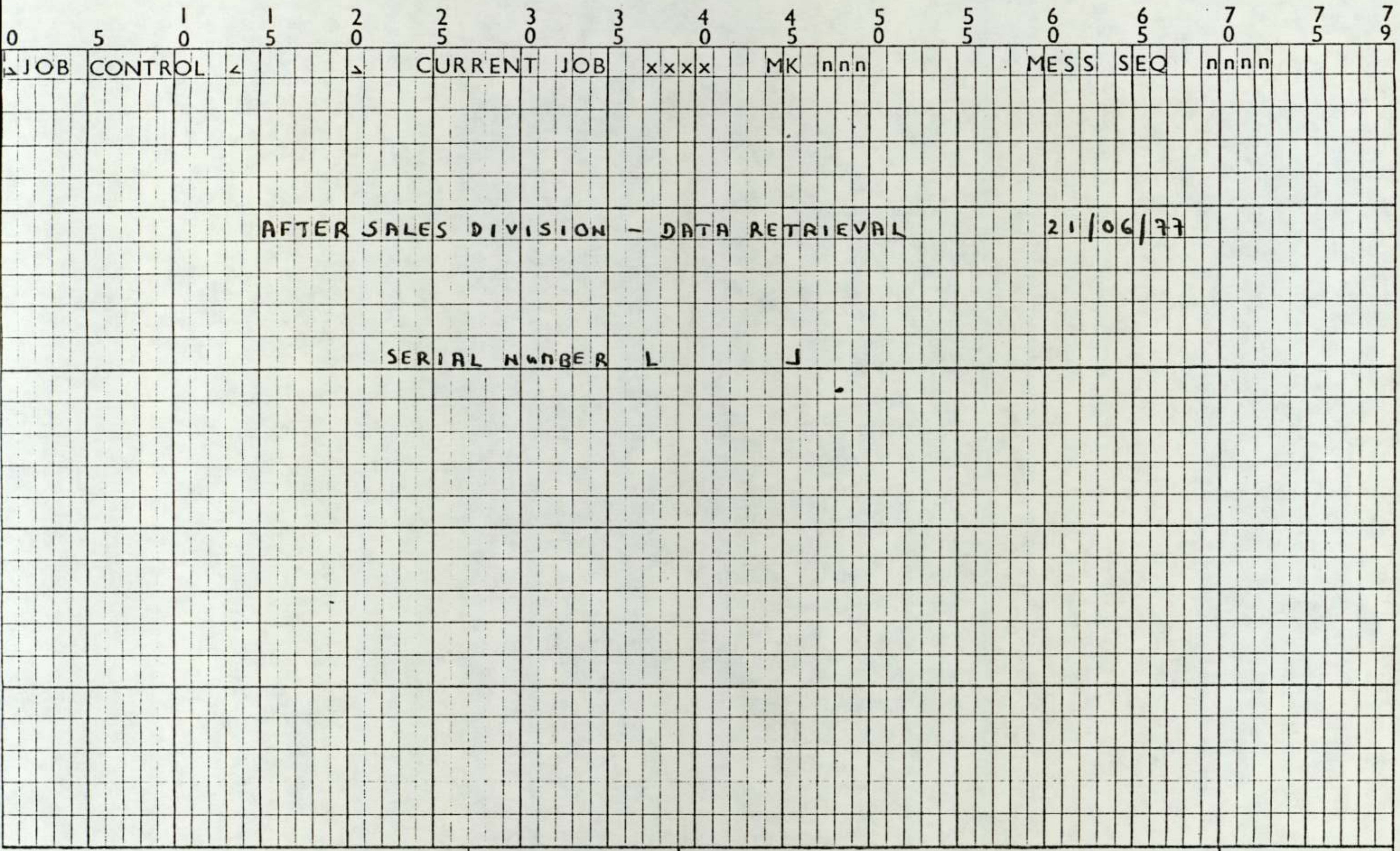
The selling prices for that part number are given in the bottom left hand corner. Five categories of customer are defined by the Sales Manager and for each a separate price is appropriate. This price reflects the amount of business the customer does with S.H.T. and the level of service he has received. A.S.D's policy is to extract as high a price for a spare as is possible and this feature of quoting prices for each category is a first step toward fulfilling this policy.

In fact the data actually held on the file are that shown in the top left corner of the screen, the constituent labour, material and overhead costs. The factor code is the reference number of the set of constants which are compounded with the raw data to produce the selling prices. If the Sales Manager wishes to alter the factor by which the cost is multiplied to give the price for the 'urgent' category of customer, a new set of factors can be entered and referred to by the next numerical factor code. The program will then automatically perform its calculations using these new factors.

Another set of modifiers which are used to determine an actual selling price are shown in the top right hand corner, the metal variations. These are a method of relating the fluctuating raw material costs to the cost of a finished item. When a part is being designed the quantity of each of three base metals (copper, zinc and nickel) in that part is calculated. This is then related to the total cost for that part to give the 'variations' for each metal. If copper rises or falls by £10 per ton relative to some periodically revised base figure, the price charged for that item is increased or decreased by an amount, calculated by multiplying the base metal price change with the appropriate variation. In the model the facility for doing this calculation automatically has not been included. It would require that the daily price of each metal is entered into the system at the start of each day.

The bottom right hand section of the screen relates to the delivery date for that part number. There had been considerable discussion about the possibility of either A.S.D. maintaining a stock of spares, or the manufacturing divisions holding the stock for A.S.D.

FIG 9.1



⌞JOB CONTROL ⌟ ⌞ CURRENT JOB xxxx MK nnn MESS SEQ nnnn

AFTER SALES DIVISION - DATA RETRIEVAL 21/06/77

SERIAL NUMBER L J

PARAMETER SET IDENTITY PSON

SCREEN IDENTITY INITIAL

MAXIMUM CHARACTERS INPUT

MAXIMUM CHARACTERS OUTPUT

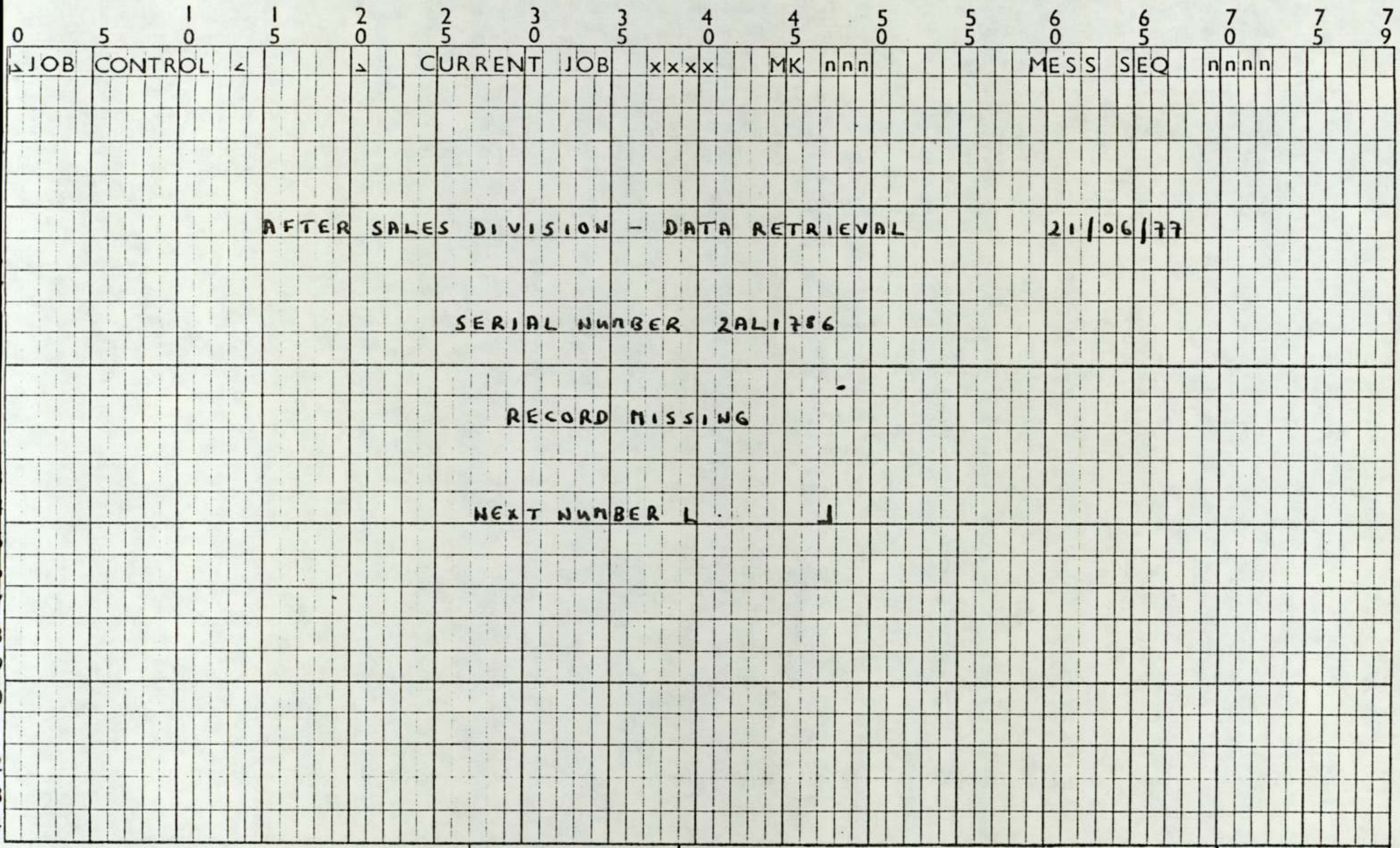
DATE

FIG 9.2

```
0    5    10   15   20   25   30   35   40   45   50   55   60   65   70   75  79
⌞JOB CONTROL ∠      ∟  CURRENT JOB  xxxx  MK nnn         MESS SEQ  nnnn

              AFTER SALES DIVISION - DATA RETRIEVAL         21/06/77


                         SERIAL NUMBER   2AL1786

             ORIGINAL CUSTOMER GLOBAL SHIPPING LTD

             CUSTOMER CODE     A2016               .

             DATE SUPPLIED     17 05 74

             APPLICATION CODE  32

             SIZE DESIGNATION  009CZ93D1

             GA NUMBER         44453-5080

             DESCRIPTION      LUBRICATING OIL COOLER

             MATERIALS CODE   12603
                                         NEXT NUMBER └        ┘
```

PARAMETER SET IDENTITY	PSON	MAXIMUM CHARACTERS INPUT	
SCREEN IDENTITY	DATA	MAXIMUM CHARACTERS OUTPUT	

FIG 9.3



```
⌞JOB CONTROL <      ⌞   CURRENT JOB  xxxx   MK nnn         MESS SEQ  nnnn




              AFTER SALES DIVISION - DATA RETRIEVAL        21/06/77


                         SERIAL NUMBER  2AL1786


                            RECORD MISSING


                          NEXT NUMBER └        ┘
```

PARAMETER SET IDENTITY PSON

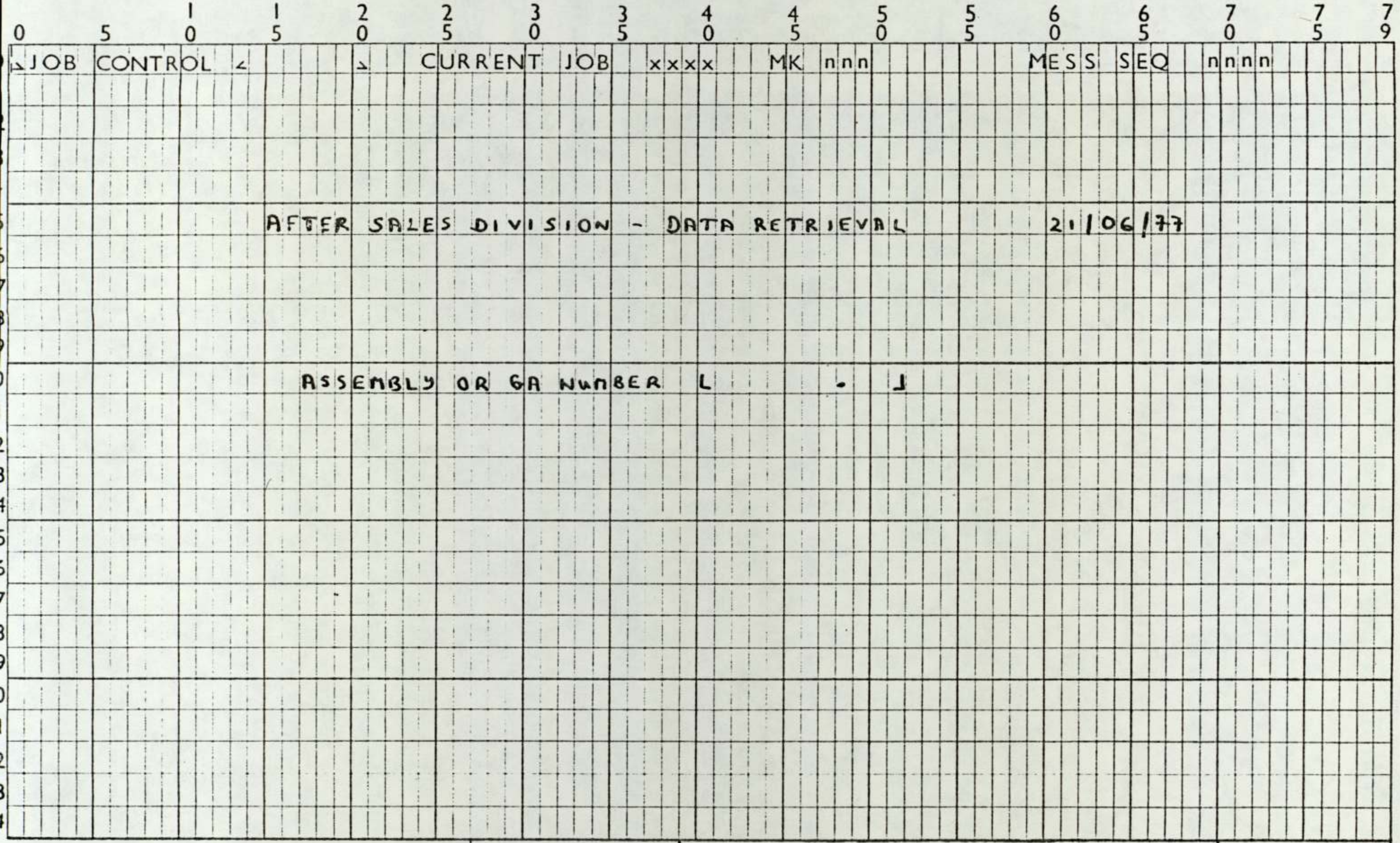
SCREEN IDENTITY ERROR

MAXIMUM CHARACTERS INPUT

MAXIMUM CHARACTERS OUTPUT

DATE

FIG 9.4



⌞JOB CONTROL ⌞ ⌞ CURRENT JOB xxxx MK nnn MESS SEQ nnnn

AFTER SALES DIVISION - DATA RETRIEVAL 21/06/77

ASSEMBLY OR GA NUMBER L . ⌋

PARAMETER SET IDENTITY PSTW

SCREEN IDENTITY INITIAL

MAXIMUM CHARACTERS INPUT

MAXIMUM CHARACTERS OUTPUT

DATE

FIG 9.5

```
0    5    10   15   20   25   30   35   40   45   50   55   60   65   70   75  79
⌞JOB CONTROL ⌟      ⌞  CURRENT JOB   xxxx   MK nnn         MESS SEQ  nnnn

              AFTER SALES DIVISION - DATA RETRIEVAL         21/06/77

                    ASSEMBLY/GA NUMBER 44453-5080     LUBE OIL COOLER


      PART NUMBER   DESCRIPTION               QUANTITY

      43357-4022   TUBESTACK                    0001
      38885-1041   FITTING KIT                  0001
      38581-4002   SEALING KIT                  0001
      34532-1092   CYLINDER 01A020GR14          0001
      37435-3113   FIXED END BOX  GR14          0001
      37435-3121   EXPANSION END BOX            0001
      32234-4008   COVER    01A020GR14          0002
      36213-3009   INSPECTION DOOR              0002
      31767-1004   LEAKAGE RING                 0001




                                             NEXT NUMBER  ⌞          ⌟

```

PARAMETER SET IDENTITY PSTW

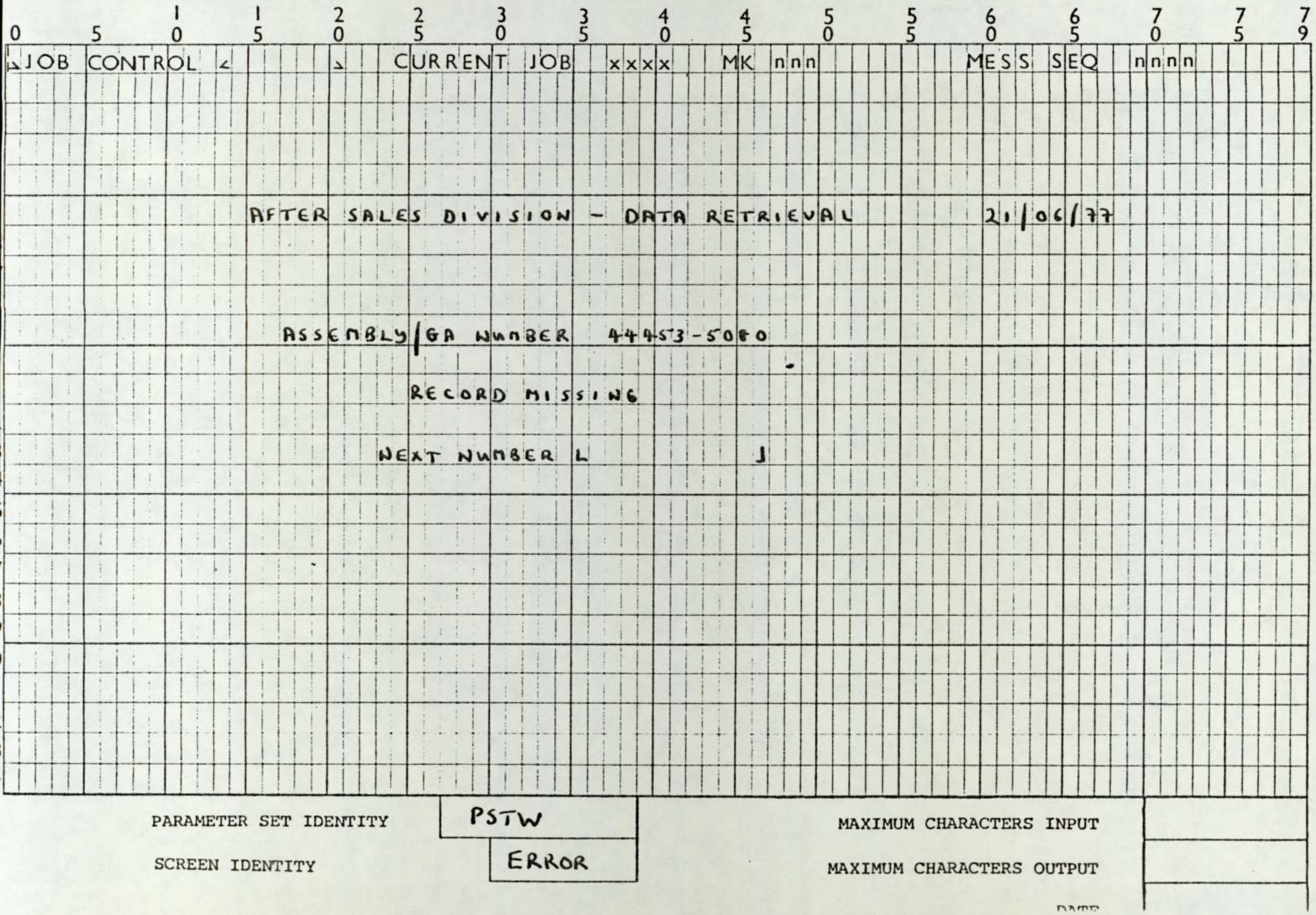
SCREEN IDENTITY DATA

MAXIMUM CHARACTERS INPUT

MAXIMUM CHARACTERS OUTPUT

DATE

FIG 9.6



⌞JOB CONTROL ⌟ ⌞ CURRENT JOB xxxx MK nnn MESS SEQ nnnn

AFTER SALES DIVISION - DATA RETRIEVAL 21/06/77

ASSEMBLY/GA NUMBER 44453-5060 .

RECORD MISSING

NEXT NUMBER L J

PARAMETER SET IDENTITY PSTW

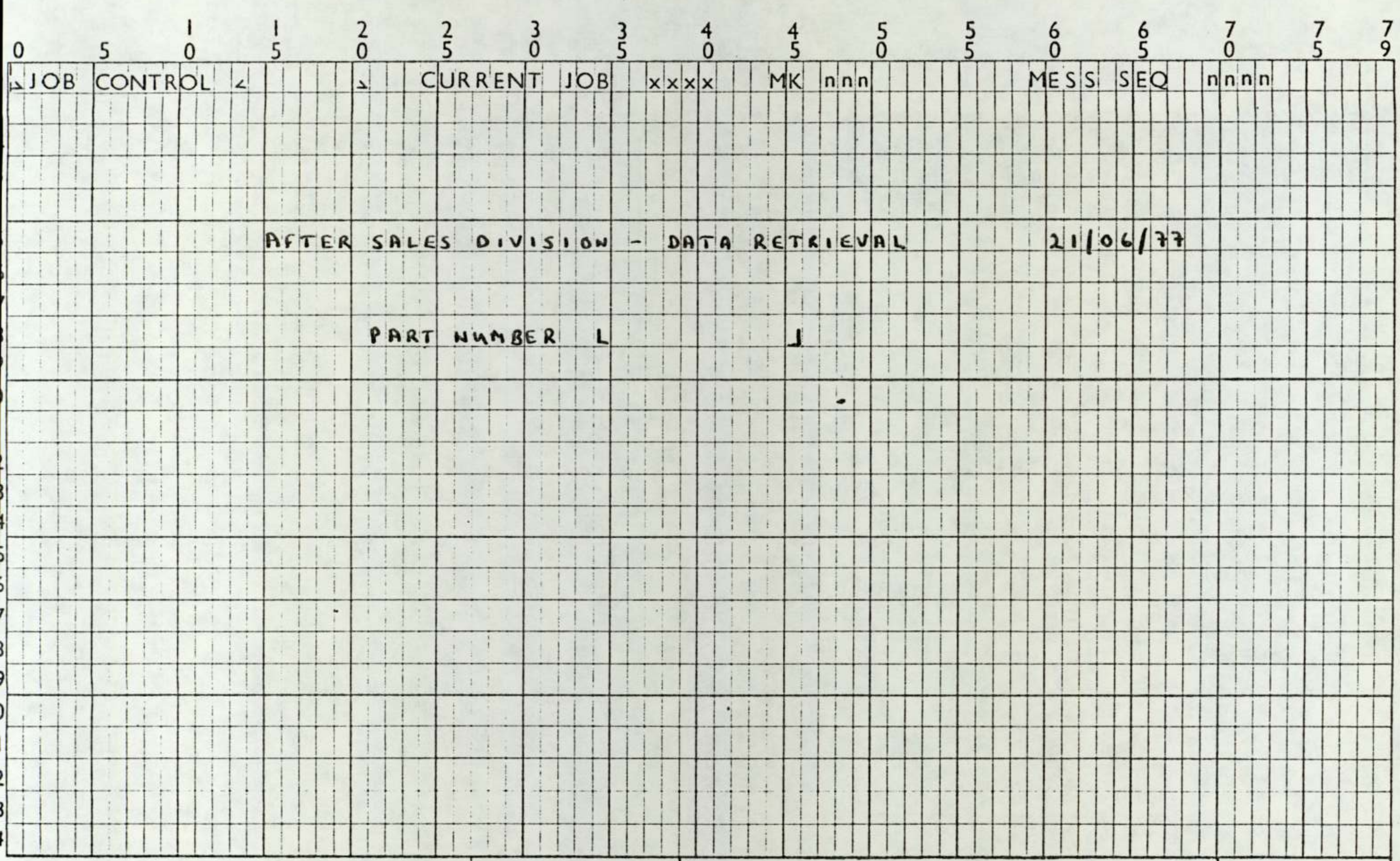
SCREEN IDENTITY ERROR

MAXIMUM CHARACTERS INPUT

MAXIMUM CHARACTERS OUTPUT

DATE

FIG 9.7



JOB CONTROL
CURRENT JOB xxxx MK nnn MESS SEQ nnnn

AFTER SALES DIVISION - DATA RETRIEVAL 21/06/77

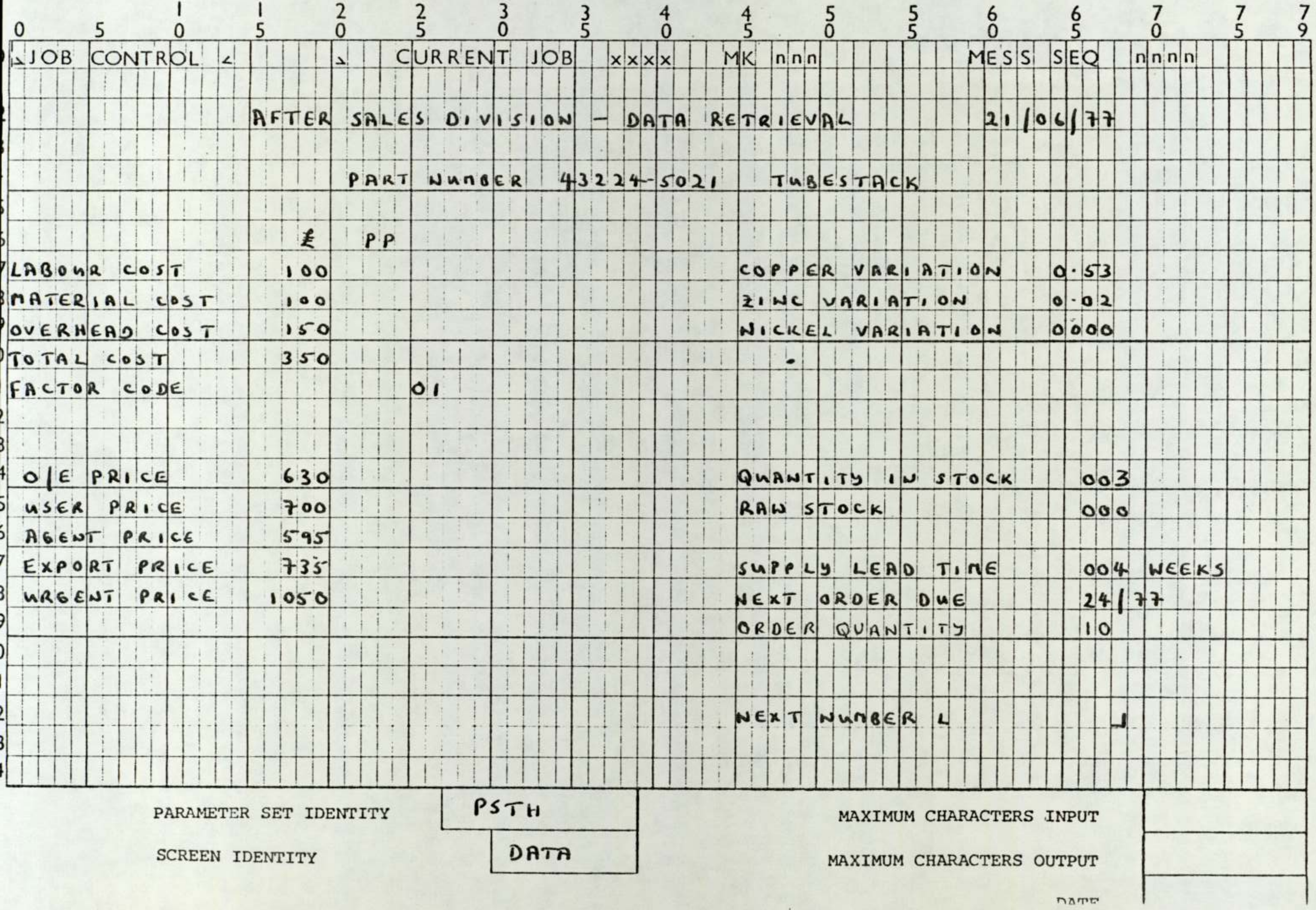
PART NUMBER L J

PARAMETER SET IDENTITY PSTH

SCREEN IDENTITY INITIAL

MAXIMUM CHARACTERS INPUT

MAXIMUM CHARACTERS OUTPUT



```
⊾JOB CONTROL ∠      ⊾   CURRENT JOB  xxxx   MK nnn        MESS SEQ  nnnn

               AFTER SALES DIVISION - DATA RETRIEVAL        21/06/77

                     PART NUMBER  43224-5021   TUBESTACK

                  £   PP
LABOUR COST      100                         COPPER VARIATION   0.53
MATERIAL COST    100                         ZINC VARIATION     0.02
OVERHEAD COST    150                         NICKEL VARIATION   0000
TOTAL COST       350                            .
FACTOR CODE              01


 O/E PRICE       630                         QUANTITY IN STOCK    003
 USER PRICE      700                         RAW STOCK            000
 AGENT PRICE     595
 EXPORT PRICE    735                         SUPPLY LEAD TIME     004 WEEKS
 URGENT PRICE   1050                         NEXT ORDER DUE       24/77
                                             ORDER QUANTITY       10


                                             NEXT NUMBER L          ┘
```

PARAMETER SET IDENTITY PSTH

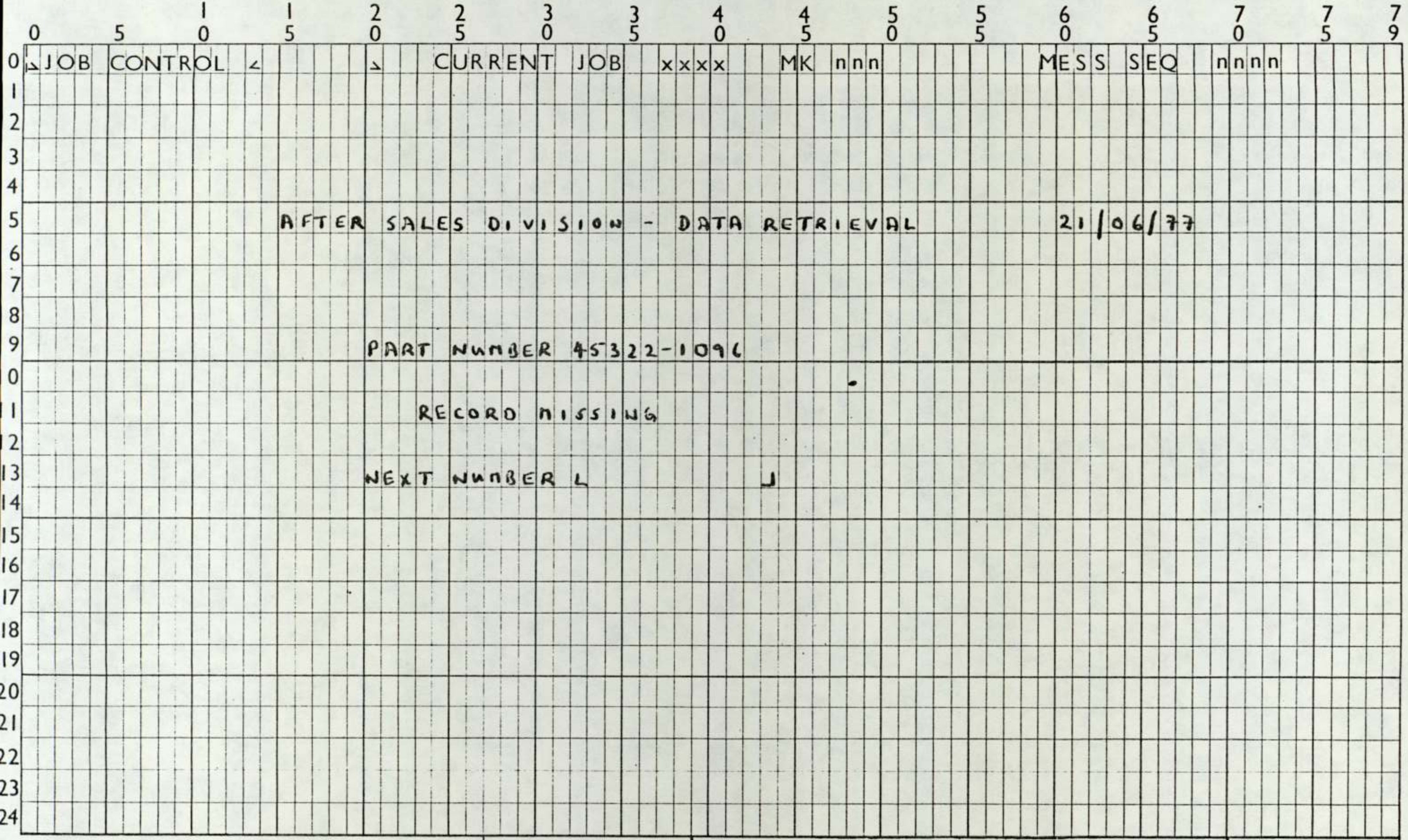
SCREEN IDENTITY DATA

MAXIMUM CHARACTERS INPUT

MAXIMUM CHARACTERS OUTPUT

FIG 9.8

FIG 9.9



0 JOB CONTROL   CURRENT JOB xxxx MK nnn   MESS SEQ nnnn

AFTER SALES DIVISION - DATA RETRIEVAL   21/06/77

PART NUMBER 45322-1096

RECORD MISSING

NEXT NUMBER L   J

PARAMETER SET IDENTITY	PSTH	MAXIMUM CHARACTERS INPUT	
SCREEN IDENTITY	ERROR	MAXIMUM CHARACTERS OUTPUT	
		DATE	

Supply could then be simply a matter of requisitioning from the stores. For this reason the top two lines refer to the availability of stock. The term 'raw stock' refers to those items, usually castings, that can be machined into more than one part number as necessary.

If the stock held is zero, the supply lead time is quoted below and is the time the divisions quote to build the spare. It could be that an order has been placed with a division to replenish the stock holding, in which instance the due date and order quantity are given as shown.

The result of displaying this information is that for standard items the S.T. can find a price and delivery time straightaway. Special items need to be estimated and will have to be referred to the manufacturing division, so are not catered for by this system.

This model represents the business system which was suggested as being appropriate to the real needs of the A.S.D. Sales Technicians as established during the investigation phase of the project.

IX.6 The Comments of the Sales Technicians

The model was demonstrated to the S.T's throughout August of 1977 and their comments, both immediate and considered, were noted.

Their general reaction was to endorse the validity of the model, but interestingly, to suggest some further points to be included. Since the model was designed around their comments and observation of their work this indicates that it is difficult for the practical analyst to establish the fine details of a job in which he is not directly involved. It was not that the S.T's deliberately avoided imparting information, but rather that they answered questions directly. If no question was asked on a particular issue, the information was not volunteered.

For this reason five points of detail were suggested, upon seeing the demonstration of the model, as being worthy of inclusion, see Exhibit 2.

Other than these specific points the S.T's confirmed that a system like that presented by the model would reduce the time it took them to answer quotations. However, several of the S.T's seemed reluctant to discuss the issue and when pressed, suggested that such a system would make their job considerably more dull and routine than it is now. At least the frequent need to visit the drawing stores, classification and coding, the P.P.L. drawers, and so on gives the opportunity to meet other members of the staff and reduce the tedium of sitting down all the time. Further, if they have to leave their desks during the course of their legitimate work, no-one notices if they leave their desks just to go for a walk. The retrieval system would obviate this need and as such was not particularly attractive.

EXHIBIT 2 - ADDITIONAL ITEMS OF DATA REQUIRED

1. To list the tubeplate material on the structure file. This would save the Repairs S.T's the need to get out a drawing whenever a tubestack needed to be rebuilt.

2. To include the length in inches or centimetres of 'sections' in air coolers. A section is the actual heat transfer element and is bolted in place on the larger units. It would help the S.T. to have this length quoted on the customer file in place of the size designation, which A.C.D. rarely use, since it would serve a similar function.

3. When a fan & motor drive are present on a cooler there is a part number for these items together. However, the usual requirement is to supply a new motor or else new bearings for the fan. When building the structure file these points should be included for the benefit of A.S.D.

4. Include the Series number on charge air coolers. This gives the broad class to which the cooler belongs and is another element of the convenient shorthand notation used to identify units. e.g. The example given earlier of a customer describing his cooler as a Series 7 with sweated-on headers in gun-metal.

5. The repairs S.T's suggested that the test pressures and inspection requirements that are always given on the Works Order be included in the customer file or structure file. This would save them having to look up in the W.O. log books to find out what test conditions should be applied to any unit that has been repaired.

IX.7 The Reaction of A.S.D. Management

The model was demonstrated to A.S.D's four managers individually during August of 1977 and subsequently discussed collectively.

The immediate response from each was enthusiastic, to the extent of asking when the completed system would be available.

This question provided the cue to discuss the issues lying behind the demonstration. In order to answer directly the question of development times, it is necessary to know the extent of the design work involved. This in turn requires some knowledge of the broad environment of the division. To design a system to suit the A.S.D. situated on the main S.H.T. site is one matter. To design a similar system for the division remote from the main site is a significantly different task.

There is no barrier to either. But the implications of the projected move for the design of the data retrieval system are considerable.

An example is the possibility of A.S.D. setting up its own stock holding. The current arrangement is that the manufacturing divisions maintain a stock on which A.S.D. can draw and the Sales Technicians have appropriate methods for finding out the stock position. If A.S.D. moves and sets up a stores, the information so neatly presented on the data retrieval system has to be derived from a suitable stock recording routine. But to be useful this routine has to reflect actuality precisely, since the S.T's will make committments and allocate stock on the strength of the data presented. To achieve this requires considerable attention to be paid to the specification of the associated manual procedures for physically recording the stock.

This does not necessarily preclude a standard stock recording package from the job. It serves to illustrate that the data retrieval is the basis of the division's operation and as such determines the rigour of the supporting facilities. If these supporting facilities are inadequate then the data retrieval will be too.

Since the quality of the retrieved information is a function of the routines that derive it, the cost and development time of the data retrieval system depend upon the extent of these routines. The routines in turn depend upon the broad decisions to be taken about the division's organisation following the move.

This argument applies to:

- stock recording
- production scheduling
- the ordering of parts from the manufacturing divisions.

There is an additional complication in the last of these due to it not being totally the responsibility of A.S.D.

To implement the ordering system calls for co-operation from the divisions. Further, the maintenance of the Log Books and parts lists in a manner that was suitable for A.S.D. requires negotiation and agreement with the divisions.

These latter points, the relations with the divisions, had been realised. But the implications of the move on the data retrieval system and its supporting routines had not. The main principle of development to which the managers were working was a piecemeal one. The idea, insofar as it had been made explicit, was to establish the individual elements, stock recording, re-ordering etc., then subsequently to derive data from them for the retrieval system.

In the event, matters were completely dominated by the need to resolve the main issue of whether A.S.D. could move or not. The direct outcome of the extensive discussion about the demonstration and the plans for developing the complete system was that nothing resulted.

Until it was decided that A.S.D. would move, no detailed organisational changes would be made. Hence the broad context and the scope of the routines deriving information for the data retrieval would not be determined. It was probable that the move would be effected before the plans for these matters were considered further.

Whilst this attitude is perfectly reasonable, it did not enable the design of the Business System to proceed as planned. During the months which elapsed between the demonstration of the model and the resolving of A.S.D's future in March of 1978, the only practical work which was undertaken was a review of the information sources around the S.H.T. site which could be accessed by the data retrieval system.

CHAPTER X FURTHER ANALYSIS WORK

SUMMARY

The existing sources of data within S.H.T. are reviewed and assessed. Production methods in the other manufacturing areas are analysed.

SECTIONS

X.1 Analysis of the Customer File

The first class of data to organise is that to be recorded on future production. Current practice is to make out entries in the Works Order and Serial Number log books. The W.O. entries are done by the drawing offices of T.C.D. and A.C.D. from their copy of the W.O. The Serial number books are drawn up by the contracts department of each division taking data from both the W.O. and the customer's order.

Allocation of Serial Numbers takes place when the W.O. is first drawn up, so in a sense, coolers are being manufactured to fit a serial number, rather than the numbers being allocated as the cooler leaves the works.

Two books are necessary since frequently a customer will modify the number of units he has ordered. This modification can easily be made on the W.O., but the next serial numbers which are needed for the new units will be out of sequence with the original ones. It is necessary to maintain the two books to enable these non-consecutive serial numbers to be related to their Works Order. Also the W.O. numbers are repeated every few years and confusion would arise if this 2-book system was not employed.

The model has provided a list of all the data to be recorded on this customer file, see Exhibit 1.

EXHIBIT 1 - CUSTOMER FILE DATA

DATA	EXAMPLE
Serial Number	2AL 4396
Customer Name	Allen's Marine Ltd.
Customer Code	C1036
Date Supplied	15th May 1968
G.A. Number	43527-6001
Size Designation	6CZ58D2
* Series Number	7
* Section Length	28 inches
Description	Lubricating Oil Cooler
Application Code	17
Materials Code	12600
Test & Inspection Details	Serck Class H 60 psi Water Side 60 psi Oil Side

* Only for A.C.D. products

Every item on this list is available, or can be easily found out, by the clerk in the manufacturing division's contracts department when the log book is compiled at present. A suitable input sheet could be designed on to which the clerk enters the data.

These sheets would be collected weekly, probably punched on to cards, listed out and returned to the division for checking. When validated they would be added as new records to the customer file.

This system could be implemented very quickly once the specification of the data content has been formally agreed and is the first element of the data retrieval system which would be established.

Once this is completed, the next stage is to transcribe the existing records on to this system from 1971 to date. This involves a compilation from the Serial Number and W.O. log books and is a considerable clerical task. The log books have been compiled by many different people over the years and the number of different formats of recording is high. This means that the task of sorting out the data is not straightforward.

To begin with, the handwriting itself is sometimes very difficult to read. Some Works Order sheets deal with a number of different customer orders and serial number sequences. Precise rules need to be established to ensure that this jumbled data is recorded in a single way. Specifically, sequences of serial numbers are written down in eight formats some of which are open to multiple interpretation, data are not always written in the appropriate box on the works order form and can be hidden in the body of the record, which, for A.C.D., may be up to three pages long.

Thus the rules for the transcription must cater for every eventuality and must be carefully formulated.

In some instances reference will have to be made to a data source outside of the existing log books in order to establish items of information, listed in Exhibit 1, such as the length of sections for an A.C.D. unit. But none of this is any problem to an experienced S.T. and the non-exceptional instances could be dealt with by staff not possessing the S.T's detailed technical knowledge.

X.2 Analysis of the Structure Files

Both SECD and the Block Shop of A.C.D. employ a computer-based Breakdown of Requirements in their production planning process, for which a product structure file is necessary.

Similar files are maintained for both T.C.D. and the other areas of A.C.D., but because neither uses the file, their accuracy and completeness is an unknown quantity. These files are extremely important to A.S.D., so three analyses were done to establish just how accurate and extensive they were.

The structure files can be viewed as consisting of a string of part numbers, one record per part number. For each number there is a list of the parts within that number. To obtain a complete breakdown of all the bits inside a product the G.A. number is looked up on the file and against it are listed all the parts needed to assemble that G.A., one of which will be the tubestack for example. But some of these parts are themselves assemblies and by looking up their numbers a breakdown of them can be obtained. This process can be repeated down to the raw material and bought in item level.

For A.S.D's purposes the company M.P.F. needs to be introduced. This is a file, maintained by Classification and Coding, of all the Brisch part numbers authorised since 1977. Against each part number are held details of that part, such as description, size, specification and so on. Since the structure files do not include any descriptions, access to the M.P.F. is essential for the display as per Fig. 9.5 to be made.

Details of the three analyses are given in Exhibit 2.

The conclusion drawn from this work is that the T.C.D. structure file is adequate to support A.S.D.s requirements back to 1970/1971 and A.C.D's is adequate to 1974. Each possesses a measure of cover prior to these dates, but it is incomplete and hence an inadequate basis for the retrieval system.

The M.P.F. is completely adequate to complement the structure files in all respects.

EXHIBIT 2 - ANALYSES OF STRUCTURE FILES

Investigation 1

This involved asking the staff of the division who were responsible for maintenance what they thought about the files.

A.C.D: "In 1974 the complete order book for one month was broken down into its primary components and all the assemblies were enteredon to the structure file. Since that date every new design and re-issued old design has been included in the file. Thus it will be 100% accurate post 1974 and will tail off to around 50% by 1970. For items of steelwork used on the larger products some old style part numbers have been used." (e.g. the 16 digit P2032152495H5493).

Management Services were asked the same question about the A.C.D. file and replied that the extent was much as suggested above, but that overall accuracy of the data would be 90 - 95% rather than 100%. Also no raw materials are included on the file.

T.C.D: "It will be complete and accurate for all assemblies used since 1970, with a decay before that time depending upon the repeat order rate." Yet management services suggest that although it certainly does extend back as far as 1970, the division has little interest in maintaining it and so the accuracy is 75% only. Again there are no raw materials included and there are "problems" (unspecified) with duplicated part numbers and casting numbers.

EXHIBIT 2 Cont'd.... <u>Investigation 2</u>

In an attempt to further quantify the above comments a list of twenty randomly selected G.A. numbers per major product group was taken for each year of manufacture. These numbers came from the Works Order Log Books, were converted to Brisch numbers if necessary and then the structure file was examined for each division to see if the numbers appeared there.

For A.C.D. the results were aggregated across the three major groups and given as a percentage hit rate for that year.

YEAR	%	YEAR	%
1976	100	1967	20
1975	100	1968	25
1974	100	1967	5
1973	65	1966	10
1972	55	1965	5
1971	55	1964	0
1970	40	1963	0

For T.C.D. the results are given as lightweight/ heavyweight.

YEAR	%	YEAR	%
1976	100/20	1969	50/40
1975	70/50	1968	70/20
1974	100/90	1967	40/30
1973	100/90	1966	60/ 0
1972	100/100	1965	50/ 0
1971	100/80	1964	30/ 0
1970	60/40	1963	5/ 0

These results are illustrated in the accompanying graphs.

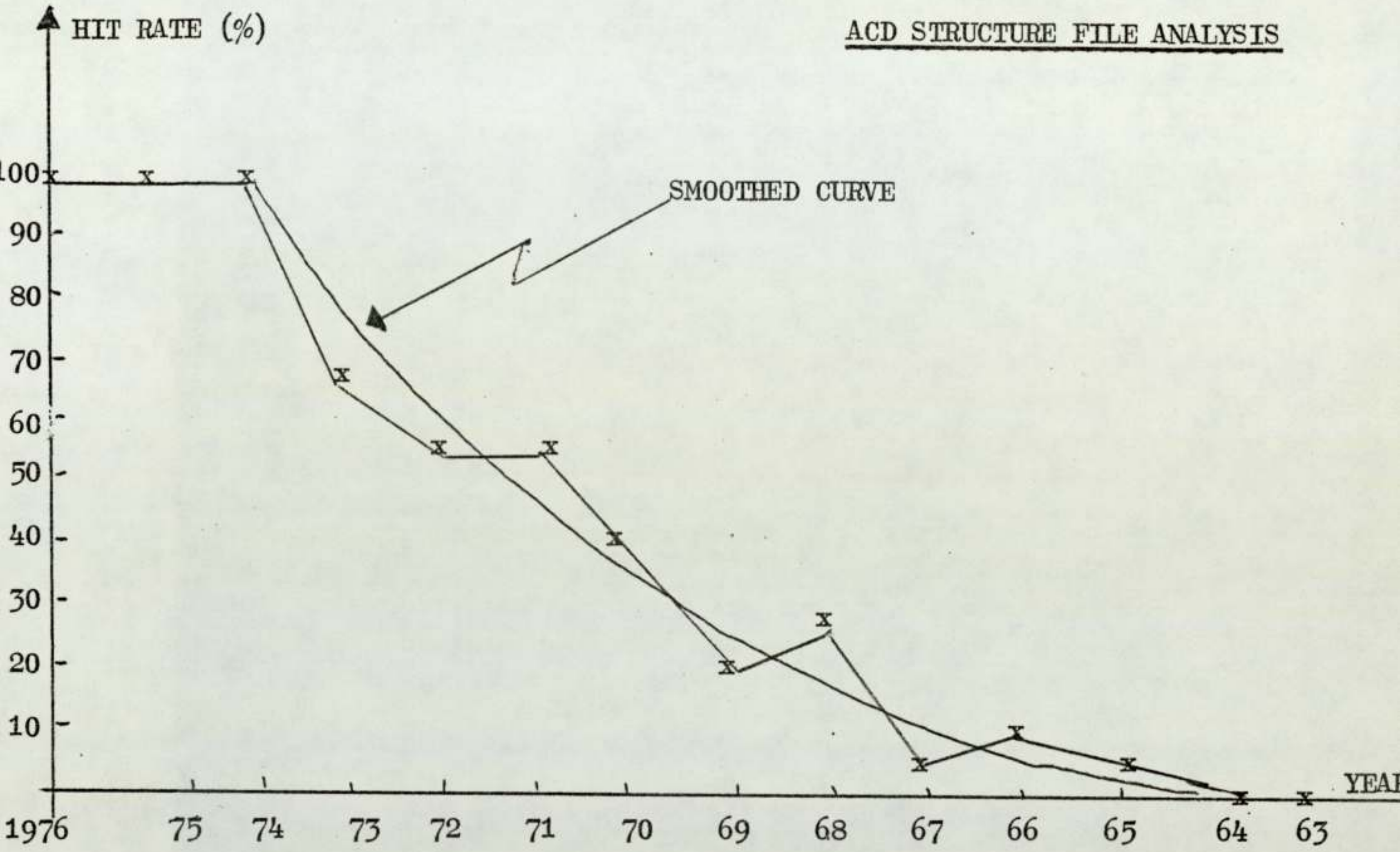
EXHIBIT 2 Cont'd....

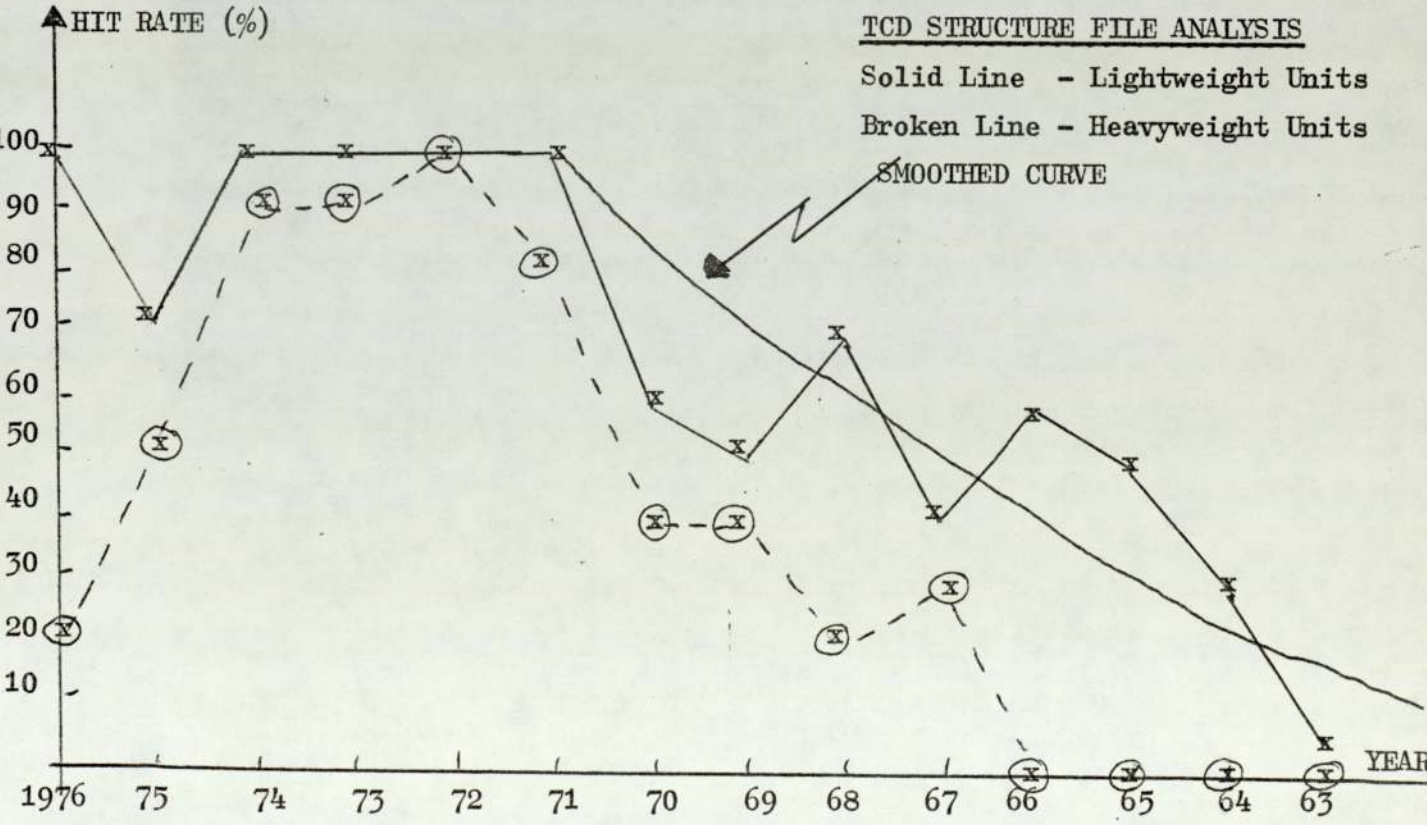
Investigation 3

The previous analysis had one major drawback which was that it did not reflect the actuality of demand in the selection of its very small sample. In order to see how well these files would serve in practice, the list of all the orders and enquiries for December of 1976 was followed through to see if the G.A's were on the files.

The results were, that for this month, 50% of all T.C.D. dealings and 40% of A.C.D's could be dealt with on those files.

These figures are broadly consistent with both the age analysis and the results of investigation 2 above.


ACD STRUCTURE FILE ANALYSIS


TCD STRUCTURE FILE ANALYSIS

Solid Line - Lightweight Units

Broken Line - Heavyweight Units

X.3 Stock Analysis

During 1977 the Sales Technicians of A.C.D. and T.C.D. had been producing a list of the most commonly ordered manufactured spares. This was intended as a first approximation to the stock which A.S.D. would hold as and when circumstances permitted.

Since the suggested retrieval system leans quite heavily upon the stock holding for the supply of delivery date information, it is important to know just how effective this stock holding will be and what proportion of orders it would deal with.

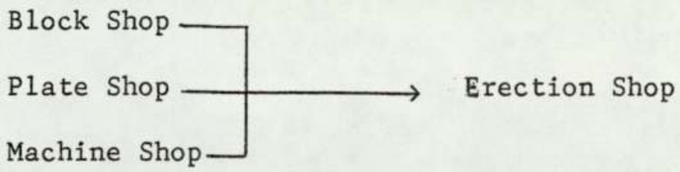
The list of stock items was compared with the much used list of orders and enquiries for November and December of 1976.

Assuming that no stock-outs occurred (i.e. stock items are always available), some 40% of A.C.D. orders/enquiries would have been fulfilled from stock and 37% of those for T.C.D.

However, as the stock holding increases and A.S.D. sets up the machining facility discussed earlier (effectively making a wider range of items available from stock) so this 40% will increase to fulfil the majority of orders.

X.4 Production Methods in Air Cooling Division

The production area of A.C.D. is divided into four separate shops, shown below:-



The two basic groups of product, (intercoolers and radiators, which have product codes of 630 and 610/640 respectively) require different manufacturing techniques. All heat transfer sections for both types are produced in the Block Shop, but whereas the inter-cooler casings and headers are machined from castings in the Machine Shop, the ironmongery to support the radiator elements is made in the plate shop. The Erection Shop is the final assembly area where the sections are installed into the casings.

Briefly, the production is organised as follows:-

Customers agree on a delivery date with the Production Coordinator who bases his assessments on his knowledge of past performances. The order then enters the divisional Delivery Schedule at one of the weekly updates, this schedule being a list of customers, quantities and delivery dates. Nearly one half of all the orders received by A.C.D. is for new designs for which the drawings need to be done. Since all new orders for radiators need to be re-designed the delivery date must take into consideration this design lead time. (Typically, the total design and production lead time of a large radiator will be the order of 30 - 40 weeks).

According to the operations controller, approximately 40% of all orders are modified in some way between acceptance and delivery, be that prompted by the customers, who may alter their requirements, or by the division, who may be forced to revise an optimistic delivery date. Thus, the delivery schedule is continuously being amended. The heat transfer section requirements are isolated early on in the order's life and a separate list of these (the 609 order book) is sent to the Block Shop - a section which is one of the most advanced as regards the use of the computer. (This will be returned to later).

The production controller produces a monthly build plan for the three other areas from his delivery schedule, batching across works orders being sought wherever possible, although this is rendered difficult in the case of the Erection Shop by the arrival of sections from the Block Shop piecemeal, rather than all in one batch. Those build plans are broken down manually using the Production Parts List, (a list of the components in a cooler) and the Route Cards, (a list of the manufacturing operations for each component) to form the detailed list of operations which are then entered on the Progress Cards, one card for each order. Prompted by their build programmes, the foremen collect the appropriate progress cards and hence know what jobs their area must be organised to do.

There are several lower level schemes by which the reality of the metal work is made to as nearly as possible fit the delivery schedule. However, the results are not very impressive. The division has a very high inertia, in that the lead time on orders is very long. The division appears unflexible and formally unaware of what is going on inside the various shops. Some 10½% of its £4 million turnover is arrears, of which 0·6% is more than three months late. One area, the Block Shop, with its computer aided routines stands in stark contrast to the remainder of the divisions with their imprecise manual methods for production control.

X.5 Production Methods in Tubular Cooling Division

T.C.D. manufactures heat exchangers within three main product groups:-

Product Group	Quantity per Month	Turnover
750	350	£1·2m
720	250	£1·3m
710	110	£3·3m

All of the 750 range are standard, that means all parts should be available from stock and procurement is simply a matter of requisitioning. Of the 720 range, approximately half the coolers produced are standard, the remainder are special, as are all the 710 range. Specials require certain components to be bought in direct to the job, but nevertheless, roughly 80% of all the parts used on 710's are in fact standard. Obviously special items incur a longer lead time than standards, so the manufacturing process is divided according to the standard/special distinction. Control of production is completely manual and begins with the arrival of the divisional delivery schedule for the forthcoming month. This is rewritten to form three listings, the production programmes for each product group. Long lead time items are identified and ordered, the stock balances are built up so as to be adequate to cover the programme and the two feeder shops are issued with instructions to manufacture as per programme. These feeder shops are stackbuilding, where the tubestacks are made, and the Machine Shop, where the castings are machined. Production is completed in Final Assembly, where the cooler is put together and tested. Special items are obviously worked on as the material becomes available, but standard stacks and common castings are produced in adequate batches to cover the programme with any surplus being absorbed into stock.

Certain coolers have a lead time of 1 - 2 weeks, which, being well within the cycle time of the programme, requires that a secondary programme is issued in the middle of each month detailing these short inertia units.

The division works to its production programmes. All loading and planning is manual and the usual final minute changes in requirements and priorities cause problems to the production controllers. Daily production meetings, an internal progress department and close liaison between the Production Manager and the foremen are necessary to keep the production flowing, but nevertheless, the divisional inertia is high.

X.6 Production Methods in the Block Shop

Block Shop employs a Breakdown, Stock and Order status routine although manual links are operated between these systems. All systems were developed in-house and work as follows:-

The starting point is a list of all the finished goods requirements incumbent upon the section for the forthcoming period. This is the 609 order book, which is a manually raised extract from the divisional delivery schedule. The A.C.D. delivery schedule is not sufficiently adequate for direct input to the Breakdown system. It needs to be considered manually, line by line, to incorporate the latest amendments to requirements, formal notification of which has yet to filter through. The list is then broken down by multiplying the requirements by the component list so as to produce a gross listing of all the "things" that the division needs in order to fulfil the demands on it. Block Shop operates a changes Breakdown in which only the alterations from the previous period's requirements are broken down. Using this system, a six monthly Clean Sweep Gross Breakdown needs to be performed in order to reassess the "cover" stock figures - the quantities of commonly used stock items appropriate to cover demands for the next period.

Once the breakdown is produced it needs to be netted against stock.

(This is the process of subtracting stock from the demand to determine the outstanding quantity. e.g. If the breakdown calls for five widgets to be available for the next period, and there are two in stock, three more are ordered). The stores records are computerised so that a listing is available of current stock holding to enable this netting to be performed manually by a tedious comparison of stock and requirements for each item. The next distinction to be made is between components manufactured by the division and those bought in from outside suppliers. An order status report is maintained on the computer which lists all orders placed by the division, both internal and external. Materials and Production Control clerks have the job of placing the appropriate orders taking into account demand, lead time and the orders already placed. Many commonly used parts are ordered from external suppliers on a continual schedule, so the clerk has to strike balance between excess cost of holding stock and shortage of the components. The orders, both internal and external, are made up, the material is requisitioned from the stores and, in conjunction with the production manager, the programme and the internal orders he receives, the foreman of any particular area knows what work he needs to produce in his shop that period.

Real life is complex,in that priorities and requirements are seldom constant. There are many informal ways of ensuring that the reality of production reflects the reality of the demand, with the formal computer record being somewhere between the two, and rarely immediately up to date.

e.g. When a new 609 order book is received in the Block Shop, a meeting is arranged between the Production Controller of A.C.D. and the Operations Supervisor of Block Shop to establish the immediate priorities which bring this feeder shop into line with the latest version of the Erection Shop programme. This is in fact the third level of programme for the Block Shop. The other two being the 609 order book and a separate listing of long lead time items required for subsequent periods. The iterative nature of this programming is due to the lack of precise knowledge of the demands on the division, the internal capacity and the awareness of what is being done at any given time.

These Breakdown processes require that certain further information is available to the computer, primarily the BOMF (Bill of Materials File). This comprises two files, a Relations file and a Master Parts File which between them list the items that make up any assembly. A significant reason for only SECD and the Block Shop having the B/D procedure is that of the production areas, which have the smallest product range and the greatest repetition of demand. Since the B/D batches across works orders, these two areas are best suited to using the process.

CHAPTER XI REVIEW OF THE PRACTICAL WORK

SUMMARY The methodology of the data retrieval project is reviewed and the impact of external factors discussed. The need to integrate subsystems is identified as a consequence of increasing technological capability.

SECTIONS

XI.1 Methodology

Fig. 8.1 is reproduced overleaf as the outline of the methodology adopted for the Data Retrieval Project.

In reviewing this approach two aspects are considered:

- how closely the stated approach was followed
- how appropriate this approach was to the problem.

The chronology of the Data Retrieval Project is shown in Exhibit 1. It supports the first conclusion, that 'Analysis' is not isolable as a single phase. Certainly the analysis has to be done before a comprehensive and well supported statement of requirements can be finalised. But the impression that might be created by the single box marked 'Analysis' in Fig. 11.1 of it being a neatly localised task is not correct. Although the analyst's initial work is determined by the starting brief, it is largely the results of the analysis that influence its further course.

For example, during the analysis phase it was discovered that the initial statement of requirements was incomplete. This points to the necessity of not limiting the scope and success of the project by defining the boundaries of the system at the outset of the work. At a more detailed level the boundaries of the investigation cannot be specified in advance. In this project the need to determine the age distribution of the heat exchangers dealt with by A.S.D. only arose during the setting of the system boundaries that occurred during the Business System Design. The analysis phase must be sufficiently flexible to enable further details to be established as necessary even after the main analysis has been concluded.

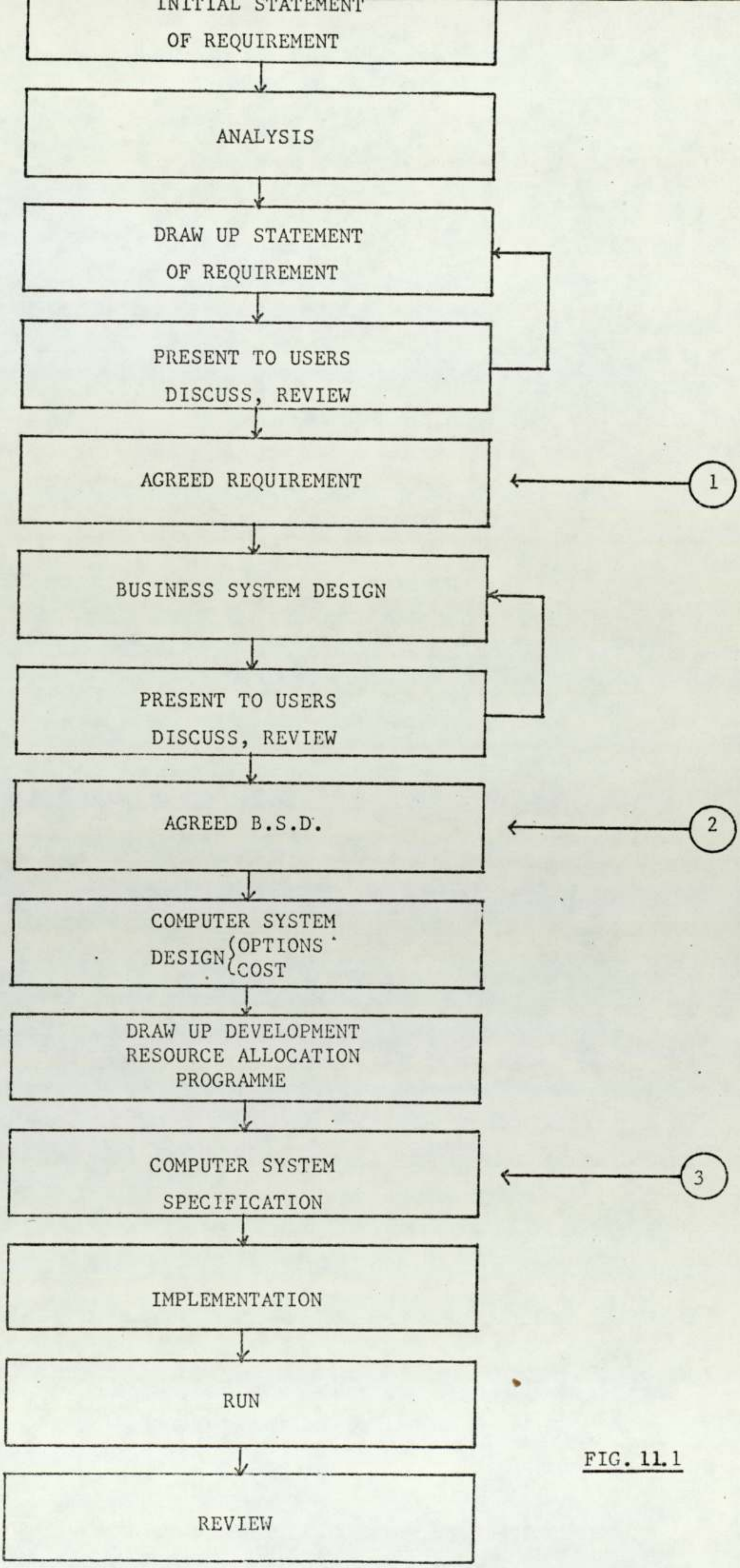

INITIAL STATEMENT
OF REQUIREMENT
ANALYSIS
DRAW UP STATEMENT
OF REQUIREMENT
PRESENT TO USERS
DISCUSS, REVIEW
AGREED REQUIREMENT
1
BUSINESS SYSTEM DESIGN
PRESENT TO USERS
DISCUSS, REVIEW
AGREED B.S.D.
2
COMPUTER SYSTEM
DESIGN {OPTIONS
COST
DRAW UP DEVELOPMENT
RESOURCE ALLOCATION
PROGRAMME
COMPUTER SYSTEM
SPECIFICATION
3
IMPLEMENTATION
RUN
REVIEW

FIG. 11.1

EXHIBIT 1

The Chronology of the Second Project

SEPTEMBER 1976	- The Service Director issued the initial statement of the requirements (given in VIII.1)
SEPTEMBER 1976 to FEBRUARY 1977	- the detailed analysis of the operations and environment of A.S.D. was made (described in VIII.3-12)
FEBRUARY 1977	- the revised system requirement was drawn up and discussed (VIII.13)
FEBRUARY 1977 to MARCH 1977	- the Business System Design was considered and further analysis work undertaken (VIII.14, 15)
MARCH 1977	- the design and development of the system model was started for the reasons given in IX.3. Details of Model in IX 4 & 5.
AUGUST 1977	- the model was extensively demonstrated to, and discussed with, the sales technicians and management of A.S.D.
AUGUST 1977 to MARCH 1978	- further analysis work was undertaken as reported in X. The outcome of A.S.D. request to move was awaited.
MARCH 1978	- the decision was taken to cut back A.S.D's operations and the data retrieval project was abandoned.

Subject to the qualification of the analysis phase being distributed rather than localised, the approach of Fig.11.1 was followed during the practical work.

The second issue, of the degree to which this methodology was appropriate, gives rise to three significant points.

It was apparent from this work that the Management team of A.S.D. were not familiar with the details of the Sales Technician's jobs. None of the four managers had been an S.T. and there was no reason for their needing that information during the normal course of their work. But this lack of knowledge manifested itself through the initial statement of requirements being incomplete. The first point of interest is that the methodology adopted questioned the initial statement of requirements. This need not have been done and the initial statement could have been adopted as the real requirement against which the system was designed. On implementation, no significant improvement in S.T. performance would have been realised.

The second point concerns the extent to which A.S.D's managers were involved throughout the work. By means of frequent informal discussion, progress was reported and reviewed. This gave rise to considerable interest and involvement on the part of, particularly, the Sales Manager who was responsible for the S.T's (see the organisation charts, Fig.8.3 and Fig. 8.4). Because of this involvement the restatement of the system requirement did not appear as a direct refutation of the original statement, but as an evolution from it. The prevalent management feeling was of strong loyalty to A.S.D. and enthusiasm that here was one section of S.H.T. undertaking exciting new developments. This spirit of interest and encouragement was particularly helpful in maintaining the momentum of the project during the protracted development of the system model. It is concluded that management should be involved in systems development work to the extent of knowing what is going on and knowing that they do influence the outcome. If this can be achieved, success is more likely to result than if management are not consulted, or considered, more than is minimally necessary.

The third point concerns the changing nature of the environment of the project. Companies need continually to be evolving and changing to adapt to external circumstances. It is not realistic to presume that systems requirements remain constant through time. The problem is to know how to identify and incorporate the changes. It was toward the end of the analysis phase that the Service Director announced his intention to move from the main S.H.T. site. This had a considerable impact upon the proposed retrieval system as described in Chapter IX. Since the implications of the suggestion were far from clear because so many factors were unresolved, the system model was developed as a means of focussing discussion and highlighting the possible alternatives.

This principle can be generalised: it is concluded that a demonstration of a proposed system provides the prospective users the opportunity to assess and communicate its suitability. Further, the implications of any impending change can be highlighted.

A graphic illustration of the validity of this principle occurred when the model was demonstrated to the S.T's. Despite the fact that each S.T. had been shown a paper model of the system and listings of the data it would present, and despite the fact that their views and comments had formed the shape of the system, the extra points listed in Chapter IX, Exhibit 1 were mentioned as necessary inclusions.

This illustrates that the capabilities and limitations of computing are not necessarily understood by the general public. The system model eliminates the 'embarrassment' of showing this up by providing a suggested system that can safely be criticised by the prospective users. Further, it eliminates the difficulty of finding out certain details during the analysis phase. e.g. During the First Project one of the Materials Control Clerks would not explain how he found out the work in progress status of batches of castings. During the Data Retrieval project none of the S.T's volunteered the information that they needed to know the test pressures. But in the latter case it was gleefully pointed out during the demonstration, that the computer had "got it wrong". Without this opportunity to criticise the proposed system the oversight would have been perpetuated in the design of the finished system.

The technique of developing the system model was well suited to the project because it succeeded in focussing discussion on the implications of A.S.D's move. It had a further result in prompting consideration of the future role of the S.T's. The S.T's had identified that the computer based system would make their job considerably more boring. The reaction of A.S.D's management was to consider whether specialist telephonist - computer operators should be employed to deal with first time and routine queries, with the S.T's available to handle the awkward technical queries.

These results support the conclusion that the methodology adopted was effective in overcoming the problems created by the environment. As such it would have produced a successful data retrieval system had the external circumstances of A.S.D. not caused the project to be abandoned.

XI.2 The Impact of External Factors on the Data Retrieval Project

In VIII.15 the reasons for the Service Director deciding to try and move A.S.D. from the main S.H.T. site were described. These reasons resulted from the conflict of interest between A.S.D. and the manufacturing divisions. Whereas the former could not continue without the latter, the converse did not apply. Thus, when A.S.D. proposed moving away and establishing a stock of commonly requested spares, this was construed as a threat to the profitability of the manufacturing divisions and opposed.

Following ten months of discussion the main board of S.H.T. decided to effectively disband A.S.D. and return the responsibility for manufactured spares supply back to the respective divisions. In doing so the arguments in VIII.1 for the creation of A.S.D. and the Service Director's expectation of increasing the original equipment sales as a consequence of the improved service function were implicitly rejected.

Following the execution of this decision the Service Director moved to another company within the Serck Group.

One of the factors in the debate concerning the future of A.S.D. was the proposed data retrieval system. The system model had identified what information would have to be derived from the manufacturing divisions to support the work of the S.T's (see Chapter VIII and Chapter IX). The development of these routines requires an investment of time fromthe staff of the manufacturing divisions because they have the knowledge of products and procedures around which the systems would be designed. But with divisions being antithetic to A.S.D. for the reasons described, there is no chance of any mutual development programme being instituted. This in turn means that A.S.D. could not employ the complete data retrieval system if remote from the main S.H.T. site.

The conclusion is that irrespective of the technical merit of the data retrieval system, or of its worth to the company as a means of improving the level of after-sales service, it will not be implemented. Although an efficient A.S.D. will bring more money into the company, (according to the Sales Director) the organisational changes that are implied are unacceptable to the manufacturing divisions.

The implications of organisational decisions for computer system design will now be considered.

XI.3 The Integration of Subsystems

The Service Director's initial concept of the data retrieval system was of an isolated system. It is isolated in that it involves the derivation, storage and interrogation of a single category of data. Fig. 11.2 shows how this system would appear.

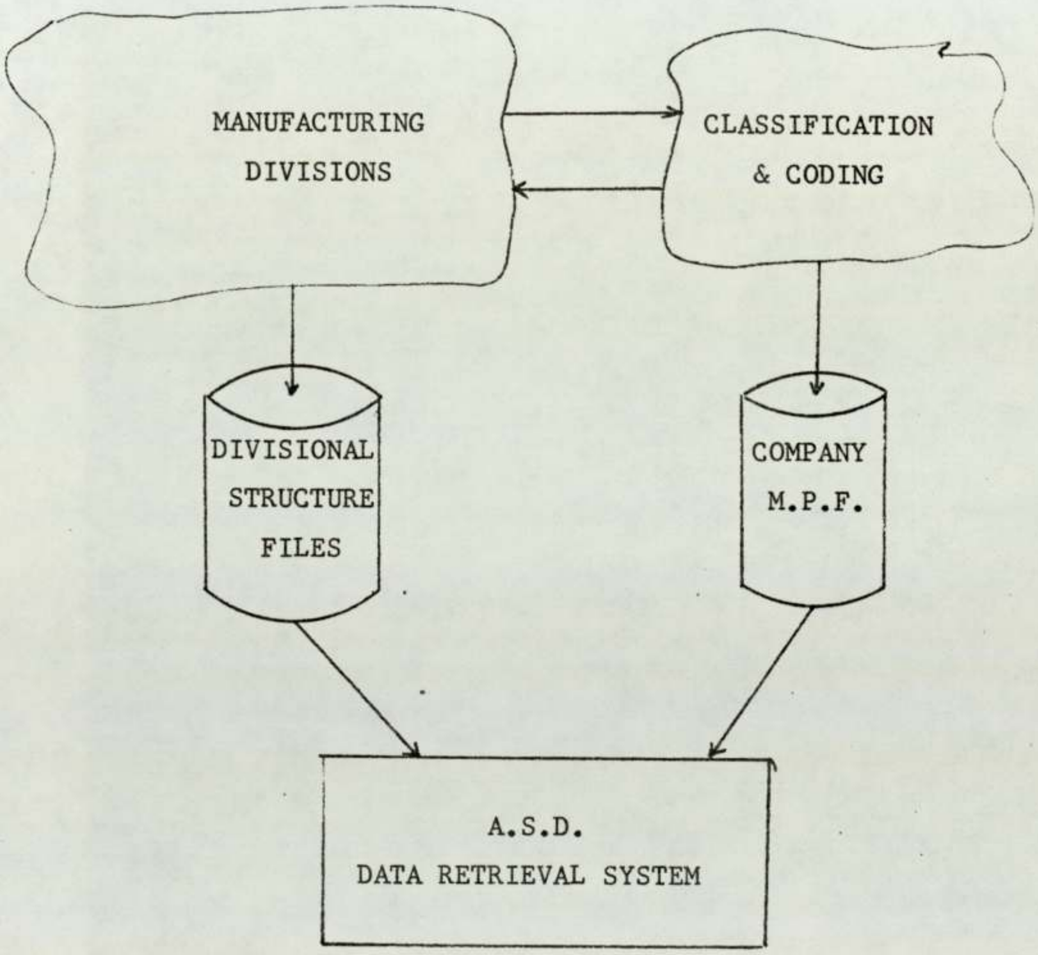


FIG. 11.2 THE ISOLATED RETRIEVAL SYSTEM

The equivalent diagram for a system to meet the revised requirement is given by Fig.11.3. It has five subsystems beyond these in Fig. 11.2.

The problems of developing the integrated system are caused precisely by these extra subsystems. They cut across the divisional boundaries and the benefits do not accrue to one authority alone, neither is just one authority responsible for each subsystem.

The proposed data retrieval system is the sum of the individual subsystems. Anything less will fail to meet the real requirements of A.S.D. Because certain of the subsystems cut into the manufacturing divisions it is necessary to obtain their agreement, initially, and co-operation latterly, to bring about development of these subsystems. The remaining subsystems are completely within the domain of A.S.D. and can be developed at that management's discretion and subject to their sole responsibility.

There are some arguments that claim it is in the manufacturing divisions' interests to develop the retrieval system. For example, both the M.P.F. and structure file were reviewed in Chapter X and were found to be incomplete and inaccurate to some degree. For A.S.D. to use them requires extensive checking, correction and extension to be undertaken. This would remove one task from the development required to implement the proposed computer based production control routines. (See the Management Services Five Year

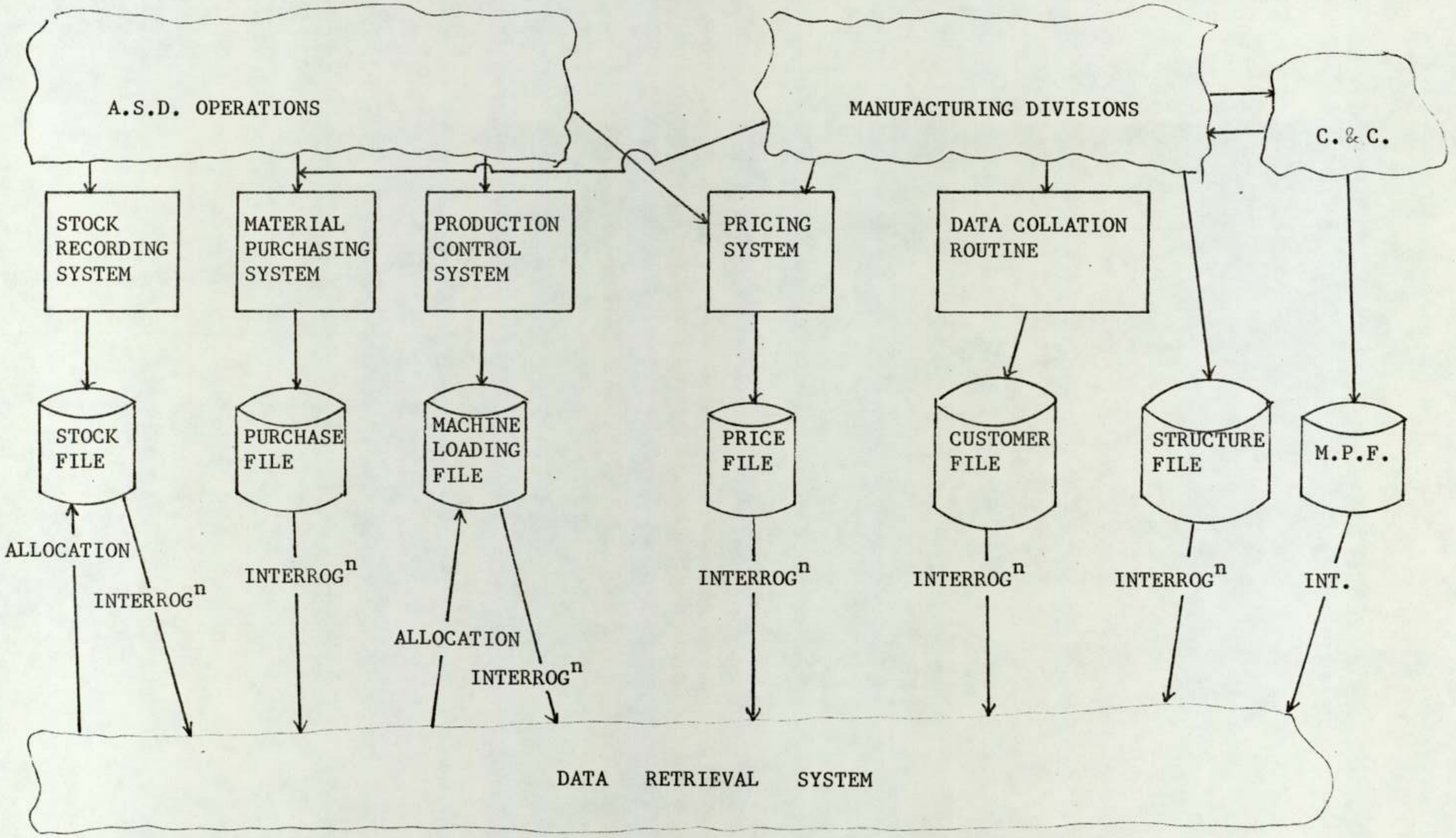


FIG. 11.3 SYSTEMS INTERACTION

Plan, Chapter VI, Section 4). Secondly, the success of A.S.D. is likely to prompt large sales of original equipment.

But the customer data, pricing and purchasing subsystems are for the exclusive benefits of A.S.D. and call for considerable involvement from the manufacturing divisions to both develop and operate. This was the major sticking point in the manufacturing divisions' rejection of the proposed retrieval system. Why should they invest staff time in creating a system whose result is to reduce their nominal turnover?

So the confrontation between A.S.D. and the divisions had come to a head. Implicit in A.S.D's case was the need for the integrated retrieval system. The divisions were equally resolute not to contribute to any scheme that assisted A.S.D. to take the profit on the sale of manufactured spares.

The road to compromise was not a clear one because the performance of the retrieval system is critically dependent upon the performance of the subsystems. Remove any element and the performance of the whole system is reduced to the speed at which the missing subsystem can be performed manually. The computer in this application is the very basis of the S.T's job and determines the rate at which they can work. By 1980 the analysis indicates, 80% of all enquiries and orders will be handled through the retrieval system. A.S.D's management need to incorporate this fact into their planning because the limiting capability of the division is now going to lie elsewhere. Further, considerable marketing capital can be made from the system. Under these circumstances the management were unwilling to compromise on exploitation of these commercial possibilities, brought about by the computer's capability.

The evidence assembled during this work points to the conclusion that the need to integrate subsystems is becoming more important. As the cost of computers falls, so the capability of equipment at a given price increases and more companies can afford a sophisticated machine.

The tendency toward the adoption of on-line facilities and database techniques (as discussed in Chapter VII) is further bringing about the need and opportunity to integrate.

Consideration of the production control routines dealt with during the first project leads to the same conclusion. The stock control, purchasing and breakdown routines were treated as isolated systems and run in batch mode, one at a time, with no communication between program suites. The suggested extension to the Nett Breakdown routine effectively integrates the stock recording and breakdown systems. The sole reason for having artificially broken up the systems in this way was to match the results to the capability of the computer. Remove that constraint and the possibility for extensive integration arises.

However, the experience of A.S.D. highlights the organisational conflict that can arise when these changes are made.

CHAPTER XII MODELLING

SUMMARY Kelly's Construct Theory is proposed as the determinant of computer usage. The consequences are discussed and alternative models of computer application are described.

SECTIONS

XII. 1 Modelling as a Principle

The period since the Second World War has seen the birth and rapid expansion of a set of analytic disciplines whose purpose is to assist management through numerical means. These disciplines include Operational Research, Econometrics and Manpower Planning. The fundamental principle of each is to generate a mathematical model of the situation under consideration and use this model to test ideas and develop an optimal course of action. Considerable benefits are obtained by these methods and sophisticated techniques have been developed to cope with ever more complex problems.

For example, over a period of [illegible] years, Forrester has extended his modelling activities from single companies through to complete world systems. (see Forrester 1975). These complex models require the support of considerable computing power and demonstrate another principle of the analytic disciplines: numerical methods can be evolved to solve problems and deal in a rigorous statistical manner with situations which could not otherwise be handled.

But mathematical models are just one element of a spectrum of models that exist as man attempts to understand his environment and the activities in which he engages.

According to Kelly (1955) the very means by which man perceives or conceives of external reality is the application of a construct system. A construct is; " a template or representational schema which the person creates and then attempts to fit over the realities of which the world is composed."

A basic assumption of this personal construct theory is that events are subject to as great a variety of constructions as our wits enable us to contrive. Consideration of this gives rise to three points:

(1) -the range corollary; " a construct is convenient for the anticipation of a finite range of events only".

(2) -the sociality corollary; " to the extent that one person construes the construction processes of another, he may play a role in a social process involving the other person."

(3) -the extent to which events can be anticipated is a measure of the success of a particular construct.

The implications of this theory for the way that computers are employed within commerce are as follows.

The computer is applied according to a person's understanding of what a computer is, and what computers do for a business. This understanding is abstracted from the sense data the person receives about computing from the outside world. Sources of this sense data might include the computer manufacturers, the person's computer advisors, published material on computer usage and his direct experience. From these elements is distilled an understanding, a personal construct, of the business computing situation which forms the basis of decision and action.

In Chapter XI the dominant characteristic of the A.S.D. data retrieval system was identified as being its integrative nature. Further, it was proposed that integration is a key factor determining the worth of future computer systems, and one which is becoming increasingly important. But the integrated system represents a very different type of system from the isolated ones which have been developed in S.H.T.

Kelly's theory suggests that the conceptual understanding of the former involves a different construct from that necessary to conceive of the latter. Since the experience of computer applications is the major determinant of the construct dictating their future use, the continued imposition of the isolated system construct is inadequate to support the consideration of an integrated system.

One source of the problems which development of integrated systems poses for S.H.T. is this mismatch of models.

XII.2 Limitations and Implications

Kelly makes the assumption that the complexity of a construct is determined by the variety of interpretation that man can apply to the received sense data. Psychological investigation has revealed that man's capability for dealing with simultaneous stimuli is tiny compared to the number of these stimuli. But the use of symbolism, in which a single symbol stands for the synthesis of a mass of detail raises man's capability for thinking to a level above that of direct operations.

Nevertheless, personal constructs are abstractions from reality and can only be considered valid to the extent to which they can be tested against reality. This supports the view that constructs are necessarily simplifications of reality. The history of science is essentially the progress of the successive iteration of this modeling and testing.

One of the deeply ingrained characteristics of Western thought is its analytic nature (see Waddington 1977). Under this scheme the understanding of an object requires the investigation of its elements. This also applies in a temporal sense, because the standard description and explanation of events requires them to be broken down into the serial, one-at-a-time narration suited to our way of thinking. It is emphasised that this analytic approach, originated by the Greeks, is entirely arbitrary and is to be contrasted with the holistic approach of systems science or

Eastern philosophy.

To illustrate the limitation intrinsic in the adoption of the analytic model the following example from nuclear physics is offered.

The search for the building blocks of the universe, the ultimate constituents of matter, continues today with governments spending millions of pounds on supporting the work. Newton's idea of the universe consisting of a number of basic entities having properties created by God and not amenable to further analysis remains an acceptable paradigm 300 years after his death. Yet with each successive discovery the particles hailed as ultimate have turned out to be composite. Despite the discovery of large numbers of subatomic and sub-nuclear particles, no end is in sight. Instead, an alternative model has arisen. The Bootstrap Hypothesis starts from the idea that there are no fundamental particles. A particle has to be viewed as a process rather than an object. With matter and energy being equivalent the universe is seen as a dynamic web of inter-related events.

None of the properties of the web is fundamental, they all follow from the properties of the other parts, and the overall consistency of their mutual interactions determines the structure of the entire web. This idea arose in the context of the S. Matrix Theory of a particular 'elementary' particle, the hadron. A hadron may be either a composite particle, a constituent particle 'within' another hadron or the exchange particle that holds the constituents together to form the composite. Under the analytic, building block model this cannot be understood. A particle cannot be part of an identical particle. The Bootstrap Hypothesis states that the whole set of hadrons is self determining - that is, each particle helps to generate other particles which in turn generate the first one. If one hadron is 'removed' the structure can no longer exist. The distinction between these two models is absolute. (For a technical description see Physics Today, Volume 23 (October, 1970) pages 23-28).

The relevance of this example is to demonstrate that man seeks explanation for events in terms of his accepted constructs, and structures his activities accordingly. It is only the mismatch of prediction and experience that forces development of a new construct.

In S.H.T. the experience of computer usage has been with isolated systems. This has given rise to a particular model of computer usage, with which any future applications will necessarily comply. Yet if one factor in the process changes, such as the capability of the computer, then the existing model is inadequate to support the application of the new machine. The range corollary of Kelly indicates that, in the same way as the analytic model of matter gives way to the bootstrap model once a certain level of experimental detail is attained, the isolated system model of computer usage needs to be supplanted by one more appropriate for handling of the new capability.

In Exhibit 1, Beer (1966) cites an example that demonstrates how the resolution of an issue is intrinsic in the mental representation adopted for that issue.

Consider a situation that is closely analogous to the development of business computing: the development of rapid communication by means of the telephone system.

During the 19th century an extensive messenger system had developed to enable businesses to communicate within and between towns in Britain. The speed with which information could be transmitted by this means imposed obvious constraints upon the manner in which business was conducted. Local situations would have to be controlled locally because it was impractical to effect continual communication with a distant head office over points that arose. When, however, the telephone system was introduced new possibilities arose. Local managers could refer any awkward points to the head office. The interval between alerting management and receiving the decision reduced by a significant factor. New types of business became possible, telephone sales and playing foreign stock markets for example. Before the telephone neither was practical, but the increase in technological capability introduced a new factor into the models that managers employed to run their business. Those that failed to adjust to the change or reckoned it would blow over, failed to

EXHIBIT 1

"Great disquiet has existed in Britain as to whether the country should join the E.E.C., or whether it should seek to create an equivalently coherent marketing system inside the British Commonwealth. Interestingly, the protagonists of both points of view each selected a model, declaring this in advance to be 'right', the language of which was competent to express only one conclusion or the other. Thus, for instance, one group declared that common marketing is possible only among nations of equivalent technological advancement. The attempt to resolve this problem in terms of that model, not surprisingly, points to an inevitable conclusion; Europe. There is, in fact, no other choice. And of course, once this model has been adopted, one cannot even express the argument that perhaps countries of in-equivalent technological advancement could very well collaborate, using the entropy of the system as measured by the technological imbalance precisely as the driving force of marketing. Conversely, the other group opted for a model based on an historical conception of Britains role in the World. Once this model is adopted, Commonwealth marketing is the only answer. It becomes impossible to even express the counter argument that a new economic bloc is emerging in a Western Europe which by definition includes Britain, for the model states as part of its own structure that Britain is not included in Western Europe. So how can anybody be so absurd as to think it should join the E.E.C. at all?"

Beer (1966)

exploit the possibilities. Individuals were forced to revise their personal constructs of business communications.

Similarly, the recent developments in computer technology have created new possibilities for computer usage beyond the isolated systems that have been the central core of industrial computing since it began. As in the case of the telephone, new avenues are available for companies to exploit. By setting up an integrated data retrieval system, A.S.D. will be able to improve its service image considerably and provide Serck with an advantage over competing organisations.

But S.H.T. is not organised to exploit the opportunity. If it had been, A.S.D. would have a computer based data retrieval system.

One reason is that the prevalent management attitude is appropriate for the earlier level of technology and the isolated systems development. It is not appropriate for the current and future computer technology where the emphasis will be on integrated systems.

XII.3 Alternative Models

The directly preceeding sections have demonstrated that whenever the application of a computer to business is being discussed, the arguments for or against any particular idea are determined by the mental models of computer usage that are being invoked. Further, the arguments are intrinsic in the model adopted.

There are two necessary aspects to any computer application model; the organisational component and the computer component. The former is the idea of the structure of the company, of the interaction of its various functions and its overall objectives. The latter is the idea of what a computer does and the sort of tasks it can perform.

The Traditional Model is the one prevalent in S.H.T. during the period of this research. It is traditional insofar as it is widely held and is based upon two well established management ideas - the functional organisation chart and the efficiency principle.

A functional organisation chart (see Fig. 8.3) breaks a business down into its elemental activities. This is a tool of simplification and its primary use is to enable responsibility to be allocated. (See Child 1977 for a discussion of organisation and its representation).

The computer component is still the first one propounded by the computer manufacturers, of a fast, data processing machine. Its advantages over manual methods are speed and accuracy.

These two elements are combined under the classic efficiency principle of scientific management introduced by F. Taylor. This states that there is an optimally efficient way to do any job and it is up to the scientific manager and his staff to find it. When presented with a batch processing computer the natural outcome of the traditional model is to automate existing practice rather than using it to execute some sophisticated decision algorithms or to do demand forecasting, both of which would be extensions to the companies current activities.

This model can be criticised on two major counts. The first is that the efficiency approach has the ever present possibility of sub-optimisation, where the performance of one subsystem is optimised at the expense of the overall system.

The second is that using the computer to automate existing practice reinforces the division between functions imposed by the analytic nature of Western thought. A prime example of this is the isolated production control packages described in Chapter IV.

Organisational Models are those whose organisation component is something other than the functional organisation chart. Typical of these is Galbraith's information processing model. (Galbraith 1973). The basic premise of this is that the organisation is a machine for making decisions. The greater the amount of task uncertainty, the greater the amount of information that has to be processed among decision makers during task execution in order to achieve a given level of performance.

This model directs the use of the computer to the information processing for decision making aspects of the company, with the efficiency model determining how the device is employed.

Because this and the other organisational models are not part of the practicing managers mental stock in trade, they have had little practical impact to date. Nevertheless, they represent an alternative to the functional organisation chart approach as a model for directing computer usage.

Corporate Models are those derived principally from econometrics with the express intension of describing the inter-relations between a company's financial, marketing and production activities.

The organisational component is functional, in line with the framework provided by Naylor (1976). However, the computer component dictates that the computer is a means for recording the mathematical relations defining the model and supporting the use of the model to forecast the outcome of combinations of events and decisions.

Whilst this application is certainly a valid one for computing, it is not yet widespread. Nevertheless, its benefits as propounded in Grinyer and Wooller (1975) are such as to make it a valuable project for the larger companies and one for which generalised packages will be evolved.

<u>The Systemic Model</u> such as that of Harrison (1974) is based upon the systemic view of organisation.

The systems approach provides a unifying concept and makes it possible to identify "basic considerations that the scientist believes must be kept in mind when thinking about the meaning of a system" (Churchman 1968).

These considerations are:-

- the total system objectives and the performance measures of the whole system
- the system's environment
- the resources of the system
- the activities of the system
- the management of the system

Using such a model the conflict between A.S.D. and the manufacturing divisions appears differently from using the functional organisational models. The question becomes one of optimising the performance of S.H.T. instead of the individual divisions and this increases the importance attached to the Service Director's claims for the importance of A.S.D's success in the market place.

This systemic model should lie, and ostensibly does lie, at the heart of the systems approaches. However, the latter have been shown to be essentially systematic rather than systemic (Chapter VII). Further, they are executed by the low level systems analysts who are in a poor position to adopt a systemic view of the organisations usually having no authority to question the system requirement against which they work.

Thus the worth of the systemic model is to the managers who define how the company is considered. That, Kelly explains, will determine where the computer will be applied. But under the divisional regime pertaining in S.H.T. the divisional managers are hardly encouraged to adopt a systemic view. Corporate considerations do not figure in the divisional model of the company.

Despite the fact that General Systems Theory has attracted considerable attention, there are significant barriers to its acceptance in industry. The experience of A.S.D's relations with the manufacturing divisions illustrates this point precisely. The Manager of Management Services as the senior computer systems person within the company is dealing with the divisions individually. The extent to which he can adopt a systemic view is demonstrated by the five year plan. It amounts to no more than a broad brush statement of policy since he lacks the authority to do anything other than advise the divisions.

If General Systems Theory was part of conventional thinking, then the Manager of Management Services would have authority beyond the divisional intrigue.

This would change the face of computing in S.H.T. and render the development of integrated systems more acceptable.

<u>The Database Model</u> is claimed to be a new approach to business computing. (See Martin 1976). However, the balance of evidence is against this claim. The basic premise of database is the collation of all the significant management and operational data into a pool from which it can be drawn as and when required. When a new selection is desired the relevant retrieval program can be written.

Three objections to this principle are as follows:

1. How are the criteria for 'significant' data derived? That

must be done according to some model of the organisation and what data it finds useful. Database itself conspicuously fails to provide such a model.

2. The data held in the pool restricts the range of retrieval programs. The database cannot be infinite, therefore the second claim is not valid, data cannot be drawn from a pool in which it is not previously included.

3. If a new application calls for the database to be extended (as is implicitly argued in the example provided by Prowse 1980) then the selection of the data to support the application, the creation of the database and the writing of the application program are directly equivalent to the design and development of an isolated file processing system. It is merely the different computing technique that makes them seem separate.

These objections do not imply that database is not a valuable technique. But they do demonstrate that its practice is not necessarily very different from isolated systems work.

<u>The Cybernetic Model</u> of organisation developed by Beer is reported in Brain of the Firm (1972).

Cybernetics is the science of communication and control and has its central tenet that all viable systems are subject to the same principles of control. Beer implies from this that a model of control derived from a study of one viable system is valid for any other. The model he proposes is drawn from a study of neurophysiology.

It comprises five basic functions:

- implementation
- co-ordination
- control
- intelligence
- policy

each of which must be present and working for the organism to be viable. (For a brief review of the functions, see Espejo and Watt, 1978).

By mapping an existing organisation onto this framework, deficiencies in any of the five functions are revealed and suitable prescriptive measures taken.

Best and Molloy (1979) conclude that there are discrepancies between the functional organisation in the nervous system, and the arrangement given in Beer's model. However, their proposed model to remedy this is offered, not as a contradiction to Beer, but as a successive approximation to the underlying system structure.

The application of Beer's model to S.H.T. identifies the lack of a system 2, the co-ordination function as being one cause of the operational problems in S.H.T. The only communication between A.S.D. and the manufacturing divisions is either at the operational level or at director level. Participants in either are in a poor position to monitor the interaction and to effect co-ordination: the former because they would be co-ordinating themselves, possibly against their self interest, and the latter because they lack the detailed information to adjudicate in every case. This lack of co-ordination manifests itself through the resentment that grew up between A.S.D. and the manufacturing divisions.

A second cause of the conflict as identified by Beer's model lies in the inadequacy of the System 3, the internal control function.

The purpose of this system is to maintain the internal stability of the company as a whole. That it fails is demonstrated by the lack of the corporate view in the discussion about A.S.D's projected move from the main site.

An important feature of Beer's model is its prescriptive nature. In this instance the 'solution' is not to set up a group of people called System 2 or System 3, whose job is to effect the interdivisional co-ordination or the corporate control. Rather, the model highlights to the existing managers the systemic nature of the company and the different roles that they are required to play, in order to maintain the viability of the company. In this way the model provides an alternative organisational construct to the traditional model, one which is intended to describe systemic matters. If the management of A.S.D. and the manufacturing divisions were to adopt Beer's model, it would provide a means of discussing the organisational problems. This forum would reveal the following solution to the difficulties of liaison. Each party needs to wear a variety of 'hats' indicating the range of their responsibilities. One such hat is certainly that of the System 5 of their own division, the role that is their present nominal function. In addition there is need to establish a system two hat which will effect the required co-ordination. In this way the model directs how the managers view their own activities and enforces a systemic stance. Certainly a divisional director is responsible for his division: but concurrently he has to be responsible for the viability of S.H.T.

Beer also proposes a model for computer usage. This too is based upon physiology and involves the measurement of indices of organisational performance. By monitoring carefully selected indices a picture of the condition and activity of the organisation is established. This is equivalent to pulse rate, blood pressure and sugar level being measures of physiological state and performance. Through appropriate statistical means, Beer suggests the elemental measures may be compounded to provide control information for each level of authority within the organisation. Espejo and Watt (1978) provide a concise review of this theory which is initially proposed in Beer (1959) and of which some applications are described in Beer (1972) and (1975).

In conclusion, Beer's cybernetic model has an organisation component more easily applicable than the alternative systemic models, such as Harrisons or Forrester's. It's computer component is radically different from that of any other model, but there is not yet any detailed reporting from which its use can be judged.

CHAPTER XIII CONCLUSIONS

SUMMARY

The conclusions derived from the practical work are presented and the general implications discussed. Specific recommendations are made for S.H.T. and suggestions for further work proposed.

SECTIONS

XIII.1. Results from the Work

The first project, of examining the production control routines within S.E.C.D., demonstrated that computer based systems developed with the techniques of conventional Systems Analysis can be inadequate.

Three separate categories of shortcoming were identified in VI.1. as:

- the analyst had produced an unworkable design
- the original system specification was too restricted
- the batch processing computer could not meet the real demands of the production control system.

The experience of doing the systems work that produced this analysis gave rise to three conclusions about the operation of systems analysis.

Conclusion 1 Management's specification of the boundaries and requirements of a project does not necessarily define a workable system.

Conclusion 2 The only people who will determine whether or not a system is workable are its users, so they must be provided with ample opportunity to test and criticise any proposed system.

<u>Conclusion 3</u> An analyst performing a systems investigation has to seek information from users of the existing system. These respondents may fail to volunteer all the information the analyst requires.

The review of how computers are used in Production Control demonstrated that the prevalent approach is to develop a software package or module, to perform a specific, restricted task. The only extent to which such systems are integrated is their sequential execution in a program suite.

For the second project, of considering a data retrieval system for A.S.D., the approach of Fig. 8.1. was adopted. This was intended to offset the detrimental effects of the conclusions listed above. The principal technique was to allow considerable opportunity for review and discussion. In XI.1. this approach is reviewed and the general conclusion is that it would have been effective in meeting its aims, had it been allowed to continue.

A direct result of the practical work in the second project was to confirm all three of the conclusions drawn from the first project. A retrieval system covering the area specified in the Service Director's initial statement of the project would have failed to improve the speed of the Sales Technicians. (See VIII.13 for detailed discussion). This point was expressed by the Sales Technicians themselves, who failed, on some items, to state precisely what their information requirement was.

One benefit of the system model as a demonstration to both users and user management was in providing a forum where criticisms of the analyst's understanding could be presented. As such, the principle of always developing a model prior to fixing the detailed system specification is offered as an important communication technique for systems analysis.

The single factor that eventually caused the second project's practical work to be abandoned was the Service Director's intention to move A.S.D. from the main S.H.T. site and change the links between A.S.D. and the manufacturing divisions. This decision significantly altered the means through which the information required for the retrieval system would be derived. The requirements themselves, as functions of the Sales Technician's job, remain constant. But the data would be derived in different ways, because the dividing line between A.S.D. and the manufacturing divisions has been revised.

Seven further conclusions for the process of Systems Analysis and Development may be drawn from the experience of the second project.

Conclusion 4 Systems Analysis takes place in a dynamic environment. Circumstances will change throughout a development project and the analyst must ensure that:

- all changes are identified and their impact on the development determined.

- an approach is followed that enables changes to be incorporated into the design of the system.

Failure to follow these will result in a static approach that produces inflexible systems that have not evolved to meet changed circumstances.

Conclusion 5 The data retrieval system for A.S.D. remote from the S.H.T. site will require all the subsystems shown in Fig. 11.3. To provide the Sales Technicians with the necessary improved level of performance the computer becomes the basis of the S.T's way of working. (See discussion of XII.2).

Conclusion 6 The principle of the previous conclusion may be generalised. As the capability of the computer increases so new methods of working become possible, based on use of a computer.

Conclusion 7 A central aspect of this progress is a tendency to move away from isolated to integrated systems. The former are the results of an approach determined by the difficulty of making early computer systems work at all. (See VII.1 for a review of these early years of business computing). Integrated systems now present less of a computer technical development problem and are essential to support the new methods of working.

Conclusion 8 This new computer capability should have an impact on corporate planning at the highest level. That A.S.D. should move from the site is a matter for strategic decision based upon the company benefits derived from the move. Effective computerised data retrieval is a determinant of divisional efficiency which the Service Director claims will result in increased sales of spares and of new heat exchangers. (See arguments of VIII.1). Therefore it must be a factor in the strategic decisions.

Conclusion 9 Where a proposed integrated system cuts across existing boundaries of the organisation, development must be based on a systemic view of that organisation. The manufacturing divisions rejected A.S.D's proposals from the standpoint of self-interest, which reflects the divisional view of S.H.T. Authorisation to develop the integrated retrieval system for A.S.D. is a super-divisional matter. (See XII.3) for analysis under Beer's cybernetic model of organisation).

Conclusion 10 The prevalent attitude of general management did not support the development of integrated systems. The divisional view is appropriate for the development of the isolated systems that constitute S.H.T's existing computer usage.

XII.2 Generalised Prescriptions

The final section of Chapter VII concluded that:

> "Systems Analysis is the means through which general business management bring about computer based systems."

In the previous section it has been argued that as the ratio of computer performance to price increases, so does the organisational impact that the machine can have.

The problem then, is to develop systems analysis so that the facilities offered by modern computing can be fully exploited.

But the evidence of XII.1 and XII.2 is that development of systems analysis itself, is only one part of the total requirement. For general business management to take advantage of computing implies:

- computing is a factor in corporate planning
- the mental model of the organisation which determines computer usage must be systemic
- the management appreciate that they do not necessarily know either the machine's capability nor the requirement of a possible system.

Enlightened systems approaches have identified the need to ascertain the objectives of the company, as well as the objectives of the particular system, when defining the scope and direction of development work. This is all intended to establish the 'real' requirements of the particular system, where 'real' connotes the overall optimisation of benefit for the company. Into this equation should be brought factors external to the immediate-system issue. However, it is apparent that in the case of S.H.T. there is no formal means whereby this can be achieved.

Systems analysts have techniques for selecting the 'best' computer from the vast spectrum of possibilities, for any given business context. However, the argument is that the context should be moulded, in part, by the capability of computing. Management Services could choose the best computer for A.S.D's data retrieval system, given that A.S.D. were to specify what the system covered. But unless A.S.D's managers find out what computing could do for the data retrieval they cannot reasonably finalise the system specification. If they do, then the accusation may be levelled that they are failing to exploit the capability of computing. Which is the purpose of the third implication listed as the start of this section.

The generalised prescription for a company intending to develop integrated systems is at three levels.

<u>Management Level</u> Managers must act according to the principle that computing is a factor in business policy. This is necessary because the capability of modern technology supports whole new business enterprises and methods of working.

A systemic view of the organisation is essential to avoid suboptimisation.

Appropriate technical computing advice must be accessed. This might be through a data processing director, or through effective use, in an advisory role, of the computing and systems staff. Intrinsic in this is the need for management to appreciate that optimal solutions in this context are derived through the conjunction of both entrepreneurial and computing skills and experience.

Systems 'Integrator' Level The need is for systems analysis to develop a new face, that of integrating agent. The purely technical systems staff operate at too low a level in the organisation to be effectively involved in the discussion with management.

A systems integrator is required to co-ordinate the decision process concerning computer usage. On one hand the management have ideas for company development, on the other the computing staff are aware of the latest technical development and possibilities. The integrator must act to bring these two factors together and ensure that the best decision results.

This role is well known and exploited in other contexts. In manufacturing firms a 'materials manager' performs an integrative function. He co-ordinates the scheduling and inventory decisions so that they are made in the best interests of the firm. If he were not present, functional departments engaged in the workflow would seek to minimise their individual costs at the expense of each other. In a large aerospace development, a project manager acts as intergrator between all the parties involved. The role is described in Maier (1967) and the characteristics of people suitable for the job are given by Ziller etal (1969). Finally the organisational benefits derived from employing integrating staff are propounded in Galbraith (1973) and Child (1977).

The Systems Development Level Integrated systems are, patently, more difficult to design and develop than isolated ones. The impact of conflicting departments has to be considered and incorporated into the final design. The experience of the two projects is that the use of a system model is an effective way of identifying the shortcomings of a system before implementation. The recommendation is that it should be adopted as a stage in the design of integrated systems.

XIII.3. Recommendations for S.H.T.

The organisation of the Management Services department and the way in which it developed systems was reviewed in Chapter VI.

In terms of the analysis just presented the role of the Manager of M.S. is a critical one. He is effectively acting as the systems integrator although that aspect of his role has not been made explicit. The systems analysts are responsible for the detail work within a project once the boundaries and specification of of that project have been defined. The M. of M.S. is responsible for determining the boundaries and specification for large projects, the chief systems designer for the smaller scale work.

However, two elements of the generalised prescription discussed in the previous section are lacking from the situation in S.H.T.

These are:

- the need for management to treat computing as an element of business policy on which they need expert advice
- the need for management to adopt a systemic view of the company.

These deficiencies have resulted in the phenomena encountered during the practical work, the failure of the company to overcome the inter-divisional conflict and to emphasise the corporate advantages of A.S.D's move above the divisional disadvantages.

The M. of M.S. operates only at the level of departmental head and as such his ability to inject the case for computing into corporate policy is limited.

This circumstance is equivalent to one described by Corfield in a recent report on product design within British industry. (Corfield 1979). His conclusion is that the product design function should be a board level responsibility. Further, it should be carried out in a multi-disciplinary way, with all the relevant functions of the business being brought to bear on the process. This latter requirement implies the first. Considerable stress is laid upon the vital role that continued education and training plays in maintaining a healthy design function within a company.

The findings of the Corfield report serve to reinforce one conclusion drawn from the practical work described in this thesis. Namely, that the development of integrated systems, like product design, requires the authority to cut across divisional boundaries. The M. of M.S. lacks this authority.

<ins>Recommendation 1</ins> A board member is appointed having both direct responsibility for, and experience of, data processing.

<ins>Recommendation 2</ins> That the role of systems integrator is isolated as an explicit function with responsibilities as outlined in the previous section.

If the latter point had been in effect during the second project, the expected result would have been to the creation of a forum where the interdivisional conflict could have been discussed. Under Beer's organisational model the system integrator plays a 'System 2' role of co-ordinating between the divisions.

Whilst the opportunity to discuss the conflict is not equivalent to its resolution, the adoption of a systemic view of the company places the conflict in perspective. This perspective is an outcome of the activity and standpoint of a system integrator.

XIII.4 Further Work

The chief limitation of the results from this research is their localised nature. The conclusions were derived from a study of a single company in a single industry.

Further work should be directed toward generalising the results across other companies in the same industry and across other industries. Scanning the situations vacant columns of a major newspaper reveals the fact that there are large companies who appoint data processing directors. It would be useful to access the experience of these companies.

A similar situation pertains with the development of integrated systems. The advent of microprocessor technology has very recently made possible integrated production control systems that were hitherto unacceptably expensive. What is the experience of companies who have implemented them and what were the development processes?

The proposed function of a systems integrator was derived from a perception of the need in S.H.T. and the ideas put forward by Maier (1967) and the other authors on integration. A formal study of findings in the other fields requiring integrators would support a more detailed exposition of the systems integrator's role. Work should be directed toward this point.

The fourth main element of future work concerns systemic models of the organisation. Beer's model is described in detail by several authors (Beer, 1972, 1974 and 1979, Espejo & Watt (1978) and extended by Best & Molloy (1979)). But a detailed report of an application of both the organisational and computing component has not yet appeared. Before the merit of the model can be ascertained it is necessary to remedy this lack.

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APPENDIX

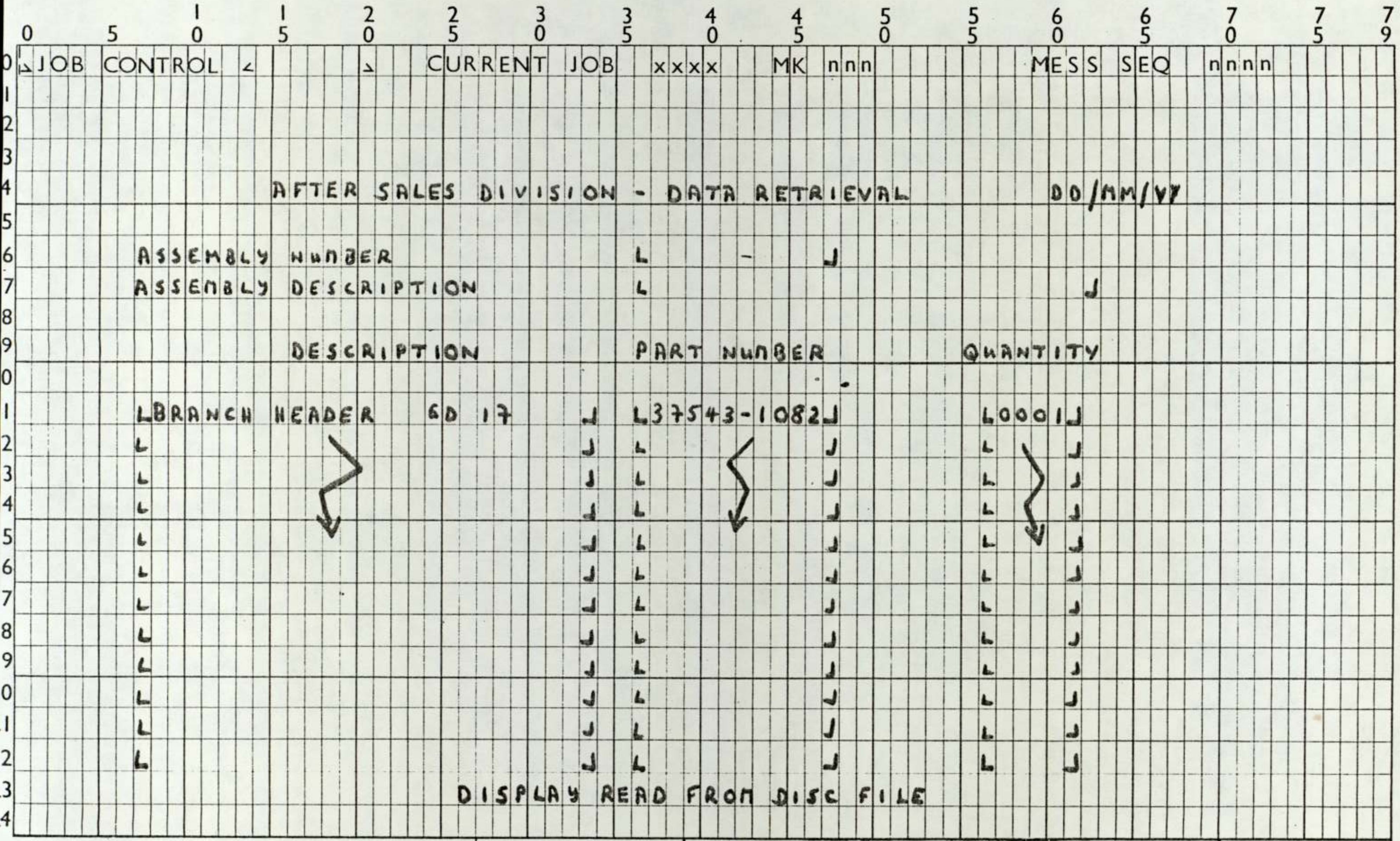
This appendix details the computer model of the ASD data retrieval system previously described in chapter IX. The three files created were the Customer, Structure and Supply files and a total of six programmes were written of which three created and maintained the files and the remainder performed the retrievals for the system user.

The design evolution ran as follows. The broad concept of using three files to contain the various categories of information was selected and the precise data to be contained on each file was finalised by drawing up video screen layout sheets. (See Figure A 1). Since these sheets contain what will finally be seen by any user great care was taken to ensure their validity and that no data items have a length exceeding that allocated on the screen. Having thus fixed the files both qualitatively and quantitatively in this manner, the precise file structure could be defined and allocated using the standard ICL software.

(12 serial numbers, 4 structures and two sub-structures and 15 price/delivery records were entered for the purposes of the model).

Now the programmes could be written and this entailed the use of the logic planning sheet shown in Figure A 2. An Applications Manager programme consists of a number of groups of parameters each specifying an action or description according to their type which can be identified by means of the initial letter of each parameter. The final set of statements, the direc-

FIGURE A. 1



```
⊿JOB CONTROL ∠      ⊿   CURRENT JOB  xxxx   MK nnn         MESS SEQ  nnnn



               AFTER SALES DIVISION - DATA RETRIEVAL        DD/MM/YY

       ASSEMBLY NUMBER              L     -    J
       ASSEMBLY DESCRIPTION         L                         J

                DESCRIPTION         PART NUMBER        QUANTITY

       LBRANCH HEADER   6D 17    J  L37543-1082J        L0001J
       L                         J  L          J        L    J
       L                         J  L          J        L    J
       L                         J  L          J        L    J
       L                         J  L          J        L    J
       L                         J  L          J        L    J
       L                         J  L          J        L    J
       L                         J  L          J        L    J
       L                         J  L          J        L    J
       L                         J  L          J        L    J
       L                         J  L          J        L    J
       L                         J  L          J        L    J
                          DISPLAY READ FROM DISC FILE
```

PARAMETER SET IDENTITY PSFI

SCREEN IDENTITY CHECK SCREEN

MAXIMUM CHARACTERS INPUT

MAXIMUM CHARACTERS OUTPUT

DATE 27/4/77

APPLICATIONS MANAGER - LOGIC PLANNING SHEET

for parameter set PSFI

LEVEL 1 LEVEL KEY 0

MAJOR CONDITION		ACTION	MINOR CONDITION
FIRST TIME	Z1	Output clear screen and initial screen.	
		Transfer 0 to line counter	
NOT FIRST TIME	Z2	Input record F1:1 from disc. Overlay with screen data Input from disc record F1:1.	
		Output clear screen and error messages.	Record Missing Z3
NOT FIRST TIME AND RECØRD FØUND.	Z5	Transfer initial value of cursor position to P3 and output "Read from disc" statement.	1st time round loop Z6
		Output cursor position and first field.	Loop counter not equal to 12 Z7
		Calculate new value of P3	Z7
		Output cursor position and second field.	Z7
		Calculate new value of P3	Z7
		Add one to line counter.	Z7
FIRST TIME	Z1	Set not first indicator.	

FIGURE A 2

tives, whose initial letter is L, contain the detail about what the programme actually does. Each programme is read through several times by the computer which performs the appropriate actions on each pass it makes through the logic. The setting out of this logic is made easier using Figure A 2 since it reduces what may appear a tangled confusion to a straightforward sequence of events. As an aid to appreciating an Applications Manager programme, the main parameter types have intiial letters X, M, F, Q, Z and L which has been mentioned. (A transcript of the programmes is included in this Appendix).

The X statements provide the headings, primarily, and can be listed from an examination of the layout sheets.

M's define what files and peripheral equipment is to be used.

F's define the inputs to the programme, so that in order for the computer to read a number the operator has just entered onto the VDU system, an F field must be defined for that number.

Similarly, the Q's provide the output statements. For the computer to write a word to a VDU an appropriate Q must be provided.

Z parameters are the conditions which are used to determine in which sequence the L directives are enacted to achieve whatever the programme is designed to achieve.

The six programmes are labelled PSON (which stands for Parameter Set ONe), PSTW (Parameter Set TWo), PSTH, PSFO, PSFI and PSSI. The first three of these are the interrogating ones whose appearance to the user has been detailed in chapter IX.

PSFO, PSFI and PSSI are the creation and maintenance programmes for the customer, structure and supply files respectively, and they work as follows.

When a programme is called up an initial screen is displayed which invites the user to enter data appropriate to the file in question. Once this is done the SEND key is pressed and the data is written away to the file, over-writing anything already there. To ensure that this process has been performed correctly, the programme thenreads the record it has just written on the file and presents the data back on the screen of the VDU. The operator then check to ensure that the data stored on the file is as he intends. This facility turned out to be very useful during the early stages of development when certain file addressing problems were encountered.

```
22/08/77 PARAMETER VALIDATION PROGRAM (#UT21 MK 803)   PARAMETERS FOR #

SEQ     < - - - - - - - - - - - - - - - - PARAMETERS - - - - - - - - - -
  1     UT23G,0,PSON,1,,,,
  2         X,1,37,AFTER SALES DIVISION - DATA RETRIEVAL,
  3         X,2,13,SERIAL NUMBER,
  4         X,3,17,ORIGINAL CUSTOMER,
  5         X,4,13,CUSTOMER CODE,
  6         X,5,13,DATE SUPPLIED,
  7         X,6,16,APPLICATION CODE,
  8         X,7,16,SIZE DESIGNATION,
  9         X,8,9,AA NUMBER,
 10         X,9,14,MATERIALS CODE,
 11         X,10,14,RECORD MISSING,
 12         X,11,1,B,                                  TO COMPARE WITH MU2
 13         X,12,11,DESCRIPTION,
 14         X,13,11,NEXT NUMBER,
 15         S,1,1,
 16         M,1,1,AV,1,                                INPUT FROM VDU
 17         M,1,2,200,
 18         M,1,20,G,                                  GRAPHIC MODE
 19         M,2,1,AV,N,                                OUTPUT TO VDU
 20         M,2,2,500,
 21         M,3,1,DA,Q,                                DISC INPUT
 22         M,3,2,29,
 23         M,3,8,ASD-CUST-FLE,
 24         M,3,9,-1,
 25         M,3,10,-1,                                 FILE VERSION NO
 26         F,1,1,F,7,7,,                              INPUT FROM VDU
 27         F,3,1,F,40,2.3,,                           DISC I/P CUSTOMER NA
 28         F,3,2,F,5,12.3,,
 29         F,3,3,F,6,14.0,,
 30         F,3,4,F,2,15.2,,
 31         F,3,5,F,9,16.0,,
 32         F,3,6,F,10,18.1,,
 33         F,3,7,F,25,20.3,,
 34         F,3,8,F,5,27.0,,
 35         G,2,1,F,37,5/15,X1,,,                      INITIAL SCREEN
 36         G,2,2,F,8,5/60,P2,,,                       INITIAL SCREEN
 37         G,2,3,F,13,9/22,X2,,,                      INITIAL SCREEN
 38         G,2,4,F,2,9/37,P54,,,                      INITIAL SCREEN
 39         G,2,5,F,2,9/45,P53,,,                      INITIAL SCREEN
 40         G,2,6,F,37,2/15,X1,,,
```

```
 39          Q,2,5,F,2,9/45,P53,,,                                INITIAL SCREEN
 40          Q,2,6,F,37,2/15,X1,,,
 41          Q,2,7,F,8,2/60,P2,,,
 42          Q,2,8,F,13,6/28,X2,,,
 43          Q,2,9,F,7,6/45,F1:1,,,
 44          Q,2,10,F,17,8/13,X3,,,
 45          Q,2,11,F,40,8/31,F3:1,,,
 46          Q,2,12,F,13,10/13,X4,,,
 47          Q,2,13,F,5,10/31,F3:2,,,
 48          Q,2,14,F,13,12/13,X5,,,
 49          Q,2,15,F,6,12/31,F3:3,,,
 50          Q,2,16,F,16,14/13,X6,,,
 51          Q,2,17,F,2,14/31,F3:4,,,
 52          Q,2,18,F,16,16/13,X7,,,
 53          Q,2,19,F,9,16/31,F3:5,,,
 54          Q,2,20,F,9,18/13,X8,,,
 55          Q,2,21,F,10,18/31,F3:6,,,
 56          Q,2,22,F,11,20/13,X12,,,




22/08/77 PARAMETER VALIDATION PROGRAM (#UT21 MK 803)   PARAMETERS FOR #

SEQ      < - - - - - - - - - - - - - - PARAMETERS - - - - - - - - - - -
 57          Q,2,23,F,25,20/31,F3:7,,,
 58          Q,2,24,F,14,22/13,X9,,,
 59          Q,2,25,F,5,22/31,F3:8,,,
 60          Q,2,26,F,11,23/41,X13,,,                           NEXT NUMBER
 61          Q,2,27,F,2,23/54,P54,,,                            NEXT NUMBER
 62          Q,2,28,F,2,23/62,P53,,,                            NEXT NUMBER
 63          Q,2,29,F,14,11/29,X10,,,                           RECORD MISSING
 64          Q,2,30,F,3,0/0,P59,,,                              CLEAR SCREEN
 65          Q,2,31,F,1,9/38,P61,,,
 66          Q,2,32,F,1,23/55,P61,,,
 67          Z,1,S1#X11,                                        FIRST ENTRY
 68          Z,2,S1=X11,                                        NOT FIRST ENTRY
 69          Z,3,M3:23=X11,                                     RECORD MISSING
 70          Z,4,M3:23#X11,                                     RECORD FOUND
 71          L,1,0,Z1,[Q,2,Q1-Q5Q31],
 72          L,1,Z2,[I,3,F1:1][Q,2,Q6-Q9Q26-Q29]Z3,
 73          L,1,Z2,[Q,2,Q6-Q28Q32]Z4,
 74          L,1,Z1,[T,S1,X11],
 75          L,1,,[Q,2,Q30],
 76          *




22/08/77 PARAMETER VALIDATION PROGRAM (#UT21 MK 803)   PARAMETERS FOR #

SEQ      < - - - - - - - - - - - - - - PARAMETERS - - - - - - - - - - -
 21          R,3,1,DA,Q,                                        DISC INPUT
```

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30/09/77 PARAMETER VALIDATION PROGRAM (#UT21 MK  803)   PARAMETERS FO

SEQ      < - - - - - - - - - - - - - - - PARAMETERS - - - - - - - -
   1     UT23G,0,PSTW,1,,,,
   2          X,1,37,AFTER SALES DIVISION - DATA RETRIEVAL,
   3          X,2,21,ASSEMBLY OR GA NUMBER,
   4          X,3,9,COMPONENT,
   5          X,4,11,PART NUMBER,
   6          X,5,8,QUANTITY,
   7          X,6,14,RECORD MISSING,
   8          X,7,1,M,
   9          X,8,11,NEXT NUMBER,
  10          N,1,13,
  11          N,2,1,
  12          N,3,900,
  13          N,4,31,
  14          N,5,33,
  15          N,6,36,
  16          S,1,1,
  17          M,1,1,AV,T,
  18          M,1,2,200,
  19          M,1,20,G,
  20          M,2,1,AV,N,
  21          M,2,2,500,
  22          M,3,1,DA,Q,
  23          M,3,2,127,
  24          M,3,8,ASD-STRUKFLE,
  25          M,3,9,-1,
  26          M,3,10,-1,                                    FILE VERSION
  27          F,1,1,F,10,7,,                                INPUT FROM VDU
  28          F,3,1,F,25,3.2,,                              ASSY DESCRIPTION
  29          F,3,2,F,25,9.3,,,
  30          F,3,3,F,10,,,
  31          F,3,4,F,4,,,                                  QUANTITY
  32          F,3,5,F,25,,,
  33          V,1,F3:2,39,12,
  34          U,1,1,F,25,0,,,
  35          U,1,2,F,10,25,,,
  36          U,1,3,F,4,35,,,
  37          Q,2,1,F,37,5/15,X1,,,                         INITIAL SCREEN
  38          Q,2,2,F,8,5/60,P2,,,                          INITIAL SCREEN
  39          Q,2,3,F,21,10/17,X2,,,                        INITIAL SCREEN
  40          Q,2,4,F,2,10/40,P54,,,                        INITIAL SCREEN
  41          Q,2,5,F,2,10/51,P53,,,                        INITIAL SCREEN
  42          Q,2,6,F,37,2/15,X1,,,                         HEADINGS
  43          Q,2,7,F,8,2/60,P2,,,                          HEADINGS
  44          Q,2,8,F,10,4/21,F1:1,,,                       HEADINGS
  45          Q,2,9,F,11,7/6,X4,,,
  46          Q,2,10,F,11,7/30,X4,,,
  47          Q,2,11,F,9,7/36,X3,,,
  48          Q,2,12,F,8,7/62,X5,,,
  49          Q,2,13,F,1,,P61,,,
  50          Q,2,14,F,10,,U1:2,,,
  51          Q,2,15,F,25,,U1:1,,,
  52          Q,2,16,F,4,,U1:3,,,
  53          Q,2,17,F,1,22/60,P61,,,
  54          Q,2,18,F,11,22/46,X8,,,
  55          Q,2,19,F,2,22/59,P54,,,
  56          Q,2,20,F,2,22/70,P53,,,


30/09/77 PARAMETER VALIDATION PROGRAM (#UT21 MK  803)   PARAMETERS FO

SEQ      < - - - - - - - - - - - - - - - PARAMETERS - - - - - - - -
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30/09/77 PARAMETER VALIDATION PROGRAM (#UT21 MK  803)    PARAMETERS FO

SEQ     < - - - - - - - - - - - - - - - - PARAMETERS - - - - - - - -
  57          Q,2,21,F,14,12/34,X6,,,
  58          Q,2,22,F,3,0/0,P59,,,
  59          Z,1,S1#X7,                                       FIRST ENTRY
  60          Z,2,S1=X7,                                       NOT FIRST ENTRY
  61          Z,3,M3:23#X7,                                    RECORD FOUND
  62          Z,4,M3:23=X7,                                    RECORD MISSING
  63          Z,5,V1<N1,                V1<13
  64          Z,6,Z2+Z3+Z5,
  65          L,1,0,Z1,[O,2,Q22Q1-Q5],
  66          L,1,Z2,[I,3,F1:1][O,2,Q22Q6-Q8Q18-Q21]Z4,
  67          L,1,Z2,[T,V1,N2]Z2[T,P3,N3][O,2,Q22Q6-Q9Q12Q13-Q20]Z3,
  68          L,1,Z6,[O,2,Q13Q14]
  69          L,1,[C,P3,P3+N4]
  70          L,1,[O,2,Q13Q15]
  71          L,1,[C,P3,P3+N5]
  72          L,1,[O,2,Q13Q16]
  73          L,1,[C,P3,P3+N6]
  74          L,1,[C,V1,V1+N2][R],
  75          L,1,Z1,[T,S1,X7],
  76          *
```

```
/11/77 PARAMETER VALIDATION PROGRAM (#UT21 MK  803)   PARAMETERS FOR #UT

0     < - - - - - - - - - - - - - - - - - PARAMETERS - - - - - - - - - - - - -
1     UT231,0,PSTH,1,,,,
2         X,1,37,AFTER SALES DIVISION - DATA RETRIEVAL;
3         X,2,11,PART NUMBER,
4         X,3,1,£,
5         X,4,2,PP,
6         X,5,11,LABOUR COST,
7         X,6,13,MATERIAL COST,
8         X,7,10,TOTAL COST,
9         X,8,11,FACTOR CODE,
10        X,9,9,LEAD TIME,
11        X,10,14,ORIGINAL EQUIP,
12        X,11,4,USER,
13        X,12,5,AGENT,
14        X,13,6,EXPORT,
15        X,14,6,COPPER,
16        X,15,4,ZINC,
17        X,16,6,NICKEL,
18        X,17,5,STOCK,
19        X,18,9,RAW STOCK,
20        X,19,14,RECORD MISSING,
21        X,20,1,M,
22        X,21,15,OVERHEAD COST,
23        X,22,6,URGENT,
24        X,23,11,NEXT NUMBER,
25        S,1,1,
26        M,1,1,AV,T,
27        M,1,2,200,
28        M,1,20,G,
29        M,2,1,AV,N,
30        M,2,2,500,
31        M,3,1,DA,Q,
32        M,3,2,33,
33        M,3,8,ASD-SPLY-FLE,
34        M,3,9,-1,
35        M,3,10,-1,                                      FILE VERSION   NUMBE
36        F,1,1,F,10,7,,                                  INPUT FROM VDU
37        F,3,1,F,25,3.2,,                                PART DESCRIPTION
38        F,3,2,F,5,9.3,,
39        F,3,3,F,5,11.0,,
40        F,3,4,F,5,12.1,,
41        F,3,5,F,5,13.2,,
42        F,3,6,F,2,14.3,,
43        F,3,7,F,2,15.1,,
44        F,3,8,F,8,15.3,,
45        F,3,9,F,8,17.3,,
46        F,3,10,F,8,19.3,,
47        F,3,11,F,8,21.3,,
48        F,3,12,F,8,23.3,,
49        F,3,13,F,6,25.3,,
50        F,3,14,F,6,27.1,,
51        F,3,15,F,6,28.3,,
52        F,3,16,F,5,30.1,,
53        F,3,17,F,5,31.2,,
54        Q,2,1,F,37,5/15,X1,,,                           INITIAL  SCREEN
55        Q,2,2,F,8,5/60,P2,,,                            INITIAL  SCREEN
56        Q,2,3,F,11,8/21,X2,,,                           INITIAL  SCREEN




/11/77 PARAMETER VALIDATION PROGRAM (#UT21 MK  803)   PARAMETERS FOR #UT

0     < - - - - - - - - - - - - - - - - - PARAMETERS - - - - - - - - - - - - -
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Q     < - - - - - - - - - - - - - - - - PARAMETERS - - - - - - - - - - -
57         Q,2,4,F,2,8/34,P54,,,                 INITIAL SCREEN
58         Q,2,5,F,2,8/45,P53,,,                 INITIAL SCREEN
59         Q,2,6,F,37,2/15,X1,,,
60         Q,2,7,F,3,2/60,P2,,,
61         Q,2,8,F,11,4/21,X2,,,
62         Q,2,9,F,10,4/34,F1:1,,,
63         Q,2,10,F,25,4/51,F3:1,,,
64         Q,2,11,F,1,6/18,X3,,,
65         Q,2,12,F,2,6/22,X4,,,
66         Q,2,13,F,11,7/0,X5,,,
67         Q,2,14,F,5,7/16,F3:2,,,               CONSTITUENT COSTS
68         Q,2,15,F,13,8/0,X6,,,                 CONSTITUENT COSTS
69         Q,2,16,F,5,8/16,F3:3,,,
70         Q,2,17,F,13,9/0,X21,,,                CONSTITUENT COSTS
71         Q,2,18,F,5,9/16,F3:4,,,
72         Q,2,19,F,10,10/0,X7,,,                CONSTITUENT COSTS
73         Q,2,20,F,5,10/16,F3:5,,,
74         Q,2,21,F,11,11/0,X8,,,
75         Q,2,22,F,2,11/19,F3:6,,,
76         Q,2,23,F,9,12/0,X9,,,
77         Q,2,24,F,2,12/19,F3:7,,,
78         Q,2,25,F,14,13/0,X10,,,               BUYER COSTS
79         Q,2,26,F,8,13/16,F3:8,,,
80         Q,2,27,F,4,14/0,X11,,,                BUYER COSTS
81         Q,2,28,F,8,14/16,F3:9,,,
82         Q,2,29,F,5,15/0,X12,,,                BUYER COSTS
83         Q,2,30,F,8,15/16,F3:10,,,
84         Q,2,31,F,6,16/0,X13,,,                BUYER COSTS
85         Q,2,32,F,8,16/16,F3:11,,,
86         Q,2,33,F,6,17/0,X22,,,                BUYER COSTS
87         Q,2,34,F,8,17/16,F3:12,,,
88         Q,2,35,F,6,18/0,X14,,,                BUYER COSTS
89         Q,2,36,F,6,18/19,F3:13,,,
0          Q,2,37,F,4,19/0,X15,,,                BUYER COSTS
1          Q,2,38,F,6,19/19,F3:14,,,
2          Q,2,39,F,6,20/0,X16,,,                BUYER COSTS
3          Q,2,40,F,6,20/19,F3:15,,,
4          Q,2,41,F,5,7/42,X17,,,                STOCK
5          Q,2,42,F,5,7/51,F3:16,,,
6          Q,2,43,F,9,9/38,X18,,,                STOCK
7          Q,2,44,F,5,9/51,F3:17,,,
8          Q,2,45,F,11,22/46,X23,,,              NEXT NUMBER
9          Q,2,46,F,2,22/59,P54,,,               NEXT NUMBER
0          Q,2,47,F,2,22/70,P53,,,               NEXT NUMBER
1          Q,2,48,F,14,9/23,X19,,,               RECORD MISSING
2          Q,2,49,F,3,0/0,P59,,,                 CLEAR SCREEN
3          Q,2,50,F,1,8/35,P61,,,                    POSITION CURSOR
4          Q,2,51,F,1,22/60,P61,,,                   POSITION CURSOR
5          Z,1,S1#X20,                           FIRST ENTRY
6          Z,2,S1=X20,                           NOT FIRST ENTRY
7          Z,3,M3:23#X20,                        RECORD FOUND
8          Z,4,M3:23=X20,                        RECORD MISSING
9          L,1,0,Z1,[0,2,Q1-Q5Q50],
0          L,1,Z2,[I,3,F1:1][0,2,Q1Q2Q45-Q48]Z4,
1          L,1,Z2,[0,2,Q6-Q47Q51]Z3,
2          L,1,Z1,[T,S1,X20],
```

```
/11/77 PARAMETER VALIDATION PROGRAM (#UT21 MK  803)   PARAMETERS FOR #UT

0      < - - - - - - - - - - - - - - - - PARAMETERS - - - - - - - - - - -
13         L,1,,[0,2,Q40],
14         *
```

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22/08/77 PARAMETER VALIDATION PROGRAM (#UT21 MK #03)   PARAMETERS FOR

SEQ      < - - - - - - - - - - - - - - - - PARAMETERS - - - - - - - - - -
  1      UT23G,0,PSF0,1,,,,,
  2          X,1,37,AFTER SALES DIVISION - DATA RETRIEVAL,
  3          X,2,13,SERIAL NUMBER,
  4          X,3,13,CUSTOMER NAME,
  5          X,4,13,CUSTOMER CODE,
  6          X,5,13,DATE SUPPLIED,
  7          X,6,16,APPLICATION CODE,
  8          X,7,11,DESIGNATION,
  9          X,8,9,GA NUMBER,
 10          X,9,14,GA DESCRIPTION,
 11          X,10,14,MATERIALS CODE,
 12          X,11,1,M,
 13          X,12,14,RECORD MISSING,
 14          X,13,31,DISPLAY READ FROM CUSTOMER FILE,
 15          N,1,33,
 16          S,1,1,
 17          M,1,1,AV,T,
 18          M,1,2,200,
 19          M,1,20,G,                                   GRAPHIC MODE
 20          M,2,1,AV,N,                                 VDU OUTPUT
 21          M,2,2,500,
 22          M,3,1,DA,A,                                 DISC FILE
 23          M,3,2,29,
 24          M,3,8,ASD-CUST-FLE,
 25          M,3,9,-1,
 26          M,3,10,-1,
 27          F,1,1,F,7,7,,                               VDU INPUTS  SERIAL
 28          F,1,2,F,40,,,                               CUSTOMER NAME
 29          F,1,3,F,5,,,                                CUSTOMER CODE
 30          F,1,4,F,6,,,                                DATE SUPPLIED
 31          F,1,5,F,2,,,                                APPLICATION CODE
 32          F,1,6,F,9,,,                                DESIGNATION
 33          F,1,7,F,10,,,                               GA NUMBER
 34          F,1,8,F,25,,,                               GA DESCRIPTION
 35          F,1,9,F,5,,,                                MATERIALS CODE
 36          F,3,1,F,40,2.3,,                            DISC INPUTS  CUSTOME
 37          F,3,2,F,5,,,                                CUSTOMER CODE
 38          F,3,3,F,6,,,                                DATE SUPPLIED
 39          F,3,4,F,2,,,                                APPLICATION CODE
 40          F,3,5,F,9,,,                                DESIGNATION
 41          F,3,6,F,10,,,                               GA NUMBER
 42          F,3,7,F,25,,,                               GA DESCRIPTION
 43          F,3,8,F,5,,,                                MATERIALS CODE
 44          Q,2,1,F,37,4/15,X1,,,                       INITIAL SCREEN
 45          Q,2,2,F,8,4/60,P2,,,                        INITIAL SCREEN
 46          Q,2,3,F,13,6/5,X2,,,                        INITIAL SCREEN
 47          Q,2,4,F,2,6/26,P54,,,                       INITIAL SCREEN
 48          Q,2,5,F,2,6/34,P53,,,                       INITIAL SCREEN
 49          Q,2,6,F,13,7/5,X3,,,                        INITIAL SCREEN
 50          Q,2,7,F,2,7/26,P54,,,                       INITIAL SCREEN
 51          Q,2,8,F,2,7/67,P53,,,                       INITIAL SCREEN
 52          Q,2,9,F,13,8/5,X4,,,                        INITIAL SCREEN
 53          Q,2,10,F,2,8/26,P54,,,                      INITIAL SCREEN
 54          Q,2,11,F,2,8/32,P53,,,
 55          Q,2,12,F,13,9/5,X5,,,                       INITIAL SCREEN
 56          Q,2,13,F,2,9/26,P54,,,                      INITIAL SCREEN
```

```
NO    <- - - - - - - - - - - - - - - PARAMETERS - - - - - - - - - - - -
 57         Q,2,14,F,2,9/33,P53,,,                  INITIAL SCREEN
 58         Q,2,15,F,16,10/5,X6,,,                  INITIAL SCREEN
 59         Q,2,16,F,2,10/26,P54,,,                 INITIAL SCREEN
 60         Q,2,17,F,2,10/29,P53,,,                 INITIAL SCREEN
 61         Q,2,18,F,11,11/5,X7,,,                  INITIAL SCREEN
 62         Q,2,19,F,2,11/26,P54,,,                 INITIAL SCREEN
 63         Q,2,20,F,2,11/36,P53,,,                 INITIAL SCREEN
 64         Q,2,21,F,9,12/5,X8,,,                   INITIAL SCREEN
 65         Q,2,22,F,2,12/26,P54,,,                 INITIAL SCREEN
 66         Q,2,23,F,2,12/37,P53,,,                 INITIAL SCREEN
 67         Q,2,24,F,14,13/5,X9,,,                  INITIAL SCREEN
 68         Q,2,25,F,2,13/26,P54,,,                 INITIAL SCREEN
 69         Q,2,26,F,2,13/52,P53,,,                 INITIAL SCREEN
 70         Q,2,27,F,14,14/5,X10,,,                 INITIAL SCREEN
 71         Q,2,28,F,2,14/26,P54,,,                 INITIAL SCREEN
 72         Q,2,29,F,2,14/32,P53,,,                 INITIAL SCREEN
 73         Q,2,30,F,7,6/27,F1:1,,,                 NUMERIC PART OF CHEC
 74         Q,2,31,F,40,7/27,F3:1,,,                NUMERIC PART OF CHEC
 75         Q,2,32,F,5,8/27,F3:2,,,                 NUMERIC PART OF CHEC
 76         Q,2,33,F,6,9/27,F3:3,,,                 NUMERIC PART OF CHEC
 77         Q,2,34,F,2,10/27,F3:4,,,                NUMERIC PART OF CHEC
 78         Q,2,35,F,9,11/27,F3:5,,,                NUMERIC PART OF CHEC
 79         Q,2,36,F,10,12/27,F3:6,,,               NUMERIC PART OF CHEC
 80         Q,2,37,F,25,13/27,F3:7,,,               NUMERIC PART OF CHEC
 81         Q,2,38,F,5,14/27,F3:8,,,                NUMERIC PART OF CHEC
 82         Q,2,39,F,31,18/21,X13,,,                DISPLAY READ FROM DI
 83         Q,2,40,F,14,12/19,X12,,,                RECORD MISSING MESSA
 84         Q,2,41,F,13,8/18,X2,,,                  RECORD MISSING MESSA
 85         Q,2,42,F,7,8/34,F1:1,,,                 RECORD MISSING MESSA
 86         Q,2,43,F,3,0/0,P59,,,                   CLEAR SCREEN CODE
 87         Q,3,1,F,4,0.0,N1,,,                     WORD COUNT
 88         Q,3,2,F,7,,F1:1,,,                      SERIAL NO
 89         Q,3,3,F,40,,F1:2,,,                     CUSTOMER NAME
 90         Q,3,4,F,5,,F1:3,,,                      CUSTOMER CODE
 91         Q,3,5,F,6,,F1:4,,,                      DATE SUPPLIED
 92         Q,3,6,F,2,,F1:5,,,                      APPLICATION CODE
 93         Q,3,7,F,9,,F1:6,,,                      DESIGNATION
 94         Q,3,8,F,10,,F1:7,,,                     GA NUMBER
 95         Q,3,9,F,25,,F1:8,,,                     GA DESCRIPTION
 96         Q,3,10,F,5,,F1:9,,,                     MATERIALS CODE
 97         Z,1,S1#X11,                             FIRST ENTRY
 98         Z,2,S1=X11,                             NOT FIRST CONDITION
 99         Z,3,M3:23=X11,                          RECORD MISSING
100         Z,4,M3:23#X11,
101         L,1,0,Z1,[O,2,Q43Q1-Q29],
102         L,1,Z2,[I,3,F1:1][O,3,Q1-Q10],
103         L,1,Z2,[I,3,F1:1][O,2,Q1Q2Q40-Q42]Z3,
104         L,1,Z2,[O,2,Q1-Q39]Z4,
105         L,1,Z1,[T,S1,X11],
106         *
```

```
SEQ    < - - - - - - - - - - - - - - - PARAMETERS - - - - - - - -
  1    UT23G,0,PSFI,1,,,,
  2        X,1,37,AFTER SALES DIVISION - DATA RETRIEVAL,
  3        X,2,15,ASSEMBLY NUMBER,
  4        X,3,20,ASSEMBLY DESCRIPTION,
  5        X,4,11,DESCRIPTION,
  6        X,5,11,PART NUMBER,
  7        X,6,8,QUANTITY,
  8        X,7,14,RECORD MISSING,
  9        X,8,1,M,
 10        X,9,27,DISPLAY READ FROM DISC FILE,
 11        X,10,1, ,
 12        X,11,1,*,
 13        X,12,14,
 14        N,1,127,
 15        N,2,1,
 16        N,3,1108,
 17        N,4,29,
 18        N,5,20,
 19        N,6,51,
 20        N,7,13,
 21        S,1,1,
 22        M,1,1,AV,1,                                   VDU INPUT
 23        M,1,2,200,
 24        M,1,20,G,
 25        M,2,1,AV,A,                                   VDU OUTPUT
 26        M,2,2,500,
 27        M,3,1,DA,A,                                   DISC FILE
 28        M,3,2,127,
 29        M,3,8,ASD-STRUKFLE,
 30        M,3,9,100,
 31        M,3,10,-1,
 32        M,3,12,100,
 33        F,1,1,F,10,7,,                                VDU INPUT    ASS
 34        F,1,2,F,25,17,,
 35        F,1,3,F,25,,,                                 DESCRIPTION
 36        F,1,4,F,10,,,                                 PART NUMBER
 37        F,1,5,F,4,,,                                  QUANTITY
 38        F,3,1,F,10,1.0,,                              DISC INPUT   ASS
 39        F,3,2,F,25,3.2,,                    ASSEMBLY DESCRIPION
 40        F,3,3,F,25,9.3,,
 41        F,3,4,F,10,,,                  PART NUMBER
 42        F,3,5,F,4,,,                                  QUANTITY
 43        F,3,6,F,25,,,
 44        V,1,F3:3,39,12,
 45        U,1,1,F,25,0,,,
 46        U,1,2,F,10,25,,,
 47        U,1,3,F,4,35,,,
 48        Q,2,1,F,37,4/15,X1,,,                         INITIAL SCREEN
 49        Q,2,2,F,8,4/60,P2,,,                          INITIAL SCREEN
 50        Q,2,3,F,15,6/8,X2,,,                          INITIAL SCREEN
 51        Q,2,4,F,2,6/36,P54,,,                         INITIAL SCREEN
 52        Q,2,5,F,2,6/47,P53,,,                         INITIAL SCREEN
 53        Q,2,6,F,20,7/8,X3,,,                          INITIAL SCREEN
 54        Q,2,7,F,2,7/36,P54,,,                         INITIAL SCREEN
 55        Q,2,8,F,2,7/62,P53,,,                         INITIAL SCREEN
 56        Q,2,9,F,11,9/16,X4,,,                         INITIAL SCREEN
```

```
22/08/77 PARAMETER VALIDATION PROGRAM (#UT21 MK  803)   PARAMETERS FOR

SEQ    < - - - - - - - - - - - - - - - PARAMETERS - - - - - - - -
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SEQ      < - - - - - - - - - - - - - - - - - PARAMETERS - - - - - - - - - - -
  57          Q,2,10,F,11,9/36,X5,,,                                INITIAL SCREEN
  58          Q,2,11,F,8,9/55,X6,,,                                 INITIAL SCREEN
  59          Q,2,12,F,2,11/7,P54,,,                                INITIAL SCREEN
  60          Q,2,13,F,2,12/7,P54,,,                                INITIAL SCREEN
  61          Q,2,14,F,2,13/7,P54,,,                                INITIAL SCREEN
  62          Q,2,15,F,2,14/7,P54,,,                                INITIAL SCREEN
  63          Q,2,16,F,2,15/7,P54,,,                                INITIAL SCREEN
  64          Q,2,17,F,2,16/7,P54,,,                                INITIAL SCREEN
  65          Q,2,18,F,2,17/7,P54,,,                                INITIAL SCREEN
  66          Q,2,19,F,2,18/7,P54,,,                                INITIAL SCREEN
  67          Q,2,20,F,2,19/7,P54,,,                                INITIAL SCREEN
  68          Q,2,21,F,2,20/7,P54,,,                                INITIAL SCREEN
  69          Q,2,22,F,2,21/7,P54,,,                                INITIAL SCREEN
  70          Q,2,23,F,2,22/7,P54,,,                                INITIAL SCREEN
  71          Q,2,24,F,2,11/33,P53,,,                               INITIAL SCREEN
  72          Q,2,25,F,2,12/33,P53,,,                               INITIAL SCREEN
  73          Q,2,26,F,2,13/33,P53,,,                               INITIAL SCREEN
  74          Q,2,27,F,2,14/33,P53,,,                               INITIAL SCREEN
  75          Q,2,28,F,2,15/33,P53,,,                               INITIAL SCREEN
  76          Q,2,29,F,2,16/33,P53,,,                               INITIAL SCREEN
  77          Q,2,30,F,2,17/33,P53,,,                               INITIAL SCREEN
  78          Q,2,31,F,2,18/33,P53,,,                               INITIAL SCREEN
  79          Q,2,32,F,2,19/33,P53,,,                               INITIAL SCREEN
  80          Q,2,33,F,2,20/33,P53,,,                               INITIAL SCREEN
  81          Q,2,34,F,2,21/33,P53,,,                               INITIAL SCREEN
  82          Q,2,35,F,2,22/33,P53,,,                               INITIAL SCREEN
  83          Q,2,36,F,2,11/36,P54,,,                               INITIAL SCREEN
  84          Q,2,37,F,2,12/36,P54,,,                               INITIAL SCREEN
  85          Q,2,38,F,2,13/36,P54,,,                               INITIAL SCREEN
  86          Q,2,39,F,2,14/36,P54,,,                               INITIAL SCREEN
  87          Q,2,40,F,2,15/36,P54,,,                               INITIAL SCREEN
  88          Q,2,41,F,2,16/36,P54,,,                               INITIAL SCREEN
  89          Q,2,42,F,2,17/36,P54,,,                               INITIAL SCREEN
  90          Q,2,43,F,2,18/36,P54,,,                               INITIAL SCREEN
  91          Q,2,44,F,2,19/36,P54,,,                               INITIAL SCREEN
  92          Q,2,45,F,2,20/36,P54,,,                               INITIAL SCREEN
  93          Q,2,46,F,2,21/36,P54,,,                               INITIAL SCREEN
  94          Q,2,47,F,2,22/36,P54,,,                               INITIAL SCREEN
  95          Q,2,48,F,2,11/47,P53,,,                               INITIAL SCREEN
  96          Q,2,49,F,2,12/47,P53,,,                               INITIAL SCREEN
  97          Q;2,50,F,2,13/47,P53,,,                               INITIAL SCREEN
  98          Q,2,51,F,2,14/47,P53,,,                               INITIAL SCREEN
  99          Q,2,52,F,2,15/47,P53,,,                               INITIAL SCREEN
 100          Q,2,53,F,2,16/47,P53,,,                               INITIAL SCREEN
 101          Q,2,54,F,2,17/47,P53,,,                               INITIAL SCREEN
 102          Q,2,55,F,2,18/47,P53,,,                               INITIAL SCREEN
 103          Q,2,56,F,2,19/47,P53,,,                               INITIAL SCREEN
 104          Q,2,57,F,2,20/47,P53,,,                               INITIAL SCREEN
 105          Q,2,58,F,2,21/47,P53,,,                               INITIAL SCREEN
 106          Q,2,59,F,2,22/47,P53,,,                               INITIAL SCREEN
 107          Q,2,60,F,2,11/56,P54,,,                               INITIAL SCREEN
 108          Q,2,61,F,2,12/56,P54,,,                               INITIAL SCREEN
 109          Q,2,62,F,2,13/56,P54,,,                               INITIAL SCREEN
 110          Q,2,63,F,2,14/56,P54,,,                               INITIAL SCREEN
 111          Q,2,64,F,2,15/56,P54,,,                               INITIAL SCREEN
 112          Q,2,65,F,2,16/56,P54,,,                               INITIAL SCREEN




22/08/77 PARAMETER VALIDATION PROGRAM (#UT21 MK  803)   PARAMETERS FOR

SEQ      < - - - - - - - - - - - - - - - - - PARAMETERS - - - - - - - - - - -
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SEQ     < - - - - - - - - - - - - - - - - - PARAMETERS - - - - - - - - - -
 113         Q,2,66,F,2,17/56,P54,,,                          INITIAL SCREEN
 114         Q,2,67,F,2,18/56,P54,,,                          INITIAL SCREEN
 115         Q,2,68,F,2,19/56,P54,,,                          INITIAL SCREEN
 116         Q,2,69,F,2,20/56,P54,,,                          INITIAL SCREEN
 117         Q,2,70,F,2,21/56,P54,,,                          INITIAL SCREEN
 118         Q,2,71,F,2,22/56,P54,,,                          INITIAL SCREEN
 119         Q,2,72,F,2,11/61,P53,,,                          INITIAL SCREEN
 120         Q,2,73,F,2,12/61,P53,,,                          INITIAL SCREEN
 121         Q,2,74,F,2,13/61,P53,,,                          INITIAL SCREEN
 122         Q,2,75,F,2,14/61,P53,,,                          INITIAL SCREEN
 123         Q,2,76,F,2,15/61,P53,,,                          INITIAL SCREEN
 124         Q,2,77,F,2,16/61,P53,,,                          INITIAL SCREEN
 125         Q,2,78,F,2,17/61,P53,,,                          INITIAL SCREEN
 126         Q,2,79,F,2,18/61,P53,,,                          INITIAL SCREEN
 127         Q,2,80,F,2,19/61,P53,,,                          INITIAL SCREEN
 128         Q,2,81,F,2,20/61,P53,,,                          INITIAL SCREEN
 129         Q,2,82,F,2,21/61,P53,,,                          INITIAL SCREEN
 130         Q,2,83,F,2,22/61,P53,,,                          INITIAL SCREEN
 131         Q,2,84,F,3,0/0,P59,,,                            CLEAR SCREEN
 132         Q,2,85,F,27,23/26,X9,,,
 133         Q,2,86,F,15,7/18,X2,,,                           RECORD MISSING
 134         Q,2,87,F,10,7/36,F1:1,,,                         RECORD MISSING
 135         Q,2,88,F,14,6/53,X7,,,
 136         Q,2,89,F,10,6/37,F3:1,,,                         NUMERIC PART OF (
 137         Q,2,90,F,25,7/37,F3:2,,,                         NUMERIC PART OF (
 138         Q,2,91,F,1,,P61,,,
 139         Q,2,92,F,25,,U1:1,,,
 140         Q,2,93,F,10,,U1:2,,,
 141         Q,2,94,F,4,,U1:3,,,
 142         Q,2,95,F,1,6/37,P61,,,                 POSITION CURSOR.
 143         Q,2,96,F,14,6/53,X12,,,
 144         Q,3,1,B,4,0.0,N1,,,                              OUTPUT TO DISC
 145         Q,3,2,F,10,,F1:1,,,                              OUTPUT TO DISC
 146         Q,3,3,F,25,,F1:2,,,                              OUTPUT TO DISC
 147         Q,3,4,F,25,,F1:3,,,                              OUTPUT TO DISC
 148         Q,3,5,F,10,,F1:4,,,                              OUTPUT TO DISC
 149         Q,3,6,F,4,,F1:5,,,                               OUTPUT TO DISC
 150         Q,3,7,F,25,,F1:3,,,                              OUTPUT TO DISC
 151         Q,3,8,F,10,,F1:4,,,                              OUTPUT TO DISC
 152         Q,3,9,F,4,,F1:5,,,                               OUTPUT TO DISC
 153         Q,3,10,F,25,,F1:3,,,                             OUTPUT TO DISC
 154         Q,3,11,F,10,,F1:4,,,                             OUTPUT TO DISC
 155         Q,3,12,F,4,,F1:5,,,                              OUTPUT TO DISC
 156         Q,3,13,F,25,,F1:3,,,                             OUTPUT TO DISC
 157         Q,3,14,F,10,,F1:4,,,                             OUTPUT TO DISC
 158         Q,3,15,F,4,,F1:5,,,                              OUTPUT TO DISC
 159         Q,3,16,F,25,,F1:3,,,                             OUTPUT TO DISC
 160         Q,3,17,F,10,,F1:4,,,                             OUTPUT TO DISC
 161         Q,3,18,F,4,,F1:5,,,                              OUTPUT TO DISC
 162         Q,3,19,F,25,,F1:3,,,                             OUTPUT TO DISC
 163         Q,3,20,F,10,,F1:4,,,                             OUTPUT TO DISC
 164         Q,3,21,F,4,,F1:5,,,                              OUTPUT TO DISC
 165         Q,3,22,F,25,,F1:3,,,                             OUTPUT TO DISC
 166         Q,3,23,F,10,,F1:4,,,                             OUTPUT TO DISC
 167         Q,3,24,F,4,,F1:5,,,                              OUTPUT TO DISC
 168         Q,3,25,F,25,,F1:3,,,                             OUTPUT TO DISC
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SEQ     < - - - - - - - - - - - - - - - - PARAMETERS - - - - - - - - - -
 169        Q,3,26,F,10,,F1:4,,,                        OUTPUT TO DISC
 170        Q,3,27,F,4,,F1:5,,,                         OUTPUT TO DISC
 171        Q,3,28,F,25,,F1:3,,,                        OUTPUT TO DISC
 172        Q,3,29,F,10,,F1:4,,,                        OUTPUT TO DISC
 173        Q,3,30,F,4,,F1:5,,,                         OUTPUT TO DISC
 174        Q,3,31,F,25,,F1:3,,,                        OUTPUT TO DISC
 175        Q,3,32,F,10,,F1:4,,,                        OUTPUT TO DISC
 176        Q,3,33,F,4,,F1:5,,,                         OUTPUT TO DISC
 177        Q,3,34,F,25,,F1:3,,,                        OUTPUT TO DISC
 178        Q,3,35,F,10,,F1:4,,,                        OUTPUT TO DISC
 179        Q,3,36,F,4,,F1:5,,,                         OUTPUT TO DISC
 180        Q,3,37,F,25,,F1:3,,,                        OUTPUT TO DISC
 181        Q,3,38,F,10,,F1:4,,,                        OUTPUT TO DISC
 182        Q,3,39,F,4,,F1:5,,,                         OUTPUT TO DISC
 183        Z,1,F1:1 = X11,                        F1 = *
 184        Z,2,S1 = X10,                          S1 = SPACE
 185        Z,3,S1 # X10,                          S1 # SPACE
 186        Z,4,F1:2 = X11,                       F2 = *
 187        Z,5,F1:2 # X11,                       F2 # *
 188        Z,6,M3:23 # X8,                       RECORD FOUND
 189        Z,7,M3:23 = X8,                       RECORD MISSING
 190        Z,8,V1 < N7,                          V1 < 13
 191        Z,9,Z3 + Z5,
 192        Z,10,Z3 + Z4,
 193        Z,11,Z3 + Z4 + Z6 +Z8,
 194        C,
 195        C,      REQUEST FOR NEW INITIAL SCREEN
 196        L,1,Q,Z1,[T,S1,X10],
 197        C,
 198        C,      OUTPUT INITIAL SCREEN
 199        C,
 200        L,1,Z2,[O,2,Q84Q1-Q83Q95],
 201        C,
 202        C,      NOT A REQUEST TO DISPLAY A RECORD
 203        C,
 204        L,1,Z9,[I,3,F1:1][O,3,Q1-Q39],  SEEK KEY AND WRITE RECORD
 205        L,1,Z9,[O,2,Q95],
 206        C,
 207        C,      REQUEST TO DISPLAY A RECORD ( FIELD 1=KEY, FIELD 2
 208        C,
 209        L,1,Z10,[I,3,F1:1]
 210        L,1,[O,2,Q102Q88]Z7         RECORD MISSING
 211        L,1,[I,V1,N2]Z6[T,P3,N3]Z6,  RECORD FOUND
 212        C,
 213        C,      OUTPUT DETAIL IF RECORD TO BE DISPLAYED IS FOUND
 214        C,
 215        L,1,Z11,[O,2,Q90Q96Q91Q92]         DESCRIPTION
 216        L,1,[C,P3,P3+N4]
 217        L,1,[O,2,Q91Q93]                PART NO.
 218        L,1,[C,P3,P3+N5]
 219        L,1,[O,2,Q91Q94]                QTY
 220        L,1,[C,P3,P3+N6]
 221        L,1,[C,V1,V1+N2][R],
 222        L,1,Z2,[T,S1,X8],
 223        *
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SEQ      <- - - - - - - - - - - - - - - PARAMETERS - - - - - - - - - -
  1      UT236,0,PSSI,1,,,,
  2          X,1,37,AFTER SALES DIVISION - DATA RETRIEVAL,
  3          X,2,11,PART NUMBER,
  4          X,3,11,LABOUR COST,
  5          X,4,13,MATERIAL COST,
  6          X,5,13,OVERHEAD COST,
  7          X,6,10,TOTAL COST,
  8          X,7,11,FACTOR CODE,
  9          X,8,9,LEAD TIME,
 10          X,9,9,O/E PRICE,
 11          X,10,10,USER PRICE,
 12          X,11,11,AGENT PRICE,
 13          X,12,12,EXPORT PRICE,
 14          X,13,12,URGENT PRICE,
 15          X,14,10,COPPER VAR,
 16          X,15,8,ZINC VAR,
 17          X,16,10,NICKEL VAR,
 18          X,17,5,STOCK,
 19          X,18,9,RAW STOCK,
 20          X,19,14,RECORD MISSING,
 21          X,20,1,M,
 22          X,21,1,£,
 23          X,22,5,WEEKS
 24          X,23,14,READ FROM FILE,
 25          X,24,11,NEXT NUMBER,
 26          N,1,33,
 27          S,1,1,
 28          M,1,1,AV,T,
 29          M,1,2,200,
 30          M,1,20,G,
 31          M,2,1,AV,N,
 32          M,2,2,500,
 33          M,3,1,DA,A,
 34          M,3,2,33,
 35          M,3,8,ASD-SPLY-FLE,
 36          M,3,9,-1,
 37          M,3,10,-1,
 38          F,1,1,F,10,7,,                                  VDU INPUTS   PART N
 39          F,1,2,F,25,,,                                   DESCRIPTION
 40          F,1,3,F,5,,,                                    LAB,MAT'L,O/H,TOTAL
 41          F,1,4,F,2,,,                                    FACTOR CODE,LEAD TI
 42          F,1,5,F,8,,,                                    PURCHASER COSTS
 43          F,1,6,F,6,,,                                    VARIANCES
 44          F,1,7,F,5,,,                                    STOCK & RAW STOCK
 45          F,3,1,F,10,1.0,,                                DISC INPUTS PART NU
 46          F,3,2,F,25,,,                                   DESCRIPTION
 47          F,3,3,F,5,,,                                    COSTS
 48          F,3,4,F,2,,,                                    FACTOR CODE LEAD TI
 49          F,3,5,F,8,,,                                    COSTS TO PURCHASER
 50          F,3,6,F,6,,,                                    VARIANCES
 51          F,3,7,F,5,,,                                    STOCK & RAW STOCK
 52          Q,2,1,F,37,4/15,X1,,,                           INITIAL SCREEN
 53          Q,2,2,F,8,4/60,P2,,,                            INITIAL SCREEN
 54          Q,2,3,F,2,6/21,P54,,,                           INITIAL SCREEN
 55          Q,2,4,F,2,6/32,P53,,,                           INITIAL SCREEN
 56          Q,2,5,F,11,6/9,X2,,,                            INITIAL SCREEN
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SEQ   < - - - - - - - - - - - - - - - PARAMETERS - - - - - - - - - - -
 57      Q,2,6,F,2,6/37,P54,,,                        INITIAL SCREEN
 58      Q,2,7,F,2,6/63,P53,,,                        INITIAL SCREEN
 59      Q,2,8,F,13,8/8,X3,,,                         INITIAL SCREEN
 60      Q,2,9,F,2,8/29,P54,,,                        INITIAL SCREEN
 61      Q,2,10,F,2,8/35,P53,,,                       INITIAL SCREEN
 62      Q,2,11,F,1,8/28,X21,,,                       INITIAL SCREEN
 63      Q,2,12,F,13,9/8,X4,,,                        INITIAL SCREEN
 64      Q,2,13,F,1,9/28,X21,,,                       INITIAL SCREEN
 65      Q,2,14,F,2,9/29,P54,,,                       INITIAL SCREEN
 66      Q,2,15,F,2,9/35,P53,,,                       INITIAL SCREEN
 67      Q,2,16,F,13,10/8,X5,,,                       INITIAL SCREEN
 68      Q,2,17,F,1,10/28,X21,,,                      INITIAL SCREEN
 69      Q,2,18,F,2,10/29,P54,,,                      INITIAL SCREEN
 70      Q,2,19,F,2,10/35,P53,,,                      INITIAL SCREEN
 71      Q,2,20,F,10,11/8,X6,,,                       INITIAL SCREEN
 72      Q,2,21,F,1,11/28,X21,,,                      INITIAL SCREEN
 73      Q,2,22,F,2,11/29,P54,,,                      INITIAL SCREEN
 74      Q,2,23,F,2,11/35,P53,,,                      INITIAL SCREEN
 75      Q,2,24,F,11,12/8,X7,,,                       INITIAL SCREEN
 76      Q,2,25,F,2,12/29,P54,,,                      INITIAL SCREEN
 77      Q,2,26,F,2,12/32,P53,,,                      INITIAL SCREEN
 78      Q,2,27,F,9,13/8,X8,,,                        INITIAL SCREEN
 79      Q,2,28,F,2,13/29,P54,,,                      INITIAL SCREEN
 80      Q,2,29,F,2,13/32,P53,,,                      INITIAL SCREEN
 81      Q,2,30,F,5,13/34,X22,,,                      INITIAL SCREEN
 82      Q,2,31,F,9,14/8,X9,,,                        INITIAL SCREEN
 83      Q,2,32,F,1,14/28,X21,,,                      INITIAL SCREEN
 84      Q,2,33,F,2,14/29,P54,,,                      INITIAL SCREEN
 85      Q,2,34,F,2,14/38,P53,,,                      INITIAL SCREEN
 86      Q,2,35,F,10,15/8,X10,,,                      INITIAL SCREEN
 87      Q,2,36,F,1,15/28,X21,,,                      INITIAL SCREEN
 88      Q,2,37,F,2,15/29,P54,,,                      INITIAL SCREEN
 89      Q,2,38,F,2,15/38,P53,,,                      INITIAL SCREEN
 90      Q,2,39,F,11,16/8,X11,,,                      INITIAL SCREEN
 91      Q,2,40,F,1,16/28,X21,,,                      INITIAL SCREEN
 92      Q,2,41,F,2,16/29,P54,,,                      INITIAL SCREEN
 93      Q,2,42,F,2,16/38,P53,,,                      INITIAL SCREEN
 94      Q,2,43,F,12,17/8,X12,,,                      INITIAL SCREEN
 95      Q,2,44,F,1,17/28,X21,,,                      INITIAL SCREEN
 96      Q,2,45,F,2,17/29,P54,,,                      INITIAL SCREEN
 97      Q,2,46,F,2,17/38,P53,,,                      INITIAL SCREEN
 98      Q,2,47,F,12,18/8,X13,,,                      INITIAL SCREEN
 99      Q,2,48,F,1,18/28,X21,,,                      INITIAL SCREEN
100      Q,2,49,F,2,18/29,P54,,,                      INITIAL SCREEN
101      Q,2,50,F,2,18/38,P53,,,                      INITIAL SCREEN
102      Q,2,51,F,10,19/8,X14,,,                      INITIAL SCREEN
103      Q,2,52,F,2,19/29,P54,,,                      INITIAL SCREEN
104      Q,2,53,F,2,19/36,P53,,,                      INITIAL SCREEN
105      Q,2,54,F,8,20/8,X15,,,                       INITIAL SCREEN
106      Q,2,55,F,2,20/29,P54,,,                      INITIAL SCREEN
107      Q,2,56,F,2,20/36,P53,,,                      INITIAL SCREEN
108      Q,2,57,F,10,21/8,X16,,,                      INITIAL SCREEN
109      Q,2,58,F,2,21/29,P54,,,                      INITIAL SCREEN
110      Q,2,59,F,2,21/36,P53,,,                      INITIAL SCREEN
111      Q,2,60,F,5,22/8,X17,,,                       INITIAL SCREEN
112      Q,2,61,F,2,22/29,P54,,,                      INITIAL SCREEN
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22/08/77 PARAMETER VALIDATION PROGRAM (#UT21 MK 803)   PARAMETERS FOR #

SEQ      < - - - - - - - - - - - - - - - PARAMETERS - - - - - - - - - - - -
 113        Q,2,62,F,2,22/35,P53,,,                       INITIAL SCREEN
 114        Q,2,63,F,9,23/8,X18,,,                        INITIAL SCREEN
 115        Q,2,64,F,2,23/29,P54,,,                       INITIAL SCREEN
 116        Q,2,65,F,2,23/35,P53,,,                       INITIAL SCREEN
 117        Q,2,66,F,3,0/0,P59,,,                         CLEAR SCREEN
 118        Q,2,67,F,14,10/26,X19,,,                      RECORD MISSING
 119        Q,2,68,F,11,13/18,X2,,,                       RECORD MISSING
 120        Q,2,69,F,10,13/34,F1:1,,,                     RECORD MISSING
 121        Q,2,70,F,14,12/50,X23,,,                      READ FROM FILE
 122        Q,2,71,F,10,6/22,F3:1,,,                      DISC INPUTS
 123        Q,2,72,F,25,6/38,F3:2,,,                      DISC INPUTS
 124        Q,2,73,F,5,8/30,F3:3,,,                       DISC INPUTS
 125        Q,2,74,F,5,9/30,F3:3,,,                       DISC INPUTS
 126        Q,2,75,F,5,10/30,F3:3,,,                      DISC INPUTS
 127        Q,2,76,F,5,11/30,F3:3,,,                      DISC INPUTS
 128        Q,2,77,F,2,12/30,F3:4,,,                      DISC INPUTS
 129        Q,2,78,F,2,13/30,F3:4,,,                      DISC INPUTS
 130        Q,2,79,F,8,14/30,F3:5,,,                      DISC INPUTS
 131        Q,2,80,F,8,15/30,F3:5,,,                      DISC INPUTS
 132        Q,2,81,F,8,16/30,F3:5,,,                      DISC INPUTS
 133        Q,2,82,F,8,17/30,F3:5,,,                      DISC INPUTS
 134        Q,2,83,F,8,18/30,F3:5,,,                      DISC INPUTS
 135        Q,2,84,F,6,19/30,F3:6,,,                      DISC INPUTS
 136        Q,2,85,F,6,20/30,F3:6,,,                      DISC INPUTS
 137        Q,2,86,F,6,21/30,F3:6,,,                      DISC INPUTS
 138        Q,2,87,F,5,22/30,F3:7,,,                      DISC INPUTS
 139        Q,2,88,F,5,23/30,F3:7,,,                      DISC INPUTS
 140        Q,2,89,F,11,23/50,X24,,,                         NEXT NUMBER FAC
 141        Q,2,90,F,2,23/62,P54,,,                          NEXT NUMBER FAC.
 142        Q,2,91,F,2,23/73,P53,,,                          NEXT NUMBER FAC
 143        Q,2,92,F,1,6/22,P61,,,                           POSITION CURSOR
 144        Q,2,93,F,1,23/63,P61,,,                          POSITION CURSOR
 145        Q,3,1,F,4,0.0,N1,,,
 146        Q,3,2,F,10,,F1:1,,,
 147        Q,3,3,F,25,,F1:2,,,
 148        Q,3,4,F,5,,F1:3,,,
 149        Q,3,5,F,5,,F1:3,,,
 150        Q,3,6,F,5,,F1:3,,,
 151        Q,3,7,F,5,,F1:3,,,
 152        Q,3,8,F,2,,F1:4,,,
 153        Q,3,9,F,2,,F1:4,,,
 154        Q,3,10,F,8,,F1:5,,,
 155        Q,3,11,F,8,,F1:5,,,
 156        Q,3,12,F,8,,F1:5,,,
 157        Q,3,13,F,8,,F1:5,,,
 158        Q,3,14,F,8,,F1:5,,,
 159        Q,3,15,F,6,,F1:6,,,
 160        Q,3,16,F,6,,F1:6,,,
 161        Q,3,17,F,6,,F1:6,,,
 162        Q,3,18,F,5,,F1:7,,,
 163        Q,3,19,F,5,,F1:7,,,
 164        Z,1,S1#X20,                                   FIRST ENTRY
 165        Z,2,S1=X20,                                   NOT FIRST CONDITION
 166        Z,3,M3:23=X20,                                RECORD MISSING
 167        Z,4,M3:23#X20,                                RECORD FOUND
 168        L,1,0,Z1,[0,2,06601-065092],
```

```
22/08/77 PARAMETER VALIDATION PROGRAM (#UT21 MK  803)   PARAMETERS FOR #

SEQ      < - - - - - - - - - - - - - - - - PARAMETERS - - - - - - - - - - - -
 169          L,1,Z2,[I,3,F1:1][0,3,Q1-Q19],
 170          L,1,Z2,[I,3,F1:1][0,2,Q1Q2Q67-Q69]Z3,
 171          L,1,Z2,[0,2,Q1-Q65Q70-Q91Q93]Z4,
 172          L,1,Z1,[T,S1,X20],
 173          L,1,,[0,2,Q66],
 174          *
```

```
2/08/77 PARAMETER VALIDATION PROGRAM (#UT21 MK  803)   PARAMETERS FOR #U

EQ      < - - - - - - - - - - - - - - - - PARAMETERS - - - - - - - - - - - -
 33          M,3,1,DA,A,
  W               ^
 35          M,3,8,ASD-SPLY-FLE,
  W               ^
0 PARAMETER ERRORS
```