COMPUTER-ASSISTED PRODUCTION SCHEDULING, PLANNING AND CONTROL IN FOUNDRIES

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SUMMARY

The present study describes a pragmatic approach to the implementation of production planning and scheduling techniques in foundries of all types and looks at the use of 'state-of-the-art' management control and information systems.

Following a review of systems for the classification of manufacturing companies, a definitive statement is made which highlights the important differences between foundries (ie. 'component makers') and other manufacturing companies (ie. 'component buyers'). An investigation of the manual procedures which are used to plan and control the manufacture of components reveals the inherent problems facing foundry production management staff, which suggests the unsuitability of many manufacturing techniques which have been applied to general engineering companies.

From the literature it was discovered that computer-assisted systems are required which are primarily 'information-based' rather than 'decision based', whilst the availability of low-cost computers and 'packaged-software' has enabled foundries to 'get their feet wet' without the financial penalties which characterized many of the early attempts at computer-assistance (ie. pre- 1980). Moreover, no evidence of a single methodology for foundry scheduling emerged from the review.

A philosophy for the development of a CAPM system is presented, which details the essential information requirements and puts forward proposals for the subsequent interactions between types of information and the sub-systems of CAPM which they support.

The work developed was oriented specifically at the functions of production planning and scheduling and introduces the concept of 'manual interaction' for effective scheduling. The techniques developed were designed to use the information which is readily available in foundries and were found to be practically successful following the implementation of the techniques into a wide variety of foundries.

The limitations of the techniques developed are subsequently discussed within the wider issues which form a CAPM system, prior to a presentation of the conclusions which can be drawn from the study.

Key Words: Foundries, Computer Aided Production Management, Micro-computer Applications, Scheduling, Production Control

Dedication

For Evelyne and David

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CHAPTER 1

1. Introduction

1.1 Attitudes and Trends

There have been indications in recent years [1,2,3,4] that the UK foundry industry is recovering from the depression years of the late 1970's/early 1980's. Indeed the outlook on a world-wide front [5,6] supports the view that the remaining parts of the foundry industry are recovering, although the extent of recovery is not yet clear.

The causal relationships between the health of the industry and various (apparently influential) factors over the last twenty years or so, have been studied and documented. The interactions between: the industry and customer requirements; technological advances in other manufacturing sectors; untimely government/EEC legislation (from a business point of view, not environmental or ergonomic); social values and the world-wide recession form the basis of many articles [4,7,8,9, 10,11,12,13,14]. Many authors admit to the complexity of such interactions and the subsequent difficulty of understanding the underlying relationships involved.

Not all parts of the foundry industry have suffered to the same extent as the ferrous castings sector [15], but the overall output of castings has been falling for many years [4,11,12,16]. Appendix 2. contains statistics showing the decline of foundries in the UK and the changes which have occurred within the pattern of employment.

Reflecting a view of the industry, by the industry, Reynolds and Stevenson [12] stated that it was at a 'crossroads' and:

"At this time (1984), the future of castings seems to lie in the balance, with great technological and economic possibilities counter-balanced by questions of productivity, labour and the environment."

Moreover, if the optimism and change in fortunes which McCombe [2] discovered in a survey of founding in the West Midlands (July, 1985), is paralleled across the U.K., then perhaps the 'balance' has begun to swing positively, in favour of the industry.

A recurring theme, especially since the late 1960's, has been the need for change, ie, a change in the way those responsible for the organisation of manufacturing, observe and act on advances in technology, and apply management techniques and organisational skills. This implied criticism suggests a lack of research into critical facets of the industry, relative to other manufacturing enterprises [17,18, 19].

In 1971, Crook [20] pointed out the necessity of re-evaluating management attitudes and techniques in marketing, production control, the environment and people (customers and employees).

However, during his address to the Institute of British Foundrymen (Edward Williams Lecture, 1975), M. Grandpierre [21] suggested that one of the problems of engineering a change of 'attitudes' was:

"... the psychological resistance to change ... from the shop floor through to higher management ..."

With more relevance to the present study, Niles [22] reported a similar problem, which he had encountered during the implementation of master scheduling systems into foundries, viz:

> "Changing the people who scheduled the foundry and the managers and foremen who used the schedule."

A year later (1984), Kennedy [11] discussed the 'people and technology interaction' problem and stated that the weakness of much of the foundry industry was due to the failure of the industry to attract and retain the 'better' engineers and applied scientists (see also Appendix 2.).

If the industry is recovering and if relative prosperity is to be the aim, then with fewer foundries, the problem is not one of securing customer orders for work. Rather, it is producing components to meet the requirements of both customer and foundry.

This widely accepted view is thought to be achievable through the adoption of modern manufacturing/organisational techniques and the application of technology. However, it is suggested that these factors alone will only be partially successful - the 'key' factor being the ability and willingness of the people concerned to 'change'.

While it is undeniably difficult for those responsible for the day-to-day management of a foundry to get involved with 'manufacturing nouveau', help is available. The main stumbling block appears to be the 'time-out' required for <u>adequate</u> training. Yet, sufficient training time/money is essential for the successful application of technology and must be granted to those involved in implementing new systems.

The use of independent consultants, especially with the aid of government grants currently available [23,24], is the most logical step forward in introducing new developments to those companies with minimal time and money budgetted for research and development, provided care is exercised in their choice [25,26,27].

Despite the problems, foundries have been involved; not only with advances in process technology (eg. Disamatic moulding lines, the 'V' process, robotics and computerised process monitoring), but also in improvements in estimating, job costing and 'methoding , together with improved organisational techniques for manufacture, made possible by the assistance of computers and associated technology [28,29].

All sources (literature, customers and foundries themselves) suggest that there is a strategic need for a UK foundry industry [2,4,12] (assuming that manufacturing in the UK as a whole, does not disappear!).

Therefore, the continued stimulation for research is essential. As other manufacturing industries (ie. those buying components from foundries) adopt advanced technology and implement modern methods of controlling their own organisations (eg. MRP, MRPII, JIT, OPT etc.) they will become increasingly 'strict' with their suppliers, especially in terms of:-

- Quality - heralded by BS 5750
- The placing of orders/schedules - as demonstrated by the motor

vehicle manufacturing industry and the ODETTE project

- Guaranteed 'on-time' deliveries
- After-sales service

1.2 The Research Structure

The present study is concerned with the management of production, or the organisation of manufacturing, with the aid of computers. Essentially it is a study of the production control function in foundries, from receipt of customer orders to despatch from the factory. Currently, this topic is attracting much study in various manufacturing sectors [30,31,32,33,34] and has acquired the formal name of Computer Aided Production Management [34]. In line with other modern terminology (eg. JIT, OPT, MRP etc.), the abbreviation 'CAPM' has become the recognised acronym for this particular field.

Specifically, the requirements for, and the applications of CAPM, within foundries (15 - 400 employees), of all types, are studied. As the title of the study suggests, particular emphasis has been placed on the production scheduling function.

Solutions to production control problems biased towards micro-computers predominate, since the foundry sector contributing to this research study has historically [35], had difficulty finding both the time and money for computer systems development. Despite this, ideas for computer-assistance have not been curtailed by having to 'think small'.

It must be stated here that the researcher regards the computer as a tool, not as a panacea and the accent is on people and technology - not on computer 'wizardry'.

As one writer stated [36]:

> "The human element in the computer-profit equation is this: Computers will never replace people - but computers will help people be more successful in making their business more profitable."

The study commences with a review of foundries and their operations, including the inherent problems facing production controllers. A study of the literature subsequently provides: evidence of the historical implementation of CAPM; a review of scheduling theory and practice, and an investigation into some of the 'packaged-software' solutions, currently available.

A suggested CAPM approach to foundry manufacturing organisation, together with a presentation of software proposals for feasible solutions to defined aspects of production control, form the basis of further chapters.

The study is completed by a discussion of the use of the software modules which have been developed during this research and subsequently installed at the participating foundries. Moreover, an examination of the areas for further research precedes the presentation of conclusions which can be drawn from the study.

CHAPTER 2

2. A Profile of Foundries and their Production Control Systems

2.1 Introduction

The current chapter is devoted to examining the foundry industry by an evaluation of the following points:

- classification of the manufacturing organisations
- types of company and corporate objectives
- approaches to production control
- factors affecting the efficiency of production control

Therefore, it prepares the foundations for the research, upon which a framework for CAPM concepts can be constructed, via the literature review. A structure for CAPM can then be developed around the proposed framework, in the ensuing chapters.

2.2 Manufacturing Environments

Several ways of classifying general manufacturing companies have been proposed in the literature [37,38,39,40] and their applicability has been discussed [41]. The approach adopted by Barber and Hollier [41] is descriptively superior to many of the other systems referenced, and serves as a useful preface to the present section.

Their approach involved a cluster analysis of the results from a survey-questionnaire on production control complexity using numerical taxonomic methods. The analysis led to the definitions of six basic groups into which companies could be categorized. The 'group 4' classification summary is quoted, in part, below:

> "This group was characterized by low product complexity and a very low level of complexity of manufacturing operations. Companies in this group manufacture a wide range of products mainly to customer order. Throughput times were short. Very few components were bought in and labour costs were the major element of product costs"

The summary, is in the author's opinion, the closest (of the six groups) to describing foundries, indeed, valve manufacturing was referenced as one of the industries surveyed.

The first sentence of the quote, however, contrasts directly with general views put forward by authors involved with foundries; that cast products are complex in terms of both production methods used and finished product requirements [42]. Whilst the latter view was stated by (mainly) foundry people on foundries, the former quote was part of an industry-wide survey, taking into account other manufacturing organisations, producing for example, aircraft, radar-equipment and machine tools.

Barber's and Hollier's approach would therefore seem acceptable in this sense, but with the following provisos:

- Some foundries can and do cast complex components, not only by size and weight, but for example, with up to ninety elements making up parts of the corework for a particular job [21,43,44]
- Superficially, organising for manufacture in foundries appears to be relatively simple. Later sections in this chapter look at the functional problems and put forward the opposite argument.

- Increased mechanisation is altering the balance of cost away from flexible labour to fixed overhead charges

The group classification above, serves to introduce batch production founding in the UK, but on a more general level it is useful to consider a second classification system (by production), developed by Burbidge [45]. The system involved the identification of three main factors affecting the complexity of production control (and hence the production method used). The third 'affecting factor' stated, was the:

> "... variety of different products, components and materials which have to be produced."

Within the 'variety' factor, three types of production system were defined:

- explosive systems
- process systems
- implosive systems

Briefly, explosive systems cover organisations whose final products can be 'exploded' down through various levels to derive sibling sub-assemblies and component parts. For example, all assembly industries - automobile, television, aircraft, etc. Process systems (in their purest form) generally combine a few materials into one mass to produce one end product (variety-wise). Process industries include the chemical, food-processing and glassmaking. Implosive systems differ from process systems because a **variety** of end products, or components 'implodes' down to one 'mass' of a raw materials mix. In this category lie foundries, and both rubber and plastics moulding companies.

Combining the two classification systems enables foundries to be placed quite accurately within manufacturing in general.

In summary; as a basic industry [2,10,13,15], foundries generally combine a few raw materials into one mass prior to casting (via several types of process) a variety of components, or 'primary products' [46]. A wide range of metal and alloy specifications are cast in an even wider range of shapes and sizes. The components are mainly made to explicit customer orders [28,47,48], with little or no assembly work involved in the final product.

Clearly, there will always be exceptions to the rule in any generalisation of this nature. Some foundries do produce both to stock and to customer order [17,49], for example, in the cast bar or tube sector. Moreover, the absence of assembly work in the end product suggests that what is conceived as a 'traditional' bill-of-materials (b-o-m) problem does not exist [17,28,46,50], although some 'assembly work' is necessary at times, for jobs requiring cores.

Despite these few exceptions, the general summary above, provides a base from which to study production control in the foundries with which the present study is concerned.

2.3 Companies and Corporate Objectives

> "Nowhere is there greater complexity and diversity in manufacturing than in the foundry industry. Here types of metal and size of casting promote wide disparity of production method."

Such a statement [13] is indicative of the problems of developing a set of production organisation procedures which can be of benefit to many types of foundry.

A particular foundry <u>may</u> specialise in one specific metal or alloy (eg. bronze, aluminium or stainless steel), but many foundries work in two or more metals/alloys, usually on one side or the other of the non-ferrous/ferrous divide. For example, aluminium and zinc, or spheroidal graphite iron and grey iron are regular combinations. Occasionally, a foundry crosses the non-ferrous/ferrous boundary and one or two notable examples cast components from all the materials listed above.

The type of metal/alloy, size, quantity and quality required determine the moulding/casting method which is most appropriate to the foundry. Figures 2.1 and 2.2 illustrate schematically, three types of mould/cast process. Figure 2.1 depicts the materials which are generally used in each of the processes, while figure 2.2 presents a general overview of the production flow through the types of foundry utilising these processes.

What is not apparent from the figures, is the extent to which the production is mechanised, semi-automated, or purely manual in nature, depending on the type of manufacture concerned (eg. jobbing, batch, repetition, continuous). Moreover, some foundries provide two or more mould/cast processes to produce castings to the various specifications required.

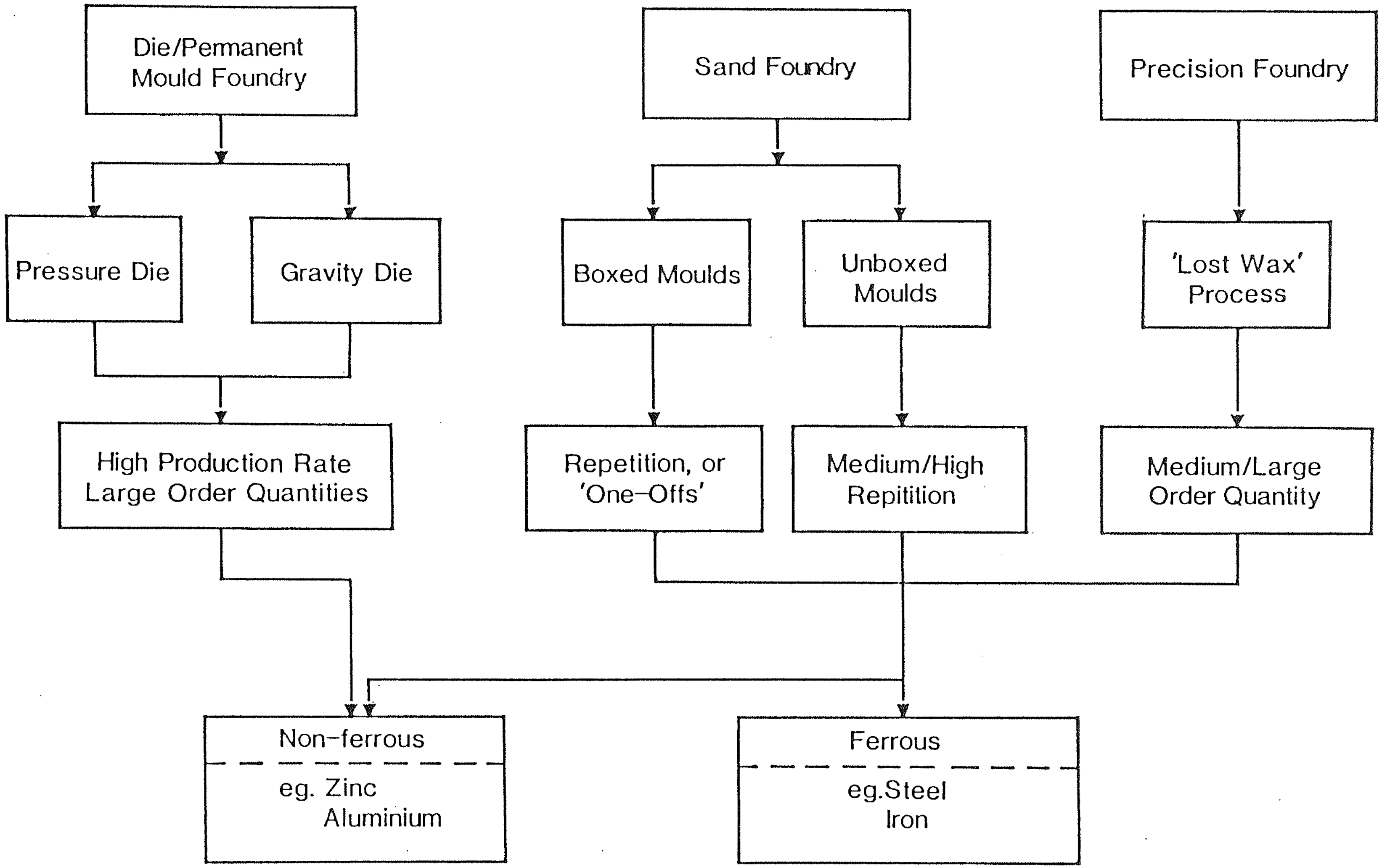
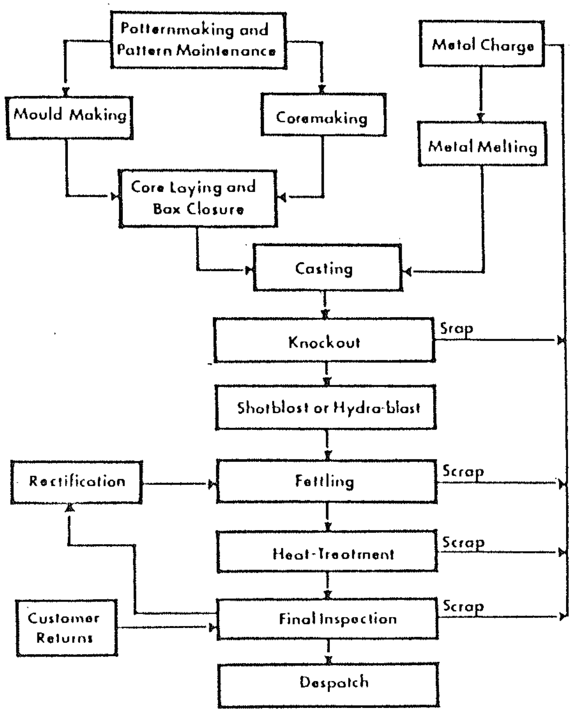
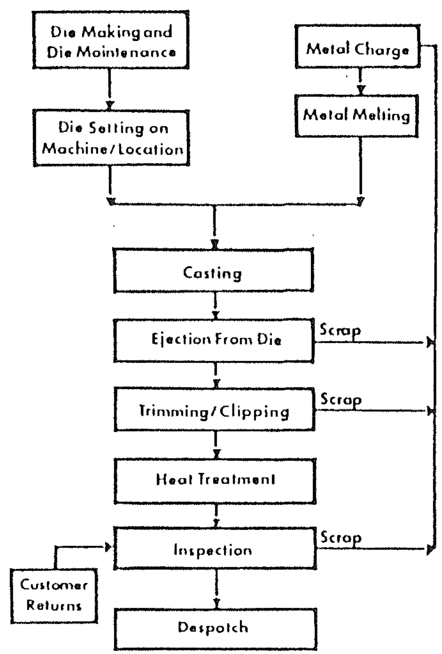


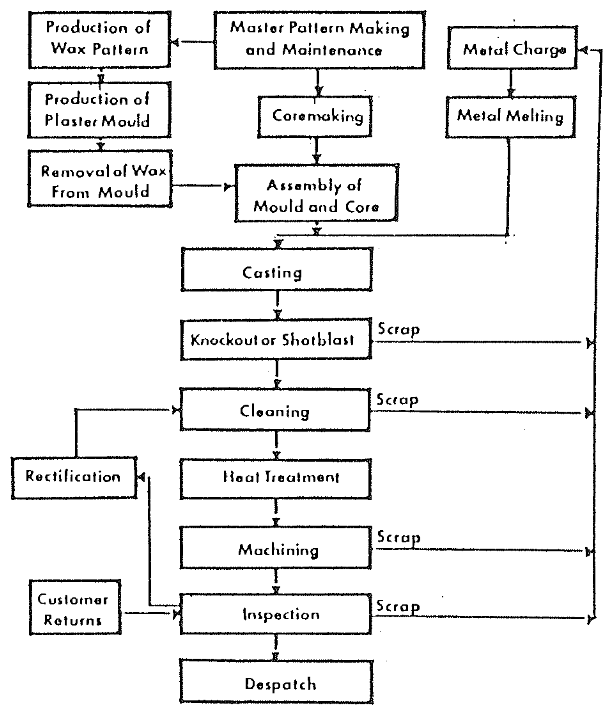
Figure 2.1 Examples of Types of Foundries by Production Method



An Example of Foundry Production Flow in a Sand Foundry



An Example of Foundry Production Flow in a Die/Permanent Mould Foundry



An Example of Foundry Production Flow in a Precision Foundry

Figure 2.2 Types of Foundry Production Flow

One way to address the problem of organising manufacture in such a diverse industry is to consider the 'similarities' of foundries, with respect to the production control function, whilst clearly acknowledging the fact that intrinsic manufacturing differences between types of foundries do exist.

Figure 2.2 illustrates three distinct areas in all foundries, which production control departments have to co-ordinate. They are:

- the pre-casting stage
- the casting stage
- the after-casting stage

The type of foundry will dictate the level of complexity at any of the given stages of manufacture. For example, a foundry casting flake and spheroidal graphite irons may simply fettle, inspect and despatch its cast components. On the other hand, a non-ferrous, gravity or pressure die-caster may offer a whole range of after-casting operations, including heat-treatment, machining, powder coating, anodising, plating and polishing, prior to inspection and despatch. And similarly, a steel foundry may offer a comprehensive, but different range of post-casting operations.

Figure 2.2 also implies the sequence-dependent movement of castings from one processing stage to another and the 'cascading' [17] effect has led to foundry production flow being described as:

"... a single direction of work flow." [48], or

"... the production line in a foundry is uni-directional." [17]

The above generalisation, from an 'ideal-world' situation, does not cover problems occurring during component production, which lead to the scrapping and re-working of jobs. For example, the 'inspect - weld-repair - grind - inspect' cycle in a steel foundry sets up what can be described as a 'production eddy' from the main production flow.

Irrespective of the type of foundry, most companies have aims to which any production control system would aspire. Ultimately, the measure of a system's worth will be in terms of these aims, or corporate objectives, which are set by the foundries' directors or by, for example:

> "... the triumvirate immediately above him (ie. Production Controller) - the Sales Manager, the Treasurer and the Plant Manager ..." [47]

Corporate objectives will vary from company to company, but most foundries would identify with some, or all of the following [21,28,51, 52,53] listed below:

- maximization of foundry profitability
- the production of quality finished castings
- satisfied customers through the on-time delivery of castings at the appropriate level of quality and in accurate quantities
- reducing customer complaints about servicing to near zero
- reducing clerical errors, especially counting errors, to zero
- reducing quality control errors on specifications and inspection requirements to zero
- order entry to be completed as soon as possible (at least

within twenty-four hours)

- customer order acknowledgements to be despatched within forty-eight hours, maximum, from receipt of order
- to free staff, especially managers, from tedious clerical work, and so enable more timely decisions

Many factors affect the success of a particular company's achievement of the objectives listed, with or without computer-assistance. An adequate return on investment will depend on a combination of the factors listed below:

- Selling price
- Volume of output
- Scrap rate
- Direct labour and material costs per unit of output
- Level of overhead expense

However, before investigating the factors affecting the efficiency of production control in foundries, it is useful to consider manual approaches to foundry production organisation with the aid of examples drawn from ferrous and non-ferrous companies.

2.4 Approaches to Production Control

The present section outlines a pattern of basic disciplines for traditional, manual approaches to production control. The procedures from the arrival of a customer's order into the production control department, to despatch from the foundry will be investigated.

Yates and Fuller [35] identify two 'extremes' between which lie most foundries' (manual) production control systems.

- "... some operate with very informal production control arrangements based on meeting the demands of customers by frequent shop floor discussion, ...
- ... while others have highly sophisticated and formal systems in which the production control department becomes the nerve centre of the organisation."

Yet the literature supports the view that there is a commonality of approach to organisation and procedures and in the problems encountered [48,54,55]. Therefore, for the purposes of investigation, the activities within the production control sphere can be discussed under the following headings:

- Order processing
- Forward Planning
- Detailed Plant Scheduling
- Shop-floor documentation and monitoring of work in progress
- Management reports/analysis of foundry performance

2.4.1 Order Processing

Prior to the production of jobs a foundry has to decide which jobs to make. Most foundries work to explicit customer orders, which may be either schedules, calling for periodic quantities of a recurring job (batch production), or one-off orders for a specific quantity (jobbing work). A third type of order pattern involves the semi-continuous or continuous production of running lines [17,28,52,56]. Many foundries work to more than one type of order pattern in their areas of specialisation.

Where several types of castings are covered by one order form, the sales department normally allocate an 'internal works order number' enabling separate identification of each order item. For example, one works order number may cover the whole customer order, but the addition of 'item numbers' to each job on the order provides a unique identification code.

All jobs require process planning and cost estimate documents. These can exist as combined, or separate documents and vary in the amount of information they provide. The process planning details may simply be methods instruction sheets, or 'castings history cards' [48], containing some, or all of the following:

- Customer name (and number)
- Part (or pattern or die) number
- Names of personnel with previous experience of the job
- Material specification
- Description
- Poured weight/casting weight
- Lead-time or Average make period
- Core (or insert) requirements
- Likely scrap weight (or scrap percentage)
- Moulding or casting output rate information
- Number of castings per mould (or shots per die)

- Required after-casting operations/monitoring stages
- Cost and selling price
- Pattern status
- Standard and actual timing data for operations
- etc

Each time a new customer order is received, foundries have a new design specification to work to; the estimation and quotation work for which, is normally required in a matter of days rather than weeks. The information held on previous, but similar jobs (as defined by various classification techniques), can be used as 'reference' data, together with calculated and empirical data to assess the manufacturing requirements.

Some foundries also produce detailed 'route-cards' which list the operations in sequence, together with instructions, for each work station involved in the production of the job. The cards usually detail 'standard quantity' information, that is, the resource quantity used, in the respective units, for each operation. Lead-times (usually in days or weeks) for each operation are normally held on the route-cards, when known.

Notification of incoming work to the production control department is in the form of several documents relating to the production of the job, accumulated and subsequently transferred from sales (usually). The pre -production department order processing activities can take from hours to days, from the arrival of the customer order; depending on the size of the foundry, the responsibility of its employees and the nature of the work. Nevertheless, all work received by the production control department should be

" ... completely defined and cleared for production ..." [47]

Official order acceptance procedures vary from foundry to foundry. For example, a foundry may hold a daily meeting between, for example, the works director, the quality control manager and the estimating manager to decide whether the customer order can be produced in a period acceptable to both the customer and the foundry. In all cases, to fulfil customer orders, the production of new, or repeat jobs has to be co-ordinated with:

i) existing jobs (some of which will already be in production), customer returns, re-works, re-issues for scrapped jobs and relevant finished stock supplies (for repeat jobs)

ii) the procurement of materials, patterns, cores (or 'inserts' for permanent-moulders)

iii) the requirements of the foundry (corporate

iv) the requirements of the customer (eg. delivery date and the relative importance of the customer to the foundry).

Such information is derived partly from formal procedures and partly from 'informal' knowledge. The evaluation of i), above, will determine whether incoming jobs can be started (ie. cast) and delivered on time.

Traditionally the amount and type of manufacturing capacity that jobs require is calculated at the moulding stage in sand foundries and at the casting stage in die foundries (ie. at the capital intensive process stage). Thus, after the gross capacity requirements for incoming jobs have been determined (in the resource units used by the foundry), they can then be viewed with respect to the existing work-load, which is allocated to a foundry's regular production periods (usually a week in length). Based on the above technique, the customer delivery date requirements can be 'vetted' (see also Trinder and Watts [48]).

The formal procedure above, can be contrasted with the informal knowledge about a customer, or the availability of suitable labour normally retained mentally), which are additional, essential parameters in the evaluation 'equation'.

Via the above procedures, if a particular order is not accepted (ie. it is incompatible with either customer requirements or foundry management policy) then alternatives are suggested and re-evaluated until a compromise, or order rejection results. Once the orders are approved for production, the production controller assigns one, or more dates (see below for examples).

- casting date
- pattern inspection date
- delivery date

Providing that all jobs have been defined properly, realistic sample and production delivery dates can also be assigned for jobs which are being estimated.

At some point just before, or just after the above procedure, the raising of 'customer order acknowledgement' documents occurs. The responsibility for this procedure falls to the sales or production control department, depending on the traditional practices of the foundry.

The size of foundry, the sophistication of their production control practices and the requirements of customers' orders, will also determine the amount of works documentation which is subsequently produced. Where a large number of documents are produced for each customer order, some foundries have semi-automated the documentation production task, using masking/duplicating machines. For example, one exacting, steel repetition foundry produces a minimum of fourteen documents per customer order, so that all relevant departments are kept informed.

The production of works documentation leads to the planning, programming and scheduling functions, which are necessary stages in co-ordinating the parameters listed above. Most foundries (should) carry out these procedures, but do so in practice to different levels of complexity and effectiveness.

2.4.2 Forward Planning

The data obtained from the procedures above, which is supplied to the planners in a variety of forms (eg. Gantt charts, planning boards, lists), enables the 'forward planning' of jobs over a finite time period (or 'planning horizon') extending into the foundry's future.

Using purely manual methods, forward planning is normally restricted to identifying each of the jobs planned for moulding or casting in successive time periods (weekly, sometimes fortnightly), even though many foundries recognise the need to calculate the load on other major production sections (eg. coremaking). At this stage, the planner has to cope with both jobs that are awaiting resources (eg. raw materials) and jobs that can be started with the currently available resources, possibly within the same time period. The former category of jobs cannot be ordered into the shop until a confirmation procedure has been invoked, indicating that the jobs can go 'live'. For example, notification from the pattern department that the required patterns have been procured.

The allocation of jobs to individual time periods constitutes one part of the forward planning function, however. The use of the information provided on the documentation and empirical knowledge about the job, the foundry and the customer, assists the planner in 'balancing' jobs over the various workstations. Given the clerical capacity, future potential 'bottle-necks' can be avoided, together with the other extreme of under-utilization of workstations: although any course of action leading to the achievement of a balanced work-load (by, for example, combining orders to form economic batch sizes, or to optimize the use of the melting facilities or labour), will be conducted within the corporate policies of the foundry.

Communication with other departments (eg. sales) may also assist in balancing the future work loads on the foundry. The planner knows the impending work-load over a given planning horizon and therefore can highlight potential 'lulls' which are forthcoming on particular workstations. Moreover, communication allows realistic decisions to be made concerning the uptake of 'rush' or 'asap' jobs.

Three other potential benefits should be obtained from forward planning. The raw material requirements, for jobs which have been planned, facilitates the calculation of forward metal loads, which in turn allows purchasing to co-ordinate the arrival of raw materials with planned production dates.

The highlighting of 'overdues' (ie. orders that have passed the due-date for either production or delivery) is another essential pre-requisite to foundry operation. Such information allows the planner to 'work-in' the outstanding jobs as foundry capacity dictates.

A third benefit is the pin-pointing of recurring trouble spots. For example, if a particular section is continuously a source of bottleneck trouble, then changing the layout of existing plant may contribute to an improvement in production flow.

2.4.3 Detailed Plant Scheduling

Forward planning ('long-term planning') requirements are subsequently converted into 'short-term' plans, (shop schedules, or work-to-lists) which relate the forward load calculations with appropriate shop-floor documentation.

The forward load for a particular period is communicated to the foundry, usually a few days in advance of the period-start-date. It may consist of a list of the appropriate jobs, sorted by section or metal type, or may simply be the manufacturing instruction cards for each job, or a combination of both. In drawing up the short-term plan, the planner will have analyzed the job requirements, including any scrap allowances on the various production resources and any stocks of cores/inserts which may be available.

Two detailed scheduling stages are normally identified in foundries. Scheduling of the moulding or casting sections and scheduling of the after-casting operations. Short-term scheduling of the moulding or casting stage consists of extracting from the forward load, a list of jobs for individual workers or sections to work to. The detailed schedule is passed to shop-floor supervision (eg. a foreman), who has the responsibility for organising the period's work on a day-to-day basis, although in some foundries exact instructions from the planning department are sent to foundry supervision on a daily basis. Several factors are taken into account prior to the selection of jobs. For example:

- shortcomings from previous days
- day-to-day demands from the production control department, requesting priority treatment for particular jobs identified as necessary by progressing activities
- production efficiency considerations, such as the hourly usage of metal (melting facility utilisation)
- pattern/die changes coinciding with meal breaks/shift changes
- balancing the load on the core-shops (sand foundries)

- matching up of small quantity jobs to ensure adequate mould utilisation
- to allocate jobs to individual casters (die foundries) so a full programme of work remains for all personnel throughout the period.

Much of the data associated with the points above is normally retained mentally by the foreman.

The second detailed scheduling stage is usually performed by the foreman and involves the scheduling of the after-casting operations. Given a number of jobs awaiting work at a particular work station, the foreman has to decide which of the jobs to tackle next. Such decisions are based on job priority (signified by due-date), supplemented by requests from progress personnel, sales and customers. In general, little documentation accompanies the after-casting scheduling tasks.

A current short-term schedule should be amended as often as is necessary, during the period, to take into account the work done and deviations from the schedule. Those foundries with sufficient clerical resources may advocate a daily issue of the schedule over say a four to five day period, rather than a weekly one to cover the whole period.

Forward and short term plans dictate the foundry's proposed production commitments and therefore should be communicated to other departments (in an appropriate format), for example, to production and sales managers and to purchasing.

2.4.4 Shop-floor Documentation and Monitoring of work-in-progress

The media for issuing instructions to the shop varies from foundry to foundry. Instructions may be raised on cards, at the documentation production stage, with each relevant card bearing the title of the department or section it is to inform. Such cards would then be posted to the relevant departments informing personnel of the imminent arrival of jobs and the action to be taken.

Instructions may also be produced on route-cards which 'travel' around the foundry with the job - each section obtaining the required information from the appropriate part of the document. Various foundries employ both methods and sometimes a combination of both exists in a given foundry.

On the other hand, small foundries may operate mainly by word of mouth and use one document to inform several departments. For example, where cores are not specifically planned, the timely production of a moulding schedule provides forewarning to the core-shops of the job requirements. Similarly, the fettling shop is informed by the same document of what they can expect to receive.

Other departments need forewarning of jobs which are imminent. In a sand foundry, the pattern shop needs time to check on the availability of patterns and core boxes, so that the co-ordination of effort to bring the two resources together at the moulding stage is not hindered.

Shop instructions have another important role: that of informing the foundry which job is being produced. As much information as is required to avoid ambiguity between jobs should be included, taken from a combination of the following (listed below):

- pattern number
- works internal reference
- customer name
- description

Each day, individual operators, section foremen or progress chasers report the production or days achievements. Work-booking documents exist in many forms (see fig. 2.3 for an example of a 'heat-sheet'); indeed one ultimate use for the shop-floor instruction sheets, described earlier, could be as the basis for returning production information from the shop-floor. Where separate documents are used, the three basic sets, most commonly in use, are those listed below:

- time-sheets, heat-sheets or job tickets (production department), listing the jobs that have been tackled
- inspection records, indicating good and scrap components (with reasons) against each job
- despatch returns, identifying the jobs which have been despatched.

In many sand foundries, the number of time sheets involved is one. That is, a 'heat-sheet', recording the production from the mould/cast monitoring stage. In contrast, die or precision foundries may monitor at 'tooling available', 'cast', 'fettle', 'heat-treat' and 'sub-contract' stages.

The ability to report and record incidences of batch-splitting, for the

Form No. 11

HEAT SHEET

Observer	Weight Table		T.	C	Q.	Metal	Heat No.
	Tapped	E	5	500		4/40	E 376
		B	4	500			B 2109 (2)
Entered on P.C. Record	Waste	E		500		Code	Plant Ref.
		B	1	500			[illegible]
	Net Poured	E	5	000		No. of Ladles	Date
		B	4	000		2	27/10/82

Tackle	Moulder	Order			Cast			Scrap			Casting Weight Kilos		
		Description	Number	Item	Boxes	Per Box	Total	Boxes	Total	Code	Unit	Total	
Floor		Press Bottom											
		A 23228	22227	10	1	1	1				5775		F.S.
[illegible]		Loco Cover											
		A 23297	22227	12	1	1	1				51		—

Total Scrap	Total Cast

Figure 2.3 Example Of A Heat-Sheet

re-working of jobs, or the economic utilization of resources is essential in any foundry work-booking system.

Inspection records show the jobs that have been passed as good production, those that require re-working and those that are to be scrapped, (together with appropriate reasons).

Despatch returns are frequently made up of 'multi-part' documents. After despatching a job, copies of the despatch document ('advice note') are sent to foundry departments and also the customer.

All work-booking sheets are normally routed through the production control department, prior to being sent to various commercial departments. Production clerks extract the relevant information from all three categories of sheet, enabling the work-in-progress file, or work's order cards to be updated as the various production stages required for the job are monitored. The work-in-progress file and its subsequent maintenance is one of the most essential control features of any production organisation system. It also provides quick response times to customer enquiries about their jobs, the status of which enables the production controller to estimate the production time remaining prior to job completion.

Another important feature of work-in-progress tracking is the provision of 'historical' data. Many foundries require the facility to be able to record the transactions that have occurred during a job's production sequence. The provision of historical records and their subsequent analysis allows feedback and control of the various aspects of job production to be monitored. Moreover, recent quality requirements, applied to foundries, as to other component makers (eg. BS 5750), have greatly increased the need for the latter type of conformation.

2.4.5 Management Reports and Analysis of Foundry Performance

The information which is derived from the work-booking sheets can be compared to the original production plans in order to highlight areas where opportunities exist for improvement; for example, in the areas of existing production procedures and plant layout. Providing the clerical capacity is available, a performance analysis of a foundry's practice can be achieved, normally by the drawing up of management reports. The reports may cover areas such as those listed below:

- the percentage of on-time deliveries (and overdue margins)
- outstanding jobs, grouped by customer and required date
- evaluation of the work-in-progress
- scrap analysis by reason codes
- periodic stock (finished and unfinished) level checks

Management reports containing summary information in particular groupings, or sorted formats, are another essential output when processing the data acquired from the shop-floor.

Some approaches to manual production control methods in foundries have been stated. Use has been made of section headings to describe the 'sequence of events' in progressing a job through a foundry from the receipt of a customer order, to despatch from the foundry. It is worth remembering, however, that while many foundries will identify with the procedures outlined, the exact order of execution of such procedures will vary, as will the detail to which the planning and scheduling functions are carried out. Moreover, it is common to find departments 'overlapping' in their responsibilities.

Many factors affect the successful practice of production control in foundries and this subject forms the basis of the next section.

2.5 Factors affecting Production Control

The overview to manual approaches to production control which has been presented, reveals an industry that has apparently fewer complications in its production organisation procedures than are found in other manufacturing organisations. For example, jobs are mainly made to specific customer orders obviating the need for forecasting future sales.

A corollary to making to order is that stocks of finished components tend not to be held; similarly, the scarcity of 'bought-out' components contributing to the finished product suggests that a formal inventory management system, with its associated data-processing requirements, is not generally applicable. Moreover, a single-level product structure denies a traditional b-o-m requirement and corresponding 'parts explosion'.

Taking these factors into account, together with the absence of a firm master production schedule suggests the redundancy of techniques such as 'Material Requirements Planning' (MRP).

A closer study of foundry practice, however, contradicts the above implied 'simplicity'.

2.5.1 Order Processing Problems

By definition, foundries that 'make-to-order' rely on customers to place orders with them. However, irrespective of how efficient the sales department is, the arrival of orders cannot be reliably predicted and therefore little control can be exercised on the pattern of jobs arriving at the foundry (especially in jobbing foundries). Nevertheless, the influx of customer orders and their acceptance does form the basis for future load determination, production and delivery service promises and cost profiles, over a given foundry's planning horizon.

Job-costing is a vital pre-cursory activity to the acceptance, or otherwise, of customers' orders since realistic pricing is essential to the profitable existence of the foundry. And whilst the subject of job-costing is not one of primary concern to the present study, ultimately, the production control department has the responsibility of producing the required products within pre-defined cost limits. Therefore, some of the factors influencing its activities are listed below [57,58,59]:

- Materials that go into a casting normally are not requisitioned or purchased for specific jobs.
- In some sectors of the industry, far more material must be made

ready and poured, as a rule, than is afterwards present in the finished product.

- When a casting is poured, labour and overheads required for the melt, pour and shakeout cannot usually be charged to a specific customer.
- The cost of down-time on the moulding plant, or variation in the amount of metal required to fill individual moulding boxes.
- In some areas of the castings industry (eg. steel), more than half of the total cost can be accrued after the casting has been poured.

Repeat jobs have still to be assessed, as a result of increases in energy and raw materials costs, labour and rates.

'Variety' may be the spice of life, but in the context of production control, the larger the variety of end products, the more complex the control system required. The 'product mix' (i.e. size, weight and shape of components and the material used) is not unique to foundries, but few industries experience the same diverse requirements for end products as (especially) the jobbing and repetition sectors of the foundry industry.

A further complicating factor is that of order quantity (or 'end-product volume'). In general, manufacturers who make high volumes-to-stock are able to create programmes for scheduling 'jobs' onto work-centres so as to make efficient use of their resources by allowing long production 'runs'.

The points above illustrate one category of factors influencing the efficiency of a production control system, ie, those that exist as a result of the nature of the industry. A second category consists of factors which reflect the limitations of manual procedures. In the former case, the lack of success in applying 'standard package' solutions, developed for general assembly-type manufacturing, is evidence of the inherent differences of foundry practice; whilst many foundry managers would agree that the major advantage of a manual system is that it is initially cheap to install.

A common limitation that has been levelled at manual paperwork systems is that their successful application depends on key personnel and to some extent on the ability of these personnel to memorize pertinent facts. The complete understanding of the system is limited to a few persons which makes the system vulnerable to staff changes [48,49,79]. The 'miracle worker' is a frequently met (and potentially dangerous) phenomenon in foundries.

2.5.2 Shop-Floor Planning and Control Problems

One of the key roles in any foundry is performed by the person (or persons) responsible for the forward planning and detailed scheduling of work, within the imposed timing restrictions. With the clerical methods available, the forward loading in terms of manpower and equipment availability is restricted to examining the demand level from the customers and translating this into a weekly manufacturing programme for the moulding or casting facilities. Furthermore, the difficulty of assessing the effect of forward loading on the foundry as a whole, particularly between processes which are measured in different resource units, may lead to bottle-neck situations at various processing sections within the foundry.

Similarly, detailed scheduling and re-scheduling activities are frequently based on decisions concerning only part of the total manufacturing processes involved. This is due in part to the time required and the complexity of performing manual calculations to optimize the many criteria, especially where there is a lack of accurate 'timing' data.

Several other factors hinder the forward planning and detailed scheduling functions (extending sometimes into the actual production of jobs). For example: the integration of 'overdue' jobs into the production plans so as to cause the least disturbance to section loads which have already been balanced; the inclusion of 'rush orders'; the 'yield' factor which has to be taken into account when determining the required quantities from particular processes, and disruptions produced by changes in customer demands. These include amendments to the original order quantity, delivery-date revision, specification re-evaluation or even cancellation of the entire order. It is often not possible for a foundry to take a firm stance against this type of activity, particularly if the customer is the recipient of a large percentage of the annual output.

The production of jobs to a given programme (or schedule) is also subject to change especially if the procedures for ordering work into the foundry are informal. They include procedures which allow salesmen to push:

"... particular 'pet' orders to the top of the list ..." [28], customers to expedite their own jobs and the detrimental effect of poorly designed incentive schemes, by which foundry employees are paid. In addition, variable production capacity of foundry sections, due to absenteeism and breakdowns, necessitates essential alterations to current production programmes.

2.5.3 Information Transfer Problems

Foundries which produce complex castings (in terms of the core-work involved) are clearly aware of the problems of co-ordinating the core-requirements per job, with the existing work-load on the core-shop, to ensure that sufficient stocks of cores are available at the job moulding stage. In such cases, the identification of all the core elements is desirable if not practically feasible, by existing manual methods.

With coremaking, as with other subsequent processing sections, it is not sufficient for a production control system to schedule work onto the appropriate sections. The reporting back of information relating to the job, in terms of quantity of good components produced, the scrap quantities and the reasons for scrapping, are essential, if any form of control is to be exercised. The limited (sometimes very) shelf-life of cores merely exaggerates the difficulties.

Poor feed-back from the shop-floor stems from inaccuracies of data capture; usually the miscounting of quantities of components passing through the monitoring stages and the failure to associate the components produced with the identification codes adopted by the foundry.

Normally, the shop-floor recognises the part or pattern number to which the job belongs. However, where there exist similar jobs, designated under a similar code number, it is not unusual to find that the wrong code number has been transmitted back to the production control department. Another problem is that time-sheets are sent back with only half of the code number on them. The production clerk then has the task of establishing the correct code identification before booking the work into the work-in-progress file.

A further task for the production clerk is the relating of work to a particular customer order, especially if there are several orders for the part in question, although the problem can be overcome, to some extent, by the design and accuracy of the works documentation. Tracing 'split-batches' complicates the work-booking task further, especially when irate customers are demanding to know the whereabouts of their order.

The use of data which has been fed-back from the shop-floor, in conjunction with existing job and methoding details forms the basis of management reports, normally prepared on a weekly basis. However, the clerical effort required precludes the provision of anything other than limited management information, presented in the form of long lists or tabulations. Thus, the manager has the task of sorting out the important from the trivial, prior to taking decisions.

The above points complete the background introduction to foundries. Their place within general manufacturing has been discussed and the diversity of the industry, together with corporate objectives, have been examined.

Some approaches to production control (manual procedures) have been considered and many of the factors affecting the organisation for production have been investigated. However, no attempt has been made to indicate how individual foundries have manually resolved the conflicts of interest between themselves and their customers, or their intrinsic problems in controlling production.

CHAPTER 3

3. CAPM Philosophy and its Application to Foundries

3.1 Introduction

Background literature has already been referenced during the course of introducing the present study. The main purpose of the research, as defined by the title of the study, commences with the following investigation/review.

CAPM is a composite subject, existing as several interacting sub-systems. To illustrate this point, figure 3.1 shows the functions of CAPM within general manufacturing, proposed by Corke [30]. The sub-systems of CAPM required within the foundry environment (described in section 2.2) are somewhat different to those employed in general manufacturing and figure 3.2 represents an equivalent, interdependent set of CAPM functions, which are considered to be fundamental to the organisation of foundry manufacturing.

The differences between the two CAPM systems begins with how both types of industry answer the manufacturing question of 'what to make and when'. For example, greater emphasis is placed on the function of sales forecasting by companies whose modus operandi is more suited to the interaction of the sub-systems represented by figure 3.1 (ie. engineering companies which, in general, assemble component parts to stock). These companies use various forecasting techniques in conjunction with existing sales orders to produce a master schedule - from which the outstanding material (and component) needs can be computed.

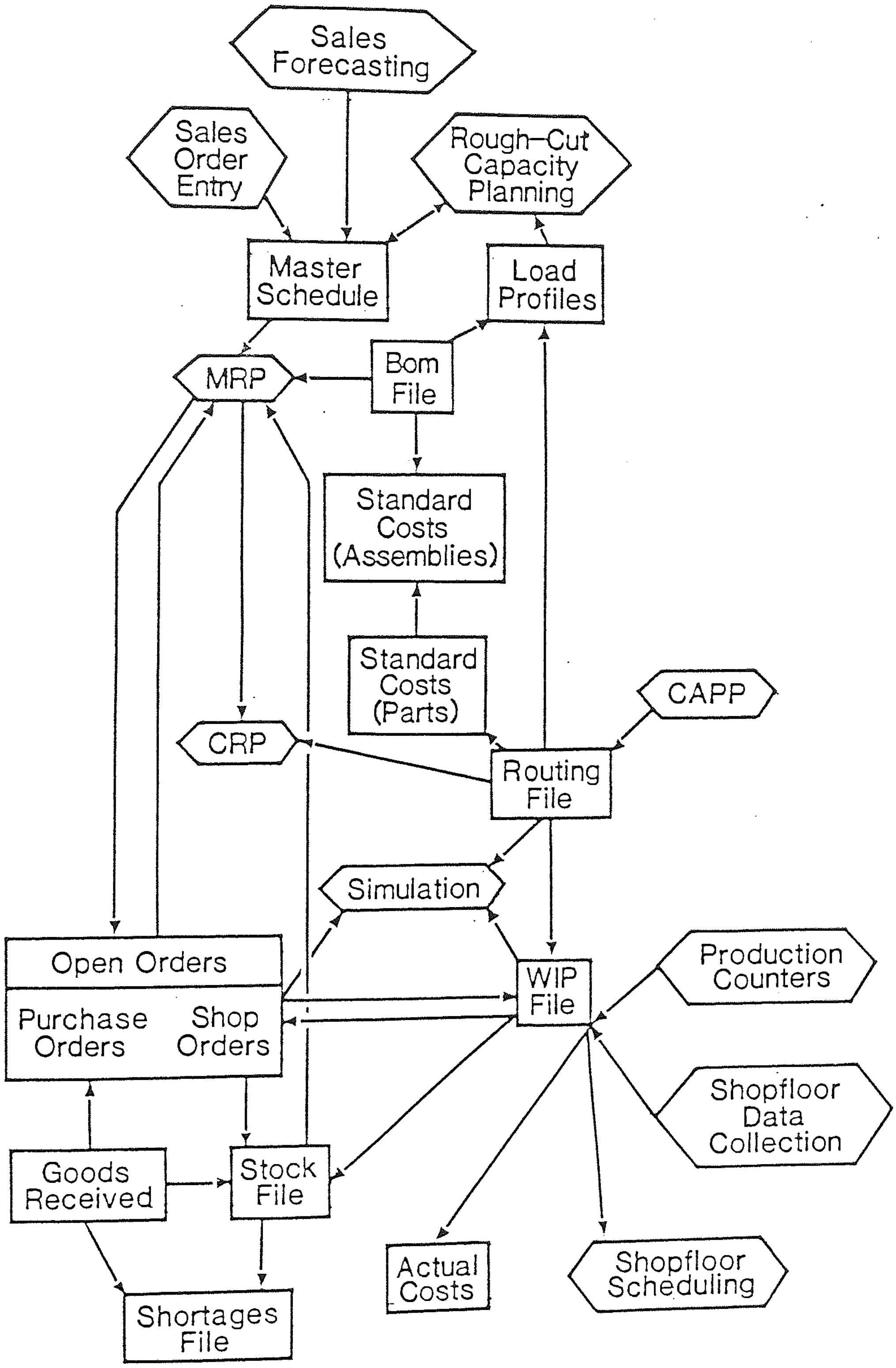


Figure 3.1 Functions Within CAPM

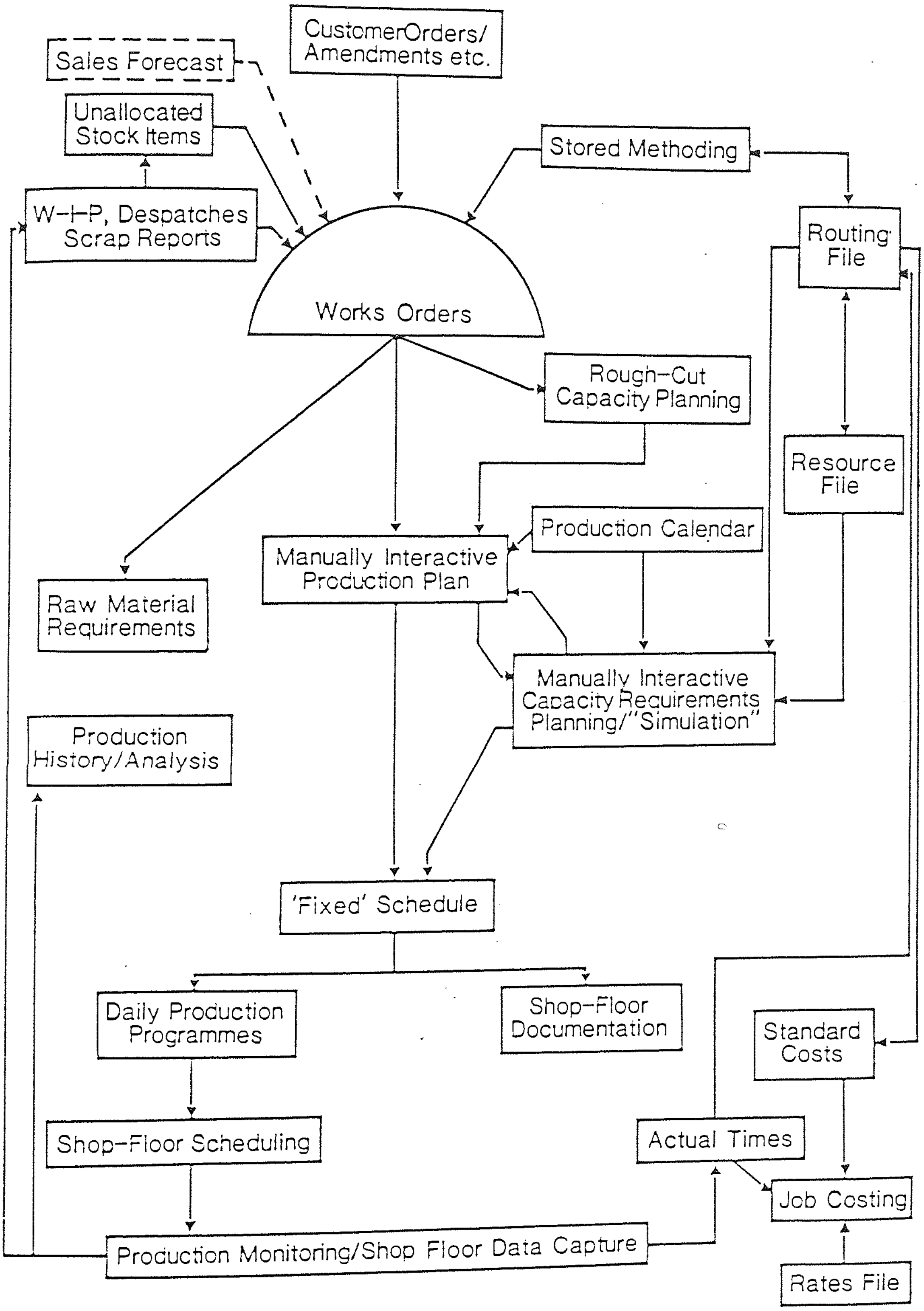


Figure 3.2 Functions Within CAPM Required by Foundries

The master schedule can be evaluated, in material terms, by an application of the widely publicized technique of material requirements planning (MRP), which produces a time-phased plan of 'how much is required of what, and by when'. Purchase orders for items which are to be 'bought out' and shop orders for items which can be made 'in-house', can then be raised.

Ultimately, the combination of manufactured items and purchased materials and components are processed and assembled into the final product. However, a highly efficient stock control system is required to co-ordinate the movement of materials and components into and out of the works. Figure 3.1 illustrates the 'closed-loop' activity surrounding the stock file in order to achieve a high level of inventory management efficiency.

In contrast, whilst few foundries manufacture components for stock, the majority of foundries do experience continually changinging demands for components (section 2.5). As a result, the production of a master schedule is impracticable and therefore they must work from the most 'up-to-date' version of the works order book, to enable an accurate analysis of the outstanding raw materials requirements.

Raw materials are foundries only 'bought out' items, in terms of the final component (other purchased items may include, for example, chills and exothermic sleeves). Consequently, foundry purchasing is normally limited to a small range of alloys, which precludes the need for an extensive stock control sub-system - a fact which is conveyed by figure 3.2.

The only realistic way to assimilate the literature relating to CAPM in foundries is to group the various aspects of the subject under a series of 'broad headings', rather than try to cover the whole research area at once. Such an approach is adopted here. A relative comparison of writers' opinions is then possible, within the context of the work presented in the current study.

3.2 Subjects for Review

The major categories which evolved from reviewing the literature are as shown in figure 3.3.

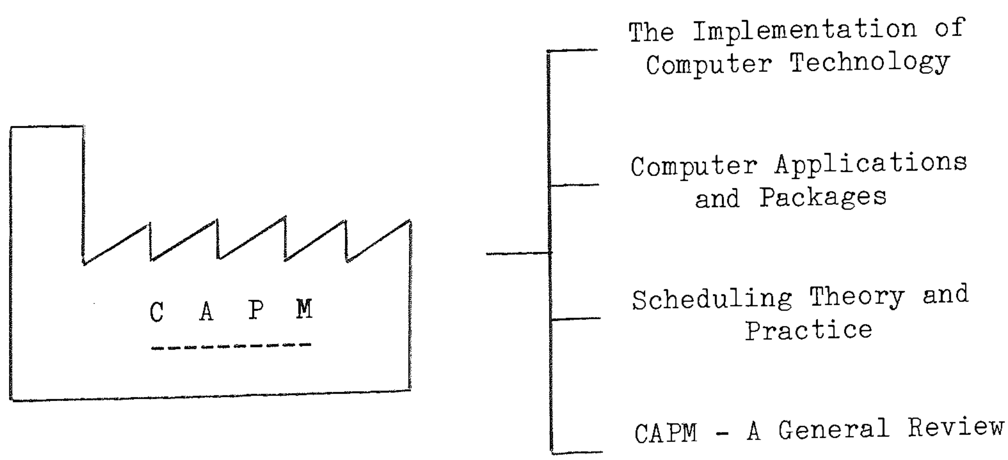


Figure 3.3 The Literature Classified

The first of the categories investigates the implementation of computer technology, historically, in the foundry industry and reviews the choices which face the potential 'system-buyer'.

The second category details the applications which have been developed for foundry use. These include references from 'case-studies', describing how individual foundry's have 'done it' and an examination of some of the commercially available packages - which provide evidence of why some of the accepted CAPM techniques for general manufacturing are of little use to foundries.

The subject of scheduling forms the basis of the third category, in which a theoretical introduction is followed by a review of the practice of foundry scheduling, as described by the literature.

Whilst scheduling is perceived to have a vitally important role within foundry CAPM systems, the literature reveals that few foundry practitioners in the UK have experienced the benefits to be gained from operating a scheduling 'tool'; the reasons for the lack of success in implementing scheduling packages are investigated in section 3.3. In addition, it is suggested that a generally applicable scheduling function must be designed with inherent 'flexibility', to enable several different combinations of criteria to be examined and to be sufficiently responsive to the type of manufacturing environment which exists within the foundry industry.

The latter category overviews the extent to which CAPM has been adopted by industry in general, through the use of several surveys/reports.

3.3 The Literature Reviewed

3.3.1 The Implementation of Computer-Assistance

Computer-assisted production control in foundries or, to be more exact, the historical development of computer-assistance, is the subject under review. The picture that emerges is that CAPM was not generally available for small to medium-sized foundries until the advent of the microcomputer as a business tool.

The assumption that a degree of computer-assistance was (and is) required by most foundries is overwhelmingly supported by the literature [19,42,49,50,51,54,57,60,61,62,63].

3.3.1.1 Early Developments in CAPM

To illustrate the development of CAPM in foundries, it is useful to consider some of the conclusions of one of the earliest surveys of computer technology in the foundry industry, conducted in the United States by Knight [18], in 1967, viz:

i. very few foundries have a reliable base of data which can be used to develop operating and administrative systems.

ii. the majority of the work done was in the administrative area, with computer applications being information and/or accounting oriented.

iii. the cost of developing and implementing a 'system' was prohibitive for most foundries with less than 500 employees

iv. either each foundry 'does it alone' (as some of the larger foundries had attempted) or some type of industry-wide effort was necessary, to be of benefit to all participating foundries.

A comparison can be achieved in terms of availability (ie. cost), by comparing the third point listed above, with the following statement

[64] made in 1984:

> "Fully interactive computer systems can be cost justified by foundries with as few as 20 employees, ..."

Moreover, further observation uncovers a second level of development. The type of data processing carried out in the majority of foundries in the late 1960's is indicated by Knight's second point. The types of computer system referred to in the latter quote would typically include:

- an order entry system
- production scheduling
- customer order status evaluation
- core scheduling
- invoicing
- sales forecasting (order backlog)
- cost estimating
- foundry accounts

Hence the areas of implementation have become more identifiable with the needs of foundries, a feature which figures largely in many researchers' work.

In the intervening years, three major developments have occurred bringing about the current level of progress in today's foundry systems.

Firstly, there has been a gradual increase in the awareness of foundry management of the need for improved organisation of manufacturing (especially over the last few years with the tightening of standards, for example, the onset of BS 5750).

Secondly, the rapid advances in micro-computer technology have meant that data storage has become relatively cheap (and is becoming cheaper); processing power can be housed in a fraction of the space required twenty years ago, and a greater variety of hardware and software is now available - with the emphasis on choosing the software first.

Thirdly, the interest shown by external 'bodies', apart from the foundry industry's own technical institutions (including software houses and consultants), has enabled many smaller foundries to get involved. There is no doubt that the availability of financial support for CAPM implementation by means of government grants (eg. BTAS, AMT, etc.) has accelerated the adoption of CAPM.

The literature reveals a number of case-studies [36,43,44,46,49,51,60, 63,65,66,67,68,69,70,71,72,73,74] which provide firm evidence in support of the attempts by individual foundries to adopt some form of computer-assistance (these reflect the 'successes': the extent to which foundries have been unsuccessful is not so well documented!). All of the case-studies approached the implementation of a 'system' on a 'do-it-alone' basis (see Knight's conclusion iv, above) and the early systems (pre- 1970 to mid 1970's) were largely implemented on mainframe -computers ('in-house', bureau service or time-sharing), progressing onto mini-computers as the technology advanced.

Therefore, during this period, unless a foundry possessed its own data-processing department, had access to the computer when required and had its own programmers, the actual benefits gained from utilizing a system were limited. For example, using a bureau service/time-sharing dictated when reports could be 'run off' the system and in many instances, a foundry would receive revised schedules only once in a period of several days [51,67].

In 1969, topical reports in the foundry journals of the UK examined the features which had combined to produce the [19]

"... present low status of the computer art in U.K. foundries;"

identifying, among others, the cost of computers, intrinsic differences of the industry in the UK, disparaging computer applications press and the lack of stimulation from foundry media [19,56].

A year later, similar reports from Swiss and German sources [58,75], described the 'mechanism' and some applications of 'Electronic Data Processing' (EDP) in Europe, but warned of the dangers of poorly applied systems.

Thus, an understandably cautious approach was advocated by many papers [42,48,51,56] reflecting the high cost of the initial hardware investment and the added cost of developing software. Only those foundries with sufficient capital resources, together with the 'drive' of highly motivated individual(s) [51,76] were able to take advantage of some form of EDP.

3.3.1.2 Initial Generalised Systems

This unsatisfactory situation (especially, for the typically 'small' foundries in the UK) was partially addressed in 1972, by the collaboration between the British Cast Iron Research Association (BCIRA) and Hoskyns Systems Limited (HSL), which performed a study of the feasibility of developing common, computer-assisted production control systems for the British Foundry Industry [35] (the second 'approach' observed by Knight).

The primary objective of this study was that foundries should be able to use a system at a fraction of the cost of developing their own system. Moreover, of equal importance, the grounds were established for a commonality of approach towards computer-assisted production control [55].

Almost in parallel with the work of the BCIRA/HSL, the British Non-ferrous Metals Research Association (BNFMRA) carried out their own survey [77], which supported the findings of the BCIRA/HSL study (ie. the 'commonality of approach' and the need for 'simple' systems). The results of the study were projected further [48], proposing that the approach to organisation and procedures appeared to extend to the practices employed in the ferrous sector.

Despite this work, the potential 'gains' of using the new technology were only being realized by a few concerns and in 1974, the first of a series of reports was published by 'Working Group E2' - formed under the auspices of the Technical Services Committee of the IBF - to evaluate and advise on the use of computers in the foundry industry [42].

The 'softly, softly' approach to implementing a system was advised, with 'low-risk applications' only (eg. scrap analysis) being considered as first applications, hinting at the need for the hitherto undefined, 'modular' approach to system design.

Thus far, although the literature [1,17,42,49,54,56,63,65,68,78,79] stated the advantages of computerised systems over the disadvantages of manual methods, as yet, only the BCIRA/HSL collaboration had resulted in a basic, standard system for production control [48,50]. Unfortunately, small and medium-sized foundries were not able to afford the hardware requirements for this system and a scheme was devised whereby these foundries could 'rent' an amount of computer time at a data processing centre.

To overcome the limitations of the BCIRA/HSL system, the British Non-Ferrous Technology Centre (BNFTC) developed their own system for foundry production control during 1974 to 1977. The system operated in 'real-time' and required a minicomputer to run the package. Although the initial investment in the BNFTC system was about a tenth of that reported [80] for an implementation of the BCIRA/HSL's system, it was sufficient to deter the smaller foundries and many of the medium-size concerns.

The criterion of 'foundry-size' which seemed to determine the potential 'user' from a 'non-user' (of CAPM systems), was stated more firmly by a survey of more than 200 British foundries [81], in 1974. The survey revealed that the size of foundry was the over-riding factor, a factor which also influenced the extent to which a system was used.

However, for those foundries who could implement computer-assistance, several options were available in terms of the type of system which could be purchased, for example:

- 'tailor-made' (bespoke software) systems
- 'packaged' ('turnkey') programmes
- modified, general package solutions

To complicate matters further, the rapid advances in the technology meant that a choice of automation (in terms of the information processing capabilities) was available; a system could operate in one or more of the following modes:

- batch processing
- 'on-line'
- 'real-time'
- 'on-line/real-time'

The new technology was also accompanied by a new set of 'jargon' and the problems facing foundries attempting to select a system were rooted in understanding how the technology worked and what the computer could do, quite apart from the justified 'fear of change' [82], which the technology might bring.

The literature of the late 1970's/early 1980's [17,53,62,63] began to address the 'need to know' aspect and emphasized the areas of foundry production control practice which should be investigated with a view to automation, listing among others:

- order acceptance and forward plant loading
- detailed plant scheduling encompassing the issue of 'work-to' lists for work-centres
- monitoring the progress of work and taking immediate decisions concerning modifications to schedules to react to variances from the planned course of action
- preparation of management reports

3.3.1.3 Micro-Computer-Based Systems

The underlying problem of providing a means for implementing computer-assistance (apart from a very basic level) in the small to medium-size range of foundries was not really overcome until the early 1980's (1981/1982). The turn of the decade saw the emergence of the micro-computer as a viable business tool, sufficiently powerful to process relatively large volumes of information, rapidly.

Thus, the potential to utilize the assistance provided by computers was now available to most sizes of foundry, but the problems of choosing an appropriate system still remained. The 'micro' had emerged, but it required it's own applications software if it was to be of use.

The procedures for controlling production in the multi-level, b-o-m manufacturing industries were amongst the first to be analysed and 'improved' through the evolution of more formal techniques, such as

MRP and 'Manufacturing Resources Planning' (MRPII).

These techniques had proved practically impossible to maintain by manual methods, yet were readily adaptable to the type of logical processing power provided by the computer. However, their application to the foundry industry was questionable, due to the nature of the industry (reference section 2.) which in turn affected the suitability of the available software. Moreover, as one foundry practitioner stated [82]:

> "Immediately you start talking about computers you are likely to be surrounded by very good specialists who will tie you up in knots."

Such an opinion was not felt in isolation [54,83,84] and thus it was evident that the further education of foundry staff in the 'new' technology <u>and</u> the further education of computer 'experts' in foundry practices (and other production control techniques), was required.

3.3.1.4 The Present Position

From 1981 onwards, entrepreneurial enterprises penetrated the foundry software market offering hardware/software and training in the use of both. Whilst the majority of companies (eg. software houses) subsequently favoured the more 'fashionable' sector of manufacturing, that is, the multi-level, b-o-m industries (high volume production/assembly to stock), a few kept their focus of development upon the foundry sector. Of these, a clear market leader has developed, with a claim of 120 systems in use at the time of writing.

In effect, packaged software, which would otherwise be provided on a 'one-off' basis costing thousands of pounds, became available for under ten thousand pounds (say £7,500), so that a system - hardware and software - could (and can) be purchased for an investment of around £10,000.

Packaged software represents only one of the available methods which could be used to implement CAPM into the foundry, which is taken from a list comprising:

- in-house systems
- bespoke systems
- mini-computer packages (both foundry specific and general CAPM)
- micro-computer packages (" " ")
- mainframe links
- turnkey approaches
- database/code generators
- spread-sheet systems
- expert/rule-based systems

Of these, a 'packaged' version of an expert system (as developed for the medical profession) may prove to be of extreme interest in the next three to five years. The use of artificial intelligence and 'fuzzy logic' [85] to overcome the relative inflexibility of traditional logic, has enabled users to get more than a simple 'yes-no' answer.

Nevertheless, for the small to medium-sized foundry (especially the first-time user) the packages available for micro-computers are currently the most cost effective - the more proficient of which, impose a few desirable codes of practice for organising production, rather than totally re-organising the existing procedures.

The following section reviews some of the techniques ('computerised procedures') which have been applied/suggested to foundries, via the use of computers and concludes with a brief look at the options which are available to the potential 'system buyer', within the context of the commercial packages currently available.

3.3.2 Applications and Options

What remains to be done?

The question aptly provides the aim for the following review, which surveys the applications and proposals that have been developed for computers in the foundry environment. The objective refers to the additional research which is required for the continuing development of 'general solutions' for small to medium-sized foundries. However, it is necessary first to investigate what has already been achieved.

3.3.2.1 Experience Pre-1972

Some of the first published articles (pre - 1970) to report on 'how they did it' were large, American 'tied-foundries', possessing their own data-processing departments and main-frame computer installations. Computer-assistance had been initially employed in the areas of process control (eg. furnace monitoring, spectrography, oxygen consumption), power consumption monitoring, payroll, accounts, sales and estimating/costing.

Examples of such installations [44,65] reported on the use of computers for order processing, w-i-p monitoring, scrap analysis and scheduling. However the cost of developing such comprehensive systems was not stated, nor the time requirement or the problems encountered during implementation (which is also true for most of the articles reviewed).

Articles from 1970/71 [66,67] provided evidence of the two basic approaches which foundries had adopted in 'going-it-alone'. The choice of whether a system was to be 'decision-based' or, 'information-based' was determined by the amount of information which a foundry possessed on its operations (eg. <u>accurate</u> process times, yield allowances, machine performances, etc.) and which had been captured, manually, over a period of several years [60,67,70].

The use of the term 'decision' is perhaps unfortunate, since in practice, no system was capable of actual decision making. Instead, the stored information was processed via a pre-determined logic route to provide a 'solution', as opposed to simply presenting the information to the user, as with information-based systems.

Whichever type of approach was adopted, the foundries controlled their operations by the resulting 'reports', which were specifically written to suit the individual concern's requirements and biased towards a particular criterion. The Flynn and Emrich Corporation [66] preferred the orientation towards "dollar value", rather than that of "weight", favoured by other installations.

By 1972, the success (or otherwise) of implementing a system was recognised as requiring the involvement of all relevant personnel [66, 68] and total commitment from the top management hierarchy. Such commitment was indeed required to overcome periods of disenchantment, occurring as a result of lengthy implementation times.

For example, in the same year, a published review in the UK [68] reported that after nine-months development, a system was partially installed in a small (130 employees) foundry which was capable of producing four reports. An additional eighteen months work resulted in a more comprehensive system which was totally information-based. In spite of this, the report concluded that small foundries could justify the time and money spent on developing a computer-assisted system and added that

> "... if foundries were to stay in business they are left with no option but to use the computer as a management tool."

A comparative report from the US, provided evidence [69] of how a small foundry (105 employees) had utilized the benefits of computer - assistance. A more sophisticated system was in evidence, enabling the reformatting, analysis and reporting of information for the functions of order processing, work booking and report production.
Both the case-studies stated that the greatest benefit derived was in the area of customer relations, through the increased ability to quote (and meet) reliable delivery dates. Unfortunately, further quantitative comparison is not possible through the lack of published

cost and time information.

3.3.2.2 Subsequent Developments

The support for information-based systems for the ferrous sector in the UK [50,55] grew with the BCIRA/HSL collaboration which advocated for simplistic systems, in opposition to decision-making systems. The details of the system developed by the collaboration are not included here as the source material is unpublished work, as classified by the BCIRA.

The non-ferrous sector were also represented, as described by a report [77] in 1973, detailing a common production control framework and how computer-aided systems might improve on the "current" situation. Moreover, it was suggested [48] that the main areas of improvement lay in the production and disemination of information for making decisions, during

> " ... such procedures as accepting orders, expediting orders, (and) meeting changing market demands ..."

The package developed by the BNFTC was similar in design to the BCIRA/HSL concept, being information-based through the provision of reports, but it had the advantage of operating in real-time on a mini-computer. The comprehensiveness of the package dictated the need for a complex set of procedures, which once mastered, provided the user with a satisfactory tool for computer-assisted production control in foundries.

The common theme was that whilst the information requirements of foundries were very similar, the criteria for taking decisions varied widely. This extremely valid point highlighted the need for 'flexibility' in the way selected items of information should be accessed and manipulated if a system was to be of general use.

In contrast, a paper published in the Foundry Trade Journal in 1974, of Swiss origin [60], provided evidence of the apparent difference of opinion (and development) between European foundries and their counterparts in the UK - see also [58,75]. The case-study emphasized the need to record processing times, transport times and storage times in order to schedule production operations. However, it was also stated that the cost of a system was a function of the volume of information which was available for processing.

In the same year, the first report of Working Group E2 [42] (see 3.3.1) suggested ways in which the computer could be used to assist management to control the foundry. With the high costs of development abundantly clear, 'low-risk' applications (eg. scrap reporting) were proposed as a useful introduction to computerisation, following the sequence outlined in a 'five-step plan'. No reference was made to the feasibility of creating generally applicable programmes, for use in a number of different types of foundry.

Essentially, individual foundries were still the prime initiators in the quest for CAPM, which required the participants to survey the hardware and software markets with extreme care. Such an approach was adopted by the Dudley Foundry Company [51] in 1977, whom were confident of their existing manual procedures, but required computer-assistance to remove the tedium of administration and to improve the integrity of the information being processed.

The system was installed on a minicomputer and the programs were custom written for the foundry's use to cover the areas of order processing, forward loading, scrap analysis, plus limited reporting facilities. The problems of dual and triple responsibilities developed between the foundry, the hardware supplier and the software house and the advantages of single-sourcing were subsequently expressed. Following an initial investment of £25,000 (hardware) and seven months of programme development, the system went 'live' and ran with limited success for two years.

A second system was installed on different hardware (costing £70,000) with further bespoke software, and was claimed to fulfil most of the foundry's requirements. However, subsequent company closure led to the failure of the development of the system on a wider scale.

3.3.2.3 Trends Toward General Solution Systems

Thus far, the literature had revealed a wide, but limited variety of applications of computer-assistance to the foundry industry in the UK (also see 3.3.2.1). The attempts at a cohesive effort towards a general 'solution' suffered from the general (lack of) availability of hardware, the education 'gap' between foundries and computer suppliers and the problems of producing a package to satisfy the individual requirements of foundries from a common production control structure.

A similar situation was being experienced in the US. A summary of the utilization of computers [54] confirmed that the variety of systems implemented there reflected the diversity of the industry. Moreover, whilst it was acknowledged that:

> "... similarities ... exist between a large-scale captive production foundry and a small, closely held, family-owned-and-operated facility, the problems of each must be addressed at different levels."

Accordingly, computer-assistance in the US was reported as being implemented at different levels, although the lengthy 'lead-times' for software generated by individual foundries (from 1 to 3.5 years) were stated as a warning to the unwary, since they opposed the prompt start of operations.

An equivalent review in 1979 by The British Foundryman detailed the findings of the re-constituted Working Group E2. The first part of the report [62] identified the following trends:

- the continuing reduction in size of companies which could effectively use computers had meant that foundries with a turnover of £0.5M derived benefit from computers costing £14,000, which provided comprehensive facilities for order processing, payroll and accounting
- there was an increased implementation of computer systems operating in 'real-time'
- the development of process control applications had been been hindered by the high costs
- The development of firms selling expertise in the use of

computers was increasing

The second part of the report [63] reviewed an application of the BCIRA /HSL product which had been implemented on a computer installation at a tied foundry, over a period of two years. The reported costs (both original and running) ensured that only the larger foundries were likely to derive benefit from computer-assistance, other than in the areas of financial administration.

In an attempt to 'bridge the gap' between foundrymen and computers, a series of articles [64,74,83,86,87], appeared in the journal of Modern Casting, describing: what the computer could do for a foundry, the decisions and planning required prior to 'computerization' and reports on how particular companies had 'done it'.

The call for more pressure to be placed on software houses was supported by a report [57] published in 'Foundry Management & Technology' (1982), proclaiming that manufacturing software must be capable of application to a variety of needs. The author stated that the development of hardware into a more reliable, less costly instrument had not been matched by equivalent developments in the field of software design, highlighting that the manufacturing-type software, currently available, had been designed for companies that typically purchased component parts.

The concern for applications covering the functions of production control was given impetus, ironically, as a result of the recession. The worst effects of the recession had left a much leaner industry and the emphasis, for those foundries surviving, was on productivity and profitability. The efficiency of the production control system employed had the most direct effect on these measures and was identified as the area which was likely to gain most from the introduction of computers [1,17,53].

3.3.2.4 Current Concepts Of Computer-Based Systems

In a report on 'Whose foundry needs production control?' [17], the members of Working Group M62 of the Institute of British Foundrymen addressed the problem of the lack of analytical study afforded to the subjects of production planning and monitoring. The tentative conclusions suggested that production could be controlled via a computer used by foundrymen themselves, without the need for 'computer staff'.

The report also included a review of three case-studies, in different types of foundries, which indicated the developments occurring in hardware technology, but more importantly provided evidence that at least one 'packaged-system' had been developed for production control in foundries, on a micro-computer.

A more recent study [79], in 1984, of the use of computers for production control, advocated the use of real-time computer systems to provide more up-to-date information, for the functions of:

- Estimating and quotation preparation
- Maintenance of records of casting master data
- Order entry and acknowledgement printing

- Re-pricing to reflect changes in metal prices, labour and overhead cost movement
- Planning of work-loads for moulding and casting work centres
- Printing of operational documents such as moulding tickets and route-cards
- Recording of w-i-p movements as castings are processed
- Recording of despatches and advice note/invoice preparation
- Historical cost reporting
- Preparation of reports on production performance

The concluding remarks urged foundries to place sufficient emphasis on the specification and pre-planning stages to ensure that the most effective system was designed and successfully implemented. The use of generally applicable systems was considered unsuitable, since the engineering approach to package development 'did not reflect important aspects of foundry control', however, at least one apparently successful foundry software package had been omitted from the study.

Taking the literature as a whole, it was evident that the next phase in the development of micro-computer applications should be directed towards the functions of production planning, scheduling and monitoring, in order to assist in the making of better decisions, which in turn should contribute to increased profitability [242,243].

The controversial subject of scheduling is dealt with as a separate section, whilst the current section is completed with a brief look at the main production management packages which are available for micro-computers.

3.3.2.5 Packages

In addition to the 'packages' developed by the BCIRA/HSL and the BNFTC, at least one other foundry package had been developed for use on mini-computers by 1982. A small, non-ferrous foundry (35 employees) used a system for production control, payroll and accounts which was originally developed specifically for the company (Gascoignes Foundry) [88]. The system was subsequently modified and marketed under the title of 'FO.COM 42' at a cost of around £20,000, by a commercial software house (ADS). The package is no longer available.

By 1984, a second, more comprehensive system, had been advertised under the name of 'FORUM' by Management Information Services Ltd (an associate company of Foundry Management and Design Ltd.). The package had been developed over a four-year period and was expected to cost between £35,000 and £50,000, providing the facilities of order processing, production resource availability, master production scheduling, advanced scheduling and reporting, metal analysis, progress reporting and integrated stock control, together with payroll and financial systems.

The package provided satisfactory facilities for production control but not at a cost which induced many different types of foundries to 'take the plunge'. The industry required 'low-cost' competent packages if the introduction of CAPM was to be on a large scale.

Since 1980, the annual 'Which Computer?' production control surveys [25,89,90,91,92,93] have provided a concise (if not complete) indication of the packaged software available for CAPM. The most recent survey [93] indicates that the packages which are capable of running production control on micro-computers are becoming more numerous although the field is reduced when applying the criterion of 'foundry'.

Nevertheless, the current vendors of production control software for micro-computers fall into one of two categories. Those whose packages address the light engineering industries, typified by multi-level b-o-m and large volume assembly (category 1.) and those whom address the component making industries, particularly foundries (category 2.).

Table 3.1, below, lists the main contenders in each category - the cost figure is included for reference only, since the modular design of each package enables them to be sold as a series of units, which are individually priced (see also Appendix 3.)

Table 3.1 Examples of Production Control Packages For Micro-Computers

Company Name	Product Name	Cost (£)	Users
Category 1.			
Kewill Systems Plc	Micross	6500 +	250 +
Safe Computing	Micro-SaFeS	7000 +	80-100
Sheffield Micro	Planit/Uniplan	7000 +	80-100
Category 2.			
Dewtec Computer Systems Ltd	Dewtec Multi-User	7500 +	120 +
Management Information Services	PC-Forum	7500	5-10
Foundry Business Systems Ltd		7000 +	10-15

In addition, the BCIRA have recently released a micro-based system for Production Planning, at a cost to non-members of £300.00, which is a singular price for the claimed facilities. The author has not seen a review of this package to-date, but it is supplied as a program only, with no installation support.

At least four other micro-computer based packages for foundry production control have been reported in the US [64]. Again, no references to their use in the UK has been reported, to the author's knowledge. However, the clear market leader is a package advertised by B & L Systems Inc., of Michigan, whom have 'down-sized' a system which formerly ran on their IBM-36 computer.

The main difference in the system design of the packages from the two categories, is the emphasis which is placed on the primary sub-systems comprising each type of package. Category 1. is concerned with the problem of large volumes of mainly dependent component parts, which is reflected in the commonly found modules (eg. b-o-m, stock control, trial kitting, MRP, purchase control).

The important aspects of the packages comprising category 2. (eg. capacity planning, detailed scheduling, monitoring w-i-p, performance analysis) are of secondary importance in the industries addressed by the packages grouped under category 1. For example, foundry production purchasing is basically limited to just a small range of raw materials and therefore, computer-based stock control of these few items does not carry the same importance as a module for performance analysis.

Moreover,

> "... production consists mainly of single-item products so material requirements planning and multi-level assembly structures are irrelevant." [79]

In both cases, the primary sub-system requirements, which are of most importance to the application, forms the basis which most probably determines the sequence of implementation of the rest of the system [94]. For example, MRP depends on bills-of-material, stock recording, order processing and forecasting modules for its inputs. The amount of data processing required at this stage, however, is prohibitive to the majority of foundry applications and therefore, a much simpler materials requirement module is balanced by more comprehensive modules addressing different aspects of CAPM (eg. capacity requirements planning and performance analysis functions), in the packages grouped under category 2.

Whilst these general engineering packages are comprehensive/impressive in their own right, their basic unsuitability for foundry applications clearly dictates that first choice should be given to the packages which have been developed specifically for the industry.

Of the three packages listed, only the Dewtec system is currently advertised widely, whilst both Dewtec and MIS were in evidence at the recent "Foundry '86 International" show at the National Exhibition Centre, (September, Birmingham). The main features of the two packages are presented below.

PC-FORUM is to FORUM what Micro-SaFeS was to SaFeS, that is, an alternative system, capable of running on a micro-computer to address the requirements of "smaller companies", in this case, foundries. The package comprises five interactive modules, viz:

1. Foundry Management Package
2. Production Control
3. Financial Control
4. Payroll and Personnel
5. Stock Control

For the purposes of production control, a combination of modules 1 and 2 is claimed to provide the following facilities:-

- a database system + casting file and reports
- weight estimating
- cost estimating/re-costing
- quotation preparation/sales order processing
- despatching and advice notes
- invoicing
- scrap reporting and analysis
- works order creation
- forward loading/production scheduling
- production programmes/shop floor documentation
- production monitoring.

The Dewtec Multi-User system is comprised of a similar range of facilities, including:-

- a database for storing 'methodings' and order details

- standard reports and report generator
- weight estimating
- cost estimating/re-costing
- price/quotations and wordprocessing
- works order processing and order acknowledgement
- forward loading/production scheduling
- preparation of production programmes
- works documentation/quality assurance
- statistical process control
- production monitoring
- advice note and invoice preparation
- historical production/despatch records
- payroll

No evidence is available to the author on any installations of the former package (although two installations of the original minicomputer version have been referenced [95]), whilst the latter system has been discussed on at least two occasions [17,28]. Both systems are reports -based and run on a variety of micro-computers (eg. IBM, Apricot, etc.)

3.3.3 Scheduling - Theory and Practice

The scheduling problem is extremely complex as demonstrated by some of the authoritative texts on the subject [96,97]. Therefore, it is necessary to move away from 'foundry specific' areas in order to give a broad picture of the possible solutions, before attempting to relate the theory of scheduling to the practical applications which have been reported in foundry (and other) journals.

It is proposed to demonstrate that no generally applicable package exists for the purposes of scheduling foundry operations and that the design of such a package involves a combination of techniques, which is strongly influenced by human rules.

So that it is clear what the author understands by scheduling, the general definition, provided by Baker [96], is re-iterated here.

> "Scheduling is the allocation of resources over time to perform a collection of tasks"

Within the general definition, scheduling can also be applied to the tasks of **planning** what product is to be made, what resources will be used to make the product and on what scale, whilst the actual **function** of scheduling presumes that all the information relating to the task of planning, is known.

The literature reveals a wealth of research which has addressed the problem of scheduling the production of jobs, encompassing the whole manufacturing spectrum from pure-flow production environments through to pure job-shop manufacture, of which the following references are but a few [96,97,98,99,100,101,102,103,104,105,106,107,108,109,110,111,112, 113]. The discrepancies between the idealised models studied by researchers and the complexities of the 'real-world' have led to a 'theory-practice' gap [114], the closing of which has traditionally been left to the practitioners in 'real world' environments.

Scheduling theory begins with a translation of decision-making goals into an explicit objective function and decision-making restrictions into explicit constraints [96]. Frequently, a solution to a scheduling problem amounts to answering the questions of:

- which resources will be allocated to each task
- When will each task be performed

Therefore 'allocation' decisions and 'sequencing' decisions have to be made for a satisfactory schedule. In addition, if the set of tasks available for scheduling does not change over time, the system is termed **static**, in contrast to cases in which new tasks arise over time, where the system is termed **dynamic**. Static models have received the most research attention, but have proved to be of little practical value. Foundries provide good examples of the intractable dynamic models, where the arrival of jobs, though continuous, is intermittent - which has stimulated research into 'queuing theory'. The main scheduling techniques which have emerged are:-

1. Network Methods
2. Mathematical Programming
3. Enumerative and Partially Enumerative Methods
4. Heuristic Rules and Simulation
5. Algorithmic Rules
6. Manual Methods

A combination of more than one technique is common and has been discussed in depth [96].

3.3.3.1 Network Methods

Traditionally, network methods such as Critical Path Analysis (CPA) and

Programme Evaluation and Review Technique (PERT) have been regarded as tools for the planning and scheduling of large, non-repetitive jobs. Scheduling involves the expenditure of resources over a pre-defined set of 'activities' or operations, which are subject to certain logical constraints. The resources are expressed in units of time and the 'lines' of the network, which join up the activities, are proportional to the time consumed.

3.3.3.2 Mathematical Programming

The determination of an optimal schedule can be formulated as an integer programming problem, for example, by making use of linear programming to build a model which is capable of representing a multitude of constraints. Boolean-type operators are handled by the introduction of integer variables, usually 0 and 1. The inclusion of these variables, however, prevents the use of efficient Simplex linear programming codes which in turn reduces the 'realism' of the model. In a similar manner to CPA, linear inequality constraints may be used to prevent operations being performed until the previous operation in the specified sequence is complete.

3.3.3.3 Enumerative and Partially Enumerative Techniques

The effect of the 'combinatorial' problem on the number of possible ways of scheduling work over resources, is demonstrated below. Since it is not practically feasible to enumerate all the possible combinations, techniques have been devised for partial enumeration, aiming at optimal or, near optimal solutions [114].

The 'branch and bound' technique is an example of a partially enumerative technique, in which a tree-structure is generated. The nodes in the tree constitute the jobs and the branch connecting a group of nodes (which starts from the root of the tree) constitutes a unique schedule sequence. The 'bound' refers to the lower bound, for example, 'makespan time'. Thus, in the build-up of a schedule, at a given node in the schedule tree will be the opportunity to branch in one of a number of ways. The choice may be determined by always branching from the node with the lowest bound value (the 'travelling salesman' problem provides a good example for the application of this technique [112]).

3.3.3.4 Heuristic Rules and Simulation

The difficulties of scheduling dynamic situations, especially dynamic job-shops, by analytical means, has led to the use of simulation models. The output from a simulation is a set of statistics which describes the behaviour of the model over the simulated interval of operation. Detailed scheduling decisions are usually produced by applying 'rules of thumb', or dispatching/heuristic/priority rules, during the course of the simulation.

For example, the SPT rule (shortest processing time - priority is given to the waiting operation with the shortest imminent operation time) provides an example of a local priority rule, whilst FCFS - first come, first served and EDD - earliest due date - provide examples of global rules. Moreover the rules are termed either 'static' or 'dynamic', depending on whether the set of tasks available for scheduling changes with time.

3.3.3.5 Algorithmic Rules

Algorithms (literally step by step procedures) involve the arrangement of jobs in a matrix in such a way as to minimize a 'time-based' scheduling rule - the so-called 'dominant' property. The Algorithmic rule can take many guises and is usually a formal representation of one of the analytical techniques described. For example, the Ignall-Schrage algorithm [96] which describes the basic branch and bound procedure.

3.3.4 Manual Methods

3.3.4.1 The Use Of Gantt Charts

An example of a manual technique for scheduling is the widely known Gantt Chart. Similar charts are a common enough sight in foundries, where use is made of peg-boards, or plastic sheets (or even the four walls of a room) to graphically represent the timing of current job production. The Gantt chart also provides an example of a combination of two techniques, since in manipulating the chart, the scheduler is making decisions largely based on heuristic rules.

No simple graphic means exists to measure or describe the success of the practical application of scheduling in either the engineering sector or, the foundry sector. The researchers themselves have admitted that the pursuit of optimality remains intractable in all but the 'smallest of problems' [107] (eg. one machine with a variety of criteria). Moreover, it has been shown that as far as manufacturing costs are concerned, there is at most only a difference of 0.5% between the best and the worst priority rules [115,116].

Attention is thus drawn back to foundries and the relevant literature, which provides written evidence of the techniques which have been employed.

The literature reveals that the approaches adopted by foundries have been the result of specific applications to inherent requirements, which have been implemented, mainly, on large computers. The problems of creating a general packaged 'solution' for use with micro-computers are based in the machine's capability to process volumes of information and the fact that foundries occupy several niches in the continuum of manufacturing.

Foundry scheduling has not always been conceived as problematical [117]. The approach adopted by Gillespie assumed that all timing information asssociated with operations would be known and a straightforward back-schedule from the customer's due date would determine when a job had to be started. This type of scheduling alone, however, tends to neglect the overall effect of the job on the rest of the foundry in terms of the capacity requirements and the 'flow' of jobs through the foundry. Moreover, the amount of manual computation involved is often prohibitive.

One of the first reported computer-assisted applications of scheduling involved the listing of 'sorted' information, to assist the Caterpillar Tractor Company (US 1969) [44]. The problem of scheduling up to 32 different castings on a moulding line at any one time - and there were eight moulding lines - was pared down to relative simplicity through the printing of a daily schedule by pattern set and castings within the set. Thus, through the use of a set of sorted criteria (ie. types of castings within pattern sets) a 'feasible solution' was obtained, which was reported to provide a satisfactory, workable schedule.

The type of problem referenced above, in which the ordering of jobs completely determines a schedule, is a specialised scheduling problem, and more usually referred to as a **sequencing** problem. The difficulty of producing 'the best' (or, optimal) solution to sequencing problems is due to the 'combinatorial problem', which all schedulers face in such circumstances and to which the literature has provided an apt name, viz: the 'n jobs/m machines' problem (in the example above, the 'n jobs/m lines' problem).

In theory, the number of possible alternative schedules facing the scheduler is give by $(n!)^m$, and whilst in practice there are technical and policy restraints which limit the number of alternatives (eg. meeting due-dates) unfortunately, even the reduced set of feasible schedules is often too large for complete enumeration.

Table 3.2, below, demonstrates the full magnitude of the problem using a 'cut-down' version of the example quoted above (so that meaningful numbers can be computed!) and which assumes that all jobs could be processed down all the lines.

Table 3.2 Scheduling - the Combinatorial Problem

'n' jobs	'm' machines	Alternative Schedules $(n!)^m$
4	1	24
8	2	1,625,700,000
16	4	tens of billions

3.3.5 Applications of Computer-Based Simulation to the Scheduling Problem

The interest in foundry scheduling in the UK was underlined by a paper [52] presented at The Institute of British Foundrymen's annual conference in 1970, which examined the feasibility of a foundry's existing technical people, installing their own computerized scheduling and control systems. The author's opted to develop a sequential simulation model, based on the heuristic rules used by moulding department personnel for scheduling moulding production at a malleable iron foundry.

It was reported that a schedule for one particular grade of iron, established by the programmes governing the model, corresponded closely to that produced in practice. Unfortunately, no follow up reports have been found to detail the results of this promising early research.

Not only the UK foundry industry was involved with the possible application of computer technology to production scheduling. Swiss publications [58,60] provided evidence that the subject was of international interest and in the same year, a report [75] in the German journal 'Giesserei', described the scheduling of capacity in the foundry industry with the assistance of electronic data processing

The method of scheduling was similar in concept to that described above. A 'simulation model' of the plant's characteristics was developed and subsequently governed by a set of priority rules to meet a defined objective function. For example, following a 'back-schedule' from the customer's due-date, if a job was obviously late, the programme attempted to 'split' the order over a series of machines, such that part of the order could be completed whilst (say) the moulding operation for the rest of the job was continued.

In conclusion, the report stated that applications of the programme were about to be implemented in foundries in Germany, although its initial application had been in a Finnish foundry (since German foundry concerns had considered the programme more useful to the engineering sector). Virtual elimanation of late deliveries was claimed (after a 'running-in' period of twelve months). No cost information was divulged, whilst the prerequisite for adopting the system was the existance of valid production timing and capacity information.

Yet another example of employing a simulative technique was provided by The Sibley Machine and Foundry Corporation [67], whom had their foundry 'translated' into a mathematical model which utilised foundry data captured over a period of three years. Production schedules were received every five days, covering furnace loading and after-cast operation capacity loading, for a finite time period. To put their achievement into perspective, an observer noted that:

> "... few foundries keep sufficient records to assure efficient manual control, much less computerized scheduling."

Clearly, Sibley was one of the 'few', but the observation was supported by other authors [18,42] as being the general case.

In 1974, the Foundry Trade Journal published an article [60] describing the use of the PSK production scheduling system at the Oberwinterthur foundry in Switzerland. The sytem took 64 man-months to develop and was expected to take two years to implement. Characteristically, the system was based on a foundry model, governed by heuristic rules.

Back in the UK, the consensus of rather mixed opinions on the desirability of computer scheduling, forwarded by Working Group E2 [42], supported the use of simulation/heuristic techniques by generally agreeing that a system should be based on the

> "... loading rules used by an experienced human scheduler..."

3.3.6 Applications of Other Theoretical Scheduling Techniques

Further stimulation on the subject of scheduling was provided by a report [21] which considered the problem of scheduling mould production. The report examined the feeding of a moulding line with cores and identified two extreme situations which were plagued by the combinatorial problem.

The technique of linear programming was employed to optimise the mould combinations, but a revised schedule was produced only once a month and foundry supervision had a 'free choice' on the sequencing of jobs, providing that the monthly demand was met.

Further case-studies from the US [70] and Italy [71] described the use of simulative techniques which were subject to various criteria, whilst one of the first (1978) workshop scheduling packages (SWORD) to appear in the UK, formed the basis of an interesting application involving the organisation of the production of malleable-iron chain links for stock/specific chain orders [49].

The package had been developed for the Department of Industry (DOI) and was designed primarily for the smaller engineering company in a batch/jobbing environment. The system was run via a bureau service (at Leeds) and after an eleven week implementation period began to provide scheduling information on a twice weekly basis. No clear indications of how the package functioned was given, but the claimed benefit was in the area of improving the flow of work through the foundry and chain-assembly shop.

The subject of job-shop scheduling (JSS) had received much attention in the literature [97,98,104,118,119], and in 1978, a direct application of JSS to foundries, using computer-assistance, formed part of a wider and more detailed study of foundry management control [112].

The study addressed the problems of scheduling in two distinct types of foundries - one representing jobbing/batch production in a small foundry and the other, batch/long run production in a gravity die-casting concern.

The author devised a simulation model to describe the jobbing/batch production foundry and a mathematical algorithm (utilizing 0-1 integer programming) to describe the batch/long run production foundry. The results of the study were encouraging in the sense that the outputs from both models were shown to have financial benefits when compared to the figures which were actually obtained, using the normal procedures adopted by the participating foundries.

The simulation model was reported [112] not to be totally proven, however, due to a lack of accurate process data for the machine shop, whilst the number of alternative job choices for the production mix (linear programming) problem, precluded the determination of an optimum solution within a satisfactory span of computer processing time. A 'best' solution was therefore accepted, rather than the optimal, although the construction of a classification system, as a precursory activity, was proposed to assist in moving the problem toward a more optimal solution.

A follow up paper [13], summarized the results of the study and reported that the financial advantages were enhanced as a result of the successful transition from running the programmes on a mainframe computer to a 'low-cost' micro-computer.

3.3.7 The Integration of Manual and Computerised Systems

Thus far, the literature revealed that the complexity of scheduling foundry operations necessitated a simplification of the 'real-world' situation and in the first instance, it was considered that the priority rules should be applied to the scheduling of mould production, which for most concerns is the focal point of foundry operations [53,64]. The need for 'human interaction' with the 'suggested' schedules produced by the computer, was also stressed [64], so as to retain the flexibility which was (and is) available through the use of manual systems.

The scheduling of after-casting operations is not as clearly defined. A method which has been suggested [53] is that a list of jobs, ranked according to priorities (eg. due-date and customer) could be issued and subsequently expedited by shop supervision. Other work [120] stressed the potential for deliberately de-coupling pre-casting/casting and post-casting operations, and theorised on the use of 'buffer stock' as a 'de-coupling mechanism', in order to assist the development of 'good schedules' for both mould/cast operations and for post-casting operations.

Clearly, the emphasis on getting the computer to do 'everything' was not a policy advocated by most exponents of foundry scheduling and the use of a model (of whatever sophistication) which was governed by a set of rules was (and is) favoured by many authors and practitioners. The research into the theoretical side of scheduling still continues, but current literature suggests that the authors involved at a practical level, are now equally concerned with the planning of capacity and the establishment of 'lead-times' [28,30,115,121,122,123,124].

The term 'lead-time' as used in the present context, describes the manufacturing lead-time experienced in intermittent production systems, although 'manufacturing throughput-time' would perhaps, provide the more clear definition.

The problem of production scheduling in foundries is often exacerbated by uncertainties and variations in the manufacturing lead-times. Tatsiopoulos and Kingsman [115] stated that in intermittent production systems, manufacturing lead-times are often very long, yet the actual job processing times are usually quite small. They identified the 'move' or transit time between operations as the dominating factor governing manufacturing lead-times, as witnessed by the speed with which 'rush' orders can be expedited through a system.

They further identified the method of capacity planning and the backlog of work in the shop as important parameters which affected manufacturing lead-times and hence the production of schedules.

Capacity planning has already received a great deal of attention [30, 124,125,126,127] and currently adopts one of the three proven approaches identified by Goddard [127], viz:

- resource requirements planning (RRP)
- rough cut capacity planning (RCCP)
- capacity requirements planning (CRP)

Each technique involves a time-phased prediction of the resources required but differs from the others in terms of who uses them and the amount of detail which is produced.

The two methods of loading each technique have been the subject of much debate, that is, whether to load the resource to infinite or, its **finite** capacity - such that at no point in the resultant schedule is the maximum stated capacity of any resource ever exceeded [96].

In summary, the problems of scheduling foundries have stemmed from a combination of balancing fluctuating loads with fluctuating capacities, a lack of accurate information and conflicting criteria from which to formulate an objective function.

3.3.8 Formulation of a Workable Scheduling Routine

Published foundry reports have provided evidence of the individual attempts by foundries to utilize the computer for production scheduling. Many of the systems involved the preparation of production schedules which were subsequently distributed on a weekly or, even monthly basis. Yet, their achievement depended on the completion of schedules from the previous period and the day-to-day events occurring on the shop-floor. Therefore, the schedules proved [129] to be unnatainable and had little in common with what was actually manufactured during the period.

The literature has not provided any real evidence of a generally applicable methodology for foundry scheduling on micro-computers and it is proposed that capacity planning and careful lead-time management, together with the application of heuristic rules to a simulated foundry 'model' (however superficial) will provide the means for addressing the two areas comprising the scheduling problem. That is, the making of allocation and sequencing decisions. In addition, the feedback of accurate production information, on a real-time/daily basis is considered an essential function to the development and execution of satisfactory production schedules.

3.3.9 CAPM - An Overall Picture

The implementation of CAPM into manufacturing in general has been the subject of numerous studies since the early 1970's [130]. At least twelve studies undertaken over the last ten years have been grouped [131] into:

- Large-Scale Surveys - [132]
- In-Depth Studies - [76,129]
- Diagnostic Studies - [131]

The methods of implementation have been discussed widely [22,33,133, 134,135], yet the evidence provided by the literature is often pessimistic, pointing to a large gap between the success and failure rates of companies implementing CAPM systems [33,136,137]. Indeed, research at UMIST in 1984 [33] revealed that 80% of companies surveyed were dissatified with their choice of system.

The most recent (1986) report on the 'state of the art' in CAPM applications has been compiled by researcher's from the Science and Engineering Research Council (SERC) [76]. An in-depth study involving 33 manufacturing sites yielded an overall impression that the implementation of CAPM in the UK was "woefully unscientific", with users not making full use of the facilities provided by CAPM packages.

Within the context of system design, the findings of the report suggest that users will clearly benefit from functionally simple packages which are capable of easy integration. In addition, a programme of further research is currently been evaluated to address the problems which are preventing users from perceiving their problems clearly.

Until the time comes when potential users understand completely their requirements and the software manufacturers have produced packages which can be quickly tailored to meet these requirements, the 'bon mot' provided by the concluding remarks of a report by Working Group E2 [42] still holds true, viz:

> "... for the less experienced - and that means the majority - the motto must be to 'make haste slowly'."

CHAPTER 4

4. An Approach to CAPM in Foundries

4.1 Introduction

The present section addresses the question of:

"What information is required for the organisation of manufacturing in foundries and how may it be expressed and manipulated within the constraints which govern foundry practice, in order to meet corporate objectives?"

The study of these requirements has led to the development of a philosophy for the application of CAPM in foundries, which is presented here within the context of current micro-computer technology.

4.2 An Overview

The overall picture which emerges from the literature review (supported by the author's discussions with foundry personnel suggests that the successful implementation of CAPM in foundries depends on three factors:-

1. The ability (of a system) to 'mechanise' the inherent production control functions required by foundries.
2. The facility to provide several 'levels of sophistication' in terms of the functions offered for production control, whilst maintaining a simplistic appearance.
3. The ability and willingness of employees to adapt to new procedures and revised documentation.

The underlying conditions which influenced the proposals developed in the current study reflect the constraints which govern a foundry's choice of system and take into account the evidence provided by the literature review.

In practice, the implementation of a CAPM system is limited by cost considerations which usually stipulate that a system must be capable of use by existing foundry personnel, albeit with some training, and that the total cost of a system (hardware, software, installation, customization, training and maintenance) should not exceed a given (often very limited) budget.

Moreover, the literature survey implied the need for 'versatility' of system design, with the emphasis on 'suggestive/informative' systems, over 'decision-based' systems. Two factors could be identified in support of information-based systems:-

Firstly, theoretical and practical research has indicated the complex problems of attempting to pass control of foundry operations over to executive control by the computer.

Secondly, for the system to make 'good' decisions, all pertinent data would have to be available to the system. This factor alone, would impose an intolerable degree of rigidity in any system designed for CAPM in foundries and the work involved in collection/maintenance of information would render the timely making of decisions, impossible.

At the present time, the only feasible course of action for many foundries who propose to implement a system, is to purchase a foundry-specific software-package 'solution', which in general, exploits the features which have proved to be common to many types of foundry organisation. The investment required for such a system is relatively small (since development costs have normally been spread over a number of users) provided that micro-computer applications are sought after.

The following sections describe the types of information which are integral to CAPM, prior to a presentation of proposals for the 'paper-less' organisation of manufacturing. The proposals are directed towards the functions of production planning, scheduling and monitoring, as opposed to dwelling on the design of a suitable information retrieval/storage system (database), which has been the subject of detailed development work by many systems and software-houses; eg:

- 'Informix' - Sphinx Limited
- 'Retrieve' - Sage Business Software
- 'dBase II' and dBase 'III' - Ashton Tate
- 'Paradox' - Ansa
- 'Q & A' - Paradigm
- 'Delta 4' - Compsoft
- 'DATAEASE' - Sapphire Systems Ltd
- 'Omnis 3' - Blyth Software Ltd

These are just a few of the database management packages currently available. In addition, most software applications-packages incorporate their own database management system which has been specifically designed for the intended application.

4.3 Types of information

The information which is being processed continuously by foundries can be organised into basic groups. Further study reveals how one type of information interacts with another and a system for managing and manipulating the information for the purposes of production control, begins to emerge.

Table 4.1, below, identifies the major categories of information which can be associated with the function of production control in foundries.

Table 4.1 Types of foundry information

Information Type	Relative-Activity
Basic Casting/Methoding	Mainly Static (Revisions)
Customer Schedules/Orders	Dynamic
Work Booking/Scrap/Despatch	Dynamic
Foundry Resources	Static and Dynamic
Routing/Process Layout	Mainly Static
Production Archives	Static Transactions
Customer Details	Mainly Static

The table is incomplete in the sense that the information required for a total CAPM approach for foundries (eg. job-costing information) has been excluded, but it is considered sufficiently complete for the purposes of organising and controlling the manufacture of jobs.

A further 'property' may be attributed to the data-types in Table 4.1 which reflects the amount of **maintenance** a particular category of data requires, once it has been created. It is an important property and one that a foundry should consider carefully. For example, are there time and clerical resources available to keep a system up-to-date, once it has been set-up? Will there be sufficient keyboard time? The single-user/multi-user micro-computer environments allow a great deal of flexibility over these matters and a CAPM system should be capable of being 'upgraded' from single-user to multi-user, if required at a later date.

4.3.1 Basic Casting/Methoding Information

Examples of **elements** of information comprising this category are expressed in summary form, below (see Table 4.2):

Table 4.2 Basic Casting Information

Element Name	Element Name
Pattern/Part/Die Number	Description
Customer Account Number	Customer Name
Base Metal Grade	Metal Grade Specification
Gross (or Poured) Weight	Cast &/or Fettled Weight
Castings per Box/Impressions per Die	Moulding-Box/Die Spec.
Pattern/Die Details	Drawing Number
Typical Batch Production Size	Manuf'g Thro'put Time
Core Requirements	Production Scrap %
Sales Price	Cost
Product Group Category Codes	Free Form Notes
Free Stock	Job/Pattern Status

In addition to the information in Table 4.2, the details on each work-in-progress 'monitoring' point, where components are counted after processing, should be closely related to the basic casting data, and would normally be described in terms of the following:

- Process Stage Number & Description
- Section/Workstation
- Actual Time
- Standard/Estimated Time

The monitoring points are 'selected operations' taken from a more complete list of operations normally defined as a route-card or process layout.

4.3.2 Customer Orders/Schedules

Unlike the basic casting information, the information relating to customer orders/schedules can be termed 'dynamic' because of the frequency of modifications which have to be made to the schedules/orders, involving changes to quantities, call-offs, specifications and delivery patterns.

The elements of information comprise those which are required to raise an order (in addition to those provided by the basic casting details) and those which refer to the subsequent production of the job. Table 4.3, below, identifies examples from both groups of information.

The left-hand side of Table 4.3 describes the additional information which is required to raise a new customer order/schedule, whilst the right-hand side represents the breakdown of work-in-progress, together with planning and summary information relating to the production activities surrounding job manufacture.

Table 4.3 Schedule/Order Information Elements

Element Name	Element Name
Foundry/Works Internal Reference	Production Planning Dates
Part/Pattern/Die Number	Work-in-Progress Quantities
Order/Schedule Received/Entry Date	Total Cast
Order/Schedule Required Date(s)	Total Despatched
Customer Order Reference	Total Scrapped
Order/Schedule Quantity	Total Returns
Type of Order	Total Rectified

4.3.3 Work Booking (Work-in-Progress) Information

The return slips (eg. heat-sheets, time-sheets) which are passed back from the shop-floor, vary in format and content from one foundry to another, and provide a number of departments with work-bookings information. For the purposes of updating the records held by the production control department, the information typically required, is summarised by Table 4.4, overleaf.

The information listed in the table contributes to the requirements for maintaining a further set of records, the 'production archives', which are discussed, below.

Table 4.4 Shop-floor Monitoring/Work Booking Information Elements

Element Name
Foundry/Works Internal Reference or, Part/Pattern/Die Number Heat Number and/or Cast Code Employee Clock Number and Shift Actual Production Time Booking/Monitoring Date Production/Inspection/Despatch/Scrapped Quantity Section, Work Station/Centre Despatch Advice Note Number Reasons For Scrap

4.3.4 Foundry Resource Information

Resource information comprises 'static' elements and 'dynamic' elements which relate to the capacity loading for that resource over a given time period (or 'planning horizon'). Table 4.5 lists examples of the static elements.

Table 4.5 Foundry Resource Information - Static Elements

Element Name
Section, Work Station/Centre Description Cost Centre Number Standard and Current Labour Rates/Std.Time Unit Scrap Rate Alternative Resource(s) Move Time & Units Set-up Time & Units and Process Time & Units Resource Units and Capacity Values Etc.

The section/work centre does not refer solely to mechanised resources, eg. 'human capacity' constraints can be considered as a resource.

Elements which can be termed 'dynamic' relate to the actual 'loading' of that resource and consist of quantity and timing information (eg. production dates). These elements should be 'updated' as jobs progress through the resource.

4.3.5 Routing Information

As foundries in Britain strive to meet the requirements of BS 5750, the quality control procedures involved will demand more exacting details on the processes required for component production (equivalent pressures are seen to exist also in other countries with the proliferation of legislation covering product liability). Such information is normally held as part of a route-card or process layout document. The minimum amount of information which needs to be held for each distinct operation or instruction, is as follows:-

- Operation Number
- Section, Workstation/Centre
- Set-up Time
- Run Time
- Operation Description, or
- Quality Control Instruction

In addition, a 'move' time may also be held, together with notes detailing special requirements; eg. 'non-conforming' items.

4.3.6 Production Archives ('Historical' Information)

In providing full 'traceability', ie. a permanent record of the 'events' describing the production of a component, the types of information required are 'derived', rather than manually created.

Table 4.6, below, lists examples of the types of information which can be associated with this category (the abbreviation 'P.T.D.' stands for period-to-date).

Table 4.6 Archived Transaction Elements

Element	Element
Part/Pattern/Die Number	Cumulative Made
Foundry Internal Reference	P.T.D. Made
Production/Inspection/Despatch Quantity	Cumulative Despatched
Advice Note/Heat Number	P.T.D. Despatched
Customer	Cumulative Scrapped
Customer Order Reference	P.T.D. Scrapped
Transaction Date	Cumulative Returned
Shipment Value	P.T.D. Returned
Production Section/Stage	Cumulative Rectified
Employee Clock Code	P.T.D. Rectification
Weight of Material	
Material	
Required Delivery Date by Customer	
Scrap Reasons	

4.3.7 Customer Details

Most of the static information asssociated with customer's details is of little value to the functions of production planning, scheduling and control, but the peripheral activities of raising documentation (eg. customer order acknowledgements, advice note production and invoicing) provide for a more complete order processing system.

4.4 Foundations for a CAPM System

Each of the information categories defined in Table 4.1 can be regarded as a 'database' (or as belonging to a database), which collectively form the foundations of a CAPM system. A database is defined here as a group of information which can be manipulated by a set of utilities. It is assumed that a system would possess the maintenance facilities to create, amend, delete, enquire and duplicate 'records' of information.

The level of control which can be achieved is a function of: the number of databases which are being maintained; how 'complete' the databases are, in terms of the information held within them; the integrity of the information and the system's ability to process and present the information in a form which is readily understood by foundry personnel whilst reflecting sound production control practices.

Database definition, however, is just one aspect of a series of 'set-up' procedures which a system should support through the provision of 'parameter-driven' software. Such a facility enables the terminology currently used by a foundry to be incorporated into a system and the definition of the number of elements of information which are to be maintained by each database. Most of the set-up details should be 'transparent' to the user, being implemented at the users request during system initialisation.

An initialisation procedure which is of more direct relevance to the functions of production planning, scheduling and control, is the definition of a 'production calendar' within the system. The utility should provide the user with the ability to designate calendar days as 'non-working days' (for example, works 'shutdown', weekends, public bank holidays). Moreover, it should be possible to define 'non-working days' to cover more than a one-year period (taking into account leap-years!) - thus enabling a contribution towards long-term forward planning practices. The full use of the calendar is investigated during the sections dealing with production planning and scheduling.

4.5 Proposals For Foundry CAPM

The preceding sections have presented the types of information which are required for foundry production planning, scheduling and control and have briefly described a mechanism for maintaining the information. The problem of manipulating the information toward an effective CAPM solution is addressed by the following proposals.

The structure of a CAPM system should reflect the sequence of tasks which are required for production planning, scheduling and control. Thus, following the creation of the databases described, a system should guide the user through the primary activities of:

- order processing/order book maintenance
- production planning
- capacity loading and scheduling
- the raising of production programmes/works documentation
- work bookings

The additional tasks of:

- creating management reports
- production performance analysis (eg. scrap analysis, delivery performance, variance analysis of estimated versus actual cost)
- breakdown of job production by employee
- etc.

. . . should be provided and maintained automatically by a system, from the information afforded by the primary activities.

Each of the activities is discussed below. Where relevant, sections are included (eg. 4.5.1) which describe how one set of information interacts with another, stipulating the conditions which should prevail prior to certain types of action.

4.5.1 Methoding Maintenance

Following the installation of a CAPM system, one of the first tasks required of the production control department involves the entry of basic casting details (for each pattern/die record) into the system so that the 'computerized records' would have as much information (usually more, in one collective area) as the existing manual system.

The pattern/die code should be unique for each job and prior to accepting further details, a system should check to ensure that the pattern/die code had not previously been entered. Care should be taken over the 'construction' of the pattern/die number. For many concerns, the numbers used by the existing manual system can be transferred to the computerized records; however, an opportunity is presented for the **classification** of patterns/dies, should a company wish to pursue this course of action. Once they have been identified to the system, the pattern/die records should act as the 'trigger' for most of the of the other CAPM related functions.

The removal of records from the system should be possible either manually, or by automatic means. The latter case would require certain criteria to be met prior to the deletion of records; eg. a comparison between the current calendar date and a 'last used' date. Furthermore, in both cases, up to three validation checks should be made by the system, before initiating the deletion procedure, viz:-

1. a check to see if any orders, in the current order book, were for the specified pattern/die
2. a check to see if any routing information had been created for the pattern/die
3. a check to see if any 'production archive' details were related to the pattern/die

If one, or more, of the checks failed, the system should advise the user to remove the necessary records from the appropriate sources first, before trying to delete the pattern/die record.

It should be possible to link into five other databases from a given pattern/die record using the 'key' elements, already entered, as links to the respective modules, for example (Table 4.7):

Table 4.7 Key Elements for Information Interaction

'Key' Element		Module
customer name	--->	customer base
customer number	--->	accounts/ledgers*
material code	--->	raw material stock records*
pattern/die number	--->	routing file
process/monitoring section	--->	resource file

* Assuming that these functions were part of a system.

4.5.2 Route-Card Maintenance

It should not be possible to create a route-card if the relevant pattern/die card has not been created first.

In addition to defining the operations which constitute the route-card, the system should enable the separate definition of the sequence in which operations are to be carried out, enabling a foundry to exploit any flexibility it may have in its manufacturing resources. By default, the standard routing should be assumed by the system unless the alternative sequence had been defined.

Assuming that it was possible to define the particular operations which were also monitoring points, any changes in the normal routing of a job would then also reflect in the sequence of monitoring points for that job. Moreover, the 'cyclical' processing of jobs could be catered for.

4.5.3 Resource Maintenance

For every resource in the foundry there is a corresponding 'resource capacity', measured in a set of units which ultimately can be related to time.

The resource **loading** information should also be expressed as a function of a time-base, ie. as indicated by the resource units (for example 'weekly'). The information would normally be updated automatically from work bookings and the activities surrounding customer orders/ schedules maintenance (eg. call-off amendment).

Such a facility would provide a 'real-time' enquiry facility on at least the 'key' resource centres of a foundry together with a potentially powerful tool for planning the **flow** of work throughout these (usually identified as 'bottleneck' resources) and other resources.

4.5.4 Orders/Schedules Maintenance

The same restriction should apply to the orders/schedules database as imposed on the route-card database. That is, it should not be possible to enter orders/schedules without prior reference to an existing pattern/die record. In practical terms, the restriction renders the raising of an order for which there is no methoding, impossible.

However, three advantages would be derived from the proposed 'restriction'. Firstly, a minimum amount of information would have to be entered into the system, facilitating the 'batch input' of new orders/schedules, consisting of the:

- pattern/die number
- customer order reference
- the 'type' of order and the internal reference
- order/schedule/call-off quantity
- required/due date
- order/schedule/call-off entry date

Secondly, by referencing the pattern/die details (which would be created and stored once only) any duplication of effort is avoided and therefore the risk of clerical errors being introduced is greatly reduced. Moreover, the minimum amount of media storage is utilized for 'filing away' the customer requirements.

Thirdly, at the time of raising an order, the system should present other 'parameters' for consideration by the user. That is, whether:-

- a scrap percentage, based on the expected yield, should be incorporated into the order quantity/call-off
- the number of impressions/die, or number of moulds/box (or plate) should be taken into account
- finished components which had not been allocated to a particular order, should be used

The facility to print off 'customer order acknowledgements' (and revised schedules) should be an integral part of an order processing module, but on a batch basis, so that the user can incorporate any special comments (eg. pattern of delivery) prior to printing.

For the majority of foundries there exists a close relationship between the components progressing through the foundry and the customer orders to which they are being manufactured. The relationship may not be so apparent on the shop-floor, but one aspect of the production controller's job is to know how a job is progressing, especially when a customer enquiry is telephoned through.

The w-i-p and summary information (eg. total moulded) can be stored as either a separate database or as part of the individual customer's order/schedule record. It does not really matter to the foundry which method is adopted by a system, providing the utilities are available to organise the information accordingly; for example, the provision of utilities for the purposes of re-allocating/re-scheduling work-in-progress.

4.5.5 Production Planning and Scheduling

One of the chief aims of a foundry planning and scheduling system should be to engineer a change from 'heap scheduling' [22] or, 'management by crisis', towards a system which organises the manufacture of jobs in such a way as to:

- increase the performance of on-time deliveries
- decrease work-in-progress inventory levels
- increase productivity by improving the balance between resources and orders/schedules

Such a system **can** be achieved without computers, but computer-assistance greatly enhances the 'tools' which are available to the planner/scheduler to organise work loads [139].

The literature review provided evidence of the essential tools for foundry planning and scheduling, viz: lead-time (manufacturing through-put-time) management, capacity planning and the application of 'rules' to a model of foundry production management procedures. A planning and scheduling 'model' can be described as consisting of:

- establishing minimum lead-times for each product
- profiling the order book: identifying 'overdues', current work and future or, 'forward' requirements
- planning production capacity by time period
- creating production programmes
- Analysing performance: eg. delivery performance

In the absence of a firm master production schedule, foundries require a schedule of jobs from which to draw a fixed (short-term) programme of work, even though the schedule will be subject to amendments on a continuous basis. Provided that the information stored by a CAPM system is kept up-to-date, the computer can be directed to provide such a schedule, as frequently as required by the production planners and/or schedulers, based on the results provided by 'modelling' the current foundry situation.

4.5.5.1 <u>Minimum Lead-Time</u>

Ideally, the run-times, set-up times and move-times would have been defined for all the processes involved in the manufacture of a particular job. Then, using the customer's required delivery date and/ or the 'current date', a backward or, forward scheduling procedure would determine the 'earliest start-date', 'latest start-date', 'earliest finish-date', 'latest finish-date', etc.

Unfortunately, few foundries store the amount of timing information required for such detailed analysis. Furthermore, for those foundries with fast throughput times (eg. days rather than weeks) a system **has** to respond quickly to limited information in order that the most timely and useful information is made available for organising the manufacture of jobs.

However, foundries tend to 'know' or, are able to estimate, typical batch processing times for jobs, which comprise of, for example (assuming no 'move' time, ie. waiting in a backlog of orders):

. pattern shop	p days
. coremaking	c days
. mould making/casting	m days
. fettling	f days
total	p + c + m + f days

Therefore, the minimum lead-time, or the shortest possible 'promise-date' would be the 'total' number of days from the time a firm order was received.

A 'typical lead-time' can be associated with every job - as one of the elements of the basic casting details - and used each time an order for that job is placed on the foundry. A CAPM system should be designed to cater for this function, whilst providing a more sophisticated approach, ie. a 'factored' lead-time which can accommodate differing order quantities for the same job.

In addition to establishing lead-times, there are other constraints which have to be considered simultaneously, before taking the decision to order a job on the foundry; eg. those areas of the foundry which are known to govern the flow of work through the foundry, ie. the so-called 'bottleneck' sections. Moreover, the impact of new jobs onto foundry resources should not be considered in isolation, yet only the overall production picture which is presented by an evaluation of the order book (firm orders) provides much of the information required for production planning.

4.5.5.2 Order-Book Profile

For many foundries, computer-assistance provides the only method for evaluating the order-book in its entirety and a CAPM system should be designed to provide several methods of obtaining an overall production picture, taking into account:

- who is using the system (and therefore, what the user wishes to receive from the system)
- the level of sophistication which a foundry is prepared to accept and/or is practically capable of.

For production management, a summary 'backlog profile' or, delivery schedule, would describe the quantity of undelivered orders by time period, beginning in the current time period and extending into the future over a practical time-span ('delivery horizon'). Clearly, the delivery schedule would be subject to continual change as new orders were received and old orders were delivered. The CAPM system should be called on to re-evaluate the order book by sorting the 'balance-to-deliver' quantities into the time periods covered by the delivery horizon (eg. weekly 'time buckets'). The number of orders which were 'past due' (ie. 'late') should also be signified, acting as a 'red flag' to the production manager that a situation required attention.

The delivery profile report can be taken a stage further to provide a second summary order-book profile report, which begins to show the effect of product lead-times on the required-dates promised. For each order, the system would subtract an appropriate lead-time from the customer required delivery-date, to arrive at a 'suggested production date' for the order.

Jobs would be designated as 'overdue' if the calculation produced a suggested production date which lay in the 'past in terms of the current time period). A further refinement to the calculation would take into account any days which had been defined as 'non-working days' to the production calendar (eg. by adding one day to the suggested-date and re-testing the suitability of that date. If the revised date proved unsuitable, the 'loop' would be repeated until the first 'working-date' was found).

Thus, the production manager would be provided with a schedule, sorted (eg.) by customer and pattern/die number, showing the 'balance-to-make' quantities and suggested start-dates for the production of jobs.

So far, the 'profiles' described have not taken into account any capacity requirements, yet the 'suggested production' schedule would attempt to predict the load on the foundry (to infinite capacity) for each time-period, thus providing the production manager with a summary rough-cut capacity plan which can reflect the product mix. However, to plan within capacity and to create meaningful short-term schedules, the planner requires more information about each order which should be presented in such a way as to enable ease of interpretation and manipulation.

4.5.5.3 Planning Production with Capacity Constraints

Foundry planners would require a breakdown of the suggested production schedule, in a format which reflected the criteria normally used for scheduling jobs. Therefore, the sytem should enable the planner to select the contents of a 'planning report', incorporating the elements of information stored in basic casting and order-book 'files'.

Further versatility should be provided by a system to enable a planner to define a specific 'planning horizon'. Moreover, it should also be possible to specify the order in which the information should be presented (the 'sort' sequence), for example:

- by 'suggested-date' and process section
- by process section and 'suggested-date'
- by material grade and 'suggested-date'
- etc.

In the first instance, a planning 'report' should be displayed on the computer screen - see figure 4.1, below.

Figure 4.1 An Example of a Production Plan

User: xxxx Function: Production Planning Date: xx/xx/xx

Seq. No.	Internal Ref.	Pattern /Die No.	Process Section	Material Grade	Mould /Die	No.of Shots	Req'd Date	Sug'd Date	E C
1	xxxxxx	xxxxxx	xxxxx	xxxx	xx	x	xxxxx	xxxxx	E
2	xxxxx	xxxxxx	xxxxx	xxxx	xx	x	xxxxx	xxxxx	E
3	xxx	xxxxxx	xxxxx	xxxx	xx	xx	xxxxx	xxxxx	C
Sub-Total -->						xxx			
4	xxx	xxxx	xxxxxx	xxxx	xx	xx	xxxxx	xxxxx	C
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.

A planner would therefore be presented with a list of jobs, sorted (say) by resource section and 'suggested-date', sub-totalling on change of week - the suggested start-of-production-date should be calculated as described above, incorporating the production calendar.

The 'E/C' option would enable a planner to 'c'onfirm the suggested date, or, to 'e'nter one of a planners own choosing, eg. based on the simultaneous consideration of the potential loading on the process section, the numbers and type of mould/die required and by utilizing his/her own knowledge in conjunction with the customer's required delivery date. If a planner chose to enter a date, the system would check the entry against the production calendar, before acceptance.

The sequence number ('Seq No.') should be provided, enabling a planner to 'batch' a number of jobs together, by the appropriate movement of one 'line' of the production plan at a time.

Having 'saved' a satisfactory plan, further options should be provided enabling a planner to view the results of the plan under different sort categories, eg. material grade and suggested-date. In effect, a 'what-if' facility should be provided by the system.

Ultimately, a production plan would be printed off for confirmation by the production manager. The print-out format should reflect the changes made and also incorporate additional information (process times, core requirements/times, total weight of material) - made possible by the increased line length.

Furthermore, by accepting the production plan, not only the appropriate order records should be updated with the confirmed 'planned dates', but also the associated load-on-resource information, which would be stored in production-date order, adjacent to the resource capacity information (section 4.3.4).

To complement the planning procedure described, the system should also provide the facility for examining the load on particular 'key' resources (ie 'bottleneck' resources) at any stage during the evaluation of a production plan. The identification of bottleneck resource centres is essential since all subsequent planning and scheduling operations would be governed by the organisation of work through these key production centres. Thus, assuming a planner had batched sets of jobs over several time-periods, the impact on the resource centres concerned should be graphically displayed at the planner's command. The resources would still be loaded to infinite capacity, but where the load for a particular time period (eg, a week) exceeded the stated maximum resource capacity for that time period, the system should 'flag' the situation, drawing the planner's attention to the potential problem (eg. by means of a capacity 'line' traversing the chart).

Since each 'load-column' would contain summary information of all the pertinent jobs, expressed in the designated resource units, the system should also enable the planner to 'enquire' on the jobs comprising a particular week's load, thus identifying the jobs 'causing' a potential overload situation. Moreover, the facility to re-plan the start-of-production-date, for any job, would be essential, providing a mechanism for balancing the flow of work through the resource. In re-planning the start of production, any date entered should be subject to a production calendar 'cross-reference', to avoid the entry of invalid dates.

By providing the facility to identify jobs with an appropriate resource and by 'sorting' and 'storing' the resource loadings for given time periods, the system should then enable the planner to cope with the phenomenon of 'split batches'.

For example, if a given weekly load on a resource was found to be 'over -capacity', a review of the orders comprising the weekly load-total would identify the job-load composition. If the planner had to split a particular batch quantity (and say make 'x' amount this week and 'y' amount next week) in order to balance the flow of work through the resources, the system should:

- enable the 'x' and 'y' quantities to be established against a start-of-production date, respectively
- 'file' the split-batch-quantity, in 'date-order', together with the internal order reference against the appropriate resource

Any 'confirmed' changes made to the production plan via the load-chart module would be reflected in the original production plan when the planner instructed the system to 'return' to the former mode of operation. However, the system should enable the planner to use the load-chart function without necessarily invoking the interactive planning procedure (ie. in 'stand-alone' mode).

Using the techniques described above, the planner should be able to produce a 'short-term' plan for job production, in terms of satisfying the customer orders, whilst balancing the flow of work through the resources. Following the acceptance of the production plan, the system should enable the printing of production programmes ('work-to-lists') detailing the weekly manufacturing requirements for the foundry, by production section.

4.5.5.4 Production Programmes

The production programmes would subsequently be handed to the foundry supervisor whom would sequence the jobs on a day-to-day basis and would have the responsibility of ensuring that the weekly targets were achieved.

4.5.6 Works Documentation

A system should provide the means for producing works documentation although it should not 'force' the maintenance of this module on the users, since many foundries can adapt other documentation (which should be provided by a system) to describe the route of a job. The ability of a system to complement existing manual procedures also reflects the necessary flexibility of design.

Whether the medium for producing the documents takes the form of a 'document generator', or consists of a series of 'standard' documents (or both), it should be possible to select one, or a batch of documents to be printed either by pattern/die number or works internal order number. The following list represents a typical set of works documentation:

- route card
- operation card/batch card
- material requisition card
- pattern release card
- quality assurance documentation

The information printed on the documentation would normally be derived from the pattern/die register, the order/schedule records and the route -card records. In addition, the provision of areas of 'free-form text', for users to convey special notes/instructions should be made available, for subsequent transfer to the relevant documents during printing.

The issue of pattern release documents informs the pattern department of imminent work. The pattern department can signify the availability of patterns by returning the document, appropriately 'marked', to the production control department. Where patterns are supplied by the customer, stores should use the document to signify when the customer has delivered them to the foundry. In both cases, a job or, pattern 'status' can be identified which can be 'flagged' against a system's record of the pattern/die.

Operation cards represent the breakdown of production programmes and can serve at least two purposes: the first is to inform the operator of what has to be done and how to do it, the second is for the operator to inform the production control department of what has been done. Thus, on completion of a job, the operation card should be signed by the operator/supervisor and include all relevant work-booking information for subsequent processing by the production control department.

4.5.7 Work Booking

The modules presented thus far have been concerned with the pre-production activities of organising and planning for the manufacture of jobs and the subsequent dispatching of works orders to the foundry.

To provide 'control', it is essential that feed-back from the shop-floor to a CAPM system is maintained on at least a daily basis, although preferably on a more regular basis. At the most basic operating level, the work-booking information can be manually entered against the individual order/schedule records held by a system. At the other extreme, 'terminals' (ie. micro-computers) which are located at monitoring points within foundries can be used to update a system in real-time, which provides the most accurate (and most expensive) basis for subsequent planning and scheduling activities.

Another option is to make use of 'hand-held' terminals with which to record information from the shop-floor for subsequent transfer to a CAPM system on a regular basis (of which the author has first-hand experience). The hand-held units are powered from re-chargeable batteries and can be easily carried around the foundry.

Periodically, the unit would be returned to the production control office for interrogation of its 'transaction files'. By transferring the information from the hand-held machine into the system (normally via an asynchronous communications cable connected to the RS232-C parallel port of the micro-computer) the w-i-p information can be updated, but only on a batch basis. Any exceptions (eg. badly entered pattern/die numbers) can be printed out in the form of a report, which would necessitate manual adjustments to the order and w-i-p records.

The manual version of a batch updating procedure involves entering the information returned from the shop-floor into a 'work booking module' which is integrated into a CAPM system and provides the user with the same alternatives for dealing with anomalies (eg. 'over production') as the real-time option.

Whichever method is employed, the work-booking module should enable the booking of work against either the pattern/die number or the works internal order number and be capable of accomplishing several other tasks, simultaneously, in addition to automating the manual procedure of updating the works order cards. Moreover, the provision for booking scrap , despatches, rectifications and customer returns should be incorporated into the method employed.

For complete flexibility, a CAPM system should support all of the options listed, enabling a foundry to progress through stages of sophistication when it was considered appropriate.

4.5.7.1 Updating Production Archive/Resource Records

To provide full traceability of the events surrounding the production of jobs, the system should automatically update the production archives from the bookings of production, scrap, despatches, rectifications and customer returns. Each 'booking' should be stored in summary form, together with relevant details from the pattern/die and order/schedule records, for later interrogation.

The module should also update the relevant resource records enabling the loading of new jobs onto production centres, whilst passing w-i-p onto the next designated resource.

4.5.8 Despatch Notes and Invoicing

The system should provide a facility for the printing of advice notes and invoices, in a similar manner to the production of customer order acknowledgements, described earlier. Following the despatch procedure a transaction file should be updated with the relevant details necessary for producing the documents.

At an appropriate time, the transaction file would be interrogated and unprinted documents could then be 'flagged', which should invoke a procedure to enable selected documents to be 'prepared', prior to printing. The ability of a system to provide documents which emulate the existing paperwork is desirable since it assists in the acceptance of a system by enabling users to 'identify' with the output from a system.

4.5.9 Reports

The provision of information on the current situation and also for the purposes of comparing predicted and actual events, is essential to the control of the foundry. The application of the micro-computer to this chore is one of the areas where time-savings are most apparent.

Without doubt, the most covenient vehicle for performing the necessary tasks is the provision (by the system) of report generators.

The following list presents some of the features which should be provided by a system's report generator(s):

- report title
- column headings
- data element definition
- identification of 'key' data elements
- identification of 'sort' data elements

- identification of 'sub-total' data elements
- identification of 'total' data elements
- the option to create and save 'keylists' (high volume data processing)
- the option to suppress meaningless data (eg. zero quantity data)
- the option to print summary information only
- the provision to select 'blank' columns of data to be printed
- the provision of a calculator function, enabling users:
  - to input their own algebra
  - to 'round' figures down, or up
  - to subtract a span of time from a selected date
- reports library
- the option to run a 'saved' report, or to re-use the report 'mask' for a different selection of data elements

4.5.10 Production Archives

For production traceability and to provide the production department with a performance analysis utility, the keeping of production archives (or 'historical') information, is an essential part of the system.

The information stored within the database consists mainly of cumulative quantity information and work-booking transactions. Apart from the initial setting of the cumulative elements, the database should be extended from the activities surrounding other modules within a CAPM system.

Periodically (eg. every six months, or annually), the information within the historical database would require 'clearing' from the system (depending on the capacity of the storage media and the degradation of the speed of response exhibited by the system). The system should provide the option of clearing all the information from the database, or just a part of the information. Whichever option is taken, the information designated to be cleared from the system should be printed, prior to deletion, so that a permanent, 'hard-copy' of the information can be manually archived. The 'cumulative' quantity figures would be left untouched by this action, but the 'period-to-date' figures would be re-initialised to zero.

Reporting facilities are an essential requirement for this module, including the ability to link to the pattern/die register. As with the reports section, discussed above, a report generator should be provided by the system for the creation of management information and performance analyses; for example, a report showing the number of jobs despatched on time (produced by comparing the actual date of despatch and the customer 'required-by' date).

The preceding sections have suggested an approach towards production planning, scheduling and control in foundries, using the assistance provided by micro-computer technology.

Emphasis has been placed on the need for 'flexibility' to be incorporated into the design of a system, thus enabling many foundries to enjoy the benefits of packaged software. At the same time, the adoption of a CAPM system will impose a certain degree of standardization into procedures and the advantages of 'change' must be communicated and demonstrated to the employees whom will ultimately be operating the system, at all levels.

Attention is now turned to the presentation of feasible solutions which address specific functions within foundry CAPM, viz: the functions of production planning and scheduling.

CHAPTER 5

5. Approaches to Production Scheduling

5.1 Introduction

The work presented in the current chapter describes practical approaches to 'levels' of foundry scheduling which have been developed and installed into several foundries.

Discussions with foundry production personnel (see Appendix 1.), together with the overall picture obtained from the literature review suggested that the design of a scheduling system should be centred around the provision of 'structured' information (ie. information which has been selected and sorted, etc.) thus forming a basis for executive decision making.

Moreover, the fact that foundries work to an order-book which can only be described as erratic dictated that a scheduling and planning system had to be flexible, and capable of responding rapidly to the inevitable order-book fluctuations.

5.2 The Scheduling Problem

Foundries often lack reliable time "standards" for individual manufacturing operations. Where standard times are available, they are usually confined to the capital intensive "key" operations. As a rule, the key operations may also be identified as 'bottleneck' resources, ie. resources which limit throughput (assuming that a perfectly 'balanced foundry' does not exist!). Since the bottleneck resources determine the flow of work through 'non-bottlenecks' (a principle of the OPT philosophy), the foundry scheduling problem can be simplified, initially, to scheduling the flow of work through defined bottleneck areas. Such areas are usually identified as coremaking and moulding (for sand foundries) and casting (for die foundries).

Whilst the bottleneck resources associated with these key areas may be loaded to finite capacity, true 'backward scheduling' is generally impractical because the 'after-casting' operations times are either inaccurate or 'missing'. The problem is exacerbated in 'jobbing' foundries where a high proportion of the live order-book consists of jobs for which only 'estimates' are available at best.

However, given the identity of bottleneck resources for each job, the next stage in co-ordinating the manufacture of jobs involves scheduling work through these resources. This task usually falls to the person(s) responsible for planning and controlling production (eg. the production controller, production planner, production scheduler, etc.) whom will be referred to as the 'production planner' for the remainder of the chapter.

5.3 The Production Planner's Problem

The problem of scheduling castings manufacture in any foundry may be stated as follows:-

..... Given an 'order-book' detailing outstanding customer requirements, when should the balance-to-deliver-quantities be processed through the bottleneck resource(s) in order to meet the required dates .....

More specifically, the production planner's task is to produce production programmes or, 'work-to' lists for the coremaking, moulding and casting areas (sand foundry), or the casting machines (die foundries). For die foundries it may also be required to produce a listing of any requirements for cast-in inserts or miscellaneous additional assembled components.

To accomplish this task, up-to-date information must be on hand, detailing:

- customer delivery requirements
- replacements
- customer returns
- work-in-progress
- lead-time to manufacture castings
- expected scrap rates
- available resource capacities

Attempts to manipulate all these factors simultaneously have proved to be practically impossible by manual methods, but a computer can be programmed to actively assist in the preparation and presentation of information, in a form which is readily understood and which can be used effectively by the production planner.

In essence, the computer-assisted scheduling techniques described below, reflect different levels of computer involvement with foundry planning/scheduling information requirements.

5.4 Scheduling Concepts

The conflicting objectives of balancing the flow of work through key resource centres, whilst at the same time satisfying customer requirements for 'on-time' deliveries, ensures that 'ideal' solutions to scheduling problems are rarely possible.

Moreover, the evidence provided by the literature survey suggested that entirely computerised solutions to the scheduling problem were not favoured by the industry, whilst few systems developed for use in a micro-computer environment were of practical value or, generally applicable to a wide range of foundries.

These points are addressed in the approach to scheduling adopted here, which makes use of the micro-computer's effective searching, sorting and calculating functions for information manipulation, leaving the production scheduler to apply detailed knowledge to the 'suggested' schedule which is generated.

In each of the scheduling techniques described below, the initial computer-based task is to simply identify the production load: ie. by considering the entire order-book, the balances to cast, or 'nett requirements' can be determined. The calculation to establish 'nett requirements' is accomplished in two steps, viz:

Gross requirements = Customer Orders (discrete orders/schedules)

+ Replacements (internal scrap & customer returns)

+ Samples and Pattern/Die checks (eg. for approval)

+ Make-To-Stock (eg. policy for long-running parts)

The 'nett requirements' or, balances-to-cast are computed from:-

Balance-to-Cast = Gross Requirements (as determined above)

+ Scrap Allowance (to allow for foundry scrap/'yield')

- Quantity Already Cast (Work-in-progress 'stock')

The computed balance-to-cast is finally 'rounded up' to account for the number of moulds per box or, impressions per die (eg: if the balance-to-cast turned out to be 267 for a part with 4 moulds per box, then the number would be rounded up to to 268; ie. 67 boxes; since 'partial-boxes' cannot be made).

A second computer-based task involves the computation of 'suggested start-of-production-dates' or 'suggested manufacturing-dates', for jobs which have not been 'planned' (jobs/orders are referred to as 'firm' until they have been given a 'planned' date. Thus, only planned orders should have their delivery dates confirmed by the foundry). That is:

the suggested manufacturing-date = customer required date - lead time

(where 'lead time' = manufacturing throughput time)

The computers 'suggested manufacturing-date' may also be subject to non-automatic revision: eg. a check for this date against specified 'non-working' days may prove positive, which would result in the revision of the suggested date. Normally the procedure is to 'add-a-day' and re-check the revised date, continuing in the 'loop' until an acceptable date is found.

The final balance-to-cast figure and suggested manufacturing-date are used by the scheduling techniques presented below. The difference between each of the techniques, lies in the degree to which work-centres are actually loaded by the computer and the relative contributions required from the production scheduler and the computer, towards the provision of workable schedules.

5.5 Scheduling Techniques

The techniques developed provide the facilities to:-

- identify (in advance) all 'non-productive-days'
- define resources in terms of nominal capacities
  - expressed in appropriate units
- perform rough-cut scheduling
- perform infinite capacity scheduling
- perform interactive scheduling
- produce production programmes

To assist the description of the scheduling techniques, 'screen dumps' have been incorporated into the text, which have been taken from a micro-computer installation (see Figure 5.1, overleaf, for an example of the hardware). The installation maintains the databases, and the information associated with the databases, as specified in Chapter 4.

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Figure. 5.1 Example Of A Micro-Computer

5.5.1 Production Calendar Definition

The production calendar is the equivalent of the Gregorian calendar which is used in every day life. By assigning particular days as 'non-working' days (over a range of years), the user can define works shutdowns, public bank holidays, etc. for later use in conjunction with the planning and scheduling functions.

Figure 5.2, below, represents the computer display of the calendar maintenance function. The user is prompted for a 'year' and a 'month' and the computer calculates the correct number of days to be organised against the appropriate weekdays - two months at a time.

```
USER :  CLIVE      <V:86F01> *FUNCTION: CALENDAR UPKEEP  *        DATE:26/ 8/86

        N O V E M B E R                     D E C E M B E R
   Sun Mon Tue Wed Thu Fri Sat         Sun Mon Tue Wed Thu Fri Sat
                             1                1   2   3   4   5   6

    2   3   4   5   6   7   8           7   8   9  10  11  12  13

    9  10  11  12  13  14  15          14  15  16  17  18  19  20
                            A
   16  17  18  19  20  21  22          21  22  23  24  25  26  27

   23  24  25  26  27  28  29          28  29  30  31

   30

   Update November's  non-work           8     | '0'=yes/no
   day status (Y/N) ?:                   ^     | '('=range on/off
                                      4< * >6  | ')'=end on/off
   1986                                  v     | '7'=print
                                         2     | 'E'=end
```

Figure 5.2 Example of Production Calendar Maintenance

The functions in the bottom right-hand 'window', enable the user to define non-working days: for example, by moving the 'arrowhead' to the appropriate day and "toggling" the '0' key or, by using the parentheses to define a 'range' of dates. The user is given the option to 'save' any changes made, which instructs the system to update the calendar 'file', stored on the computer (program listing A4.1 - Appendix 4.).

5.5.2 Production and Delivery Schedules

The scheduling techniques can be accessed from one menu (see Figure 5.3), which represents a sequence of procedures for realising the planning and scheduling 'model' described in Chapter 4.

```
USER : CLIVE   V:86F01  *FUNCTION: SCHEDULING & PROGS        *DATE:26/ 8/86 *

          (01) Rough-Cut Scheduling
               (Nett Requirements Scheduling by Customer)

          (02) Man-in-the-Loop Scheduling
               (Capacity Scheduling by Production Week)

          (03) On-Line Interactive Scheduling
               (Interactive Scheduling by Work Centre)

          (04) Print Production Programmes
               (Work-to Lists)

             Option Please  :  :
```

Figure 5.3 Options Within the Production Planning and Scheduling Model

The first and second 'levels' of scheduling involve the provision of summary information relating to the backlog of orders (delivery schedule) and the creation of a rough-cut capacity plan. These are represented by option '(01)' off the menu shown in Figure 5.3, which produces the information selected in the form of a report. To access the report, production staff enter the following parameters:-

1. a range of customers
2. a date - from which the planning horizon can be calculated
3. the required report (both the delivery schedule and nett requirements schedule run from the same program)

The program scans through the order book, sorting the 'firm' and 'planned' customer orders/schedules by part number within customer name and accumulating the relevant 'quantity' figures for each part number: subsequently, each cumulative figure is allocated to an appropriate weekly 'time-bucket'.

Selection of the delivery schedule report instructs the program to place the 'balance-to-deliver' quantities 'into' the time-buckets which incorporate the customers' required delivery dates, whilst the nett requirements report places the 'balance-to-make' quantities against the time-buckets which correspond to a 'suggested production-week', as calculated by the computer or, to a 'planned production week', which has been previously defined to the system by the production planner.

Figures 5.4 and 5.5, below, show examples of each report (program listing A4.2 - Appendix 4.).

Report Title : Customer Delivery Schedules (Summary)
Customer : All Records
Date Produced : 3/ 9/85
Dates Covered : Entire Orderbook

* Notes : Report shows the balances to deliver to fulfil Customer Delivery Schedules by weeks ending, as indicated.

Customer : TITEX TOOLS LTD

Part Number	Description	O/due	02/06	09/06	16/06	23/06	30/06	07/07	14/07	21/07	28/07	04/08	11/08	18/08	Fwd.	Made
TT/1372	CRANKED LINK	0	0	300	0	0	250	0	200	180	0	100	0	0	100	351
TT/2258	PORT INLET	0	100	850	0	0	1420	200	1000	850	0	200	0	0	100	0
Sub-Totals ---)		0	100	1150	0	0	1670	200	1200	1030	0	300	0	0	200	

Customer : BROWN & SHARP

Part Number	Description	O/due	02/06	09/06	16/06	23/06	30/06	07/07	14/07	21/07	28/07	04/08	11/08	18/08	Fwd.	Made
GHV-0570	BALANCE WEIGHT	0	0	0	0	0	0	36	120	50	0	0	0	0	0	206
GHV-2831	PUMP HOUSING 9IN	0	0	0	0	0	12	15	0	15	0	0	0	0	0	30
GHV-2831/D	FRONT YOKE	0	0	0	0	0	1400	1250	1100	950	0	0	0	0	0	0
GHV-2915	BACK PLATE (G)	0	0	0	0	0	275	250	275	150	0	0	0	0	0	0
Sub-Totals ---)		0	0	0	0	0	1687	1551	1495	1165	0	0	0	0	0	

Customer : MELLINGS LTD

Part Number	Description	O/due	02/06	09/06	16/06	23/06	30/06	07/07	14/07	21/07	28/07	04/08	11/08	18/08	Fwd.	Made
RLV005T	PUMP HOUSING 4IN	0	0	0	0	0	250	400	375	500	0	0	0	0	0	0
RLV069T	BACK PLATE	0	0	0	0	0	35	40	35	25	0	0	0	0	0	0
Sub-Totals ---)		0	0	0	0	0	285	440	410	525	0	0	0	0	0	

Figure 5.4 Order Backlog Report

Report Title : Suggested Production Schedules
Customer : All Records
Date Produced : 3/ 9/85
Dates Covered : Entire Orderbook

* Notes : Report shows nett quantities to be made in order to exactly meet customer delivery schedules. At this stage, no attempt has been made to 'batch' production runs.

Customer : TITEX TOOLS LTD

Part Number	Description	O/due	02/06	09/06	16/06	23/06	30/06	07/07	14/07	21/07	28/07	04/08	11/08	18/08	Fwd.
TT/1372	CRANKED LINK	0	0	256	0	206	184	0	104	0	0	0	104	0	0
TT/2258	PORT INLET	1000	0	1494	211	1053	894	0	211	0	0	0	185	0	0
Sub-Totals --->		1000	0	1750	211	1259	1078	0	315	0	0	0	289	0	0

Customer : BROWN & SHARP

Part Number	Description	O/due	02/06	09/06	16/06	23/06	30/06	07/07	14/07	21/07	28/07	04/08	11/08	18/08	Fwd.
GHV-0570	BALANCE WEIGHT	0	0	1	0	0	40	0	0	0	0	0	0	0	0
GHV-2031	PUMP HOUSING 9IN	0	0	0	0	0	14	0	0	0	0	0	0	0	0
GHV-2031/D	FRONT YOKE	0	0	1436	1282	1128	974	0	0	0	0	0	0	0	0
GHV-2915	BACK PLATE (G)	0	0	282	256	282	154	0	0	0	0	0	0	0	0
Sub-Totals --->		0	0	1719	1538	1410	1182	0	0	0	0	0	0	0	0

Customer : MELLINGS LTD

Part Number	Description	O/due	02/06	09/06	16/06	23/06	30/06	07/07	14/07	21/07	28/07	04/08	11/08	18/08	Fwd.
RLV005T	PUMP HOUSING 4IN	0	0	264	412	388	516	0	0	0	0	0	0	0	0
RLV069T	BACK PLATE	0	0	36	42	36	27	0	0	0	0	0	0	0	0
Sub-Totals --->		0	0	300	454	424	543	0	0	0	0	0	0	0	0

Figure 5.5 Nett Requirements Summary

5.5.3 Production Planning

Option '(02)' off the menu (Figure 5.3) is used to address the capacity planning aspects of the planning and scheduling model. The approach adopted here is based on a manually interactive principle ('man-in-the-loop'), which delegates the sorting and 'number crunching' activities to the computer, leaving the production planner to exercise judgement and practical experience to override the computer's suggested production plan.

In order to produce a production plan, the planner enters the 'planning criteria' requested by the prompts displayed in Figure 5.6, below.

```
USER : CLIVE    V:86F01  *FUNCTION: PRODUCTION PLANNING        *DATE:26/ 8/86 *



                    (01)  Required Report (A, B or C)

                    (02)  Low Date        (DD,MM,YY)

                    (03)  High Date       (DD,MM,YY)


                  *(A) Suggested Week Mould & Cast Section
                  *(B) Mould & Cast Section + Suggested Date
                  *(B) Material      + Suggested Date


                     Any Alterations (Y/N) ?
```

Figure 5.6 Examples of Production Planning Criteria

The information which is located within the order book (ie. firm and planned orders with 'balance-to-cast' quantities greater than zero) is grouped according to the criteria specified and the program 'suggests' a manufacturing-date if the job has not already been 'planned' (as signified by the presence of a 'planned-date' within the order record). A date-range can be selected to suit the forward planning requirements of a particular foundry (program listing A4.3 - Appendix 4.).

The resulting printed report shows the 'suggested' production plan for successive weeks, although at this stage, no attempt has been made to consolidate the required production capacity with what is actually available. Instead, the report quantifies the consequences of it's suggested schedule in terms of several units of measure: eg. work hours, number of moulds or shots, value, tonnage and so on, as illustrated by Figure 5.7, overleaf.

The 'S' against the 'Suggested Start Date', in Figure 5.7, signifies that the computer has 'suggested' the manufacturing-date, whilst the 'P' defines existing 'planned-dates'. By scrutinising the production plan, the planner can accept the 'suggested-date' or, manually 'set' a revised manufacturing date (ie. by writing on the report). Thus, a facility is provided for 'job-batching', since the 'same' date can be set against appropriate jobs, by the production planner. Any dates that are altered can subsequently be entered against the appropriate order/schedule using the order-book correction utility, provided with the database.

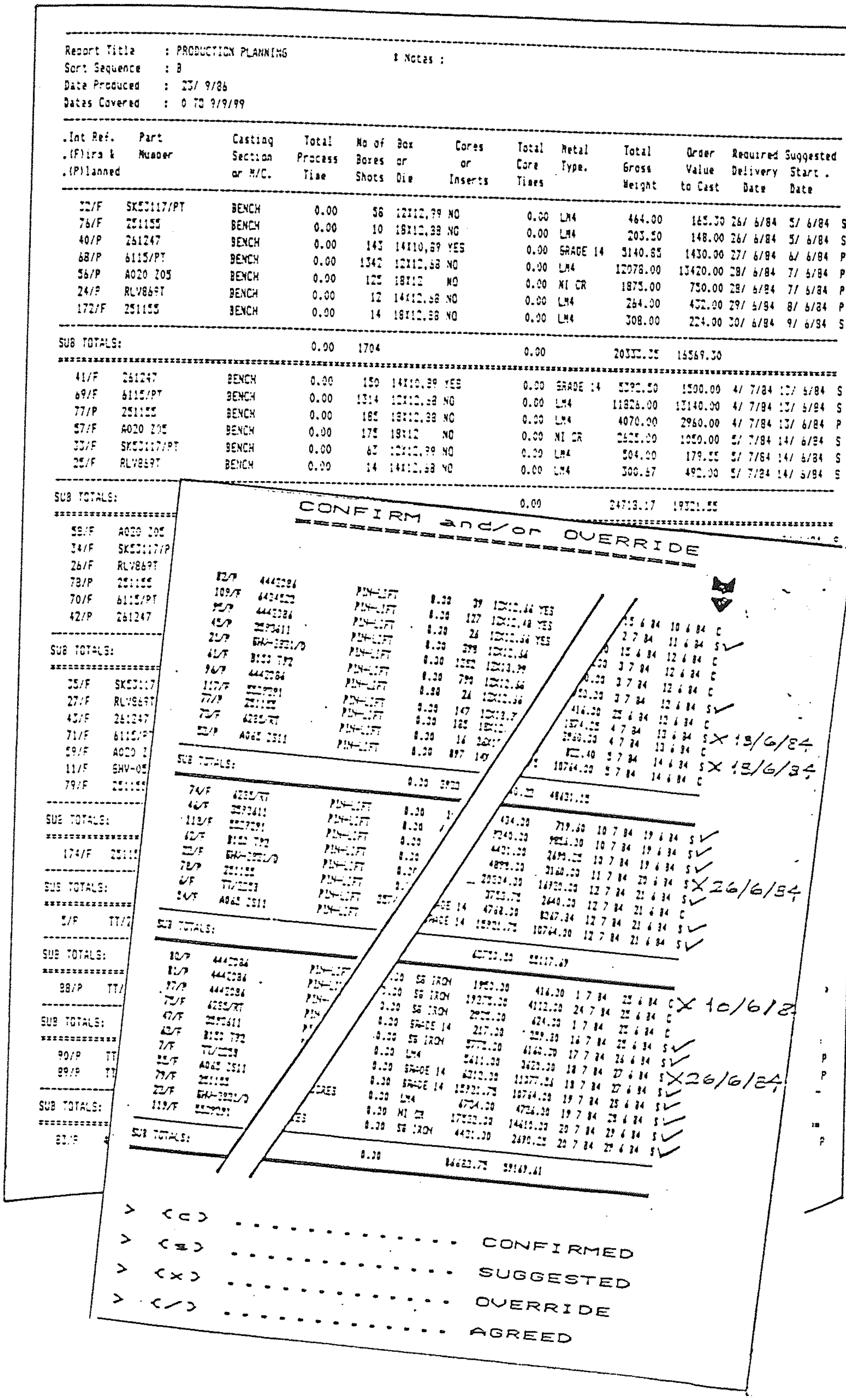


Figure 5.7 A Suggested Production Plan

The 'man-in-the-loop' scheduling approach therefore relies on both man and machine to turn a suggested production plan, which loads resources to the infinite capacity rule, into a a feasible production programme in which resources are loaded to finite capacity.

5.5.4 Interactive Scheduling

The third (and most sophisticated) level of the planning and scheduling model incorporates:

- the creation and maintenance of a resource database
- the projection of load profiles for specified sections
- the provision of an interactive capacity scheduling tool

The resource database (program listing A4.4 - Appendix 4.) enables sections, work stations, manpower, etc. to be defined in terms of a series of resource units so that more than one criterion can be used to evaluate the effect of particular planning decisions.

The resource profiling module is based on a presentation of the work-load which is to be routed through the resource for discrete time periods within a given planning horizon. It is similar in concept to the production plan in the sense that jobs are sorted according to a set of criteria and where necessary, a suggested manufacturing-date is determined by the computer (which is checked against the production calendar). Whilst the resource selected is still loaded to infinite capacity, the nominal capacity associated with the resource (ie. as defined within the resource database) is used by the computer to flag an overload situation (see Figure 5.8, overleaf).

The planner is prompted for a set of criteria, which include:

- the section 'code' (eg. SHELL - shell moulding section)
- the order category (eg. "P" - 'planned' orders only)
- the 'quantity category' (eg. the quantity available to process as opposed to the order quantity)
- the resource units (eg. moulds/week)
- a date from which to start the planning horizon

The computer selects the jobs from the order-book which match the criteria entered and following the 'sorting' of jobs into specific time -periods, a load-chart is displayed on the monitor, see Figure 5.8.

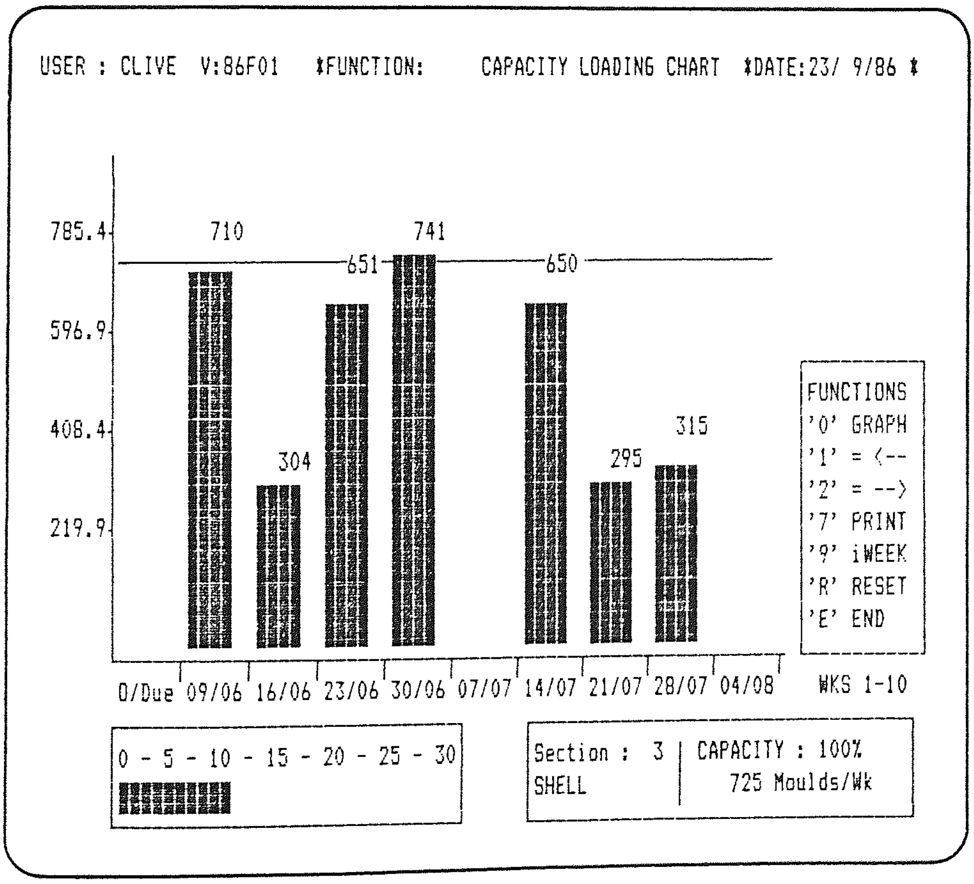


Figure 5.8 Resource Profiling

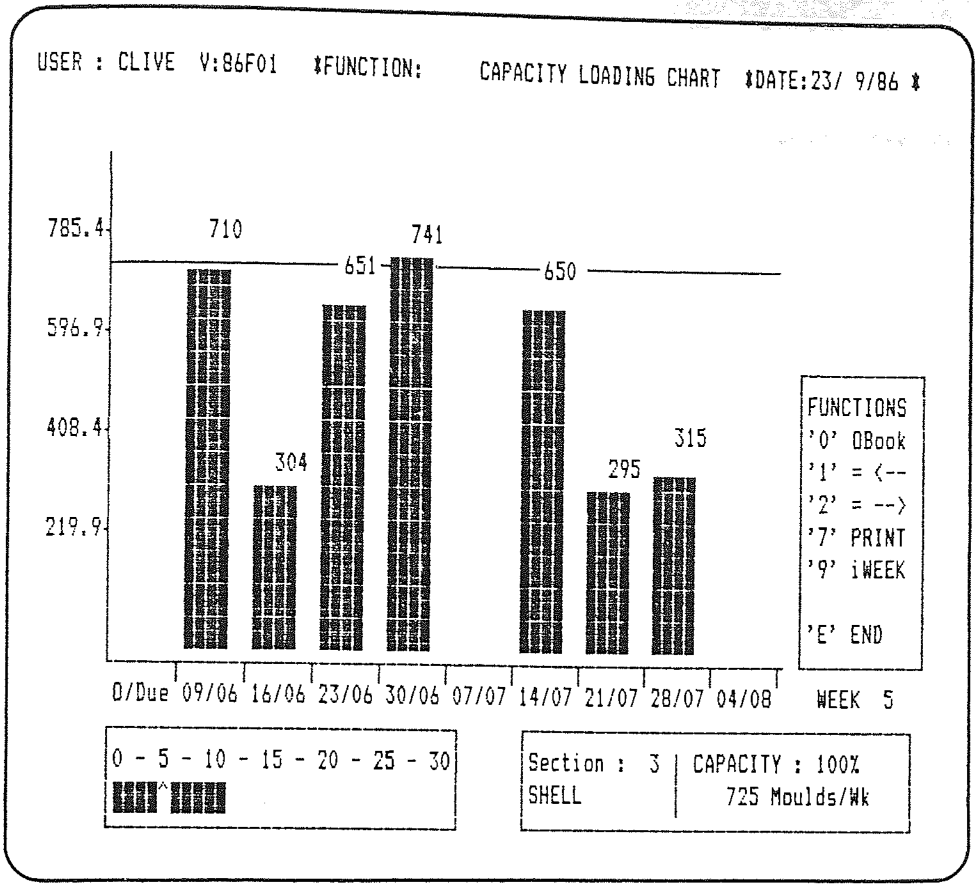
Figure 5.8 shows a resource profile for the 'SHELL' section covering the first ten weeks of a thirty-week planning horizon. The 'first week' is designated for 'overdue' jobs, ie. jobs which the computer has calculated should have been started in terms of the date entered (from which the planning horizon was calculated).

A nominal ('one hundred percent') capacity line is drawn across the chart, so the planner can observe where overload situations are likely to occur in a given week.

The bottom left-hand window contains the 'range-marker' which shows the current ten-week period displayed of the thirty-week planning horizon. Using the function keys listed in the right-hand window, the planner can select any ten-week range within the planning horizon and re-display the appropriate load-profile.

Since the production planner will normally be most interested in those weeks where overloads have been highlighted, the system provides the facility to select and interrogate the jobs which comprise a particular week's work: eg. depressing function key '9' "toggles" the planner in and out of the 'individual-week look-up' mode of operation. Selecting this mode has the effect of 'freezing' the position of the range-marker, whilst enabling the planner to select a particular week.

Continuing the example provided by Figure 5.8 (which highlighted an 'overload' in the week ending '30/06'), Figure 5.9 shows the functions of selecting the 'problem week' and displaying the orders making up the load total (which are sorted first by metal grade).



USER : CLIVE V:86F01 * Section: SHELL Wk.Ending: 30/06*DATE: 23/ 9/86

Order Ref: 39/F

Part Number	Customer(12)	Metal	Price	Resource Units	Planned	Req'd
GHV-2915	BROWN & SHAR	GRADE 14	5.88	75	26/06/84s	17/07/84
RLV005T	MELLINGS LTD	GRADE 14	4.00	125	26/06/84s	17/07/84
B428 T05	BUTTERFIELD	GRADE 14	2.75	52	28/06/84s	19/07/84

% of load total = 34.00 : % of weekly capacity = 34.75862

Part Number	Customer(12)	Metal	Price	Resource Units	Planned	Req'd
A040 Z01/M	LISTERS LIMI	LM4	3.00	10	28/06/84s	19/07/84

% of load total = 1.349 : % of weekly capacity = 1.37931

Part Number	Customer(12)	Metal	Price	Resource Units	Planned	Req'd
SK02311/PT	NCR CIMEG	PL NI CR	12.00	475	4/7/84	s18/07/84

% of load total = 64.10 : % of weekly capacity = 65.51724

Part Number	Customer(12)	Metal	Price	Resource Units	Planned	Req'd
GHV-2831	BROWN & SHAR	SG IRON	3.00	4	25/06/84s	16/07/84

% of load total = .5398 : % of weekly capacity = 0.55172

Load tot: 741:(102 % of wkly cap.)
Cap.(100%) 725 Moulds/Wk : 6: 1

Keypad: 0=yes/no , 1=up ,2=down
5= change, 7=print,9=abort

Figure 5.9 Weekly Load Composition

Where the computer has suggested a manufacturing-date, the date displayed under the heading 'planned' (in Figure 5.9) is suffixed with the letter 's'.

A further set of function keys enables the planner to alter the 'planned' dates which appear on the screen. Thus, the suggested manufacturing date can be confirmed, or a revised manufacturing date can be entered (which is checked against the production calendar). The action of entering a revised date, which moves a job from the original week to a different week, affects the weekly load composition, such that when the load-chart is re-displayed the planner can see the effect of the changes made (see Figure 5.10).

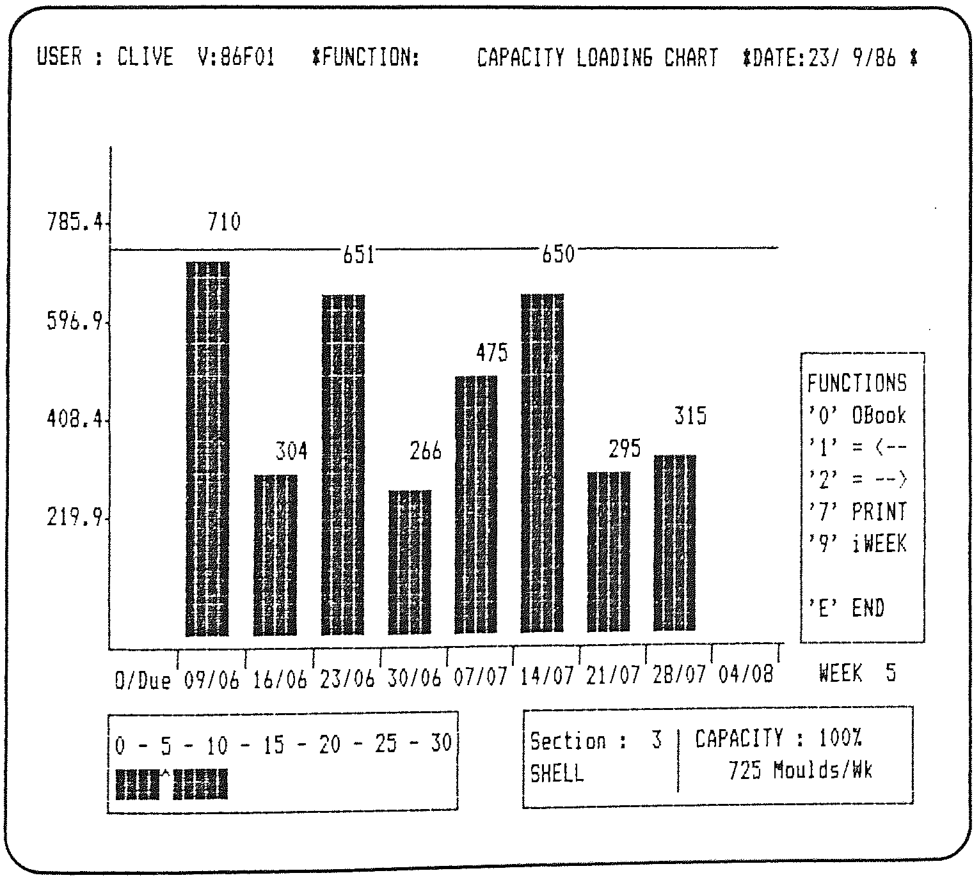


Figure 5.10 Example Of Load Chart Balancing

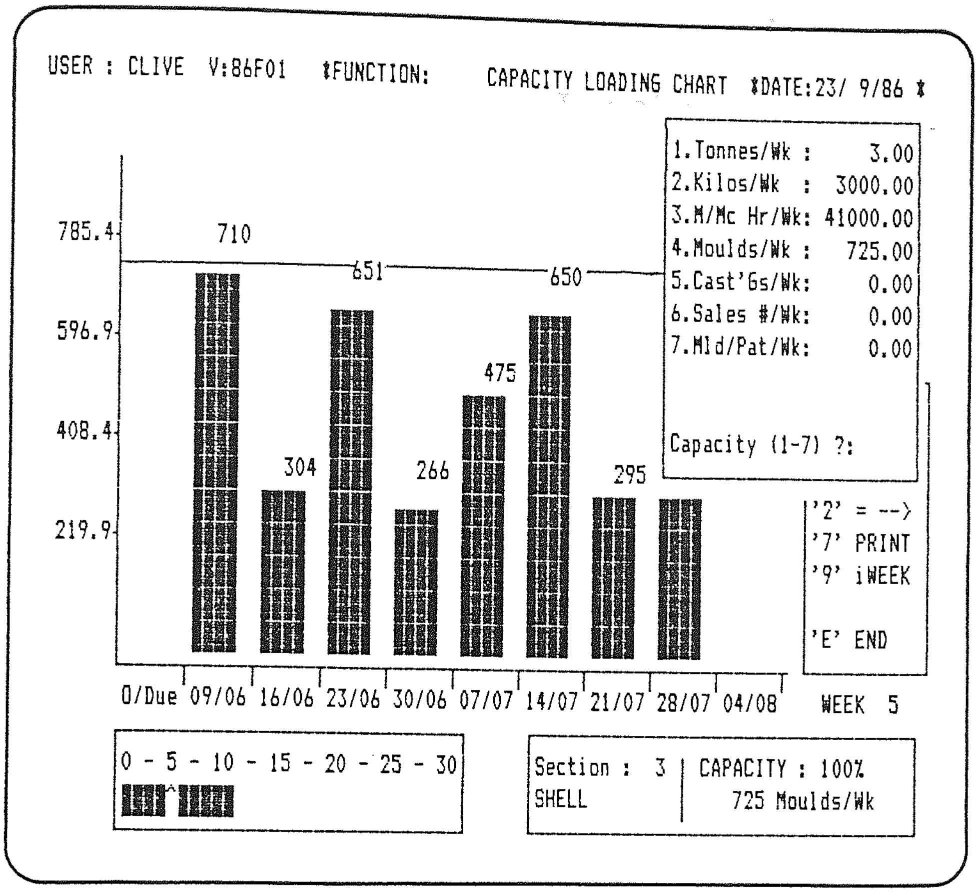
Using the 'what-if' functions provided, the planner can therefore allocate 'planned manufacturing-dates' to particular jobs, and attempt to **balance the flow of work** through the resource specified. Once an acceptable load profile has been achieved, the computer automatically revises the manufacturing dates of all jobs concerned

The planner may wish to review the load profile under an alternative resource unit (eg. to see if sales targets will be met) and figure 5.11 overleaf, illustrates the procedure for re-displaying the load-chart, together with the resulting profile. The interactive scheduling procedure can be repeated if necessary if the 'new' load profile demands attention. (Program listing A4.5 - Appendix 4.)

5.5.5 Production Programmes

Following the approval of a production plan, master production programmes or, 'work-to-lists' can be generated for each work-centre (or resource). Work-to-lists are only produced for jobs which have been planned for production and are mainly concerned with the 'key' resource activities of coremaking, moulding and moulding/casting.

The planner selects the required key resource activity and enters a 'finish-date', which provides an upper limit on the planned jobs to be selected from the order-book. In this way, a means of controlling the release of work into the foundry, over (say) a week or fortnightly period is provided, although revised programmes can be produced as often as required. The details printed on the resulting production programmes include technical/descriptive information stored on the



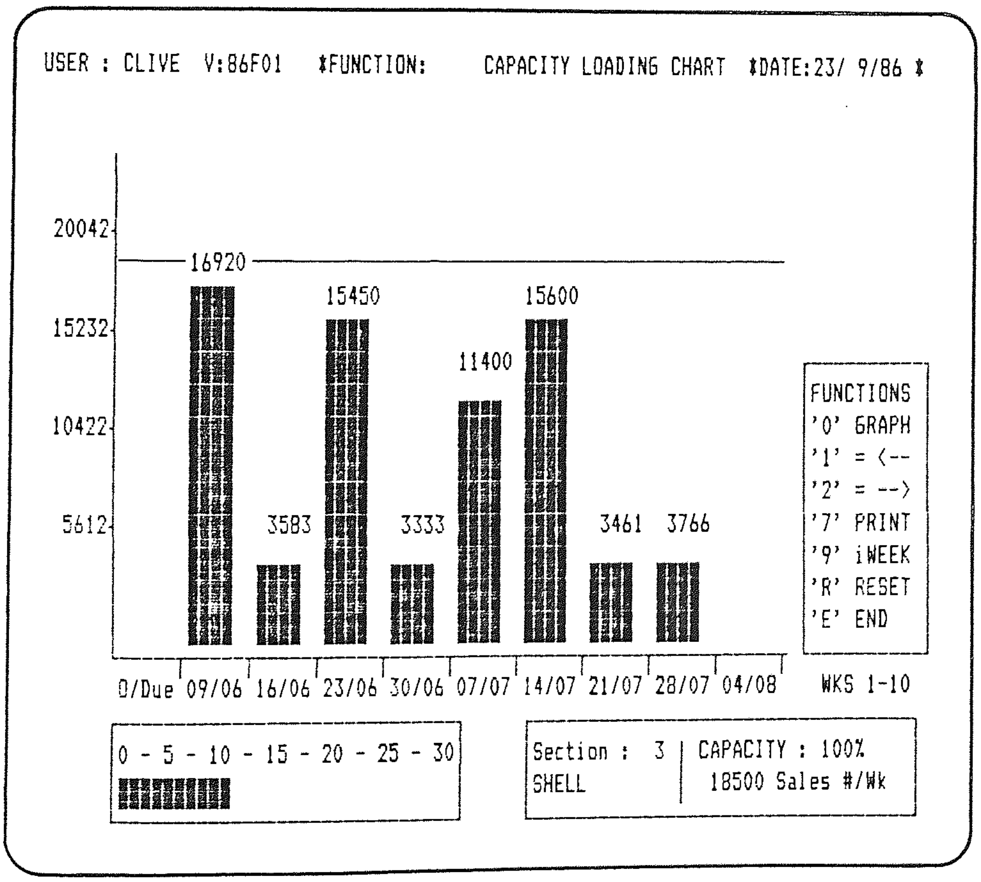


Figure 5.11 Load Profiling With Alternative Resource Units

computer database (see Figure 5.12, overleaf).

Figure 5.12 shows a production programme which covers the 'BENCH' and 'PIN-LIFT' sections of a foundry. The dotted dividing-line between each section enables the programme to be separated into individual lists which can be handed to the supervisors concerned, who can organise the sequencing of jobs from the production programmes.

Jobs requiring cores (or inserts) can be printed-off in a similar manner, thus forewarning the coreshop supervisors of the need to 'supply' particular cores by a certain date.

(The production programme computer program is incorporated within program listing A4.3 - Appendix 4.)

The preceding pages have presented approaches towards the planning and scheduling functions within foundry CAPM.

Three specific techniques were described, which provide three levels of production scheduling 'sophistication' in terms of the:

- functionality of each technique
- information that is required by each technique
- potential for manual interaction

The discussion which follows assesses the integration of the techniques into foundries and covers the wider issues concerning foundry CAPM.

Report Title : PRODUCTION PROGRAMME
Selected Option : Mould & Cast
Date Produced : 23/ 9/86

* Notes :

.Internal Ref No. .(P)lanned only .	Part Number	Casting Section or M/C.	Total Process Time	Total No of Imprs.	Box or Die	No of Boxes Shots	Total Gross Weight	Metal Type.	Cores or Inserts	Required Delivery Date	Planned Casting Date	
40/P	261247	BENCH	0.00	286	14X10,89	143	5140.85	GRADE 14	YES	27/ 6/84	6/ 6/84	P
68/P	6115/PT	BENCH	0.00	1342	12X12,68	1342	12078.00	LM4	NO	28/ 6/84	7/ 6/84	P
56/P	A020 Z05	BENCH	0.00	125	18X12	125	1875.00	NI CR	NO	28/ 6/84	7/ 6/84	P
24/P	RLV869T	BENCH	0.00	36	14X12,68	12	264.00	LM4	NO	29/ 6/84	8/ 6/84	P
77/P	251155	BENCH	0.00	740	18X12,38	185	4070.00	LM4	NO	4/ 7/84	13/ 6/84	P
42/P	261247	BENCH	0.00	296	14X10,89	148	5320.60	GRADE 14	YES	12/ 7/84	21/ 6/84	P
78/P	251155	BENCH	0.00	660	18X12,88	165	3630.00	LM4	NO	12/ 7/84	21/ 6/84	P
SUB TOTALS:		-	0.00	3485		2120	32378.45					

.Internal Ref No. .(P)lanned only .	Part Number	Casting Section or M/C.	Total Process Time	Total No of Imprs.	Box or Die	No of Boxes Shots	Total Gross Weight	Metal Type.	Cores or Inserts	Required Delivery Date	Planned Casting Date	
5/P	TT/2258	PIN-LIFT	0.00	877	12X9,8/8	877	7016.00	GRADE 14	NO	6/ 6/84	15/ 5/84	P
88/P	TT/2258	PIN-LIFT	0.00	105	12X9,8/8	105	840.00	GRADE 14	NO	1/ 6/84	25/ 5/84	P
90/P	TT/2258	PIN-LIFT	0.00	105	12X9,8/8	105	840.00	GRADE 14	NO	30/ 6/84	1/ 6/84	P
89/P	TT/2258	PIN-LIFT	0.00	126	12X9,8/8	126	1008.00	GRADE 14	NO	25/ 6/84	1/ 6/84	P
83/P	4442086	PIN-LIFT	0.00	10	12X12,66	3	187.50	SG IRON	YES	10/ 6/84	6/ 6/84	P
44/P	3593611	PIN-LIFT	0.00	1848	12X12,66	462	6930.00	SG IRON	YES	28/ 6/84	7/ 6/84	P
82/P	4442086	PIN-LIFT	0.00	131	12X12.66	33	2456.25	SG IRON	YES	15/ 6/84	10/ 6/84	P
96/P	4442086	PIN-LIFT	0.00	104	12X12,66	26	1950.00	SG IRON	YES	25/ 6/84	12/ 6/84	P
95/P	4442086	PIN-LIFT	0.00	104	12X12,66	26	1950.00	SG IRON	YES	15/ 6/84	12/ 6/84	P
21/P	GHV-2831/D	PIN-LIFT	0.00	1282	12X18,99	1282	23076.00	NI-CR	NO	3/ 7/84	12/ 6/84	P
45/P	3593611	PIN-LIFT	0.00	1592	12X12.66	398	5970.00	SG IRON	YES	3/ 7/84	12/ 6/84	P
53/P	A065 Z511	PIN-LIFT	0.00	897	14X14,99	897	15921.75	GRADE 14	NO	5/ 7/84	14/ 6/84	P
81/P	4442086	PIN-LIFT	0.00	1028	12X12,66	257	19275.00	SG IRON	YES	24/ 7/84	25/ 6/84	P
80/P	4442086	PIN-LIFT	0.00	104	12X12,66	26	1950.00	SG IRON	YES	1/ 7/84	25/ 6/84	P
97/P	4442086	PIN-LIFT	0.00	156	12X12,66	39	2925.00	SG IRON	YES	1/ 7/84	25/ 6/84	P
91/P	TT/2258	PIN-LIFT	0.00	105	12X9,8/8	105	840.00	GRADE 14	NO	15/ 7/84	1/ 7/84	P
103/P	3734617	PIN-LIFT	0.00	104	12X12,66	26	1950.00	SG IRON	YES	25/ 7/84	5/ 7/84	P
102/P	3734617	PIN-LIFT	0.00	104	12X12,66	26	1950.00	SG IRON	YES	25/ 7/84	5/ 7/84	P
98/P	4442086	PIN-LIFT	0.00	208	12X12,66	52	3900.00	SG IRON	YES	15/ 7/84	12/ 7/84	P
84/P	4442086	PIN-LIFT	0.00	104	12X12,66	26	1950.00	SG IRON	YES	1/ 8/84	15/ 7/84	P
165/P	4442086	PIN-LIFT	0.00	104	12X12,66	26	1950.00	SG IRON	YES	1/10/84	25/ 7/84	P
85/P	4442086	PIN-LIFT	0.00	104	12X12,66	26	1950.00	SG IRON	YES	1/ 9/84	15/ 8/84	P
188/P	TT/1372	PIN-LIFT	1236.00	412	250X375	206	1648.00	SG IRON	HOT BOX	11/11/84	11/11/84	R
189/P	TT/1372	PIN-LIFT	618.00	206	250X375	103	824.00	SG IRON	HOT BOX	17/11/84	17/11/84	R
190/P	TT/1372	PIN-LIFT	1344.00	448	250X375	224	1792.00	SG IRON	HOT BOX	20/11/84	20/11/84	R
191/P	TT/1372	PIN-LIFT	1542.00	514	250X375	257	2056.00	SG IRON	HOT BOX	12/12/84	12/12/84	R
SUB TOTALS:			4740.00	10882		5739	113105.50					

Figure 5.12 A Production Programme

CHAPTER 6

6. Discussion

6.1 Introduction

The pragmatic approach to CAPM adopted throughout the course of the research, has led to the development of techniques which assist the organisation and control of manufacturing in foundries.

Three distinct techniques were described in Chapter 5, which collectively form a scheduling and planning 'package'. The package has been implemented in several foundries whom agreed to participate in the research programme (Appendix 1).

The present chapter first reviews the background considerations which stimulated the particular planning and scheduling methodologies. It continues with an appraisal of the subsequent use of the 'package' and establishes the benefits of employing the system, as well as identifying the limitations.

Finally, an overview is presented of some of the wider issues pertaining to CAPM systems, which contributed to the development of the ideas implicit within the current study.

6.2 Planning and Scheduling Methodologies

The rationale underlying the adopted approach to a generalised computer -assisted production planning and scheduling system for foundries, was developed from three sources of information:-

i) an in-depth review of the literature

ii) discussions with foundry personnel

iii) published reviews of several existing CAPM users within the industry

Specific considerations included the lack of accurate information; for example 'standard times', especially 'move' times, which are significant in controlling the throughput of jobs in production systems of an intermittent nature.

Probably the most notable difference in the adopted approach is the provision of a facility to evaluate delivery committments in terms of one or more 'units of resource', other than 'times'.

Such a facility is essential when, for example, measuring the 'production capacity' of heat-treatment furnaces, or shot-blast cabinets, etc., where it is meaningless to use resource units of man-hours or machine hours. That is, different sized castings may require the same 'run-time' in a shot-blast cabinet, but the physical space requirements in each case would be very different - thus the forward load for 'shot-blasting' could not be assessed in terms of the extension of quantities and run-times.

Another example is the loading of, say, a mechanical moulding section in terms of the number and type of boxes per day. Whilst it may be possible to express this capacity in terms of moulding hours, the use of 'moulds per day' is certainly more familiar to foundry personnel. There are, however, cases with loose pattern work (in which more than one job is moulded in a box) in which individual times are not available and the only measure of capacity would be 'box-type'.

6.21 The Basis For A Workable Solution

It emerged that any 'useable' methodology could not be based on the capture and maintenance of large volumes of manufacturing data, if it was going to be applicable to a wide variety of foundries (reasons: lack or absence of such data; unavailability of staff to monitor and input the data/revisions, etc.). Consequently, the applications software was designed to rely only on the information which is readily available in foundries, thus enabling data to be maintained on a regular basis as part of normal production department practice, without adding to the clerical workload.

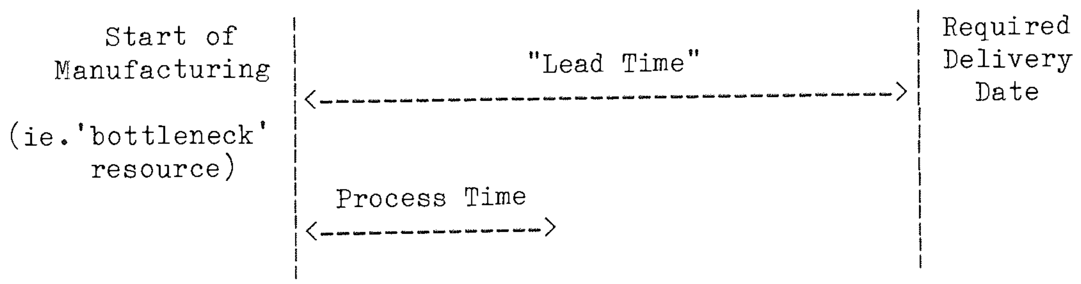
A 'three-level' structure of increasing sophistication eventually evolved, through which 'user-specified' information (ie. data selected via keyboard entries) could be sorted and presented for decision making by the production controller.

The philosophy of having three 'levels' of computer-assisted scheduling was based on the principle of providing foundry staff with a gradual introduction into CAPM. The increase in sophistication associated with each technique, enables the user to 'grow into the system', by providing a route to more refined (and potentially more accurate and responsive) scheduling.

At the most simplistic level, the information provided by the package enables the production planner to assess the amount of 'capacity' which is likely to be required to meet the outstanding nett requirements. At the other end of the scale, the most sophisticated technique provides the planner with a facility to 'interactively plan' jobs into production, whilst being made aware of the loading implications of any planning decisions made.

All three techniques are based on the loading of jobs (ie. the 'nett requirements') onto 'bottleneck resources', to the infinite capacity rule. This is achieved by the 'subtraction' of lead-times (or, manufacturing throughput times) from customers' required-dates. Therefore, jobs are loaded according to the EPPD priority rule ('Earliest Planned Production Date') - see Figure 6.1, below.

Figure 6.1 The Scheduling Approach Adopted By The Present Study



6.22 The Use Of Lead-Time

In the present context, 'lead-time' has the same implication as in standard MRP systems - namely, the elapsed time from placing the order (on the foundry) to completion. By subtracting lead-time from the required delivery date we are implicitly adopting the J-I-T ideal. Moreover, lead-time is assumed to be the same (for a given job) regardless of batch size.

Clearly, lead-time should be viewed as a "company policy" for each casting. For example, straightforward jobs will have a lead time of 2 weeks; jobs requiring sub-contract heat-treatment have 8 weeks, etc.

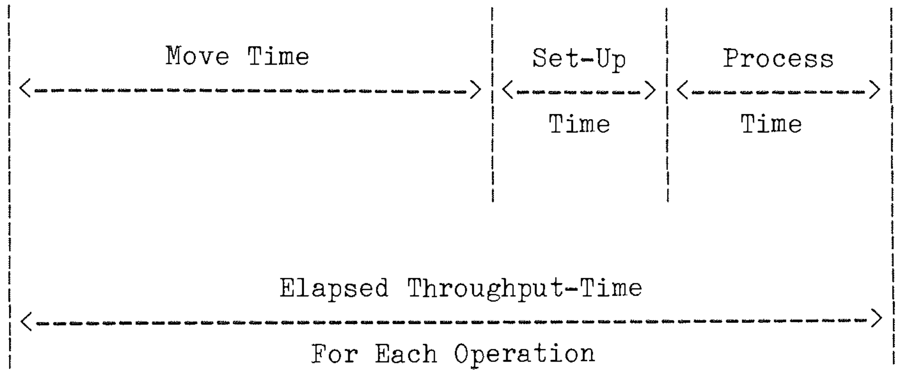
Whilst the lead-time concept has, so far, been used to plan moulding (the bottleneck operation) it would be relatively simple to associate move times with other key operations, so that scheduled 'start-dates' could be related to the moulding date. The step towards practical finite capacity scheduling would then be quite small.

6.23 Finite Capacity Considerations

In order to balance the flow of production within true finite capacity planning constraints, a system would require the run, set-up and move times (see Figure 6.2, below) for each operation to be monitored on the shop-floor and 'fed-back' to the production control department, so that a system could 'learn' from actual performance. In addition, priority rules and scheduling constraints would need to be devised and combined in such a way as to produce an optimal or, near optimal solution. As evidenced by the literature, such an approach has proved to be unworkable in the foundry environment, except in the most simplified of cases.

Whilst the finite-capacity methodology may be possible in the repetition environment, it is highly questionable whether the jobbing environment would lend itself to such an approach because of the 'guestimate' methoding which accompanies new (and therefore each) job. A further complication is that of combining, say, the scheduling of work on moulding sections with the need for 'batch' furnace charges for particular alloys.

Figure 6.2 A 'Traditional' Approach To Scheduling



The conclusions to be drawn from the various considerations suggested that a man/machine partnership would provide a 'best solution' to the problem of foundry planning and scheduling. The philosophy of 'human intervention' was ultimately adopted in all the techniques developed.

6.3 System Applications and Limitations

The variety of foundries (from both material and mould/cast process considerations) who adopted the planning and scheduling techniques presented here, are as listed in Appendix 1.

6.31 The First Level

The 'first level' technique comprises the 'order-backlog' and 'nett requirements' reports, which are used by most of the production management staff. Since the Order-Backlog Report lists the outstanding 'balances-to-deliver', over a planning horizon of 12 weeks, plus the quantities which are 'overdue', production staff are provided with a summary of what will be required during the forthcoming weeks and what jobs need chasing to honour delivery committments.

The Nett Requirements Report enables planning staff to get an overall picture of the forward load on the foundry, based on the order-backlog report, plus the identification of jobs which are behind schedule, in terms of their start-of-production dates. From the summary information provided by these two reports, production planning staff can request more detailed information on the required jobs by moving to the 'second level' technique - the 'planning report'.

6.32 The Second Level

The Planning Report, which facilitates 'man-in-the-loop' scheduling, is used extensively by production planning staff to organise the loading of batches of work onto production centres. The required criteria for 'sorting' the report is selected by the user: for example, the planner at Parker Foundry selects jobs to be listed by 'mould section' and 'suggested-week'. The resulting report is then used to batch jobs together based on the mould section and the planner's current knowledge of the foundry. Another common sort-sequence is 'mould section' and 'alloy type' - again in date order. Such a listing will readily highlight overloads in melting capacity for certain alloys.

The 'planner' at Wolverhampton Ironfounders (who is also the Managing Director!) is more concerned with cored-jobs. In his case, the timing of core-production/-assembly with mould production is critical, especially so with the fast throughput times which typify this particular foundry's production methods.

The extent to which jobs are 'planned', using the procedure detailed in Section 5.5.3, is dependent on several factors, which include:-

1. How advanced a particular foundry wishes to make its planning procedures
2. Access to the computer: in a single user environment (which covers 60% of the foundries listed) the activities surrounding other CAPM functions are competing for keyboard time. Thus, the entry of new orders/methods has to be balanced against work bookings, the printing of management reports, supplying the planners with the appropriate information, printing off works documentation, revising the order details in line with customer amendments and the entry of revised or confirmed production manufacturing dates.

Recent, feedback from production staff suggests that the procedure for "man-in-the-loop" scheduling could be automated further. It is suggested that this could be achieved by printing the report to the screen in the first instance, thus enabling the planners to amend the timing and batching information relating to jobs on a more direct basis. A print-off could then be obtained and, on further study, other changes made via the screen prior to printing off the 'final plan'.

6.33 The Third Level

Before committing the 'final plan' to the foundry, the 'third level' technique enables the planners to 'fine-tune' the proposed schedule, by a consideration of the effects of the decisions made, on various resources. Thus, the two main ways in which the resource profiling module is used is as follows:-

1. Simply as a means of 'enquiring' on the loading of a particular resource for a given planning horizon.
2. As 1., together with the interactive scheduling facility

The interactive scheduling module can be set-up to provide a resource profile on a single resource, a group of 'similar' resources or, all resources for a particular process - eg. the total loading on all moulding sections within a company. This was achieved by defining individual resource records (in terms of the resource capacity) within the resource 'file' in a particular way, as demonstrated by the following examples for the shell moulding section of a company:-

1.	S100	300 moulds/week	- defines a standard machine
2.	S100A	300 " "	- defines a standard machine with 'alterations'
3.	S100AS	250 " "	- defines a standard machine with 'special alterations'
4.	S100A?	550 " "	- a cumulative resource capacity for all S100A machines
5.	S100?	850 " "	- a cumulative resource capacity for the S100 section

Thus the planner could request a load profile for a particular machine or the resource section in total.

In practice, a limiting factor reported by many foundries was the time required to survey the key sections, since the load-profiles had to be produced one at a time (5 to 15 minutes per section depending on the size of the order-book) and the speed of the micro-computer on which the software was 'running'.

A further constraint within the module was pointed out by several users and concerned the interactive scheduling part of the module. The system did not provide a facility to enable the planner to 'split-batches' over several time-buckets in order to balance production flow. Discrete order/scheduled quantities could be handled (ie. 'moved' from one time-bucket to another) but not the interactive breakdown of these orders into 'partial batches'. In these cases, the planner had to note the time periods and the jobs concerned for later manual revision (facilitated by the order-book 'amend' utility).

However, within the bounds of these constraints, the planners can, 'at the touch of a button', review a load profile of a specified work-centre, under a variety of different resources. Overload situations are highlighted and the 'interactive scheduling' function enables production controllers to 'fine-tune' the production plan, which has been created, initially, via the second-level technique.

Despite the limitations, the overall results of the combined planning and scheduling 'model' were encouraging and underlined the practical success of the implementation of techniques which were based on the infinite capacity rule (which also proved to be OPT oriented).

6.4 CAPM - A General Need?

Since the late 1970's, manufacturing industries in general have been under severe pressure to reduce costs, which has resulted in reductions in labour employed and a corresponding total fall in output.

The foundry industry has experienced severe reductions in its numbers, which have been caused by a variety of factors (as listed in Chapter 1) leaving the remaining parts of the industry in competition to stay in business. In common with other industries, competitive pressure has fuelled the search for a strategy for higher industry efficiencies, with the aim of 'closing-the-loop' around all facets of the procedures governing order entry to final delivery.

The strategy has become known as Computer Integrated Manufacture (CIM).

CAPM is one aspect of CIM (others include CAD, CAM, CAPP, MRP, etc.) which can be regarded as a centralized and integrated approach to the organisation of manufacturing operations.

Applications of general purpose CAPM systems in foundries have met with little success as a result of the inherent differences between foundries and other engineering and assembly companies (for which CAPM systems have mainly been developed).

This is to a large extent due to foundries being primary industries, that is, 'component makers' and as such, they tend to experience a very erratic order book, which reflects the customer's nett requirements for parts, which are usually revised each time a customer demands alterations to a schedule. It is therefore impossible for most foundries to have their own master-schedule which can be 'frozen' for a period of time.

As a result, the application of widely publicized techniques such as MRP, inventory control, bills-of-materials, etc. are of secondary importance (or even irrelevant) to the 'cycle of functions' which collectively provide a production control procedure for foundries; which consists of:

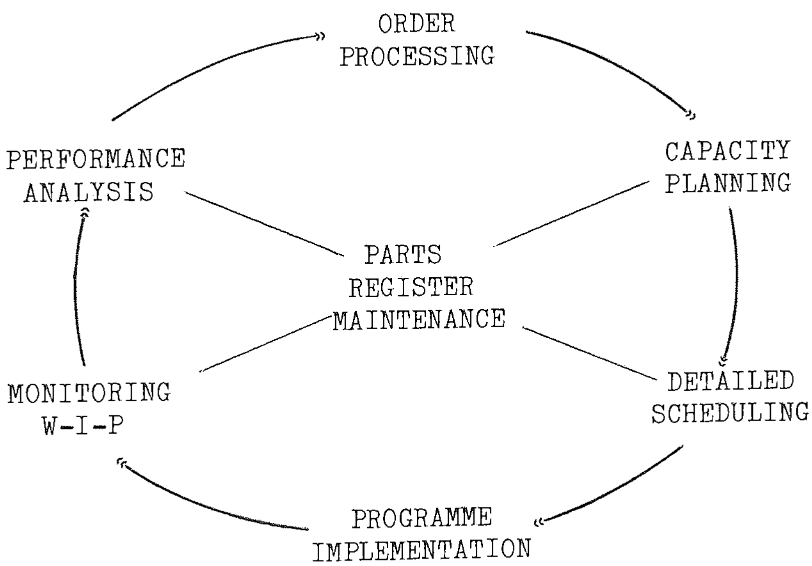


Figure 6.3 The Cycle Of Functions For The Organisation And Control Of Foundry Manufacturing

The characteristic nature of foundry operations has more in common with the principles of the production control philosophy known as Optimised

Production Technology (OPT*) - although the application of such a philosophy to the foundry industry, in its present form, is highly improbable as a result of the copious amounts of accurate information which are required to augment the system software. Moreover, central to OPT is "establishing the bottlenecks" - in foundries this is inevitably moulding or coremaking.

6.41 <u>The Case for Implementing Foundry CAPM Systems</u>

One of the principle reasons for implementing a CAPM system is the deterioration of manual systems, from the point of view of accuracy and speed of access, whilst one of the main benefits which should be identifiable from implementing a system, is the improvement in the **quality** of information.

Moreover, the adoption of the J-I-T philosophy by companies which purchase castings (eg. the automobile industry) is placing pressure on foundries to adopt new technology (eg. the transmission of information by paperless means). If the information is to be received in a form which can be read by a computer, it seems logical that a CAPM system should be devised which would be automatically updated from the 'electronic mail' being 'posted' down the telephone lines.

The **overall aim** governing the implementation of a foundry CAPM system, however, should be directed at the conflicting objectives which govern

---

* However, this does not mean that OPT and MRP are incompatible, quite the reverse in fact, since OPT makes use of order, routing and bill-of-materials information which have to be provided from within the OPT system itself or, from an external (MRP) system.

foundry practice, viz:

- to provide good customer service: ie. to quote and stick to acceptable delivery dates

... whilst at the same time:

- keeping finished stock and work-in-progress to a minimum
- keeping the flow of work through the available resources (ie. manpower and plant) as balanced as possible

Proper use of a CAPM system should provide the necessary basis for optimising these 'conflicts' - but it must have whole-hearted support from the 'top down' to be successful.

The overall Production Control function within a foundry CAPM system should be seen as:

- An Organising Function
- A Controlling Function
- A Management Function

... and not simply:

- A Technical Function
- Only A Progress Function
- A Data Processing Function

The factors governing the success (or failure) of a CAPM installation are listed in order of importance, below:

- PEOPLE
- Information
- Software
- Hardware

6.42 The Human Factor

A system will stand or fall depending on the people who are operating it, regardless of how valid the system might be. For successful operation, a CAPM system requires that foundry managers and staff who are using the system on a day-to-day basis, possess a comprehensive understanding of the principles involved. They must fully understand their respective roles and be aware of the impact they can potentially have on the system (eg. the consequences of inaccurate information on work-in-progress movements).

The importance of training foundry managers and staff in the new procedures cannot be overstressed and it is considered that the area of 'systems training' will develop significantly during the next 2-3 years to accommodate the increase in the implementation of techniques for CIM. For example, at the time of writing, the EITB have launched a series of Awareness Seminars for Foundry Directors and Special Topic Courses for Operations Staff.

6.43 Information Requirements

The types of information required for a CAPM system have been detailed in Chapter 4. Summarising, these data may be broadly categorised as follows:-

1. Parts Register
2. Commercial, Technical and Financial Information
3. Orders/Schedules
4. Work Centres (resource information)
5. Operation Times
6. Work-In-Progress Monitoring Points ("milestones")
7. Routing and Quality Control Instructions
8. Work Bookings, plus scrap, despatches, rectifications and customer returns
9. Material Details
10. Customer Details

It is vitally important that a foundry take steps to ensure the accuracy and validity of the information within the categories listed above.

6.44 Software Considerations

The software used to develop a foundry CAPM system is of relatively little importance to foundry managers and staff who are chiefly concerned with the way in which a system functions. However, within the context of the present study, the two levels of software which had a bearing on system development were:-

1. The Operating System Environment
2. The Programming Language

The common choice of operating system for many business micro-computers is currently MS-DOS or PC-DOS and was the operating system used during the development of the systems described in Chapter 5 (single-user systems). In multi-user implementations, the system workstations operated under a network architecture known as Novell NetWare.

The important criterion governing the choice of programming language was 'transportability': ie. the ability of a language to be compatible across a range of different micro-computers (within the same operating system environment).

The version of the BASIC language developed by Microsoft - MS-BASIC - exhibited this quality and was subsequently used to develop the planning and scheduling applications, although the final programs were 'compiled', using the proprietary compiler supplied by Microsoft. The act of compiling the source-code programs had the following beneficial effects over the original coding:-

1. Increased speed of execution time (by a factor of between 5-10, depending on the application)
2. Reduced program size (in bytes) which took up less media storage capacity
3. 'tamper' proof programs, once installed at a remote site

6.45 Hardware Considerations

Hardware is no longer considered as the most important part of a system due especially to the developments in micro-processor technology (circa 1981/1982) and the subsequent emergence of 'machine-independent software'.

The governing factor which restricts the choice of hardware will be the 'budgeted figure' which a company has allowed for a system. Within this figure, foundries should ensure that the 'ideals' of: 'reliability', 'proven hardware support availability' and 'speed of operation', are all met to acceptable levels. However, the emergence of the micro-computer as a 'serious business tool' ensures that foundries are offered a 'low-cost/low-risk' entry point into CAPM.

CHAPTER 7

7. Future Work

The paths of development which emerge from the results of implementing systems lie in several directions, although each has a common focus, viz: the continued profitability of foundries, via the simultaneous reduction in operating costs, reduction in work-in-progress levels and increase in productivity.

The present study has concentrated on the technical problems of developing a workable foundry-based scheduling system which could operate on low-cost micro-computers.

The 'future work', within the context of the systems developed, lies in the improvement of the limitations discussed in Chapter 6 and the further development of a fourth level of 'scheduling sophistication' which combines all the above techniques, so that the planner can view the relevant information in whatever form is required, immediately.

The pursuit of more advanced (and hopefully more accurate) scheduling methods is to be continued with the emphasis on identifying piece-part lead-times and process move-times. Moreover, in parallel with this work, research into improved shop-reporting techniques and methods of identifying jobs as they are being processed is of paramount importance.

The wider issues surrounding the implementation of a CAPM system incorporate people problems, the need for staff training and organisational problems which affect (eg.) the flow of information from one department to another.

It is considered that low-cost comprehensive training programmes, which are aimed at the clarification of the principles of production control (relevant to the industry) should become an integral part of a total CAPM package and should provide invaluable assistance in overcoming the problems of system 'acceptance': ie. by demonstrating that it is in everyone's interest to work around the information provided and requested by the system.

CHAPTER 8

8. Conclusions

1. There is a strategic need for a UK Foundry Industry.

2. The current economic climate has left foundries with no choice but to increase the economic measures of productivity and profitability (in order to stay in business within a highly competitive industry).

3. The most direct effect on these 'measures' is the efficiency of the production control system in operation.

4. The application of computer-assistance to the functions within production control is considered (by the industry and the literature) to be the'tool' most likely to improve the efficiency of a system.

5. Prior to 1981/1982, practical (ie. useful) computer-assisted production control methods were only available to those foundries who could afford the high initial investment for hardware and subsequent software development.

6. The rapid technological advances in the computer industry in the early 1980's, brought about the emergence of micro-computer's which could be considered as serious business 'tools' (a trend which is continuing at the time of writing) and thus provided smaller foundries with a method of implementing computer-assistance.

7. The subsequent development of packaged-software by entrepreneurial enterprises (eg. software houses) has enabled many foundries to adopt computer-assistance in the area of production control.

8. At the time of writing, there are three main foundry-specific packages available in the UK, which address most of the aspects of foundry organisation for manufacturing, and one clear market leader.

9. The emphasis placed on Computer Integrated Manufacture (CIM) by other manufacturing industries (ie. companies which buy components from foundries) has put pressure on foundries to adopt more advanced methods of production management.

10. Both external and internal stimuli have fostered foundry interest in one of the functions contributing to CIM, known as CAPM (Computer Aided Production Management).

11. The inherent nature of foundry operations challenges the systematic order of implementation of the sub-systems which form the traditional CAPM approach (ie: inventory control, bills-of-materials, MRP, etc.) and is seen to have more in common with the relatively recent philosophy of Optimised Production Technology (OPT - definition of bottleneck resources, capacity planning, detailed scheduling, batch production, etc.).

12. The adoption of a CAPM system will impose a more 'regimented'

approach to the functions of foundry production planning and control, if it is properly employed.

13. The foundry industry is primarily a service industry (ie. 'single-level' component makers, mainly to customers' orders) with a primary objective of satisfying customer requirements.

14. The sophistication of the functions of foundry planning and scheduling, within CAPM, is dependent on the accurate feed-back of information from the shop-floor and the existance of standard times and resource information.

15. The dynamic nature of foundry production together with the lack (in general) of 'standard' information has led to the development of CAPM systems which are information-based, enabling production planners to exercise their experience on the 'suggestions' provided by the system.

16. The principle of 'information provision' has been extended by the work presented here, which incorporates labour saving computer-assistance (sorting and collating of information into a pre-digested form) and introduces the concept of on-line 'manual interaction' for the purposes of foundry production planning and scheduling

17. The design of packaged software which is applicable to a wide range of foundries is considered feasible by incorporating flexibility into the design of system software (ie. 'parameter-

driven' software).

18. The 'key' factors in the successful implementation of a CAPM system are the PEOPLE who are to use the system on a day-to-day basis (which require adequate training and education).

APPENDICES

APPENDIX 1

Appendix 1

Foundries Participating in the Research

The following foundry personnel were contacted during the course of the research and subsequently agreed to participate in an evaluation of the software proposals which were developed.

Pages removed due to Confidentiality reasons

Pages removed due to Confidentiality reasons

APPENDIX 2

Appendix 2

Foundry Statistics

The following charts and tables describe some of the changes in the foundry industry between 1967/68 to 1983/84. The information is reproduced with kind permission from Mr B. J. Cave - Director of the EITB.

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APPENDIX 3

Appendix 3

A Review of some of the Packages providing CAPM

The following review briefly describes fourteen companies who market software packages for the Manufacturing Industry. Whilst the review is biased towards software packages running on micro-computers, a few mini- and mainframe systems have been included. Where possible, up-to-date prices are quoted for each system in pounds sterling, unless otherwise stated.

Company : British Cast Iron Research Association
Address : Alvechurch Birmingham B48 7QB
Telephone: 0527 66414
Package : Production Planning
Hardware : Z80 microprocessor units and the CP/M operating system

Modules/Facilities

- Planning of up to 40 work centres and 20 metal grades
- Loading up to 40 weeks in advance
- Summary and detailed loading of each resource
- Weekly work instructions for each work centre
- Differentiation between priority, firm and tentative orders or enquiries
- Arrears reported and re-scheduled
- Information on options available as a result of overloading

Cost : 300.00 (software only)

Company : Computerline Production Management Systems Ltd
Address : 118 Church Road, Addlestone, Weybridge, Surrey, KT15 1SG
Telephone: 0932 55757
Package : MAN-TRAC (MAnagement by Time, Resource And Cost)
Hardware : Machines operating under PC-DOS, MS-DOS and CP/M

Modules/Facilities

1.	MAN-TRAC 1	Inventory Control	600.00
2.	MAN-TRAC 2	Workshop Scheduling	1200.00

3.	MAN-TRAC 3	Job-Costing	500.00
4.	MAN-TRAC 4	Purchase Order Progress	300.00
5.	MAN-TRAC 5	Shop Documentation	300.00

Cost : 7500.00 (software, hardware and implementation - 1984's prices)
1950.00 - first year licence fee
500.00 - Annual licence renewal fee

Company : Concept Computer Systems Ltd
Address : Princess House, High St, Bagshot, Surrey GU19 5AF
Telephone: 0276 76303
Package : CONCEPT II - Production Control System
Hardware : DEC

Modules/Facilities

1. Data Base Management
2. Sales Order Processing
3. Forecasting and Planning
4. Inventory Management
5. Production Costing
6. Purchase Order Control
7. Capacity planning and loading
8. Works Order Management

Company : Davy Computing Ltd
Address : Moorfoot House, 2 Clarence Lane, Sheffield S3 7UZ
Telephone: 0742 71201
Package : PRODUX (for jobbing manufacture)
Hardware : Burroughs B25 and XE520 range, IBM PC, ALTOS Multi-user systems, SANYO range of micros.

Modules/Facilities

PRODUX 1 - Financial Accounts

1. Sales
2. Purchase Ledger
3. Nominal Ledger
4. Payroll
5. Invoicing
6. Production Interface

PRODUX 2 - Material Control

1. Stock Control
2. Bill-of-Materials
3. Routing
4. Nett MRP
5. Sales Order Processing
6. Purchase Order Processing
7. Works Order Processing
8. Order Scheduling
9. Financial Accounts Interface

PRODUX 3 - Shop Floor Control

1. Shop Floor Documentation
2. Infinite Scheduling
3. Rough Cut Capacity Planning and Analsis
4. W-I-P Valuation and Added Value
5. W-I-P Tracking
6. Load Statements
7. Labour Analysis
8. Material Control Interface

PRODUX 4 - Job Costing Control

1. Estimating
2. Actual Costing
3. Variance Reporting and Job Profitability
4. Time Sheet Entry and Analysis
5. Purchase Order Processing
6. Sales Order Processing
7. Stock Control
8. Work Load Reporting
9. Financial Accounts and Material Control Interface

Company : Dewtec Computer Systems Ltd
Address : 36, Holloway Circus, Queensway, Birmingham B1 1EQ
Telephone: 021 643 8003
Package : DEWTEC Multi-User
Hardware : IBM PC, AT and compatibles, Sirius/Victor, Apricot Xi/Xen Olivetti M24/28, COMPAQ, RML

Modules/Facilities

Standard Module		Optional Modules	
Production Control	7250.00	Report Generator	1500.00
		Works Documentation	1500.00
		Production & Despatch Records	1500.00
		Price Maintenance	500.00
		Advice Notes & Invoicing	P.O.A.
		Customer Order Acknowledgement	1000.00
Weight Estimating	500.00	Quotation Module	1000.00
Costing & Estimating	5500.00	Job Costing Module	4500.00
		Routing Module	500.00
		Cost of Sales Reporting	1000.00

Company : IBM UK Ltd.
Address : Manufacturing Industry Support Centre, PO Box 31, Birmingham Road, Warwick CV34 5JL
Telephone: 0926 32525
Package : COPICS - Communications Oriented Production Information and Control System
Hardware : IBM Mainframes

Modules/Facilities

1. Customer Order Servicing - Data Management
2. Customer Order Servicing - Order Management
3. B-O-M Utilities II
4. B-O-M On-line II
5. Inventory Accounting II
6. Inventory Planning and Forecasting II
7. Advanced Function/MRP II
8. Shop Order Release II
9. Plant Monitoring and Control
10. On-line Routing
11. Facilities Data Control
12. CAPOSS-E*, Capacity Planning and Op. Sequencing System-Extended
13. Purchasing
14. Receiving
15. Product Cost Calculations
16. CORMES - Communications Oriented Message System

* Finite Capacity. Schedules activities for due dates based on priority rules and capacity limitations.

Company : Kewill Systems Limited
Address : Clive House, Queens Road, Weybridge, Surrey KT13 9XB
Telephone: 0932 52046
Package : MICROSS Manufacturing System
Hardware : IBM Mainframes

Modules/Facilities

1.	Stock Control	950.00
2.	Bill-of-Materials	950.00
3.	Requirements Planning	950.00
4.	Purchase Order Printing	750.00
5.	Sales Order Printing	1150.00
6.	Production Control	2500.00
7.	Shop Floor Documentation	750.00
8.	Shop Floor Data Collection	1950.00
9.	Job Costing	1500.00

Company : Marcus Software Systems
Address : 26 Albion Place, Leeds, West Yorks LS1 6JS
Telephone: 0532 434488
Package : MARCOUNT - Accounting Suite and MARFACT - Production Suite
Hardware : Machines running MS-DOS, CP/M-86, CP/M 2.2

Modules/Facilities

MARCOUNT

1. Sales Purchase/Nominal Ledgers 885.00
2. Sales Invoicing 295.00
3. Stock Control 345.00
4. Job Contract Costing 345.00
5. Pareto Analsis 125.00
6. Company Forecasting 195.00
7. Project Planning 195.00

MARFACT

1. MRP 450.00
2. B-O-M 450.00
3. Capacity Planning 695.00
4. M/C Scheduling 450.00
5. Stock Control 345.00
6. Sales Order Processing - 345.00
7. Purchase Order Processing 345.00
8. Statistics 150.00

Company : MIS Ltd.
Address : 38, Albert Road North, Reigate, Surrey RH2 9EQ
Telephone: 07372 45854
Package : PC-FORUM
Hardware : IBM PC and compatibles, Alpha Micro, Olivetti, ICL, Apricot Apple, DEC, Wang

Modules/Facilities

1. Foundry Management Package
2. Production Control
3. Financial Control
4. Payroll and Personnel
5. Stock Control

Company : MSS Services Ltd
Address : PO Box 31, Worthing,West Sussex
Telephone: 0903 34755
Package : Various Packages
Hardware : Machines running PC-DOS,MS-DOS, CP/M-86, CP/M 2.2, EPSON QX-10, APPLE II and APPLE III

Modules/Facilities

1.	Stock Recording and Control	300.00
2.	Bill-of-Materials	450.00
3.	MRP	500.00
4.	Production Control	800.00
5.	Kitting	400.00
6.	Estimating	400.00
7.	Standard Costing	400.00
8.	Product Costing	400.00
9.	Employment Agencies Record Systems	400.00
10.	Personnel Manpower Management	400.00
11.	Accountatnts Incomplete Record System	800.00

(Module Costs from 1984)

Company : NCR Limited
Address : 206 Marylebone Road, London NW1 6LY
Telephone: 01 723 7070
Package : IMCS II - Interactive Manufacturing Control System
Hardware : NCR Minicomputers

Modules/Facilities

1. Bill-of-Materials
2. Purchasing and Receiving
3. Order Processing
4. Sales Analysis
5. Capacity Planning
6. Work-in-Progress
7. Routing
8. Master Production Scheduling
9. MRP
10. Inventory Management

Company : Safe Computing Limited
Address : 89-91 High Street, Leicester LE1 4JB
Telephone: 0533 29321
Package : MICRO-SaFeS
Hardware : Machines running BOS operating system

Modules/Facilities

1. Part Master
2. Part List
3. Stock Control
4. Basic Costing
5. ABC Ananlysis/Perpetual Audit
6. Routing
7. Extended Costing
8. Factory Paperwork
9. Trial Kitting
10. Master Manufacturing Schedule
11. Purchase Order
12. Work-in-Progress
13. Job/Variance Costing
14. MRP
15. CRP

Company : SCICON Manufacturing Systems
Address : Sanderson House, 49 Berners Street, London W1P 4AQ
Telephone: 01 580 5599
Package : MANMAN
Hardware : Hewlett-Packard, HP 3000 Minicomputers

Modules/Facilities

1. Purchase Ledger
2. Nominal Ledger
3. Sales Order Processing and Accounting
   - Order Entry
   - Invoicing
   - Sales Ledger
   - Sales Analysis
4. Manufacturing Management
   - Inventory Control
   - BOM/Engineering Design
   - WIP/Shop Floor Control
   - Purchasing
   - MRP
   - Capacity Requirements Planning
   - Cost Accounting

Company : Sheffield Micro (Business Systems) Ltd
Address : Victoria House, Rutland Park, Sheffield S10 2PB
Telephone: 0742 680256
Package : PLANIT/UNIPLAN
Hardware : ICL CRS series of microcomputers and ICL PC's

Modules/Facilities

1. PARTPLAN
   - Material Control and Requirements Planning
   - Sales Order Processing
   - Purchase Order Processing
   - Works Order Processing
   - Stock and BOM
   - MRP
2. JOB PLAN
   - Job Costing
   - Estimating
   - Scheduling
   - Analysis
   - Exception Reporting
3. LEDGERPLAN - ACCOUNTS
   - Sales Ledger
   - Invoicing Analysis
   - Purchase Ledger
   - Nominal Ledger
   - Payroll and SSP
   - Multi-Company Option
4. WIPPLAN
   - Work-in-Progress
   - Routing
   - Shop Floor Loading
   - Capacity Planning
   - Tracking
   - Shop Floor Documentation
5. INFOPLAN - Report Generator - Links to the above modules

APPENDIX 4

Appendix 4

Program Listings

The following program listings are contained within this Appendix:-

A4.1 Calendar Maintenance Program

```
5 REM $INCLUDE:'SHARE'
10 REM ***** CALENDAR UPKEEP PROG *****
15 DEF FNCP$(ROW,COL)=CHR$(27)+"Y"+CHR$(34+ROW)+CHR$(32+COL)
19 IF NME$="" OR DTE$="" THEN CHAIN "LOGON"
80 EL$="84H85C86D87E88M89A90B91C92K93F94G95A96I97D98E99F00N":AFLAG=0:BFLAG=0
90 DIM
MN$(12),M(12),M1$(12),LOGO$(5),XY(1,7,6),SEY%(1,7,6),W%(200),TIM%(200),SET%(5),T
ES%(5),DE%(200)
100 REM ** START **
110 YE=FIX(DTE/10000):COUNT=0
115 L=INSTR(EL$,MID$(STR$(YE),2,2)):L$=MID$(EL$,L+2,1)
120 ON ASC(L$)-64 GOTO 130,135,140,145,150,155,160,130,135,140,145,150,155,160
130 J0=1:GOTO 170
135 J0=2:GOTO 170
140 J0=3:GOTO 170
145 J0=4:GOTO 170
150 J0=5:GOTO 170
155 J0=6:GOTO 170
160 J0=7
170 IF AFLAG=99 THEN RETURN
175
M(1)=31:M(2)=28:M(3)=31:M(4)=30:M(5)=31:M(6)=30:M(7)=31:M(8)=31:M(9)=30:M(10)=31
:M(11)=30:M(12)=31
180 MN$(1)="       J A N U A R Y       ":MN$(2)="     F E B R U A R Y     "
181 MN$(3)="         M A R C H         ":MN$(4)="        A P R I L        "
182 MN$(5)="           M A Y           ":MN$(6)="         J U N E         "
183 MN$(7)="          J U L Y          ":MN$(8)="       A U G U S T       "
184 MN$(9)="     S E P T E M B E R     ":MN$(10)="      O C T O B E R      "
185 MN$(11)="      N O V E M B E R      ":MN$(12)="     D E C E M B E R     "
191 M1$(1)=" January's ":M1$(2)="February's ":M1$(3)="  March's  ":M1$(4)="
April's  "
192 M1$(5)="   May's   ":M1$(6)="  June's   ":M1$(7)="  July's   ":M1$(8)="
August's  "
193 M1$(9)="September's":M1$(10)=" October's ":M1$(11)="November's
":M1$(12)="December's "
194 LOGO$(1)="'0'=yes/no":LOGO$(2)="'('=range on/off":LOGO$(3)="')'=end
on/off":LOGO$(4)="'7'=print":LOGO$(5)="'E'=end"
199 REM ** START OF CALENDAR PRINT **
200 C=9:R=2:C8=C:Z7=0:COUNT=0:FLAG17=0:NO$="":DEL%=0
202 GOSUB 30000:GOSUB 31000
203 AFLAG=0:PRINT FNCP$(R+13,C8)FRGD$"Enter year (eg."YE"):
"BKGD$:MAXL=2:MINL=2:ROW=R+13:COL=C8+21:GOSUB 60980:IF VAL(I$)<84 OR VAL(I$)>99
THEN 203
204 IF VAL(I$)=YE THEN 205 ELSE AFLAG=99:YE=VAL(I$):GOSUB 115:AFLAG=0
205 PRINT FNCP$(R+16,C8)RIGHT$("    "+STR$(YE+1900),4):IF FIX(YE/4)=YE/4 THEN
M(2)=29 ELSE M(2)=28
206 J1=J0:C=9:R=2:I=1:J2=J1:M=0:C8=C
207 CLOSE:GOSUB 40000:IF BFLAG=99 THEN RETURN
208 FLAG17=FLAG17+1:GOSUB 1700:CS=C+((J2-1)*4):RS=R
210 M=M+1
212 GOSUB 700
215 IF FIX(M/2)<>M/2 THEN FOR Z=R TO R+10 STEP 2:PRINT FNCP$(Z,C)SPC(27):PRINT
FNCP$(Z,44)SPC(27):NEXT Z
220 IF FIX(M/2)=M/2 THEN Z7=35:GOTO 225 ELSE Z7=0:PRINT FNCP$(R-
2,C)BKGD$ULON$MN$(M):PRINT FNCP$(R-2,C+35)MN$(M+1)ULOFF$
225 FLAG=0:Z=1
227 IF I+(M*100)=W%(CTS-1+Z) THEN FLAG=9:Z=Z+1:GOTO 230
230 IF FLAG<>9 THEN PRINT FNCP$(RS,CS)RIGHT$("  "+STR$(I),2):GOTO 234
231 IF FIX(M/2)=M/2 THEN SEY%(1,FIX((CS-Z7)/4-1),RS/2)=9 ELSE SEY%(0,FIX((CS-
Z7)/4-1),RS/2)=9
```

```
232 PRINT FNCP$(RS,CS)FRGD$RON$RIGHT$("  "+STR$(I),2)ROFF$BKGD$
234 FLAG=0
235 IF FIX(M/2)=M/2 THEN X=FIX((CS-35)/4-1):Y=RS/2:XY(1,X,Y)=I ELSE X=FIX(CS/4-
1):Y=RS/2:XY(0,X,Y)=I
240 I=I+1:IF I>M(M) THEN 300
250 CS=CS+4:J2=J2+1:IF FIX((J2-1)/7)=(J2-1)/7 THEN CS=C:RS=RS+2
260 GOTO 227
300 REM * NEW MONTH *
315 IF FIX(M/2)=M/2 THEN GOSUB 500
319 IF CS>35 THEN CS=CS-35
320 J2=FIX(CS/4):IF J2>7 THEN J2=1
330 IF FIX(M/2)<>M/2 THEN C=44 ELSE C=9
335 IF C=9 THEN FOR Z=1 TO 6:FOR Z1=1 TO 7:XY(0,Z1,Z)=0:XY(1,Z1,Z)=0:NEXT
Z1:NEXT Z
340 I=1
360 GOTO 208
500 REM ** ENTER HOLS **
505 M1=M-1
510 SCT=0:TCT=0:YES=0:PRINT FNCP$(R+13,C8)FRGD$"Update "M1$(M1)" non-work":PRINT
FNCP$(R+14,C8)"day status (Y/N) ?:
"CUP$:MAXL=1:MINL=1:ROW=R+14:COL=C8+20:GOSUB 60980:IF I$<>"Y" AND I$<>"N" THEN
510
515 IF I$="Y" THEN 530
520 IF M1=M THEN Z9=1:NO$="N":GOTO 650 ELSE Z9=0:NO$="N":GOTO 650
530 PRINT FNCP$(R+13,C8)"See instructions ----->    ":PRINT
FNCP$(R+14,C8)SPACE$(27)
540 IF FIX(M1/2)=M1/2 THEN XD=68 ELSE XD=33
550 PRINT FNCP$(R+11,XD)RON$"  "ROFF$
555 YD=R+10:IF XD=68 THEN Z9=1:Z8=35 ELSE Z9=0:Z8=0
556 X1=XD:Y1=YD
559 YES=0
560 P$=INPUT$(1)
570 IF P$="E" THEN GOSUB 800:IF EFLAG=0 THEN GOTO 650 ELSE GOTO 559
572 IF P$="7" THEN GOSUB 60000:GOTO 560
574 IF P$="2" THEN GOSUB 1000:GOTO 559
576 IF P$="4" THEN GOSUB 1100:GOTO 559
578 IF P$="6" THEN GOSUB 1200:GOTO 559
580 IF P$="8" THEN GOSUB 1300:GOTO 559
590 IF P$="0" THEN GOSUB 1400:GOTO 560
600 IF P$="(" THEN GOSUB 1500:GOTO 560
610 IF P$=")" THEN GOSUB 1600:GOTO 560
620 GOTO 560
650 IF NO$="N" THEN 690
655 FOR Z=1 TO 7:FOR Z1=1 TO 6
657 IF SEY%(Z9,Z,Z1)=9 THEN
COUNT=COUNT+1:TIM%(COUNT)=XY(Z9,Z,Z1):TIM%(COUNT)=TIM%(COUNT)+(M1*100)
658 IF SEY%(Z9,Z,Z1)=8 THEN DEL%=DEL%+1:DE%(DEL%)=XY(Z9,Z,Z1)+(M1*100)
659 NEXT Z1:NEXT Z
690 FOR Z=1 TO 7:FOR Z1=1 TO 6:SEY%(Z9,Z,Z1)=0:NEXT Z1:NEXT Z
695 NO$=""
699 IF M1=M THEN GOSUB 1790:RETURN ELSE M1=M1+1:GOTO 510
700 REM ** ? CURRENT MONTH'S HOLS **
710 M2=M:CT=0:CTS=0
720 FOR Z=1 TO 200:M3=FIX(W%(Z)/100)
730 IF M3<>M2 THEN 750
740 IF CT=0 THEN CTS=Z
745 CT=CT+1
750 NEXT Z
799 RETURN
800 REM ** BLANK OUT BLOCK **
```

```
805 FOR Z=1 TO 5:IF SET%(Z)<>99 AND TES%(Z)<>99 THEN 807
806 IF SET%(Z)=99 AND TES%(Z)=99 THEN EFLAG=0 ELSE EFLAG=9:RETURN
807 NEXT Z
810 IF VAL(XY$)=0 THEN XY$="  "
820 PRINT FNCP$(Y1+1,X1)"  ":IF Y1+1=R+11 THEN PRINT
FNCP$(Y1+1,X1)CHR$(196)CHR$(196)
830 Z1=1:Z=1:LAG=0
840 IF SEY%(Z9,Z,Z1)=2 AND LAG=0 THEN EFLAG=9:RETURN
850 IF (SEY%(Z9,Z,Z1)<>1 AND SEY%(Z9,Z,Z1)<>2) THEN 890
860 IF SEY%(Z9,Z,Z1)<>1 THEN 880
862 WHILE SEY%(Z9,Z,Z1)<>2:SEY%(Z9,Z,Z1)=9:LAG=1:Z=Z+1
864 IF Z>7 THEN Z=1:GOTO 865 ELSE GOTO 866
865 Z1=Z1+1:IF Z1>6 THEN 899 ELSE GOTO 866
866 WEND
880 SEY%(Z9,Z,Z1)=9:LAG=0
890 Z=Z+1:IF Z>7 THEN Z=1:GOTO 895 ELSE GOTO 840
895 Z1=Z1+1:IF Z1>6 THEN 899 ELSE GOTO 840
899 EFLAG=0:RETURN
900 REM ** FORMAT DISPLAY **
910 IF XY=0 THEN XY$="  " ELSE XY$=RIGHT$("  "+STR$(XY),2)
920 IF YX=0 THEN YX$="  " ELSE YX$=RIGHT$("  "+STR$(YX),2)
930 RETURN
1000 REM ** DOWN **
1010 Y1=Y1+2:IF Y1>R+10 THEN Y1=R+10
1020 XY=XY(Z9,FIX((X1-Z8)/4-1),Y1/2):YX=XY(Z9,FIX((X1-Z8)/4-1),(Y1-2)/2)
1030 GOSUB 900
1040 PRINT FNCP$(Y1-1,X1)"  ":PRINT FNCP$(Y1+1,X1)" ^"
1099 RETURN
1100 REM ** LEFT **
1110 X1=X1-4:IF X1<C8+Z8 THEN X1=C8+Z8
1120 XY=XY(Z9,FIX((X1-Z8)/4-1),Y1/2):YX=XY(Z9,FIX((X1-Z8+4)/4-1),Y1/2)
1130 GOSUB 900
1140 PRINT FNCP$(Y1+1,X1+4)"  ":PRINT FNCP$(Y1+1,X1)" ^"
1141 IF Y1+1=R+11 THEN PRINT FNCP$(Y1+1,X1+4)CHR$(196)CHR$(196)
1199 RETURN
1200 REM ** RIGHT **
1210 X1=X1+4:IF X1>C8+Z8+24 THEN X1=C8+Z8+24
1220 XY=XY(Z9,FIX((X1-Z8)/4-1),Y1/2):YX=XY(Z9,FIX((X1-Z8-4)/4-1),Y1/2)
1230 GOSUB 900
1240 PRINT FNCP$(Y1+1,X1-4)"  ":PRINT FNCP$(Y1+1,X1)" ^"
1241 IF Y1+1=R+11 THEN PRINT FNCP$(Y1+1,X1-4)CHR$(196)CHR$(196)
1299 RETURN
1300 REM ** UP **
1305 Y1=Y1-2:IF Y1<R THEN Y1=R
1310 XY=XY(Z9,FIX((X1-Z8)/4-1),Y1/2):YX=XY(Z9,FIX((X1-Z8)/4-1),(Y1+2)/2)
1320 GOSUB 900
1330 PRINT FNCP$(Y1+3,X1)"  ":PRINT FNCP$(Y1+1,X1)" ^"
1331 IF Y1=R+8 THEN PRINT FNCP$(R+11,X1)CHR$(196)CHR$(196)
1399 RETURN
1400 REM ** TOGGLE **
1405 IF XY(Z9,FIX((X1-Z8)/4-1),Y1/2)=0 THEN RETURN
1407 IF SEY%(Z9,FIX((X1-Z8)/4-1),Y1/2)=1 OR SEY%(Z9,FIX((X1-Z8)/4-1),Y1/2)=2
THEN RETURN
1410 YES=YES+1:IF FIX(YES/2)=YES/2 THEN H$=ROFF$ ELSE H$=RON$
1420 IF H$=RON$ AND SEY%(Z9,FIX((X1-Z8)/4-1),Y1/2)=9 THEN PRINT
FNCP$(R+13,C8+50)"yes  ":GOTO 1499
1430 IF H$=RON$ THEN SEY%(Z9,FIX((X1-Z8)/4-1),Y1/2)=9:PRINT
FNCP$(R+13,C8+50)"yes  ":PRINT FNCP$(Y1,X1)RON$XY$ROFF$ ELSE SEY%(Z9,FIX((X1-
Z8)/4-1),Y1/2)=8:PRINT FNCP$(R+13,C8+50)"no   ":PRINT FNCP$(Y1,X1)ROFF$XY$
1499 RETURN
```

```
1500 REM ** START RANGE **
1505 IF SEY%(Z9,FIX((X1-Z8)/4-1),Y1/2)=9 THEN RETURN
1510 IF XY(Z9,FIX((X1-Z8)/4-1),Y1/2)=0 THEN RETURN
1520 X2=X1-Z8-1:IF X2<C8+3 THEN RETURN
1530 Y2=Y1:X2=X1-1
1532 IF SEY%(Z9,FIX((X1-Z8)/4-1),Y1/2)<>1 THEN 1535
1533 SEY%(Z9,FIX((X1-Z8)/4-1),Y1/2)=0:SCT=SCT-1:PRINT FNCP$(Y2,X2)" "
1534 IF SCT<0 THEN SCT=0:SET%(SCT)=0:RETURN ELSE SET%(SCT)=0:RETURN
1535 SCT=SCT+1:IF SCT>5 THEN SCT=5:RETURN
1540 PRINT FNCP$(Y2,X2)FRGD$"("BKGD$
1550 SET%(SCT)=99:SEY%(Z9,FIX((X1-Z8)/4-1),Y1/2)=1
1599 RETURN
1600 REM ** END RANGE **
1605 IF SEY%(Z9,FIX((X1-Z8)/4-1),Y1/2)=9 THEN RETURN
1610 IF XY(Z9,FIX((X1-Z8)/4-1),Y1/2)=0 THEN RETURN
1620 X2=X1+2:Y2=Y1
1622 IF SEY%(Z9,FIX((X1-Z8)/4-1),Y1/2)<>2 THEN 1625
1623 SEY%(Z9,FIX((X1-Z8)/4-1),Y1/2)=0:TCT=TCT-1:PRINT FNCP$(Y2,X2)" "
1624 IF TCT<0 THEN TCT=0:TES%(TCT)=0:RETURN ELSE TES%(TCT)=0:RETURN
1625 TCT=TCT+1:IF TCT>5 THEN TCT=5:RETURN
1630 PRINT FNCP$(Y2,X2)FRGD$")"BKGD$
1640 TES%(TCT)=99:SEY%(Z9,FIX((X1-Z8)/4-1),Y1/2)=2
1699 RETURN
1700 REM ** ENTER A MONTH **
1705 IF FIX(FLAG17/2)=FLAG17/2 THEN RETURN
1710 PRINT FNCP$(R+13,C8)FRGD$"Enter month (1-12):
"BKGD$:C=C8:J2=J1:PRINT FNCP$(R+14,C8)"(0 TO
ABORT)"SPACE$(15):MAXL=2:MINL=1:ROW=R+13:COL=C8+20:GOSUB 60980:IF VAL(I$)<0 OR
VAL(I$)>12 THEN 1710
1715 IF VAL(I$)=0 THEN GOTO 1796
1720 M0=VAL(I$):IF FIX(M0/2)=M0/2 THEN M=M0-1 ELSE M=M0
1730 J2=J1:C=9:C8=C+((J2-1)*4):FOR Z=1 TO M-1
1735 FOR I9=1 TO M(Z):J2=J2+1:IF FIX((J2-1)/7)=(J2-1)/7 THEN J2=1
1738 NEXT I9
1770 NEXT Z
1780 M=M-1:RETURN
1790 REM ** SAVE CHANGES **
1792 IF COUNT=0 THEN RETURN ELSE PRINT FNCP$(R+14,C8)SPACE$(27):GOSUB 3500
1793 PRINT FNCP$(R+13,C8)"Save changes (Y/N) ?:
":MAXL=1:MINL=1:ROW=R+13:COL=C8+22:GOSUB 60980:IF I$<>"Y" AND I$<>"N" THEN 1793
1794 IF I$="N" THEN 1795 ELSE GOSUB 41000:PRINT FNCP$(R+13,C8)"Calendar file
updated -    ":PRINT FNCP$(R+14,C8)"hit any key to continue    ":GOSUB 20020
1795 COUNT=0:DEL%=0:CLOSE:GOSUB 40000:RETURN
1796 PRINT FNCP$(R+13,C8)"Another Year (Y/N) ?:     ":PRINT
FNCP$(R+14,C8)SPACE$(26)
1798 ROW=R+13:COL=C8+21:MINL=1:MAXL=1:GOSUB 60980:IF I$<>"Y" AND I$<>"N" THEN
1798
1799 IF I$="N" THEN X=241:GOTO 61150
1800 GOSUB 3000:BFLAG=99:GOSUB 200:BFLAG=0
1810 GOTO 208
2000 REM ***** SORT ( STRING TYPE ) *****
2010 SW%=COUNT:IF COUNT=0 THEN RETURN
2020 PO%=0:SW%=SW%\2:IF SW%=0 THEN RETURN
2030 PO%=PO%+1
2040 IF (PO%+SW%)>COUNT THEN 2020
2050 IF W%(PO%)<=W%(PO%+SW%) THEN 2030
2070 SWAP W%(PO%),W%(PO%+SW%):GOTO 2090
2080 PO%=PO%-1
2090 IF PO%-SW%<1 THEN 2040
2100 IF W%(PO%)>=W%(PO%-SW%) THEN 2030
```

```
2120 SWAP W%(PO%),W%(PO%-SW%):GOTO 2080
3000 REM ** CLEARDOWN FOR ANOTHER YEAR **
3010 FOR Z0=1 TO 2:FOR Z1=1 TO 7:FOR Z2=1 TO 6
3020 XY(Z0-1,Z1,Z2)=0:SEY%(Z0-1,Z1,Z2)=0:NEXT Z2:NEXT Z1:NEXT Z0
3030 FOR Z=1 TO 200:TIM%(Z)=0:W%(Z)=0:NEXT Z
3040 RETURN
3500 REM ** W%(ARRAY) SORT II **
3510 Z=0
3520 Z=Z+1:IF W%(Z)=0 OR Z=200 THEN 3530
3525 GOTO 3520
3530 IF Z=200 THEN RETURN
3540 FOR Z1=Z TO Z+COUNT-1:W%(Z1)=TIM%(Z1-Z+1):NEXT Z1
3550 COUNT=Z+COUNT-1:GOSUB 2000
3552 IF DEL%=0 THEN 3560
3554 Z1=0:FOR Z=1 TO DEL%
3555 Z1=Z1+1:IF Z1>200 THEN 3559
3556 IF W%(Z1)=DE%(Z) THEN 3558
3557 GOTO 3555
3558 W%(Z1)=9999:DE%(Z)=0
3559 Z1=0:NEXT Z
3560 GOSUB 4000
3570 RETURN
4000 REM ** SORT OUT W%(ARRAY) **
4010 FOR Z=1 TO 199:IF W%(Z)=W%(Z+1) THEN W%(Z)=9999
4015 NEXT Z
4020 GOSUB 2000
4030 FOR Z=1 TO 200:IF W%(Z)=9999 THEN W%(Z)=0
4035 NEXT Z
4040 RETURN
20000 REM **** ANY KEY ROUTINE ****
20010 PRINT FNCP$(21,0)"                                    Hit any key to continue
"CUP$
20020 S$=INKEY$:IF S$="" THEN 20020
20030 IF ASC(S$)=190 THEN GOSUB 61230
20040 RETURN
30000 REM ** SCREEN CLEAR **
30010 WIDTH 255
30020 PRINT NOLIN$NOCAR$NOCUR$BKGD$CLS$
30030 PRINT FNCP$(-2,0)RON$SPACE$(80)ROFF$
30040 PRINT FNCP$(-2,17)"            *FUNCTION: CALENDAR UPKEEP  *"
30050 PRINT FNCP$(-2,0)RON$"USER :       "ROFF$
30060 PRINT FNCP$(-2,66)RON$"DATE:"ROFF$
30070 PRINT FNCP$(-2,8)RON$NME$ROFF$:PRINT FNCP$(-2,71)RON$DTE$ROFF$
30080 RETURN
31000 REM ** DRAW BOXES **
31010 FOR Z=C TO C+26:PRINT FNCP$(R-3,Z)CHR$(196):PRINT FNCP$(R-
3,Z+35)CHR$(196):PRINT FNCP$(R+11,Z)CHR$(196):PRINT
FNCP$(R+11,Z+35)CHR$(196):NEXT Z
31020 PRINT FNCP$(R-3,C-1)CHR$(218):PRINT FNCP$(R-3,C+27)CHR$(191):PRINT
FNCP$(R-3,C+34)CHR$(218):PRINT FNCP$(R-3,C+62)CHR$(191)
31030 PRINT FNCP$(R+11,C-1)CHR$(192):PRINT FNCP$(R+11,C+27)CHR$(217):PRINT
FNCP$(R+11,C+34)CHR$(192):PRINT FNCP$(R+11,C+62)CHR$(217)
31040 FOR Z=1 TO 13:PRINT FNCP$(R-3+Z,C-1)CHR$(179):PRINT FNCP$(R-
3+Z,C+27)CHR$(179):PRINT FNCP$(R-3+Z,C+34)CHR$(179):PRINT FNCP$(R-
3+Z,C+62)CHR$(179):NEXT Z
31044 PRINT FNCP$(R-1,C)ULON$"Sun Mon Tue Wed Thu Fri Sat":PRINT FNCP$(R-
1,C+35)"Sun Mon Tue Wed Thu Fri Sat"ULOFF$
31045 GOSUB 32000
31050 RETURN
32000 REM ** DRAW FUNCTIONS BOX **
```

```
60150 RETURN
60980 REM INPUT STRING ROUTINE
60990 I$=""
61000 PRINT FNCP$(ROW,COL)I$RON$SPACE$(MAXL-LEN(I$))ROFF$CUP$
61010 GOSUB 61110
61020 IF X=8 THEN GOTO 61060
61030 IF X=13 AND LEN(I$)>=MINL THEN GOTO 61080 ELSE IF X=13 GOTO 61000
61040 IF LEN(I$)<MAXL THEN I$=I$+A$
61050 GOTO 61000
61060 IF LEN(I$)>0 THEN I$=LEFT$(I$,LEN(I$)-1)
61070 GOTO 61000
61080 I$=LEFT$(I$+SPACE$(MAXL),MAXL)
61090 PRINT FNCP$(ROW,COL)I$CUP$
61100 RETURN
61110 REM GET VALID CHARACTER
61120 A$=INKEY$:IF A$=""THEN GOTO 61120
61130 X=ASC(A$)
61140 IF (X>31 AND X<91 AND X<>34 AND X<>37) OR X=8 OR X=13 THEN RETURN
61150 IF X=185 OR X=27 THEN CLOSE:CHAIN "CAPMENU"
61160 IF X=190 THEN GOSUB 61200
61170 IF X=186 THEN GOSUB 62000:LPRINT
61180 IF X=189 THEN GOSUB 62000:FOR L=1 TO 10:LPRINT:NEXT L
61190 GOTO 61120
61200 GOSUB 62000
61210 REM
61220 REM
61230 DEF SEG=&HF000
61240 FOR I2 = 0 TO 23
61250 WE$=""
61260 FOR J2 = 0 TO 158 STEP 2
61270 WE$=WE$+CHR$(ABS(PEEK(I2*160+J2)-64))
61280 NEXT J2
61290 LPRINT WE$
61300 NEXT I2
61310 WIDTH 255
61320 RETURN
62000 RETURN
62010 PRINT CURPOS$CHR$(55)CHR$(32)"                                    PUT THE PRINTER
ON                              "CHR$(7)CUP$
62020 A$=INKEY$:IF A$="" THEN 62020
62030 X=ASC(A$):IF X=241 THEN 61150
62040 PRINT CURPOS$CHR$(55)CHR$(32)"
"CUP$
62050 RESUME
63998 END
63999 REM "CAL"(APRICOT CRE 07/08/85)
```

A4.2 Production/Delivery Schedule Program

```
5 REM $INCLUDE:'SHARE'

12 DIM MD(36),MDP(22),MD#(2),MD$(20)
13 GOSUB 55000:MAC$=MID$(TX$(36),17,1)
15 DIM Y(7),L(12),WE(14),POT(14),STOT(14),GTOT(14)
16 IF MAC$="I" THEN 18
17 WIDTH LPRINT 255:GOTO 19
18 WIDTH "LPT1:",255
19 IF NME$="" OR DTE$="" THEN CHAIN "PPC"
20 GOSUB 62000
21 GOSUB 16000
22 CUM%=0:SE=VAL(MID$(TX$(36),15,1))
23 SY1=83:SD1=3:SM1=1:PN=1:CCMS=0:SD%=10
25 FOR I=1 TO 12:READ L(I):NEXT I
26 FOR I=1 TO 7:READ Y(I):NEXT I
27 DATA 31,28,31,30,31,30,31,31,30,31,30,31:
28 DATA 5,6,7,1,2,3,4:
30 DEF FNCP$(ROW%,COL%)=CHR$(27)+"Y"+CHR$(34+ROW%)+CHR$(32+COL%)
40 GOSUB 30000
50 ROW%=8:COL%=46:MAXL%=16:MINL%=1
60 GOSUB 60900:KEY$=I$:KEYLEN=16
70 IF I$=SPACE$(16) THEN 50
75 ROW%=11:COL%=46:GOSUB 60700
80 GOSUB 22500
90 IF FLAG THEN 50
100 DMY=COMDAT:GOSUB 26000
120 DTEMP=(Y2*10000)+(WN*100)+D1
125 REM ** CALC. FOR DATES **
130 DIF=7-D1:WED=DD1+DIF
135 IF Y1>1900 THEN Y1=Y1-1900
140 IF INT(Y1/4)=Y1/4 THEN L(2)=29
150 IF WED>L(M1) THEN GOSUB 400
160 CWE=(Y1*10000)+(M1*100)+WED:REM ** CURRENT W/END DATE
165 WE(2)=CWE
170 REM ** ARREARS W/END DATE **
180 GOSUB 460
185 WE(1)=AWD
190 REM ** NEXT 12 W/ENDS CALC. **
200 FOR I=3 TO 14
210 WED=WED+7
220 IF WED>L(M1) THEN GOSUB 405
230 WE(I)=(Y1*10000)+(M1*100)+WED
240 NEXT I
250 REM ** >WE(11)=F'WARD **
300 REM ** MAIN PART OF PROG. **
310 GOSUB 2600:REM ** KEY & PROCESS **
315 GOSUB 1600: REM ** PRINT HEADERS
320 I6%=0:COUNT=0
330 GOSUB 40000:REM ** OPEN FILES **
340 GOSUB 42000:REM ** NO. ON FILE? **
350 GOSUB 2700:REM ** READ & VALIDATE **
360 GOSUB 2000: REM ** SORT-STRING TYPE **
370 GOSUB 9800:REM ** COLLATING & PRINTING
380 GOSUB 9200
390 REM:S$=" Total Quantities --->"+SPACE$(15)
392 REM:FOR I3=1 TO 14:S$=S$+RIGHT$("      "+STR$(GTOT(I3))+" ",6):NEXT I3
394 REM:LPRINT STRING$(126,"="):LPRINT S$:LPRINT STRING$(126,"="):LPRINT:LPRINT
396 GOTO 600
400 REM ** 1ST W/END DATE CALC. **
405 Y2=Y1:M2=M1+1
```

```
410 IF M2>12 THEN M2=M2-12:Y2=Y1+1
420 WED=WED-L(M1)
430 M1=M2:Y1=Y2
440 RETURN
460 REM ** CALC. FOR O/DUE DATE **
465 Y2=Y1:M2=M1
470 DIF=WED-7:IF DIF>0 THEN GOTO 500
480 M2=M1-1:IF M2<=0 THEN M2=12-M2:Y2=Y1-1
490 DIF=L(M2)-(7-WED)
500 AWD=(Y2*10000)+(M2*100)+DIF
510 RETURN
600 X=27:GOTO 61150
1600 REM ** PRINTING HEADERS **
1605 IF MID$(KEY$,1,1)="?" THEN KEY1$=LEFT$(TX$(5),11) ELSE KEY1$=KEY$
1610 LPRINT:LPRINT
1620 LPRINT STRING$(156,"-")
1625 IF PROG$="2" THEN GOSUB 1690:GOTO 1670
1630 LPRINT LEFT$(TX$(6),79)LEFT$(TX$(7),25)
1640 LPRINT ID3$"      : ";KEY1$;MID$(TX$(8),36,43)LEFT$(TX$(9),23)
1650 LPRINT LEFT$(TX$(10),28)DTE$MID$(TX$(10),29,50)LEFT$(TX$(11),21)
1660 LPRINT LEFT$(TX$(12),37)
1670 LPRINT STRING$(156,"-"):LPRINT
1680 RETURN
1690 REM ** PROG$=2 OPTION **
1692 LPRINT LEFT$(TX$(13),79)LEFT$(TX$(14),27)
1693 LPRINT " "ID3$"      : ";KEY1$;MID$(TX$(15),36,43)LEFT$(TX$(16),27)
1694 LPRINT LEFT$(TX$(17),28)DTE$MID$(TX$(17),29,50)LEFT$(TX$(33),32)
1695 LPRINT LEFT$(TX$(18),79)LEFT$(TX$(19),27)
1696 RETURN
2000 REM *** SORT ( STRING TYPE ) ***
2010 SW%=COUNT:IF COUNT=0 THEN S$=LEFT$(TX$(20),26):LPRINT S$:GOTO 600
2020 PO%=0:SW%=SW%\2:IF SW%=0 THEN RETURN
2030 PO%=PO%+1
2040 IF (PO%+SW%)>COUNT THEN 2020
2050 IF AR$(PO%,1)<=AR$(PO%+SW%,1) THEN 2030
2060 SWAP AR(PO%,1),AR(PO%+SW%,1)
2070 SWAP AR$(PO%,1),AR$(PO%+SW%,1):GOTO 2090
2080 PO%=PO%-1
2090 IF PO%-SW%<1 THEN 2040
2100 IF AR$(PO%,1)>=AR$(PO%-SW%,1) THEN 2030
2110 SWAP AR(PO%,1),AR(PO%-SW%,1)
2120 SWAP AR$(PO%,1),AR$(PO%-SW%,1):GOTO 2080
2500 REM *** CHECK SUFFIX ****
2510 FOR K=16 TO 1 STEP -1
2520 IF K=1 THEN FL=1:RETURN
2530 IF MID$(D$(2),K,1)<>"/" THEN 2590
2540 IF MID$(D$(2),K+1,1)=MID$(TX$(32),20,1) THEN FL=1:RETURN
2550 FL=0:RETURN
2590 NEXT K
2600 REM *** KEY & PROCESSING ***
2610 KEY$=LEFT$(KEY$+SPACE$(KEYLEN),KEYLEN)
2620 PRINT FNCP$(21,0)LEFT$(TX$(34),79)CUP$
2630 MATCH=INSTR(KEY$,"?"):IF MATCH=0 THEN MATCH=KEYLEN
2640 RETURN
2700 REM *** READ & VALIDATE ***
2701 PRINT FNCP$(17,40)LEFT$(TX$(37),23):PRINT FNCP$(17,56)REC%
2705 I6%=I6%+1:IF I6%>REC% THEN RETURN
2710 SRN%=I6%:GET #2,SRN%
2715 IF F$(2)=SPACE$(16) OR INSTR(F$(2),CHR$(0))<>0 THEN 2705
2720 GOSUB 10000:REM GOSUB 2500
```

```
2725 REM IF FL=1 THEN 2705
2730 RN%=DP(22):GOSUB 25000
2735 IF D(23)=0 THEN 2705
2736 CM=0:FOR AB%=12 TO 11+SE:CM=CM+DP(AB%):NEXT AB%
2737 IF PROG$="2" AND CM=0 THEN 2705
2738 IF PROG$="1" AND DP(3)-DP(10)<=0 THEN 2705
2740 IF LEFT$(KEY$,MATCH-1)=LEFT$(D$(3),MATCH-1) THEN
COUNT=COUNT+1:AR(COUNT,1)=SRN% ELSE 2705
2770 AR$(COUNT,1)=RIGHT$(SPACE$(7)+STR$(DP(1)),7)+D$(1)
2850 PRINT FNCP$(17,28)I6%CUP$:GOTO 2705
9200 REM ** PRINTOUT PART NUM. & SUB-TOT FOR CUST.CHANGE **
9210 GOSUB 9310
9220 S$=LEFT$(TX$(21),18)+SPACE$(21)
9230 LPRINT STRING$(156,"-")
9240 FOR I3=1 TO 14:FT$=STR$(STOT(I3))
9250 IF STOT(I3)>9999999! THEN FT$=STR$(INT(STOT(I3)/1000))+"k"
9260 S$=S$+RIGHT$(SPACE$(7)+FT$+" ",8):NEXT I3
9270 PRINT FNCP$(21,0)SPACE$(79)CUP$
9280 LPRINT STRING$(156,"="):LPRINT
9290 FOR I3=1 TO 14:GTOT(I3)=GTOT(I3)+STOT(I3):STOT(I3)=0:NEXT I3
9295 RETURN
9300 REM ** PRINT OUT PART NUMBER DETAILS **
9310 S$=" "+PD$+" "+DD$+"   "
9320 FOR I3=1 TO 14:FT$=STR$(POT(I3))
9322 IF POT(I3)>9999999! THEN FT$=STR$(INT(POT(I3)/1000))+"k"
9324 S$=S$+RIGHT$(SPACE$(7)+FT$+" ",8):NEXT I3
9325 IF PROG$="2" THEN 9330 ELSE FT$=STR$(CCMS)
9327 IF CCMS>9999999! THEN FT$=STR$(INT(CCMS/1000))+"k"
9328 S$=S$+RIGHT$(SPACE$(7)+FT$+" ",8)
9330 LPRINT:LPRINT S$
9340 FOR I3=1 TO 14:STOT(I3)=STOT(I3)+POT(I3):POT(I3)=0:NEXT I3
9345 CCMS=0
9350 PN=1:RETURN
9400 REM ** PROG$=2 OPTION FOR LEAD TIME OFFSET **
9410
A=VAL(MID$(STR$(D(23)),6,2)):B=VAL(MID$(STR$(D(23)),4,2)):C=VAL(MID$(STR$(D(23))
,2,2))
9415 IF INT(C/4)=C/4 THEN L(2)=29
9420 REM * USE EITHER 9430 OR 9440 FOR LEAD TIME IN WKS. OR DAYS, RESPECT'Y *
9430 MD24=INT(MD(24)):IF MD(24)-MD24>0 THEN MD24=INT(MD(24)*7+1) ELSE MD24
=INT(MD(24)*7)
9440 REM * MD24=INT(MD(24)):IF MD(24)-MD24>0 THEN MD24=MD24+1
9450 A1=A-MD24
9460 IF A1>0 THEN GOTO 9500
9465 C1=C
9467 B1=B
9470 B1=B1-1:IF B1<=0 THEN B1=12:C1=C1-1
9480 MD2=MD24-A:A1=L(B1)-MD2:IF A1<=0 THEN A=A+L(B1):GOTO 9470
9490 C=C1:B=B1
9500 D(23)=(C*10000)+(B*100)+A1
9505 L(2)=28
9510 RETURN
9800 REM *** PRINTING & SUCH LIKE ***
9810 FOR I8=1 TO COUNT
9820 SRN%=AR(I8,1)
9830 GOSUB 10000
9840 RN%=DP(22)
9850 GOSUB 25000
9860 IF I8=1 THEN CD=DP(1):CD$=D$(3):GOSUB 45000
9870 IF DP(1)=CD THEN 9880 ELSE GOSUB 9200:CD=DP(1):CD$=D$(3):GOSUB 45000:GOTO
```

```
9880:REM **SUB-TOT ON CHANGE OF CUST.**
9888 IF PN=1 THEN PD$=D$(1):DD$=D$(4) ELSE 9890
9890 IF D$(1)=PD$ THEN 9900 ELSE GOSUB 9300:GOTO 9880:REM ** ? DETAILS ON PART
NUM. CHANGE **
9900 I2=1
9905 IF PROG$="2" THEN GOSUB 9400
9906 IF PROG$="1" THEN CUM=DP(3)-DP(10):GOTO 9910 ELSE 9907
9907 FOR T1=12 TO 11+SE:CUM=CUM+DP(T1):NEXT T1
9910 IF D(23)<=WE(I2) THEN POT(I2)=POT(I2)+CUM:GOTO 9945
9920 I2=I2+1:IF I2>13 THEN GOTO 9943
9930 IF D(23)>WE(I2-1) AND D(23)<=WE(I2) THEN POT(I2)=POT(I2)+CUM:GOTO 9945
9940 GOTO 9920
9943 POT(14)=POT(14)+CUM
9945 CUM=0:PN=PN+1
9946 TZ%=1:FOR T1%=SE+1 TO SD%:CCMS=CCMS+DP(11+SE+TZ%):TZ%=TZ%+1:NEXT T1%
9948 NEXT I8
9950 REM ** FOR ORDER STATUS **
9960 GET #1,SRN%:GET #2,SRN%:GET #7,SRN%
9970 GOTO 10010
10000 REM *** READ ORDER ***
10002 GOTO 9950
10003 FOR J1% = 1 TO 3
10006 GET #J1%,SRN%
10007 NEXT J1%
10009 GET #7,SRN%
10010 B%=1:C%=1:G%=1:H=1
10020 FOR J1% = 1 TO 3
10030 D$(J1%)=F$(J1%)
10040 NEXT J1%
10050 FOR J1% = 18 TO 20
10060 D$(J1%)=MID$(CORD$,B%,8)
10070 B%=B%+8
10080 NEXT J1%
10090 FOR J1% = 3 TO 22
10100 DP(J1%)=CVS(MID$(PCT$,C%,4))
10110 C%=C%+4
10120 NEXT J1%
10130 FOR J1% = 23 TO 24
10140 D(J1%) = CVS(MID$(SPT$,G%,4))
10150 G%=G%+4
10160 NEXT J1%
10170 FOR J1%=27 TO 36
10180 D(J1%)=CVS(MID$(SPT$,G%,4))
10190 G%=G%+4
10200 NEXT J1%
10210 RETURN
16000 REM **** GET SPECIALS FROM SCREENS FOR DELSCHED ****
16010 OPEN "R",#15,"MAIN.FIL",80
16020 FIELD #15,80 AS MS$
16030 GET #15,12
16040 ID3$=MID$(MS$,6,12)
16050 ID4$=MID$(MS$,45,12)
16980 CLOSE #15
16990 RETURN
22500 REM ********* GET YES OR NO ANSWER ***********
22510 MAXL%=1:MINL%=1:ROW%=21:COL%=45
22520 GOSUB 60980
22530 IF I$=MID$(TX$(2),2,1) THEN FLAG=1:RETURN
22540 IF I$=MID$(TX$(2),4,1) THEN FLAG=0:RETURN
22550 GOTO 22500
```

```
25000 REM **** TO READ METHODING FILE ****
25005 GET #6,RN%:D$(3)=F$(6):REM AFORE GET INSERT IF TYPE$="F" THEN
25010 GET #8,RN%
25030 D$(4) = F$(8)
25050 B%=1:C%=1:T%=1:P%=1
25060 FOR J1% = 5 TO 17
25070 D$(J1%) = MID$(ROPE$,B%,8)
25080 B% = B% + 8
25090 NEXT J1%
25100 FOR J1% = 1 TO 2
25110 DP(J1%) = CVS(MID$(INR$,C%,4))
25120 C% = C% + 4
25130 NEXT J1%
25140 FOR J1% = 1 TO 22
25150 D(J1%) = CVS(MID$(FPT$,T%,4))
25160 T% = T% + 4
25170 NEXT J1%
25180 FOR J1% = 1 TO 2
25190 D#(J1%) = CVD(MID$(DPT$,P%,8))
25200 P% = P% + 8
25210 NEXT J1%
25220 FOR J1%=7 TO 8
25230 D(J1%+18)=CVS(DA$(J1%))
25240 NEXT J1%
25245 IF PROG$="2" OR PROG$="1" THEN GOSUB 28000
25250 RETURN
26000 REM **** dd/mm/yy --> d/ww/yy ****
26010 DMY$=RIGHT$(STR$(DMY),6)
26020 Y1=VAL(MID$(DMY$,1,2)):M1=VAL(MID$(DMY$,3,2)):DD1=VAL(MID$(DMY$,5,2))
26030 Y2=Y1
26040 IF Y1>99 THEN GOTO 26060
26050 Y1=Y1+1900
26060 DF=DD1:MF=M1:YF=Y1:GOSUB 26500:U=ND
26070 D1=Y(U-7*INT(U/7)+1)
26080 WN=0:GOSUB 26700
26090 RETURN
26500 REM ** SOLVING FOR DAY NO. **
26510 ND=DF-1
26520 FOR I1=1 TO MF-1:ND=ND+L(I1):NEXT I1
26530 I1=INT(YF/100)
26540 IF YF<>4*INT(YF/4) GOTO 26590
26550 IF YF/100=I1 GOTO 26590
26560 IF ND>59 GOTO 26590
26570 IF MF=3 GOTO 26590
26580 ND=ND-1
26590 ND=ND+36524!*I1+INT(365.25*(YF-100*I1))
26600 RETURN
26700 REM ** SOLVING FOR WEEK NO. **
26710 IF Y2=SY1 THEN 26740
26720 FOR I5=1 TO ((Y2-1)-SY1)
26730 IF SY1+I5=4*INT((SY1+I5)/4) THEN WN=WN+1
26735 NEXT I5
26740 IF Y2=4*INT(Y2/4) AND M1>2 THEN WN=WN+1
26750 WN=WN+L(SM1)-(SD1-1)+DD1
26760 IF Y2<>SY1 THEN 26790
26770 FOR I1=SM1+1 TO M1-1:WN=WN+L(I1):NEXT I1
26780 GOTO 26860
26790 ME=12-SM1:I1=SM1+1
26800 FOR I5=1 TO (Y2-(SY1+1)):ME=ME+12:NEXT I5
26810 FOR I5=1 TO ME:WN=WN+L(I1)
```

```
26820 I1=I1+1
26830 IF I1>12 THEN I1=1
26840 NEXT I5
26850 FOR I5=1 TO M1-1:WN=WN+L(I5):NEXT I5
26860 REM **
26864 IF D1<>7 THEN WN=WN+7-D1
26866 WN=WN+1:REM ** ALLOWING FOR 1 OF JAN '83 **
26868 WN=INT(WN/7.024)+1
26870 IF WN>52 THEN WN=WN-52 ELSE GOTO 26880
26875 IF M1=12 AND WN=53 THEN Y2=Y2+1
26877 GOTO 26870
26880 RETURN
28000 REM **** READ       METHO2.FIL ****
28010 GET #10,RN%
28020 MDP(3)=CVS(DA$(9))
28030 FOR J1%=18 TO 20
28040 MD$(J1%)=DA$(J1%-16)
28050 NEXT J1%
28060 MD(23)=CVS(DA$(5))
28070 MD(24)=CVS(DA$(6))
28080 GET #5,RN%
28090 GET #6,RN%
28100 MD$(2)=F$(5)
28110 MD$(3)=F$(6)
28120 RETURN
30000 REM **** MAIN REPORT OPTIONS ****
30010 IF PROG$="2" THEN INS%=30 ELSE INS%=29
30015 PRINT NOCUR$BKGD$CLS$
30020 PRINT FNCP$(-
2,0)RON$LEFT$(TX$(3),13)ROFF$MID$(TX$(3),14,50)RON$RIGHT$(TX$(3),17)CUP$
30030 PRINT FNCP$(-2,7)RON$NME$ROFF$CUP$
30040 PRINT FNCP$(-2,69)RON$DTE$ROFF$CUP$
30050 PRINT FNCP$(-2,39)LEFT$(TX$(INS%),20)CUP$
33060 PRINT FNCP$(8,15)LEFT$(TX$(22),10)ID3$"    :"CUP$
33070 PRINT FNCP$(9,15)LEFT$(TX$(23),21)CUP$
33075 PRINT FNCP$(11,15)LEFT$(TX$(24),14)CUP$
33076 PRINT FNCP$(12,15)LEFT$(TX$(25),25)CUP$
33080 PRINT FNCP$(21,21)LEFT$(TX$(35),25)CUP$
33110 PRINT ROFF$FRGD$CUP$
33120 RETURN
37500 REM ** FORMATTING ROUTINE **
37505 SDP=NP+1
37510 Q=ABS(M)+5*10^(-SDP):M$=RIGHT$(SPACE$(12)+STR$(SGN(M)*INT(Q)),DP)
37520 M$=M$+"."+MID$(STR$(1+Q-INT(Q))+"000000",4,NP):RETURN
40000 REM ***ENQUIRY SUBROUTINE***
40010 REM OPENING FILES 1,2,3 & 4
40020 FOR J1% = 1 TO 3
40030 FILENAME$ = OD$+RIGHT$(STR$(J1%)+".FIL",5)
40040 OPEN "R",#J1%,FILENAME$,16
40050 FIELD #J1%,16 AS F$(J1%)
40060 NEXT J1%
40062 FOR J1%=4 TO 6:FILENAME$=MD$+RIGHT$(STR$(J1%)+".FIL",5)
40064 OPEN "R",#J1%,FILENAME$,16:FIELD #J1%,16 AS F$(J1%)
40066 NEXT J1%
40070 OPEN "R",#7,OD$+"ORDER.FIL",152
40080 FIELD #7,24 AS CORD$,80 AS PCT$,48 AS SPT$
40090 OPEN "R",#9,OD$+"RECORD.FIL",2
40100 FIELD #9,2 AS REC$
40110 OPEN "R",#8,MD$+"METHOD.FIL",240
40120 FIELD #8,16 AS F$(8),104 AS ROPE$,16 AS DPT$,88 AS FPT$,8 AS INR$,4 AS
```

```
DA$(7),4 AS DA$(8)
40150 OPEN "R",#10,MD$+"METHO2.FIL",170
40160 FIELD #10,3 AS DA$(1),50 AS DA$(2),50 AS DA$(3),50 AS DA$(4),4 AS DA$(5),4
AS DA$(6),4 AS DA$(9)
40170 OPEN "R",#11,MD$+"CTMETH.FIL",2
40180 FIELD #11,2 AS MREC$
40183 GET #11,1
40186 REC%=CVI(MREC$)
40190 RETURN
42000 REM **** ESTABLISH NUMBER OF RECORDS ON ORDER FILE ****
42010 GET #9,1
42020 REC% = CVI(REC$)
42030 RETURN
45000 REM ** TO PRINT OUT CUST. NAME HEADING **
45010 LPRINT:LPRINT ID3$" : ";CD$
45020 LPRINT "------------------------------- "
45030 LPRINT
45040 S1$=" "+ID2$+"     "+ID4$+"          "+LEFT$(TX$(26),5)+"  "
45050 FOR I4=2 TO 13:S1$=S1$+MID$(STR$(WE(I4)),6,2)+"/"+MID$(STR$(WE(I4)),4,2)+"
":NEXT I4
45060 S1$=S1$+CHR$(32)+LEFT$(TX$(27),4)
45065 IF PROG$="1" THEN S1$=S1$+"    "+LEFT$(TX$(28),4)+" "
45070 LPRINT S1$
45080 LPRINT STRING$(156,"-")
45100 RETURN
46000 REM DISMANTLE A DATE
46010 A=INT(C/10000):C=C-A*10000
46020 B=INT(C/100):C=C-B*100
46030 D$=LEFT$(STR$(C)+STR$(B)+STR$(A)+"          ",9)
46040 RETURN
50000 REM *** MATCH SUBROUTINE ***
50010 RN% = RN% + 1
50020 IF RN% = REC%+1 THEN FLAG = 0:RETURN
50030 GET #KF%,RN%
50040 RN$ = F$(KF%)
50050 IF LEFT$(KEY$,H) = LEFT$(RN$,H) THEN GOTO 50070
50060 GOTO 50010
50070 FLAG = 1
50080 RETURN
55000 REM *** Read Text File Routine ***
55005
VLE$="07007107207441942042142242342442542642742842943043143243343443543643743843
9440441442615616660661674306108006307"
55010 OPEN "R",#1,"MAIN.FIL",80
55020 FIELD #1,80 AS MUC$
55030 CT%=0
55040 FOR I%=1 TO LEN(VLE$) STEP 3
55050 EL=VAL(MID$(VLE$,I%,3))
55060 CT%=CT%+1
55070 GET #1,EL
55080 TX$(CT%)=MUC$
55090 NEXT I%
55100 CLOSE #1
55110 RETURN
60700 MAXL%=8:MINL%=0:REM *** DATE CHANGE ROUTINE ***
60710 GOSUB 60980:IF VAL(I$)=0 THEN COMDAT=0:DAT$="0":GOTO 60810
60720 A=INSTR(I$,"/"):IF A=0 THEN A=INSTR(I$,".")
60730 IF A=0 THEN 60700 ELSE P$=LEFT$(I$,A-1)
60740 B=INSTR(A+1,I$,"/"):IF B=0 THEN B=INSTR(A+1,I$,".")
60750 IF B=0 THEN 60700 ELSE B$=MID$(I$,A+1,B-(A+1))
```

```
60760 C$=MID$(I$,B+1,2)
60770 A=VAL(P$):B=VAL(B$):C=VAL(C$)
60780 IF B<1 OR B>12 OR A<1 OR A>31 OR C>99 OR C<81 THEN 60700
60790 COMDAT=(C*10000)+(B*100)+A
60800 DAT$=P$+"/"+B$+"/"+C$
60805 GOTO 60820
60810 I$=DTE$:GOTO 60720
60820 PRINT FNCP$(ROW%,COL%)DAT$CUP$
60830 RETURN
60980 REM INPUT STRING ROUTINE
60990 I$=""
61000 PRINT FNCP$(ROW%,COL%)I$RON$SPACE$(MAXL%-LEN(I$))ROFF$CUP$
61010 GOSUB 61110
61020 IF X=8 THEN GOTO 61060
61030 IF X=13 AND LEN(I$)>=MINL% THEN GOTO 61080 ELSE IF X=13 GOTO 61000
61040 IF LEN(I$)<MAXL% THEN I$=I$+A$
61050 GOTO 61000
61060 IF LEN(I$)>0 THEN I$=LEFT$(I$,LEN(I$)-1)
61070 GOTO 61000
61080 I$=LEFT$(I$+SPACE$(MAXL%),MAXL%)
61090 PRINT FNCP$(ROW%,COL%)I$CUP$
61100 RETURN
61110 REM GET VALID CHARACTER
61120 A$=INKEY$:IF A$=""THEN GOTO 61120
61130 X=ASC(A$)
61140 IF (X>31 AND X<127) OR X=8 OR X=13 THEN RETURN
61150 IF X=185 OR X=27 THEN CLOSE:IF PROG$="2" THEN CHAIN"P0-00" ELSE CHAIN"P02-
00"
61160 IF X= 247 THEN GOSUB 61200
61170 IF X=186 THEN GOSUB 62000:LPRINT
61180 IF X=189 THEN GOSUB 62000:FOR L=1 TO 10:LPRINT:NEXT L
61190 RETURN
61200 REM
61210 REM
61220 REM
61230 DEF SEG = &HF000
61240 FOR I2 = 0 TO 22
61250 WE$=""
61260 FOR J2 = 0 TO 158 STEP 2
61270 WE$=WE$+CHR$(ABS(PEEK(I2*160+J2)-100))
61280 NEXT J2
61290 LPRINT WE$
61300 NEXT I2
61310 WIDTH 255
61320 RETURN
62000 RETURN:REM "**** GENERAL ERROR ROUTINE ****"
62010 PRINT FNCP$(21,0)TX$(4);FNCP$(21,25)ERR;FNCP$(21,49)ERL;CUP$
62020 A$=INKEY$:IF A$="" THEN 62020
62030 X=ASC(A$):IF X=27 THEN 61150
62040 PRINT FNCP$(21,0)SPACE$(79)CUP$
62050 RESUME
63998 END
63999 REM "P02-D (IBM - 86F01 - CRE 29/04/1986)"
```

A4.3 Production Planning/Programmes Program

```
5 REM $INCLUDE:'SHARE'
12 I6%=0:TYPE$="":OPT$=""
13 GOSUB 55000:MAC$=MID$(TX$(48),17,1)
14 AFLAG=0
15 IF MAC$="I" THEN 17
16 WIDTH LPRINT 255:GOTO 18
17 WIDTH "LPT1:",255
18 DIM MD(36),MDP(22),MD#(2),MD$(20),Y%(7),L%(12)
19 IF NME$="" OR DTE$="" THEN CHAIN "PPC"
21 GOSUB 16000
23 SY1=83:SD1=3:SM1=1:PV=VAL(MID$(TX$(48),7,5)):WV=VAL(MID$(TX$(48),1,5)):REM
"PV=PRICE PER : WV=WEIGHT PER"
25 FOR I%=1 TO 12:READ L%(I%):NEXT I%
26 FOR I%=1 TO 7:READ Y%(I%):NEXT I%
27 DATA 31,28,31,30,31,30,31,31,30,31,30,31:
28 DATA 5,6,7,1,2,3,4:
30 DEF FNCP$(ROW%,COL%)=CHR$(27)+"Y"+CHR$(34+ROW%)+CHR$(32+COL%)
32 OPT$=""
35 IF PROG$<>"" THEN 300
40 GOSUB 30000
50 SE%=VAL(MID$(TX$(48),15,1)):ROW%=21:COL%=37:MAXL%=2:MINL%=1:GOSUB 60980
60 OP%=VAL(I$):IF OP%>8 OR OP%<1 THEN 50
70 IF OP%=8 THEN CHAIN"P05-A"
80 IF OP%=1 THEN SE%=VAL(MID$(TX$(48),15,1))
130 IF OP%<>7 THEN 200
140 GOSUB 32500
150 ROW%=21:COL%=39:MAXL%=2:MINL%=1:GOSUB 60980
160 SE%=VAL(I$)
170 IF SE%<1 OR SE% >10 THEN 150
200 STRN%=VAL(FILENAME$(OP%))
210 GOSUB 41000
220 IF OP%=7 THEN IDENTI$=LEFT$(PROC$(SE%)+SPACE$(14),14) ELSE IDENTI$=""
230 GOSUB 35000
240 IF OP%=4 THEN AFLAG=1
250 GOSUB 17000
260 IF FLAG THEN 230 ELSE GOSUB 44000
263 IF OP%=1 THEN 1100
264 IF OP%=6 THEN 1300
266 IF OP%=3 THEN 1200
268 IF OP%=2 THEN 1400
270 GOTO 1000
280 X=27:GOTO 61150
300 REM *** WHERE PLANNING & PROGRAMME ARE ACCESSED ***
305 OP%=0:SE%=VAL(MID$(TX$(48),15,1))
310 IF PROG$="1" THEN 400
320 IF PROG$="2" THEN 800
330 END
400 REM *** FOR PLANNING PROG ***
405 SE%=VAL(MID$(TX$(48),15,1))
410 GOSUB 31000:REM *** PLANNING SCREEN ***
420 ROW%=6:COL%=55:MAXL%=1:MINL%=1:GOSUB 60980:IF ASC(I$)<65 OR ASC(I$)>67 THEN
420 ELSE TYPE$=I$
425 OPT$=TYPE$
430 ROW%=8:COL%=55:GOSUB 60700:START=COMDAT:START$=DAT$
440 ROW%=10:COL%=55:GOSUB 60700:FINISH=COMDAT:FINISH$=DAT$
445 ROW%=21:COL%=44:MAXL%=1:MINL%=1:GOSUB 60980:IF I$<>MID$(TX$(2),4,1) AND
I$<>MID$(TX$(2),2,1) THEN 445
447 IF I$=MID$(TX$(2),2,1) THEN 405
448 FOR II8%=14 TO 16:PRINT FNCP$(II8%,10)SPC(50)CUP$:NEXT II8%
450 KEY$="?"+SPACE$(15)
```

```
460 STRN%=827
470 GOSUB 41000:AFLAG=1
480 GOSUB 17000
490 GOSUB 44000
500 GOSUB 2600:REM *** KEY & PROCESSING ***
510 I6%=0:COUNT%=0
520 GOSUB 40000:REM *** OPEN ALL FILES ***
530 GOSUB 42000:REM *** HOW MANY ON FILE ***
540 GOSUB 2700:REM *** VERIFY ***
550 GOSUB 2000:REM *** SORT ( STRING TYPE ) ***
560 GOSUB 9800:REM *** PRINTING & SUCH LIKE ***
570 S$=LEFT$(TX$(7),79)
580 IF ST>0 THEN GOSUB 9200
585 S$=LEFT$(TX$(8),79)
590 GOSUB 3400:REM *** TOTAL PRINT & ZERO VARIABLES ***
600 X=27:GOTO 61150
800 REM *** FOR PROGRAMME PROG ***
810 GOSUB 31500:REM *** SCREEN FOR PROGRAMME OPTION ***
820 ROW%=21:COL%=38:MAXL%=1:MINL%=1:GOSUB 60980:IF VAL(I$)<1 OR VAL(I$)>3 THEN
820
830 SE%=VAL(I$):OPT$=LEFT$(PROC$(SE%)+SPACE$(14),14):IF SE%=1 THEN 900
840 YN$=LEFT$(TX$(10),3)
900 REM *** COREMAKING FROM PROGRAMME PROG (800-870) ***
910 TYPE$="E":KEY$="?"+SPACE$(15)
920 START=0:START$="0":ROW%=11:COL%=47:GOSUB 60700:FINISH=COMDAT:FINISH$=DAT$
930 STRN%=841
940 GOTO 470
1000 REM *** MAIN BODY OF NORMAL PROGRAM ***
1010 TYPE$="":GOSUB 2600:REM *** KEY & PROCESSING ***
1020 I6%=0:COUNT%=0
1030 GOSUB 40000:REM *** OPEN ALL FILES ***
1040 GOSUB 42000:REM *** HOW MANY ON FILE ***
1050 GOSUB 2700:REM *** READ & VALIDATE ***
1060 GOSUB 3500:REM *** SORT ( NORMAL TYPE ) ***
1070 GOTO 560
1100 REM *** METAL TYPE ( PART OF NORMAL PROGRAM OPTION ) ***
1110 TYPE$="G"
1120 GOTO 500
1200 REM *** WORK-IN-PROGRESS SUMMARY ( PART OF NORMAL PROGRAM OPTION ) ***
1210 TYPE$="F":GOSUB 2600:REM *** KEY & PROCESSING ***
1220 I6%=0:COUNT%=0
1230 GOSUB 40000:REM *** OPEN ALL FILES ***
1240 REM CLOSE #3:REM *** TO GET METHOD CUSTOMER NAME ***
1250 REM OPEN "R",#6,"6.FIL",16:FIELD #6,16 AS F$(3)
1260 GOTO 530
1300 REM *** CUSTOMER ORDERS ( PART OF NORMAL PROGRAM OPTION ) ***
1310 GOTO 1210
1400 REM ** JOB STATUS **
1410 TYPE$="H":GOSUB 2600:REM *** KEY & PROCESSING ***
1420 GOTO 1220
2000 REM *** SORT ( STRING TYPE ) ***
2010 SW%=COUNT%:IF COUNT%=0 THEN S$=LEFT$(TX$(6),26):LPRINT S$:GOTO 600
2020 PO%=0:SW%=SW%\2:IF SW%=0 THEN RETURN
2030 PO%=PO%+1
2040 IF (PO%+SW%)>COUNT% THEN 2020
2050 IF AR$(PO%,1)<=AR$(PO%+SW%,1) THEN 2030
2060 SWAP AR(PO%,1),AR(PO%+SW%,1)
2070 SWAP AR$(PO%,1),AR$(PO%+SW%,1):GOTO 2090
2080 PO%=PO%-1
2090 IF PO%-SW%<1 THEN 2040
```

```
2100 IF AR$(PO%,1)>=AR$(PO%-SW%,1) THEN 2030
2110 SWAP AR(PO%,1),AR(PO%-SW%,1)
2120 SWAP AR$(PO%,1),AR$(PO%-SW%,1):GOTO 2080
2500 REM *** CHECK SUFFIX ****
2510 FOR K=16 TO 1 STEP -1
2520 IF K=1 THEN FL=1:RETURN
2530 IF MID$(D$(2),K,1)<>"/" THEN 2590
2535 IF TYPE$=MID$(TX$(40),1,1) OR TYPE$=MID$(TX$(40),2,1) OR
TYPE$=MID$(TX$(40),3,1) THEN IF MID$(D$(2),K+1,1)=MID$(TX$(40),20,1) THEN
FL=1:RETURN
2540 IF TYPE$=MID$(TX$(40),5,1) OR OP%=1 THEN IF
MID$(D$(2),K+1,1)<>MID$(TX$(40),16,1) THEN FL=1:RETURN
2550 IF TYPE$<>MID$(TX$(40),6,1) AND TYPE$<>MID$(TX$(40),7,1) THEN IF
MID$(D$(2),K+1,1)=MID$(TX$(40),20,1) THEN FL=1:RETURN
2560 IF TYPE$=MID$(TX$(40),6,1) AND OP%=3 THEN IF
MID$(D$(2),K+1,1)=MID$(TX$(40),20,1) THEN FL=1:RETURN
2570 FL=0:RETURN
2590 NEXT K
2600 REM *** KEY & PROCESSING ***
2610 KEY$=LEFT$(KEY$+SPACE$(KEYLEN%),KEYLEN%)
2620 PRINT FNCP$(21,0)LEFT$(TX$(9),79)CUP$
2630 MATCH%=INSTR(KEY$,"?"):IF MATCH%=0 THEN MATCH%=KEYLEN%
2640 RETURN
2700 REM *** READ & VALIDATE ***
2704 PRINT FNCP$(17,40)LEFT$(TX$(49),23):PRINT FNCP$(17,56)REC%
2705 I6%=I6%+1:IF I6%>REC% THEN RETURN
2710 SRN%=I6%:GET #2,SRN%
2715 IF F$(2)=SPACE$(16) THEN 2705
2720 GOSUB 10000:GOSUB 2500:IF FL=1 THEN 2705
2721 PISS%=SE%
2722 IF PROG$="1" THEN SE%=VAL(MID$(TX$(48),15,1))
2723 CUMP=0:FOR T1%=12 TO 11+SE%:CUMP=CUMP+DP(T1%):NEXT T1%
2724 SE%=PISS%
2725 IF (PROG$="2" OR PROG$="1" OR OP%=7) AND CUMP=0 THEN 2705
2726 IF OP%=4 AND DP(10)>=DP(3) THEN 2705
2730 RN%=DP(22)
2740 GOSUB 25000
2741 IF TYPE$=MID$(TX$(40),5,1) AND D$(6+SE%)=SPACE$(8) THEN 2705
2742 IF TYPE$=MID$(TX$(40),8,1) AND D(26)=0 THEN 2705
2743 IF (TYPE$=MID$(TX$(40),5,1) AND (((SE%=2 OR SE%=3) AND
YN$=LEFT$(TX$(11),4)) OR SE%=1)) AND (D$(7)=LEFT$(TX$(12),8) OR
D$(7)=LEFT$(TX$(13),7) OR D$(7)=LEFT$(TX$(14),5) OR D$(7)=SPACE$(8)) THEN 2705
2745 IF TYPE$=MID$(TX$(40),5,1) AND (SE%=2 OR SE%=3) AND YN$=LEFT$(TX$(14),4)
AND (D$(7)<>LEFT$(TX$(12),8) AND D$(7)<>LEFT$(TX$(13),8) AND
D$(7)<>LEFT$(TX$(14),8) AND D$(7)<>SPACE$(8)) THEN 2705
2750 IF TYPE$=MID$(TX$(40),5,1) OR TYPE$=MID$(TX$(40),7) THEN GOSUB 3000:GOTO
2760 ELSE 2755:REM ** GET DEFAULT DATE (PROG) **
2755 IF SR(ITEMS,2)=37 THEN GOSUB 4500:GOTO 2705
2757 IF PROG$<>"1" THEN 2760
2758 GOSUB 29000
2760 REM
2761 IF (D(SR(ITEMS,2))>0)AND (D(SR(ITEMS,2))>=START) AND
(D(SR(ITEMS,2))<=FINISH) AND (LEFT$(KEY$,MATCH%-1)=LEFT$(D$(KEY+SEX),MATCH%-
1))THEN COUNT%=COUNT%+1:AR(COUNT%,1)=SRN% ELSE 2705
2766 IF TYPE$=MID$(TX$(40),1,1) OR TYPE$=MID$(TX$(40),2,1) OR
TYPE$=MID$(TX$(40),3,1) OR TYPE$=MID$(TX$(40),6,1) OR TYPE$=MID$(TX$(40),8,1)
THEN DMY=D(23):GOSUB 27000:DTEMP=(Y2*10000)+(WN*100)+D1
2767 IF TYPE$=MID$(TX$(40),7,1) THEN DMY=D(26+SE%):GOSUB
27000:DTEMP=(Y2*10000)+(WN*100)+D1
2768 IF TYPE$="" OR TYPE$=MID$(TX$(40),5,1) THEN DMY=D(SR(ITEMS,2)):GOSUB
```

```
27000:DTEMP=(Y2*10000)+(WN*100)+D1
2769 IF PROG$="1" THEN DMY=D(23):GOSUB
27000:SRT$=RIGHT$(STR$(Y2),2)+RIGHT$(STR$(WN),2)
2770 IF TYPE$=MID$(TX$(40),1,1) THEN
AR$(COUNT%,1)=RIGHT$(SPACE$(4)+SRT$,4)+D$(9)
2780 IF TYPE$=MID$(TX$(40),2,1) THEN
AR$(COUNT%,1)=D$(9)+RIGHT$(SPACE$(8)+STR$(DTEMP),8)
2790 IF TYPE$=MID$(TX$(40),3,1) THEN
AR$(COUNT%,1)=D$(5)+RIGHT$(SPACE$(8)+STR$(DTEMP),8)
2810 IF TYPE$=MID$(TX$(40),5,1) THEN
AR$(COUNT%,1)=D$(6+SE%)+RIGHT$(SPACE$(6)+STR$(DTEMP),6)
2820 IF TYPE$=MID$(TX$(40),6,1) THEN
AR$(COUNT%,1)=RIGHT$(SPACE$(7)+STR$(DP(1)),7)+D$(1)+RIGHT$(SPACE$(6)+STR$(DTEMP)
,6)
2830 IF TYPE$=MID$(TX$(40),7,1) THEN
AR$(COUNT%,1)=D$(5)+RIGHT$(SPACE$(6)+STR$(DTEMP),6)
2833 IF TYPE$<>MID$(TX$(40),8,1) THEN 2840
2836 NP=2:DP=7:M=D(26):GOSUB
37500:AR$(COUNT%,1)=M$+RIGHT$(SPACE$(7)+STR$(DP(1)),7)+D$(1)+RIGHT$(SPACE$(6)+ST
R$(DTEMP),6)
2840 IF TYPE$="" THEN AR(COUNT%,2)=DTEMP
2850 print fncp$(17,28)i6%cup$:GOTO 2705
3000 REM ** FOR PROGRAMME (1,2,3) DATES **
3010 IF D(26+SE%)<>0 THEN D(SR(ITEMS,2))=D(26+SE%):FLG=0:GOTO 3050 ELSE 3020
3020 IF D(29)<>0 THEN D(SR(ITEMS,2))=D(29):FLG=2:GOTO 3050 ELSE 3030
3030 D(SR(ITEMS,2))=D(23):FLG=1:GOTO 3050
3050 RETURN
3400 REM *** TOTAL PRINT & ZERO VARIABLES ***
3410 FOR I1 = 1 TO TOTS
3415 ON TOT(I1,2) GOTO 3440,3420,3430
3417 GOTO 3440
3420 M=TOTAL(I1):DP=7:NP=2:GOSUB 37500:IF FK=1 THEN M$=LEFT$(M$,8)+"k."
3425 S$=LEFT$(S$,TOT(I1,1))+M$+"
":GOTO 3440
3430 S=TOTAL(I1):IF S>9999999! THEN S=INT(S/1000):FK=1 ELSE FK=0
3432 M$=RIGHT$(SPACE$(7)+STR$(S),7):IF FK=1 THEN M$=RIGHT$(M$+"k",7)
3435 S$=LEFT$(S$,TOT(I1,1))+RIGHT$("               "+M$+" ",8)+"
"
3440 NEXT I1
3450 LPRINT STRING$(LEN(HD$(6))+2,"="):LPRINT LEFT$(S$,LEN(HD$(6))):LPRINT
STRING$(LEN(HD$(6))+2,"="):LPRINT
3460 FOR I1=1 TO TOTS
3470 TOT(I1,1)=0:TOTAL(I1)=0:STOTAL(I1)=0
3480 NEXT I1
3490 S$="":RETURN
3500 REM *** SORT ( NORMAL TYPE ) ***
3510 SW%=COUNT%:IF SW%=0 THEN S$=LEFT$(TX$(6),26):LPRINT S$:GOTO 600
3520 PO%=0:SW%=SW%\2:IF SW%=0 THEN RETURN
3530 PO%=PO%+1
3540 IF (PO%+SW%)>COUNT% THEN 3520
3550 IF AR(PO%,2)<=AR(PO%+SW%,2) THEN 3530
3560 SWAP AR(PO%,2),AR(PO%+SW%,2)
3570 SWAP AR(PO%,1),AR(PO%+SW%,1):GOTO 3590
3580 PO%=PO%-1
3590 IF PO%-SW%<1 THEN 3540
3600 IF AR(PO%,2)>=AR(PO%-SW%,2) THEN 3530
3610 SWAP AR(PO%,2),AR(PO%-SW%,2)
3620 SWAP AR(PO%,1),AR(PO%-SW%,1):GOTO 3580
4010 S$="":RETURN
4500 REM *** CHECK FOR DATE  37 I.E. USER SELECTED (SE%) ***
```

```
4505 IF OP%=7 AND D(26+SE%)=0 THEN D(26+SE%)=D(23)
4510 IF (D(26+SE%)>0)AND (D(26+SE%)>=START) AND (D(26+SE%)<=FINISH) AND
(LEFT$(KEY$,MATCH%-1)=LEFT$(D$(KEY+SE%),MATCH%-1))THEN
COUNT%=COUNT%+1:AR(COUNT%,1)=I6%:DMY=D(26+SE%):GOSUB
27000:DTEMP=(Y2*10000)+(WN*100)+D1:AR(COUNT%,2)=DTEMP
4515 PRINT FNCP$(17,28)I6%CUP$
4520 RETURN
4600 REM ** START DATE FOR PROD. PLAN. **
4610
A=VAL(MID$(STR$(D(23)),6,2)):B=VAL(MID$(STR$(D(23)),4,2)):C=VAL(MID$(STR$(D(23))
,2,2))
4615 IF INT(C/4)=C/4 THEN L%(2)=29
4620 REM * USE EITHER 9430 OR 9440 FOR LEAD TIME IN WKS. OR DAYS, RESPECT'Y *
4630 MD24=INT(MD(24)):IF MD(24)-MD24>0 THEN MD24=INT((MD(24)*7)+1) ELSE MD24
=INT(MD(24)*7)
4640 REM * MD24=INT(MD(24)):IF MD(24)-MD24>0 THEN MD24=MD24+1
4650 A1=A-MD24
4660 IF A1>0 THEN GOTO 4710
4670 C1=C
4675 B1=B
4680 B1=B1-1:IF B1<=0 THEN B1=12:C1=C1-1
4690 MD2=MD24-A:A1=L%(B1)-MD2:IF A1<=0 THEN A=A+L%(B1):GOTO 4680
4700 C=C1:B=B1
4710 D(23)=(C*10000)+(B*100)+A1
4715 L%(2)=28
4720 RETURN
5000 END
6000 REM ****************** STRING ELEMENTS *******************
6003 IF (TYPE$=MID$(TX$(40),5,1) OR PROG$="1") AND SR(I5%,2)=7 THEN 6030
6005 IF (TYPE$=MID$(TX$(40),5,1) AND PROG$="2") AND SR(I5%,2)=3 THEN
S$=S$+LEFT$(" "+LEFT$(D$(3),8)+"        ",9):RETURN
6007 IF PROG$="1" AND SR(I5%,2)=2 THEN GOTO 6020
6010 IF SR (I5%,2)<=4 THEN S$=S$+LEFT$(D$(SR(I5%,2))+"
",17):RETURN
6020 S$=S$+LEFT$(" "+D$(SR(I5%,2))+"          ",9):RETURN
6030 S$=S$+LEFT$(" "+D$(SR(I5%,2)+(SE%-1))+"          ",9):RETURN:REM *** CAUSE
IS 7:NEED SECTION SE%-1 ***
7000 REM **************** FLOATING POINT ELEMENTS **************
7010 IF DP(2)=0 THEN DP(2)=1
7030 IF SR(I5%,2)=37 OR SR(I5%,2)=38 THEN  M=D#(SR(I5%,2)-36):NP=2:DP=7:GOSUB
37500:S$=S$+M$+" ":RETURN:REM PRINT OUT CASTING WEIGHTS
7040 IF SR(I5%,2)<38 THEN M=D(SR(I5%,2)):NP=2:DP=7:GOSUB 37500:S$=S$+M$+"
":RETURN:REM PRINT OUT FLOATING POINT NUMBERS
7050 ON SR(I5%,2)-38 GOTO
7060,7070,7080,7090,7100,7120,7130,7140,7150,7160,7170,7180
7060 GOSUB 8800:M=(DP*D#(2))/WV:GOTO 7800:REM [sigma/O(10)]*O(12)
7070 GOSUB 7900:M=(SIGMA*D(1))/PV:GOTO 7800:REM [sigma*O(14)]
7080 M=(DP(3)*D(1))/PV:GOTO 7800:REM [O(05)*O(14)]
7090 M=((DP(3)-DP(10))*D(1))/PV:GOTO 7800:REM [(O(05)-O(24))*O(14)]
7100 M=(DP(10)*D(1))/PV:GOTO 7800:REM [O(24)*O(14)]
7120 R=SE%:SE%=10:GOSUB 7900:R1=SIGMA:SE%=R:GOSUB 7900:M=((R1-
SIGMA)*D(1))/PV:GOTO 7800:REM [(everything after cast*O(14)]
7130 M=D(2+SE%)*DP(11+SE%):GOTO 7800:REM [(O(27) or O(32) ... O(72))*(O(30) or
O(35) ... O(75))]
7140 GOSUB 8800:M=(DP*DP(2))*D(2+SE%):GOTO 7800:REM [sigma * (O(27) or O(32) ...
O(72))]
7150 GOSUB 7900:M=(SIGMA*D#(1))/WV:GOTO 7800:REM [sigma * O(11)]
7160 GOSUB 7900:M=(SIGMA*D(1))/PV:GOTO 7800:REM [sigma * O(14)]
7170 GOSUB 7900:M=D(25)*SIGMA:GOTO 7800:REM [O(17)*sigma]
7180 M=DP(12)*D(3):GOTO 7800:REM [O(30)*O(27) total core times ]
```

```
7190 PISS%=SE%:SE%=2:GOSUB 7900:M=SIGMA*D(4):SE%=PISS%:GOTO 7800:REM [sigma *
D(37)]
7800 NP=2:DP=7:GOSUB 37500:S$=S$+M$+" ":RETURN
7890 END
7900 REM SIGMA QUANTITIES IN PROCESS STAGES
7905 SIGMA=0
7910 FOR SI=SE%+11 TO 12 STEP -1
7920 SIGMA=SIGMA+DP(SI)
7930 NEXT SI
7940 RETURN
8000 REM****************** INTEGER ELEMENTS ********************
8005 IF DP(2)=0 THEN DP(2)=1
8010 IF SR(I5%,2)<23 THEN DP=DP(SR(I5%,2)):GOTO 8900
8020 ON SR(I5%,2)-22 GOTO 8030,8040,8050,8060
8030 GOSUB 3800:GOTO 8900:REM [sigma/D(10)] rounded up
8040 R=SE%:SE%=10:GOSUB 7900:R1=SIGMA:SE%=R:GOSUB 7900:DP=R1-SIGMA:GOTO 8900:REM
[every thing after cast]
8050 DP=DP(11+SE%):GOTO 8900:REM [D(30) or D(35) ... D(75)]
8060 GOSUB 8800:DP=(DP*DP(2)):GOTO 8900:REM [sigma]
8070 PISS%=SE%:SE%=2:GOSUB 7900:DP=SIGMA/DP(2):SE%=PISS%:GOTO 8900
8080 DP=DP(12)/DP(2):GOTO 8900
8090 GOSUB 7900:DP=(SIGMA/DP(2)):IF DP-(SIGMA/DP(2))<>0 THEN
DP=((SIGMA/DP(2))+.5):GOTO 8900 ELSE  8900:REM [sigma/D(10)] rounded up
8800 GOSUB 7900:DP=(SIGMA/DP(2)):IF DP-(SIGMA/DP(2))<>0 THEN
DP=((SIGMA/DP(2))+.5):REM [sigma/D(10)] rounded up
8810 RETURN
8900 IF DP<0 THEN DP=0
8901 S=INT(DP+0.99):IF S>9999999! THEN S=INT(S/1000):FK=1 ELSE FK=0
8902 M$=RIGHT$(SPACE$(7)+STR$(S),7):IF FK=1 THEN M$=RIGHT$(M$+"k",7)
8905 S$=S$+RIGHT$("                "+M$+" ",8):RETURN
9000 REM ******** DATE ELEMENTS *********
9002 IF TYPE$<>MID$(TX$(40),5,1) THEN FLG=3
9003 IF SIF > 0 THEN C=D(23):GOSUB 46000:GOTO 9041
9007 IF TYPE$=MID$(TX$(40),5,1) AND SR(I5%,2)=37 THEN GOSUB
3000:D(26+SE%)=D(SR(ITEMS,2)):GOTO 9040 ELSE 9010
9010 IF SR(I5%,2)>36 THEN ON SR(I5%,2)-36 GOTO 9030
9020 C=D(SR(I5%,2)) :GOSUB 46000:S$=S$+D$:RETURN
9030 IF OP%=7 AND D(26+SE%)=0 THEN D(26+SE%)=D(23):FLG=1 ELSE 9040
9040 C=D(26+SE%):GOSUB 46000
9041 REM
9042 IF FLG=0 THEN D$=LEFT$(D$,9)+"P"
9043 IF FLG=1 THEN D$=LEFT$(D$,9)+"R"
9044 IF FLG=2 THEN D$=LEFT$(D$,9)+"C"
9049 S$=S$+D$:RETURN:REM DATES BY OPTION NUMBER
9050 STOP
9100 REM *** SUBTOT STRING BIT ***
9110 IF I8%=1 THEN ORI$=D$(SBT)
9120 IF D$(SBT)=ORI$ THEN RETURN
9130 ORI$=D$(SBT):GOSUB 9200:RETURN
9200 REM *** PRINT OUT SUB TOTALS ***
9205 S$=LEFT$(TX$(7),79)
9210 FOR T8=1 TO TOTS
9215 ON TOT(T8,2) GOTO 9240,9220,9230
9217 GOTO 9240
9220 M=STOTAL(T8):DP=7:NP=2:GOSUB 37500:IF FK=1 THEN
M$=LEFT$(M$,8)+"k.":S$=LEFT$(S$,TOT(T8,1))+M$+"
"
9225 S$=LEFT$(S$,TOT(T8,1))+M$+"
":GOTO 9240
9230 S=STOTAL(T8):IF S>9999999! THEN S=INT(S/1000):FK=1 ELSE FK=0
```

```
9232 M$=RIGHT$(SPACE$(7)+STR$(S),7):IF FK=1 THEN M$=RIGHT$(M$+"k",7)
9235 S$=LEFT$(S$,TOT(T8,1))+RIGHT$("            "+M$+" ",8)+"
"
9240 NEXT T8
9250 LPRINT STRING$(LEN(HD$(6))+2,"-"):LPRINT LEFT$(S$,LEN(HD$(6))):LPRINT
STRING$(LEN(HD$(6))+2,"="):IF TYPE$="E" AND (SE%=2 OR SE%=3) AND I8%<=COUNT%
THEN GOSUB 44035
9255 IF TYPE$=MID$(TX$(40),8,1) AND I8%<=COUNT% THEN GOSUB 45000
9260 S$="  "
9270 FOR T8=1 TO TOTS:STOTAL(T8)=0:NEXT T8
9280 RETURN
9300 REM *** SUBTOT INTEGER BIT ***
9310 IF I8%=1 THEN ORIP=DP(SBT)
9320 IF DP(SBT)=ORIP THEN RETURN
9330 ORIP=DP(SBT):GOSUB 9200:RETURN
9400 REM *** SUBTOT FLOATING POINT BIT ***
9410 IF I8%=1 THEN ORI=D(SBT)
9415 IF I8%=1 THEN GOSUB 45000:REM ** JOB STATUS PRINT HEADERS **
9420 IF D(SBT)=ORI THEN RETURN
9430 ORI=D(SBT):GOSUB 9200:RETURN
9500 REM *** SUBTOT DATE BIT ***
9501 RDAT=D(SBT)
9502 IF PROG$="1" THEN GOSUB 29000
9505 DMY=D(SBT):GOSUB 27000:DTEMP=(Y2*10000)+(MN*100)+D1
9510 IF I8%=1 THEN ORI=VAL(LEFT$(STR$(DTEMP),5))
9520 IF VAL(LEFT$(STR$(DTEMP),5))=ORI THEN D(SBT)=RDAT:RETURN ELSE 9530
9530 ORI=VAL(LEFT$(STR$(DTEMP),5)):GOSUB 9200:D(SBT)=RDAT:RETURN
9600 REM *** ITEM MANIPULATOR ***
9610 FOR I5%=1 TO ITEMS
9620 ON SR(I5%,1) GOSUB 6000,7000,8000,9000
9630 IF S$="" THEN RETURN
9640 NEXT I5%
9650 RETURN
9700 REM *** TOTAL MANIPULATOR ***
9710 FOR I9=1 TO TOTS
9720 IF TOT(I9,2)=3 THEN EA$=MID$(S$,TOT(I9,1)+1,8):GOTO 9750
9730 IF TOT(I9,2)=2 THEN EA$=MID$(S$,TOT(I9,1)+1,10):GOTO 9750
9740 GOTO 9770
9750 IF INSTR(EA$,"k")<>0 OR INSTR(EA$,"K")<>0 THEN EA=VAL(EA$)*1000 ELSE
EA=VAL(EA$)
9760 TOTAL(I9)=TOTAL(I9)+EA:STOTAL(I9)=STOTAL(I9)+EA
9770 NEXT I9
9780 RETURN
9800 REM *** PRINTING & SUCH LIKE ***
9805 PRINT FNCP$(21,0)RON$LEFT$(TX$(9),79)ROFF$CUP$
9810 FOR I8%=1 TO COUNT%
9820 SRN%=AR(I8%,1)
9830 GOSUB 10000
9840 RN%=DP(22)
9850 GOSUB 25000
9860 S$="  "
9864 REM  IF PROG$<>"1" THEN GOTO 9870
9865 REM GOSUB 4600
9870 ON ST GOSUB 9100,9400,9300,9500
9880 GOSUB 9600:REM *** ITEM MANIPULATOR ***
9881 IF PROG$<>"1" THEN 9890
9882 GOSUB 29000
9883 C=D(23)
9884 GOSUB 46000
9885 IF SIF=1 THEN D$=D$+" S"
```

```
9886 IF SIF=2 THEN D$=D$+" P"
9887 IF SIF=3 THEN D$=D$+" P"
9888 S$=S$+D$
9890 IF S$="" THEN 9920
9900 LPRINT S$
9905 REM IF TYPE$="E" AND SEX=1 THEN LPRINT MD$(18)
9910 GOSUB 9700:REM *** TOTAL  BUILDING ***
9920 NEXT I8%
9930 RETURN
9950 REM *** FOR ORDER STATUS ***
9960 GET #1,SRN%:GET #2,SRN%:GET #7,SRN%
9970 GOTO 10010
10000 REM *** READ ORDER ***
10001 IF (TYPE$=MID$(TX$(40),5,1) OR TYPE$=MID$(TX$(40),4,1)) AND PROG$="2" THEN
10003
10002 GOTO 9950
10003 FOR J1% = 1 TO 3
10006 GET #J1%,SRN%
10007 NEXT J1%
10009 GET #7,SRN%
10010 B%=1:C%=1:G%=1:H%=1
10020 FOR J1% = 1 TO 3
10025 IF J1%=3 AND (TYPE$<>MID$(TX$(40),5,1) AND TYPE$<>MID$(TX$(40),4,1)) AND
PROG$<>"2" THEN D$(3)=F$(6):GOTO 10040
10030 D$(J1%)=F$(J1%)
10040 NEXT J1%
10050 FOR J1% = 18 TO 20
10060 D$(J1%)=MID$(CORD$,B%,8)
10070 B%=B%+8
10080 NEXT J1%
10090 FOR J1% = 3 TO 22
10100 DP(J1%)=CVS(MID$(PCT$,C%,4))
10110 C%=C%+4
10120 NEXT J1%
10130 FOR J1% = 23 TO 24
10140 D(J1%) = CVS(MID$(SPT$,G%,4))
10150 G%=G%+4
10160 NEXT J1%
10170 FOR J1%=27 TO 36
10180 D(J1%)=CVS(MID$(SPT$,G%,4))
10190 G%=G%+4
10200 NEXT J1%
10210 RETURN
16000 OPEN "R",#15,"MAIN.FIL",80
16010 FIELD #15,80 AS MS$
16020 GET #15,14
16030 ID7$=MID$(MS$,6,12)
16040 CLOSE #15
16990 RETURN
17000 REM **** DISASSEMBLE REPORT SEQUENTIAL INFORMATION ****
17005 ST=VAL(LEFT$(SUBTOT$,1)):SBT=VAL(RIGHT$(SUBTOT$,2))
17007 IF TYPE$="E" THEN SBT=(SBT+SE%)
17010 KEY=VAL(RIGHT$(KEYPTR$,2)):KEYLEN%=VAL(LEFT$(KEYPTR$,2)):SEX=0:IF KEY >6
AND KEY <17 THEN SEX=SE%
17020 ITEMS=VAL(LEFT$(ITEMPTR$,2)):TOTS=VAL(LEFT$(TOTAL$,2))
17030 FOR I5%=0 TO ITEMS-1
:SR(I5%+1,1)=VAL(MID$(ITEMPTR$,3+I5%*3,1)):SR(I5%+1,2)=VAL(MID$(ITEMPTR$,4+I5%*3
,2)):NEXT I5%
17040 FOR I5%=0 TO TOTS-
1:TOT(I5%+1,1)=VAL(MID$(TOTAL$,3+I5%*4,3)):TOT(I5%+1,2)=VAL(MID$(TOTAL$,6+I5%*4,
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1)):NEXT I5%
17045 IF KEYLEN%=0 THEN 17000
17047 IF OP%=4 THEN GOSUB 28000
17050 IF AFLAG=1 THEN RETURN
17100 ROW%=7:COL%=39:GOSUB 60700:START=COMDAT:START$=DAT$
17110 ROW%=8:GOSUB 60700:FINISH=COMDAT:FINISH$=DAT$
17120 ROW%=9:MINL%=1:MAXL%=KEYLEN%:GOSUB 60980:KEY$=I$
17130 PRINT FNCP$(21,0)SPACE$(17)LEFT$(TX$(5),23)CUP$
17140 GOSUB 22500:RETURN
22500 REM ********* GET YES OR NO ANSWER ***********
22510 MAXL%=1:MINL%=1:ROW%=21:COL%=39
22520 GOSUB 60980
22530 IF I$=MID$(TX$(2),2,1) THEN FLAG=1:RETURN
22540 IF I$=MID$(TX$(2),4,1) THEN FLAG=0:RETURN
22550 GOTO 22500
25000 REM **** TO READ METHODING FILE ****
25002 IF (TYPE$="E" OR TYPE$="D") AND PROG$="2" THEN 25010
25005 GET #6,RN%:D$(3)=F$(6):REM AFORE GET INSERT IF TYPE$="F" THEN
25010 GET #8,RN%
25030 D$(4) = F$(8)
25050 B%=1:C%=1:T%=1:P%=1
25060 FOR J1% = 5 TO 17
25070 D$(J1%) = MID$(ROPE$,B%,8)
25080 B% = B% + 8
25090 NEXT J1%
25100 FOR J1% = 1 TO 2
25110 DP(J1%) = CVS(MID$(INR$,C%,4))
25120 C% = C% + 4
25130 NEXT J1%
25140 FOR J1% = 1 TO 22
25150 D(J1%) = CVS(MID$(FPT$,T%,4))
25160 T% = T% + 4
25170 NEXT J1%
25180 FOR J1% = 1 TO 2
25190 D#(J1%) = CVD(MID$(DPT$,P%,8))
25200 P% = P% + 8
25210 NEXT J1%
25220 FOR J1%=7 TO 8
25230 D(J1%+18)=CVS(DA$(J1%))
25240 NEXT J1%
25245 GOSUB 26000
25250 RETURN
26000 REM **** READ BLOODY METHO2.FIL ****
26010 GET #10,RN%
26020 MDP(3)=CVS(DA$(9))
26030 FOR J1%=18 TO 20
26040 MD$(J1%)=DA$(J1%-16)
26050 NEXT J1%
26060 MD(23)=CVS(DA$(5))
26070 MD(24)=CVS(DA$(6))
26080 GET #5,RN%
26090 GET #6,RN%
26100 MD$(2)=F$(5)
26110 MD$(3)=F$(6)
26120 RETURN
27000 REM **** dd/mm/yy --> d/ww/yy ****
27010 DMY$=RIGHT$(STR$(DMY),6)
27020 Y1=VAL(MID$(DMY$,1,2)):M1=VAL(MID$(DMY$,3,2)):DD1=VAL(MID$(DMY$,5,2))
27030 Y2=Y1
27040 IF Y1>99 THEN GOTO 27060
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27050 Y1=Y1+1900
27060 DF=DD1:MF=M1:YF=Y1:GOSUB 27100:U=ND
27070 D1=Y%(U-7*INT(U/7)+1)
27080 WN=0:GOSUB 27210
27090 RETURN
27100 REM ** SOLVING FOR DAY NO. **
27110 ND=DF-1
27120 FOR I1=1 TO MF-1:ND=ND+L%(I1):NEXT I1
27130 I1=INT(YF/100)
27140 IF YF<>4*INT(YF/4) GOTO 27190
27150 IF YF/100=I1 GOTO 27190
27160 IF ND>59 GOTO 27190
27170 IF MF=3 GOTO 27190
27180 ND=ND-1
27190 ND=ND+36524!*I1+INT(365.25*(YF-100*I1))
27200 RETURN
27210 REM ** SOLVING FOR WEEK NO. **
27220 IF Y2=SY1 THEN 27260
27230 FOR I5%=1 TO ((Y2-1)-SY1)
27240 IF SY1+I5%=4*INT((SY1+I5%)/4) THEN WN=WN+1
27250 NEXT I5%
27260 IF Y2=4*INT(Y2/4) AND M1>2 THEN WN=WN+1
27270 WN=WN+L%(SM1)-(SD1-1)+DD1
27280 IF Y2<>SY1 THEN 27310
27290 FOR I1=SM1+1 TO M1-1:WN=WN+L%(I1):NEXT I1
27300 GOTO 27380
27310 ME=12-SM1:I1=SM1+1
27320 FOR I5%=1 TO (Y2-(SY1+1)):ME=ME+12:NEXT I5%
27330 FOR I5%=1 TO ME:WN=WN+L%(I1)
27340 I1=I1+1
27350 IF I1>12 THEN I1=1
27360 NEXT I5%
27370 FOR I5%=1 TO M1-1:WN=WN+L%(I5%):NEXT I5%
27380 REM **
27390 IF D1<>7 THEN  WN=WN+7-D1
27400 WN=WN+1:REM ** ALLOWING FOR 1 OF JAN '83 **
27410 WN=INT(WN/7.024039)+1
27420 IF WN>52 THEN WN=WN-52 ELSE GOTO 27450
27430 IF M1=12 AND WN=53 THEN Y2=Y2+1
27440 GOTO 27420
27450 RETURN
28000 REM *** PRINT DATE WHERE EVER I WANT IT ***
28010 START=0:START$="0":FINISH=DTE:FINISH$=DTE$
28020 PRINT FNCP$(7,39)START$CUP$
28030 PRINT FNCP$(8,39)FINISH$CUP$
28040 ROW%=9:COL%=39:MINL%=1:MAXL%=KEYLEN%:GOSUB 60980:KEY$=I$
28050 REM PRINT FNCP$(21,2)"DO YOU WISH TO CHANGE THE DATES ?"CUP$:GOSUB
22500:IF FLAG THEN RETURN
28060 PRINT FNCP$(21,0)SPACE$(17)LEFT$(TX$(5),23)CUP$:GOSUB 22500:IF FLAG THEN
28040
28070 RETURN
29000 REM ***** SUFFIX CHECK FOR PLANNING *****
29010 IF INSTR(F$(2),"/F")<>0 THEN SIF=1:GOSUB 4600:RETURN
29020 REM IF INSTR(F$(2),"/P")<>0 AND D(28)<>0 AND TYPE$="A" THEN
SIF=2:D(23)=D(28):RETURN
29030 IF INSTR(F$(2),"/P")<>0 AND D(26+SE%)<>0 THEN SIF=3:D(23)=D(26+SE%):RETURN
29040 GOSUB 4600:SIF=1
29050 RETURN
30000 REM **** MAIN REPORT OPTIONS ****
30010 WIDTH 225
```

```
30030 PRINT NOLIN$NOCAR$
30040 PRINT NOCUR$BKGD$CLS$
30060 PRINT FNCP$(-
2,0)RON$LEFT$(TX$(3),13)ROFF$MID$(TX$(3),14,50)RON$RIGHT$(TX$(3),17)CUP$ROFF$
30070 PRINT FNCP$(-2,35)LEFT$(TX$(47),12)CUP$
30090 PRINT FNCP$(3,25)LEFT$(TX$(16),32)CUP$
30100 PRINT FNCP$(5,25)LEFT$(TX$(17),16)CUP$
30110 PRINT FNCP$(7,25)LEFT$(TX$(18),30)CUP$
30120 PRINT FNCP$(9,25)LEFT$(TX$(19),20)CUP$
30130 PRINT FNCP$(11,25)LEFT$(TX$(20),26)CUP$
30140 PRINT FNCP$(13,25)LEFT$(TX$(21),40)CUP$
30150 PRINT FNCP$(15,25)LEFT$(TX$(22),26)CUP$
30155 PRINT FNCP$(17,25)LEFT$(TX$(50),20)CUP$
30160 PRINT FNCP$(21,21)LEFT$(TX$(41),20)CUP$
30170 PRINT FNCP$(-2,69)RON$DTE$ROFF$CUP$
30180 PRINT FNCP$(-2,7)RON$NME$ROFF$CUP$
30190 PRINT ROFF$FRGD$
30200 RETURN
31000 REM *** SCREEN FOR PLANNING OPTION ***
31005 PRINT NOCUR$BKGD$CLS$
31010 PRINT CURPOS$CHR$(32)CHR$(32)RON$"
"ROFF$CUP$
31020 PRINT FNCP$(-
2,0)RON$LEFT$(TX$(3),13)ROFF$MID$(TX$(3),14,50)RON$RIGHT$(TX$(3),17)CUP$ROFF$
31030 PRINT FNCP$(-2,35)LEFT$(TX$(44),19)CUP$
31050 PRINT FNCP$(6,20)LEFT$(TX$(23),33)CUP$
31060 PRINT FNCP$(8,20)LEFT$(TX$(24),30)CUP$
31070 PRINT FNCP$(10,20)LEFT$(TX$(25),30)CUP$
31080 PRINT FNCP$(14,18)LEFT$(TX$(26),20)+PROC$(SE%)+MID$(TX$(26),33,9)CUP$
31090 PRINT FNCP$(15,18)LEFT$(TX$(27),5)+PROC$(SE%)+MID$(TX$(27),18,26)CUP$
31100 PRINT FNCP$(16,18)LEFT$(TX$(27),5)+ID7$+MID$(TX$(28),19,17)CUP$
31110 PRINT FNCP$(21,21)LEFT$(TX$(5),23)CUP$
31120 PRINT FNCP$(-2,7)RON$NME$ROFF$CUP$
31130 PRINT FNCP$(-2,69)RON$DTE$ROFF$CUP$
31140 PRINT ROFF$FRGD$CUP$
31150 RETURN
31500 REM *** SCREEN FOR PROGRAMME OPTION ***
31505 PRINT NOCUR$BKGD$CLS$
31510 PRINT CURPOS$CHR$(32)CHR$(32)RON$"
"ROFF$CUP$
31520 PRINT FNCP$(-
2,0)RON$LEFT$(TX$(3),13)ROFF$MID$(TX$(3),14,50)RON$RIGHT$(TX$(3),17)CUP$ROFF$
31530 PRINT FNCP$(-2,35)LEFT$(TX$(45),20)CUP$
31550 PRINT FNCP$(6,29)"(01) "PROC$(1)"      "CUP$
31560 PRINT FNCP$(7,29)"(02) "PROC$(2)CUP$
31565 PRINT FNCP$(8,29)"(03) "PROC$(3)"  "CUP$
31570 PRINT FNCP$(21,21)LEFT$(TX$(41),15)CUP$
31575 PRINT FNCP$(11,30)LEFT$(TX$(29),11)CUP$
31580 PRINT FNCP$(-2,7)RON$NME$ROFF$CUP$
31590 PRINT FNCP$(-2,69)RON$DTE$ROFF$CUP$
31600 PRINT ROFF$FRGD$CUP$
31610 RETURN
32500 REM **** SCREEN FOR OPTION SEVEN ****
32510 PRINT NOCUR$BKGD$CLS$
32540 PRINT CURPOS$CHR$(32)CHR$(32)RON$"
"ROFF$
32550 PRINT FNCP$(-
2,0)RON$LEFT$(TX$(3),13)ROFF$MID$(TX$(3),14,50)RON$RIGHT$(TX$(3),17)CUP$ROFF$
32560 PRINT FNCP$(-2,35)LEFT$(TX$(46),14)CUP$
32580 OPEN "R",#15,"MAIN.FIL",80
```

```
32590 FIELD #15,80 AS OS$
32600 FOR I% = 1 TO 10
32610 GET #15,I%+42
32620 PRT$="("+MID$((STR$(I%)),2,2)+")"+MID$(OS$,1,12)
32630 PRINT FNCP$(I%+4,25)PRT$CUP$
32640 NEXT I%
32680 PRINT FNCP$(21,18)LEFT$(TX$(30),16)CUP$
32690 PRINT FNCP$(-2,7)RON$NME$ROFF$CUP$
32700 PRINT FNCP$(-2,69)RON$DTE$ROFF$CUP$
32710 PRINT ROFF$FRGD$CUP$
32720 RETURN
35000 REM **** GET KEY & DATE SCREEN ****
35010 PRINT NOCUR$BKGD$CLS$
35020 PRINT CURPOS$CHR$(32)CHR$(32)RON$"
"ROFF$
35030 PRINT FNCP$(-
2,0)RON$LEFT$(TX$(3),13)ROFF$MID$(TX$(3),14,50)RON$RIGHT$(TX$(3),17)CUP$
35060 PRINT FNCP$(-2,7)RON$NME$ROFF$CUP$
35065 PRINT FNCP$(-2,35)LEFT$(TX$(47),12)CUP$
35070 PRINT FNCP$(-2,69)RON$DTE$ROFF$CUP$
35080 PRINT FNCP$(7,28)LEFT$(TX$(31),10)CUP$
35090 PRINT FNCP$(8,28)LEFT$(TX$(32),8)CUP$
35100 PRINT FNCP$(9,28)LEFT$(TX$(33),6)CUP$
35102 IF OP%=1 THEN KY$=LEFT$(TX$(34),13):GOTO 35108
35103 REM ** IF OP%=2 THEN KY$="Casting Section ":GOTO 35108 **
35105 IF OP%=7 THEN KY$=LEFT$(TX$(36),15):GOTO 35108
35107 KY$=LEFT$(TX$(37),14):GOTO 35108
35108 PRINT FNCP$(13,28)LEFT$(TX$(33),7)RON$KY$ROFF$
35110 PRINT ROFF$FRGD$CUP$
35120 RETURN
36000 REM **** DISLAY ALL INFO ROUTINE ****
36010 FOR J1% = 1 TO 51
36020 ROW% = MNA%(J1%,1):COL% = MNA%(J1%,6):ELE = MNA%(J1%,3):TYPE = MNA%(J1%,2)
36030 MAXL% = MNA%(J1%,4):MINL% = MNA%(J1%,5)
36040 IF TYPE = 1 THEN I$=D$(ELE)
36050 IF TYPE = 2 THEN MAXL% = 7:I$=RIGHT$("       "+STR$(DP(ELE)),MAXL%)
36060 IF TYPE = 3 THEN IF MINL% = 8 THEN GOTO 36100 ELSE
M=D(ELE):NP=2:DP=4:GOSUB 37500:I$=M$
36070 IF TYPE = 4 THEN M=D#(ELE):NP=3:DP=5:GOSUB 37500:I$=M$
36080 PRINT FNCP$(ROW%,COL%)I$
36090 GOTO 36140
36100 I$=RIGHT$(STR$(D(ELE)),LEN(STR$(D(ELE)))-1)
36110 DT(1)=VAL(MID$(I$,5,2)):DT(2)=VAL(MID$(I$,3,2)):DT(3)=VAL(MID$(I$,1,2))
36120
DAT$=RIGHT$(STR$(DT(1)),2)+"/"+RIGHT$(STR$(DT(2)),2)+"/"+RIGHT$(STR$(DT(3)),2)
36130 PRINT FNCP$(ROW%,COL%)DAT$CUP$
36140 NEXT J1%
36150 RETURN
37500 REM ** FORMATTING ROUTINE **
37501 NN$="999999999999"
37502 IF M<0 THEN M=0
37503 IF M>VAL(LEFT$(NN$,DP)) THEN M=M/1000:FK=1 ELSE FK=0
37505 SDP=NP+1
37510 Q=ABS(M)+5*10^(-SDP):M$=RIGHT$(SPACE$(12)+STR$(SGN(M)*INT(Q)),DP)
37520 M$=M$+"."+MID$(STR$(1+Q-INT(Q))+"000000",4,NP):RETURN
40000 REM ***OPENING FILES***
40010 REM OPENING FILES 1,2,3 & 4
40020 FOR J1% = 1 TO 2
40030 FILENAME$ = OD$+RIGHT$(STR$(J1%)+".FIL",5)
40040 OPEN "R",#J1%,FILENAME$,16
```

```
40050 FIELD #J1%,16 AS F$(J1%)
40060 NEXT J1%
40062 FOR J1%=4 TO 6:FILENAME$=MD$+RIGHT$(STR$(J1%)+".FIL",5)
40064 OPEN "R",#J1%,FILENAME$,16:FIELD #J1%,16 AS F$(J1%)
40066 NEXT J1%
40070 OPEN "R",#7,OD$+"ORDER.FIL",152
40080 FIELD #7,24 AS CORD$,80 AS PCT$,48 AS SPT$
40090 OPEN "R",#9,OD$+"RECORD.FIL",2
40100 FIELD #9,2 AS REC$
40110 OPEN "R",#8,MD$+"METHOD.FIL",240
40120 FIELD #8,16 AS F$(8),104 AS ROPE$,16 AS DPT$,88 AS FPT$,8 AS INR$,4 AS
DA$(7),4 AS DA$(8)
40130 OPEN "R",#3,OD$+"3.FIL",16
40140 FIELD #3,16 AS F$(3)
40150 OPEN "R",#10,MD$+"METHO2.FIL",170
40160 FIELD #10,8 AS DA$(1),50 AS DA$(2),50 AS DA$(3),50 AS DA$(4),4 AS DA$(5),4
AS DA$(6),4 AS DA$(9)
40170 OPEN "R",#11,MD$+"CTMETH.FIL",2
40180 FIELD #11,2 AS MREC$
40183 GET #11,1
40186 REC%=CVI(MREC$)
40190 RETURN
41000 REM **** OPENING SEQUENTIAL DATA FILES ****
41005 COU%=4
41010 OPEN "R",#1,"MAIN.FIL",80
41015 FIELD #1,80 AS UCK$
41020 GET #1,STRN%:GOSUB 57000:HD$(1)=TX$
41030 GET #1,(STRN%+1):GOSUB 57000:HD$(2)=TX$
41035 GET #1,(STRN%+2):GOSUB 57000:HD$(3)=TX$
41040 IF TYPE$<>"D" AND TYPE$<>"E" THEN COU%=COU%+1:STRN%=STRN%+1:GET
#1,STRN%+2:GOSUB 57000:HD$(4)=TX$
41045 P%=STRN%+2
41050 FOR I%=1 TO 6:P%=P%+1
41055 GET #1,P%:IF I%/2<>INT(I%/2) THEN S$=LEFT$(UCK$,79) ELSE GOSUB
57000:S$=S$+TX$:HD$(COU%)=S$:COU%=COU%+1
41060 NEXT I%
41065 IF TYPE$<>"D" AND TYPE$<>"E" THEN STRN%=STRN%-1
41067 IF STRN%=841 THEN STRN%=STRN%-1
41070 GET #1,(STRN%+10):KEYPTR$=LEFT$(UCK$,4)
41080 GET #1,(STRN%+11):ITEMPTR$=LEFT$(UCK$,(VAL(LEFT$(UCK$,2))*3)+2)
41090 GET #1,(STRN%+12):TOTAL$=LEFT$(UCK$,(VAL(LEFT$(UCK$,2))*4)+2)
41100 GET #1,(STRN%+13):SUBTOT$=LEFT$(UCK$,3)
41120 CLOSE #1
41999 RETURN
42000 REM **** ESTABLISH NUMBER OF RECORDS ON ORDER FILE ****
42010 GET #9,1
42020 REC% = CVI(REC$)
42030 RETURN
44000 REM PRINT OUT HEADERS
44003 LPRINT STRING$(LEN(HD$(6))+2,"-")
44005 IF OP%=7 THEN LPRINT HD$(1);IDENTI$;SPC(23);LEFT$(TX$(42),7):GOTO 44020
ELSE 44010
44010 LPRINT HD$(1)
44015 IF (PROG$<>"" AND OPT$<>"") OR TYPE$="E" THEN LPRINT HD$(2)" "OPT$:GOTO
44030 ELSE 44020
44020 LPRINT HD$(2)"  "KEY$
44030 LPRINT HD$(3)"  "DTE$
44033 IF TYPE$="E" THEN LPRINT STRING$(LEN(HD$(6))+2,"-")
44035 IF TYPE$="E" AND (SE%=2 OR SE%=3) THEN GOTO 44037
44036 IF TYPE$="E" THEN LPRINT HD$(4):GOTO 44050 ELSE GOTO 44040
```

```
44037 LPRINT:LPRINT:LPRINT STRING$(LEN(HD$(6)),"-"):LPRINT:LPRINT:LPRINT HD$(4)
44038 GOTO 44050
44040 LPRINT HD$(4)"  "START$" TO "FINISH$
44045 LPRINT STRING$(LEN(HD$(6))+2,"-")
44047 IF OP%=2 AND TYPE$<>"H" THEN RETURN
44050 LPRINT HD$(5)
44060 LPRINT HD$(6)
44062 IF TYPE$="E" THEN 44070
44065 LPRINT HD$(7)
44070 LPRINT STRING$(LEN(HD$(6))+2,"-")
44080 RETURN
45000 REM *** TO PRINT OUT A JOB STATUS AND HEADING ***
45010 NP=2:DP=5:M=ORI:GOSUB 37500:O$=M$
45020 LPRINT:LPRINT LEFT$(TX$(43),21)O$MID$(TX$(43),32,16)
45030 LPRINT "-----------------                -------------  "
45040 GOSUB 44045
45050 RETURN
46000 REM DISMANTLE A DATE
46010 A=INT(C/10000):C=C-A*10000
46020 B=INT(C/100):C=C-B*100
46030
D$=RIGHT$(SPACE$(2)+STR$(C),2)+"/"+RIGHT$(SPACE$(2)+STR$(B),2)+"/"+RIGHT$(SPACE$
(2)+STR$(A),2)+" "
46040 RETURN
50000 REM *** MATCH SUBROUTINE ***
50010 RN% = RN% + 1
50020 IF RN% = REC%+1 THEN FLAG = 0:RETURN
50030 GET #KF%,RN%
50040 RN$ = F$(KF%)
50050 IF LEFT$(KEY$,H%) = LEFT$(RN$,H%) THEN GOTO 50070
50060 GOTO 50010
50070 FLAG = 1
50080 RETURN
55000 REM *** Read Text File Routine ***
55005
VLE$="070071072074108151273296306388389390391392393394395396397398399400401402403
404405406407408409410411412413414415416660661225417418617618619620006307904"
55010 OPEN "R",#1,"MAIN.FIL",80
55020 FIELD #1,80 AS MUC$
55030 CT%=0
55040 FOR I%=1 TO LEN(VLE$) STEP 3
55050 EL=VAL(MID$(VLE$,I%,3))
55060 CT%=CT%+1
55070 GET #1,EL
55080 TX$(CT%)=MUC$
55090 NEXT I%
55100 CLOSE #1
55110 RETURN
57000 REM ** strip down I$ routine to text only **
57010 CT=79:FLAG2=0
57020 WHILE FLAG2=0
57030 IF MID$(UCK$,CT,1)<>" " OR CT=1 THEN FLAG2=1
57040 CT=CT-1
57050 WEND
57060 TX$=LEFT$(UCK$,CT+1)
57070 RETURN
60700 MAXL%=8:MINL%=1:REM *** DATE CHANGE ROUTINE ***
60710 GOSUB 60980:IF VAL(I$)=0 THEN COMDAT=0:DAT$="0":GOTO 60810
60720 A=INSTR(I$,"/"):IF A=0 THEN A=INSTR(I$,".")
60730 IF A=0 THEN 60700 ELSE P$=LEFT$(I$,A-1)
```

```
60740 B=INSTR(A+1,I$,"/"):IF B=0 THEN B=INSTR(A+1,I$,".")
60750 IF B=0 THEN 60700 ELSE B$=MID$(I$,A+1,B-(A+1))
60760 C$=MID$(I$,B+1,2)
60770 A=VAL(P$):B=VAL(B$):C=VAL(C$)
60780 IF B<1 OR B>12 OR A<1 OR A>31 OR C>99 OR C<81 THEN 60700
60790 COMDAT=(C*10000)+(B*100)+A
60800 DAT$=P$+"/"+B$+"/"+C$
60810 PRINT FNCP$(ROW%,COL%)DAT$CUP$
60830 RETURN
60980 REM INPUT STRING ROUTINE
60990 I$=""
61000 PRINT FNCP$(ROW%,COL%)I$RON$SPACE$(MAXL%-LEN(I$))ROFF$CUP$
61010 GOSUB 61110
61020 IF X=8 THEN GOTO 61060
61030 IF X=13 AND LEN(I$)>=MINL% THEN GOTO 61080 ELSE IF X=13 GOTO 61000
61040 IF LEN(I$)<MAXL% THEN I$=I$+A$
61050 GOTO 61000
61060 IF LEN(I$)>0 THEN I$=LEFT$(I$,LEN(I$)-1)
61070 GOTO 61000
61080 I$=LEFT$(I$+SPACE$(MAXL%),MAXL%)
61090 PRINT FNCP$(ROW%,COL%)I$CUP$
61100 RETURN
61110 REM GET VALID CHARACTER
61120 A$=INKEY$:IF A$=""THEN GOTO 61120
61130 X=ASC(A$)
61140 IF (X>31 AND X<127) OR X=8 OR X=13 THEN RETURN
61150 IF X=185 OR X=27 THEN CLOSE:CHAIN "P0-00"
61160 IF X= 247 THEN GOSUB 61200
61170 IF X=186 THEN GOSUB 62000:LPRINT
61180 IF X=189 THEN GOSUB 62000:FOR L%=1 TO 10:LPRINT:NEXT L%
61190 RETURN
61200 GOSUB 62000
61230 DEF SEG = &HF000
61240 FOR I2 = 0 TO 22
61250 WE$=""
61260 FOR J2 = 0 TO 158 STEP 2
61270 WE$=WE$+CHR$(ABS(PEEK(I2*160+J2)-100))
61280 NEXT J2
61290 LPRINT WE$
61300 NEXT I2
61310 WIDTH 255
61320 RETURN
62000 RETURN:REM "**** GENERAL ERROR ROUTINE ****"
62010 PRINT FNCP$(21,0)TX$(4);FNCP$(21,25)ERR;FNCP$(21,49)ERL;CUP$
62020 A$=INKEY$:IF A$="" THEN 62020
62030 X=ASC(A$):IF X=27 THEN 61150
62040 PRINT FNCP$(21,0)SPACE$(79)CUP$
62050 RESUME
63998 END
63999 REM "P05-00 (86F01 - CRE - 01/05/1986)IBM
```

A4.4 Resource Maintenance Program

```
5 REM $INCLUDE:'SHARE'
10 REM ***** P06-C :RESOURCE UPKEEP *****
13 GOSUB 55000
15 DEF FNCP$(ROW%,COL%)=CHR$(27)+"Y"+CHR$(34+ROW%)+CHR$(32+COL%)
19 IF NME$="" OR DTE$="" THEN CHAIN "PPC"
20 GOSUB 40000
25 DIM WC(7),WS$(7)
30 KEY$=SPACE$(8)
110 GOSUB 10000
120 ROW%=21:COL%=17:MAXL%=8:MINL%=1
125 GOSUB 30000
130 PRINT FNCP$(21,0)LEFT$(TX$(6),16)CUP$
140 GOSUB 60980
142 PRINT FNCP$(2,26)I$CUP$
145 KEY$ = LEFT$(I$+SPACE$(8),8)
150 RN%=0
160 GOSUB 50000
165 IF RN$=SPACE$(8) AND FLAG=1 THEN 160
170 IF FLAG<>1 THEN S$=LEFT$(TX$(7),21)+" - "+LEFT$(TX$(1),22):GOSUB 9000:GOTO
30
180 GOSUB 25000
181 GOSUB 35000
185 PRINT FNCP$(14,26);RN%
200 GOSUB 60000
210 IF EL<>0 THEN 200
220 GOSUB 1000
230 S$=LEFT$(TX$(12),20)+" - "+LEFT$(TX$(1),22):GOSUB 9000
245 GOSUB 30000
250 GOTO 30
1000 REM *** WRITE METHOD ***
1010 LSET WS0$=WC0$
1020 FOR I=1 TO 7:LSET WS$(I)=MKS$(WC(I)):NEXT I
1030 LSET WSC$=MKI$(WCC%)
1040 LSET WS$=KEY$
1250 PUT #1,RN%
1263 PUT #2,RN%
1270 RETURN
9000 REM " HIT SPACE BAR ROUTINE"
9005 MESS$=SPACE$(79):MID$(MESS$,INT((79-LEN(S$))/2),LEN(S$))=S$
9010 PRINT FNCP$(21,0)MESS$CUP$
9020 MAXL%=1:MINL%=1:ROW%=21:COL%=INT((79-LEN(S$))/2)+LEN(S$)+2:GOSUB 61110
9030 IF A$<>" " THEN 9020
9040 PRINT FNCP$(21,0)SPACE$(79)CUP$
9050 RETURN
10000  WIDTH 255
10010 REM DRAW SCREEN 1.3.1/2/3/4
10020 PRINT NOLIN$NOCAR$
10030 PRINT NOCUR$BKGD$
10040 PRINT CLS$
10050 PRINT FNCP$(-
2,0)RON$LEFT$(TX$(3),13)ROFF$MID$(TX$(3),14,50)RON$RIGHT$(TX$(3),17)CUP$
10060 PRINT FNCP$(-2,7)RON$NME$ROFF$CUP$
10070 PRINT FNCP$(-2,69)RON$DTE$ROFF$CUP$
10080 PRINT FNCP$(-2,39)LEFT$(TX$(13),17)CUP$
10130 PRINT FNCP$(2,2)LEFT$(TX$(8),24)CUP$
10132 PRINT FNCP$(3,2)LEFT$(TX$(9),24)CUP$
10134 PRINT FNCP$(4,2)LEFT$(TX$(10),24)CUP$
10140 FOR I=6 TO 12:PRINT FNCP$(I,2)HD$(I-5):NEXT I
10150 PRINT FNCP$(14,2)LEFT$(TX$(11),24)CUP$
10390 PRINT FRGD$CUP$
```

```
10400 RETURN
25000 REM ** READ CAPACITY FILE **
25010 GET #2,RN%
25020 FOR I=1 TO 7:WC(I)=CVS(WS$(I)):NEXT I
25030 WCD$=WS0$:WCC%=CVI(WSC$)
25040 RETURN
30000 REM ** BLANK OUT ALL ENTRIES **
30010 WC$="
":WCD$=SPACE$(40):WCC%=0:WC(1)=0:WC(2)=0:WC(3)=0:WC(4)=0:WC(5)=0:WC(6)=0:WC(7)=0
30040 RETURN
35000 REM ** DISPLAY ALL INFO **
35010 COL%=26:ROW%=2
35020 PRINT FNCP$(ROW%,COL%)KEY$
35025 ROW%=ROW%+1
35030 PRINT FNCP$(ROW%,COL%)WCD$
35035 ROW%=ROW%+1
35040 PRINT FNCP$(ROW%,COL%)RIGHT$("  "+STR$(WCC%),2)
35045 ROW%=ROW%+2
35050 FOR I=1 TO 7
35060 M=WC(I):NP=2:DP=6:GOSUB 37500
35070 PRINT FNCP$(ROW%,COL%)M$
35080 ROW%=ROW%+1:NEXT I
35090 RETURN
37500 REM ** FORMATTING ROUTINE **
37505 SDP=NP+1
37510 Q=ABS(M)+5*10^(-SDP):M$=RIGHT$(SPACE$(12)+STR$(SGN(M)*INT(Q)),DP)
37520 M$=M$+"."+MID$(STR$(1+Q-INT(Q))+"000000",4,NP):RETURN
40000 REM ***ENQUIRY SUBROUTINE***
40020 OPEN "R",#1,MD$+"CAP1.FIL",8
40030 FIELD #1,8 AS WS$
40040 OPEN "R",#2,MD$+"CAP.FIL",70
40050 FIELD #2,40 AS WS0$,2 AS WSC$,4 AS WS$(1),4 AS WS$(2),4 AS WS$(3),4 AS
WS$(4),4 AS WS$(5),4 AS WS$(6),4 AS WS$(7)
40110 OPEN "R",#3,MD$+"CTCAP.FIL",2
40120 FIELD #3,2 AS REC$
40130 GET #3,1
40140 REC% = CVI(REC$)
40150 RETURN
50000 REM *** MATCH SUBROUTINE ***
50010 RN% = RN% + 1
50020 IF RN% = REC%+1 THEN FLAG = 0:RETURN
50030 GET #1,RN%
50040 RN$ = WS$
50050 IF KEY$ = RN$ THEN GOTO 50070
50060 GOTO 50010
50070 FLAG = 1
50080 RETURN
55000 REM *** Read Text File Routine ***
55005 VLE$="070071072074078226227228229230231235593660661"
55010 OPEN "R",#1,"MAIN.FIL",80
55020 FIELD #1,80 AS MUC$
55030 CT%=0
55040 FOR I%=1 TO LEN(VLE$) STEP 3
55050 EL=VAL(MID$(VLE$,I%,3))
55060 CT%=CT%+1
55070 GET #1,EL
55080 TX$(CT%)=MUC$
55090 NEXT I%
55100 CLOSE #1
55110 RETURN
```

```
60000 PRINT FNCP$(21,0)LEFT$(TX$(5),79)CUP$
60020 ROW%=21:COL%=17:MAXL%=2:MINL%=1
60030 GOSUB 60980
60040 EL=VAL(I$)
60045 IF EL=0 THEN RETURN
60050 IF EL<2 OR EL>10 THEN GOTO 60020
60080 IF EL=2 THEN ROW%=3:COL%=26:MAXL%=40:MINL%=0:GOSUB 60430
60090 IF EL=3 THEN ROW%=4:COL%=26:MAXL%=2:MINL%=1:GOSUB 60480
60100 IF EL>3 AND EL<11 THEN GOSUB 60590
60160 GOTO 60020
60430 REM ***STRING CHANGE ROUTINE***
60440 GOSUB 60980
60450 WCD$=I$
60460 PRINT FNCP$(ROW%,COL%)I$" "CUP$
60470 RETURN
60480 REM ***INT CHANGE ROUTINE***
60490 MAXL%=2 :MAXN = 7!
60500 GOSUB 60980
60510 X$=SPACE$(LEN(I$))
60520 IF VAL(I$) >MAXN OR VAL(I$) <1 THEN PRINT FNCP$(ROW%,COL%)X$"  "CUP$:GOTO
60500
60530 WCC%=VAL(I$)
60540 I$=RIGHT$("       "+STR$(WCC%),MAXL%)
60550 X$=SPACE$(LEN(I$))
60560 PRINT FNCP$(ROW%,COL%)X$"  "CUP$
60570 PRINT FNCP$(ROW%,COL%)I$"  "CUP$
60580 RETURN
60590 REM ***FLOATING POINT ROUTINE***
60595 COL%=26
60600 REM ** IF MINL% = 8 THEN GOTO 60700
60610 MINL%=0:MAXL%=9:ROW%=2+EL:GOSUB 60980
60620 X$=SPACE$(LEN(I$))
60630 IF LEN(I$) <MINL% THEN PRINT FNCP$(ROW%,COL%)X$"  "CUP$:GOTO 60610
60635 IF VAL(I$)=> 999999! THEN 60610 ELSE 60640
60640 WC(EL-3)=VAL(I$)
60650 M=WC(EL-3):NP=2:DP=6
60660 GOSUB 37500
60680 PRINT FNCP$(ROW%,COL%)M$"  "CUP$
60690 RETURN
60700 MAXL%=8:MINL%=6:REM *** DATE CHANGE ROUTINE ***
60710 GOSUB 60980
60720 A=INSTR(I$,"/"):IF A=0 THEN A=INSTR(I$,".")
60730 IF A=0 THEN 60700 ELSE P$=LEFT$(I$,A-1)
60740 B=INSTR(A+1,I$,"/"):IF B=0 THEN B=INSTR(A+1,I$,".")
60750 IF B=0 THEN 60700 ELSE B$=MID$(I$,A+1,B-(A+1))
60760 C$=MID$(I$,B+1,2)
60770 A=VAL(P$):B=VAL(B$):C=VAL(C$)
60780 IF B<1 OR B>12 OR A<1 OR A>31 OR C>99 OR C<81 THEN 60700
60790 COMDAT=(C*10000)+(B*100)+A
60800 DAT$=P$+"/"+B$+"/"+C$
60810 PRINT FNCP$(ROW%,COL%)DAT$CUP$
60820 D(I)=COMDAT
60830 RETURN
60850 REM ***DOUBLE PRECISION ROUTINE***
60855 GOSUB 60980
60857 IF VAL(I$)=> 100000! THEN 60855 ELSE 60860
60860 D#(I) = VAL(I$)
60870 M=D#(I):NP=3 : DP=5
60880 GOSUB 37500
60900 PRINT FNCP$(ROW%,COL%)M$"  "CUP$
```

```
60910 RETURN
60980 REM INPUT STRING ROUTINE
60990 I$=""
61000 PRINT FNCP$(ROW%,COL%)I$RON$SPACE$(MAXL%-LEN(I$))ROFF$CUP$
61010 GOSUB 61110
61020 IF X=8 THEN GOTO 61060
61030 IF X=13 AND LEN(I$)>=MINL% THEN GOTO 61080 ELSE IF X=13 GOTO 61000
61040 IF LEN(I$)<MAXL% THEN I$=I$+A$
61050 GOTO 61000
61060 IF LEN(I$)>0 THEN I$=LEFT$(I$,LEN(I$)-1)
61070 GOTO 61000
61080 I$=LEFT$(I$+SPACE$(MAXL%),MAXL%)
61090 PRINT FNCP$(ROW%,COL%)I$CUP$
61100 RETURN
61110 REM GET VALID CHARACTER
61120 A$=INKEY$:IF A$=""THEN GOTO 61120
61130 X=ASC(A$)
61140 IF (X>31 AND X<127) OR X=8 OR X=13 THEN RETURN
61150 IF X=185 OR X=27 THEN CLOSE:CHAIN "P06-00"
61160 IF X=247 THEN GOSUB 61200
61170 IF X=186 THEN GOSUB 62000:LPRINT
61180 IF X=189 THEN GOSUB 62000:FOR L=1 TO 10:LPRINT:NEXT L
61190 GOTO 61120
61200 GOSUB 62000
61230 DEF SEG = &HF000
61240 FOR I2 = 0 TO 22
61250 WE$=""
61260 FOR J2 = 0 TO 158 STEP 2
61270 WE$=WE$+CHR$(ABS(PEEK(I2*160+J2)-100))
61280 NEXT J2
61290 LPRINT WE$
61300 NEXT I2
61310 WIDTH 255
61320 RETURN
62000 RETURN:REM "**** GENERAL ERROR ROUTINE ****"
62010 PRINT FNCP$(21,0)TX$(4);FNCP$(21,25)ERR;FNCP$(21,49)ERL;CUP$
62020 A$=INKEY$:IF A$="" THEN 62020
62030 X=ASC(A$):IF X=27 THEN 61150
62040 PRINT FNCP$(21,0)SPACE$(79)CUP$
62050 RESUME
63998 END
63999 REM "P06-C(IBM 86F01       CRE             - 18/04/1986)
```

A4.5 Resource Loading Program

```
5 REM $INCLUDE:'SHARE'
10 REM ***** C2 *****
16 DIM ORD%(1000),ORD1%(70),SPOS(100,4),L8%(52),PF%(1000)
17 DIM MD(24),MD$(3),Y%(7),L%(12),WC(7),WS$(7),BL(70),WE(31),CH$(30),DATUM(10,2)
19 DEF FNCP$(ROW,COL)=CHR$(27)+"Y"+CHR$(34+ROW)+CHR$(32+COL)
22 PRINT FNCP$(17,17)"Loading data blocks ......                              "
23 SY1=83:SD1=3:SM1=1:SY8=83:SD8=3:SW8=1:AFLAG=0:PROG$="1"
25 FOR I=1 TO 12:READ L%(I):NEXT I
26 FOR I=1 TO 7:READ Y%(I):NEXT I
27 DATA 31,28,31,30,31,30,31,31,30,31,30,31:
28 DATA 5,6,7,1,2,3,4:
29 FOR I=1 TO 19:READ L8%(I):NEXT I
32 DATA 4,3,2,1,-1,-2,-3,-4,1,00,-1,-2,-4,-5,1,00,-2,-3,-4
35 OPEN "R",#1,MD$+"RECNO.FIL",2:FIELD #1,2 AS RECNO$
40 FOR I%=1 TO BP(2):GET #1,I%:ORD%(I%)=CVI(RECNO$):NEXT I%
50 DMY=BP(1):GOSUB 27000:TART=(Y2*10000)+(WN*100):GOSUB
1510:NW%=WN:YY1=VAL(MID$(STR$(TART),2,2))
95 RH$="^":REM ** CREATE CHR CLOCKS **
110 M=1:FOR I=128 TO 142:FOR I1=1 TO 4:CH$(M)=CH$(M)+CHR$(I):NEXT I1:M=M+1:NEXT
I
120 FOR I=144 TO 159:FOR I1=1 TO 4:CH$(M)=CH$(M)+CHR$(I):NEXT I1:M=M+1:NEXT I
130 CH$="":DH$="":RAN$=""
140 FOR I=1 TO 4:CH$=CH$+CHR$(143):DH$=DH$+CHR$(32):NEXT I
141 FOR I=1 TO 10:RAN$=RAN$+CHR$(143):NEXT I
148 REM * NB!! NOTE THAT YDIV MUST ./. INTO YLEN%-1 EXACTLY **
149 YLEN%=16:XLEN%=61:XSTART%=6:YSTART%=0:XUNIT%=6:YDIV=3:FTIM=0:CT1%=0:CO$=""
150
CLOSE:KEYLEN=8:I6%=0:COUNT=BP(2):YY%=YSTART%+YLEN%:LAG=0:AG=0:SS=0:PD=0:LN=0:HED
$=" ":XX%=XLEN%+8:FIRS=0:FTI=0:H$="":GAL=0:GA=0
200 IF CO$="YES" THEN 270 ELSE CT1%=0
270 GOSUB 40000:REM *OPEN FILES*
290 GOSUB 11000:IF FLAG<>1 THEN CLOSE:GOTO 150
300 IF FTIM=0 THEN R5=17:C5=17 ELSE R5=-1:C5=0
310 PRINT FNCP$(R5,C5)"Sorting data ..."SPC(21)
315 IF FTIM=0 THEN 320 ELSE 330
320 GOSUB 2000:REM *SORT DATA*
330 GOSUB 9800:REM *PROC DATA*
332 PRINT FNCP$(-1,0)SPACE$(50)
340 RS=1:GOSUB 400:GOSUB 800:REM *DRAW GRAPH*
360 GOSUB 1105:REM *BROWSE*
370 GOSUB 1800:REM *SAVE GRAPH*
371 PRINT FNCP$(-1,0)SPACE$(50)
375 FTIM=99:GOTO 150
380 X=27:GOTO 61150
400 REM ***** DRAW GRAPH FRAMEWORK *****
402 PRINT FNCP$(-1,0)SPACE$(50)BKGD$
405 AFLAG=0
406 IF H$="0" THEN 410
407 IF FTIM=99 THEN FOR Z=-1 TO 15:PRINT FNCP$(Z,7)SPACE$(72):NEXT Z:GOTO 490
410 PRINT NOLIN$NOCAR$
420 PRINT NOCUR$BKGD$CLS$
430 PRINT FNCP$(-2,0)RON$"
"ROFF$
440 PRINT FNCP$(-2,17)"              *FUNCTION: LOADING CHART   *"CUP$
450 PRINT FNCP$(-2,0)RON$"USER :        "ROFF$CUP$
460 PRINT FNCP$(-2,66)RON$"DATE:"ROFF$CUP$
470 PRINT FNCP$(-2,8)RON$NME$ROFF$CUP$
480 PRINT FNCP$(-2,71)RON$DTE$ROFF$CUP$
485 IF AFLAG=99 THEN RETURN
490 R%=YY%-9:C%=XLEN%+7:XM%=10:YM%=8:GOSUB 640:REM ** DRAW BOX **
```

```
510 PRINT FNCP$(YY%-8,XX%)ULON$"FUNCTIONS"ULOFF$
511 PRINT FNCP$(YY%-7,XX%)"'0' GRAPH"
512 PRINT FNCP$(YY%-6,XX%)"'1' = <--"
513 PRINT FNCP$(YY%-5,XX%)"'2' = -->"
514 PRINT FNCP$(YY%-4,XX%)"'7' PRINT"
515 PRINT FNCP$(YY%-3,XX%)"'9' iWEEK"
516 PRINT FNCP$(YY%-2,XX%)"'R' RESET"
517 PRINT FNCP$(YY%-1,XX%)"'E' = END"
518 PRINT FNCP$(YY%+1,XLEN%+9)"WKS  1-10"CUP$
520 FOR I=1 TO YLEN%:PRINT FNCP$(I,XSTART%)CHR$(179):NEXT I
530 FOR I=1 TO XLEN%:PRINT FNCP$(YLEN%,XSTART%-1+I)CHR$(196):NEXT I
540 PRINT FNCP$(YLEN%,XSTART%)CHR$(192)
560 UNIT=((CCC*130)/100)/(YLEN%-1)
565 DIV2=UNIT*YDIV
570 UNIT2=UNIT/16
580 IF CCC=0 THEN PRINT FNCP$(21,0)CHR$(7)FRGD$"Enter a Capacity Figure :
"BKGD$CUP$:ROW=21:COL=26:MINL=1:MAXL=5:GOSUB 60980:IF VAL(I$)=0 THEN 580 ELSE
CCC=VAL(I$):PRINT FNCP$(21,0)SPACE$(50)CUP$:GOTO 560
590 DIV=DIV2+(UNIT/2)
600 FOR I=YLEN%-YDIV-1 TO YDIV STEP -YDIV
601 IF DIV>99999! THEN DIV$=RIGHT$("    "+STR$(FIX(DIV/1000)),4)+"k":GOTO 605
602 IF DIV<1 THEN DIV$="0"+MID$(STR$(DIV),2,4):GOTO 605
603 IF (INSTR(STR$(DIV),".")>=6 OR INSTR(STR$(DIV),".")=0) THEN DP=5:NP=0 ELSE
DP=3:NP=2
604 M=DIV:GOSUB 37500:DIV$=LEFT$(M$,5)
605 PRINT FNCP$(I,1)DIV$CHR$(180):DIV=DIV+DIV2:NEXT I
610 FOR I=XSTART%+XUNIT% TO XLEN%-1+XUNIT% STEP XUNIT%:PRINT
FNCP$(YLEN%,I)CHR$(194):NEXT I
620 V=1:FOR I=XSTART%+1 TO XLEN% STEP XUNIT%:PRINT
FNCP$(YLEN%+1,I)MID$(STR$(WE(V)),6,2)+"/"+MID$(STR$(WE(V)),4,2)CUP$:V=V+1:NEXT I
622 PRINT FNCP$(YLEN%+1,XSTART%+1)"O/Due"
625 GOSUB 710:REM ** DRAW RANGE FINDER **
627 PRINT FRGD$CUP$
630 RETURN
640 REM ***** PRINT BOX *****
650 FOR I%=1 TO XM%:PRINT FNCP$(R%,C%+I%)CHR$(196)CUP$:PRINT
FNCP$(R%+1+YM%,C%+I%)CHR$(196)CUP$:NEXT I%
660 PRINT FNCP$(R%,C%)CHR$(218)CUP$:PRINT FNCP$(R%,C%+XM%+1)CHR$(191)CUP$
670 FOR I%=1 TO YM%:PRINT FNCP$(R%+I%,C%)CHR$(179)CUP$:PRINT
FNCP$(R%+I%,C%+XM%+1)CHR$(179)CUP$:NEXT I%
690 PRINT FNCP$(R%+YM%+1,C%)CHR$(192)CUP$:PRINT
FNCP$(R%+YM%+1,C%+XM%+1)CHR$(217)CUP$
700 RETURN
710 REM ***** DRAW RANGE FINDER *****
715 R%=YY%+2:C%=XSTART%:XM%=30:YM%=2:GOSUB 640
716 R%=YY%+2:C%=43:XM%=34:YM%=2:GOSUB 640
760 FOR I=1 TO 2:PRINT FNCP$(YY%+2+I,57)CHR$(179):NEXT I
770 PRINT FNCP$(YY%+3,XSTART%+1)"0 - 5 - 10 - 15 - 20 - 25 - 30"
780 PRINT FNCP$(YY%+4,XSTART%+RS)RAN$SPACE$(31-LEN(RAN$)-RS)
785 PRINT FNCP$(YY%+3,44)"Section: ";RIGHT$("  "+STR$(OP),2)
786 PRINT FNCP$(YY%+3,59)"CAPACITY : 100%"
787 PRINT FNCP$(YY%+4,44)RON$CON$ROFF$
788 PRINT FNCP$(YY%+4,59)RIGHT$("     "+STR$(CCC),5)" "MID$(HD$(WCC%),9,10)
790 RETURN
800 REM ***** DRAW BLOCKS *****
810 C%=XUNIT%+1:FLA=0
830 FOR I= 1 TO 10
840 NOR=BL(I)/UNIT
845 IF NOR>32000 THEN NOR%=32000 ELSE NOR%=INT(BL(I)/UNIT)
850 IF NOR%>YLEN%-1 THEN NOR%=YLEN%-1:NOR=YLEN%-1
```

```
860 IF NOR%=0 AND BL(I)<>0 THEN BLC=2:GOTO 890
865 IF BL(I)=0 THEN BLC=1:GOTO 890
870 IF NOR%=NOR THEN BLC=0 :GOTO 890
880 IF BL(I)<>0 AND NOR%<>NOR THEN BLC=2:GOTO 890
890 IF NOR%=0 THEN I1=1:F=BL(I):GOTO 950
895 IF NOR%=YLEN%-1 THEN BLC=1
900 FOR I1=1 TO NOR%
910 PRINT FNCP$(YLEN%-I1,C%)CH$" "CUP$
930 NEXT I1
940 F=BL(I)-UNIT*NOR%
950 F=INT(F/UNIT2)
952 IF F>=UNIT THEN F=0
954 IF F<1 THEN F=1
955 IF NOR%=YLEN%-1 THEN F=0
960 FOR J=1 TO F:PRINT FNCP$(YLEN%-I1,C%)CH$(J)" ":NEXT J
970 FOR I4=(YLEN%-(NOR%+BLC)) TO 0 STEP -1:PRINT FNCP$(I4,C%)"     "CUP$:NEXT I4
972 IF BL(I)=0 THEN PRINT FNCP$(YY%-(NOR%+BLC),C%)"     ":GOTO 976 ELSE IF
BL(I)>99999! THEN PRINT FNCP$(YY%-(NOR%+BLC),C%)RIGHT$("
"+STR$(FIX(BL(I)/1000)),4)"k":GOTO 976
975 COD=BL(I):GOSUB 2860:IF COD=0 THEN PRINT FNCP$(YY%-(NOR%+BLC)-
1,C%)"0"+MID$(STR$(BL(I)),2,4) ELSE PRINT FNCP$(YY%-(NOR%+BLC),C%)RIGHT$("
"+STR$(COD),5)CUP$
976 IF FLA=1 THEN RETURN
980 C%=C%+XUNIT%:NEXT I
990 GOSUB 1350:REM ** DRAW CAP LINE **
998 RETURN
1000 REM ***** IND. WEEK LOOK UP *****
1001 RH=RS
1002 PRINT FNCP$(YY%-3,XX%)RON$"'9' iWEEK"ROFF$:PRINT FNCP$(YY%-2,XX%)SPACE$(9)
1003 PRINT FNCP$(YY%-7,XX%)"'0' OBook":PRINT FNCP$(YY%+1,XLEN%+9)"WEEK "RIGHT$("
"+STR$(RH),2)"  "CUP$
1004 PRINT FNCP$(YY%+4,XSTART%+RH)RON$RH$ROFF$:PRINT FNCP$(YY%+1,7+(RH-
RS)*6)RON$MID$(STR$(WE(RH)),6,2)+"/"+MID$(STR$(WE(RH)),4,2)ROFF$:IF RH=1 THEN
PRINT FNCP$(YY%+1,7+(RH-RS)*6)RON$"O/Due"ROFF$
1005 H$=INPUT$(1)
1006 IF (H$="9" OR H$="E") THEN RETURN ELSE IF H$="7" THEN GOSUB 60000:GOTO 1005
1007 IF H$="1" THEN GOSUB 1010:GOTO 1005 ELSE IF H$="2" THEN GOSUB 1015:GOTO
1005
1008 IF (H$="0" AND BL(RH)<>0) THEN GOSUB 1020:GOSUB 400:GOSUB 1190:GOTO 1002
ELSE GOTO 1005
1009 GOTO 1005
1010 REM ** MOVE HAT LEFT **
1011 RH=RH-1:IF RH<RS THEN RH=RS
1012 PRINT FNCP$(YY%+4,XSTART%+RH)RON$FRGD$RH$BKGD$" "ROFF$FRGD$:GOSUB 1091
1013 PRINT FNCP$(YY%+1,XLEN%+9+5)RIGHT$("  "+STR$(RH),2)
1014 RETURN
1015 REM ** MOVE HAT RIGHT **
1016 RH=RH+1:IF RH>RS+9 THEN RH=RS+9
1017 PRINT FNCP$(YY%+4,XSTART%+RH-1)RON$BKGD$" "FRGD$RH$ROFF$:GOSUB 1091
1018 PRINT FNCP$(YY%+1,XLEN%+9+5)RIGHT$("  "+STR$(RH),2)
1019 RETURN
1020 REM ***** DISPLAY ORDERS *****
1021 PRINT NOLIN$NOCAR$NOCUR$BKGD$CLS$
1022 FOR PR=1 TO 2:PRINT FNCP$(-3+PR,0)ULON$"
":NEXT PR
1023 PRINT FNCP$(-2,14)"              * Section: "FRGD$CON$BKGD$"  Wk.Ending:
"FRGD$MID$(STR$(WE(RH)),6,2)+"/"+MID$(STR$(WE(RH)),4,2)" *"CUP$
1024 IF RH-RS=0 AND RS=1 THEN PRINT FNCP$(-2,57)"O/Due *"
1025 PRINT FNCP$(-2,0)BKGD$"USER :        "CUP$
1026 PRINT FNCP$(-2,67)"DATE:"CUP$
```

```
1027 PRINT FNCP$(-2,7)FRGD$NME$BKGD$CUP$:PRINT FNCP$(-2,72)FRGD$DTE$BKGD$CUP$
1028 PRINT FNCP$(0,0)ULON$"Part Number      Customer(12) Metal     Price
Resource Units  Planned Required"ULOFF$CUP$
1029 PRINT
FNCP$(19,0)STRING$(41,CHR$(196))CHR$(194)STRING$(38,CHR$(196))CUP$:COD=BL(RH):AF
LAG=8:GOSUB 2860:AFLAG=0
1030 IF COD>999999! THEN M$=RIGHT$("      "+STR$(FIX(COD/1000)),6)+"k" ELSE
M$=RIGHT$("       "+STR$(COD),7)
1031 PRINT FNCP$(20,0)FRGD$"Load tot:"M$":("RIGHT$("
"+STR$(FIX((BL(RH)/CCC)*100)),6)" % of wkly cap.) "BKGD$CHR$(179)"
"ULON$"Keypad"ULOFF$": "FRGD$"0"BKGD$"=display, "FRGD$"1"BKGD$"=up,
"FRGD$"2"BKGD$"=down"
1032 PRINT FNCP$(21,0)"Cap.(100%):"RIGHT$("     "+STR$(CCC),5)"
"MID$(HD$(WCC%),9,10)SPACE$(14)CHR$(179)SPACE$(9)FRGD$"5"BKGD$"=P.Dates,
"FRGD$"7"BKGD$"=print, "FRGD$"9"BKGD$"=abort"FRGD$CUP$
1033 REM ***** ? ORDERS TO SCREEN *****
1034 GOSUB 1052:IF COUNT1=0 THEN RETURN ELSE LOOP=ORD1%(RH):CT=0:ST=1:SS=ST
1035 L=1:FOR O2=ST TO LOOP:IF O2=1 THEN ME$=LEFT$(AR$(O2,0),8)
1036 IF ME$=LEFT$(AR$(O2,0),8) THEN 1038 ELSE PRINT FNCP$(L,0)SPC(80):PRINT
FNCP$(L,0)BKGD$"% of load total = "MID$(STR$((CT/BL(RH))*100),2,5)" : % of
weekly capacity = ";:PRINT USING "#####.#####";(CT/CCC)*100:PRINT FRGD$:L=L+1:IF
L>18 THEN 1041
1037 PRINT FNCP$(L,0)SPACE$(80):L=L+1:CT=0:IF L>18 THEN 1041
1038 IF MID$(AR$(O2,1),72,1)="s" THEN PRINT
FNCP$(L,0)MID$(AR$(O2,1),1,71)RON$"s"ROFF$MID$(AR$(O2,1),73,8) ELSE PRINT
FNCP$(L,0)AR$(O2,1)
1039 GOSUB 1085:CT=CT+VAL(MID$(AR$(O2,1),51,10)):ME$=LEFT$(AR$(O2,0),8):L=L+1:IF
L>18 THEN 1041
1040 NEXT O2
1041 IF L>18 THEN 1043 ELSE PRINT FNCP$(L,0)SPC(80):PRINT FNCP$(L,0)BKGD$"% of
load total = "MID$(STR$((CT/BL(RH))*100),2,5)" : % of weekly capacity = ";:PRINT
USING "#####.#####";(CT/CCC)*100:PRINT FRGD$
1042 FOR O2=L+1 TO 18:PRINT FNCP$(O2,0)SPACE$(80):NEXT O2
1043 IF AG=1 THEN RETURN
1044 G$=INPUT$(1)
1045 IF G$="9" THEN FOR O2=1 TO
LN:SPOS(O2,0)=0:SPOS(O2,1)=0:SPOS(O2,2)=0:SPOS(O2,3)=0:SPOS(O2,4)=0:NEXT
O2:LN=0:RETURN
1046 IF G$="5" AND SS=ST THEN YE=0:GOSUB 2200
1047 IF G$="5" AND SS<>ST THEN PRINT FNCP$(-1,0)BKGD$ULON$CHR$(7)"Re-
Display"FRGD$ULOFF$CUP$
1048 IF G$="7" THEN LAG=1:GOSUB 60000:LAG=0
1049 IF G$="2" THEN GOSUB 1081 ELSE IF G$="1" THEN GOSUB 1071
1050 IF G$="0" AND SS<>ST THEN GOSUB 1096:SS=ST
1051 GOTO 1044
1052 REM ************** GET ORDERS ***************
1053 COM=0:DOD=0:FOR O2%=1 TO RH-1:COM=COM+ORD1%(O2%):NEXT O2%
1054 FOR O2=1 TO ORD1%(RH):SRN%=AR(COM+O2,1):GOSUB 10600
1055 RN%=D%(22):GOSUB 26300:AR$(O2,0)=D$(5)+RIGHT$("     "+STR$(SRN%),5)
1057 DMY8=AR(COM+O2,0):GOSUB
3300:PD$=MID$(STR$(DTEMP8),6,2)+"/"+MID$(STR$(DTEMP8),4,2)+"/"+MID$(STR$(DTEMP8)
,2,2):IF (D(26+OP)=0 AND PF%(COM+O2)=0) THEN PD=1 ELSE PD=0
1058 IF D(23)=0 THEN RD$=SPACE$(8) ELSE
RD$=MID$(STR$(D(23)),6,2)+"/"+MID$(STR$(D(23)),4,2)+"/"+MID$(STR$(D(23)),2,2)
1059 IF COFF$="B" THEN DOD=D%(11+OP) ELSE IF COFF$="C" THEN DOD=D%(3) ELSE IF
COFF$="A" THEN FOR Z%=1 TO OP:DOD=DOD+D%(11+Z%):NEXT Z%
1060 IF GAL=99 THEN RETURN
1061 M=D(1):NP=2:DP=5:GOSUB 37500:PM$=M$:M=D#(1)*DOD:NP=2:DP=5:IF M>99999! THEN
M=M/1000:GOSUB 37500:CM$=MID$(M$,1,7)+"k" ELSE GOSUB 37500:CM$=M$
1062 VA=DOD:GOSUB 2772:AR$(O2,1)=D$(1)+" "+MID$(MD$(3),1,12)+" "+D$(5)+" "+PM$+"
```

```
"+RIGHT$("          "+STR$(COD),10)+"  "
1063 AR$(O2,1)=AR$(O2,1)+"  "+PD$+" "+RD$
1064 IF PD<>0 THEN MID$(AR$(O2,1),72,1)="s"
1065 DOD=0:NEXT O2
1066 COUNT1=ORD1%(RH):IF COUNT1=0 THEN GOTO 1067 ELSE GOSUB 3500
1067 PRINT FNCP$(21,27)BKGD$": "RIGHT$("     "+STR$(COUNT1),5)":
"FRGD$"1"CUP$
1070 RETURN
1071 REM ***** MOVE UP *****
1072 ST=ST-1:IF ST<1 THEN ST=1
1074 GOTO 1084
1081 REM ***** MOVE DOWN *****
1082 ST=ST+1:IF ST>ORD1%(RH) THEN ST=ORD1%(RH)
1084 PRINT FNCP$(21,35)RIGHT$("     "+STR$(ST),5)CUP$:RETURN
1085 REM ***** HOLD POS OF 's' WHILE PRINTING *****
1086
LN=LN+1:SPOS(LN,0)=VAL(MID$(AR$(O2,0),9,5)):SPOS(LN,1)=L:SPOS(LN,2)=VAL(MID$(AR$
(O2,1),70,2))*10000+VAL(MID$(AR$(O2,1),67,2))*100+VAL(MID$(AR$(O2,1),64,2)):SPOS
(LN,4)=O2
1088 RETURN
1091 REM ***** MOVE DATE BLOCK *****
1092 IF H$="1" THEN PRINT FNCP$(YY%+1,7+(RH-
RS+1)*6)BKGD$MID$(STR$(WE(RH+1)),6,2)+"/"+MID$(STR$(WE(RH+1)),4,2)FRGD$ ELSE IF
H$="2" THEN PRINT FNCP$(YY%+1,7+(RH-RS-1)*6)BKGD$MID$(STR$(WE(RH-
1)),6,2)+"/"+MID$(STR$(WE(RH-1)),4,2)FRGD$
1093 PRINT FNCP$(YY%+1,7+(RH-
RS)*6)RON$MID$(STR$(WE(RH)),6,2)+"/"+MID$(STR$(WE(RH)),4,2)ROFF$
1094 IF (RS=1 AND RH=1 AND H$="1") THEN PRINT FNCP$(YY%+1,7)RON$"0/Due"ROFF$
ELSE IF (RS=1 AND RH=2 AND H$="2") THEN PRINT FNCP$(YY%+1,7)BKGD$"0/Due"FRGD$
1095 RETURN
1096 REM ***** DISPLAY *****
1097 PRINT FNCP$(-1,0)ULON$BKGD$SPC(10)ULOFF$FRGD$:FOR O2=1 TO
LN:SPOS(O2,0)=0:SPOS(O2,1)=0:SPOS(O2,2)=0:SPOS(O2,3)=0:SPOS(O2,4)=0:NEXT
O2:LN=0:AG=1:ME$=LEFT$(AR$(ST,0),8):CT=0:O=ST-1
1098 WHILE LEFT$(AR$(O,0),8)=ME$
1099 CT=CT+VAL(MID$(AR$(O,1),51,10)):O=O-1:WEND
1100 GOSUB 1035:AG=0
1104 RETURN
1105 REM ***** BROWSING *****
1110 RS=1
1120 V$=INPUT$(1)
1129 IF V$="0" THEN GOSUB 1190:GA=0
1130 IF V$="1" THEN GOSUB 1170:GA=9
1140 IF V$="2" THEN GOSUB 1290:GA=9
1145 IF V$="7" THEN GOSUB 60000
1147 IF V$="9" AND GA=0 THEN GOSUB 1000:GOTO 1165
1148 IF V$="9" AND GA<>0 THEN PRINT FNCP$(-1,0)"Re-Graph"CHR$(7)
1149 IF V$="R" THEN GEND=0:GOSUB 3400
1150 IF V$="E" THEN GOSUB 3100:RETURN
1160 GOTO 1120
1165 IF H$="E" THEN GOSUB 3100:RETURN ELSE PRINT FNCP$(YY%-3,XX%)BKGD$"'9'
iWEEK":PRINT FNCP$(YY%-7,XX%)"'0' GRAPH":PRINT FNCP$(YY%+1,XLEN%+9)"WKS
"RIGHT$("  "+STR$(RS),2)"-"RIGHT$("  "+STR$(RS+9),2)
1166 PRINT FNCP$(YY%-2,XX%)BKGD$"'R' RESET"FRGD$
1167 PRINT FNCP$(YY%+4,XSTART%+RS)BKGD$RAN$:PRINT FNCP$(YY%+1,7+(RH-
RS)*6)MID$(STR$(WE(RH)),6,2)+"/"+MID$(STR$(WE(RH)),4,2)FRGD$
1168 IF RS=1 THEN PRINT FNCP$(YY%+1,7)BKGD$"0/Due"FRGD$CUP$
1169 GOTO 1120
1170 REM ** MOVE TO LEFT **
1180 RS=RS-1:IF RS=0 THEN RS=1:RETURN
```

```
1181 PRINT FNCP$(YY%+4,XSTART%+RS)BKGD$RAN$" "FRGD$
1182 RETURN
1189 REM ** RE-DRAW GRAPH **
1190 C%=XUNIT%+1:PRINT FNCP$(-1,0)SPC(12)
1195 IF LIN%=LIN THEN PRINT FNCP$(YY%-LIN%,7)SPACE$(XLEN%) ELSE PRINT FNCP$(YY%-
LIN%-1,7)SPACE$(XLEN%)
1198 PRINT FNCP$(YY%+1,XLEN%+13)RIGHT$("  "+STR$(RS),2)"-"RIGHT$("
"+STR$(RS+9),2)CUP$
1200 FOR I=RS TO RS+9
1208 PRINT
FNCP$(YY%+1,C%)BKGD$MID$(STR$(WE(I)),6,2)+"/"+MID$(STR$(WE(I)),4,2)FRGD$CUP$
1210 FLA=1:GOSUB 840
1287 C%=C%+XUNIT%:NEXT I
1288 IF RS=1 THEN PRINT FNCP$(YY%+1,7)BKGD$"O/Due"FRGD$CUP$
1289 GOSUB 1350:RETURN
1290 REM ** MOVE TO RIGHT **
1300 RS=RS+1:IF RS>21 THEN RS=21:RETURN
1301 PRINT FNCP$(YY%+4,XSTART%+RS-1)BKGD$" "RAN$FRGD$
1302 RETURN
1350 REM ***** DRAW CAPACITY LINE *****
1360 LIN%=INT(CCC/UNIT):LIN=CCC/UNIT:IF LIN%>YLEN%-1 THEN LIN%=YLEN%-
1:LIN=YLEN%-1
1366 IF LIN-LIN%<>0 THEN DIFF1=CCC-(UNIT*LIN%):DIFF1=INT(DIFF1/UNIT2) ELSE
DIFF1=0
1370 IF LIN%=LIN THEN I2=YY%-LIN%+3 ELSE I2=YY%-LIN%+3-2
1371 DEF SEG=0
1372 PROW%=DIFF1*2:PVAL%=5152+(47*32)
1374 FOR I9%=PROW%+PVAL% TO PROW%+544+PVAL% STEP 32
1376 POKE I9%,85
1378 POKE I9%+1,1
1379 NEXT I9%
1380 DEF SEG=&HF000
1390 WE$=""
1400 FOR J2=0 TO 158 STEP 2
1405 WU=PEEK(I2*160+J2):IF WU<64 THEN WU=WU+156 ELSE WU=WU-64
1410 WE$=WE$+CHR$(WU)
1415 NEXT J2
1420 FOR J2=XSTART%+2 TO XSTART%+XLEN%:W=ASC(MID$(WE$,J2,1))
1425 IF (W)127 AND W<144) THEN W=W+16
1429 IF W=32 THEN W=160
1430 IF LIN%=LIN THEN PRINT FNCP$(YY%-LIN%,J2-1)CHR$(W) ELSE PRINT FNCP$(YY%-
LIN%-1,J2-1)CHR$(W)
1450 NEXT J2
1460 RETURN
1510 REM ***** CALC. FOR DATES *****
1520 WE(1)=0:DIF=7-D1:WED=DD1+DIF
1530 IF Y1>1900 THEN Y1=Y1-1900
1540 IF INT(Y1/4)=Y1/4 THEN L%(2)=29
1550 IF WED>L%(M1) THEN GOSUB 1670
1560 CWE=(Y1*10000)+(M1*100)+WED:REM ** CURRENT W/END DATE
1570 WE(2)=CWE
1610 REM ** NEXT 29 W/ENDS CALC. **
1620 FOR I=3 TO 30
1630 WED=WED+7
1640 IF WED>L%(M1) THEN GOSUB 1680
1650 WE(I)=(Y1*10000)+(M1*100)+WED
1660 NEXT I
1662 L%(2)=28
1665 RETURN
1670 REM ** 1ST W/END DATE CALC. **
```

```
1680 Y2=Y1:M2=M1+1
1690 IF M2>12 THEN M2=M2-12:Y2=Y1+1
1700 WED=WED-L%(M1)
1710 M1=M2:Y1=Y2
1720 RETURN
1800 REM ***** SAVE GRAPH *****
1805 CLOSE
1880 OPEN "R",#12,"GRAPH.FIL",270
1881 FIELD #12,8 AS KE$,2 AS SE$,2 AS COD$,4 AS GR$,4 AS GDAT$,10 AS LAB$,120 AS
GR1$,120 AS GR2$
1883 OPEN "R",#13,"GRAPH1.FIL",2
1884 FIELD #13,2 AS GREC$
1885 GET #13,1
1886 GREC%=CVI(GREC$)
1900 PRINT FNCP$(-1,0)"Save load chart (Y/N):
"
1905 ROW=-1:COL=22:MINL=1:MAXL=1:GOSUB 60900:IF I$<>"Y" AND I$<>"N" AND I$<>"7"
THEN 1905
1906 IF I$="N" THEN RETURN
1907 IF I$="7" THEN GOSUB 60000:GOTO 1900
1915 I=1
1920 IF I>20 THEN 1940
1930 GET #12,I:IF KE$=SPACE$(8) THEN 1951 ELSE I=I+1:GOTO 1920
1940 PRINT FNCP$(-1,0)CHR$(7)"File full - Hit any key to continue
"CUP$:GOSUB 20020:RETURN
1951 GREC%=I:LSET KE$=CON$:LSET COD$=MKI$(WCC%):LSET GR$=MKS$(CCC):LSET
GDAT$=MKS$(BP(1)):LSET LAB$=MID$(HD$(WCC%),9,10):LSET SE$=MKI$(OP)
1952 TEMP$="":TEM$="":FOR I=1 TO
30:TEMP$=TEMP$+MKS$(BL(I)):TEM$=TEM$+MKS$(WE(I)):NEXT I
1954 LSET GR1$=TEMP$:LSET GR2$=TEM$
1956 PUT #12,GREC%
1960 PRINT FNCP$(-1,0)"Load chart saved - Hit any key
"CUP$
1962 GOSUB 20020
1969 CLOSE:RETURN
2000 REM ***** SORT ( STRING TYPE ) *****
2010 SW%=COUNT:IF COUNT=0 THEN S$="No matching orders on file":LPRINT
S$:X=241:GOTO 61150
2020 PO%=0:SW%=SW%\2:IF SW%=0 THEN RETURN
2030 PO%=PO%+1
2040 IF (PO%+SW%)>COUNT THEN 2020
2050 IF AR(PO%,0)<=AR(PO%+SW%,0) THEN 2030
2060 SWAP AR(PO%,1),AR(PO%+SW%,1)
2062 SWAP PF%(PO%),PF%(PO%+SW%)
2063 SWAP ORD%(PO%),ORD%(PO%+SW%)
2065 SWAP AR(PO%,2),AR(PO%+SW%,2)
2070 SWAP AR(PO%,0),AR(PO%+SW%,0):GOTO 2090
2080 PO%=PO%-1
2090 IF PO%-SW%<1 THEN 2040
2100 IF AR(PO%,0)>=AR(PO%-SW%,0) THEN 2030
2105 SWAP PF%(PO%),PF%(PO%-SW%)
2106 SWAP ORD%(PO%),ORD%(PO%-SW%)
2110 SWAP AR(PO%,1),AR(PO%-SW%,1)
2115 SWAP AR(PO%,2),AR(PO%-SW%,2)
2120 SWAP AR(PO%,0),AR(PO%-SW%,0):GOTO 2080
2200 REM ***** CONFIRM PLANNED DATES *****
2210 AN$="":PRINT FNCP$(20,51)FRGD$"0=yes/no "CUP$:PRINT FNCP$(21,51)"5=
Change"CUP$
2215 NL=1:PRINT FNCP$(SPOS(NL,1),63)RON$MID$(AR$(SPOS(NL,4),1),64,8)ROFF$
2217 SRN%=VAL(MID$(AR$(SPOS(NL,4),0),9,5)):GOSUB 10000
```

```
2218 PRINT FNCP$(-1,0)BKGD$ULON$"Order Ref: "D$(2)ULOFF$FRGD$
2220 DT$=INPUT$(1)
2230 IF DT$="9" THEN PRINT FNCP$(21,51)FRGD$"5"BKGD$"=P.Dates, "FRGD$CUP$:PRINT
FNCP$(20,51)"0"BKGD$"=display"FRGD$:GOSUB 2400:RETURN
2240 IF DT$="7" THEN LAG=1:GOSUB 60000:LAG=0:GOTO 2220
2250 IF DT$="2" THEN GOSUB 2300:YE=0:GOTO 2220
2260 IF DT$="1" THEN GOSUB 2330:YE=0:GOTO 2220
2270 IF DT$="0" THEN GOSUB 2280:GOTO 2220
2272 IF DT$="5" THEN GOSUB 2900:GOSUB 2300:YE=0:GOTO 2220
2275 GOTO 2220
2280 REM ***** confirm y/n *****
2281 IF MID$(AR$(SPOS(NL,4),1),72,1)<>"s" THEN RETURN
2282 YE=YE+1:IF (YE/2)=INT(YE/2) THEN AN$="N" ELSE AN$="Y"
2284 IF AN$="Y" THEN PRINT
FNCP$(SPOS(NL,1),63)ULON$MID$(AR$(SPOS(NL,4),1),64,8)ULOFF$:PRINT
FNCP$(20,51)FRGD$"0=yes    " ELSE PRINT
FNCP$(SPOS(NL,1),63)RON$MID$(AR$(SPOS(NL,4),1),64,8)ROFF$:PRINT
FNCP$(20,51)FRGD$"0=no     "
2286 IF AN$="Y" THEN SPOS(NL,3)=9 ELSE SPOS(NL,3)=0
2288 RETURN
2300 REM ***** move down *****
2310 NL=NL+1:IF NL>LN THEN NL=LN
2312 IF SPOS(NL-1,1)=0 THEN 2320
2315 IF AN$="N" OR AN$="" OR YE=0 THEN PRINT FNCP$(SPOS(NL-
1,1),63)MID$(AR$(SPOS(NL-1,4),1),64,8)
2320 PRINT FNCP$(SPOS(NL,1),63)RON$MID$(AR$(SPOS(NL,4),1),64,8)ROFF$
2322 SRN%=VAL(MID$(AR$(SPOS(NL,4),0),9,5)):IF SRN%=0 THEN 2324 ELSE GOSUB 10000
2323 PRINT FNCP$(-1,11)ULON$BKGD$D$(2)ULOFF$FRGD$
2324 RETURN
2330 REM ***** move  up *****
2340 NL=NL-1:IF NL<1 THEN NL=1
2345 IF SPOS(NL+1,1)=0 THEN 2360
2350 IF AN$="N" OR AN$="" OR YE=0 THEN PRINT
FNCP$(SPOS(NL+1,1),63)MID$(AR$(SPOS(NL+1,4),1),64,8)
2360 PRINT FNCP$(SPOS(NL,1),63)RON$MID$(AR$(SPOS(NL,4),1),64,8)ROFF$
2362 SRN%=VAL(MID$(AR$(SPOS(NL,4),0),9,5)):IF SRN%=0 THEN 2364 ELSE GOSUB 10000
2363 PRINT FNCP$(-1,11)BKGD$ULON$D$(2)ULOFF$FRGD$
2364 RETURN
2400 REM ***** save changes *****
2410 PRINT FNCP$(-1,0)ULON$"Save the confirmed planned dates (Y/N) ?:
"SPACE$(10)FRGD$:ROW=-1:COL=42:MAXL=1:MINL=1:GOSUB 60900:IF I$<>"Y" AND I$<>"N"
THEN 2410
2425 PRINT FRGD$ULOFF$:IF I$="Y" THEN GOTO 2426 ELSE 2470
2426 IF HED$="N" THEN 2440 ELSE 2427
2427 LPRINT STRING$(106,"-")
2428 LPRINT "USER : "NME$"   * PLANNED  DATE CHANGES * DATE: "DTE$:LPRINT
2429 LPRINT "Original                           Revised"
2430 LPRINT "--------------------------        --------------------------"
2431 LPRINT "Order              Planned      Order              Planned  Part
Customer          Qty Required"
2432 LPRINT "Reference          Date         Reference          Date     Number
Date"
2433 LPRINT STRING$(106,"-"):HED$="N"
2440 O2=1:WHILE O2<LN+1
2441 IF SPOS(O2,3)=5 THEN 2450
2442 IF SPOS(O2,3)=0 THEN 2450 ELSE SRN%=SPOS(O2,0):GOSUB 10000:RN%=D%(22):GOSUB
26300:PAN$=D$(2):D26=D(26+OP):D(26+OP)=SPOS(O2,2):GOSUB 47500:GOSUB 2490
2443 IF D26=0 THEN D26$=SPACE$(8) ELSE
D26$=MID$(STR$(D26),6,2)+"/"+MID$(STR$(D26),4,2)+"/"+MID$(STR$(D26),2,2)
2444 PRI$="":PRI$=PAN$+"  "+D26$+SPACE$(6)+D$(2)+"  "
```

```
2445 GOSUB 2585:PRI$=PRI$+PTEMP$+"  "+D$(1)+" "+MD$(3)+" ":GAL=99:DOD=0:GOSUB
1059:GAL=0
2446 PRI$=PRI$+RIGHT$("     "+STR$(DOD),5)+"
"+MID$(STR$(D(23)),6,2)+"/"+MID$(STR$(D(23)),4,2)+"/"+MID$(STR$(D(23)),2,2):LPRI
NT PRI$
2447 IF SPOS(O2,3)<>0 THEN GOSUB 2496
2448 SPOS(O2,3)=5
2450 O2=O2+1:WEND
2455 GOSUB 2500
2460 PRINT CURPOS$CHR$(33)CHR$(32)BKGD$ULON$"All changes have been saved - Hit
any key to continue      "SPACE$(15)FRGD$ULOFF$:GOSUB 20020
2470 PRINT FNCP$(-1,0)BKGD$ULON$SPACE$(78)ULOFF$FRGD$
2476 FOR O2=1 TO LN:IF I$="N" OR (I$="Y" AND SPOS(O2,3)=0) THEN PRINT
FNCP$(SPOS(O2,1),63)MID$(AR$(SPOS(O2,4),1),64,8):GOTO 2479
2479 NEXT O2
2480 RETURN
2482 REM ***** OPENING TEMP FILE *****
2483 CLOSE #14:OPEN "R",#14,"TEMP.FIL",30
2484 FIELD #14,2 AS TREC$,16 AS PNO$,4 AS PDTE$,8 AS SP$
2485 CLOSE #14:KILL "TEMP.FIL"
2486 OPEN "R",#14,"TEMP.FIL",30
2487 FIELD #14,2 AS TREC$,16 AS PNO$,4 AS PDTE$,8 AS SP$
2488 RETURN
2490 REM ***** TEMP FILE WRITE BACK *****
2492 LSET PNO$=D$(2):LSET PDTE$=MKS$(D(26+OP)):LSET TREC$=MKI$(SRN%):LSET
SP$=SPACE$(8)
2494 CT1%=CT1%+1:PUT #14,CT1%
2495 RETURN
2496 REM ***** RECALC BL(I) VALUES *****
2497 DMY=D(26+OP):GOSUB 27000:DTEMP=(Y2*10000)+(WN*100)+D1
2498 FOR I9=1 TO LOOP:IF SPOS(O2,0)=AR(COM+I9,1) THEN 2499 ELSE NEXT I9
2499 AR(COM+I9,0)=DTEMP:PF%(COM+I9)=9:RETURN
2500 GOSUB 2000
2502 FOR I9%=1 TO 70:BL(I9%)=0:ORD1%(I9%)=0:NEXT I9%
2505 PRINT FNCP$(-1,0)ULON$BKGD$SPC(60)CUP$:GOSUB 9800:PRINT
ULOFF$FRGD$CUP$:RETURN
2585 REM ***** STRING A DATE ROUTINE *****
2587
PTEMP$=MID$(STR$(D(26+OP)),6,2)+"/"+MID$(STR$(D(26+OP)),4,2)+"/"+MID$(STR$(D(26+
OP)),2,2)
2595 RETURN
2700 REM ** CALC QTY*CAP **
2772 ON WCC% GOTO 2780,2790,2800,2810,2820,2830,2840
2780 COD=(VA*D#(1))/1000:GOTO 2850
2790 COD=VA*D#(1):GOTO 2850
2800 COD=(VA*D(2+OP))/60:GOTO 2850
2810 IF D%(2)=0 THEN COD=VA:GOTO 2850 ELSE COD=VA/D%(2):GOSUB 2860:VA=COD:GOTO
2850
2820 COD=VA:GOTO 2850
2830 COD=VA*D(1):GOTO 2850
2840 REM *SPARE*
2850 RETURN
2860 REM *RID DEC PLACES*
2862 CUB=INSTR(STR$(COD),"."):IF CUB<=0 THEN RETURN
2863 IF WCC%=4 AND AFLAG<>8 THEN 2864 ELSE IF VAL(MID$(STR$(COD),CUB+1,1))>4
THEN COD=COD+1
2864 IF WCC%=4 AND AFLAG<>8 AND VAL(MID$(STR$(COD),CUB+1,1))>1 THEN COD=COD+1
2865 COD=FIX(COD):RETURN
2900 REM ***** CHANGE PLANNED DATE *****
2910 MINL=1:MAXL=8:ROW=SPOS(NL,1):COL=63:GOSUB
```

```
60700:SPOS(NL,2)=COMDAT:SPOS(NL,3)=8
2920
MID$(AR$(SPOS(NL,4),1),64,8)=MID$(STR$(COMDAT),6,2)+"/"+MID$(STR$(COMDAT),4,2)+"
/"+MID$(STR$(COMDAT),2,2)
2930 SPOS(NL,2)=COMDAT
2990 RETURN
3100 REM ***** UPDATE THE ORDER BOOK *****
3105 IF (OP)0 AND OP(4) THEN 3110 ELSE RETURN
3110 PRINT FNCP$(-1,0)FRGD$CHR$(7)"Update Order File (Y)es/(R)eset/(C)ontinue ?:
"SPACE$(30)
3120 COL=45:ROW=-1:MAXL=1:MINL=1:GOSUB 60980:IF I$()"Y" AND I$()"R" AND I$()"7"
AND I$()"C" THEN 3110
3125 IF I$="7" THEN GOSUB 60000:GOTO 3110
3126 IF I$="C" THEN CO$="YES":RETURN ELSE CO$=""
3130 IF I$="R" THEN GEND=9998:PRINT FNCP$(-1,0)"Re-setting"SPC(45):GOSUB
3425:GEND=0:RETURN ELSE PRINT FNCP$(-1,0)"Sure (Y/N)?:"SPC(50)
3140 COL=12:GOSUB 60980:IF I$()"Y" AND I$()"N" THEN 3140
3150 IF I$="N" THEN GOTO 3110 ELSE PRINT FNCP$(-1,0)"Updating Order File . . . .
. .                                       "
3160 FOR I%=1 TO CT1%
3170 GET #14,I%
3180 TREC%=CVI(TREC$):PN$=PNO$:PDTE=CVS(PDTE$)
3190 SRN%=TREC%:GOSUB 10000
3200 D$(2)=PN$:D(26+OP)=PDTE:GOSUB 15000
3210 NEXT I%
3220 CO$=""
3250 PRINT FNCP$(-1,0)"Update Complete - Hit any key to continue
":GOSUB 20020:RETURN
3300 REM ***** DATCON4 - YYWWD --> YYMMDD *****
3310 GOSUB 3324
3320 DTEMP8=(YT8*10000)+(MTH8*100)+DY8
3322 RETURN
3324 REM *** WHAT YEAR ? ***
3326 DWY8$=RIGHT$(STR$(DMY8),6)
3328 Y8=VAL(LEFT$(DWY8$,2)):D8=VAL(RIGHT$(DWY8$,2)):WN8=VAL(MID$(DWY8$,3,2))
3330 YT8=Y8
3332 Y8=Y8+1900
3334 IF Y8()4*INT(Y8/4) THEN YEAR8=365 ELSE YEAR8=366
3336 IF YEAR8=366 THEN L%(2)=29
3338 SDT8=L8%(YT8-80)-1
3340 CWD8=(WN8*7)-(7-D8)
3342 CP8=SDT8+CWD8
3344 IF CP8)YEAR8 THEN 3366
3346 CT8=0:GN8=0
3348 WHILE GN8+L%(CT8+1)(CP8
3350 CT8=CT8+1
3352 GN8=GN8+L%(CT8)
3354 WEND
3356 MTH8=CT8+1
3358 IF CP8-GN8(=0 AND SDT8(0 THEN GOSUB 3376:GOTO 3372
3360 DY8=CP8-GN8
3362 YR8=YT8
3364 GOTO 3372
3366 DY8=CP8-YEAR8
3368 YT8=YT8+1
3370 MTH8=1
3372 L%(2)=28
3374 RETURN
3376 REM
3378 CP8=L%(12)+CP8
```

```
3380 GOTO 3382
3382 MTH8=12:DY8=CP8:YT8=YT8-1
3384 RETURN
3400 REM ***** RESET COMPLETELY *****
3405 PRINT FNCP$(-1,0)CHR$(7)"All changes will be lost. Ok. to continue (Y/N)?:
"
3410 ROW=-1:COL=50:MAXL=1:MINL=1:GOSUB 60980:IF I$<>"N" AND I$<>"Y" THEN 3410
3415 IF I$="N" THEN 3470
3420 PRINT FNCP$(-1,0)"Re-setting . . . . . . . . . . . ."SPACE$(20)
3422 LAG=0:AG=0:SS=0:PD=0:LN=0:CT1%=0:HED$=" ":FIRS=0:CO$=""
3425 FOR I6%=1 TO COUNT:GET #11,I6%
3426 RES1=CVS(RES1$):RES2%=CVI(RES2$):RES3=CVS(RES3$)
3427 PF%(I6%)=0:AR(I6%,0)=RES1:AR(I6%,1)=RES2%:AR(I6%,2)=RES3:SRN%=RES2%:GOSUB
10500:ORD%(I6%)=D%(22):NEXT I6%
3428 FOR I6%=1 TO 70:ORD1%(I6%)=0:BL(I6%)=0:NEXT I6%
3430 FOR I6%=1 TO 100:FOR I5%=1 TO 4:SPOS(I6%,I5%)=0:NEXT I5%:NEXT I6%
3440 GOSUB 2000:GOSUB 9800:IF GEND=9998 THEN RETURN ELSE RS=1:GOSUB 400:GOSUB
800:GOSUB 2482
3450 PRINT FNCP$(-1,0)"Re-set complete  - Hit any key to continue . .
."SPACE$(18):GOSUB 20020
3470 PRINT FNCP$(-1,0)SPACE$(70):RETURN
3500 REM ***** SORT ( NORMAL string TYPE ) *****
3510 SW%=COUNT1:IF SW%=0 THEN S$="No matching orders on file":LPRINT S$:GOTO 150
3520 PO%=0:SW%=SW%\2:IF SW%=0 THEN RETURN
3530 PO%=PO%+1
3540 IF (PO%+SW%)>COUNT1 THEN 3520
3550 IF AR$(PO%,0)<=AR$(PO%+SW%,0) THEN 3530
3560 SWAP AR$(PO%,0),AR$(PO%+SW%,0)
3570 SWAP AR$(PO%,1),AR$(PO%+SW%,1):GOTO 3590
3580 PO%=PO%-1
3590 IF PO%-SW%<1 THEN 3540
3600 IF AR$(PO%,0)>=AR$(PO%-SW%,0) THEN 3530
3610 SWAP AR$(PO%,0),AR$(PO%-SW%,0)
3620 SWAP AR$(PO%,1),AR$(PO%-SW%,1):GOTO 3580
4000 REM ** WINDOW CAPACITIES **
4005 R=-1:C=55:WCC%=CVI(WSC$):R%=-1:C%=55:XM%=22:YM%=10:GOSUB 640
4050 FOR Z=1 TO 7:M=CVS(WS$(Z)):NP=2:DP=5:GOSUB 37500
4060 PRINT FNCP$(R+Z,C+1)MID$(HD$(Z),6,13)":"M$
4070 NEXT Z
4075 FOR Z=8 TO 10:PRINT FNCP$(R+Z,C+1)SPC(22):NEXT Z
4080 PRINT FNCP$(R+10,C+1)"Capacity (1-7) ?:
":MAXL=1:MINL=1:ROW=9:COL=74:GOSUB 60980:IF VAL(I$)<0 OR VAL(I$)>7 THEN 4080
ELSE WCC%=VAL(I$)
4081 IF VAL(I$)=0 THEN GOSUB 60000:GOTO 4080
4085 IF MID$(HD$(WCC%),9,5)="SPARE" OR MID$(HD$(WCC%),9,5)="Spare" THEN 4080
4090 PRINT FNCP$(R+10,C+1)"Re-value(Y/N) ?:   ":GOSUB 60980:IF I$<>"Y" AND
I$<>"N" THEN 4090
4100 IF I$="Y" THEN 4110 ELSE FTI=0:GOTO 4120
4110 MAXL=8:COL=70:PRINT FNCP$(R+10,C+1)"New value = ?:     ":GOSUB 60980:IF
VAL(I$)=0 THEN 4110 ELSE M=VAL(I$):CCC=VAL(I$):FTI=999:NP=2:DP=5:GOSUB
37500:PRINT FNCP$(R+10,COL)M$
4120 PRINT FNCP$(R+10,C+1)"Alterations (Y/N) ?:  ":MINL=1:MAXL=1:COL=76:GOSUB
60980:IF I$<>"Y" AND I$<>"N" THEN 4120
4130 IF I$="Y" THEN 4080 ELSE RETURN
4600 REM ***** START DATE FOR PROD. PLAN. *****
4610
A=VAL(MID$(STR$(D(23)),6,2)):B=VAL(MID$(STR$(D(23)),4,2)):C=VAL(MID$(STR$(D(23))
,2,2))
4615 IF INT(C/4)=C/4 THEN L%(2)=29
4620 REM * USE EITHER 9430 OR 9440 FOR LEAD TIME IN WKS. OR DAYS, RESPECT'Y *
```

```
4630 MD24=INT(MD(24)):IF MD(24)-MD24>0 THEN MD24=INT((MD(24)*7)+1) ELSE MD24
=INT(MD(24)*7)
4640 REM * MD24=INT(MD(24)):IF MD(24)-MD24>0 THEN MD24=MD24+1
4650 A1=A-MD24
4660 IF A1>0 THEN GOTO 4710
4670 C1=C
4675 B1=B
4680 B1=B1-1:IF B1<=0 THEN B1=12:C1=C1-1
4690 MD2=MD24-A:A1=L%(B1)-MD2:IF A1<=0 THEN A=A+L%(B1):GOTO 4680
4700 C=C1:B=B1
4710 D23=(C*10000)+(B*100)+A1
4715 L%(2)=28
4720 RETURN
9800 REM ***** PROCESSING  & SUCH LIKE ******
9810 PRINT FNCP$(-1,0)"      of "COUNT" processed."
9820 CUM=0:CO=0:I8%=0
9830 I8%=I8%+1:CUU=0:IF I8%>COUNT THEN GOTO 9870 ELSE PRINT FNCP$(-1,0)I8%
9840 IF VAL(MID$(STR$(AR(I8%,0)),2,4))<VAL(MID$(STR$(TART),2,4)) THEN
RN%=ORD%(I8%):GOSUB 25000:VA=AR(I8%,2):GOSUB 2700:CUM=CUM+COD:CO=CO+1:CUU=9
9850 IF CUU=0 THEN 9870
9865 IF FIRS=0 THEN LSET RES1$=MKS$(AR(I8%,0)):LSET RES2$=MKI$(AR(I8%,1)):LSET
RES3$=MKS$(AR(I8%,2)):PUT #11,I8%
9867 GOTO 9830
9870 IF CUM<0 THEN CUM=0
9880 BL(1)=CUM:CUM=0:ORD1%(1)=CO:LOOP=CO+1:CO=0:IF I8%>COUNT THEN 9990
9890 FOR I8%=LOOP TO COUNT:RN%=ORD%(I8%):GOSUB 25000
9900 PRINT FNCP$(-1,0)I8%
9910 IF I8%=LOOP THEN WE$=LEFT$(STR$(AR(I8%,0)),5):WEEK=NW%
9920 IF WE$=LEFT$(STR$(AR(I8%,0)),5) THEN 9950 ELSE 9930
9930 IF CUM<0 THEN CUM=0
9932 AV%=VAL(MID$(WE$,4,2)):Y9=VAL(MID$(WE$,2,2))
9935 IF (AV%<WEEK OR (AV%)=WEEK AND Y9>YY1)) THEN AV%=((Y9-YY1)*52)-WEEK+AV%+2
ELSE AV%=AV%-WEEK+2
9936 IF AV%>70 THEN 9970
9940 BL(AV%)=CUM:CUM=0:ORD1%(AV%)=CO:CO=0
9950 VA=AR(I8%,2):GOSUB 2700:CUM=CUM+COD:WE$=LEFT$(STR$(AR(I8%,0)),5):CO=CO+1
9960 IF FIRS=0 THEN LSET RES1$=MKS$(AR(I8%,0)):LSET RES2$=MKI$(AR(I8%,1)):LSET
RES3$=MKS$(AR(I8%,2)):PUT #11,I8%
9970 NEXT I8%
9980 AV%=VAL(MID$(WE$,4,2)):Y9=VAL(MID$(WE$,2,2))
9981 IF (AV%<WEEK OR (AV%)=WEEK AND Y9>YY1)) THEN AV%=((Y9-YY1)*52)-WEEK+AV%+2
ELSE AV%=AV%-WEEK+2
9982 IF AV%>70 THEN 9990
9985 BL(AV%)=CUM:CUM=0:ORD1%(AV%)=CO:CO=0
9990 FIRS=99:LOOP=0:RETURN
10000 REM ***** READ ORDER *****
10002 GET #1,SRN%:GET #2,SRN%:GET #7,SRN%:GET #3,SRN%
10010 B=1:C=1:G=1:H=1
10020 FOR J1 = 1 TO 3
10030 D$(J1)=F$(J1)
10040 NEXT J1
10050 FOR J1 = 18 TO 20
10060 D$(J1)=MID$(CORD$,B,8)
10070 B=B+8
10080 NEXT J1
10090 FOR J1 = 3 TO 22
10100 D%(J1)=CVI(MID$(PCT$,C,2))
10110 C=C+2
10120 NEXT J1
10130 FOR J1 = 23 TO 24
```

```
10140 D(J1) = CVS(MID$(SPT$,G,4))
10150 G=G+4
10160 NEXT J1
10170 FOR J1=27 TO 36
10180 D(J1)=CVS(MID$(SPT$,G,4))
10190 G=G+4
10200 NEXT J1
10210 RETURN
10500 REM ** SHORT ORDER READ I **
10510 GET #7,SRN%:D%(22)=CVI(MID$(PCT$,39,2)):RETURN
10600 REM ** SHORT ORDER READ II **
10610 GET #1,SRN%:GET #7,SRN%:C%=19:G%=9
10620 D$(1)=F$(1):D%(22)=CVI(MID$(PCT$,39,2)):D%(3)=CVI(MID$(PCT$,1,2))
10630 FOR J%=12 TO 21:D%(J%)=CVI(MID$(PCT$,C%,2)):C%=C%+2
10640 D(J%+15)=CVS(MID$(SPT$,G%,4)):G%=G%+4:NEXT J%
10650 D(23)=CVS(MID$(SPT$,1,4)):RETURN
11000 REM ** READ CAPACITIES **
11010 CN%=0:KF%=12:MATCH=BP(3)
11020 GOSUB 50000
11040 GET #13,CN%
11042 IF FTIM=0 THEN 11045 ELSE GOSUB 4000:GOTO 11050
11045 GOSUB 30000
11050 IF FTI=999 THEN 11060 ELSE CCC=CVS(WS$(WCC%))
11060 CLOSE #12:CLOSE #13:CLOSE #14
11065 IF CO$="YES" THEN GOSUB 2486 ELSE GOSUB 2482:REM ** OPEN TEMP.FIL **
11070 FLAG=1:RETURN
15000 REM **** WRITE TO ORDER ****
15010 TEMP$=""
15020 FOR J1 = 1 TO 3
15030 LSET F$(J1) = D$(J1)
15040 NEXT J1
15050 FOR J1 = 18 TO 20
15060 TEMP$ = TEMP$+D$(J1)
15070 NEXT J1
15080 LSET CORD$=TEMP$
15090 TEMP$=""
15100 FOR J1 = 3 TO 22
15110 TEMP$=TEMP$+MKI$(D%(J1))
15120 NEXT J1
15130 LSET PCT$=TEMP$
15140 TEMP$=""
15150 FOR J1 = 23 TO 24
15160 TEMP$=TEMP$+MKS$(D(J1))
15170 NEXT J1
15173 FOR J1 = 27 TO 36
15175 TEMP$=TEMP$+MKS$(D(J1))
15177 NEXT J1
15180 LSET SPT$=TEMP$
15190 TEMP$=""
15200 FOR J1 = 1 TO 3
15210 PUT #J1,SRN%
15220 NEXT J1
15225 PUT #7,SRN%
15230 RETURN
20000 REM **** ANY KEY ROUTINE ****
20010 PRINT FNCP$(21,0)"                                    Hit any key to continue
"CUP$
20020 S$=INKEY$:IF S$="" THEN 20020
20030 IF ASC(S$)=190 THEN GOSUB 61230
20040 RETURN
```

```
25000 REM ** SHORT METHOD READ I **
25010 GET #8,RN%:C%=1:T%=1:P%=1
25020 FOR J%=1 TO 2:D%(J%)=CVI(MID$(INR$,C%,2)):C%=C%+2
25030 D#(J%)=CVD(MID$(DPT$,P%,8)):P%=P%+8:NEXT J%
25040 FOR J%=1 TO 22:D(J%)=CVS(MID$(FPT$,T%,4)):T%=T%+4:NEXT J%
25050 FOR J%=7 TO 8:D(J%+18)=CVS(DA$(J%)):NEXT J%
25060 RETURN
26300 REM ** SHORT METHOD READ II **
26310 GET #6,RN%:GET #8,RN%:P%=1:T%=1:C%=1
26315 FOR J%=1 TO 2:D%(J%)=CVI(MID$(INR$,C%,2)):C%=C%+2
26320 D#(J%)=CVD(MID$(DPT$,P%,8)):P%=P%+8:NEXT J%
26330 FOR J%=1 TO 22:D(J%)=CVS(MID$(FPT$,T%,4)):T%=T%+4:NEXT J%
26340 MD$(3)=F$(6):D$(5)=MID$(ROPE$,1,8):RETURN
27000 REM **** dd/mm/yy --> d/ww/yy ****
27010 DMY$=RIGHT$(STR$(DMY),6)
27020 Y1=VAL(MID$(DMY$,1,2)):M1=VAL(MID$(DMY$,3,2)):DD1=VAL(MID$(DMY$,5,2))
27030 Y2=Y1
27040 IF Y1>99 THEN GOTO 27060
27050 Y1=Y1+1900
27060 DF=DD1:MF=M1:YF=Y1:GOSUB 27100:U=ND
27070 D1=Y%(U-7*INT(U/7)+1)
27080 WN=0:GOSUB 27210
27090 RETURN
27100 REM ** SOLVING FOR DAY NO. **
27110 ND=DF-1
27120 FOR I1=1 TO MF-1:ND=ND+L%(I1):NEXT I1
27130 I1=INT(YF/100)
27140 IF YF<>4*INT(YF/4) GOTO 27190
27150 IF YF/100=I1 GOTO 27190
27160 IF ND>59 GOTO 27190
27170 IF MF=3 GOTO 27190
27180 ND=ND-1
27190 ND=ND+36524!*I1+INT(365.25*(YF-100*I1))
27200 RETURN
27210 REM ** SOLVING FOR WEEK NO. **
27220 IF Y2=SY1 THEN 27260
27230 FOR I5=1 TO ((Y2-1)-SY1)
27240 IF SY1+I5=4*INT((SY1+I5)/4) THEN WN=WN+1
27250 NEXT I5
27260 IF Y2=4*INT(Y2/4) AND M1>2 THEN WN=WN+1
27270 WN=WN+L%(SM1)-(SD1-1)+DD1
27280 IF Y2<>SY1 THEN 27310
27290 FOR I1=SM1+1 TO M1-1:WN=WN+L%(I1):NEXT I1
27300 GOTO 27380
27310 ME=12-SM1:I1=SM1+1
27320 FOR I5=1 TO (Y2-(SY1+1)):ME=ME+12:NEXT I5
27330 FOR I5=1 TO ME:WN=WN+L%(I1)
27340 I1=I1+1
27350 IF I1>12 THEN I1=1
27360 NEXT I5
27370 FOR I5=1 TO M1-1:WN=WN+L%(I5):NEXT I5
27380 REM **
27390 IF D1<>7 THEN  WN=WN+7-D1
27400 WN=WN+1:REM ** ALLOWING FOR 1 OF JAN '83 **
27410 WN=INT(WN/7.024039)+1
27420 IF WN>52 THEN WN=WN-52 ELSE GOTO 27450
27430 IF M1=12 AND WN=53 THEN Y2=Y2+1
27440 GOTO 27420
27450 RETURN
30000 REM ** CAP SCREEN **
```

```
30004 R7=4:C7=17:AFLAG=99:GOSUB 410:AFLAG=0
30005 WCC%=CVI(WSC$)
30008 PRINT FNCP$(R7-2,C7)ULON$"SECTION"ULOFF$":"CON$
30010 FOR LOOP=1 TO 7:M=CVS(WS$(LOOP)):NP=2:DP=5:GOSUB 37500
30020 PRINT FNCP$(R7-1+LOOP,C7-10)SPACE$(10)MID$(HD$(LOOP),6,25)M$"
"
30025 NEXT LOOP
30040 PRINT FNCP$(21,0)"Select Capacity (1-7, default="RIGHT$("
"+STR$(WCC%),2)") :                    "CUP$
30050 ROW=21:COL=36:MAXL=2:MINL=0:GOSUB 60980:CC%=VAL(I$):IF CC%<0 OR CC%>7 THEN
30050
30051 IF CC%=0 THEN CC%=WCC%:PRINT FNCP$(21,36)STR$(WCC%)CUP$
30052 IF MID$(HD$(CC%),9,5)="SPARE" OR MID$(HD$(CC%),9,5)="Spare" THEN 30050
30053 WCC%=CC%
30054 PRINT FNCP$(21,0)SPACE$(75)CUP$
30055 PRINT FNCP$(21,17)"Any Alterations (Y/N):"CUP$:MAXL=1:COL=48:GOSUB
60980:IF I$<>"Y" AND I$<>"N" THEN 30055
30056 IF I$="Y" THEN 30040
30060 RETURN
37500 REM ** FORMATTING ROUTINE **
37505 SDP=NP+1
37510 Q=ABS(M)+5*10^(-SDP):M$=RIGHT$(SPACE$(12)+STR$(SGN(M)*INT(Q)),DP)
37520 M$=M$+"."+MID$(STR$(1+Q-INT(Q))+"000000",4,NP):RETURN
40000 REM ***OPENING FILES***
40010 REM OPENING FILES 1,2,3 & 4
40020 FOR J1 = 1 TO 2
40030 FILENAME$ = OD$+RIGHT$(STR$(J1)+".FIL",5)
40040 OPEN "R",#J1,FILENAME$,16
40050 FIELD #J1,16 AS F$(J1)
40060 NEXT J1
40062 FOR J1=4 TO 6:FILENAME$=MD$+RIGHT$(STR$(J1)+".FIL",5)
40064 OPEN "R",#J1,FILENAME$,16:FIELD #J1,16 AS F$(J1)
40066 NEXT J1
40070 OPEN "R",#7,OD$+"ORDER.FIL",112
40080 FIELD #7,24 AS CORD$,40 AS PCT$,48 AS SPT$
40090 OPEN "R",#9,OD$+"RECORD.FIL",2
40100 FIELD #9,2 AS REC$
40110 OPEN "R",#8,MD$+"METHOD.FIL",236
40120 FIELD #8,16 AS F$(8),104 AS ROPE$,16 AS DPT$,88 AS FPT$,4 AS INR$,4 AS
DA$(7),4 AS DA$(8)
40130 OPEN "R",#3,OD$+"3.FIL",16
40140 FIELD #3,16 AS F$(3)
40142 OPEN "R",#12,"CAP1.FIL",8
40143 FIELD #12,8 AS WS$
40144 OPEN "R",#13,"CAP.FIL",70
40145 FIELD #13,40 AS WS0$,2 AS WSC$,4 AS WS$(1),4 AS WS$(2),4 AS WS$(3),4 AS
WS$(4),4 AS WS$(5),4 AS WS$(6),4 AS WS$(7)
40146 OPEN "R",#14,"CTCAP.FIL",2
40147 FIELD #14,2 AS CREC$
40148 GET #14,1
40149 CREC% = CVI(CREC$)
40150 OPEN "R",#10,MD$+"METHO2.FIL",168
40160 FIELD #10,8 AS DA$(1),50 AS DA$(2),50 AS DA$(3),50 AS DA$(4),4 AS DA$(5),4
AS DA$(6),2 AS DA$(9)
40170 OPEN "R",#11,MD$+"RESET.FIL",10
40180 FIELD #11,4 AS RES1$,2 AS RES2$,4 AS RES3$
40190 RETURN
47500 'TO CHANGE ORDER NUMBER ON CASTING ONLY
47510 FOR K=16 TO 1 STEP -1
47520 IF ASC(MID$(D$(2),K,1)) <> 32 THEN 47545
```

```
47530 NEXT K
47545 MID$(D$(2),K,1)="P"
47600 RETURN
50000 REM *** MATCH SUBROUTINE ***
50010 CN% = CN% + 1
50020 IF CN% = CREC%+1 THEN FLAG = 0:RETURN
50030 GET #KF%,CN%
50040 CN$ = WS$
50050 IF LEFT$(CON$,KEYLEN) = LEFT$(CN$,KEYLEN) THEN GOTO 50070
50060 GOTO 50010
50070 FLAG = 1
50080 RETURN
60000 REM ***** GRAPH MAPPING *****
60010 LPRINT CHR$(27)"$"
60012 LPRINT CHR$(27)")"
60015 IF LAG<>0 THEN 60020 ELSE LPRINT CHR$(27)"B"
60020 DEF SEG=&HF000
60025 LPRINT CHR$(152)STRING$(80,CHR$(149))CHR$(153)
60030 FOR I2=0 TO 23
60040 WE$="":LPT1$=""
60050 FOR J2=0 TO 158 STEP 2
60060 WU=PEEK(I2*160+J2):IF WU<64 THEN WU=WU+156 ELSE WU=WU-64
60070 WE$=WE$+CHR$(WU)
60080 NEXT J2
60090 FOR J2=1 TO 80
60095 W=ASC(MID$(WE$,J2,1))
60097 IF W=32 THEN W1=32:GOTO 60110
60098 IF W=160 THEN W1=241:GOTO 60110
60100 IF W<128 THEN W1=W:GOTO 60110
60102 IF W=194 THEN W1=145 ELSE IF W=180 THEN W1=146 ELSE IF W=196 THEN W1=149
60103 IF W=179 THEN W1=150 ELSE IF W=218 THEN W1=152 ELSE IF W=191 THEN W1=153
60104 IF W=192 THEN W1=154 ELSE IF W=217 THEN W1=155
60105 Z=127:J6=1:FOR J7=1 TO 15 STEP 2
60106 IF (W=Z+J7 OR W=Z+J7+1 OR W=Z+16+J7 OR W=Z+16+J7+1) THEN W1=Z+J6
60107 J6=J6+1:NEXT J7
60110 LPT1$=LPT1$+CHR$(W1)
60120 NEXT J2
60130 LPRINT CHR$(150)LPT1$CHR$(150)
60135 IF (I2=0 OR (I2=2 AND LAG=1)) THEN LPRINT
CHR$(150)STRING$(80,CHR$(149))CHR$(150)
60140 LPT1$="":NEXT I2
60142 LPRINT CHR$(154)STRING$(80,CHR$(149))CHR$(155)
60145 LPRINT CHR$(27)"A"CHR$(27)"<"
60150 RETURN
60700 MAXL=8:REM *** DATE CHANGE ROUTINE ***
60710 GOSUB 60980:IF VAL(I$)=0 THEN COMDAT=0:DAT$="0":GOTO 60820
60720 A=INSTR(I$,"/"):IF A=0 THEN A=INSTR(I$,".")
60730 IF A=0 THEN 60700 ELSE P$=LEFT$(I$,A-1)
60740 B=INSTR(A+1,I$,"/"):IF B=0 THEN B=INSTR(A+1,I$,".")
60750 IF B=0 THEN 60700 ELSE B$=MID$(I$,A+1,B-(A+1))
60760 C$=MID$(I$,B+1,2)
60770 A=VAL(P$):B=VAL(B$):C=VAL(C$)
60780 IF B<1 OR B>12 OR A<1 OR A>31 OR C>99 OR C<81 THEN 60700
60790 COMDAT=(C*10000)+(B*100)+A
60800 DAT$=P$+"/"+B$+"/"+C$
60810 PRINT FNCP$(ROW,COL)DAT$CUP$:RETURN
60820 I$=DTE$:PRINT FNCP$(ROW,COL)I$:GOTO 60720
60980 REM INPUT STRING ROUTINE
60990 I$=""
61000 PRINT FNCP$(ROW,COL)I$RON$SPACE$(MAXL-LEN(I$))ROFF$CUP$
```

```
61010 GOSUB 61110
61020 IF X=8 THEN GOTO 61060
61030 IF X=13 AND LEN(I$))=MINL THEN GOTO 61080 ELSE IF X=13 GOTO 61000
61040 IF LEN(I$)(MAXL THEN I$=I$+A$
61050 GOTO 61000
61060 IF LEN(I$))0 THEN I$=LEFT$(I$,LEN(I$)-1)
61070 GOTO 61000
61080 I$=LEFT$(I$+SPACE$(MAXL),MAXL)
61090 PRINT FNCP$(ROW,COL)I$CUP$
61100 RETURN
61110 REM GET VALID CHARACTER
61120 A$=INKEY$:IF A$=""THEN GOTO 61120
61130 X=ASC(A$)
61140 IF (X)31 AND X(91 AND X()34 AND X()37) OR X=8 OR X=13 THEN RETURN
61150 IF X=27 THEN CLOSE:CHAIN "ONLINE"
61160 IF X=190 THEN GOSUB 61200
61170 IF X=186 THEN GOSUB 62000:LPRINT
61180 IF X=189 THEN GOSUB 62000:FOR L=1 TO 10:LPRINT:NEXT L
61190 RETURN
61200 REM
61230 DEF SEG = &HF000
61240 FOR I2 = 0 TO 23
61250 WE$=""
61260 FOR J2 = 0 TO 158 STEP 2
61270 WE$=WE$+CHR$(ABS(PEEK(I2*160+J2)-64))
61280 NEXT J2
61290 LPRINT WE$
61300 NEXT I2
61310 WIDTH 255
61320 RETURN
62000 RETURN:REM "**** GENERAL ERROR ROUTINE ****"
62010 PRINT FNCP$(21,0)"            SYSTEM ERROR "ERR" ENCOUNTERED AT LINE
"ERL" - HIT ANY KEY "CHR$(7)CUP$
62020 A$=INKEY$:IF A$="" THEN 62020
62030 X=ASC(A$):IF X=27 THEN 61150
62040 PRINT FNCP$(21,0)SPACE$(79)CUP$
62050 RESUME
63998 END
63999 REM "C2 (APRICOT86A01/E - CRE 27/11/85)
```

REFERENCES

REFERENCES

1. Diggles, A.P., 'Computer and Foundry Management', Foundry Trade Journal, (153), pp. 314-318, August 1982

2. McCombe, C., 'West Midland Foundry Industry Resurgent', Foundry Trade Journal, (159), No. 3310, pp. 51-63, July 18th 1985

3. Unattributed, 'Robots', The British Foundryman, (78), No. 6, pp. 30-32, July 1985

4. Gledhill, N., and Parker, J., 'UK ironfounding - an overview', Metals and Materials, pp. 94-96, February 1986

5 Siefer, W., and Orths, K., 'The Foundry Industry In the Eighties', Foundry M & T, (111), No. 1, pp. 24-27, January 1983

6. Unattributed, 'Casting Shipments Will Recover', Foundry M & T, (112), No. 1, pp. 22-26, January 1984

7. Greening, N., 'Developments and Trends in the Ferrous Castings Industry', The Production Engineer, (54), pp. 233-236, April 1975

8. Lamont-Smith, S.G., "Medium term prospects for ferrous foundries', The British Foundryman, (68), Part 11, pp. 281-285, November 1975

9. Unattributed, 'ICC Business Ratios Report - Iron Foundries', Inter Company Comparisons Information Group Limited, 1983

10. Hitchens, D.M.W.N., 'Business Efficiency in Ironfounding: A Study of a Competitive Industry', Technicopy Ltd, pp. 1-16, 1977, England

11. Kennedy, A.J., 'Traditional Industries in a non-traditional world', The British Foundryman, (77), Part 8, pp. 421-428, October 1984

12. Reynolds, J.A., and Stevenson, R., 'The Foundry Industry and The Economy - Action and Interaction', The British Foundryman, (77), Part 2, pp. 75-81, February/March 1984

13. Southall, J.T., and Law, T.D., 'Approaches to improved job scheduling in foundries', The British Foundryman, (73), pp. 287-291, October 1980

14. Harrison, M., 'A suitable case for treatment', The Engineer, (256), No. 6635, pp. 22-23, May 26th 1983

15. Parry, C.W., 'The role of R + D in a basic industry', R + D Management, (28), No. 4, July/August 1985

16. Unattributed, '18th Census of World Casting Production - 1983', Modern Casting, (74), No. 12, pp. 19-21, December 1984

17. Report of Working Group M62., 'Whose Foundry Needs Production Control', The British Foundryman, (76), Part 10, pp. 176-183, October 1983

18. Knight, C.F., 'Computer Technology in the Foundry Industry', Modern Casting, (52), No. 3, pp. 89-100, September 1967

19. Law, T.D., and Humphrey, C.D., 'The Application of Computers in the Foundry Industry', The British Foundryman, (62), No. 3, pp. 117-131, March 1969

20. Crook, A.J., 'Management Attitudes and Techniques in the Future', The British Foundryman, (64), No. 11, pp. 411-418, November 1971

21. Grandpierre, M., 'Data Processing and Automation', Foundry Trade Journal, (137), pp. 317-330, September 1974

22. Niles, J.L., 'Systems, Productivity, and the Great Rhode Island Apple Shortage', Production and Inventory Management 1st Quarter, (24), 1983

23. Law, T.D., 'How to use foundry consultants', The British Foundryman, (78), pp. 223-225, June 1985

24. Apsley, S.D., 'The use of the consultant in the foundry', The British Foundryman, (78), pp. 220-221, June 1985

25. Unattributed, 'Survey: Production Control', Which Computer?, May 1984, London

26. Hamlin, M., 'How to play the field in Computer Selection', BPICS Control, (11), No. 1, pp. 20-23, December/January 1985

27. Willmore, N., 'Users call for end to 'cowboy consultancies', Computer News, No. 137, p. 10, August 28th 1986, London

28. Scrimshire, D.A., Law, T.D., and Dallmer, D.A., 'Computerized Foundry Production Scheduling - An analysis of Problems and Solutions', A.F.S. Transactions, pp. 151-159, 1984

29. Griffiths, A.J., and Lewis, H.J., 'Robots in Foundries', Production Engineer, (65), No. 2, p. 43, February 1986

30. Corke, D.K., 'A Guide To CAPM', The Institution Of Production Engineers, 1985, London

31. Rushton, D.F.H., 'How does CAPM work?', The Production Engineer, (63), No. 9, p. 17, September 1984

32. Southern, T., 'What does a CAPM system consist of ?', The Production Engineer, (63), No. 9, pp. 15-16, September 1984

33. Barber, K.D., 'CAPM - little cause for optimism', The Production Engineer, pp. 12-13, (63), No. 11, November 1984

34. Unattributed, 'What is CAPM and why do we need it?', The Production Engineer, (64), No. 6, pp. 25-27, June 1985

35. Yates, A.T., and Fuller, A.G., 'An Introduction to the Principles of Production Control', BCIRA Journal, (20), No. 1, pp. 55-62, January 1972

36. Seman, N.G., 'Iron Foundrymen Study Efficient use of EDP', Foundry M & T, (106), pp. 86-90, December 1978

37. Wild, R., 'The Techniques of Production Management', Holt, Rinehart and Winston Ltd, 1971, Surrey

38. Ingham, H., 'Balancing Sales and Production', Pitman, 1971, London

39. Rowan, T.G., and Chatterton, A.N., 'The Production Systems

Audit', The Production Engineer, (53), No. 2, 1974

40. Warnecke, H.J., and Scharfe, P., 'Some criteria for the development of integrated manufacturing systems', Proceedings of the second International Conference on Production Research, 1973, Copenhagen

41. Barber, K.D., and Hollier, R.H., 'The use of Numerical Analysis to Classify Companies According to Production Control Complexity', International Journal of Production Research, (24), No. 1, pp. 203-222, 1986

42. Working Group E2., 'The use of the computer in foundry management control', The British Foundryman, (67), pp. 180-186, July 1974

43. Unattributed, 'Deere Waterloo's Computer Reporting System', Foundry M & T, (103), No. 9, pp.91-94, September 1975

44. Unattributed, 'Caterpillar Builds a New Foundry', Foundry, (97), pp. 87-112, May 1969

45. Burbidge, J.L., 'The Principles of Production Control', 4th Edition, Macdonald and Evans Limited, pp. 13-17, Plymouth 1978

46. Unattributed, 'On-line Computer Aids Fick Foundry Marketing', Foundry M & T, (107), No. 6, pp. 134-138, June 1979

47. AFSI, 'Industrial Engineering in the Foundry', Published by the American Foundrymen's Society Inc., pp. 5-9, 1963

48. Trinder, C.V., and Watts, G.A., 'Production Control in the non-ferrous castings industry', The British Foundryman, (66), pp. 237-244, August 1973

49. Unattributed, 'J. King & Co (Leeds) Ltd Adopt "SWORD" Workshop Scheduling Computer Program', Foundry Trade Journal, (145), pp. 1038-1042, October 1978

50. Montgomery-Smith, A., and Owen, M.S., 'What a computer can do for a foundry', BCIRA Journal, (21), No. 1, pp. 51-56, January 1973

51. Jones, G.L., 'Computer-Aided Production Control for Jobbing and Short Series Foundry Work', Foundry Trade Journal, (142), No. 3106, pp. 439-468, March 3rd 1977

52. Law, T.D., and Green, R.J., 'The use of computers for foundry scheduling and production control', The British Foundryman, (63), No. 5, pp. 138-153, May 1970

53. First Report of Working Group M62(E7), 'Outline requirements for a production planning and control system for a foundry', The British Foundryman, (76), pp. 56-59, 1983

54. Seman, N.G., 'Computer Utilization in the Foundry', Foundry M & T, (106), pp. 44-57, November 1978

55. Montgomery-Smith, A., Fuller, A.G., Deaner, R.G., and Owen, M.S., 'The development of computer assisted production control', The British Foundryman, (66), No. 5, pp. 142-152, May 1973

56. Binmore, A.C., 'An introduction to the use of the computer as an aid to foundry management', The British Foundryman, (62), No. 6, pp. 224-229, June 1969

57. Laney, R.S., 'Foundry Manufacturing Software Must Meet Varied Needs', Foundry M & T, (110), No. 3, pp. 29-39, March 1982

58. Waespi, W., 'Electronic data processing in foundry operations', The British Foundryman, (63), No. 2, pp.44-59, February 1970

59. Binmore, A.C., 'Industrial Engineering', The British Foundryman, (70), Part 7, pp. 183-190, July 1977

60. Benz, H., 'Production Control and Scheduling in a Foundry by means of Electronic Data Processing', Foundry Trade Journal, (136), No. 2993, pp. 395-400, April 11th 1974

61. Deaner, R.G., and Owen, M.S., 'Use of the BCIRA-Hoskyns system in Production Planning, BCIRA Journal, (22), No. 3, pp. 282-285, May 1974

62. Second Report of Working Group E2, 'Computer Applications in Foundries - Part 1', The British Foundryman, (72), pp. 204-208, 1979

63. Third Report of Working Group E2, 'Computer Applications in Foundries - Part 2', The British Foundryman, (72), pp. 237-239, 1979

64. Kanicki, P., and Bailey, R., 'Micros and Minis lead Metalcasting into Computer Age', Modern Casting, (74), pp. 21-24, February 1984

65. Dahlke, D.W., 'Steel Metalcaster Computerises Operations', Modern Castings, (55), No. 3, pp. 93-95, April 1969

66. Unattributed, 'Small Computer Reduces Growing Pains', Foundry, (99), No. 11, pp. 120-122, November 1971

67. Wakefield, B.D., 'Computer Untangles Foundry Problems', Iron Age, (207), No. 12, p. 57, March 25 1971

68. Varley, C., and Daniels, G.M., 'Computer assisted production control in a small jobbing repetition foundry', The British Foundryman, (65), pp. 198-201, May 1972

69. Wagner, A.J., 'Small Computer Pays Its Way', Modern Casting, (62), pp. 35-37, December 1972

70. Rohmiller, C.E., 'Scheduling For Profit', Trans A.F.S, (83), pp. 415-418, 1975

71. Drago, D., 'Production Planning with an Office Computer', Foundry M & T, (104), pp. 62-70, April 1976

72. Duff, J.R., 'A total computer-based administration for a medium sized foundry', The Production Engineer, (55), No. 5, pp. 253-256, May 1976

73. Unattributed, 'A Pragmatic Approach to Foundry Computerisation - Draycast Foundries Adopt a Comprehensive Scheme', Foundry Trade Journal, (47), No. 3177, pp. 1212-1216, December 6th 1979

74. Ferguson, D., and Notte, M.A., 'How Speciality Casts Did It', Modern Casting, (72), pp. 55-57, April 1982

75. Casper, T.V., 'Kapazitatsterminierung in der GieBereiindustrie mit Hilfe der elektronischen Datenverarbeitung', Giesserei,

(57), No. 25, pp. 788-792, December 3rd 1970

76. Lawrence, A., 'Are CAPM Systems Just Too Complex?', Industrial Computing, p. 13, September 1986

77. Watts, G.A., 'Production Control in Non-Ferrous Foundries', Foundry Trade Journal, (134), pp. 651-652, May 1973

78. Andres, C.E., 'Practical Production Controls for the Jobbing Foundry', Modern Casting, (52), No. 5, pp. 77-87, October 1967

79. Trinder, C.V., and Moss, P., 'Real-Time Systems for Foundry Production Control', The British Foundryman, (77), Part 8, pp. 429-435, October 1984

80. Sabaratnum, S., 'Development of a micro-based Foundry Production Control System', PhD Thesis, December 1982, The University of Aston In Birmingham

81. Law, T.D., and Southall, J.T., 'Current computer applications in foundries', The British Foundryman, (67), pp. 173-179, July 1974

82. Varley, C., and Daniels, G.M., 'Computer assisted production control in a small jobbing repetition foundry', The British Foundryman, (65), pp. 198-201, May 1972

83. DeSilvio, L.F., '(Computerizing Your Foundry) Your Needs Come First', Modern Casting, (72), No. 3, pp. 36-37, March 1982

84. Cave, B.J., Private Communication

85. Mamdami, A., '"Fuzzy Logic"', The Engineer, (254), pp. 44-45, October 21st 1982

86. Kramme, L.W., 'What A Computer Can Mean To Your Foundry', Modern Casting, (72), No. 4, pp. 54-55, April 1982

87. Kotschi, R.M., 'What every foundryman needs to know about computers. Part 4. Data Base Management', Modern Casting, (74), pp. 33-36, January 1984

88. Weil, J., 'Real time production control in a small foundry',

Proceedings of the BNF fifth computer conference - BNF Technology Centre, 27th - 28th November 1978, Wantage

89. Unattributed, "Production Control - A Market Survey', Which Computer?, pp. 115-121, June 1985, London

90. Unattributed, "Production Control - A Market Survey', Which Computer?, pp. 96-107, May 1985, London

91. Unattributed, 'Production Control Systems - Our Annual Survey', Which Computer?, pp. 29-37, Deceber 1980, London

92. Unattributed, 'Survey: Production Control Systems', Which Computer?, pp. 62-70, March 1983, London

93. Unattributed, 'Market Survey: Production Control', Which Computer?, pp. 101-108, April 1986, London

94. Barber, K.D., and Hollier, R.H., 'The effects of computer-aided Production Control Systems on Defined Company Types', International Journal of Production Research, (24), No. 2, pp. 311-327, 1986

95. Law, T.D., Private Communication

96. Baker, K.R., 'Introduction to Sequencing and Scheduling', John Wiley and Sons, Inc., USA 1974

97. Conway, R.W., Maxwell, W.L., and Miller, L., 'Theory of Scheduling', Addison-Wesley Publishing Co., 1967, New York

98. Simpson, M.G., 'Batch Production Scheduling', The Production Engineer, (46), pp. 88-92, February 1967

99. Mellor, P., 'Job Shop Scheduling', The Production Engineer, (46), pp. 82-86, February 1967

100. Dogramaci, A., 'Production Scheduling of Independent Jobs on Parallel Identical Processors', International Journal Of Production Research, (22), No. 4, pp. 535-548, 1984

101. Eilon, S., 'Job Shop Scheduling', The Production Engineer, (56),

pp. 47-48, January/February 1977

102. Gifler, B., and Thompson, G.L., 'Algorithms for Solving Production Scheduling Problems', Operations Research, (8), pp. 487-503, 1960

103. Gonzalez, J., and Reeves, G.R., 'Master Production Scheduling: a multiple-objective linear programming approach', International Journal of Production Research, (21), No. 4, pp. 553-562, 1983

104. Gupta, S.K., 'n jobs and m machines job-shop problems with sequence-dependent set-up times', International Journal of Production Research, (20), No. 5, pp. 643-656, 1982

105. Hitomi, K., and Ham, I., 'Operations Scheduling for Group Technology Applications', CIRP Annals: Manufacturing Technology, pp. 419-422, 1976, Berne

106. Lee, W.B., Steinberg, E., and Khumawala, B.M., 'Aggregate versus disaggregate production planning: a simulated experiment using LDR and MRP', International Journal of Production Research, (21), No. 6, pp. 797-811, 1983

107. Muhlemann, A.P., Lockett, A.G., and Farn, C.K., 'Job-Shop Scheduling Heuristics and Frequency of Scheduling', International Journal of Production Research, (20), No. 2, pp. 227-241, 1982

108. Park, Y.B., Pegden, C.D., and Enscore, E.E., 'A survey and evaluation of static flowshop scheduling heuristics', International Journal of Production Research, (22), No. 1, pp. 127-141, 1984

109. Parry-Hughes, G., 'The Structured Approach to Batch Control', Control and Instrumentation, (17), No. 3, pp. 39-41, March 1985

110. Sahney, V.K., and Kapur, K.C., 'An optimization model for labour limited scheduling under a round robin policy', International Journal Production Research, (12), No. 3, pp. 377-390, 1974

111. Sarin, S.C., and Elmaghraby, S.E., 'Bounds on the performance of a heuristic to schedule precedence - related jobs on parallel machines', International Journal of Production Research, (22), No. 1, pp. 17-30, 1984

112. Southall, J.T., 'Aspects of Management Control In the Foundry Industry', PhD Thesis, 1978, The University of Aston In Birmingham

113. Wang, M.F., and Rosenshine, M., 'Scheduling for a combination of made-to-stock and made-to-order jobs in a job shop', International Journal of Production Research, (21), No. 5, pp. 607-615 September/October 1983

114. King, J.R., 'The theory-practice gap in job-shop scheduling', The Production Engineer, (55), No. 3, pp. 138-143, March 1976

115. Tatsiopoulos, I.P., and Kingsman, B.G., 'Lead-Time Management', European Journal of Operation Research, (14), pp. 351-358, 1983

116. Berr, U., and Papendieck, A., 'Produktionsreihenfolgen und Losgrossen', Werkstattstechnik, (4), No. 60, pp. 191-196, 1970

117. Gillespie, J.J., 'Foundry Organisation And Management', Sir Isaac Pitman And Sons Limited, 1937, London

118. Blackstone, J.H., Phillips, D.T., and Hogg, G.L., 'A State-of-the-Art survey of dispatching rules for manufacturing job shop operations', International Journal of Production Research, (20), No. 1, pp. 27-45, 1982

119. Browne, J., and Davies, B.J., 'The Design and Validation of a Digital Simulation Model for Job Shop Control Decision Making', International Journal of Production research, (22), No. 2, pp. 335-357, 1984

120. Sim, N.H., MSc. Thesis, 1978, The University of Aston In Birmingham

121. Scheel, J., 'Making to Order - Management Strategies as a Basis for Production Planning Systems', The Nineteenth European Technical Conference on Production and Inventory Control, pp. 60-77, 15th - 17th November 1984

122. Harrison, M.C., 'The Concepts of Optimized Production Technology (OPT)', Proceedings from The Twentieth European Technical Conference and Exhibition on Production and Inventory Control, pp. 15-28, October 24th-26th, 1985, Birmingham

123. Laing, R.M., 'Master Scheduling, Manufacturing Planning and Management Education', BPICS Control, (11), No. 1, 24th January 1985

124. Black, J., 'Developing Your Own Capacity Planning System', The Production Engineer, (63), No. 3, pp. 29-31, March 1984

125. Orlicky, J., 'Material Requirements Planning', McGraw-Hill Book Company, 1975, USA

126. Novitsky, M.P., 'Master Production Scheduling in Process Industries', Production and Inventory Management 1st Quarter, (25), pp. 48-53, 1984

127. Teplitz, C.J., 'MRP can work in your Jobshop', Production and Inventory Management 4th Quarter, (19), pp. 21-26, 1978

128. Goddard, W.E., 'Practical Principles of Capacity Planning', BPICS Control, (12), No. 4, pp. 9-17, June/July 1986

129. NEDO, 'Computers in Production Control', National Economic Development Office, p. 2, May 1985

130. King, J.R., 'Production Planning and Control (PPC) by Computer: A Survey', The Production Engineer, (51), No. 10, pp. 333-336, October 1972

131. Burcher, P.G., Private Communication

132. Unattributed, 'Survey Summary. The Market for IT in Engineering', Published by Butler Cox & Partners Ltd, 1984, London

133. Graham, S.H., 'How to Computerise your Production Control Facility (or not as the case may be)', BPICS Control, (11), No. 6, pp. 30-31, October/November 1985

134. Southern, G., 'CAPM System Transparency in Small Companies', BPICS Control, (11), No. 5, pp. 13-19, August/September 1985

135. Lucas, D., 'Putting CIM theory into practice', The Engineer, (260), No. 6739, pp. 67-71, May 23rd 1985

136. Kochhar, A.K., 'Why Computerised Production Control Systems continue to disappoint', The Production Engineer, (61), No. 12, December 1982

137. Kochhar, A.K., 'Implementation of computerised production control systems - the gap between success and failure', BPICS Control, (10), No. 6, pp. 15-19, October/November 1984

138. Forsman, E., 'Conducting The Needs Analysis', Modern Castings, (72), No. 3, pp. 38-39, March 1982

139. Lockyer, K.G., 'Production Management - The Art Of The Possible', International Journal Of Operations And Production Management, (4), No. 4, pp. 28-36, 1984

Additional Reading

140. Lee, S.M., and Ebrahimpour, M., 'Just-In-Time Production System: Some Requirements For Implementation', International Journal Of Operations and Production Management, (4), No. 4, pp. 3-15, 1984

141. Haylett, R., 'OPT - production control with a difference', The Production Engineer, (65), No. 5, pp. 34-41, May 1986

142. Pendlebury, J., and Yeomans, J., 'OPT - The Challenge To Decision Makers', BPICS Control, (11), No. 4, p. 17, June/July 1985

143. Unattributed, 'Scheduling: MRP and other sacred cows slaughtered', Works Management, (38), No. 1, p. 7, December 1984/January 1985