CLM-R 237

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Report

PROJECT PLANNING

FROM SIMPLE NETWORKS TO PROCESSING BY COMPUTER

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CULHAM LABORATORY
Abingdon Oxfordshire

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PROJECT PLANNING

FROM SIMPLE NETWORKS TO PROCESSING BY COMPUTER

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'PLANS NEVER WORK BUT PLANNING IS IMPORTANT'
Dwight D. Eisenhower

SUMMARY

The use of special techniques is essential to the management of complex projects. The techniques available to determine a project's duration, cost and manpower requirements are discussed and instruction given in their application. It is assumed that the reader does not have prior knowledge of the subject.

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C O N T E N T S

SECTION 1

INTRODUCTION

As projects increase in size and complexity sophisticated procedures have to be used to monitor progress, expenditure and manpower requirements. The use of these procedures is illustrated by taking a small project as a model, showing how its construction can be planned by drawing a logic diagram and how the information shown on the diagram can be processed by computer.

The techniques described can be applied to both small and large projects. For the former, where there may be only a few hundred activities, it might well be possible to process the plan manually. For most projects of this size it is possible for the officer responsible for the project to draw up and manage the plan himself but, in the case of the large project processing by computer is essential requiring the appointment of a Planning Officer with appropriate support staff.

Information in many forms has to be provided at various stages of construction to meet the needs of those concerned with the project at all levels:-

For example:-

(a) Plans are required at the conceptual stage in parallel with the preparation of outline specifications and designs. Although information at this time will be of a global nature planning will draw the attention of management to problem areas which must be given priority if an optimum target date for completion is to be achieved.

(b) Where the estimate of time taken for the completion of a task is exceeded this has to be drawn to the attention of the Project Manager for him to take appropriate remedial action.

(c) The form in which the information is supplied must be easily understood by staff who may not be concerned with planning logic but are interested in seeing how they are affected. This applies equally to Senior Management, who are interested in the overall time scale and resource requirements, to junior staff with a need to know when their piece of equipment, or drawing, is required.

To integrate the many hundreds of inter-disciplinary tasks, which go to make up a typical project, so-called NETWORK DIAGRAMS are used to determine the order in which the tasks are to be dealt with and to highlight those which are critical to the projects' completion on time. The construction of a diagram, and its preparation for both manual and computer processing, is described. The manufacture of a pump unit is taken as a model common to all sections. As this project has been described previously (Section 8 - references 1 and 2) details which are not dealt with here might be covered in the published literature.

It will be seen that there are slight differences in presentation between the network construction and computer processing sections. The reason for this is that the constructional aspects are described in a language which is similar to that used in other manuals, so that the beginner will not be too confused by differences in terminology. As the method used for computer processing will be based on the project control software developed by the Organisation, or provided by a specialist software house, alterations to the standard terminology are necessary. The presentation described here has been developed at the UKAEA's Culham Laboratory to control the design and construction of experiments for research into the production of power by the nuclear fusion process. In addition to printing out project data this system will also produce computer plots of networks and resource requirements against a time base.

The beginner is advised to study Section 2 first and then complete the examples in Appendix 3 and some from the books listed in Section 8 (6 - Critical Path Analysis - Problems and Solutions - being particularly recommended). To appreciate that projects do not proceed as planned, read Appendix 2. Follow with Section 3 which shows how the network can be converted into bar chart form to meet the needs of staff referred to in (c) above. Having now mastered the manual techniques, proceed to Sections 5, 6 and 7 to learn how to deal with resources and how to schedule the network data for processing by the computer.

SECTION 2

CONSTRUCTING A NETWORK DIAGRAM

For illustration purposes the manufacture of a pump unit (Section 8 - references 1 and 2) is taken as being a typical construction project embracing: design, specification, manufacture and test work.

The first thing to do is to draw up a list of the tasks which have to be undertaken. These tasks are termed ACTIVITIES. This is a subjective exercise, unique to the person drawing up the plan. Someone else would describe the project in a different way but the end result should be about the same. For a large multi-discipline project this work is carried out by a Planning Officer under the guidance of specialists. ACTIVITY

The activities are not listed in any special order at this stage being simply a schedule of work:-

TABLE 2.1

THE PUMP UNIT PROJECT

Design pump unit
Detail Impeller and shaft
Specify motor and coupling
Manufacture impeller
Detail casing
Manufacture shaft
Detail bedplate
Contract action for motor
Contract action for coupling
Manufacture casing
Manufacture bedplate
Manufacture motor
Manufacture coupling
Assemble pump unit
Test pump unit

This list is now studied to determine the sequence of operation. The first attempt will probably be unsuccessful and several attempts may be necessary to produce a diagram pleasing to the eye and which also shows the activities in a logically correct sequence. The first attempt should therefore be in rough form on a large sheet of paper when the most valuable tool will be found to be an eraser.

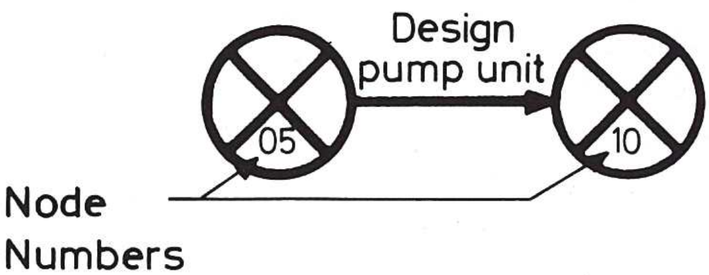
The activity to be dealt with first is 'Design Pump Unit'. To represent this a line is drawn with an arrow to indicate the flow of work as shown by Fig.2.1.

To identify this activity circles are drawn at each end of the line. These circles are referred to as NODES and are divided into four sectors. As the network develops numbers are entered in the sectors for activity coding and programme timing reference purposes. The lower sector is used to identify the node and since there are 15 activities it is reasonable to assume that there will be about the same number of nodes. These could be numbered 1, 2, 3 etc. but there might be difficulties in the future if a new activity has to be included. To allow for this an allowance is made in the numbering system by using a sequence 05, 10, 15, etc.

NODES

To illustrate:-

Fig. 2.1



The node number is often used to highlight an EVENT in the programme. For example 'Event 10' occurs when the pump unit has been designed. An event of particular significance to the project's completion is sometimes referred to as a MILESTONE EVENT. The node numbers main use is to identify the activity for example, the activity above, which links nodes 05 and 10 is described as:-

EVENT

MILESTONE EVENT

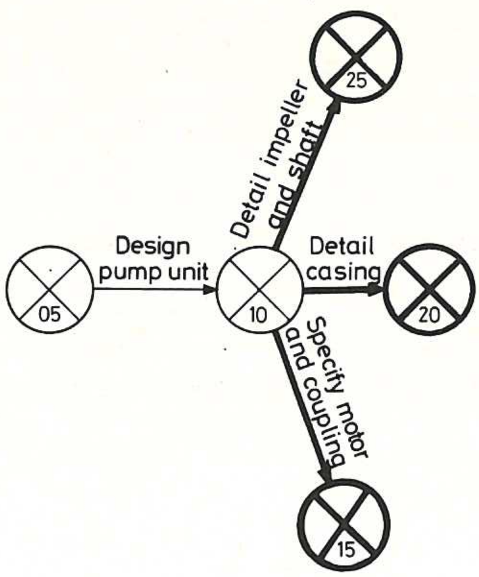
ACTIVITY DESCRIPTION

ACTIVITY 05 - 10

The description of 'Design Pump Unit' can be added but where space is limited, on a costing sheet for example, 05 - 10 is sufficient as it is unique to this activity.

Having designed the unit detail drawings and specifications can be prepared. As these follow the first activity they are drawn to the right of it to show that the flow of work proceeds from the left to the right of the diagram:-

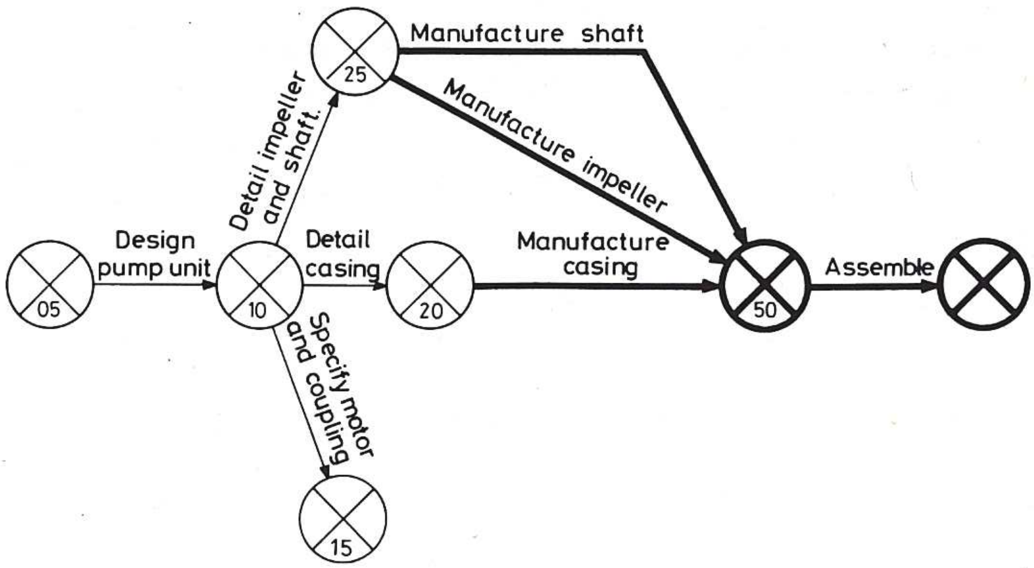
Fig. 2.2



Activities following on from the above are drawn in a series - parallel configuration to eventually converge on to a common activity.

After detailing the impeller, shaft and casing, manufacture of all three can proceed as parallel activities followed by an assembly operation, noting that the last activity cannot be identified at this time. There is however, a further problem of identification as a network might show:-

Fig. 2.3



This is incorrect* as the two activities MANUFACTURE SHAFT and MANUFACTURE IMPELLER have the same 25 - 50 identity. To identify them separately it is necessary to introduce the DUMMY activity. The network will now appear as Fig 2.4.

DUMMY

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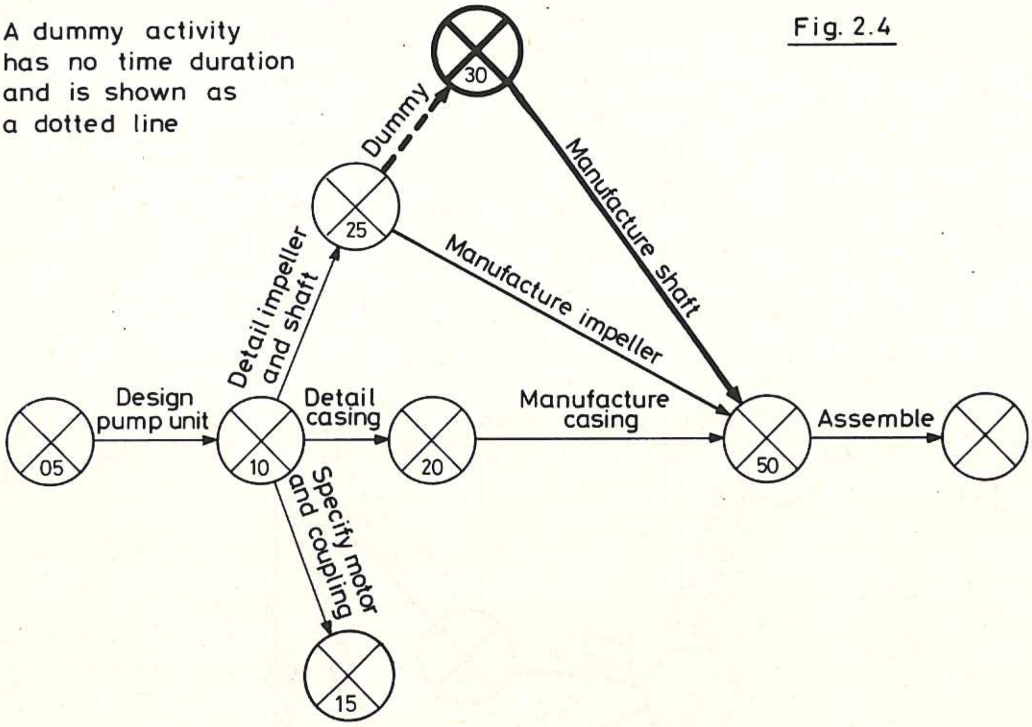
* When processing by computer this is permissible - See Section 5

A dummy activity has no time duration and is shown as a dotted line

Fig. 2.4

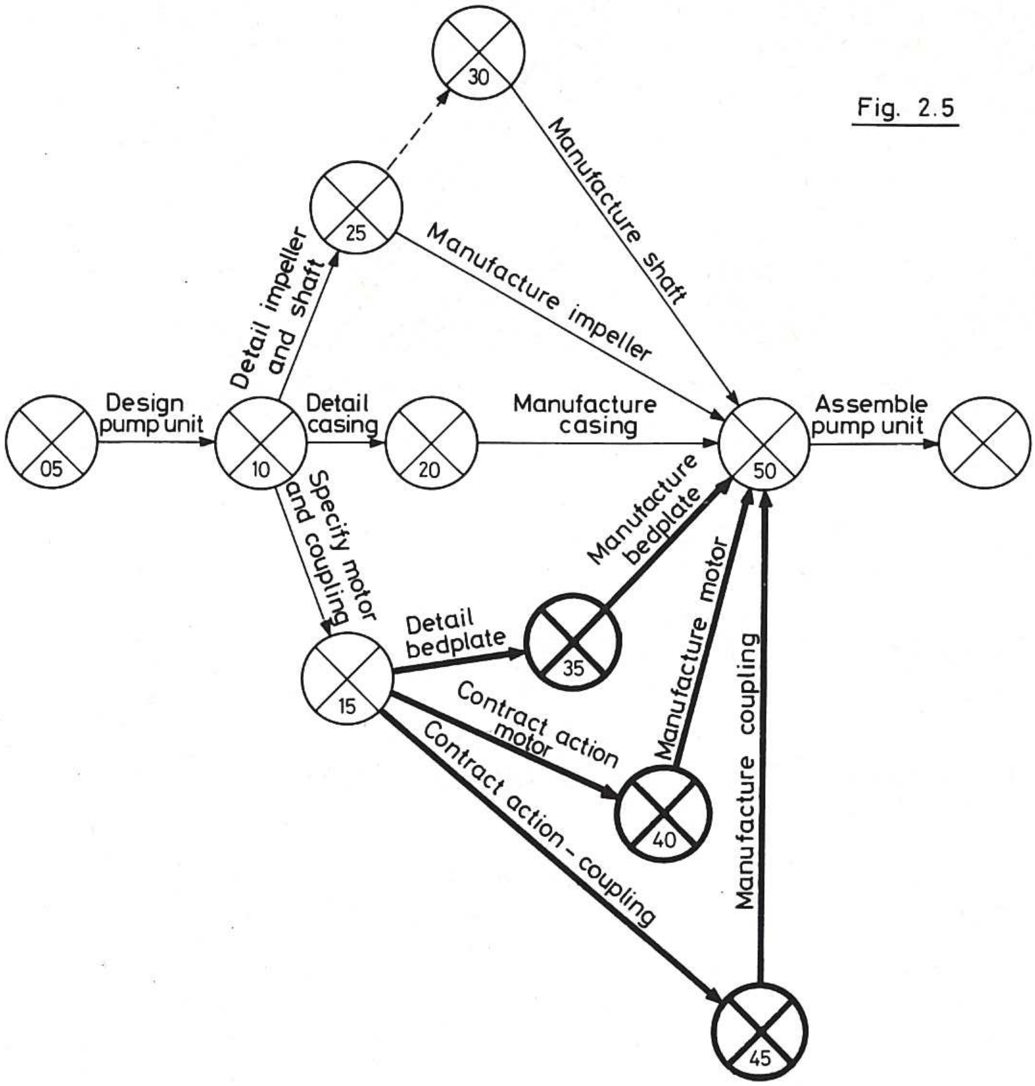


These activities can now be indentified as

25 - 50 Manufacture impeller

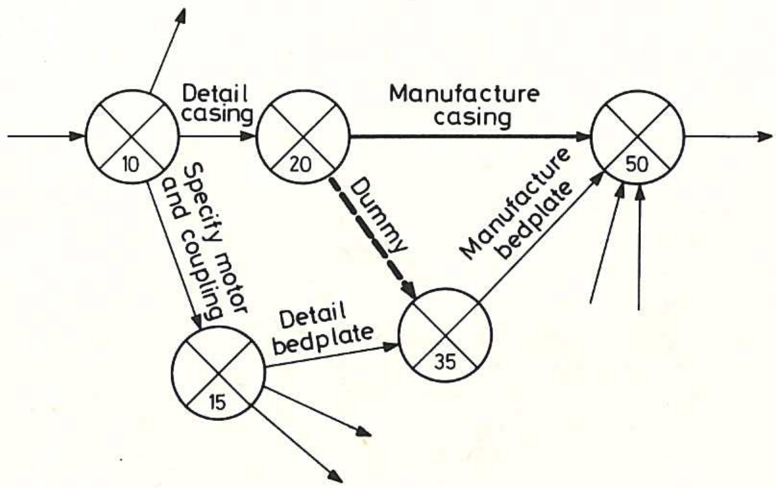
30 - 50 Manufacture shaft

Before assembly can start the motor, coupling and bedplate have to be obtained. As this work can proceed in parallel with the above it is shown:-



On examination of the network at this stage it might be decided that manufacture of the casing can proceed immediately detailing is complete but manufacture of the bedplate cannot start until both the casing and bedplate have been fully detailed. This dependency is shown by another use of the dummy activity to link nodes 20 and 35 being particularly careful to use an arrow to indicate the flow of work.

Fig. 2.6



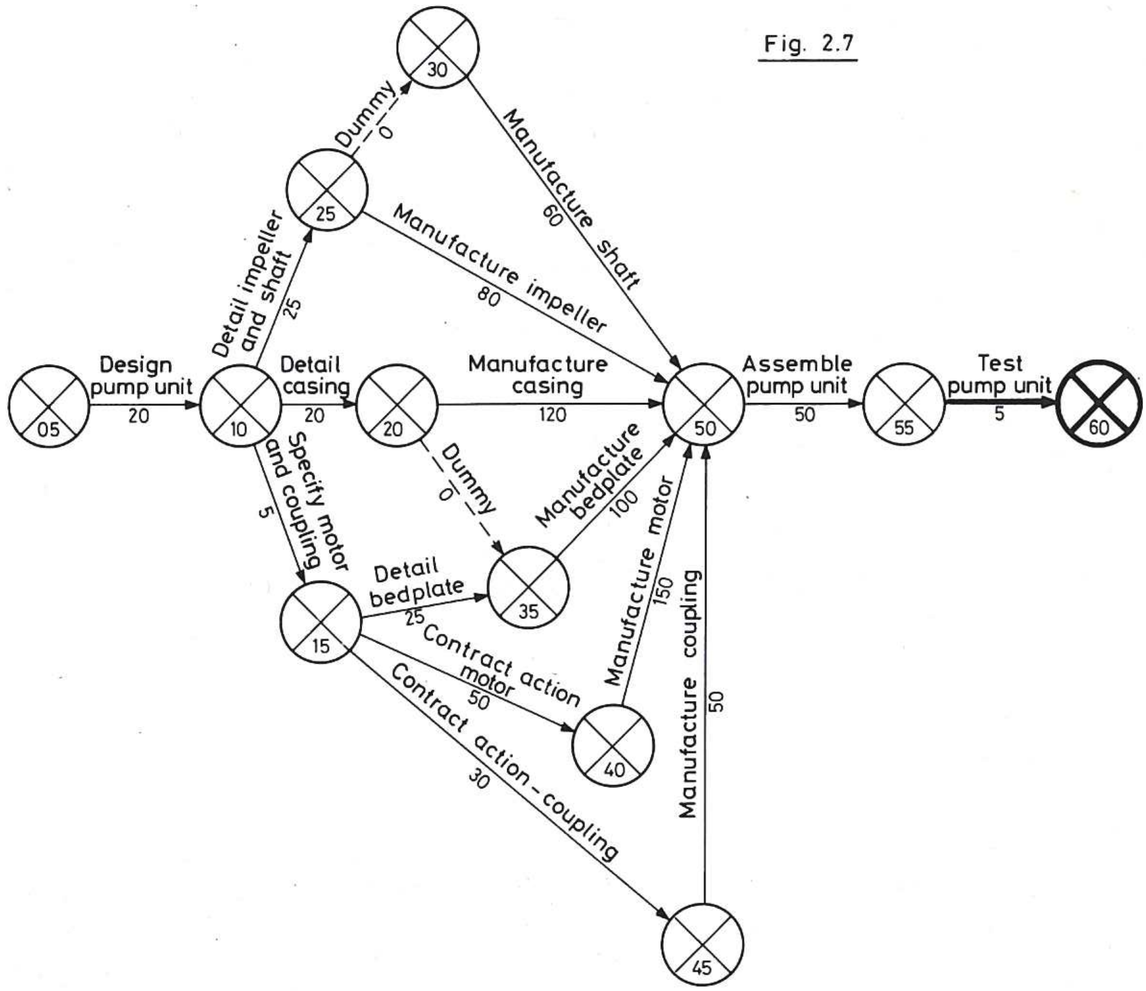
Having completed the assembly the pump can be tested to complete the framework of the diagram as Fig 2.7.

ACTIVITY DURATION TIME

As it is most likely that this particular network will have been drawn by the person responsible for the project he will now estimate how long it will take to complete each activity by consulting the manufacturers and suppliers. If, however, this exercise is taken to represent a major project the Planning Officer will submit the diagram to the person responsible for this work and obtain his agreement that it is logically correct. The responsible officer will decide the duration times.

The estimated duration times are next superimposed on the diagram against each activity. This can be shown in hours, days, weeks, etc, but care must be taken to use the same units. In this example days are selected. The diagram is now:

Fig. 2.7

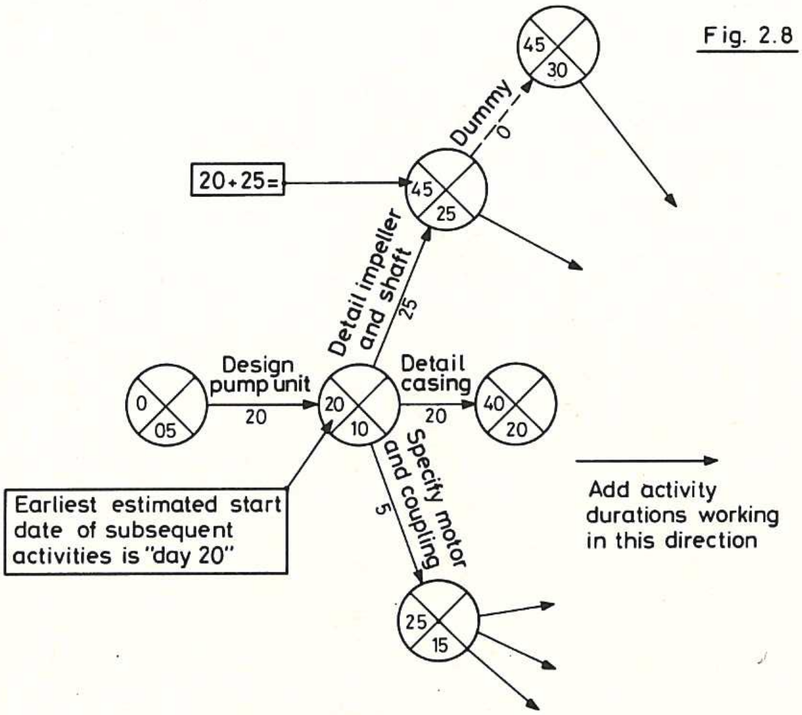


The overall duration time of the project is now calculated taking the start time as day '0'. This is done by starting at node 05, entering '0' in the left hand sector of the node circle to show the EARLIEST START DATE of activity 05 - 10. As it takes 20 days to design the pump unit it follows that the earliest time that detailing can start is day 20, as shown

EARLIEST START DATE

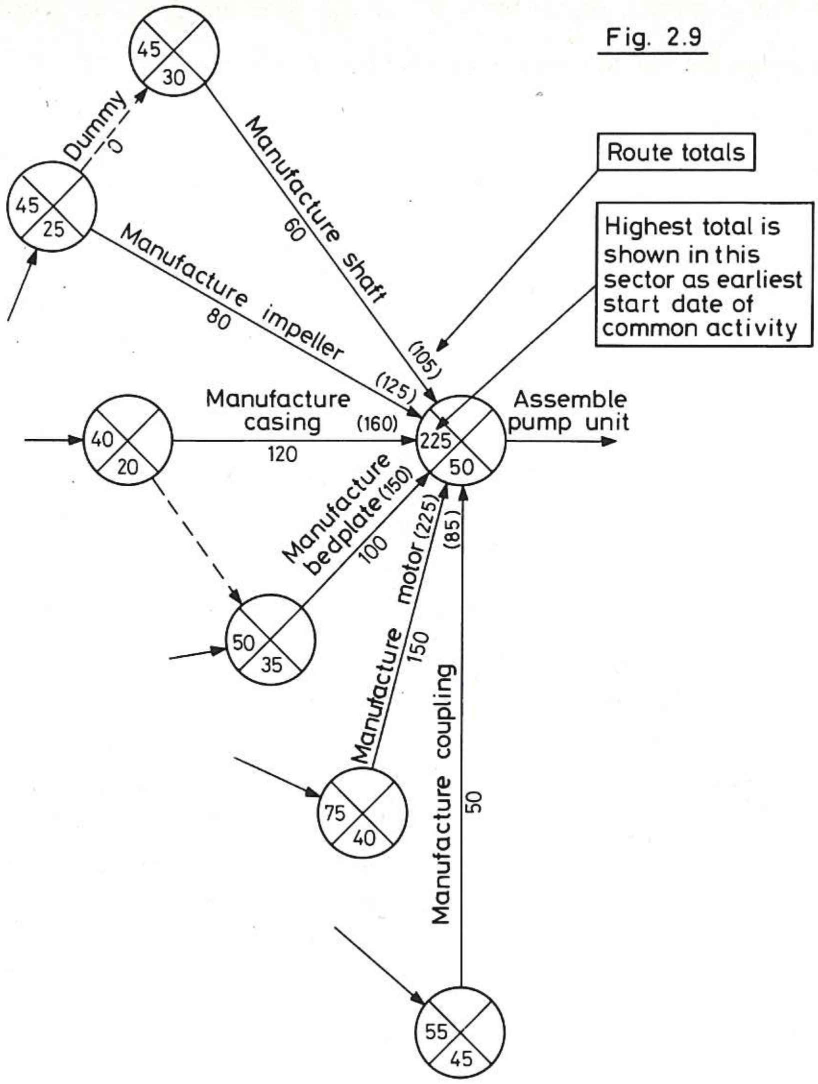
by node 10 of Fig. 2.8. The network shows three diverging routes from this node the overall durations of which are next calculated until they converge on to a common activity.

Fig. 2.8



As shown by Fig. 2.9 the activities converge on to node 50 where the route totals are examined. It is seen that the earliest time that the coupling can be manufactured is estimated to be day 85 but it might take 125 days from the start of the project to design and manufacture the impeller. Reviewing the other route totals shows that day 225 is the earliest time that assembly of the pump unit can be started. This highest figure is the one that is entered in the node circle.

Fig. 2.9



EARLIEST COMPLETION

By adding the times for assembly and testing it is calculated that the EARLIEST COMPLETION DATE for the project is day 280 as Fig. 2.10.

FORWARD PASS

The procedure described above is known as MAKING THE FORWARD PASS.

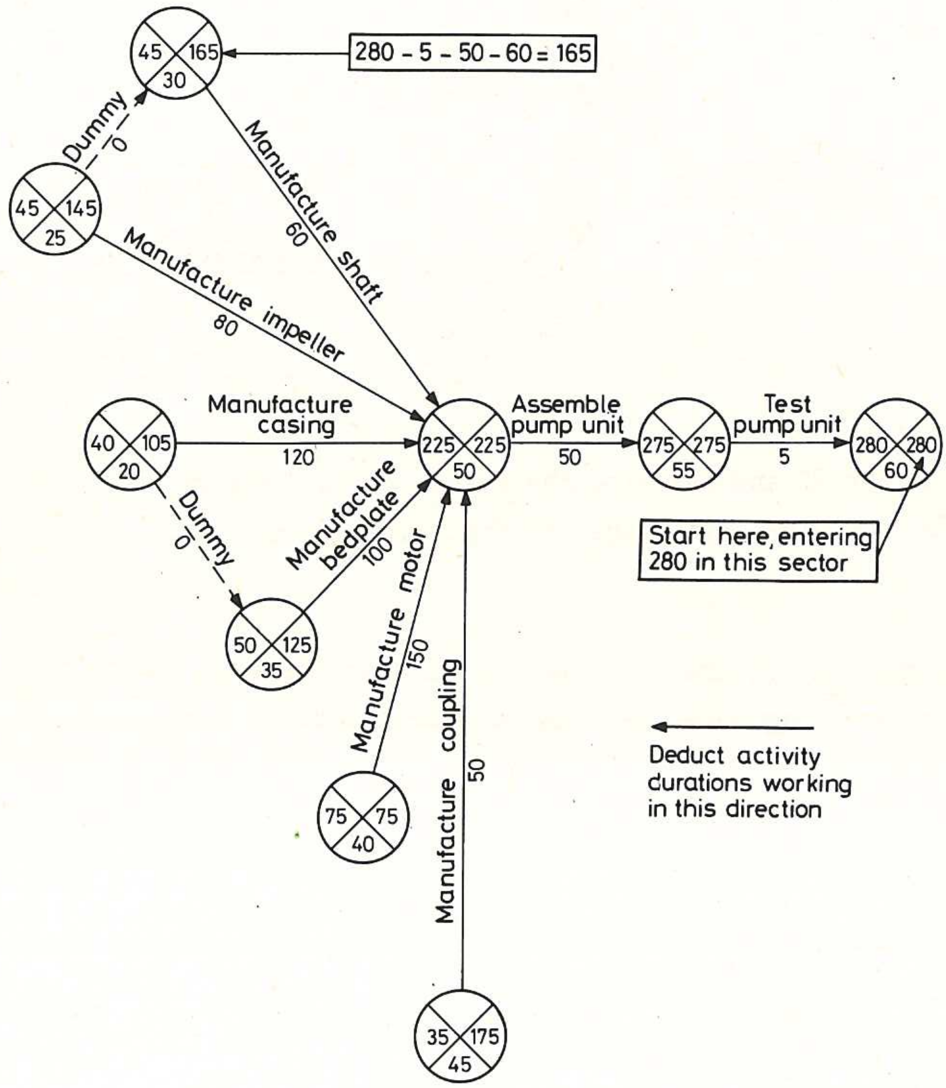
BACKWARD PASS

The next task, known as MAKING THE BACKWARD PASS is to go back through the network to determine which activities will have to be given priority to achieve completion by day 280.

It follows that the LATEST COMPLETION DATE of the project is also day 280 and this number is written in the right hand sector of the node circle, as shown in Fig. 2.10. By deducting 5 and 50 days for testing and assembling, the latest date for procuring all the piece parts is day 225, as node 50.

LATEST COMPLETION DATE

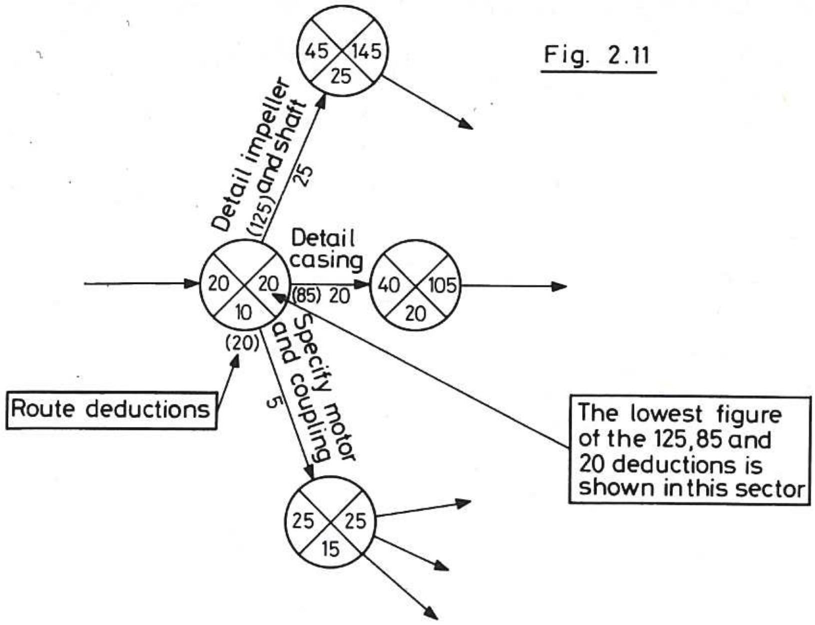
Fig. 2.10



Continuing the backward pass over the six routes the figures in the right hand sectors of some of the nodes are found to differ from those in the left, being 165 for node 30, 125 for node 35 etc. When these routes converge back on to node 10, as Fig. 2.11

the lowest of these figures is shown to indicate the latest completion date of the preceeding activity.

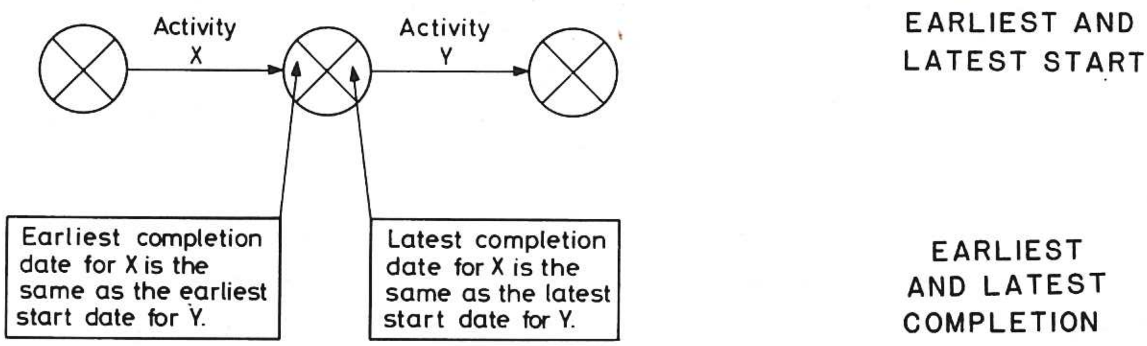
Fig. 2.11



Deducting 20 and entering the result as '0' in node circle 05 completes this stage, as Fig. 2.16.

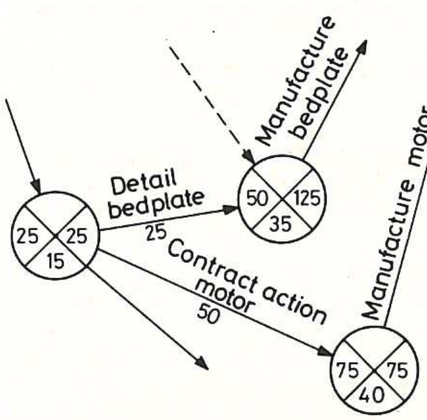
The terminology used by Planners to describe an activity's start and finishing time can now be understood.

Fig. 2.12



An appraisal is now made of the importance of each activity by comparing the earliest and latest dates. Take a part of the network as an example:-

Fig. 2.13



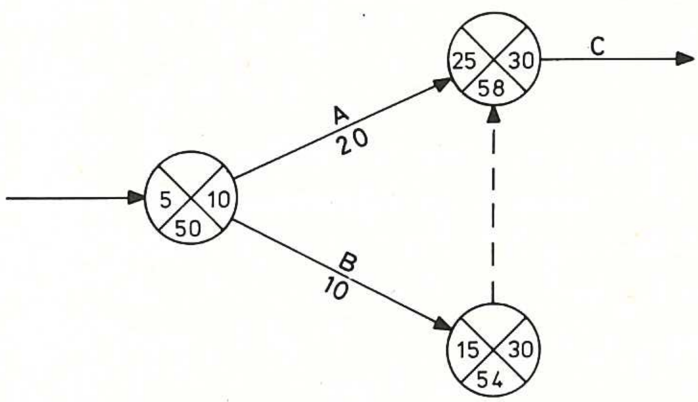
It is seen that the earliest time detailing of the bedplate can start is day 25 and the earliest time for completion is day 50, but, detailing does not have to be completed until day 125 when it becomes an activity critical to the overall completion date. This permissible delay of 75 days is termed SLACK (synonymous with FLOAT used by some writers).

SLACK

FLOAT

SLACK can be further described as being either TOTAL or FREE. This difference is best illustrated by reference to Fig. 2.14 taking a part of a network where the activities are not critical and the durations are shown in days:-

Fig. 2.14



Activity A can be delayed 5 days before becoming critical. This is called a TOTAL SLACK of 5 days.

TOTAL SLACK

If activity B should be delayed 10 days, making an actual duration of 20 days to equal A's, this will not affect the start of C. This delay of 10 days is called FREE SLACK.

FREE SLACK

If, however, activity B is delayed by 15 days this will make it critical as the total slack of 15 days (shown in node 54 as the difference between 15 and 30) has been used up.

In other words FREE SLACK is that amount of additional time which can be expended on an activity before affecting the duration of a related activity.

A limitation of the presentation of Fig. 2.16 is that day 25 appears to be the latest start date for all three activities following from node 15, whereas this is only true of one, the others having 75 and 120 days of slack which is only seen by reference to nodes 35 and 45.

Fig. 2.13 also shows that the earliest estimated time that the motor can be ordered is day 25 which is also the latest time it has to be ordered if the 50 days estimated for contract action is correct. Any delay will affect the overall completion date consequently this is termed a CRITICAL ACTIVITY. The route through critical activities is known as the CRITICAL PATH. The critical path, or paths as there can be more than one, is shown by a thick line to complete the diagram as Fig. 2.16.

CRITICAL ACTIVITY

CRITICAL PATH

The way three of the sectors of the node circle are used is now known. Fig 2.15 shows that the fourth sector is used to enter the actual completion date of the preceding activity which should be the same as the actual start date of the succeeding activity. The use of this sector is discussed further in Appendix 2.

ACTUAL COMPLETION

ACTUAL START

Fig. 2.15

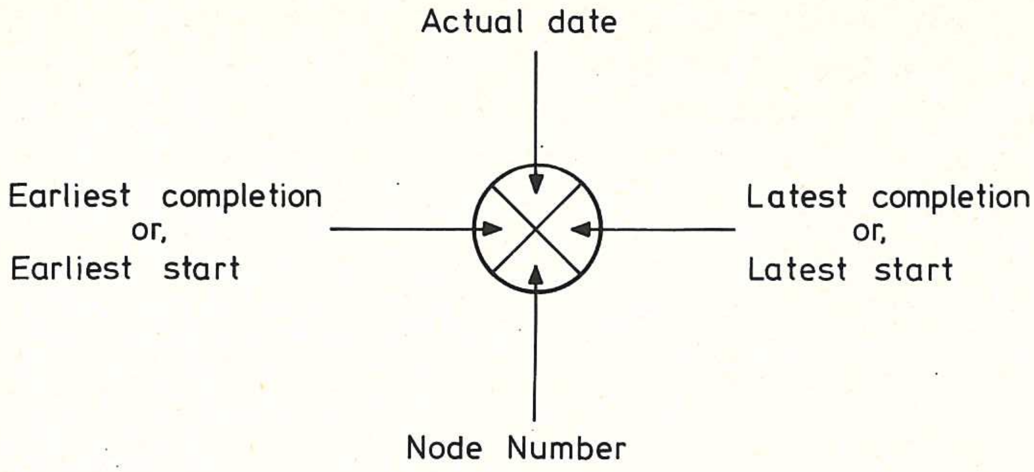
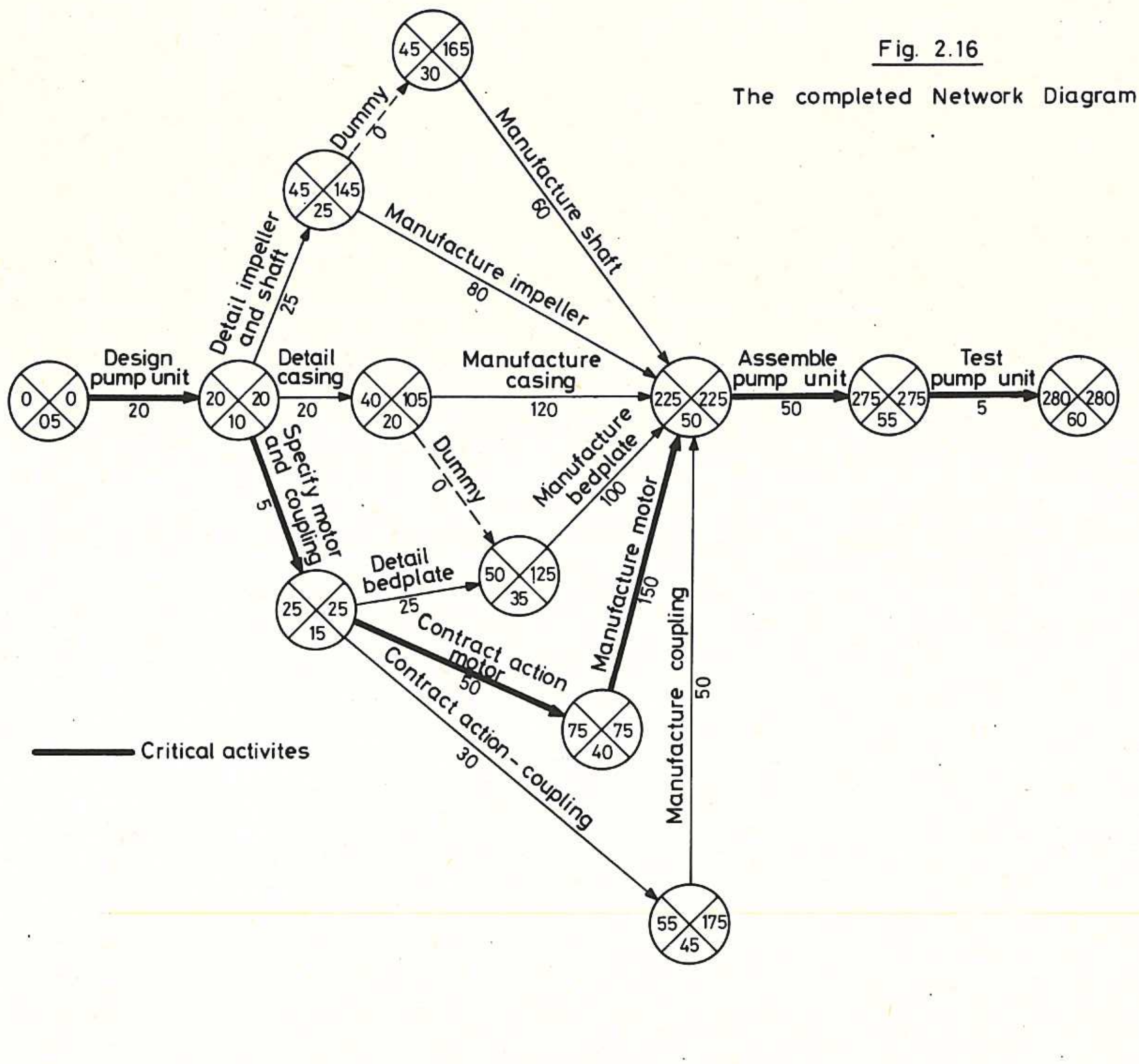


Fig. 2.16

The completed Network Diagram



At this stage the officer responsible for the project, together with the Planning Officer if appropriate, studies the critical activities to see what measures can be taken to shorten the time taken to build the unit. Here it is obvious that this is set by the time taken to supply the pump motor. If it is vital to complete in the shortest possible time it may be advantageous to place the contract with a firm quoting lowest delivery accepting that their price may be higher than that of other firms.

In this instance it is found to be impossible to shorten the time scale so attention is now given to the preparation of simplified information and the resources required to complete the project on time.

SECTION 3

CONSTRUCTING A CASCADE BAR-CHART

One of the functions of management, some would argue the most important one, is to communicate effectively with personnel at all levels. One of the ways this can be achieved is to provide staff with information that can be easily understood and which will also highlight their particular responsibilities. With regard to the planning function diagrams have to be designed to suit the needs and level of understanding of the recipient. It is this need for simplification that has led to the adoption of specially constructed precedence diagrams CASCADE being one of many such systems.

To control complex projects network diagrams are a vital management tool. In their construction all the constituent parts of the project have to be considered and co-ordinated to involve the work of many people. Those responsible for planning have to use these sophisticated techniques so that their requirements can be specified in a logical manner to both senior management and junior staff. To present information to these categories in network form might, however, be counter-productive since they could find it either too detailed or confusing. A good Planner appreciates these difficulties realising that a network diagram appears to many people to be just a maze of lines and circles covered by mystic numbers and words.

CASCADE in no way supersedes the network system but is complementary to it to meet the needs of those not concerned with planning logic. Network diagrams are prepared in exactly the same way described in Section 2 and they are available to anyone concerned with, say, checking that the sequence of activities has been drawn correctly. Having issued the network, and any associated data to those with a 'need to know' summary information and CASCADE diagrams are prepared for general distribution.

The first step is to obtain a print of the network diagram and then to number each activity to a set procedure. Each activity is next listed in numerical sequence drawing horizontal lines, representing durations, against a time base. This results in a logical bar chart where the critical path is shown as a stepped line running from the top left of the diagram to bottom right. Hence the name CASCADE.

The pump unit project is used to show how a diagram is constructed. This can be considered to represent a major project where each activity is a summary of the work by one group which, in turn, is detailed on another network comprising hundreds of activities. The bar-chart which results from such an exercise gives senior management, in particular,a clear picture of the project in its entirety.

PROCEDURE

The Planner's first tack is to prepare a fully detailed network diagram as Fig. 2.16. The node numbers shown previously are redundant in this case as the principal objective of this exercise is to number the activities in a logical sequence which determines the position of each activity on the resulting bar chart.

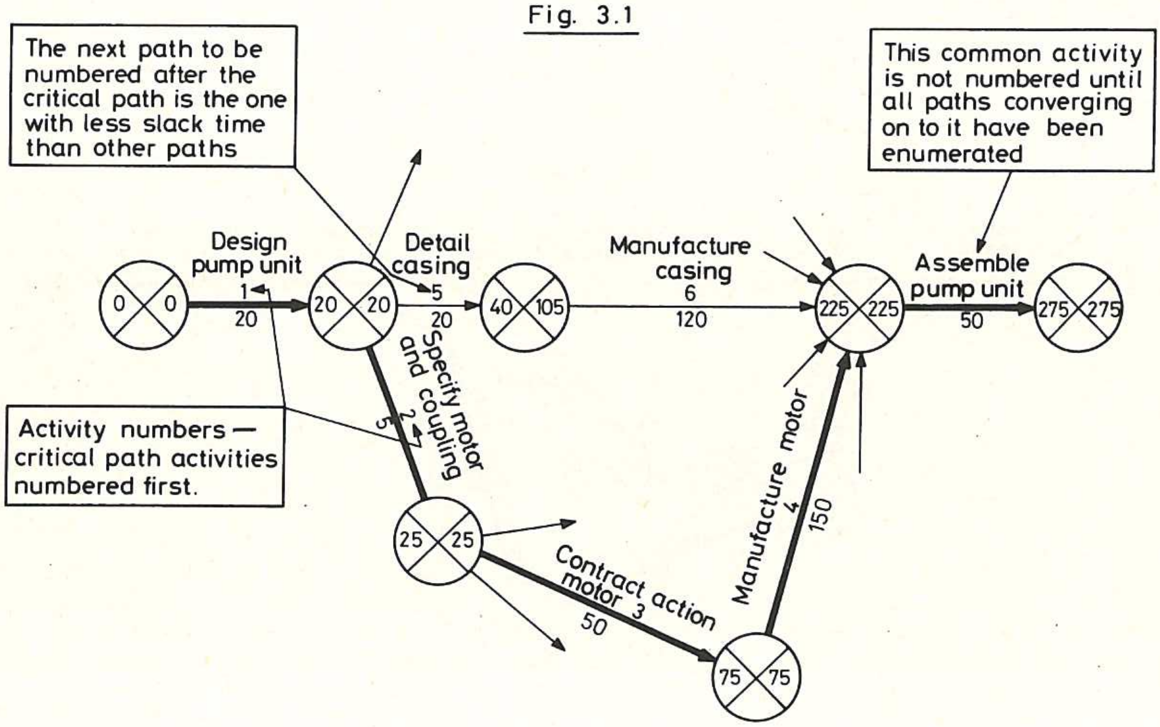
The procedure for numbering the activities is to start with 1, for the first activity, and to number in sequence the single activities directly in series with it until a node is reached where the paths diverge. The critical path is then selected and its activities sequentially numbered until one activity is reached on to which other paths also converge. This common activity is not numbered until all the paths which converge on to it have been enumerated in order of importance to the projects completion date.

It is impossible to be specific where there is more than one critical path. The order of selection will be to the individuals' preferences. He may number the path, up to the common activity, which has the most activities first, or, the one which will give the best bar-chart presentation.

In the case of the pump project "Design pump unit" is numbered 1. As there are no single activities directly in series with it the critical activities of specify motor and coupling, contract action motor and manufacture motor are numbered next as 2, 3 and 4. By definition the assembly activity cannot be numbered at this time because other paths converge on to it. Going back to the second node it is seen that the casing activities have less slack than the others so these are numbered 5 and 6.

The diagram will show at this stage:-

Fig. 3.1

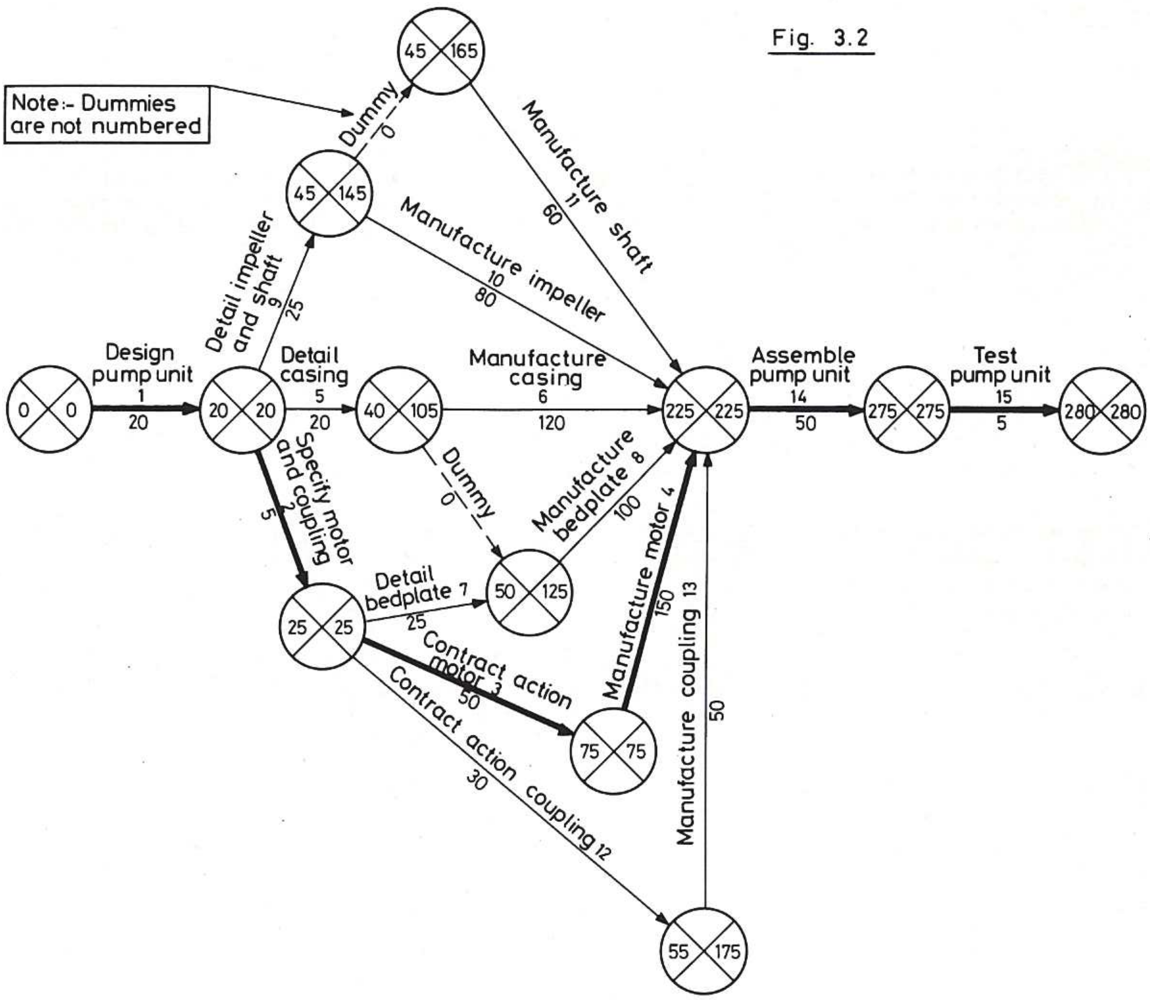


The remaining activities up to the common activity "Assemble pump unit" are similarly enumerated in order of slack time i.e

	Overall Slack In Days	Activity Number
Detail and manufacture bedplate	75	7 and 8
Detail impeller and shaft	100	9
Manufacture impeller	100	10
Manufacture shaft	120	11
Contract action and manufacture coupling	120	12 and 13

The subsequent assembly and test activities are numbered next. Dummies are not identified. The completed diagram will now be:-

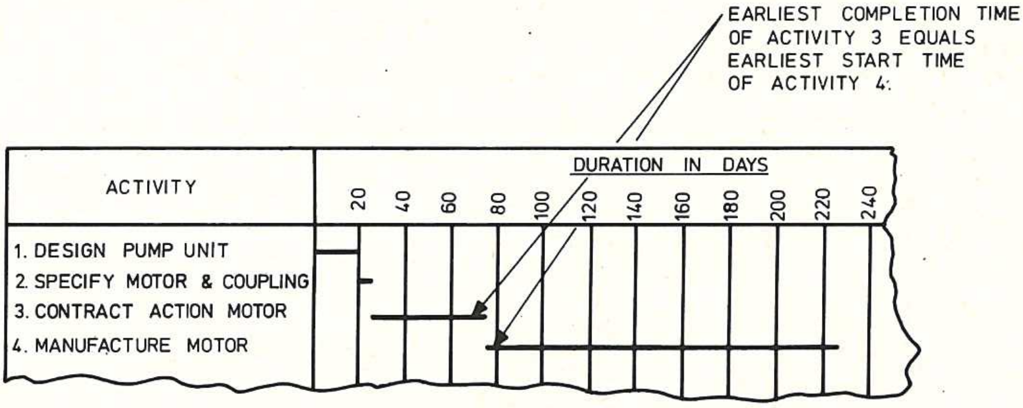
Fig. 3.2



The Cascade bar chart is now drawn by listing all activities in numerical order. The duration of each activity is indicated by a line drawn to scale which starts at the earliest start time.

To illustrate:-

Fig. 3.3



The chart is completed by adding the remaining activities. Vertical dotted lines are drawn to indicate the dependence of activities. The duration of dependent activities is shown from their earliest start times.

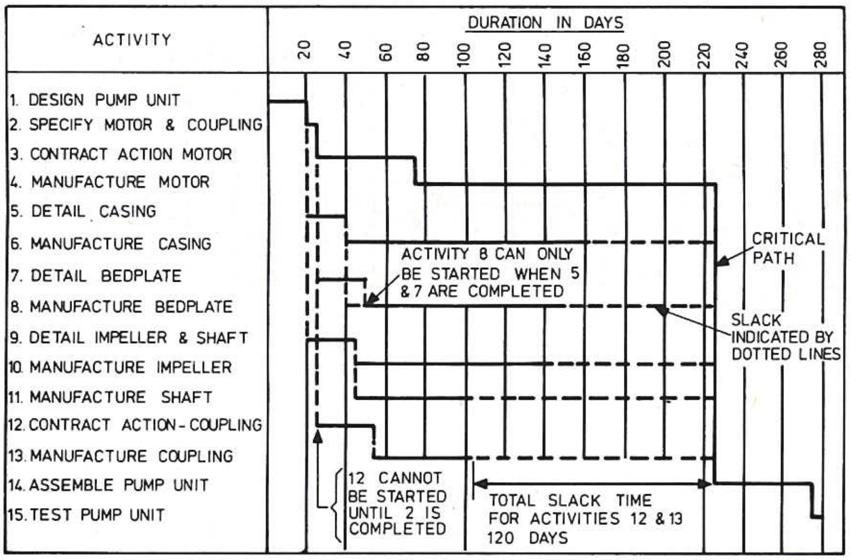
Vertical solid lines link critical activities to show the critical path.

Horizontal dotted lines, extending to the critical path, indicate the slack time for that activity, and the ones which precede it and on which it is dependent.

The completed bar chart:-

Fig. 3.4

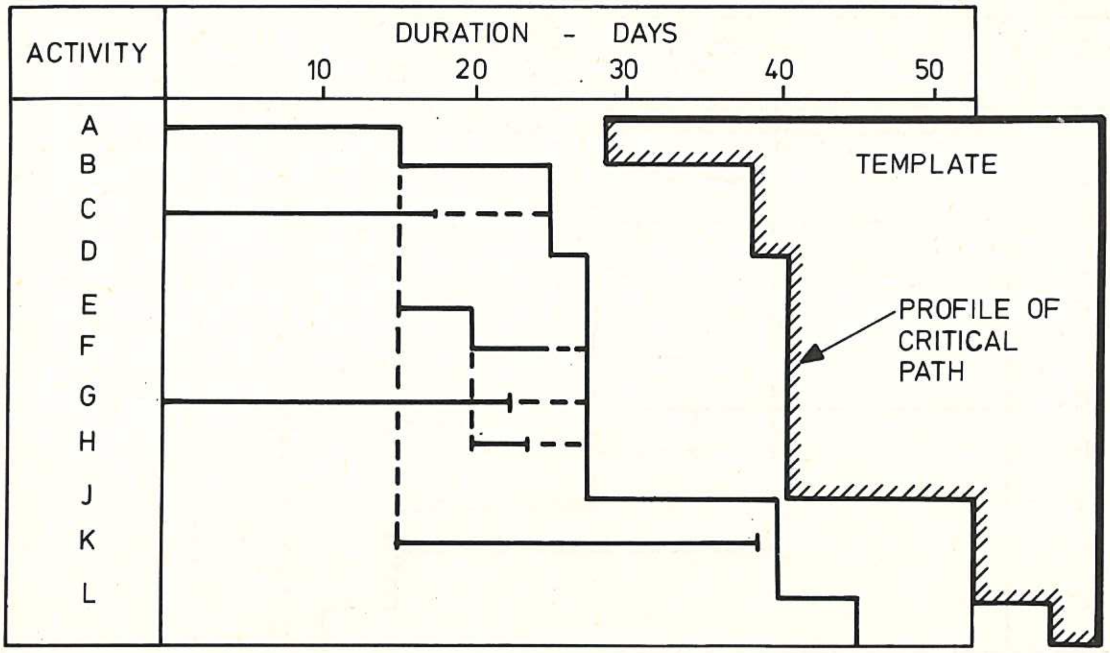
CASCADE BAR CHART PUMP UNIT MANUFACTURE



After completing one activity, and deciding which should be dealt with next, it is obvious that critical activities must be given first priority. This decision is much more difficult for those activities which are not critical as can be seen by Fig 3.5 where the differences in slack for activities C, E, F, G, H and K are not easy to distinguish.

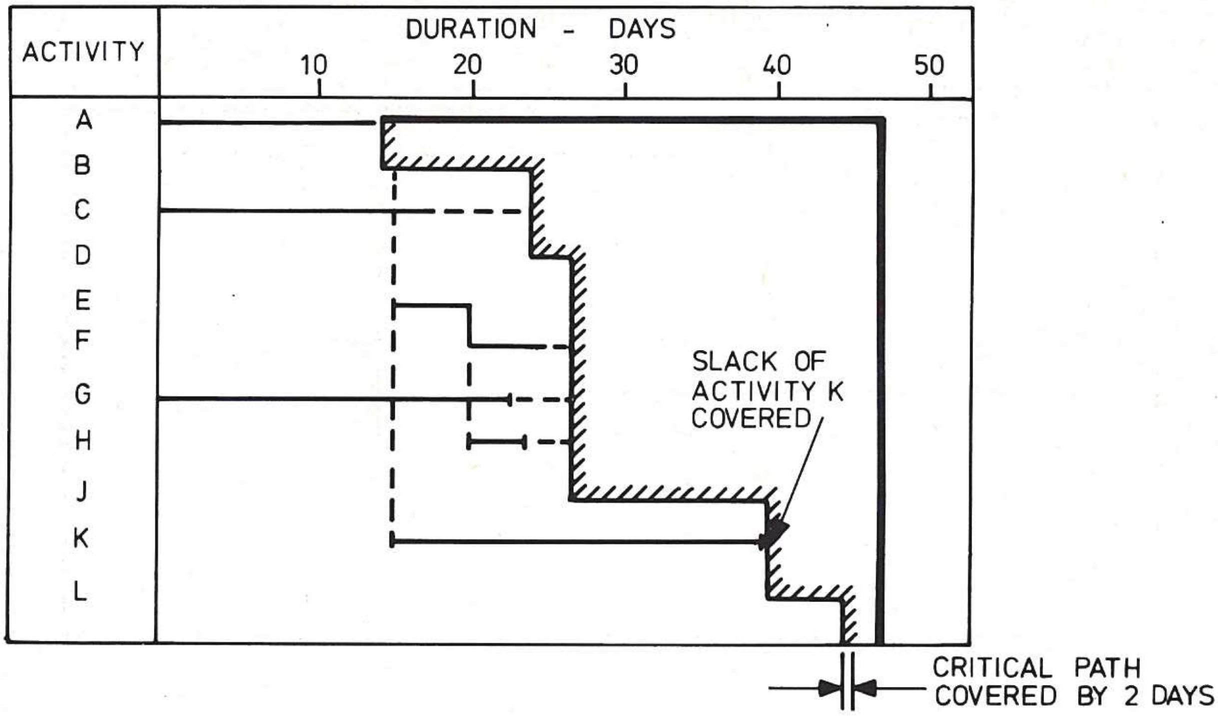
A feature of the CASCADE method is that it can be used to determine the priority of non-critical activities. To determine this order, or precedence, a template cut to the shape of the critical path, as Fig. 3.5, can be a useful visual aid. At meetings this is effective in dispelling any idea, that some may have, that the order in which the activities are listed on the chart is an indication of precedence!

Fig. 3.5



The template is placed on the chart and moved to the left, to completely cover the critical path, until it covers the dotted line, indicating slack, of a particular activity. In this instance it will be seen from Fig. 3.6 that the slack of activity K is covered first when the template has been moved 2 days beyond the critical path.

Fig. 3.6



By continuing this process of moving the template to the left and noting when the slack of a particular activity is covered, a precedence schedule can be drawn up:-

Priority	Activity	Number of Days Near-Critical
1	(A (B (D (J (L	0
2	K	2
3	E and F	5 (Total)
4	H	8 (Assuming E is completed on time)
5	G	10
6	C	15

SECTION 4

MANPOWER AND COST HISTOGRAMS

When making estimates for the duration of each activity the officer responsible for the project is obviously influenced by the resources likely to be made available by Senior Management. Before they commit themselves Senior Management will need to know say, how many men will be required, what their disciplines and categories will be and at what time they will be needed. They will certainly want to know how much the project is going to cost and when the bills have to be paid.

One of the best ways of presenting this information is by the use of histograms which show the resource plotted against a time base.

The procedure followed in drawing resource histograms is reasonably straight forward and is therefore not described in great detail. What is important is the interpretation of the histogram and how it can be used as a guide to judge the best way to allocate resources.

The procedure used is to show on the network, against each activity:-

(a) the number and category of personnel required to complete the particular activity in the time that has been estimated.

eg. 2 engineers, 3 draughtsmen, etc.

This need not be in whole numbers. If the activity only needs an engineer's attention for half of his time this would be shown as '0.5 engineers'.

(b) The estimated cost

The above is illustrated by Fig.4 .1 which shows part of the pump unit network

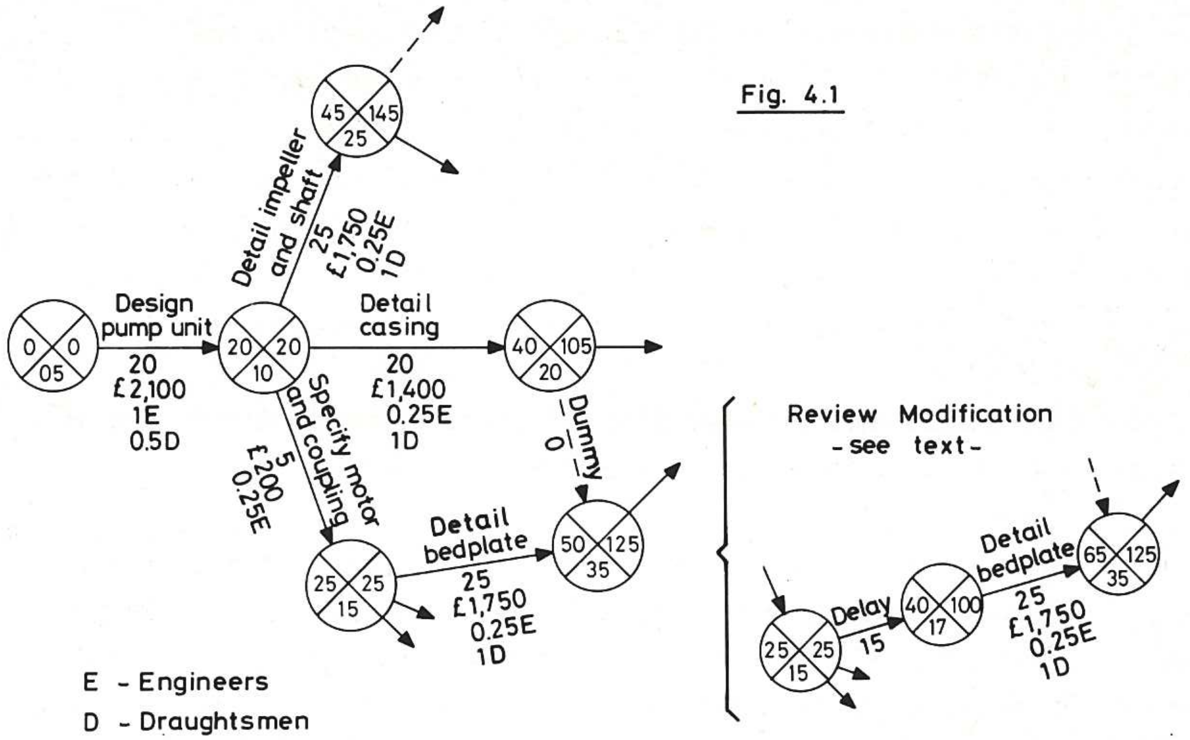


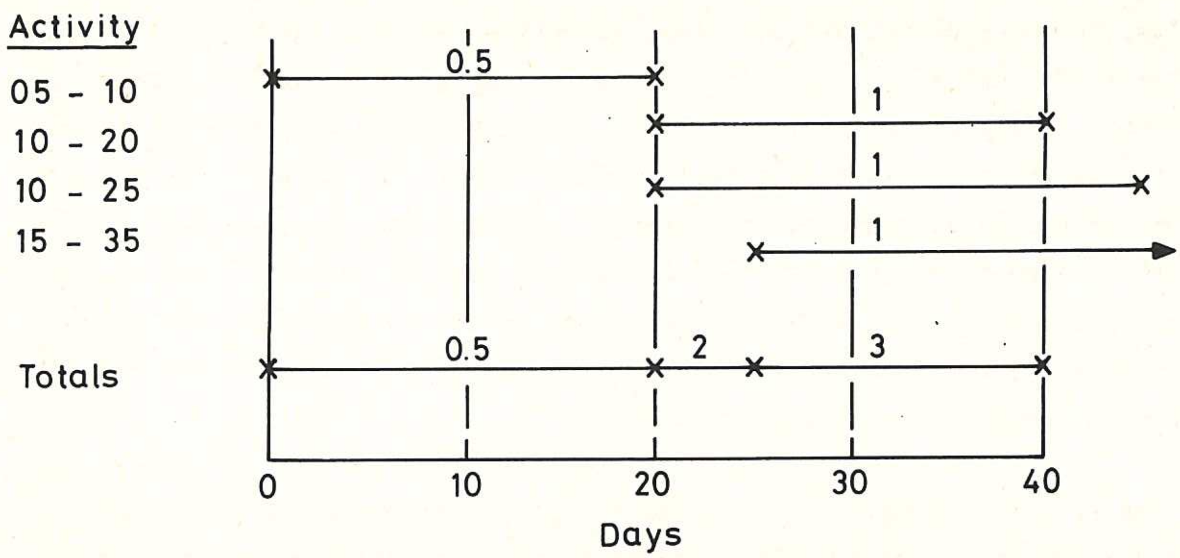
Fig. 4.1

PERSONNEL HISTOGRAMS

It is assumed that each activity can be started at its earliest start date. (This may have to be revised later when reviewing the completed histogram as discussed below). The first thing to do is to convert the data of Fig. 4.1 to bar-chart form, taking draughtsmen as an example. It is seen that activity 05 - 10 requires 0.5 draughtsmen from day 0 to day 20, 10 - 20 requires 1 draughtsman from day 20 to day 40, etc. These requirements are plotted for the periods concerned, as shown by Fig. 4.2 which applies up to day 40.

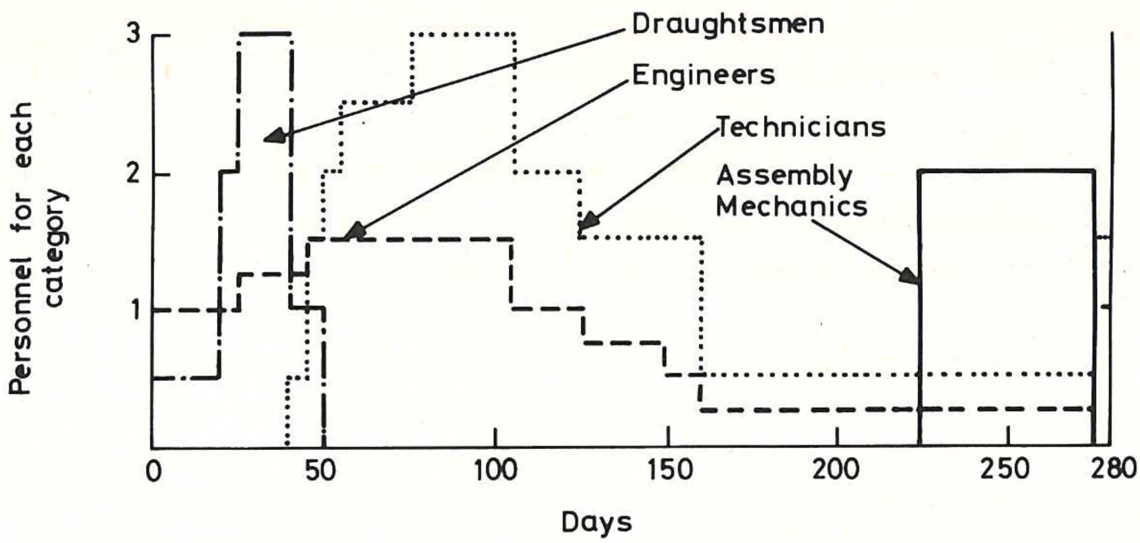
The requirements for each activity are now added together to show that 0.5 draughtsmen are required up to day 20, 2 between days 20 and 25, 3 between days 25 and 40

Fig. 4.2



This procedure is continued to completion when the totals are plotted against time to give the required histogram. This is repeated for other categories. The resulting histograms are usually plotted on separate sheets but are shown in Fig.4.3 in composite form for the convenience of printing.

Fig. 4.3



Reviewing the above in conjunction with the network diagram, Fig. 2.16, it is seen that three draughtsmen are required from day 25 to day 40. To provide a more uniform work load Senior Management might ask the Planner if it is not possible to use only two draughtsmen at this time. The Planner finds that if activity 15 - 35, which has 75 days slack, is delayed by 15 days this peak can be levelled out. Before making any modifications to the network he checks to see that the requirements for other categories are not adversely affected by this change. If they are not, and this measure is agreed with others, he introduces a special activity, called a DELAY, OR RESTRAINT, ACTIVITY, between nodes 15 and 35 together with a new node numbered 17. This new activity 15 - 17 is allocated a duration of 15 days as shown in the inset of Fig. 4.1.

The effect of levelling out peaks for other categories is assessed in a similar way, the duration times adjusted and delay activities introduced to suit. If Senior Management cannot meet the resource requirement by, say, being unable to allocate two mechanics for fifty days to assemble the pump, then the completion date will have to be amended.

COST HISTOGRAMS AND GRAPHS

Histograms for committed and expended costs (See Appendix 1 for an explanation of these terms) are prepared in a similar way to that described above for personnel. The shape will not be as 'rectangular' as Fig. 4.3 since this shows resources spread over a period whereas costs will be incurred on a specific day. The histograms serve to highlight times when large amounts have to be committed and expended. If these clash with other projects' requirements duration times might be altered, as discussed above for personnel.

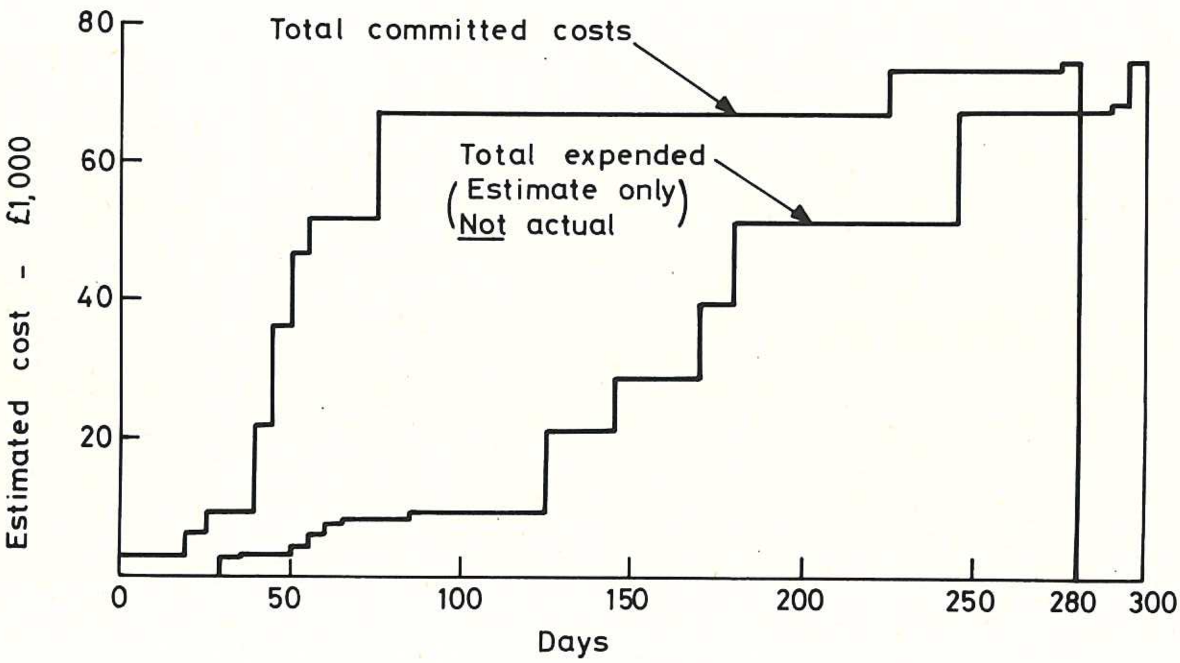
For the committed cost histogram it is assumed that each activity is started at its earliest start date. The cost for each activity is then plotted in bar chart form and totalled in the same way as for manpower Fig. 4.2.

The procedure for plotting expended cost histograms is slightly different since it is assumed that each activity is completed by its earliest completion date. A provision is also made for the time taken after completion to pay the bills. For the pump project it can be assumed that payment for activities costing less than £5,000 will be settled ten days after completion, greater amounts taking twenty days. Since the design work of 20 days duration for activity 05 - 10 is estimated to cost £2,100 the settlement date is assumed to be day 30.

Of possibly greater interest to Senior Management are graphs showing the total committed and expended costs as shown by Fig. 4.4. These are plotted by adding the individual activity cost to the previous total at the appropriate estimated time in the programme.

For large projects the possibility of staging both committed and expended costs, for activities of high cost and long duration, has to be considered. This is discussed further in Section 6.

Fig. 4.4



SECTION 5

PROCESSING BY COMPUTER - THE TIMING OF ACTIVITIES

For description purposes only the program which calculates the timing of activities is referred to here as the BASE PROGRAM. The programs used to produce the manpower and cost histograms discussed in section 6 are termed SUB PROGRAMS as they rely on the base program for project data.

A complex project will be made up of a number of sub-projects. In the case of the pump unit this might form part of a major pumping facility the construction of which will embrace several disciplines and many hundreds of activities. For this facility a network is prepared for each sub-project typically to the state shown by Fig. 2.7. Since it is assumed that this is a large project an officer will have been appointed dedicated to Planning duties. The Planner will agree that the network is correct with the Officer responsible after which he will discuss it with other Officers to determine how it interacts with their networks. A co-ordinating network will finally be prepared and agreed by the Project Manager to bring together the sub-project requirements. On completion of this important and time-consuming exercise the information shown on each network is prepared for computer processing by carefully identifying each activity and compiling lists of data. The way in which this information is prepared is described but it is beyond the scope of this manual to discuss the program itself and the way the input sheets are dealt with by the data processing department.

As stated in the introduction this presentation differs from that of earlier sections, this presentation being written specifically to suit a computer program developed to control the design and construction of large nuclear fusion experiments. Other systems are, however, similar to this differing in matters of detail only.

IDENTIFICATION OF ACTIVITIES AND NODES

The major difference between the manual and computer processing methods is the way in which activities are identified. With a simple network each activity is identified by the numbers in the node circles, for example:-

Activity number of DESIGN PUMP UNIT, see Fig. 2.1, is 0510 indicating that this links nodes 05 and 10.

For a small manually processed project with less than say, 50 activities, this is quite satisfactory. Where several hundred activities are involved the capacity of the node numbering systems has to be increased. Where four characters are used, for example, this would result in an eight character activity identification. This method would obviously be extremely cumbersome therefore an activity reference system is introduced which is completely independent of that used for the nodes. (Nodes still need to be identified as the program calculations are based on the node references).

For this particular program each activity is identified by four characters, printed under the line representing the activity. This identity can be either:-

(a) a four digit system, eg, 1234

or (b) a mixture of letters and digits, called an ALPHA-NUMERIC system, eg, A578, 13B2, 25ED which has a greater capacity than (a).

Node circles are similarly identified but, to avoid confusing activity and node numbers, it is advised that an alpha-numeric system be used to identify nodes whenever four digits are used for activities and vice versa.

To accommodate a four character reference in the node circle the sector used previously to show the achieved time (as Fig.A2.1) is omitted, the circle now showing earliest and latest start/completion times in the top two quadrants and the node number in the bottom half, as Fig. 5.1. Achieved time data is very useful for post-mortem purposes, to assist in the planning of projects in the future, but it is not of immediate concern to the Planner when he is managing a current project. This data is, however, not lost as it does appear on the print-out as the activities are completed so it is available for analysis at a later date.

Another difference between the computer and manual systems is that the introduction of a dummy activity to avoid duplication of activity numbers (see Figs. 2.3 and 2.4) is unnecessary with the computer system. Dummies which show the dependence of activities are still used, each dummy being identified with an activity number and listed on the computer input sheets showing the duration as zero. See dummy activity 1620 on Fig. 5.2.