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**PLANNING AND SCHEDULING  
OF  
NEW FERTILIZER PROJECT CONSTRUCTION**

**WITH REFERENCE TO THE  
DURGAPUR FERTILIZER PROJECT**

**MANAGEMENT GROUP  
COMMITTEE ON PLAN PROJECTS  
PLANNING COMMISSION  
DECEMBER, 1965**

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## PREFACE

This Manual is designed to outline the use of Network Scheduling Techniques in the planning and control of the construction of new fertilizer projects.

In presenting a comprehensive method for using the Network Scheduling System on fertilizer project construction, aspects of the proposed Durgapur Fertilizer Project have been used as examples in the system design. The system is not specifically designed for this project however, and can be applied to other fertilizer projects.

This Manual has been prepared, in conjunction with the Durgapur Authorities, by Messrs. P. Bowden and M. Thyagarajan of the Management Division of the Committee on Plan Projects. Also assisting in the overall system design and implementation were Messrs. Bharat B. Shah and C.S. Parthasarathy.

CHAPTER I

INTRODUCTION

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INTRODUCTION

The construction of new fertilizer projects is of prime importance if India is to cope with the demand for increased agricultural production.

The Third Plan target for Nitrogenous fertilizers was 1,000,000 tonnes (capacity) compared with the Second Plan target of 382,000 tonnes (capacity).

A major portion of this Third Plan target, (about 750,000 tonnes) was to be constructed in the Public Sector. The target of 1,000,000 tonnes, however, is not likely to be achieved mainly due to slow progress in the implementation of both Private and Public Sector schemes. It is expected that by the end of the Third Plan, the installed capacity will only be 350,000 tonnes of Nitrogen.

This situation has caused the Government to increase the target for installed capacity in Nitrogenous fertilizers, during the Fourth Plan to 2,200,000 tonnes.

If the proposed fertilizer production target for the Fourth Plan is to be achieved, the

development of the Fertilizer Industry should be such that the projects are executed with significantly fewer delays than were experienced in the Third Plan period. One method of achieving this objective is through sound and effective planning, scheduling and control of the project.

Modern techniques for planning and programming of complex projects have been developed in recent years, and these have proved to be of considerable benefit in reducing construction delays. With a view to introducing these techniques to the Public Sector projects, a Management and Administration Division has been set up in the Planning Commission under the aegis of the Committee on Plan Projects (COPP).

At the request of the Fertilizer Corporation of India (FCI), the 'Management Group' of this Division undertook a study of the Durgapur Fertilizer Project, the objective being to assist the Project Authorities in the development of a system for planning, scheduling and control of



the construction of this Plant.

The Project is located at Durgapur, about 100 miles from Calcutta in the Burdwan District of West Bengal. The Project envisages a final production of fertilizers equivalent to 135,000 tonnes of Nitrogen and 110,000 tonnes of  $P_2O_5$  per annum.

The methods of planning and scheduling fertilizer project construction, developed in this Manual have used the Durgapur Project as illustration. These methods are derived from the Network Planning Technique. Cost control and cost reporting methods designed for fertilizer projects have also been included. Before dealing with the network system design and its application, therefore, a brief history of the Durgapur Project has been given (In Chapter II).

Dr. S.K. Mukherjee, General Manager of the Durgapur Project and his senior officials and staff took keen interest and initiative

in adopting these techniques for their Project, and all the procedures contained in this Manual have been designed in collaboration with the Durgapur staff. Their enthusiasm and cooperation have been primarily responsible for the implementation of the planning and control procedures outlined in the Manual and this implementation will eventually prove beneficial in the use of these advanced techniques for the construction of modern industrial complexes.

It should be noted that the concepts outlined in this Manual can be applied to the construction of other fertilizer projects in the public sector, and generally, with little modification to the construction of any industrial project depending upon the nature and scope of the work involved in each case.

As the Durgapur Project was at its preliminary stage at the time of preparation of

this Manual, there were still various uncertain points of the Project such as the approval of the Government in regard to source and terms of foreign exchange, as well as other matters in connection with the Project implementation. As such, the figures, schedules, plants, product pattern and other data furnished in the figures and in the text are all tentative. Uptodate networks and working schedules can only be produced after the above decisions have been made. This Manual therefore, although it primarily uses examples from the Durgapur Project, is not fully applicable to this Project in the present form and context. The reader may well keep this in view while using this Manual. Some of the schedules and reports that are being used in a similar system for the FACT expansion at Cochin have been included as an appendix by way of further illustration to this report.

CHAPTER II

HISTORY OF THE PROJECT

CHAPTER II                      HISTORY OF THE PROJECT

The demand for increased capacity for production of fertilizer has already been outlined. From a number of fertilizer projects that were proposed to meet this demand, a suitable site was selected at Durgapur to serve the needs of West Bengal. This Plant has been approved for immediate implementation, subject to deciding on a suitable source of foreign exchange.

The Project was originally initiated by the Government of West Bengal and licensed by the Government of India for execution in the Private Sector, with the participation of the State Government. After further deliberation, it was entrusted to the Fertilizer Corporation of India for execution.

A Feasibility Report for the Project was completed by the Fertilizer Corporation of India in December 1963. The Project came up for

consideration by the Planning Commission in May 1964, and the Commission accepted the Project and gave clearance subject to financial approval in June 1964. Under the directive of the Government, the Fertilizer Corporation of India completed the Working Project Report and the Project Estimates in August 1964. The Government authorised the Fertilizer Corporation to take advance action on such preliminary matters as securing possession of land from the West Bengal Government; negotiating prices of power, water, petroleum naphtha; undertaking contour surveys and soil investigations in the factory area; and investigation of transportation facilities. Work has already started on most of these items.

At the time of writing (October 1965), the Project has received a tentative financial approval and is in the process of seeking a source of foreign exchange in order to go ahead with the award of the major contracts.

In the earlier planning undertaken for Durgapur it was decided that the Project Authorities would, with the exception of the Phosphoric Acid and Ammonia Plants, let out all work in a series of individual contracts to be controlled by the Project. The two Plants mentioned were to be let as package or turnkey contracts to foreign firms in which the smaller contracts (Civil Design Foundations, Erection etc.) would be controlled by the main contractor.

Subsequently, it was decided that all major plants should be let as turnkey contracts while most of the remaining plants - Ammonium Sulphate, Urea and Ammonium Phosphate Sulphate (Complex Fertilizer) plants should be under the control of the Planning and Development Division of the FCI and that this Group should act, in a sense, as turnkey contractors to the Durgapur Project Authorities.

Now, however, consequent on the emergency and the need to save foreign exchange, the character of some of the contracts might be changed in order to effect maximum savings in foreign exchange.

It should be noted that the aspects of the system outlined in this Manual could be used in both cases, i.e; construction of the Project through a series of individual contractors directly controlled by the Project as well as construction through turnkey contractors who have direct control over the smaller contractors of the Project (Civil Design, Civil Works, Mechanical Erection etc). In the former case, the system design could be used by the Project Authorities, and in the latter, by the turnkey contractors including the Planning and Development Division of the FCI who will have the responsibility of coordinating many sub-contractors. This aspect is dealt with further in the Contract Scheduling Section of this Manual.



As already outlined, the major objective of the Durgapur Project is to produce fertilizers equivalent to 135,000 tonnes of Nitrogen and 110,000 tonnes of  $P_2O_5$  per annum in the form of Ammonium Phosphate Sulphate which is a Complex Fertilizer. Production of this Ammonium Phosphate Sulphate is planned at 500,000 - 579,000 tonnes per year. The principal intermediate products would be:

- . Phosphoric Acid, using imported Phosphate Rock;
- . Ammonia, using Naphtha from the Barauni Refinery Project;
- . Ammonium Sulphate, using Gypsum obtained as a by-product from the Phosphoric Acid Plant;
- . Ammonium Phosphate obtained by reacting the Phosphoric Acid with Anhydrous Ammonia; and
- . Sulphuric Acid.

The capital outlay for the entire Project is estimated in the Final Project

at Rs.40.68 crores. The source of financing is to be provided by the Government, half as equity and half as 6% interest bearing loan. The foreign exchange portion of the outlay is estimated to be Rs.17.04 crores, but will increase if the source of procurement is from the United States.

Recognizing the need for an early completion of this Project and cognizant of the engineering efforts involved in the planning, design and construction, the Fertilizer Corporation has formulated, in the Project Report, a tentative time schedule of 36 months for the completion of the Project from the date of approval. This date was assumed as the 1st January 1965, but due, however, to the delay in obtaining foreign exchange, this date will obviously be delayed.

The Fertilizer Corporation of India requested the participation of the Management

Group in planning and programming the construction of the Durgapur Project. A four member Team of the Management Group of COPP, therefore undertook a detailed study of the Project. The Team visited the Project Staff at Rourkela and Calcutta and held discussions with the Project Authorities on various aspects of the Project. The members of the Team assisted in developing several networks for the Project and developed, in conjunction with the Project Authorities, techniques for planning, scheduling and control of the Project. These techniques, together with a system for maintaining an accurate forecast of construction costs are outlined in the following chapters.

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CHAPTER III  
SYSTEM SYNOPSIS

CHAPTER III

SYSTEM SYNOPSIS

The completion of a complex project such as the Durgapur Fertilizer Project is accomplished in two distinct phases: One is the Planning Phase, in which the project objectives are defined, networks are constructed and schedules are established. The second phase is the Control Phase in which the schedules are approved, work is authorized, project status information is collected and corrective action taken to achieve the project objectives.

During construction, project management frequently checks progress against the plan. If deviations occur, they must be reported and corrective action taken. If corrective action is not possible, the schedule or objectives of the project may need to be revised. This concept of the planning and control cycle in the construction of a major project is illustrated

in figure 1 and outlined below:

Planning Phase:

The Planning Phase includes the establishment of:

- . A Work Breakdown Structure;
- . A Master Control Network;
- . Detailed Networks;
- . Supporting Schedules;
- . Contract Schedules.

Control Phase:

The Control Phase includes:

- . Performance Reports;
- . Cost Reports;
- . Management action and replanning.

These two phases are described in the paragraphs that follow:

Planning Phase:

Work Breakdown Structure:

Development of the plan of construction begins with the identification of the physical

# MANAGEMENT CYCLE

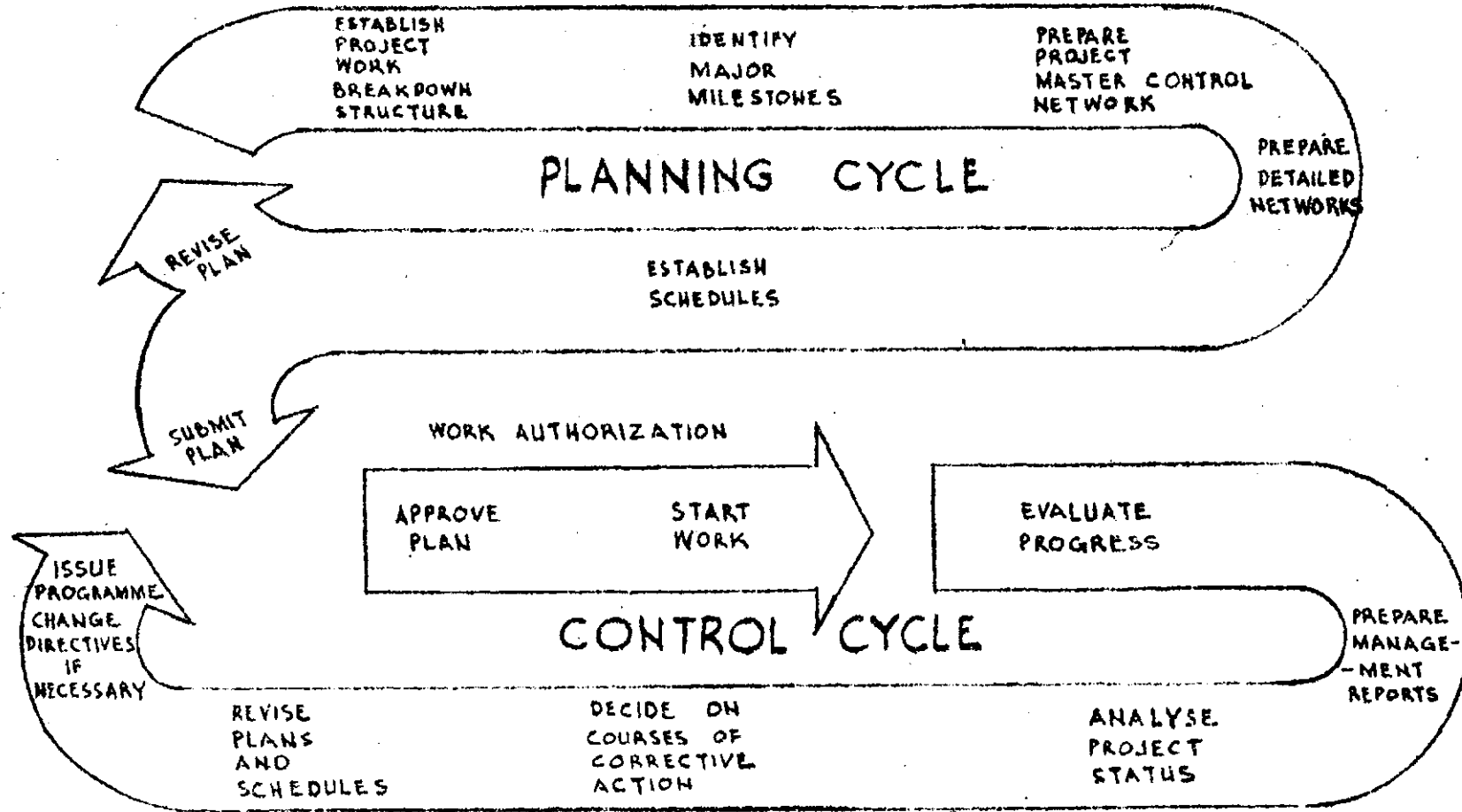


FIGURE 1.

end objectives of the project. As these objectives are developed in successively greater detail, they form a framework for planning and control of the project. Such a framework for the Durgapur Plant is shown in figure 2. The breakdown of each item into its component parts is known as the Work Breakdown Structure for the project. As can be seen from the illustration, this framework:

- . Defines the project tasks to be performed in successively greater detail;
- . Provides for assignment of responsibility to all project participants;
- . Provides a basis for uniform planning;
- . Establishes the basis for constructing networks.

The Work Breakdown Structure is developed at the highest level of the project with the identification of major end items. The



size and complexity of the project controls, the number of levels into which these major items are sub-divided.

Master Control Network:

With the completion of the Work Break-down Structure it is possible to start developing the network plan for the project. However, on a project such as Durgapur, one network would be too large and unwieldy for convenient use. It is advantageous, therefore, to develop a summary network for the project, which can be used as a framework for more detailed networks. This summary network will also contain major events in the construction plan and thus serve as a summary or management display of the project schedule. This Master Control Network (figure 3) has, therefore, the following objectives:

FERTILIZER CORPORATION OF INDIA

DURGAPUR FERTILIZER PROJECT

WORK BREAKDOWN STRUCTURE

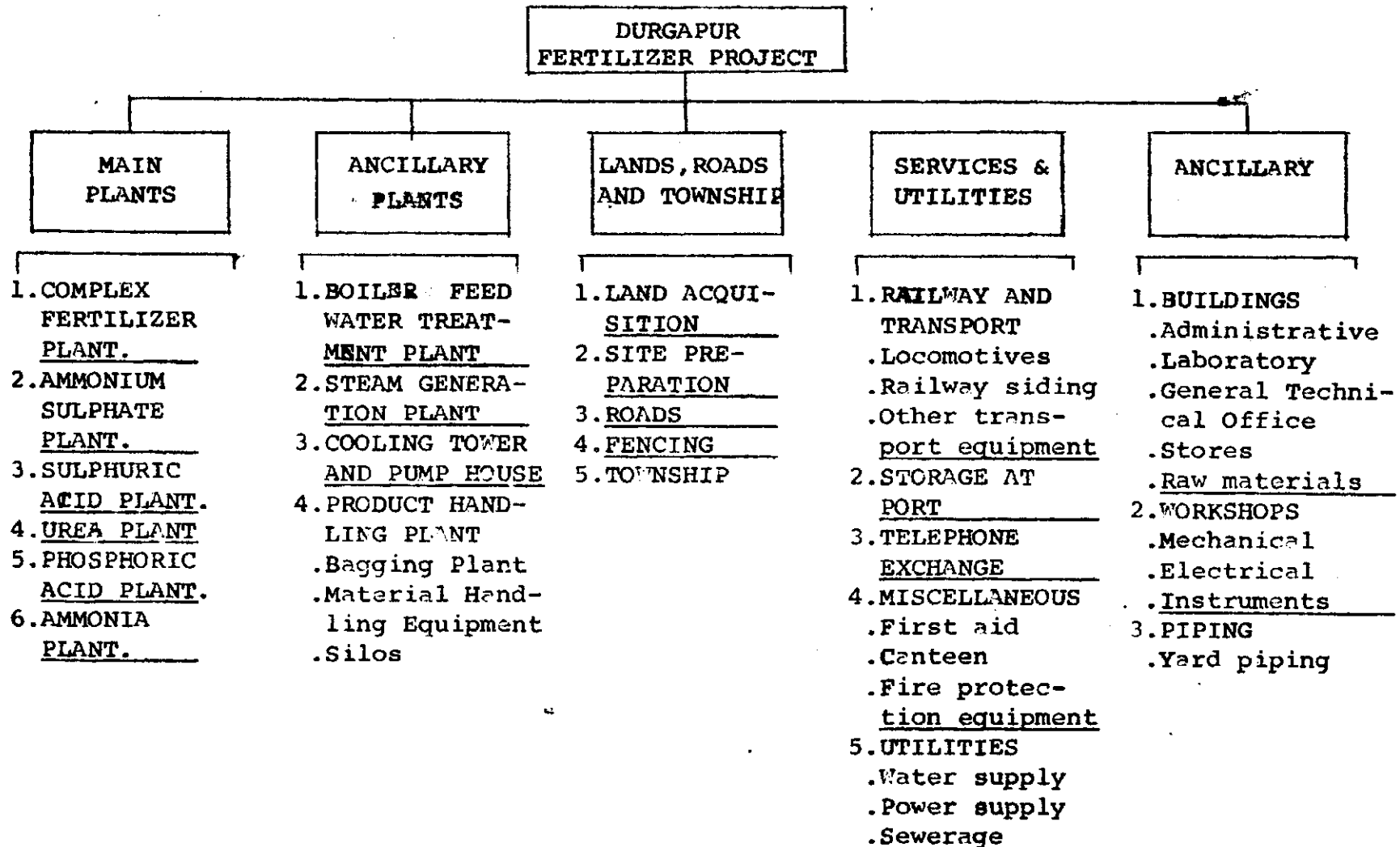
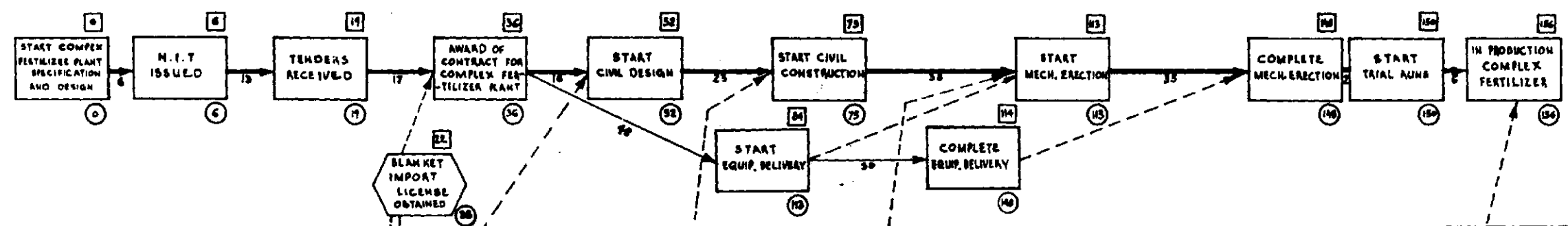


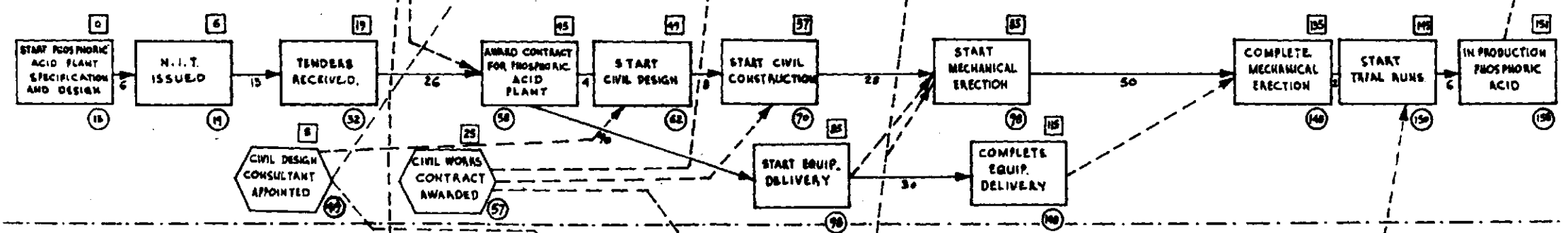
FIGURE 2

# MASTER CONTROL NETWORK (EXTRACT)

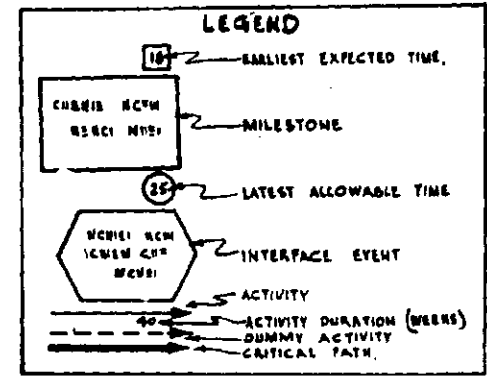
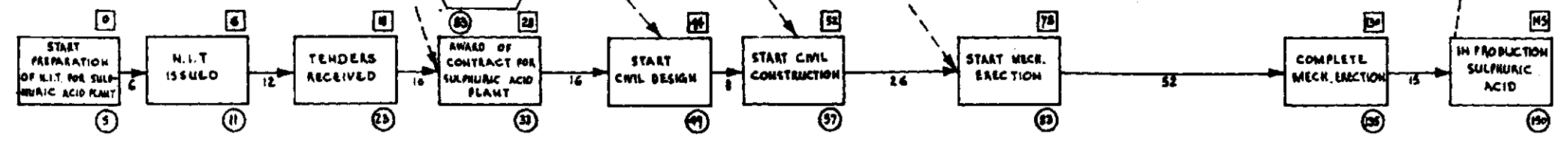
**COMPLEX FERTILIZER PLANT**



**PHOSPHORIC ACID PLANT**



**SULPHURIC ACID PLANT**



FERTILIZER CORPORATION OF INDIA  
DURGAPUR FERTILIZER PROJECT  
MASTER CONTROL NETWORK  
(EXTRACT)  
FIGURE 3

- . To provide a top-level schedule for the project which is easily read and understood by the project management;
- . To provide an overall schedule which summarizes the details contained in the lower level networks.

Detailed Networks:

The next step in the system is the development of the detailed networks.

These lower level networks are prepared to support the Master Control Network for the project.

Each network shows, in detail, all the activities required to traverse from one milestone on the Master Control Network to another. If the Master Control Network is considered as an outline chart of the overall project, the detailed networks may be defined as detailed charts of the elements of the project. They provide most of the information needed for firm

planning at the operating level. If any changes are made in the plan during preparation of detailed networks, the Master Control Network is modified to reflect these changes. The lower level networks, therefore, carry down key events shown on the Master Control Network and establish supporting activities and events as required. Thus, while the detailed networks are an operating tool under the immediate control of the executive responsible for performing the work, their status is displayed on the Master Control Network. The procedures to be used in preparing detailed networks are given in Chapter IV.

Supporting Schedules:

While it could be possible to assign schedule dates for the accomplishment of most events, at times it may not be practical to record all minor events on a network.

Such events may be 'Civil Works complete' for every portion of foundation, 'Equipment Delivery complete' for every piece of equipment, 'Start Fabrication' of every piece of structure etc. These events are, however, required to be phased in with the overall programme. It is, therefore, necessary to record such dates separately. Such a record has been termed a Supporting Schedule.

In another situation, it may not be necessary to prepare a network for a particular item in the Work Breakdown Structure due to its simplicity. To exercise an overall control, however, the schedule for this item has to be developed and a check kept against progress. This can also be undertaken by means of a Supporting Schedule. The purpose and

objectives behind the establishment of supporting schedules are discussed in Chapter VII.

Contract Schedules:

The network technique highlights the inter-dependencies between various participants in the project and thus facilitates the assignment of time schedules and responsibilities for the various contracts on the project.

In a major project like Durgapur where most of the work is undertaken by contract and where each contract is generally dependent on other contracts, it is desirable to fix time schedules for all points of interface between contracts, thus enabling the overall completion of the project to be achieved within schedule. In a network schedule, where these points of contact

are clearly defined, establishment of a firm schedule for each contractor is greatly simplified.

On the Durgapur Project, where the great bulk of the work may be undertaken by turnkey contract, much of the day-to-day coordination of sub-contractors has to be left to the main contractors. It will be still necessary however, as outlined later in this manual, for the Project Authorities be aware of the progress of the main contractors and, if necessary, exert a controlling influence over their progress.

#### Control Cycle:

Completion of the planning phase leaves the manager with a detailed plan and schedule for construction of the project.

Due to the many uncertainties inherent



in construction work, particularly in India, this schedule will not remain static and it is very necessary, that, as construction proceeds, a periodic check be kept on the progress of the work.

As schedule performance and cost reports are generated and presented to the General Manager, the status of the project is measured against the original plan. As slippages in the schedule are brought to light, the effect on the project should be measured. If remedial action is possible, it should be taken. Any change in the plan, either through remedial action, or through the effect of a slippage which cannot be remedied, should be incorporated in an official revision of the project schedule and distributed to all managers.

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CHAPTER IV  
NETWORK DEVELOPMENT

CHAPTER IV

NETWORK DEVELOPMENT

Development of the Master Control

Network based on the Work Breakdown Structure is the first step in establishing the project schedule. This step may be undertaken quite early whilst preparing the Project Report for the proposed undertaking. The objectives in early establishment of a Master Control Network are very broad and can be summarised as under:

- . To establish a schedule for the project upon which an economic analysis can be based;
- . To establish the milestones in the construction process which can later be expanded into detailed schedules;
- . To establish the project's Critical Path which will enable, even in the early stages, some analysis of whether the estimated project duration is feasible.

However, as the project is approved, and detailed construction planning gets under way,

this Master Network will be expanded. Generally it is simpler to develop a series of detailed networks, along the lines of the Work Breakdown Structure than to develop the detailed network in one piece. As the detailed networks are developed, and the planning for the project becomes more accurate, the Master Control Network will need to be adjusted in order to reflect the revisions brought about by a more careful analysis of the project.

As the detailed networks are developed, the problem of coordinating and integrating one with the other and with the Master Network is introduced. This part of the system development is treated in Chapter V. The remainder of this Chapter, however, is devoted to the techniques of developing detailed networks.

Before describing the method of developing a detailed network, certain terms and symbols must be defined.

An Event:

An event is a defineable accomplishment in the project plan, recognizable at a particular instant of time. It is a point in time and not a passage of time. It does not, therefore, consume time or resources. The symbol used to represent an event on a network is a circle. Examples of events from the Durgapur networks would be as follows:

- . Tenders scrutinized for supply of stainless steel items for Ammonium Sulphate Plant;
- . Board's approval for contract for supply of stainless steel items obtained;
- . Foundations of Desulphurization Section of Ammonia Plant completed;
- . Erection of Boiler Burner Section of Sulphuric Acid Plant completed;
- . Start equipment delivery for Reaction Section of Phosphoric Acid Plant.

Milestone:

A milestone is used in the Master Control Network and is a key event where a major action is scheduled to be accomplished. It is represented by a rectangular box symbol in a network. Examples of milestones in the Durgapur networks would be:

- . NIT issued for Complex Fertilizer Plant;
- . Contract awarded for Ammonia Plant;
- . Erection completed on the Urea Plant.

An Interface Event:

An interface event is an event which occurs in more than one network. For instance, the Mechanical Erection Contract is a functional effort for which a separate network has to be developed. It is obvious that this contract is to be awarded before Mechanical Erection can be started in any plant. The event 'award of Mechanical Erection Contract'

does not belong to a particular network, but is a common event which occurs in all plant networks. It is therefore termed an 'interface event'. The use of interface events is dealt with in greater detail in the next Chapter. Some other interface events in the Durgapur networks would be:

- . Civil Design Contract awarded;
- . Civil Works Contract awarded.

The interface events in a network are shown by a hexagonal symbol. Event symbols are in figure 4.

An Activity:

An activity represents performance of work between two events and is represented on the network by an arrow joining the events. It is a time consuming element, and utilizes resources. An activity which does not consume

time or resources is termed a 'dummy activity'. Dummy activities which are shown by dotted arrows are used in the networks to show the inter-dependency between separated events on the network. The direction of the arrow indicates the sequence in which the events are to be accomplished.

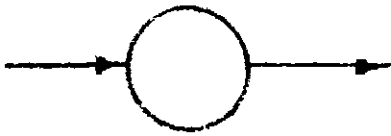
Rules for framing network:

A few simple rules will guide the arrangement of the detailed networks:

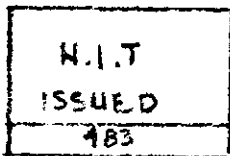
- . An event cannot occur until all activities leading to it have been completed;
- . Any activity succeeding an event cannot be started until the event has occurred;
- . An event cannot occur twice, that is, there can be no network looping back to a previously accomplished event;
- . A full description of each activity should be written above the arrow;



# EVENT SYMBOLS



EVENT

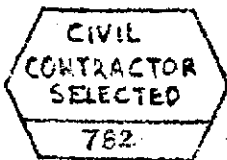


S. 15 MAY/65

MILESTONE

(ON MASTER NETWORK)

S: SCHEDULE DATE

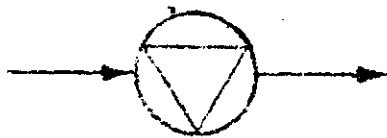


S. 24 JAN/66

INTERFACE EVENT

(INDICATES POINTS OF RESPONSIBILITY TRANSFER BETWEEN NETWORKS;

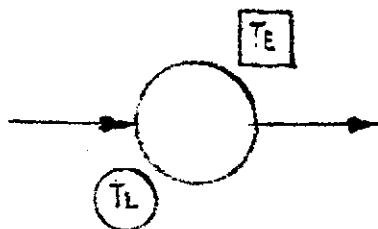
NEED NOT BE SHOWN ON MASTER NETWORK)



S. 18 JUL/65

SPECIFICATION DATE

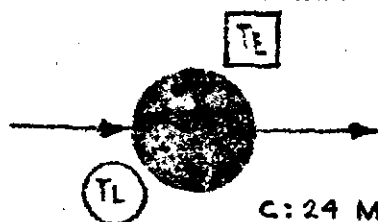
INDICATES EVENTS THAT WILL BE INCLUDED IN THE CONTRACT SPECIFICATION SHOWN ON MASTER OR DETAILED NETWORK.



EVENT TIMES

TE = EARLIEST EXPECTED DATE

TL = LATEST ALLOWABLE DATE



COMPLETED EVENT

C: COMPLETED DATE

C: 24 MAY/66

- . All restraints and interdependencies in the programme must be shown.

A specimen network is shown in figure 5.

### Timing the Network:

#### Activity Duration Time: ( $t_e$ )

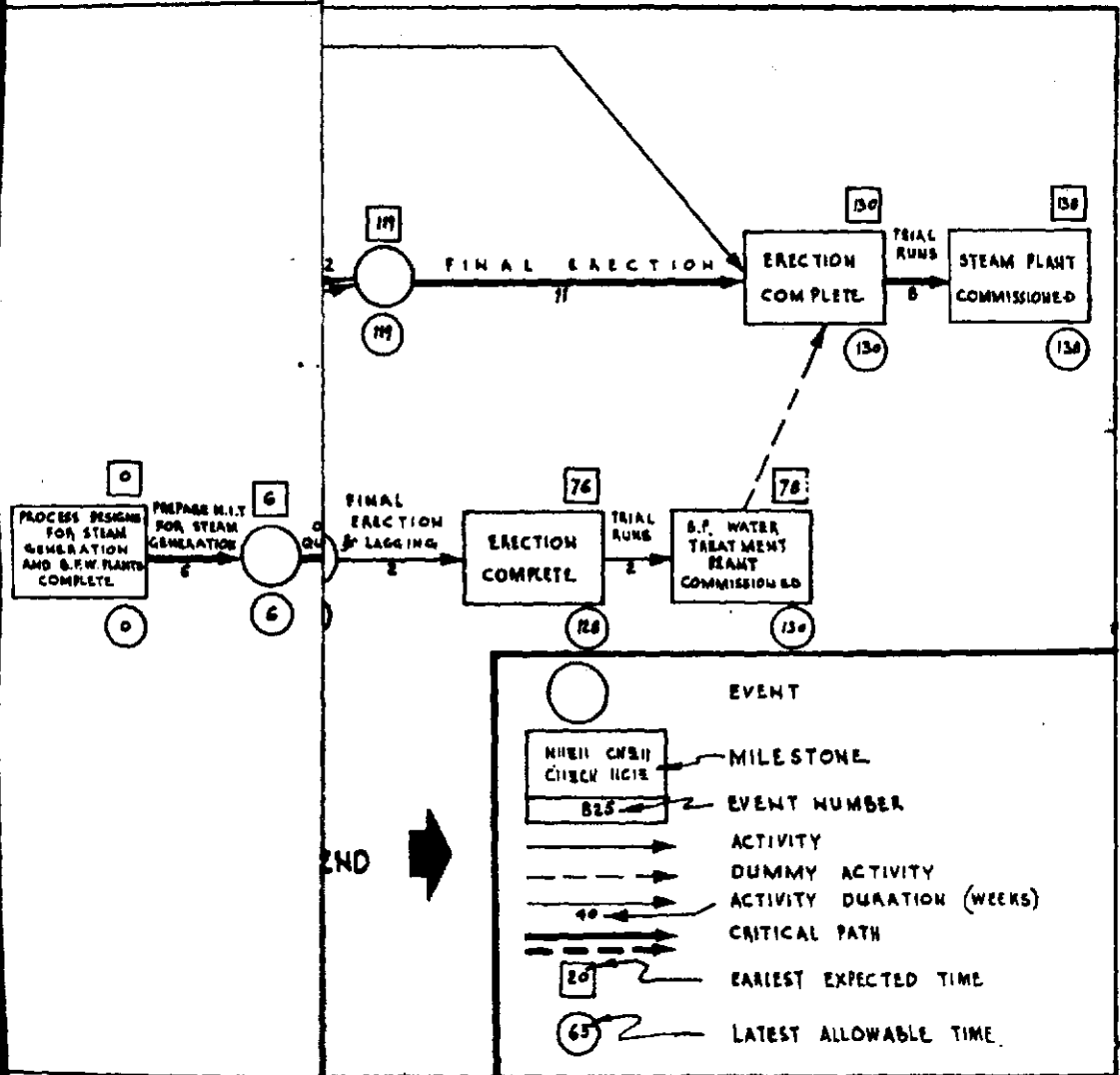
After developing the logic of the network, the next step is to establish the time required to complete each activity. Time durations for the Durgapur networks are given in weeks and should be the 'most likely time' for completion of the activity as estimated by the manager responsible for the work. The time assigned to an activity is termed the 'Activity Duration Time' and is given the symbol ' $t_e$ '. The time is recorded below the activity line.

It cannot be too strongly emphasized,

however, that if the time estimates for individual activities are too optimistic then much of the value to network scheduling is lost. If the Board's approvals have taken four months on past projects, then four months should be allowed in developing the schedules for this project; no amount of wishful thinking should change such estimates.

Earliest Expected Time: ( $T_E$ )

Having assigned all time durations ( $t_e$ 's) to the network, the time of completion of each event on the network is calculated. The accumulated activity time provides the 'Earliest Expected Time' ( $T_E$ ) for completion of the project.  $T_E$  represents the earliest time that all preceding activities can be completed. The  $T_E$  for any event is, therefore, obtained by summing up the  $t_e$  values along the longest path to that event. The  $T_E$  for the



**FERTILIZER CORPORATION OF INDIA**  
**DURGAPUR FERTILIZER PROJECT**  
**NETWORK FOR STEAM GENERATION AND BOILER FEED WATER PLANTS**

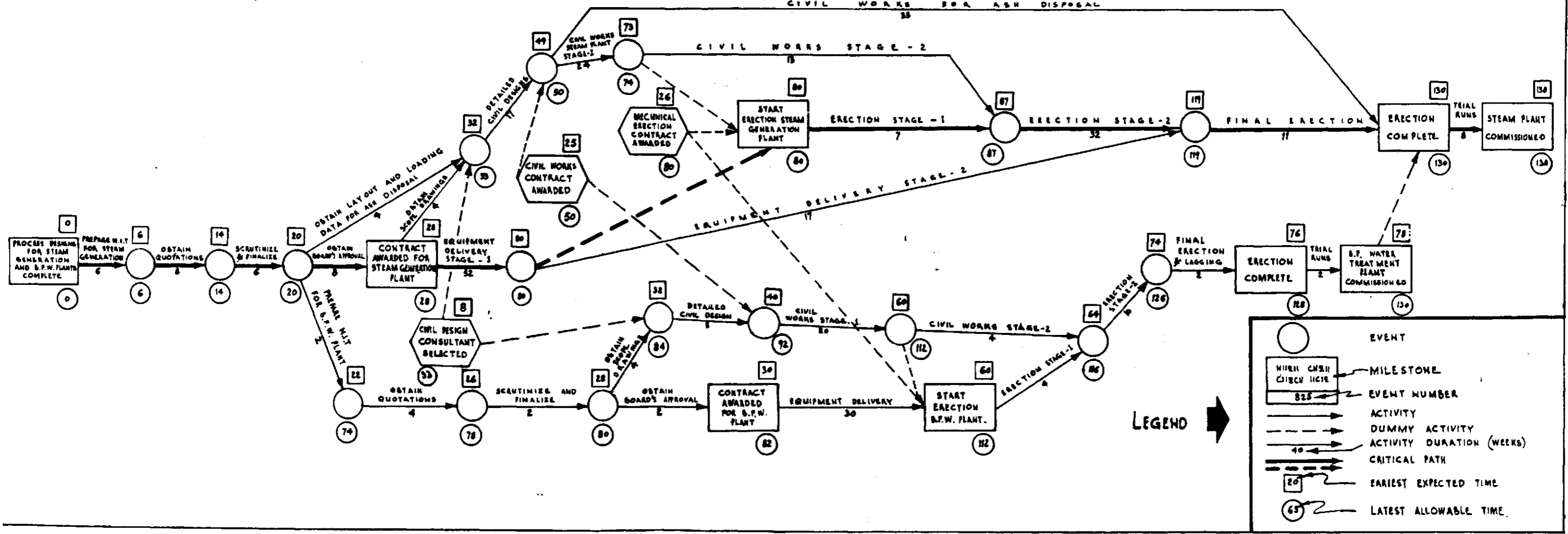


FIGURE. 5

end event of the project gives the earliest time at which the project could be completed.

The  $T_E$  values are recorded just above the events in the network, with the figures enclosed in boxes.

Latest Allowable Time:

The next stage in the network analysis is to determine the Latest Allowable Time ( $T_L$ ) of each event. This may be defined as the latest time by which an event may be accomplished without slipping the time of the final event. It is calculated backward from the end event on the network. As a specific scheduled date ( $T_S$ ) has been assigned by management for the completion of the project, then  $T_S$  becomes the  $T_L$  for the end event. Having fixed the  $T_L$  for the end event, the  $T_L$ 's of the other

events on the networks may be determined. The  $T_L$  of any event is obtained by subtracting from the  $T_S$  the sum of durations along the longest time path from that event to the end of the network. The  $T_L$  for a particular event is recorded in a circle near that event (refer to figure 5).

Slack Calculations:

Event Slack:

Event Slack is the time difference between the Latest Allowable Time ( $T_L$ ) and the Earliest Expected Time ( $T_E$ ) for an event. This slack value is the length of time that the event can be delayed without affecting the completion time of the project.

For any event Slack may be positive, zero, or negative:

Zero Slack ( $T_L$  equals  $T_E$ ) indicates that the project will be completed on schedule. Zero Slack occurs when the directed end date coincides with the  $T_E$  value of the end event;

Positive Slack ( $T_L$  is greater than  $T_E$ ) indicates that the project will probably finish ahead of its scheduled completion date;

Negative Slack ( $T_L$  is less than  $T_E$ ) indicates that the project is likely to overrun its end date and unless corrective measures are taken, the project will probably slip its directed end date.

Activity Slack:

Activity Slack is the amount of time latitude available so that the completion of the activity can be delayed without affecting the overall project duration. The Total Slack in respect of an activity is, therefore, the maximum time available to complete that activity calculated by subtracting the Earliest Expected Time of the event from the Latest Allowable



Time of the succeeding event less the duration of the job. Event Slack and Activity Slack are illustrated graphically in figure 6.

Critical Path:

The Critical Path runs through those events where the algebraic value of slack is a minimum. It is the most time consuming path through the network, along which no slippage can be tolerated if the project is to be completed in the shortest possible time. The events lying on the Critical Path are termed Critical Events (refer to figure 5).

After developing the network, and the  $T_E$ 's and  $T_L$ 's noted against all events in the network, the Critical Path is identified and marked by a thick line. With this, the network construction is complete. The  $T_E$ 's,  $T_L$ 's and the Critical Path for a typical network of the

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EVENT AND ACTIVITY SLACK

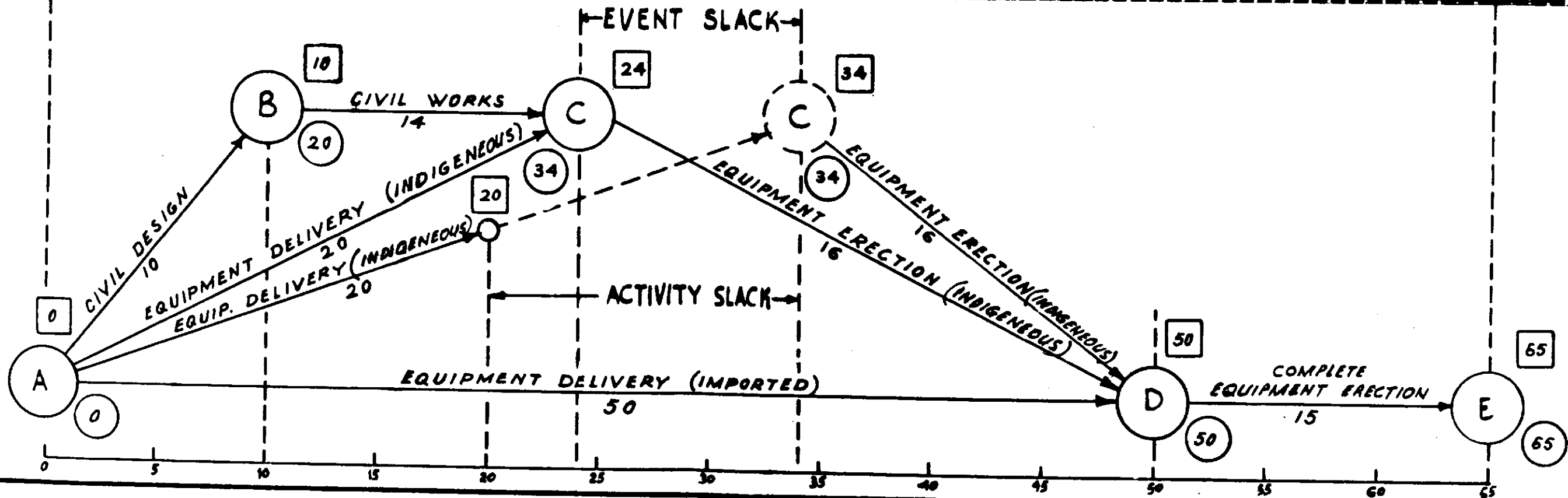
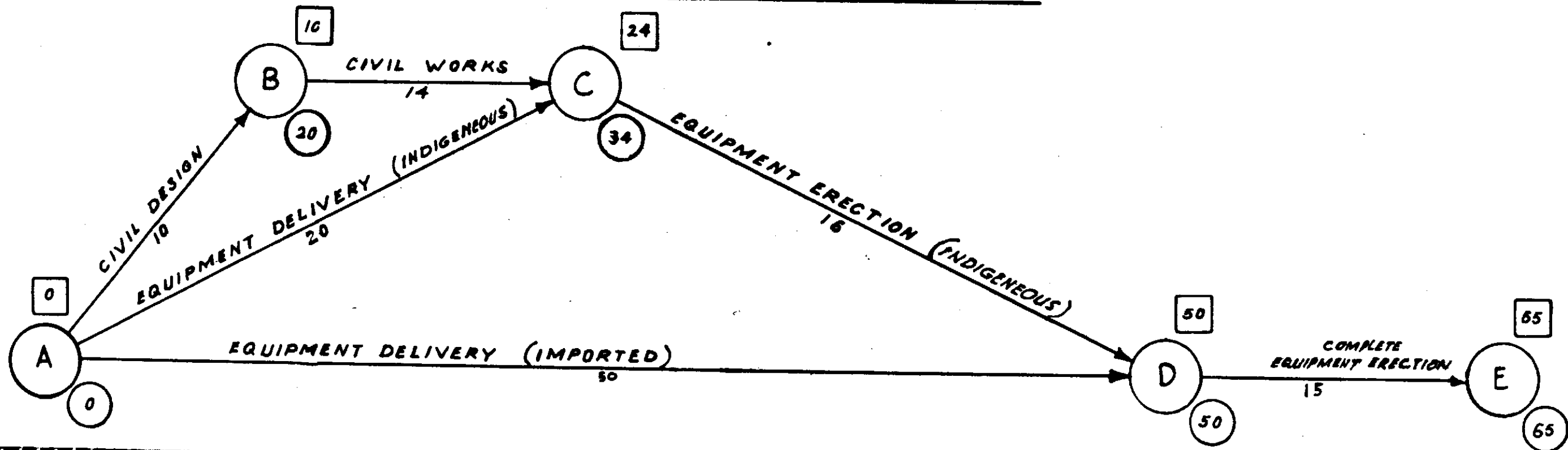


FIGURE. 6

Durgapur Project are shown in figure 5.

In case the Completion Date ( $T_E$ ) is beyond the Directed End Date, (i.e. there is Negative Slack in the network), it will be necessary to re-examine the network to determine if the Completion date derived from the networks could be brought back to meet the Directed Date. This can be achieved in one or more of the following methods:

- . The first step would be to closely examine the Activity Duration Estimates ( $t_e$ 's) along the Critical Path;
- . By addition of more resources to Critical Activities - be it money, manpower or equipment. This process of 'buying time' for earlier completion of the project should be balanced against the advantages of obtaining quicker return from the project;
- . By greater paralleling of activities. This could possibly be obtained by further breaking down the jobs into smaller units. Concurrent performance could reduce overall construction time;

- . Event Slack;
- . Activity Slack;
- . Identify flaws such as closed loops etc. in the logic of the network.

Computers become more attractive as the size and complexity of the networks increase; or where the network technique is used on several programmes within an organization; or where frequent updatings or simulations are to be made. Although details differ considerably, computer programmes generally require certain common input data, and print out data (output) in more or less standard forms. The inputs, the calculations done and the outputs received from the computer are given below:

Inputs to the Computer:

- . Event codes or numbers;
- . Event or activity description;
- . Time estimates.

Calculation done by the Computer:

- .  $T_E$ ,  $T_L$ , Event and Activity Slack;
- . Updating of networks based on revised input;
- . Sorting of activities or events;
- . Time/date conversions.

Outputs:

- . Events and their  $T_E$ 's,  $T_L$ 's, finding the Critical Path and Simulations etc;
- . List of events by slack;
- . Ranking of events and/or activities in a specified order.

A computer programme is also useful to

do the following:

- . Synthesizing the network and the time data to indicate the relationship to the programme objectives; and
- . Computing rapidly the effects of alternate courses of action.

A Manual on "Planning and Scheduling with the Network Technique (PERT/CPM)" has been

brought out separately by the Management Group of COPP and the reader may refer to this document for the various input and output formats and the procedure for using these formats for network computations. It is quite practical however, and possibly cheaper, to operate the system described in this manual by hand.

Benefits of network scheduling:

The benefits of network scheduling may be summarised as follows:

- . The detailed planning required to create a valid network eliminates the looseness of planning frequently encountered with other methods;
- . The network development and the Critical Path analysis highlight inter-dependencies which are frequently not well defined by conventional planning methods, thus aiding coordination and communication between project participants;

- . The Critical Path determination focusses management's attention upon those activities which are the determining factors in the timely completion of the project;
- . The analysis of the Non-Critical Paths can play an important part in the deployment of resources, thus reducing the overall project time;
- . The network scheduling technique permits the detection of potential slippages and shows the impact of a slippage on other activities.

The benefits to be gained from network scheduling are, therefore, worth the effort of implementation. Adoption of the technique requires little change in the organization and procedures of the project, but will considerably assist in the detailed planning and control of the project. The larger and more complex is the project, the greater will be the advantages gained from using the technique.

Before the system can become fully operational at Durgapur, however, each detailed

network that has been developed under the guidelines given above, needs to be cross checked for consistency with the other networks and also with the master network. This integrative process is described in the next Chapter.

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**CHAPTER V**

**NETWORK INTEGRATION**

CHAPTER V

NETWORK INTEGRATION

In large programmes, as stated earlier, detailed networks are developed to the depth of detail necessary for control at the operating level. As such, the full picture of the planned construction effort is portrayed by the detailed networks and supporting schedules. However, planning and control of the project through the use of networks is essentially a managerial action. It is desirable, therefore, that the Manager has some means of summarizing the great amount of detail in the working schedules.

In addition, the detailed networks at each operating level need to be integrated with each other, and particularly for those events which are common to several networks. Only through such an integration are the line managers able to coordinate their

programmes with the overall programme of the project. These aspects are discussed in the following paragraphs:

Network Summarization:

Summarization of detailed networks is effected by means of the Master Control Network. As the primary purpose of the Master Control Network is to provide a managerial "overview" of the project, too much detail would be confusing. It is for this reason that all the inter-connections between detailed networks are not shown on the Master Network. The greater part of the coordination of the detailed networks is shown, therefore, on these networks only, and not on the Master. The Master, however, can serve as a broad vehicle for linking up the detailed networks.

As the Master Network is only a representative summary of the detailed networks, it

is not always possible to give a comprehensive representation of the detailed network in the Master. Such a situation is illustrated in figure 7. In this example of Ammonia Plant the detailed plant network has been broken into the following four major subsections:

- . Desulphurization Section;
- . Reforming Section;
- . Purification Section; and
- . Compressor Section.

The possible summarization of the above sections on the Master Network could be:

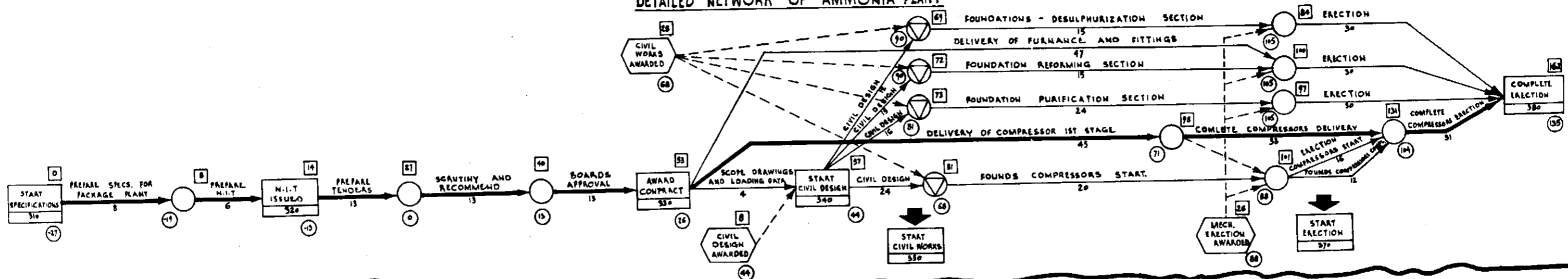
- . To show the most important section only;
- . To show the activities on the Critical Path;
- . To show a less definite but more general representation of the detailed network.

In figure 7, the third possibility has been chosen and only a general representation

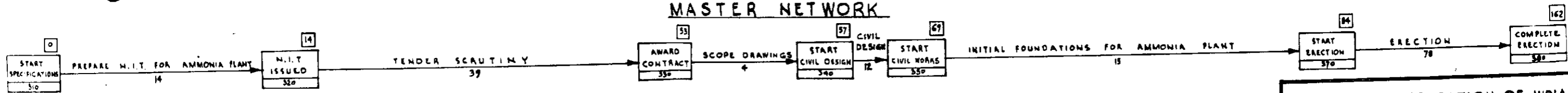
of the detailed network has been given. It is still necessary to ensure that the total length of time of the detailed network is portrayed on the Master Network. The Master activity durations, therefore, are chosen to show the total time for construction of the plant.

While summarizing the detailed network in the manner shown in figure 7, a question may arise as to whether it is essential to show important detailed activities on the Master. For instance, in the detailed network of Ammonia Plant, an important activity is 'delivery of compressors' which lies on the Critical Path. Obviously, a slippage in the completion of this activity would cause a slippage in the completion of the Project. While summarizing this detailed network in the Master by adopting the third possibility described above, the Critical Activity 'delivery of compressors' is not shown on the Master. There are two reasons

## NETWORK SUMMARIZATION DETAILED NETWORK OF AMMONIA PLANT



## MASTER NETWORK



**LEGEND**  
→ CRITICAL PATH

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NETWORK SUMMARIZATION

FIGURE .7

for this. Firstly, the possibility of "showing the activities on the Critical Path" as described in the earlier paragraph has not been chosen to summarize the detailed network. Only a "less definite but a more general representation of the detailed network" has been considered in this case. Secondly, though the "delivery of compressors" is a Critical Activity, there may not be any slippage in the completion of this activity during the construction stage of the plant. On the other hand many other items could also slip, thereby causing a slippage in the project. If, however, the activity on the Critical Path viz; "delivery of compressors" does slip, the Master Control Network could be revised to show this information.

Interface Events:

As stated earlier, co-ordination of

the detailed networks is for the most part handled on the networks themselves. There are a number of items of work which appear on more than one network. Civil Design, Civil Construction and Mechanical Erection are major examples. As explained previously, the work involved in these contracts can be portrayed on separate "functional networks". The necessity of awarding the contract before the Civil Works can be undertaken on each of the major plants is, of course, obvious. Some method is, therefore, necessary for showing the relation between events on different networks. The method used to show this relationship is the 'Interface Event'. An interface Event signals the necessary transfer of responsibility, or information from one network to another (see figures 8 and 9).

The award date of one of the functional contracts would be an example. The Expected



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 NETWORK INTEGRATION - INTERACE EVENTS  
 PLANT NETWORK - COMPLEX FERTILIZER

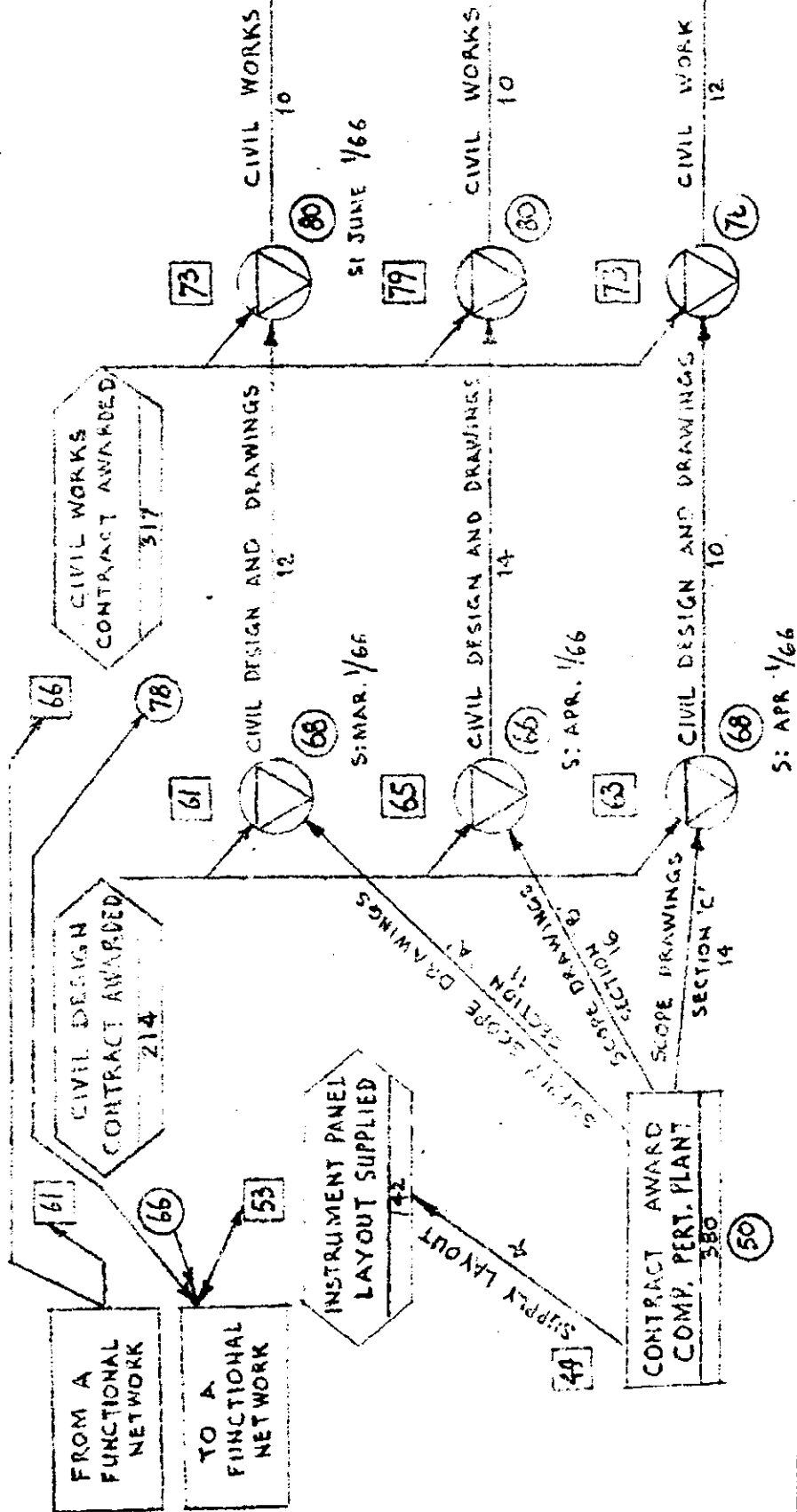


FIGURE 8

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 NETWORK INTEGRATION  
 FUNCTIONAL NETWORK-CIVIL DESIGN

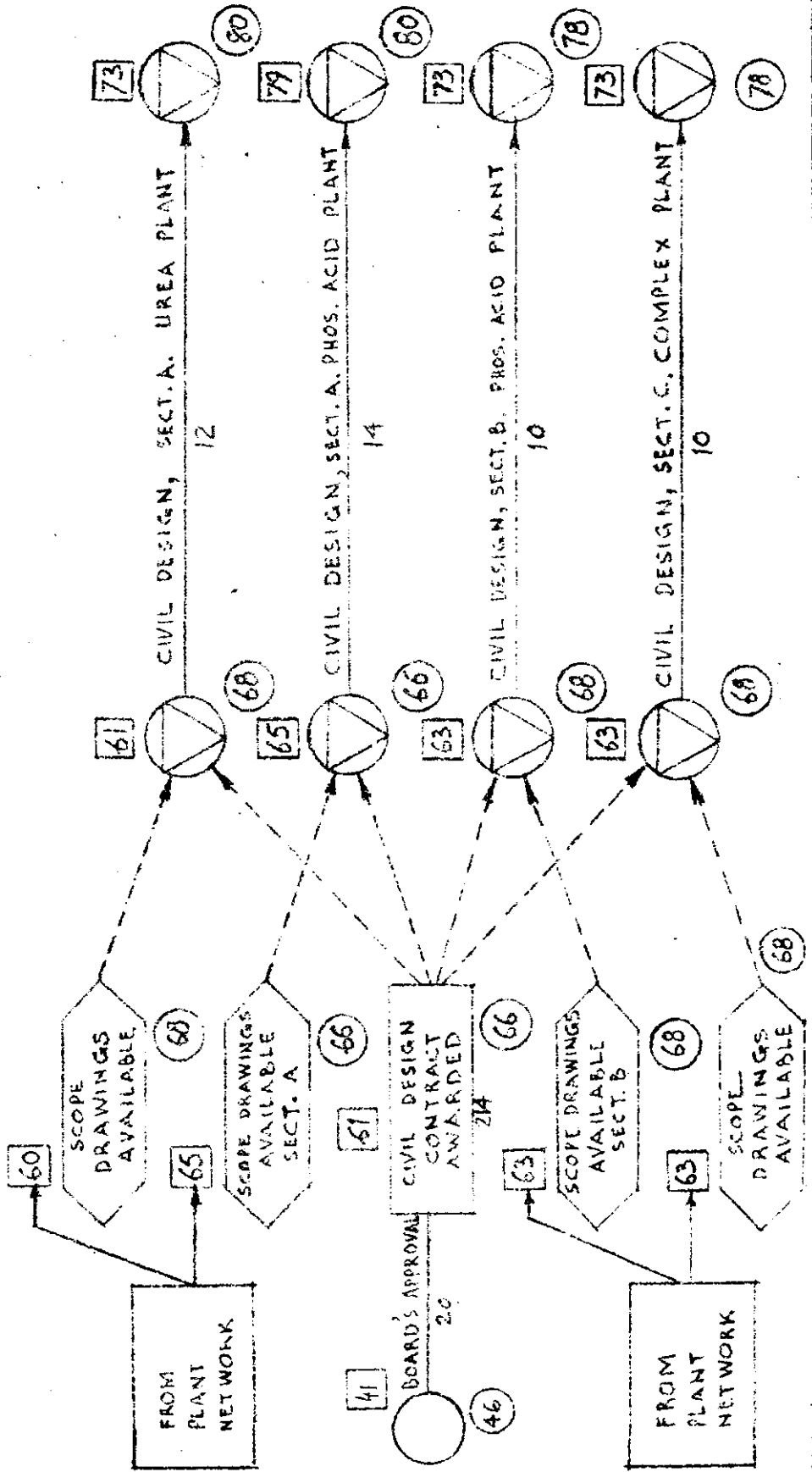


FIGURE . 9

Date ( $T_E$ ) for this event, which comes from the functional network, is used in the main plant network for calculating the Expected Date ( $T_E$ ) of starting the contract. Figure 8 shows a portion of the Complex Fertilizer Plant Network. The Civil Design and Civil Works shown on this network can be started only after the award of the contracts for these two items. The events "Civil Design Contract awarded" and "Civil Works Contract awarded" are, therefore, shown as Interface Events in the diagram. The values of  $T_E$ 's for the events "Start Civil Design" and "Start Civil Works" are determined from the values of  $T_E$ 's for the two Interface Events.

Similarly, the  $T_L$  values of the Interface Events "Civil Design Contract awarded" and "Civil Works Contract awarded" are derived from the plant networks and are used in the functional networks calculations

Likewise, the  $T_E$  value of the Interface Event "Instrument Panel Layout Supplied" coming from the plant network also goes to the functional network. These inter-relationships are depicted in figure 8.

When an Interface Event is used in networks, as in figure 9, it is necessary to transfer the Expected Dates ( $T_E$ ) or Latest Allowable Dates ( $T_L$ ) from one network and use it as a basis for calculation in other networks. For instance, figure 9 shows part of a functional network of the Civil Design for the Urea, Phosphoric Acid and Complex Fertilizer plants. Starting the Civil Design of each plant is dependent on the availability of scope drawings and the award of Civil Design contract. Hence, the event "scope drawings available" which comes from the network for each plant is an interface event in the Civil Design Network. The  $T_E$  value for the event "scope drawings available" is

derived from the plant network and is used, in conjunction with the  $T_m$ 's already on the functional network to calculate the earliest time that Civil Design can start for each plant.

Similarly, the  $T_L$ 's for the event which shows the Completion of Civil Design are derived from the plant networks and are used to calculate the  $T_L$ 's for the other events in the functional network.

The transfer of calculated dates between different networks may give rise to errors. It is simpler to make a direct transfer, but as an alternative, the project may use an 'Interface Log' to keep track of Interface Events. An example of such a log is given in figure 10. This log is not used for all Interfaces but is only kept for those events which Interface with

several networks. For instance, figure 10 shows the interface of Civil Design with more than one plant. If the Civil Design Contract is for one plant only, then this effort can be portrayed on the plant network. There is no need for a separate Civil Design network and thus for interfacing the two networks. If the project finds that it can keep track of Interfaces without the log, then its use should be discontinued.

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INTERFACE LOG

INTERFACE EVENT NO. 214	EVENT DESCRIPTION Civil Design Contract awarded	NETWORK T <sub>E</sub> week 61
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RECIPIENT NETWORK

NETWORK DESCRIPTION	EVENT DESCRIPTION	T <sub>E</sub>	T <sub>L</sub>	S
Detailed Network for Complex Fertilizer Plant	i) Start Civil Design & drawings - Ammonia Vapourization Section	61	68	61
	ii) -do- - Ammonium Phosphate Section	65	66	65
	iii) -do- - Granulating Salt Section	63	68	65
Detailed Network for Ammonia Plant.	i) Start Civil Design & drawings - Desulphurization Section	61	72	65
	ii) -do- - Reforming Section	72	90	80
	iii) -do- - Purification Section	68	79	72
	iv) -do- - Compressor Section	61	61	61

FIGURE 10

**CHAPTER VI**

**SCHEDULING**



CHAPTER VI

SCHEDULING

After establishing an overall Master Control Network for the project and developing detailed networks, it is necessary to fit these networks to a time schedule. Scheduling of the network may be defined as the translation of the plan into a time table with specific calendar dates.

Scheduled dates are established as specified dates in each of the contracts, or become targets that the project authorities themselves have to meet in order to accomplish their work on schedule.

The reason for developing scheduled or target dates is to clarify the schedule responsibility of all project participants. Scheduling also assures that the effort of each project participant is directly related to total project objectives and correctly phased with that of the other project participants. On a complex

programme such as the Durgapur Project, network scheduling not only shows the inter-relationships between participants' activities but also provides an overall visibility to top management of programme targets.

During early development of the networks, there is a period of exploration of construction methods and an examination of different schedule activities. At this stage, the project has not generally been tied to calendar dates. The occurrence of events are expressed in time units from the beginning of the network. Each event also has a latest allowable time, which provides some flexibility in the time by which the event should be completed. With the fixing of project start dates and the nomination of a desired project end date, the network plan becomes more useful when key events are expressed in calendar dates.

Scheduling of the network starts after the network integration is completed. In the system development therefore, scheduling is carried out as a separate step to the development of the networks. Before assigning firm dates for accomplishment of events, all Negative Slack in the network should be identified and eliminated.

Translation of networks into schedules is accomplished by assigning the resources and facilities to complete the planned tasks at desired dates. In the scheduling process, therefore, the following factors are to be considered:

- . The availability of required manpower and equipment facilities during specific calendar periods;
- . Correct judgement of a reasonable time for performing work under existing constraints;
- . Uncertainties in particular activities which may require the provision of extra time; and

. Varying number of work days and holidays per month.

In the assignment of scheduled dates to events, the criterion should also be that dates should not be assigned too close to the Latest Allowable Time ( $T_L$ ) for events, as such a schedule would result in a very tight programme. Care should, therefore, be taken to schedule the events suitably between the Earliest and the Latest Allowable times.

The scheduled dates assigned to a network should not normally be changed. Once schedules are developed and approved, they should be communicated to all concerned with the project. By the scheduling process, the activities of project participants at different working levels are welded into one tight comprehensive plan which conforms to the overall objectives of the project.

Another important advantage of the Network Technique is that it offers scope for

Manpower Scheduling and Resource Allocation on a project. This aspect, which is important from cost-reduction point of view, is described in the paragraphs that follow:

Manpower Scheduling:

In order to keep construction costs to minimum, it is necessary that the resources available to the project be applied in the most efficient manner to achieve the desired end objectives. Since skilled manpower is a principal resource involved in the construction industry, the planning and control of this resource offers a significant method of cost reduction on a project. Furthermore, the methods of scheduling outlined earlier offer a useful tool for ensuring that the manpower resources are utilized in the most effective manner.

It should be noted, however, that manpower planning can be undertaken only for

those skills where Project Management has the authority to control the number of men applied to each item of work. At Durgapur (and in most Public Sector projects) this planning can be applied to their own direct hire employees only. The planning of contract manpower is the responsibility of the contractor. The techniques outlined in the section, however, are applicable to all organizations participating in a project.

The essence of resource minimization in any construction undertaking is to avoid a situation similar to that shown in Figure 11. This figure illustrates the overall manpower loading that could be required for a project if no attempt is made to level off demand. This graph could equally be developed for a contractor's organization, for a special skill or trade, or even for an entirely different resource such as an item of construction equipment.

# MANPOWER LOADING GRAPH

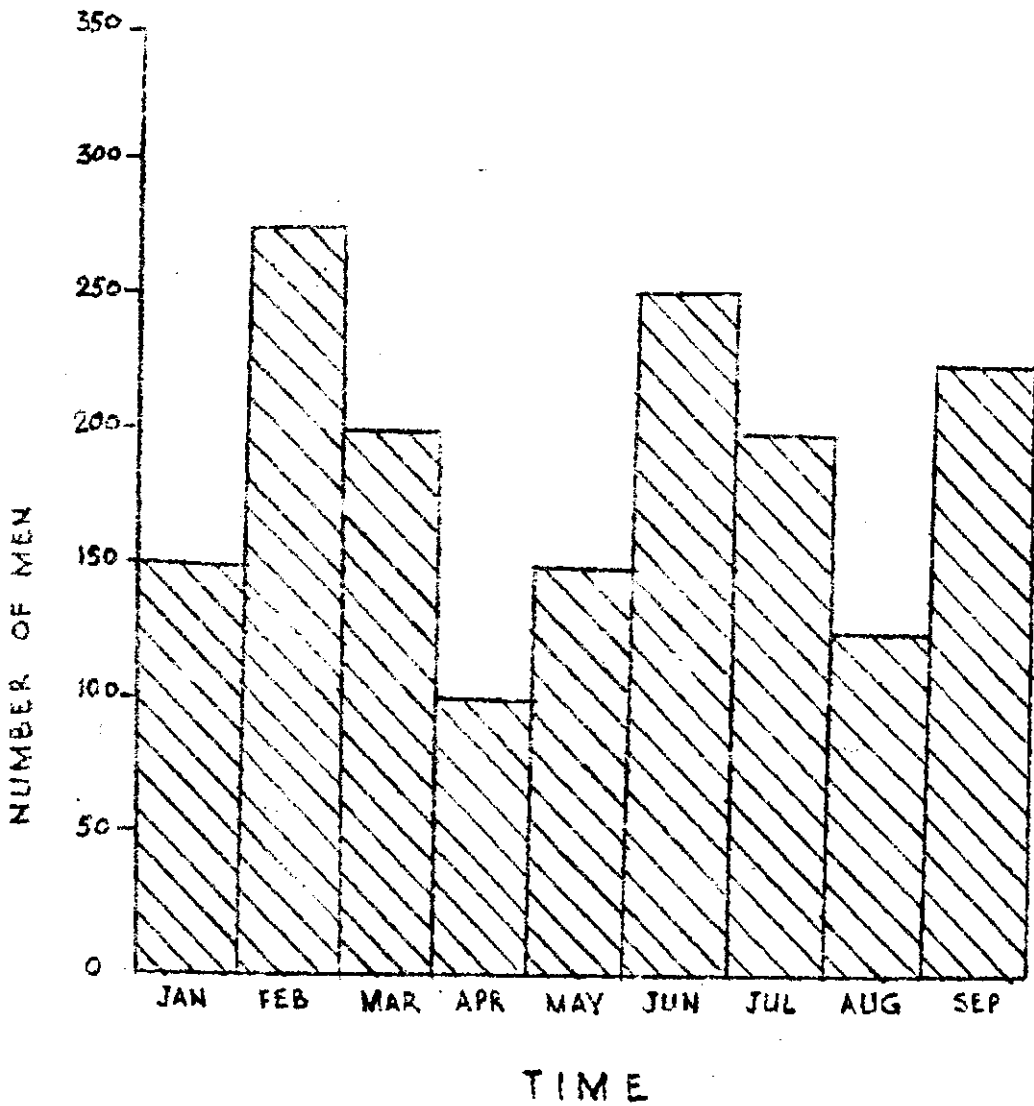


FIGURE 11

The graph indicates that the project management will be forced to either:

- (i) Hire men in order to meet peak demands and carry them through idle periods; or
- (ii) Indulge in a practice of hiring and discharging of labour in order to cover the peaks and valleys.

Either practice is not good. The first is expensive; the second is likely to cause labour unrest on the project. It will be cheaper in the long run to plan the construction work in such a way that an even demand is placed on as many resources as possible.

In practice also it will be found that the site manager, when faced with an uneven resource loading will tend to slip jobs so that he does not have to hire additional labour. Such adhoc decisions often have a detrimental effect on the overall project schedule and it is far more effective if resources are planned in such a way that they are used effectively in



maintaining project objectives. The Critical Path Method of Scheduling is very effective in assisting in this early resource planning.

Manpower Levelling with the Network Technique:

Manpower planning should be undertaken at the time the organization is preparing its job schedule. At this point in time it is faced with meeting only the end objective-project completion date for the GOI agency or contract target date(s) for the contractor. Many intermediate target dates have to be established and manpower planning is an important part of establishing these dates. The network technique provides two advantages in this phase. They are knowledge of

- (i) the Critical Path; and
  - (ii) the slack available in individual activities or blocks of work.
- (i) It is possible, during the manpower scheduling process to transfer resources used on non critical activities to more

critical activities. As mentioned in a previous chapter this is a method of reducing the overall time required for the project. It is also a method of evening the load on any one resource.

(ii) Activities with slack values may also be scheduled so that the resources used on one can be used on a second and subsequent activity. In this way the two activities which were originally completely independent and could be done simultaneously if resources were available, now become dependent as both are now using the same resource. The scheduled dates of starting and finishing each activity indicate this dependency.

A bar chart on a calendar scale is a useful tool for showing the scheduling of activities within their slack limitations.

Estimating of Resources:

As stated earlier, resource levelling may be undertaken for the total labour force within an organization, for each major skill within the organization or for items of construction equipment.

Resource levelling may also be undertaken for each activity in the network using this resource. This has the advantage that the slack in each activity is clearly defined. Resource levelling by activity however has a disadvantage in the number of activities using a particular resource. A less accurate, but simpler method, therefore, is to level by blocks of work. For instance, if the demand on a concrete mixer is being analysed, instead of looking at every activity involving concreting, the analyst could examine only groups of activities requiring concrete.

Concreting foundations may be described on the network by a start, continue and complete activity for each subsection. The analyst, however, could only examine the foundation workload for each building.

Even by such approximate methods it is possible to considerably reduce peak demands on vital resources; and thus create a schedule which is realistic and more likely to be achieved during the construction of the work.

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CHAPTER VII  
SUPPORTING SCHEDULES

CHAPTER VII

SUPPORTING SCHEDULES

While the schedules shown in the Master Network provide an 'overview' of the entire project to top management regarding the dates of accomplishment of key events, those shown in the detailed networks give the dates of completion of detailed tasks to the line managers at various working levels. These detailed networks, however, do not contain many minor items of work. In addition, many smaller contracts do not require the establishment of separate networks. Insulation contract, erection contract, equipment delivery contracts may be quoted as examples.

Completion of the project, however, still requires the completion of these minor items on schedule. Schedule slippages of these minor items can cause slippages in the achievement of major milestones, eventually affecting

the entire programme. Therefore, a schedule establishing the completion dates of minor items is necessary for phasing with the overall programme. The exercise of control over the schedule will be facilitated by presenting the items in a separate scheduling document or Supporting Schedule. These Supporting Schedules are necessary for the complete monitoring of the total programme to ensure that no items are likely to cause trouble.

The purpose and objectives behind the establishment of supporting schedules may be summarized as follows:

To facilitate control over each contract. Each contract will have a number of schedule dates which will eventually be written into the contract document. Control over these dates will be facilitated through use of a Supporting Schedule;

To develop the schedule for functional contracts. Some of the functional contracts (Civil Works, Design, Electrical etc.) may not warrant a separate network. The schedule of some items in these contracts therefore can be interpolated from the main plant networks and presented in a Supporting Schedule;

- . To develop schedules for work not shown on networks. Not all schedule dates are recorded on a network. For instance, it is not anticipated that delivery of every piece of equipment will be shown on the network. Dates for delivery of equipment, however, need to be established. These dates can be interpolated from the networks and presented in a supporting schedule.

Illustration of supporting schedules is given in figures 12 and 13 in tabular form. However, supporting schedules where appropriate, can be developed in gantt or bar chart format.

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FERTILIZER CORPORATION OF INDIA

DURGAPUR FERTILIZER PROJECT

SCHEDULE FOR CIVIL WORKS CONTRACT

Contract N.I.T.'s to be issued:

Tenders to be received:

Contract to be awarded:

PLANT	FIRST DRAWING RELEASE	FINAL DRAWING RELEASE	FOUNDATIONS COMPLETED	CIVIL WORKS COMPLETED
<u>AMMONIA PLANT</u>				
Section A				
Section B				
Section C		(Contracted dates in Civil Designer's contract)	(Contracted dates in Civil Works contract)	(Contracted dates in Civil Works contract)
Section D				
<u>COMPLEX FERTILIZER PLANT</u>				
Section A				
Section B etc.				

FIGURE 13

**CHAPTER VIII**  
**CONTRACT SCHEDULING**

CHAPTER VIII

CONTRACT SCHEDULING

As is usual on most Public Sector projects, most of the work on the Durgapur Project will be carried out under contract. If the project is to be completed on target all participating contractors should perform their work to a schedule which is integrated with the overall project plan. Without this integrated approach to the contractor's work, a slippage, even in a small item in the contract, may affect several other participants and, in turn, the accomplishment of the target date of the project. The completion of the entire project on time and within cost estimates, therefore, depends to a very large extent, on the proper planning and coordination of each and every contract in the project.

Before any contracts are awarded, it is, therefore, necessary that the entire design and construction effort under contract be scheduled

to meet the project completion date. After the contract document is signed and the work has been started, it is very difficult to develop a schedule which will effectively bind the contractor to completion of his work in accordance with the project's overall interests.

If a contractor's work is not contractually linked with that of other participating groups, it becomes very easy for the contractor to develop a schedule which is to his own advantage, and which gives a good chance for potential claims and extras in the future. Such a schedule may also confuse responsibility and any attempt to invoke the penalty clause in the contract at a later date would be very difficult. The solution, therefore, lies in the prior development of a schedule which outlines the effort required by each contractor.

Establishing a contractor's schedule:

The first step in the award of any contract is the issue of Notice Inviting Tender (NIT).

It is therefore necessary to develop each contract schedule prior to the issue of NIT. Besides defining the completion date of the contract, the schedule should define the required date for any significant point of communication between the contractor and another participant on the project. For example, the schedule for the foundations contractor should not only specify the date of completion of the contract, but the dates when each major section should be completed. This will enable machinery to be erected in an orderly sequence and within the overall objectives of the project schedule.

In developing this schedule it is not always possible to take into consideration the contractors' workload. An opportunity must be given to the contractor, therefore, to suggest amendments to the schedule in his tendering documents. This can be done by requesting a schedule from the contractor at the time of issue of NIT.

Any amendments requested by the contractor which fall within the overall project schedule may be accepted. This contract schedule also provides a method of maintaining control over the contractor as outlined in the next section.

One difficulty that may be encountered in the prior establishment of a contractor's schedule is fixing dates for the delivery of major items of equipment from abroad. Generally, foreign contractors are unwilling to commit themselves on an equipment delivery schedule, other than accepting a penalty clause on the completion date of the contract. These dates are important, however, in that the scheduling of many other work revolves around them. Every attempt should be made therefore to firm these dates at the earliest possible moment.

When the bulk of the work is to be undertaken by turnkey contractors, the need for a tight control by the Project Authorities is

considerably lessened, as functional contractors (Civil Design, Foundations, etc.) are now responsible to only the turnkey contractor. Project authorities are not required to coordinate the efforts of each functional contractor working on several different plants at the same time. Control over the turnkey contract is, however, still necessary. In addition, it should, therefore, be noted that many of the aspects of the control procedures outlined in this manual may be adopted by the turnkey contractor, as already discussed in Chapter II.

Exercising control over the contract:

Once the contract has been awarded and construction gets under way, the project authorities need to check, at periodic intervals, that the contractor's progress conforms to the overall plan for the project. To achieve this, the project authorities need to give themselves authority, in the contract document, to control

the contractors' schedule.

A number of control clauses, as outlined below, will therefore greatly assist the Project Authorities in ensuring that the contractor executes his work in accordance with the project schedule.

These control clauses are:

- . That the contractor should submit a schedule (possibly by the Critical Path Method) with the tender documents;
- . That the contractor should show, in his schedule, all events which are significant in the completion of the contract. More information should be shown in the contractor's schedule than actual contract commitments;
- . That the contractor should specify in the tender document the resources in men, materials and equipment that will be used on the contract;
- . That the contractor should participate in periodical meetings with the Project Authorities to discuss the progress of the work;
- . That in case of a schedule slippage, the contractor should take such action as necessary to bring back his work to schedule without additional cost to



the project, either by employing over-time operations, increasing the number of shifts, capacity of equipment etc., or as directed by the project authorities;

- . That the contractor should immediately inform the Project Authorities if there is any change in his schedule;
- . That the contractor should submit with the tender documents a statement of progress payments so that cash flows for the project can be forecast (the usefulness of this clause is discussed in Chapter X);
- . That the turnkey contractor should furnish, at periodical intervals, say monthly or quarterly, a review report of work done, lagging etc. together with an updated network, when necessary.

Clauses of this nature will considerably assist the Project Authorities in maintaining the progress of each contract in accordance with the overall schedule. In this context, it is worthwhile making a careful study of the merits and demerits of the Penalty and Bonus clauses proposed to be included in contracts. This aspect is discussed below:

Penalty and Bonus Clauses:

Penalty Clauses:

It has been a common practice in contracts with both indigenous and foreign companies to include a penalty clause on the completion date of the contract. Penalty clauses are calculated by management to provide reimbursement to the project, if the contract is not completed on time. The amount of reimbursement is such that it compensates the loss that the project may sustain as a result of delayed realization of benefits. Penalty clauses also provide some authority over the contract in determining that the contract objectives are achieved on time.

In the past, however, penalty clauses have not been effective on many GOI projects. Generally, the contractor is able to lay blame for a slippage in his contract at the door of another party. For instance, the Civil Works Contractor is frequently

in a position to claim the penalty clause to be null and void as working drawings were not supplied to him in time or alternatively that certain items of material were not delivered at a rate that suited his schedule. As a matter of fact, contractors in addition to voiding the penalty clauses, are frequently able to claim extra payment due to delays caused in their contract by non-fulfilment of the work of another party.

The only solution for making penalty clauses more effective is to place a penalty on every point of contact between the contractor and another party. For instance, rather than specifying a penalty against the completion date of a Civil Works contract, it would be more effective to specify when each block of work should be completed so that the subsequent contractor can proceed in an orderly manner. Similarly, other parties which have inputs into the Civil Works contract, should be equally penalized for non-fulfilment of their obligations.

On certain types of contracts, an even more effective method of achieving project objectives is to pay a bonus for completion of the contract at a point earlier than specified. This aspect of contracting is discussed more completely below.

Bonus Clauses:

Bonus clauses are calculated from the increase in revenue that a project is likely to achieve if a contract is completed earlier than scheduled. They should, however, be only given for those contracts which provide a finished operating project. Bonus clauses, if provided in contracts which are only part of the entire project are likely to throw the project schedule askew, for some contractors will take advantage of the bonus clauses whereas other contractors will not. As the completion of a project has to await completion of the slowest contract within it, nothing has been gained by

having some of the contracts completed early.

Bonus clauses also have the disadvantage that the contractors will increase the resources that they plan to apply to the contract in order to be able to take advantage of the bonus clauses. These increased resources will frequently be reflected in higher bid rates from all parties. If a bonus clause is set for such project, the amount per month that is decided upon as bonus should be reduced by a factor which allows for the higher contract tenders.

Bonus clauses should be used with discretion, therefore, although it has been successfully argued in a number of Western countries that a penalty clause should not be attached to a contract unless the contractor is given an opportunity to earn a corresponding amount of bonus.

With the completion of the networks, establishment of schedules and the development of contracts, the planning phase of a fertilizer project is virtually completed. The next aspect of the system, therefore, is concerned with ensuring that adherence to the plan is as close as possible; and that any deviations from the plan are incorporated into a revised plan by a working system of management control. This portion of the system design is discussed in the following Chapters.

**CHAPTER IX**  
**SCHEDULE REPORTING**

CHAPTER IX

SCHEDULE REPORTING

When construction of the project gets under way, the Project Authorities must ensure that progress of the work is such that the project will be completed by its scheduled date. This is accomplished by periodic checking of progress against the plan laid out in the project schedule.

To facilitate analysis of progress, a reporting system has been designed for the Durgapur Project which was adopted by the Project Management. A display system has also been developed to provide an overall picture of the entire Project or elements of the Project at a glance. To be effective, the reports and displays must be clear and concise and presented in a form convenient for use by the Project Management. Of the reports and displays outlined below, only the first (Project Status



Report) has been firmly recommended for adoption by the Durgapur Project. The other reports and displays have been included for information and consideration for adoption by the Project Authorities.

Project Status Report:

This report (figure 14) is a summary of those activities which are the most critical on the Project at a date of reporting. It is a simple format which will be effective in bringing information on the project status to top management. The report has been designed as a monthly report to be submitted by the Planning Group to the General Manager of the Durgapur Project and to the Board of Directors of FCI. A similar report of this type can also be made for each plant in the project.

If the scheduling system described in this Manual is being carried on an electronic computer, then it is also possible to print out this report

OF REPORT 31 OCT 1965

REMARKS

SCHEDULED DATE TO BE MISSED  
DUE TO DELAY IN RELEASE OF  
FOREIGN EXCHANGE.

-DO-

-DO-

-DO-

-DO-

-DO-

SCHEDULED DATE TO BE MISSED

-DO-

ON SCHEDULE

SCHEDULED DATE TO BE MISSED

SCHEDULED COMPLETION DATE IS TO  
BE SLIPPED DUE TO FOREIGN EX-  
CHANGE NOT BEING RELEASED AS  
PER SCHEDULE

SCHEDULED COMPLETION DATE IS  
TO BE SLIPPED DUE TO FOREIGN  
EXCHANGE NOT BEING RELEASED  
AS PER SCHEDULE.

THE FERTILIZER CORPORATION OF INDIA  
DURGAPUR FERTILIZER PROJECT

PROJECT STATUS REPORT

DATE OF REPORT 31 OCT 1965

ITEM	CRITICAL ACTIVITY	SCHEDULED COMPLETION DATE	LATEST ALLOWABLE DATE	EXPECTED COMPLETION DATE	SLACK + OR - (WEEKS)	REMARKS
1. COMPLEX FERTILIZER PLANT	PREPARATION AND ISSUE OF NIT	11 FEB 65	11 FEB 65	30 NOV 65	-42	SCHEDULED DATE TO BE MISSED DUE TO DELAY IN RELEASE OF FOREIGN EXCHANGE.
2. AMMONIA PLANT	PREPARATION AND ISSUE OF NIT FOR PACKAGE PLANT	11 FEB 65	01 MAY 65	30 NOV 65	-30	-DO-
3. SULPHURIC ACID PLANT	PREPARATION AND ISSUE OF NIT	11 FEB 65	18 MAR 65	15 OCT 65	-30	-DO-
4. PHOSPHORIC ACID PLANT	PREPARATION AND ISSUE OF NIT	11 FEB 65	13 MAY 65	30 NOV 65	-28	-DO-
5. AMMONIUM SULPHATE PLANT	PREPARATION AND ISSUE OF NIT	11 MAR 65	13 MAY 65	30 NOV 65	-23	-DO-
6. UREA PLANT	PREPARATION AND ISSUE OF NIT	11 FEB 65	02 JUL 65	30 NOV 65	-20	-DO-
7. STEAM GENERATION PLANT	ESTABLISH TOTAL STEAM REQUIREMENTS	-	08 JAN 66	08 JAN 66	0	SCHEDULED DATE TO BE MISSED
8. BOILER FEED WATER TREATMENT PLANT	ESTABLISH TOTAL WATER REQUIREMENTS	-	03 SEP 66	03 SEP 66	0	-DO-
9. COOLING TOWER AND PUMP HOUSE	PREPARE AND ISSUE NIT	02 JUL 66	27 AUG 66	02 JUL 66	+2	ON SCHEDULE
10. PRODUCT HANDLING PLANT	ESTABLISH REQUIREMENTS FOR PRODUCT HANDLING	-	14 MAY 66	27 JAN 66	+15	SCHEDULED DATE TO BE MISSED
SUMMARY	START COMPLEX FERTILIZER PRODUCTION	01 JAN 68	01 JAN 68	21 OCT 68	-42	SCHEDULED COMPLETION DATE IS TO BE SLIPPED DUE TO FOREIGN EXCHANGE NOT BEING RELEASED AS PER SCHEDULE
	START UREA PRODUCTION	01 JAN 68	01 JAN 68	31 JUL 68	-30	SCHEDULED COMPLETION DATE IS TO BE SLIPPED DUE TO FOREIGN EXCHANGE NOT BEING RELEASED AS PER SCHEDULE.

FIGURE 14

given. Functional  
cluded in this column.

t Critical Activity  
e slack value, the  
shown.

ivity derived from  
lates also.

e project is to be  
(ent network).

~~activity will be completed~~

ate and the Expected

lule, on schedule or  
, the reasons for  
etc. should be

each month by computer.

In this report the Critical Activity for each plant in the project has been shown. The Critical Activity is that activity with the greatest Negative Slack which is next to be finished. If two activities from the same plant network have the same slack and are to be finished at the same time, then both of them may be reported. Activities in this report should be in the order of criticality.

Against each Critical Activity, the following information is reported:

- . Latest Allowable Date;
- . Expected Completion Date;
- . Slack;
- . Schedule Completion Date.

The back of the report should carry an explanation for each of these columns.

It should be noted that this report is predictive in nature, i.e., it highlights a current activity which has Negative Slack.

This activity may not have caused the Negative Slack but the report does indicate the current effect and also the effect on the project completion date if corrective replanning is not undertaken.

The report is also based on the management by exception principle. In other words, only current difficulties are shown in the report. Such a report gives the General Manager a quick idea of where his attention is required. In order to provide general information, a descriptive report is prepared in conjunction with the status report which gives statistic measurements of tons of steel erected, cubic yards of concrete placed etc.

In addition to the above report, other displays and reports described below may be generated as desired by Project Management.

Project Milestone Chart:

The Milestone Chart is a display prepared

on the basis of the Master Control Network (figure 15). The function of this chart is to display the scheduled dates of major milestones in the project. It should be noted that a minimum number of milestones are shown in this display so that overall clarity is increased.

This chart may also be used as a progress report by showing the completion dates of the milestones with a different symbol. As the chart is generated from a network, the current prediction for completion of future milestones and of the end date of the project can also be displayed.

Milestone Chart for individual Plants:

This chart (figure 16) is the same as the Project Milestone Chart. The function of the chart is to display the scheduled dates of milestones in each plant. The plant manager, instead of referring to his detailed network, can have an overall picture of his work through

this display. Since it is difficult to detect the actual scheduled date of each milestone in this chart through the arrows, the date of each milestone is shown at the bottom of the chart. This chart can also be used as a progress report by noting the actual date of accomplishment of each milestone.

Expenditure Progress Chart:

This display gives an overall view of the expenditure and progress to date and at completion. The chart as shown in figure 17 will display:

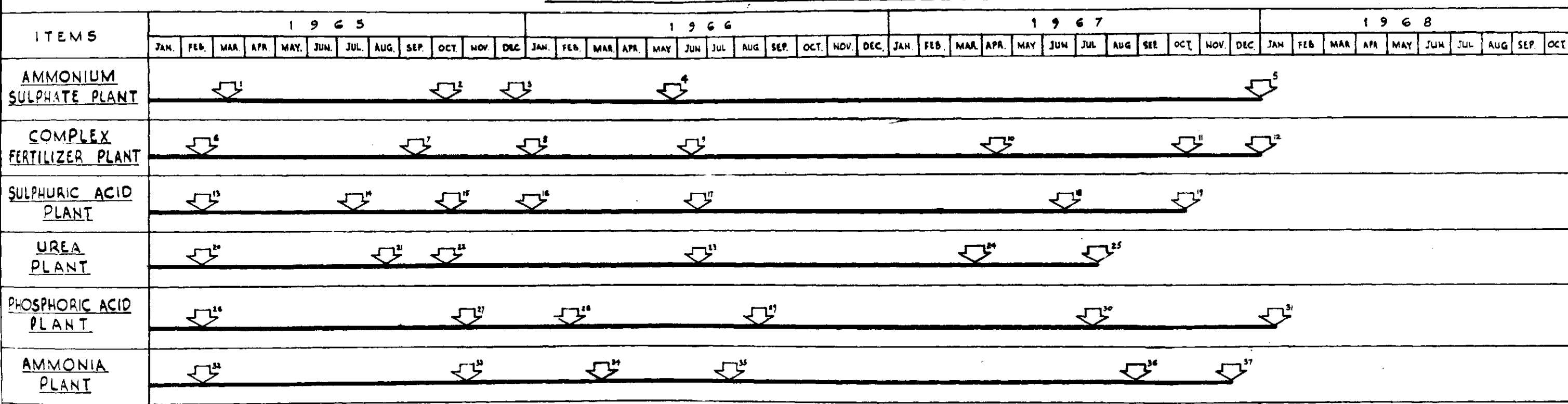
- . The planned cumulative costs to perform the work; this is the original cash flow chart for the project;
- . The actual cumulative costs expended to date;
- . The projection of costs to completion of work on a month by month basis.

From this display, management can determine:

The estimated date of completion of the project;



# PROJECT MILESTONE CHART



## GLOSSARY OF MILESTONES

DESCRIPTION	SCHEDULED DATE	DESCRIPTION	SCHEDULED DATE	DESCRIPTION	SCHEDULED DATE	DESCRIPTION	SCHEDULED DATE	DESCRIPTION	SCHEDULED DATE
AMMONIUM SULPHATE PLANT		COMPLEX FERTILIZER PLANT		SULPHURIC ACID PLANT		UREA PLANT		PHOSPHORIC ACID PLANT	
1. N.I.T. FOR STAINLESS STEEL ITEMS ISSUED.	11. MAR. 65	6. N.I.T. ISSUED FOR A.S.P. PLANT	11. FEB. 65	13. N.I.T. ISSUED FOR H <sub>2</sub> SO <sub>4</sub> PLANT	11. FEB. 65	20. N.I.T. ISSUED FOR UREA PLANT	11. FEB. 65	26. N.I.T. ISSUED FOR P <sub>2</sub> O <sub>5</sub> PLANT	11. FEB. 65
2. AWARD OF CONTRACT FOR STAINLESS STEEL ITEMS.	15. OCT. 65	7. AWARD OF CONTRACT FOR COMPLEX FERTILIZER PLANT	10. SEP. 65	14. AWARD OF CONTRACT FOR H <sub>2</sub> SO <sub>4</sub> PLANT	15. JUN. 65	21. AWARD OF CONTRACT FOR UREA PLANT	27. AUG. 65	27. AWARD OF CONTRACT FOR P <sub>2</sub> O <sub>5</sub> PLANT	18. NOV. 65
3. START CIVIL CONSTRUCTION	24. DEC. 65	8. START CIVIL DESIGN	07. JAN. 66	15. START CIVIL DESIGN	25. OCT. 65	22. START CIVIL CONSTRUCTION	22. OCT. 65	28. START CIVIL CONSTRUCTION	4. FEB. 66
4. START ERECTION	27. MAY. 66	9. START CIVIL CONSTRUCTION	10. JUN. 66	16. START CIVIL CONSTRUCTION	07. JAN. 66	23. START ERECTION	17. JUN. 66	29. START ERECTION	26. AUG. 66
5. AMMONIUM SULPHATE IN PRODUCTION	01. JAN. 68	10. START ERECTION	13. APR. 67	17. START ERECTION	24. JUN. 66	24. COMPLETE ERECTION	30. MAR. 67	30. COMPLETE ERECTION	13. JUL. 67
		11. COMPLETE ERECTION	19. OCT. 67	18. COMPLETE ERECTION	29. JUN. 67	25. UREA IN PRODUCTION	20. JUL. 67	31. PHOSPHORIC ACID IN PRODUCTION	01. JAN. 68
		12. COMPLEX FERTILIZER IN PRODUCTION	01. JAN. 68	19. SULPHURIC ACID IN PRODUCTION	19. OCT. 67				

**LEGEND**

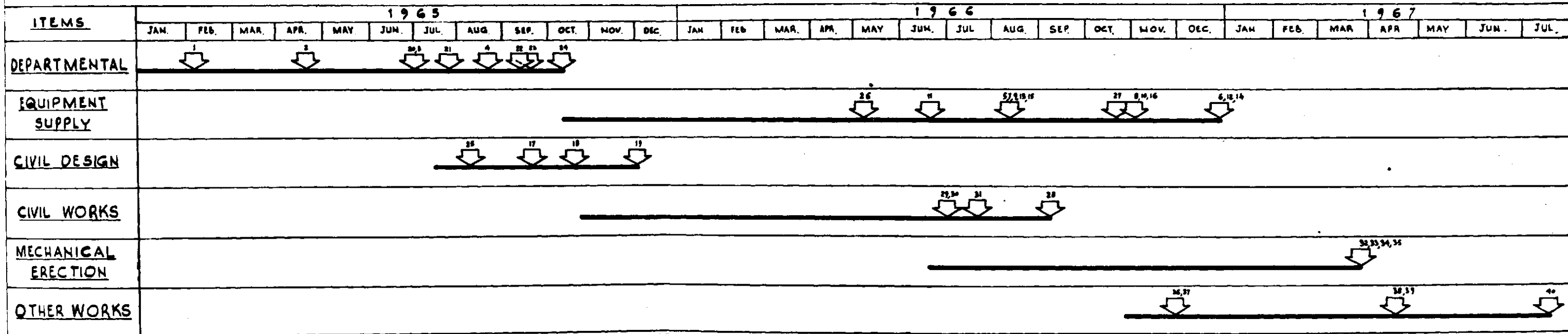
↓ = SCHEDULED DATE

**FERTILIZER CORPORATION OF INDIA  
DURGAPUR FERTILIZER PROJECT  
PROJECT MILESTONE CHART**

11. FEB. 65  
12. NOV. 65  
22. MAR. 66  
27. JUL. 66  
01. SEP. 67  
01. DEC. 67

FIGURE. 15

# MILESTONE CHART FOR UREA PLANT



## GLOSSARY OF MILESTONES

DESCRIPTION	SCHEDULED DATE	DESCRIPTION	SCHEDULED DATE	DESCRIPTION	SCHEDULED DATE	DESCRIPTION	SCHEDULED DATE
1. N.I.T. ISSUED FOR UREA PLANT	11. FEB. 65	10. COMPLETE EQUIPMENT DELIVERY CRYSTAL SEPARATION SECTION	04. NOV. 66	18. COMPLETE CIVIL DESIGN FOR FOUNDATIONS AND PLANT BUILDING STAGE - I	22. OCT. 65	27. COMPLETE SITE FABRICATION	28. OCT. 66
2. RECEIVED TENDERS FOR UREA PLANT	22. APR. 65	11. START EQUIPMENT DELIVERY PAINTING, DRYING AND COATING SECTION	17. FEB. 66	19. COMPLETE CIVIL DESIGN FOR FOUNDATIONS AND PLANT BUILDING STAGE II	23. DEC. 65	28. COMPLETE CIVIL WORKS FOR UREA SYNTHESIS SECTION	09. MAR. 66
3. SCRUTINIZED AND RECOMMENDED TENDERS	01. JUL. 65	12. COMPLETE EQUIPMENT DELIVERY PAINTING, DRYING AND COATING SECTION	30. DEC. 66	20. START PREPARATION OF N.I.T. FOR CO <sub>2</sub> GAS HOLDER	01. JUL. 65	29. COMPLETE CIVIL WORKS FOR PURIFICATION AND RECYCLE SECTION	01. JUL. 66
4. CONTRACT AWARDED FOR UREA PLANT.	27. AUG. 65	13. START DELIVERY OF INSTRUMENTS AND INSTRUMENT ERECTION MATERIALS.	12. AUG. 66	21. N.I.T. ISSUED FOR CO <sub>2</sub> GAS HOLDER	29. JUL. 65	29. COMPLETE CIVIL WORKS FOR CRYSTAL SEPARATION SECTION	01. JUL. 66
5. START EQUIPMENT DELIVERY UREA SYNTHESIS SECTION	30. DEC. 66	14. COMPLETE DELIVERY OF INSTRUMENTS AND INSTRUMENT ERECTION MATERIALS	30. DEC. 66	22. RECEIVED TENDERS FOR CO <sub>2</sub> GAS HOLDER	10. SEP. 65	31. COMPLETE CIVIL WORKS FOR PAINTING, DRYING AND COATING SECTION.	27. JUL. 66
6. COMPLETE EQUIPMENT DELIVERY UREA SYNTHESIS SECTION	12. AUG. 66	15. START DELIVERY OF ELECTRICAL ITEMS.	12. AUG. 66	23. SCRUTINIZED AND FINALIZED TENDERS FOR CO <sub>2</sub> GAS HOLDER	24. SEP. 65	32. COMPLETE MECHANICAL ERECTION UREA SYNTHESIS SECTION	30. MAR. 67
7. START EQUIPMENT DELIVERY PURIFICATION AND RECYCLE SECTION	04. NOV. 66	16. COMPLETE DELIVERY OF ELECTRICAL ITEMS.	04. NOV. 66	24. CONTRACT AWARDED FOR GAS HOLDER COMPLETE	08. OCT. 65	33. COMPLETE MECHANICAL ERECTION PURIFICATION AND RECYCLE SECTION.	30. MAR. 67
8. COMPLETE EQUIPMENT DELIVERY PURIFICATION AND RECYCLE SECTION.	12. AUG. 66	17. COMPLETE SUPPLY OF CIVIL SCOPE DRAWINGS AND LOADING DATA	24. SEP. 66	25. COMPLETE CIVIL DESIGN FOR CO <sub>2</sub> GAS HOLDER	15. AUG. 65	34. COMPLETE MECHANICAL ERECTION CRYSTAL SEPARATION SECTION.	30. MAR. 67
9. START EQUIPMENT DELIVERY CRYSTAL SEPARATION SECTION				26. START SITE FABRICATION	02. NOV. 66		

**LEGEND**

⇓ = SCHEDULED DATE

FERTILIZER CORPORATION OF INDIA  
DURGAPUR FERTILIZER PROJECT  
**MILESTONE CHART  
FOR UREA PLANT**

FIGURE. 16

# EXPENDITURE PROGRESS CHART

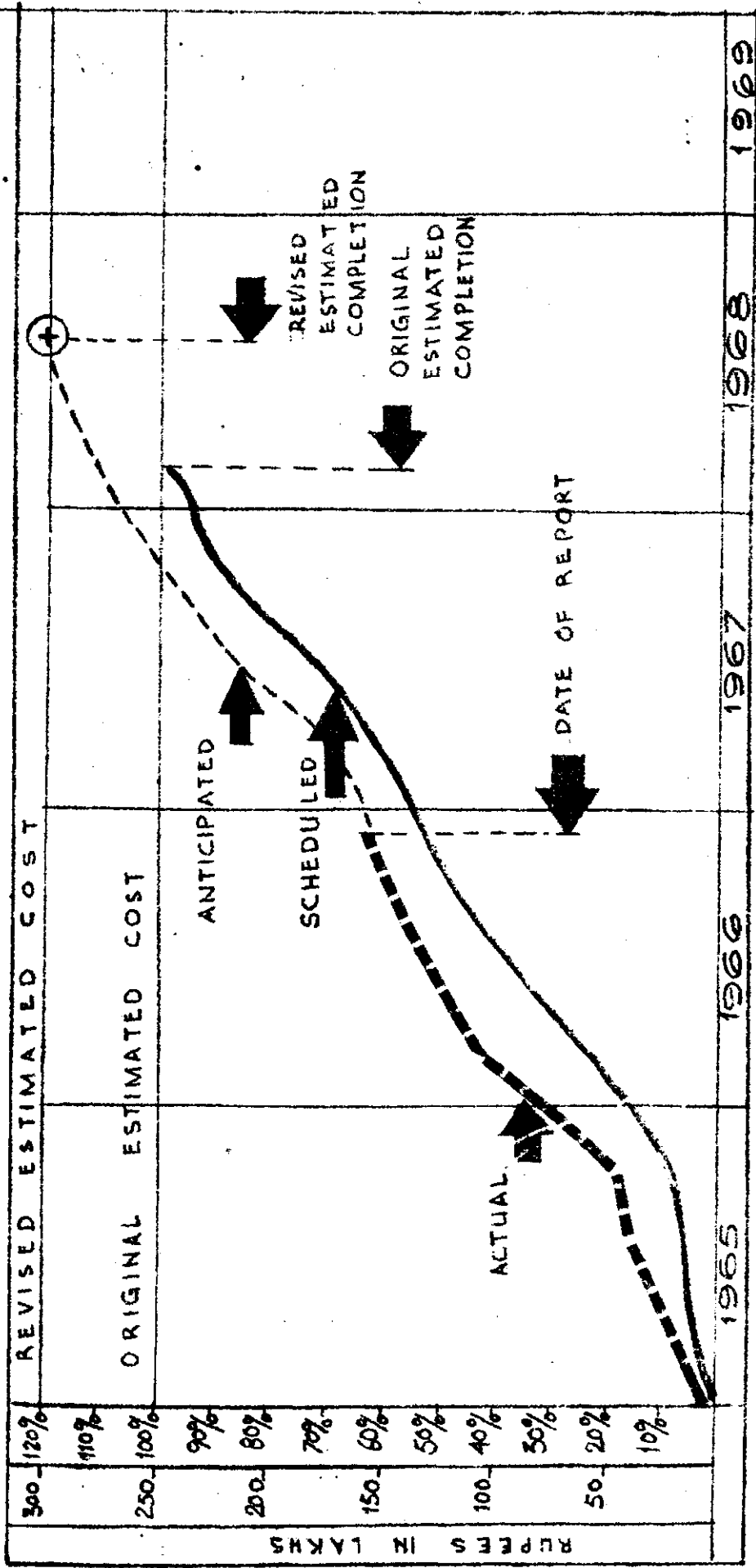


FIGURE . 17

- . The cost incurred to date, and whether this exceeds the original estimate;
- . The estimated cost (overrun or underrun) at completion of the project.

This graphical presentation of financial progress enables project management to see, at a glance, both current status and future financial trends of the project.

The Expenditure Progress Chart can be prepared both in the form of a graph as shown in figure 17 or in a tabular statement.

Schedule Outlook Chart:

This chart is a graphic means of displaying the schedule overrun or underrun that has been predicted in each reporting period.

The purpose of this display (figure 18) is to show the currently predicted completion date of the project and the trend that has taken place over the past months. The trend of the project schedule brought out periodically

through this chart enables the General Manager to see the effect of decisions that have been made in the past.

Though the Schedule Outlook Chart is more useful for display at the General Manager's level, the plant managers may also use this kind of chart to watch the trend of their schedules and to take effective steps to avoid slippage.

# SCHEDULE OUTLOOK DISPLAY

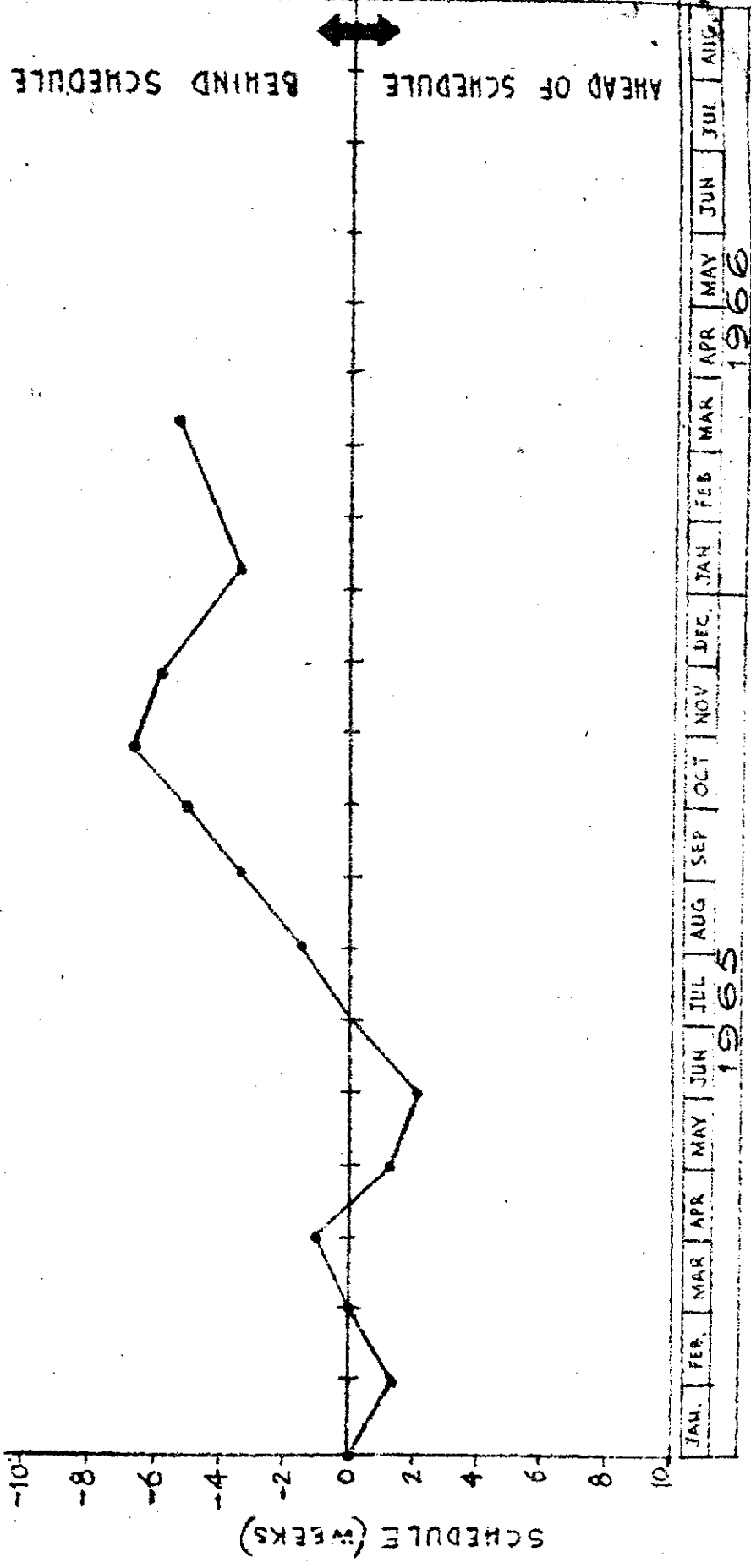


FIGURE 18.

**CHAPTER X**  
**COST REPORTING**

CHAPTER X

COST REPORTING

The procedure for planning and reporting of schedule progress on the Durgapur Project has been discussed in the previous chapters. The complete system of management planning and control as envisaged for the project, however, also includes exercising control over the final cost of the project. This aspect of the system is outlined in this chapter.

The objective of controlling and reporting costs on a project of this nature is to minimise the amount by which the final cost exceeds the original project estimate. For the attainment of this objective, the system would require:

- . A method of collecting the costs incurred in the project;
- . Identifying where cost overruns have been incurred; and
- . Exercising control in order to reduce cost overruns



It is primarily the second of the three items which is the concern of this document.

The first step is an accounting problem and can be handled by any number of methods now currently in use.

The third step is also considered in this chapter, but as will be outlined in the succeeding paragraphs, the amount of control of costs that a General Manager of a plant such as Durgapur is able to exercise is very small.

Identification of cost overruns in a project, is only possible by comparing actual expenditure against the original project estimate. On the majority of public sector projects, and Durgapur is not an exception, the bulk of the work is carried out by contractors. Cost overruns are therefore primarily incurred in contracts, although some excess can be incurred in the costs of the supervising Government agency. Overruns in project costs therefore can be incurred by one

or more of the following methods:

- . The contract tendered price being in excess of the amount allowed in the original project estimates;
- . The final contract price on completion being in excess of the contract award price; and
- . The departmental charges being in excess of the amount in the original estimates.

On each of these three possible causes of overrun in project cost, however, the project authorities are able to exert little influence in the area of cost reduction. The reasons for this are outlined below:

Contract tendered price in excess of the amount allowed in the original project estimates:

The project authorities can exercise little or no control over the price at which any contract is awarded. They are able to choose the lowest bidder but any variance in the award price over that allowed in the original estimate will be reflected in a

variance in the final cost of the project.

Final contract price in excess of the contract award price:

Cost overruns in this category are essentially the cost increases in the project brought about by one of the following factors:

- . Changes in scope of the contract;
- . Payment of 'claims' made by the contractor;
- . Operation of a contract escalation clause.

Experience has shown that these cost increases form the largest part of the final cost overruns in most public sector projects. Except by taking a strong line in the negotiations for 'claims', these cost overruns can only be controlled by better planning of the contract before it is awarded. More detailed and thorough planning of the project will ensure that the items that may cause a change in scope are planned well in advance and included in the contract objectives.

Once the contract has started, however, the final cost will depend on the amount of work required to achieve the technical objectives of the project. Provided the technical objectives have been well conceived, little benefit will accrue to the project by a system of reporting costs (even against preestablished targets) on a monthly or quarterly basis.

The departmental charges in excess of the amount in the original estimates:

The third cause of final cost overruns - excessive departmental charges - is a controllable cost. Possible causes for increases in departmental charges are:

- . Excess staffing of the project;
- . Increase in duration of the project;
- . Poor estimate of original departmental requirements.

However, departmental charges are only a small percentage of the total cost of the

project. For the Durgapur Project, departmental charges are less than five percent of the total project cost.

Exercise of a rigid control of these departmental costs will not therefore significantly reduce the final cost of the project.

In general, therefore, as the majority of cost increases are incurred under contract, the Project Authorities are able to exercise very little effort towards reducing the final cost of projects, once the contracts are awarded.

The objectives behind any cost reporting system on a project of this nature, therefore, can only be to record and report deviations from the project estimates. These deviations are then projected as a final cost overrun or underrun.

The question would arise, therefore, that if little or no control is possible, why record and report deviations? Why not just spend the

required amount of money and record it on a historical basis?

There are two answers to the question. Firstly, recording cost data supplies information that may be used in the preparation of the estimates for future projects. If, in addition to just reporting the cost of each item, costs are also reported as deviations from the original estimates, the inaccuracies in the original estimate are highlighted, and future estimates become even more reliable.

Secondly, in order to assess the demands on their own monetary resources, the Fertilizer Corporation of India and the Government need a continuous and accurate forecast of the future cash requirements of the project.

The demands that the project will make on the Government can only be accurate if the project revises its estimates of the completion costs of the project on a systematic and periodic

basis. The system of cost control proposed for the Durgapur Project, therefore, is a system of regular monitoring and reporting of costs in excess of the project estimate. A broad outline of the system is given in the following paragraphs:

Proposed Cost Reporting System for Durgapur Project:

In projecting any cost overrun in the project into a final cost overrun, the immediate difficulty is realised of comparing the accounts under which money is spent on the project and the accounts under which the project was originally estimated. The expenditures on the project are by contract; the original estimates, however, were generally prepared for each item of work that was eventually to be constructed.

If the overruns associated with every contract are to be recorded then it is necessary to breakdown the original project estimates into

the constituent contracts that make up the total estimate. An example would be the splitting of the original estimate for housing into its constituent contracts of erection, electrical, drainage etc. As soon as each contract is awarded, therefore, the overrun/underrun as measured against the reconstituted project estimate can be projected to the final project cost. Similarly if the final cost of the contract is in excess of the award price, the excess can be projected as a overrun in the total project cost.

However, control to this degree of accuracy is unnecessary. Only major contracts, which constitute the bulk of the expenditure need be isolated. Such contracts would be the Supply of Equipment for the major plants, Civil Works, Civil Design, Mechanical Erection etc. Cost overruns associated with these contracts only need be identified and projected as final



cost overruns. The remaining smaller contracts, such as the many that make up the housing account, need only be controlled as a block, after all the contracts that contribute to the housing account have been awarded.

Project Cost Report:

The Project Cost Report can be presented either by contracts or by the items that make up the Original Project Estimates. This latter method, although somewhat more time consuming in that allocation of contract costs is required, provides a better basis for showing projected overruns.

This cost report which is prepared monthly compares the estimated cost of each major item with actual cost to date plus the projected cost to completion of project (figure 19). Thus, the projected cost overruns or under-runs could be assessed in advance. Through this report, it is possible to provide information on

FERTILIZER CORPORATION OF INDIA

DURGAPUR FERTILIZER PROJECT

PROJECT COST REPORT (Rs. in lakhs)

	PROJECT	ACTUAL	ESTIMATE	PROJECTED
TRIBUTION LIGHT				
21. TRANSPORT FACILITIES	90.30	18.30	90.30	0
22. LIBRARY AND OFFICE	6.79	2.00	6.79	0
23. MEDICAL AND PUBLIC HEALTH	21.78	14.00	22.00	0.22 (+)
24. DEPARTMENTAL	139.50	30.00	139.50	0
25. TESTING AND COMMISSIONING CHARGES	126.00	NIL	126.00	0
26. SPARES FOR PLANTS	130.00	10.00	130.00	0
<b>TOTAL</b>	<b>3226.41</b>	<b>855.50</b>	<b>3281.27</b>	<b>154.86 (+)</b>

FIGURE 19

FERTILIZER CORPORATION OF INDIA  
DURGAPUR FERTILIZER PROJECT  
PROJECT COST REPORT (Rs. in lakhs)

ITEM	PROJECT ESTIMATE	ACTUAL COST TO DATE	ESTIMATE TO COMPLETION	PROJECTED OVERRUN(+) OR UNDERRUN(-)
1. LAND	21.00	10.00	21.00	0
2. LAND DEVELOPMENT	46.85	15.38	50.00	3.15(+)
3. TOWNSHIP	136.85	30.00	140.00	3.15(+)
4. EARTHMOVING & CONSTRUCTION EQUIPMENT	23.55	15.00	28.55	6.00(+)
5. AMMONIA PLANT	743.10	182.75	787.80	44.70(+)
6. PHOSPHORIC ACID PLANT	239.10	96.48	250.00	10.90(+)
7. SULPHURIC ACID	213.99	35.44	200.91	13.08(-)
8. AMMONIUM SULPHATE	306.80	95.00	316.78	9.98(+)
9. COMPLEX FERTILIZER	132.60	55.76	131.10	1.50(+)
10. BAGGING PLANT & PRODUCT HANDLING	54.80	10.24	60.76	5.96(+)
11. STEAM GENERATION	137.50	39.87	130.48	7.02(-)
12. COST OF CIVIL WORKS	301.02	130.12	380.12	79.10(+)
13. EQUIPMENT	5.00	2.27	4.35	0.65(-)
14. COMPRESSED AIR	2.50	NIL	2.50	0
15. YARD PIPING	21.20	5.78	20.75	0.45(-)
16. WATER TREATMENT AND DISTRIBUTION	71.70	8.78	78.98	7.28(+)
17. WAREHOUSE, WORKSHOP	58.40	7.45	60.00	1.60(+)
18. WORKSHOP AND MISC. BUILDINGS	59.88	5.88	62.00	2.12(+)
19. AUXILIARY SERVICES	45.60	10.00	50.00	4.40(+)
20. POWER SUPPLY, DISTRIBUTION LIGHT	90.60	25.00	90.60	0
21. TRANSPORT FACILITIES	90.30	18.30	90.30	0
22. LIBRARY AND OFFICE	6.79	2.00	6.79	0
23. MEDICAL AND PUBLIC HEALTH	21.78	14.00	22.00	0.22(+)
24. DEPARTMENTAL	139.50	30.00	139.50	0
25. TESTING AND COMMISSIONING CHARGES	126.00	NIL	126.00	0
26. SPARES FOR PLANTS	130.00	10.00	130.00	0
<b>TOTAL</b>	<b>3226.41</b>	<b>855.50</b>	<b>3281.27</b>	<b>154.86(+)</b>

FIGURE 19

the current costs as well as the final cost of the project.

Cash Flow Chart:

Periodical assessment of the status of the project through the Project Cost Report would determine the funds required for the execution of the project. However, this total amount needs to be broken down into requirements by year (so that budgets may be prepared) and into even smaller periods (to assist in preparing cash flow statements - see figure 20).

To simplify this effort, the Project Authorities at Durgapur can request a schedule of progress payments from each contractor. Continuous and accurate forecast of the future cash requirements of the project are possible through this schedule. The payments should be tied, as far as possible, to the accomplishment of measureable items of work. Revisions to

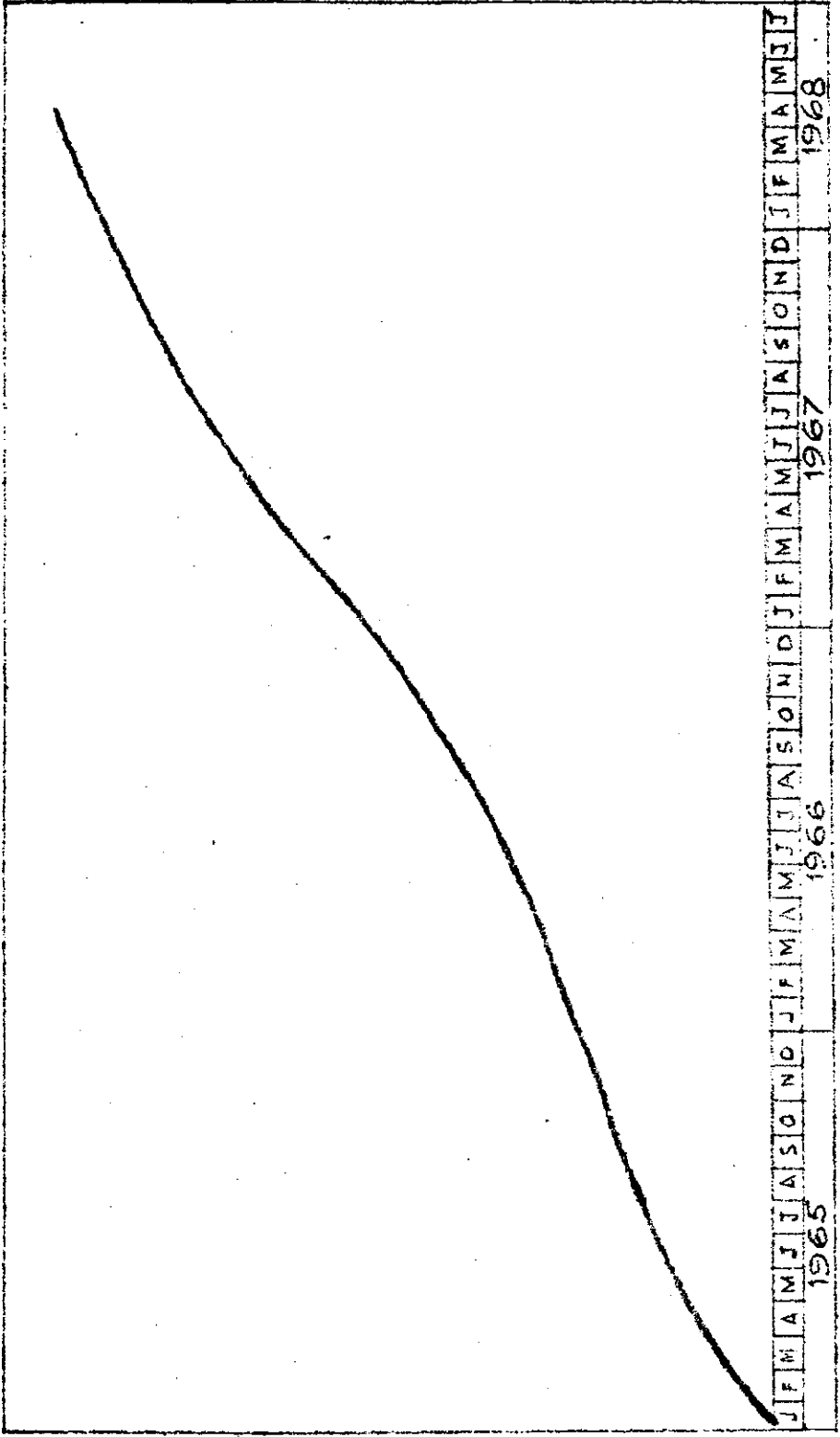
the schedule of payments is thus facilitated.

The preparation and periodical revision of the cash flow statements is the responsibility of the Accounts Branch of the project with assistance from the Planning Group.

This information can then be used to prepare the expenditure progress chart shown in figure 17.

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# CASH FLOW CHART



RUPES IN LAKHS

M O N T H S

FIGURE.20.

CHAPTER XI

ORGANIZATION FOR IMPLEMENTATION

CHAPTER XI      ORGANIZATION FOR IMPLEMENTATION

The successful implementation of the planning and control system described in the preceding chapters, would primarily depend upon the organization that is to implement the system for the project and this organization's structural relationship with the rest of the project.

The fundamental concept of the system should be the integration of scheduling, manpower planning, cost accounting and reporting procedures in a common framework with work organization and responsibility clearly assigned. The system requires that all positions should have specific responsibilities and authorities attached to them. This applies particularly to those officers responsible for coordinating several departments. This would avoid overlap of responsibility and ensure an organizational pattern which will function effectively.



There is a considerable need for a high level of coordination and control, if progress is to be maintained together with working efficiency and strict cost control in the project. The combination of the activities of management involves relationships which must be properly organised to ensure effective operation. The different skills of the separate contributors must be coordinated. The need for an effective organizational set-up which will effect this coordinating action is, therefore, a necessity for the implementation of the system in the project.

It is advantageous that a Centralised Group provide the guidance and assistance in obtaining uniformity in planning approach and implementation of methods. This Centralised Group could assume the role of a service or staff organization, implementing the network system, collecting all data, processing and

analysing it for management information and use. The creation of a staff organization of this kind should be such that the organization is not responsible for the direct execution of any part of the project; but it should be responsible for the planning of the entire work of the project. This Staff Group may be called "Planning Group" for the project.

The organisational structure should be such that the Planning Group works under the direct control of the General Manager of the project. The Group Head should have the same status as that of the other Heads of Departments. Such an organization pattern developed for the Durgapur Project is shown in figure 21.

For effective functioning, the Planning Group may be broken into the following three units:

- . Planning and Scheduling Cell;
- . Cost Engineering Cell; and
- . Technical Methods Cell.

### Planning and Scheduling Cell:

The Planning and Scheduling Cell specialises in the planning and scheduling aspects of the project. It should ensure that technical advice is always available and the full potential of the planning methods is placed at the disposal of the Project Management. The functions of this Cell are, therefore, primarily to implement and maintain the procedures outlined in this Manual. It should be noted, however, that the networks reflect each individual manager's plan of work and that the members of the Planning Cell are assistants in this work only. In coordinating the work depicted on several networks, the Planning Cell should point out any inconsistencies or discrepancies to the managers concerned, but leave any adjustments to these managers. On occasions, the Planning Cell may find that line managers will tend to adjust their network estimates to show the most favourable prediction of project

THE FERTILIZER CORPORATION OF INDIA  
DURGAPUR FERTILIZER PROJECT  
PROPOSED ORGANIZATION WITH PLANNING GROUP

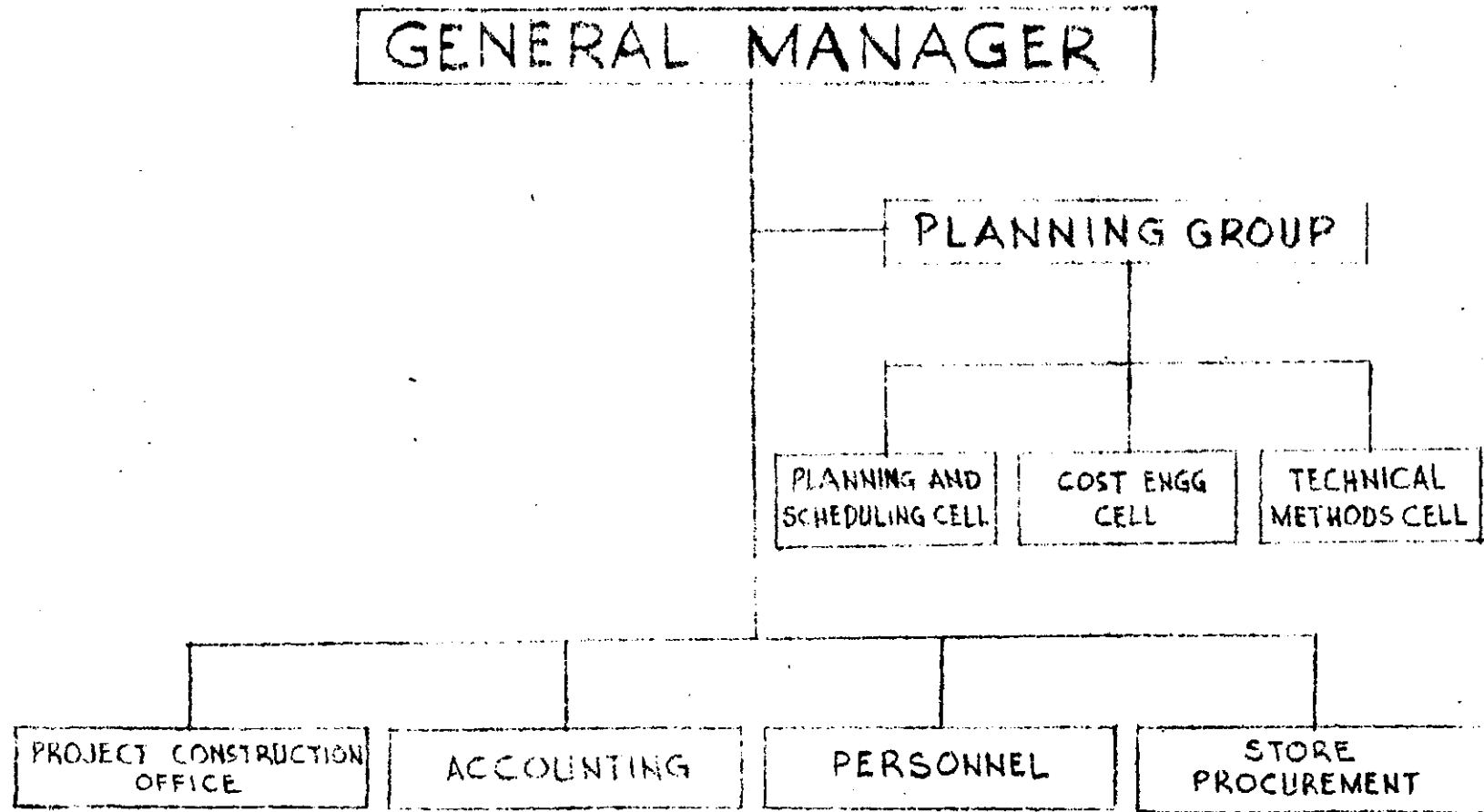


FIGURE. 21

completion date. Once they discover this and after first indicating this to the line manager, the Cell should resolve the matter with the General Manager of the project. As has been stated before, much of the benefit of network scheduling is lost if a false picture is portrayed of the project schedule.

The number of persons required to operate the Planning and Scheduling Cell would depend upon the size and complexity of the project and the extent to which line managers will control their own networks. For a project such as the Durgapur, a three to four man Group should be sufficient.

The constitution of this cell should be such that it possesses men with necessary skills required for the efficient performance of their functions. The personnel performing the functions of this Cell must be thoroughly knowledgeable in the mechanics of the system,

particularly of network construction and analysis, and also should be familiar with the most effective methods of presenting the results.

In framing this team, the management would be often faced with certain difficulties as to the choice of the suitable personnel. The characteristics of the men to carry out the functions of this Cell should be:

- . An analytical approach to the planning of construction projects;
- . Confidence and ability to deal with all levels of Project Management;
- . A detailed understanding of network planning techniques; and
- . A working knowledge of the organization of the entire project.

The team may comprise one senior officer to supervise and to deal with the various departments involved, and two or three junior officers to carry out the detailed preparation of data and developing networks etc. Drafting assistance,

probably on a full time basis, is also required.

Cost Engineering Cell:

The task of the Cost Engineering Cell would be to evolve cost control and cost reporting procedures. The functions of this Cell may be summarised as follows:

To coordinate with the Finance Department of the project in the design of the most satisfactory cost reports, installation and operation of a cost information and control system for the project and in the compilation of budget and exercising budgetary control on the project cost;

To evaluate the cost implications of alternate construction methods and of alternate schedules proposed by the other two Cells in the Group; and

To evaluate the cost economics of the elements of the Project throughout the construction stage, with a view to reducing construction costs;

To contribute on all financial matters in the evaluation of contracts.

For the effective functioning of this Cell, it should work in a close liaison with the other two Cells of the Planning Group and the

Finance and the Accounts Department of the project.

A single man in the Cost Engineering Cell would be sufficient to perform the above functions.

Technical Methods Cell:

The Planning of the actual construction processes to be used is the responsibility of the contractors. However, on departmental work or work involving more than one contractor it has proved advantageous to provide, as a staff assistant, an experienced engineer whose sole duty is to determine the cheapest or most efficient method of construction. In that this engineer has no day-to-day duties in a line capacity, he can devote his full energies to this function. It is for this reason that the duty of evolving cheaper construction methods is not left with the line managers. These managers will still design the methods of construction to be used; it is the Technical Methods Engineer's duty to assist them and determine if improved methods can be used.



The functions of the Cell may, therefore, be outlined as follows:

- . To continually watch over and collect performance data;
- . To continually examine and analyse performance data to evolve alternative economical construction methods;
- . To make detailed studies and suggest alternative cheaper materials, consistent with technical performance and engineering efficiency; and
- . To continuously study the equipment performance and optimise its use as well as carry out any other work-studies needed on the project.

These functions of the Technical Methods Cell would require close coordination with the Planning and Scheduling Cell and the Cost Engineering Cell. The alternative technical methods of construction evolved by the Technical Methods Cell could be fed to the other two cells for planning and scheduling of the methods and evaluation of their cost economies. It should be noted that on a project where a

large percentage of the work is undertaken by contract, the usefulness of a Technical Methods Engineer is not immediately apparent. It is possible that the savings he effects may not outweigh his salary. Therefore, whether such an engineer is employed is left to the discretion of the General Manager of the Durgapur Project.

It is very essential that these three Cells work with a proper understanding of their objectives. Since a great deal of communication is required between each, a small group will function more effectively. Though the staff strength suggested above may be adequate to begin with, it may be necessary to slightly increase the strength at the time of peak construction.

The Fertilizer Project at Durgapur involves several different functional organisations. To Project Management, it may appear that addition of other units in the Planning Group would enable other tasks of an indirect nature such as speci-

fications writing, engineering design, customs clearances etc. to be carried out by the Group. Added Cells in the Group would decrease flexibility, however, and such functions can generally operate effectively within the technical line organizations.

The setting up and operating of a Planning Group described above may cost more than existing units. Adoption of the procedures outlined in this Manual certainly involves a greater degree of effort in both the planning and control stages. However, it should be noted that such a Group centralizes many functions that previously took place in the line organizations. More important, however, is the increased efficiency in planning and control that is brought about by setting up such a Group. This increased efficiency in the greater control that is placed in the hands of Project Management and in the added certainty

that the project will be completed closer to its original cost estimates and schedules, will more than counterbalance the costs of such a Group.

## APPENDIX

APPENDIX

IMPLEMENTATION OF THE SYSTEM  
ON  
THE COCHIN FERTILIZER PROJECT

Introduction:

The Cochin Fertilizer Plant is one among the many projects proposed by the Government to be undertaken during the Fourth Plan, to achieve the planned targets in the Fertilizer Industry. This new plant will be located at Cochin in Kerala near the present Cochin Refinery.

The techniques of planning, scheduling and monitoring of a construction project outlined in this Manual are also in the process of being applied to this new fertilizer factory at Cochin. The COPP Management Group of the Planning Commission, at the instance of the Fertilizers and Chemicals Travancore Limited (FACT), undertook a study of this project to evolve a similar system for its construction. A separate Manual is under preparation but, in

the meantime, this appendix gives a brief outline of the system that is in use on the Cochin Project. Before outlining the system, a brief history of the FACT project and the size of the Cochin Plant are given below.

FACT history:

The Fertilizers and Chemicals Travancore Limited (FACT) is located at Alwaye in Kerala State and is the first factory in India to take up the large scale production of chemical fertilizers. Planned around 1944, this plant was commissioned in 1947. FACT has already built up an expertise in the field of fertilizer production and has set up its own Planning and Design Organization for its expansion programme. Aware of the experienced Organization that has already been built up, the Government decided that the FACT should be assigned a specific role in the field of fertilizer production. Accordingly, the preparation of the Project Report and the subsequent construction of the Cochin Project have been entrusted to the FACT Authorities.

Size of the Cochin Plant:

The Cochin Fertilizer Factory is to produce (200,000 tonnes of Ammonia per annum from which 600,000 tonnes per year of 20-20-0 Complex Fertilizer (Ammonium Phosphate) and 60,000 tonnes of Urea will be manufactured, leaving a balance of 12,500 tonnes of Ammonia for direct sales for industrial use. The intermediate products will be 375,000 tonnes of Sulphuric Acid, 129,000 tonnes of Phosphoric Acid and 360,000 tonnes of Ammonium Sulphate per year.

The capital outlay for the project as given in the Project Report is Rs.31.65 crores of which the foreign exchange component will be Rs.11.50 crores. The capital for this project will be provided by the Government, half as equity and half as 6% interest bearing loan.

The system developed for the Cochin Fertilizer Project follows the system outlined in this Manual and is briefly discussed in the following paragraphs:



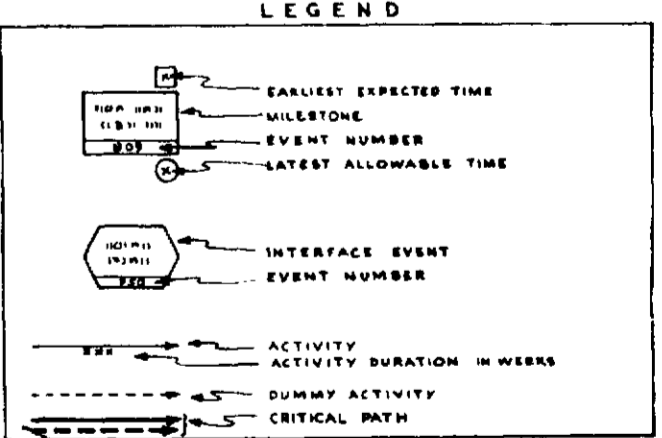
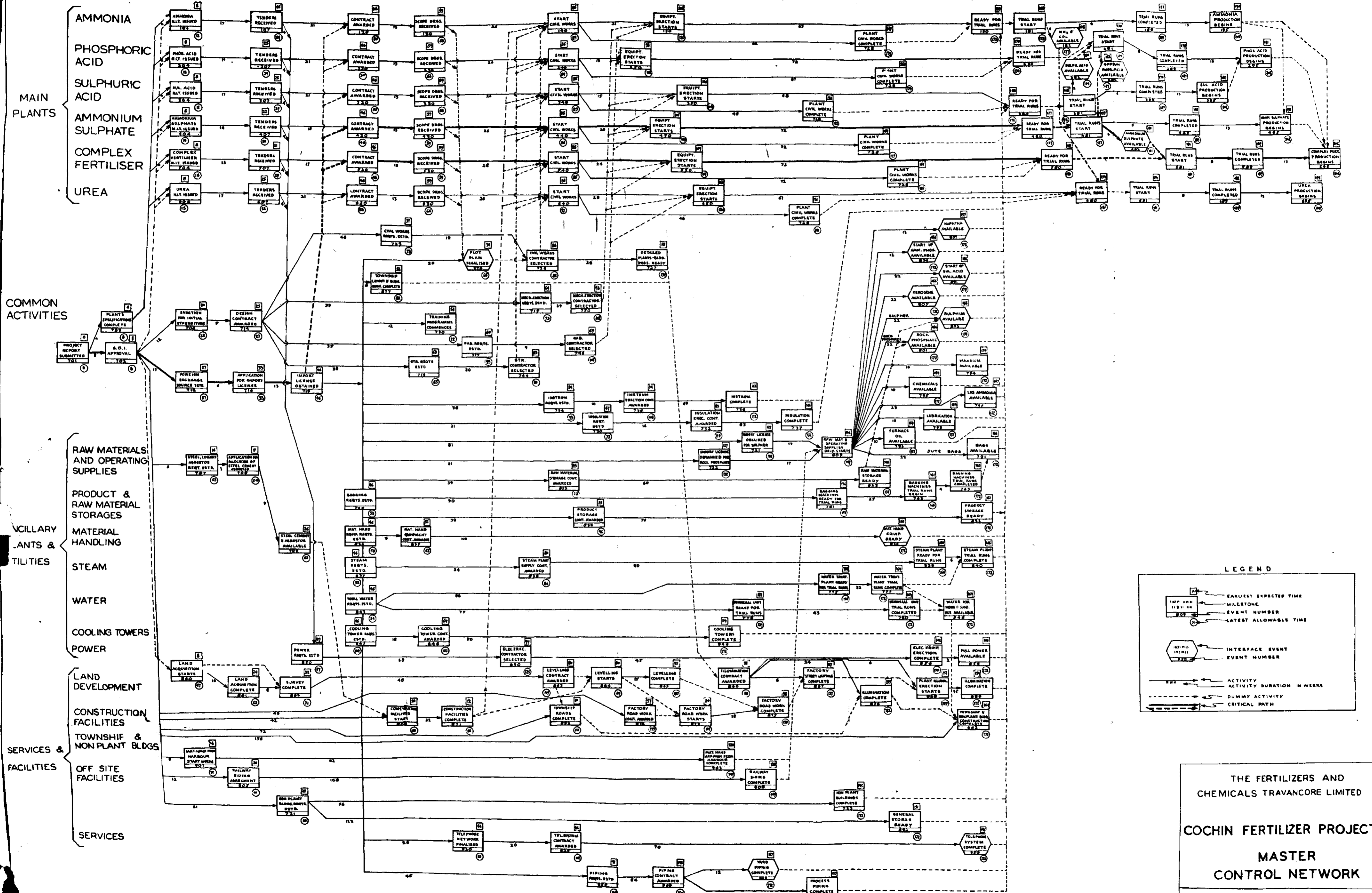
System Development:

Master Control Network:

The Work Breakdown Structure for the Cochin Project has been developed and from it the preliminary Master Control Network. This network is shown in figure 22. The network shows 36 months as the period which has been envisaged in the Project Report as the completion time for the project from the date of release of foreign exchange and receipt of import license. Weeks have been adopted for the activity durations on this network.

At the time of writing this appendix, the FACT Authorities have completed the Project Report and Estimates and the Government has also granted approval to the Project (July 1965), but the source of foreign exchange has not yet been determined. In the Master Control Network, however, the date of commencement for the Project has

# MASTER CONTROL NETWORK



THE FERTILIZERS AND  
CHEMICALS TRAVANCORE LIMITED

**COCHIN FERTILIZER PROJECT**

**MASTER CONTROL NETWORK**

been taken from the date of approval to the Project. The Critical Path runs through the Ammonium Sulphate and Complex Fertilizer Plants.

The Master Control Network developed for the Cochin Project and shown in figure 22 has not been scheduled by assigning specific calendar dates for the accomplishment of the significant events in the network. This is because of the uncertainties of the dates for the 'foreign exchange clearance' and the 'import license'. The true picture of the Project Completion Date will be known only after the clearance of these uncertainties. The Master Control Network shown in figure 22 is, therefore, only a preliminary network containing the work of both the Government and the FACT Authorities.

The Master Control Network for any project is normally drawn to a calendar

time-scale. This has not been done in this case as schedule dates were not developed for the network.

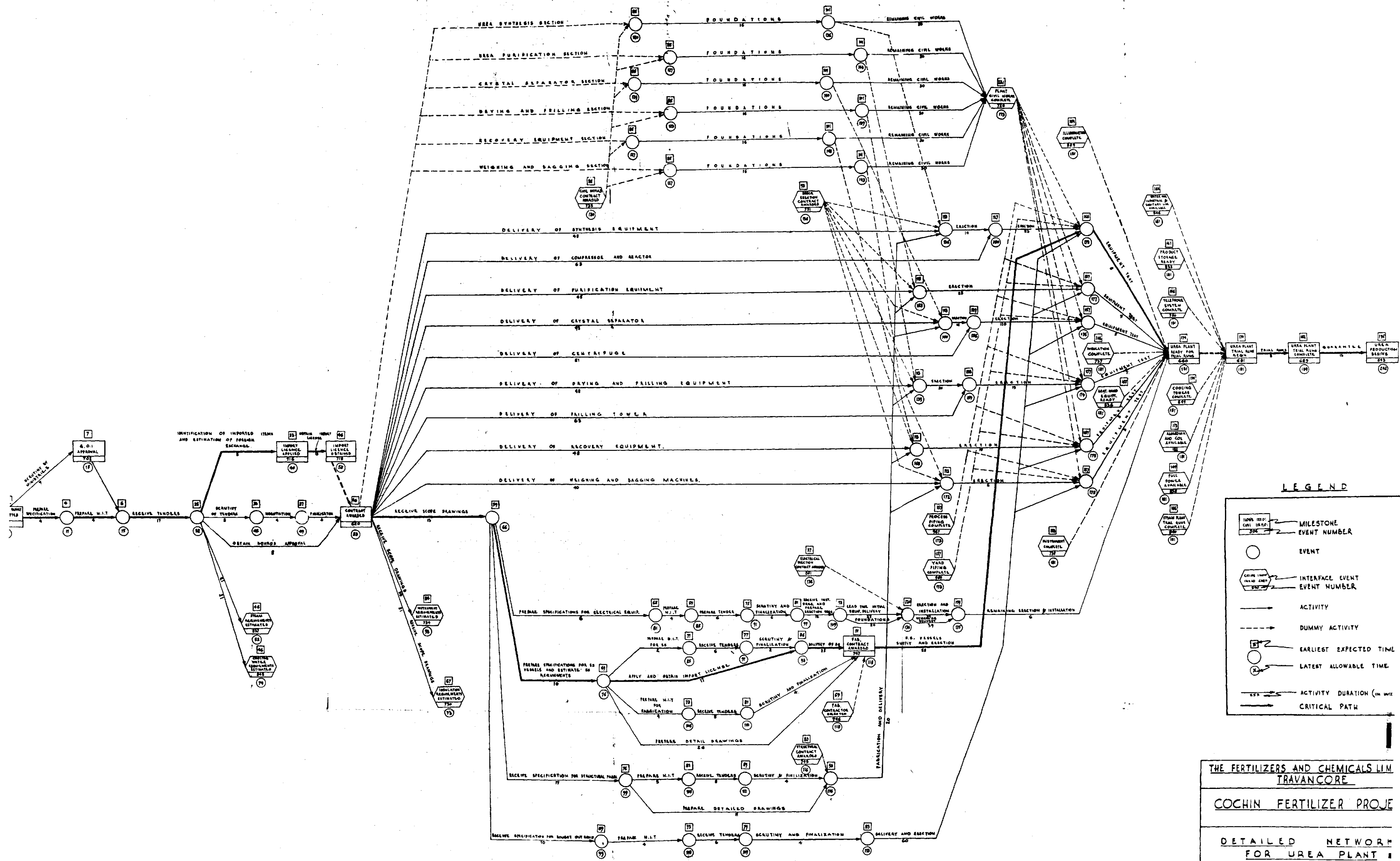
Detailed networks:

After developing the Master Control Network and identifying the Critical Path, detailed networks have been developed for all the main and auxiliary plants, utilities, services, facilities and the common functional efforts of the Project. The Critical Path in respect of each network has been identified. Each detailed network has been integrated with the overall plan for the Project. One such detailed network developed for the Urea Plant of the Cochin Project is shown in figure 23. This network again, is a preliminary network without any schedule dates.

Schedule Reporting:

A system for schedule reporting has been developed for the Cochin Project. This system is similar to the one developed for

# DETAILED NETWORK FOR UREA PLANT



the Durgapur Plant.

The implementation of the network techniques on projects such as Durgapur and FACT has widened the knowledge of the application of such techniques in the construction field. There has been an increasing demand from several organisations, both in the Public and Private Sectors for assistance in this application. This Manual, therefore, has been written to provide information on the application of the techniques in the construction industry generally. It is hoped that it will lead to an eventual improvement in the planning and control of public sector projects.

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