ACKNOWLEDGEMENTS -

To my parents, my thanks for their encouragement, patience and support. I also want to thank my wife for her help in editing the draft of this report and for providing invaluable suggestions. My special thanks to those people at work who have contributed in one way or another to the Scrubber Program.

I wish to express my gratitude to Mr. W. Dawson, my report supervisor, for providing information, guidance and advice which were an important factor in the development of this technical report.

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CHAPTER 1 - INTRODUCTION

1.1 Introduction

In the last few years management has given great importance to several managerial techniques which, if properly applied, result in more organized and controlled projects.

Some of the techniques are related to the planning, scheduling, monitoring and controlling of projects. When these stages are properly implemented, management can obtain important savings in terms of time and expenditures. The project dealt with in this technical report involves the use of critical path method networking technique - CPM.

In Chapter 2, the theory which is the basis of CPM is explained, as well as the two possible representations of the network.

Three parameters are studied in the Scrubber Program, i.e. TIME, COST, and MANPOWER.

This technical report provides graphic aid's and figures which summarize and facilitate understanding of CPM analysis.

Program reports are included in order to familiarize the reader with planning documents and procedures. An evaluation of computer usage in various reports of the program is presented.

Some planning structures were developed to aid in easy accomplishment of the planning objectives in the program. These structures are treated in detail in Chapter 3.

A presentation of the planning work in the scrubber program, the strengths and weaknesses of some reports and the reaction of the program's personnel to these reports are discussed in Chapter 4.

A complete explanation of the methods used to control manhours, cost and drawings in engineering and engineering services is outlined, step by step, in Chapter 5.

In order to clarify the involment of the planning department in the Scrubber Program a short description of the Program organization follows. Alcan personnel performs the job of project and construction manager for the Scrubber Program. The planning department is responsible for the preparation and monitoring of the project's schedules, resource allocations, rate of expenditures, and cash flows. Also in some projects the department has been involved in the control of Engineering costs, manhours and drawings.

The milestones of the project schedules are given to the contractors and project leaders, and any further detailed planning is the contractor's responsability. Changes suggested by the contractors or project leaders are if feasible introduced in the project schedules. Often complex contracts going out for bids already contain a detailed schedule and here again the winner of the bid can suggest changes in the schedule. Then the job is monitored against the revised schedule.

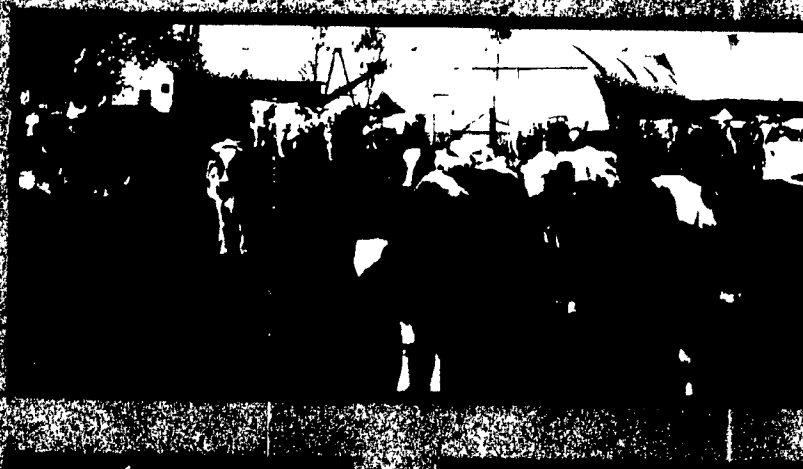
1.2 Scrubber System Presentation

The following brochure on the Scrubber System illustrates:

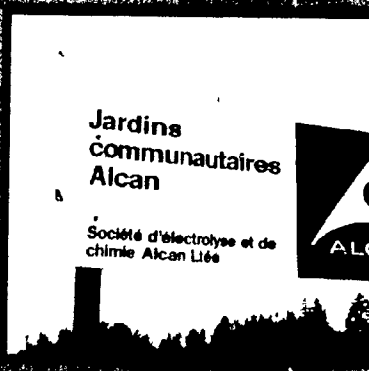
1) The scrubber towers utilized in the program

2) A flow diagram of the product scrubbed, showing other projects of the Scrubber Program, i.e. Settler, water and soda lines, and disposal lines

3) Tables which in various ways illustrate the impact of the Scrubber Program on the atmosphere and the surrounding region.




AYRSHIRES
LA FERME HISTOOK


Jardins
communautaires
Alcan
Société d'électrolyse et de
chimie Alcan Ltée

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COLOURED PAPER
PAPIER DE COULEUR

aires

et de

ALCAN

Système d'épuration

Recherche et rédaction:
François Lapointe
Agathe Plamondon

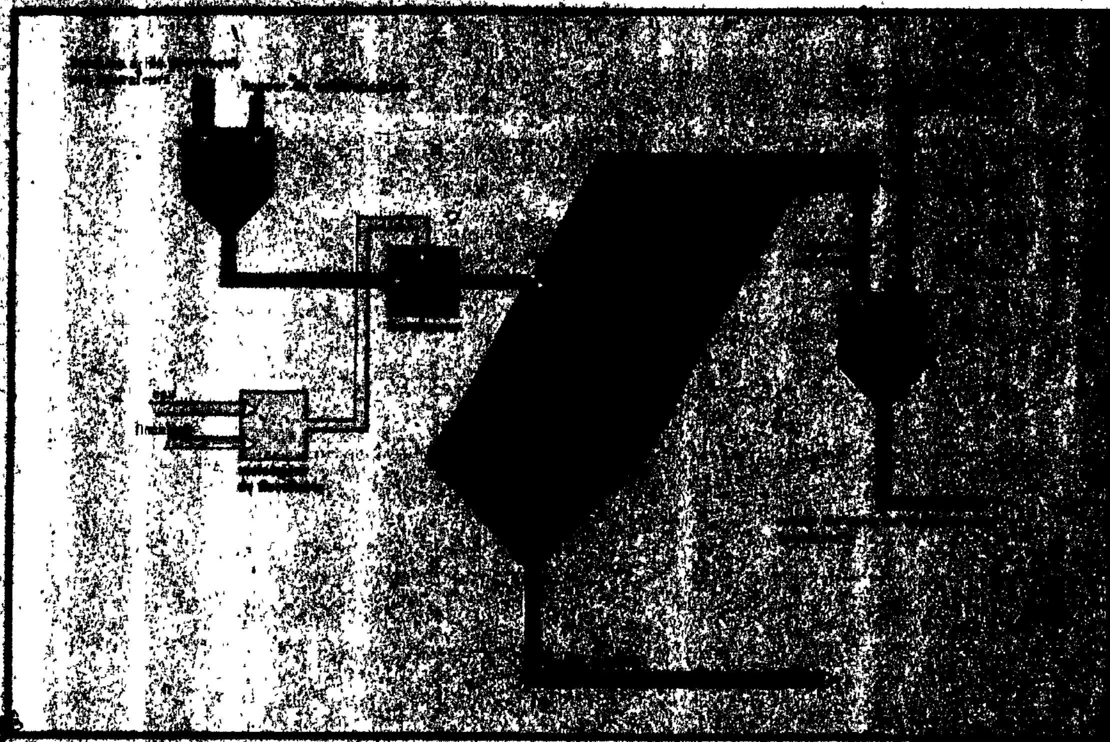
Photographies:
Les photographes [illegible] Ltée
Les productions photographiques M.W. Inc.

Collaboration:
Communication par l'image

Composition & montage:
[illegible] Corneau
[illegible]

Conception:
Paul [illegible]

Production:
Michel Fillion



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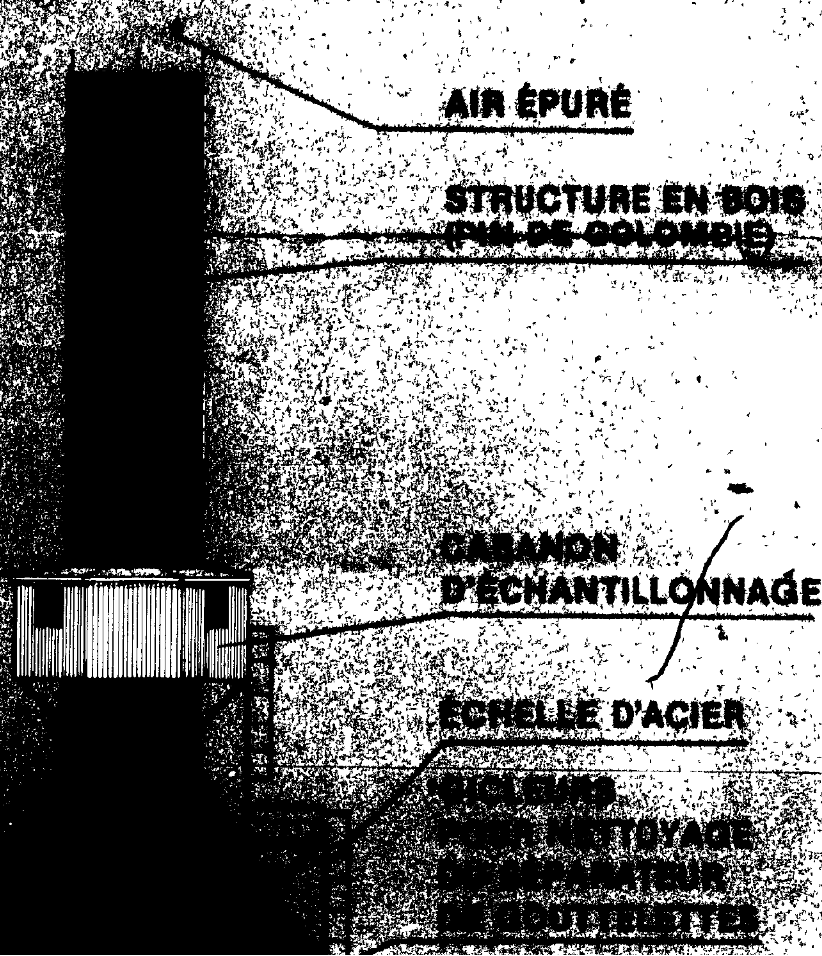

SYSTÈME D'AÉRATION DE TOITURE

HOTTE

CONDUITE SECONDAIR

CUVE

CONDUITE PRIMAIRE

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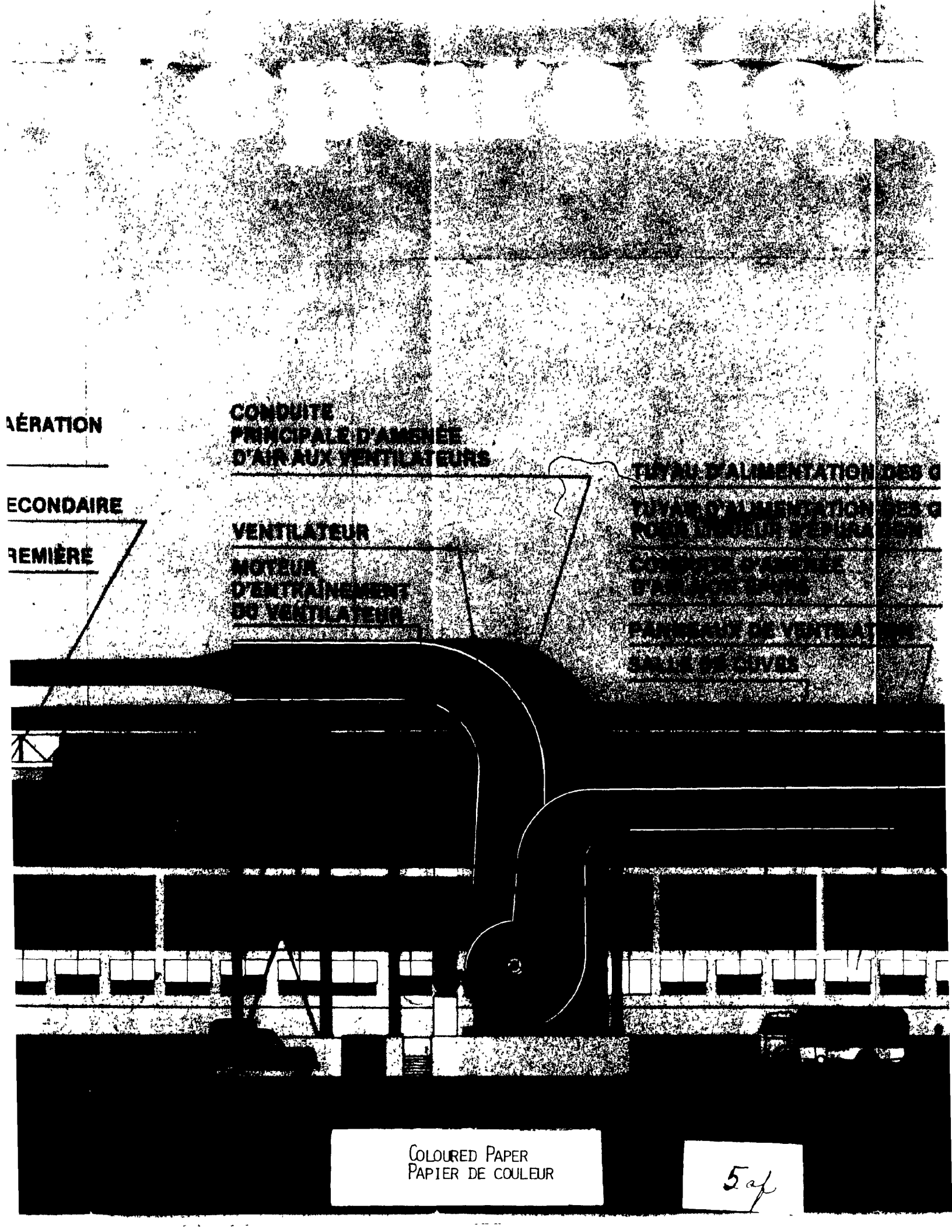

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Papier de couleur

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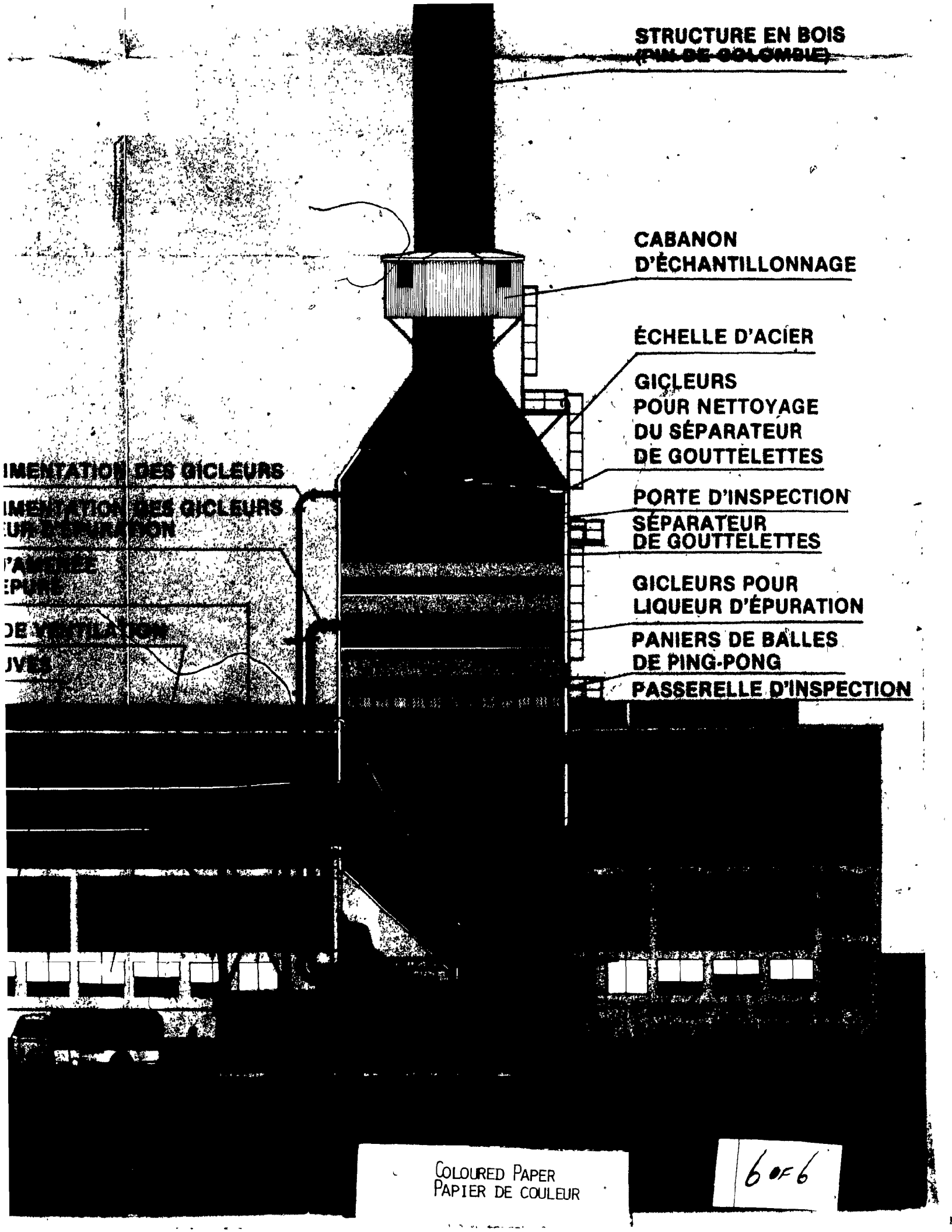

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ÉDITION SPÉCIALE

Le Lingot

Lundi le 16 juin 1980 — Société d'électrolyse et de chimie Alcan Ltée

LE DÉFI: PRODUIRE DE L'ALUMINIUM DE PLUS EN PLUS EN HARMONIE AVEC LE MILIEU

L'activité industrielle d'alumineries de l'envergure de celles d'Alcan au Saguenay et Lac-Saint-Jean comporte des préoccupations relatives à la protection de l'environnement et à l'assainissement de l'air, de l'eau et des conditions de travail. Après plus de 50 ans, l'objectif premier de la Compagnie demeure toujours de produire de l'aluminium et de se développer de plus en plus en harmonie avec le milieu.

Le programme actuel de protection de l'environnement, pour toutes les usines de Sécal au Québec, a été présenté au Service de protection de l'environnement en mai 1973. Initialement évalué à 140 millions $, ce programme devait s'étendre sur une période de treize ans, soit de 1973 à 1986. Après des révisions successives en 1974, 1977, 1978 et, plus récemment en 1980, il est maintenant prévu que le programme s'échelonnera sur une période de dix ans, soit de 1973 à 1983, et qu'il nécessitera des déboursés globaux de plus de 200 millions $. Plus du quart de cette somme a été ou sera consacré à l'achat et à l'installation d'épurateurs à lits de balles dans les salles de cuves de l'Usine Arvida, dont la dernière phase vient d'être annoncée au coût de 20 millions $.

La diligence avec laquelle se déroule ce programme met bien en évidence les efforts faits par la Compagnie au chapitre de l'amélioration des conditions de travail et de l'assainissement de l'air. Plusieurs projets, classés sous la rubrique de l'amélioration de la qualité de l'air, ont en effet beaucoup d'impact sur l'assainissement des conditions de travail. Cette affirmation s'applique tout particulièrement aux épurateurs à lits de balles et à la haute ventilation qui diminuent les pertes de poussières et de gaz dans l'atmosphère et qui contribuent aussi à améliorer le mieux-être des employés dans les salles de cuves.

Dans cette édition spéciale du Lingot, nous souhaitons mettre à votre disposition un document à la fois objectif et précis sur notre programme de protection de l'environnement et plus particulièrement, sur ce que sont les épurateurs à lits de balles, leur rôle spécifique, leurs caractéristiques, leur fonctionnement et leur efficacité.

L'impact de nos activités industrielles sur la qualité de l'air est pour nous une constante préoccupation. Tout n'est pas encore parfait, mais plus que jamais, nous respectons le milieu.

Nous croyons en effet que nos employés et aussi la population en général ont le droit de bien connaître nos nombreux efforts rattachés à la lutte contre la pollution sous toutes ses formes. Après tout, nous faisons quelque chose et nous sommes fiers de ce que nous faisons.

Une ferme-témoin

Sécal exploite depuis 1957 une ferme témoin p
où les effets des fluorures se faisaient le plus
balles à l'Usine Isle Maligne, la ferme Mistook

Ces épurateurs sont particulièrement efficaces
avoir des effets significatifs sur la végétation,
consommation animale.

Sans recourir à des équipements spéciaux, les
démontrer que cette ferme et les autres envir

Respect des normes

Depuis 1975, la norme gouvernementale de 40
destiné à la consommation animale du ministè
qui tend à éliminer les effets indésirables des
ferme Mistook est une ferme prospère compar
de production laitière sont semblables aux mo
elle est la preuve évidente que la Compagnie
régionale de l'UPA, collabore au développeme

L'arbre est dans ses feuilles

	APRÈS
	64.4
	3200 pi3/cuve
	160 pieds
	95%
	95%
	95%
	90%
	70%
	35%
	50%
	40%

in

me-témoin près de la municipalité d'Alma. Située dans une zone
ient le plus sentir, avant l'installation d'épurateurs à lits de
me Mistook s'étend sur 320 acres cultivables.

ent efficaces sur les fluorures gazeux, seul type de fluorures à
végétation, plus précisément sur le fourrage destiné à la

péciaux, les responsables du Service immobilier ont réussi à
autres environnantes peuvent être exploitées avec succès.

ntale de 40 parties par million (p.p.m.) dans le fourrage
du ministère de l'environnement est respectée, ce
irables des fluorures gazeux sur le bétail. Aujourd'hui, la
ère comparable aux fermes environnantes et dont les chiffres
les aux moyennes provinciale et régionale. Ouverte au public,
Compagnie Alcan, de par sa participation à la Fédération
veloppement de l'industrie agricole et du milieu en général.

Usines de Jonquière
CONCENTRATION
LUOR DANS LE FOURRAGE

Un outil de travail indispensable

C'est dans les salles de cuves des Usines Arvida et Isle Maligne que l'on fabrique l'alumi
le procédé d'électrolyse. De par la nature du procédé il se dégage du cours des opération
fluorures et des poussières.

Notre premier souci est donc de maintenir de bonnes conditions de travail en améliorant
qualité de l'air dans les salles de cuves et, parallèlement, dans le voisinage des usines.

Le meilleur moyen d'atteindre cet objectif est encore de capter les émanations à leur sou
même, grâce à un système d'aspiration branché directement sur chacune des 2 700 cuves
ainsi aspiré des cuves est épuré des fluorures et des poussières qu'il contient avant d'êt
libéré dans l'atmosphère.

Un des types d'épurateurs utilisés actuellement dans les usines d'électrolyse est l'épurat
lits de balles. Cet épurateur peut contenir jusqu'à 375,000 balles de ping pong, retenues
par des grillages faits de matière plastique et installées dans une tour de bois de quelqu
pieds de haut.

Les gaz et les poussières, aspirés des cuves par l'action de moteurs qui vont jusqu'à 600
circulent de bas en haut et s'épurent au contact de la liqueur d'épuration qui, elle, circul
en bas. Ce sont ces deux pressions combinées qui entraînent un mouvement de rotation
part des balles, lesquelles, au passage, captent les particules. Il en résulte une épuratio
d'un rendement de plus de 95 pour cent sur les fluorures gazeux et de 65 à 85 pour cent
poussières.

La décantation

La liqueur d'épuration chargée des gaz et des poussières est pompée dans un bassin de
décantation. Les fluorures contenus dans les boues du décanteur et dans la liqueur sont
récupérés sous forme de cryolithe qui est recyclée dans le processus de fabrication de
l'aluminium. La solution claire en surface est, pour sa part, recirculée dans les épurateur
s'agit là d'une illustration fort valable du principe de la transformation des matières poll
en substances utiles.

Protection du milieu

Nos efforts ne s'arrêtent cependant pas là puisqu'aux usines du complexe de Jonquière,
tous les procédés sont munis de systèmes de contrôle de la pollution de l'air. Pour l'ense
usines, on compte en effet plus de 150 dépoussiéreurs et épurateurs qui servent à purifie
de 10 000 000 de pieds cubes d'air à la minute.

Les épurateurs à lits de balles ne sont pas à proprement parler des outils de production,
sens qu'ils n'ajoutent en rien à la qualité de nos produits; toutefois, ils n'en sont pas moi
indispensables à l'amélioration de la qualité du milieu. Dans ce sens, nous croyons que to
efforts valent la peine d'être faits et bien faits.

TOUTE UNE ÉQUIPE

Depuis 1946, il y a des épurateurs dans les salles de cuves Soderberg mais il va sans
ne possédaient pas le taux d'efficacité de ceux que l'on construit aujourd'hui. C'est en
qu'une équipe d'ingénieurs et de techniciens, sous la direction de A.W. Kielback, déc
l'utilisation de balles de ping pong pouvait améliorer le procédé d'épuration.

Les spécialistes

Les Collinge, Morasse, Meilleur, Banville, Neat, sont autant de noms qui ont pris la
qu'on peut associer aujourd'hui à la conception, au génie mécanique ou électrique, à
l'instrumentation ou à la coordination de ces équipements.

L'Usine Vaudreuil,
l'instrumentation,
Saint-Jean participe

Coor

spensable

da et Isle Maligne que l'on fabrique l'aluminium par rocédé il se dégage du cours des opérations des

bonnes conditions de travail en améliorant la allèlement, dans le voisinage des usines.

encore de capter les émanations à leur source é directement sur chacune des 2 700 cuves. L'air et des poussières qu'il contient avant d'être

t dans les usines d'électrolyse est l'épurateur à qu'à 375,000 balles de ping-pong, retenues en place installées dans une tour de bois de quelque 160

r l'action de moteurs qui vont jusqu'à 600 forces, t de la liqueur d'épuration qui, elle, circule de haut qui entraînent un mouvement de rotation de la t les particules. Il en résulte une épuration de l'air fluorures gazeux et de 65 à 85 pour cent sur les

poussières est pompée dans un bassin de ues du décanteur et dans la liqueur sont lée dans le processus de fabrication de our sa part, recirculée dans les épurateurs. Il ipe de la transformation des matières polluantes

qu'aux usines du complexe de Jonquière, presque ntrôle de la pollution de l'air. Pour l'ensemble des éreurs et épurateurs qui servent à purifier près

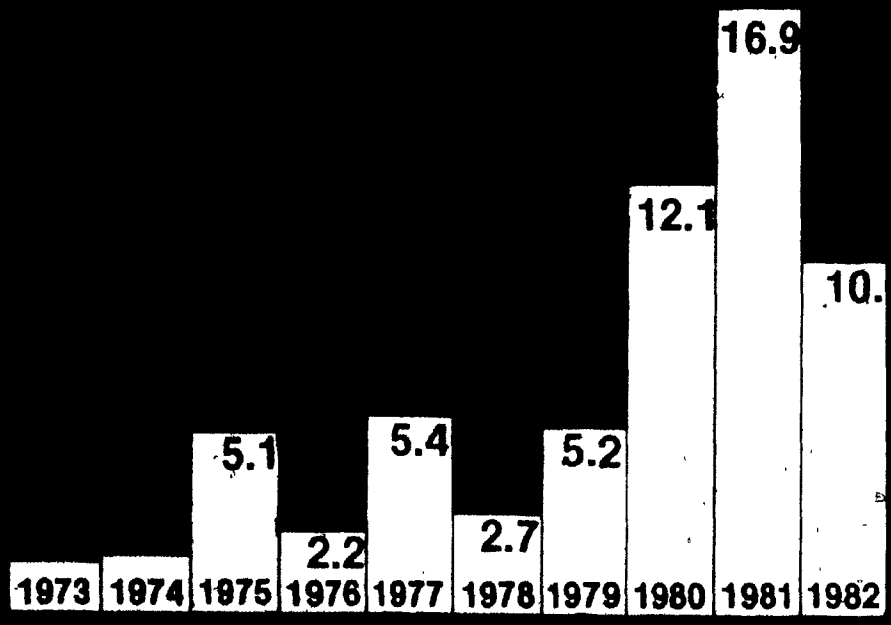
oprement parler des outils de production, en ce s produits; toutefois, ils n'en sont pas moins milieu. Dans ce sens, nous croyons que tous ces

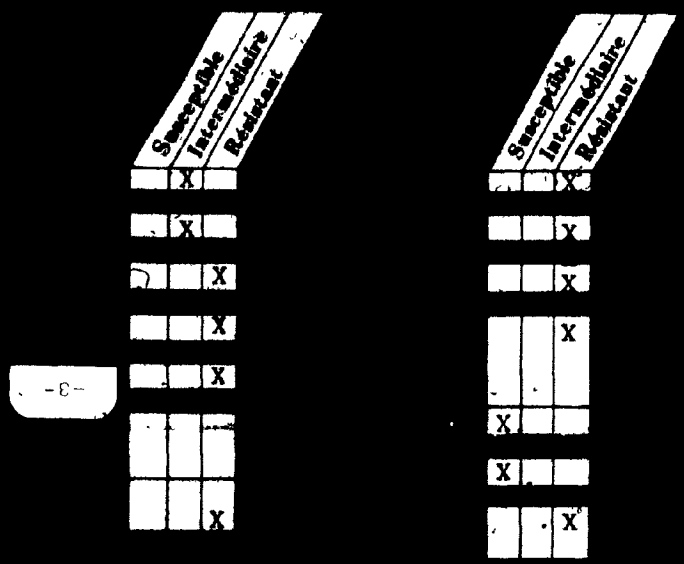
es de cuves Soderberg mais il va sans dire qu'ils que l'on construit aujourd'hui. C'est en 1956 us la direction de A.W. Kielback, découvrait que liorer le procédé d'épuration.

sont autant de noms qui ont pris la suite et u génie mécanique ou électrique, à pements.

le la tuyauterie et un spécialiste de mbreux sous-traitants du Saguenay et Lac-me.

cette équipe planifie son travail un





dont la dernière phase vient d'être annoncée au coût de 20 millions $.

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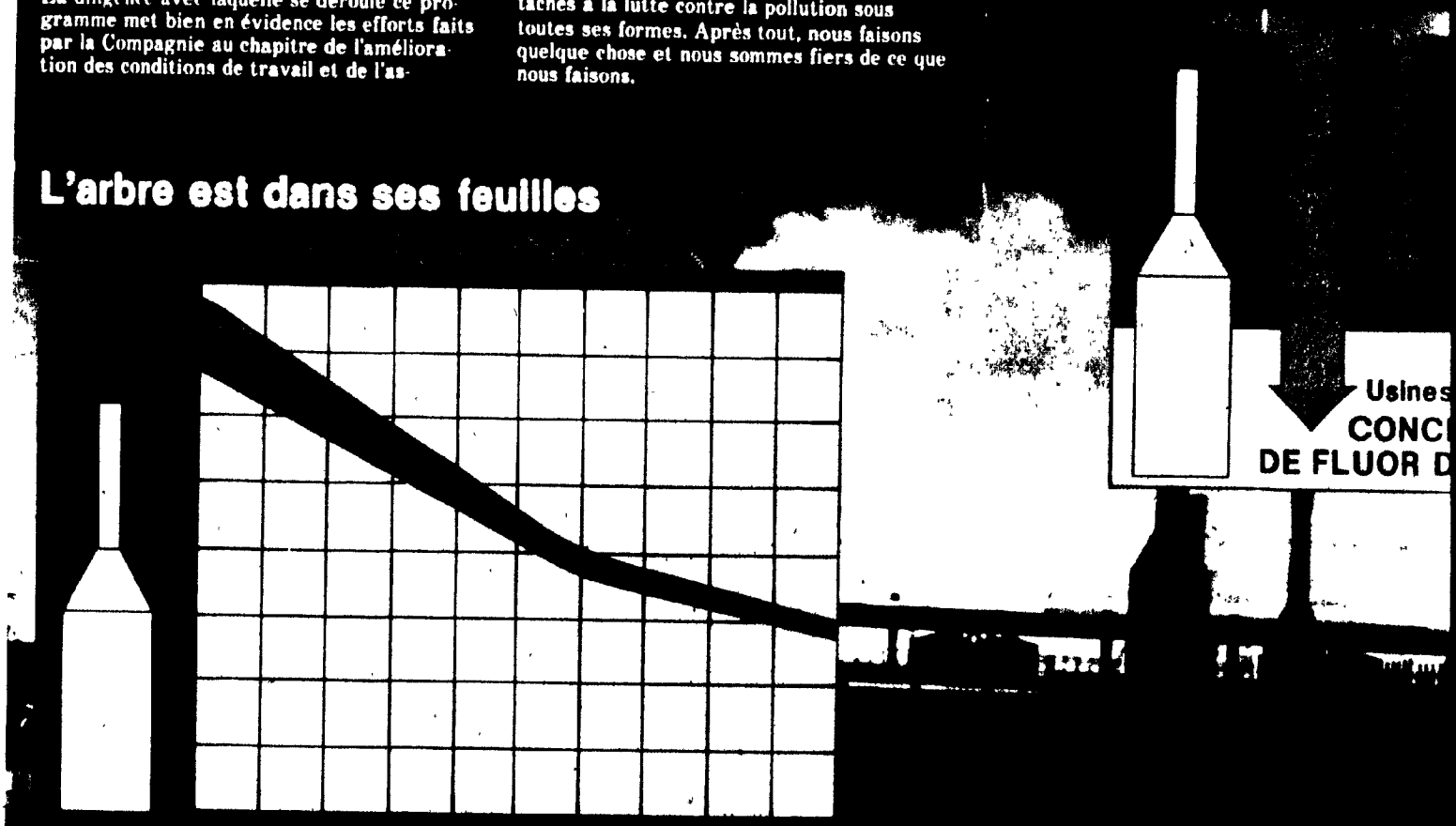

Émission de gaz et de particules aux usines de Jonquière

L'utilisation d'épurateurs à lits de balles dans les usines d'électrolyse Arvida et Isle Maligne donne déjà des résultats très favorables quant à la réduction des émissions atmosphériques et de leurs effets sur la qualité de l'air dans les salles de cuves, à la campagne autant qu'à la ville.

Ainsi, au terme du programme actuel, les effets des fluorures gazeux sur les plantes ornementales dans le quartier nord du secteur Arvida, le seul présentement affecté par ces émissions, auront été réduits à un niveau acceptable. Plus précisément, les émissions pour l'ensemble des installations du complexe de Jonquière auront été réduites de près de 70 pour cent.

Il est également important de noter que les fluorures atmosphériques, dans les concentrations que l'on peut trouver près des usines d'électrolyse, ne représentent aucun danger pour la santé publique. Etant donné que les concentrations maximales pour la protection de la végétation sont de quelques milliers de fois plus basses que pour la protection de la santé de la population, il va de soi que la qualité de la vie n'est en aucun temps menacée.

Par ailleurs, la diminution des émissions de particules de poussières et leur meilleure dispersion à la suite du programme ont déjà contribué, à une amélioration importante de la qualité de l'air dans le quartier nord du secteur Arvida. De plus, à la fin du programme d'assainissement de l'air, les particules en suspension et les retombées de poussières atteindront un niveau acceptable compte tenu des normes pour ces contaminants.

A n'en pas douter, il s'agit d'un pas majeur dans la bonne direction.

Depuis 1946, il y a des épurateurs dans les salles de cuves Soderberg mais il va ne possédaient pas le taux d'efficacité de ceux que l'on construit aujourd'hui. C qu'une équipe d'ingénieurs et de techniciens, sous la direction de A.W. Kiel l'utilisation de balles de ping-pong pouvait améliorer le procédé d'épuration.

Les spécialistes

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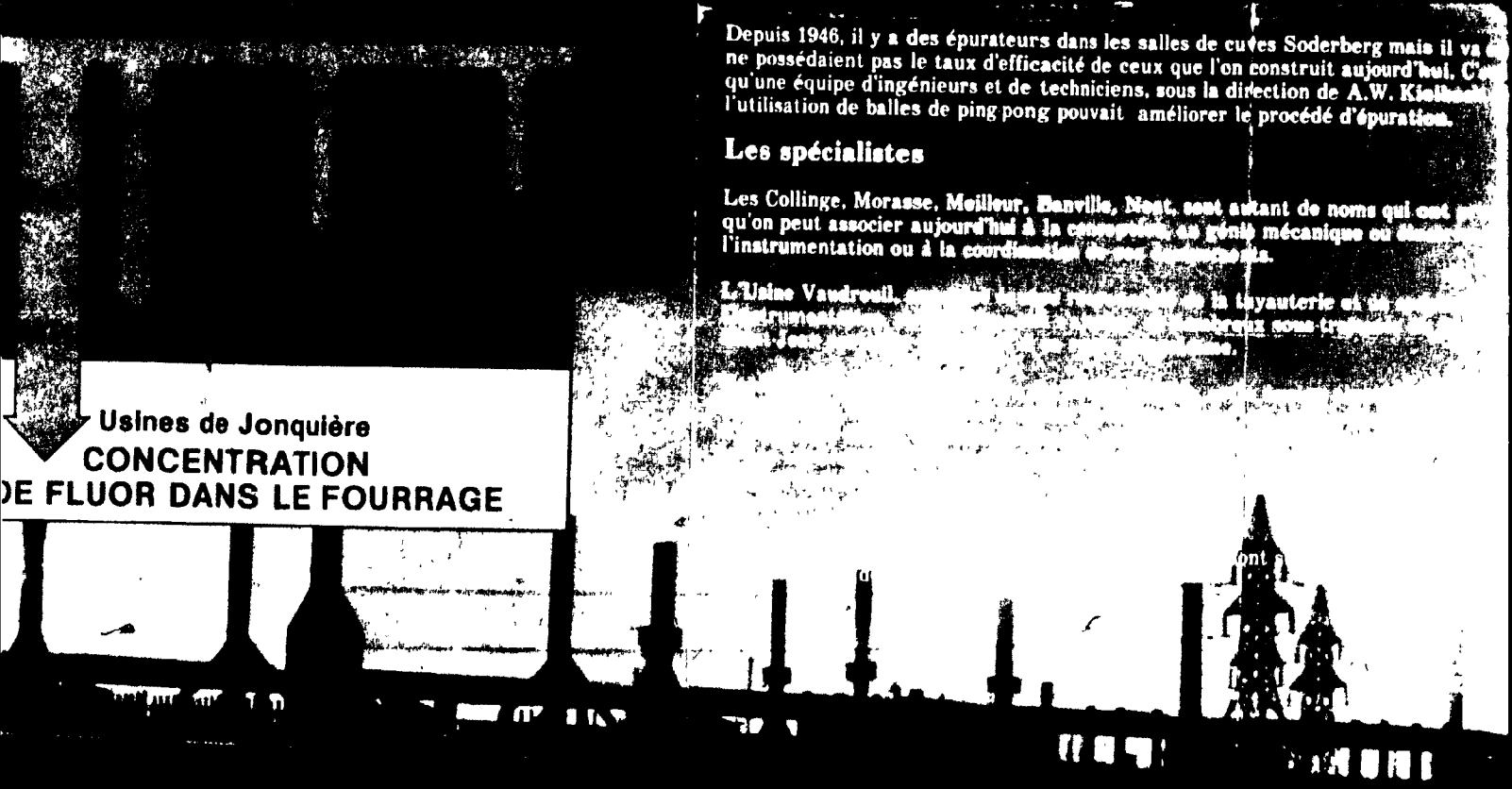
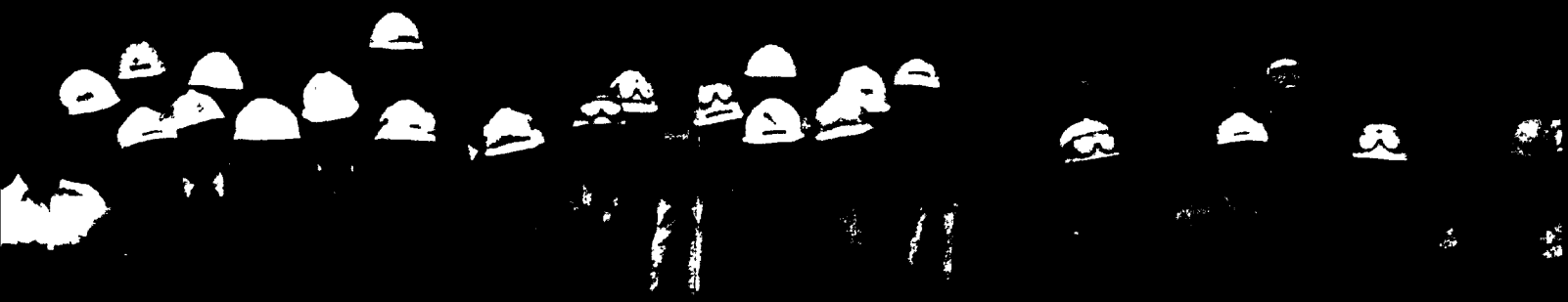
L'Usine Vaudreuil, [illegible] la tuyauterie et [illegible] sous-tr[illegible]

Usines de Jonquière

CONCENTRATION DE FLUOR DANS LE FOURRAGE





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[illegible] soudeurs afin d'[illegible]

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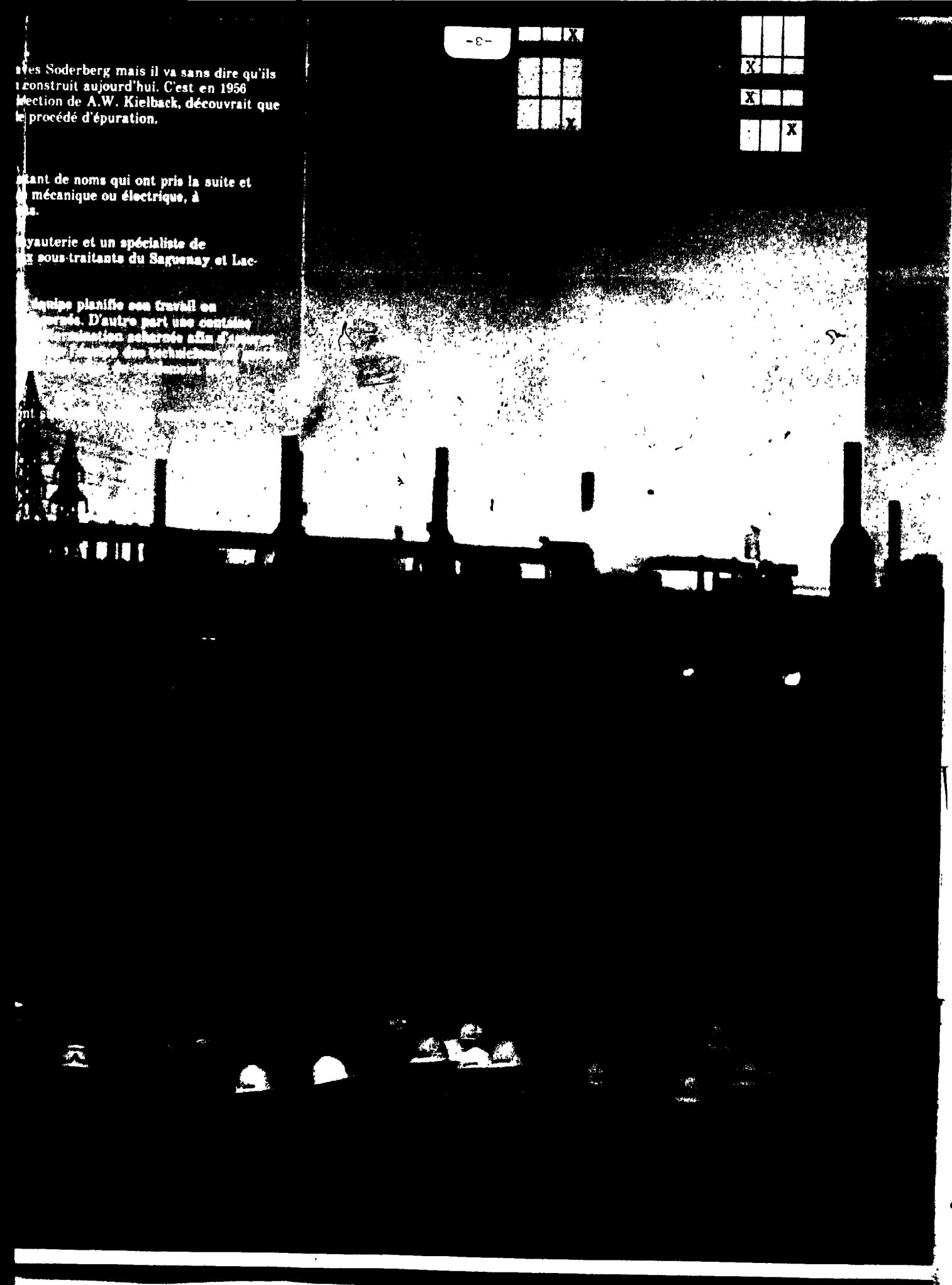

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CHAPTER 2 - BRIEF PRESENTATION OF PLANNING NETWORKING TECHNIQUES

2.1 Historical Background

Networking techniques for planning, scheduling and monitoring were introduced in 1956 by Dupont. Dupont used the computer for the network's arithmetic calculations thus producing fast and economical computations. Other planning tools had been used before 1956, the most commonly used being the Gantt Charts. (Figure 2.1)

Since the late 1950's, two techniques have been most widely utilized as planning tools. These are:

1) Project Evaluation and Review Technique (PERT), a probabilistic analysis applied in projects executed in uncertain environments, and

2) Critical Path Method (CPM), an heuristic analysis applied in projects in which there are no major uncertainties.

This paper, which focuses on CPM, will now briefly discuss the analysis of CPM. The presentation will be divided into two parts; firstly the pre-requisites for implementing the analysis (treated in detail in the next chapter) and secondly the analysis itself, which is dealt with in this chapter. The analysis is divided into four stages, i.e. Planning, Scheduling, Monitoring and Controlling.

2.2 Planning Stage

This stage begins when the tasks for the project are determined and activities and their logical interrelationships are established. The product is a network that shows the logical activity sequence in which the project would be executed. Then the durations of the activities can be obtained from different sources; i.e. construction

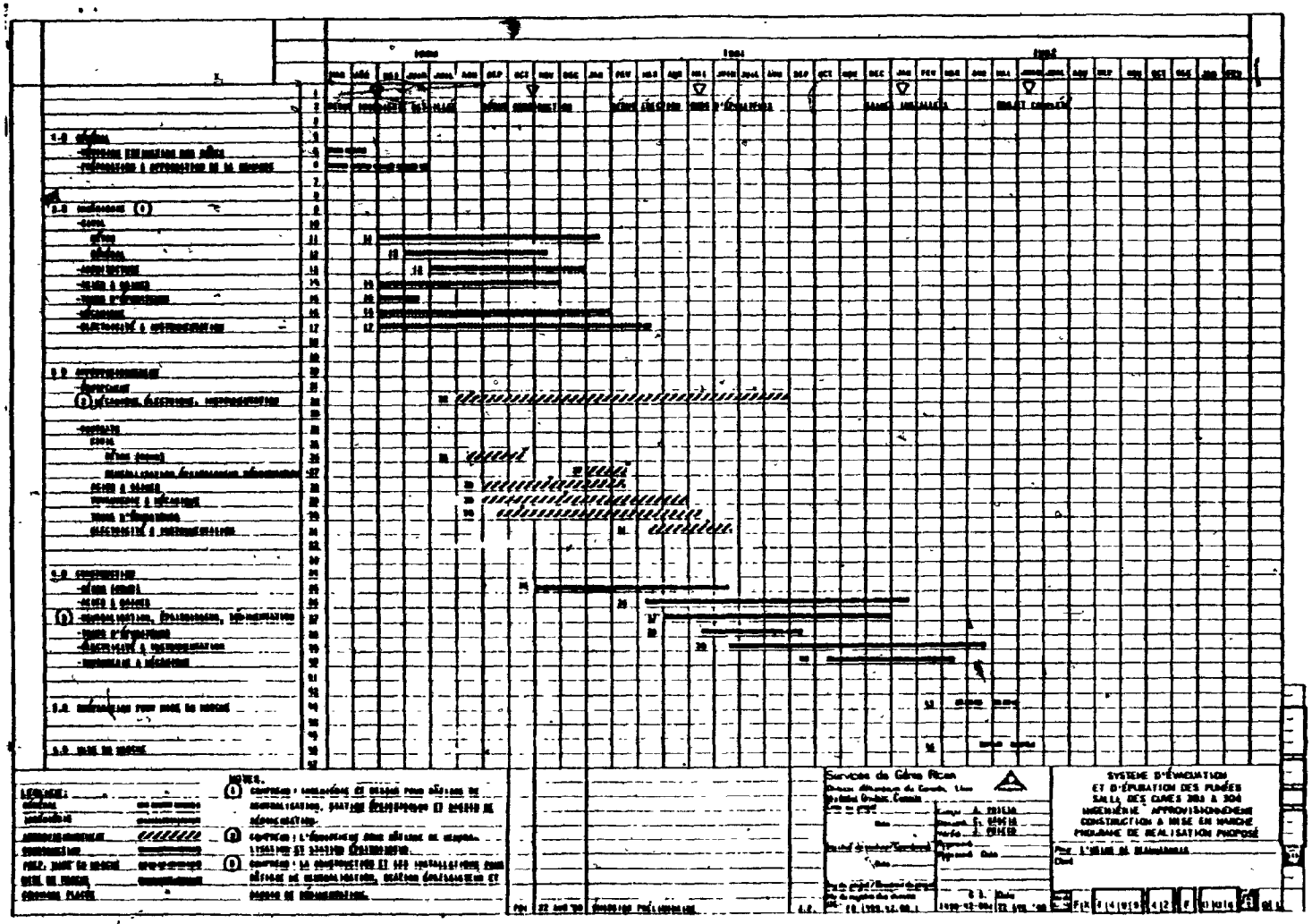


FIGURE 2.1 - EXAMPLE OF GANTT CHART.

reports with similar activities, contractor's information on the project, cost estimates with labour and material breakdown, etc.

Basically a network can be represented as an arrow or precedence diagram depending on whether the activity is shown as an arrow or as a node. (Figure 2.2)

Arrow diagrams have dummy activities (duration zero) whose purpose is to indicate that some activities must be completed before others are started.

In precedence diagrams, four logical relationships between activities are used to represent the network.

These are: finish to start, start to start, start to finish and finish to finish. (Figure 2.3)

Lag times can be introduced into any of these relationships thus allowing greater flexibility.

Once the network logic is completed, a time computation will provide times for each activity.

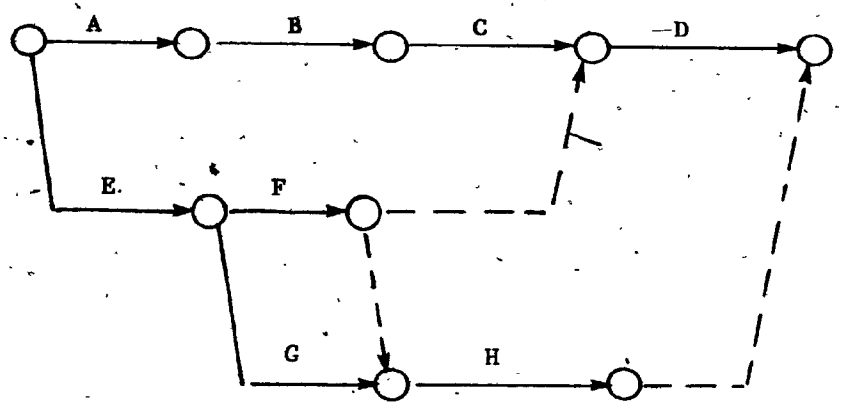
The computation consists of:

1) executing a forward pass in the network, in which the early start and early finish for each activity of node are obtained:

ES_j = Max (ES+d) of all activities preceding activity j

$EF_j = ES_j + d_j$ d_j = duration of activity j

ARROW DIAGRAM



PRECEDENCE DIAGRAM

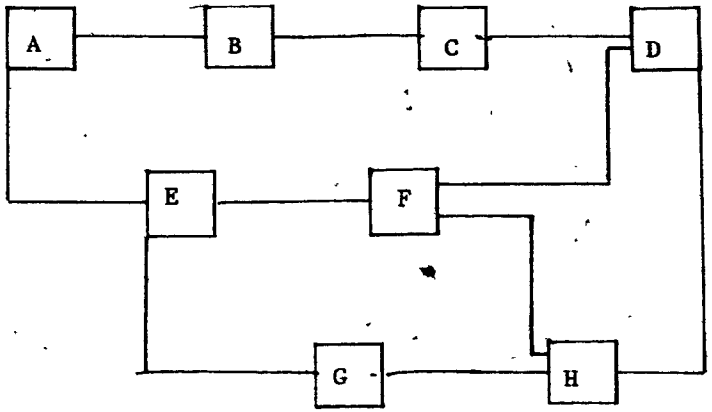
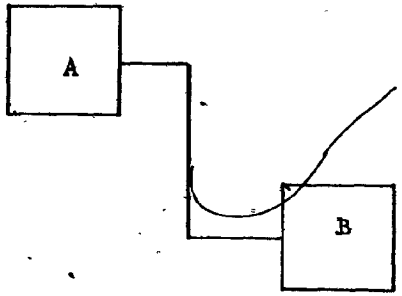
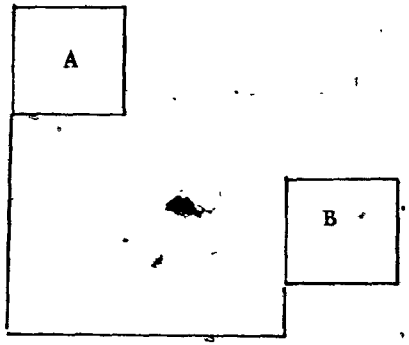


FIGURE 2.2 - NETWORK REPRESENTATION

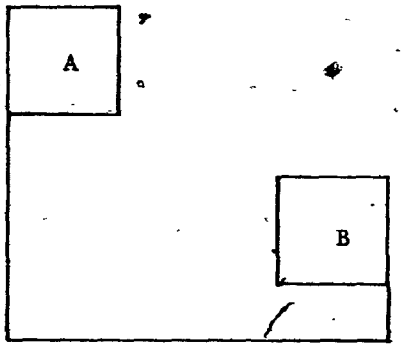
FINISH TO START



START TO START



START TO FINISH



FINISH TO FINISH

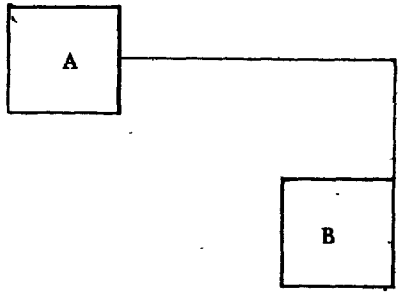


FIGURE 2.3 - PRECEDENCE DIAGRAM. LOGICAL RELATIONSHIPS.

Followed by:

2) a backward pass in which the late finish and late start for each activity or node are obtained:

$LF = \text{Min } (LF - d)$ of all activities succeeding activity j

$LS_j = LF_j - d_j$ $\quad d_j$ = duration of activity j

Each activity then has:

ES Early Start
EF Early Finish
LS Late Start
LF Late Finish

With these activity times, floats (Total, Free and Independent) can be obtained.

The floats give a measurement of the amount of time any activity can be delayed without affecting:

1) the completion date of the project (total float), or

2) the starting date of another activity (Free and Independent Floats)

Total Float	$LF - ES - d$
Free Float	$ES_k - ES_m - d$
Independent Float	$ES_1 - LF_m - d$

K following activities
L following activity
M activity

Total Float $\geq$ Free Float $\geq$ Independent Float

The criticallity of the various paths in the network is determined by their total float. Special attention should be given to the longest path in the network which also has the lowest total float. This path is named the Critical Path and it establishes the project completion date.

When CPM was first utilized, arrow diagrams were almost the only representation of network diagrams. However, the latest trend is to switch to precedence network diagrams because of: facility in inputing the network information into the computer; flexibility given by the logical relationships, thereby avoiding activity splitting (usage of dummy activities); and greater facility in resource constrained scheduling.

2.3 Scheduling Stage

The scheduling stage starts when the network information is converted to a working schedule by assigning calendar dates. The major factors to be taken into account for scheduling are: resources (manpower, materials, machinery, money), weather factors, vacation periods, labour regulations, etc.

The schedules usually are reproduced either as:

1) a barchart listed by early start, in which case the logical interrelationship between activities is lost,

2) a time scaled CPM Network in which a time frame is kept while maintaining the network logic, or

3) a computerized planning schedule.

With a schedule the CPM analysis can go further by: obtaining resource allocations; forecasting rate of expenditures and cash flows; studying time sensitivity analysis with different weather conditions, crew sizes, effects on strikes, etc.; optimizing cost and scheduling duration with cost trade-off models.

2.4 Monitoring Stage

At this stage schedules are kept revised and updated as the project progresses. The frequency at which progress is reported depends on the corporate policy and the type of project.

The philosophy behind networking techniques in general is "to manage projects by exception", that is to say, to pinpoint only the areas of problem in the project. For this it is important that management at different levels receive only information that concerns them and in which they can take some action.

2.5 Controlling Stage

Some projects require that certain parameters such as cost, manhours, materials, etc., be controlled closely to avoid over-expenditures.

This controlling is achieved by:

1) taking the parameter and establishing its performance against its total estimate

2) comparing that performance with the actual expenditures

3) forecasting the parameter's completion requirements

4) recommending actions to improve performance when necessary.

The link between control and CPM is established by the activity percent completion which can be found in the monitoring stage. A detailed presentation of controlling is presented in Chapter 5.

2.6 Use of Computer

There are many computer software packages which deal with CPM, and there are extensive references on them.

With the use of the computer, it is possible to calculate and forecast requirements in cost and resources for large networks (1000 activities or more) in a short period of time. To manually calculate and produce forecasts in these networks would be too lengthy to be practical.

Software CPM package capabilities vary greatly, going from a simple calculation of the critical path to sophisticated programs with costs, constrained resource schedules, target schedules, multiprojects, network plotting, etc.

CHAPTER 3 - PRE-PLANNING

3.1 Program Objectives Definition

A certain amount of pre-planning, as the first step in the creation of a system for planning scheduling and monitoring a project is often neglected. The result is that because of a lack of understanding of the "what's", "when's" and "how's" of the project, the management team goes "off the track" with the resulting delays and over-expenditures.

Pre-planning begins with a definition of the objectives that are to be achieved by the system.

The planning objectives for the projects which will be treated in this report can be summarized as:

1. Provide a time frame for the different projects of the Scrubber Program.

2. Develop and monitor schedules at different managerial levels.

3. Forecast rate of expenditure and cash flows for the program with periodical updates for budgeting purposes.

4. Estimate manpower requirements in construction for evaluation of manpower availability.

5. Develop a system to control cost manhours and drawings in the in-house engineering.

Once the objectives were stated and agreed upon, three structures were developed to carry out and to meet the planning objectives efficiently.

These were:

1) Work Breakdown Structure
2) Coding Structure
3) Report Structure

3.2 Work Breakdown Structure (WBS)

This structure is a hierarchical breakdown of the Scrubber Program project. Each component on a particular level is divided into sub-components on a lower level. Following this procedure, it is possible to arrive at the detail desired at the lowest level of the WBS.

By going through the exercise of developing the WBS, a clear picture of the program is produced. Figure 3.1

The relationships between the projects, stages, engineering disciplines, discipline packages, tasks and activities can be easily visualized and understood.

The WBS as a basic and primary structure facilitates: 1) establishment of the two remaining structures; 2) definition of the information given to individuals in the project organization, e.g. top management is interested in progress at the discipline package level but the resident engineers are requested to monitor the projects at the activity level; 3) evaluation to determine the degree of detail in the information necessary, in terms of cost and manhours, to develop rate of expenditures, cash flows and manpower forecasts.

SCRUBBER PROGRAM

WORK BREAKDOWN STRUCTURE

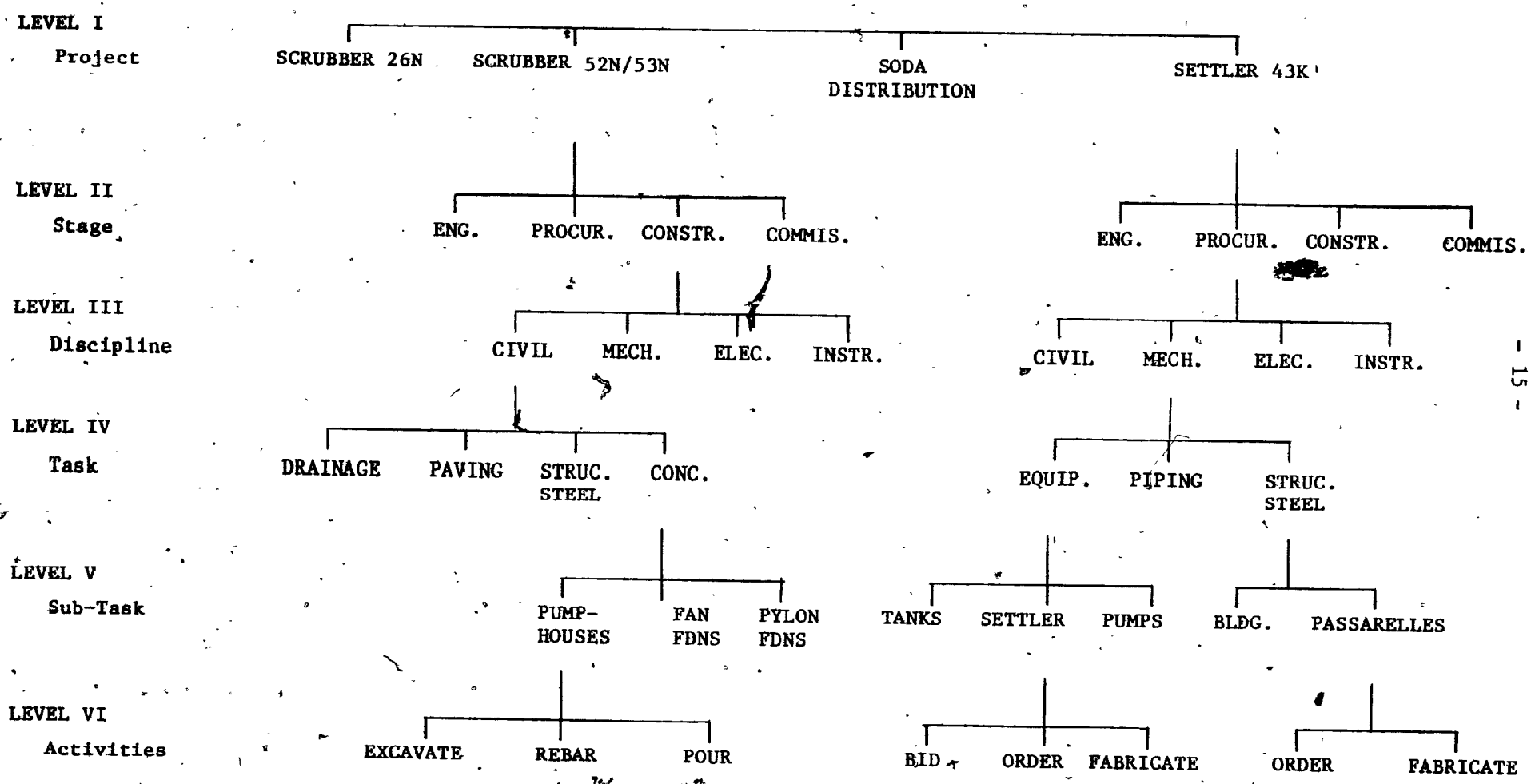


FIGURE 3.1 - PROGRAM WORK BREAKDOWN STRUCTURE

3.3 Report Structure

The following is a short introduction to the components of the report structure. The next chapter will include a detailed explanation of the information provided by the reports used in the Scrubber Program.

The schedules developed started with a summarized time scaled network used at the highest level of the WBS. This schedule, named the Strategic Plan, has played special importance in several ways, including: 1) As a master coordination schedule for different project leaders and plan operators. 2) When major changes in the company policies for the program have occurred. Figure 3.2

The development of the Strategic Plan was based on summaried CPM networks which were developed with information on: historical data for similar projects; scopes of work; and cost estimates for the projects involved. Figure 3.3

The rate of expenditure, cash flow and manpower allocation reports were all produced: 1) after distributing the costs and manhours within the projects in the Strategic Plan, and 2) after inputing the Strategic Plan information into a software computer package.

For the larger projects in the program, manually detailed CPM time scaled schedules were developed. The number of activities scheduled for these networks depended on the phase[1] in which they were being executed, as well as their complexibility.

[1] A project proceeds through several progressive phases which are: feasibility study, preliminary engineering, final engineering, construction and commissioning.

SCRUBBER PROGRAM

REPORT STRUCTURE

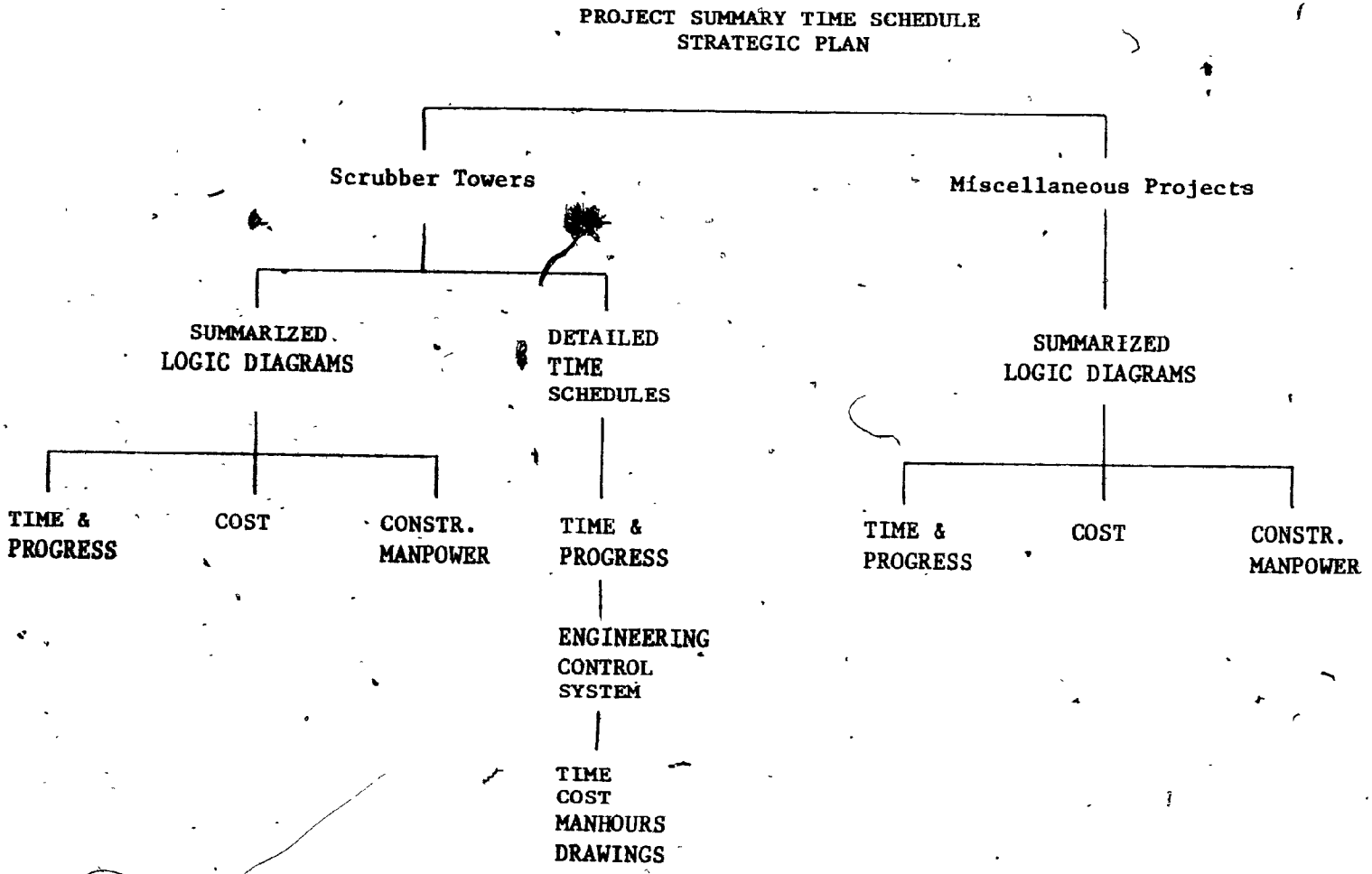


FIGURE 3.2 - PROGRAM REPORT STRUCTURE

SCRUBBER PROGRAM

SCHEDULES & LOGIC DIAGRAMS

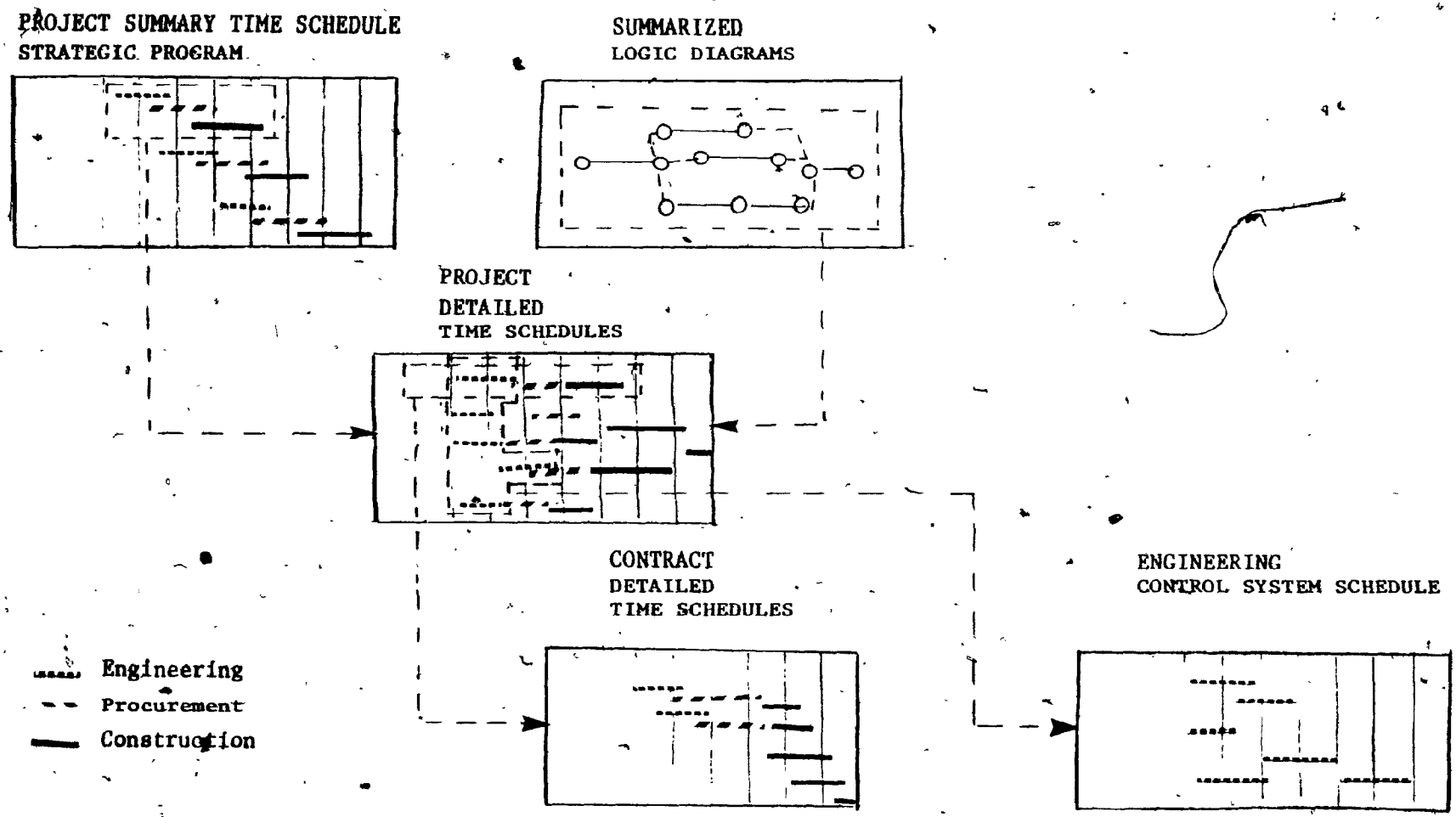


FIGURE 3.3 - PROGRAM SCHEDULE'S LOGIC DIAGRAMS

The computerized reports were run with the Project-2 software package.[2] This package allows great flexibility because of the capabilities included in its various processors. These processors include: basic network, target, resource allowcation, resource constrained allocation, costs, multiproject, graphics, etc.

The capabilities of Project-2 include: three codes per activity which allow several sorting and selecting combinations (used for summary reports); several sample reports in each processor; multi-calendars; activity listings; activity groupings; and many others which are too lengthy to be discussed in this paper.

3.4 Coding Structure

The coding structure for the computerized reports defines one code per activity which then allows various sorts (eg. early start, late start, total float, etc.) selections, or summarizations.

The coding structure must be developed in direct relationship to the WBS and report structure. Then many possible reports at a specific management level can be outputed as they are required.

The software Project-2 package allows for the definitions of three activity codes. The activities in the Scrubber Program have a seven digit code and the definition of each position is provided in the following chart. Figure 3.4

[2] Project-2 is a software package for network based project scheduling and control. The package was developed by Project Software and Development, Inc.

SCRUBBER PROGRAM

CODING STRUCTURE

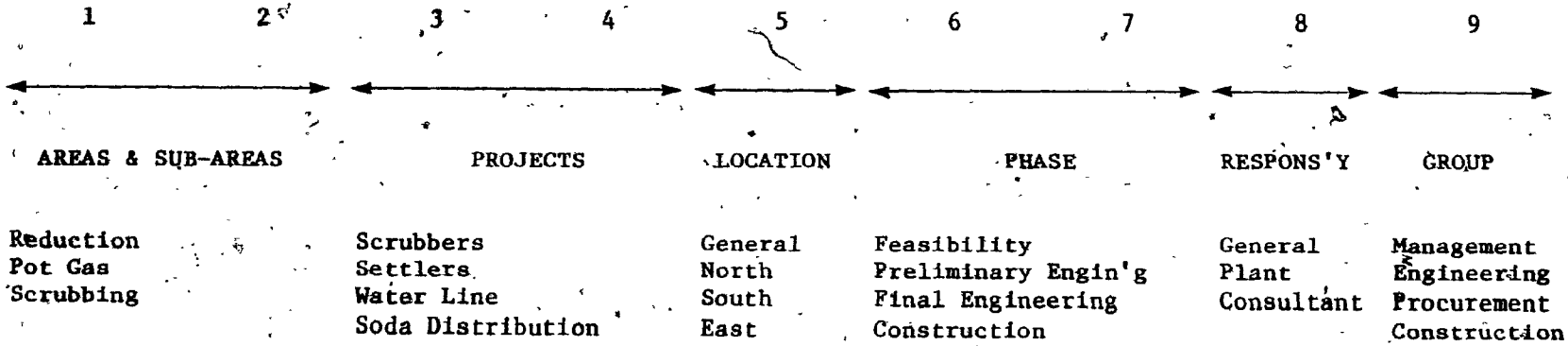


FIGURE 3.4 - PROGRAM CODING STRUCTURE

Area & Sub Area

Codes 1,2 refer to the company coding system for reduction and pot gas exhausting.

Project

Codes 3,4 differentiate the various projects within the Scrubber Program.

Location

Code 5 defines the location of the projects in the plant.

Phase

Codes 6,7 assign the activities to either Feasibility Study, Preliminary Engineering or Final Engineering.

Responsibility

Code 8 defines the organization responsible for the execution of the activity.

Group

Code 9 names the group responsible for the execution of the activity.

CHAPTER 4 - THE PROGRAM

4.1 General

On implementation the program was divided into two parts: the preparation and the operation. In the implementation, three parameters (i.e. TIME, COST, MANHOURS) are introduced into the networks.

The preparation stage can be divided into the following steps: study information, network preparation and issue reports. (Fig. 4.1)

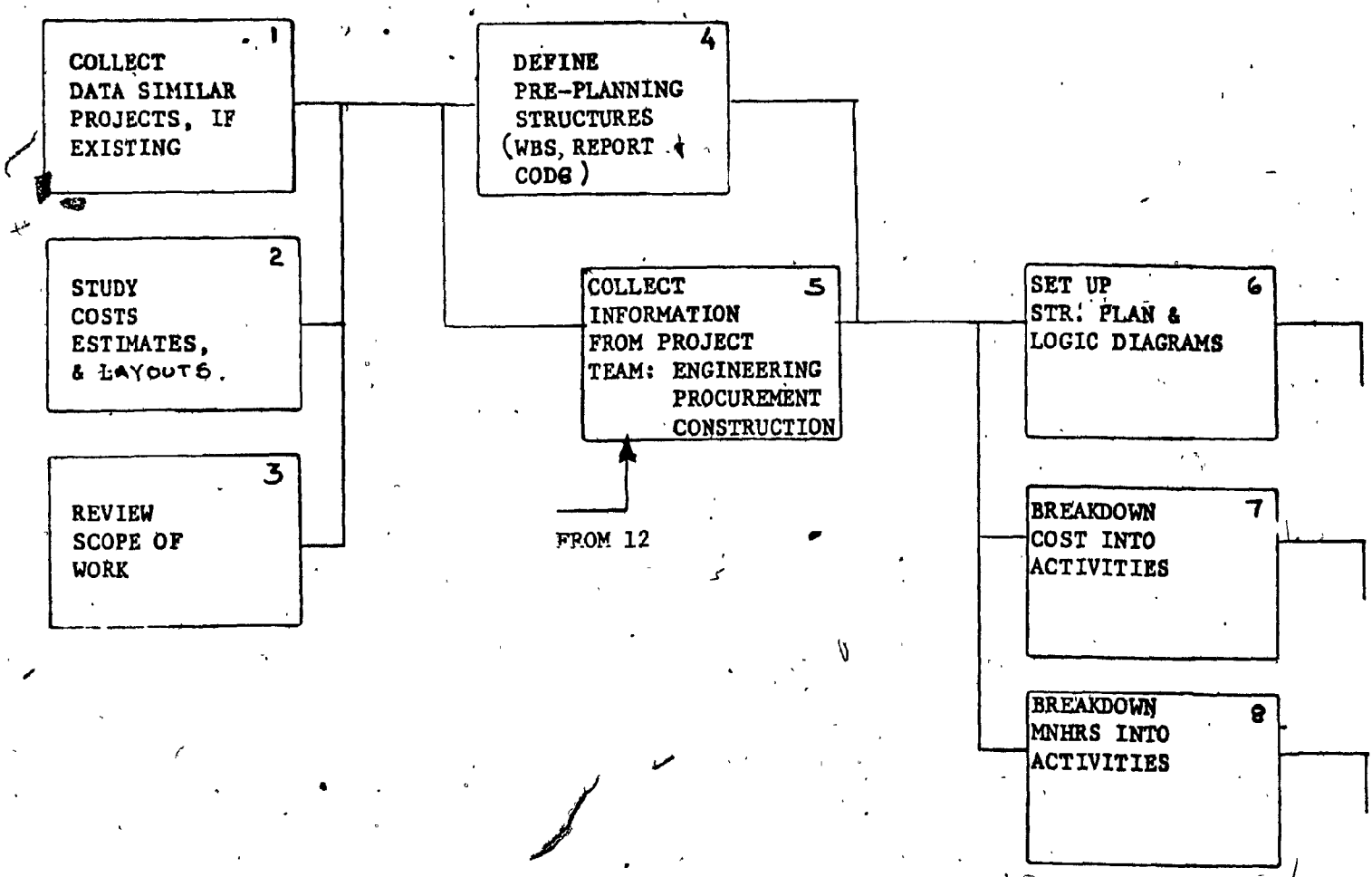
In the operation stage, the progress information and actual expenditures in cost and manhours are reported and the program reports updated for the succeeding work period; (schedules are updated every two months, cost every six months, construction manhours when required).

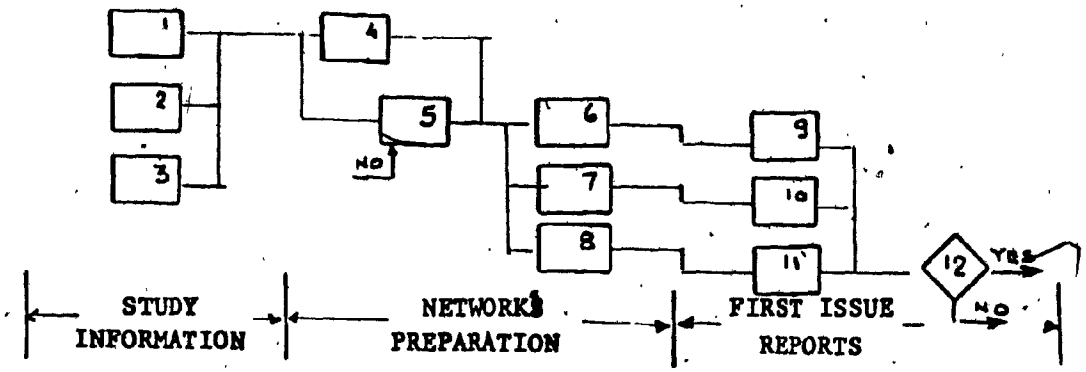
The operation stage can also be divided into the following steps: collecting information, inputing information, and issuing updated reports. (Figure 4.2)

Three parameters; TIME, COST and MANHOURS will be discussed and the method of planning and monitoring their reports will be explained.

Because only time analysis, in relation to CPM technique, was dealt with in Chapter 2, a general introduction to cost and resource allocations will be presented.

SCRUBBER PROGRAM
PROJECT IMPLEMENTATION
PREPARATION (PLANNING)





1 of

SCRUBBER PROGRAM
OJECT IMPLEMENTATION
EPARATION (PLANNING)

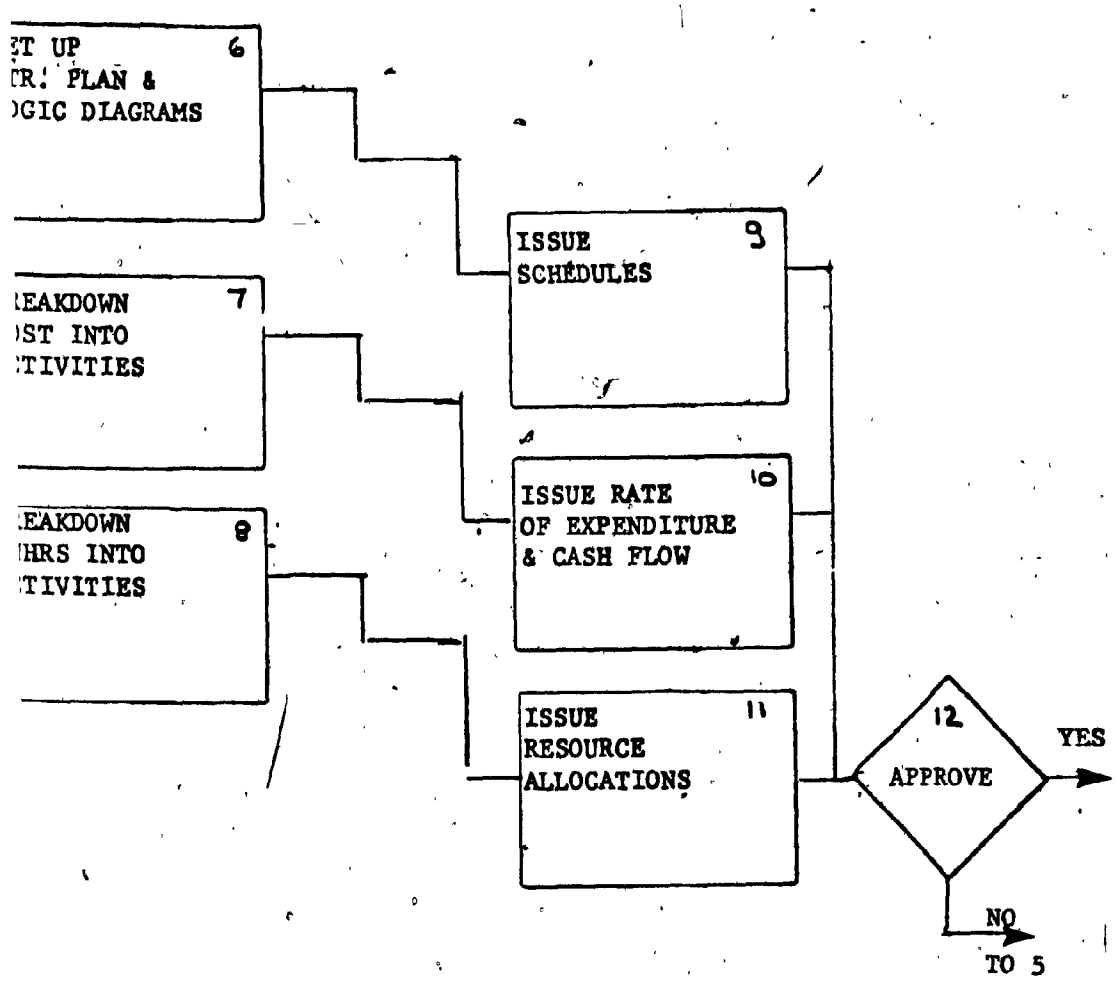
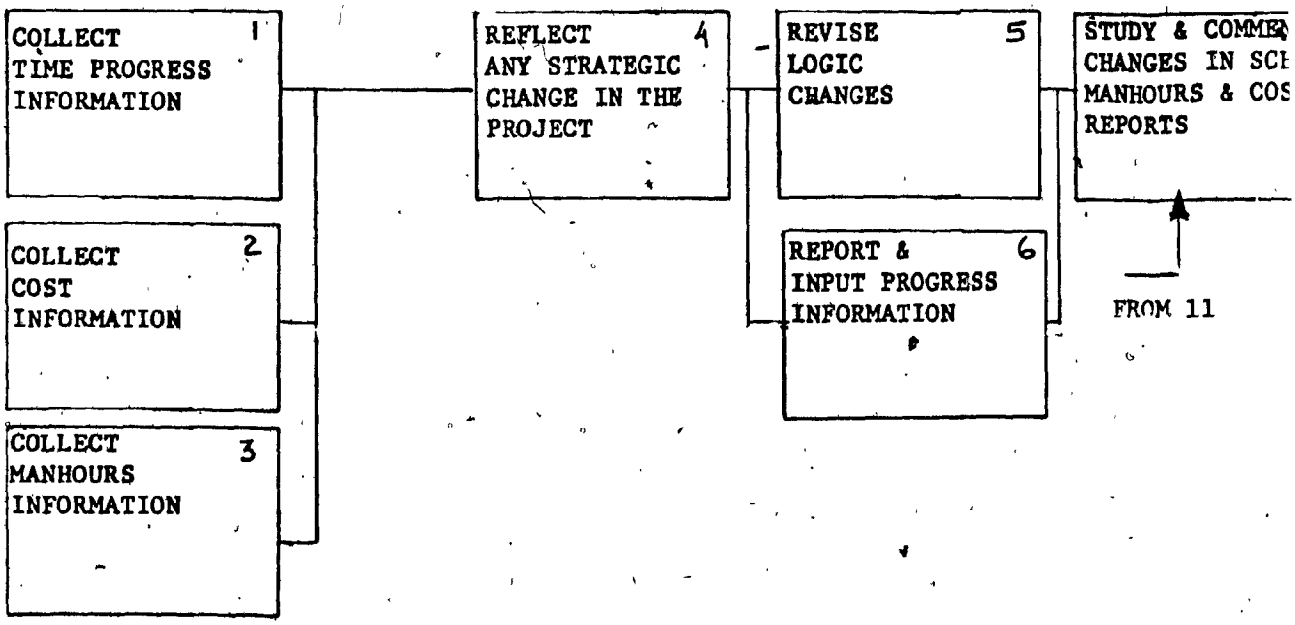
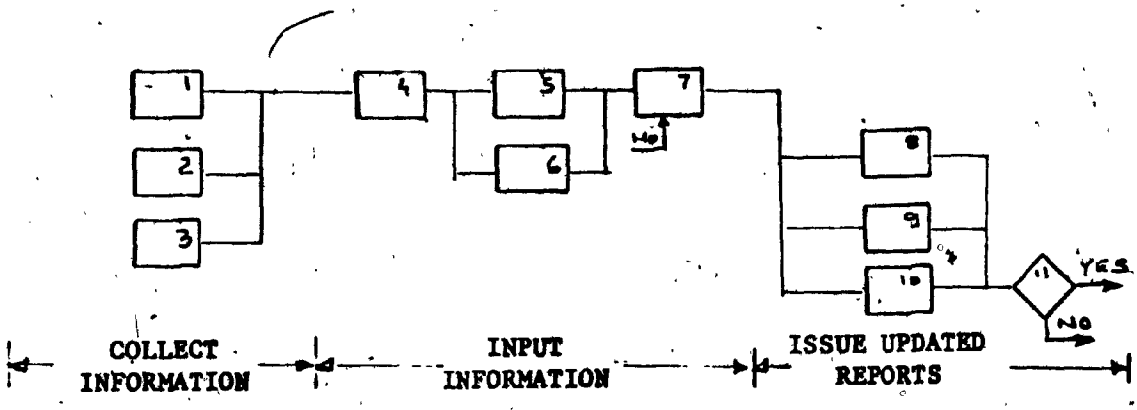


FIGURE 4.1 - PROGRAM IMPLEMENTATION PREPARATION

SCRUBBER PROGRAM
PROJECT IMPLEMENTATION
OPERATION (MONITORING)





1 of

)GRAM
ENTATION
[TORING)

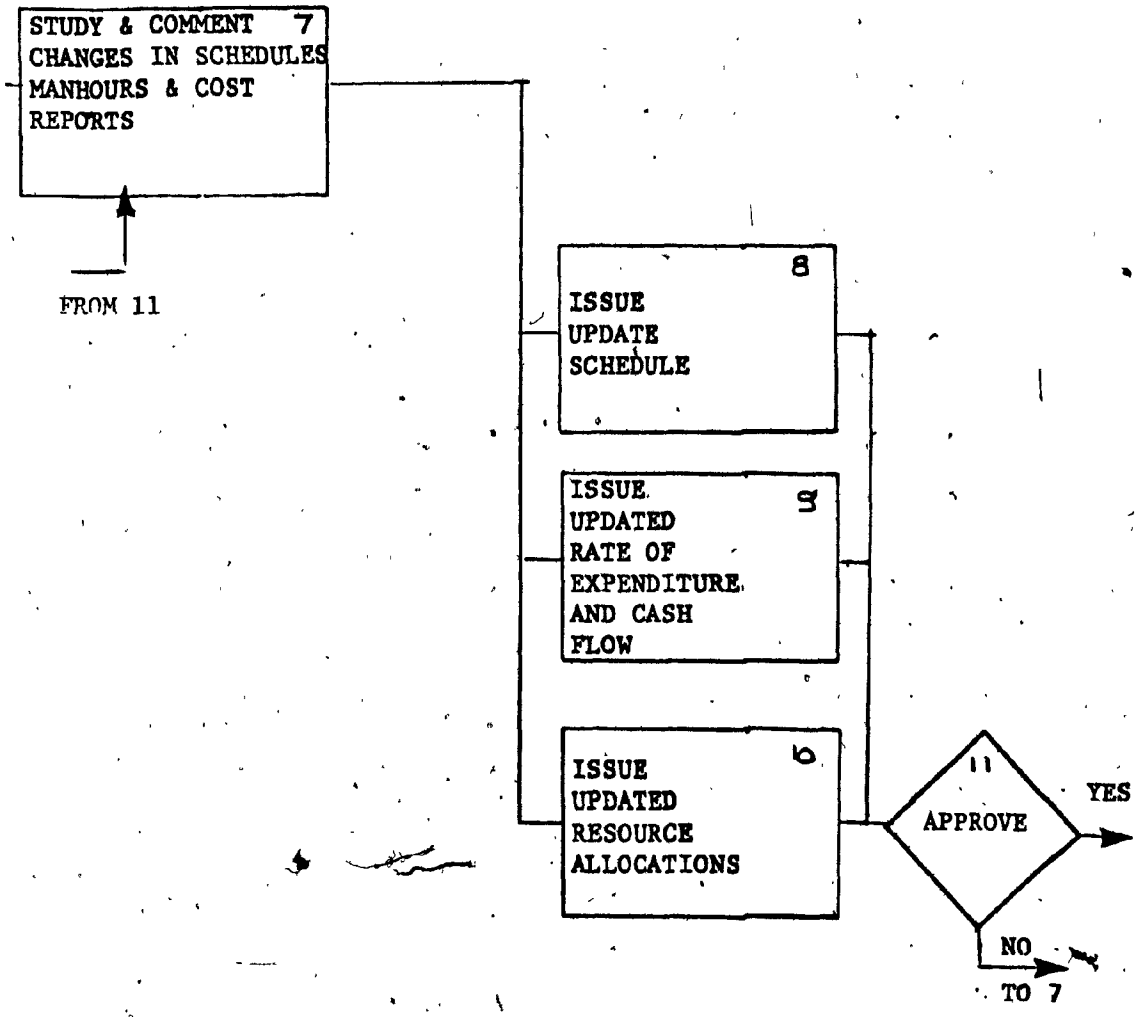


FIGURE 4.2 – PROGRAM IMPLEMENTATION.OPERATION

2 of 2

4.2 Time

4.2.1 Preparation

4.2.1.1 Strategic Plan

These documents are summarized time schedules which include all the projects in the program. The crucial events are outlined by milestones. These events are either important decisions expected by a certain date or actions which have to be completed to avoid delay in the Scrubber Program.

In the development of the Stretegic Plan, master project networks and their critical paths were studied. Then with: 1) The company's strategy to meet government regulations; 2) consideration of constraints such as weather, equipment, site accessibility; and 3) utilization of available resources; the plan schedule was created. figure 4.4

This Strategic Plan has been the most important document, in terms of communication, used in the execution of the program. It has also been the network which has the detail necessary to carry the cost and manhour information. This information is carried in the computer in a precedence network. However, in the network presentation, activities are represented by arrows. (Figure 4.5)

Management makes the budgeting decisions and determines construction manpower requirements based on information from the Strategic Plan.

4.2.1.2 Time Scaled CPM Networks

For the scrubber towers project, time scaled schedules were developed in preliminary engineering (50 activities) and final engineering (150 activities). These networks have activities that are monitored in engineering, procurement, construction and commissioning. Because on a time scaled the activities are not scheduled either in early start or in late start, a careful float evaluation has to be done.

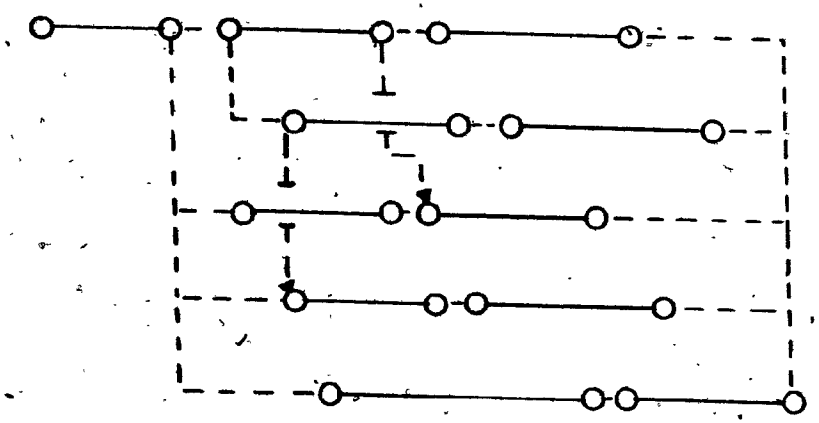
To avoid excessive crossovers in the network's representation, some logical relationships are indicated by means of a number by which activities are entered or exited. (Figure 4.3)

By having a different tape for each of the stages,, (i.e. engineering, procurement and construction), activities are more clearly visualized.

Network activities are arranged by disciplines, packages and tasks, (illustrated in the WBS). The networks show their interdependencies and constraints.

These schedules are the planning documents which are followed by project leaders and contractors.

In some cases, in order to more clearly illustrate the information, sketches with the structural elements to be constructed are included as well as detailed descriptions of activities, listing steps necessary for their completion. e.g. In the activity "Ducting Installations", the method of connecting existing and newly erected ducts in order to minimize shut off times in the plant operation is described.



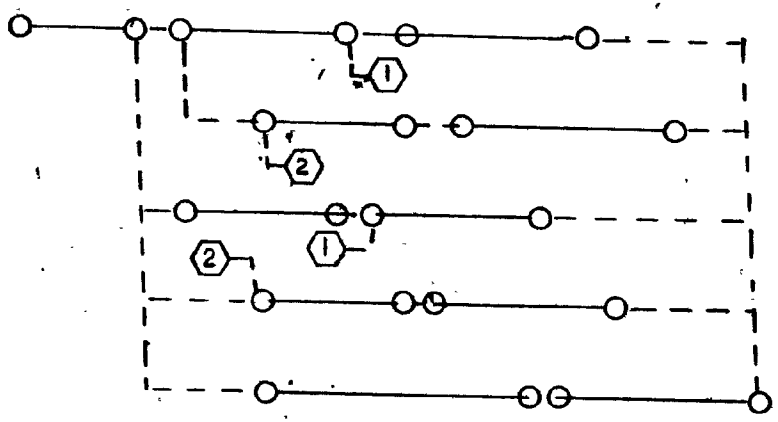
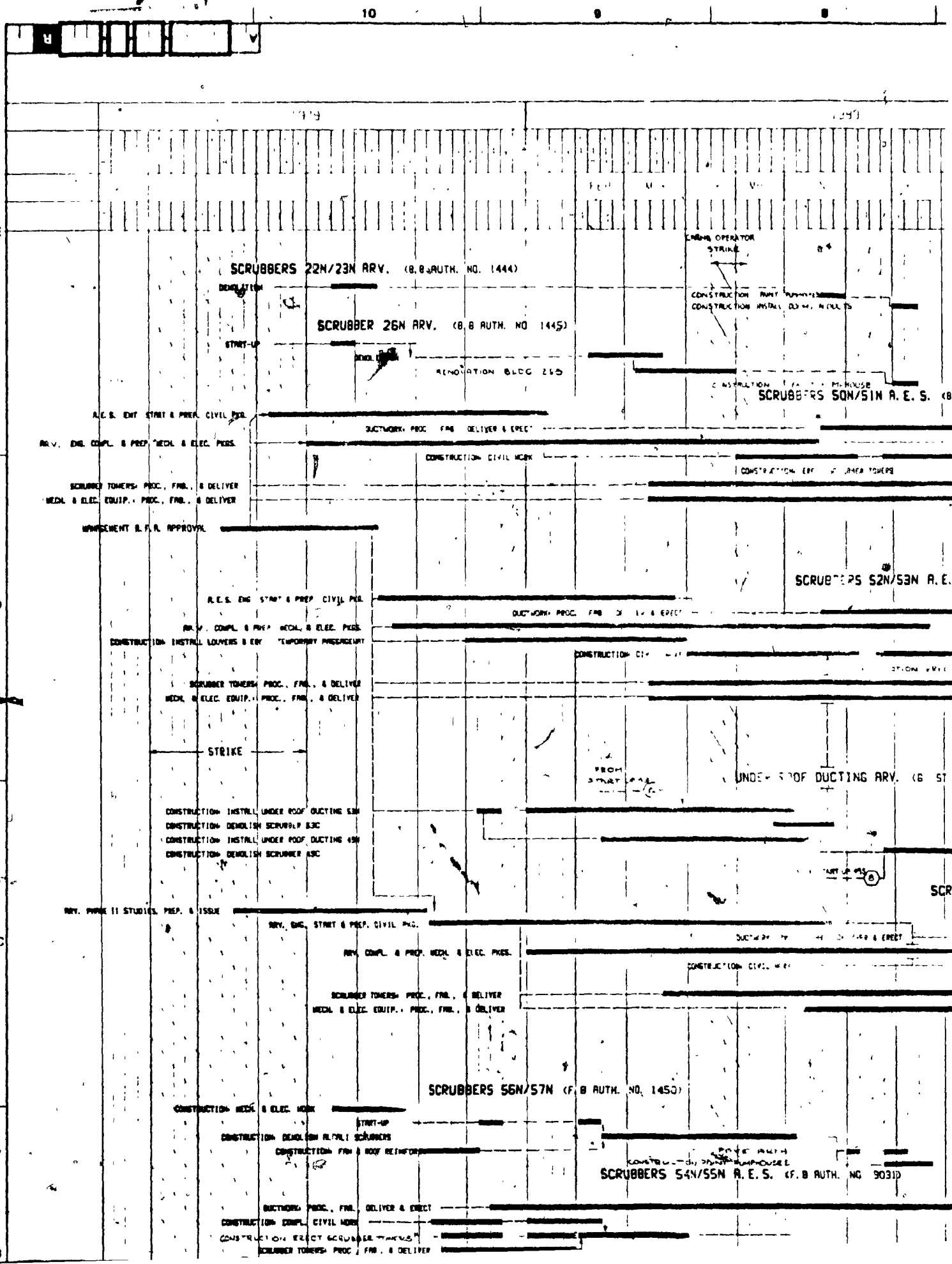
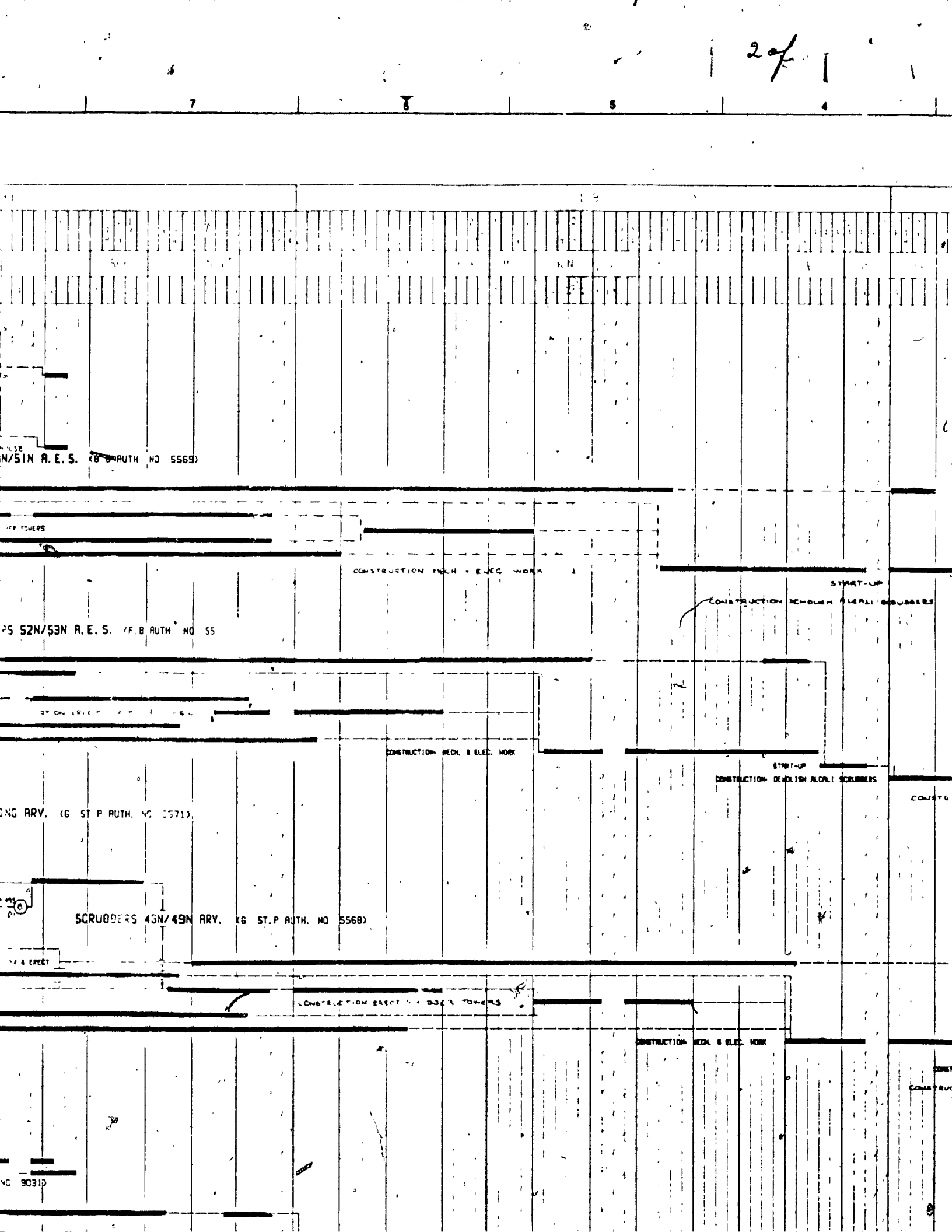


FIGURE 4.3 - NETWORK'S INTERDEPENDENCIES

1 of 1


10
9
8
E
D
C
B
SCRUBBERS 22N/23N ARV. (B.B AUTH. NO. 1444)
SCRUBBER 26N ARV. (B.B AUTH. NO 1445)
CRANE OPERATOR STRIKE
RENOVATION BLDG 265
SCRUBBERS 50N/51N A.E.S. (B
A.E.S. ENG. START & PREP. CIVIL PKG.
DUCTWORK PROC. FAB. DELIVER & ERECT
ARV. ENG. COMPL. & PREP. MECH. & ELEC. PKGS.
CONSTRUCTION CIVIL WORK
SCRUBBER TOWERS PROC., FAB., & DELIVER
MECH. & ELEC. EQUIP. PROC., FAB., & DELIVER
MANAGEMENT & F.R. APPROVAL
SCRUBBERS S2N/S3N A.E.S
A.E.S. ENG. START & PREP. CIVIL PKG.
DUCTWORK PROC. FAB. DELIVER & ERECT
ARV. COMPL. & PREP. MECH. & ELEC. PKGS.
CONSTRUCTION INSTALL LOUVERS & EQUIP. TEMPORARY PASSAGEWAY
CONSTRUCTION CIVIL WORK
SCRUBBER TOWERS PROC., FAB., & DELIVER
MECH. & ELEC. EQUIP. PROC., FAB., & DELIVER
STRIKE
FROM START
UNDER ROOF DUCTING ARV. (B ST P
CONSTRUCTION INSTALL UNDER ROOF DUCTING S3N
CONSTRUCTION DEMOLISH SCRUBBER S3C
CONSTRUCTION INSTALL UNDER ROOF DUCTING 45N
CONSTRUCTION DEMOLISH SCRUBBER 45C
START-UP
SCRUB
ARV. PHASE II STUDIES, PREP. & ISSUE
ARV. ENG. START & PREP. CIVIL PKG.
DUCTWORK PROC. FAB. DELIVER & ERECT
ARV. COMPL. & PREP. MECH. & ELEC. PKGS.
CONSTRUCTION CIVIL WORK
SCRUBBER TOWERS PROC., FAB., & DELIVER
MECH. & ELEC. EQUIP. PROC., FAB., & DELIVER
SCRUBBERS S6N/S7N (F.B AUTH. NO. 1450)
CONSTRUCTION MECH. & ELEC. WORK
START-UP
CONSTRUCTION DEMOLISH & INSTALL SCRUBBERS
CONSTRUCTION FDN & ROOF REINFORCEMENT
SCRUBBERS S4N/S5N A.E.S. (F.B AUTH. NO. 9031)
DUCTWORK PROC., FAB., DELIVER & ERECT
CONSTRUCTION COMPL. CIVIL WORK
CONSTRUCTION ERECT SCRUBBER TOWERS
SCRUBBER TOWERS PROC., FAB., & DELIVER


7
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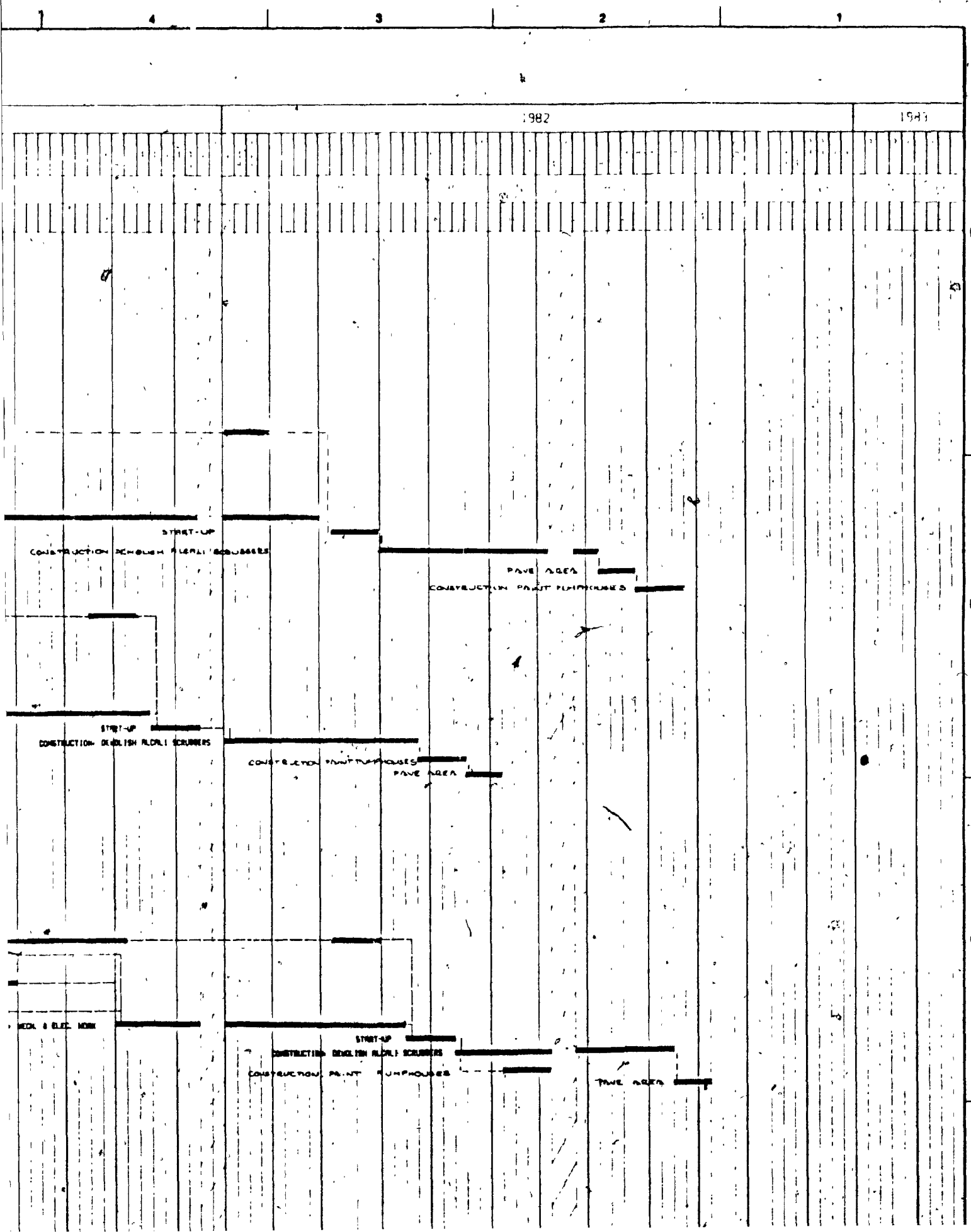
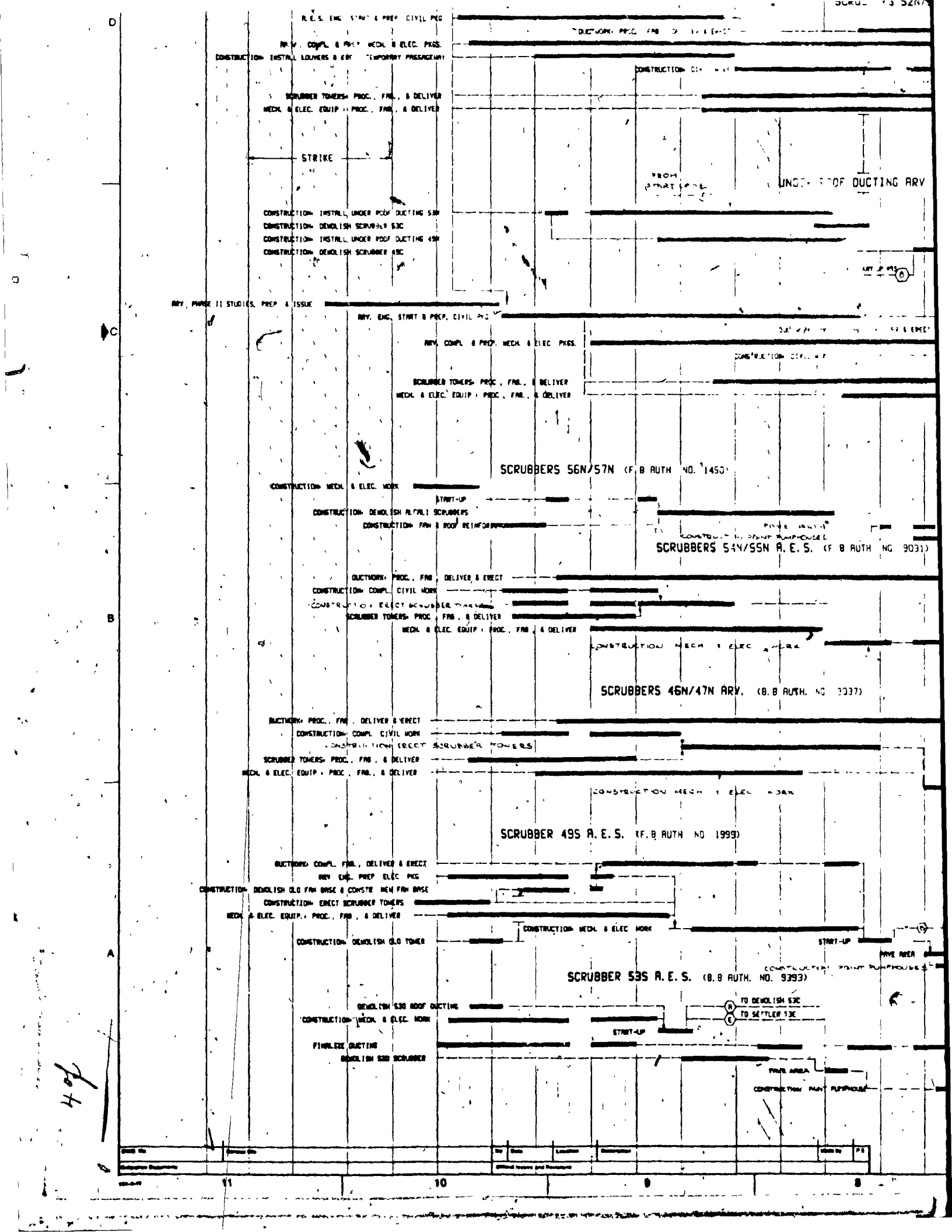
N/51N A.E.S. (B & R AUTH NO 5569)
CONSTRUCTION MECH & ELEC WORK
START-UP
CONSTRUCTION DEMOLISH ALKALI SCRUBBERS
PS 52N/53N A.E.S. (F.B AUTH NO 55
CONSTRUCTION MECH & ELEC. WORK
START-UP
CONSTRUCTION DEMOLISH ALKALI SCRUBBERS
NG ARV. (G ST P AUTH. NO 5571)
SCRUBBERS 48N/49N ARV. (G ST.P AUTH. NO 5568)
CONSTRUCTION ERECT & ELEC TOWERS
CONSTRUCTION MECH & ELEC. WORK
NG 9031D


4
3
2
1
1982
1983
E
D
C
START-UP
CONSTRUCTION DEMOLISH ALKALI SCRUBBERS
PAVE AREA
CONSTRUCTION PAINT PUMPHOUSES
START-UP
CONSTRUCTION DEMOLISH ALKALI SCRUBBERS
CONSTRUCTION PAINT PUMPHOUSES
PAVE AREA
MECH & ELEC WORK
START-UP
CONSTRUCTION DEMOLISH ALKALI SCRUBBERS
CONSTRUCTION PAINT PUMPHOUSES
PAVE AREA


R.E.S. ENG. START & PREP. CIVIL PKG
ARV. COMPL. & PREP. MECH. & ELEC. PKGS.
CONSTRUCTION: INSTALL LOUVERS & ERY
SCRUBBER TOWERS: PROC., FAB., & DELIVER
MECH. & ELEC. EQUIP.: PROC., FAB., & DELIVER
STRIKE
CONSTRUCTION: INSTALL UNDER ROOF DUCTING S3N
CONSTRUCTION: DEMOLISH SCRUBBER S3C
CONSTRUCTION: INSTALL UNDER ROOF DUCTING 45N
CONSTRUCTION: DEMOLISH SCRUBBER 45C
ARV, PHASE II STUDIES, PREP & ISSUE
ARV. ENG., START & PREP. CIVIL PKG
ARV. COMPL. & PREP. MECH. & ELEC. PKGS.
SCRUBBER TOWERS: PROC., FAB., & DELIVER
MECH. & ELEC. EQUIP.: PROC., FAB., & DELIVER
SCRUBBERS 56N/57N (F.B AUTH NO. 1450)
CONSTRUCTION: MECH. & ELEC. WORK
START-UP
CONSTRUCTION: DEMOLISH N/S#1 SCRUBBERS
CONSTRUCTION: FAN & ROOF REINFORCEMENT
SCRUBBERS 54N/55N A.E.S. (F.B AUTH NO. 9031)
DUCTWORK: PROC., FAB., DELIVER & ERECT
CONSTRUCTION: COMPL. CIVIL WORK
SCRUBBER TOWERS: PROC., FAB., & DELIVER
MECH. & ELEC. EQUIP.: PROC., FAB., & DELIVER
SCRUBBERS 46N/47N ARV. (B.B AUTH. NO. 9037)
DUCTWORK: PROC., FAB., DELIVER & ERECT
CONSTRUCTION: COMPL. CIVIL WORK
SCRUBBER TOWERS: PROC., FAB., & DELIVER
MECH. & ELEC. EQUIP.: PROC., FAB., & DELIVER
SCRUBBER 49S A.E.S. (F.B AUTH NO. 1999)
DUCTWORK: COMPL. FAB., DELIVER & ERECT
ARV ENG. PREP ELEC PKG
CONSTRUCTION: DEMOLISH OLD FAN BASE & CONSTR. NEW FAN BASE
CONSTRUCTION: ERECT SCRUBBER TOWERS
MECH. & ELEC. EQUIP.: PROC., FAB., & DELIVER
CONSTRUCTION: MECH. & ELEC. WORK
CONSTRUCTION: DEMOLISH OLD TOWER
START-UP
SCRUBBER 53S A.E.S. (B.B AUTH. NO. 9393)
DEMOLISH S3N ROOF DUCTING
TO DEMOLISH S3C
TO SETTLER S3C
CONSTRUCTION: MECH. & ELEC. WORK
START-UP
FINALIZE DUCTING
DEMOLISH S3N SCRUBBER
11
10
9
8


CONSTRUCTION MECH. & ELEC. WORK
START-UP
CONSTRUCTION DEMOLISH ALCALI SCRUBBERS
OF DUCTING ARV. (G ST P AUTH NO 5571)
SCRUBBERS 43N/49N ARV. (G ST.P AUTH. NO. 5568)
CONSTRUCTION ERECT STEEL TOWERS
CONSTRUCTION MECH. & ELEC. WORK
(G B AUTH. NO. 9031)
START-UP
CONSTRUCTION DEMOLISH ALCALI SCRUBBERS
CONSTRUCTION PAINT PUMP-HOUSES
TO 500A DISTRIBUTION
START UP
CONSTRUCTION PAINT PUMPHOUSES
DEMOLISH 49C
NOTE:
LEGEND:
B.B
F.B
B.M
G. ST. P

NOTE:

THIS DRAWING REPLACES
PD-1270-42-8-103 R 010

LEGEND:

B. B	B. BOUDREAU
F. B	F. BERUBE
B. M	B. MORIN
G. ST. P	G. ST. PIERRE
	CONSTR. HOLIDAY
	STRIKE

FIGURE 4.4

Alcan Engineering Services
Division of Aluminum Company of Canada, Ltd.
Montréal, Québec, Canada

Released to Project	
Date	
Designed	J P
Drawn	COMP. PLOTTER
Checked	J P
Approved	
Authorized	Date
Project Engineer / Project Manager	
Drawing Reference No.	1270 42 8 003
Scale	1270421122
Date	24 SEP 79

SCRUBBER PROGRAM
(POT EXHAUST)
STRATEGIC PLAN

SHEET 1 OF 2

For L'USINE D'ARVIDA

Client Société d'électrolyse et de chimie Alcan Ltée

FO 1270 42 F 011 R 05 AO

6 of 6

4.2.1.3 Logic Diagrams

These summarized networks illustrate those project schedules at the highest level in the report structure. In this structure the activities in the scrubber towers projects represent packages, and those in the miscellaneous projects represent tasks.

These schedules match the Strategic Plan and their activity information is that which is inputed into the computer for cost and manhour reports. The computer schedule indicates the task's total float, giving the estimated number of weeks by which package delay would delay project completion.

Differences in vacation periods for construction trades necessitated the use of multicalendars, which are handled by the Project-2 computer package.

By having activity code definition, summarized schedules, which include all projects can be outputed. (Report 4.3). Higher levels of management can easily visualize the project's starting and completion dates.

In the logic diagrams a breakdown of cost and manhours is shown as well as the totals for the various classes of both costs and resources. (Figure 4.10)

4.2.2 Operation

Monitoring occurs in the Scrubber Program every two months when progress is reported in the various schedules. The progress information is collected during meetings and field inspection with the project leaders.

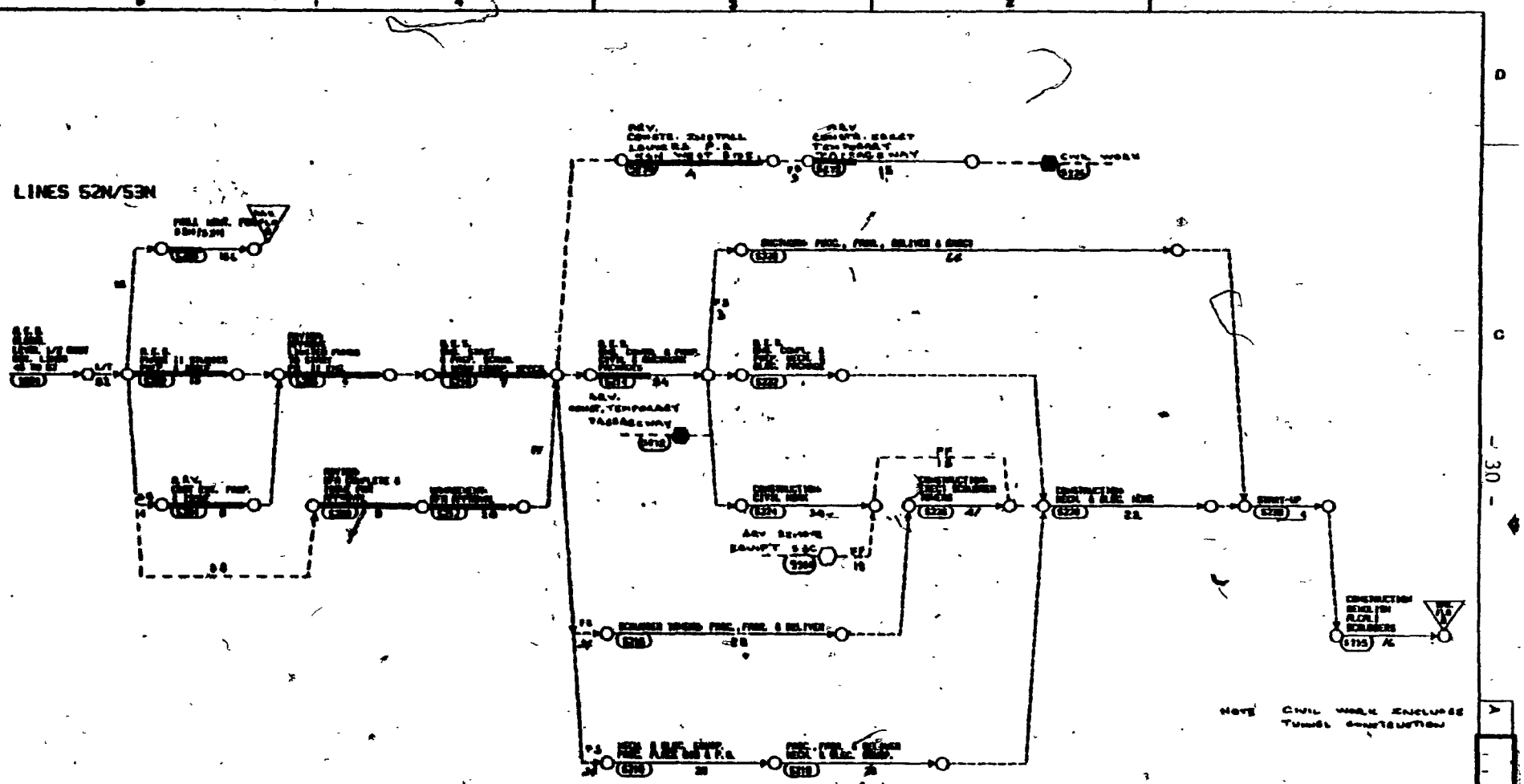


FIGURE 4.5 – LOGIC DIAGRAM

This information is reported in the detailed CPM time scaled networks of the scrubber tower projects. This progress is represented in the networks by a shadowed area behind the data date. Then the information from these projects is summarized and along with the information from the miscellaneous projects, is illustrated in the Strategic Plan.

The progress information is then computerized and reported against a target schedule.[1]

The scrubber program has had several target schedules due to changes in the program's financial allocation, a plant strike and unavailability of some resources in the surrounding plant region.

Advantages and disadvantages are to be found in having time scales or logic diagrams as monitoring tools of the Scrubber Program. Computerized monitoring requires an extensive understanding of CPM technique in order to; differentiate current schedules from planning as well as target schedules; analyze changes of floats; analyse slippages.

The advantage of monitoring with logic diagrams rather than with time scales is that the logical changes and progress in the network are more easily introduced. As there is no time frame, changes can be rapidly incorporated into the schedules. Progress is shown by means of a dark tape on the activity and the activity start and finish dates are recorded. Furthermore, the current schedule can be plotted against any of the stored target schedules.

[1] A target schedule is one in which activity dates have been frozen by the computer so that they can be used as a benchmark. The Project-2 computer package allows for the creation and storage of 50 different target schedules.

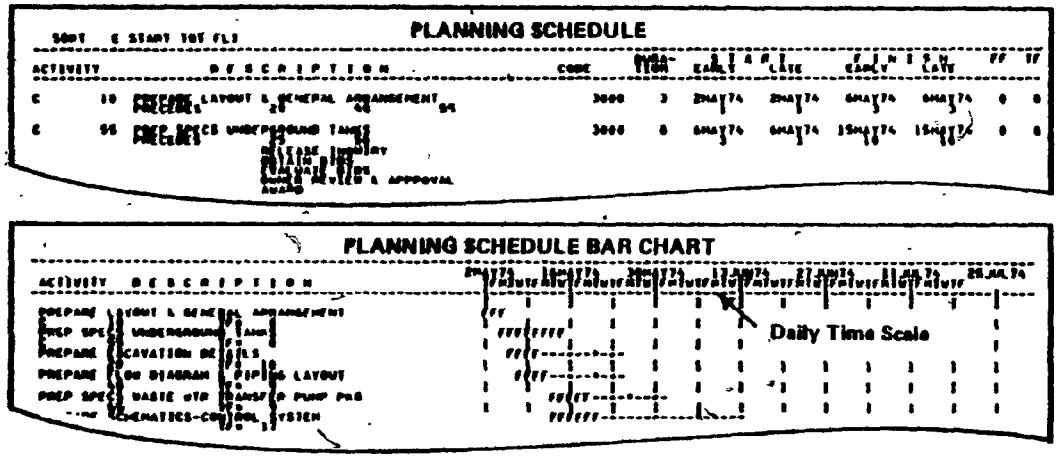
Time scaled networks are easily understood but have a disadvantage in that projects which require large revisions in the schedule can become very tedious and time consuming. Special attention should also be given to activities with delays because in some instances these activities can become critical. A revised schedule can not be easily compared with the original or other previously revised schedules. For projects which require only minor changes, time scaled networks can produce a very fast, economical and straight forward schedule. In the Scrubber Program, it has been proven that computerized schedules provide the highest levels of management with information on the project status. The time scaled networks have been an effective managerial tool to project leaders, plant operators and construction contractors.

4.2.2.1 Time Reports

Planning Schedule

PLANNING SCHEDULE & BAR CHART
A standard CPM type report showing the Early Start, Early Finish, Late Start, Late Finish, Total Float, the succeeding activities, and indicators of actual status. Also in bar chart format with daily or weekly time scale.

PLANNING SCHEDULE & BAR CHART
Etat CPM standard indiquant pour chaque activité les dates de début et de fin au plus tôt et au plus tard, la marge totale, les activités successeurs et un indicateur du statut actuel. Cet état existe également sous la forme d'un bar chart, l'échelle horizontale pouvant être le jour ou la semaine.



The sort is given at the beginning of each report.

This is a standard CPM schedule showing either the succeeding or preceding activities.

At the user's option, expanded activity descriptions are listed beneath an activity.

The Planning Schedule Bar Chart shows the early start (first "F"), early finish (last "F"), total float (——) and late start (•) of each activity.

L'ordre de tri est indiqué au titre de chaque rapport. Ceci est un ordonnancement standard indiquant pour chaque activité les successeurs ou les prédécesseurs. L'utilisateur a la possibilité de faire éditer la seconde zone de description des activités.

Le bar chart montre la date de début au plus tôt (premier F), la date de fin au plus tôt (dernier F), la marge totale (———) et la date de fin au plus tard (•) de chaque activité.

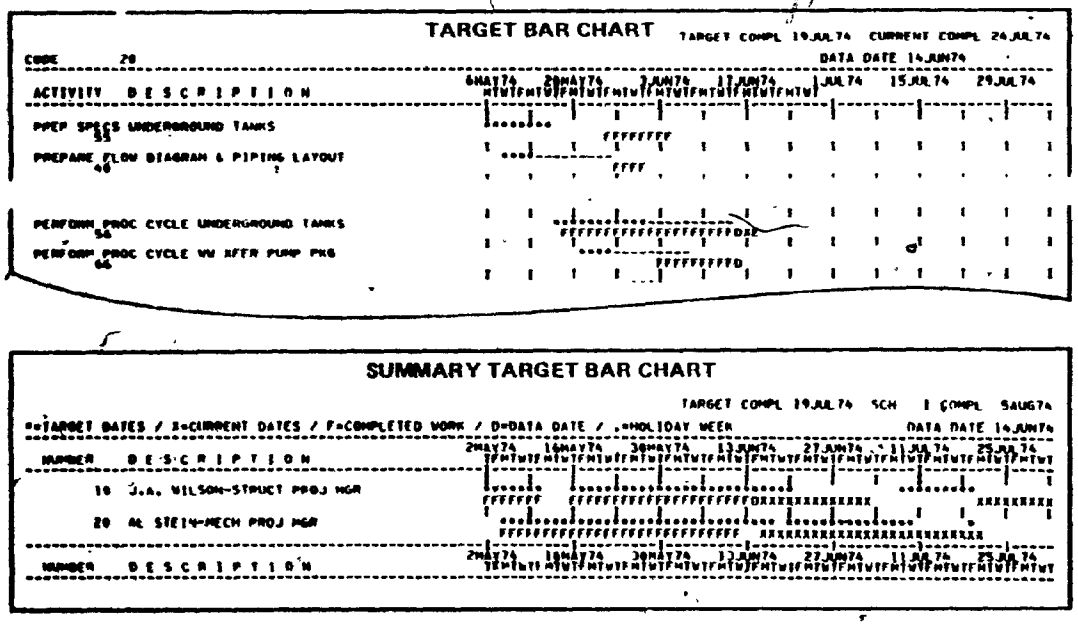
```
BAR CHART LEGEND

PLANNING SCHEDULE

!X! = SCHEDULED WORK
!M! = MILESTONE
!.! = NONWORKING DATE
!<! = ON/BEFORE RANGE START
!>! = ON/AFTER RANGE FINISH
!-! = TOTAL FLOAT
!*! = LATE START
```

COLOURED PAPER
PAPIER DE COULEUR

Target Schedule



The Target Bar Chart permits a visual comparison of the Target dates (upper bars) with the Current dates (lower bars). All activities in the illustration are behind schedule (lower bars end after the Target bars).

The Target bar shows the Target

The Current bar shows completed work (F), the Data Date (D), work scheduled in the future (X), and reported starts or finishes in the future (E).

All activities have been summarized (collapsed) into major groups to display the overall status of the project.

Le bar chart permet une comparaison facile des deux ordonnancements Pour chaque activité, la barre supérieure représente l'objectif et la barre inférieure les dates actuelles La barre supérieure est composée de '•••' qui indiquent l'ordonnancement objectif et de

'F' correspondant aux jours travaillés, d'un 'D' marquant la date de la dernière mise à jour, et de 'X' correspondant aux jours qui doivent être travaillés; une date future de début ou de fin, indiquée dans un compte-rendu d'avancement, est marquée par un 'E'

Toutes les activités ont été réunies en deux groupes.

COLOURED PAPER
PAPIER DE COULEUR

```
T A R G E T   S C H E D U L E

!X! = SCHEDULED WORK
!M! = MILESTONE
!.! = NONWORKING DATE
!<! = ON/BEFORE RANGE START
!>! = ON/AFTER RANGE FINISH
!F! = COMPLETED WORK
!D! = DATA DATE
!A! = REPORTED DATE
!E! = EXPECTED DATE

!/! = LATEST TARGET LATE FINISH
!*! = TARGET DATE
!N! = NEEDED DATE
```

REPORT 4.1

[illegible] Montreal, Quebec Canada H3C [illegible]

18 April 1980
S.O. 1270.42.12.2

To: Mr. G. St-Pierre

From: J. Prieto

Subject: Arvida Scrubber Programme
Planning & target Schedules

Enclosed please find a planning schedule, a target schedule and a logic diagram for the projects in the scrubber programme which have not been completed.

1. Settler L-26
2. Scrubber Tower 26N
3. Settler 43K
4. Scrubber Towers 46N/47N
5. Scrubber Towers 48N/49N
6. Scrubber Tower 49N
7. Scrubber Towers 50N/51N
8. Scrubber Towers 52N/53N
9. Scrubber Tower 53S
10. Scrubber Towers 54N/55N
11. Settler 50-53
12. Scrubber Towers 56N/57N
13. Soda Distribution
14. Refoulement des boues
15. Water Line
16. Centralization of Alarms
17. Under roof ducting installation

Copies of the schedules and logic diagrams will be issued to the project leaders.

JP:cm

Encl...

Circulate S.O. copy to:

Mr. R.A. Beattie
Mrs. M. Morter

Circulate file copy to:

Mr. P. Hawryluk
Mr. H.A. Hughes
Mr. J. Prieto
Mr. C. Brien

ARVIDA SCRUBBER PROGRAM(POT EXHAUST) AES.SO 1270 SERIES

RUN DATE 18APR80 0920HRS P L A N N I N G S C H E D U L E PROJECT START 18APR77

PROJECT 1270 - STRATEGIC PLAN: CURRENT COMPL. 11OCT82

CODE 52 LINE 52N/53N-AUTH.5570 F.BERUBE SORT NODES DATA DATE 31MAR80 PAGE 1

ACTIVITY	DESCRIPTION	MODE=C/F	CODE	DURATION	START EARLY	START LATE	FINISH EARLY	FINISH LATE	FF	TF
C 5200	ARV.MGM.PROJECT MANAGEMENT	52N/53N	425210011 FIN FLO	156 0	19MAR79 101	19MAR79 A 101	8MAR82 256	8MAR82 256	0	0
5214	AES.ENG.PREP.CIVIL & DUCTWORK PACKAGES	52N/53N	425213323	25 *	80CT79 130	15OCT79 A 131	24MAR80 154	31MAR80 A 155	0	1
5216	AES PRO.PROC.,FAB.&DEL.SCRUBBER TOWERS	52N/53N	425213525	31	17MAR80 153	31MAR80 A 155	13OCT80 183	27OCT80 185	2	2
5218	AES.PRO.PLACE BIDS&P.O.-MECH.&ELEC.EQUIP.	52N/53N	425213525	23	17MAR80 153	11AUG80 A 174	18AUG80 175	12JAN81 196	0	21
5219	AES.PRO.FAB.&DEL.-MECH.&ELEC.EQUIPMENT	52N/53N	425213525	20	25AUG80 176	19JAN81 197	5JAN81 195	1JUN81 216	21	21
CAL 1 5220	CONSTR .PROC.,FABR.,DEL.& ERECT DUCTWORK	52N/53N	425214777	50	23JUN80 155	10NOV80 173	29JUN81 204	16NOV81 222	18	18
5222	AES.ENG.PREP.MECH.& ELECT.PACKAGES	52N/53N	425213323	22	7APR80 156	5JAN81 195	1SEP80 177	1JUN81 216	39	39
C CAL 1 5224	CONSTR .CIVIL WORK	52N/53N	425214777	34	7APR80 144	7APR80 144	8DEC80 177	8DEC80 177	0	0
C CAL 1 5226	CONSTR .ERECT.SCRUBBER TOWERS	52N/53N	425214777	21	3NOV80 172	3NOV80 172	6APR81 192	6APR81 192	0	0
C CAL 1 5228	CONSTR .MECHANICAL & ELECTRICAL WORK	52N/53N	425214777	22	8JUN81 201	8JUN81 201	16NOV81 222	16NOV81 222	0	0
C CAL 1 5230	CONSTR .START UP	52N/53N	425215977	4	23NOV81 223	23NOV81 223	28DEC81 226	28DEC81 226	0	0
C CAL 1 5235	CONSTR. DEMOLISH.ALCALI SCRUBBERS	52N/53N	425214777	16	4JAN82 227	4JAN82 227	19APR82 242	19APR82 242	0	0
C CAL 1 5240	CONSTR .PAVE AREA	52N/53N	425214777 FIN FLO	4 0	24MAY82 247	24MAY82 247	14JUN82 250	14JUN82 250	0	0
C CAL 1 5255	CONSTR .PAINT PUMPHOUSES	52N/53N	425214777	4	26APR82 243	26APR82 243	17MAY82 246	17MAY82 246	0	0
CAL 1 5272	CONSTR .ERECT TEMPORARY PASSAGEWAY	52N/53N	425214777	16 *	26NOV79 127	3DEC79 A 128	24MAR80 142	31MAR80 A 143	1	1

TARGET DATA DATE 18APR77 | ARVIDA SCRUBBER PROGRAM(POT EXHAUST) | AES.SO 1270 SERIES

RUN DATE 18APR80 0920HRS | T A R G E T B A R C H A R T | PROJECT START 18APR77

PROJECT 1270 STRATEGIC PLAN: | CURRENT COMPL. 110CT82

CODE 52 LINE 52N/53N-AUTH.5570 F.BERUBE | SORT CODES 34 E START | DATA DATE 31MAR80 PAGE 1

ACTIVITY DESCRIPTION	MODE=T/FE
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CONSTR .ERECT TEMPORARY PASSAGEWAY 5272	52N/53N
AES.PRO.PLACE BIDS&P.O.-MECH.&ELEC.EQUIP. 5218	52N/53N
AES PRO.PROC..FAB.&DEL.SCRUBBER TOWERS 5216	52N/53N
AES.ENG.PREP.MECH.& ELECT.PACKAGES 5222	52N/53N
CONSTR .CIVIL WORK 5224	52N/53N
CONSTR .PROC..FABR..DEL.& ERECT DUCTWORK 5220	52N/53N
AES.PRO.FAB.&DEL.-MECH.&ELEC.EQUIPMENT 5219	52N/53N
CONSTR .ERECT.SCRUBBER TOWERS 5226	52N/53N
CONSTR .MECHANICAL & ELECTRICAL WORK 5228	52N/53N
CONSTR .START UP 5230	52N/53N
CONSTR. DEMOLISH.ALCALI SCRUBBERS 5235	52N/53N
CONSTR .PAINT PUMPHOUSES 5255	52N/53N
CONSTR .PAVE AREA 5240	52N/53N

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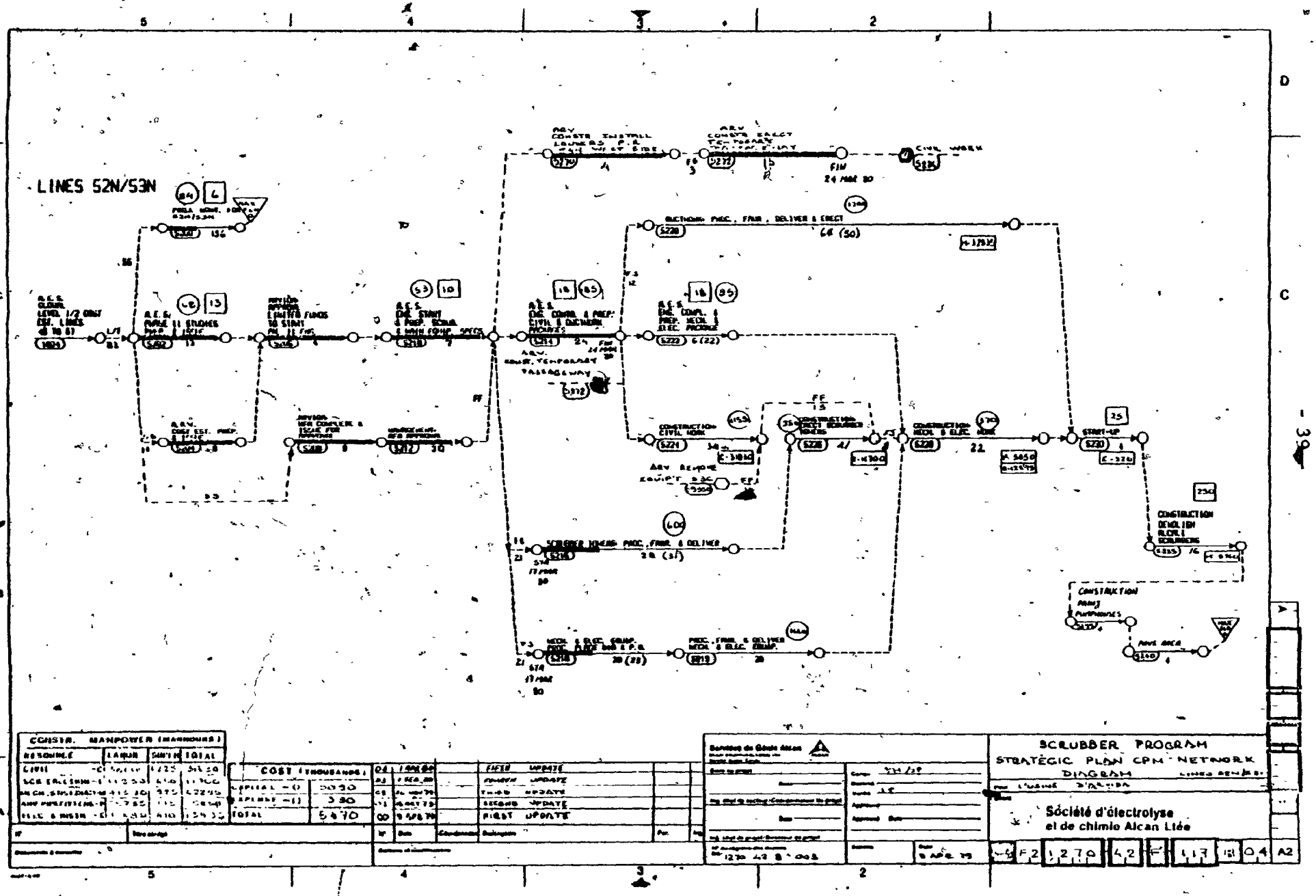

LINES 52N/53N
SCRUBBER PROGRAM
STRATEGIC PLAN CPM NETWORK DIAGRAM
Société d'électrolyse et de chimie Alcan Ltée

REPORT 4.2

[illegible] Canada M3C 3-
[illegible]

7 June 1980
S.O. 1270.42.15.2

To: Mr. G. St-Pierre

From: J. Prieto

Subject: Arvida Scrubber Program
Update of May 1980

Attached please find copies of the following schedules updated and revised as of 30 May 1980.

	Schedules	Drawing No.
1)	Strategic Plan (Sheet 1)	FO-1270-42-F-011-R04
	Strategic Plan (Sheet 2)	FO-1270-42-F-012-R04
2)	Time Scaled CPM Networks	
	Scrubber Towers 46N/47N	FO-1270-42-F-127-R01
	Scrubber Towers 48N/49N	FO-1270-42-F-128-R00
	Scrubber Tower 49S	F2-1522-42-F-001-R03
	Scrubber Towers 50N/51N	FO-1714-42-F-001-R03
	Civil Contract 50N/51N	FO-1714-42-F-003-R00
	Scrubber Towers 52N/53N	FO-1719-42-F-001-R02
	Civil Contract 52N/53N	FO-1719-42-F-004-R01
	Scrubber Towers 54N/55N	FO-1609-42-F-002-R01
	Scrubber Towers 56N/57N	F2-1270-42-F-013-R01

JP/19/cm

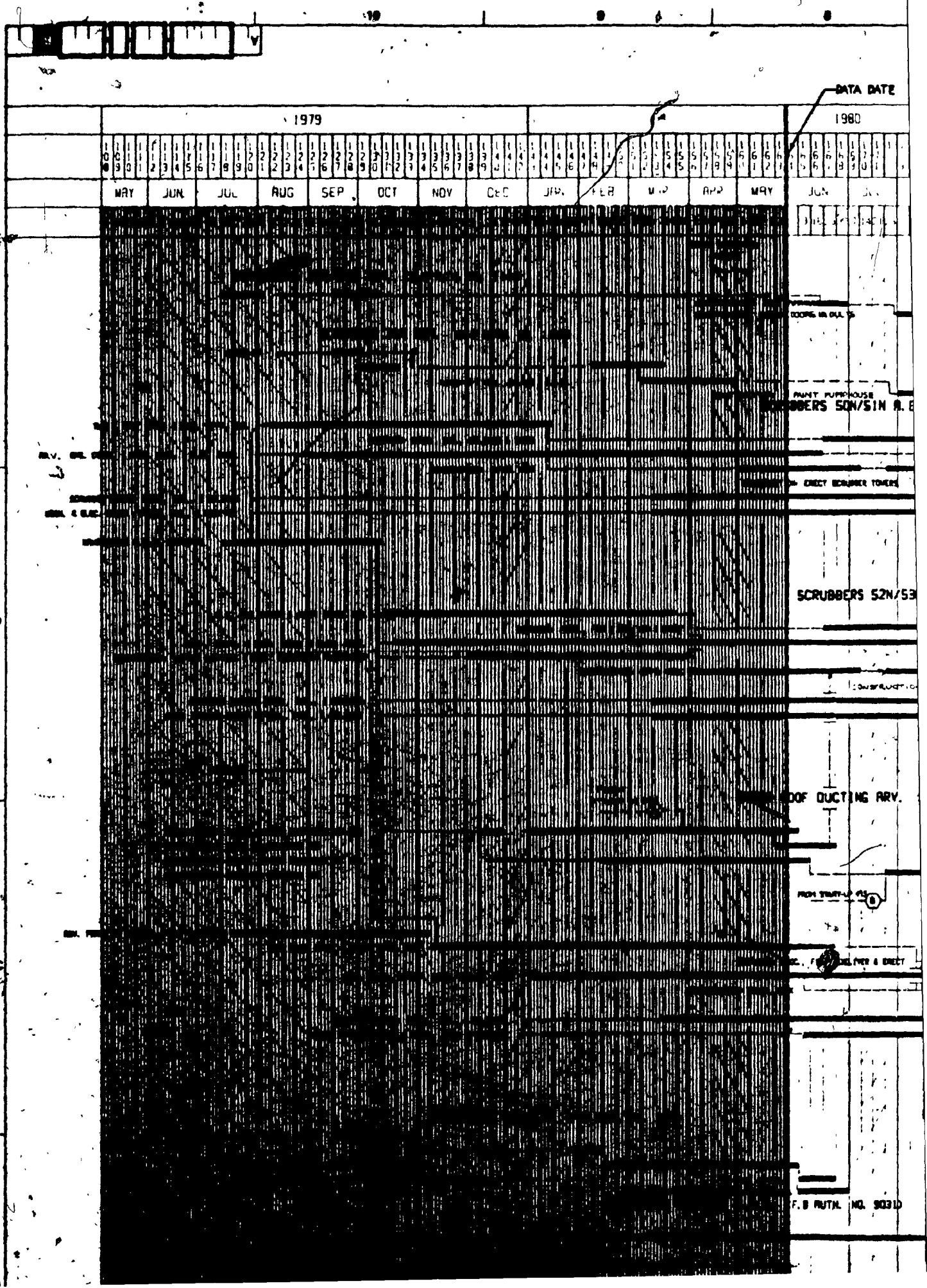
Atts...

Circulate S.O. copy to:

Mr. R.A. Beattie
Mrs. M. Morter

Circulate file copy to:

Mr. H.A. Hughes
Mr. C. Brien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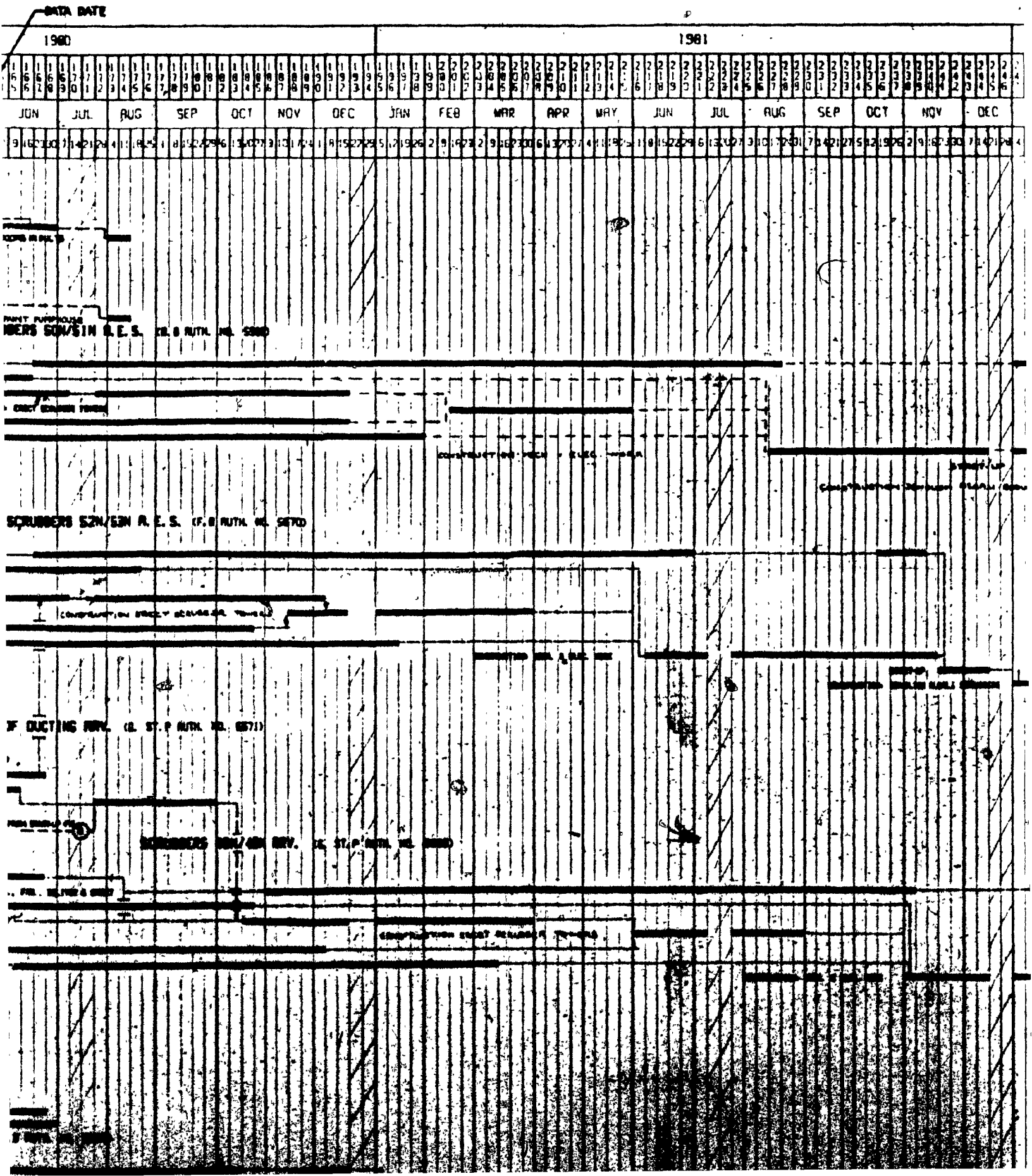
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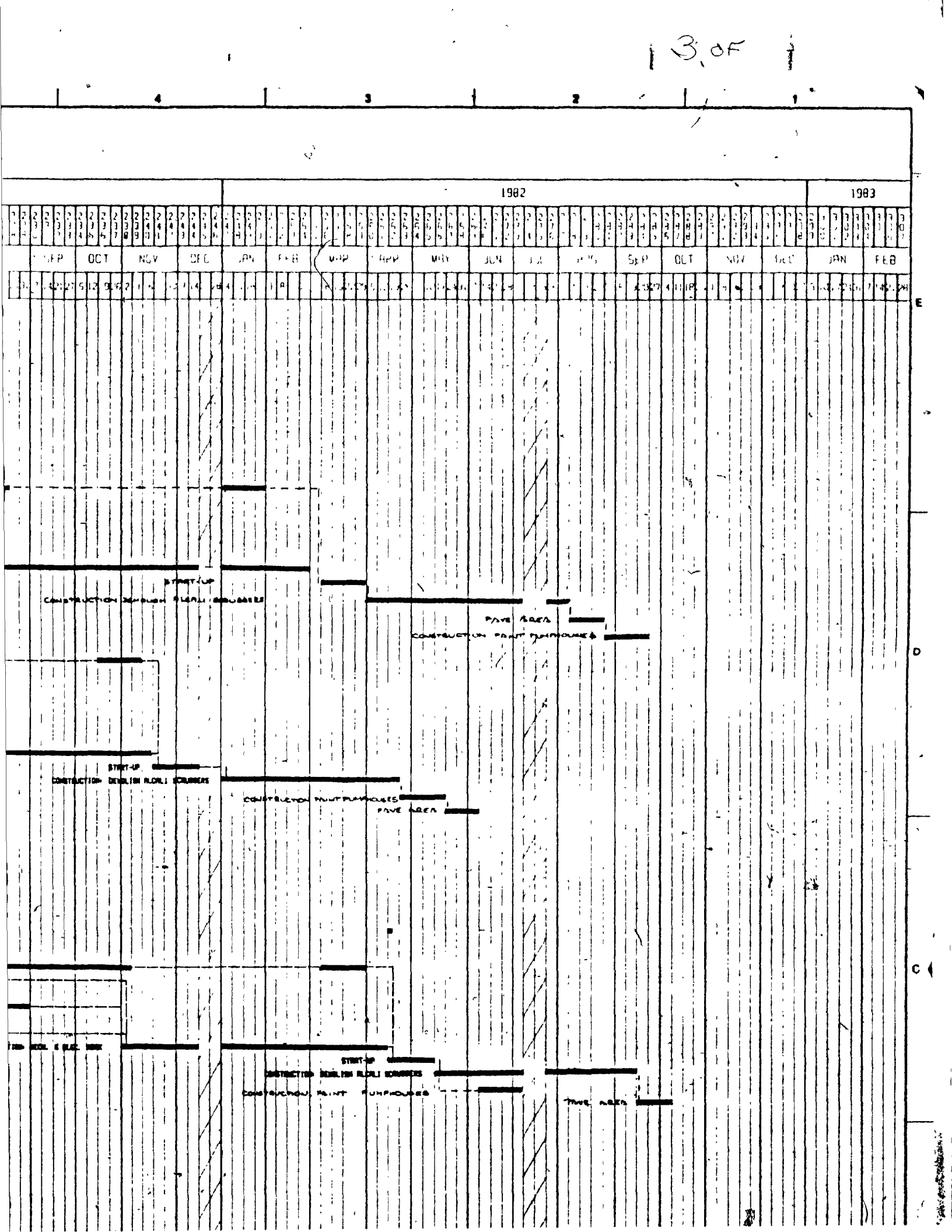
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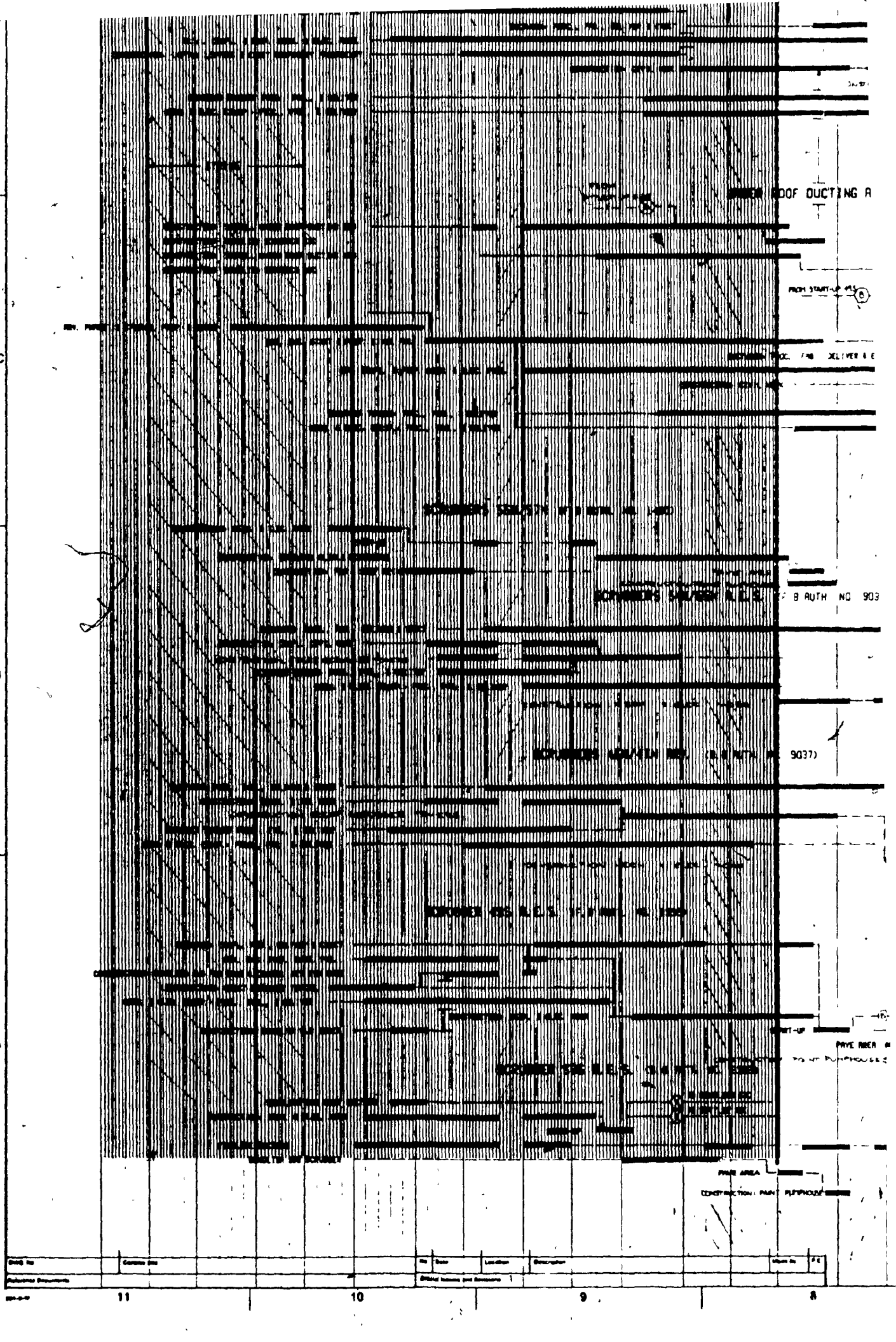
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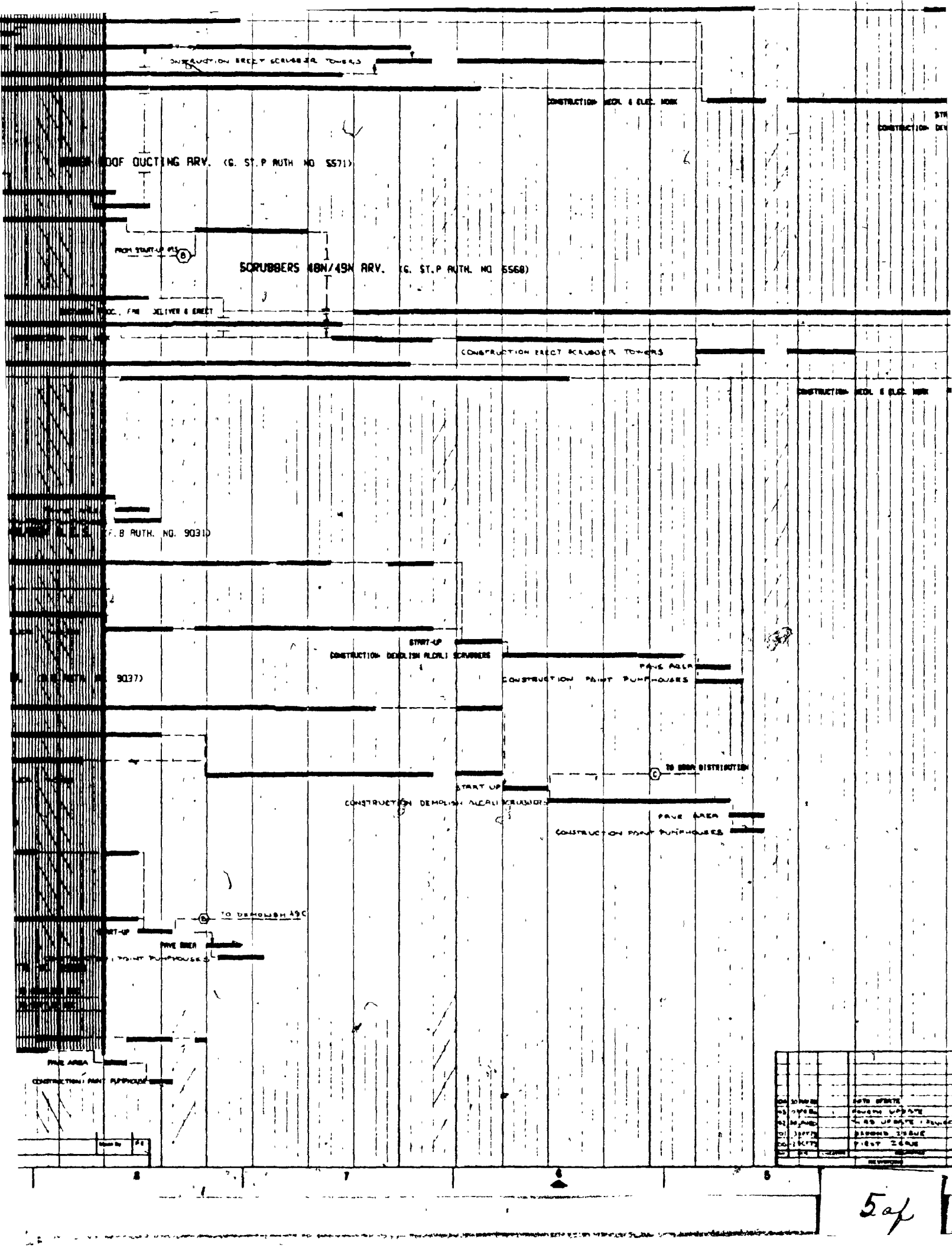
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CONSTRUCTION MECH & ELEC. WORK
F.B AUTH. NO. 9031)
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CONSTRUCTION PAINT PUMPHOUSES
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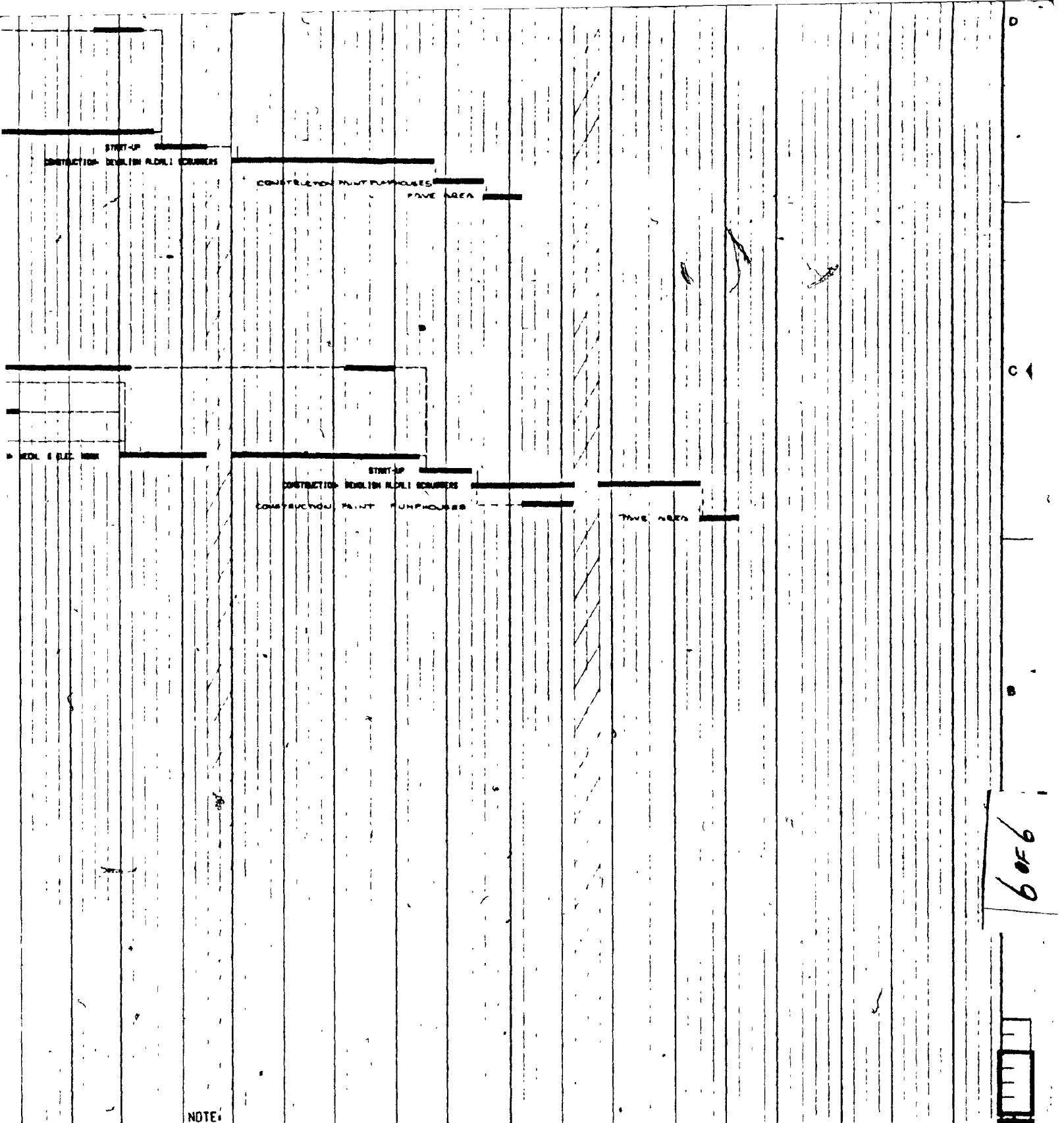

NOTE:

THIS DRAWING REPLACES
PD-1270-42-8-103 R 010

LEGEND

B.B	B. BOUDREAU
F.B	F. BERUBE
B.M	B. MORIN
G. ST.P	G. ST. PIERRE
	CONSTR. HOLIDAY
	STRIKE

Alcan Engineering Services	SCRUBBER PROGRAM (POT EXHAUST) STRATEGIC PLAN
Division of Aluminum Company of Canada, Ltd.	SHEET 1 OF 2
Montréal, Québec, Canada	
Released to Project	Designed J P
Date	Drawn COMP. PLOTTER
Area Eng. / Project Coordinator	Checked J P
Date	Approved
Project Engineer / Project Manager	Approved Date
Drawing Reference No. 1270 42 8 003	Date 1270 42 122 / 24 SEP 70
For	L'USINE D'ARVIDA
Client	Société d'électrolyse et de chimie Alcan Ltée
Size	FO 1270 42 F 011 R: 04 A0

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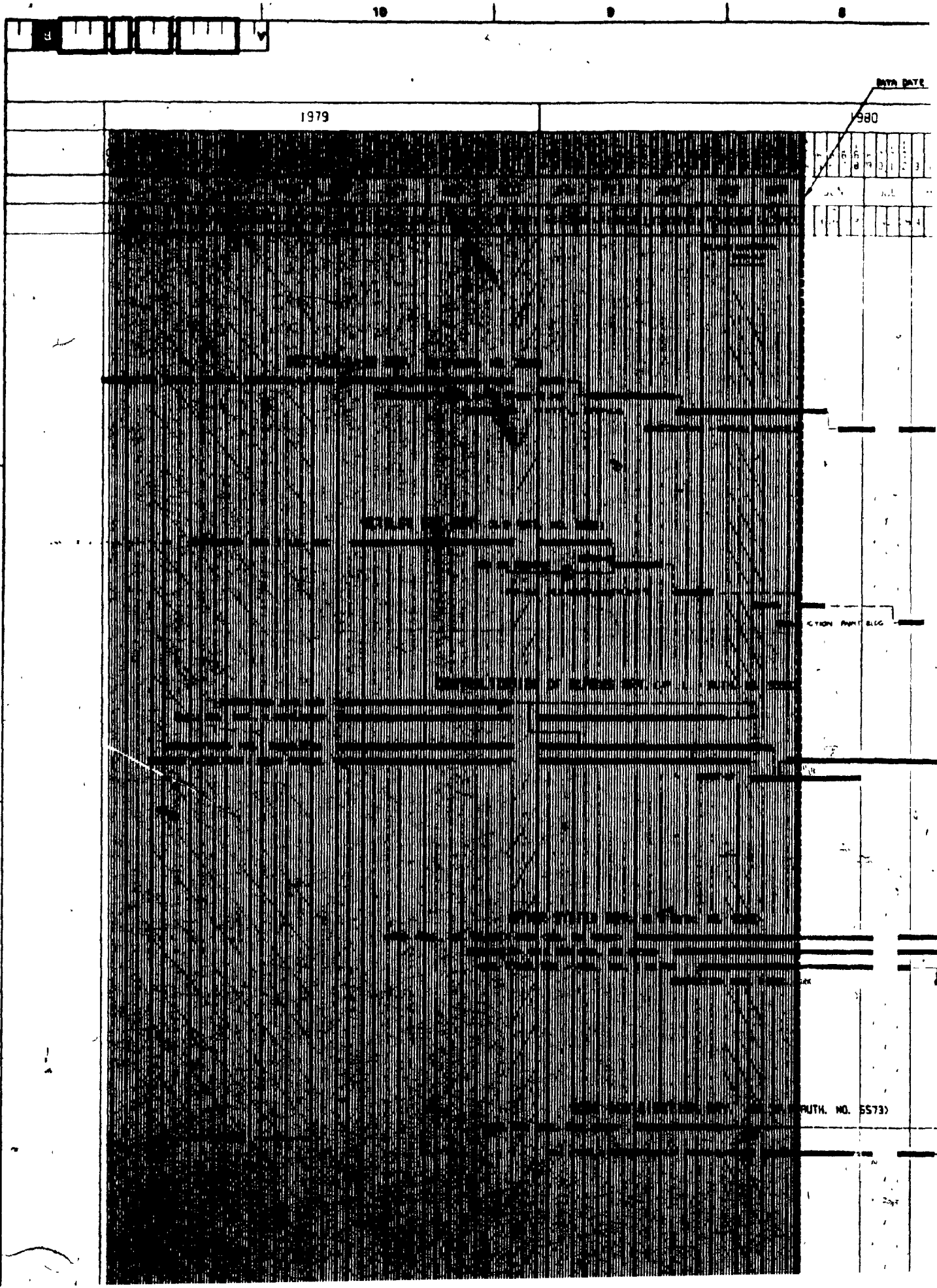
DRAWING UPDATE	J P
P&ID UPDATE + DRAWINGS	J P
PRELIMINARY ISSUE	J P
FIRST ISSUE	J P

6 of 6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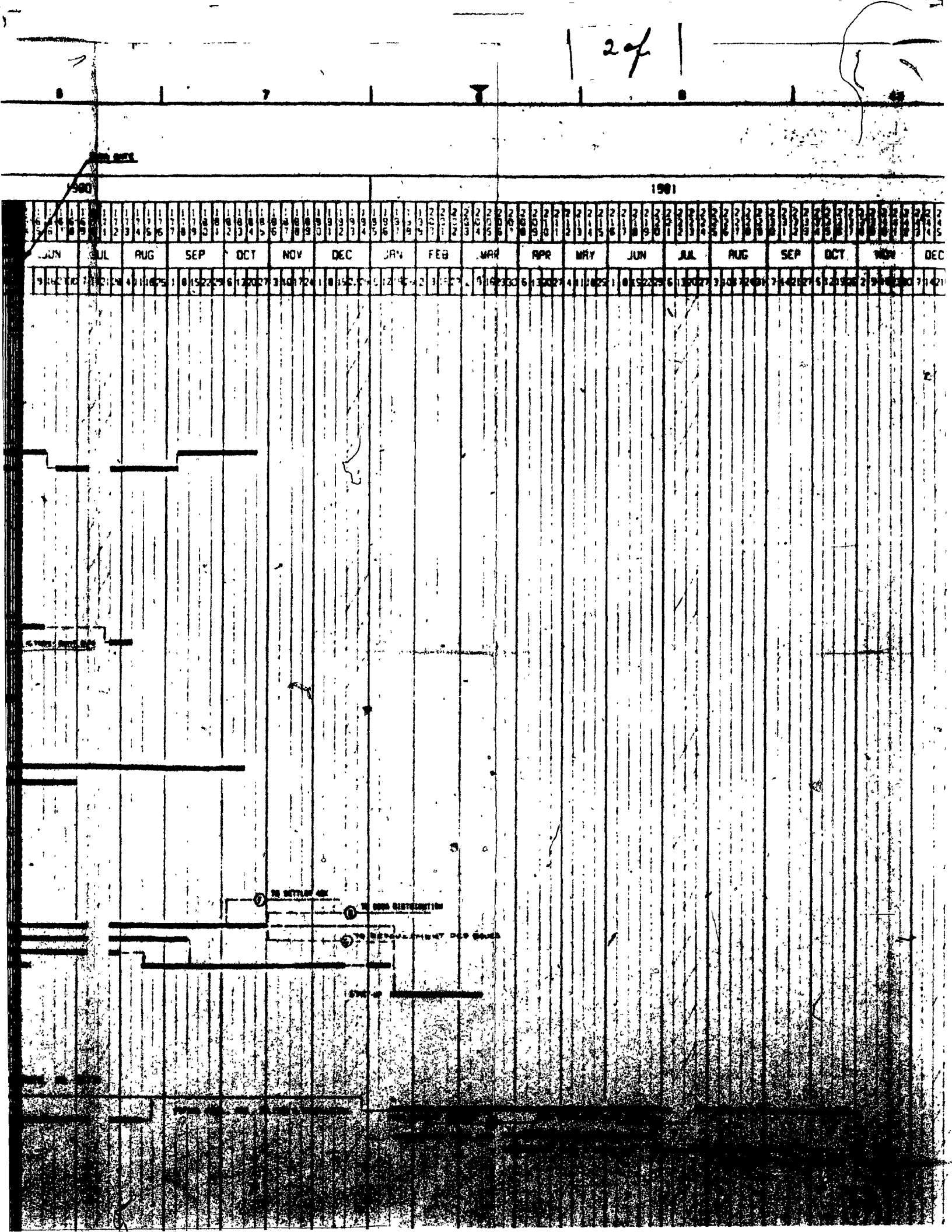
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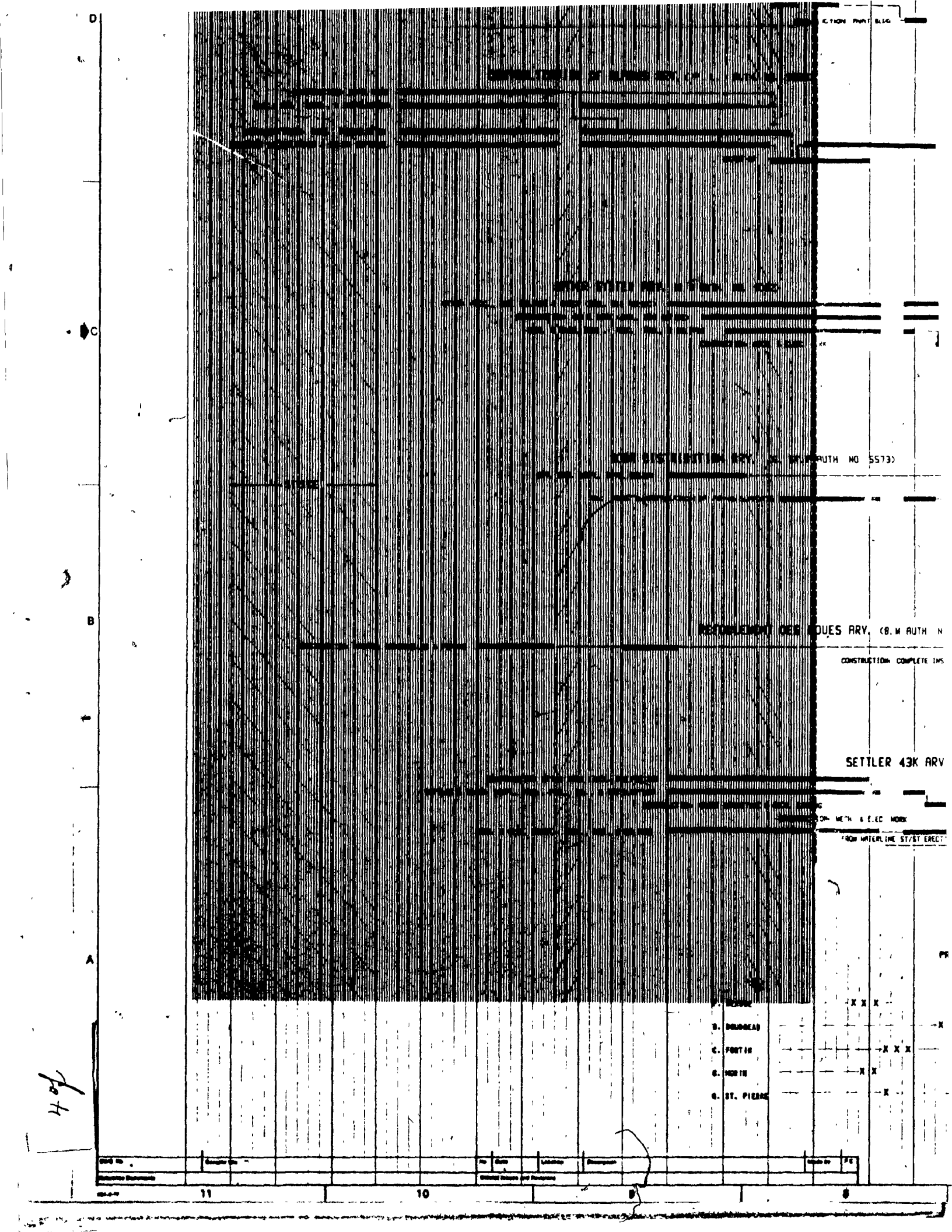
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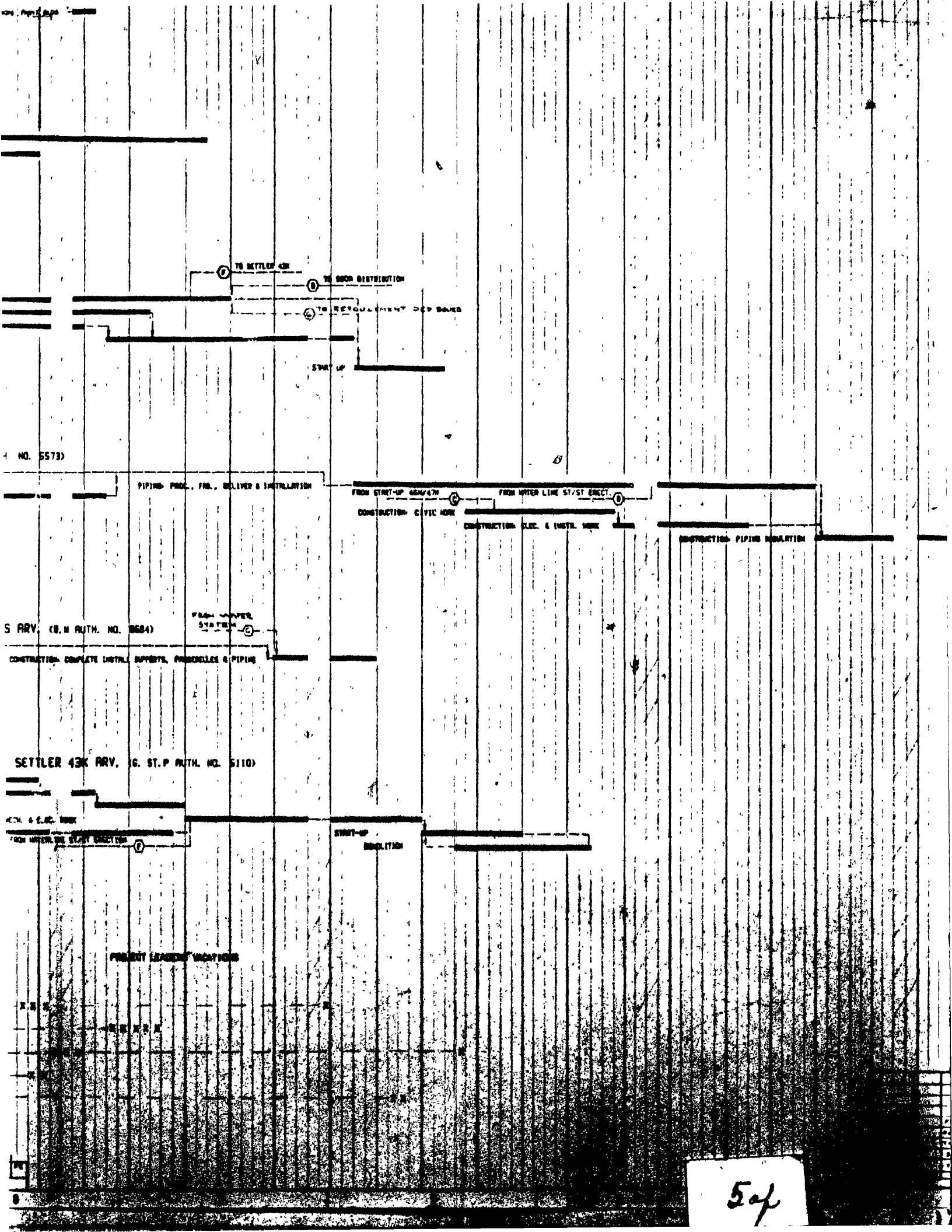
TO SETTLER 43K
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START UP
NO. 5573)
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CONSTRUCTION CIVIC WORK
CONSTRUCTION ELEC. & INSTR. WORK
CONSTRUCTION PIPING INSULATION
S ARV. (B.M AUTH. NO. 3684)
CONSTRUCTION COMPLETE INSTALL SUPPORTS, PROCEDURES & PIPING
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ON- PIPING INSULATION

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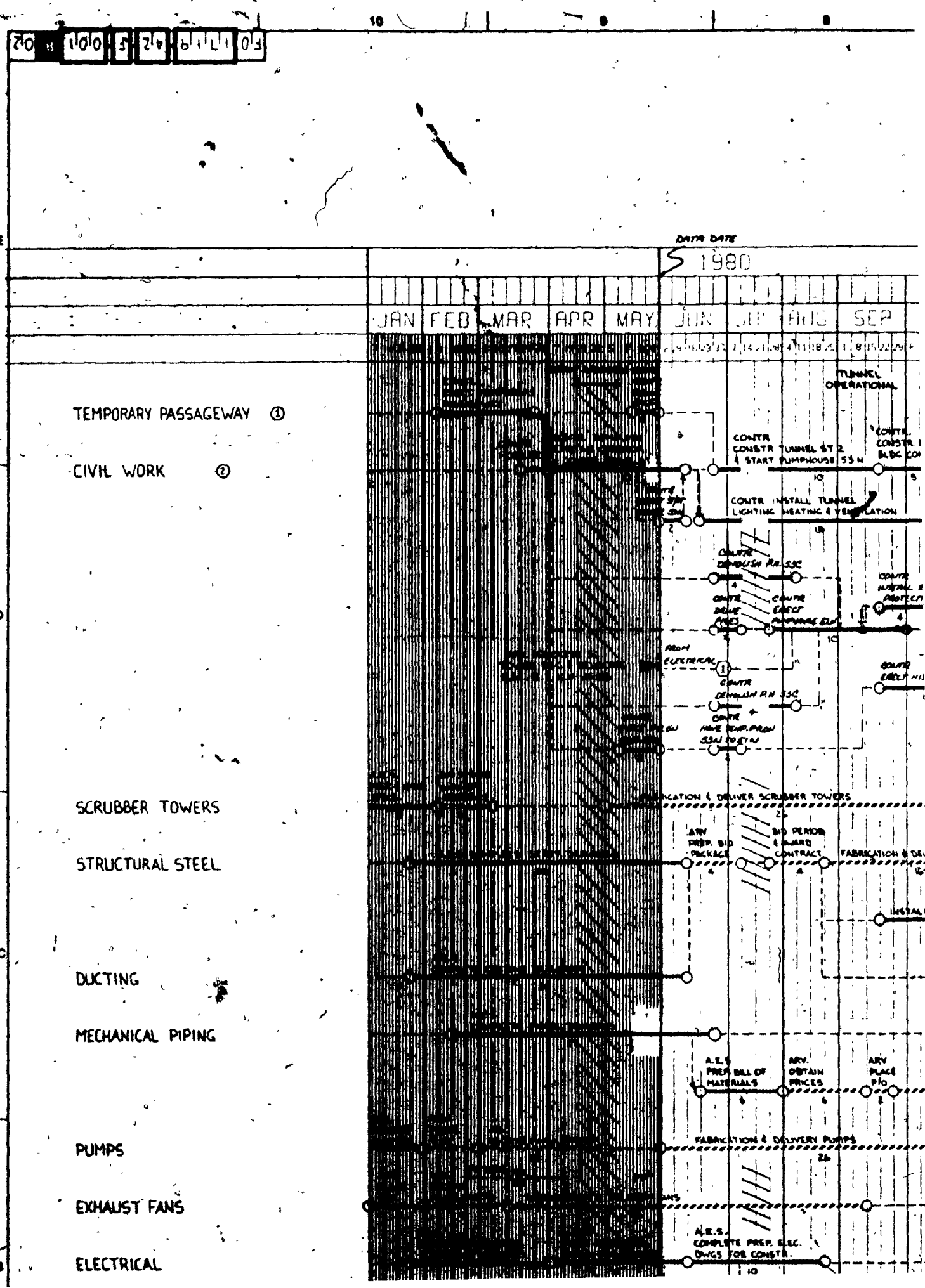
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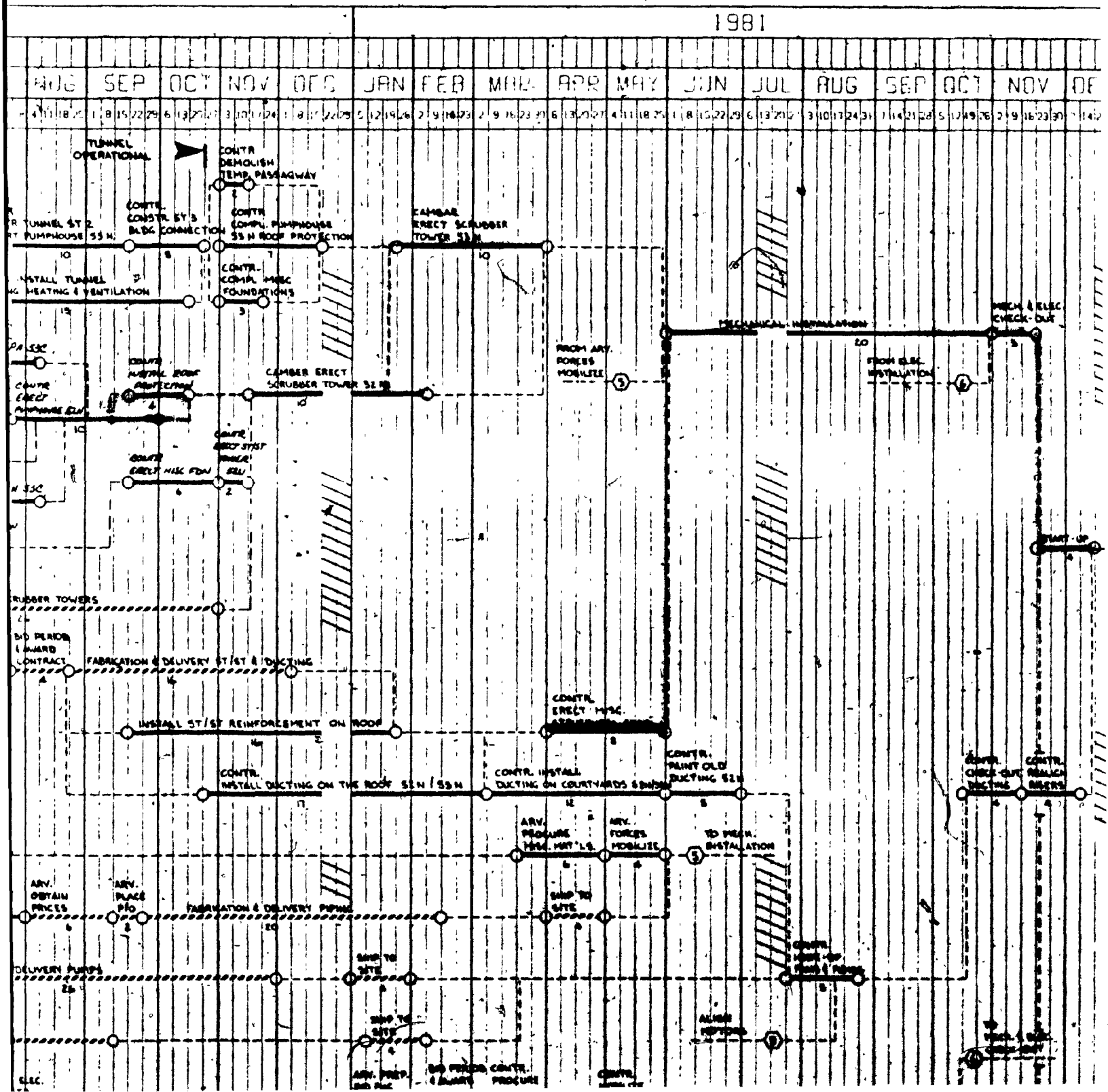
SCRUBBER TOWERS
STRUCTURAL STEEL
DUCTING
MECHANICAL PIPING
PUMPS
EXHAUST FANS
ELECTRICAL
TUNNEL OPERATIONAL
CONTR CONSTR TUNNEL ST 2 & START PUMPHOUSE 55 N
CONTR INSTALL TUNNEL LIGHTING HEATING & VENTILATION
FROM ELECTRICAL
FABRICATION & DELIVERY PUMPS
A.E.S. COMPLETE PREP. ELEC. DWGS FOR CONSTR.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CONTR DEMOLISH TEMP. PASSAGEWAY
CONTR. CONSTR. ST 3 BLDG CONNECTION
CONTR COMPL. PUMPHOUSE 55N ROOF PROTECTION
CAMBAR ERECT SCRUBBER TOWER 52N
CONTR.-COMPL. MISC FOUNDATIONS
MECHANICAL INSTALLATION
MECH. & ELEC. CHECK-OUT
FROM ELEC. INSTALLATION
FROM ARV. FORCES MOBILIZE
CAMBER ERECT SCRUBBER TOWER 52N
CONTR ERECT MISC FDN
START-UP
FABRICATION & DELIVERY ST/ST & DUCTING
INSTALL ST/ST REINFORCEMENT ON ROOF
CONTR. ERECT MISC.
CONTR. INSTALL DUCTING ON THE ROOF 52N / 55N
CONTR. INSTALL DUCTING ON COURTYARDS 53N/54N
CONTR. PAINT OLD DUCTING 52N
CONTR. CHECK-OUT DUCTING
CONTR. REMARK RISERS
ARV. PRESSURE MAINT'LS.
ARV. FORCES MOBILIZE
TO MECH. INSTALLATION
ARV. OBTAIN PRICES
ARV. PLACE P/O
FABRICATION & DELIVERY PIPING
SHIP TO SITE
DELIVERY PUMPS
CONTR. MECH. START-UP PUMPS & MOTORS
ELEC.

1982

SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC

MECH. & ELEC. CHECK - OUT

START - UP

CONTR. DEMOLISH ELEC. & MECH. EQUIP. & FAN

CONTR. REPAIR ROOF & WALL FAN ROOM

CONTR. DEMOLISH BLDG. & REMOVE DEBRIS

BACKFILL PUMPHOUSE PITS

CONTR. MECH. DEMOLITION

CONTR. CHECK-OUT & TESTING

CONTR. SEALING RISERS

CONTR. PAINT PUMPHOUSES

CONTR. PAVE

ST/ST TOWERS

TEMPORARY PYLON MOVE FROM C.Y. 55N

TEMPORARY PASSAGEWAY

KEY PLAN

SCRUBBER TOWERS

STRUCTURAL STEEL

DUCTING

MECHANICAL PIPING

PUMPS

EXHAUST FANS

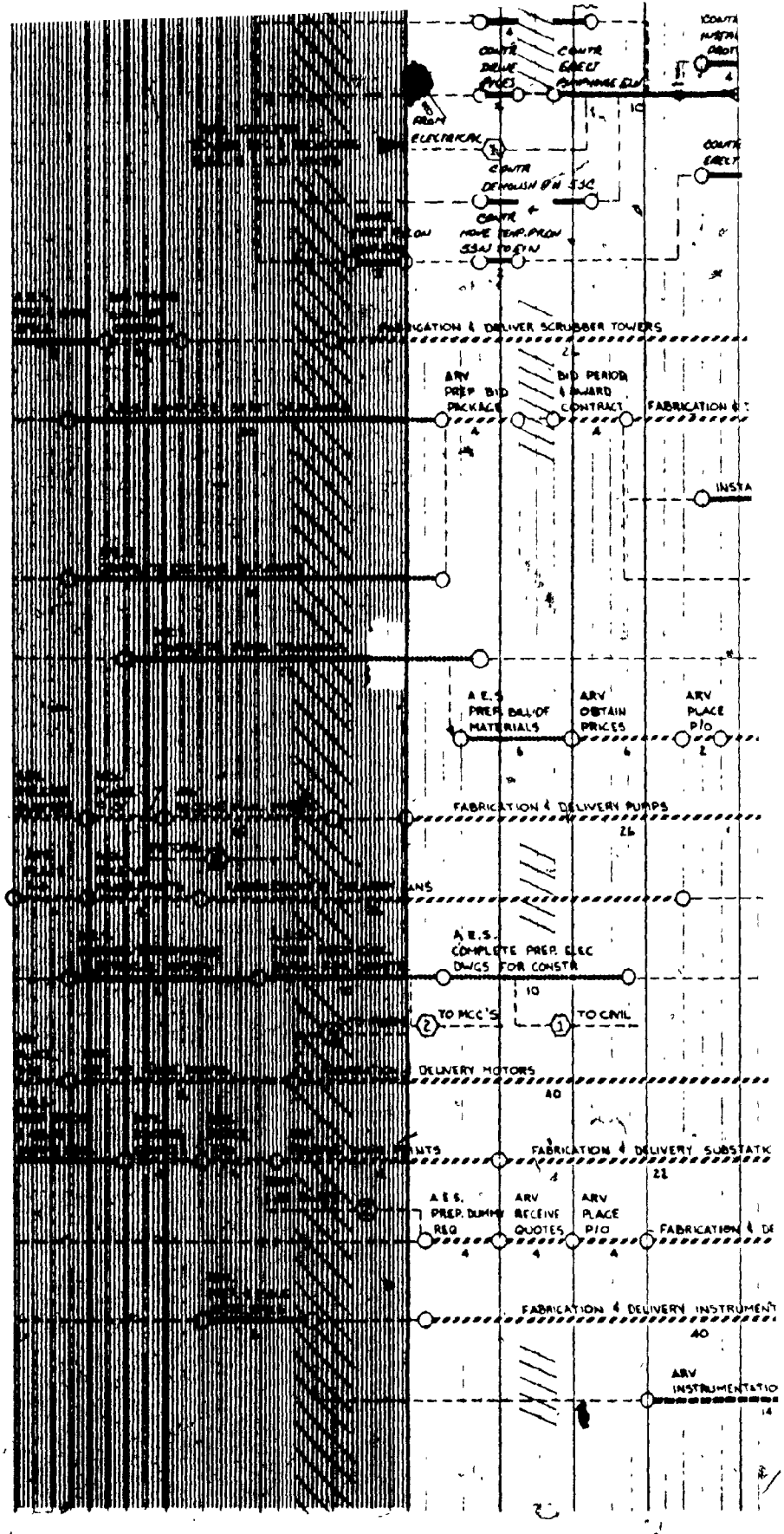
ELECTRICAL

ELECTRICAL MOTORS

SUBSTATION

MCC'S & CONTROL PANELS

INSTRUMENTATION



NO.	DD MMM YY	REMARKS & REVISION
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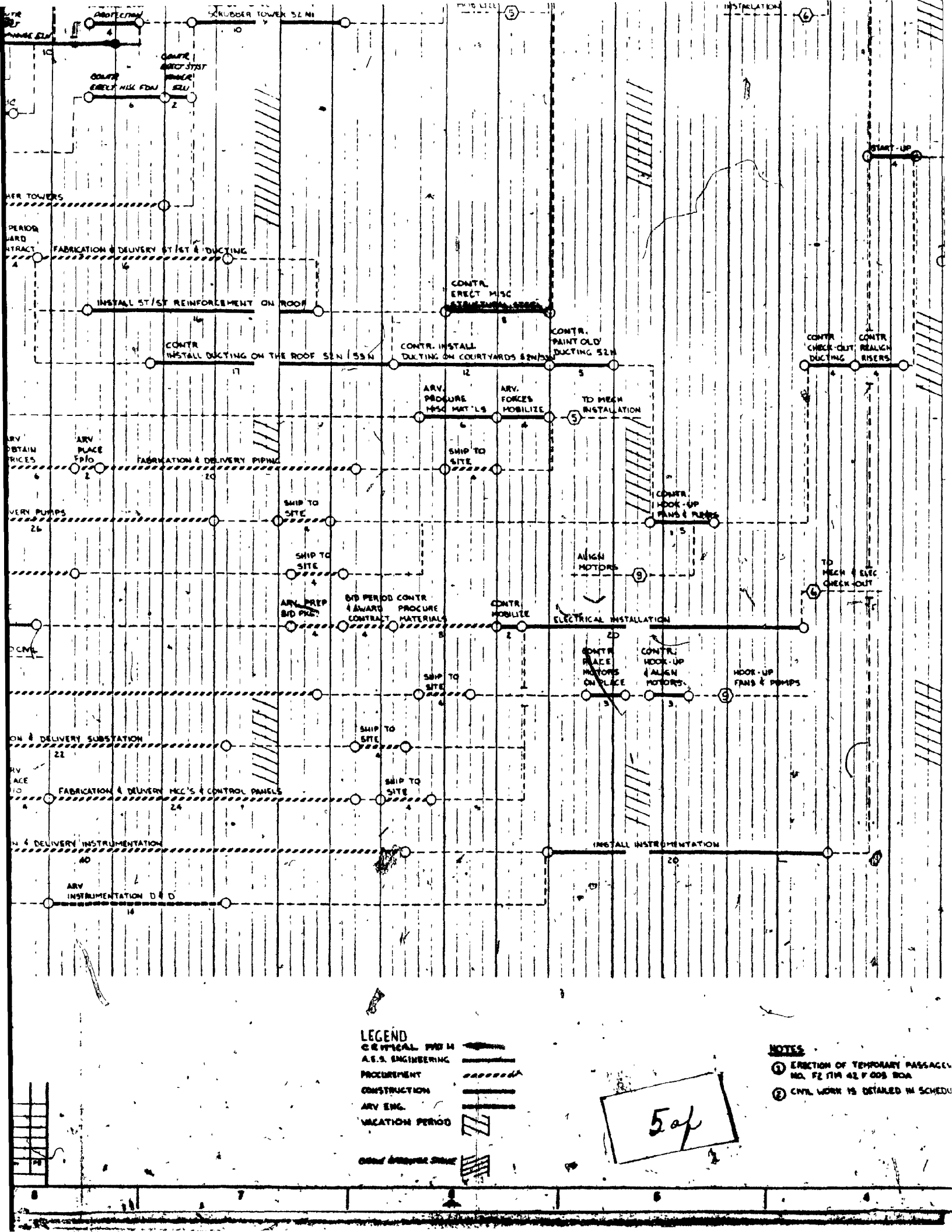
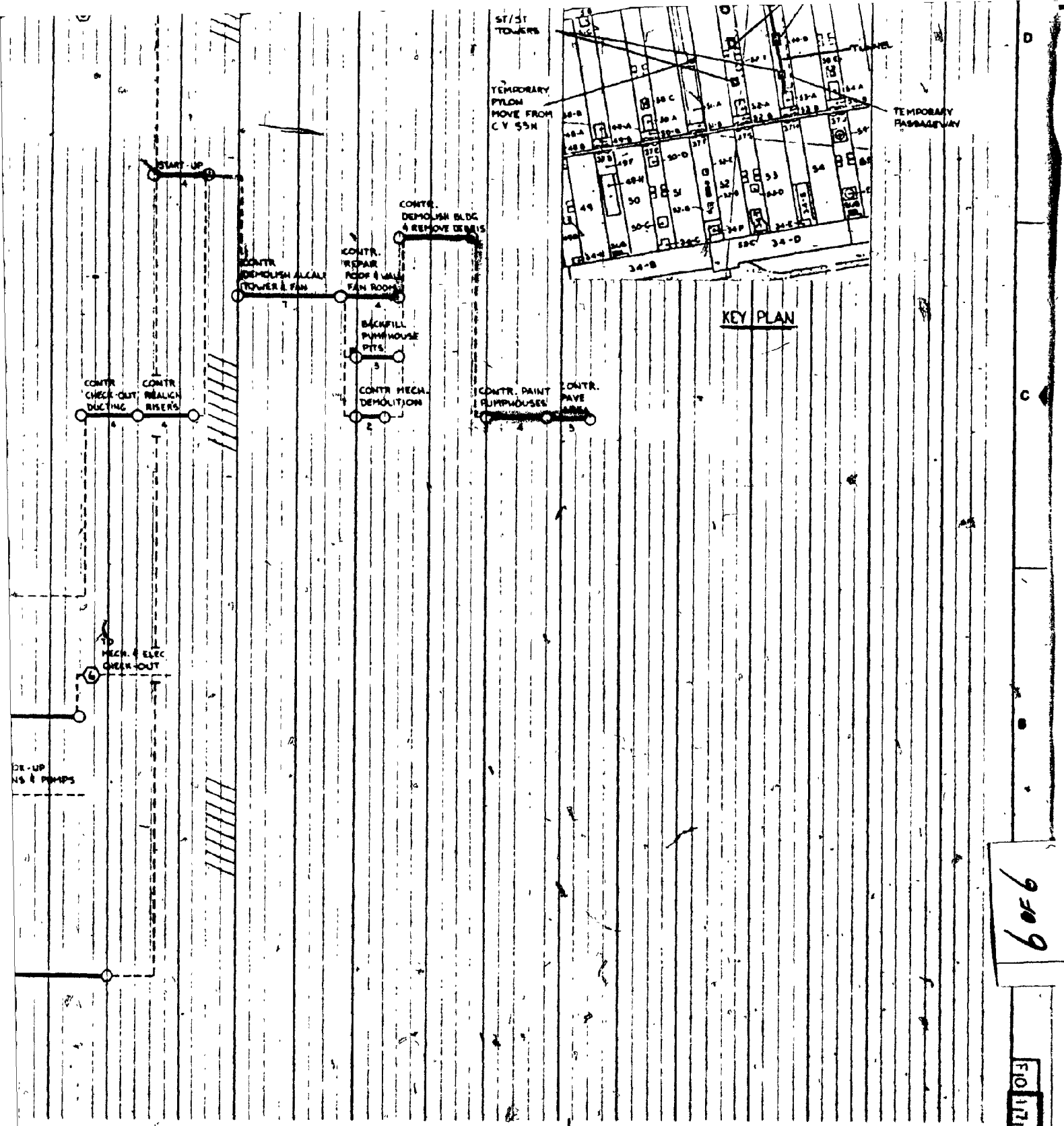
00	14 MAR 80	FIRST ISSUE
08	15 JUN 79	PRELIMINARY 2ND ISSUE
04	25 MAY 79	PRELIMINARY 1ST ISSUE


SCRUBBER TOWER S2 N1
START - UP
FABRICATION & DELIVERY ST/ST & DUCTING
INSTALL ST/ST REINFORCEMENT ON ROOF
CONTR. ERECT MISC
CONTR. PAINT OLD DUCTING S2N
CONTR INSTALL DUCTING ON THE ROOF S2N / S5N
CONTR. INSTALL DUCTING ON COURTYARDS S2N/S5N
CONTR CHECK-OUT DUCTING
CONTR REALIGN RISERS
ARV. PROCURE MISC MAT'LS
ARV. FORCES MOBILIZE
TO MECH INSTALLATION
ARV PLACE P/O
FABRICATION & DELIVERY PIPING
SHIP TO SITE
CONTR HOOK-UP FANS & PUMPS
ALIGN MOTORS
TO MECH & ELEC CHECK-OUT
ARV PREP BID PKG.
BID PERIOD CONTR AWARD CONTRACT
CONTR PROCURE MATERIALS
CONTR MOBILIZE
ELECTRICAL INSTALLATION
CONTR PLACE MOTORS ON PLACE
CONTR. HOOK-UP & ALIGN MOTORS
HOOK-UP FANS & PUMPS
FABRICATION & DELIVERY MCC'S & CONTROL PANELS
INSTALL INSTRUMENTATION
ARV INSTRUMENTATION D & D
LEGEND
CRITICAL PATH
A.E.S. ENGINEERING
PROCUREMENT
CONSTRUCTION
ARV ENG.
VACATION PERIOD
NOTES
1 ERECTION OF TEMPORARY PASSAGE
NO. FZ ITM 42 F 005 BOA
2 CIVIL WORK IS DETAILED IN SCHEDU
5 of



909

NOTES

1. ERECTION OF TEMPORARY PASSAGEWAY IS DETAILED IN SCHEDULE NO. FE 1119 42 F 008 R04
2. CIVIL WORK IS DETAILED IN SCHEDULE NO. FO 1119 42 F 008 R00

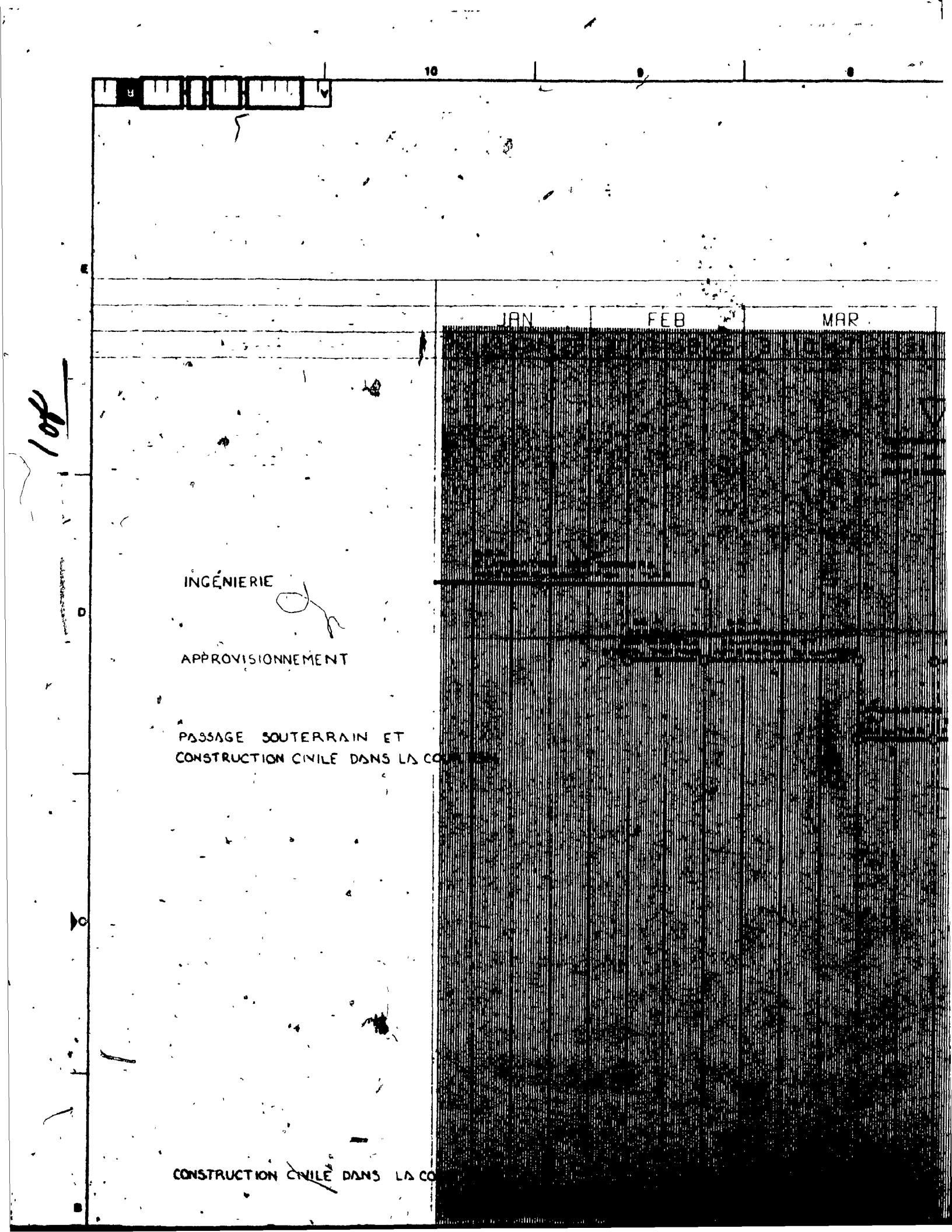
Alcan Engineering Services

EPURATEURS 52 N / 53N
PASSAGE SOUTERRAIN

RÉSEAU DES ACTIVITÉS À L'ECHELLE DU TEMPS

Société d'électrolyse et de chimie Alcan Ltée

FO 1119 A 412 F 008 R00


JAN
FEB
MAR
INGÉNIERIE
APPROVISIONNEMENT
PASSAGE SOUTERRAIN ET
CONSTRUCTION CIVILE DANS LA CO
CONSTRUCTION CIVILE DANS LA CO

1980

MAR | APR | MAY | JUN | JUL | AUG

2 9 16 23 30 7 14 21 28 4 11 18 25

TION CIVILE
COUR S2N
MENT 2 JUN80

MONTAGE DES ACIERS DE CONSTRUCTION TOUR S2N

CONTR COMMENCER MONTAGE DES ACIERS DE CONSTRUCTION POUR TOUR S3N

CONTR EXCAVATION STADE 2

CONTR COMMENCER C.A.B POUR PASSAGE STADE 2

CONTR COMMENCER C STATION DE

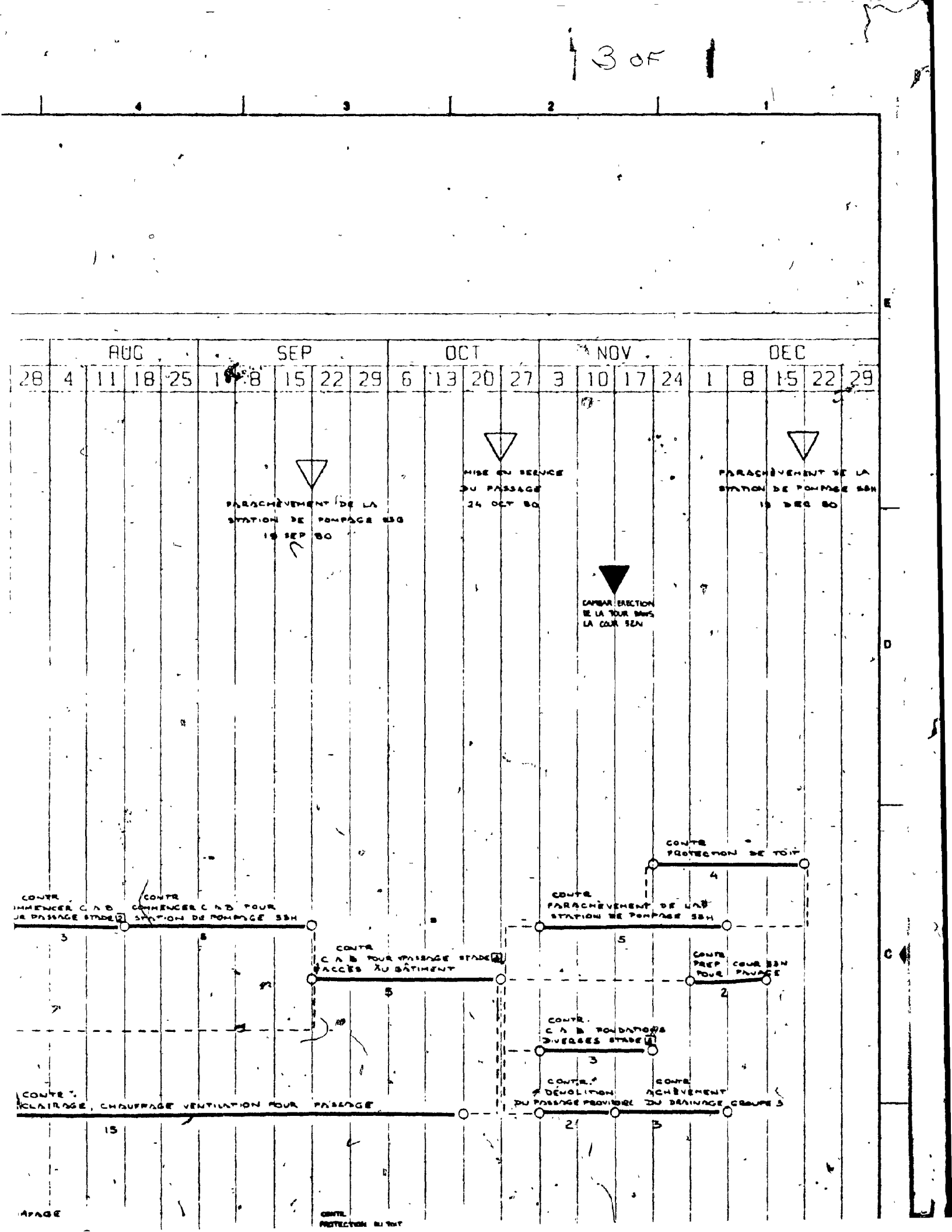
TION
LA COUR S3N

CAISSON ENCAGER L'EPURATEUR S3N

CONTR DEPLACEMENT DU PYLÔNE PROVISOIRE DE LA COUR S3N A S3N

CONTR ÉCLAIRAGE, CHAUFFAGE VENT

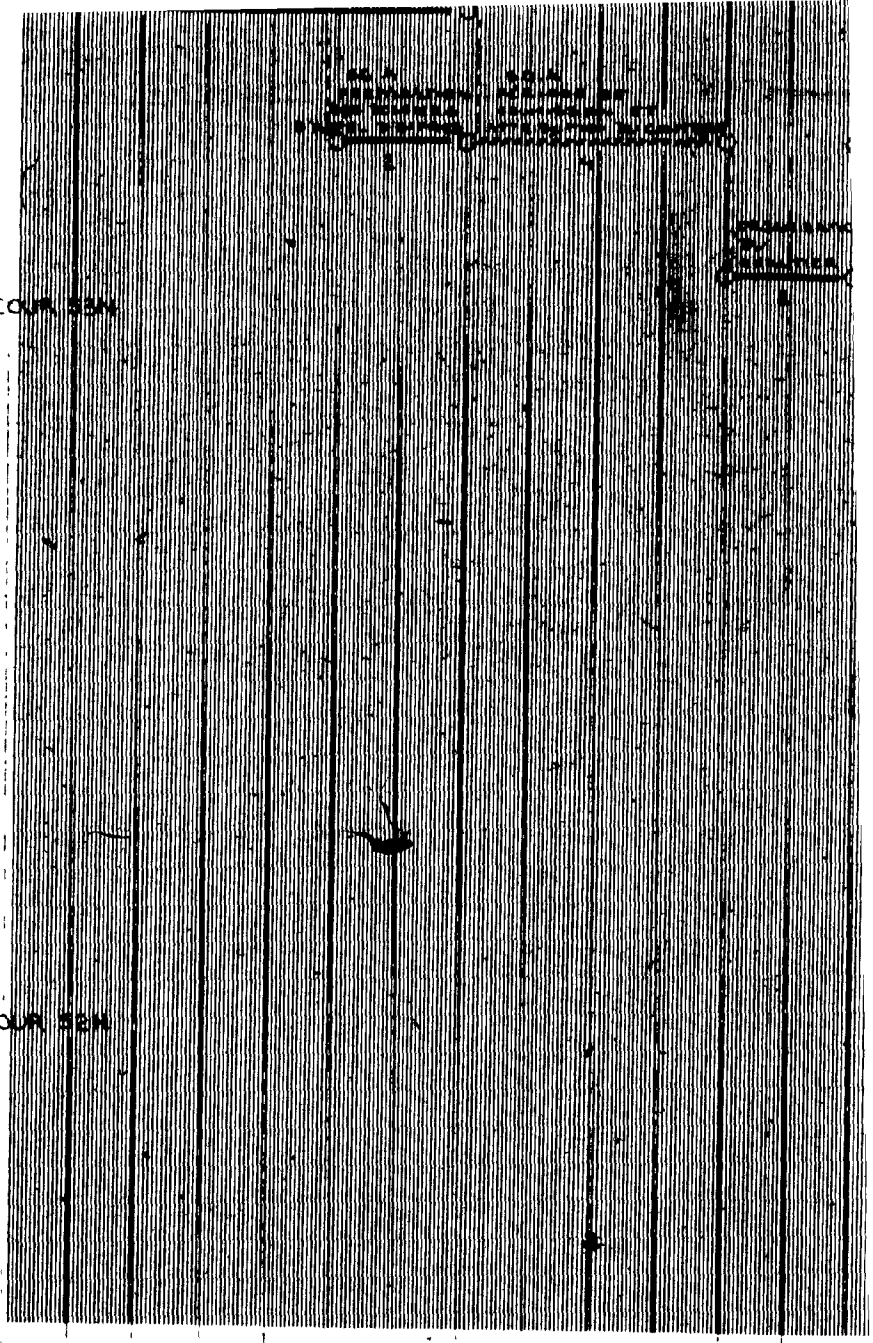
CONTR DÉMOLITION DE COMPAGE EXISTANTE - S2C


AUG
SEP
OCT
NOV
DEC
28 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 1 8 15 22 29
PARACHÈVEMENT DE LA STATION DE POMPAGE SSH 15 SEP 80
MISE EN SERVICE DU PASSAGE 24 OCT 80
PARACHÈVEMENT DE LA STATION DE POMPAGE SSH 15 DEC 80
CAMBAR ERECTION DE LA TOUR DANS LA COUR SSH
CONTR PROTECTION DE TOIT
4
CONTR
3
CONTR COMMENCER C A B POUR STATION DE POMPAGE SSH
5
CONTR PARACHÈVEMENT DE LA STATION DE POMPAGE SSH
5
CONTR C A B POUR PASSAGE STADE
ACCÈS AU BÂTIMENT
5
CONTR PREP POUR COUR SSH PASSAGE
2
CONTR. C A B FONDATIONS DIVERSES STADE
3
CONTR. ECLAIRAGE, CHAUFFAGE VENTILATION POUR PASSAGE
15
CONTR. DÉMOLITION DU PASSAGE PROVISOIRE
2
CONTR ACHÈVEMENT DU DRAINAGE GROUPE 3
3
CONTR PROTECTION DU TOIT

APPROVISIONNEMENT

PASSAGE SOUTERRAIN ET
CONSTRUCTION CIVILE DANS LA COUR SSW

CONSTRUCTION CIVILE DANS LA COUR SSW

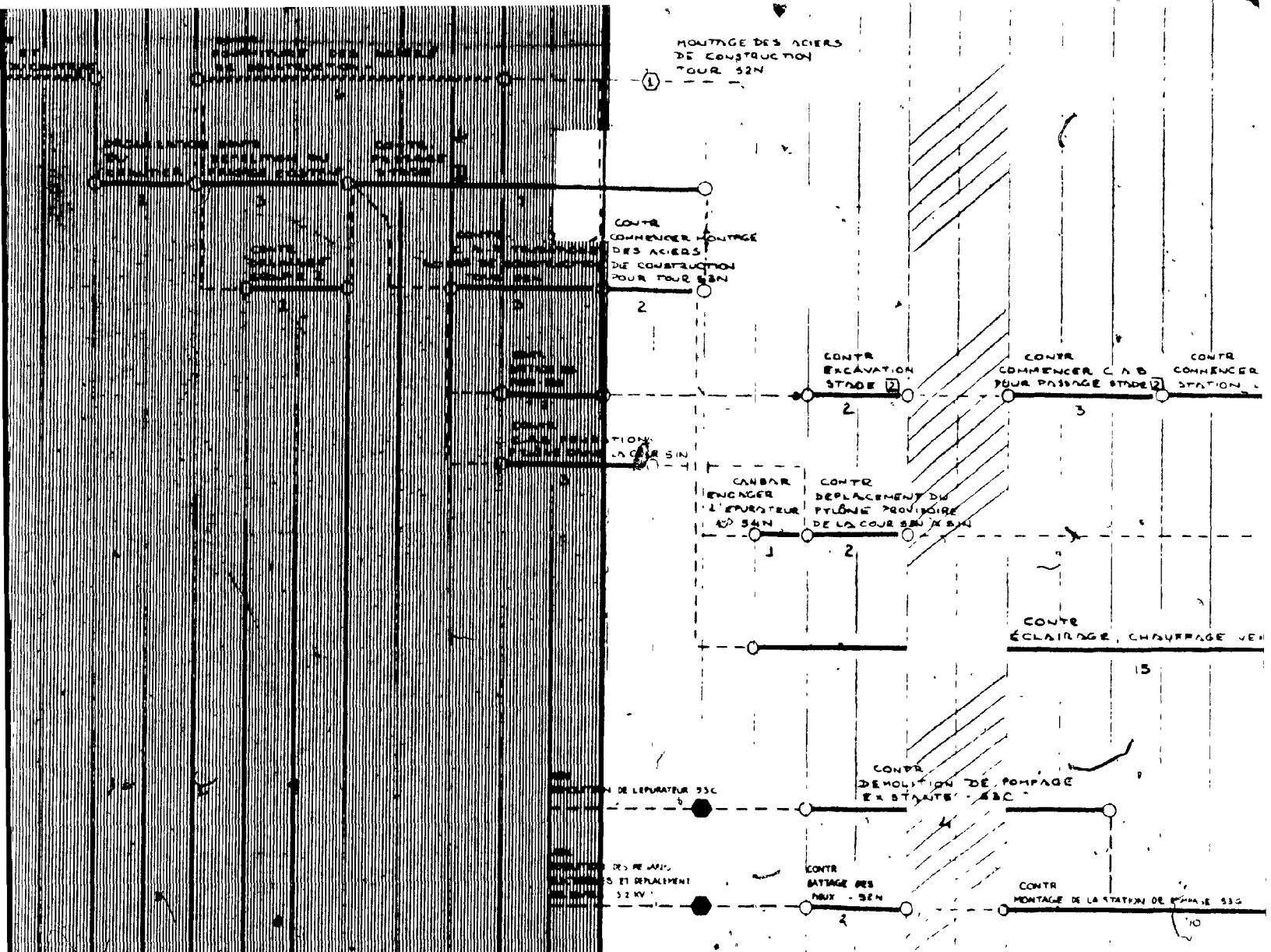


LÉGENDE

INGENIERIE
APPROVISIONNEMENTS
CONSTRUCTION
C A/B (COFFRAGES, ARMATURES, BETON)
VACANCES
EVENEMENT DU CONTRAT
EVENEMENT DU PROJECT

01	24 MAY 80		PREMIERE EMISSION	
00	20 MAR 80		DERNIERE EMISSION	
00A	22 FEB 80		EMISSION PRELIMINAIRE	J P
No.	Date	Location	Description	Made by

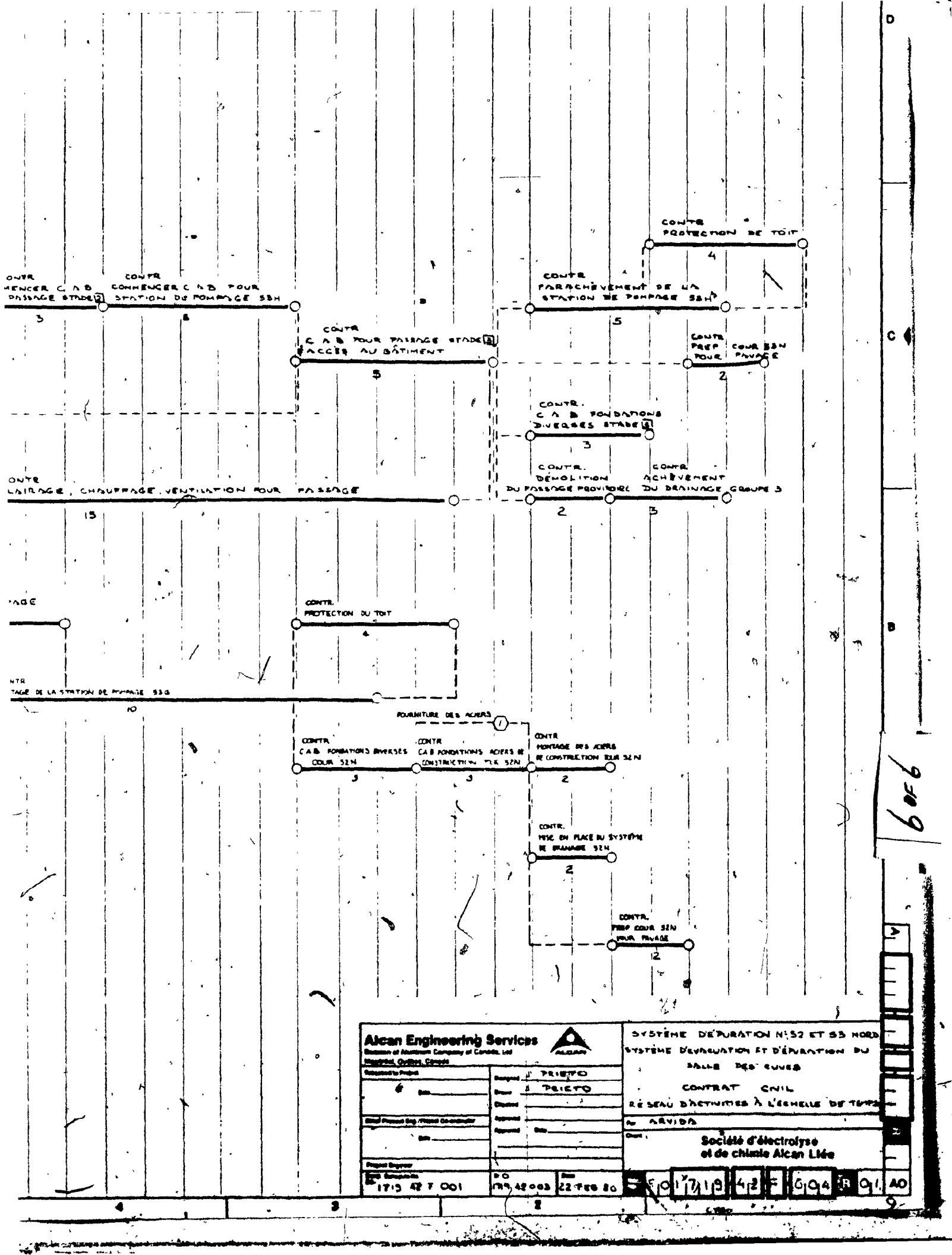
11 10 9 8



NOTES

1. LE RÉSEAU À L'ÉCHELLE DU TEMPS EST ÉTABLI EN FONCTION DES PRESCRIPTIONS STIPULÉES AU PLAN N° 55 1715 42C 022 R01 ET AU DEVIS DESCRIPTIF N° ES 4719 42 E 002
2. ÉCLAIRAGE, CHAUFFAGE ET VENTILATION POUR PASSAGE SOUTERRAIN SEULEMENT
3. L'ENTREPRENEUR SERA RESPONSABLE DE L'APPROVISIONNEMENT DES ACIERS DE CONSTRUCTION (POUR LES TOURS ET POUR LES COLONNES DE LA SALLE DE CONTRÔLE)

5 of


CONTR
PROTECTION DE TOIT
4
CONTR
MENCER C A B
PASSAGE STADE 2
3
CONTR
COMMENCER C A B POUR
STATION DU POMPAGE SSH
8
CONTR
PARACHÈVEMENT DE LA
STATION DE POMPAGE SSH
5
CONTR
C A B POUR PASSAGE STADE 2
ACCÈS AU BÂTIMENT
5
CONTR
PREP POUR COUR SSH
PAVAGE
2
CONTR.
C A B FONDATIONS
DIVERSES STADE 2
3
ONTR
LAIRAGE, CHAUFFAGE, VENTILATION POUR PASSAGE
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CONTR.
DÉMOLITION
DU PASSAGE PROVISOIRE
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CONTR
ACHÈVEMENT
DU DRAINAGE GROUPE 3
3
AGE
CONTR.
PROTECTION DU TOIT
4
NTR
TAGE DE LA STATION DE POMPAGE SSG
10
FOURNITURE DES ACIERS
1
CONTR
C A B FONDATIONS DIVERSES
COUR SZN
3
CONTR
C A B FONDATIONS ACIERS DE
CONSTRUCTION TOUR SZN
3
CONTR
MONTAGE DES ACIERS
DE CONSTRUCTION TOUR SZN
2
CONTR.
MISE EN PLACE DU SYSTÈME
DE DRAINAGE SZN
2
CONTR.
PREP COUR SZN
POUR PAVAGE
2
Alcan Engineering Services
Division of Aluminium Company of Canada, Ltd
Montréal, Québec, Canada
Prepared by PRIETO
Drawn PRIETO
Checked
Approved
Approved
Project Engineer
Job Sequence
1715 42 T 001
P.O.
189 42 003
Date
22 Feb 80
SYSTÈME D'ÉPURATION N°52 ET 55 NORD
SYSTÈME D'ÉVACUATION ET D'ÉPURATION DU
SALLE DES CUVES
CONTRAT CNIL
RÉSEAU D'ACTIVITÉS À L'ÉCHELLE DE TEMPS
For ARVIDA
Client
Société d'électrolyse
et de chimie Alcan Ltée
E 01 17 19 42 F G 04 R 01 A0
6 of 6
4
3
2

4.3 Cost

4.3.1 General

Cost has been introduced into CPM networking technique for two different purposes: 1) To determine cash flows; 2) To establish an activity based cost control system.

CPM's technique has fulfilled the first purpose very well, as the cost estimates for the projects can be broken down and easily distributed throughout the activities. However, it has not proven to give the same degree of success for control, as the traditional accounting systems are not compatible with cost control on an activity basis.

Only in the last few years have increasingly flexible cost control systems been able to make the costs and CPM networks more compatible.

Cost control will be discussed in Chapter 5, however, cash flows and rate of expenditures will be presented here. Properly analyzed allocation curves can provide a project's team with a good financial picture of a particular job. As shown in Figures 4.6.a and 4.6.b monthly and cumulative expenditures and disbursements can be calculated.

Contractors are able to make an assessment of the amount which they will have to borrow to finance the job, as well as how much profit can be accrued in a particular period of time. (Figure 4.7)

Following this summarized presentation on costs, a discussion on how costs have been dealt with in the Scrubber Program will be presented.

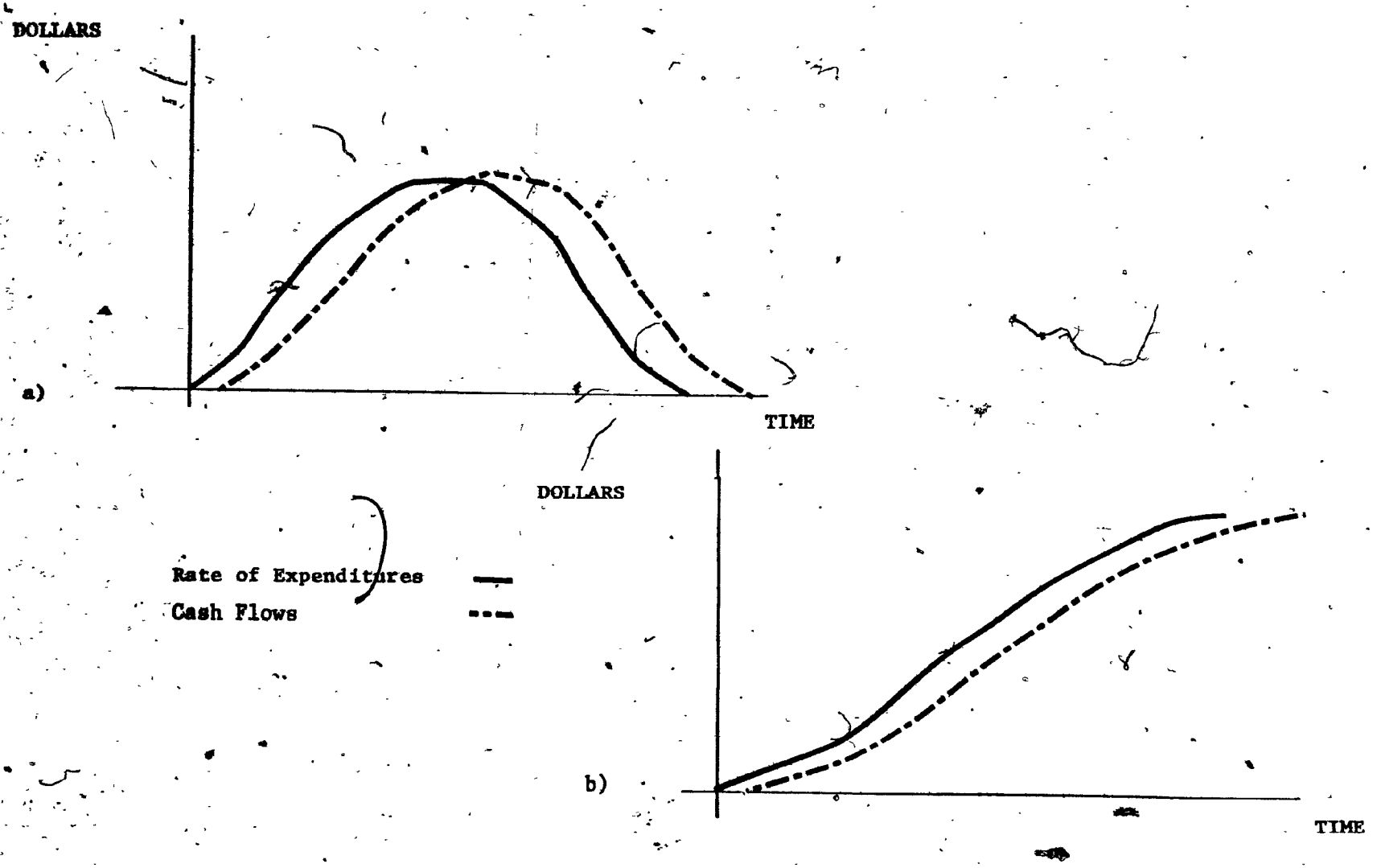
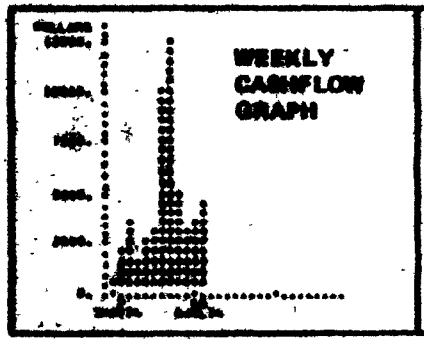


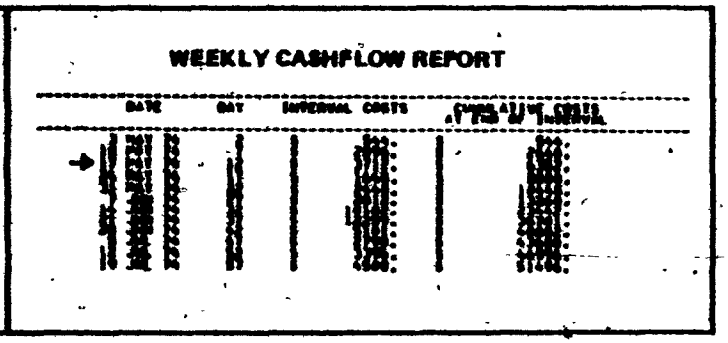
FIGURE 4.6 - a) MONTHLY AND b) CUMULATIVE RATE OF EXPENDITURES AND CASH FLOWS

Cost Analysis

CASHFLOW REPORT
Tabular listing of the interval and cumulative projected or actual cashflow, plus a histogram and cumulative S-curve of projected cashflow or actual cashflow. Also possible to superimpose cumulative S-curves. Time scale can be days, weeks, months, or a multiple thereof.

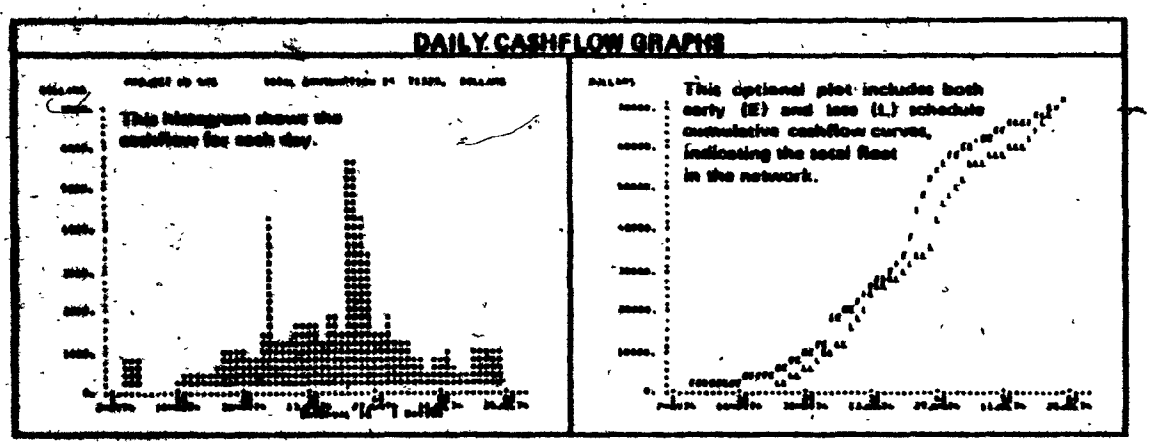
CASHFLOW REPORT
Liste, courbe cumulée et histogramme des cashflow réels et prévus. Il est possible de superposer des courbes cumulées. L'intervalle de temps peut être le jour, la semaine, le mois ou un de leur multiple.





For the week ending 17 May, $3712 is to be spent; from the project start through 17 May, $8362 is to be spent.

$3712 doivent être dépensés pendant la semaine qui se termine le 17 mai. A la fin de cette même semaine, $8362 ont du être dépensés depuis le début du projet.



- 54 -

COLOURED PAPER
PAPIER DE COULEUR

REPORT 4.3

8 November 1979
S.O. 1270.42.12.2

To: Mr. G. St-Pierre
Arvida

From: J. Prieto

Subject: Arvida Scrubber Programme
Rate of Expenditure & Cash Flow Forecast

Enclosed please find computer printout reports with the following information:

1. Summary Working Schedule showing the duration of the Strategic Plan projects (a list of the projects can be found in Appendix 1).

2. Summary of Cost for each project including Total Cost, Capital Cost and Expense.

3. Tabular and graphical Rate of Expenditure for the total cost of the Strategic Programme. The graphical Rate of Expenditure is given in early and late start.

4. Tabular and graphical Cash Flow. The forecast of cash flow was prepared by manually shifting the Rate of Expenditure tabulation and curve by 12 weeks. The forecast of cash flow is given in early start.

5. Tabular and graphical Rate of Expenditure for the individual projects. The graphical Rate of Expenditure is given in early and late start.

JP:cm

Encl...

Copy to:

Mr. P. Folmer

Circulate S.O. copy to:

Mr. R.A. Beattie
Mrs. M. Morter

Circulate file copy to:

Mr. P. Hawryluk
Mr. H.A. Hughes
Mr. J. Prieto
Mr. C. Brien

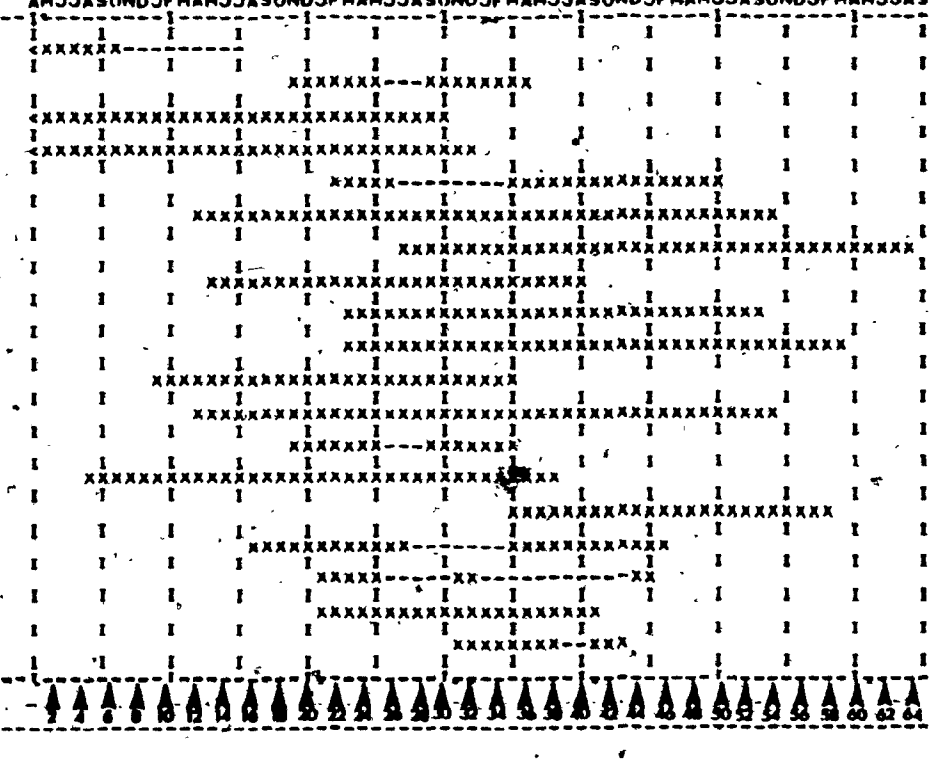
ARVIDA SCRUBBER PROGRAM(POT EXHAUST) AES.SO 1270 SERIES

RUN DATE 07NOV79 1831HRS ***** S U M M A R Y S C H E D U L E ***** PROJECT START 18APR77

PROJECT 1270 STRATEGIC PLAN CURRENT COMPLETION 16AUG82

DATA DATE 18APR77 PAGE 1

NUMBER	DESCRIPTION	MODE=C/F
0	GENERAL	
20	SETTLER L26-AUTH.2588	B.BOUDREAU
22	LINE 22N/23N-AUTH.1444	B.BOUDREAU
26	LINE 26N-AUTH.1445	B.BOUDREAU
43	SETTLER 43K-AUTH.5110	G.ST.PIERRE
46	LINE 46N/47N-AUTH.9037	B.BOUDREAU
48	LINE 48N/49N-AUTH.5568	G.ST.PIERRE
49	LINE 49S-AUTH.1999	F.BERUBE
50	LINE 50N/51N-AUTH.5569	B.BOUDREAU
52	LINE 52N/53N-AUTH.5570	F.BERUBE
53	LINE 53S-AUTH.9399	B.BOUDREAU
54	LINE 54N/55N-AUTH.9031	F.BERUBE
55	SETTLER50-53-AUTH.8896	B.BOUDREAU
56	LINE 56N/57N-AUTH.1450	F.BERUBE
58	SODA DISTR.-AUTH.5573	G.ST.PIERRE
66	WATER LINE.-AUTH.9032	B.MORIN
77	R. DES BOUES-AUTH.8684	B.MORIN
88	CENTR.ALARMS-AUTH.9036	G.ST.PIERRE
99	U/R DUCTING-AUTH.5571	G.ST.PIERRE



AHVIDA SCRUBBER PROGRAM(POT EXHAUST)

RUN DATE 07NOV79 1632HRS

PROJECT 1270 STRATEGIC PLAN

S U M M A R Y C O S T

AES.SO 1270 SERIES

PROJECT START 18APR77

CURRENT COMPLETION 16AUG82

DATA DATE 18APR77 PAGE 1

CODE MODE=C/P	DESCRIPTION	CAPITAL COSTS	EXPENSED	TOTAL COSTS
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22	LINE 22N/23N-AUTH.1444 B.BOUDREAU	2400000	300000	2700000
26	LINE 26N-AUTH.1445 B.BOUDREAU	1460000	140000	1600000
43	SETTLER 43K-AUTH.5110 G.ST.PIERRE	1460000	150000	1610000
46	LINE 46N/47N-AUTH.9037 B.BOUDREAU	4050000	300000	4350000
48	LINE 48N/49N-AUTH.5568 G.ST.PIERRE	4520000	450000	4970000
49	LINE 49S-AUTH.1999 F.BERUBE	1430000	170000	1600000
50	LINE 50N/51N-AUTH.5569 B.BOUDREAU	4635000	345000	4980000
52	LINE 52N/53N-AUTH.5570 F.BERUBE	5090000	380000	5470000
53	LINE 53S-AUTH.9393 B.BOUDREAU	1600000	330000	1910000
54	LINE 54N/55N-AUTH.9031 F.BERUBE	4080000	320000	4400000
55	SETTLER50-53-AUTH.8896 B.BOUDREAU	1200000	30000	1230000
56	LINE 56N/57N-AUTH.1450 F.BERUBE	3747000	270000	4017000
58	SODA DISTR.-AUTH.5573 G.ST.PIERRE	940000	50000	990000
66	WATER LINE.-AUTH.9032 B.MORIN	871000	44000	915000
77	R. DES BOUES-AUTH.8684 B.MORIN	929000	0	929000
88	CENTR.ALARMS-AUTH.9036 G.ST.PIERRE	730000	0	730000
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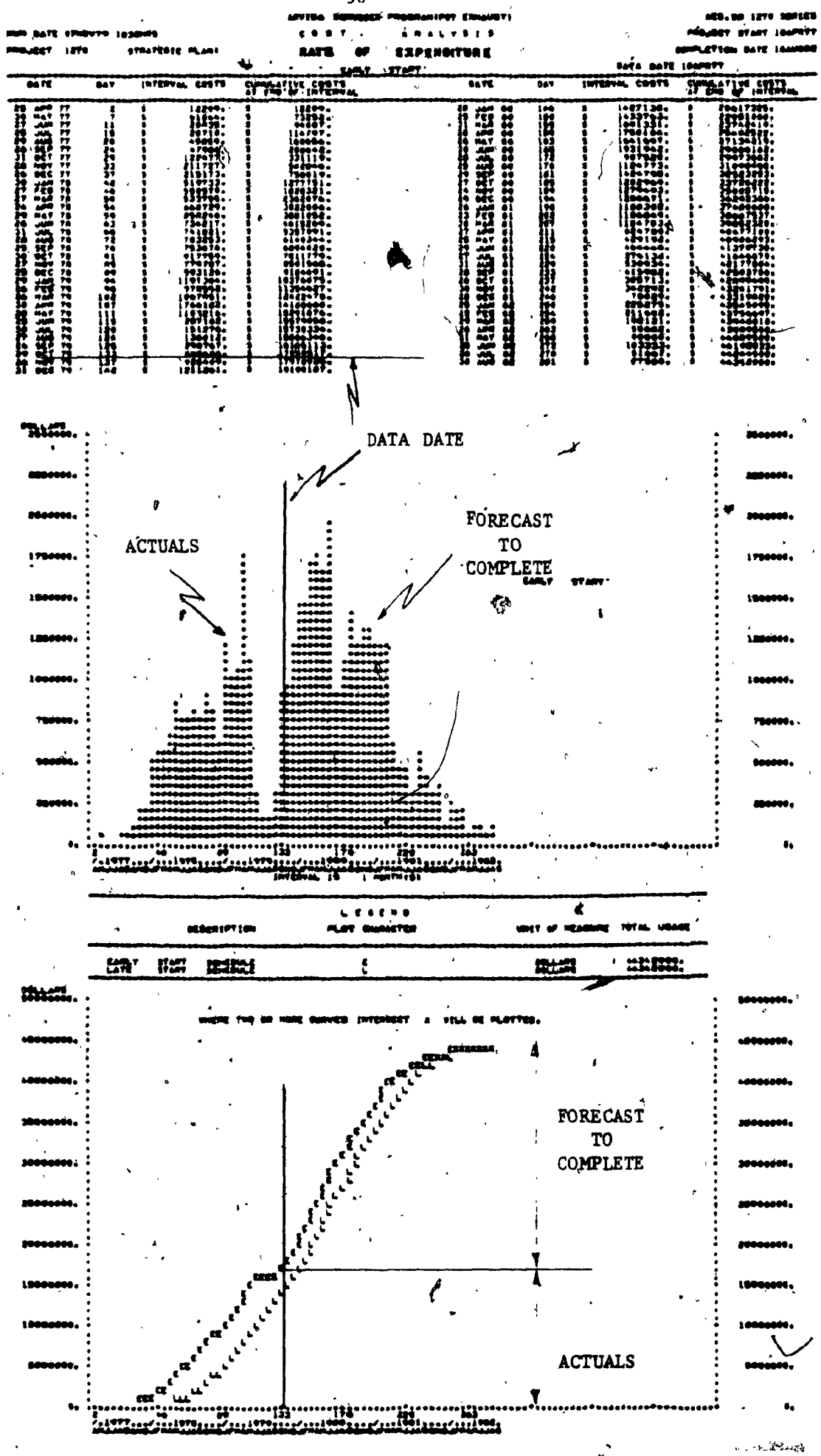
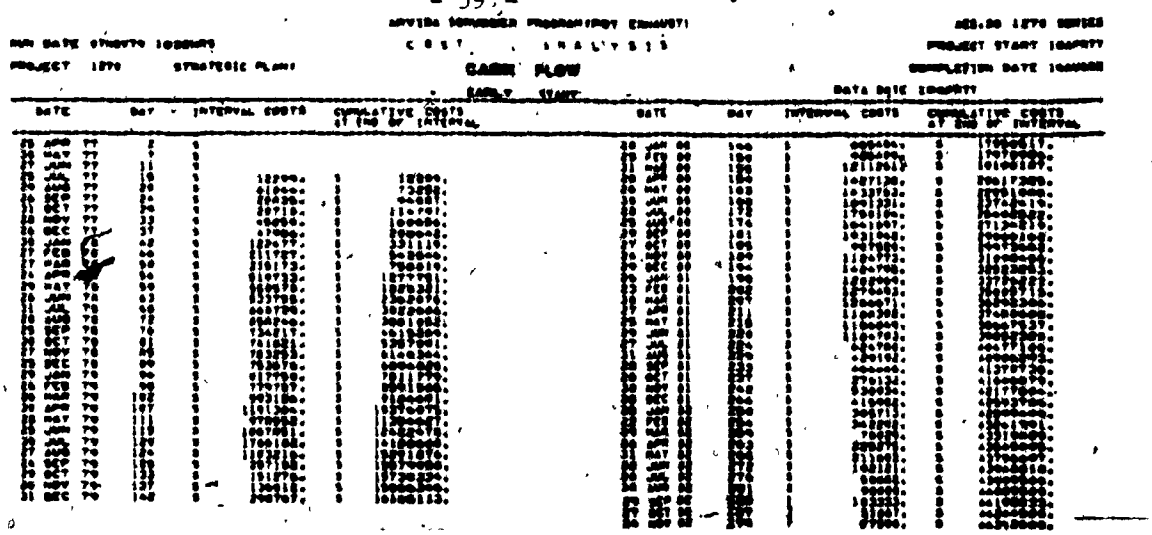
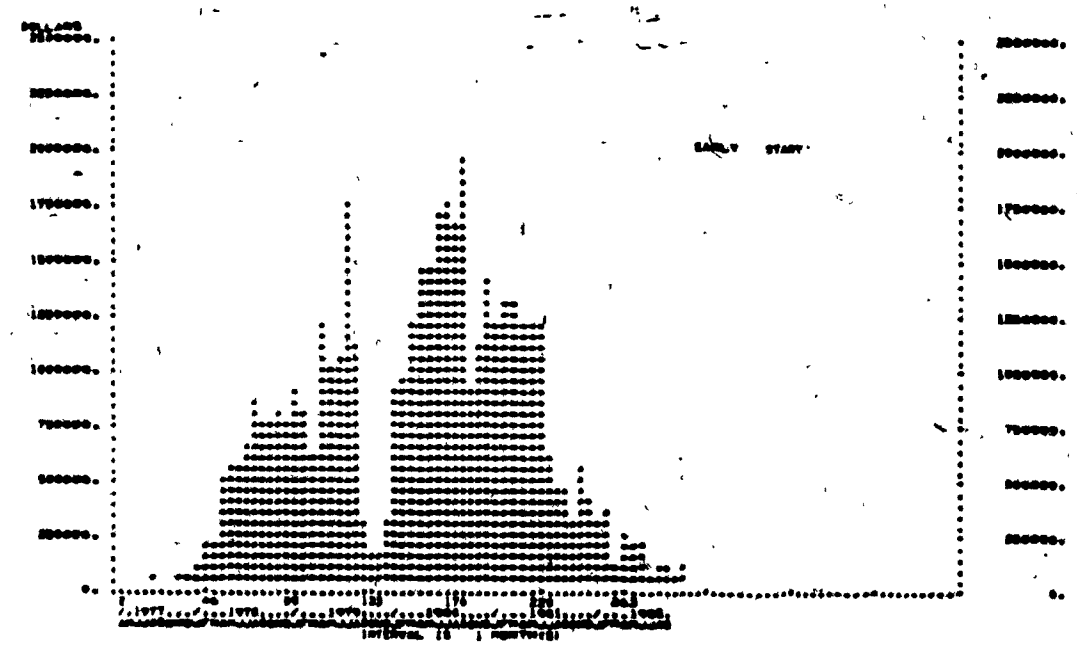
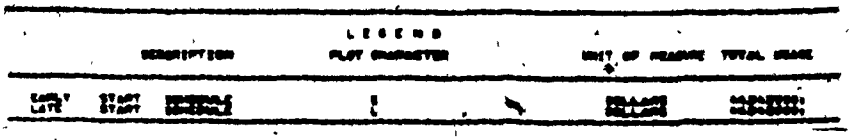
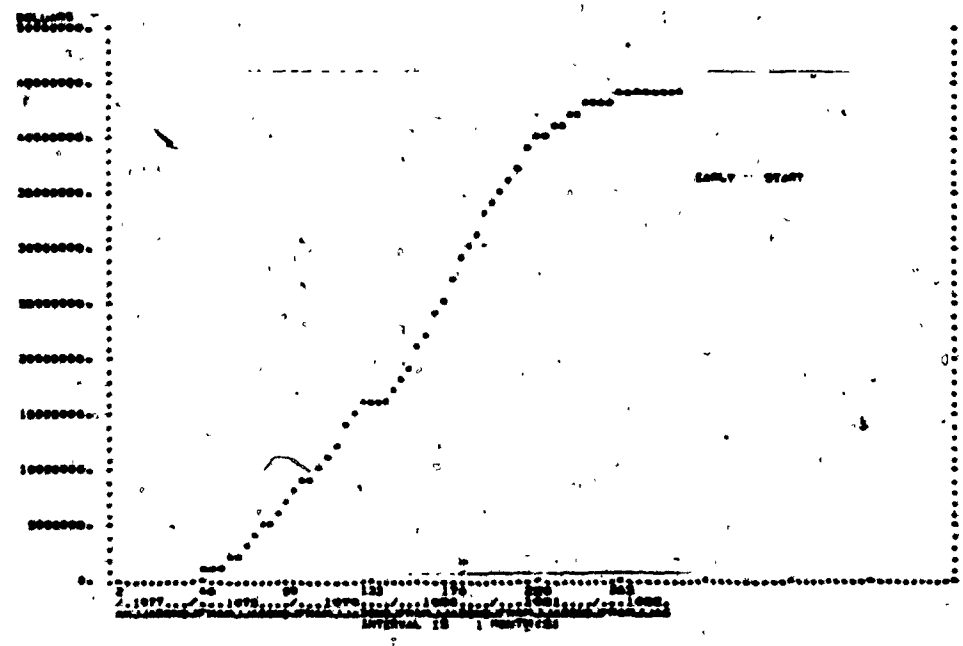
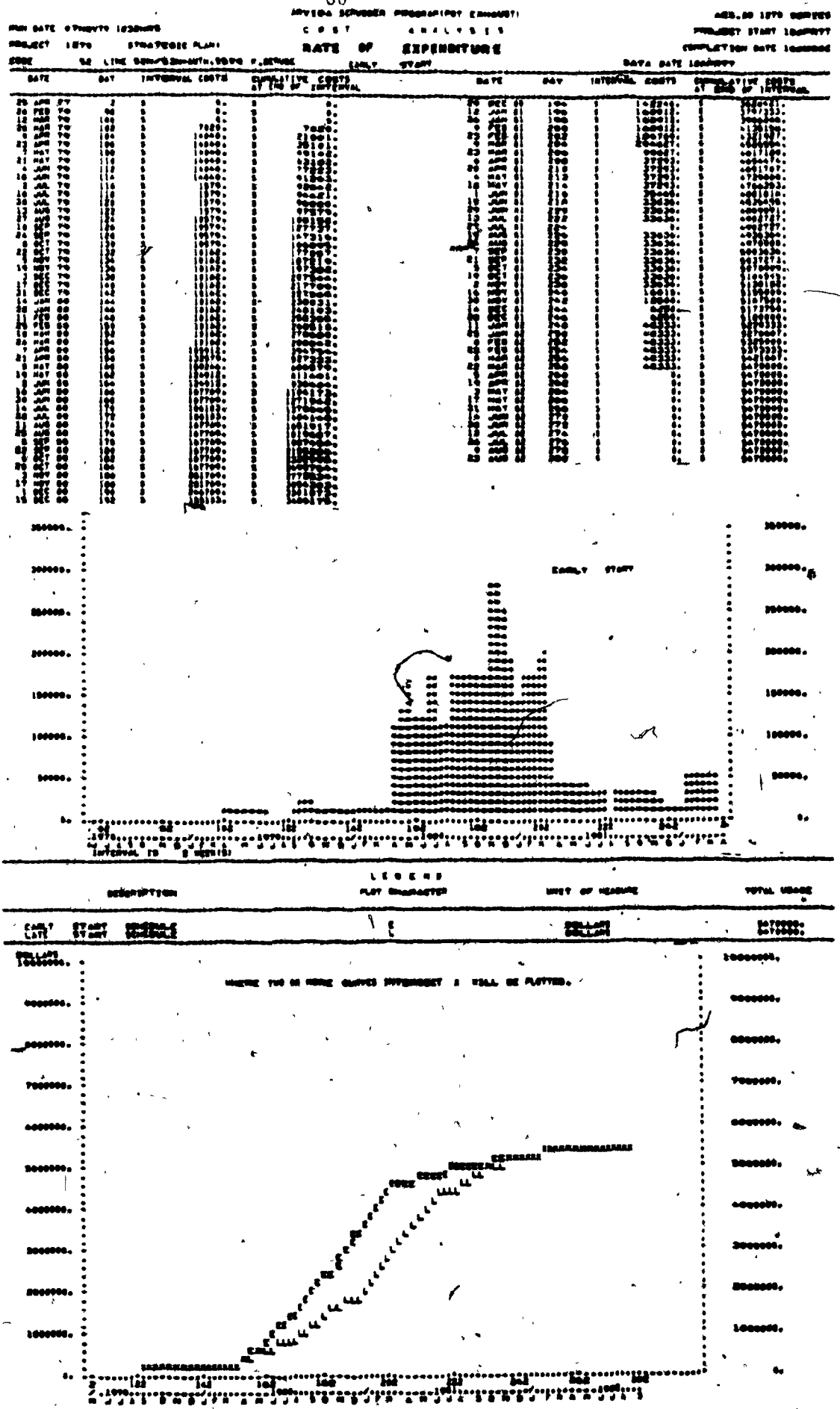

RATE OF EXPENDITURE
DATA DATE
ACTUALS
FORECAST
TO
COMPLETE
FORECAST
TO
COMPLETE
ACTUALS










COST ANALYSIS
RATE OF EXPENDITURE
EARLY START
LEGEND
DESCRIPTION
PLOT CHARACTER
UNIT OF MEASURE
TOTAL VALUE
EARLY START SCHEDULE
DOLLARS
DOLLARS

4.4 CONSTRUCTION MANPOWER

4.4.1 General

CPM technique can be used to easily establish any kind of resource allocation.

In some projects, it is important to study the resource requirements before the starting date. In case of unavailability of resources, two actions can be utilized:

1. Shifting some activities so that the requirements are lowered. This process is named "levelling". By having two parameters, i.e. time and the particular resource in question, two possibilities exist:

   a) set a fixed project completion date to obtain the "optimal" allocation, or

   b) set a fixed quantity of the resource to obtain the "minimal" project duration.

   It is obvious that the value of the integral $\int Rdt$, is the same in all three cases (Figure 4.9) and that it is the usage of activity floats that is the factor which governs the shape of the curve.

2) Taking strategic actions like the usage of multiple crews, alternative equipment, overtime payment, etc.

Following this short introduction on resource allocations, the construction manpower requirements for some trades in the Scrubber Program will now be presented.

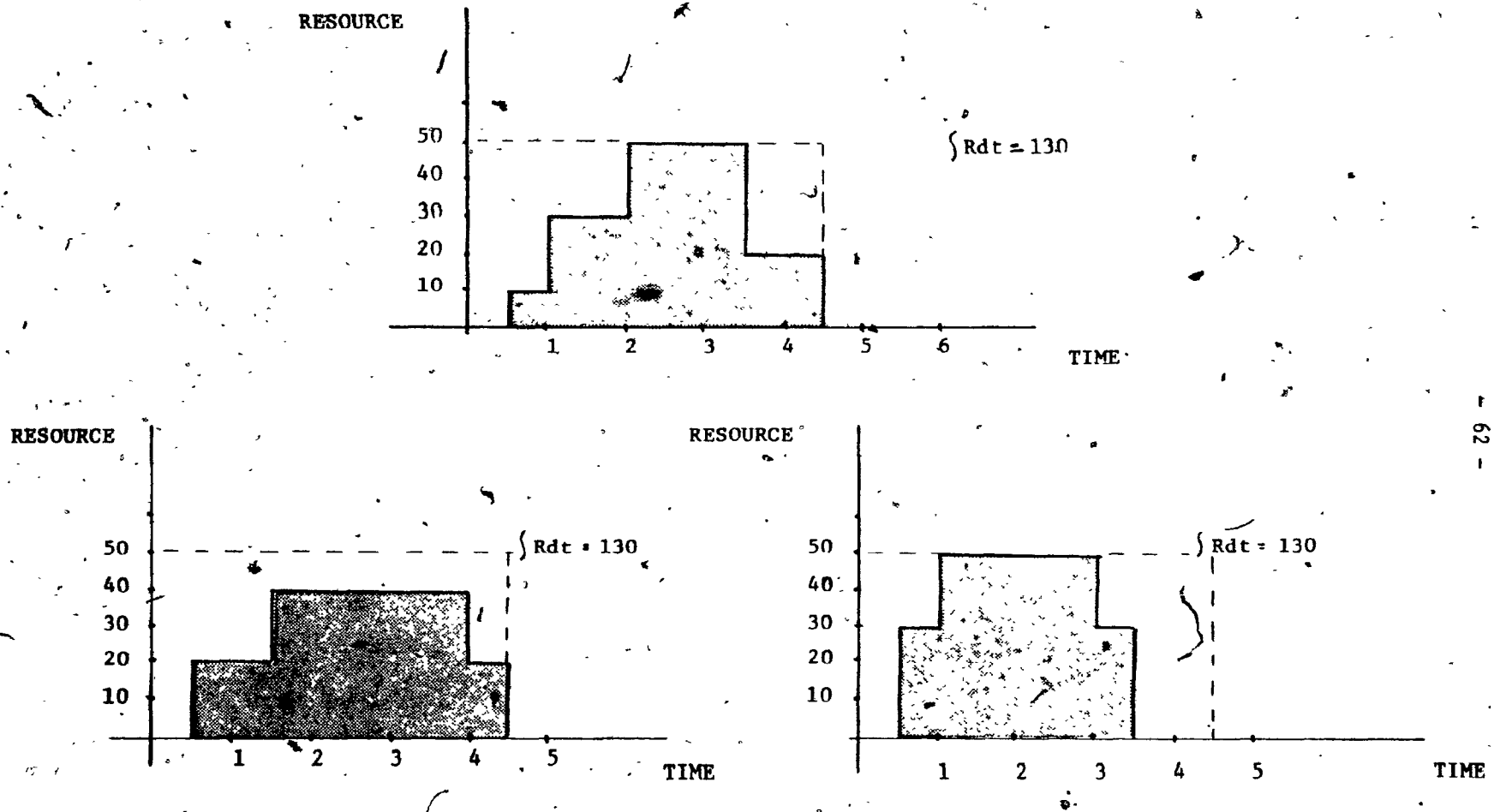


FIGURE 4.9 – RESOURCE LEVELLING

4.4.2 Preparation

It was necessary for management to know the approximate requirements in labour and supervision for five trades:

Civil
Carpenters (Tower creation)
Mechanical (Piping)
Structural Steel, and Ducting
Electrical and Instrumentation

The allocations in manhours were required due to:

1) Limited accessability to the construction sites, which restricted people working in the courtyards

2) Union regulations which would not allow their members to work along with some of the other contractors

3) Usage of limited plant pool forces which had to be requested in advance.

In analyzing manpower, planning used three major sources of information: cost estimates, construction reports, and input from project leaders who knew the crew sizes required for several tasks. Appendix IV. Manhours were established for the five trades and distributed throughout the networks activities. Figure 4.10

The manpower allocations were outputed in early and late start, and after comparison with availability of resources, no major problems were encountered.

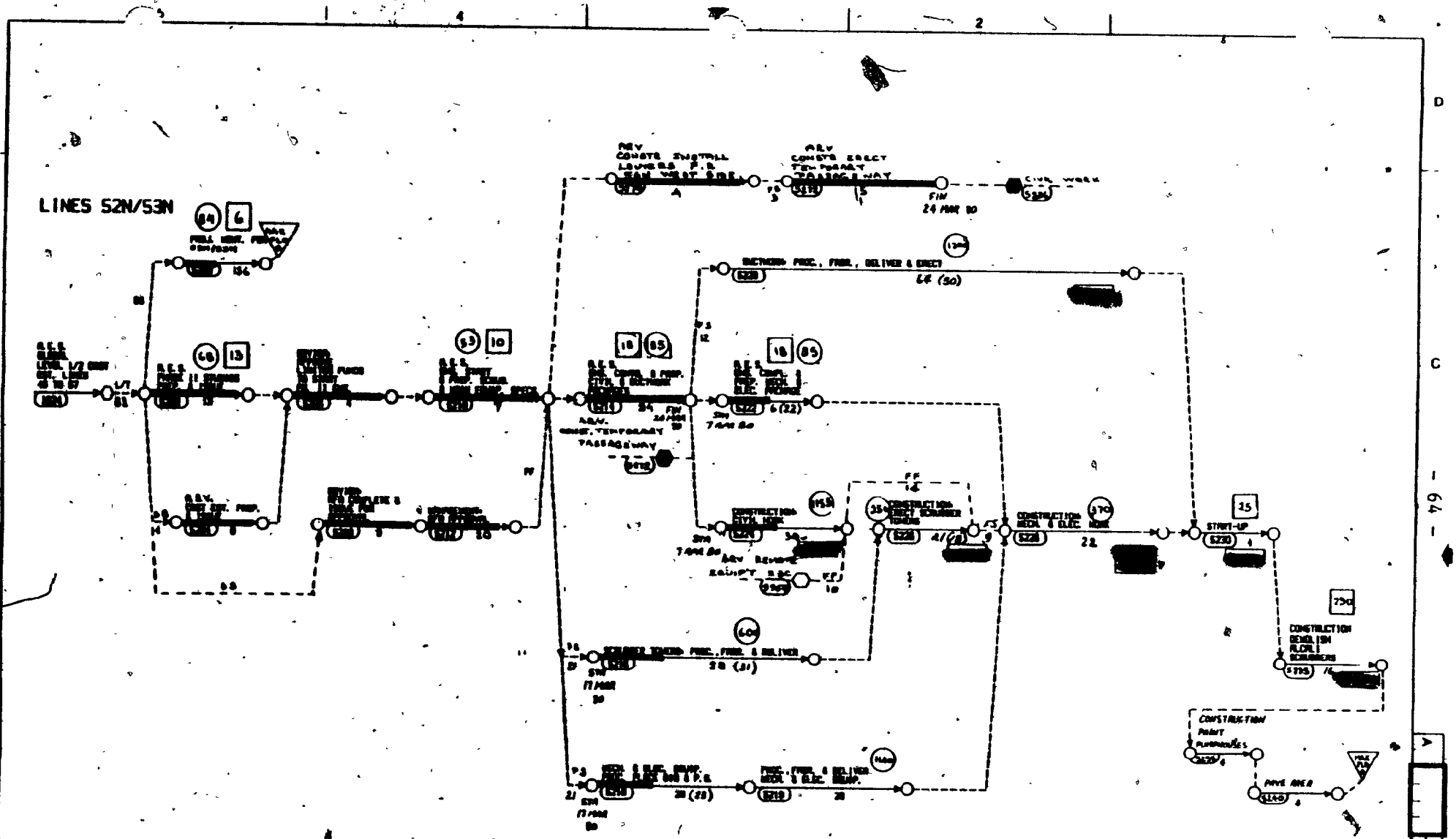


FIGURE 4.10 - CONSTRUCTION MANPOWER DISTRIBUTION

A small amount of levelling was produced by using float or changing lags in some project's activities.

The reports issued included:

1) a summary of manhours per project and per trade;

2) tables illustrating the allocation of resources per trade for the entire program;

3) graphs representing the allocation of resources per trade for the entire program.

4.4.3 Operation

The same principle used in cost was followed in updating the allocation of construction manpower.

Manhours are inputted using information on crew sizes from actual construction reports and after evaluating learning curves from previous projects. (Appendix V)

4.4.3.1 Resource Reports

Resource Allocation···Listings

RESOURCE ALLOCATION BY RESOURCES
For each resource, all activities using that resource listed, daily usage, total usage, activity durations, start, finish.

RESOURCE ALLOCATION BY ACTIVITIES
For each activity, all resources used by that activity listed, daily usage and the total usage of the resource, start, finish, and duration of the activity.

RESOURCE ALLOCATION BY RESOURCES
Pour chaque ressource sont indiquées toutes les activités qui l'utilisent, la consommation journalière et la consommation totale, la durée des activités, leurs dates de début et de fin.

RESOURCE ALLOCATION BY ACTIVITIES
Pour chaque activité sont indiquées les ressources qu'elle utilise, la consommation journalière et totale, les dates de début et de fin et la durée de l'activité.

RESOURCE ALLOCATION BY RESOURCES

			DAYS			
		1.0	8.0	8		
		0.5	2.0	4		
		1.0	5.0	5		
		1.0	5.0	5		
	AVERAGE	1.0	20.0	21		

Each activity using a resource is listed, arranged by start date. Daily and total quantities are printed. Selection of activities is available.

Toutes les activités utilisant des ressources sont éditées. L'ordre de tri est la date de début au plus tôt. Il est possible de sélectionner les activités.

RESOURCE ALLOCATION BY ACTIVITIES

		1:8	1:8		
		1:8	1:8		
		1:8	1:8		

Each resource being used by an activity is shown, including daily and total usage. You can sort the activities and select the resources to be listed.

Toutes les ressources utilisées par une activité sont éditées. Il est possible de définir l'ordre dans lequel sont listées les activités et de sélectionner les ressources.

COLOURED PAPER
PAPIER DE COULEUR

Resource Allocation···Curves

RESOURCE USAGE REPORT
Lists, histograms, or cumulative S-curves of the [illegible] cost of a particular resource. Also [illegible] only start and late start curves. [illegible] may be specified by the user.

RESOURCE MULTIPLE REPORT
[illegible] of histogram usage in tabular or [illegible] of up to 8 different resources on a single [illegible] formats are available.

RESOURCE USAGE REPORT
Liste, histogramme et courbe cumulée de l'utilisation prévue et du coût de chaque ressource. Il est possible de superposer les courbes cumulées d'utilisation ventilée selon les dates de début au plus tôt et au plus tard. L'intervalle de temps peut être le jour, la semaine ou le mois.

RESOURCE MULTIPLE REPORT
Un maximum de 8 courbes d'utilisation de ressources peuvent être définies sur une même page. Différents formats sont disponibles.

MULTIPLE RESOURCE GRAPHS

[illegible] is a cumulative usage plot showing [illegible] planned from the start [illegible] shows that the usage of E's [illegible] usage in mid-June and that [illegible] usage of C's [illegible] begins in early June.

[illegible] ressources sont représentées sur un [illegible]. L'utilisation de E illustrée [illegible] d'avril à la mi-juin et celle de C [illegible] commencent début juin.

This cumulative type display shows E plotted on top of C. For example, at day 41 the project has used a total of 60 construction units and 50 engineering units.

La courbe d'utilisation cumulée de E est représentée au dessus de celle de C. Par exemple au jour 41 le projet a utilisé 50 unités de C et 50 de E.

This interval type plot shows the daily usage of E's and C's.

Ce graphique montre l'utilisation journalière de E et de C.

COLOURED PAPER
PAPIER DE COULEUR

REPORT 4.4

Services de Génie Alcan
Division d Aluminium du Canada, Ltée.

2001, rue University Montreal Adresse postale C P 6090 Montreal Quebec, Canada H3C 3H2
Telephone 514 877-2340 Telex 05-25236 Cables ALCAN

30 November 1979
S.O. 1270.42.12.2

To: Mr. G. St. Pierre

From: J. Prieto

Subject: Arvida Scrubber Programme
Construction Manpower Requirements

Enclosed please find the following information:

1. Summary Schedule
2. Summary Manhour Distribution (Labour and Supervision)
3. Resource Allocation by Trade (Labour and Supervision)
4. Logic Diagrams with Manhour Allocation

The construction manpower requirements were analyzed for:

1. Civil
2. Canbar
3. Mechanical, Structural Steel and Ductwork
4. Arvida Pipefitters
5. Electrical & Instrumentation

Revisions were made for: Scrubber Towers 50N/51N starting construction in January 1981; "Rejoulement des boues" and Scrubber Towers 56N/57N redistributing project costs.

JP:cm

Encl...

Copy to:

Mr. P. Folmer

Circulate S.O. copy to:

Mr. R.A. Beattie
Mrs. M. Morter

Circulate file copy to:

Mr. P. Hawryluk
Mr. H.A. Hughes
Mr. J. Prieto
Mr. C. Brien

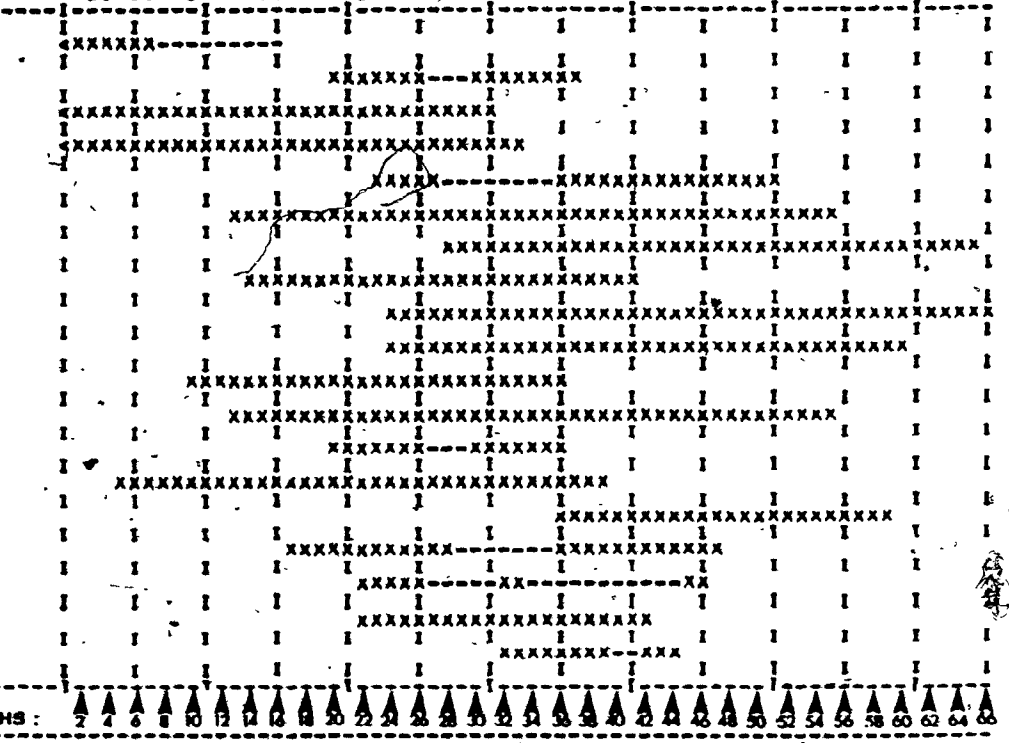
ARVIDA SCRUBBER PROGRAM(POT EXHAUST) AES.SO 1270 SERIES

RUN DATE 26NOV79 1818HRS ***** S U M M A R Y S C H E D U L E ***** PROJECT START 18APR77

PROJECT 1270 STRATEGIC PLAN1 CURRENT COMPLETION 13SEP82

DATA DATE 18APR77 PAGE 1

NUMBER	D E S C R I P T I O N	MODF=C/F
0	GENERAL	
22	SETTLER L26-AUTH.2566	B.BOUDREAU
24	LINE 22N/23N-AUTH.1444	B.BOUDREAU
26	LINE 26N-AUTH.1445	B.BOUDREAU
43	SETTLER 43K-AUTH.5110	G.ST.PIERRE
46	LINE 46N/47N-AUTH.9037	B.BOUDREAU
48	LINE 48N/49N-AUTH.5568	G.ST.PIERRE
49	LINE 49S-AUTH.1999	F.HERUBE
50	LINE 50N/51N-AUTH.5569	B.BOUDREAU
52	LINE 52N/53N-AUTH.5570	F.HERUBE
53	LINE 53S-AUTH.9393	B.BOUDREAU
54	LINE 54N/55N-AUTH.9031	F.HERUBE
55	SETTLER56-57-AUTH.8896	B.BOUDREAU
56	LINE 56N/57N-AUTH.1450	F.HERUBE
58	SUDA DISTR.-AUTH.5573	G.ST.PIERRE
66	WATER LINE.-AUTH.9032	B.MORIN
77	R. DES BOUES-AUTH.8684	H.MORIN
88	CENTR.ALARMS-AUTH.9036	G.ST.PIERRE
99	U/R DUCTING-AUTH.5571	G.ST.PIERRE



RUN DATE 27NOV79 12:01HRS

PROJECT 1270 STRATEGIC PLAN

ARVIDA SCRUBBER PROGRAM(POT EXHAUST)

SUMMARY MANHOURS

LABOR

AES.SO 1270 SERIES

PROJECT START 18APR77

CURRENT COMPLETION 13SEP82

DATA DATE 18APR77 PAGE 1

CODE MOUE=C/F	DESCRIPTION	CIVIL	CANMAR	MECH.+ ST/ST. & DUCTWORK	ARVIDA PIPEFITTERS	ELECTRICAL & INSTRUMENTATION	TOTAL
20	SETTLER L26-AUTH.2588 B.BOUDREAU	4065	0	6120	4120	3355	17660
22	LINE 22N/23N-AUTH.1444 R.BOUDREAU	10730	8435	25590	4845	10475	59985
26	LINE 26N-AUTH.1445 B.BOUDREAU	4670	6185	16175	3390	7745	38165
43	SETTLER 43R-AUTH.5110 G.ST.PIERRE	7800	0	9050	9350	6650	32050
46	LINE 46N/47N-AUTH.9037 R.BOUDREAU	19725	11000	35105	5895	12900	84595
48	LINE 48N/49N-AUTH.5560 G.ST.PIERRE	17490	11250	44415	6510	14735	94400
49	LINE 49S-AUTH.1999 F.HEMURE	5890	5000	11040	2930	7015	31875
50	LINE 50N/51N-AUTH.5569 B.BOUDREAU	16415	11250	43625	5735	13085	92110
52	LINE 52N/53N-AUTH.5570 F.HEMURE	30605	11250	41370	5735	13085	102045
53	LINE 53S-AUTH.9393 B.BOUDREAU	7950	5000	12875	3790	8235	37850
54	LINE 54N/55N-AUTH.9031 F.HEMURE	19725	11000	36340	5510	12900	85475
45	SETTLERS0-53-AUTH.8490 R.BOUDREAU	5390	0	2940	7865	4905	21140
56	LINE 56N/57N-AUTH.1450 F.HEMURE	19380	11135	37585	2475	16370	86925
58	SODA DISTR.-AUTH.5573 G.ST.PIERRE	2500	0	23750	0	3000	29250
66	WATER LINE-AUTH.9032 B.MORIN	9500	0	6350	0	2630	18480
77	P. DES ROUES-AUTH.8684 R.MORIN	0	0	6675	9355	1575	17605
88	CENTR.ALARMS-AUTH.9038 G.ST.PIERRE	7595	0	0	0	7185	14780
99	HOOD DUCTING-AUTH.5571 G.ST.PIERRE	0	0	33335	0	0	33333
	GRAND TOTALS	190630	91505	392230	77455	145895	897715

ARVIDA SCRUBBER PROGRAM(POT EXHAUST)

AE5.SD 1270 SERIES

RUN DATE 27NOV79 1201HRS

SUMMARY MANHOURS

PROJECT START 18APR77

PROJECT 1270 STRATEGIC PLAN)

SUPERVISION

CURRENT COMPLETION 13SEP82

DATA DATE 18APR77 PAGE 1

CODE MODE=C/F	DESCRIPTION	CIVIL	CANRAR	MECH., STRST. & DUCTWORK	ARVIDA PIPEFITTERS	ELECTRICAL & INSTRUMENTATION	TOTAL
20	SETTLEM L20=AUTH.2588 B.BOUDREAU	165	0	125	85	100	475
22	LINE 22N/23N=AUTH.1444 B.BOUDREAU	430	335	510	95	340	1710
26	LINE 26N=AUTH.1445 B.BOUDREAU	190	245	325	70	255	1085
41	SETTLEM 41K=AUTH.5110 G.ST.PIERRE	285	0	180	190	210	865
46	LINE 46N/47N=AUTH.9037 A.BOUDREAU	790	448	700	115	410	2455
48	LINE 48N/49N=AUTH.5568 G.ST.PIERRE	700	450	890	130	460	2630
49	LINE 49S=AUTH.1999 F.BERUBE	235	200	220	60	225	940
50	LINE 50N/51N=AUTH.5569 A.BOUDREAU	735	450	870	115	410	2580
52	LINE 52N/53N=AUTH.5570 F.BERUBE	1225	450	925	115	410	3125
53	LINE 53S=AUTH.9393 A.BOUDREAU	320	200	260	75	275	1130
54	LINE 54N/55N=AUTH.9031 F.BERUBE	785	440	730	110	410	2475
55	SETTLEM50-53=AUTH.8896 B.BOUDREAU	215	0	60	155	145	575
56	LINE 56N/57N=AUTH.1450 F.BERUBE	775	445	750	65	465	2500
58	SODA DISTR.=AUTH.5573 G.ST.PIERRE	50	0	475	0	90	615
64	WATER LINE.=AUTH.9032 B.MORIN	380	0	125	0	80	585
77	H. DES HOURS=AUTH.8804 B.MORIN	0	0	135	185	45	365
88	CENTR.ALARMS=AUTH.9036 B.ST.PIERRE	380	0	0	0	215	595
99	D/R DUCTING=AUTH.5571 G.ST.PIERRE	0	0	660	0	0	660
	GRAND TOTALS	7660	3655	7940	1565	4545	25363

ARVIDA SCRUBBER PROGRAM(POT EXHAUST)

AES,SO 1270-SERIES

RUN DATE 24NOV79-1423HRS

RESOURCE MULTIPLE REPORT

PROJECT START 18APR77

PROJECT 1270 - STRATEGIC PLAN

LABOR

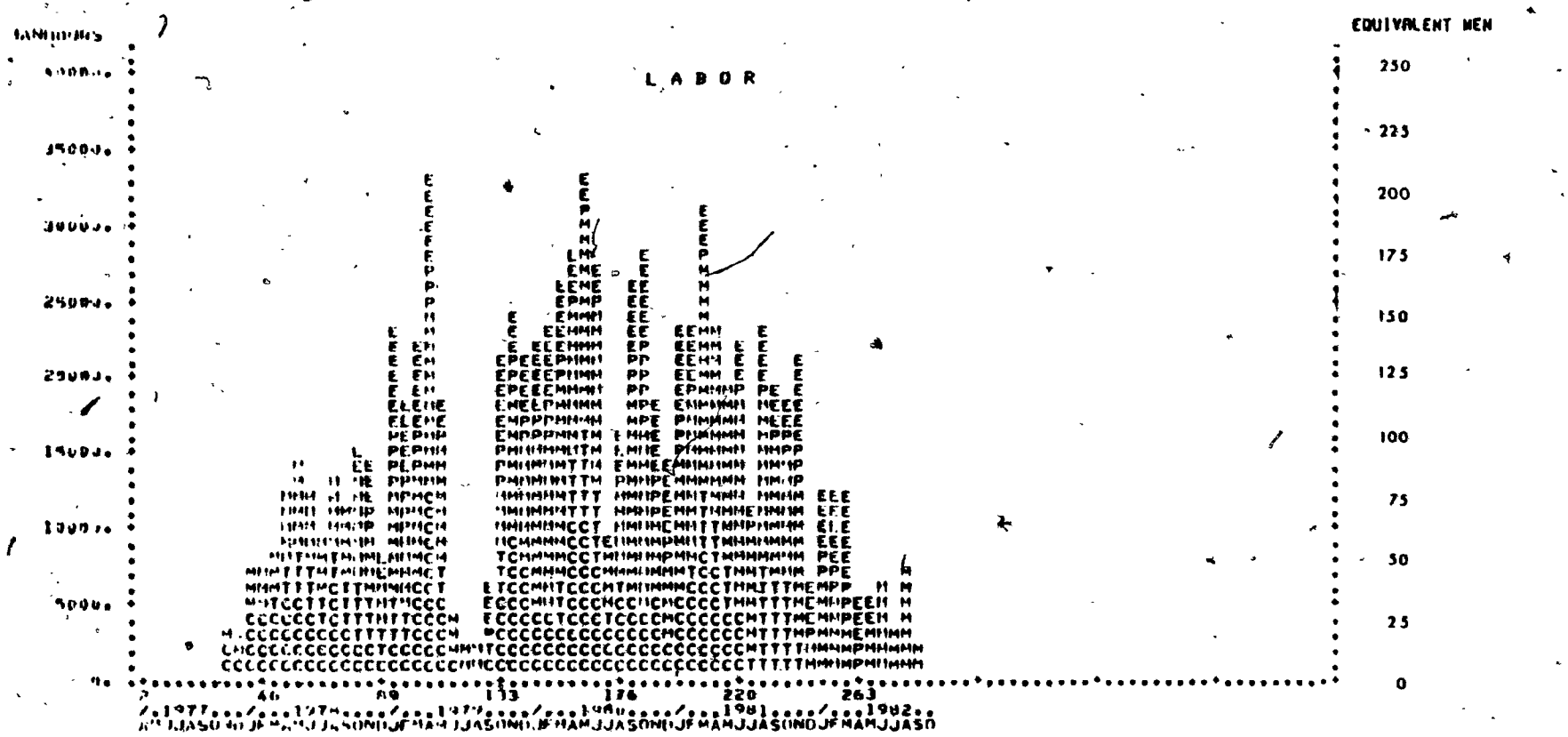
COMPLETION DATE 13SEP82

PAGE 1 DATA DATE 18APR77

DATE	JOU DAY	CIVIL	CARBAR	MECH.& STRST. & DUCTWORK	ARVIDA PIPEFITTING	ELECTRICAL & INSTRUMENTATION
25APR77	2	0.0	0.0	0.0	0.0	0.0
30MAY77	7	0.0	0.0	0.0	0.0	0.0
27JUN77	11	0.0	0.0	0.0	0.0	0.0
29JUL77	15	0.0	0.0	0.0	0.0	0.0
29AUG77	20	0.0	0.0	0.0	0.0	0.0
26SEP77	24	0.0	0.0	0.0	0.0	0.0
31OCT77	28	0.0	0.0	0.0	0.0	0.0
28NOV77	33	1893.53	0.0	1630.00	0.0	0.0
26DEC77	37	1262.35	0.0	1026.00	0.0	0.0
30JAN78	42	3739.63	0.0	3088.65	0.0	0.0
27FEB78	46	3692.21	0.0	2957.31	0.0	0.0
27MAR78	50	3941.94	602.50	3466.06	0.0	0.0
24APR78	54	4691.13	2410.00	4992.38	0.0	0.0
29MAY78	59	4982.29	3012.50	6240.38	0.0	0.0
26JUN78	63	3523.64	3647.00	4992.38	0.0	0.0
31JUL78	68	3137.00	1855.50	3744.23	0.0	0.0
28AUG78	72	5511.13	2474.00	4992.38	0.0	0.0
25SEP78	76	2460.41	3084.57	4992.38	0.0	0.0
30OCT78	81	2484.38	3976.79	6240.38	660.68	1249.37
27NOV78	85	1673.08	3181.43	4642.48	1464.84	2937.69
25DEC78	89	1208.33	2090.71	2192.42	936.53	1921.98
29JAN79	94	2321.67	2588.00	7272.53	4078.10	7856.22
26FEB79	98	1857.33	2004.00	5635.50	3262.48	6446.57
26MAR79	102	5547.33	0.0	7382.26	3262.48	6446.57
30APR79	107	12341.66	0.0	11784.53	2976.96	6285.27
28MAY79	111	5365.58	1508.00	8885.73	1142.93	1468.91
25JUN79	115	850.75	0.0	3104.66	0.0	0.0
30JUL79	120	0.0	0.0	1539.29	0.0	0.0
27AUG79	124	0.0	0.0	1539.29	0.0	0.0
24SEP79	129	775.58	1000.00	718.13	636.90	2408.57
29OCT79	133	5399.26	2400.00	3673.44	3286.29	5871.97
26NOV79	137	8867.90	0.0	9031.13	3357.48	2421.74
31DEC79	142	7013.37	0.0	7921.92	2518.11	3229.36
28JAN80	146	4001.19	0.0	10628.43	2386.05	4755.35
25FEB80	150	4358.55	0.0	10906.73	3201.09	4355.84
31MAR80	155	2667.57	3162.86	13868.42	1966.19	4717.75
28APR80	159	10099.78	3928.57	10124.23	1121.41	2312.80
26MAY80	163	10119.70	6285.71	14038.57	689.04	1467.86
30JUN80	168	6699.62	9588.00	12051.81	517.06	1736.72
28JUL80	172	2573.60	1471.43	3982.34	250.45	1087.69
25AUG80	176	4628.65	1471.43	5976.81	1801.82	2462.21
29SEP80	181	4637.12	0.0	13031.01	3648.94	4186.65
27OCT80	185	3709.70	0.0	12285.95	5921.51	5704.93
24NOV80	189	5299.78	0.0	4328.95	3101.52	5704.93
29DEC80	194	2385.08	0.0	4192.59	2893.99	4653.70
26JAN81	198	5481.87	0.0	8610.68	3187.29	8396.31
23FEB81	202	6249.16	805.57	10927.97	1324.70	3770.04
30MAR81	207	7811.48	4017.86	13645.48	799.77	2549.39
27APR81	211	8749.16	3214.29	12709.22	0.0	582.50
25MAY81	215	4068.17	3214.29	11348.39	0.0	0.0
29JUN81	220	4069.17	0.0	13743.82	1381.41	2775.00
27JUL81	224	0.0	805.57	8293.77	521.36	1110.00
31AUG81	229	0.0	7232.14	10387.57	1303.41	4325.00
28SEP81	233	0.0	4428.57	8318.09	1042.73	3870.00
26OCT81	237	0.0	6420.57	8068.65	1042.73	2820.00
30NOV81	242	0.0	1607.14	10476.85	2717.76	8223.75
28DEC81	246	0.0	0.0	2026.04	1069.73	2715.00
25JAN82	250	0.0	0.0	5701.43	2139.47	4555.00
22FEB82	254	0.0	0.0	5118.57	2139.47	4555.00
29MAR82	259	0.0	0.0	3196.00	2674.34	5693.75
26APR82	263	0.0	0.0	0.0	1547.65	3732.50
31MAY82	268	0.0	0.0	2557.50	477.92	2111.88
28JUN82	272	0.0	0.0	5482.50	0.0	218.75
26JUL82	276	0.0	0.0	3380.00	0.0	0.0
30AUG82	281	0.0	0.0	6545.00	0.0	0.0
27SEP82	285	0.0	0.0	1595.00	0.0	0.0
		190629.94	91504.94	392229.94	77454.94	145894.94

LEGEND

NUMBER	DESCRIPTION	PLOT CHARACTER	UNIT OF MEASURE	TOTAL USAGE
00.00	CIVIL LABOR	C	MANHOURS	190630.
50.00	CARPAR LABOR	T	MANHOURS	91505.
60.00	TECH'S, ST/ST, & DUCTWORK LABOR	M	MANHOURS	392230.
73.00	ARVIDA FORCES PIPEFITTERS	P	MANHOURS	77455.
90.00	ELECTRICAL & INSTRUMENTATION LABOR	E	MANHOURS	145825.



ARVIDA SCRUBBER PROGRAM(POT EXHAUST) AE5.50 1270 SERIES

RUN DATE 20NOV77 1420HRS RESOURCE MULTIPLE REPORT PROJECT START 18APR77

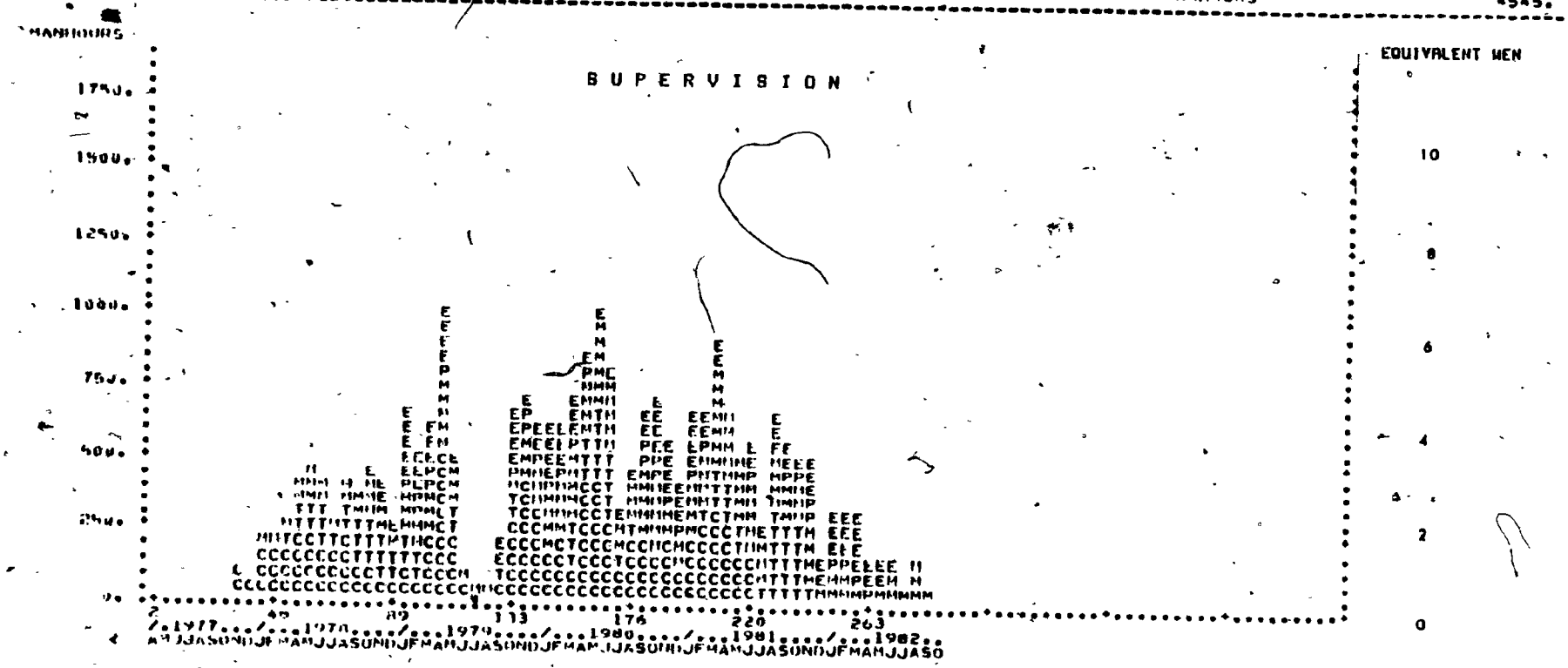
PROJECT 1270 STRATEGIC PLANT SUPERVISION COMPLETION DATE 10SEP82

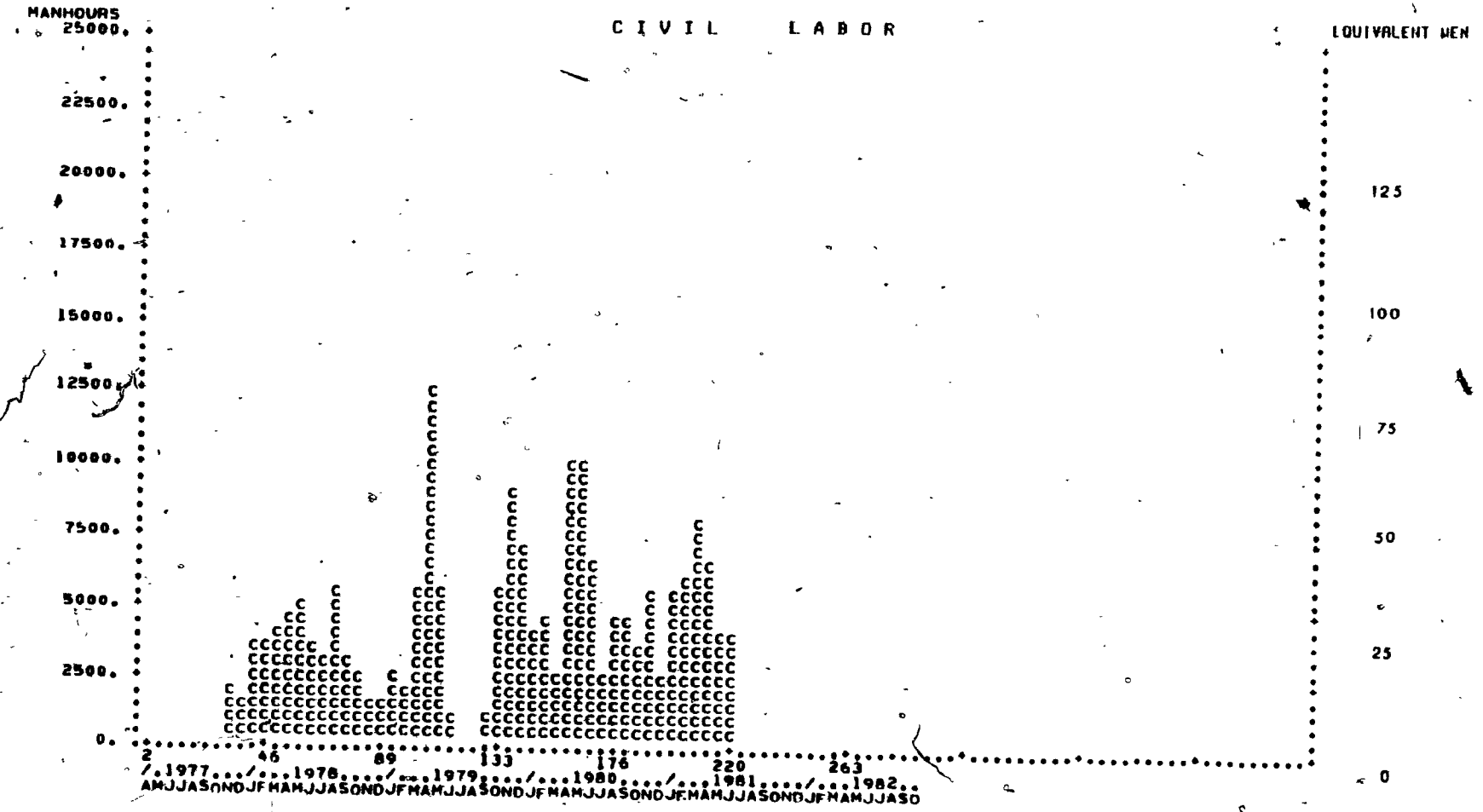
PAGE 1 DATA DATE 18APR77

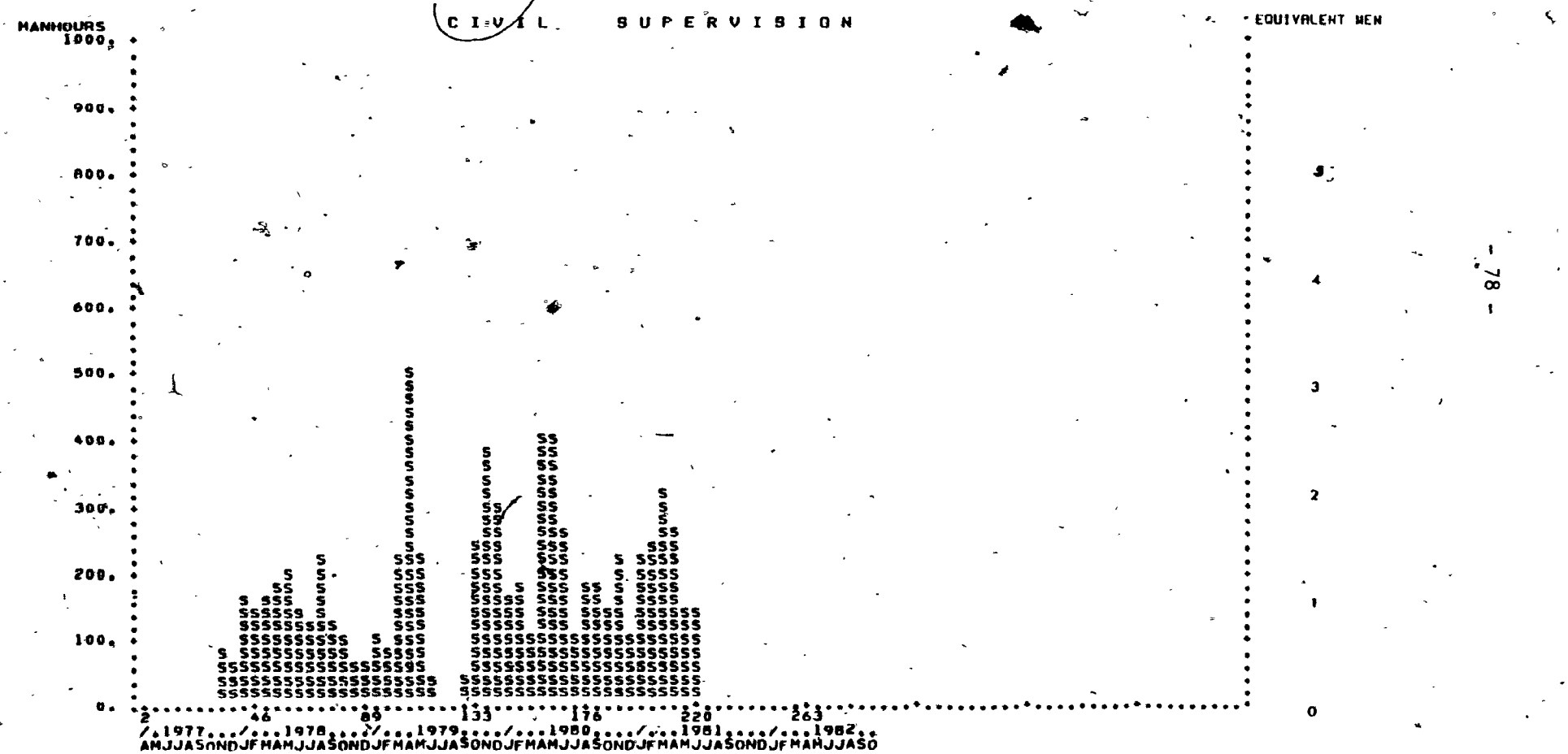
DATE	JOB DAY	CIVIL	CANADA	MECH., STEEL & DUCTWORK	ARVIDA PIPEFITTERS	ELECTRICAL & INSTRUMENTATION
25APR77	7	0.0	0.0	0.0	0.0	0.0
30MAY77	7	0.0	0.0	0.0	0.0	0.0
27JUN77	11	0.0	0.0	0.0	0.0	0.0
25JUL77	15	0.0	0.0	0.0	0.0	0.0
29AUG77	20	0.0	0.0	0.0	0.0	0.0
26SEP77	24	0.0	0.0	0.0	0.0	0.0
31OCT77	29	0.0	0.0	0.0	0.0	0.0
28NOV77	33	75.HR	0.0	38.68	0.0	0.0
26DEC77	37	50.39	0.0	20.48	0.0	0.0
30JAN78	42	150.22	0.0	60.23	0.0	0.0
27FEB78	46	148.68	0.0	59.20	0.0	0.0
27MAR78	50	150.01	23.93	69.44	0.0	0.0
28APR78	54	188.61	95.71	99.88	0.0	0.0
29MAY78	59	199.89	114.64	124.97	0.0	0.0
26JUN78	63	140.21	144.71	99.98	0.0	0.0
31JUL78	68	125.64	73.58	74.98	0.0	0.0
28AUG78	72	220.91	98.08	99.98	0.0	0.0
25SEP78	76	115.23	119.86	99.98	0.0	0.0
30OCT78	81	180.88	158.93	124.97	12.95	37.50
27NOV78	85	67.33	127.14	92.99	29.24	88.07
24DEC78	89	50.82	43.57	43.87	16.76	87.56
29JAN79	94	92.92	100.89	145.70	85.28	212.65
26FEB79	98	74.33	88.89	112.85	68.23	169.64
26MAR79	102	221.92	0.0	145.76	68.23	169.64
30APR79	107	201.97	0.0	234.98	63.69	214.88
28MAY79	111	217.12	88.89	168.98	23.63	55.98
25JUN79	115	34.17	0.0	61.79	0.0	0.0
30JUL79	120	0.0	0.0	30.71	0.0	0.0
27AUG79	124	0.0	0.0	30.71	0.0	0.0
24SEP79	128	30.33	48.80	14.73	12.38	72.50
29OCT79	133	233.39	100.89	75.22	64.55	182.79
26NOV79	137	377.73	0.0	182.56	67.17	75.29
31DEC79	142	294.24	0.0	159.75	50.38	187.86
28JAN80	146	160.24	0.0	212.88	47.17	155.57
25FEB80	150	170.38	0.0	217.43	64.73	147.93
31MAR80	155	187.84	125.71	272.50	48.79	130.34
28APR80	159	405.68	197.14	286.17	23.12	60.53
26MAY80	163	405.68	251.43	288.33	14.12	43.63
30JUN80	168	200.11	228.89	249.93	16.59	66.15
28JUL80	172	184.24	62.86	83.89	5.88	48.91
25AUG80	176	180.98	62.86	127.79	20.88	73.64
29SEP80	181	169.01	0.0	209.73	73.36	185.68
27OCT80	185	140.68	0.0	253.79	119.02	170.91
24NOV80	189	212.12	0.0	93.79	62.82	170.91
29DEC80	194	98.65	0.0	98.36	57.23	138.90
26JAN81	198	219.15	0.0	181.05	61.31	179.97
23FEB81	202	244.77	32.14	227.88	24.19	122.20
30MAR81	207	312.22	164.71	322.68	15.68	94.38
27APR81	211	252.77	128.57	295.38	0.0	38.88
29MAY81	215	142.58	224.57	227.88	0.0	0.0
29JUN81	220	142.58	0.0	275.64	24.14	82.95
27JUL81	224	0.0	32.14	166.82	19.45	33.18
31AUG81	229	0.0	289.29	207.77	24.14	129.65
28SEP81	233	0.0	257.14	164.81	28.91	91.86
26OCT81	237	0.0	257.14	161.21	28.91	84.38
30NOV81	242	0.0	64.29	209.58	84.37	145.62
28DEC81	246	0.0	0.0	48.59	21.68	98.64
25JAN82	251	0.0	0.0	114.76	42.88	136.29
22FEB82	254	0.0	0.0	161.98	42.88	136.29
29MAR82	259	0.0	0.0	93.33	53.58	170.36
26APR82	263	0.0	0.0	0.0	38.98	121.66
31MAY82	268	0.0	0.0	51.25	9.56	86.67
28JUN82	272	0.0	0.0	118.83	0.0	11.25
26JUL82	276	0.0	0.0	68.83	0.0	0.0
30AUG82	281	0.0	0.0	138.42	0.0	0.0
27SEP82	285	0.0	0.0	31.67	0.0	0.0
		7600.00	3455.00	7940.00	1565.00	4565.00

LEGEND

NUMBER	DESCRIPTION	PLOT CHARACTER	UNIT OF MEASURE	TOTAL USAGE
03.00	CIVIL SUPERVISION	C	MANHOURS	7660.
05.00	CARBAR SUPERVISION	T	MANHOURS	3655.
61.00	MECH., ST/ST, & DUCTWORK SUPER.	M	MANHOURS	7940.
74.00	ARVIDA PIPING SUPERVISION	P	MANHOURS	1565.
84.00	ELECTRICAL & INSTRUMENTATION SUPER.	E	MANHOURS	4545.




CIVIL LABOR
MANHOURS
25000.
22500.
20000.
17500.
15000.
12500.
10000.
7500.
5000.
2500.
0.
EQUIVALENT MEN
125
100
75
50
25
0
2
46
89
133
176
220
263
/.1977.../...1978..../...1979..../...1980..../...1981..../...1982..
AMJJASONDJFMAMJJASONDJFMAMJJASONDJFMAMJJASONDJFMAMJJASONDJFMAMJJASO


C I=V I L S U P E R V I S I O N
MANHOURS
1000.
900.
800.
700.
600.
500.
400.
300.
200.
100.
0.
EQUIVALENT MEN
5
4
3
2
1
0
2
46
89
133
176
220
263
/1977.../.../1978.../.../1979.../.../1980.../.../1981.../.../1982..
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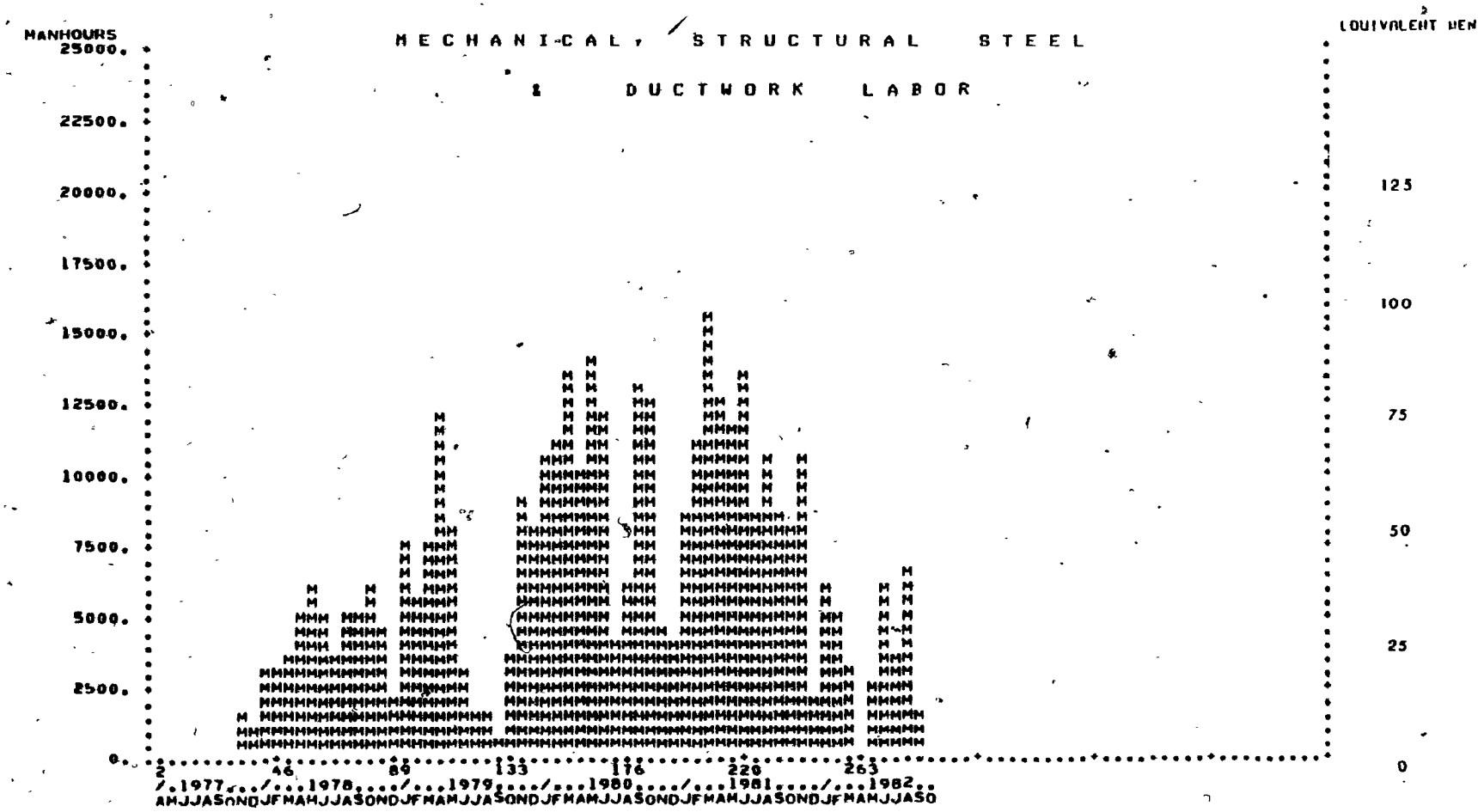
MECHANICAL, STRUCTURAL STEEL
& DUCTWORK LABOR
MANHOURS
25000.
22500.
20000.
17500.
15000.
12500.
10000.
7500.
5000.
2500.
0.
LOUIVALENT MEN
125
100
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0
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46
89
133
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263
/.1977.../...1978..../...1979..../...1980..../...1981..../...1982..
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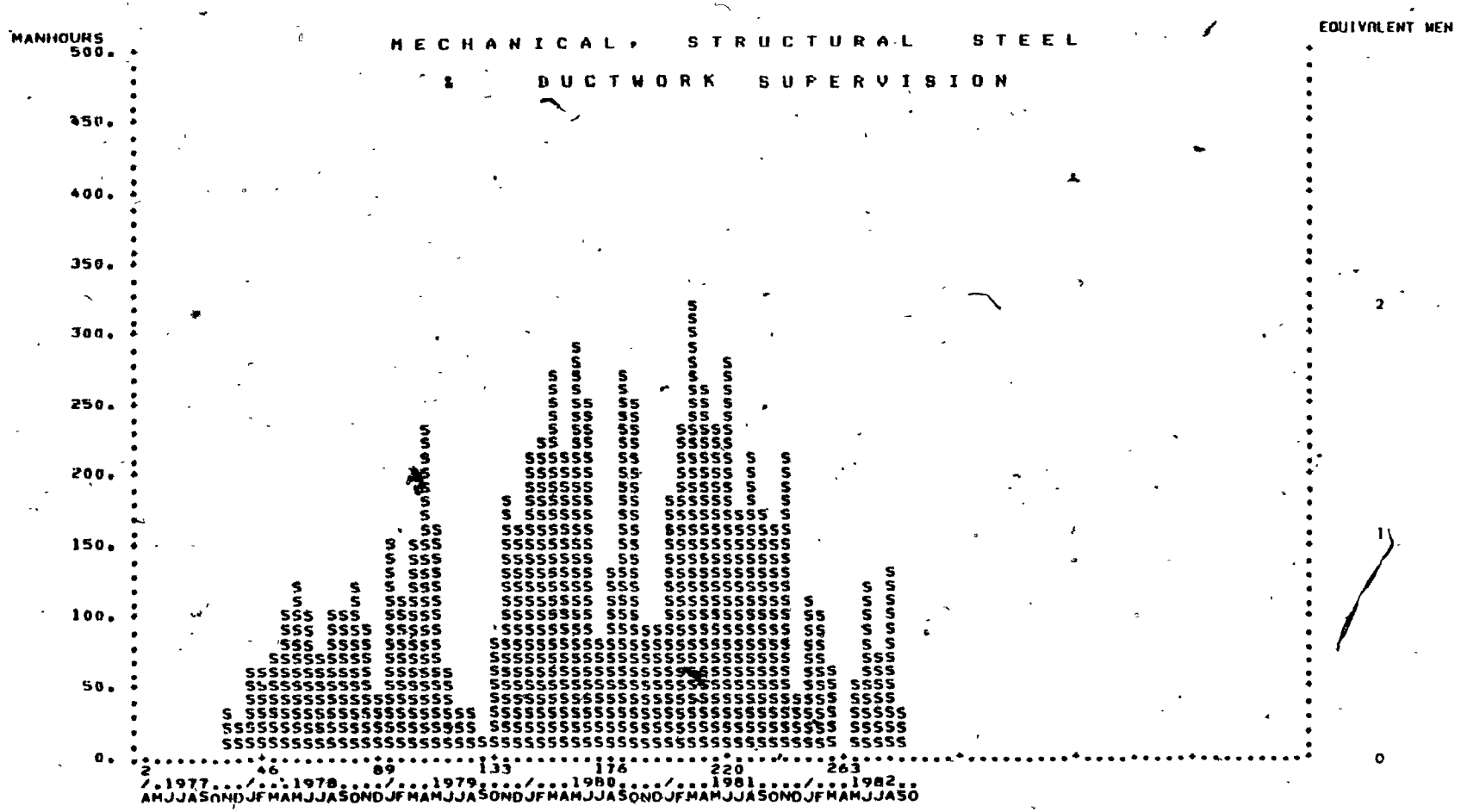
MECHANICAL, STRUCTURAL STEEL
& DUCTWORK SUPERVISION
MANHOURS
EQUIVALENT MEN
500.
450.
400.
350.
300.
250.
200.
150.
100.
50.
0.
2
1
0
46
89
133
176
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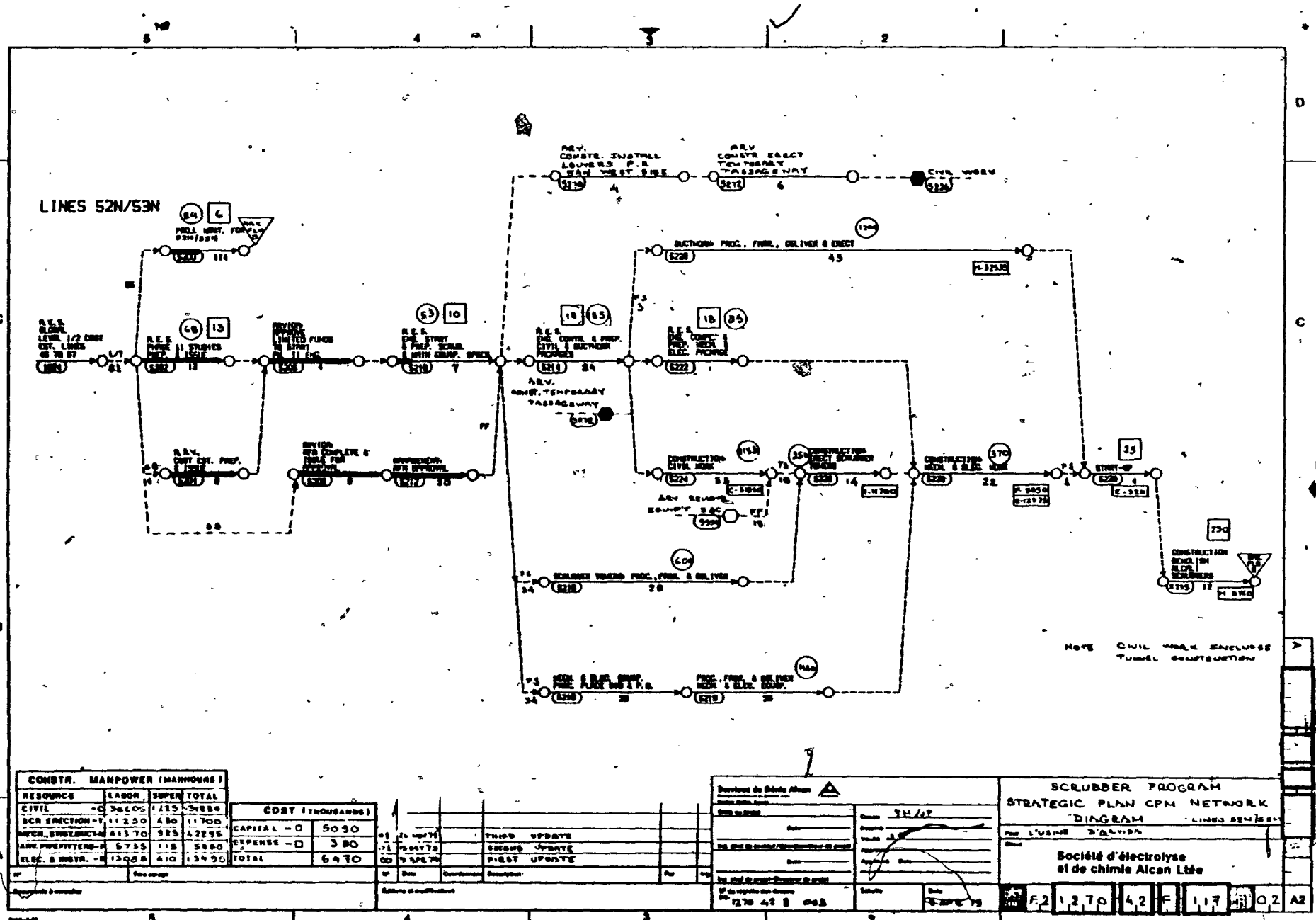


CONSTR. MANPOWER (MANHOURS)			
RESOURCE	LABOR	SUPER	TOTAL
CIVIL -C	36405	1235	37640
BCR ERECTION -T	11250	450	11700
MECH. STRUCTURE	41370	925	42295
ARC PIPEFITTERS-P	5735	115	5850
ELEC. & INSTR. -E	13008	410	13418

COST (THOUSANDS)	
CAPITAL -D	5090
EXPENSE -D	380
TOTAL	6470

SCRUBBER PROGRAM
STRATEGIC PLAN CPM NETWORK DIAGRAM
Société d'électrolyse et de chimie Alcan Ltée

F2 1270 42 F 117 02 A2

CHAPTER 5 - ENGINEERING CONTROL SYSTEM

5.1 General

At this point, it is important to discuss the differences between monitoring and controlling.

In monitoring, a project's progress is reported and it is possible to determine the existing deviations from the original or revised estimate of expenditures. Monitoring was explained in detail in the section 'TIME, COST AND CONSTRUCTION MANPOWER' in the previous chapter.

In the controlling stage, certain parameter(s) are chosen and a measurement of their performance is obtained. This performance can also be viewed as a measurement of 'accomplishment' or 'earned value'. In some cases, the performance of certain parameters depends on that of another parameter within the same project. e.g. Cost performance is affected by manhour performance, which will be explained later in this chapter.

The difference between monitoring and controlling is easily visualized in figure 5.1.

In controlling, not only can the trend in the actual's curve be studied, but also the one for earned value.

Sometimes management utilizes the graph which illustrates the earn-actual ratio, which can be viewed as a measurement of productivity. Figure 5.2

In controlling, an estimate other then the traditional "forecast to complete" can be produced. This estimate is a final indicator of all the expenditures for a parameter and is named the "parameter trend indicator".

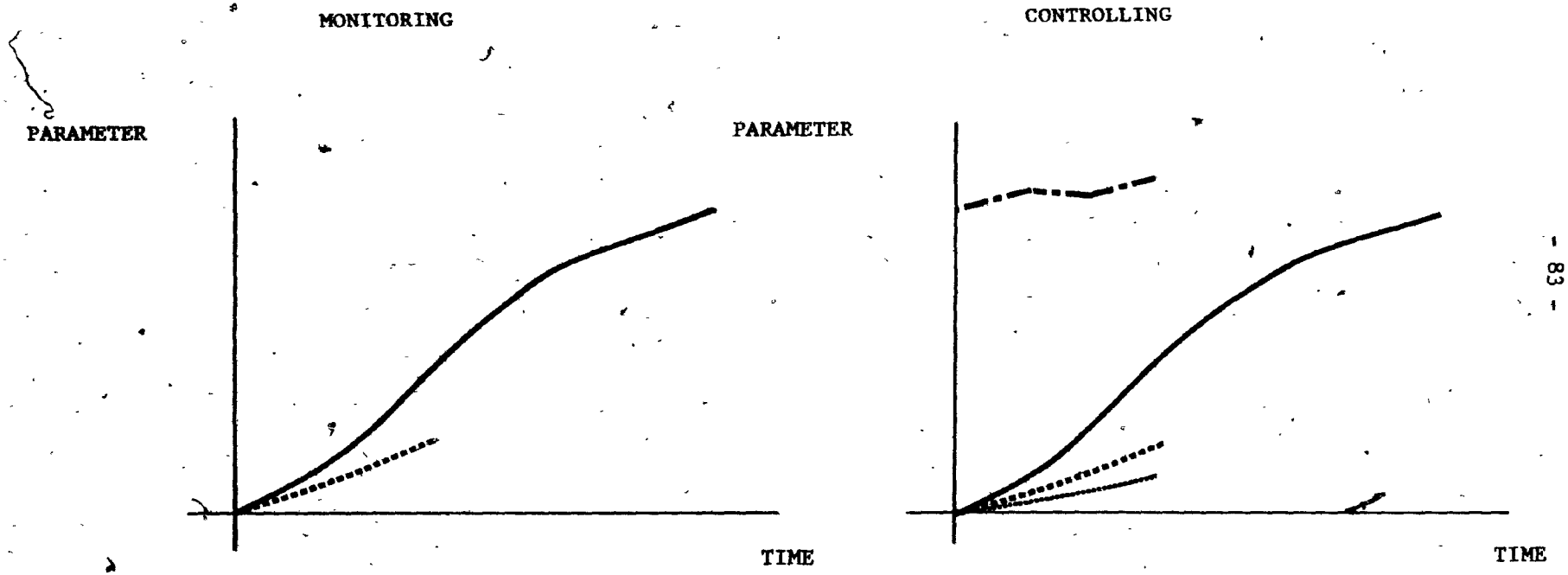


FIGURE 5.1 - MONITORING AND CONTROLLING

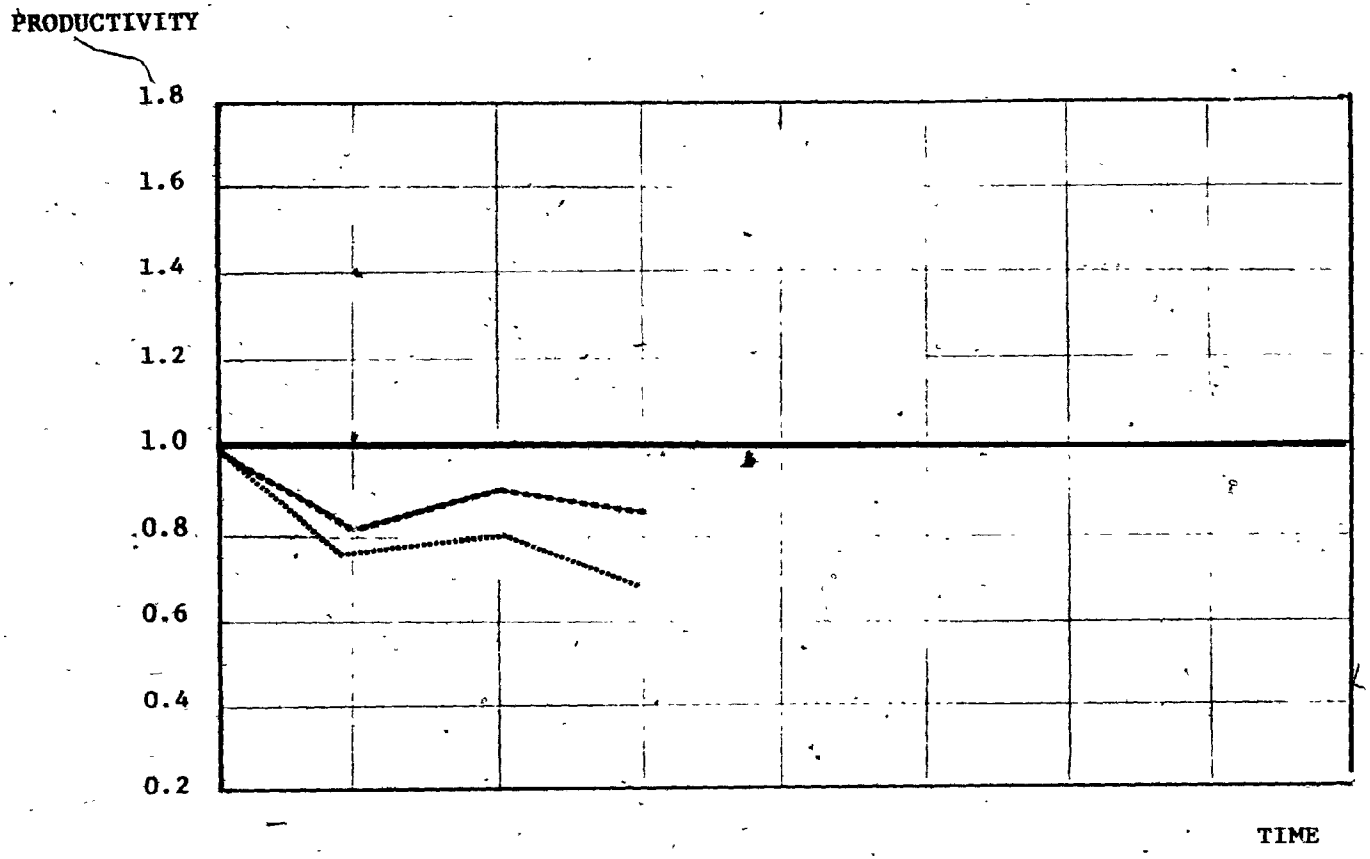


FIGURE 5.2 - PRODUCTIVITY GRAPH

A more exact estimate of how much a project is ahead or behind schedule can be established by calculating the time difference between the earned value and the original or revised estimate. Moreover, a more precise estimate of how much the parameter is under or over-expended can be determined by computing the difference between the earned value and the original or revised estimate.

In controlling a project many alternatives exist, all reflecting the current status of the project in terms of a particular parameter.(Figure 5.3) . It is important to note that in an on-going project curves can intercept.

In a project, all stages, such as engineering, procurement, and construction, can be controlled by a proper parameter selection. By choosing to control the same parameter (e.g. cost or manhours) in all stages, a complete control system for the project can be achieved by totalling all performances of the parameter. Figure 5.4

5.2 Controlling in the program

In the Scrubber Program, the planning department's last objective was to implement, in Final Engineering a Engineering Controlling System for some projects.

A complete and detailed estimate of the Engineering and Engineering Services had been developed in Preliminary Engineering. This was considered to be the target estimate.

Although this system has only been applied to a few projects, it has proven to be quite a successful controlling tool,because trends and problems are evaluated and detected in the very beginning months of the project. For the other stages in the remaining projects, management utilized a traditional controlling-monitoring approach.

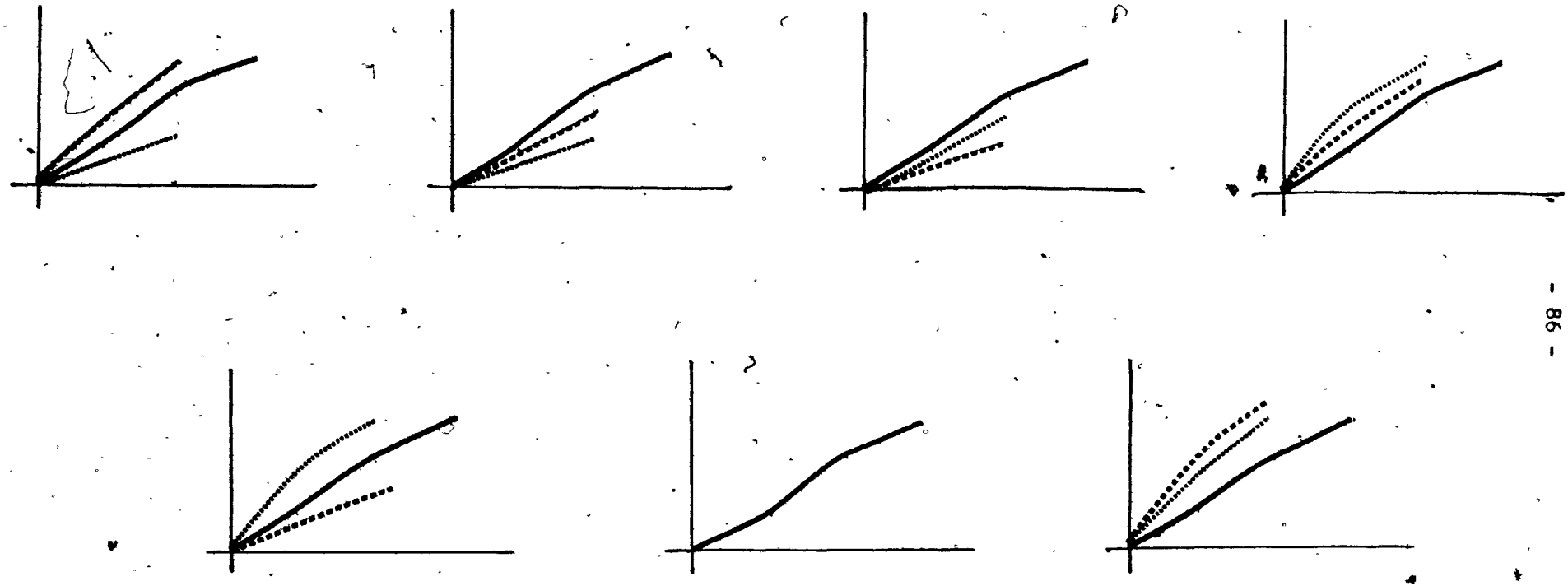


FIGURE 5.3 - PROJECT STATUS CASES

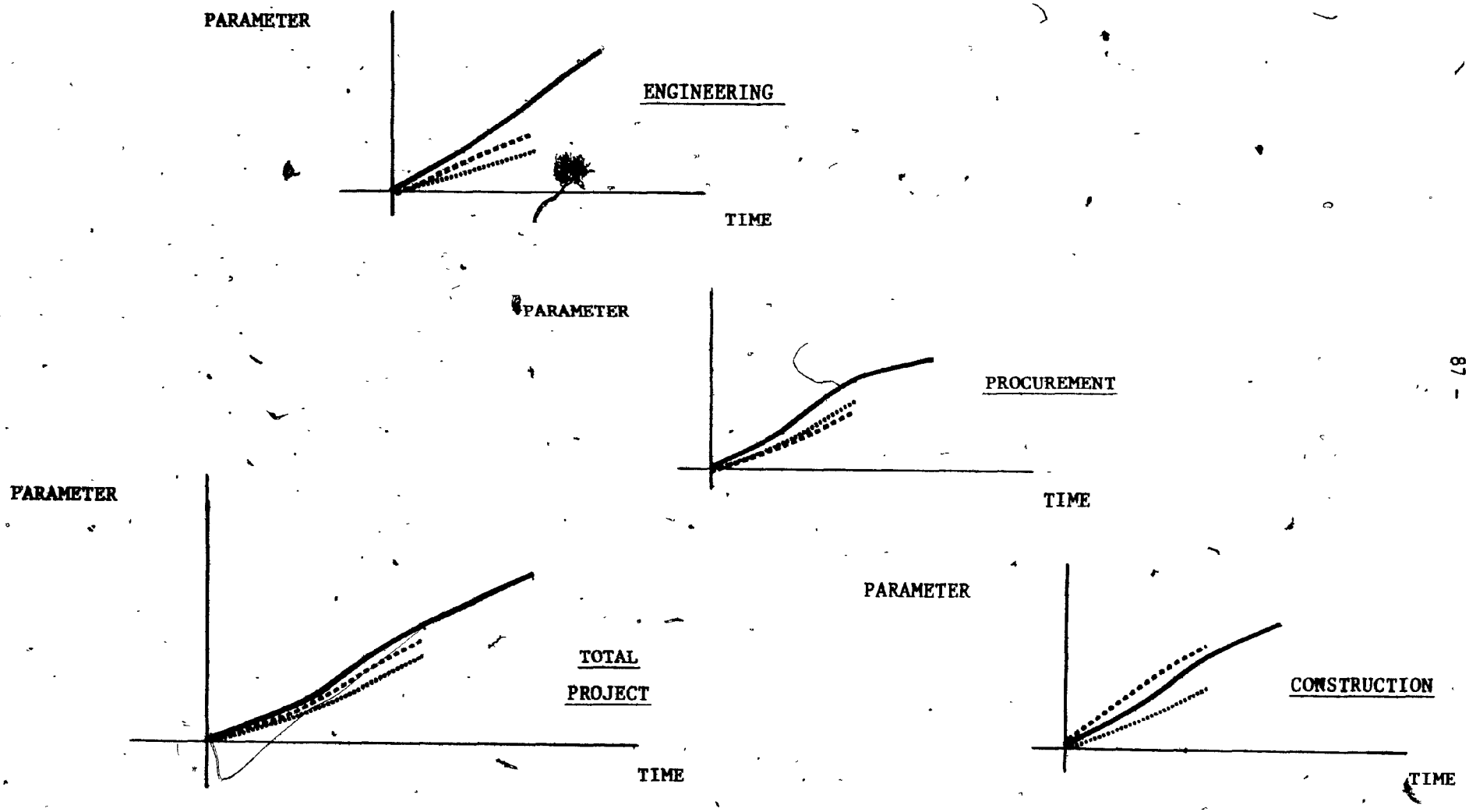


FIGURE 5.4 - TOTAL PROJECT CONTROL

For the engineering disciplines, the manhours and cost estimate are subdivided into those for conceptual engineering as well as for design and drafting. Engineering services (planning, estimating, etc) and indirect charges have a global estimate.

The cost estimate was determined by multiplying the various rates by the estimated manhours per account. Appendix VI

5.3 Report. Preparation.

The Engineering Control System provides a report which includes the documents illustrated in figure 5.5.

Manhours and costs for engineering, and those for design and drafting, were controlled independently due to the difficulty in establishing a correlation between them. In some instances design and drafting can begin a drawing with very little engineering involvement and at other times design and drafting requires that all engineering be completed in order to begin the drawing.

5.3.1 Documents

5.3.1.1 Schedule

After the list of drawings is completed and drawing schedules (Appendix VII) are in the process of been issued or are already issued, the discipline engineer, or in some cases the squad leader, along with the planner, schedule groups of drawings. These groups of drawings must be produced by engineering and design and drafting within the milestone dates as outlined on the project's master schedule.

In the schedule, dates are listed by which a

SCRUBBER PROGRAM

ENGINEERING CONTROL SYSTEM DOCUMENTS

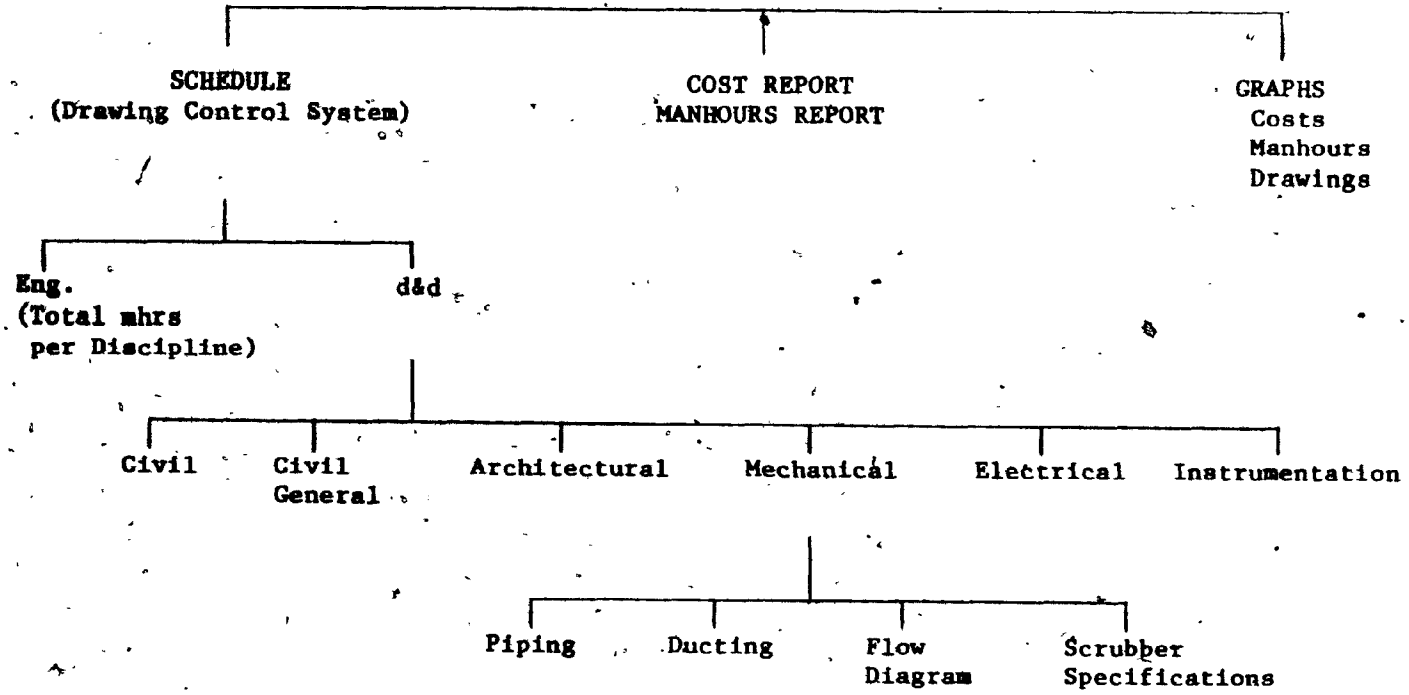


FIGURE 5.5 - PROJECTS ENGINEERING CONTROL SYSTEM DOCUMENTS

discipline requires any special information necessary to complete a group of drawings.

The drawings are distributed throughout the bid packages. Special attention is given to the distribution of manhours, in order to judge if availability of manpower will become a problem. In the case of unavailability of manpower, possible solutions are discussed and may include: hiring personel; increasing overtime work; and usage of preliminary drawings for bidding purposes, thus allowing 2-4 weeks of lead time in which to finalize and issue drawings. Manpower distributions are also required to complete the manhour, cost and drawing graphs.

Next, the duration, manhours and drawings for the drawing groups are computed. Some disciplines schedule and assign manhours to such miscellaneous "groups" as familiarization, revisions as built, specification preparation, etc. By adding all the discipline group manhours, a total design and drafting manhours is obtained. This total is then compared to the target estimate and in some instances, adjustments are introduced until a final estimate is agreed upon by the project manager and discipline engineers.

For the design and drafting, the cost estimate is easily calculated by multiplying the current hourly rates by the approved manhours.

After the Engineering and Engineering Services' manhours and costs have been discussed and approved,

it is possible to determine the total manhours and original cost estimate.

At this point, both planning and the discipline engineers set the criteria, procedures and dates for progress reporting. Appendix VIII. By following these an efficient and effective turnover is achieved.

5.3.1.2 Manhours and Cost Reports

The manhour report has six columns with the following headings: the original estimate; the revised estimate; the actual manhours; the earned manhours; the trend indicator; and the productivity factor. Column one is completed at this stage, the remaining during the system operation.

The columns in the cost report are the same as the first five columns in the manhour report. Similarly, the only column completed at this stage is the first one.

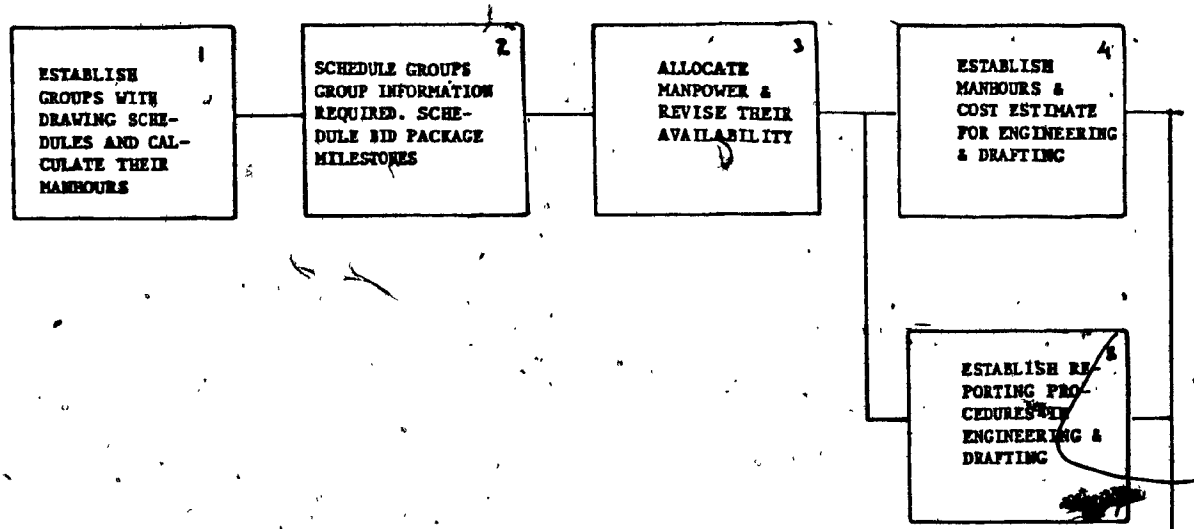
5.3.1.3 Graphs

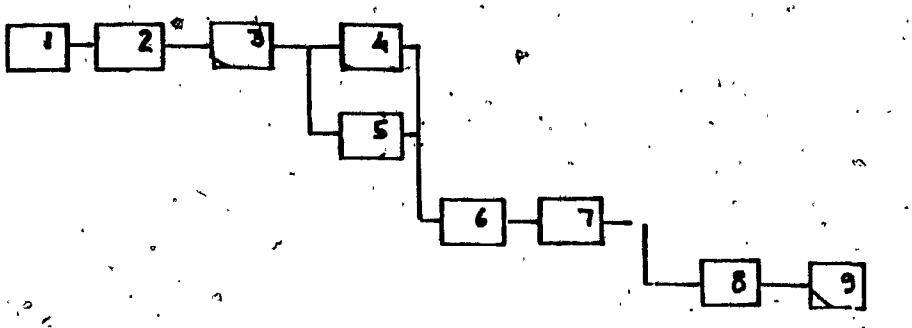
Manhours , costs and drawings are plotted on graphs using: 1) Information from previous documents and 2) the manhour discipline distribution determined when the schedule was made. These graphs provide management with a fast view of the project's performance in relation to the original estimate.

At this stage, only the "original estimate" curves are plotted on the graphs. The drawing graph has two curves; one indicating estimated drawing production,

SCRUBBER PROGRAM

ENGINEERING CONTROL SYSTEM





SCHEDULE DRAWING GROUPS → PREPARE STATUS REPORTS → PREPARE GRAPHS

10f

ER PROGRAM

OL SYSTEM PREPARATION

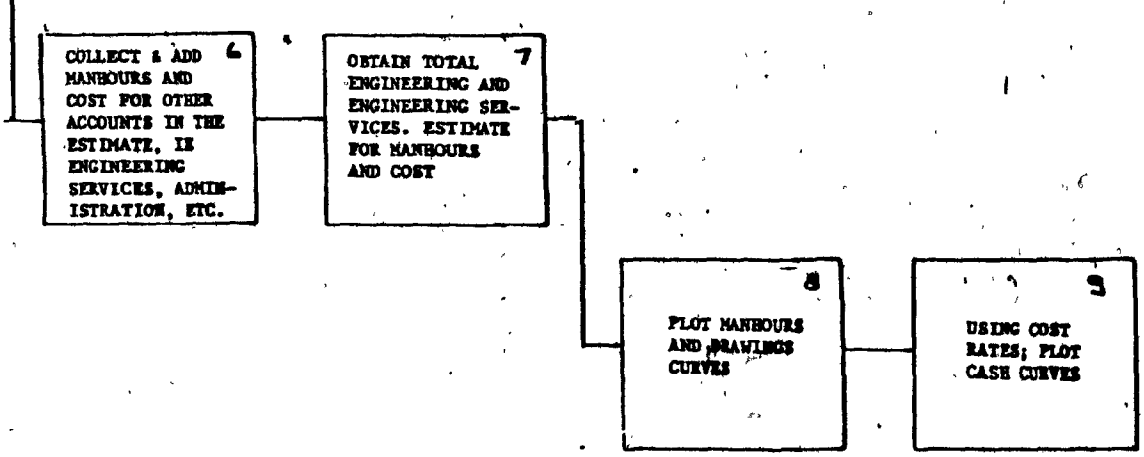


FIGURE 5.6 – ENGINEERING & ENGINEERING SERVICES CONTROL SYSTEM: PREPARATION

the other estimated drawing issuing.

Figure 5.6 shows the tasks required for the preparation of the Engineering Controlling System.

5.4 Report Operation.

At the end of each month the planning department collects the drawing schedules from the engineering disciplines. In these drawing schedules, each drawing has a corresponding drawing group.

For all disciplines, additions and deletions in drawings are checked and schedule groups are revised accordingly. For a particular month, changes in any group of drawings are underlined for easy detection by management.

From the drawing schedules the percent completion and earned manhours of each drawing are calculated. Using the manhours earned per drawing as well as equation (1), a percent earned; per group, per discipline and for the entire project is obtained.

$$\text{Percent Earned}_{\substack{\text{group}\\\text{discipline}\\\text{project}}} = \frac{\text{Manhours Earned}}{\text{Manhours Estimated}} = \frac{\sum\left(\text{Estimated Manhours}_{dwg} \times \text{Percent Complete}_{dwg}\right)}{\sum\left(\text{Estimated Manhours}_{dwg}\right)}$$

After the percent earned has been determined for the groups, the schedule is updated in consultation with each discipline engineer. In some cases new dates for drawing group completions are forecasted. At the same time the discipline engineer evaluates the engineering percent completion in order to establish earned manhours, trends and productivity factor.

At this stage the company's accounting department provides information on actual expenditures of manhours and costs. Further calculations are made in order to correlate the project expenditures with the breakdown of manhours and cost reports. Appendix IX.

By having the actual expenditures and percent earned for both disciplines and engineering services, it is possible to calculate the manhours and cost trend indicators. These indicators (Figure 5.7) forecast the total manhours and cost in the project, using the same ratio between earned and actual expenditures as the one recorded on the reporting date.

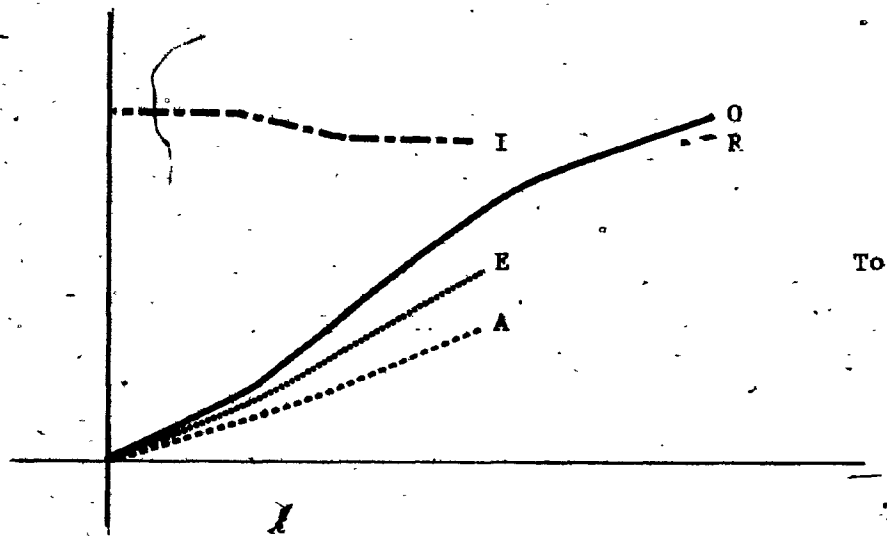
As was previously mentioned, the third and final equation is the productivity factor. This factor is the ratio between earned and actual manhour expenditures.

$$\text{Productivity} = \frac{\text{Earned Manhours}}{\text{Actual Manhours}}$$

The project manager then; 1) establishes the percent completion for engineering services accounts and 2) studies the performances of manhours & costs, and revisions introduced by the engineering disciplines. The project manager may then wish to discuss these revisions with the discipline engineer responsible for them and further calculations may be required.

At this point, planning has all the information necessary to complete the manhour and cost reports, as well as the three graphs.

When all the documents for the Engineering Control System are finalized, the report is issued to the project manager and discipline engineers. Copies of the schedule are sent to the discipline squad



O	Original Estimate	——
A	Actual Expenditures	····
R	Revised Estimate	- -
E	Earned Value	——
I	Trend Indicator	—·—

E was completed with A

To produce O or R requires X

$$X = I = \frac{O \cdot A}{E} = \frac{A}{E / O}$$

$$I = \frac{A}{\%E} = \frac{\text{Actual Expenditures}}{\text{Percent Earned}}$$

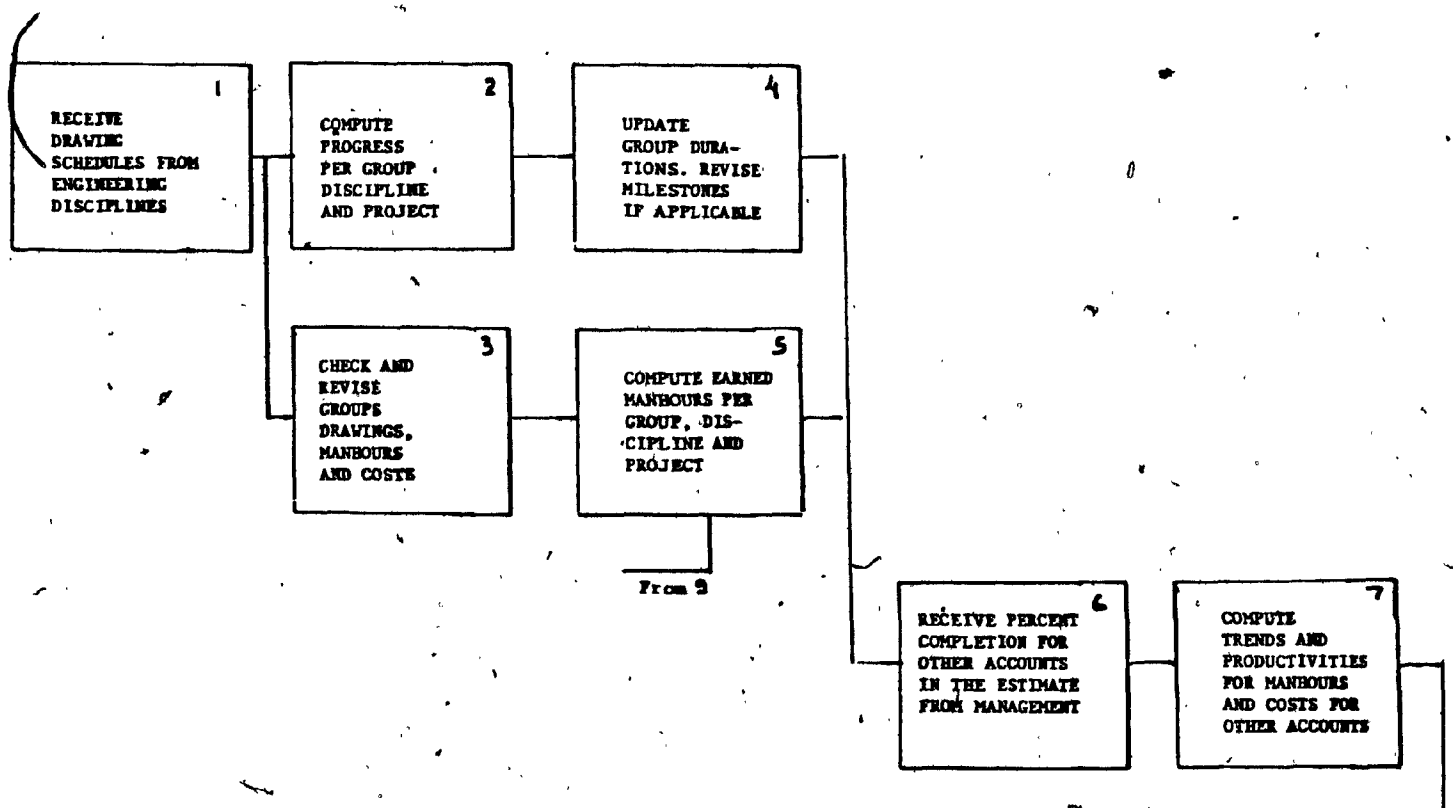
FIGURE 5.7 - PARAMETER TREND INDICATOR

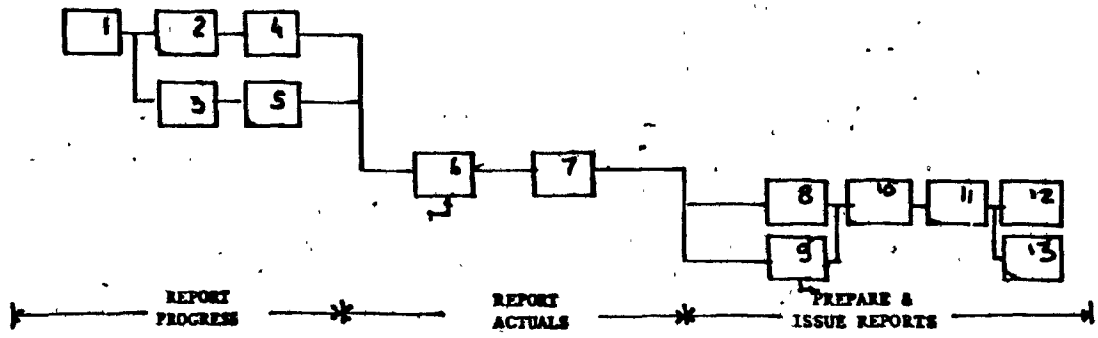
leaders.

Following the monthly update it is the project manager's responsibility to notify planning of changes which affect the Engineering Control System. Figure 5.8 shows the tasks necessary for the operation of the system.

SCRUBBER PROGRAM

ENGINEERING CONTROL SYSTEM: OPERA





1 of

PROGRAM

SYSTEM: OPERATION

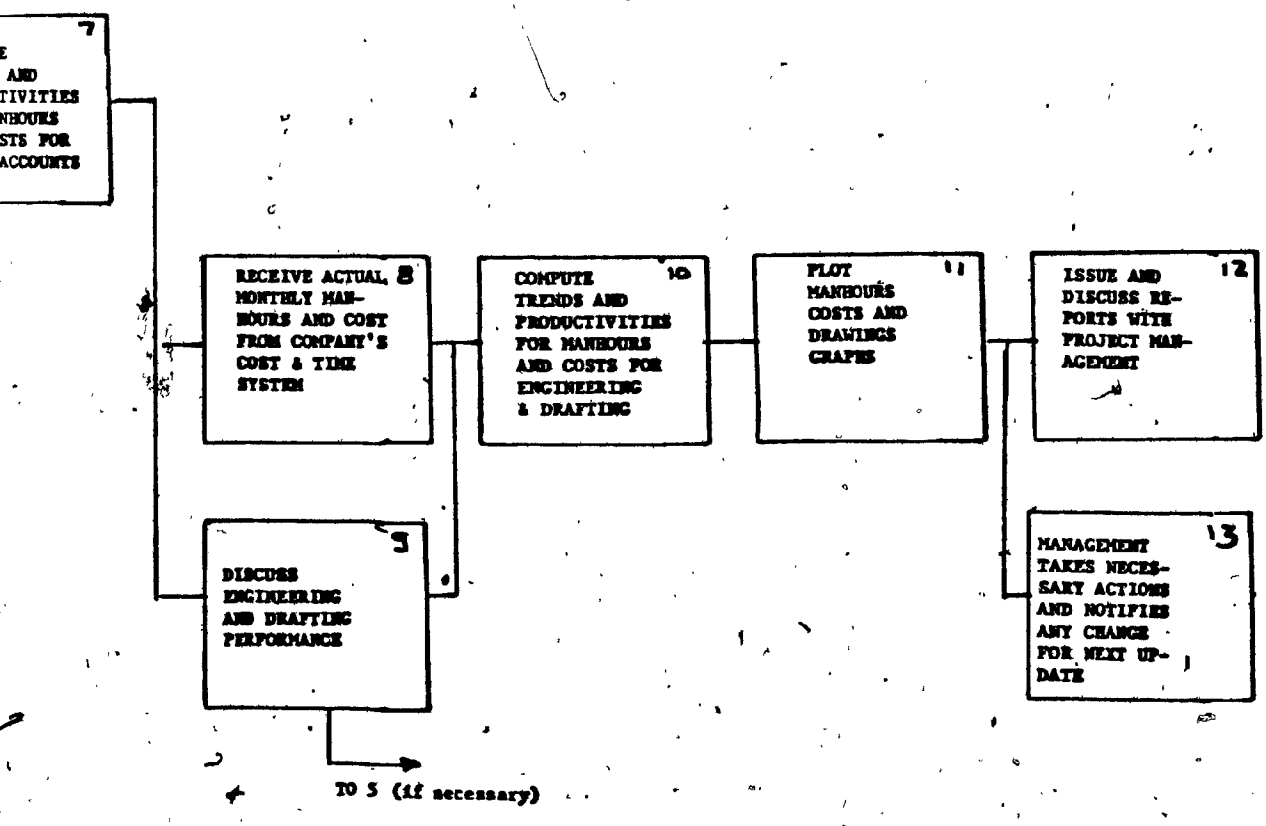


FIGURE 5.8 – ENGINEERING & ENGINEERING SERVICES CONTROL SYSTEM: OPERATION

2 of 2

5.5 Eng. Control System Report

REPORT 5.1

16 September 1980
S.O. 1499.42.02.3

To: Messrs. G. Collinge
J. Durkan

From: J. Prieto

Subject: Beauharnois Works
Wet Scrubbers P.L. Nos. 303 & 304
Engineering Control System Documents

Enclosed please find a copy of the following Engineering Control System documents for the above project. Discipline Engineer's reports do not include a copy of the Cost Report and the charges graph.

1. AES Engineering Schedule Dwg. No. FO-1499-42-F-009-R02
2. Drawing Control System Equations
3. Cost Report
4. Manhours Report
5. Charges Graph
6. Manhours Gnaph
7. Drawings Graph

These documents were developed for the update of August 1980.

JP/fg
Enclosures

Copies to:

Mrs. B. Bednarek
Mr. B. Farkas
Mr. J. Huxtable
Mr. J. Rios

Circulate S.O. copy to:

Mr. R.A. Beattie
Mrs. M. Morter

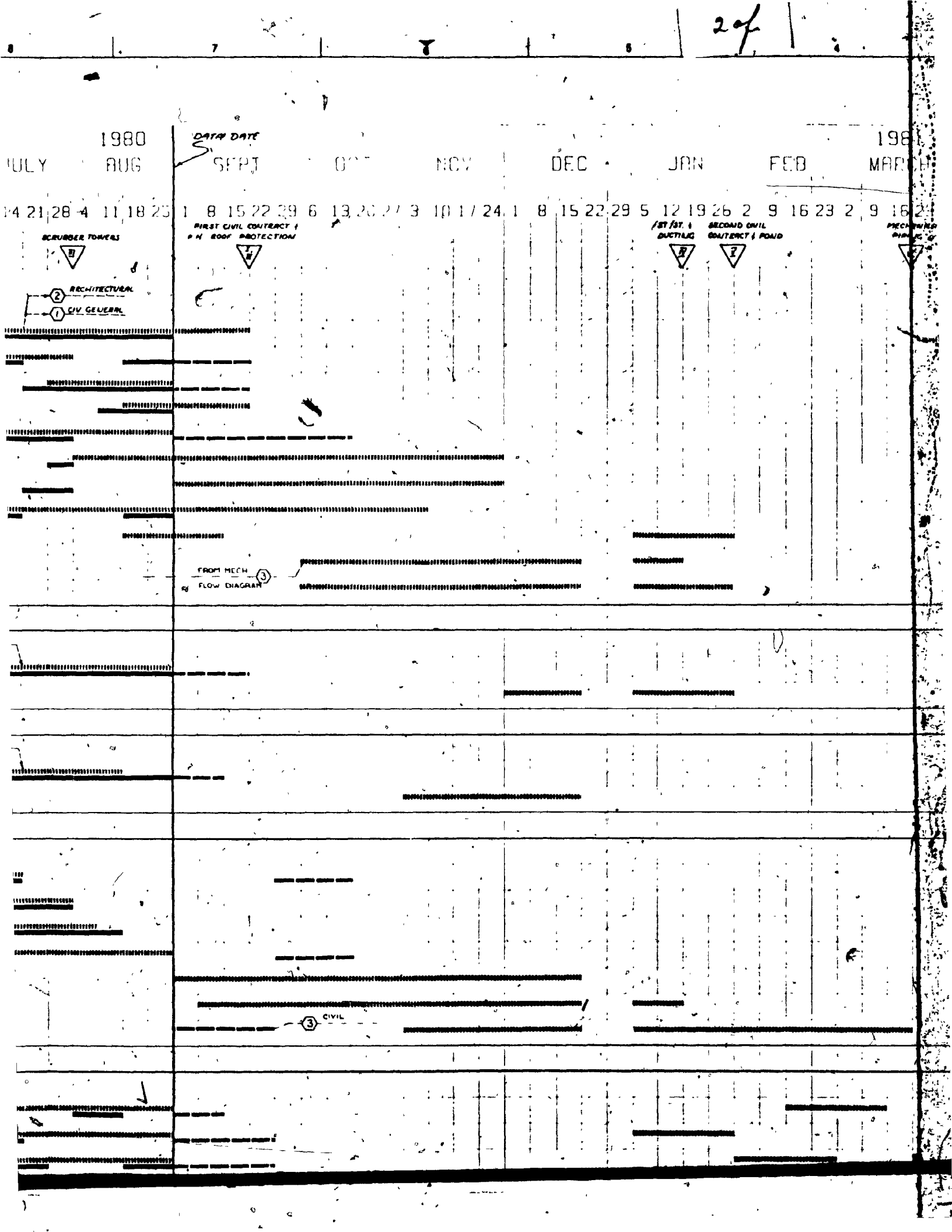
Circulate File copy to:

Mr. H.A. Hughes
Mr. B. Leclaire
Mrs. C. Garcia

		DURATION WEEKS ORIGINAL	DURATION WEEKS REVISED	D & D MANHOURS ORIGINAL	D & D MANHOURS ESTIMATE	D & D MANHOURS REVISED	D & D MANHOURS ESTIMATE	DRAWINGS ORIGINAL	DRAWINGS ESTIMATE	DRAWINGS REVISED	DRAWINGS ESTIMATE	DRAWINGS PERCENT COMPLETED (X100)	DRAWINGS PERCENT PLANNED (X100)
	BID PACKAGES												
	CIVIL:												
	SYS.1 CONCRETE												
1	PUMPHOUSE	16		1080	1210	17	19	46	37				
2	ANCHORING TOWERS	4	6	210		3		33	30				
3	FAN FOUNDATIONS	5		120		2		50	60				
4	SUBSTATION FOUNDATIONS	5	6	170	240	2	3	47	47				
	SYS.1 STRUCTURAL STEEL												
5	CENTRAL S/T & GUY WIRES	12		475	570	5	6	51	51				
6	ANCHORING TOWERS & PIPING SUPPORTS	17		665		7		6	6				
7	FAN SUPPORTS & DUCTING REINFORCEMENT	13		475		5		16	16				
8	INLET TOWER & SERVICE PLATFORMS	22		785	690	8	7	23	23				
9	STANDARDS	8		50		4							
	SYS. 2 CONCRETE												
10	EVACUATION SYSTEM	15	12	380		5							
	SYS 2 STRUCTURAL STEEL												
11	EVACUATION SYSTEM	15	14	550		8							
	TOTAL CIVIL	33		4,960	5,160	66	68	22	24				
	CIVIL GENERAL												
	SYS 1												
20	COURTYARD DRAINAGE & PAVING	11		325		4		68	66				
	SYS 2												
21	POND	7		260		2		-	-				
	TOTAL CIV. GENERAL	18		585		6		45	37				
	ARCHITECTURAL												
	SYS. 1												
30	COURTYARD	5	10	480		6		58	59				
	SYS 2												
31	EVACUATION SYSTEM	7		360		5		-	-				
	TOTAL ARCHITECTURAL	12	15	840		11		32	34				
	MECHANICAL												
	SYS 1												
40	MECHANICAL ARRANGEMENT	7	12	165		2		65	65				
41	TEMPORARY DUCTING	8		100		1		100	100				
42	TOWER SPECIFICATIONS	9		135		2		100	100				
43	FLOW DIAGRAMS	12		135		1		70	70				
44	PIPING	16		1010		10							
45	DUCTING	17		640		7							
	SYS 2												
46	EVACUATION SYSTEM	18	24	1115		11							
	TOTAL MECHANICAL	40		3300		34		18.5	16				
	ELECTRICAL:												
	SYS 1												
50	SINGLE LINE DIAGRAMS	17		170		2		70	70				
51	UNDER GROUND DUCTS	13		430		5		20	20				
52	GROUNDING	13		390		5		28	28				
		28		520		6							

JUNE JULY
2 9 16 23 30 7 14 21 28 4

SCRUBBER TOW
ARCHITE
CIV GEN
CIVIL
CIVIL


1980
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MARCH
DATA DATE
4 21 28 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 2 9 16
SCRUBBER TOWERS
FIRST CIVIL CONTRACT & N ROOF PROTECTION
/ST /ST. & DUCTWORK
SECOND CIVIL CONTRACT & POND
ARCHITECTURAL
CIV GENERAL
FROM MECH FLOW DIAGRAM
CIVIL

1981

FEB | MARCH | APRIL | MAY | JUNE | JULY

26 2 9 16 23 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29 6 13 20 27

SECOND CIVIL CONTRACT & POUR

MECHANICAL PIPING

ELECTRICAL

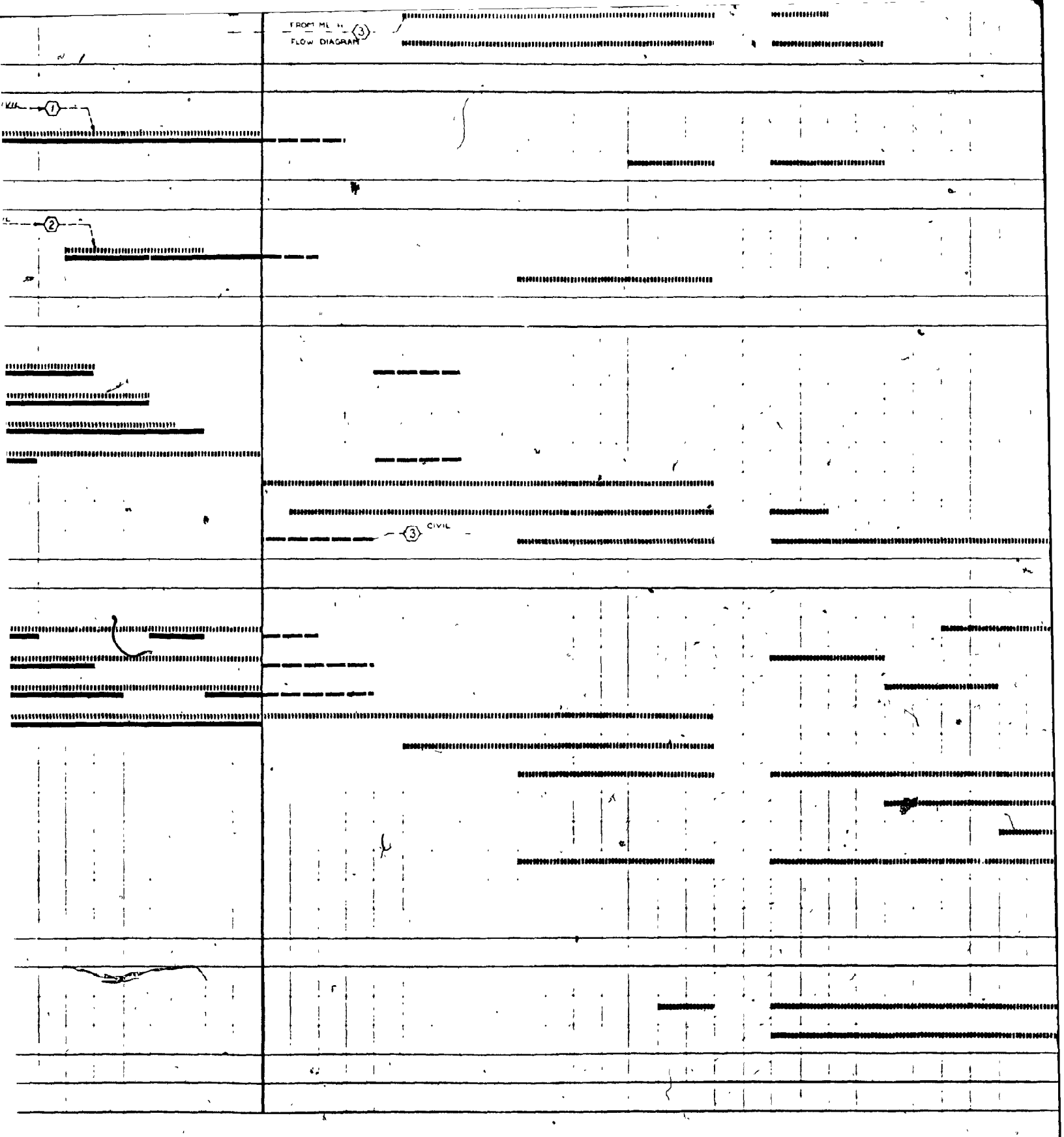
	TOTAL MANHOURS ORIGINAL ESTIMATE	REVISED ESTIMATE	ACTUAL	TREND	PRODUCTIVITY
E					
D	6910	7,110	2 201	8167	0 89
	855		348	867	0.99
	1030		9.75	1,271	0.82
C					
	7350		623	5,692	1.43

10	EVACUATION SYSTEM	15	12	380		5			
SYS 2 11	STRUCTURAL STEEL EVACUATION SYSTEM	15	14	550		8			
	TOTAL CIVIL	33		4,960	5,160	66	68	22	24
CIVIL GENERAL									
SYS 1 20	COURTYARD DRAINAGE & PAVING	11		325		4		68	66
SYS 2 21	POND	7		260		2		-	-
	TOTAL CIV GENERAL	18		585		6		45	37
ARCHITECTURAL									
SYS 1 30	COURTYARD	5	10	480		6		58	59
SYS 2 31	EVACUATION SYSTEM	7		360		5		-	-
	TOTAL ARCHITECTURAL	12	15	840		11		32	34
MECHANICAL									
SYS 1 40	MECHANICAL ARRANGEMENT	7	12	165		2		65	65
41	TEMPORARY DUCTING	8		100		1		100	100
42	TOWER SPECIFICATIONS	9		135		2		100	100
43	FLOW DIAGRAMS	12		135		1		70	70
44	PIPING	16		1010		10			
45	DUCTING	17		680		7			
SYS 2 46	EVACUATION SYSTEM	18	24	1115		11			
	TOTAL MECHANICAL	40		3300		34		185	16
ELECTRICAL									
SYS 1 50	SINGLE LINE DIAGRAMS	17		170		2		70	70
51	UNDER GROUND DUCTS	13		430		5		20	20
52	GROUNDING	13		330		5		28	28
53	LAYOUTS	28		570		6		42	43
54	LIGHTING	11		260		4			
55	CONTROL	20		1075		13			
56	LIGHTING ARRANGEMENTS	7		170		2			
57	REVISIONS	9		225		9			
SYS 2 58	EVACUATION SYSTEM	26		450		6			
59	FAMILIARIZATION			160				30	30
60	REVISIONS AS BUILT			410					
	TOTAL ELECTRICAL	46		4250		52		14	14
INSTRUMENTATION:									
SYS 1 70	SCRUBBING SYSTEM	15		330		7			
SYS 2 71	EVACUATION SYSTEM	13		330		7			
	TOTAL INSTRUMENT'N	15		660		14		-	-
	GRAND TOTAL	146		14595	14795	183	185	18.8	19

CIVIL ① CIVIL ②

02	12 SEP 80	THIRD ISSUE	JP
01	15 AUG 80	SECOND ISSUE	JP
00	27 JUN 80	FIRST ISSUE	JP

No	Date	Location	Description	Checked By



LEGEND:

- FINAL DRAWINGS
- ACTUAL COMPLETED WORK
- REVISED FORECASTED WORK
- REVISED ISSUED PACKAGE DATE
- (REPRESENTS A NUMBER) — UPDATE MONTH'S REVISION

DEFINITIONS:

1. PERCENT EARNED (ACTIVITY DISCIPLINE PROJECT) = $\frac{\Sigma(\%\ \text{PERCENT COMPLETE}_{\text{DISC}} \times \text{EST. MHRS}_{\text{DISC}})}{\Sigma\ (\text{EST. MHRS}_{\text{DISC}})}$

2. TREND (DISCIPLINE PROJECT) = $\frac{\text{ACTUAL MHRS (DISCIPLINE PROJECT)}}{\text{PERCENT EARNED (DISCIPLINE PROJECT)}}$ #

3. PRODUCTIVITY (DISCIPLINE PROJECT) = $\frac{\text{ORIGINAL OR, WHICHEVER IS REVISED MHRS PROJECT)} \times \text{PERCENT EARNED (DISCIPLINE PROJECT)}}{\text{ACTUAL MHRS (DISCIPLINE PROJECT)}}$

NOTES:

EVACUATION SY
LINE TREATME
POND (FILTRAT

INCLUDES PRO

JP	
JP	
JP	
ISSUED BY	DATE

5 of

6910	7,110	2 201	8,167	0 89
855		348	867,	0 99
1030		975	1,271	0 82
7350	1	623	5,692	1 43
5385		970	6,194	0 86
960		16	960	1.00
22,990	23,690	4653	23,151	0 %

NOTES :

1. EVACUATION SYSTEM COVERS DESIGN FOR LIME TREATMENT BUILDING, THICKENER POND & FILTRATION BLDG
2. INCLUDES PROJECT ENGINEER MANHOURS

Alcan Engineering Services Division of Aluminum Company of Canada Ltd Montréal, Québec, Canada	Designed J. PROJETO Drawn PLOTTER (CRT-42) Checked Approved Approved Date	SYSTÈME D'ÉVACUATION ET D'ÉPURATION DES FUMÉES SALLES DES CUVES 303 & 304 - ÉPURATEURS S.G.A. - CÉDULE DES ÉTUDES TECHNIQUES No USINE DE BEAUHARNOIS Client Société d'électrolyse et de chimie Alcan Ltée
Assessed to Project Date Chief Process Eng. Project Co-ordinator Date Project Engineer Contract No. 1499 - 46 F - 0015	S.A. 1499.46.01.8 Date 23 JUIN '80	F0 1499 42 F 0019 P 02 AO

F0 1499 42 F 0019 P 02

9 of 9

DRAWING CONTROL SYSTEM EQUATIONS

1) Percent Earned (activity, discipline or project)

$$= \frac{\sum \left(\text{Percent Complete per dwg} \times \text{Original Estimate MHRS per dwg} \right)}{\sum \left(\text{Original Estimate MHRS per dwg} \right)}$$

2) Trend (discipline)

$$= \frac{\text{Actual MHRS (discipline)}}{\text{Percent Earned (discipline)}}$$

3) Productivity (discipline or project)

$$= \frac{\text{Original or Revised MHRS (discipline or project)} \times \text{Percent Earned (discipline or project)}}{\text{Actual MHRS (discipline or project)}}$$

COST REPORT

PROJECT: Beauharnois Wet Scrubbers P.L. Nos. 303 and 304
AES Engineering and Engineering Services

S.O.: 1499.42.02.3
ISSUE DATE: 12 September 1980

DISCIPLINE	ORIGINAL COST ESTIMATE			REVISED COST ESTIMATE			ACTUAL CUMULATIVE			EARNED CUMULATIVE			TREND COST INDICATOR		
	Eng.	D & D	Total	Eng.	D & D	Total	Eng.	D & D	Total	Eng.	D & D	Total	Eng.	D & D	Total
Civil	74100	148800	222900				22597	37701	60298	27208	35700	62908	61542	157140	218682
Civil General	8100	17550	25650				5655	4478	10133	4470	6480	10950	10247	12128	22375
Architectural	7400	25200	32600				690	11310	12000	3115	9330	12445	1639	30548	32187
Mechanical	147000	99000	246000				12895	8935	21830	13068	15840	28908	145054	55844	200898
Electrical	43130	127500	170630				13839	15521	29360	9120	17850	26970	65447	110864	176311
Instrumentation	12000	19800	31800				566	-	566	640	-	640	10612	19800	30412
Smelter Engineering	14500		14500				350		350	464		464	10938		10938
Project Management			75000						3093			2500			92790
Project Services			286650						17959			20794			247569
Administration			34200						757			1218			21255
Construction			259500						4978			4460			289639
Direct Charges			119300						4429			4429			119300
Contingency Allow.			151870												151870
GRAND TOTALS	306230	437850	1670600				56592	77945	165753	58085	85200	176686	305479	386324	1614226

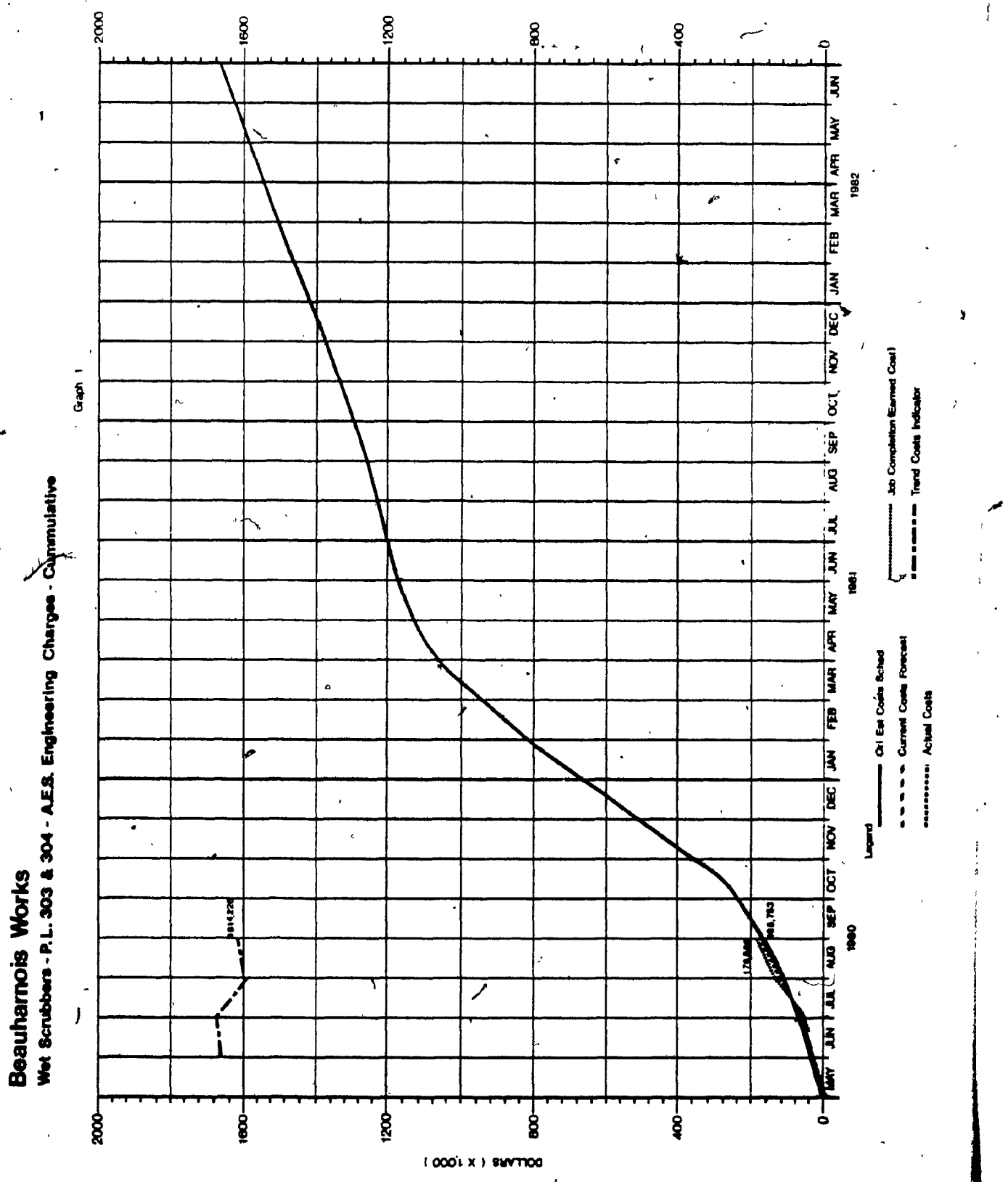
MANHOURS REPORT

S.O.: 1499.42.02.3

PROJECT: Beauharnois Wet Scrubbers-P.L. Nos. 303 and 304
AES Engineering and Engineering Services

ISSUE DATE: 12 September 1980

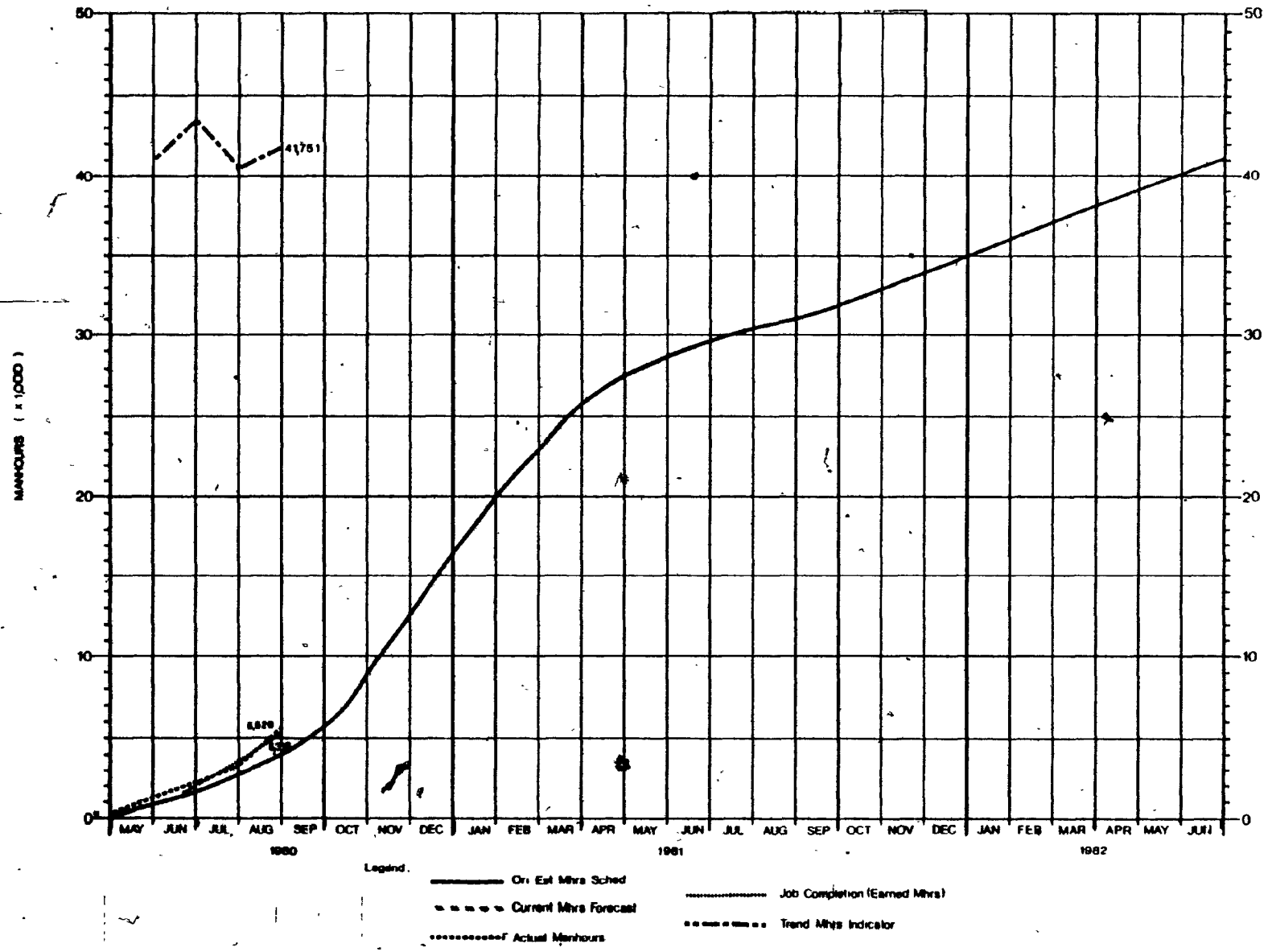
DISCIPLINE	ORIGINAL ESTIMATE			REVISED ESTIMATE			ACTUAL CUMULATIVE			EARNED CUMULATIVE			TREND INDICATOR			PRODUCTIVITY FACTOR		
	Eng.	D & D	Total	Eng.	D & D	Total	Eng.	D & D	Total	Eng.	D & D	Total	Eng.	D & D	Total	Eng.	D & D	Total
Civil	1950	4960	6910		5160	7110	716	1485	2201	716	1238	1954	1950	6217	8167	1.00	0.83	0.89
Civil	270	585	855				146	222	368	149	216	365	264	603	867	1.02	0.97	0.99
Architectural	190	840	1030				15	460	475	80	311	391	36	1235	1271	5.33	0.68	0.82
Mechanical	4050	3300	7350				360	263	623	360	528	888	4050	1642	5692	1.00	2.01	1.43
Electrical	1135	4250	5385				299	671	970	240	595	835	1419	4775	6194	0.80	0.89	0.86
Instrumentation	300	660	960				16	-	16	16	-	16	300	660	960	1.00		1.00
Smelter Engineering	250		250				8		8	8	-	8	250		250	1.00		1.00
Project Management			1500						50			50			1500			1.00
Project Services			8850						642			642			8850			1.00
Administration			1600						57			57			1600			1.00
Construction			6400						110			110			6400			1.00
Others																		
GRAND TOTALS	8145	14595	41090		14795	41290	1560	3101	5520	1569	2888	5316	8269	15132	41751	1.01	0.93	0.96

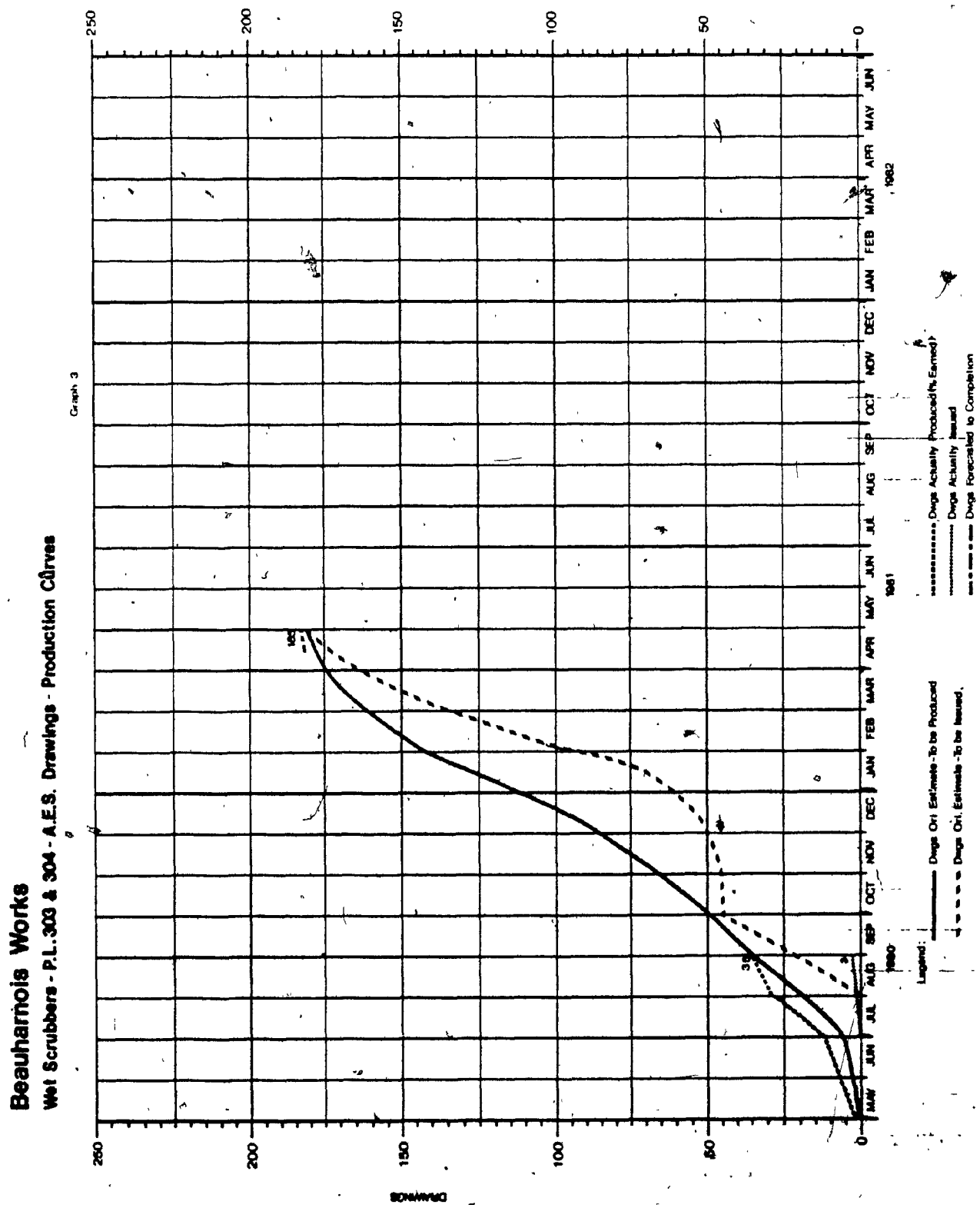

Beauharnois Works
Wet Scrubbers - P.L. 303 & 304 - A.E.S. Engineering Charges - Cummulative
Graph 1
DOLLARS (x 1,000)
2000
1600
1200
800
400
0
MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN
1980
1981
1982
Legend
Orl Est Costs Sched
Current Costs Forecast
Actual Costs
Job Completion Earned Cost
Trend Costs Indicator

Beauharnois Works

Wet Scrubbers - P.L. 303 & 304 - A.E.S. Engineering Manhours - Cummulative

Graph 2




Beauharnois Works
Wet Scrubbers - P.L. 303 & 304 - A.E.S. Drawings - Production Curves
Graph 3
DRAWINGS
250
200
150
100
50
0
MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN
1980
1981
1982
Legend:
Dwgs Ori Estimate - To be Produced
Dwgs Ori. Estimate - To be Issued
Dwgs Actually Produced (% Earned)
Dwgs Actually Issued
Dwgs Forecasted to Completion

CHAPTER 6 - CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

In the Scrubber Program CPM analysis has proven to be a successful tool for planning, scheduling, monitoring and controlling. The objectives stated prior to the start of the program are being achieved by using information from the various reports presented in this technical report. Only minor modifications in the original reports have been necessary.

The pre-planning structures developed in the program have:

1) increased planning and management's understanding of the various components and sub-components in the program and the relationships between them;

2) made it possible to estimate the degree of detail necessary in the information for various reports in the areas of time, cost and manpower.

The computer has been a very useful tool in developing both cost and manhours reports, as well as those time reports provided to the highest managerial levels.

CPM time scaled networks have been the most easily understood and well liked planning documents for both project leaders and contractors.

The budget forecasts and manpower requirements have been determined by management from the network's allocations. Thus far the forecasts have been within the anticipated levels of accuracy.

By controlling the various stages, a closer and more accurate picture of the project is provided.

Using the information from the networks, controlling can be implemented in engineering, procurement and construction with little effort.

6.2 Recommendations

A. The following recomendations are derived from experience obtained while executing the Scrubber Program:

1. Development of the pre-planning structure is strongly advised.

2. The usage of the computer, especially in large networks and in developing cost or manhours allocations, is almost always necessary. Personnel receiving CPM reports should be familiarized with this technique.

3. A careful assessment of the degree of detail necessary in the information used in developing reports or documents is important.

4. Utilization of graphic aids in reports facilitates understanding and provides background information on CPM technique.

5. It is important to keep in mind that the human factor, i.e. those persons using the documents and reports, can influence the success of CPM implementation.

6. In controlling, it is important to:

   a) Understand the differences between monitoring and controlling.

   b) Establish the parameter of control at a reasonable level; e.g. controlling groups of drawings instead of individual drawings.

c) Prepare and follow procedures so that planning reports can be produced more efficiently.

B. The following are recomendations which if utilized, woulb be expected to increase understanding and effectiveness in planning, scheduling, monitoring and controlling projects

1. It is important to produce exception reports in order to highlight variances in original schedules, original manhours and original costs.

2. By comparing, in graphical format, the original estimated curve to the actual curve, visualization of variances is facilitated.

3. To establish total project control the 'earned value' concept should be utilized at all stages, i.e engineering, procurement, construction and commissioning.

4. Project leaders and engineers who regularly deal with planning reports should receive training in:

a) CPM tecnique related to planning, current, and target schedules.

b) The philosophy of controlling manhours and costs based on 'earned value' concept.

REFERENCES

1. Archibald Villoria, Network-Based Management Systems (PERT/CPM) New York, John Wiley & Sons Inc., 1967

2. Clark & Larenzon, Applied Cost Engineering, Ed 10, New York, Marcel Deikker Inc., 1978

3. Clough R., Construction Project Management, New York, Wyley Interscience, 1972

4. Howard B., "CPM as complete Project Management" Journal of the Construction Division, May 1965

5. Kawal D., "Information Utilization in Project Planning" Journal of the Construction Division, November 1971

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8. O'Brien, Contractor's Management Handbook, Ed 9, New York, McGraw Hill 1971

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APPENDIX I EXAMPLE OF SCRUBBER TOWERS SCOPE OF WORK

APPENDIX

SCOPE OF WORK POTLINES 52-53 NORTH

GENERAL

Potlines 52 and 53 at Arvida Works each contains 137 pots. Each pot line is divided by a central passageway into a North Half containing 72 pots and a South half containing 65 pots. The 130 pots in the South sections are presently exhausted through a balanced ductwork system at a rate 3200 SCFM per pot to the floating Bed Acid Scrubbers already installed in the south courtyards. The original Alkaline scrubber system mounted on the potroom roofs still exhausts the North section pots through an unbalanced duct system at an average exhaust rate of 2500 SCFM. The proposed project will increase the exhaust rate on the North half pots to 3200 SCFM at 200°F fan gas temperature. There will be a balanced duct system and the pot exhaust will scrubbed by 28' diameter F-B Acid scrubbers. One scrubber tower alone will serve one half line and will be located to the East of its respective potroom. A bypass duct connects the two scrubber systems in order to ensure that both potlines are exhausted when one tower is out of service.

The general layout of equipment will be as scrubber system 56-57 North and as shown on drawing: AS-1270-42-G-002 - "Installation of F-B Scrubber Potlines 46-57 North, one scrubber per courtyard general arrangment".

Exhaust System

A new balanced ductwork system will be located on the roof of potline 53 and connected to the existing main ducts located just below the roof inside the potroom. The roof ductwork will be connected to two centrifugal fans which will exhaust the pot gas to the Floating Bed scrubber erected East of potline 53. Each fan will have a nominal capacity of 144,000 ACFM at 150°F, 17" S.P. and will be directly driven by a 600 HP, 480 V., 900 RPM motor.

An identical system will be installed for 52N in the courtyard between potlines 52 and 53.

During normal operation the two systems operate completely independently, however in the event one of the scrubbers is shutdown a bypass duct and damper arrangement permits the exhausting of both North half lines through the other scrubber.

The direction of the risers entering the header ducts will be changed at the time of start-up to accomodate changes in the direction of gas flow in the duct when the system is balanced.

Scrubbing system

A wood Floating-Bed Scrubber Tower will be provided for each half line. Each tower will be erected on a concrete foundation which also acts as pumphouse. The tower will consist of a 28'-0" I.D. X 63'-2 1/2" high section containing the scrubber packing (Floating Ball Bed) with counter-current sprays and mist eliminator plates. Above this section will be mounted a 9'-9" I.D. stack exhausting at 155'-0" Ft. above ground level. A sampling platform will be provided on the stack for potline 53 N at approximately 108'-0" above ground level. Provisions will be made to allow the future installation of a platform on the tower for potline 52N.

Scrubbing liquor will be recirculated at a rate of 4000 USGPM through each tower. The concentration of soluble components and solids in the scrubbing liquor will be maintained by pumping off a portion of the scrubbing liquor via new bleed lines to an existing lamella settler for neutralization and sedimentation before being returned to the scrubber via new Return Lines. The solids-rich fraction collected during sedimentation will be pumped through existing circuits to the Cryolite Recovery Plant (C.R.P.) where fluorides are recuperated. No additional settling capacity is required above that already planned and approved.

Water Supply

And adequate water supply is available at the central passageway. Water

for grid washing and gland water will be piped to the pumphouse in insulated, trace heated lines.

Power Supply

The power supply will be taken from the newly installed 13 KV power line on Hall Street: Each scrubber will be independently supplied by a 2000 KVA sub-station located in the courtyard. The fan and pump motors will all be standard 480 V., 60 C/S specification.

Courtyards

The existing tunnel that passes under the rectifier building will be extended underground and will join with existing above ground section of tunnel to the south of the new scrubber. All scrubber equipment will be located North of the existing floor fans. Part of this project is to demolish the Alkali scrubbers and associated equipment, and finally grade and pave the whole courtyard. This leaves the area of courtyard adjacent to the central passageway available for potroom operation and maintenance facilities.

Instrumentation and control equipment.

A separate air conditioned controlroom will be situated to the South of each pumphouse. Instrumentation will be supplied by "Moore Instrument Ltd." Three "Mag-Flow" meters will be installed to measure recirculation, bleed, and return flow rates. Indicators, alarms, and controls will be generally as supplied on previous F.B. scrubber systems. The dampers at the fan inlets will be fitted with electrically operated actuators which will be set to close during the mist elimination grid washing cycle and also on low recirculation liquor flow rate. These actuators will also be set to limit opering of dampers so as not to exceed a preset running amperage on the motors.

C.J. Neat
28 February 1979

CJN:CSL

APPENDIX II EXAMPLE OF SCRUBBER TOWER SUMMARY COST ESTIMATE

Société d'électrolyse et de chimie Alcan Ltée

Sommaire de l'estimation

INGENIERIE - ARVIDA
EMIS PAR LE DEPARTEMENT

PROJET SYSTEME D'EPURATION 52-53 N — ESTIMATION

SITE H.S. POTLINES 52-53 NORTH — D.N.C. No 859536X

REFERENCE — AUTO. No 5570

DEMANDEUR C.J. NEAT — DATE MARS 1979

ESTIMATEUR BASED ON ESTIMATE 54-55 N — VERIFICATEUR

ITEM	DESCRIPTION	en milliers de dollars		
		MATERIEL & EQUIPEMENT	MAIN D'OEUVRE (installation)	TOTAL
1	Instrumentation - Achat	115	-	115
2	Instrumentation - Installation	-	50	50
3	Electricité - Achat	480	-	480
4	Electricité - Installation	-	200	200
5	Travaux civils - Bétonnage	500	600	1100
6	Epurateurs - Achat	600	-	600
7	Epurateurs - Installation	-	250	250
8	Peinture & revêtement protecteur	20	35	55
9	Pompes & tuyauterie - Achat	325	-	325
10	Tuyauterie - Installation	-	120	120
11	Ventilateurs - Achat	140	-	140
12	Conduits & superstructure - Achat	550	-	550
13	Conduits & superstructure - Installation	-	650	650
14	Ingénierie - Arvida	-	90	90
15	Ingénierie - SGA	-	350	350
16	Modification des bâtiments	30	50	80
17	Enlèvement d'équipement mécanique	50	120	170
18	Modification système électrique	20	20	40
19	Démarrage	-	25.0	25.0

1004-D-3 (Rev. 4/78)

Société d'électrolyse et de chimie Alcan Ltée

Sommaire de l'estimation

INGENIERIE - ARVIDA
EMIS PAR LE DEPARTEMENT

PROJET: SYSTEME D'EPURATION 52-53 N — ESTIMATION:

SITE: H.S. POTLINES 52-53 NORTH — D.N.C. No: 859536X

REFERENCE: — AUTO. No: 5570

DEMANDEUR: C.J. NEAT — DATE: MARS 1979

ESTIMATEUR: BASED ON ESTIMATE 54-55 N — VERIFICATEUR:

ITEM	DESCRIPTION	en milliers de dollars		
		MATERIEL & EQUIPEMENT	MAIN D'OEUVRE (installation)	TOTAL
	ENVIRONMENT ACCESSORIES	50	30	80
	TOTAL			5470
	DEPENSES D'IMMOBILISATION			5090
	DEPENSES D'EXPLOITATION			380

1004-D-3 (REV. 4/75)

APPENDIX III EXAMPLE OF SCRUBBER TOWERS COST STATUS REPORT

Etat des coûts

SYSTEME D'EPURATION - LIGNE 46-47 NORD — No D.N.C. 7 595 42X — No AUTORISATION 9037

BÂTIMENT 46-47 NORD — DEMANDEUR C. NEAT — No ESTIMATION -

FIN DU MOIS MAI 1979 — EXPEDITEUR P. ATWOOD — DATE JUIN 1979

COMPTE	DESCRIPTION	estimation originale $ / dernière $	autorisation originale $ / dernière $	en milliers de dollars: DEPENSES (payées)	ENGAGEMENT (impayés)	BALANCE (estimative)	ECART (à date)	PREVISION (cout final)
4601	INSTRUMENTATION - ACHAT	100		5	60	35		100
4602	INSTRUMENTATION - INSTALLATION	40						40
4603	ELECTRICITE - ACHAT	410			189	221		410
4604	ELECTRICITE - INSTALLATION	200				200		200
4605	TRAVAUX CIVILS - BETONNAGE	480		18	428	34		480
4606	EPURATEURS - ACHATS	550		89	304	157		550
4607	EPURATEUR - INSTALLATION	220				220		220
4608	PEINTURE & REVÊTEMENT PROTECTEUR	80				80		80
4609	POMPES & TUYAUTERIE - ACHAT	330			75	255		330
4610	POMPES & TUYAUTERIE - INSTALLATION	160				160		160
4611	VENTILATEURS - ACHAT	130			83	47		130
4612	CONDUITS & SUPERSTRUCTURE - ACHAT	470				470		470
4613	CONDUITS & SUPERSTRUCTURE - INSTALLATION	440				440		440
4614	ENVIRONNEMENT & ACCESSOIRES	50				50		50

Etat des coûts

PROJET SYSTEME D'EPURATION - LIGNE 46-47 NORD — No D.N.C. 759542X — No AUTORISATION 9037

SITE BÂTIMENT 46-47 NORD — DEMANDEUR C. NEAT — No ESTIMATION

RAPPORT NO 4 — FIN DU MOIS MAI 1979 — EXPEDITEUR P. ATWOOD — DATE JUIN 1979

COMPTE	DESCRIPTION	estimation originale $ / dernière $	autorisation originale $ / dernière $	en milliers de dollars: DEPENSES (payées)	ENGAGEMENT (impayés)	BALANCE (estimative)	ECART (à date)	PREVISION (coût final)
	PAGE 2 de 2							
335 4615	TRAVAUX D'ACCESS 46-47	100		3		97		100
336 0010	INGENIERIE SGA	210		4		6		210
336 0050	INGENIERIE - HGA	20				20		20
336 0080	TECHMATE	0		5		0	+ 5	5
336 5760	INGENIERIE - USINE ARVIDA (576)	60		48		12		60
	TOTAL	4,050		172	1,139	2,744	+ 5	4,055
	DEPENSES							
338 4601	MODIFICATIONS DES BÂTIMENTS	50				50		50
338 4602	MODIFICATIONS D'EQUIPEMENT ELECTRIQUE	30		5		25		30
338 4603	ENLEVEMENT D'EQUIPEMENT MECANIQUE	150				150		50
339 0010	INGENIERIE PRELIMINAIRE - SGA	30				0	- 30	0
339 5760	INGENIERIE PRELIMINAIRE (576)	10		10		0		10
371 4600	DEMARRAGE	30				30		30
	TOTAL	300		15		255	- 30	270

APPENDIX IV EXAMPLE OF SCRUBBER TOWERS MANHOURS REQUIREMENTS

PROJECT: Epuraleurs 46-47 NORTH

REVISION: 0 (21-02-79)

AUTORISATION: 33-9037

S.O.: 1685.42.00.4

	HEURES PREVUES				HEURES CHARGEES					
	SUPER-VISION	ADMINIS-TRATION	TOTAL	CUMULATIF	SUPER-VISION		ADMINIS-TRATION		TOTAL	CUMULATIF
					YB	SP	ED	PL		
J	-	-								
F	-	-								
M	5	20	25	75	1	6	12	35	53	53
A	110	30	140	165	15.0	29	11.5	14	69.5	122.5
M	130	30	160	325	152.5	93	15.0	12	275.5	398.0
J	120	30	150	475						
J	70	20	90	565						
A	120	30	150	715						
S	25	10	35	750						
O	-	-	-							
N	-	-	-							
D	-	-	-							
TOTAL	580	170	750	750						

APPENDIX V EXAMPLE OF SCRUBBER TOWERS MANHOURS STATUS REPORT

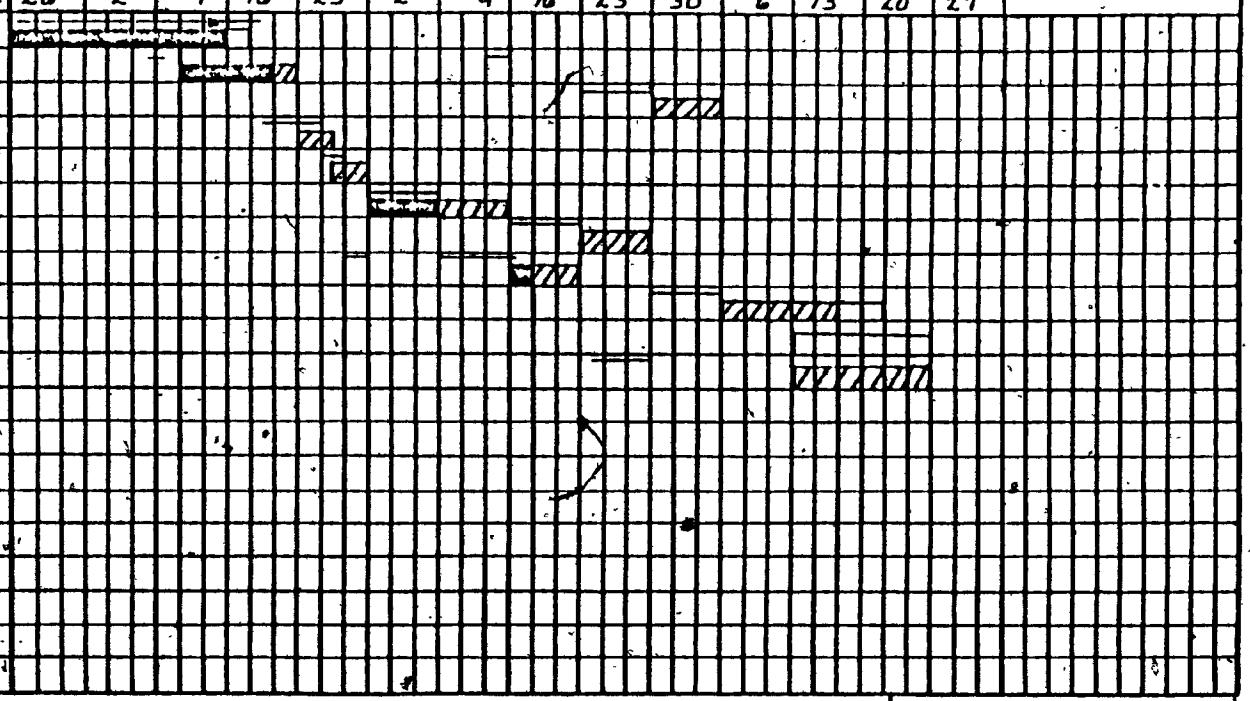
CUT OFF TO DOTTED LINES
FOR FOLDING AND BINDING

ALUMINUM COMPANY of CANADA, LIMITED
"Fondations pour

Authorization No. 33-1999 In Connection with l'Épurateur 49 Sud" Plant: Arvida

General Contractors: J. EUCLIDE PERRON LTEE

Description of Work (PART 1)	% COMPLETE
Water-line relocation	95%
Sheet-piling	100%
Duct foundations	100%
Excavation - Pumping station	100%
Foundations - Pumping station	100%
Walls - Pumping station	100%
Roof - Pumping station	100%
Backfill - Pumping station	100%
Interior - Pumping station	80%
Architectural - Pumping station	
Roof shelter - Pumping station	100%



Actual Working Time
Scheduled Working Time
% Completed this Period
% Completed Previously

Sheet 1 of 1

Period: 1 to 30 March 1979

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PROJECT FONDATIONS POUR L'EPURATEUR 49S" CONTRACTOR J.-LUCLIDE PERRON LTEE PERIOD MARCH 19..

TRADE CLASSIFICATION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
FOREMAN	1	1			1	1	1	1	1			1	1	1	1	1			1	1	1	1	1			1	1	1	1	1	
LABOURERS	4	4			4	4	4	4	4			4	4	4	4	4			4	4	4	4	4			4	4	4	4	4	
CARPENTERS	4	2			2	2	2	2	2			2	2	2	2	2			2	2	2	2	2			2	2	2	2	2	
REINFORCING STEEL ERECTORS	4													4	4							2									
TRUCK DRIVERS						2	2	2	2													1									
SHOVEL OPERATOR						1	1	1	1									1		1	1	1									

APPENDIX VI ENGINEERING & ENGINEERING SERVICES COST & MANHOURS ORIGINAL ESTIMATES

BEAUHARNOIS P.L.'s 303/304 WET SCRUBBING.

DISC.	DESCRIPTION	N° OF DWGS	MANHOURS	RATE	COST	
	DESIGN/DRAFTING					
01	CONCRETE	17	1445 ✓	30.00	43,350	2
01	STRUCTURAL ST'L	22	1980 ✓	30.00	59,400	2
01	CIVIL	4	360 ✓	30.00	10,800	
02	ELECTRICAL	42	4250 ✓	30.00	127,500	
02	INSTRUMENTATION	3	300 ✓	30.00	9,000	
18	ARCHITECTURAL	9	550	30.00	16,500	
03	ENVIRONMENTAL	40	5000	30.00	150,000	
(1)	TOTALS	137	13,885	—	416,550	
	ENGINEERING					
11	CONCRETE		850 ✓	38.00 ✓	32,300 ✓	1
11	STRUCTURAL STEEL		1100 ✓	38.00 ✓	41,800 ✓	1
11 ✓	CIVIL ✓		180 ✓	38.00 ✓	6,840 ✓	
12 ✓	ELECTRICAL ✓		1135 ✓✓	38.00 ✓	43,130	
12	INSTRUMENTATION ✓		300 ✓✓	40.00 ✓	12,000 ✓	
12	CHEMICAL ✓		150 ✓	40.00 ✓	6,000 ✓	
13 ✓	ENVIRONMENTAL ✓		3000 ✓	32.00 ✓	96,000 ✓	
17 ✓	ARCHITECTURAL ✓		150 ✓	39.00 ✓	5,850 ✓	
27	SMELTER ENGINEERING		250 ✓	58.00 ✓	14,500 ✓	
—	PROJECT ENGINEER ✓		900 ✓	50.00 ✓	45,000 ✓	
(2)	TOTALS ✓		8,015 ✓	—	303,420	
	PROJECT MANAGEMENT					
	PROJECT MANAGER		1500 ✓	50.00 ✓	75,000 ✓	
(3)	TOTAL		1500	—	75,000 ✓	

DISC.	DESCRIPTION	MANHOURS	RATE	COST
	PROJECT SERVICES			
41.	COST ESTIMATING	350	39.00	13,650.
42.	COST CONTROL	3100	33.00	102,300
43.	COST ACCOUNTING	2000	33.00	66,000
44.	PROCUREMENT	600	39.00	23,400
46.	PLANNING/SCHEDULING	2100	33.00	69,300
54.	ADMINISTRATIVE SYSTEM	700	20.00	14,000.
(4)	TOTALS	8,850	-	286,650
	ADMINISTRATION			
10.	TRANSLATION	800	27.00	21,600.
49.	PROJECT SECRETARIAL SERVICE	600	15.00	9,000
50.	GEN. OFFICE SERVICES	200	18.00	3,600.
(5)	TOTALS	1,600	-	34,200
	CONSTRUCTION			
21.	HOME OFFICE CONSTR.	900	50.00	45,000
22.	SITE CONSTRUCTION	5,500	39.00	214,500.
(6)	TOTALS	6,400	-	259,500.
	SUMMARY — MANHOUR CHARGES			
(1)		13,885	-	416,550.
(2)		8,015	-	303,420.
(3)		1,500	-	75,000.
(4)		8,850	-	286,650.
(5)		1,600	-	34,200.
(6)		6,400	-	259,500
(7)	TOTALS	40,250	-	1,375,320.

BEAUHARNOIS P.L.'s 303/304 WET SCRUBBING.

DISCIPLINE	DESCRIPTION	COST
	DIRECT SERVICE EXPENSES	
0001	OVERTIME - RELATED EXPENSES	
0002	BLUEPRINTING & REPRODUCTION	
0004	COMPUTER - PLOTTER DRAFTING	
0005	DRAFTING AIDS	
0011	ENGINEERING SERVICES	
0052	MICROFILM	
0054	GRAPHICS	
0055	GRAPHICS - BILLED VIA AES	
0056	SPECIAL PROJECT MATERIAL	119,300
0057	SPECIAL SERVICES	
0058	REIMBURSABLE OVERHEADS	
0059	PROCUREMENT SERVICES	
0060	ALCAN COMPUTER COSTS	
2102	EXTERNAL COMPUTER RENTAL	
2301	TRAVELLING EXPENSES	
4001	OUTSIDE CONSULTANT FEES	
7003	LONG DISTANCE TELEPHONE	
(8)	TOTAL	119,300

SUMMARY

(7)	MANHOUR CHARGES	1,375,320
(8)	DIRECT SERVICE EXPENSES	119,300
		1,494,620
	10% CONTINGENCY	149,460
	TOTAL:	1,644,080

APPENDIX VII EXAMPLE OF DESIGN & DRAFTING DRAWING SCHEDULE

Services de Génie Alcan

Registre des dessins

Numéro: Numéro de projet	Zone ou sous-ensemble	Catégorie	Numéro d'ordre	Titre	B/A B/M	Relevé des dates: Révision	Émission prévue / Émission reportée	Achèvement	Première Émission	Remarques	Dernière révision du R/D N°	Figures prévues: Calculs	Figures prévues: Dessins	Calculs: Effectués par / Vérifiés par	Dessin: Dessiné par / % Progression	Dessin: Vérifié par / % Progression	Schedule Group
												A l'origine / Corrigé pour compléter					
DO 1499	42	A	001 R	SALLE DE POMPAGE ET SALLE DE CONTROLE - EST								30	90		B.S		30
DO 1499	42	A	002 R	SALLE DE POMPAGE ET SALLE DE CONTROLE - OUEST								20	90		B.S.		30
DO 1499	42	A	003 R	BAT. DE CCM POUR SOUS-STATION 'B' FEUILLE - 1								30	100		B.S		50
DO 1499	42	A	004 R	BAT. DE CCM POUR SOUS-STATION 'B' FEUILLE - 2								30	100				30
DO 1499	42	A	005 R	CEDULE DES PORTES ET QUINCAILLERIES.								5	25		B.S		30
			R	SPECIFICATION POUR ETAPE I								-	75				30
			R														
			R														
DO 1499	42	A	006 R	BAT. DE NEUTRALISE - FEUILLE 1								30	90				31
DO 1499	42	A	007 R	BAT. DE NEUTRALISE - FEUILLE 2								20	90				31
DO 1499	42	A	008 R	BÂT. DE POMPAGE D'EAU.								20	80				31
DO 1499	42	A	005 R	CEDULE DES PORTES ET QUINCAILLERIE								5	25				31
			R	SPECIFICATION POUR ÉTAPE II								-	75				31
			R									75	360				
			R														
			R														

Révision du registre des dessins

Total		Ing. participant
190	840	
235	1200	Ing. chef du projet
1	435	

Statut

Titre du projet: SERIES D'ELECTROLYSES Nº 303 ET 304
SYSTEME D'EVACUATION ET DEPURATION DES FUMÉES

pour USINE DE BEAUHARNOIS — BEAUHARNOIS P.Q.

N° des calculs justificatifs | Par | Date

N° d'autorisation | Approbation

N° de la feuille: 1/1 | Par | Date

*Le nombre total de feuilles est indiqué sur la feuille N° 1

DS 1499-42-A-001 R 00

Partie réservée aux services auxiliaires ne pas écrire à des tiers

A l'usage du service administratif seulement

Approuvé par | Vérifié par | Préparé par

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APPENDIX VIII CRITERIAS & PROCEDURES FOR MONTHLY DRAWING SCHEDULE UPDATES

Drawing Schedule Update Instructions

for Drawing Control System

1. Completion on dwgs will be calculated as shown:

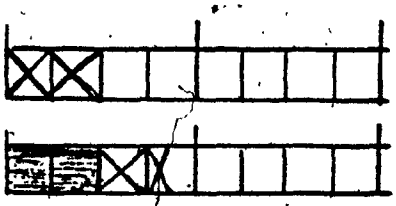
Dessiné par % Progression				Verifie par % Progression			
20%	20%	20%	20%	5%	5%	5%	5%

2. Progress should be shown:

   A. In the month of the update with a cross X.

   B. In the previous month(s) with shaded area(s)

e.g.



40% Completed

70% Completed

3. New drawings should be numbered with:

   A. A "libre" or "reserve" dwg No. in the original Dwg Schedule.

   B. A number which <u>has not</u> been used in the original dwg schedule.

APPENDIX IX EXAMPLE OF ACTUAL MANHOURS AND COST IN ENGINEERING CONTROL SYSTEM

SERVICE ORDER	SOURCE OF CHARGE	REF	HOURS-WORKED CYC-1	HOURS-WORKED CYC-2	OR A	HOURLY CHARGES	DIRECT CHARGES	********** TOTALS ********** DIS	TOT-HRS	REF TOT-CHARGE
1499-42-00-2										
**********										
*1499-42-00-2	COST SUMMARY CAPSULE	*								
*	MTH YTD	CUM. TD *								
*TOTAL	0 0	67,246 *								
**********										
1499-42-00-3										
001244	HADJIDIACOS ,C.	01	7.5	7.5		453.60				
002014	SAWONIAK, B.	01		23.0		695.52				
002059	NOEL, E.	01	31.0	27.0		1147.24				
003692	SAMBOTELGCAN, C.	CAS 01		15.0		296.70				
025408	LAPOINTE, R.	01	5.0	6.5		419.64				
029712	MALINOWSKI, V.	01	20.0	52.0		2627.28				
500834	CUNNINGHAM,T.O.	01	57.5			2098.18				
501205	KAEPPELI O.	01	41.0	69.5		2185.69				
501210	DEL VECCHIO, A.	01	86.0	71.0		3105.46		01	519.5	13029.31
002518	PENA, O.	02	68.0	64.0		3293.43				
025068	LANGLOIS ,C.	02	15.0	18.5		835.83				
036683	PRIMEAU, M.	02	7.5			273.68		02	173.0	4402.94
001703	DES MEULES ,M.	11	82.0	52.5		4067.28				
037784	RIOS,J.	11	25.5	18.0		1587.32		11	178.0	5654.60
022057	HUXTABLE J.W.	12	11.0	81.0		3357.08		12	92.0	3357.08
009126	COLLINGE, G.	13		37.5		1368.38		13	37.5	1368.38
015031	FLACK,E.C.	17	4.0			187.28		17	4.0	187.28
001583	BEDNAREK ,A.(MISS)	18	30.0	35.5		1980.72				
003177	SHARMA, B. MRS	CAS 18	63.5	19.0		1631.85				
501165	BUITRAGO, C.	18	30.0	48.5		1552.73		18	226.5	5165.30
000088	BERNARD ,M.G.	21	4.0			99.80		21	4.0	99.80
002280	SABHARWAL, V.K.	41	34.0			1028.16				
170627	MESSIER ,G.	41	20.0	9.5		892.08		41	63.5	1920.24
001968	MAILER C MISS	49	3.0			41.19				
023949	KRAPEC ,M.(MISS)	49	4.0			54.92				
148583	OSSEYRANE ,M.(MME)	49	2.0	1.5		48.06		49	10.5	144.17
600663	ADASZKIEWICZ, M.	11		39.5	A	1441.36		11	39.5	1441.36
017771	GIASSON, R.	21	44.0		A	2060.08		21	44.0	2060.08
	BLUEPRINTING & REPRODUCTI	0002					134.88		0802	134.88
	DRAFTING AIDS	0005					17.50			
	DRAFTING AIDS	0005					39.93			
	DRAFTING AIDS	0005					5.00			
	DRAFTING AIDS	0005					34.87		0005	97.30
	1860 XEROXING	0006					2.50			
	1860 XEROXING	0006					2.50			
	1860 XEROXING	0006					2.50			
	1860 XEROXING	0006					7.50			
	1860 XEROXING	0006					5.00			
	1860 XEROXING	0006					5.00		0006	25.00
	TRAVELLING EXPENSES	2301					51.55			

SERVICE ORDER	SOURCE OF CHARGE	REF	HOURS-WORKED CYC-1	HOURS-WORKED CYC-2	OR A	HOURLY CHARGES	DIRECT CHARGES	********** TOTALS ********** DIS	TOT-HRS	REF	TOT-CHARGE
1499-42-00-3											
	TRAVELLING EXPENSES	2301					42.12			2301	93.67
	OUTSIDE CONSULTANTS	4001					210.20			4001	210.20
1499-42-00-3	TOTAL CHARGES		695.5	696.5		38830.54	561.05		1392.0		39391.59
**********											
*1499-42-00-3	COST SUMMARY CAPSULE	*									
*	MTH YTD CUM. TD	*									
*TOTAL	39,392 139,867 139,867	*									
**********											
1499-42-00-4											
017771	GIASSON, R.	21	3.5			163.87		21	3.5		163.87
	1860 XEROXING	0006					3.75			0006	3.75
	COMPUTER PLOTTER DRAFTING	0004			A		-562.50			0004	-562.50
1499-42-00-4	TOTAL CHARGES		3.5			163.87	-558.75		3.5		-394.88
**********											
*1499-42-00-4	COST SUMMARY CAPSULE	*									
*	MTH YTD CUM. TD	*									
*TOTAL	395CR 846 846	*									
**********											
1499-42-01-2											
		AJSF			A		-13598.99				
		AJST			A		13598.99			* AJST	
1499-42-01-2	TOTAL CHARGES										
**********											
*1499-42-01-2	COST SUMMARY CAPSULE	*									
*	MTH YTD CUM. TD	*									
*TOTAL	0 0 13,599	*									
**********											
1499-42-01-3											
001395	ANVER ,E.(MRS)	01		4.5		89.01					
001842	SIMON,D.	CAS 01		37.5		741.75					
002565	CACCIOLA, T.	01	42.0			830.76					
045945	VELASCO ,P.	01		9.0		224.55		01	93.0		1886.07
000314	MANNISTU,PETER	07		15.5		565.60		07	15.5		565.60
014391	FARKAS ,B.	11	9.0	4.0		608.66		11	13.0		608.66
001968	MAILER C MISS	42		4.5		61.79					