OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

United Nations Industrial Development Organization

Distr.
LIMITED

ID/WG.60/5
8 June 1970

ORIGINAL: ENGLISH

UNIDO/DECHEMA Seminar on Operation, Maintenance, Design and Manufacturing of Chemical Plants and Equipment in Developing Countries

Königstein (Taunus) near Frankfurt/Main
Federal Republic of Germany
25 - 26 June 1970

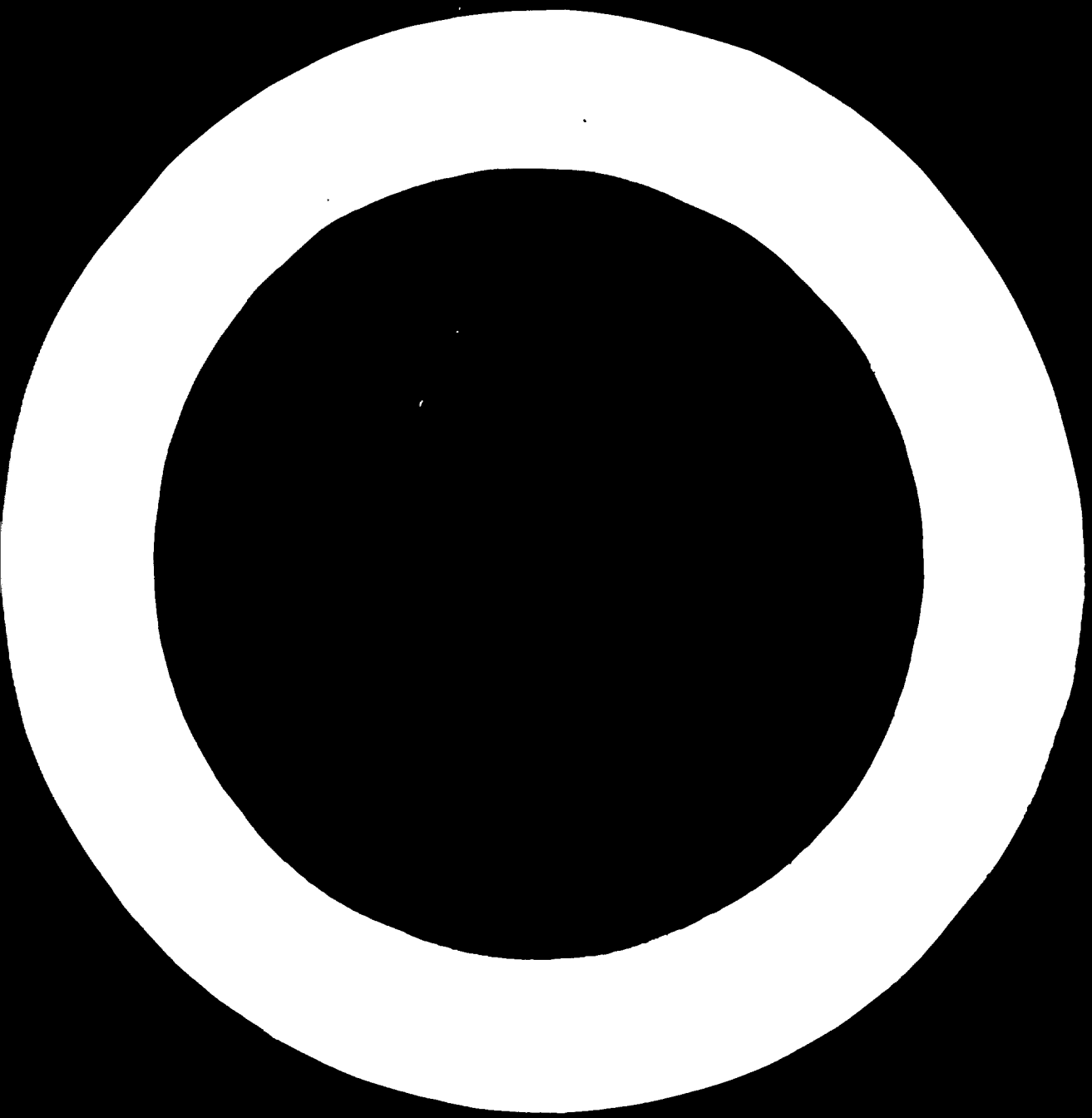
OPERATION OF CHEMICAL PLANTS IN DEVELOPING COUNTRIES 1/

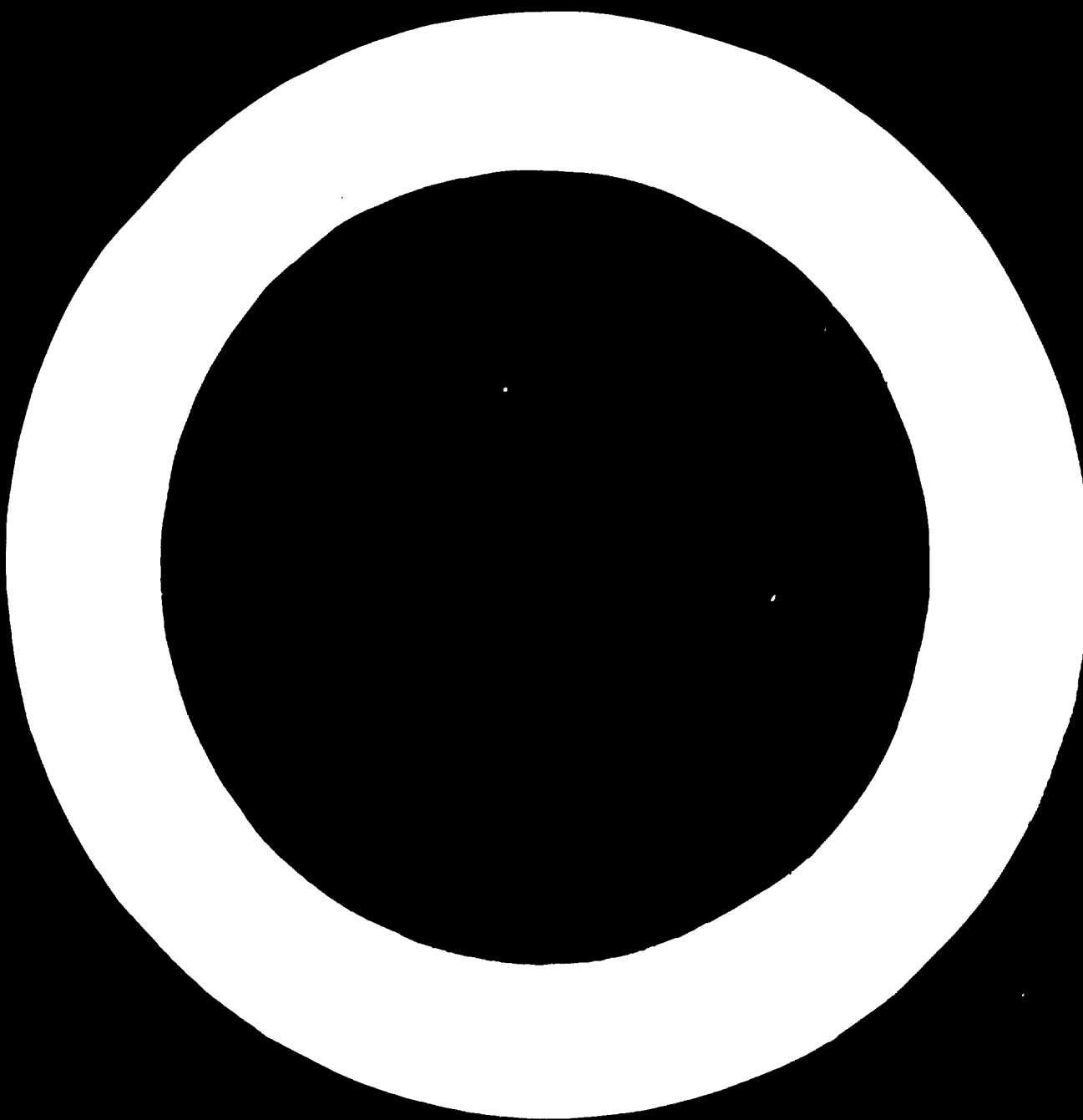
by

H. O. Georgs - H. P. Wickham
The M. W. Kellogg Co., New York
and
M. Vos
Kellogg International Corporation
London

1/ The views and opinions expressed in this paper are those of the author's and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

id.70-3490





A. INTRODUCTION

The Operation of Chemical Plants is a broad subject which must be broken down into a number of different activities. In this paper, we will discuss several of these activities such as training, staffing and the startup of the plant as well as the control and care of the plant during normal operation. It will be seen that each of these activities requires planning and scheduling for the activity before it occurs, otherwise much valuable time will be lost and the final operation of the plant may fall far short of success.

B. DESIGN

Successful operation of a chemical plant depends in the first place on the thoroughness with which the operation has been planned during the design phase. Because conditions in different countries and even in parts of the same country can vary considerably it is important that they be taken into account in the design of the plant.

In industrialized countries, it is relatively easy to find out about prevailing conditions by referring to existing codes or local laws that have usually been developed based on the experience gained for operating plants. It is also advisable to check directly on the experience with these plants. In developing countries such experience may not be available and it is therefore very important that close cooperation between the engineering contractor and the operating company be maintained through all phases of design.

Most contractors employ personnel who are experienced in plant peration and the experience of these people should be used from the arly stages onward. They should check plant design to see that startup, hutdown, and emergency conditions have been taken into account in inalizing the plant design. Their experience should enable them to predict ny unusual circumstances that may occur during operation and to re- ommend incorporation of design features to care for these situations.

They can prepare an operating philosophy early in the design tages to serve as a guide for the design departments. This operating hilosophy is a forerunner of the final operating instructions manual. f a plant model is prepared these experienced people review it to deter- ine accessibility both for operating and maintenance purposes. Various eatures are studied, such as the location of instruments and valves for ccessibility, insulation requirements for protection of plant personnel scape routes in case of fire and the like. It is customary to have a re- resentative of the operating company present during this model review o that he can appreciate the reasons for any changes. An illustration f a model of a small plant is shown in a slide as Figure 1. Slide 1

As engineering flowsheets are issued, they are scrutinised by xperienced members of the engineering and operating groups and improve- ents and changes are incorporated. Representatives of the operating ompany also review these flow sheets. In the event they lack operating xperience on the plant being reviewed, it is important that they participate n discussion with operating people who have this knowledge.

The decision on the extent to which spares are provided will of course depend greatly on local availability of such spares and influences the incorporation of standby equipment. In some situations, spare compressors and pumps are justified, or as an alternate for a given service two units of 50 to 70% capacity should be considered. Other spare material for consideration is parts or replacement for exchanger bundles, valves, packing material, piping and furnace tubing, burners, instruments, parts for pumps and compressors, and motors and turbines or parts thereof. Material which has to be obtained from a far away source at a long delivery time should be on hand to avoid a prolonged plant shutdown. Adequate shop space and equipment for repair and rebuilding should be included with the plant if such facilities are not readily available.

When the design of the plant has been developed and information has been obtained from vendors on various items of equipment, the engineering contractor prepares a comprehensive Operating Instructions Manual. This manual, which may consist of several volumes in the case of a multi-unit project, contains basically the following information:-

Description of the Flow --- which describes the complete flow through the systems, making reference to vessels, instrumentation pumps and other equipment.

Process Principles --- describes the theory and principles of the process, the process variables and their effect on product quality.

Unit Conditioning --- covers the conditioning of the equipment where pertinent to startup and subsequent operations.

Startup Instructions --- detail the general overall startup plan in narrative form. Special precautions, catalyst activation procedures and off-design considerations are elaborated upon.

Shutdown Instructions --- cover the general overall shutdown plan when the unit is taken out of service purposely and deliberately. Procedures for furnace decoking, catalyst regeneration and the like are covered.

Emergency Procedures --- where applicable, cover the procedures to follow in the event of a utility or equipment failure.

Appendix --- contains drawings pertinent to the process and technical data of importance to the operators.

This manual is issued to the client several months before plant completion to phase in with operator-training programs.

If client's operating staff is not reasonably conversant in English, arrangements should be made by the operating company to have the manual translated locally so that there will be no dialect problems. It is essential that the translator has sound process and operating knowledge, otherwise errors and misunderstandings may be introduced and the effect of the manual may be lost.

This manual is intended to be used as an overall guide and relates all the sections of the plant to each other. More detailed instructions are frequently prepared by the supervisors in charge of the specific procedures.

c. Staffing

If the operating company wishes, the engineering contractor can prepare a manpower organization chart for the entire complex of plants or parts thereof. An illustration of a simplified organization chart for a complex is shown in the attached Table I and in figures 2 through 5, all of which are shown on slides.

In this example, the detailed breakdown is only shown for the operating staff of one complex and in Figure 5, this staffing is shown for a shift of one unit in the complex. Recommendations as to the desired level of experience, qualifications of the personnel to be employed and the number of employees to be hired can be obtained from the plant designer.

Slides 2 thru 6

This plant organization should be reviewed well ahead of plant completion so that the operating company will have the opportunity to survey the local labour market. If qualified personnel cannot be hired locally, the operating company should make arrangements to get help on a temporary basis by outside recruiting, utilizing contractor's experienced personnel, by borrowing manpower from affiliated companies or some combination from available sources. In addition, it is advisable to have vendors service engineers present to advise or assist in the initial operation of their equipment.

It is all too easy to rely heavily on outside assistance but it may fail to provide the company's personnel an opportunity to gain self confidence and experience. When outside assistance is found necessary, a prime objective is to use their experience in training local personnel.

4. Training

Prior to plant completion, a training program essentially as outlined on Figure 6 should be established. This program normally includes the following elements. Slide 7

a) Plant visits by a group of supervisory personnel to a similar installation, preferably under the guidance of one of the contractors experienced operators. These supervisors will be expected to play an active part in the subsequent training program.

b) Classroom training for personnel that will be involved in the operation of the plant preferably by a training specialist or by supervisory personnel.

Orientation is an important element to be included in classroom instruction. Each man must become thoroughly familiar with the organization and his specific function and duties. Position descriptions should be prepared for each assignment, detailing these duties and responsibilities to assure that each individual knows exactly what is expected of him and what he can expect from others.

Much assistance in training can be provided by the engineering contractor or his experienced operators. Visual aids, including training simulators, if available, are also of great assistance when carrying out a successful training program.

The operating instructions manual mentioned previously is used as a basic tool for training purposes.

c. On the job training proceeds even before the plant is complete. As various portions of the plant are readied for operation, a great deal can be learned. The clients operating personnel can witness and assist with such activities as; checking of plant equipment, calibration of instruments, blowing of lines, charging of catalysts and chemicals, dryout of furnaces and similar tasks.

d. Safety policies and procedures must be developed, and the staff must be trained to adhere to those precautions which are established to prevent accidents as well as becoming familiar with the steps to be taken in the event of an accident. In most chemical plants, the operating staff are expected to play an active role in case of fire, and a fire fighting school is often used to provide the men with the knowledge they will need to properly utilize available equipment. Training must include a basic knowledge of all chemicals involved in the plant including those for fire fighting and the measures required to protect personnel as well as equipment. A sound safety program is designed to provide for safe handling of things as well as people.

After the plant has been placed in operation, classroom training should be continued for new personnel and for development of all plant operators. Shift schedules should be arranged in such a way that personnel can be made available to attend those training sessions.

The importance of the training and the preparation of the training program to obtain the maximum benefit of this exercise cannot be over-emphasized, and the success or failure of future operations may depend on the thoroughness with which this training has been conducted.

E. Preparing Plant for Startup

Some months before the plant is complete, the engineering company operators are assigned to work with construction forces. During this period, these operators will assist in scheduling of construction activities and set priorities for completion of different sections of the plant. A typical simplified schedule is shown in Figure 7. Slide 8

The engineering company operators will assist and supervise the loading of catalyst, prepare utility systems for operation and assist sub-contractors with the chemical cleaning of boiler systems. During the chemical cleaning program the furnaces refractory liners can be dried out by lighting small fires in the furnaces. Rotating equipment can be checked for alignment, lubrication systems checked and circulations initiated, compressors run-in on air or inert gas and pumps run-in on water or oil. Systems not cleaned by oil circulation may be blown with air, especially any cold sections. Circulations can then be established with air or inert gas to dry out the cold sections, followed by a leak test as the final step towards startup.

F. Startup Operations

An orderly startup of a chemical plant requires devoted attention to the details of organization, planning and scheduling. A chemical plant such as shown in Figure 8 will be the basis for discussion on startup operations. Slide 9

Before the startup of a chemical plant, it must be staffed on a round-the-clock basis with operating, maintenance and laboratory personnel and possibly an interpreter to overcome any language barriers.

The individual steps to be completed will require that supervisory personnel provide detailed written procedures to be followed. It is advisable that shift schedules for all startup personnel allow for an overlap of at least one hour at shift changes. This practice should be maintained, for operating personnel only, during normal plant operation, but the period of overlap can then be reduced to 20-30 minutes.

The steps and sequence of startup will of course depend upon the type of plant and the specific components involved. A typical simplified schedule for the startup of a plant of this magnitude is illustrated in Figure 9. Slide 10

The first and major step in any plant startup is to properly purge the unit of air before any combustible or reactive materials are admitted to the system. This may be accomplished with steam or an inert material. Refrigeration systems are placed in service and circulation established to check out these circuits. Cold oil, water and chemical circulations are established to check out instrumentation, pumps, etc., before heat is applied to the plant. Furnaces are purged of air, process steam flows are initiated and when these circuits are checked and stabilized, the furnaces are fired and brought up to temperature in preparation for the introduction of feed. After feed is introduced, the temperatures in the cold sections can be reduced which will produce the necessary gases for activation of catalyst. After the catalyst has been activated, the unit can be lined out and stabilized and the products directed to storage. Rates are then increased to design.

G. Normal Operation

As the plant approaches normal operation it becomes increasingly important to maintain records on plant performance. It is customary to have each plant keep a log of its detailed performance entering on this daily sheet readings taken every two hours for all temperatures, pressures and flow rates. Some additional data such as cooling water temperatures and ambient conditions may be recorded on a less frequent basis. These daily records are then studied by Operating and Process personnel and are frequently averaged to provide a daily performance record. The averages may be compiled into a weekly report on each unit for submission to management as an interim performance record.

Detailed performance data is of great value in decisions upon corrective steps to be taken when performance appears to have deteriorated in some way. This is particularly true of chemical processes involving catalyst and in cases where side reactions occur.

Samples of the feed and product streams as well as critical intermediate streams must be taken at frequent intervals and analyzed in the plant laboratory. Very often the laboratory reports their findings on critical streams by telephone to the plant control room but in all cases a written daily record is completed and copies sent to the Operating Supervisors. These records are also of great value not only in the day to day control of the plant but for reference in case performance appears to be deteriorating. Again they will be reviewed and correlated by Process personnel and included in the overall performance records of the plant.

An obvious objective is to keep the plant in continuous operation and to prevent so far as possible any unscheduled shutdowns. Adequate maintenance personnel must be available to make corrections or repairs to any of the parts of the plant which may need attention. It is common practice on modern plants to keep shift maintenance coverage to a minimum and to do most of the routine maintenance on normal work days. Much preventive maintenance can be accomplished in this way to avoid or minimize maintenance crises. Lubrication schedules should be set up for the routine service of mechanical equipment, valves as well as motors, pumps and compressors. Schedules should also be set up and followed for the routine cleaning of burners, strainers and the like, much of which may be handled by operating personnel. A record should be kept either by operating or maintenance personnel of those items which appear to need maintenance work during periods when the plant is shut down. This record is added to as the operating period progresses and as experience with the plant develops. It may become an almost complete list of the work items to be completed when the plant is shut down. A scheduled shut down period is planned for most chemical plants on an annual basis for the first several years in the life of the plant. In many cases, as experience develops it is found to be much more satisfactory to schedule a maintenance turnaround on a two or even a three year basis.

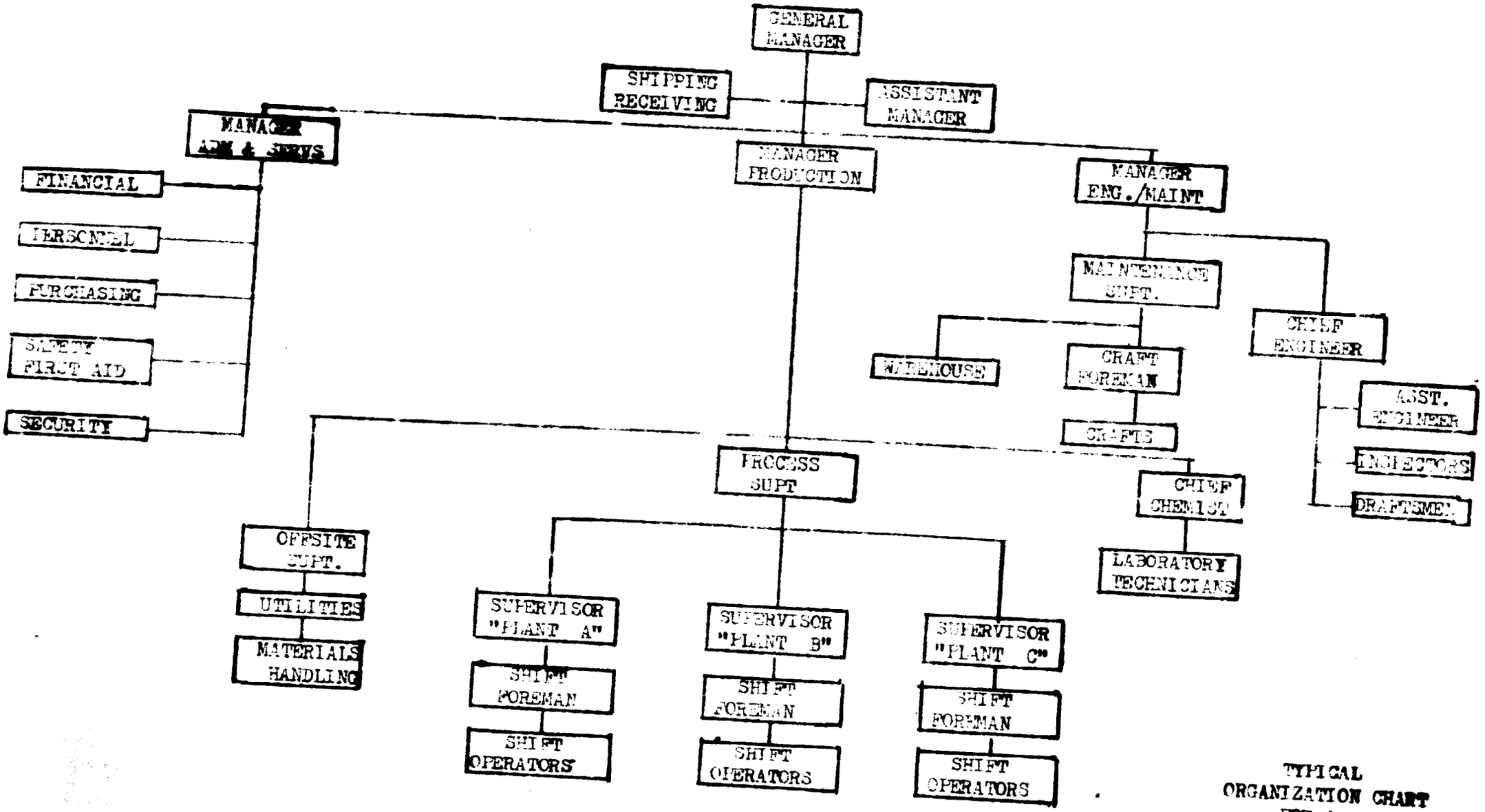
Many articles have been written on the value of planning maintenance work in advance and on the scheduling of all maintenance activities. It is quite obvious that when work is planned in advance the materials are available

when and where needed and much time can be saved in the execution of the work. Manpower must also be scheduled so that adequate crafts are available to do the necessary work in the shortest possible time.

CONCLUSION

In the preceeding discussions it was brought out that all the phases of plant operation involve planning and scheduling. Even the training program to prepare operators for their jobs in the plant must be planned in advance. Maintenance work has obvious need of planning and scheduling. In short, all aspects of plant operation are not only susceptible to planning and scheduling but will benefit thereby.

Much assistance in the preparation of plans can be gained from those having experience with the particular plant involved. The designers of the plant can be very helpful in this area and much can be learned by visiting similar units, reviewing plant data and discussing problems with the operating and maintenance staffs. The collection and use of all such information and the preparation of detailed planning of all phases will almost certainly assure that the plant will end up in successful operation.



TYPICAL
ORGANIZATION CHART
FOR A
CHEMICAL COMPLEX

TABLE I

FIGURE - 1

SLIDE - MODEL OF A PYROLYSIS FURNACE, QUENCH SYSTEM AND RECOVERY TOWER.

FIGURE - 2

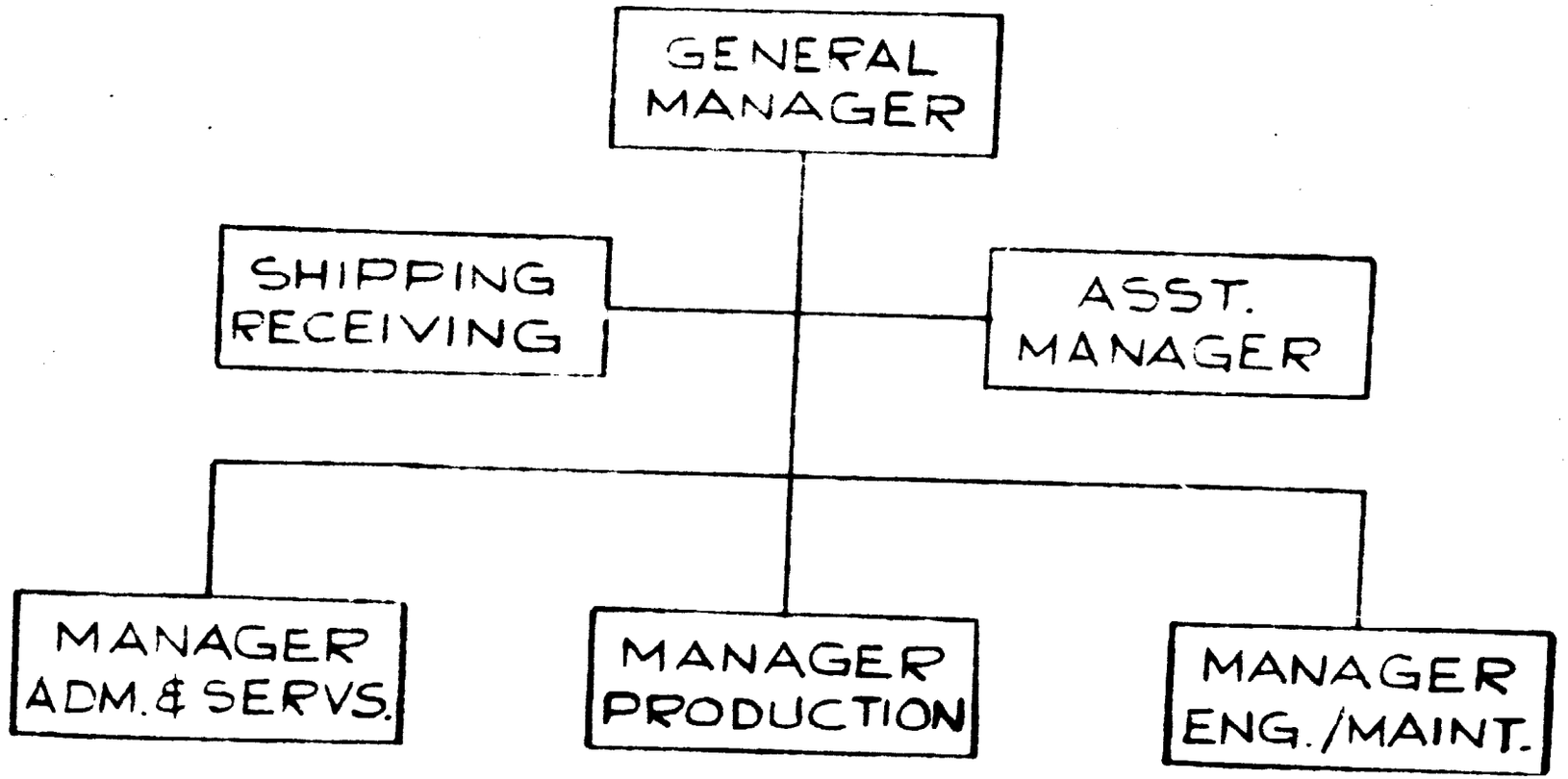

GENERAL MANAGER
SHIPPING RECEIVING
ASST. MANAGER
MANAGER ADM. & SERVS.
MANAGER PRODUCTION
MANAGER ENG./MAINT.

FIGURE - 3

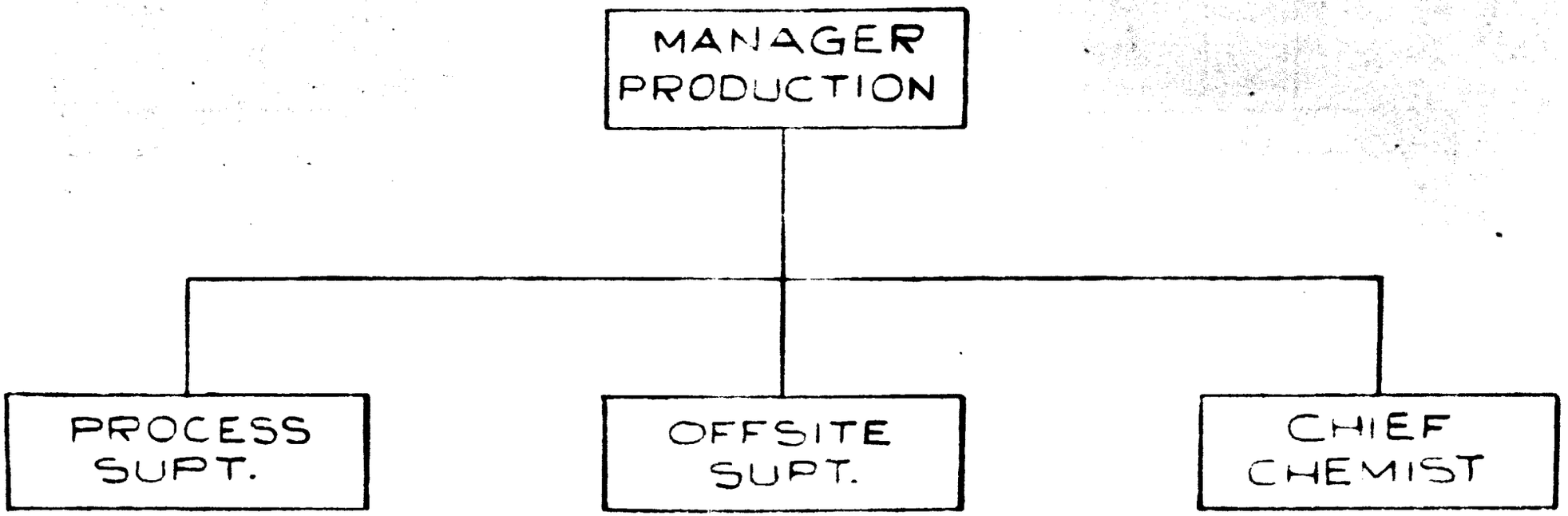

MANAGER
PRODUCTION
PROCESS
SUPT.
OFFSITE
SUPT.
CHIEF
CHEMIST

FIGURE - 4

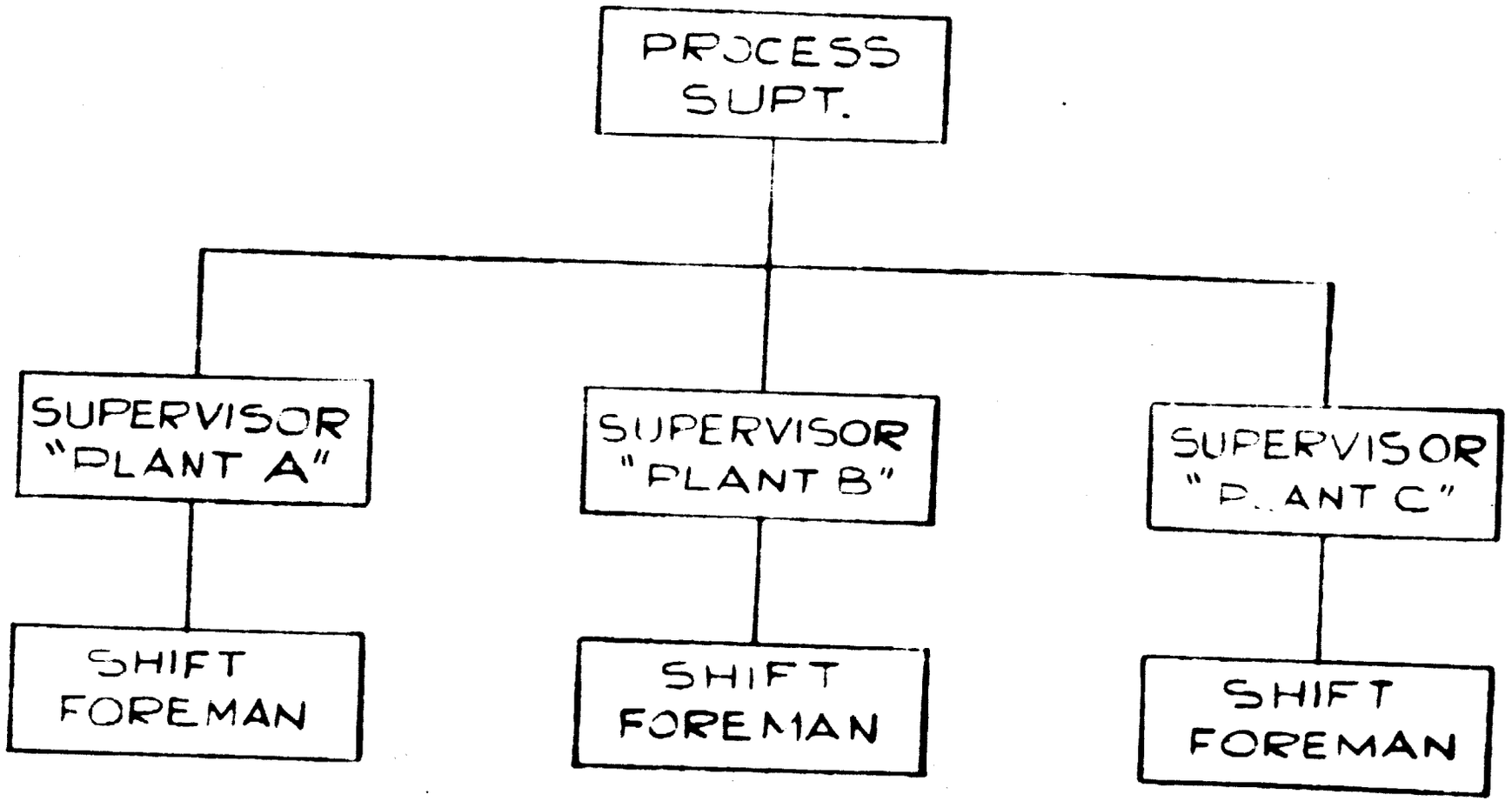

PROCESS SUPT.
SUPERVISOR "PLANT A"
SUPERVISOR "PLANT B"
SUPERVISOR "PLANT C"
SHIFT FOREMAN
SHIFT FOREMAN
SHIFT FOREMAN

FIGURE - 5

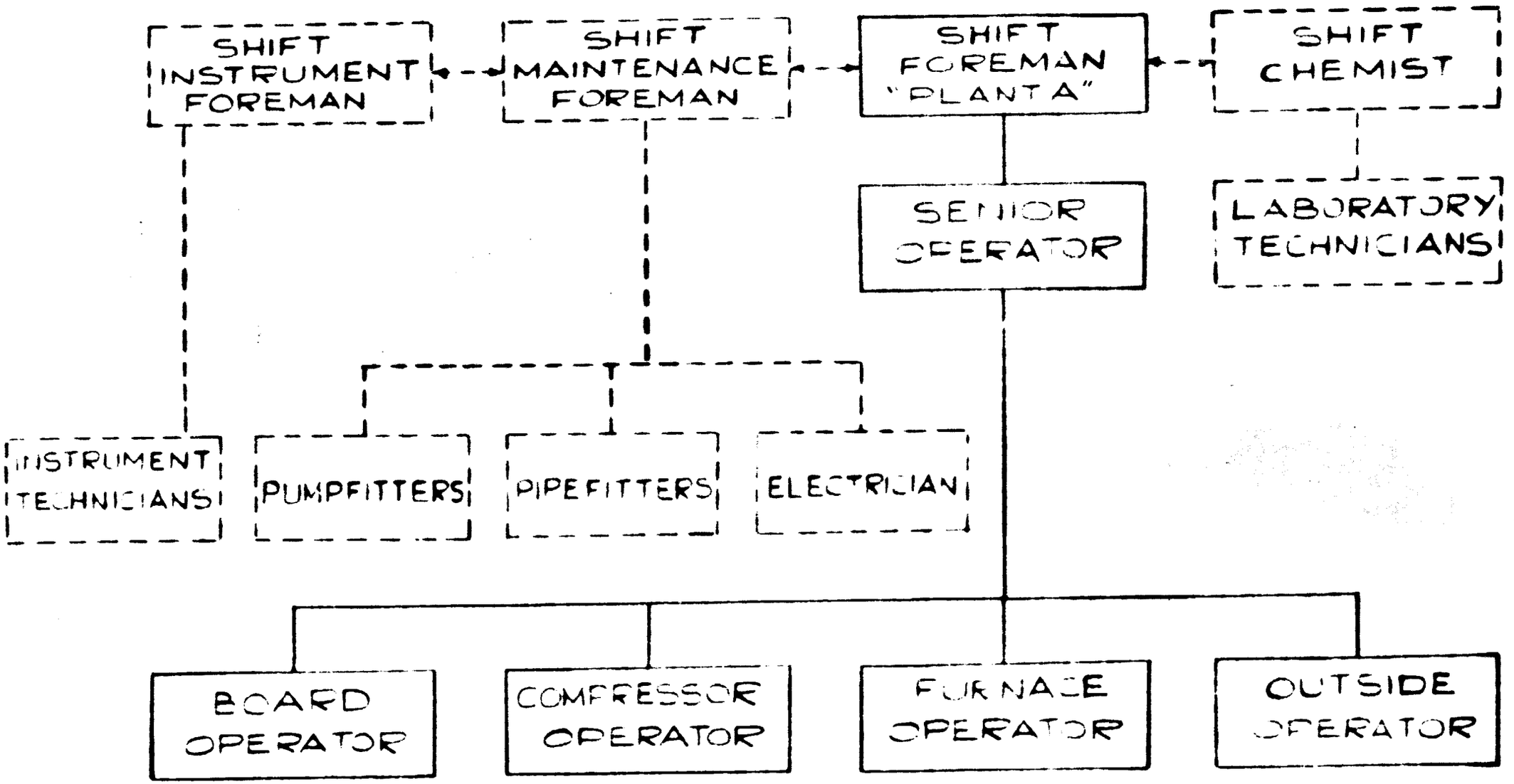

SHIFT INSTRUMENT FOREMAN
SHIFT MAINTENANCE FOREMAN
SHIFT FOREMAN "PLANT A"
SHIFT CHEMIST
SENIOR OPERATOR
LABORATORY TECHNICIANS
INSTRUMENT TECHNICIANS
PUMPFITTERS
PIPEFITTERS
ELECTRICIAN
BOARD OPERATOR
COMPRESSOR OPERATOR
FURNACE OPERATOR
OUTSIDE OPERATOR

FIGURE - 6

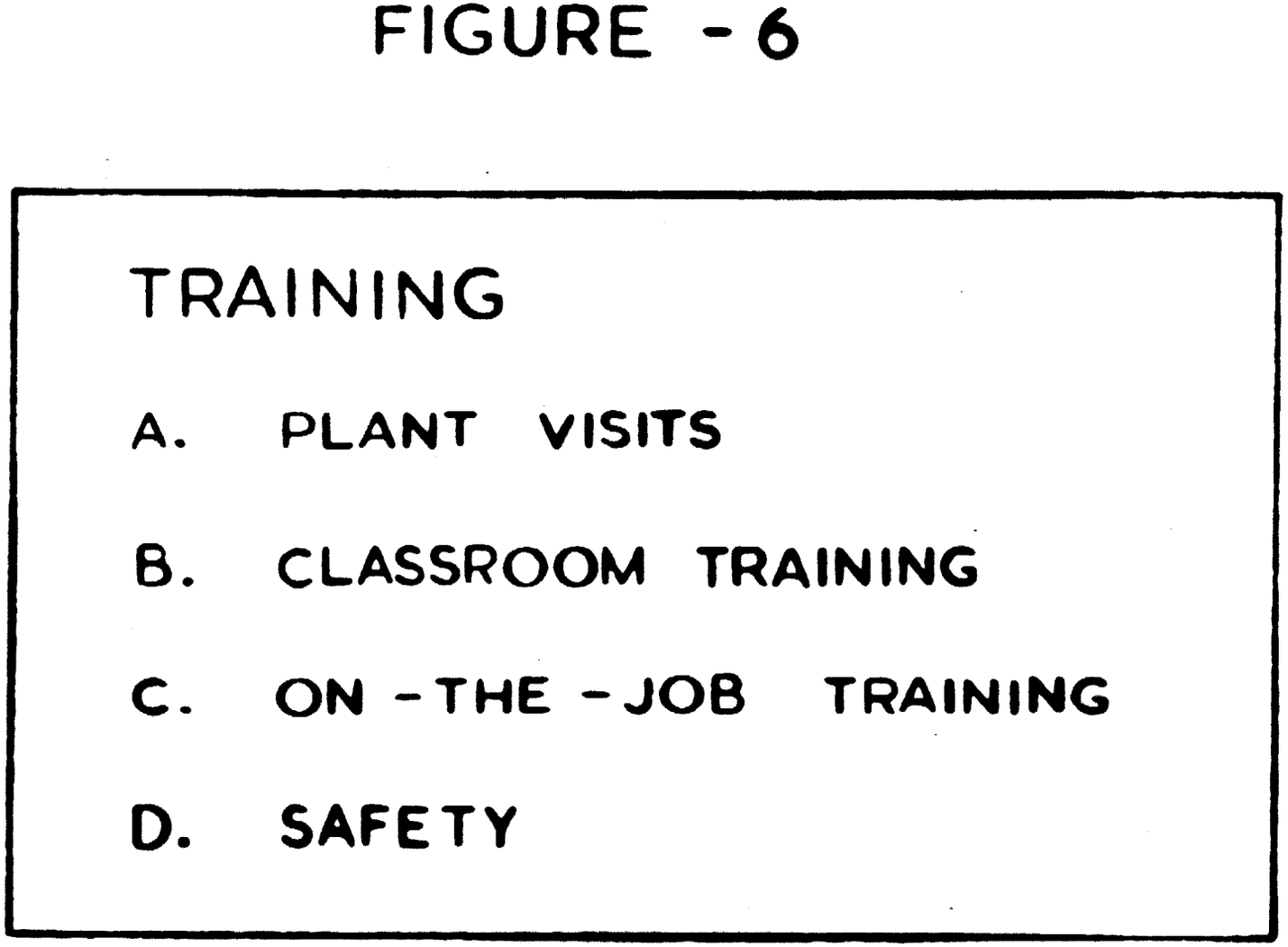

TRAINING
A. PLANT VISITS
B. CLASSROOM TRAINING
C. ON - THE - JOB TRAINING
D. SAFETY

FIGURE - 7

PRE - START UP OPERATING ACTIVITIES

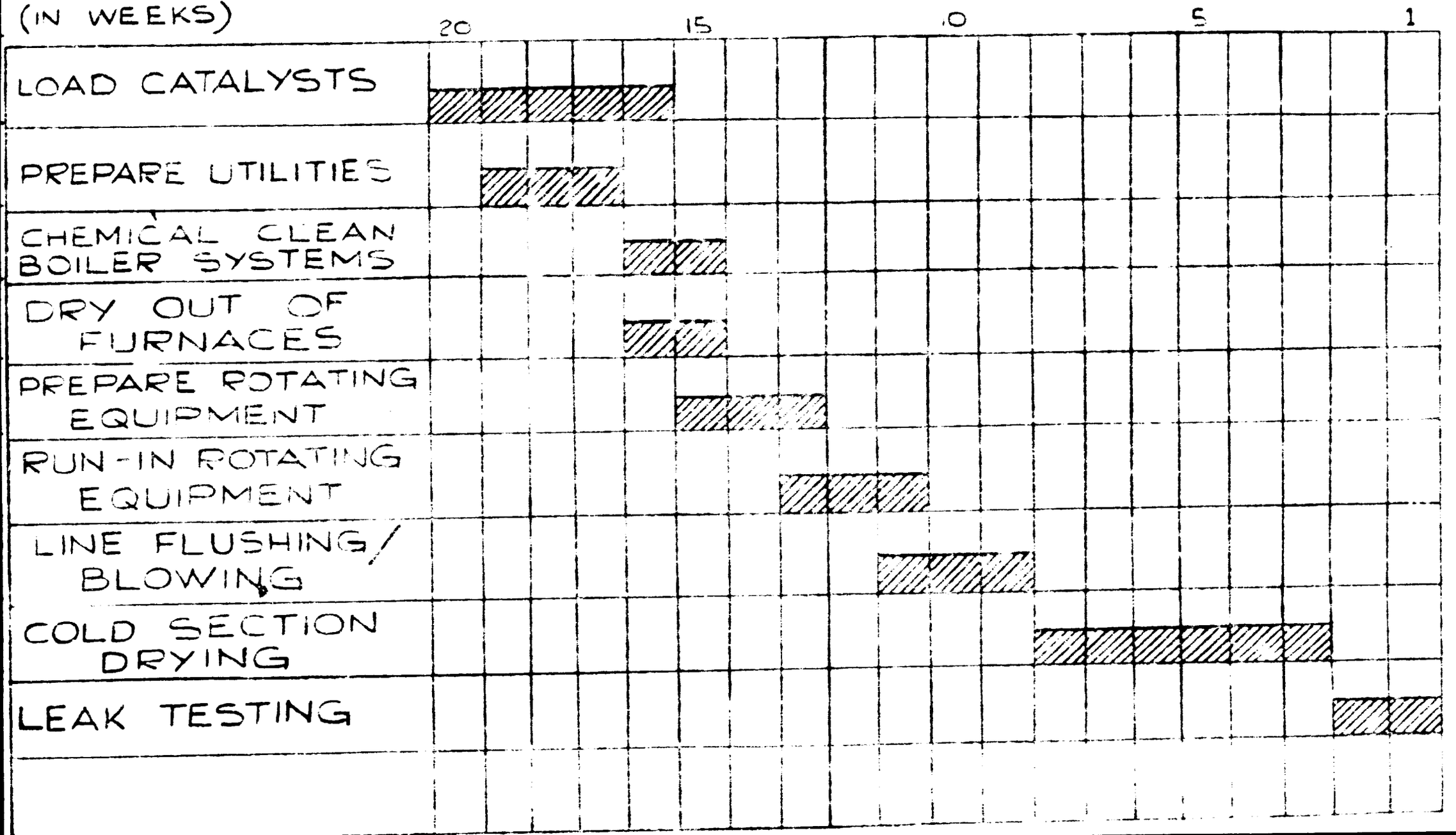
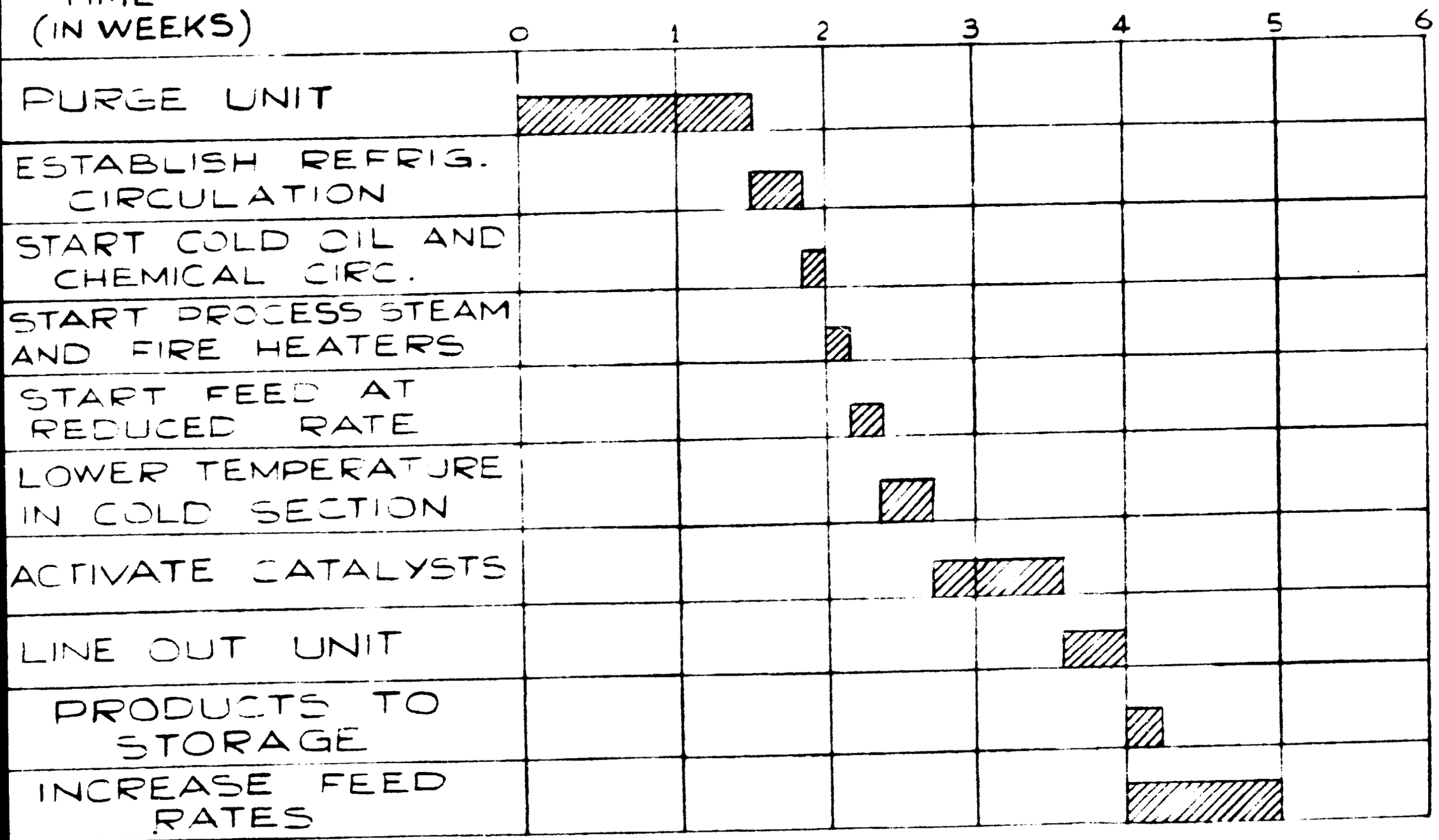


FIGURE - 8

SLIDE OF AN ETHYLENE UNIT.

FIGURE - 9

CHEMICAL PLANT START UP OPERATIONS



United Nations Industrial Development Organization

Distr.
LIMITED
ID/WG.60/5 SUMMARY
10 March 1970
ORIGINAL: ENGLISH

UNIDO - DECHEMA - Seminar on Operation, Maintenance, Design and Manufacturing of Chemical Plants and Equipment in Developing Countries

Königstein (Taunus) near Frankfurt/Main
Federal Republic of Germany
25 - 26 June 1970

SUMMARY

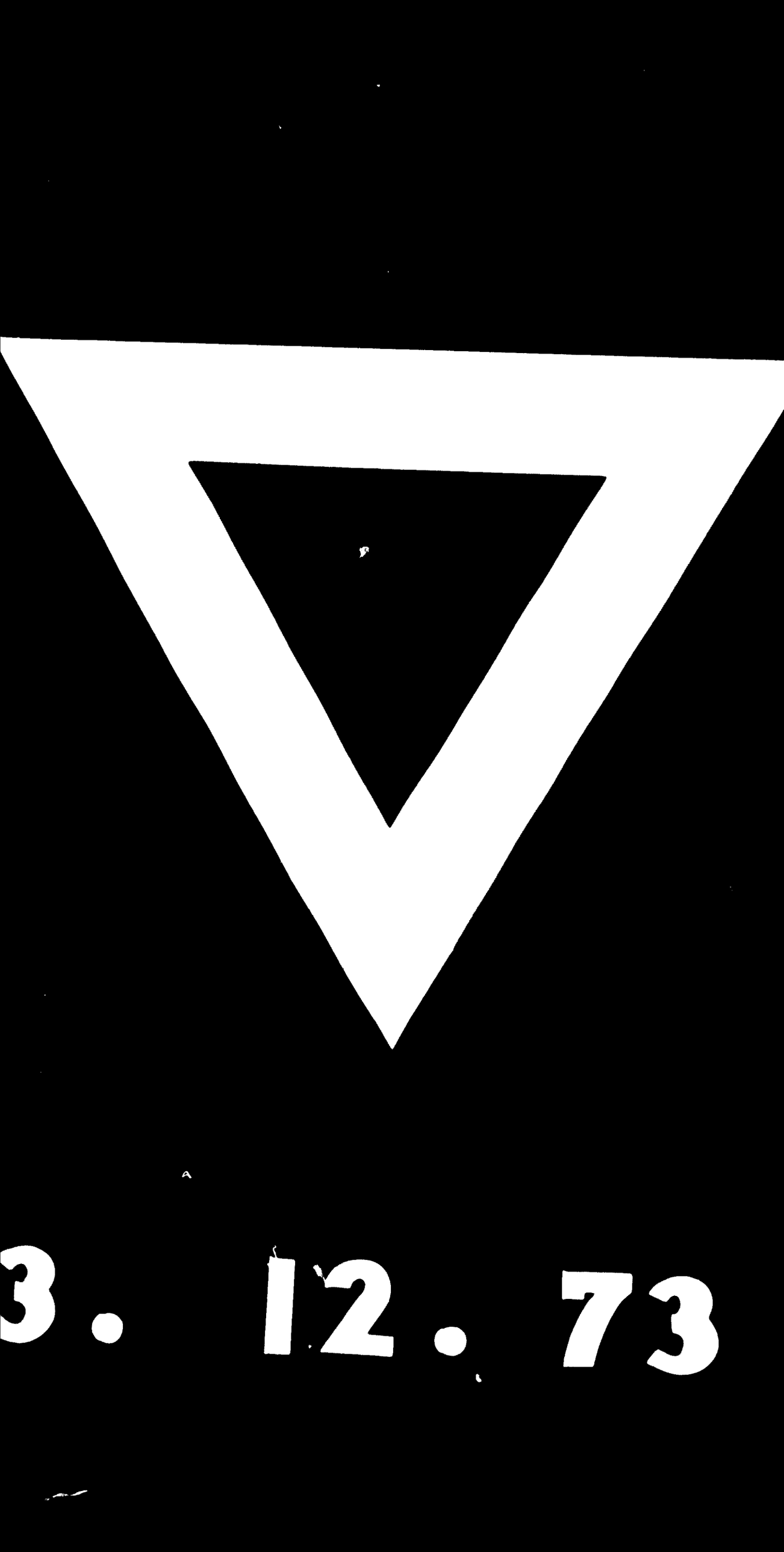
OPERATION OF CHEMICAL PLANTS IN DEVELOPING COUNTRIES 1/

by

N. Vos - H.P. Wickham - H.O. George
Kellogg International Corporation
London, United Kingdom

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

id.70-1304


3. 12. 73