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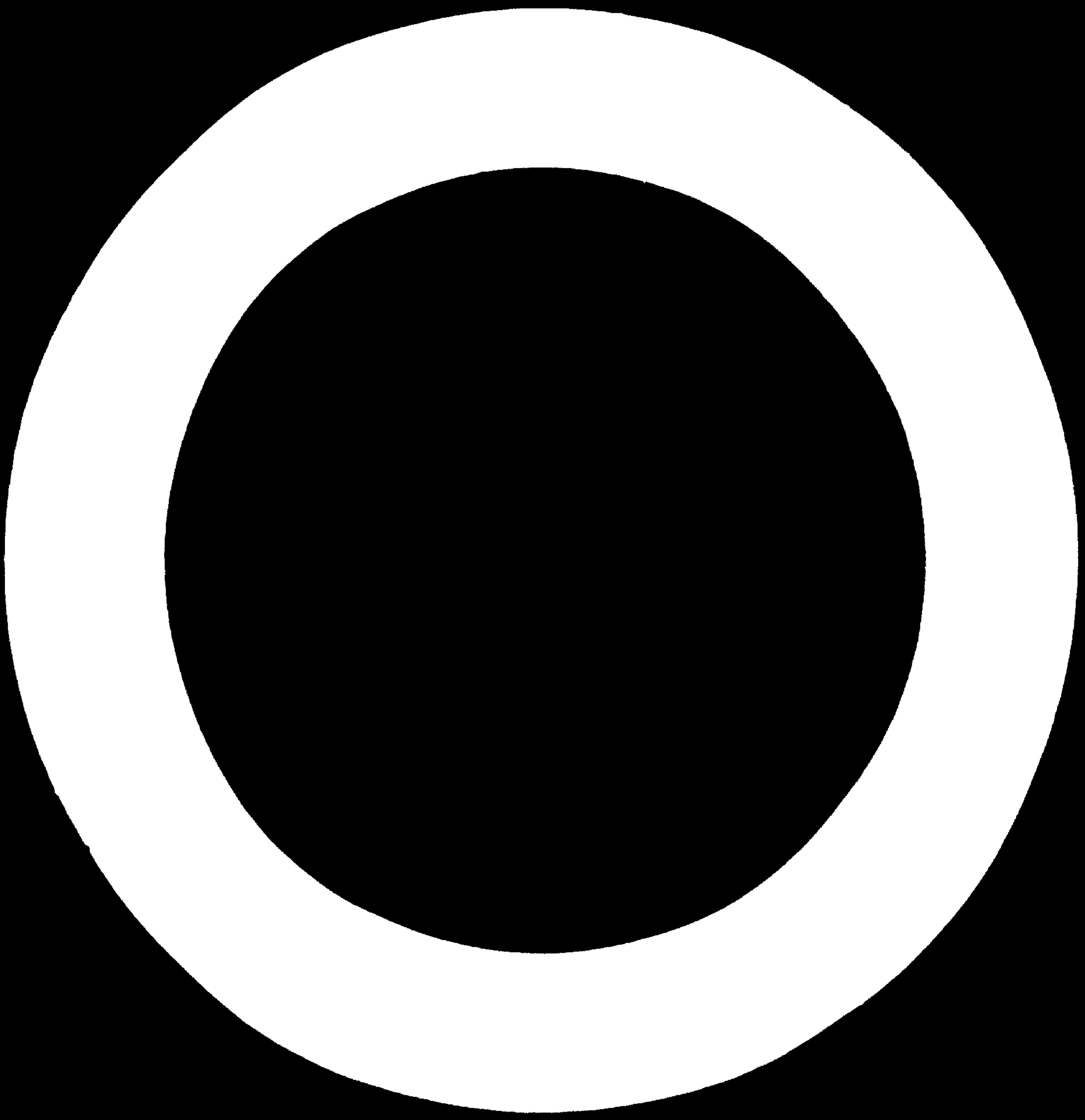
ENGLISH

A MULTIPURPOSE
ORGANOPHOSPHORUS INSECTICIDE
PRODUCTION PLANT

id. 75-8138



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PREFACE

According to data published by the Food and Agriculture Organization of the United Nations (FAO), more than half the world's population is insufficiently nourished and a great number are exposed to starvation owing to poor crops in years when natural calamities (drought, floods) occur. At the same time, rapid population growth, particularly in the developing countries, is creating an ever increasing demand for food products.

Certain scientific agricultural techniques can increase production yields per hectare, e.g., irrigation, use of selected varieties of plants and use of chemical fertilizers, but their favourable effect cannot be fully realised unless efficient measures for plant protection are taken, especially by a rational use of pesticides.

At the ad hoc Government Consultation on Pesticides in Agriculture and Public Health, held at Rome, 7-11 April 1975, the Director General of FAO estimated the total world-wide crop losses due to pests as 30-40 per cent of the potential crop. Insects bring about the greatest part of that loss, in addition to the inestimable damage they cause by transmitting such diseases as malaria and typhus to humans. It is not surprising, therefore, that insecticides are the most needed pesticides in most developing countries.

The present study refers to a multipurpose plant for the production of some or all of the five organophosphorus insecticides, dimethoate, trichlorphon, malathion, ethion and dichlorvos. These five products are among the most widely used organophosphorus insecticides. The study, which was made by the Joint Unido-Romania Centre, contains the necessary elements for determining the advisability of building such a multipurpose plant in one country or another: the requirements of materials, equipment and labour; plant specifications; and an economic analysis of the investment needed and the profits that can be realized.

INTRODUCTION

General information about organophosphorus insecticides

Organophosphorus insecticides are extremely important because, generally speaking, they have these favourable characteristics:

Powerful insecticide and acaricide action in small amounts and concentrations, therefore economical in use

Broad fields of action

Fast decomposition (metabolism) on and within plants and in mammals, with the formation of metabolites of low toxicity

Good knock-down effect on insects

Some organophosphorus insecticides are extremely toxic for mammals (e.g. ethyl-parathion); however, in the last two decades, less toxic ones (e.g. malathion, dimethoate, trichlorphon etc.) have been developed. They are quite safe if appropriate application methods are used.

The production of organophosphorus insecticides present certain difficulties. The reaction conditions require permanent and effective control. The principal raw materials - phosphorus, sulphur, chlorine - are simple but not always available, and that may represent an economic constraint. Since the specific biological activity varies from one organophosphorus insecticide to another, two, three or sometimes more insecticides must be used in most countries. Their manufacture in separate plants would require high investments that could exceed the financial means of many developing countries. That is why the implementation of a multipurpose plant to produce two to five organophosphorus insecticides, such as the plant described in this study, represents an economical solution to the problem of meeting domestic requirements.

Trends in the use of organophosphorus insecticides

The efficiency and economy of organophosphorus insecticides are still drawing the attention of specialists in plant protection. The use of these insecticides is therefore steadily expanding, and the prospects are that expansion will continue for the next 10-15 years. Thus, in the United States of America the 1975 malathion output will be almost seven times greater than in 1960, that of parathion (methyl + ethyl) four times greater. The 1975 demeton (methyl + ethyl), phorate, dimethoate, phosphamidon and

and disulfoton output will be five times higher than in 1968.

According to some estimates, the world organophosphorus insecticide output will amount to about 120,000 t of active ingredient in 1975.

The five insecticides chosen for this study

This study deals with the production of the following five organophosphorus insecticides in a single plant:

Dimethoate
Trichlorphon
Malathion
Ethion
Dichlorvos

These five were selected because, on one hand, they are among the most frequently used organophosphorus insecticides and, on the other hand, they can be rather easily manufactured in a multipurpose plant.

In addition to their wide application in agriculture, malathion, dichlorvos ar trichlorphon are very efficient in households and in animal husbandry. Malathion controls malaria in regions where mosquitoes have become DDT-resistant.

The main fields of application of the organophosphorus insecticides mentioned above, as well as some of their more important characteristics, are given in table 1.

Scope of the study

The study presents a suitable plant for the production of the selected organophosphorus insecticides, a methyl chloride recovery plant (methyl chloride is a by-product of trichlorphon production); a hydrogen sulphide destruction plant (hydrogen sulphide is a by-product of malathion, ethion and dimethoate manufacture); and a solvent recovery plant. These plants are located in a three-floor building and on an outside platform and are provided with ventilation, sanitary facilities, instrumentation, a power centre etc. There is also a treatment plant for the chemically polluted water resulting from the manufacture of these products.

Table 1. Properties of five organophosphorus insecticides

Name	Action modes	Fields of application	Toxicity	
			Lethal doses (mg/kg)	Residual
Dimethoate	Contact Ingestion Systemic Acaricide	Cereals Industrial plants Vegetables Fruit	Oral, 320-400 (rats) Oral, 35-118 (mice) Percutaneous, 750-1,000 (rats)	Low
Trichlorphon	Contact Ingestion Fumigant	Cereals Industrial plants Vegetables Fruit Vector control Household	Oral, 625 Acute dermal, 2,000 Acute inhalation, 1,500	Low
Malathion	Contact	Stored cereals Industrial plants Vegetables Fruit Vector control Animal health	Oral, 2,500 (rats)	Low
Ethion	Contact Ingestion Acaricide	Cereals Industrial plants Fruit	Oral, 179 (mice)	Low
Dichlorvos	Contact Ingestion Fumigant	Cereals Industrial plants Vegetables Fruit Vector control Household	Oral, 62 Acute dermal, 2,000 Acute inhalation 1,500	Low

The study does not include the following items:

Ground planning, levellings, access and internal roads, railways, loading and unloading platforms

Topometric survey and geotechnical studies

Provisions for utilities (thermal power station, water pumping station, cooling system, inert-gas source)

Utility networks outside the buildings except the electric cables from the low-voltage electric panel to the electromotors

Outdoor illumination of the platform

Storage spaces for raw materials, intermediate products and end products, whether liquid or solid

Fuel storage

Water treatment plant (for drinking, cooling and industrial water)

Sewage treatment

Social-administrative buildings (except the sanitary facilities provided for the plant personnel)

Fire-prevention networks

Trichlorphon and dichlorvos formulations have not been included, because these products have so large a variety of formulations (soluble powder, granules, aerosols and solutions in case of trichlorphon; emulsifying concentrates, aerosols and solutions in case of dichlorvos) that consideration of them in this study would only have complicated it. Specific formulations will be provided by the Joint UNIDO-Romania Centre on request.

I. PRODUCT MANUFACTURE

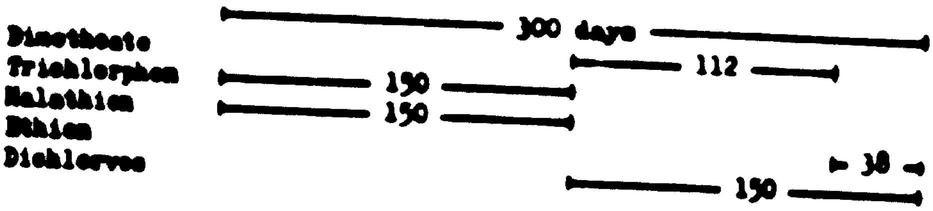
Production capacity

Production capacities are as follows (t/a of active ingredient):

Dimethoate	1 000
Trichlorphon	800
Malathion	400
Ethion	200
Dichlorvos	58

Production schedule

The plant will work 300 days a year, with four six-hour shifts daily. Production of the different insecticides will be scheduled over the year as follows:



Note that the working plan is discontinuous for the five products. The distillations, H_2S destruction, CH_3Cl and HCl recovery, and waste incineration plant run continuously, however. This schedule makes the best use of the equipment.

Processes

Process descriptions are given below by product. A flow chart for the entire plant is in drawing 1.

Dimethoate

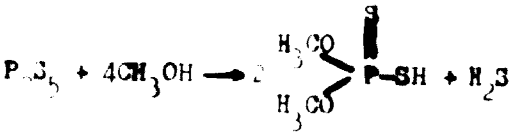
Basic chemical reactions

$$Cl-CH_2-COOH + CH_3OH \longrightarrow ClCH_2-COOCH_3 + H_2O$$

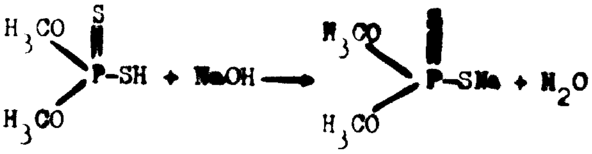
monochloro-acetic acid — methanol — methyl monochloro-acetate (MMCA)

$$Cl-CH_2COOCH_3 + CH_3NH_2 \longrightarrow ClCH_2-CONHCH_3 + CH_3OH$$

MMCA — methylamine — N-methylmonochloro-acetamide (MCAA)



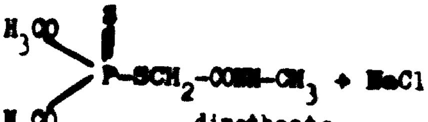
phosphorus pentasulphide — methanol — dimethyldithiophosphoric acid (DMDPA)



DMDPA — sodium salt of DMDPA (DMDPNa)

By condensation of DMDPNa with MCAA in toluene, dimethoate is obtained:

DMDPNa + MCAA ⟶



dimethoate

Process description
(See figure I)

The monochloroacetic acid is steam-melted in a melting vessel and introduced into the esterification reactor. At reflux temperature, the methanol is added in portions to the molten mass of monochloroacetic acid with H_2SO_4 and a catalyst. The reaction products, which are in the vapour state, are condensed in a separator, where the methyl monochloroacetate (MMCA) is separated from the water.

The crude MMCA passes to a neutralization vessel, where it is neutralized by stirring with a sodium bicarbonate solution. Then the lower layer, which contains the neutralized MMCA, is separated from the upper (water) layer.

The neutralized MMCA is cooled and introduced into the amidation reactor, where it reacts with the pre-cooled methylamine at a low temperature (obtained by means of brine in the jacket). The reaction mass is neutralized with H_2SO_4 at a low temperature and the product, N-methylmonochloroacetamide (MCAA), is distilled under vacuum to separate it from the methanol. The recovered methanol is re-introduced at the first step.

Meanwhile, the dimethyldithiophosphoric acid (DMDPA) is being prepared. For this purpose, kerosene is introduced in the DMDPA synthesis reactor, then P_2S_5. The mixture is warmed and methanol is gradually introduced. The reaction occurs under a slightly reduced pressure.

The H_2S released from the reaction drives along the methanol vapours, which condense and return to the reactor, while the H_2S is removed by suction and blown into the H_2S burner.

The reaction mass within the reactor is cooled and filtered to remove the unreacted P_2S_5, and the filtrate is transferred under inert-gas pressure to the neutralisation vessel. The unreacted P_2S_5 is discharged into a mobile container and sent to the incinerator.

The DMDPA is cooled in the neutralization vessel and neutralized with NaOH solution, and the solution obtained is separated. The separated sodium salt of DMDPA (DMDPNa) is transferred to the dimethoate synthesis reactor. Here, it is condensed with MCAA in toluene as the reaction medium, by heating slightly. As soon as the reaction is finished, the reaction mass is cooled and forwarded to the separation-washing vessel. The waste-water layer goes to the waste-water incinerator and the dimethoate layer in toluene is washed with a sodium bicarbonate solution and, after separation, with a sodium chloride solution. After a second separation, the organic layer is distilled.

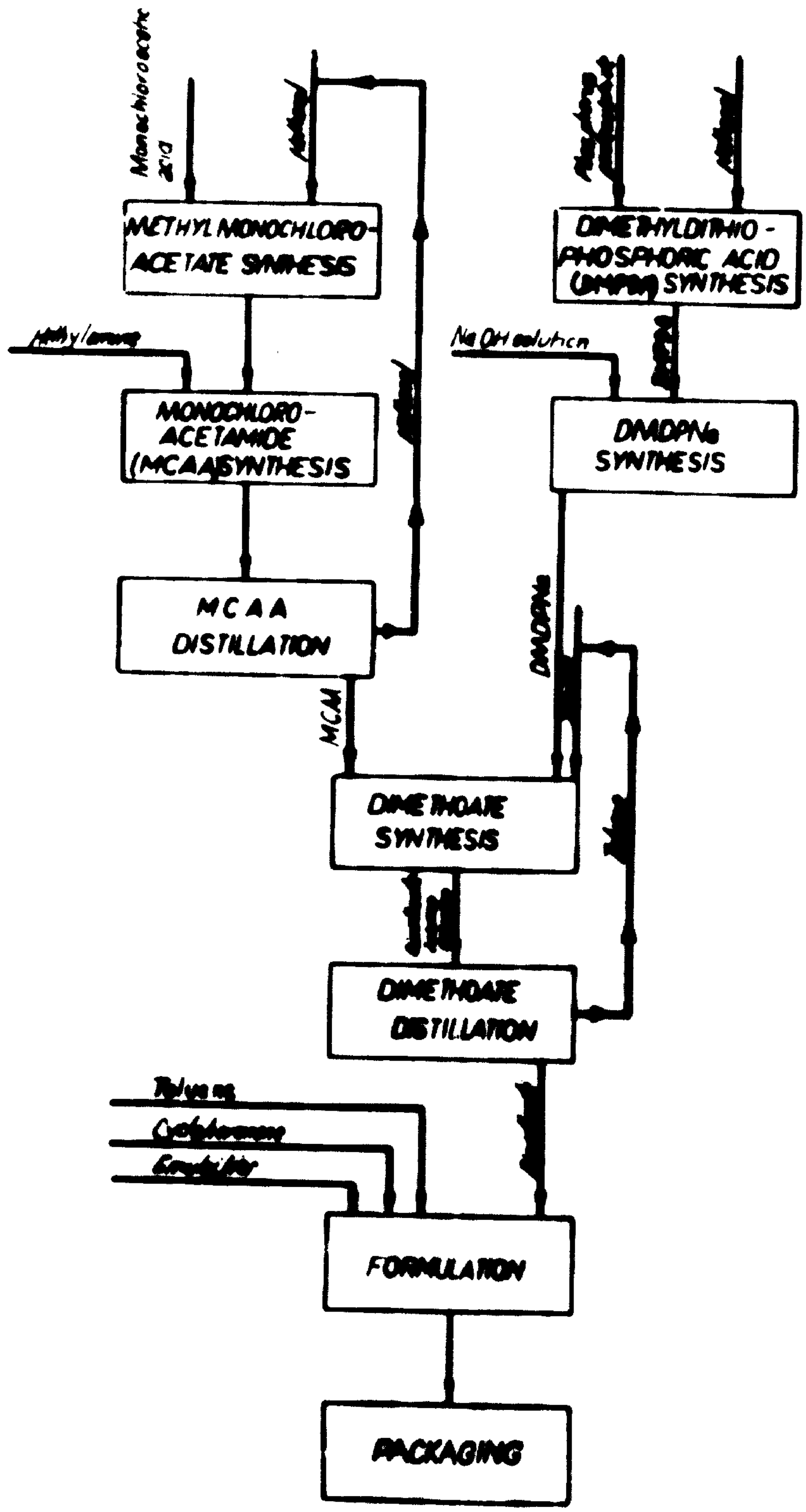


Figure I. Dimethoate synthesis flow chart

The toluene separated at distillation is recycled, and the concentrated dimethoate is formulated with toluene, cyclohexanone and emulsifier as an emulsifiable concentrate with 40 per cent active ingredient.

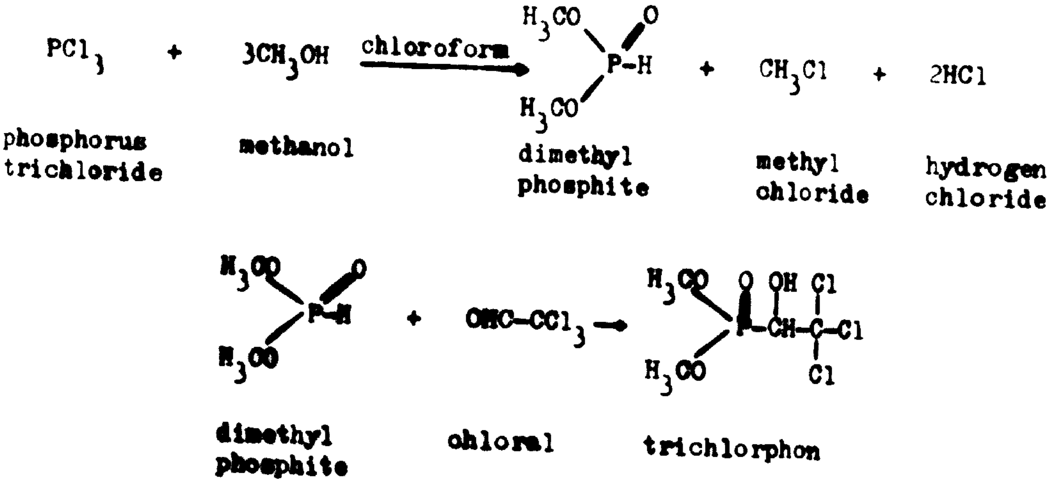
If crystallised dimethoate with 90 per cent active ingredient is required, the dimethoate-toluene solution obtained after washing is placed in a brine-cooled crystallisation reactor. After crystallization and filtration, the filtrate goes to the dimethoate synthesis, where it is used as the reaction medium.

The dimethoate crystals on the filter are washed with extraction kerosene and discharged into a distilling vessel by a helical conveyer. Here the kerosene and toluene retained in the crystals are distilled under vacuum in two steps of temperature and pressure. The kerosene-toluene mixture is cooled and sent to a collecting tank. Together with the washings, the mixture is later distilled to recover the solvents.

The hot dimethoate from the distilling vessel is discharged on a flaking machine with a drum cooled by brine and a vat heated with hot water. Scales of dimethoate having a 90 per cent purity are obtained.

Trichlorphon

Basic chemical reactions



Process description (see figure II)

The necessary quantities of chloroform and methanol are introduced in the dimethyl phosphite synthesis reactor. The blower is turned on and the phosphorus trichloride is gradually introduced. The reaction being exothermic, the solvent refluxes intensely, passing through two coolers, one water-cooled and the other brine-cooled. The temperature is maintained within the prescribed limits by controlling the rate of addition of the phosphorus trichloride. After all of the phosphorus trichloride has been added, the reaction mixture is heated slightly and refluxing is continued until the reaction is ended.

After desorbtion of the volatiles the blower is stopped, the reaction mass is cooled down by introducing cold water into the reactor jacket, and ammonia gas is added, with stirring, until the required pH is reached. Cooling is continued until all impurities settle. Then the reaction mass is filtered on a press filter and the clear dimethyl phosphite solution is transferred to the distillation kettle by pressure.

There, a quantity of chloroform (reused in the dimethyl phosphite synthesis) is distilled off under agitation until the temperature increases to the required value. Then the reaction mass goes under pressure to the trichlorphon synthesis reactor, where anhydrous chloral is gradually introduced into the reaction mass maintained at the required temperature.

After the reaction ends, the reaction mass is filtered on a filter press and transferred to a distilling vessel, where solvent distillation takes place at atmospheric pressure until the temperature reaches a prescribed level. Then the system is placed under vacuum and distillation continued. After recovery of the solvent (which is recycled to the dimethyl phosphite synthesis), the hot reaction mass is transferred by inert-gas pressure to the crystallization vessel.

A mixture of chloroform and carbon tetrachloride is added to the crystallization vessel, and the whole is heated at the prescribed temperature with stirring. Then it is cooled with brine and crystallization initiated by inoculation. Cooling is continued until the trichlorphon crystallises out. The crystals are separated from the mother liquor in a centrifuge. The mother liquor is collected in a buffer tank and is later used in the dichlorvos synthesis (see below).

The crystals are dried in a rotary drier and afterwards packaged. The product has a minimum purity of 95 per cent.

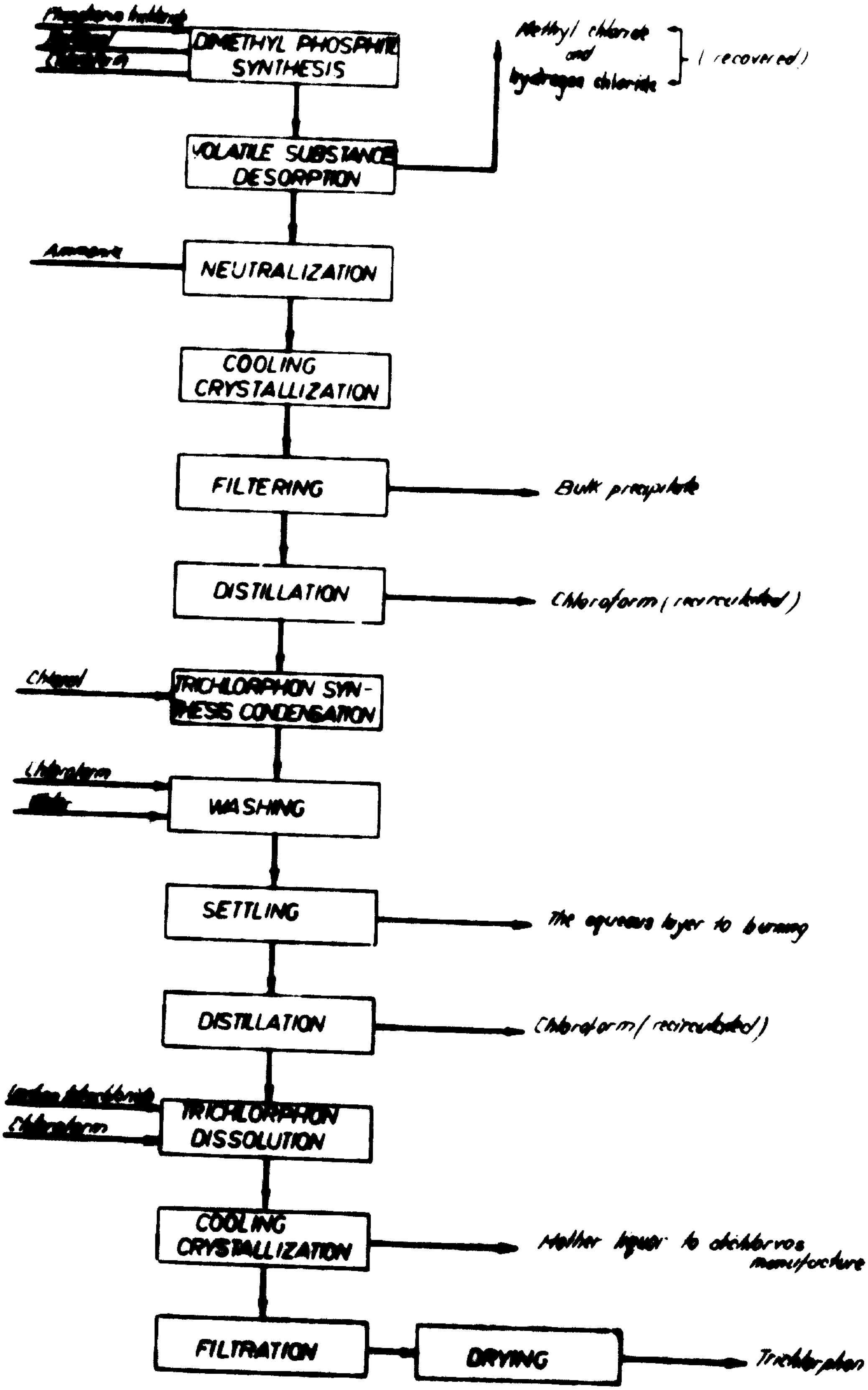
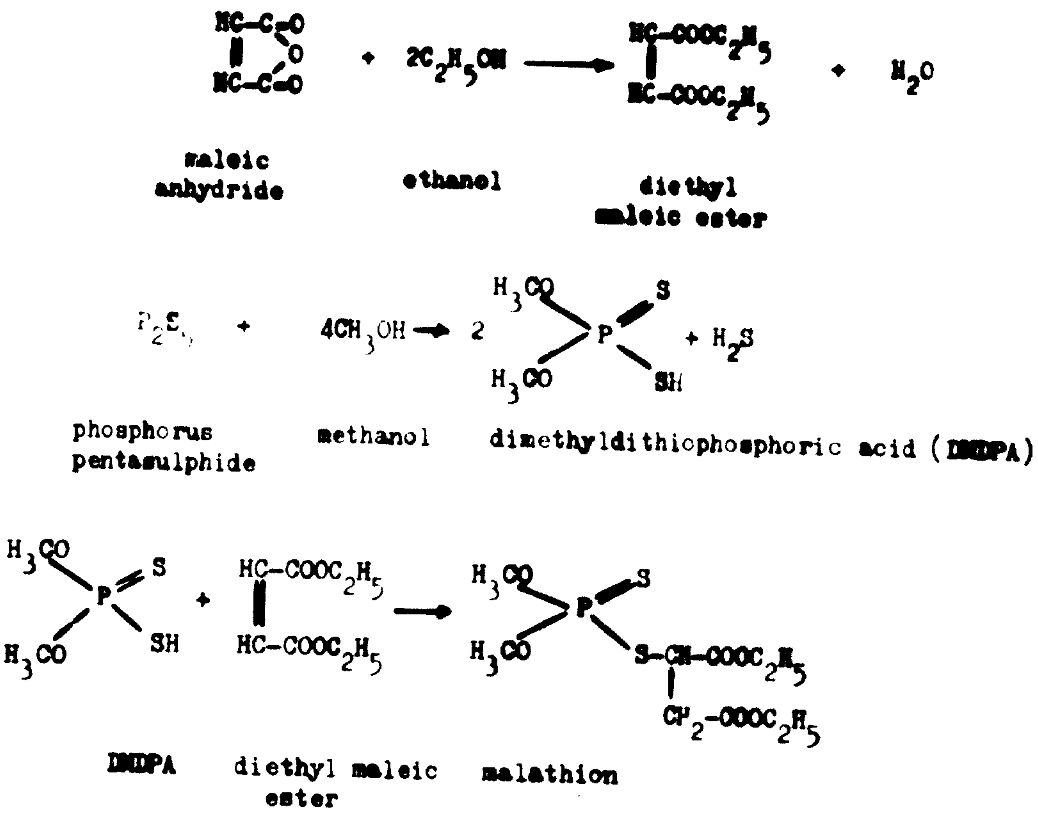


Figure II. Trichlorphon synthesis flow chart

Malathion

Basic chemical reactions



Process description (see figure III)

The necessary quantities of ethanol, benzene, maleic anhydride and concentrated sulphuric acid are introduced into the esterification reactor in that order. The reaction mass is heated, distilled in a column and cooled in a buffer vessel.

The ternary mixture from the buffer vessel is separated into two layers, the upper benzenic and the lower aqueous. On distillation of the organic layer a ternary mixture (benzene, ethanol and water) comes over first, followed by a binary azeotropic mixture of benzene and ethanol, which is collected in a vessel. The ternary mixture is distilled further to recover the solvents.

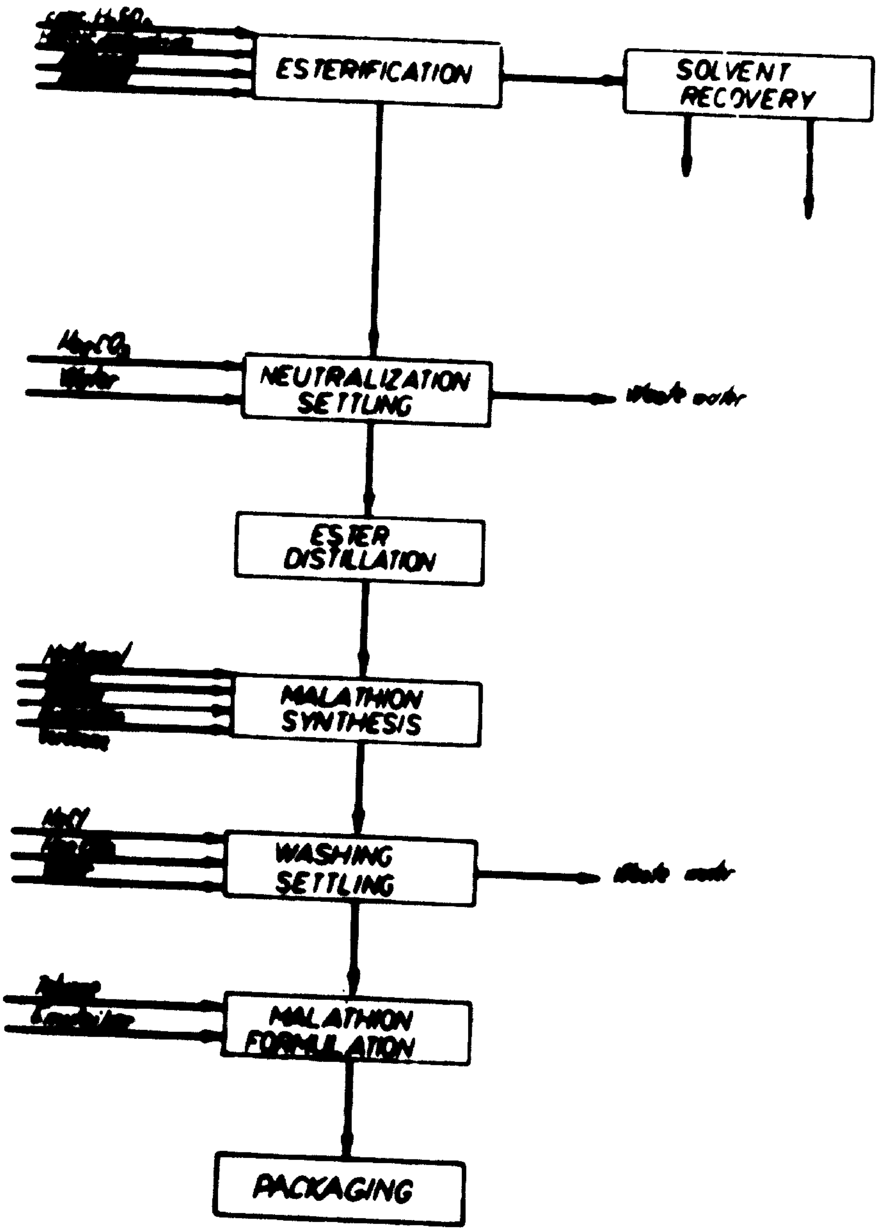


Figure III. Malathion synthesis flow chart

The residue is cooled and transferred by inert-gas pressure to a neutralization vessel. Here, aqueous sodium carbonate solution is introduced. The mixture is agitated until the required pH is reached, then the organic layer is separated and transferred to a distilling vessel and the waste water disposed of.

The distillation occurs first at atmospheric pressure. The foreruns are collected in a pad vessel, cooled and separated in two layers. The organic layer goes to a pad vessel from which it is transferred to a new esterification operation, and the aqueous layer goes to the burning station. Then the ester is distilled under vacuum. It is collected in a pad vessel, from which it is taken for the malathion synthesis.

In the first step of the malathion synthesis, the methanol and the diethyl maleic ester are placed in a mixing vessel and the mixture homogenized. Meanwhile, in the malathion synthesis reactor, extraction kerosene, toluene and phosphorus pentasulphide are introduced, and the condenser stirring and cooling are started.

The blower for hydrogen sulphide removal is started. Then the mixture is gradually heated by means of hot water in the jacket. When the required temperature is reached, the addition of methanol and diethyl maleic ester is started. The rate of addition is controlled in such a way as to maintain a constant temperature of the reaction mixture. After the introduction of the methanol-ester mixture, the temperature is maintained until the reaction is complete. Then, the reaction mass is cooled by introducing cold water in the reactor jacket. The cold reaction mixture is filtered on an enamelled filter press to remove the unreacted phosphorus pentasulphide. The crude malathion is transferred to a washing vessel, into which the washing solution, a solution of sodium chloride and sodium carbonate prepared in another vessel, is pumped.

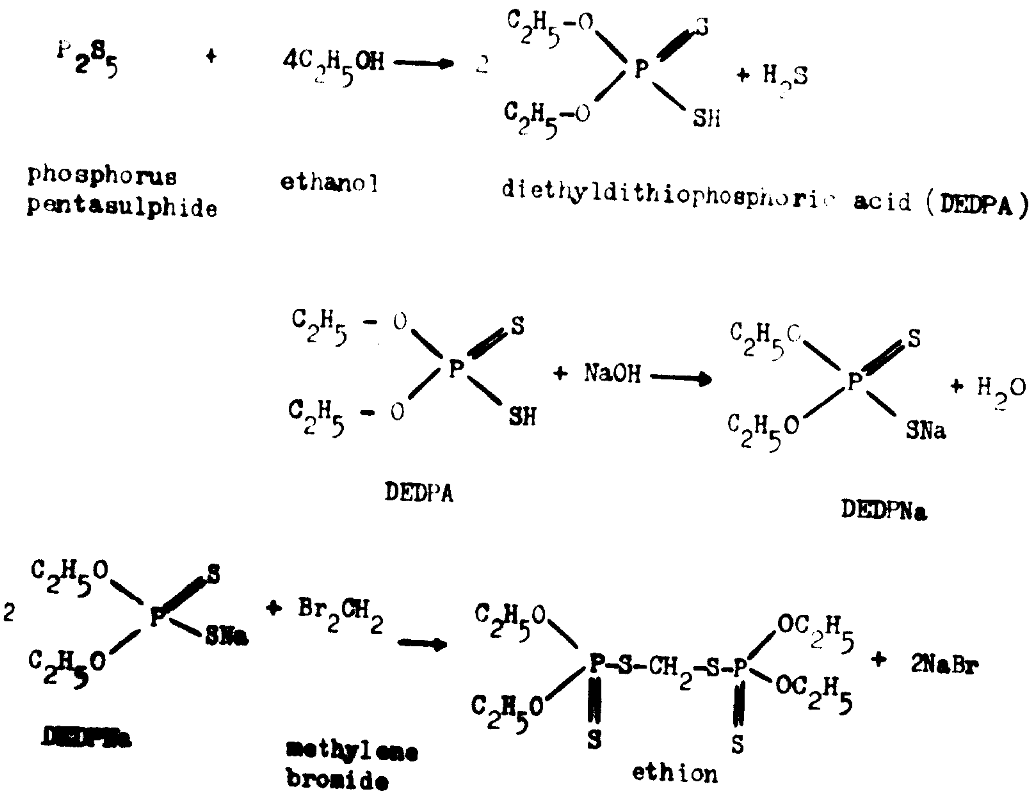
(There is some indication that one can obtain a higher purity and a better yield in a two-step reaction - (1) preparing the DMDPA, then (2) adding diethyl maleic ester to it - all in the same vessel. The plant proposed here can also be used for this method.)

After adequate agitation, the mixture is allowed to separate, the aqueous lower layer being decanted and disposed of. The malathion is filtered through a filter press and returned to the washing vessel for repeated washing. Three consecutive washings occur. The aqueous layer from the last washing is reused for the first washing of the new raw malathion charge.

After the last washing, the malathion passes through the filter into the decantation vessel for a final decantation and then into a pad-and-measuring vessel, from which it is later transferred by inert-gas pressure to the formulation unit. Here, the necessary quantities of toluene, xylene, naphtha and emulsifier are added. After homogenization by stirring and filtration, the formulated product is ready for packaging.

Ethion

Basic chemical reactions



Process description (see figure IV)

Paraffin oil (fresh for the first charge and recycled from the previous charge for charges after the first) is introduced into the diethyldithiophosphoric acid (DEDPA) synthesis reactor. Then the phosphorus pentasulphide is introduced. The suspension is heated by means of hot water in the reactor jacket and stirred continuously.

The blower is started. When the required temperature is reached, addition of the anhydrous ethanol begins. During ethanol introduction, the temperature in the vessel is maintained constant by controlling the alcohol flow rate.

After all the ethanol has been added, the temperature is maintained and the stirring continued until the reaction is complete. Then the reaction mass is cooled by introducing cold water into the reactor jacket.

The hydrogen sulphide evolved during the reaction passes through a cooler and then, by means of a blower, it is sent to the disposal unit or burner.

After the vessel has cooled, the blower is turned off, the stirring stopped and the reaction mass allowed to settle for a certain period of time. Two layers separate out, the upper layer, paraffin oil, which is left in the reactor for the next charge, and the lower layer, raw DEDPA. This is introduced into a pad vessel from which it is pumped to the next stage, preparation of the sodium salt of DEDPA (DEDPNa).

The crude acid is cooled under stirring and neutralised with sodium hydroxyde or sodium carbonate solution under stirring and cooling. The solution is filtered on a filter press, which retains the impurities and the unreacted phosphorus pentasulphide.

The filtered solution passes to a separation-decantation vessel. Here it separates into two layers. The lower, aqueous layer, containing the DEDPNa, is discharged into a pad tank and the upper, organic layer, containing paraffin oil, liquid residues and unreacted products, is sent to the burning station.

The DEDPNa from the pad vessel is pumped to the ethion synthesis reactor, where it is heated under stirring. The methylene bromide is added (in small portions). The temperature in the vessel is maintained constant by controlling the flow rate of hot water in the jacket. After methylene bromide introduction,

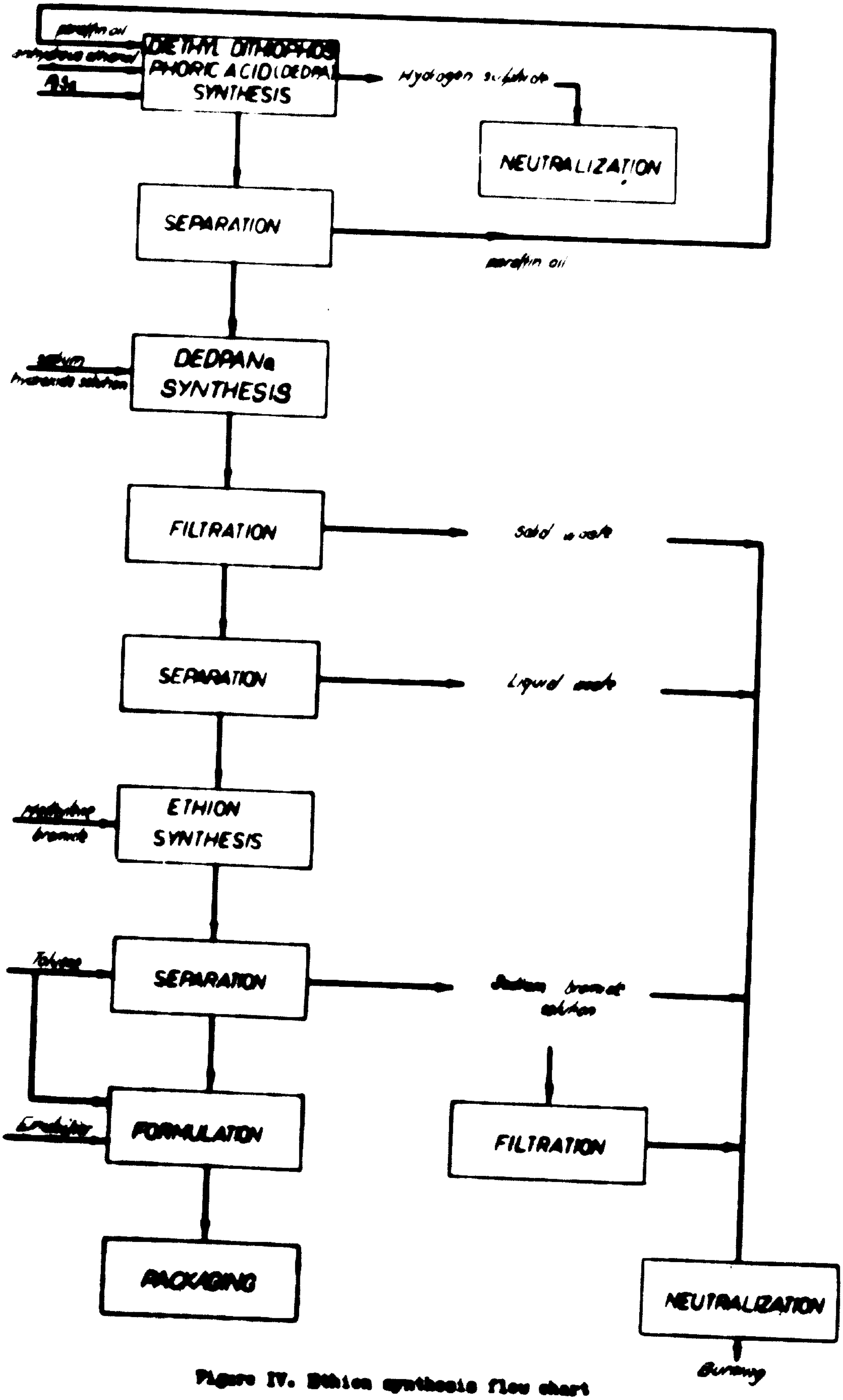


Figure IV. Ethion synthesis flow chart

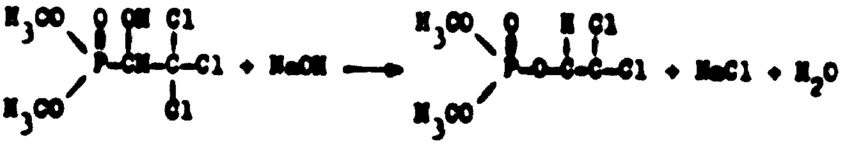
the reaction mass is stirred and heated until the reaction is complete. The reaction mass is then cooled by running cold water in the reactor jacket. After cooling, addition of toluene and stirring, the mixture is transferred to a washing-decantation vessel. Here, it is stirred with a sodium bicarbonate solution. After washing the stirring is stopped and the reaction mass is allowed to settle.

The lower aqueous layer of sodium bromide and impurities goes to the burning station, and the organic layer to a pad vessel for the storage of technical ethion.

In the formulation step, a measured amount of technical ethion is stirred with toluene and an emulsifier in the necessary amounts to produce a product with 25 per cent active ingredient.

Dichlorvos

Basic chemical reactions


trichlorphon dichlorvos

Process description (see figure V)

The mother liquors from trichlorphon synthesis, which have been collected into a buffer tank (see above), are transferred by inert-gas pressure into a concentrator, where part of the solvent is distilled off. This solvent is sent to a storage vessel and reused in trichlorphon production.

The concentrate passes to a neutralizer, where it is heated and treated with a sodium hydroxyde solution from a measuring vessel. Temperature is kept constant. When the desired pH has been attained, the reaction mass is allowed to settle in a separating vessel.

In the settler, two layers are separated. The lower, organic layer is held in a buffer tank and the upper, aqueous layer goes to the waste-water incinerator.

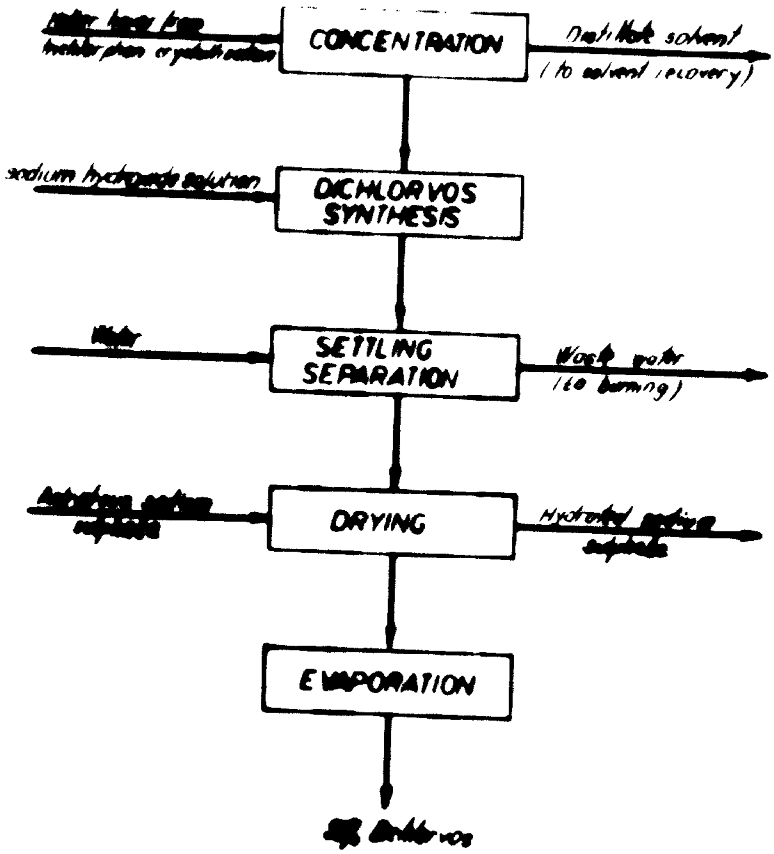


Figure V. Dichlorvos synthesis flow chart

From the buffer tank, the reaction mass is transferred by inert-gas pressure into a washing tank. Here it is washed with water while stirred, then allowed to stand and separate. The organic layer is sent to a buffer tank, and the aqueous layer disposed of.

The washed reaction product is forced by inert-gas pressure into a drying tank. Here, anhydrous sodium sulphate is added and the mixture is stirred and filtered.

The filtered technical dichlorvos is held in a buffer tank, from which it is pumped into a film evaporator, where a vacuum distillation takes place at a low temperature to protect the product. The liquid dichlorvos obtained from this step is 90 per cent pure.

End product specifications

The end products obtained in this plant meet the following specifications:

Dimethoate

Technical product - solid 90% active ingredient

Aspect : flakes
Colour : white-grey
Smell : specific
Melting point : min. 41°C
Acidity : max. 0.5 g H_2SO_4/100 g of product
Active ingredient content : min. 90%

Formulated product with 40% active ingredient

Aspect : oily liquid
Colour : yellowish-brown
Smell : specific
Active ingredient content : 40%
Density at 20°C : 1.07

Trichlorphon

Technical product - solid 95% active ingredient

Aspect : crystalline
Melting point : 74 - 76°C
Active ingredient content : min. 95%

Malathion

Formulated product with 50% active ingredient

Aspect : liquid

Colour : yellowish - red

Smell : specific

Acidity (expressed as H_2SO_4) : max. 0.5%

Active ingredient content : 50%

Ethion

Formulated product with 25% active ingredient

Aspect : clear liquid

Colour : yellowish - green

Smell : specific

Density at 20°C : 0.980

Viscosity at 20°C : 5 cP

Active ingredient content : 25%

Dichlorvos

Liquid technical product with 90% active ingredient

Aspect : liquid

Colour : light yellow

Density at 20°C : 1.43

Active ingredient content : min. 90%

II. RAW AND AUXILIARY MATERIALS

Specifications

The specifications for the raw and auxiliary materials used in production are given below in five separate sections corresponding to the insecticide products.

Dimethoate

Methanol

Aspect : clear, colourless liquid
Smell : specific
Solubility in distilled water : in any proportion, opalescence - free
Density : 0.791 - 0.792
Distills (min. 99.9%) at 64.2 - 65.2°C
Purity: 98%
Acetone : max. 0.003%
Acidity : 0.02 mgKOH/g
Evaporation residue : max. 0.001 g per 100 ml of 100% product

Extraction kerosene

Aspect : clear, colourless liquid
Density : 0.70 - 0.74
Distillation range : 70 - 115°C
Acidity : max. 1 mg KOH/100 g of product

Sulphuric acid

Aspect : oily liquid (clear or opalescent)
Density : 1.835
Concentration : 96%
SO_2 content : max. 0.1%
Fe : max. 0.02%
As : max. 0.001%
Calcination residue : 0.1% max.

Toluene

Aspect : clear, colourless liquid
Density : 0.86 - 0.87
Distills at max. 110.6°C
Mineral acidity and alkalinity : nil
Bromine number : 0.1 - 0.3 g/100 ml of toluene
Index of refraction : 1.4965 - 1.4975

Phosphorus pentasulphide

Total sulphur : min. 70%
Phosphorus : min. 27%
Fe : max. 20 ppm
Purity: min. 98%
Melting point : 222°C sharp

Monochloroacetic acid

Aspect : crystalline mass
Colour : white
Purity : min. 98%
H_2SO_4 : max. 1%
HCl : max. 0.025%
Fe : max. 0.002%
Melting point : min. 60°C
Liquid density (65°C) : 1.3703

Methylamine

Aspect : aqueous, clear solution
Concentration : min. 30%
Density : max. 0.93 g/cm^3
Flammability point : under 0°C
Viscosity : 2.8 cP
Boiling point : - 6.3°C
Melting point : - 93.5°C
Density at - 6.3°C : 0.69423

Sodium chloride

Aspect : white - greyish crystals
Purity: min. 97%
Humidity : max. 92%
Fe_2O_3 content : max. 4%

Sodium bicarbonate

Aspect : white crystalline powder
Taste : salty
Purity: min. 99%

Sodium hydroxide

Aspect : white - grey flakes
Purity: min. 96%
Na_2CO_3 : max. 2%
NaCl : max. 2%
Fe_2O_3 : max. 0.03%
Chlorates : traces

Kerosene

Aspect : clear liquid
Density : 0.835
Distillation temperature : up to 315°C
Flammability point : 28°C
Self-ignition temperature : 380 - 420°C
Melting point ≈-114°C

Cyclohexanone

Aspect : colourless liquid
Smell : aromatic
Purity: min.98.5%
Phenol : max. 0.03%
Density at 20°C : 0.943 - 0.946
Distillation between 153 - 157°C at 760 mm Hg
Acidity (as acetic acid) : max. 0.01%
Alkalinity : nil
Freezing point : - 45°C
Flammability point : 340°C

Emulsifier (Surface active agent)[1]

Aspect : yellow - brownish, viscous liquid
Smell : specific
Soluble in xylene, toluene, naphtha, solvents, emulsifies in water
Viscosity at 40°C - 71°C : 550 cP
Density : 1 - 1.03
pH : 7
Specific weight at 50°C : 1.04

Trichlorphon

Phosphorus trichloride

Aspect : fuming colourless liquid
Smell : strongly lacrimatory
Purity: 97.5%
Phosphorus oxychloride: below 2.5%
Distillation residues : nil
Feezing point : - 114°C
Boiling point : 72°C
Density : 1.56

Chloral

Aspect : oily liquid
Smell : strongly irritating
Boiling point : 97°C

Chloroform

Aspect : clear volatile colourless liquid
Smell : specific
Taste : burning - sweetish
Density (d_4^{20}): 1.470 - 1.490
Distillation range : 57 - 63°C
Minimum distillation volume : 94% (57 - 63°C)

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[1] Emulsifiers with specifications different from these may be used if they are first tested and found suitable.

Evaporation residue : max. 0.015%
Free chlorine : nil
Acidity : nil
Stabilizing alcohol : nil

Carbon tetrachloride

Aspect : clear, colourless liquid
Density : (d_4^{20}): 1.585 - 1.595
Distillation range : 73 - 82°C
Min.distillation volume : 95% (73 - 82°C)
Free chlorine : nil
Aldehydes : nil
Phosgene : traces
Acidity : (HCl) = max. 0.002%
Humidity : nil
Non-volatile residue : max. 0.0006%
Chloroform : max. 8%

Liquefied ammonia

Aspect : volatile liquid
Smell : specific pungent
Ammonia : min. 99.5%
Evaporation residue : max. 0.5%
Gaseous impurities (cm^3 in 100 g at 20°C) : nil
Fe content (as Fe_2O_3) : max. 0.0001%

Methanol

The same quality as that used for dimethoate

Sodium carbonate

Aspect : white fine powder
Purity: min. 99%
NaCl content : min. 0.6%
Water insolubles : max. 0.12%
Fe oxides : max. 0.003%

Malathion

Phosphorus pentasulphide

The same quality as that used for dimethoate

Methanol

The same quality as that used for dimethoate

Ethanol

Aspect : clear liquid colourless
Taste : burning
Purity : 99.6%
Density (d_4^{15}) : 0.798
Refraction index : 1.361
Boiling point : 78°C

Maleic anhydride

Aspect : white crystals
Concentration : 99%
Melting point : 52°C

Benzene

Aspect : clear colourless liquid
Density (at 20°C) : 0.875 - 0.881
Distillation range : 79.2 - 80.4°C
Freezing point : 4.6 - 5°C
Bromine number : max. 0.3 gr. in 100 cm^3
Organic acidity : max. 0.5 mg acetic acid in 100 cm^3 benzene

Extraction kerosene

The same quality as that used for dimethoate

Sulphuric acid

The same quality as that used for dimethoate

Toluene

The same quality as that used for dimethoate

Sodium carbonate

The same quality as that used for trichlorphon

Xylene

Aspect : slightly yellowish liquid
Refraction index : 1.4985
Boiling point : 136°C
Density (at 20°C) 0.867

Emulsifier

The same quality as that used for dimethoate

Sodium chloride

The same quality as that used for dimethoate

Sodium hydroxide

The same quality as that used for dimethoate

Ethion

Phosphorus pentasulphide

The same quality as for dimethoate and malathion

Ethanol

The same quality as for malathion

Methylene bromide

Aspect : colourless liquid
Density : (d_4^{20}) : 2.495
Freezing point : -52.8°C
Boiling point : +98.5°C

Paraffin oil

Flammability : min. 150°C

Viscosity at 50°C : 6.2 -9.75 cP

1.2 -1.8°E

Stammer colour with colour filter Su W, mm: min.25

Mineral acidity and alkalinity : nil

Organic acidity mg KOH/g: max. 0.05

Mechanical impurities : nil

Water:nil

Ash : max. 0.005%

Freezing point : max. - 20°C

Sodium hydroxide : The same quality as for dimethoate and malathion

Toluene

The same quality as for dimethoate and malathion

Benzene

The same quality as for malathion

Emulsifier

The same quality as for dimethoate and malathion

Dichlorvos

Sodium hydroxide - The same quality as for dimethoate, malathion, ethion

Sodium sulphate (anhydrous)

Aspect : crystalline

Density : 2.7

Melting point: 884°C

Soluble in water and glycerin

Purity: min.99.5%

Specific consumption

The specific consumption of the raw and auxiliary materials listed above is given below in a separate table for each end product.

Table . Specific consumption of materials in dimethoate synthesis
(Crystalline product of 90% purity)

Raw material	Specific consumption t/t active ingredient
1	2
98% monochloroacetic acid	1.215
96% sulphuric acid	0.050
98% methanol	1.111
sodium bicarbonate	0.117
30% methylamine	1.261
98% phosphorus pentasulphide	1.322
kerosene	0.238
sodium chloride	0.136
96% sodium hydroxide	0.367
toluene	0.500
extraction kerosene	0.611

Table 3. Specific consumption of materials in dimethoate synthesis
(Formulated product with 40% active ingredient)

Raw material	Specific consumption t/t active ingredient	Specific consumption t/t formulated product
1	2	3
98% monochloroacetic acid	1.000	0.432
96% sulphuric acid	0.050	0.020
98% methanol	0.999	0.399
sodium bicarbonate	0.100	0.040
30% methylamine	0.962	0.335
98% phosphorus pentasulphide	1.250	0.500
kerosene	0.080	0.008
sodium chloride	0.120	0.048
96% sodium hydroxide	0.325	0.130
toluene	1.1875	0.475
cyclohexanone	0.325	0.134
emulsifier	0.150	0.060

Table 4. Specific consumption of materials in trichlorphon synthesis[a]
(Technical product, 9[illegible]% active ingredient)

Raw material 1	Specific consumption t/t active ingredient 2
97.5% phosphorus trichloride	0.76
98% methanol	0.53
chloroform	1.61
99.5% ammonia gas	0.023
99.5% chloral	0.77
99% sodium carbonate	0.03
carbon tetrachloride	0.66
96% sulphuric acid	0.025
96% sodium hydroxide	0.35

a/ Including HCl neutralization and CH_3Cl recovery.

Table 5. Specific consumption of materials in malathion synthesis
(Formulated product with 50% active ingredient)

Raw material 1	Specific consumption t/t active ingredient 2	Specific consumption t/t formulated product 3
99% maleic anhydride	0.462	0.231
99.6% ethanol	0.544	0.272
98% benzene	0.021	0.040
96% sulphuric acid	0.027	0.013
99% sodium carbonate	0.400	0.200
99% methanol	0.360	0.180
98% phosphorus pentasulphide	0.570	0.285
toluene	0.325	0.162
extraction kerosene	0.600	0.300
96% sodium hydroxide	0.125	0.062
sodium chloride	0.810	0.405
emulsifier	0.100	0.050
xylene	0.810	0.405

Table 6. Specific consumption of materials in ethion synthesis (Formulated product with 25% active ingredient)

Raw material	Specific consumption t/t active ingredient	Specific consumption t/t formulated product
98% phosphorus pentasulphide	1.080	0.270
99.6% ethanol	1.200	0.300
methylene bromide	0.420	0.105
paraffin oil	0.100	0.025
96% sodium hydroxide	0.028	0.007
toluene	2.860	0.715
emulsifier	0.204	0.051
benzene	0.080	0.020

Table 7. Specific consumption of materials in dichlorvos synthesis (Technical product, 90% active ingredient)

Raw material	Specific consumption t/t active ingredient
96% sodium hydroxide	0.31
anhydrous sodium sulphate	0.15
trichlorphon mother solutions	26.3

III. UTILITIES

Specifications

The specifications of the utilities needed for the plant are as follows:

Process water :	temperature : max. 27°C hardness : 5° - 6° (German degrees) pressure : 3 kgf/cm²
Recirculated cooling industrial water	inlet temperature : + 28°C outlet temperature : + 38°C hardness : 5° - 6° (German degrees) pressure : 3 kgf/cm²
Cooling industrial water	inlet temperature : max. + 15°C outlet temperature : + 25°C hardness : 5° - 6° (German degrees) pressure : 3 kgf/cm²
Hot industrial water	inlet temperature : 90°C outlet temperature : + 80°C hardness 5-6° (German degrees) pressure : 3 kgf/cm²
4-ata steam	saturated
16-ata steam	saturated
Inert gas	pressure 3 kgf/cm² composition (in % vol) : 0.1% H_2 11 - 12% CO_2 0.1% CO 0.1% O_2 The rest to 100% N_2 SO_2, NO, H_2S - nil dew point : -30°C
Compressed air	pressure 3 kgf/cm² oil and dust free

Electric power	voltage 3 x 380/220 ± 5% V frequency : 50 ± 0.5 Hz
Cooling agent	inlet temperature : - 22°C outlet temperature :- 17°C
Instrument operating air	pressure : 4 - 8 kgf/cm^2 oil and dust free dew point - 40°C
Fuel oil	minimum heat value: 9,500 Kcal/kg
Methane gas	pressure max. 5,000 mm WG minimum heat value : 8,500 Kcal/Nm^3
Demineralized water for steam	corresponding to 24-ata steam boilers

Specific and hourly consumption

The consumption of utilities in the production of the five insecticides is given below in a breakdown by product.

Table 8. Consumption of utilities in dimethoate synthesis
(Crystalline product 90% active ingredient)

Utility	Consumption per ton of active ingredient	Hourly consumption med./max.
1	2	3
recirculated cooling water at + 28°C	766 m^3	212/232 m^3
process water	8 m^3	2/4.4 m^3
steam 3 kgf/cm^2	6 t	1.7/4 t
electric power	477 Kwh	153/666 Kwh
compressed air	67 Nm^3	18.4/22 Nm^3
cooling agent at -22°C	309,00 Kcal	108,000/108,000 Kcal
water at + 15°C	407,000 Kcal	200,000/200,000 Kcal
inert gas	36 Nm^3	10/17 Nm^3
hot water at + 90°C	206,000 Kcal	70,000/117,000 Kcal

Table 9. Consumption of utilities in dimethoate synthesis
(Formulated product, 40% active ingredient

Utility	Consumption per ton of active ingredient	Hourly consumption med./max.
1	2	3
Recirculated cooling water at + 28 °C	700 m^3	290/300 m^3
process water	9 m^3	4/7.5 m^3
steam 3 kgf/cm^2	8.25 t	4/6.25 t
electric power	563 Kwh	225/1,125 Kwh
compressed air	75 Nm^3	32/38 Nm^3
cooling agent at - 22°C	425,000 Kcal	178,000/178,000 Kcal
cooling water at + 15°C	625,000 Kcal	450,000/450,000 Kcal
inert gas	50 Nm^3	20/25 Nm^3
hot water at + 90°C	270,000 Kcal	113,000/175,000 Kcal

Table 10. Consumption of utilities in trichlorphon synthesis
(Technical product, 95% active ingredient)

Utility	Consumption per ton active ingredient	Hourly consumption med./max.	
1	2	3	
Recirculated cooling water at + 28°C.	100 m^3	40	80 m^3
Cooling agent - 22°C	250,000 Kcal	50,000	400,000 Kcal
Steam 3 kgf/cm^2	0.13 t	0.03	0.4 t
Compressed air	20 Nm^3	5	12 Nm^3
Inert gas	15 Nm^3	3,6	10 Nm^3
Electric power	440 Kwh	100	250 Kwh

Table 11. Consumption of utilities in malathion synthesis
(Formulated product, 50% active ingredient)

Utility	Consumption per ton active ingredient	Hourly consumption med./max.	
1	2	3	
Recirculated cooling water at + 28°C	1,727 m^3	190	204 m^3
Process water	0.26 m^3	0.03	0.4 m^3
Steam 3 kgf/cm^2	17.0 t	4	5 t
Steam 15 kgf/cm^2	0.2 t	0.24	0.4 t
Hot water at + 90°C	550,000 Kcal	63,000	70,000 Kcal
Cooling water at + 15°C	625,000 Kcal	34,000	160,000 Kcal
Inert gas	62 Nm^3	6	10 Nm^3
Electric power	1,030 Kwh	90	120 Kwh

Table 12. Consumption of utilities in ethion synthesis
(Formulated product, 2% active ingredient)

Utility	Consumption per ton active ingredient	Hourly consumption med./max.	
Process water	18.8 m^3	4.2	27.2 m^3
Cooling water, recirculated at + 28°C	1,112 m^3	246	426 m^3
Steam 3 kgf/cm^2	48 t	12	16 t
Electric power	635 Kwh	140	300 Kwh
Cooling water at +15°C	2,160,000 Kcal	560,000	3,768,000 Kcal
Inert gas	182 Nm^3	40	232 Nm^3
Compressed air	190 Nm^3	3.4	50 Nm^3

Table 13. Consumption of utilities in dichlorvos synthesis (Technical product, 90% active ingredient)

Utility	Consumption per ton active ingredient	Hourly consumption med./max.	
Recirculated cooling water at + 28°C	5 m³	0.5	2 m³
Process water	4 m³	0.1	0.1 m³
Cooling water at - 22°C	1,275,000 Kcal	23,000	260,000 Kcal
Compressed air	140 Nm³	3	70 Nm³
Inert gas	120 Nm³	25	60 Nm³
Electric power	2,470Kwh	100	500Kwh

IV. EQUIPMENT

Installation

Separate ventilation systems are provided for equipment presenting great explosion danger or the possibility of discharge of noxious substances (as in the dimethyldithiophosphoric acid and dimethyl phosphite syntheses), so that operating supervision can be performed outside the fireproof area and any possible explosion will not propagate throughout the plant. The other equipment is placed on three different levels, depending on process requirements.

The distillation columns, the hydrogen sulphide disposal plant, and the methyl chloride recovery plant are in separate metal buildings situated outside the main plant.

Requirements

The required equipment is as follows:

Vessels

Measuring vessels, day-storage tanks, buffer tanks, settling vessels, emergency tanks etc.; made of steel (OL), enamelled steel (OL em) stainless steel (V_2A, V_4A), rubber-plated steel, hard-rubber plated steel:

202 pieces 111 tons

Stirring vessels

Made of OL em, V_2A, V_4A, rubber-plated steel:

Reaction vessels (including 1 stand-by)	15
Esterification vessels	4
Distillation vessels	5
Condensing, neutralizing tanks	10
Washing, settling tanks	4
Crystallizers, re-crystallizers	10
Melting tanks	3
Miscellaneous	6
Total	57 **pieces, 380 tons**

Columns

For distillation, scrubbing, gas absorption and neutralization; made of OL, V_2A, OL em, epoxy-plated OL, rubber plated OL:

25 pieces 58 tons

Heat exchangers

Made of OL, V_2A, OL em, V_4A, igurite:

76 pieces 96 tons

Pumps

Centrifugal pumps, proportioning pumps, vacuum pumps; made of OL, OL em, grey cast iron, enamelled grey cast iron, V_2A and V_4A:

96 pieces 15 tons

Filters

Pressure filters, suction filters, centrifuges; made of OL em, V_2A, V_4A:

17 pieces 23 tons

Miscellaneous

Made of OL, V_2A, V_4A:

22 pieces 76 tons

V. LABOUR AND SAFETY

Operating staff

The plant is operated in four six-hour shifts per day by a staff of 210 persons as follows (only the requirements for the plant and waste-water burning station are listed):

Process workers	174
Maintenance workers	22
Foremen	9
Process engineers	2
Chemist	1
Chemical technician	1
Unit chief	1
Total	210
Maximum shift size	59

The shifts are short because of the hazardous nature of the work.

Personnel should be trained in similar plants for three to six months, depending on the responsibility and functions they will have.

Safety measures

The manufacturing processes in the plant involve the handling of highly corrosive, toxic and inflammable substances in exothermal reactions and the use of powerful electrical equipment. Precautions must be taken to protect personnel from the associated hazards. These measures are allowed for in the design of the plant:

Isolation of dangerous reactions and processes
General and emergency ventilation
Local ventilation at dangerous points
Automation and remote control of the dangerous processes
Personnel warning devices
Emergency lighting
Emergency electrical power supply
Fire hydrants

The automation equipment is pneumatic and, in certain places, explosion-proof. In addition to a centralised control panel, each boxed reactor is provided with a panel for pneumatic control and an alarm system.

VI. PHYSICAL PLANT

General layout

The plant consists of the following units:

No. 1 Production hall (drawings 3, 4 and 5)

No. 2 Open-air installation: a metal platform outside of, but adjacent to, No. 1 for auxiliary processes and services (drawing 7)

No. 3 Reactor-box building (drawing 6)

No. 4 Open-air platform: A concrete apron in the open adjacent to No. for handling process liquids (pumps, tanks etc.) (drawing 8)

No. 5 Gasometer

No. 6 Auxiliary buildings: Cloakrooms, instrumentation room and electric station

No. 7 Waste-water incinerator (drawing [illegible])

The general layout (drawings 2 and 1) follows these principles:

Optimum process design

Observance of the minimum distances between buildings needed to protect against fire and effect of noxious emissions

Achievement of an economic and rational road system

Rapid drainage of rain water to the sewage system

It is an optimum arrangement that will allow the erection and operation of the plant either as an independent unit or attached to an existing industrial complex.

The area required for plant buildings and infrastructure is approximately 2.2 ha (150 x 150 m).

All work relating to platform arrangement, excavation, filling etc. has not been covered in the present study, either from the point of view of engineering design or of cost.

Description of structures

The general structural specifications for the units that make up the plant are given below in two variants, one appropriate for a cool, the other for a warm, climate.

Variant I (cool climate)

No. 1. Production hall. Monolithic reinforced concrete frame with isolated foundations for pillars and continuous wall foundations. Filling to be of good-quality bricks. Other constructions may be used, depending on local conditions.

No. 2. Open-air installation. Metal, multifloor platforms are provided with monolithic reinforced concrete foundations. Coated with corrosion-proof paint.

No. 3. Reactor-box building. Identical in construction to the production hall. Because of corrosive gas emissions, metallic construction work of rolled profiles coated with corrosion-proof lacquer is provided. Windows must be large and over-pressure compartments and fireproof doors provided for the relief of pressure if an explosion occurs. The floor is of spark-proof bitumen with borders of acid-proof bricks.

No. 4. Open-air concrete platform. Acid-proof. Situated at level ± 0.00 with equipment foundations of monolithic reinforced concrete.

No. 6. Auxiliary building. Load-bearing brickwork on continuous foundations of reinforced concrete and a monolithic reinforced concrete floor. The construction is independent but adjoins the waste-water incinerator. The areas for cloakrooms and sanitary facilities will accommodate the proposed staff of 210 persons.

No. 7. Waste-water incinerator. Concrete platform at level ± 0.00 with equipment foundations and a platform at level + 5.00 made of metal frames and monolithic reinforced concrete plates, with concrete foundation.

Variant II (warm climate)

No. 1 Production hall. Multilevel construction with a metal framework, no side closures, and a light roof of corrugated asbestos-cement sheets supported on metallic frames. Insulated reinforced concrete foundations for the steel pillars. If necessary, ground-floor spaces will be enclosed by brick or reinforced concrete walls on continuous concrete foundations and ceilings of light monolithic reinforced concrete plates. The ventilation system provided for in variant I may be omitted from all spaces open to the outside.

No. 2. Open-air installation. Multifloored steelwork with monolithic reinforced concrete foundations.

No. 3. Reactor-box building. Multilevel construction having a monolithic reinforced concrete framework up to and including level +7.00, steelwork above that. Filter-protection boxes placed at ±0.00 and reactor boxes at +7.00 with three monolithic reinforced concrete walls on the inside, the fourth side (facing outside) being left unclosed.

Special-purpose ground-floor spaces (first-aid room, sanitary facilities and laboratory) closed by brick walls. Rest of building open, without side-walls, except for a roof of corrugated asbestos-cement sheet supported on metallic frames.

No. 4. Open-air concrete platform. Same as in variant I.

No. 6. Auxiliary building. Similar to variant I.

No. 7. Waste-water incinerator. None. Waste water is discharged into such places as abandoned mines and the ocean at no cost.

Air-conditioning facilities may be required in warm climates. Detailed specifications can be written when the plant location has been determined and the climatic conditions at the site precisely known.

Remarks applicable to both variants

Steelwork will be treated with the corrosion-proofing materials appropriate for local conditions.

The construction design takes into account both evenly-distributed and concentrated equipment loads.

The basic data and the external factors considered in calculating the structures and foundations are as follows:

Ground pressure: 2 kg/cm^2
Foundation depth: -2.00 m
Underground water level: -3.50 to 4.00 m

Wind speed: 30 m/sec

Seismic degree: 6

Snow load: 75 kg/m^2

It should be understood that if the design is changed to meet changes in the basic data required by local conditions, the cost estimates given below will no longer be valid.

Indoor installations

Electrical installations (drawing 9)

The total installed electrical power is P_i = [illegible] kW, based on an operating power P_o = 1471 and a required power P_r = 1212 kW, out of which 300 kW are for emergency supply and ancillaries. The electricity is supplied at 380/220 V and 50 Hz from a transformer station equipped with two 6/0.4-kV transformers, each rated at 1,600 kVA.

The power supply to vital operations (those that must not be interrupted for more than 1-2 sec) is from an emergency group with a "notbreak" run of 350 kVA.

The operating standards in the various units of the plant are as follows:

No. 1, 2, 3:	Explosive medium (VDE 0165 in the standards of the Federal Republic of Germany); explosion class 2, ignition group G3.
No. 4:	Normal medium
No. 6:	Normal medium

The supply of electricity to Nos. 1, 2, and 3 is direct from the 0.4-kV main distribution panel in the transformer station. For No. 6, a locally mounted panel supplied from the transformer station at a voltage of 0.4 kV is provided.

The main low-voltage panel in the transformer station is connected by aluminium bars to the 0.4-kV terminals of the transformers and provided with draw-out switches, retention by servomotor and electromagnetic thermal relays. There are fuses, contactors and thermal relays for each motor connexion.

The electric motors in the explosion-hazard area, are controlled by locally mounted double push-buttons (type (Ex)d2G3 in the VDE 0165 standard). Those in the waste-water incinerator are controlled from the panel. Motors rated at over 40 kW are provided with locally mounted ammeters.

Conductors are insulated copper-wire cables sheathed in polyvinyl chloride (PVC) for the motors in explosion-hazard areas and insulated aluminium-wire cables sheathed in PVC for the motors in other areas. The cables are laid on metallic bridges. Outdoor conductors within the battery limits are armoured insulated aluminium-wire cables in PVC sheaths laid in the ground or within protective tubes.

A battery of capacitors mounted in the transformer station (at 0.4 kV) are used for correction of the power factor (0.9).

The cost estimates given below include the following items:

Power distribution panels complete with contactors, fuses, thermal relays, instrumentation and distribution bars

Control cables and push-buttons

Metallic bridges for cables

Transformers

Electrical network (0.4 kV) on unit No.

Normal, emergency and outdoor lighting within the battery limits

Lightning rods

Grounding for the transformer station

Emergency group and the distribution panel for essential electrical services

Installation for power factor correction

Not included are the connexions to the 6-kV source and the 6-kV motor for the emergency group (350 kW).

Ventilation and heating

The specifications that follow do not apply to variant II, in which ventilation is not provided for.

Buildings separate from the plant are not provided with heating in this plan; a decision on suitable heating installations will depend on the climate of the location.

Regarding ventilation, the specifications for the different units follow.

No. 1: Because of the possibility of the release of noxious vapours and the danger of explosions, a mechanical ventilation unit capable of renewing the air 18 times an hour, based on outdoor air, is provided. Apart from that, local ventilation installations are installed in areas where the noxious emissions would be exceptionally severe, namely, two places at level ± 0.00 and three at ± 7.00. The fans are of explosion-proof construction and the driving motors protected ((Ex [illegible]) standard.

[illegible] ±0.00 and +7.00, each filter and reactor box will be provided with both a general and an emergency mechanical ventilation system. The air coming from the general system will be returned to atmosphere, and that from the emergency system to the waste-water incinerator. The compensation air is taken from the atmosphere.

The air in the box corridor at level +7.00 is kept under positive pressure.

At level +15.00, which is used for charging the reactor (at +7.00) with phosphorus pentasulphide, a general ventilation system and a floor dedusting unit are provided, with the compensation air taken from the atmosphere. The air from the general ventilation will be exhausted to the waste-water incinerator station, and that from the dedusting unit will be discharged to the atmosphere after passing through a dedusting cyclone.

Water supply and sewage systems

The water supply system, which, besides the normal sanitary facilities, also includes a fire-fighting system, and the sewage system are installed only as far as the battery limits. The purchaser provides the water in the quantity and quality specified below. The purchaser shall also arrange disposal of domestic waste water, rain water and chemically impure water outside the battery limits.

Flow rates and pressures

Water supply system. The maximum flow rate in the sanitary facilities is 1.2 l/sec, and the daily average flow rate is 16 m^3/day. In the indoor fire-fighting system, the flow rate is 5 l/sec (two jets of 2.5 l/sec each), and the flow rate for the outdoor fire-fighting system is 25 l/sec at a head of 55 m. The stand-by water stock for fire fighting is 240 m^3 (made available by the purchaser).

Sewage system. The maximum flow rate of domestic waste water is 16 m^3/day, free falling to the battery limits. The actual rain water flow rate depends, of course, on the climate of the location. Here it is assumed to be 100 l/sec.

The floor wash water, together with the chemically impure water from the plant, have a flow rate of 3 m^3/h (once every five days for [illegible] h).

Water physico-chemical characteristics

The drinking water has the physico-chemical characteristics specified for the plant location. If no local specifications are available, the water meets international norms. The water for the fire-fighting system meets the standards for either drinking or industrial waters.

Piping

Water supply system. The drinking water for the sanitary facilities (wash-stands, basins, showers, toilets and urinals, as well as safety showers in the production hall) is distributed through a network of ½-in. to 1½-in. zinc-coated steel piping.

Hot domestic water is obtained from locally installed boilers having a capacity of 1,000 l, and is distributed through ½-in. to 1½-in. zinc-coated steel piping.

Indoor hydrants are supplied with water through [illegible]-in. to 2½-in. black-iron piping (zinc-coated steel if the water is potable). All the indoor hydrants will have a special 2-in. spray nozzle.

The purchaser or client is responsible for the water supply to outdoor hydrants and for the chemical foam unit in the main storage spaces.

Sewage system. Domestic waste water from the various sanitary installations and safety showers is transferred through sloping cast-iron pipes (NW 50 - NW 100) joined together with tarred rope and bitumen mastic.

The rain water from the roof is discharged by free fall through cast-iron pipes (diam. 100 - 150 mm), with discharge at the pavement level.

The wash and chemically impure water from the plant is discarded by free fall through 100-mm basalt pipes. Discharge point is at the battery limits.

Waste-water incinerator

General description

The waste water from the manufacturing processes and the air contaminated with noxious emissions from the ventilation systems are destroyed by incineration in a unique plant that uses gaseous or liquid fuel for combustion. This plant consists of the following parts:

Noxious water and air circuits
Fuel circuits
Incineration units
Heat-recovery and steam-production unit

The whole assembly forms a separate unit located away from the manufacturing plant.

Plant parameters

The composition of the process waste water is as follows (percentage):

water	66.60
NaCl	8.20
NaBr	0.70
Na_2CO_3	1.30
mineral oil	7.20
$NaHCO_3$	0.60
Na_2S	0.35
NaOH	0.027
diethylthiophosphoric acid	0.290
monochloro acetamide	1.330
dimethylphosphoric acid	3.150
dimethoate	1.360
orthonitrophenetol	0.004
nitrophenetol	0.017
ethanol	0.033
orthophenetidine	0.023
xylene	0.006
unidentified organic matter	2.300
other waste	2.320

The air discharged by the ventilation systems has an organic-matter content of 0.5-1%.

Installed flow rate: [illegible] m^3/h waste water

Fuel consumption:

During the first 150 days of the year: fuel oil, 170 kg/h, or methane, 190 m^3/h

During the last 150 days of the year: fuel oil, 280 kg/h, or methane, 350 m^3/h

Electric power consumption:

Installed, 375 kW

Under operation, 250 kW

Steam production in the heat-recovery boiler:

During the first 150 days of the year, 6 t/h

During the last 150 days of the year, 15 t/h

(The steam production during the first 150 days may be increased to 15 t/h by burning supplementary fuel.)

Consumption of demineralized water for steam production:

Maximum 20 m^3/h

Consumption of industrial water:

Maximum 15 m^3/h

Flow rate of burning gases:

Maximum 30,000 m^3/h

Plant operation

The waste water is injected under pressure into the combustion chamber, where the fuel is burned at a temperature of about 1,000°-1,100°C. The noxious air is used as the source of oxygen. The products of combustion are passed to the steam boilers, where they are cooled to 280° - 290°C, and discharged into the atmosphere through a stack 25 m high.

The residues from the non-combustible matter in the waste water are stored for a time before disposal.

Other specifications

The described plant is to be operated in such a way as to ensure the destruction of all noxious wastes.

The cost estimate does not include the cost of the following items:

Removal of the residues
Utility and steam pipes
Delivery of fuel to the plant
Water demineralization
Central fuel storage

The proposed equipment may require modifications depending on fuel quality and other variables.

The plant operates only on liquid or gaseous fuels.

VII. ECONOMIC ANALYSIS

Investment estimates

Estimates of the capital investment required for the plant in its two variants are given in table 14. The estimates must be regarded as quite rough, since actual costs will depend strongly on local conditions.

Table 14. Estimated capital investment requirements for the insecticide plant

Item No.	Item	Process plant (thousand $)	Waste water incineration plant (thousand $)	Total (thousand $)
1	2	3	4	5
1.	Equipment	2,619	378	2,997
2.	Equipment erection (labour)	170	265	435
3.	Pipes (materials)	660	46	706
4.	Pipe erection (labour)	88	6	94
5.	Instrumentation (equipment)	345	57	402
6.	Instrumentation assembling (labour)	79	13	92
7.	Modifications for Tropics	131	18	149
8.	Transportation	-	-	82
9.	Constructions (materials)	-	-	var I 750 var II 600
10.	Constructions (labour	-	-	var I 500 var II 100
11.	Ventilation (installation and equipment)	-	-	var I 110 var II -
12.	Ventilation (labour)	-	-	15
13.	Water installation (equipment, and materials)	-	-	11
14.	Water installation (labour)	-	-	2
15.	Electric installation (materials)	-	-	882
16.	Electric installation (labour)	-	-	106
	Total:	var. I 4,092 var.II 4,092	var.I 783 var.II -	var.I 7,273 var.II 5,830

The investment in capital and other items is amortized according to the schedule shown in table 15.

Costs

The costs of the materials used in one year's production are set forth in table 16, and the sale-value of the end products is shown in table 17. The prices given in both tables can be counted on to increase significantly as time goes on.

Profits

All the costs and the income from sales are brought together in table 18 for the calculation of the profits and rate of profit realizable from the two variants of the plant.

Table 15. Amortization of investment and other items

Item	Investment value (thousand $)		Amortization period (years)	Amortization (%)	Amortization value (thousand $)	
	var.I	var.II			var.I	var.II
Constructions-installations	2,398	1,738	30	3.3	80	57
Process plant	4,092	4,092	15	6.7	272	272
Waste waters incineration plant	783	-	15	6.7	52	-
Subtotal	7,273	5,830		5.6	404	329
Design	727	727		5.6	41	41
Know-how	300	300		5.6	17	17
Running tests	50	50		5.6	3	3
Personnel training	50	50		5.6	3	3
Total	8,400	6,957		5.6	468	393

Table 16. Yearly raw materials - quantities and costs

Material	tons					Total	Unit price ($/t)	Yearly values (thousand $)
	Dimethoate (crystalline)	Malathion	Ethion	Trichlorphon	Dichlorvos			
1	2	3	4	5	6	7	8	9
Monochloroacetic acid	1215	-	-	-	-	1215	610	741
Sulphuric acid	50	11	-	20	-	81	40	3
Methanol	1111	144	-	424	-	1679	250	419
Extraction kerosene	611	240	-	-	-	851	106	90
Sodium bicarbonate	117	-	-	-	-	117	212	24
Methylamine 30%	1261	-	-	-	-	1261	100	126
Phosphorus pentasulphide	1322	228	216	-	-	1766	605	1068
Kerosene	238	-	-	-	-	238	90	21
Sodium chloride	136	324	-	-	-	460	9	4
Sodium hydroxyde 96%	367	50	78	280	18	793	340	269
Toluene	500	130	572	-	-	1202	255	306
Maleic anhydride	-	185	-	-	-	185	440	81
Ethanol	-	218	240	-	-	458	396	181

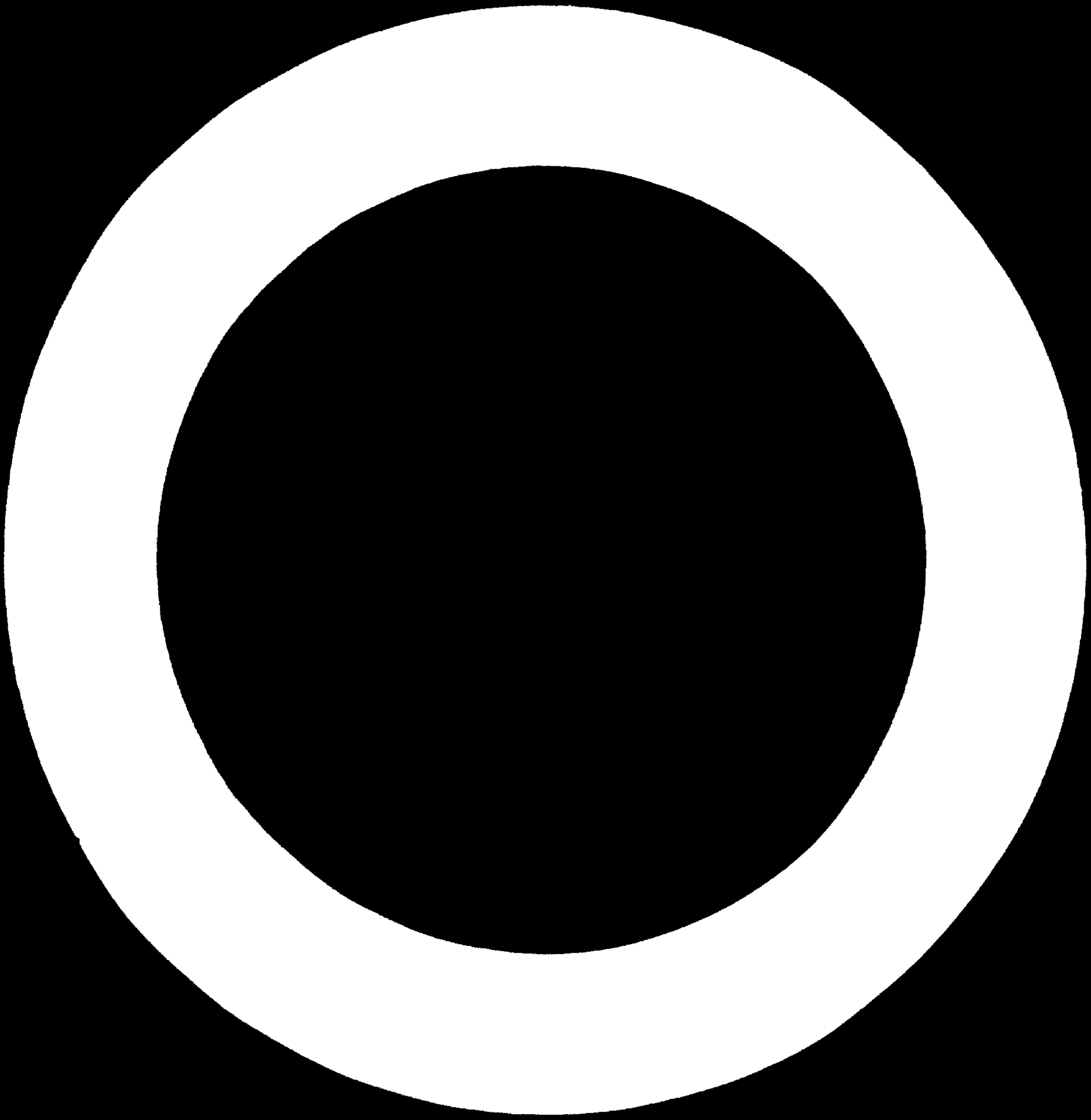
1	2	3	4	5	6	7	8	9
Benzene	-	32	16	-	-	48	700	33
Emulsifier	-	40	41	-	-	81	960	77
Sodium carbonate	-	160	-	24	-	184	184	15
Xylene	-	324	-	-	-	324	200	64
Methylene bromide	-	-	132	-	-	132	120	15
Paraffin oil	-	-	20	-	-	20	100	2
Ammonia 99.5%	-	-	-	18	-	18	180	3
Chloroform	-	-	-	1285	-	1285	220	282
Chloral 99.5%	-	-	-	616	-	616	310	314
Carbon tetrachloride	-	-	-	528	-	528	385	203
Phosphorus trichloride 97.5%	-	-	-	608	-	608	242	147
Sodium sulphate 98%	-	-	-	-	9	9	100	1
TOTAL :								4,498

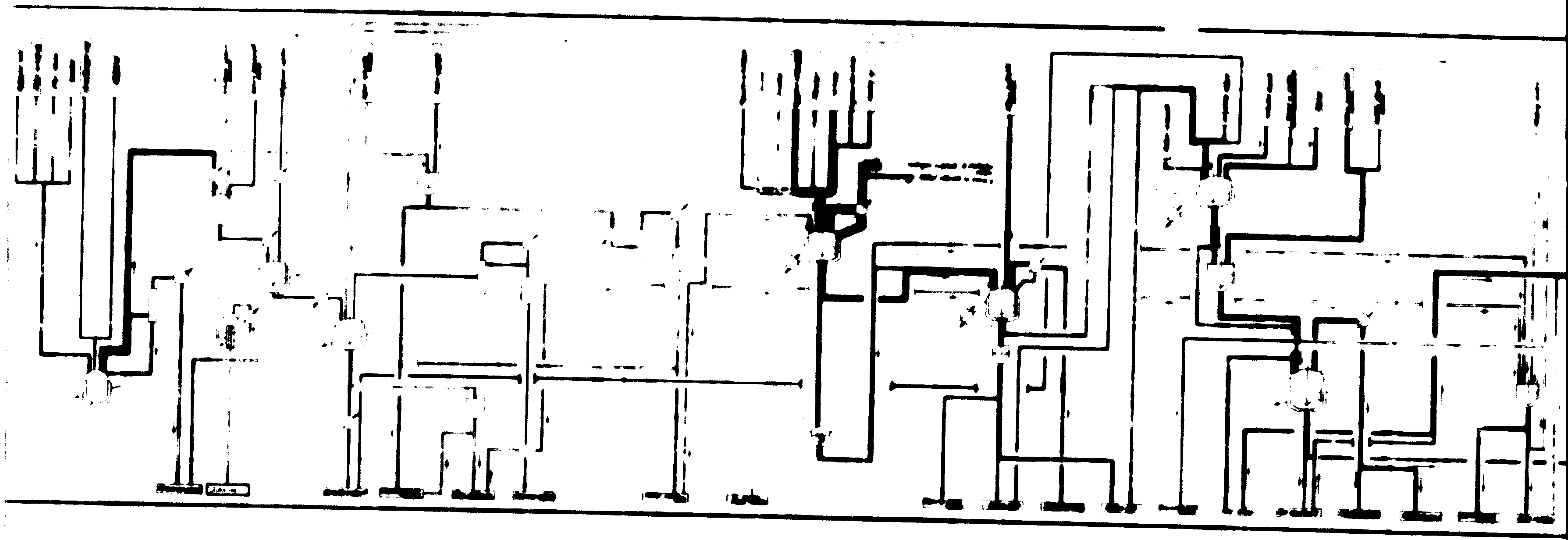
Table 17. Annual sale-value of end products

Product	Amount (t)	Unit Price ($/t)	Value (thousand $)
Dimethoate	1000	4025	4025
Trichlorphon	800	2875	2300
Malathion	400	3700	1480
Ethion	200	4800	960
Dichlorvos	58	2200	128
TOTAL :	2458		8893

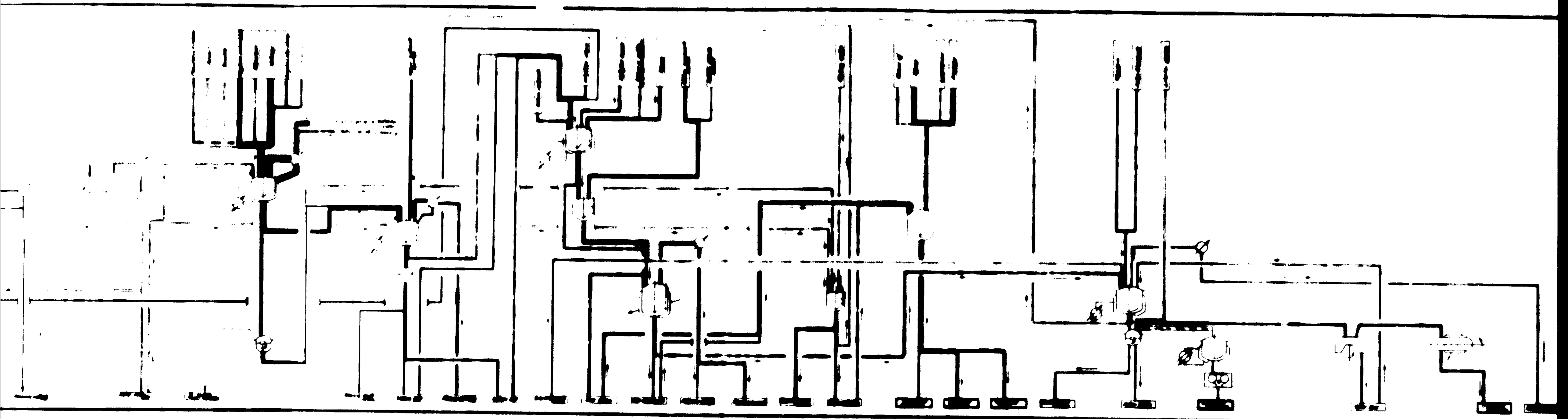
Table [illegible]. Annual income, cost and profit
(Thousands of $)

Item	var. I	var. II
1. Production value (sale prices)	8893	8893
2. Raw materials	4498	4498
3. Utilities	332	332
4. Total salaries (arbitrary)	171	171
5. Nominal capital costs(25%)	43	43
6. Fixed means amortization	468	393
7. Repairs (2% of fixed means)	145	117
8. Land rental (6000 $/ha x 2 ha)	12	12
9. Taxes on fixed means (1.5% for constructions)	36	26
10. Insurance premium	18	14
11. Other variable expenses	200	200
12. Interest (9%)	756	582
13. Know-how amortization	25	25
14. Other expenses	200	200
15. Costs for waste water incinerator	206	-
TOTAL item 2 to 15	7110	6613
GROSS PROFIT	1783	2280
Legal reserve (5% from the gross profit)	89	114
Taxable profit	1694	2166
Tax on profit (30%)	508	650
Net profit	1186	1516
Rate of profit	14%	22%

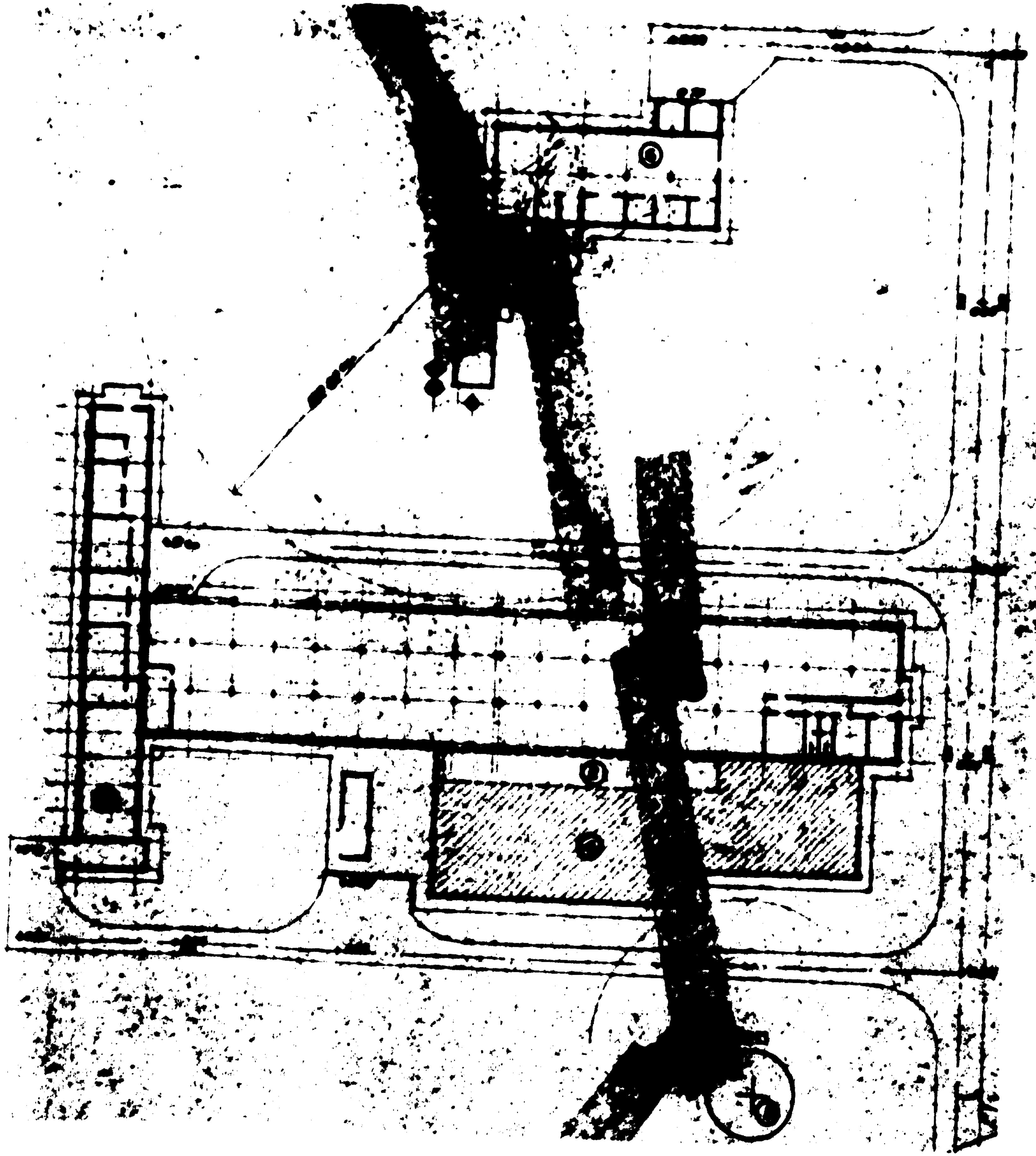




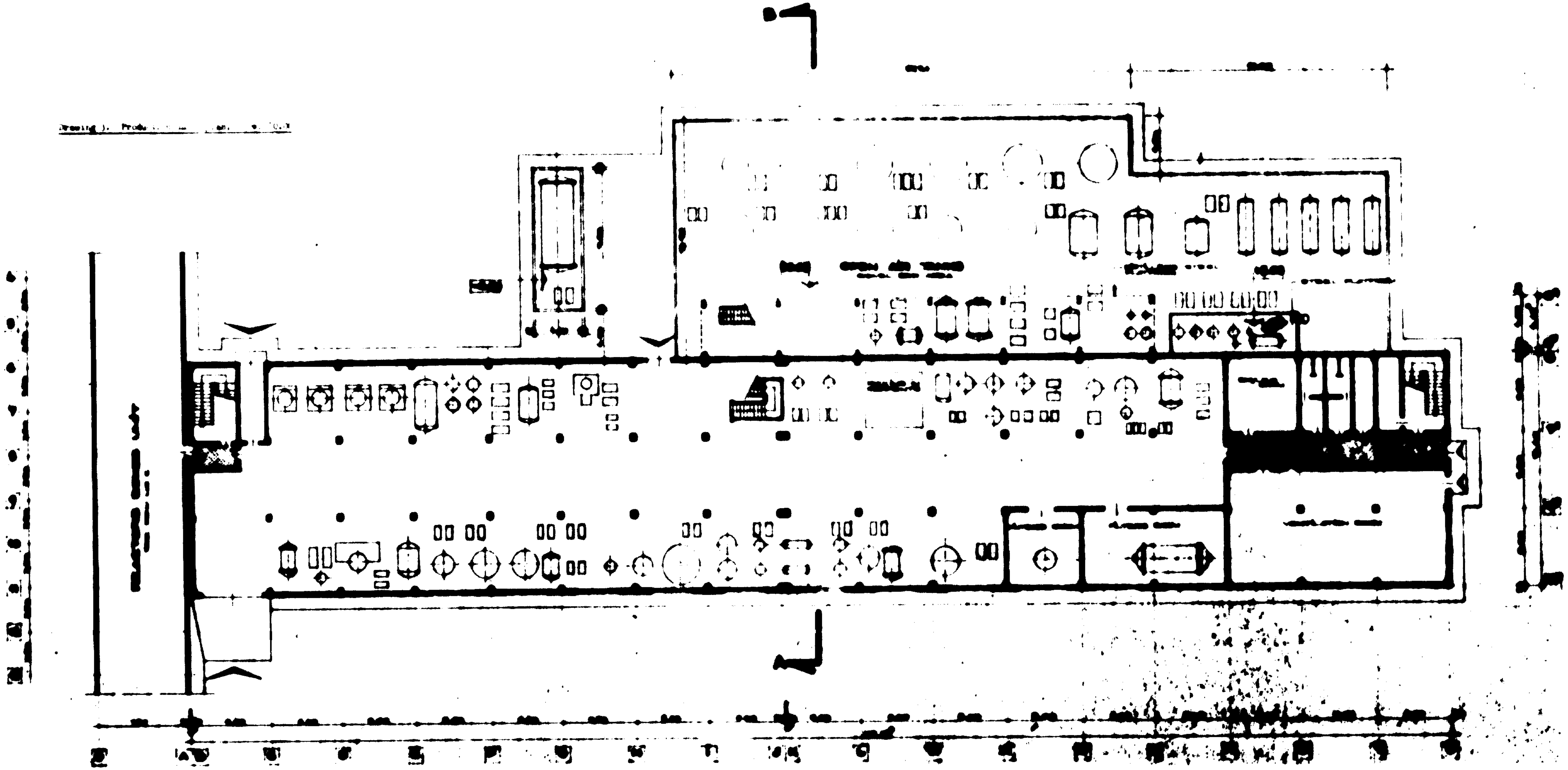
Drawing 1. General flow chart

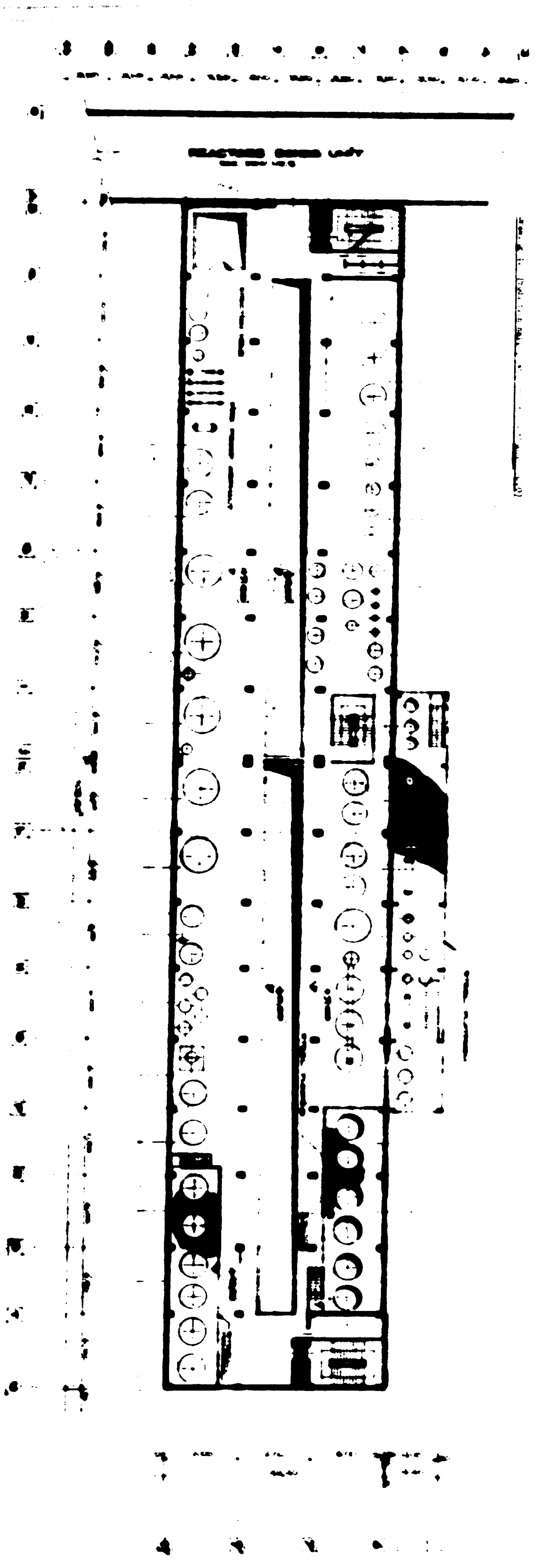


Drawing 2. General Layout



Drawing 3. Produ[illegible]





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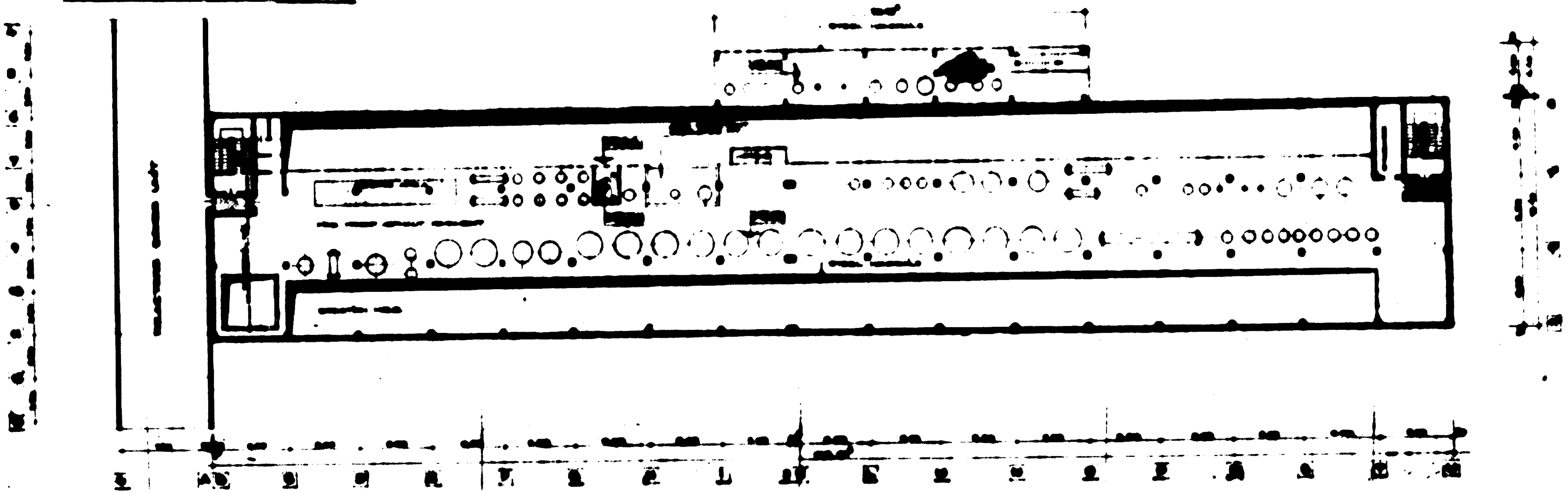
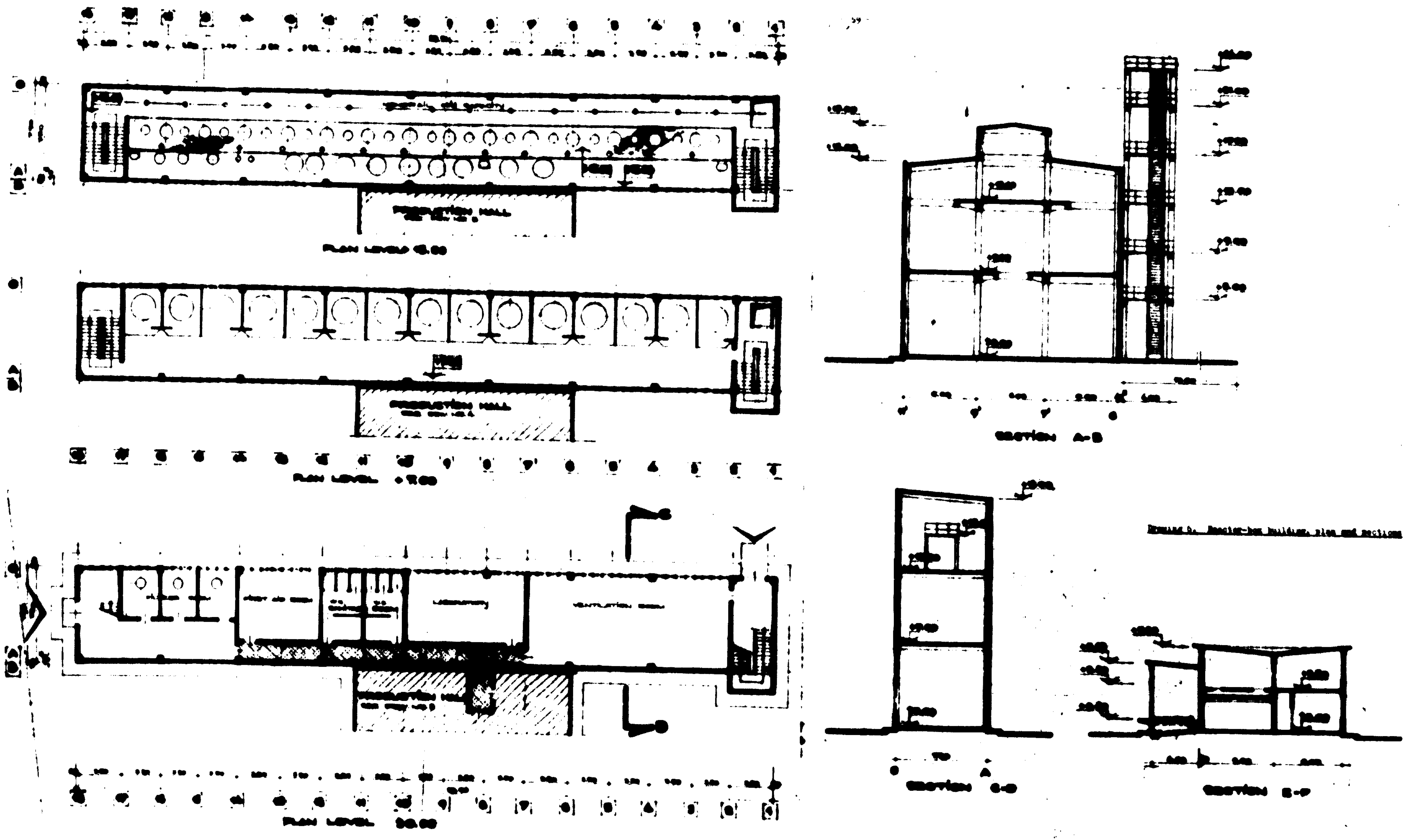
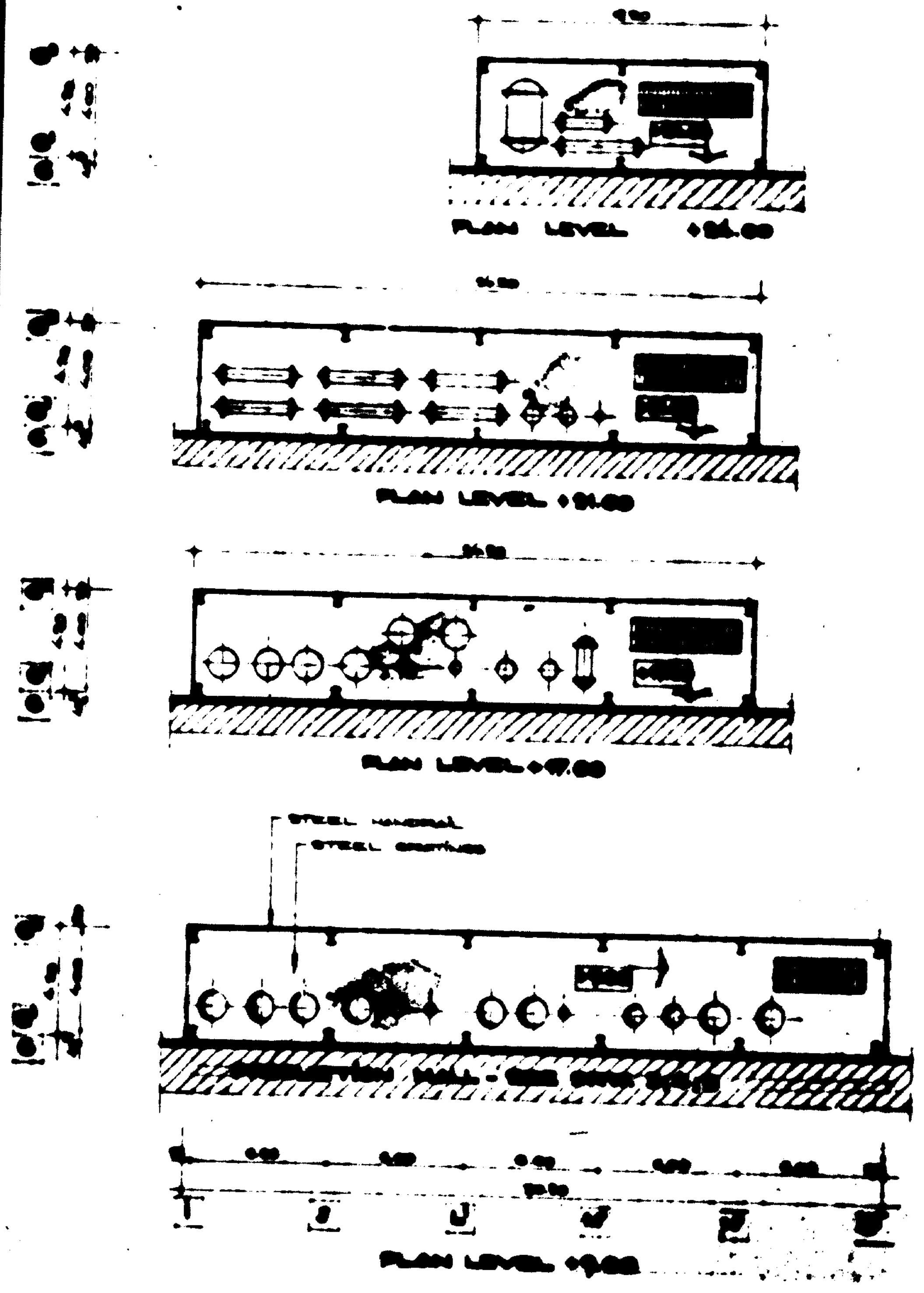
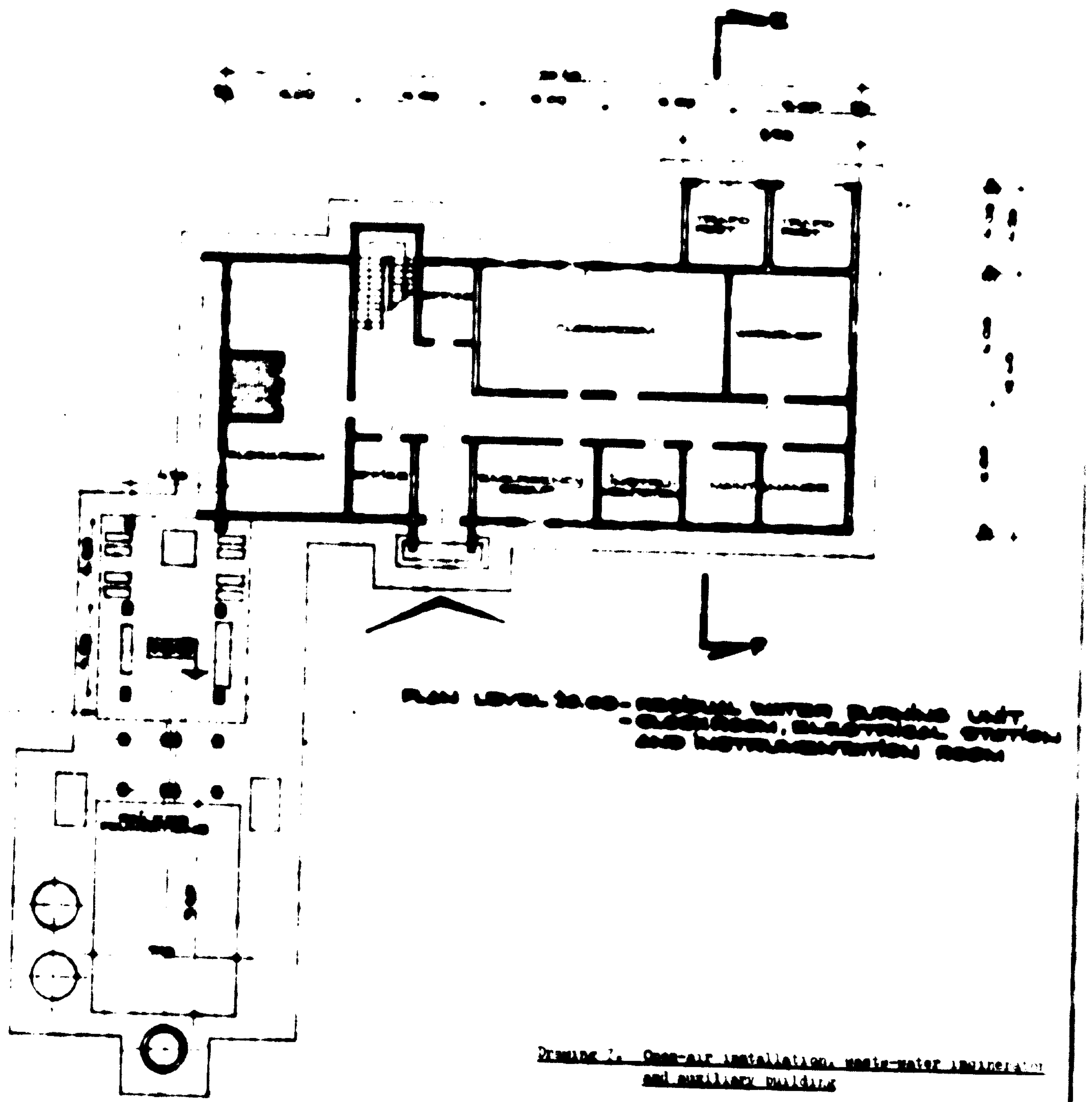




Drawing 6. Reactor-box building, plan and sections





Drawing 7. Open-air installation, waste-water incinerator and auxiliary building

[illegible]	ITEM	DIMENSIONS						[illegible]			CONSTRUCTION CHARACTERISTICS											CONSUMPTION OF MAIN MATERIALS								
																				[illegible]		CONCRETE			STEEL					
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	PRODUCTION HALL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	OPEN AIR STEEL PLATFORM	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]									[illegible]			[illegible]	[illegible]		[illegible]			
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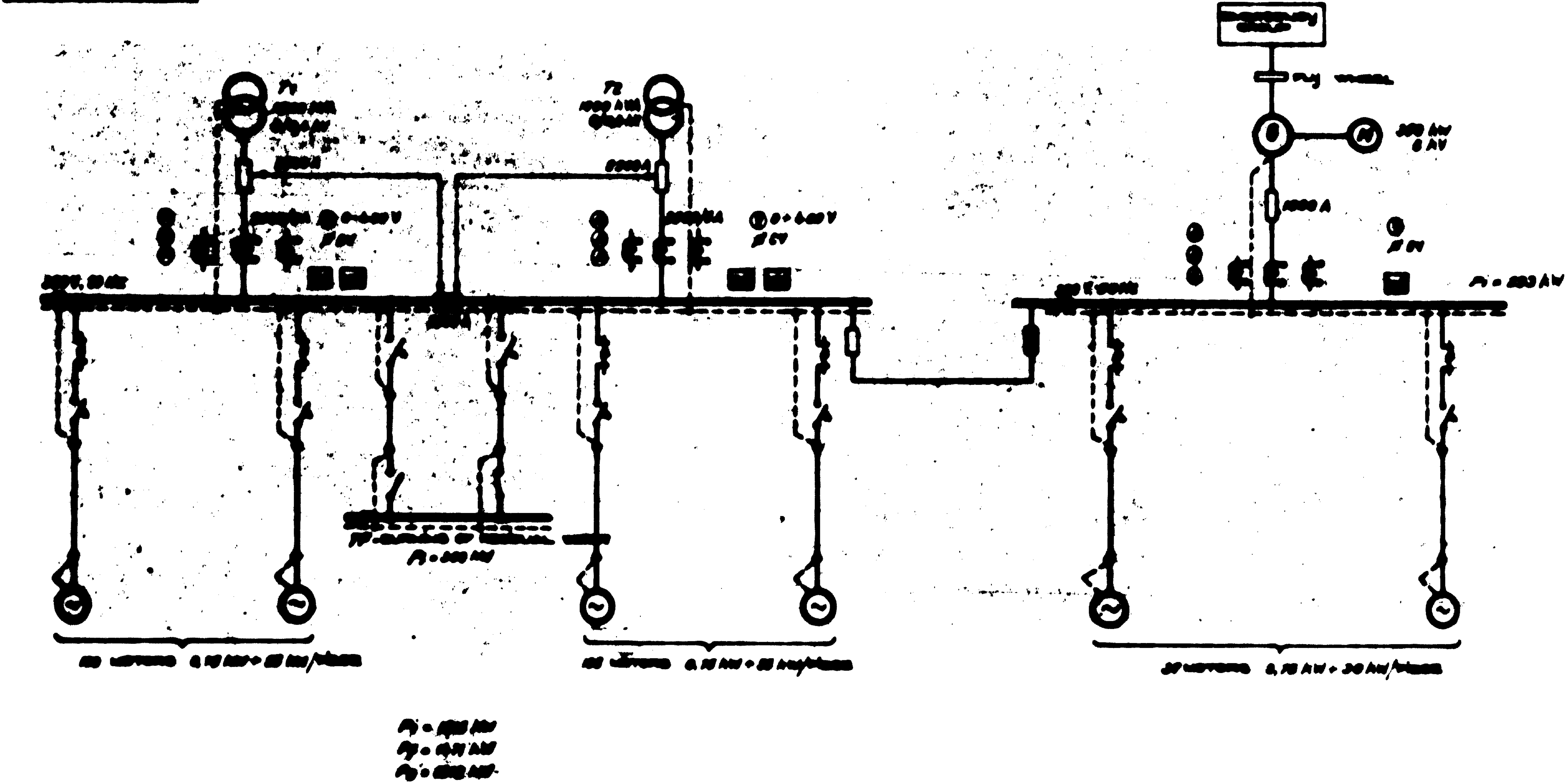
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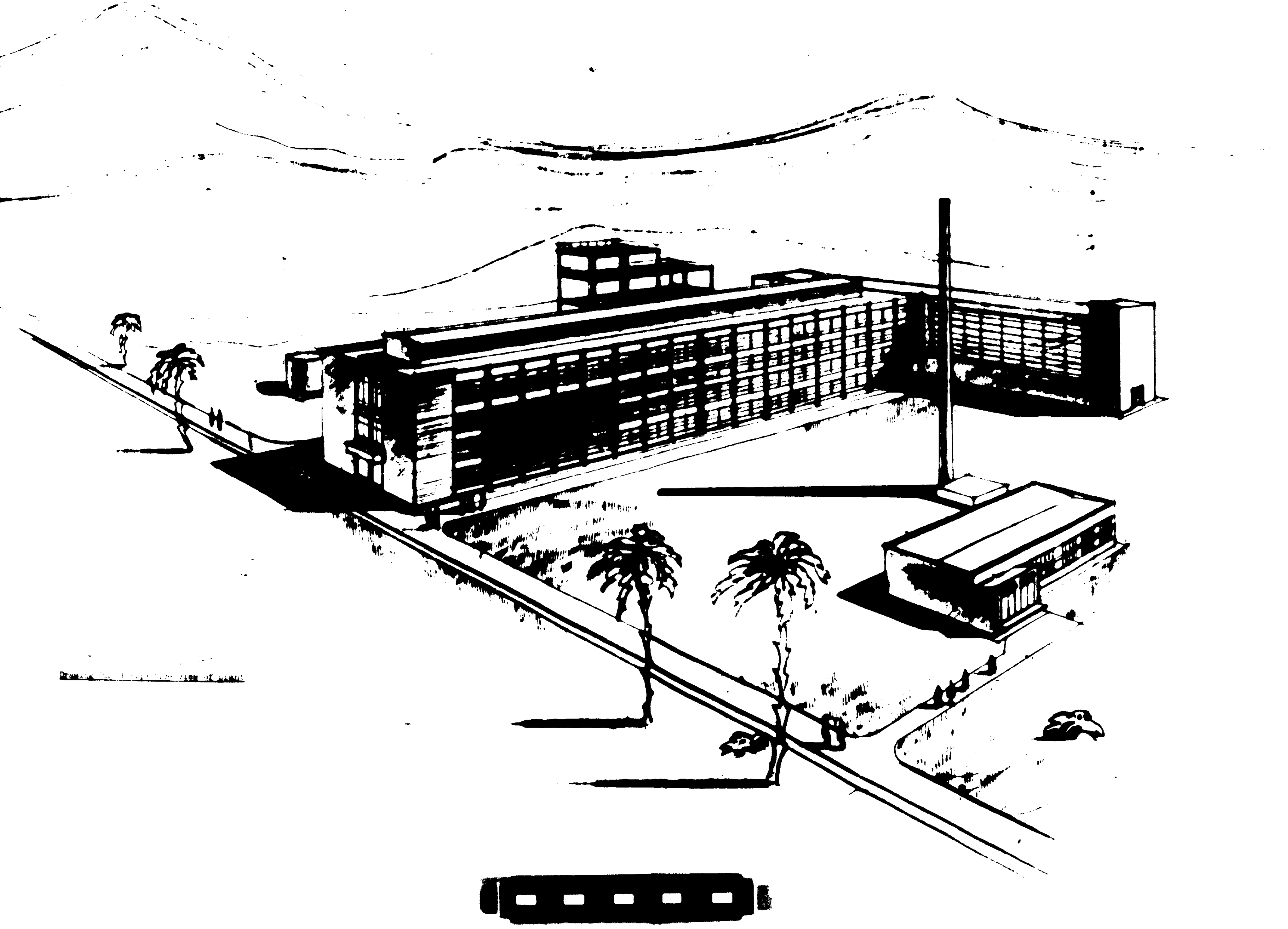
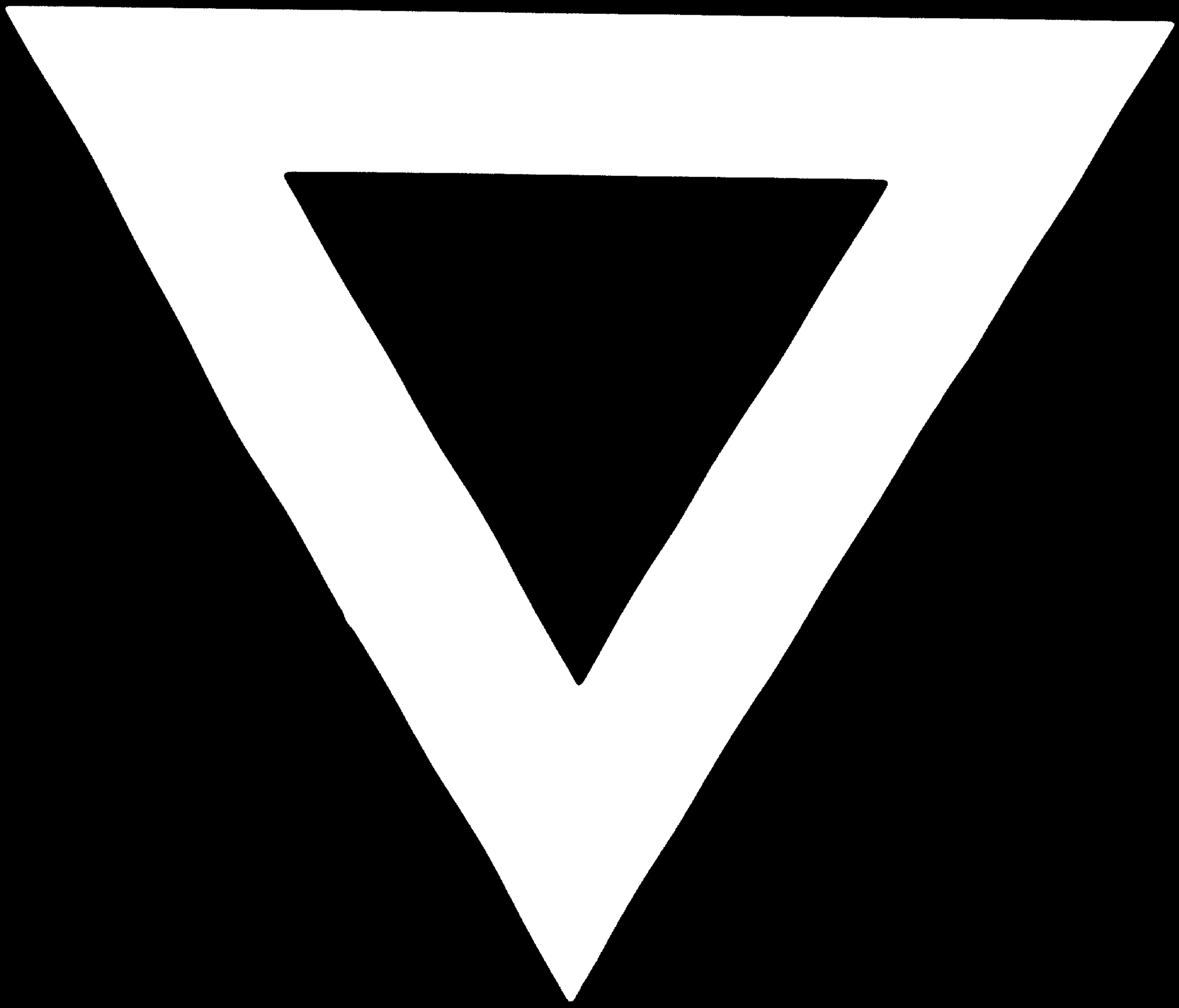


Drawing [illegible] view of plant



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