No.

SURVEY REPORT

ON

REHABILITATION
OF MAE MOH FACTORY
IN THE KINGDOM OF THAILAND

MARCH 1979

JAPAN INTERNATIONAL
COOPERATION AGENCY

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PREFACE

In response to the request of the goverment of the Kingdom of Thailand, the goverment of Japan decided to conduct a study of a rehabilitation plan for a fertilizer plant located in Mae Moh, Lampang Prefecture, and assigned the execution of the study to the Japan International Co-operation Agency.

Using the brown coal produced in the vicinity as the main raw material, the Mae Moh plant is the only modern chemical fertilizer plant in Thailand to produce ammonia, urea and ammonium sulphate, constructed by a consortium of firms centered around the Uhde G.m.b.H. of the Federal Republic of Germany and brought on stream in 1965. The plant, under the management of the Chemical Fertilizer Co., Ltd., a goverment enterprise of Thailand, has suffered an extremely low rate of operation, an average of 30%, and possibility of its rehabilitation had been a problem.

The Japan International Cooperation Agency sent to the plant a group of eight experts headed by Toyoji Tokunaga of Mitsui Toatsu Chemicals, Inc. for a period of one month from February 19 to March 18, 1978 to conduct the first survey, followed by another group of eight experts headed by Hitoshi Jindai of Mitsui Toatsu Chemicals, Inc. for a period of three months from June 25 to September 24, 1978 to conduct the second survey.

In the first survey, the operation records of the past were analyzed to identify the causes of the low rate of operation and in the second survey the equipment were subject to interior inspection and a detailed rehabilitation plan was formulated for each item of equipment. Based on the findings of the field surveys, the survey team worked further in Japan to prepare this report.

This report concludes that the Mae Moh plant can be rehabilitated and that it is worth so doing. In submitting this report, we sincerely hope that this will be fully utilized to rehabilitate the Mae Moh plant and thus contribute to the economic development of Thailand.

We wish to recognize the great efforts devoted by the members of the survey teams. We wish to express our deep appreication for the cooperation rendered by the staff of the Chemical Fertilizer Co., Ltd. and the support given to this endeavor by the Ministry of Foreign Affairs and the Ministry of International Trade and Industry.

March 1979

Shinsaku Hogen

President
JAPAN INTERNATIONAL
COOPERATION AGENCY

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SECTION 1

THE OBJECTIVES OF SURVEY TEAM

Section 1 The Objectives of Survey Team

1-1 Survey Team

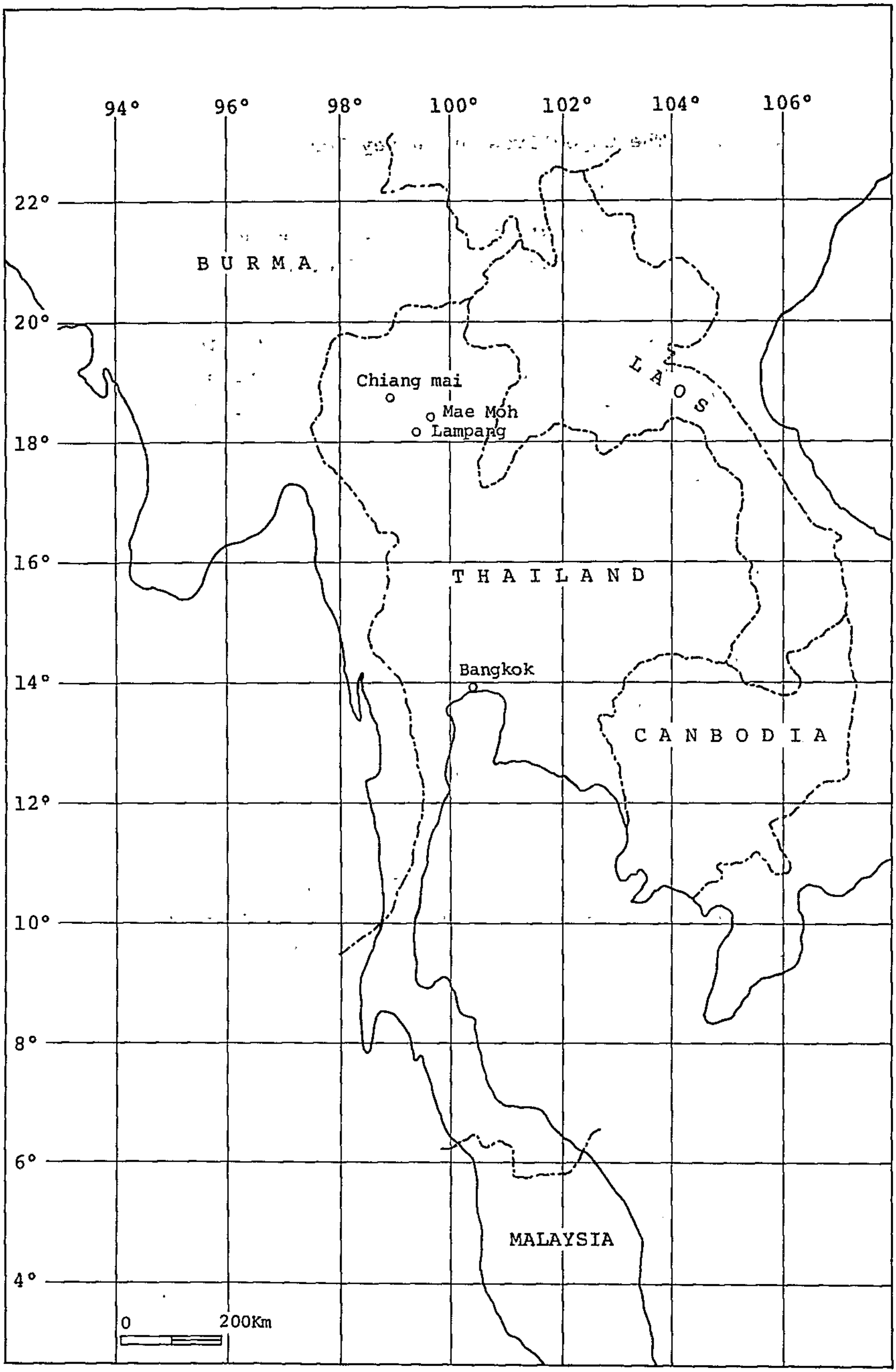
Japan International Cooperation Agency (JICA) has trusted to Mitsui Toatsu Chemicals Inc. to survey the Mae Moh factory in Thailand.

The survey team has been dispatched twice. The first survey team was composed of 7 crews and dispatched for 1 month, from Feb. 19 to Mar. 18 of 1978. The crews were as follows.

Leader (Process engineer)	1
Process engineer	2
Machine "	1
Instrument "	2
Chemist	1

Following to the results of the first Survey team, the second survey team was dispatched to put forward the research. The survey team was composed of 6 crews except the leader of the first team and dispatched 3 months from June 25 to Sep. 24.

Mr. Shimomichi, a staff of JICA, went together with the first team for 2 weeks, and also 2 welding specialists went together with 2nd team for 1 and half months.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BURMA
LAOS
Chiang mai
Mae Moh
Lampang
THAILAND
Bangkok
CANBODIA
MALAYSIA
0
200Km

1-2 Mae Moh Factory

Mae Moh factory was constructed by the engineering company of West Germany utilizing the loan from World Bank. The construction was started on 1963 and operation on 1965.

Chemical Fertilizer Co., Ltd. (hereinafter CFC) which possesses Mae Moh factory, is a private company capitalized at 700 million Baht (7 billion Japanese yen), yet the Company is actually a government enterprise, because of its 97% shares are being held by Financial ministry of Thailand.

Factory is located about 600 Km north of Bangkok and 30 Km east of Lampang city where is the seat of Lampang prefectural government.

The basin, in which Mae Moh village lies, has an altitude of 370 meters above sea level and an atmospheric pressure of 737 mmHg. The atmospheric temperature of the basin is 3 to 5°C lower than the temperature of Bangkok on the average.

The address of Mae Moh factory;
Mae Moh, Lampang, Thailand

The composition of Mae Moh factory is as follows;

Boiler (2)	Austrian made	(rent from EGAT)
Feed water plant	West German made	Levatit
Air Separation plant	"	Linde
Coal gasification plant	"	Koppers
Desulphurization plant	"	Shell
Ammonia Synthesis plant	"	Uhde
Urea Synthesis plant	"	Uhde (Stami)

Sulphuric acid plant	West German made	Lurgi
Ammonium sulphate plant	"	"

Besides above listed, as the Auxiliary section, there are Machine, instrument and electricity workshops and laboratory in Mae Moh factory.

The brown coal (Lignite), which is the main raw material of Mae Moh factory, is supplied by open wagon from the strip coal mine in the neighborhood.

The produced ammonia is converted mainly to fertilizer and a part of products is bottled and put on market.

The produced sulphuric acid is also converted mainly to fertilizer and also a part of products is put on market carried by tank lorry.

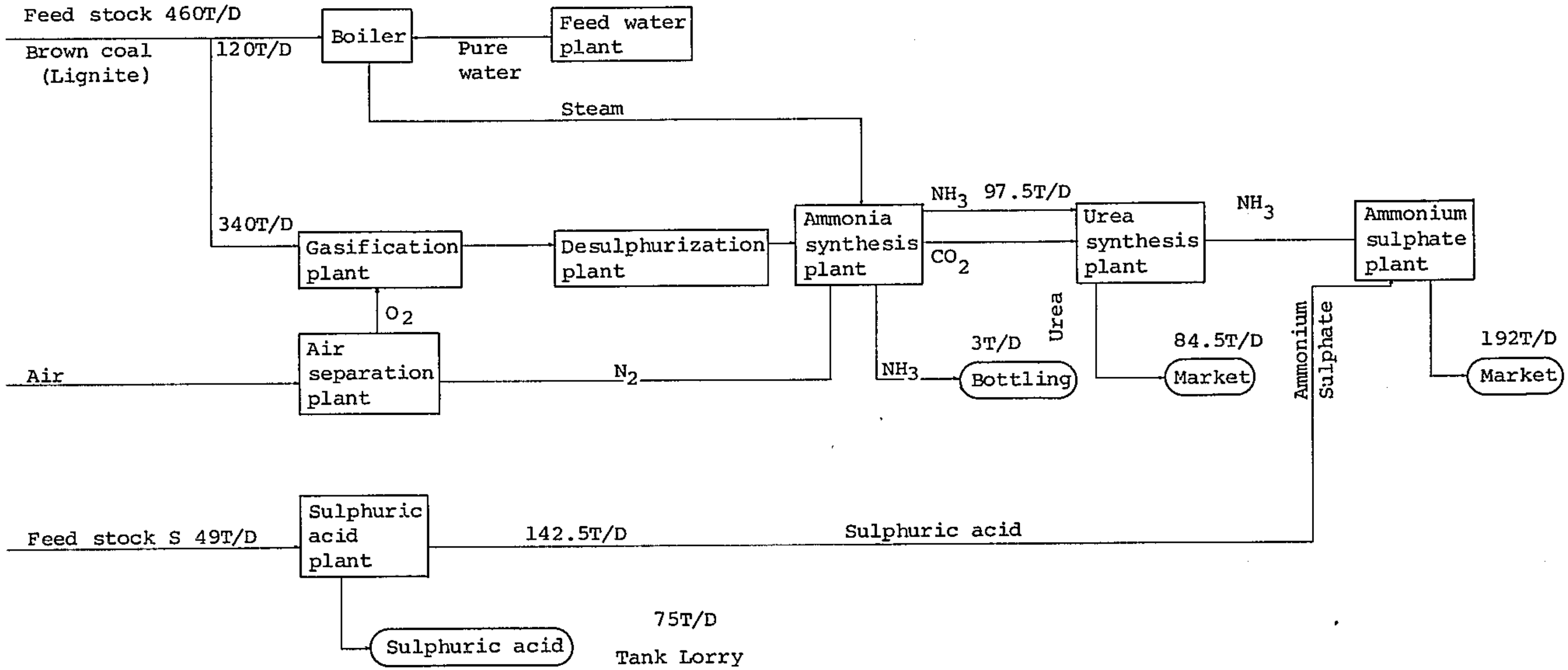
The urea and ammonium sulphate are bagged and carried out by rail way or truck.

The liquid ammonia which is put on market is consumed mainly at refrigerated warehouse in Bangkok. The sulfuric acid is consumed for water treatment of Bangkok city water. The produced urea is consumed as the raw material of plastics and industrial chemical besides it is consumed as fertilizer. The ammonium sulphate is consumed as fertilizer.

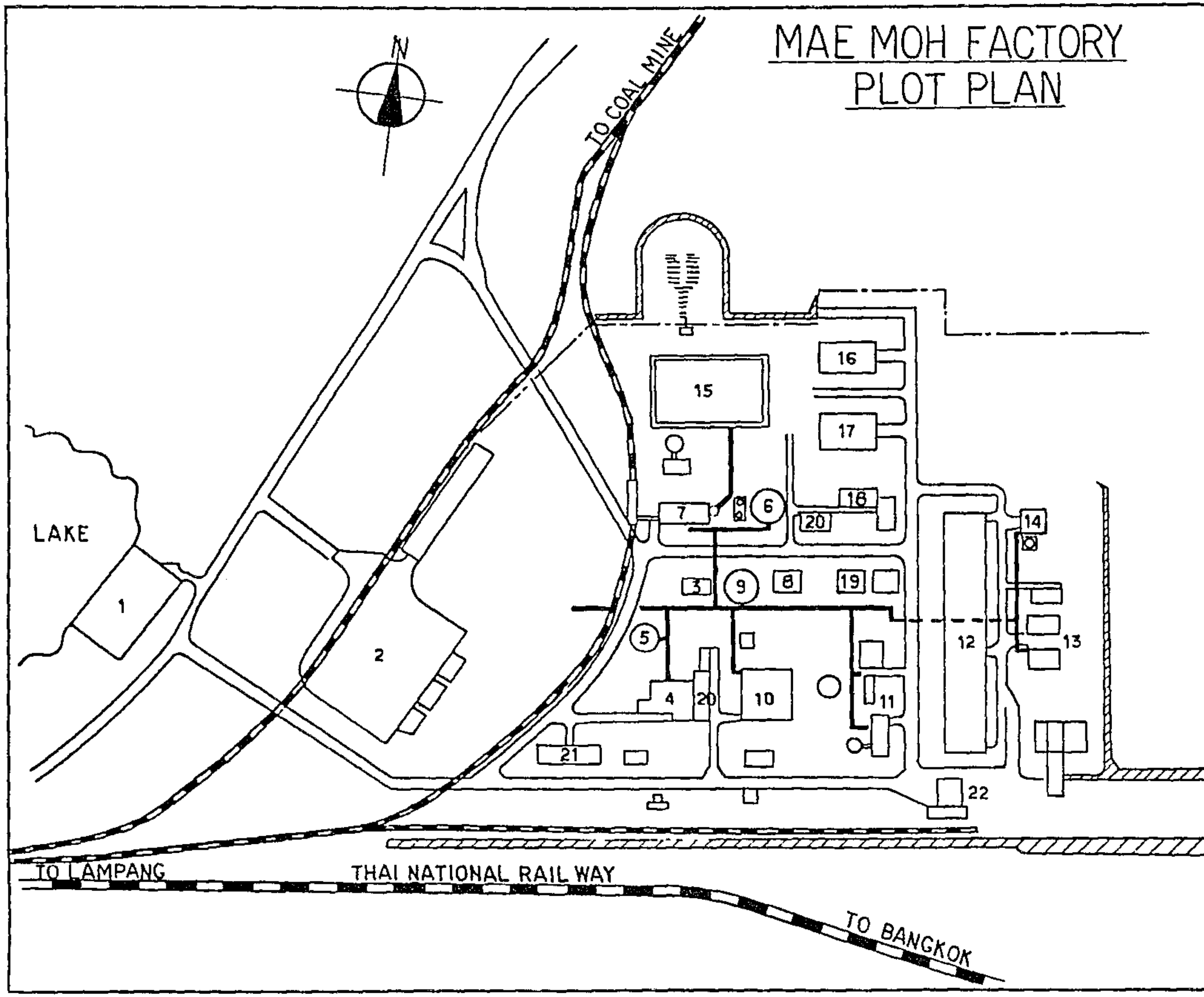
The each production was being shorter than market demand, so that the warehouse and tank was always nearly empty during our stay in Mae Moh.

FLOW DIAGRAM of Mae Moh FACTORY

(Design Base)



MAE MOH FACTORY PLOT PLAN



NO.	PLANT NAME
1	PUMP HOUSE
2	EGAT BOILER
3	FEED WATER PLANT
4	AIR SEPARATION PLANT
5	O_2 HOLDER
6	N_2 HOLDER
7	GASIFICATION PLANT
8	DESULPURIZATION PLANT
9	SYN GAS HOLDER
10	AMMONIA PLANT
11	UREA PLANT
12	PRODUCTS WAREHOUSE
13	SULPHURIC ACID PLANT
14	AMM. SULPH. PLANT
15	WATER TREATMENT
16	MACHINE WORKSHOP
17	SPARE PARTS WARE HOUSE
18	LABORATORY
19	INST. ELEC. WORKSHOP
20	ELECTRICITY CONTROL ROOM
21	OFFICE
22	BAGGING

1-3 The objectives of survey

The actual annual out put of Mae Moh factory are as follows.

Year	Ammonia TON	Urea TON	Ammonium Sulphate TON
1970	14,796	12,630	25,235
71	12,803	10,219	25,970
72	10,602	5,487	25,603
73	8,506	6,135	19,227
74	10,120	5,083	23,906
75	6,584	3,314	15,883
76	9,522	3,368	25,267
77	9,925	6,232	19,104
average	10,358	6,559	22,524
design	30,000	25,000	58,000

The average annual production of Mae Moh factory has been 30% of design. The objectives of survey team is to research the problems and possibility of rehabilitation and to study the propriety of the rehabilitation of Mae Moh factory, which is greatly distressed by these deteriorated production.

Survey team has investigated the following items.

1. Actual production records.
2. Basic design of whole plants.
3. Organization and technical level of factory.
4. Environmental pollution.

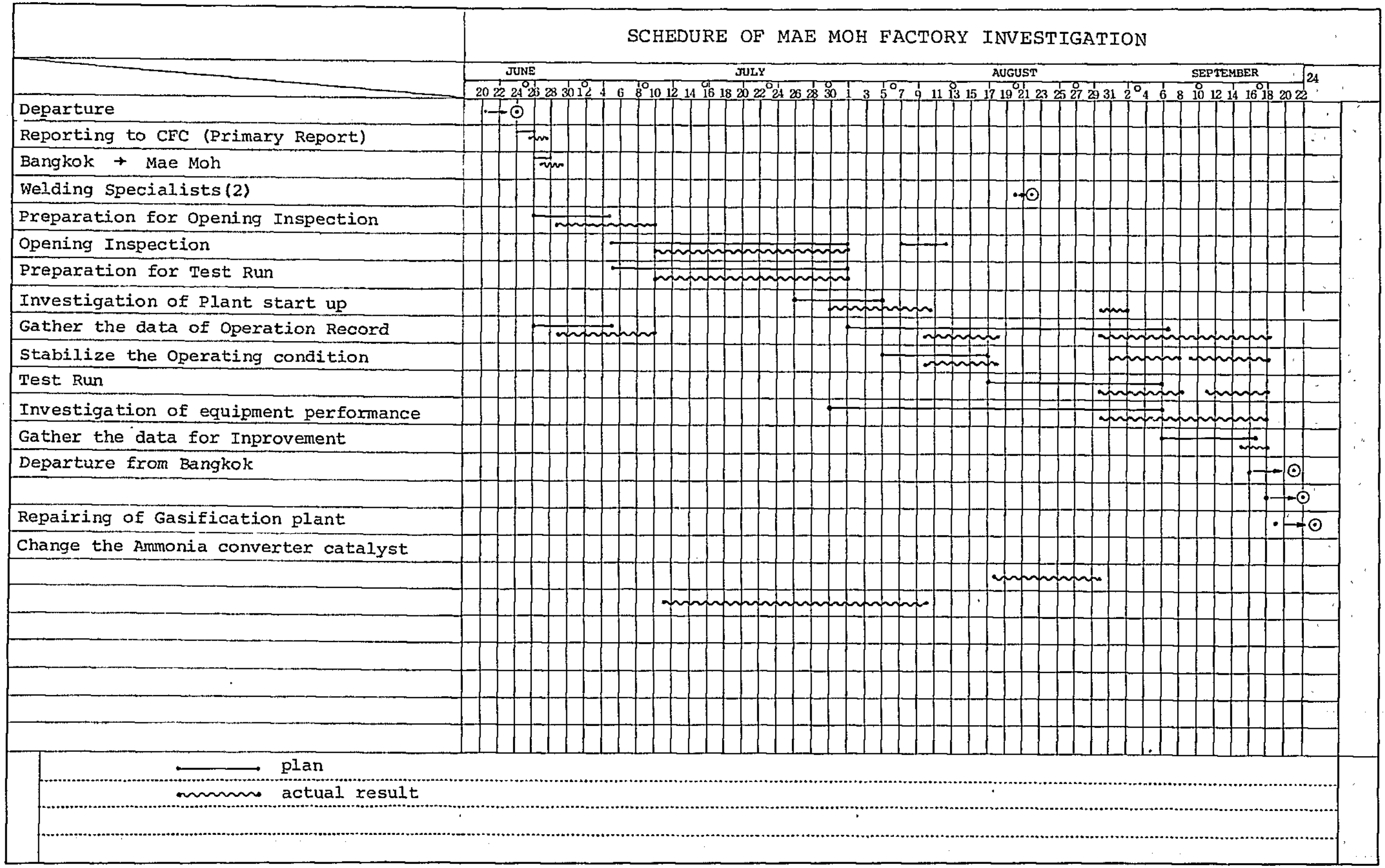
5. Inside inspection of equipment.

6. Test run of plants.

7. Gather the data for improvement of factory.

1-4 The schedule of Survey team

The plan and actual result of 2nd Survey team is shown on next page.


SCHEDURE OF MAE MOH FACTORY INVESTIGATION
JUNE
JULY
AUGUST
SEPTEMBER
20 22 24 26 28 30 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 2 4 6 8 10 12 14 16 18 20 22 24
Departure
Reporting to CFC (Primary Report)
Bangkok → Mae Moh
Welding Specialists(2)
Preparation for Opening Inspection
Opening Inspection
Preparation for Test Run
Investigation of Plant start up
Gather the data of Operation Record
Stabilize the Operating condition
Test Run
Investigation of equipment performance
Gather the data for Inprovement
Departure from Bangkok
Repairing of Gasification plant
Change the Ammonia converter catalyst
plan
actual result

SECTION 2

PROCESS OF MAE MOH FACTORY

Section 2. Process of Mae Moh factory

Prior to explain the problems and improvements of Mae Moh factory, the process of Mae Moh factory shall be introduced.

2-1 General (DWG NO D100)

The industrial water is sent from artificial damed lake. The water is utilized for cooling water and raw water of clean water and pure water, which are supplied to whole factory. The steam, which is sent from EGAT Boiler and other waste heat boilers, is controlled in Feed Water plant and supplied to whole factory.

Electricity is supplied from neighbored substation where the voltage of 30 KV is transformed to 6.6 KV. The voltage in factory is 6.6 KV, 380 V and 220 V, and the frequency is 50 Hz.

The gasification plant is composed of griding unit where the brown coal (Lignite) is pulverized and gasification unit where the pulverized coal is gasified to ammonia synthesis gas (syn gas) by partial oxidation of pulverized coal with oxygen (O_2). Oxygen is sent from air separation plant.

Desulphurization plant removes sulphur compound (mainly hydrogen sulphide, H_2S) from synthesis gas.

Ammonia synthesis plant is composed of 3 sections.

The first section is CO - conversion section where the carbon monoooxide (CO) in syn. gas is converted to carbon dioxide (CO_2) and hydrogen (H_2).

The second is purification section where the CO_2 and remaining CO are removed from syn. gas.

Third is synthesis section where the H_2 and nitrogen (N_2) are reacted under the high temperature and high pressure to be converted into Ammonia (NH_3).

In urea synthesis plant, NH_3 and CO_2 from ammonia plant are reacted to urea and the synthesised urea is purified and prilled.

The unreacted NH_3 is sent to ammonium sulphate plant.

In sulphuric acid plant, sulphure is burned with air formed sulphure dioxide (SO_2). SO_2 is further oxidized to sulphure trioxide (SO_3) with O_2 in gas by the action of catalyst.

The produced SO_3 is absorbed into sulphuric acid and diluted by water to produce sulphuric acid (H_2SO_4). In ammonium sulphate plant, NH_3 from urea plant and H_2SO_4 from sulphuric acid plant are reacted and produced ammonium sulphate ($(NH_4)_2SO_4$).

2-2 The feature of Mae Moh factory

The specific character of this factory is utilizing the coal as the main raw material. This process is unique in the world and is designed on the newest technic at the time of its construction.

Although up to recently the raw material of ammonia plant (chemical industry) has been switched over to petroleum or natural gas, yet recently various kind of coal utilization is being planned and researched. Actually in India the same kind process of Mae Moh is now being under construction. It is very significant for Thailand that the coal handling technology is kept at Mae Moh factory from the view point of effective utilization of domestic resources.

The production amount is insufficient, far from filling up the domestic demands, yet to keep the chemical fertilizer producing technology is important for the development of agricultural country of Thailand.

Further the marketing liquid ammonia and sulphuric acid from Mae Moh factory are the essential material for chemical industries and are acting the important roles on chemical industries, therefore in future the significance of existing the Mae Moh factory shall be more increased.

The third feature is that this factory is also only one factory in Thailand utilizing the high temperature and pressure technology. The technology to keep and maintain the high temperature and pressure factory is the foundation of chemical industries, actually in past ten years engineers and technicians more than 100 left factory and have been working on various chemical industries in Thailand.

As above mentioned this factory is very important factory from the view point of effective utilization of domestic resources and keeping the technical level of Thai chemical industry. Therefore it is reasonable that CFC is hold as government enterprise.

2-3-1 Feed Water Plant (DWG NO D 101)

In this feed water plant (FW Plant), cooling water, clean water, pure water and boiler Feed water are produced and steam is controlled.

Cooling water

Cooling water is pumped up from artificial lake. There are 3 pumps and normally 2 pumps are used. The design value of cooling water flow rate is 3,600 T/H.

Clean water

The raw water of clean water is taken from cooling water and sent to clarifier. In the clarifier, Ferrous hydrooxide ($Fe(OH)_2$) is added as coagurator, and the suspended solid in water is coagurated by coagulator and water is cleaned by sand filter to make clean water. Clean water is sent to whole factory as the utility water.

Pure water

The raw water of pure water is clean water. The solved ion in clean water is purified by ion exchanger. The quality of pure water is good.

Boiler feed water

Pure water is sent to deaerator in which the desolved oxygen in pure water is separated and, after the deaerator, the pure water is added the boiler treating chemicals and sent to whole plants as boiler feed water.

Steam

There are 3 kind of steam in Mae Moh factory, that is 30^K, 10^K and 3.5^K.

30^K steam is generated at EGAT Boiler and waste heat boiler in sulphuric acid plant and consumed mainly in ammonia plant.

There are 2 kind of 10^K steam, one is generated in WHB of gasification plant and the another is produced by reducing the pressure and temperature of 30^K steam. 10^K steam is mainly consumed in urea plant.

3.5^K steam is provided to whole factory as utility steam by reducing the pressure of 10^K steam.

The temperature and pressure of steam is controlled by Feed water plant.

2-3-2 EGAT BOILER (DWG NO D102 A & B)

There are 2 boilers and one is for normal operation and the other is stand-by.

The steam generation capacity is max. 26.5 T/H, pressure 48^K and temperature 450°C. The fuel is Lignite.

Lignite carried from the strip coal mine is transfered to hopper with bucket. The received Lignite is carried to coal bunker through bucket elevator and belt conveyor.

The boiler has coal spread stoker furnace and is bi-drum type.

The furnace pressure control is balanced forced draft type, that is, the combustion air is provided by forced draft fan through air preheater to furnace and the flue gas is led to stack controlling the furnace pressure by induced draft fan. The flue gas is passed through the economizer and airpreheater to recover the heat of flue gas.

There are two boiler feed water pump, one is motor driven and the other is steam turbine driven for respective boiler, and boiler is designed as to use the steam turbine driven pump for normal operation, yet the pump has not been used because of its mal-maintenance, and only motor driven pump is used.

The deaerated and checmicals added boiler feed water is pressurerized by boiler feed water pump and fed to drum through level control valve and economizer.

The generated steam is controlled its temperature by passing through the primary steam superheater, desuperheater and secondary steam superheater, and sent to Mae Moh factory through pressure reducing valve, controlled by feed water plant.

These boilers had been constructed and worked for electric power generation by EGAT, yet recently big power generation station had been constructed in neigborhood and started, therefore these boilers are rented from EGAT to CFC and CFC (Mae Moh factory) are operating and maintain the boilers.

2-3-3 Air separation plant (DWG NO D-103 A & B)

Air separation plant is generating oxygen (O_2) gas and nitrogen (N_2) gas by liquifying and rectifying the air.

The air is compressed up to 4.5^K by centrifugal air compressor and sent to air separation apparatus. On the suction line of air compressor, an air filter is installed to eliminate the dust in the air.

The remaining dust in the air after compression is washed by water in the water spray cooler.

The compressed and cleaned air is sent to regenerator in which air is chilled to -150°C flowing over the cold stone and coil loaded in regenerator.

Two regenerators make one set. When one regenerator is cooling the air, the other is being cooled the stones. When the stones in regenerator became warm by chilling the incoming air the regenerator is switched to another one, and cooled down again by outgoing impure N_2 or produced O_2.

The air chilled in regenerator is sent to rectifier bottom. A part of air before going into rectifier, is lequified when it is passed through lequifier (E_1) by heat exchanging with outgoing impure N_2.

A part of air in the rectifier bottom is again sent back to coil side of regenerator and heat exchanged with incoming air and after that it is lead to expansion turbine, where the air is expanded adiabatically from 4.5^K to 0.5^K and produced the cold. This cold is compensating the cold loss of air separation unit.

In the lower column of rectifier the air is roughly separated into N_2 gas and liquified O_2 rich air, N_2 and liquid air are sent to upper column where O_2, N_2

and impure N_2 are separated and pulled out from bottom, top and middle of upper column respectively.

The separated O_2 and N_2 are sent to O_2 and N_2 holder passing through inside the coil of regenerators. Impure N_2 is vented to atmosphere after passing over the stone in the regenerators to recover the cold.

The instrument air is extracted from the air before the regenerators and dried by the dryer in which silica gel is filled as drying agent and supplied to whole plants.

The dryer is regenerated by N_2 from lower column of rectifier.

The capacity of this plant.

O_2	3700 Nm^3/h
N_2	3500 "
Instrument Air	350 Nm^3/h

2-3-4 Gasification plant (DWG NO D-104 A,B & C)

Lignite carried from strip coal mine by wagon to . this plant is pulverized and partially oxydized by oxygen in gasifier to produce ammonia synthesis gas (syn. gas).

Grinding unit (DWG NO D-104 A)

Carried Lignite is put down to underground bunker and then carried up to hopper by raw Lignite conveyor.

The spec. of raw Lignite is as follows.

water content	35 wt%	
ash "	12 "	(FeO, CaO, SiO_2)
heat of combustion (high)	3500 Kcal/Kg wet coal.	

Lignite in hopper is carried out by Erko belt and fallen down to duct where Lignite is mixed with hot gas from hot gas producer, and the mixture is charged into hammer mill where Lignite is pulverized and dried.

The dried and pulverized Lignite dust is carried to cyclone where Lignite dust and hot gas is separated. The separated Lignite dust fall down to the finished dust bunker under the cyclone.

The hot gas, out of the cyclone, is sent to electric precipitator. The remaining dust in hot gas is recovered in this electric precipitator.

The recovered dust is sent to the finished dust bunker by conveyor and the hot gas after the electric precipitator is vented to atmosphere, yet a part of the gas is recycled to the duct before the hammer mill to control the temperature of hot gas into the hammer mill.

The fuel of hot gas producer is the Lignite dust from finished dust bunker.

Lignite dust in finished dust bunker is sealed by N_2.

size	<90 micron
water content	7 wt%
heat of combustion (high)	5500 Kcal/Kg (wet)

Gasification unit (DWG NO D104 B & C)

The Lignite dust prepared in finished dust bunker is charged to service bin by chain conveyor. The Lignite dust in service bin is fed to gasifier by screw feeder. Before the gasifier the dust is mixed with O_2 and injected into the gasifier. Inside the gasifier the Lignite dust is partially oxideized and reformed to CO rich syn. gas. The temperature inside the gasifier is estimated 1600 ∿ 1700 °C, and the pressure is controlled at 100 mmH_2O by manual control valves.

The usual composition of produced syn. gas is as follows.

CO_2=12%, CO=57%, H_2=25%, N_2=3%, H_2S=3%

The melting point of ash from Lignite is around 1400°C and so it is melting condition inside the furnace.

A part of molten ash is flowed down along the furnace wall and dropped into the seal tank, installed at the center bottom of furnace. Molten ash dropped into the seal tank is quickly cooled and solidified with sealing water. The solidified ash carried out from seal tank by chain conveyor.

The molten ash in the gasifier is mainly fly ash and flow with syn. gas and at the outlet nozzle of gasifier the gas and ash are quenched to 900 ∿ 1000°C by water spraying. Here the molten fly ash is to be solidified.

The heat of syn. gas out of gasifier is recovered passing through the radiation bioler and tubular boiler . generating 10^K steam.

The produced syn. gas is then passed through the washer, theisen washer and final cooler in which the gas is contacted with washing water to remove the fly ash and to cool down the gas.

Especially at the washer the CaO, one of the component of ash, is solved into the washing water and it reacts with H_2S in the gas. Therefore most of H_2S in the gas is removed from syn. gas before desulphurization plant.

Regarding the emergency trip system of gasification unit, an automatic oil mechanism is installed, which shut off the oxygen into the furnace and sweep out the gas in the furnace with N_2 by only pushing a button.

2-3-5 Desulphurization plant (DWG NO D-105)

This is the plant to remove sulphur compound (H_2S, COS) in syn. gas with aqueous solution of Amine Di Iso Propanol (ADIP).

The syn. gas from gasification plant is introduced to scrubber where the gas is brought into contact counter-currently with washing water and eliminated the dust in the gas. The packings in this tower is 2^B ceramic rashig ring.

Syn. gas out of scrubber is led to absorber. Here the sulphure compound and other acidic gas in syn. gas is absorbed by downflowing ADIP solution on the valve trays.

Desulphurized gas is sent to syn. gas holder.

ADIP solution of absorber is sent to regenerating tower via a heat exchanger, where the ADIP solution is heated and distilled by steam and released the absorbed acidic gas.

ADIP solution regenerated in regenerator is recycled to abosrber top by pump via a heat exchanger and coolers.

On the other hand the released acidic gas is cooled in the condenser (dephlegmator) which is mounted on the regenerator and sent to Sulphur recovery plant. Sulphur recovery plant is not used now because of the sulphure quantity to be recovered is too small and only the flare stack in the plant is used to dispose the acidic gas. A part of syn. gas before scrubber is mixed to the acidic gas from condenser. The mixed syn. gas is the aid of combustion.

2-3-6 Ammonia synthesis plant (DWG NO D-106 A,B,C & D)

There are two of 7 staged reciprocating syn.gas compressors which have 55% capacity respectively. The syn.gas is sucked by this syn.gas compressors from sny.gas holder and compressed up to 22^K by the first 3 stages. 22^K syn.gas is introduced to CO conversion section where carbon monooxide (CO) in syn.gas is converted to hydrogen (H_2) gas and carbon dioxide (CO_2) gas in CO converter. Further after CO conversion section, syn.gas is led into CO_2 absorber to remove most of CO_2 in syn. gas.

CO converted and CO_2 eliminated syn.gas is then mixed with N_2 from N_2 compressor in air separation plant to provide the syn.gas which H_2 to N_2 ratio is 3 to 1. The ratio of 3 to 1 is most suitable to synthesize the ammonia.

The gas adjusted its composition is again sent back to 4th stage suction of syn.gas compressor and by 4th and 5th stage, the gas is pressurized up to 110^K and led to purification section where the gas washed with copper solution and aq. ammonia solution to removed remaining CO and CO_2 respectively.

Purified gas is again sent back to syn.gas compressor and further compressed up to 430^K by 6 & 7 stg. and sent out to ammonia synthesis section.

(CO conversion section)

The effluent gas of syn.gas compressor 3rd stage is introduced to saturator, where syn.gas is heated and humidified by contacting countercurrently with hot water flowing down from the tower top. The water is become cool and sent back to demoisture. The saturator effluent gas is further added the high temperature steam and heated up by heat exchangers and led to CO converter where by the reaction of

$$CO + H_2O \xrightarrow{\text{Catalyst}} CO_2 + H_2$$

most of CO in syn.gas is converted to H_2. H_2 gas is required to synthesis NH_3 and CO or CO_2 is the poison of ammonia synthesis catalyst.

The CO converter effluent gas is led to demoisture via heat exchanger and water preheater. The function of demoisture is reverse to saturator,ie, the gas is cooled and dehumidified by contacting countercurrently with water flowing down from the top. The water becomes hot and is sent back to saturator via water preheater. A portion of hot water is sent to feed water plant where the hot water being exchanged the heat with deaerator feed water and itself becomes cool and returns to the top of demoisture via cooler. In this section, the hot water is being recycled in the system, therefore the impurity of gas (CO_2, H_2S, NH_3) is accumulated in hot water and induced the severe corrosion of equipment. To reduce these corrosion, a portion of hot water is blowed down and further more the pH of hot water is controlled by caustic soda which is sent from feed water plant.

(CO_2 Removal section)

The outlet gas of CO conversion section is led to CO_2 absorber where the gas is contacted countercurrently with water flowing down from tower top and most CO_2 in gas is absorbed by water. The CO_2 removed gas mixed with N_2 and sent back to syn.gas compressor. The water absorbed CO_2 is led to water tubine of pump. In the first stage of water turbine, the pressure of water is reduced from 21^K to 10^K and the gas released by reducing the pressure is separated in the separator and sent to the suction of syn.gas compressor, because of the gas is rich of H_2. Further the water is passed through the 2nd stage of water turbine and sent to degasifier. In degasifier, CO_2 is separated and the separated CO_2 is sent to CO_2 holder in urea synthesis plant.

(Purification section)

Syn.gas, removed CO_2 and mixed N_2, is led into 4th stage suction of synthesis gas compressor, and pressurized up to 110^K and introduced to copper solution scrubber. Remaining CO in syn.gas is absorbed by the copper solution which is the complex compound of copper and ammonia. Copper solution, absorbed CO, is returned to copper solution regenerator where the solution is heated and released CO which is sent back to the suction of syn.gas compressor. The regenerated copper solution is recycled to absorber after it is cooled by cooler. The outlet gas of absorber is then led to ammonia water scrubber where remaining CO_2 in syn.gas is absorbed by aqueous NH_3 solution. CO_2 absorbed solution is sent to ammonium sulphate plant.

Purified gas is compressed with 6th and 7th stage of syn.gas compressor up to 430^K and sent to ammonia synthesis section. The gas composition inlet of ammonia synthesis section is as follows.

$H_2 = 74.3\%$ $N_2 = 24.8\%$ $Ar = 0.9\%$ $CO + CO_2$ is less than 50 ppm

(Ammonia synthesis section)

The inlet gas of ammonia synthesis section is mixed with recirculating gas and which is then separated the produced ammonia in the gas and sent to ammonia synthesis converter (ACV) via recirculating gas compressor. Ammonia is synthesized in ACV by the reaction of

$$3H_2 + N_2 \xrightarrow{\text{catalyst}} 2NH_3$$

ACV has three catalyst beds and at the inlet portion of each catalyst bed, a quenching device is installed to control the each catalyst bed inlet gas temperature. Quenching is performed by injecting the cold syn. gas which is branched (the syn .gas.) from ACV inlet. ACV is usually operated at 410^K and 460 ∿ 450°C.

The outlet gas of ACV is cooled stepwisely by waste heat boiler and gas cooler.

The produced ammonia is condensed in the gas cooler. In the waste heat boiler 3.5^K steam is generated and it is used for the regeneration of copper solution. The effluent of gas cooler is mixed with fresh syn.gas from syn.gas compressor and sent to ammonia separator. To avoid the accumulation of inert gas (Argon gas) in the recirculating gas, a part of recirculating gas out of ammonia separator is vented to atmosphere via scrubber. The gas composition inlet and outlet of ACV is as follows.

	H_2	N_2	NH_3	Ar	
ACV inlet	61.7	22.0	9.2	7.1	vol%
outlet	55.1	19.8	17.0	8.1	vol%

The separated liquid ammonia is led to flash vessel where the resolved gas is released by the reduction of pressure. The separated ammonia is sent to ammonia and the released gas is led to tail gas scrubber where the NH_3 component in the released gas is absorbed with water. Then after the gas is sent to ammonium sulphate plant, and the NH_3 solution is sent to ammonia water scrubber as the absorbent of scrubber.

2-3-7 Urea synthesis plant (DWG NO D-107 A,B & C)

In urea synthesis plant, NH_3 and CO_2 is reacted under high temperature and high pressure conditions to produce urea.

Liquid ammonia from ammonia reservoir is received in ammonia buffer tank and sucked by ammonia plunger pump by which ammonia is pressurized up to 200^K and sent to primary reactor's coil. CO_2 from CO_2 holder is sucked by blower and introduced to desulphurizing tower to remove H_2S in CO_2 completely. Further CO_2 is sent to drier. Drying agent (silica gel) in drier is regenerated by air. Dry CO_2 is then sucked by CO_2 compressor and pressurized to 200^K and led to primary reactor's coil where CO_2 and liquid ammonia is mixed and reacted. The heat of reaction is taken off by the waste heat boiler outside of primary reactor's coil. The mixture out of primary reactor is led to secondary reactor and synthesized urea. The effluent out of secondary reactor, after depressurizing, is led to separator 1st stage, where unreacted NH_3 and CO_2 is separated. Further the effluent liquid is depressurized in dissociation separator where, same as former, unreacted NH_3 and CO_2 is separated.

Urea solution removed the unreacted gas is sent to evaporator via urea storage tank. In the evaporator, urea solution is vacuumed and the moisture in the solution is evaporated. The solution, more than 98% is urea, is led to the top of prilling tower where urea solution is injected into the tower and cooled and solidified to produce urea pellet.

NH_3 and CO_2 gas from separator 1st stage is sent to washing column where NH_3 and CO_2 is separated. Ammonia gas is led to ammonia condenser and condensed and recovered to ammonia buffer tank. NH_3 and CO_2 from washing column and dissociation tank is sent to ammonium sulphate plant.

2-3-8 Sulphuric acid plant (DWG NO D-108)

Solid sulphur (S), the raw material of sulphuric acid (H_2SO_4) is burned with air to make sulphur dioxide (SO_2). SO_2 gas is further reacted with oxygen by the action of catalyst in reactor to make SO_3. Then SO_3 is absorbed and reacted with 96% sulphuric acid to make H_2SO_4.

$$S + O_2 (AIR) \longrightarrow SO_2 \quad \text{(Furnace)}$$
$$SO + O_2 (AIR) \xrightarrow{\text{catalyst}} SO_3 \quad \text{(Reactor)}$$
$$SO_2 + H_2O \longrightarrow H_2SO_4 \quad \text{(Absorber)}$$

Solid sulphur is heated and melted in melting pit by steam coil to prepare the liquid S. Liquid S is sent to furnace by pump. Air from the atmosphere is brought into contact with conc. H_2SO_4 countercurrently in the drying tower and the moisture in air is removed. Dry air is exchanged the heat with SO_3 gas and itself heated and then sent to furance. Before the furnace, dry air is passed through the economizer to preheat the waste heat boiler feed water. Liquid S is burned with dry air to make SO_2 and the gas temperature becomes around 1000°C. The flue gas out of furnace is cooled down in the waste heat boiler and sent to reactor. The reactor inlet gas temperature is 430°C and pressure is +1000 mmH_2O. In the waste heat boiler, 30^K steam is generated and it is sent to feed water plant. A part of generated steam is consumed for heating the melting pit.

The reactor is composed of 4 catalyst beds and each catalyst bed inlet temperature is controlled by injection of cold air or by heat exchanging with combustion air.

More than 99% of SO_2 is converted to SO_3 in the reactor and effluent of reactor, that is SO_3 mixture, is sent to absorbing tower and drying tower is pulled out, that is the products.

Produced H_2SO_4 is sent to sulphuric acid tank. H_2SO_4 is mainly consumed to produce ammonium sulphate, but a portion of H_2SO_4 is being marketed carried by tank lorry.

2-3-9 Ammonium sulphate plant (DWG NO D-109 A & B)

In this plant NH_3 and H_2SO_4 is reacted and produced the ammonium sulphate. NH_3 from urea synthesis plant and ammonia synthesis plant is reacted with H_2SO_4 from sulphuric acid in the saturator.

When urea plant is not working, liquid NH_3 is sent from ammonia plant directly to the evaporator in this plant and evaporated and consumed to produce ammonium sulphate.

Ammonium sulphate formed in the saturator is sent to centrifuge by pump. Water eliminated ammonium sulphate is then dried by rotary drier. The dried products is bagged and carried out from factory.

2-4 Organization of factory

The number of person in Mae Moh factory is 567. as tabled on next page.

The working of operation is 3 shift by 4 groups. The working time cycle is $8^{00} \sim 16^{00}$, $16^{00} \sim 24^{00}$, $0^{00} \sim 8^{00}$.

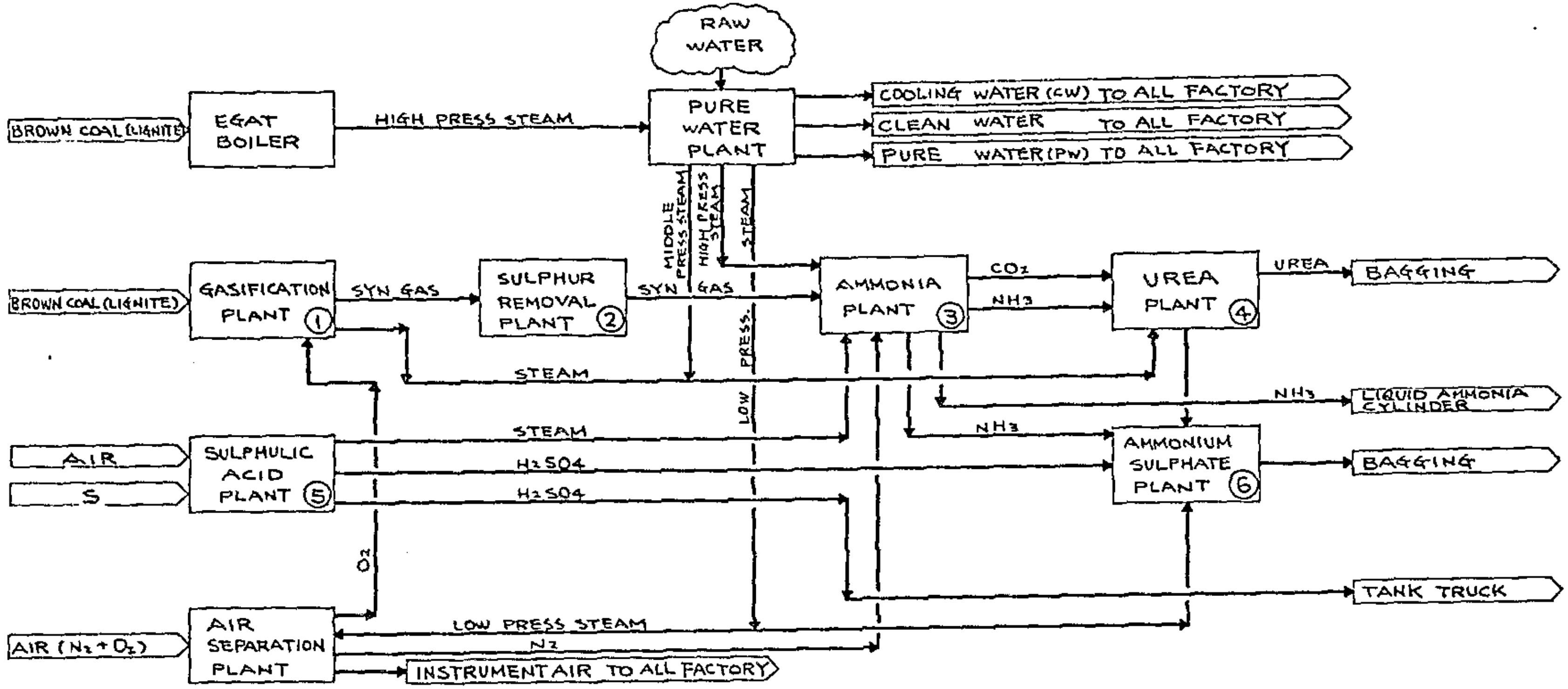
Each plant has own maintenance team which is maintain the rotating machine and repairing the small equipment.

Engineers have 3 ∿ 4 years experience and managers of operation section have been working in this factory 7 ∿ 12 years long.

Organization of Mae Moh factory

Factory Manager

	Operation sections							Auxiliary sections				General affairs			
section / position	Boiler	Air Sep.	Gas	Ammonia	Urea	Amm. Sulph.	Utility	Labo-ratory	Elect. Instr.	Machine	Prod. Control	Account.	Perso-nnel	Medical	Total
manager	1	1	1	(1)	(1)	1	1	1	1	1	1	1	1	-	10
enginner	1	-	-	1	1	-	-	3	-	2	1	-	-	-	9
assist. manager	1	1	3	2	2	4	2	-	3	2	-	2	1	-	23
workers	42	22	58	37	31	43	40	20	51	67	4	50	53	6	525
Total	45	24	62	40	35	48	42	24	55	72	6	53	55	6	567
							296				157			114	567



① $\underset{(LIGNITE)}{C} + O_2 \longrightarrow CO_2$

$C + \frac{1}{2}O_2 \longrightarrow CO$

③ $CO + \underset{(STEAM)}{H_2O} \xrightarrow{CATALYST} H_2 + CO_2$

$CO_2 + WATER \rightleftharpoons CO_2\ WATER$

$3H_2 + N_2 \xrightarrow{CATALYST} 2NH_3$

⑤ $S + \underset{(AIR)}{O_2} \longrightarrow SO_2$

$SO_2 + \frac{1}{2}\underset{(AIR)}{O_2} \xrightarrow{CATALYST} SO_3$

$SO_3 + H_2O \longrightarrow H_2SO_4$

② $H_2S + (CH_3CH(OH)CH_2)_2NH \rightleftharpoons (CH_3CH(OH)CH_2)_2NH.H_2S$

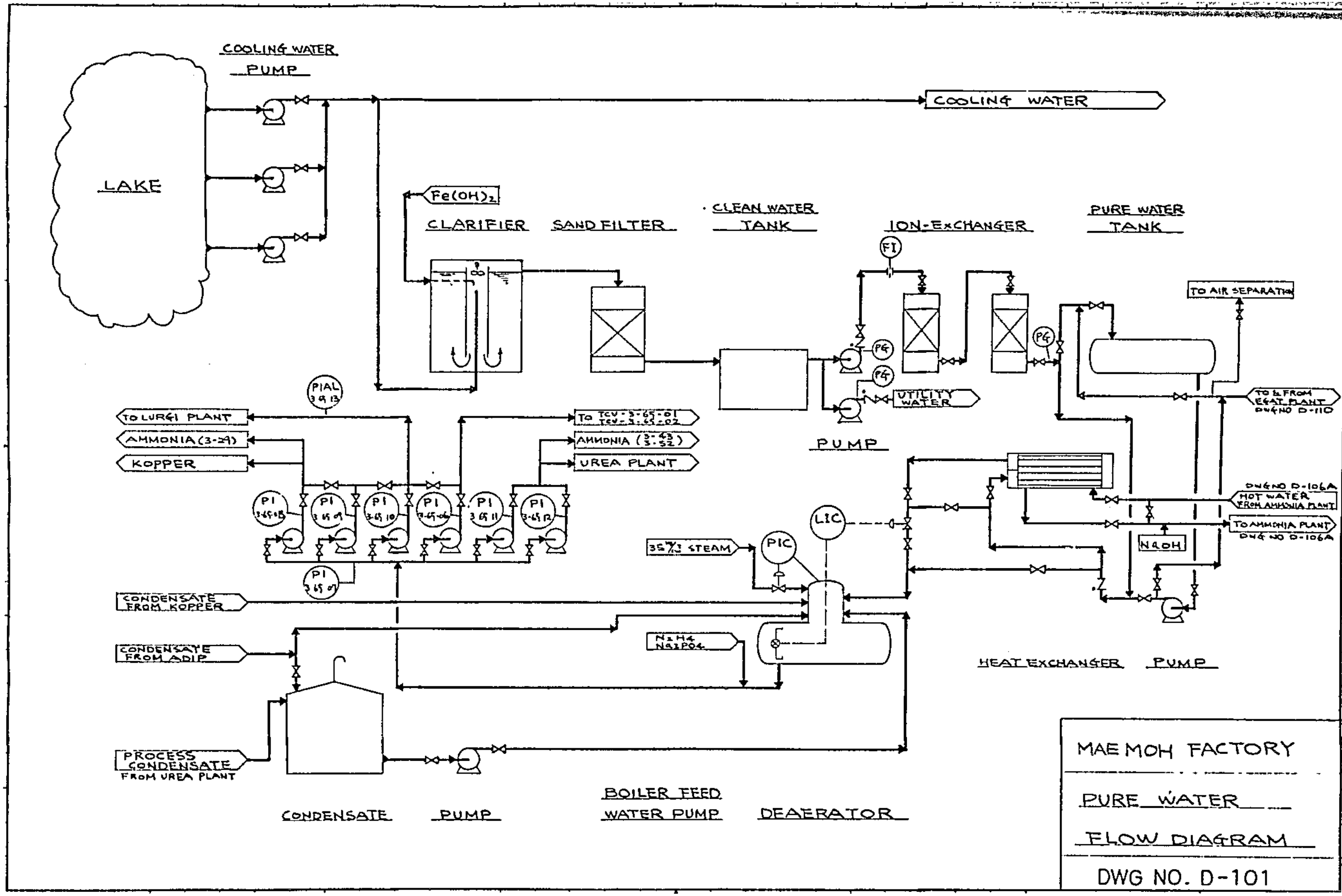
④ $CO_2 + 2NH_3 \longrightarrow (NH_2)_2CO + H_2O$

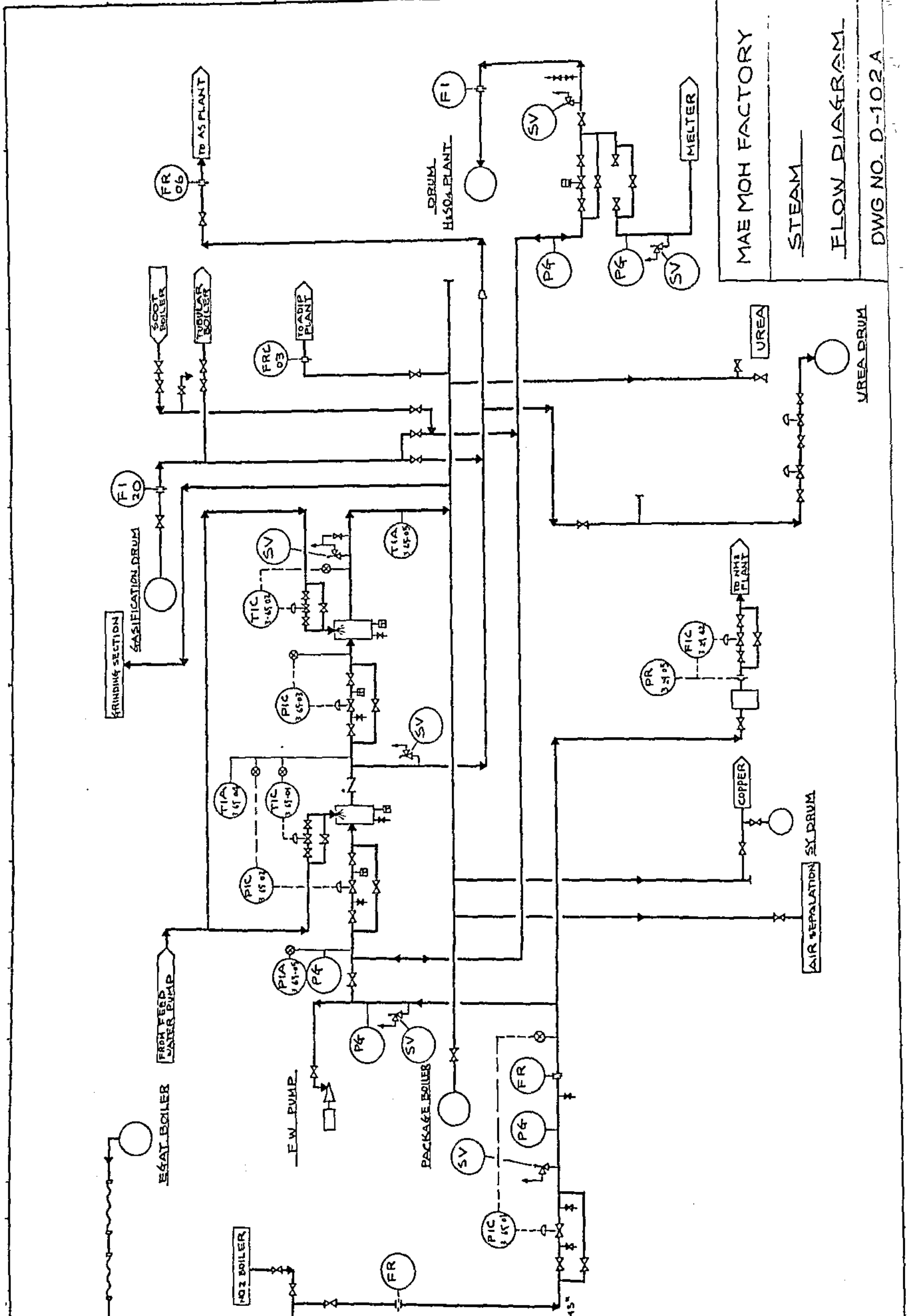
⑥ $2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$

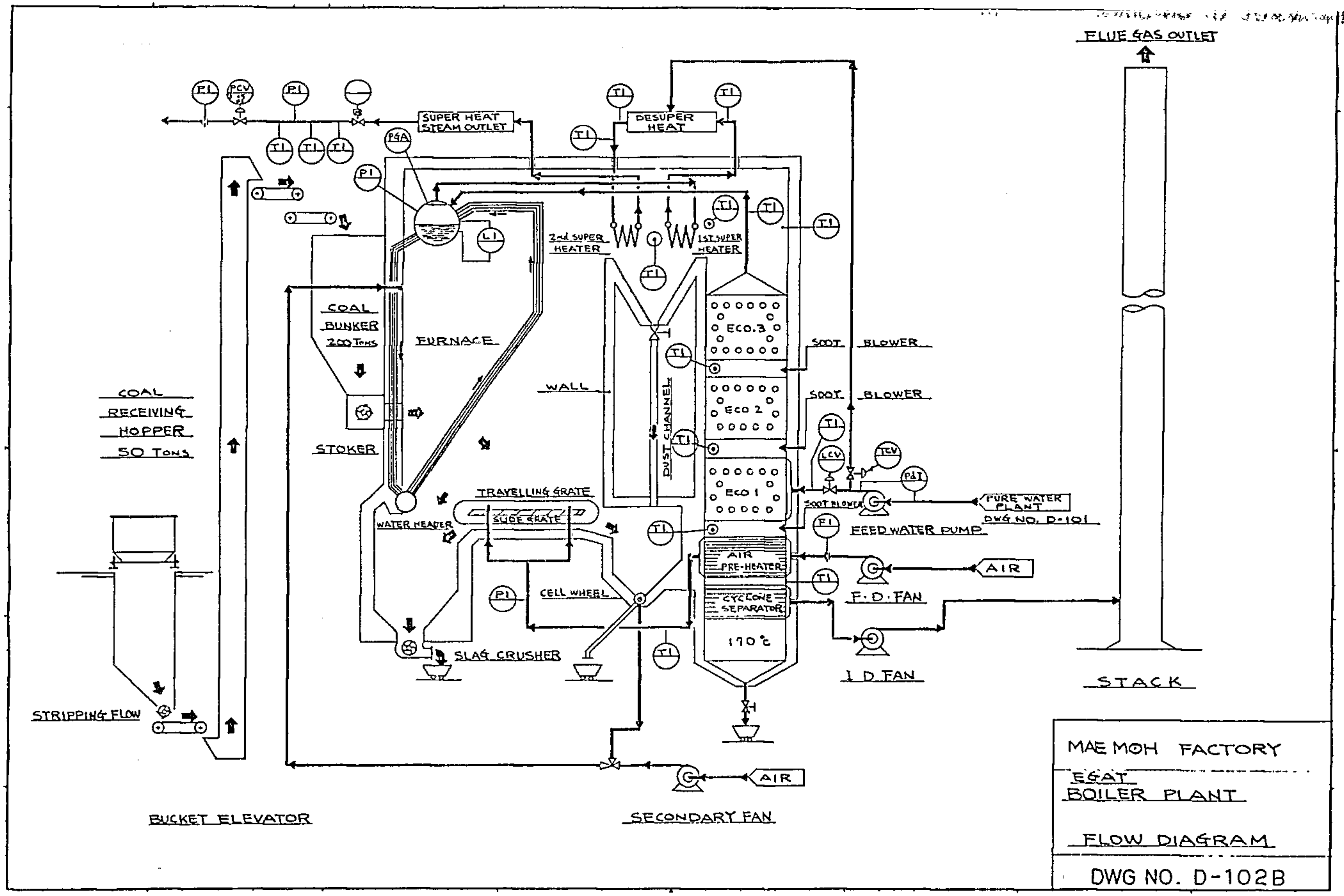
MAE MOH FACTORY

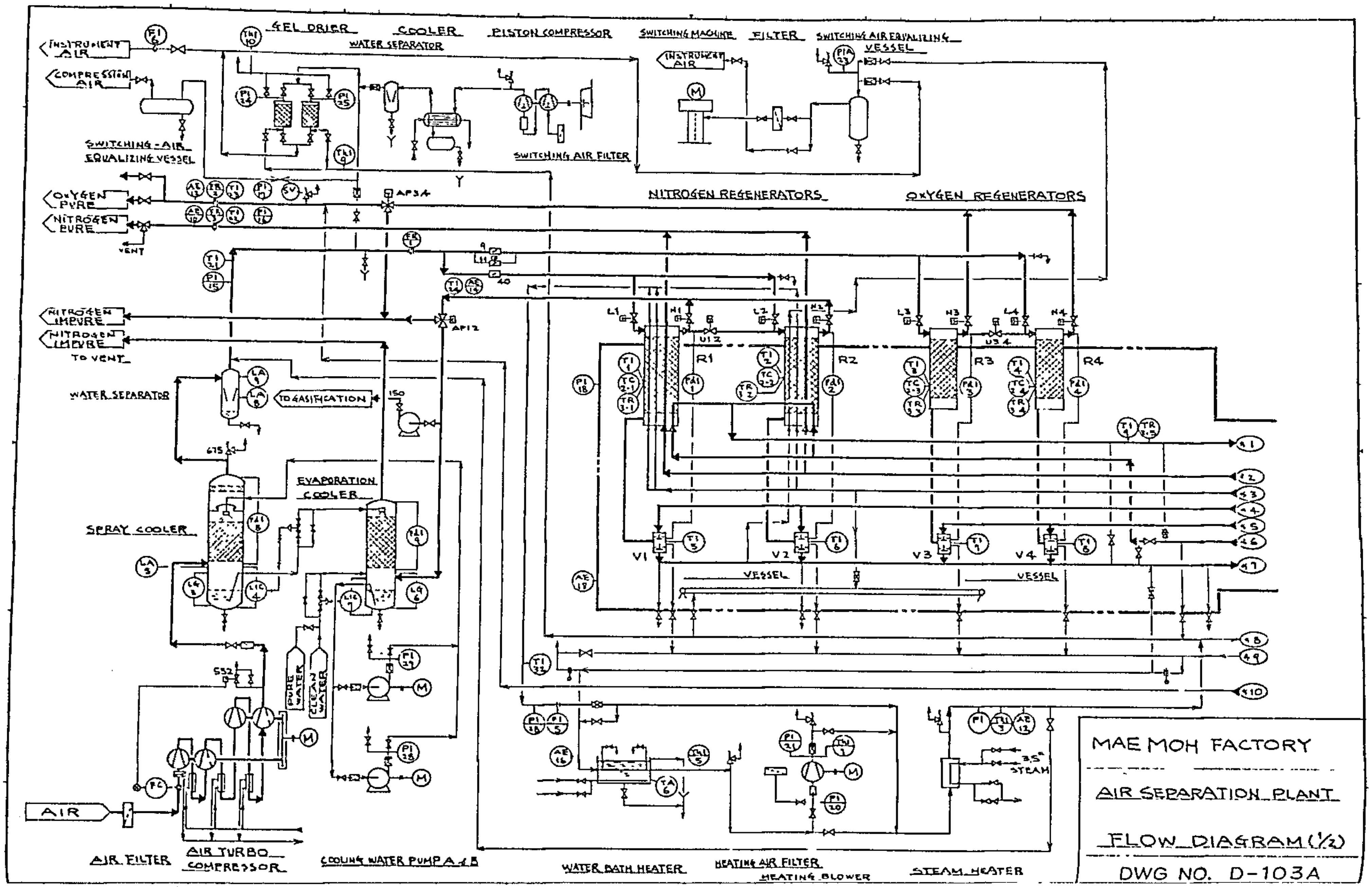
FLOW DIAGRAM (OVER ALL)

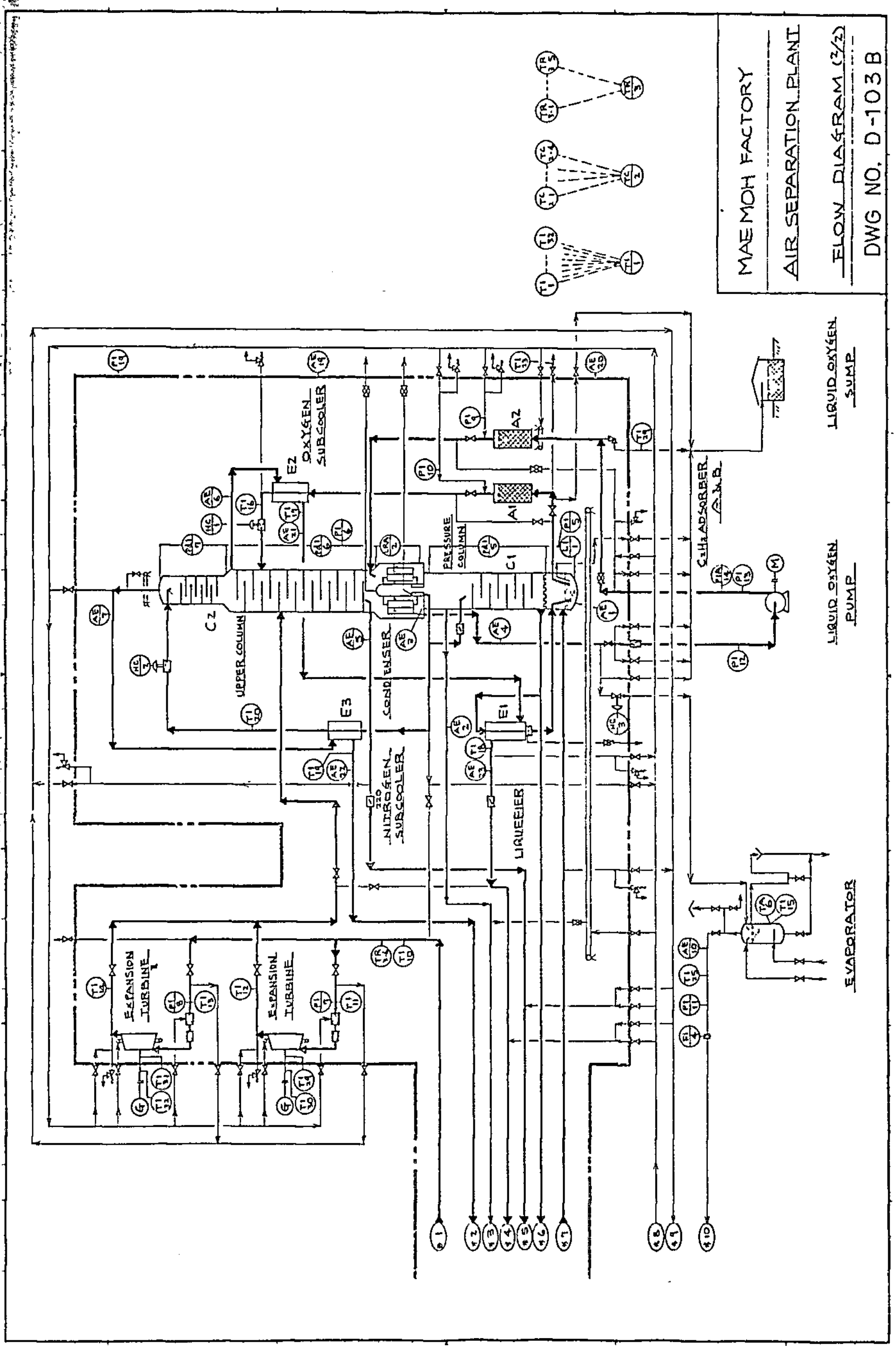
DWG. NO D-100

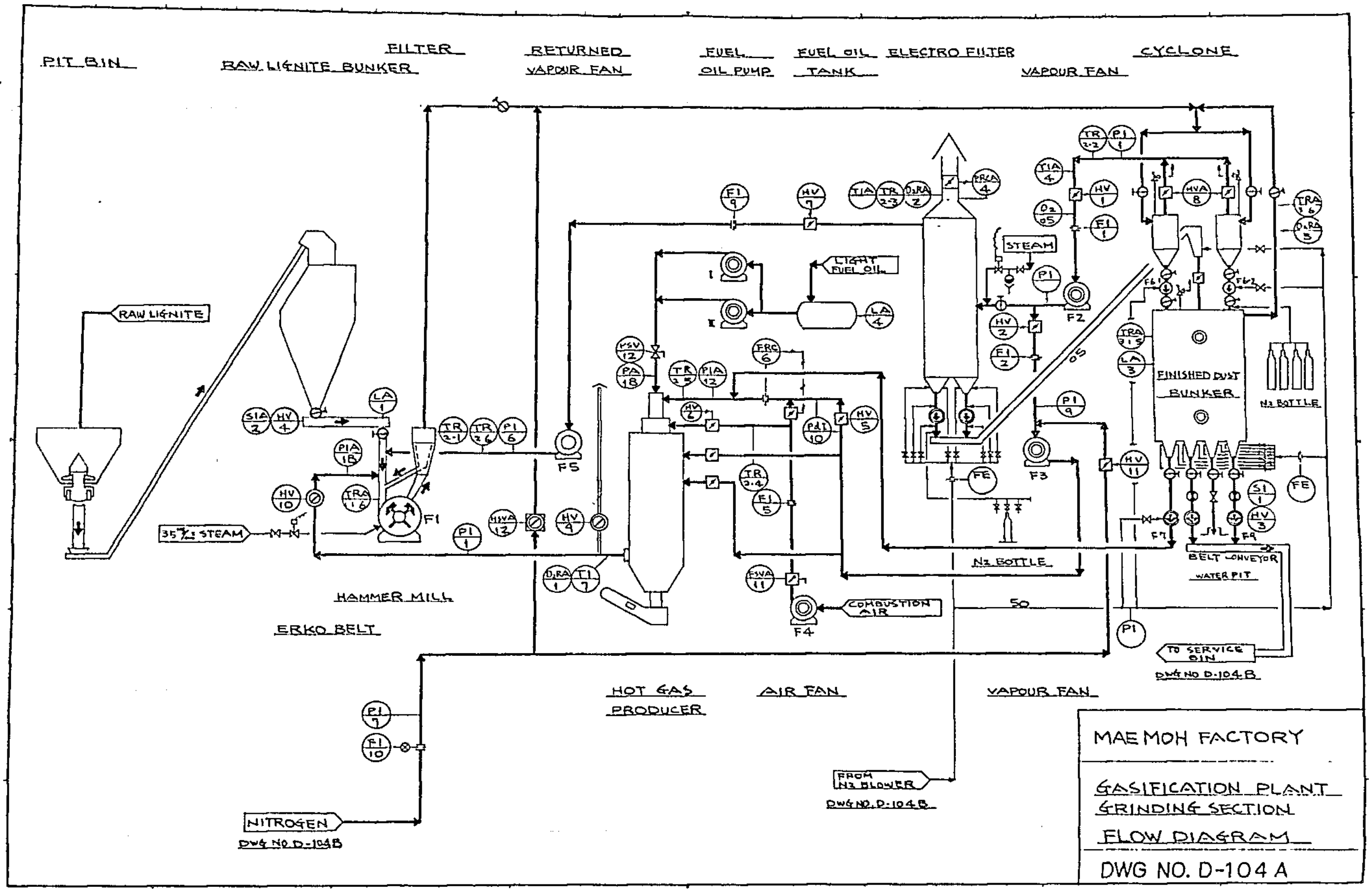

COOLING WATER PUMP
LAKE
COOLING WATER
Fe(OH)2
CLARIFIER
SAND FILTER
CLEAN WATER TANK
ION-EXCHANGER
PURE WATER TANK
FI
PG
PG
PG
UTILITY WATER
PUMP
TO AIR SEPARATION
TO & FROM EGAT PLANT DWG NO D-110
DWG NO D-106A HOT WATER FROM AMMONIA PLANT
TO AMMONIA PLANT DWG NO D-106A
NaOH
PIAL 3-65-13
TO LURGI PLANT
AMMONIA (3-29)
KOPPER
TO TCV-3-65-01 TCV-3-65-02
AMMONIA (3-43 3-52)
UREA PLANT
PI 3-65-15
PI 3-65-09
PI 3-65-10
PI 3-65-06
PI 3-65-11
PI 3-65-12
PI 3-65-07
35 K/G STEAM
PIC
LIC
CONDENSATE FROM KOPPER
CONDENSATE FROM ADIP
N2H4 Na3PO4
PROCESS CONDENSATE FROM UREA PLANT
HEAT EXCHANGER
PUMP
CONDENSATE
PUMP
BOILER FEED WATER PUMP
DEAERATOR
MAE MOH FACTORY
PURE WATER
FLOW DIAGRAM
DWG NO. D-101

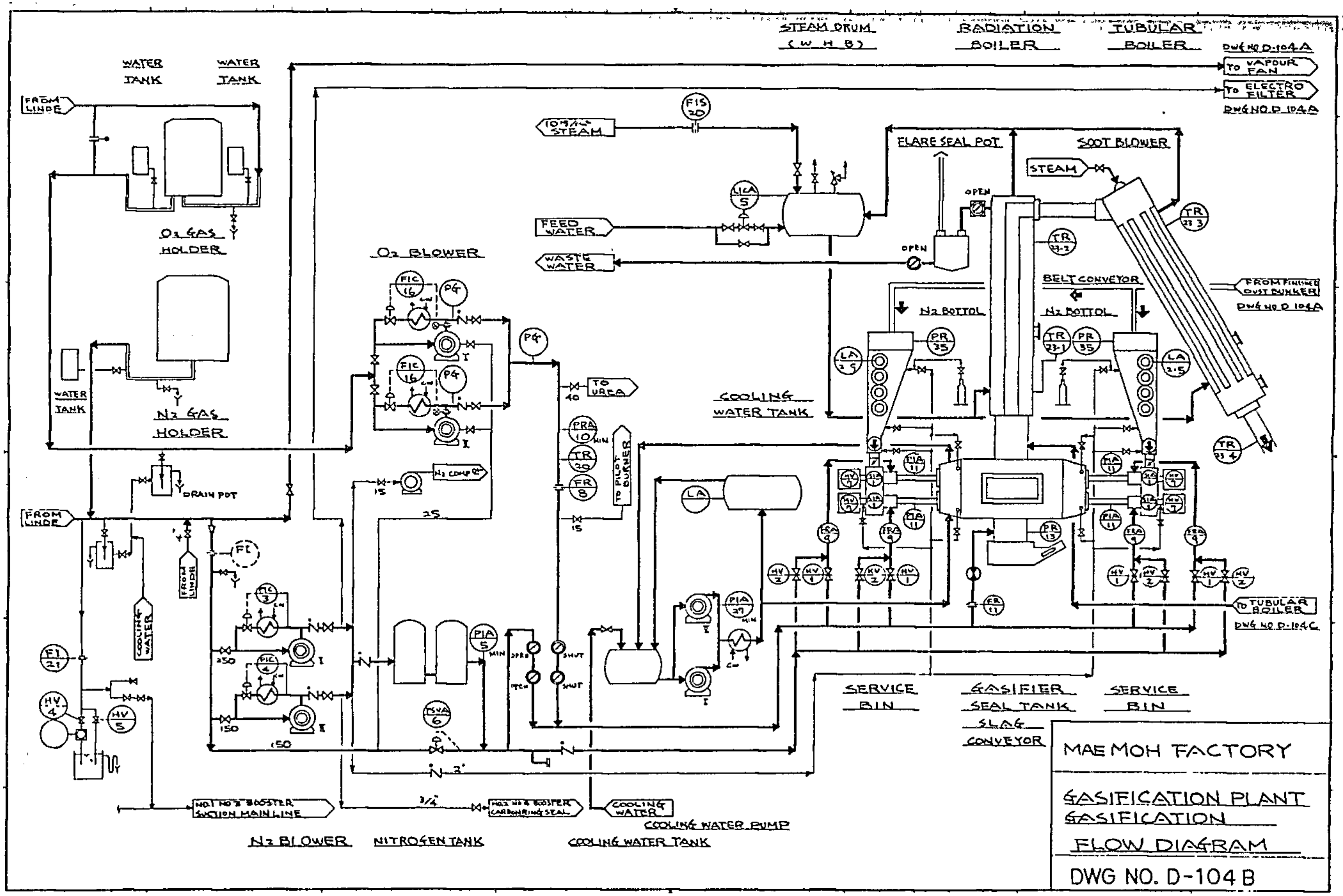

MAE MOH FACTORY
STEAM
FLOW DIAGRAM
DWG NO. D-102A
DRUM
TO AS PLANT
MELTER
SOOT BOILER
TUBULAR BOILER
TO ADIP PLANT
UREA
UREA DRUM
GASIFICATION DRUM
GRINDING SECTION
COPPER
SY DRUM
AIR SEPARATION
FROM FEED WATER PUMP
EGAT BOILER
FW PUMP
PACKAGE BOILER

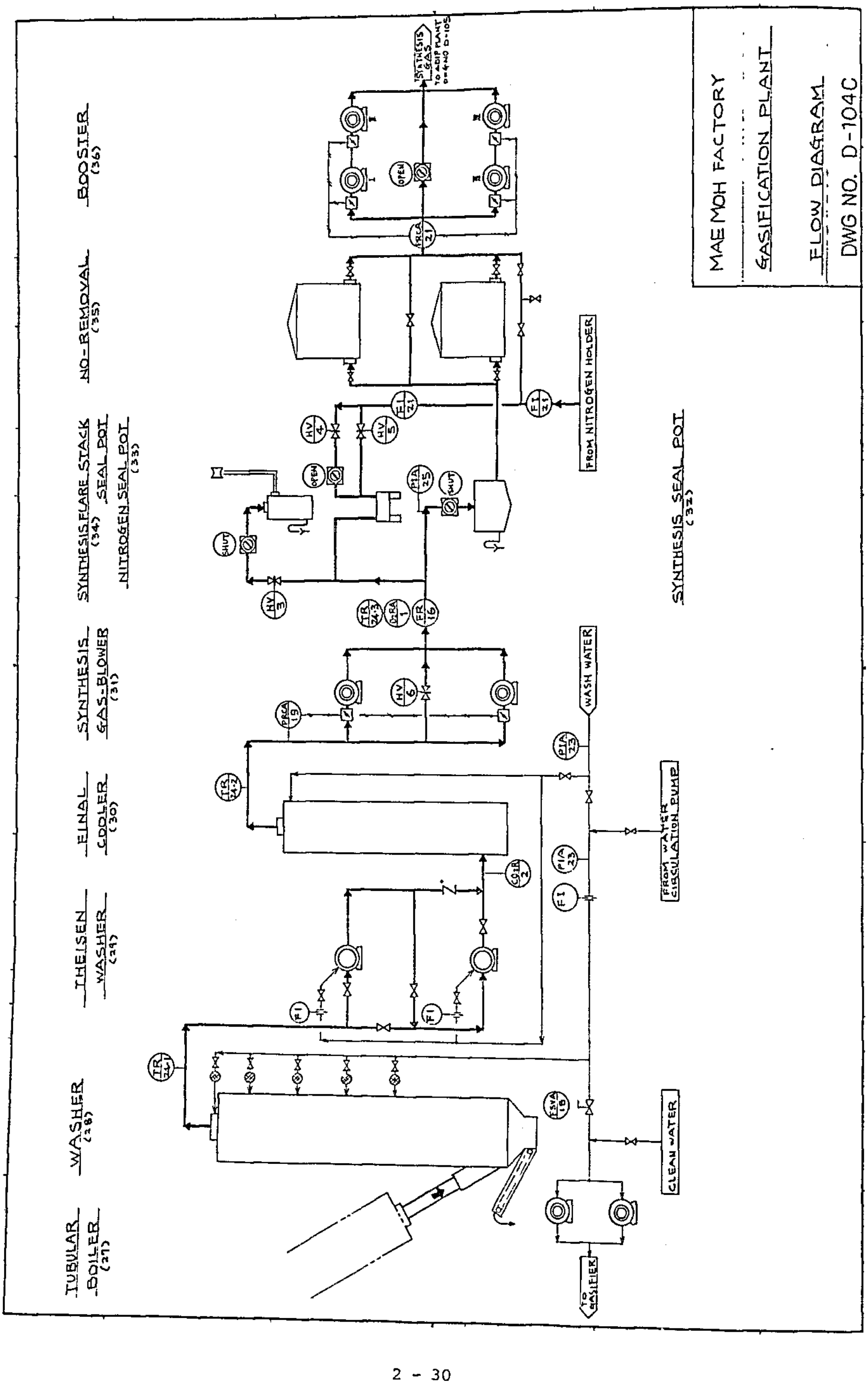

FLUE GAS OUTLET
STACK
SUPER HEAT STEAM OUTLET
DESUPER HEAT
PI
PCV
TI
PGA
LI
2nd SUPER HEATER
1ST SUPER HEATER
COAL BUNKER 200 TONS
FURNACE
STOKER
WALL
DUST CHANNEL
ECO.3
ECO 2
ECO 1
SOOT BLOWER
SOOT BLOWER
LCV
TCV
PdT
PURE WATER PLANT DWG NO. D-101
SOOT BLOWER
FEED WATER PUMP
FI
AIR
AIR PRE-HEATER
F.D. FAN
CYCLONE SEPARATOR
170 °C
I D FAN
TRAVELLING GRATE
SLIDE GRATE
WATER HEADER
CELL WHEEL
SLAG CRUSHER
COAL RECEIVING HOPPER 50 TONS
STRIPPING FLOW
BUCKET ELEVATOR
SECONDARY FAN
MAE MOH FACTORY
EGAT
BOILER PLANT
FLOW DIAGRAM
DWG NO. D-102B

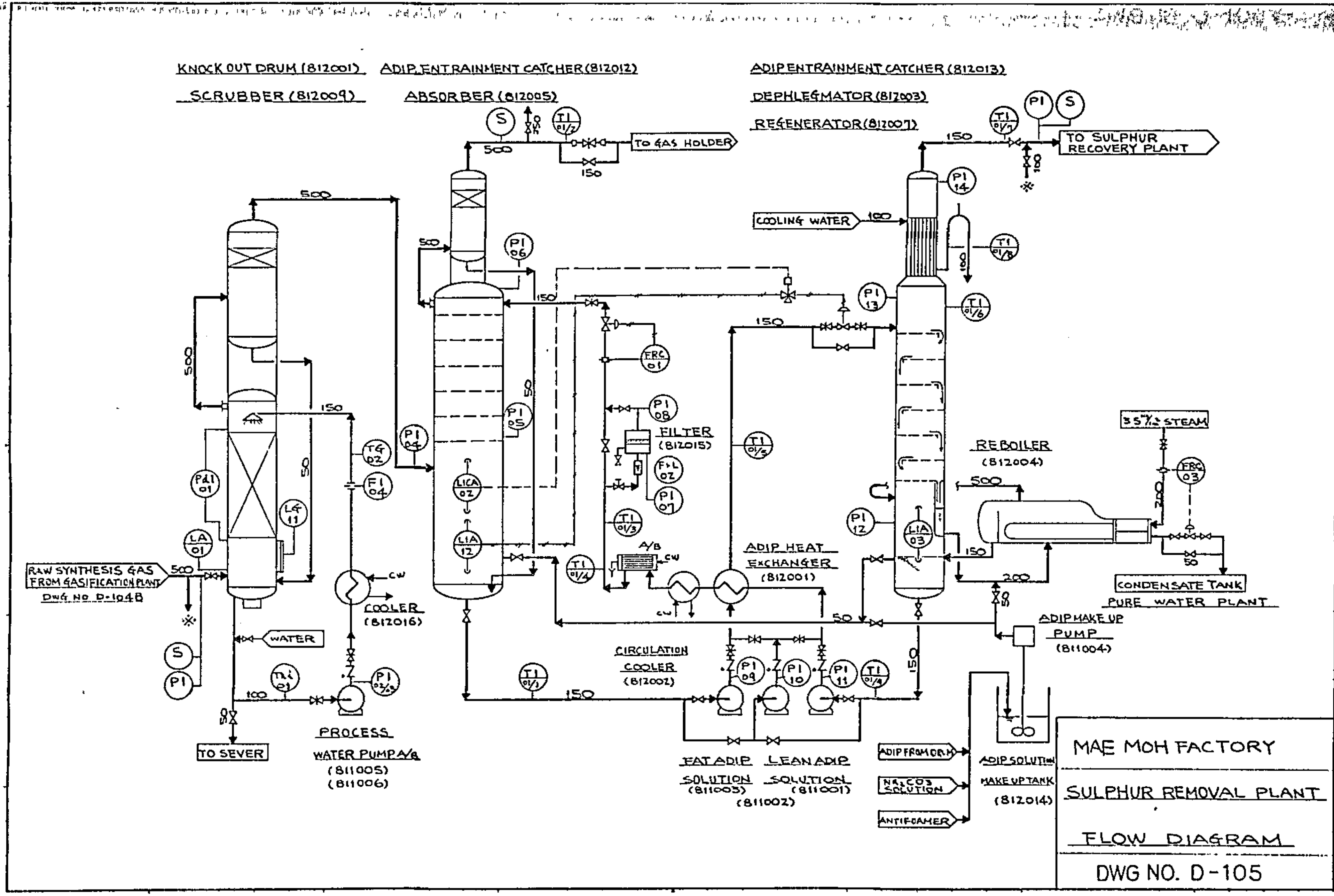

INSTRUMENT AIR
COMPRESSION AIR
SWITCHING-AIR EQUALIZING VESSEL
GEL DRIER
COOLER
WATER SEPARATOR
PISTON COMPRESSOR
SWITCHING AIR FILTER
SWITCHING MACHINE
FILTER
SWITCHING AIR EQUALIZING VESSEL
OXYGEN PURE
NITROGEN PURE
VENT
NITROGEN REGENERATORS
OXYGEN REGENERATORS
NITROGEN IMPURE
NITROGEN IMPURE
TO VENT
WATER SEPARATOR
TO GASIFICATION
EVAPORATION COOLER
SPRAY COOLER
R1
R2
R3
R4
V1
V2
V3
V4
VESSEL
VESSEL
PURE WATER
CLEAN WATER
AIR
AIR FILTER
AIR TURBO COMPRESSOR
COOLING WATER PUMP A & B
WATER BATH HEATER
HEATING AIR FILTER
HEATING BLOWER
STEAM HEATER
3.5" STEAM
MAE MOH FACTORY
AIR SEPARATION PLANT
FLOW DIAGRAM (1/2)
DWG NO. D-103A

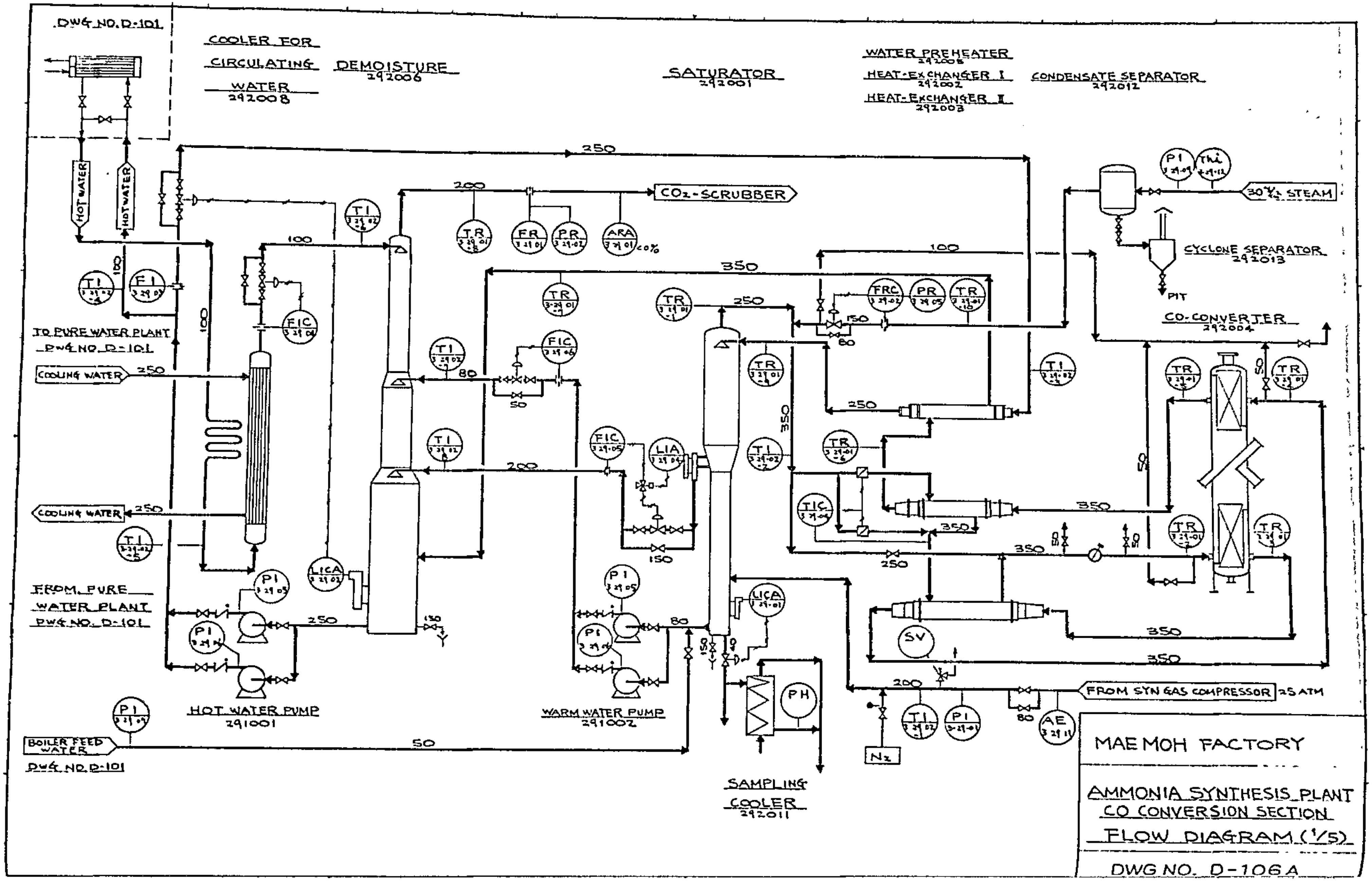

MAE MOH FACTORY
AIR SEPARATION PLANT
FLOW DIAGRAM (2/2)
DWG NO. D-103 B
OXYGEN SUBCOOLER
E2
PRESSURE COLUMN
C1
C2
UPPER COLUMN
CONDENSER
E3
E1
NITROGEN SUBCOOLER
LIQUEFIER
A1
A2
C2H2 ADSORBER A & B
LIQUID OXYGEN SUMP
LIQUID OXYGEN PUMP
EVAPORATOR
EXPANSION TURBINE
EXPANSION TURBINE

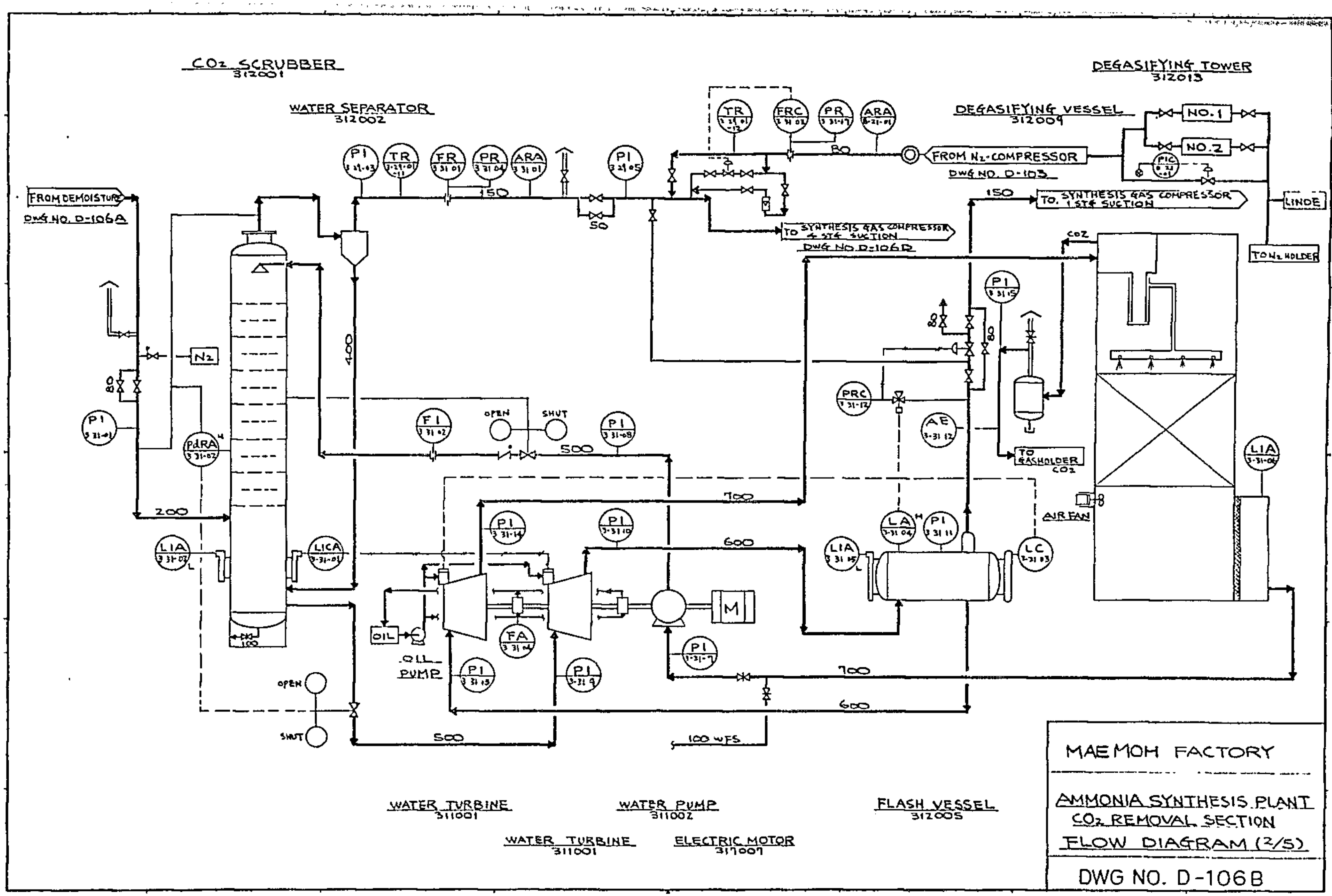

PIT BIN
RAW LIGNITE BUNKER
FILTER
RETURNED VAPOUR FAN
FUEL OIL PUMP
FUEL OIL TANK
ELECTRO FILTER
VAPOUR FAN
CYCLONE
RAW LIGNITE
35% STEAM
HAMMER MILL
ERKO BELT
HOT GAS PRODUCER
AIR FAN
VAPOUR FAN
NITROGEN
DWG NO D-104B
FROM N2 BLOWER
DWG NO. D-104B
LIGHT FUEL OIL
STEAM
COMBUSTION AIR
N2 BOTTLE
FINISHED DUST BUNKER
BELT CONVEYOR
WATER PIT
TO SERVICE BIN
DWG NO D-104B
MAE MOH FACTORY
GASIFICATION PLANT
GRINDING SECTION
FLOW DIAGRAM
DWG NO. D-104 A

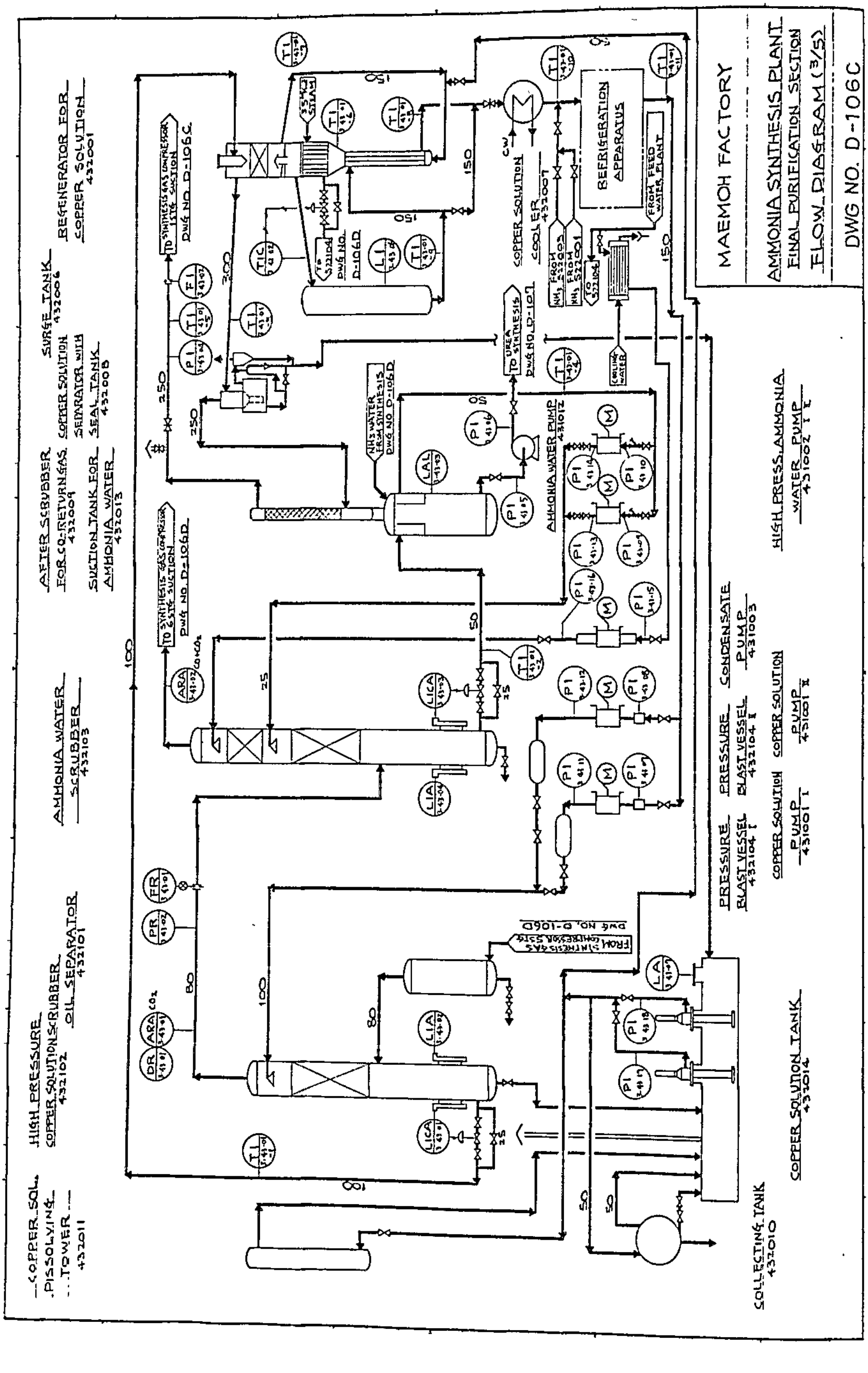

STEAM DRUM (W H B)
RADIATION BOILER
TUBULAR BOILER
DWG NO D-104A
TO VAPOUR FAN
TO ELECTRO FILTER
DWG NO D 104A
WATER TANK
WATER TANK
FROM LINDE
O2 GAS HOLDER
N2 GAS HOLDER
WATER TANK
DRAIN POT
FROM LINDE
FROM LINDE
COOLING WATER
O2 BLOWER
10kg/cm2 STEAM
FEED WATER
WASTE WATER
FIS 20
LICA 5
FLARE SEAL POT
SOOT BLOWER
STEAM
OPEN
OPEN
TR 23-2
TR 23-3
TR 23-4
BELT CONVEYOR
FROM FINISHED DUST BUNKER
DWG NO D 104A
N2 BOTTOL
N2 BOTTOL
TR 23-1
PR 35
PR 35
LA 2-5
LA 2-5
COOLING WATER TANK
FIC 16
FIC 16
PG
PG
PG
N2 COMPR
TO UREA
PRA 10 MIN
TR 20
FR 8
TO PILOT BURNER
40
15
15
25
LA
PIA 11
PIA 11
PIA 11
PIA 11
PR 13
FR 11
FRA 9
FRA 9
FRA 9
FRA 9
HV 1
HV 2
HV 3
HV 4
TO TUBULAR BOILER
DWG NO D-104C
FT
FIC 3
FIC 4
250
150
150
PIA 5 MIN
PSVA 6
OPEN
SHUT
PIA 27 MIN
FI 21
HV 4
HV 5
NO.1 NO.2 BOOSTER SUCTION MAIN LINE
3/4
NO.1 NO.2 BOOSTER CARBON RING SEAL
COOLING WATER
3"
COOLING WATER PUMP
COOLING WATER TANK
N2 BLOWER
NITROGEN TANK
SERVICE BIN
GASIFIER SEAL TANK
SLAG CONVEYOR
SERVICE BIN
MAE MOH FACTORY
GASIFICATION PLANT
GASIFICATION
FLOW DIAGRAM
DWG NO. D-104 B


TUBULAR BOILER (27)
WASHER (28)
THEISEN WASHER (29)
FINAL COOLER (30)
SYNTHESIS GAS-BLOWER (31)
SYNTHESIS FLARE STACK (34)
SEAL POT
NITROGEN SEAL POT (33)
NO-REMOVAL (35)
BOOSTER (36)
SYNTHESIS SEAL POT (32)
SYNTHESIS GAS TO ADIP PLANT DWG NO D-105
FROM NITROGEN HOLDER
WASH WATER
FROM WATER CIRCULATION PUMP
CLEAN WATER
TO GASIFIER
TR 24-1
TSVA 18
FI
CO-IR 2
PIA 23
TR 24-2
PRCA 19
HV 6
TR 24-3
FR 16
HV 3
SHUT
PIA 25
OPEN
HV 4
HV 5
FI 21
PRCA 21
MAE MOH FACTORY
GASIFICATION PLANT
FLOW DIAGRAM
DWG NO. D-104C

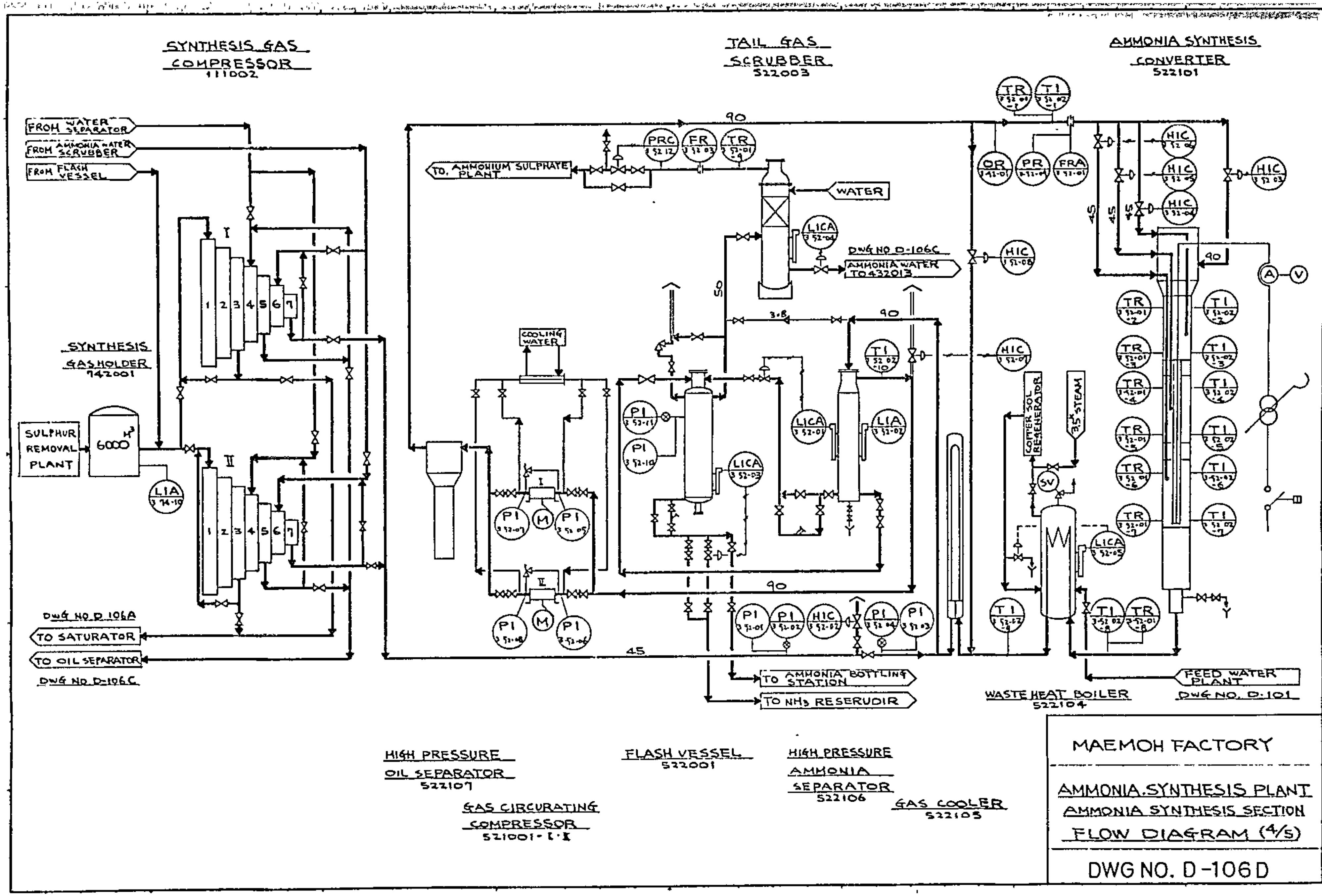

KNOCK OUT DRUM (812001)
SCRUBBER (812009)
ADIP ENTRAINMENT CATCHER (812012)
ABSORBER (812005)
ADIP ENTRAINMENT CATCHER (812013)
DEPHLEGMATOR (812003)
REGENERATOR (812007)
TO GAS HOLDER
TO SULPHUR RECOVERY PLANT
COOLING WATER
35% STEAM
REBOILER
(812004)
FILTER
(812015)
ADIP HEAT EXCHANGER
(812001)
CIRCULATION COOLER
(812002)
CONDENSATE TANK
PURE WATER PLANT
ADIP MAKE UP PUMP
(811004)
RAW SYNTHESIS GAS FROM GASIFICATION PLANT
DWG NO D-104B
WATER
TO SEVER
COOLER
(812016)
PROCESS WATER PUMP A/B
(811005)
(811006)
FAT ADIP SOLUTION
(811003)
LEAN ADIP SOLUTION
(811001)
(811002)
ADIP FROM DRM
Na_2CO_3 SOLUTION
ANTIFOAMER
ADIP SOLUTION MAKE UP TANK
(812014)
MAE MOH FACTORY
SULPHUR REMOVAL PLANT
FLOW DIAGRAM
DWG NO. D-105


DWG NO. D-101
COOLER FOR CIRCULATING WATER 292008
DEMOISTURE 292006
SATURATOR 292001
WATER PREHEATER 292005
HEAT-EXCHANGER I 292002
HEAT-EXCHANGER II 292003
CONDENSATE SEPARATOR 292012
CYCLONE SEPARATOR 292013
CO-CONVERTER 292004
30 Kg/cm^2 STEAM
PIT
CO₂-SCRUBBER
HOT WATER
HOT WATER
TO PURE WATER PLANT DWG NO. D-101
COOLING WATER
COOLING WATER
FROM PURE WATER PLANT DWG NO. D-101
BOILER FEED WATER
DWG NO. D-101
HOT WATER PUMP 291001
WARM WATER PUMP 291002
SAMPLING COOLER 292011
FROM SYN GAS COMPRESSOR 25 ATM
N₂
SV
PH
MAE MOH FACTORY
AMMONIA SYNTHESIS PLANT
CO CONVERSION SECTION
FLOW DIAGRAM (1/5)
DWG NO. D-106A

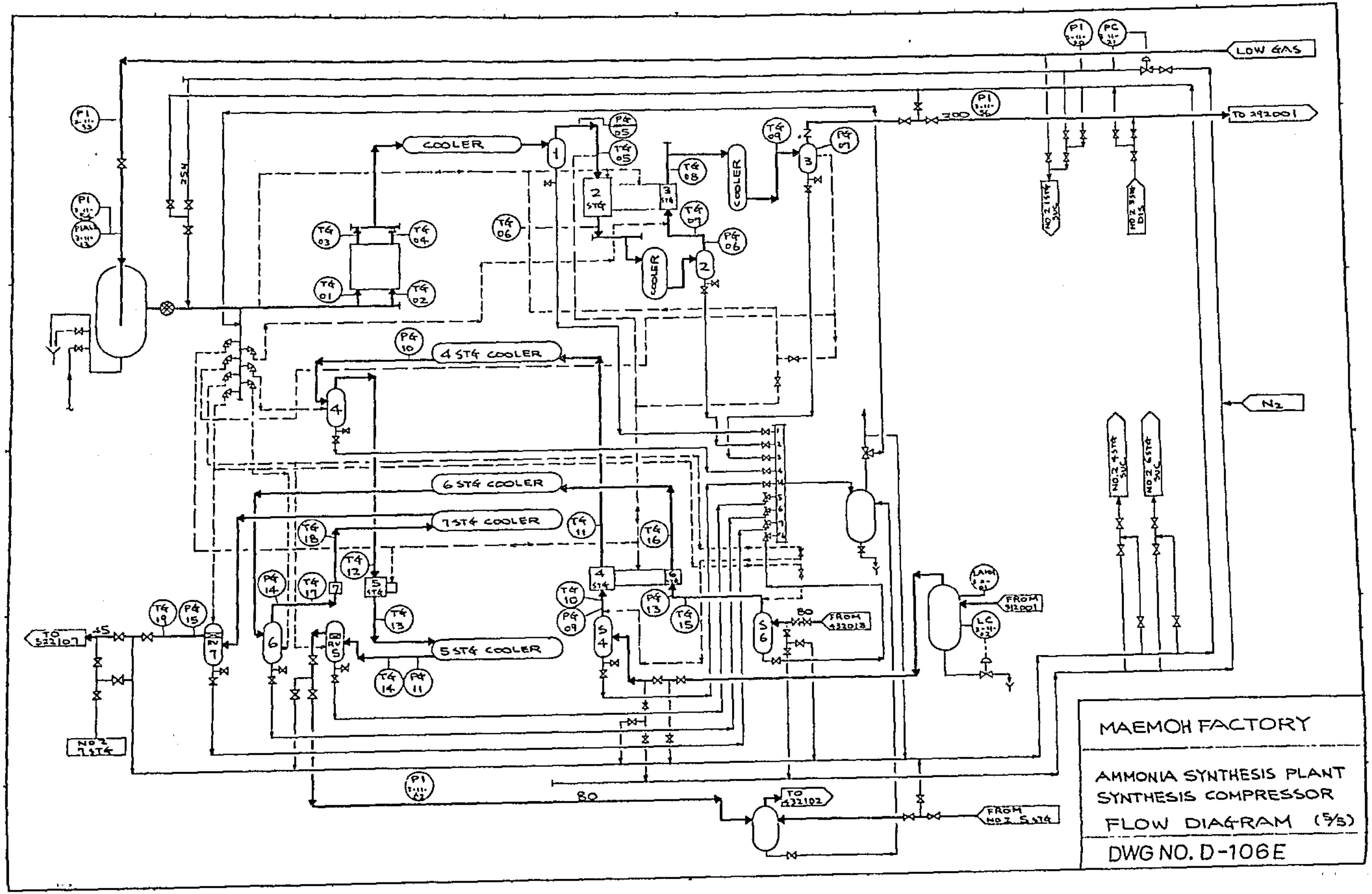

CO₂ SCRUBBER
312001
WATER SEPARATOR
312002
DEGASIFYING VESSEL
312009
DEGASIFYING TOWER
312013
FROM DEMOISTURE
DWG NO. D-106A
FROM N₂-COMPRESSOR
DWG NO. D-103
TO SYNTHESIS GAS COMPRESSOR 4 STG SUCTION
DWG NO D-106R
TO. SYNTHESIS GAS COMPRESSOR 1 STG SUCTION
TO GASHOLDER CO₂
TO N₂ HOLDER
LINDE
NO. 1
NO. 2
N₂
OIL
OIL PUMP
AIR FAN
OPEN
SHUT
100 WFS
WATER TURBINE
311001
WATER PUMP
311002
FLASH VESSEL
312005
WATER TURBINE
311001
ELECTRIC MOTOR
317007
MAEMOH FACTORY
AMMONIA SYNTHESIS PLANT
CO₂ REMOVAL SECTION
FLOW DIAGRAM (2/5)
DWG NO. D-106B

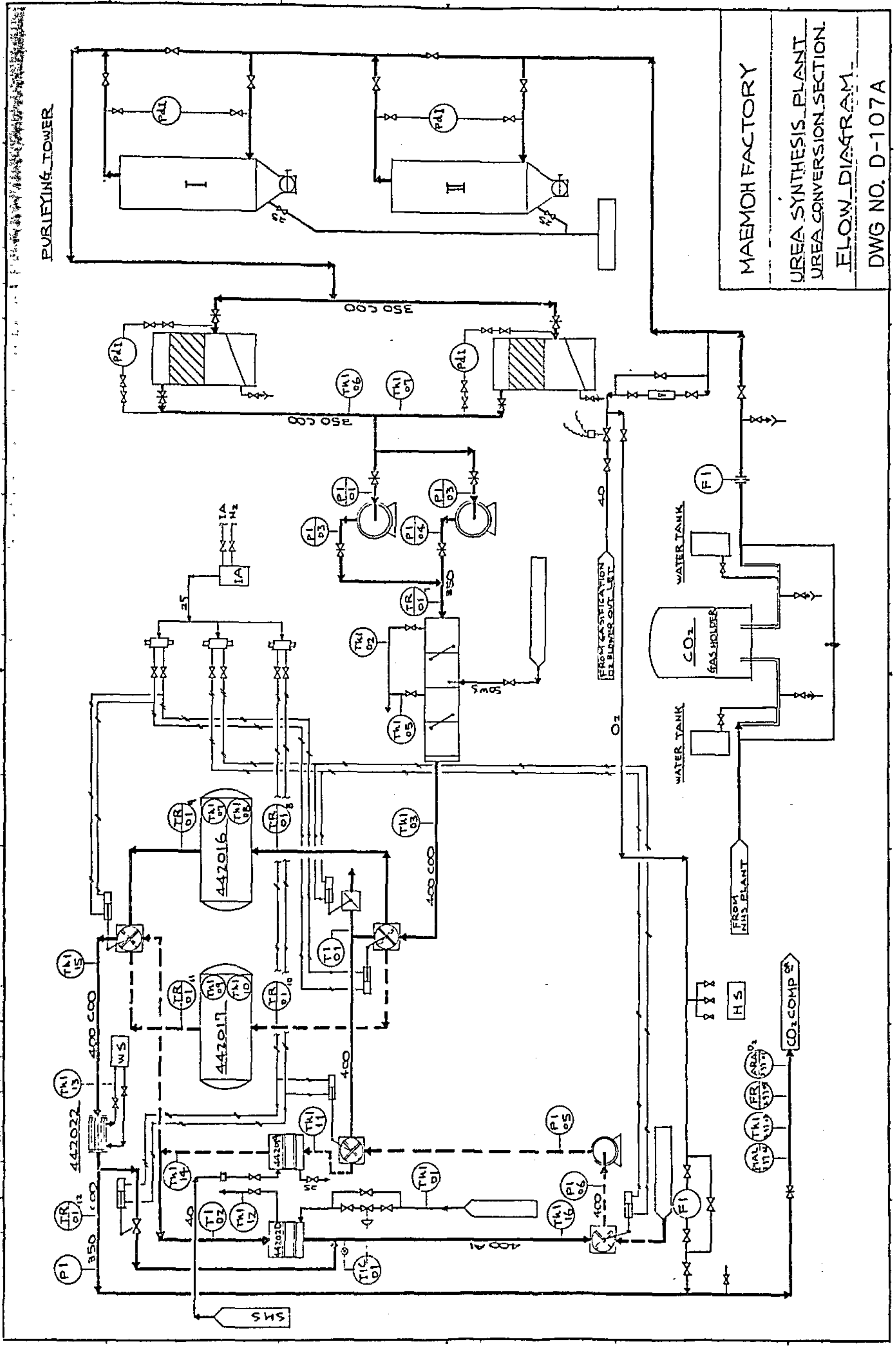


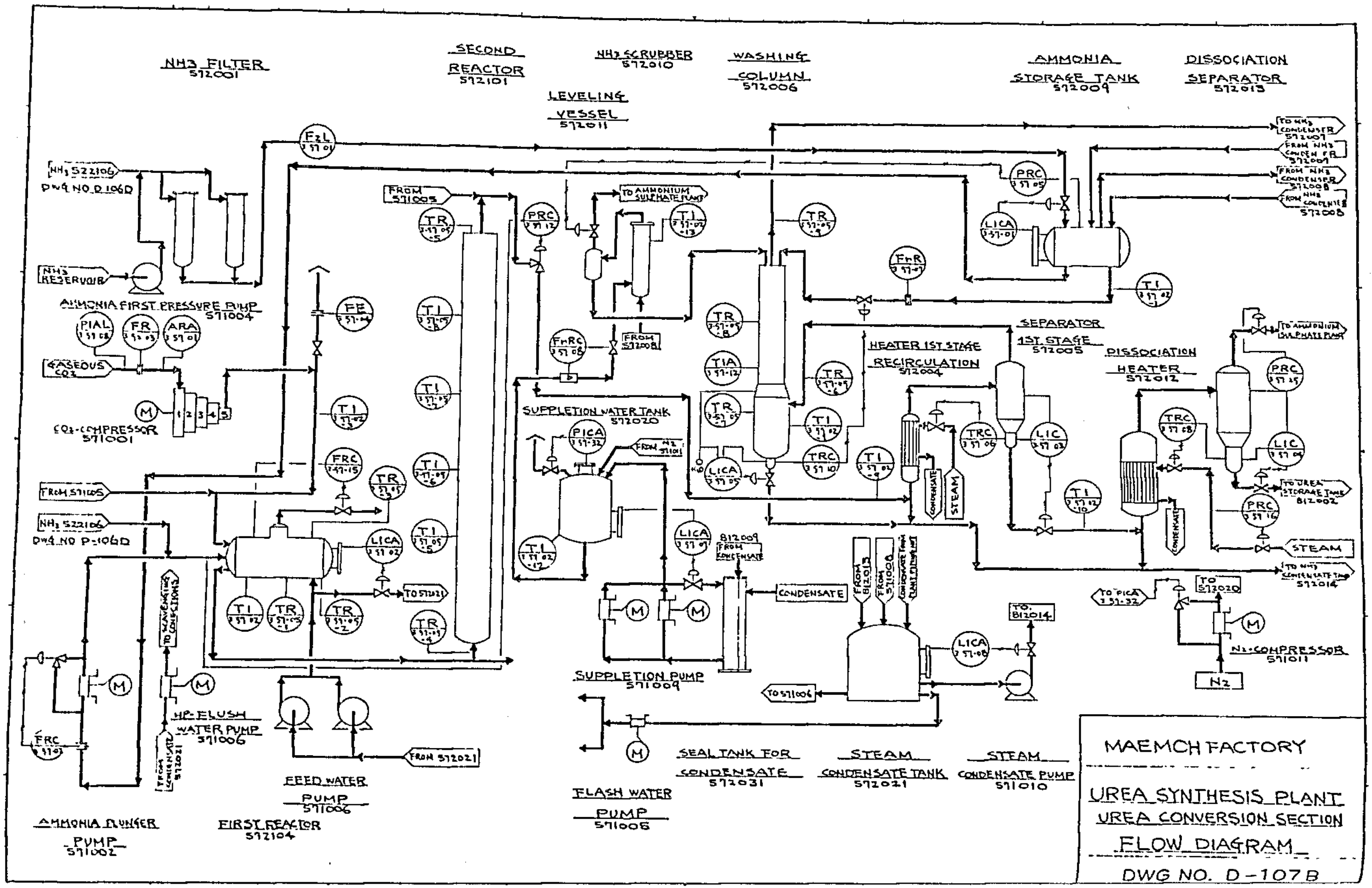
MAEMOH FACTORY
AMMONIA SYNTHESIS PLANT
FINAL PURIFICATION SECTION
FLOW DIAGRAM (3/5)
DWG NO. D-106C
COPPER SOL. DISSOLVING TOWER 432011
HIGH PRESSURE COPPER SOLUTION SCRUBBER 432102
OIL SEPARATOR 432101
AMMONIA WATER SCRUBBER 432103
AFTER SCRUBBER FOR CO2 RETURN GAS 432009
SUCTION TANK FOR AMMONIA WATER 432013
COPPER SOLUTION SEPARATOR WITH SEAL TANK 432008
SURGE TANK 432006
REGENERATOR FOR COPPER SOLUTION 432001
COPPER SOLUTION COOLER 432007
REFRIGERATION APPARATUS
COLLECTING TANK 432010
COPPER SOLUTION TANK 432014
PRESSURE BLAST VESSEL 432104 I
PRESSURE BLAST VESSEL 432104 II
COPPER SOLUTION PUMP 431001 I
COPPER SOLUTION PUMP 431001 II
CONDENSATE PUMP 431003
HIGH PRESS. AMMONIA WATER PUMP 431002 I II
AMMONIA WATER PUMP 431012
TO SYNTHESIS GAS COMPRESSOR 1ST& SUCTION DWG NO D-106C
TO SYNTHESIS GAS COMPRESSOR 6ST& SUCTION DWG NO. D-106D
FROM SYNTHESIS GAS COMPRESSOR 5ST& DWG NO. D-106D
TO UREA SYNTHESIS DWG NO. D-107
NH3 WATER FROM SYNTHESIS DWG NO. D-106D
TO 532104 DWG NO. D-106D
FROM NH3 532003
FROM NH3 532001
TO 532104
FROM FEED WATER PLANT
COOLING WATER
3.5 kg STEAM
CW



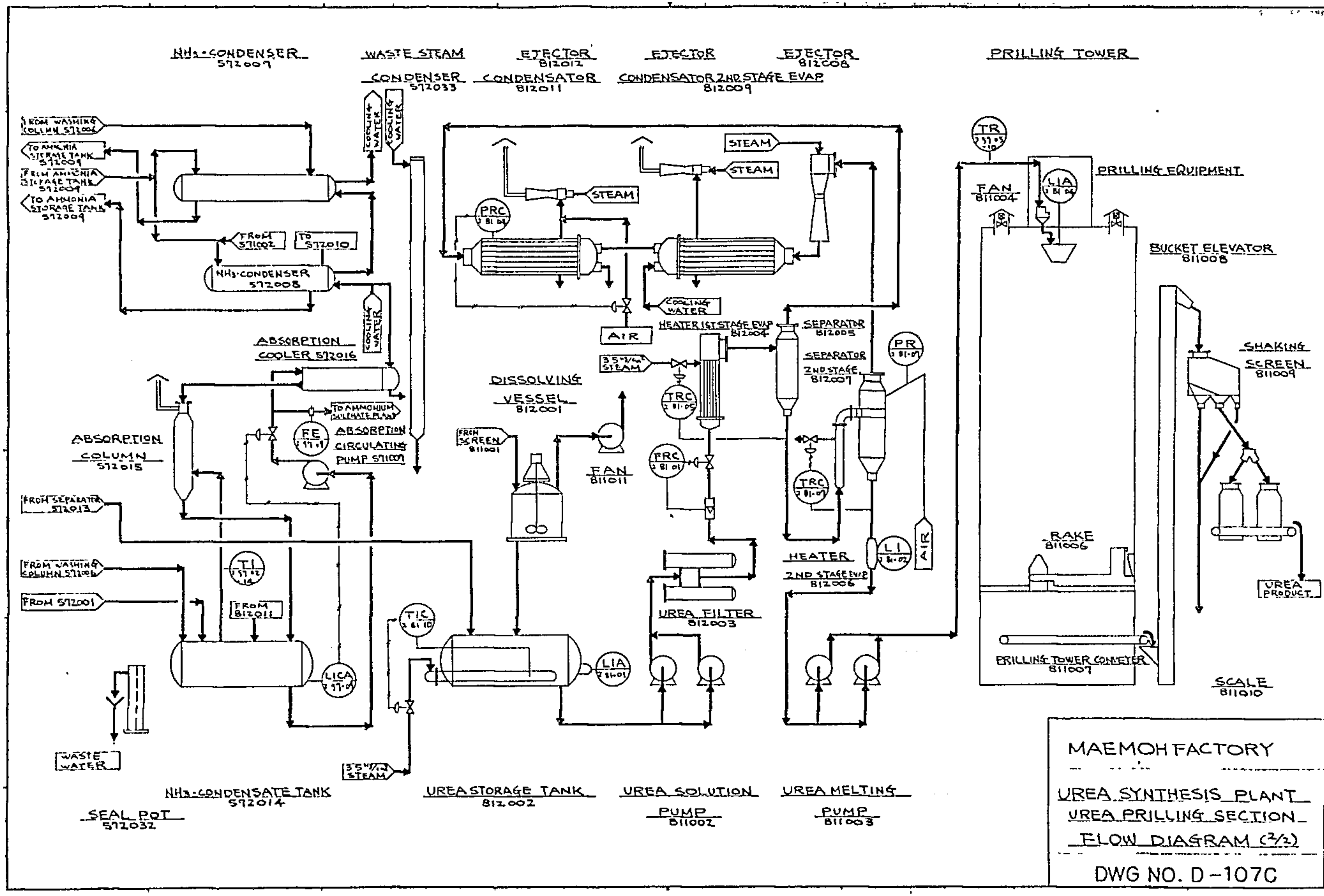
SYNTHESIS GAS COMPRESSOR 111002
TAIL GAS SCRUBBER 522003
AMMONIA SYNTHESIS CONVERTER 522101
FROM WATER SEPARATOR
FROM AMMONIA WATER SCRUBBER
FROM FLASH VESSEL
TO. AMMONIUM SULPHATE PLANT
WATER
DWG NO D-106C
AMMONIA WATER TO 432013
SYNTHESIS GASHOLDER 942001
SULPHUR REMOVAL PLANT
6000 M³
COOLING WATER
COPPER SOL REGENERATOR
3.5K STEAM
DWG NO D 106A
TO SATURATOR
TO OIL SEPARATOR
DWG NO D-106C
TO AMMONIA BOTTLING STATION
TO NH3 RESERVOIR
WASTE HEAT BOILER 522104
FEED WATER PLANT
DWG NO. D-101
HIGH PRESSURE OIL SEPARATOR 522107
FLASH VESSEL 522001
HIGH PRESSURE AMMONIA SEPARATOR 522106
GAS COOLER 522105
GAS CIRCURATING COMPRESSOR 521001-I·II
MAEMOH FACTORY
AMMONIA SYNTHESIS PLANT
AMMONIA SYNTHESIS SECTION
FLOW DIAGRAM (4/5)
DWG NO. D-106D

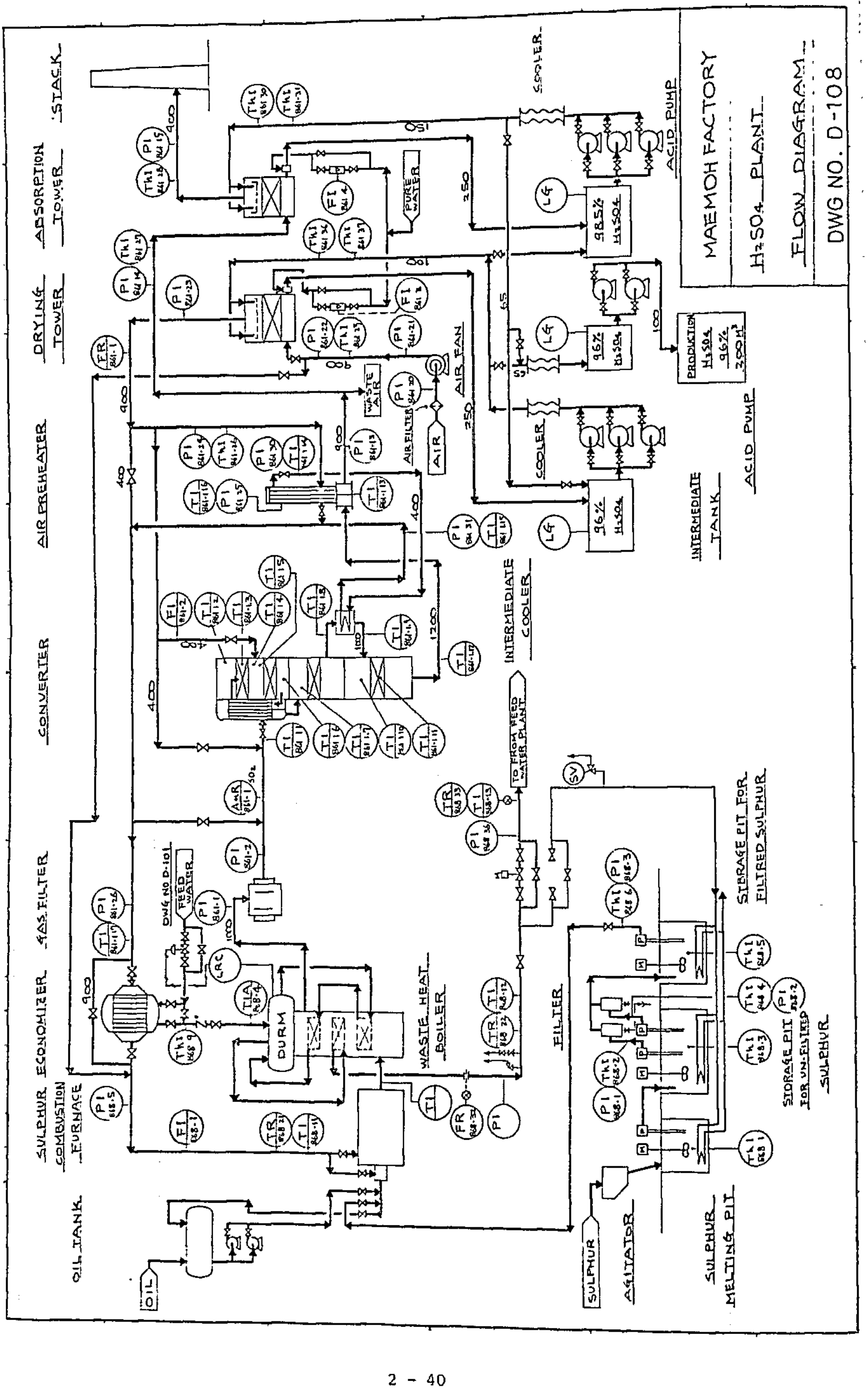

MAEMOH FACTORY
AMMONIA SYNTHESIS PLANT
SYNTHESIS COMPRESSOR
FLOW DIAGRAM (5/5)
DWG NO. D-106E
LOW GAS
TO 292001
N2
NO.2 1STG SUC
NO.2 3STG DIS
NO.2 4STG SUC
NO.2 6STG SUC
FROM 312001
FROM 432013
FROM NO.2 5STG
TO 432102
TO 522107
NO.2 7STG
COOLER
4 STG COOLER
5 STG COOLER
6 STG COOLER
7 STG COOLER
254
300
80
45

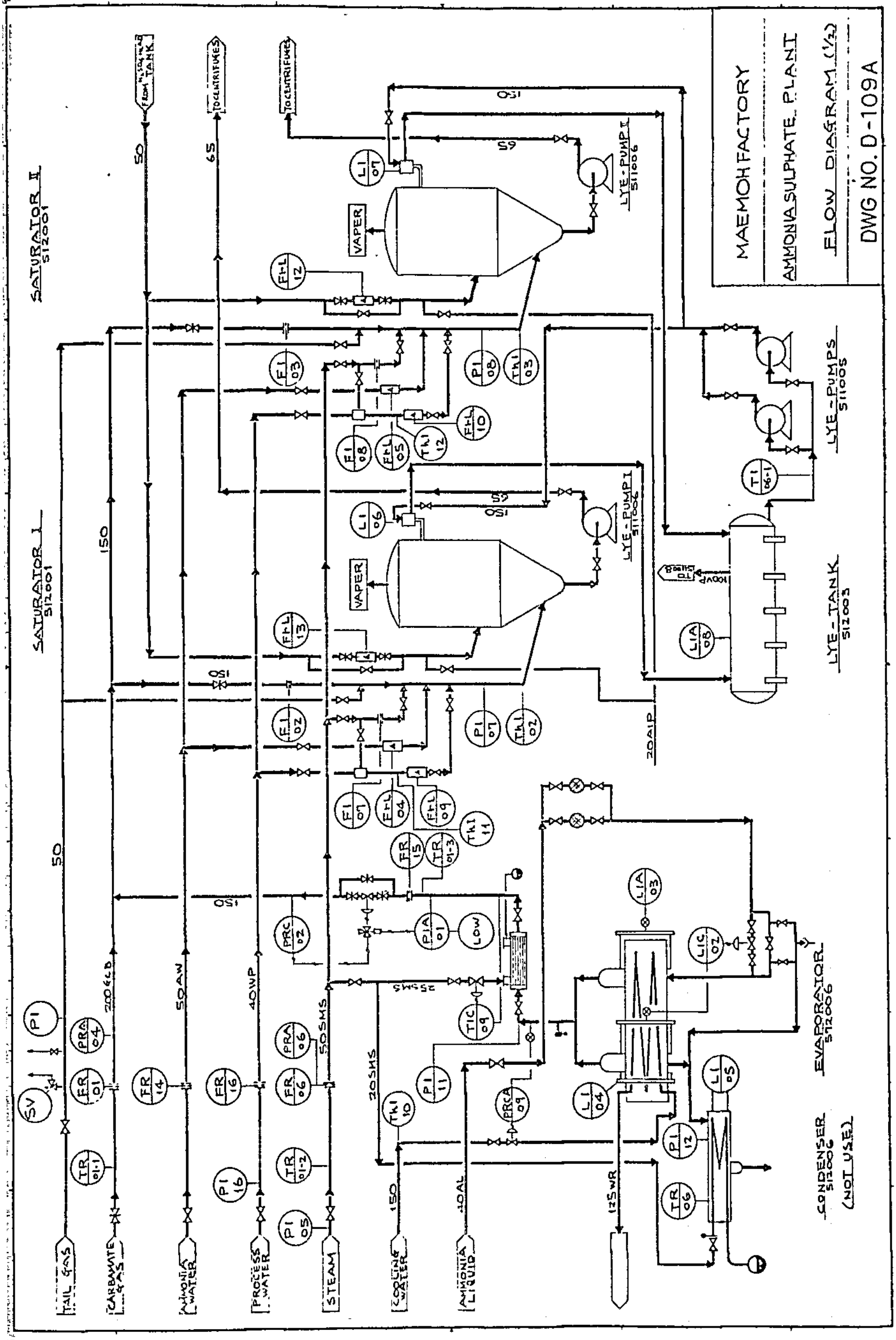

MAEMOH FACTORY
UREA SYNTHESIS PLANT
UREA CONVERSION SECTION
FLOW DIAGRAM
DWG NO. D-107A
PURIFYING TOWER
WATER TANK
WATER TANK
CO2
GAS HOLDER
FROM GASIFICATION O2 BLOWER OUT LET
FROM NH3 PLANT
CO2 COMP
442016
442017
442022
WS
HS
IA
SHS
350 C00
400 C00
400 A1

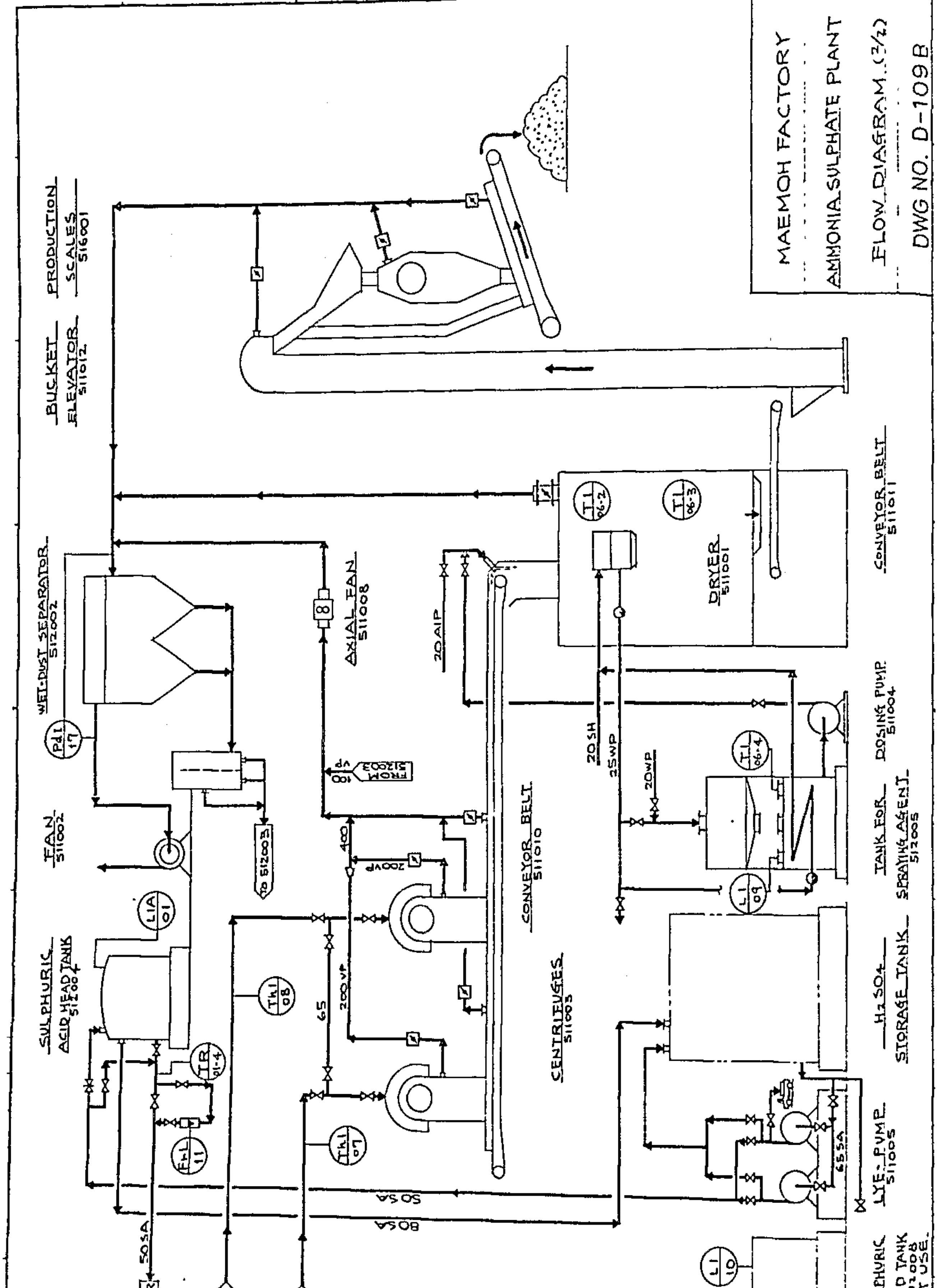


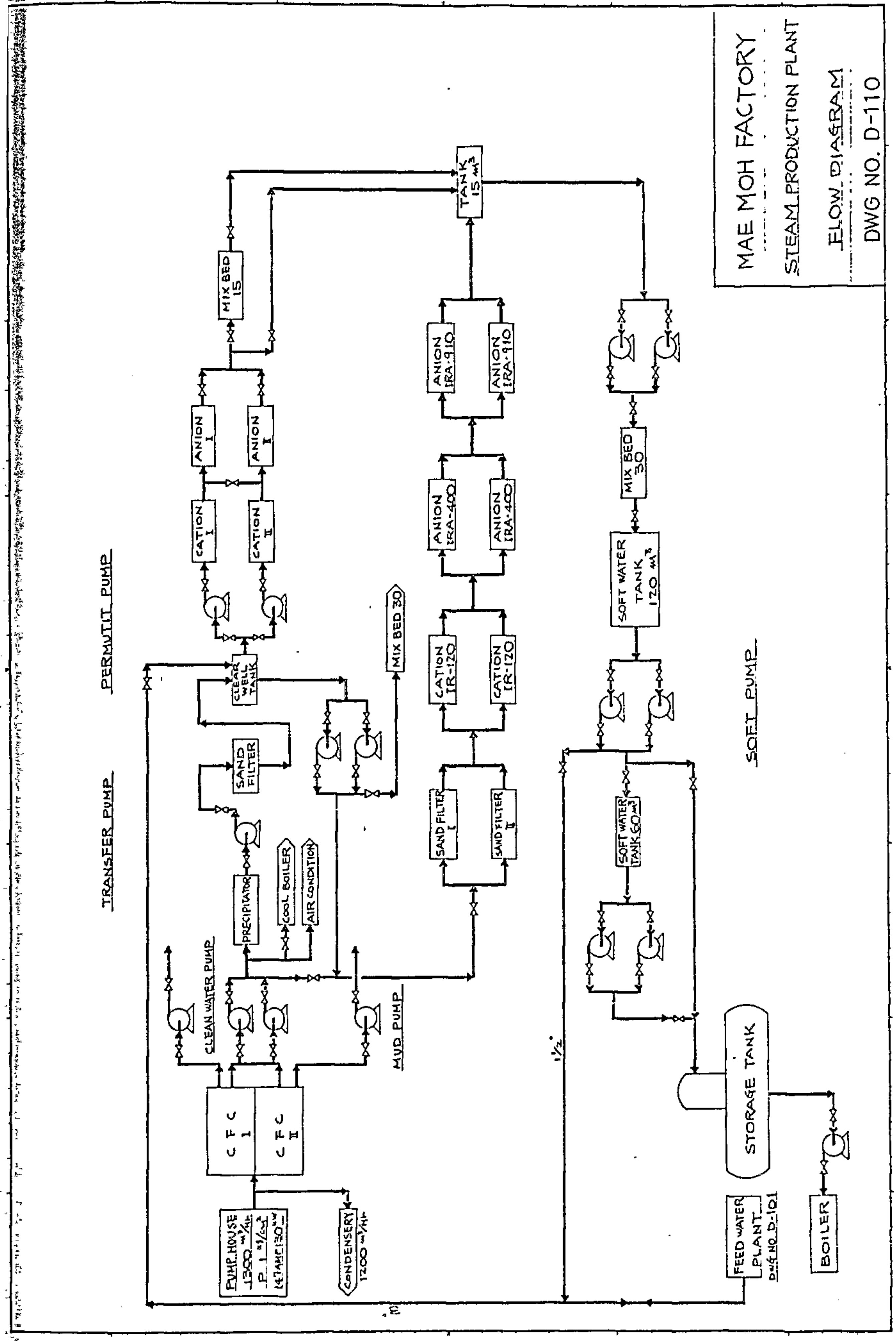
NH3 FILTER 572001
SECOND REACTOR 572101
NH3 SCRUBBER 572010
LEVELING VESSEL 572011
WASHING COLUMN 572006
AMMONIA STORAGE TANK 572009
DISSOCIATION SEPARATOR 572013
AMMONIA FIRST PRESSURE PUMP 571004
CO2-COMPRESSOR 571001
SEPARATOR 1ST STAGE 572005
HEATER 1ST STAGE RECIRCULATION 572004
DISSOCIATION HEATER 572012
SUPPLETION WATER TANK 572020
SUPPLETION PUMP 571009
HP-FLUSH WATER PUMP 571006
FEED WATER PUMP 571006
FIRST REACTOR 572104
AMMONIA PLUNGER PUMP 571002
FLASH WATER PUMP 571006
SEAL TANK FOR CONDENSATE 572031
STEAM CONDENSATE TANK 572021
STEAM CONDENSATE PUMP 571010
N2-COMPRESSOR 571011
NH3 RESERVOIR
GASEOUS CO2
FROM 571005
TO AMMONIUM SULPHATE PLANT
FROM 572008
STEAM
CONDENSATE
TO 571006
FROM 572021
N2
MAEMCH FACTORY
UREA SYNTHESIS PLANT
UREA CONVERSION SECTION
FLOW DIAGRAM
DWG NO. D-107B

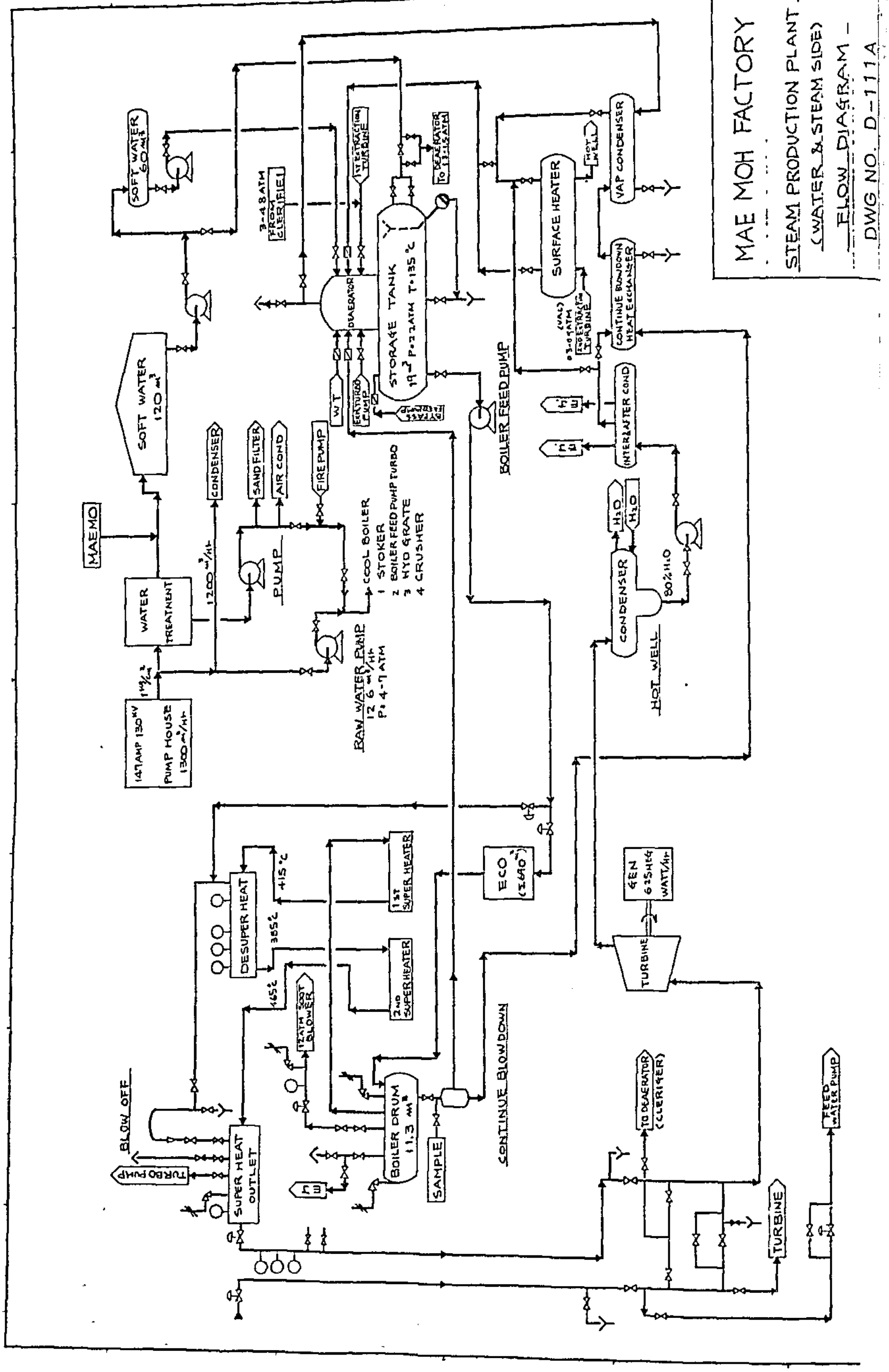

NH3-CONDENSER 572007
WASTE STEAM CONDENSER 572033
EJECTOR 812012
CONDENSATOR 812011
EJECTOR
CONDENSATOR 2ND STAGE EVAP 812009
EJECTOR 812008
PRILLING TOWER
PRILLING EQUIPMENT
FAN 811004
BUCKET ELEVATOR 811008
SHAKING SCREEN 811009
UREA PRODUCT
RAKE 811006
PRILLING TOWER CONVEYER 811007
SCALE 811010
FROM WASHING COLUMN 572006
TO AMMONIA STORAGE TANK 572009
FROM AMMONIA STORAGE TANK 572009
TO AMMONIA STORAGE TANK 572009
FROM 571002
TO 572010
NH3-CONDENSER 572008
COOLING WATER
STEAM
AIR
HEATER 1ST STAGE EVAP 812004
SEPARATOR 812005
SEPARATOR 2ND STAGE 812007
ABSORPTION COOLER 572016
TO AMMONIUM SULPHATE PLANT
ABSORPTION CIRCULATING PUMP 571009
ABSORPTION COLUMN 572015
DISSOLVING VESSEL 812001
FROM SCREEN 811001
FAN 811011
HEATER 2ND STAGE EVAP 812006
UREA FILTER 812003
FROM SEPARATOR 572013
FROM WASHING COLUMN 572006
FROM 572001
FROM 812011
WASTE WATER
NH3-CONDENSATE TANK 572014
SEAL POT 572032
UREA STORAGE TANK 812002
UREA SOLUTION PUMP 811002
UREA MELTING PUMP 811003
MAEMOH FACTORY
UREA SYNTHESIS PLANT
UREA PRILLING SECTION
FLOW DIAGRAM (2/2)
DWG NO. D-107C

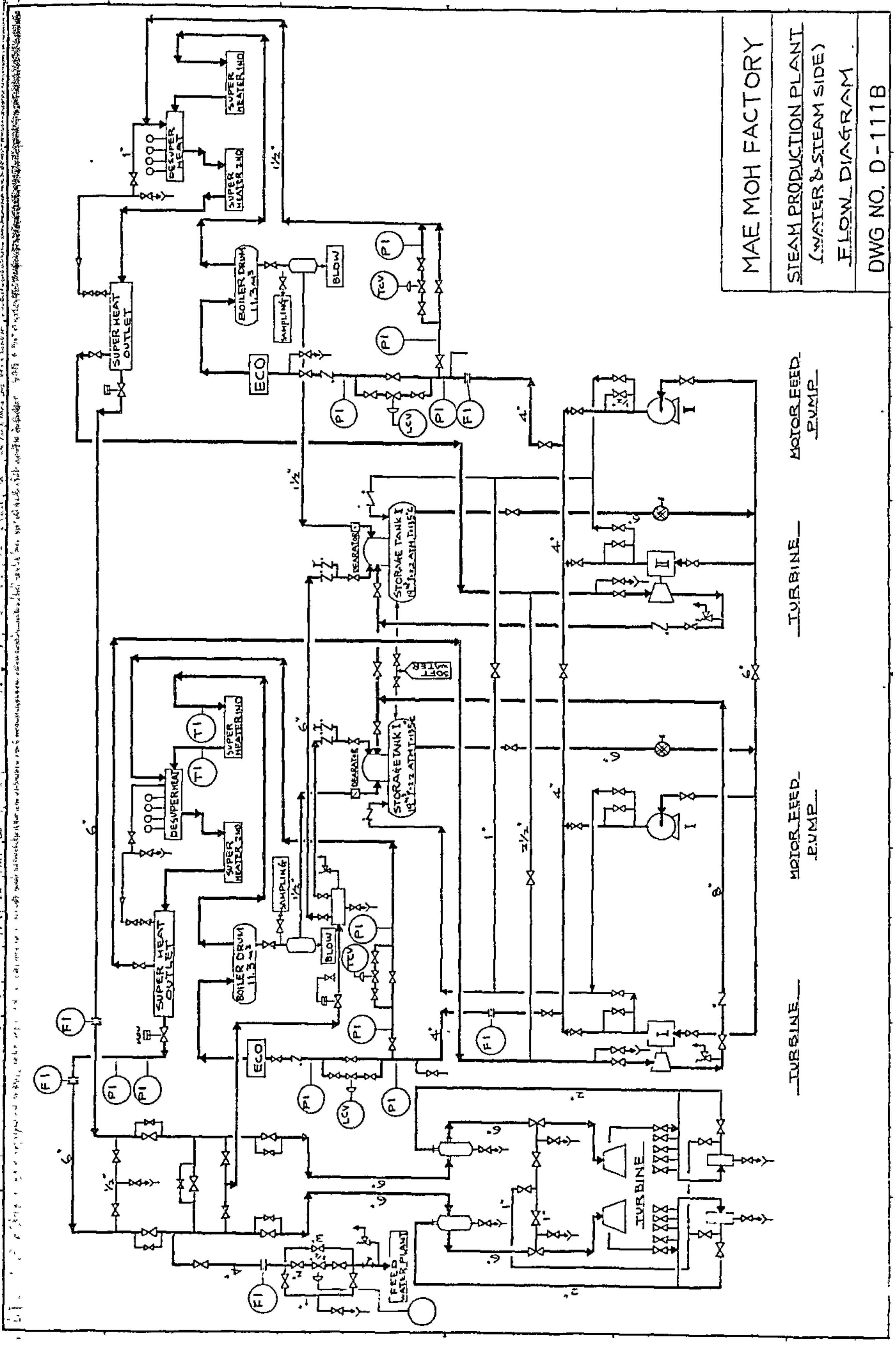

MAEMOH FACTORY
H2SO4 PLANT
FLOW DIAGRAM
DWG NO. D-108
STACK
ABSORPTION TOWER
DRYING TOWER
AIR PREHEATER
CONVERTER
GAS FILTER
SULPHUR ECONOMIZER
COMBUSTION FURNACE
OIL TANK
OIL
WASTE HEAT BOILER
DURM
FEED WATER
DWG NO D-101
INTERMEDIATE COOLER
TO FROM FEED WATER PLANT
FILTER
SULPHUR
AGITATOR
SULPHUR MELTING PIT
STORAGE PIT FOR UN-FILTRED SULPHUR
STORAGE PIT FOR FILTRED SULPHUR
AIR
AIR FILTER
AIR FAN
WASTE AIR
PURE WATER
COOLER
ACID PUMP
INTERMEDIATE TANK
96% H2SO4
98.5% H2SO4
PRODUCTION H2SO4 96% 300M3

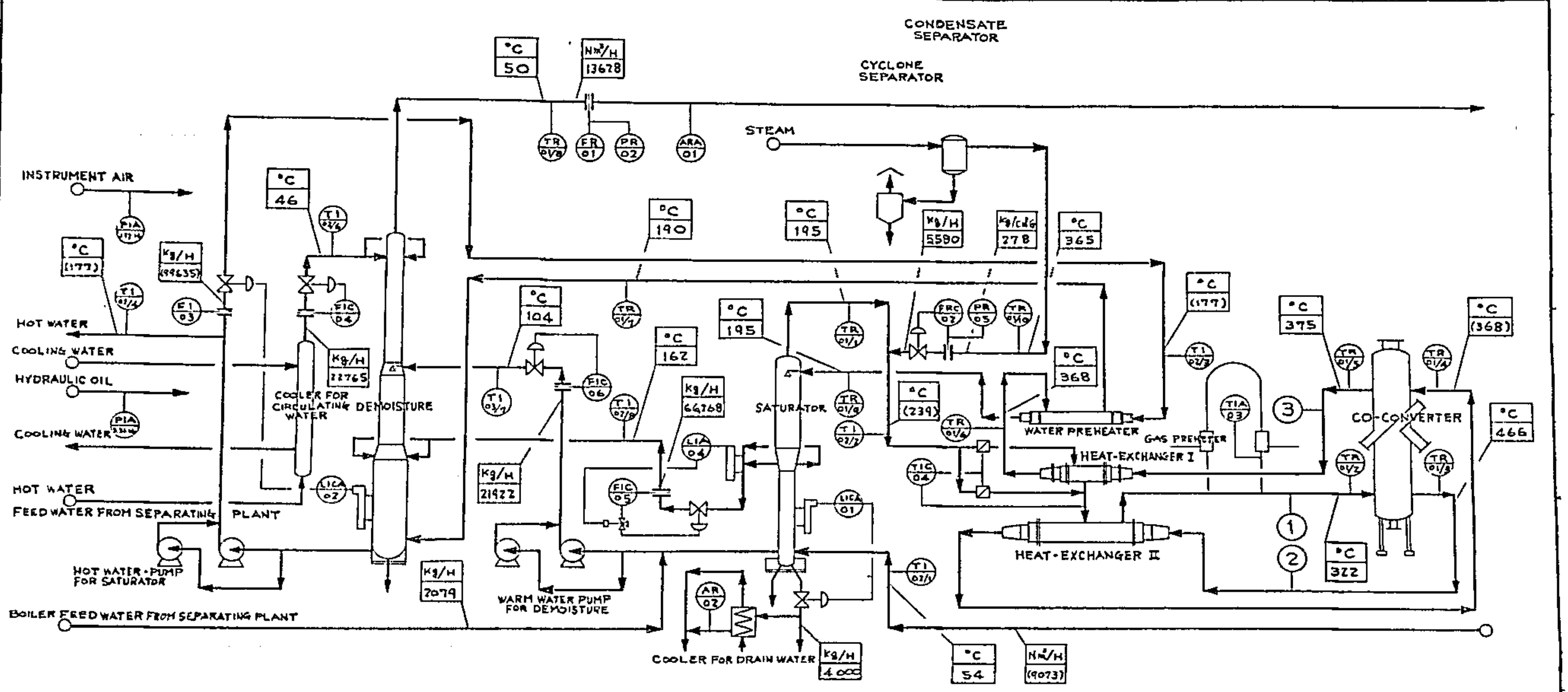

MAEMOH FACTORY
AMMONIA SULPHATE PLANT
FLOW DIAGRAM (1/2)
DWG NO. D-109A
SATURATOR I
512001
SATURATOR II
512001
LYE-PUMP I
511006
LYE-PUMP II
511006
LYE-PUMPS
511005
LYE-TANK
512003
EVAPORATOR
512006
CONDENSER
512006
(NOT USE)
VAPER
TAIL GAS
CARBAMITE GAS
AMMONIA WATER
PROCESS WATER
STEAM
COOLING WATER
AMMONIA LIQUID
TO CENTRIFUGES
FROM TANK


MAEMOH FACTORY
AMMONIA SULPHATE PLANT
FLOW DIAGRAM (2/2)
DWG NO. D-109B
PRODUCTION SCALES 516001
BUCKET ELEVATOR 511012
CONVEYOR BELT 511011
DRYER 511001
WET-DUST SEPARATOR 512002
AXIAL FAN 511008
FAN 511002
TO 512003
FROM 512003 VP
20AIP
20SH
25WP
20WP
DOSING PUMP 511004
TANK FOR SPRAYING AGENT 512005
CONVEYOR BELT 511010
400
200VP
65
200VP
CENTRIFUGES 511003
SULPHURIC ACID HEAD TANK 512004
H2SO4 STORAGE TANK
LYE-PUMP 511005
65SA
50SA
80SA
50SA
TO SATURATOR
FROM LYE PUMP I
FROM LYE PUMP II
SULPHURIC ACID TANK 512008 NOT USE.
PdI 17
LIA 01
TR 91-4
FrL 11
ThI 08
ThI 07
TI 06-2
TI 06-3
TI 06-4
LI 09
LI 10


MAE MOH FACTORY
STEAM PRODUCTION PLANT
FLOW DIAGRAM
DWG NO. D-110
TANK 15 m³
MIX BED 15
ANION I
ANION II
CATION I
CATION II
PERMUTIT PUMP
ANION IRA-910
ANION IRA-910
ANION IRA-400
ANION IRA-400
CATION IR-120
CATION IR-120
SAND FILTER I
SAND FILTER II
MIX BED 30
MIX BED 30
SOFT WATER TANK 120 m³
SOFT PUMP
SOFT WATER TANK 60 m³
STORAGE TANK
BOILER
FEED WATER PLANT DWG NO D-101
CLEAR WELL TANK
SAND FILTER
TRANSFER PUMP
PRECIPITATOR
COOL BOILER
AIR CONDITION
CLEAN WATER PUMP
MUD PUMP
C F C I
C F C II
PUMP HOUSE
1300 m³/Hr
P 1 kg/cm²
(47AMC130"W)
CONDENSERY 1200 m³/Hr
1½"


MAE MOH FACTORY
STEAM PRODUCTION PLANT.
(WATER & STEAM SIDE)
FLOW DIAGRAM
DWG NO. D-111A
SOFT WATER 60 m³
SOFT WATER 120 m³
MAEMO
WATER TREATMENT
PUMP HOUSE
CONDENSER
SAND FILTER
AIR COND
FIRE PUMP
PUMP
RAW WATER PUMP
COOL BOILER
1 STOKER
2 BOILER FEED PUMP TURBO
3 HYD GRATE
4 CRUSHER
DEAERATOR
STORAGE TANK
W.T
BOILER FEED PUMP
SURFACE HEATER
VAP CONDENSER
CONTINUE BLOWDOWN HEAT EXCHANGER
INTERAFTER COND
CONDENSER
HOT WELL
ECO
1st SUPER HEATER
2nd SUPER HEATER
DESUPER HEAT
GEN
TURBINE
BOILER DRUM
SAMPLE
CONTINUE BLOWDOWN
SUPER HEAT OUTLET
BLOW OFF
TURBO PUMP
TO DEAERATOR (CLERIFIER)
FEED WATER PUMP


MAE MOH FACTORY
STEAM PRODUCTION PLANT
(WATER & STEAM SIDE)
FLOW DIAGRAM
DWG NO. D-111B
SUPER HEATER 1ND
SUPER HEATER 2ND
DESUPER HEAT
SUPER HEAT OUTLET
BOILER DRUM 11.3 m3
SAMPLING
BLOW
ECO
PI
TI
TCV
LCV
FI
STORAGE TANK I
STORAGE TANK II
DEARATOR
SOFT WATER
MOTOR FEED PUMP
TURBINE
FEED WATER PLANT



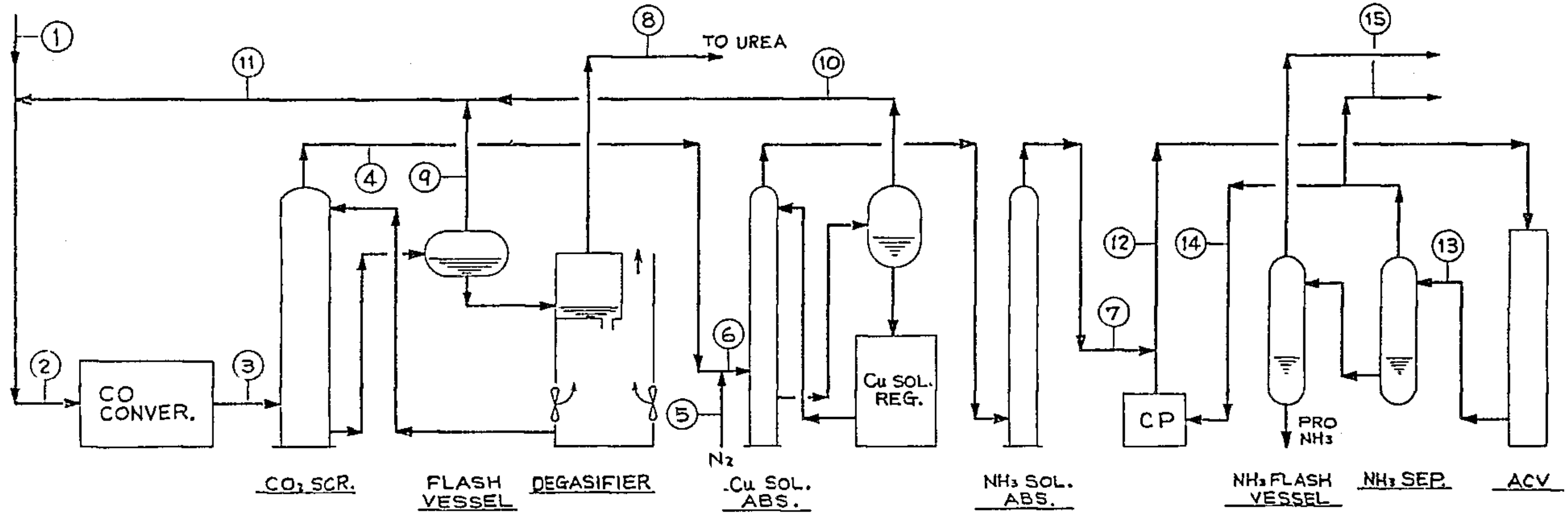
	CCV #1 INLET ①		CCV #1 OUTLET ②		CCV #2 OUTLET ③	
	Nm³/H	DRY/WET VOL %	Nm³/H	DRY/WET VOL %	Nm³/H	DRY/WET VOL %
CO_2	1167	130/ 42	5432	40.9/ 195	5706	421/ 20.5
CO	4824	53.5/ 17.3	559	42/ 2.0	285	2.1/ 1.0
H_2	2671	29.7/ 96	6936	52.2/ 249	7210	53.2/ 25.9
N_2	271	29/ 1.0	271	2.1/ 1.0	271	2.0/ 1.0
Ar	81	0.9/ 03	81	0.6/ 03	81	0.6/ 0.3
H_2O	18856	- / 67.6	14591	- / 52.3	14317	- / 51.3
TOTAL	27870	1000/100.0	27870	1000/1000	27870	100.0/100.0

MAE MOH FACTORY

MASS BALANCE

CCV SECTION

DWG.NO.



	1		2		3		4		5		6		7		8		9
	Nm³/H	%	Nm³/H	%	Nm³/H	%	Nm³/H	%	Nm³/H	%	Nm³/H	%	Nm³/H	%	Nm³/H	%	Nm³/H
CO_2	668	83	1167	13.0	5706	421									4166		499
CO	4539	56.4	4824	53.5	285	2.1	277	3.6			277	2.9					8
H_2	2501	31.1	2671	297	7210	532	6997	919			6997	72.7	6997	74.9			170
N_2	259	32	271	29	271	20	259	34	2008		2267	236	2267	243			12
Ar	78	1.0	81	0.9	81	0.6	78	1.1			78	08	78	08			3
NH_3																	
TOTAL	8045		9014		13553		7611		2008		9619		9342		4166		692

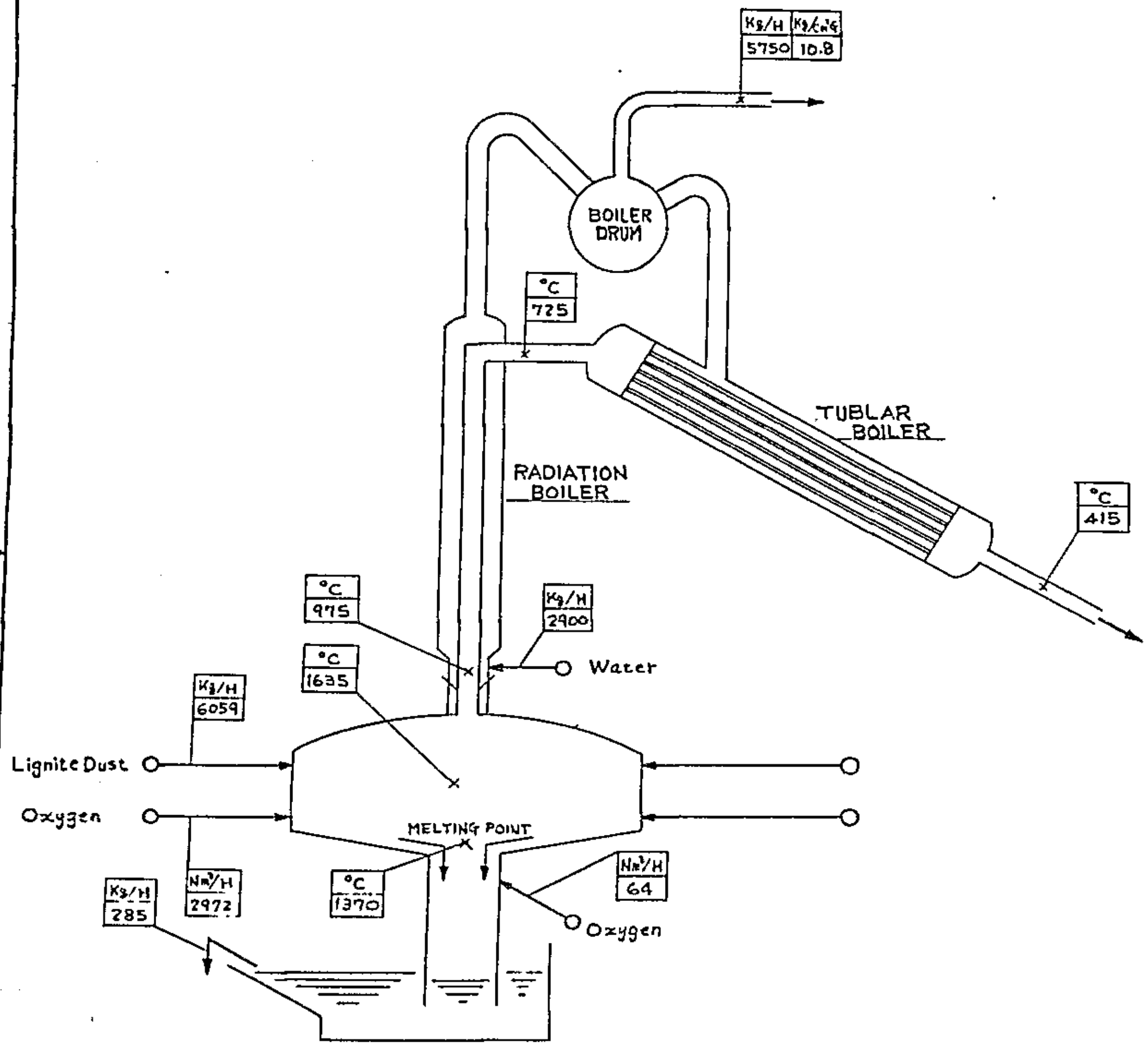
	9	10		11		12		13		14		15	
	%	Nm³/H	%	Nm³/H	%	Nm³/H	%	Nm³/H	%	Nm³/H	%	Nm³/H	%
CO_2	721			499	51.5								
CO	1.2	277		285	294								
H_2	246			170	17.6	31444	590	26098	52.5	24447	557	1651	74.6
N_2	1.7			12	1.2	13160	24.7	11378	229	10893	24.8	485	21.9
Ar	0.4			3	0.3	3771	7.1	3771	7.6	3693	84	78	3.5
NH_3						4884	9.2	8448	170	4884	11.1		
TOTAL		277		969		53259		49695		43917		2214	

MAE MOH FACTORY

MASS BALANCE

GAS PURIFICATION & SYNTHESIS SECTION

DWG.NO.



	SY・Gas OUT of GASIFIER		
	Nm³/H	DRY VoL %	WET VoL %
CO_2	868	10.7	86
CO	4658	57.7	460
H_2	2102	26.0	207
N_2+Ar	319	40	31
CH_4	8	0.1	0.1
H_2S	125	1.5	1.2
H_2O	2053	–	20.3
TOTAL	10133	100.0	1000

FLY ASH 640 kg/H

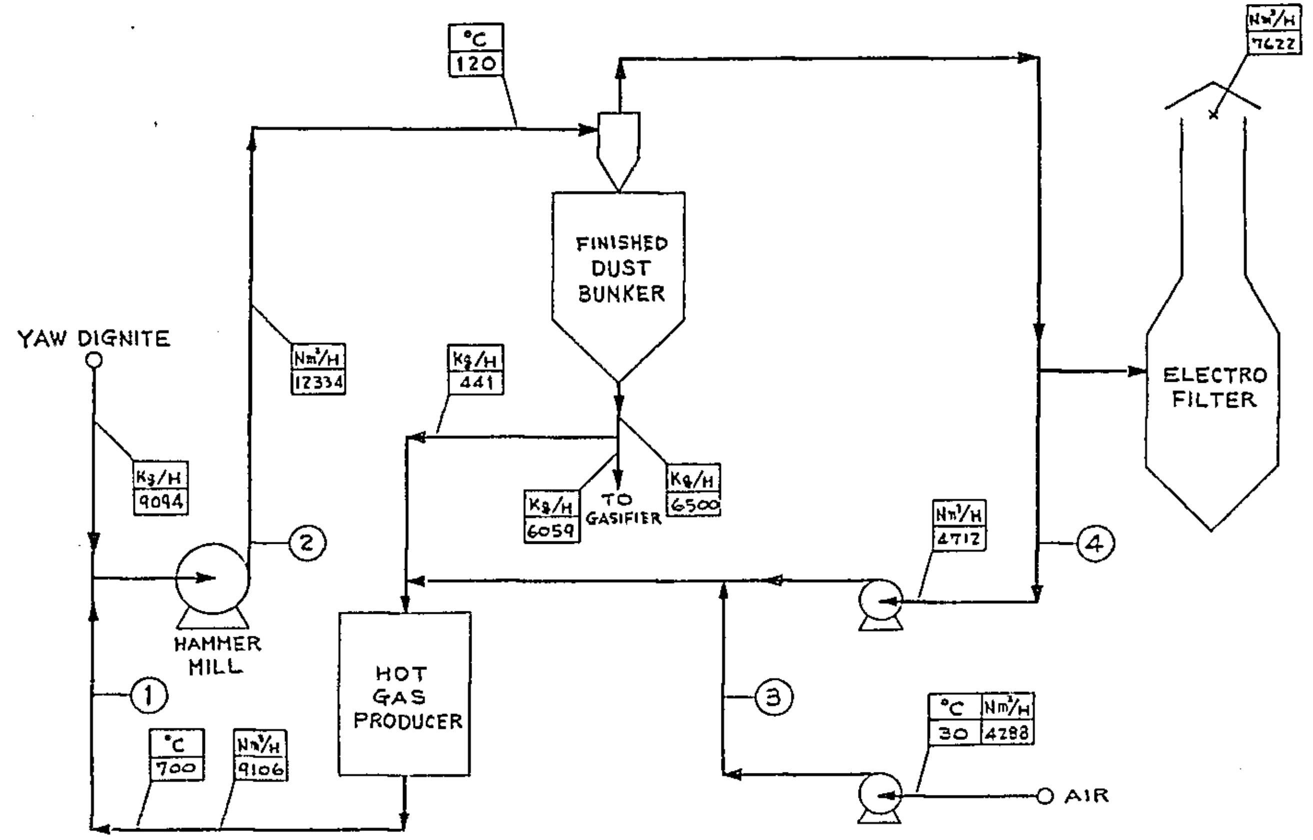
Lignite Dust	
	Wt %
Moisture	9.06
Ash	1527
C	48.93
H	3.49
S	2.70
CO_2	355
Heat of Comb	4959 Kcal/Kg (GROSS)

MAE MOH FACTORY

MASS BALANCE

GASIFICATION SECTION

DWG.NO.



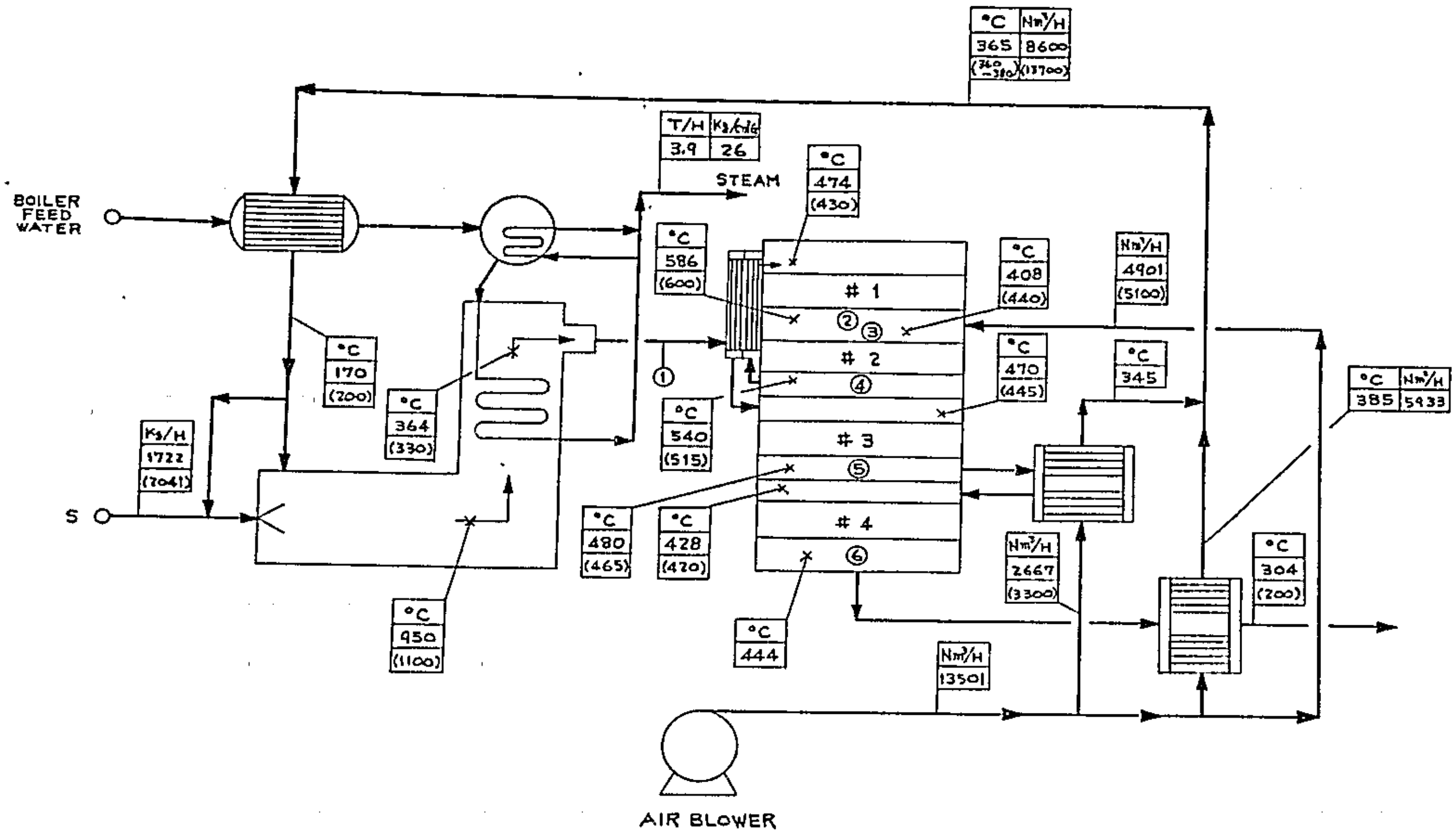
	(1)		(2)		(3)		(4)	
	Nm³/H	VoL%	Nm³/H	VoL%	Nm³/H	VoL%	Nm³/H	VoL%
CO_2				5.3				
O_2				4.8				
N_2				5.7				
H_2O				44.2				
TOTAL	9106		12334		4288		4712	

MAE MOH FACTORY

MASS BALANCE

GRINDING SECTION

DWG.NO.



	① FURNACE OUT		② #1 OUT		③ #2 IN		④ #2 OUT		⑤ #3 OUT		⑥ #4 OUT	
	Nm³/H	VOL%	Nm³/H	VOL%	Nm³/H	VOL%	Nm³/H	VOL%	Nm³/H	VOL%	Nm³/H	VOL%
SO_2	1203	140	831	99	831	6.2	190	1.5	119	0.9	16	0.1
SO_3	–		372	4.4	372	28	1013	7.8	1084	84	1187	9.2
O_2	603	7.0	417	4.9	1445	10.8	1124	8.6	1089	8.4	1037	8.0
N_2	6801	790	6801	80.8	10674	802	10674	82.1	10674	82.3	10674	82.7
TOTAL	8607		8421		13321		13001		12966		12914	

MAE MOH FACTORY

MASS BALANCE

SULPHURIC ACID PLANT

DWG.NO.

SECTION 3

CONCLUSION OF SURVEY TEAM

Section 3 Conclusion of Survey team

The survey team has concluded from the results of the investigation that the rehabilitation of Mae Moh factory is possible from the view point of equipment and economy, and to rehabilitate Mae Moh factory is necessary and benefitial for Thai national advantage.

The annual ammonia production recrods of Mae Moh factory are a little more than 30% of design production, that is, 70% reduction. The causes of this 70% reduction are summarized as follows;

(i)	Troubles of equipment (deterioration of equipment)	30%
(ii)	Problem on operational technics	15%
(iii)	Problem on the process	25%

Referring to the troubles of equipment, the problem was induced from disregarding the maintenance of equipment, while they are being superannuated year by year. From the results of equipment's inside inspection, we suppose to repair the equipment is rather simple problem, although it requires a considerable amount of investment and some of the repairing jobs will require the supervision by specialists from Japan or other countries. In this report the detailed list of equipment to be repaired is explained.

Relating to the problems on operational technics, it is induced by following causes.

(i) Insufficient number of engineers.

(ii) Insufficient technical level of engineers in Mae Moh factory.

(iii) Deterioration of operators' spirit, induced from the insufficient reliability of machine.

(iv) Unstable operating conditions, induced from the insufficient reliability of instrument.

To solve the problems of (i) and (ii), it is necessary to recruit the engineers urgently and to program the improvement of technical level by the correct instruction, yet the improvement of technical level will require a number of years.

On the other hand, as for the problems of (iii) and (iv), when the maintenance problems of equipment would have been solved and consequently the reliability of the equipment promoted, spontaneously the operating conditions would be stabilized and the morale would be improved.

It is the gasification plant that has the problem on the process. This process is difficult to operate. (The hard technics of operation is required to gasify the coal, and it is one of the reasons that the raw material for ammonia production had been switched over to petroleum in the world.) And it is really difficult to find a way to settle the problem without the remodeling the plant under the present technical level of the world.

However the situation of gasification plant would be improved remarkably when the operational technics would be promoted. The economical rehabilitation of Mae Moh factory would be feasible, as discussed in later chapter concerning the economical study, while the settlement of this gasification plant problem would take a rather long term.

Referring the economical balance of Mae Moh factory, the cost for production and investment for the rehabilitation had been studied. And the possibility of production had been estimated with due regard to the operation records and the present technical level of Mae Moh factory.

The summary of the conclusion is as follows.

The rehabilitation of Mae Moh factory would be able to be realized within the next 5 years, and the investment for the rehabilitation might be around 40 million baht.

In this conclusion, the ammonia production is expected to be 20,000 Ton/Year, which is double of present and 70% of design. And the proceeds of Mae Moh factory will exceed the break-even point fairly and bring forth not small benefits to Mae Moh factory.

As described formerly, the position of Mae Moh factory in Thailand is as follows.

(i) Mae Moh factory is only one heavy chemical factory which is availing the high pressure and high temperature technology.

(ii) In Mae Moh factory, Thai domestic resources of brown coal is utilized as the main feedstock.

(iii) The chemical fertilizer produced in Mae Moh factory has the significant meaning for agricultural country of Thailand and besides the chemical fertilizer, liquid ammonia and sulphuric acid, marketing from Mae Moh factory, are essential chemicals for Thai chemical industries.

When the development of chemical industries in Thailand is considered, the technology kept in this factory is significant. Actually in past ten years, a large number of engineers have left Mae Moh factory and have been active in the fields of plastics and other chemical industries. Further, in Mae Moh factory the latest technology at the time of its construction has been greatly utilized and so the factory, still now, is standing among the foremost factories in the wrold.

It is mentionable that the equipment market for high pressure and high temperature chemical industries is not existing in Thailand and this is one of the indirect causes induced the deterioration of Mae Moh factory. Considering reversely this fact, there is no high pressure and high temperature chemical industries in Thailand, except Mae Moh factory. Therefore if Mae Moh factory would be scrapped, a significant stagnation in the field of Thai chemical industries would come about.

Moreover it is estimated that around 1.5 billion baht might be required, if the factory same scale as Mae Moh factory would be newly constructed. Comparing to scrap and build this variable factory, it is obvious that to rehabilitate and maintain this factory shall bring advantage to Thailand.

As formerly described, liquid ammonia and sulphuric acid produced in Mae Moh factory are essencial chemicals of chemical industries and especially sulphuric acid is important requisite of Thailand, because it is consumed at water treatment plant for Bangkok city water.

Consequently it is correct for Thailand to keep Mae Moh factory, considering technical, economical and national purposes of Thailand.

SECTION 4

RESULTS OF SURVEY

Section 4 Results of Survey

4-1 Summary

It has been 13 years since the factory construction and, as a whole, been superannuated corresponding to the number of years, however we did not discover the equipment or apparatus which had the serious problem or defects on continuing the operation. It is possible to restore the equipment to the complete conditions by repairing and also it is possible to continue the operation more than five years.

Regarding the operation of the factory, the leading members of the factory had made a great effort on the rehabilitation and we similarly working in the chemical factory, were impressed. While, it is regretable that the effort has not been brought to fruition yet, because of the insufficient number and knowledge of engineers.

4-2 Past record of ammonia production

4-2-1 Monthly ammonia production

Monthly ammonia production record is as follows.

	1970	71	72	73	74	75	76	77	average
JAN.	1915.	817.	1657.	1251.	1271.	142.	1749.	956.	1220.
FEB.	1258.	1262.	1372.	1127.	1401.	981.	1192.	1079.	1209.
MAR.	886.	565.	1084.	1005.	1007.	1108.	1034.	16.	838.
APR.	1095.	1360.	202.	399.	781.	980.	597.	1001.	802.
MAY	1151.	814.	-	-	88.	453.	32.	673.	401.
JUN.	1521.	1487.	142.	551.	630.	846.	787.	1155.	890.
JUL.	1165.	1392.	1294.	345.	992.	140.	896.	1480.	963.
AUG.	1288.	47.	1056.	496.	807.	486.	958.	1145.	785.
SEP.	1408.	1409.	922.	1102.	1085.	-	443.	967.	917.
OCT.	1307.	998.	1002.	445.	899.	-	-	1002.	707.
NOV.	1141.	1208.	818.	810.	758.	-	781.	-	690.
DEC.	663.	1444.	1053.	975.	401.	1448.	1053.	451.	936.
TOTAL	14798.	12803.	10602.	8506.	10120.	6584.	9522.	9925.	863. / 10358.

The causes of reduced production following to Mae Moh factorie's report and our suggestion to the causes are summarized below.

	Date		Mae Moh factory report	Our Suggestion
1	1971	Aug.	Badness of N_2 gas purity.	Leakage of O_2 in regenerator or switching valves.
2	1972	Apr. ∿ May	Tubular boiler of gasification.	Equipment was damaged and the spare parts couldn't prepare.
3	"	Jun.	Leakage of Heat Exchanger in ammonia plant.	Repairing technics is insufficient.
4	1973	Apr. ∿ May	Repairing of gasification plant.	
5	"	Jun.	Tubular boiler.	
6	"	Jul.	Leakage of Heat Exchanger in ADIP plant.	
7	1974	May	Net,and CO converter catalyst support,were damaged.	To use the net for this catalyst is inadequate.
8	1975	May	Replacement of CO converter catalyst.	Insufficient maintenance.
9	"	Jul.	Leakage of Heat Exchanger in Ammonia plant.	
10	"	Aug. ∿ Nov.	Explosion of degasifing tower in ammonia plant.	Operation miss.
11	1976	Apr. ∿ May	Explosion of piping in CO conversion section of ammonia plant.	In sufficient maintenance.
12	"	May ∿ Jun.	Badness of N_2 gas purity.	
13	"	Spe. ∿ Oct.	Repairing heat exchanger in ammonia plant.	
14	"	Mar. & Nov.	Annual repairing.	

Considering the causes of deteriorating of the production, following tendencies become clear.

(i) The direct causes of plant shut down were leakage of equipment. These are due to the superannuation of equipment, that is, insufficient maintenance.

(ii) The indirect causes of deteriorating the production were due to too long repairing term taken a month or more to repair a equipment which, if it was in Japan, would take less than 2 weeks. It is assumed that the each shut down was not scheduled one, therefore it took long term to prepare the field conditions and the materials for repairing.

(iii) Considering the records of ammonia plant in 1974 and 1975, it is assumed that when plant was shut down by one equipment failure, the other equipment were not repaired and maintained. And soon after the repairing, the other defect come out and again the plant was shut down.

4-2-2 Cause of plant shut down

The cause of plant shut down in 1970, 1976 and 1977 (Which annual ammonia production was 14,798 TON, 9,522 TON and 9,925 TON respectively) are summarized in next page.

	Causes	1970		1976		1977		
		No of stop	No of stop days	No of stop	No of stop days	No of stop	No of stop days	
Gasification	Gasifier & Slag conveyor trouble	11	34	14	34	8	22	
	Tubular Boiler's cholking	-	-	4	7	6	18	
	Grinding section trouble	2	6	1	1	2	11	
	Emergency trip system	1	3	1	1	1	1	
	Others	3	13	6	19	1	1	
	SUM	17	53	26	62	18	53	
		(37.8)		(49.1)		(38.3)		( )%
Ammonia	CO_2 Removal section trouble	2	13	1	1	4	16	
	Syn.gas compor	2	3	4	7	-	-	
	Heat Exchanger leakage	-	-	2	19	2	4	
	Steam Mixer leakage	-	-	1	4	3	12	
	CO Removal section trouble	-	-	1	29	3	12	
	Saturator leakage	-	-	1	6	2	8	
	Water Pipe leakage	-	-	1	3	3	7	
	Others	-	-	2	3	-	-	
	SUM	4	16	13	72	17	59	
		(8.9)		(24.5)		(36.2)		( )%
Other Plants	Electric Failure (Supply)	8	17	1	1	5	5	
	Electrical trouble in the factory	4	7	3	3	2	4	
	Air Separation plant troule	3	5	5	31	1	1	
	Cooling water leakage & Pump stop	1	1	2	2	2	2	
	Boiler	1	3	-	-	1	4	
	Lignite (Shortage of supply)	3	17	-	-	-	-	
	Others	4	18	3	13	1	6	
	SUM	24	68	14	50	12	22	
		(53.3)		(26.4)		(25.5)		( )%
	TOTAL	45	137	53	184	47	134 (194)	

(194) Including the plant stopping days for annual repairing

Causes of plant shut down has been studied.

(i) The major causes of plant shut down were due to the gasification plant and ammonia synthesis plant. Recently the tendency is strong. Regarding ammonia synthesis plant, recently the number of plant shut down was increased remarkably, comparing to 1970. The cause is assumed to be due to the superannuation of equipment and the troubles were come out in the form of leakage. These circumstances are due to the insufficient maintenance of high pressure equipment neglecting the superannuation of equipment. About these facts survey team had reconfirmed at the time of equipment inside inspection.

(ii) On 1976 and 1977, the troubles of electric failure and shortage of Lignite supply were reduced comparing to 1970. These appearance were indicating that being stabilized. Although in 1977 electric failure troubles were increased, yet this is supposed to be depended on the initial start up of the new power generation plant constructed in neighborhood, which fuel is Lignite. The troubles are being expected to be rapidly decreased.

(iii) Supposing apart from the settlement of gasification plant's problem, the reappearance of 15,000 TON/YEAR ammonia production, realized on 1970, would be rather easier. That is, if the leakage trouble in ammonia plant is eliminated and the shut down days by electric failure and shortage of Lignite supply are switched over to the scheduled repairing of the whole factory.

4-2-3 Operation record

To clear the operating situation, the operation records were rearranged according to following items. (Table 4-2-3)

(a) Monthly production

(b) Stabilized operation days in each month

(c) Stopped times in each month

(d) Max. production per day of each month

(e) Max. production by one continuous operation of each month and the number of days and the average of the continuous operation.

Table 4-2-3 Operation record

1970	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	AVE.
Monthy production T/M	1915.	1258.	886.	1095.	1151.	1521.	1165.	1288.	1408.	1307.	1140.	663.	1233.
Steady prod. days	24	17	11	14	14	21	14	17	19	17	15	6	15.8
Plant shut down times	2	3	3	5	5	2	5	6	3	3	3	5	3.8
Max prod. T/DAY	93.8	62.2	60.8	63.1	63.5	61.3	61.8	62.5	61.1	65.1	60.7	82.6	66.5
One series days/prod.	23/1487	17/1023	11/642	4/237	5/299	19/1080	12/707	13/732	16/902	23/1310	(*1)	3/226	133/786
prod. Ave prod. T/D	65.	60.	58.	59.	60.	57.	59.	56.	56.	57.		75.	60.2
1976													
Monthly production T/M	1749.	1192.	1034.	597.	(32.)	787.	896.	958.	444.	-	782.	1053.	949.
Steady prod. days	22	9	9	4	0	1	4	5	1	-	8	9	7.2
Plant shut down times	3	6	6	6	(2)	6	5	9	2	-	4	4	5.1
Max prod. T/DAY	81.2	82.7	70.5	71.5	(22.)	63.7	62.7	58.6	61.0	-	68.3	70.2	69.0
One series days/prod.	15/960	7/345	5/293	6/293	-	3/130	8/334	6/281	3/147	-	5/286	8/399	6.6/347.
prod. Ave prod. T/D	64.	49.	59.	49.	-	43.	42.	47.	49.	-	57.	50.	52.5
1977													
Monthly production T/M	956.	1079.	(16.7)	1002.	673.	1156.	1480.	1145.	967.	1002.	-	451.	998.
Steady prod. days	8	12	0	6	7	11	19	8	8	11	-	3	9.3
Plant shut down times	7	3	-	5	3	7	3	5	6	3	-	5	4.7
Max prod. T/DAY	71.0	80.3	-	68.3	70.7	72.4	77.6	72.6	63.6	69.0	-	69.3	71.5
One series days/prod.	5/297	6/319	-	6/257	8/398	17/1069	11/663	8/446	5/241	7/359	-	3/115	7.6/416
prod. Ave prod. T/D	59.	53.	-	43.	50.	63.	60.	56.	48.	51.	-	38.	54.8

*1 one series 21/OCT ∿11/NOV

Considering the table 4-2-3 following facts are obvious.

(i) The potential of ammonia production rate in these days is 70 ~ 80 T/day.

(ii) The continuously operationable days is 5 ~ 10 days by recent operating conditions, yet it should be expectable to operate continuously more than 10 days if the trouble would be caused only by gasification plant. The fact is obvious, considering the operation record of 1970, when the troubles of ammonia plant were few.

(iii) It is supposed from the past operation records that the potential of continuous operation days is 20 days.

Further the situation of Mae Moh factory observed during our stay in Mae Moh is as follows.

(i) The operation was extremely unstable. Especially it was in ammonia plant. (Survey team has recommended and instructed the modification of steam control system and N_2 mixing control system, to stabilize the operation. Including these modification the recommendation to stabilize the operation are explained later.) Consequently, while the syn.gas was provided enough quantity to produce more than 70 T/day from gasification plant, the production was not sufficient.

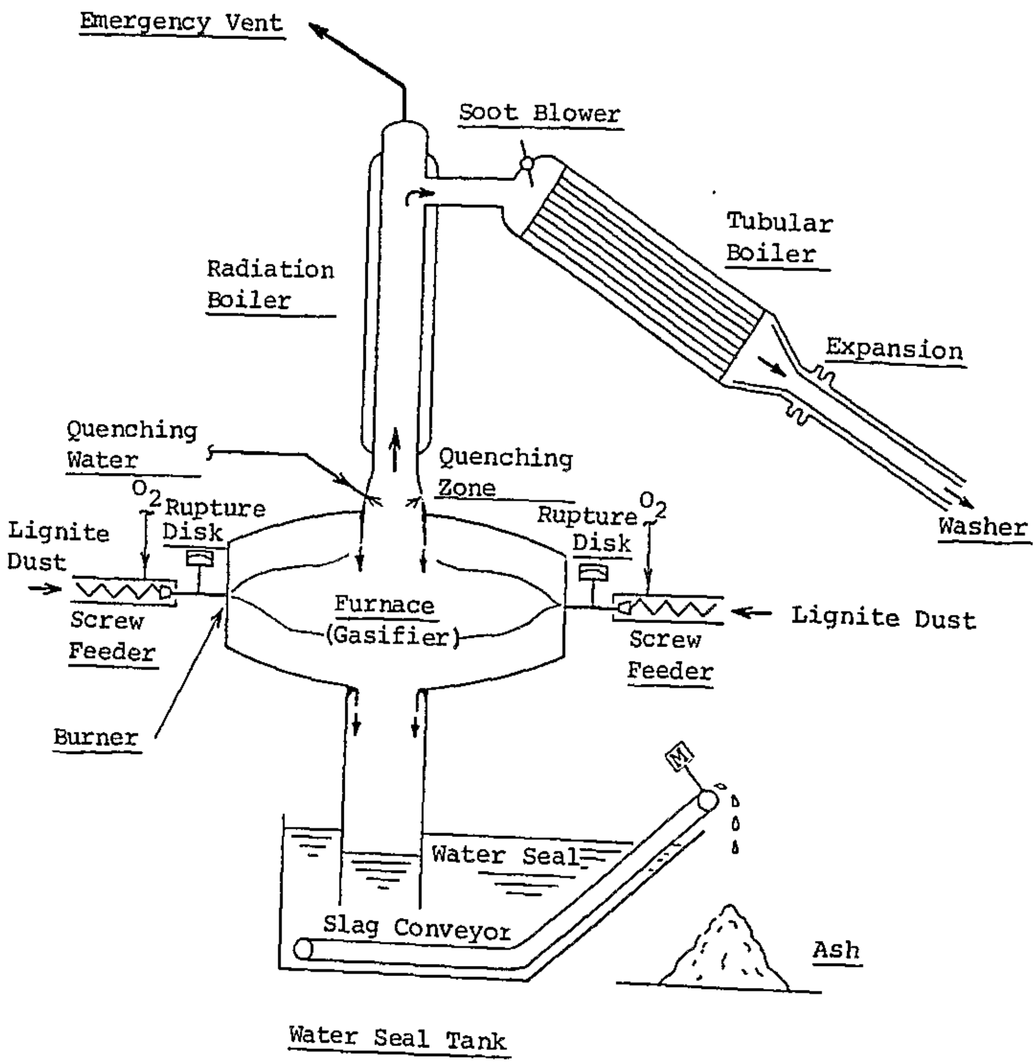
(ii) The most important improvement to increase the production is to reduce the number of the plant shut down and that is to reduce the trouble of leakage in the ammonia plant.

4-3 Problems of each plant

4-3-1 Gasification plant

Among the problems decreasing the operation rate of Mae Moh factory, the process, which has the fundamental problems, is the gasifier and tubular boiler in gasification plant. Hereinafter the problem shall be discussed fully.

Gasification unit



Process flow

Lignite dust (pulverized coal) is fed to burner by screw feeders. Oxygen gas (O_2) is mixed to Lignite dust at just upstream of the top corn of screw feeders, and it acts as the carrier of Lignite dust passing through the inlet pipe before burners. The mixture is fed into the furnace. The Lignite dust is oxidized partially in the furnace and produced the synthesis gas, and which is led to radiation boiler installed on the center of furnace through the quenching zone. The ash component from Lignite is molten state in the furnace and a part of molten ash flow down along the furnace wall and drop into the seal tank. In the bottom of seal tank, a conveyor is installed and the ash, cooled and solidified by sealing water, is carried out by this conveyor. The furnace pressure is controlled to +100 mmH_2O and sealed by water.

Ash carried with gas is also melt condition and is cooled down to 900 ∿ 1000°C by spray water when the mixture passing through the quenching zone. The fly ash should be solidified at here. (furnace temp. 1600 ∿ 1700°C and melting point of ash 1350 ∿ 1450°C)

The syn.gas out of quenching zone pass through the radiation boiler and is cooled to 600 ∿ 700 °C. The heat of gas is recovered as 10^K steam. Further the gas is cooled in the tubular boiler to 350 ∿ 450 °C. The heat is recovered as 10^K steam. The radiation and tubular boiler are in one set of steam system. The effluent gas of tubular boiler is sent to washer via the castable line.

During operation, solidified ash is hung, like as icicle, at the edge of quenching zone inlet and seal tank inlet. Operators are sticking off and down these icicle every 2 hours from peeping hole using a iron pipe. And at the top of tubular boiler, a soot blower is installed which blow away the ash accumulated on the tube sheet.

The problems, causes and their countermeasures are summarized in next table.

Problem	Cause	Countermeasure
1 Rupture disk exhaust (upstream of burners)	1 Back fire	
	a Inequality of 4 burners	• Maintenance of O_2 flow meter, screw feeder and back pressure gauge
	b Back fire from the lack of gas speed	• Load of 50% is the min. flow of burners
	2 Blockade of burners	
	a Mal-flame of burners (by errosion of burners port)	• Maintenance of burners • Control of Lignite dust size (<90μ)
	b Leakage of water jacket of burners, molten ash solidified on burners port	• Maintenance of burners • Watch the flame condition
	3 Overload	
	a Overload of Lignite in screw feeders	• Maintenance of corn and its clearance of screw feeder • Maintenance of revolution speed meter • Control the pressure of service bin
	4 Superannuation of disk	• Maintenance and periodical replacement of disk
2 Blockade of gasifier	1 Malcombustion by the oversize of Lignite dust	• Control of Lignite dust size (<90μ) by maintenance of hammer mill
	2 Inferiority of burners	
	3 Low furnace temp.	
	a Insufficient quantity of O_2	• CO_2 in effluent gas be 11 ∿ 13% • Pigeonhole the operation record
	b Overplus of moisture in Lignite	• Lignite dust size by under 90μ • Outlet temp of hammer mill is 120°C
	C Oversupply of spray water	• Pigeonhole the operation record • Radiation boiler inlet temp. be 800 ∿ 900°C • Furnace center temp. be 1400 ∿ 1500°C
	4 Malfunction of spray nozzle	
	a Leakage of water from tip conn.	• Test the spray before installation
	b Malfunction of nozzle	• ditto /the droplet size be smaller than 100μ
	c Inadequate nozzle position	• Correct utilization of stopper
	5 Malfunction of sticking	

Problem	Cause	Countermeasure
3 Trouble of slag conveyor	1 Formation of big block of slag by malfunction of sticking	
	2 Deterioration of equipment	• Extreme corrosive condition in seal tank Periodical replcement of equipment is required • Sufficient quantity of overflow water is required • Rearrangement of working circumstances arround the sealtank
4 Increasing of pressure drop in tubular boiler	1 Malcombution of oversized Lignite dust	
	2 Touch the molten fly ash to the tube sheet and its adherence	
	a Malfunction of spray	• See 2-4
	b Too high temp. of furnace	• See 2-3, The cause and countermeasure is reverse of 2-3
	c Insufficient cooling in the radiation boiler	• Periodical cleaning of radiation boiler
	d After burning of gas by the leakage of air	• Tight test
	3 Blockade of connecting short pipe between radiation and tubular boiler.	• Periodical cleaning
	a Increment of gas speed to tube sheet	
	b Drifting of gas flow	
	4 Tubular boiler tube	
	a Insufficient cleaning at periodical cleaning	• Improvement of cleaner or replacement of cleaner • Complete check after cleaning
	b Malrepairing of tubes	• Replacement of tubes • Improvement of welders technic • Improvement of repairing procedure
	5 Malfunction of sootblower	
	a Malfunction of nozzle	• Replacement
	b Leakage of cooling water	• Replacement and tight test
	c Insufficient quality of steam	• Heating up of steam line: Lighting to check the blowing steam Insulation of steam line Installation of steam trap
	d Air leakage into the chamber	

From the table it is comprehensible that the blockade problem of gasifier and the tubular boiler is the contrary relation, that is, when the temperature of gasifier is increased, the trouble of gasifier blockade would be reduced yet reversely trouble of tubular boiler would be increased. Therefore the temperature range of furnace to settle these contrary problems is narrow. Neverthless it is very difficult to prepare the uniform quality of Lignite, therefore it becomes difficult to adjust and to keep the optimum furnace temperature. Usually in the world the idea to install the stand-by gasification unit is adopted to get the continuous operation. When the one gasification unit had troubles, the stand-by unit should be started and switched without shut down of the downstream processes.

Survey team has studied this idea to provide the stand-by unit and concluded that it is too early to install one more gasification unit, because of;

(1) The investment to install the stand-by unit is estimated around 100 million baht and, by present situation of Mae Moh factory existing a lot of problems in other plants, the advantage to provide stand-by would not be exhibited satisfactory.

(2) To operate the stand-by unit, the increment of operators are required and to prepare the skilled operators available for this plant, the training term of 2 ∿ 3 years long is supposed.

(3) To construct the stand-by plant near by existing plant, it is required to shut down the existing plant more than 2 months to level the area.

It is recommendable to consider again these subjects when the problems in other plants will have been settled and the gasification plant will be distinct as the bottle neck of Mae Moh factory.

Therefore at present it is recommendable that the effort to raise the operation rate should be concentrated to keep the better conditions of equipment and to establish and accumulate the know-how for longer continuous operation.

Instrument of gasification plant

The instrument in this plant, as a whole, are superannuated extinguishly and recommendable to be renewed. The lack of reliability and frequently occuring troubles instrument are disturbing to establish the operational know-how and to operate the plant carefully. When the instrument would not be renewed it is supposed that the operation is not only proceeded smoothly but also is dangerous. The instrument list and the specifications are described in later chapter.

NO Removal Tank

The NO Removal Tank of gasification plant is called as to remove nitrogenoxide (NO) in the gas, yet it is supposed that the foundamental purpose of this equipment is to remove the dust in the gas. Survey team has analysed the NO concentration in the gas following to the analysis method of JIS K-0104 and the NO in the gas was not detected. The washing water flowing in the washer, which is installed at the downstream of tubular boiler, is saturated with calcium compounds come from ash and accordingly it is alkaline solution. Therefore the acidic component such as H_2S or NO in the tubular boiler effluent gas are resolved into the washing water. Actually H_2S in the gas to be existed by the extent of a few percent following to the material balance of Lignite and gas, yet the analysed results were several hundreds ppm. On the other hand, the dust is existing in the gas out of washer and it is inducing the blocking troubles on the absorber of desulphurization plant and filters of synthesis gas compressors in ammonia plant. In this time survey team has designed to remodel this tank for the dust filter. The drawing is attached in the report of machine maintenance. By this remodeling the dust trouble should be eliminated remarkably.

Grinding section

The explosion had taken place twice at the finished dust bunker in the grinding section during our stay in Mae Moh. The damage of equipment were not serious. The cause of these accidents was supposed due to the penetration of air into the equipment and combustion by the spontaneous ignition or static electrical ignition. These causes are really possible and many accidents had been experienced in similar processes. Survey team had recommended to inactivate the Lignite dust in the equipment by sealing them with N_2 gas and to convert the old deposed tower into N_2 gas reservoir as emergency source of N_2 gas. On the actual remodeling works of old tower, survey team instructed the procedure. Against the static electric problem, survey team has instructed to repair the bonding of grounding and to install new grounding electrode.

4-3-2 EGAT BOILER

This boiler has following 4 problems.

(1) Providing the instrument

(2) Steam generation rate

(3) Pressure control of steam

(4) Deterioration of equipment

This boiler has been scarcely provided the instrument and the instrument exisiting have been already superannuated as they are not fit to use. In this report, it is recommended to improve the level control system of drum and to renew the gas analyser.

This boiler was designed for electric power generation and the normal steam generation rate was 26 T/H, but in these days, as described formally, the generator had not been used and also the machine could not be used again. Therefore the steam generated by this boiler is consumed only in Mae Moh factory and the consumption is max. 12 T/H and normal is 8 T/H. The steam generation rate of 8 T/H would be the minimum operationable load of this boiler. Therefore operator should take care themselves not to reduce the load less than 8 T/H. The control of steam pressure is also very difficult, because the steam generation rate is too low to control the pressure. Therefore we think that to vent the steam of 3 T/H continuously to control the steam pressure and steam generation rate. However, this idea has the defect on economy of steam, therefore we would like to only suggest the idea here.

The material used in this boiler is mainly carbon steel and the operation temperature of this boiler is the maximum usable temperature of the material. We instructed to repair the crack appeared on the header of steam desupper heater. We recommend to inspect the same points of operating boiler (No.1 boiler) and to keep the limitation of material.

4-3-3 Feed water plant

In this occasion, survey team instructed to modify the steam pressure control system and the modification was successed that the steam pressure was stablized extremely. Yet the control valves are supperannuated and to be replaced. The detail of recommendation are explained in instrument report.

4-3-4 ADIP PLANT

Adip plant has two problems, one of them is adhesion or blocking of tower inside by fly ash carried with syn.gas. This problem would be settled by the remodeling of NO removal tank in gasification plant.

The another problem is the breaking of the lowest tray in adip regenerator. The breaking of the tray was caused when the steam was charged to reboiler nevertheless the level of adip solution in regenerator was extra high. We recommend a trip system to cut off the steam to reboiler when the level becomes extra high or adip pumps, which pulls out the solution from generator, are stopped. (About the detail of plan, refer the instrument report)

4-3-5 Air separation plant

Air separation plant has 4 problems.

1. Air compressor
2. Switching valves
3. Instrument air
4. Insuration and spare parts

When the trouble had taken place in this plant, whole plant were forced to be stopped for long time. It is obvious from the operation records. And the causes of trouble were mainly come from air compressor or the switching valves of regenerator. Air compressor is very high grade machine for Mae Moh factory and it had never been overhauled after its construction. The overhaul should be put in force while the instruction by the specialist is required.

The troubles of switching valves are typical of these kind plant and the trouble have been usually solved by periodical replacement and repairing of the valves. Therefore the preparation of spare valves and their atachments are very important.

The capacity of drier and other equipment for instrument air had been already become dificient, and the regeneration of drier had been regulated manually. Therefore the quality of instrument air is bad as to induce the deterioration of instrument as explained in instrument report. Moreover emergency air compressor which is driven by diesel engine, had been already damaged its auto-stating device and also the capacity of compressor is not sufficient.

As above explained, the quality and quantity of instrument air is not satisfied and especially at the electric failure the whole factory would be passed the critical situation. Therefore it is recommendable to install a new instrument air apparatus. As for recommendable spec. of apparatus please refer the machine maintenance report.

The cold insulation of this apparatus was deteriorated as to be replaced. By the renewal of insulation, the performance of air separation plant will be improved and the time required to start up the plant will be reduced.

4-3-6 Ammonia synthesis plant

Obvisouly, by past operation records, the major causes deteriorating the operation rate are due to the problems of gasification plant and this ammonia synthesis plant. The problems of ammonia synthesis plant are mainly the superannuation of equipment, and the plant had been forced to shut down by the leakage of pipings, towers and vessels. Since high pressure and high temperature combustible gases are treated in this plant, when the leakage have once been taken place, it is very difficult to repair the leaked point and moreover the leakage will be increased when the operation will be continued and it will induce the possibility of explosion. Therefore usually in this plant, when the leakage of gas had taken place, the plant should be shut down immediately and reduced its pressure and changed the gas into nitrogen.

Recently in Mae Moh factory, the repair and replacement of major equipment have been proceeding. Actually the separators and coolers of synthesis gas compressors and heat exchangers and towers in CO conversion section, which were corroded seriously, have been replaced. And also in this occasion of inside inspection, we instructed and repaired ourselves the replacement of demoisture's upper half and expansion bellow of heat exchanger.

In such a manner the maintenance of major equipment were advanced, yet the maintenance of branched small piping or inconspicuous parts of piping had not been sufficient. From hence the maintenance of these terminal piping should be put in force. When these maintenance would be neglected, the operation rate should never be raised. The maintenance will be very easy (in view of economy and technique) compairing to maintenance of major equipment, and the matter to be taken care in this maintenance jobs is to make the plan systematically and not to leave behind anything to be replaced.

The instrument in this plant have some problems of thermometers and analysers, yet the condition of instrument is far the better comparing to other plants. In this occasion we instructed to install the new automatic control systems of N_2 gas mixed to syn.gas. They are the control system of nitrogen compressor discharge pressure in air separation plant and the control system of nitrogen flow rate. Same as the steam pressure control system in feed water plant, these control system were planed by the first survey team and applicated second team. Just after these installation, operators were a little confused on practice, yet after they were acquainted with the systems, the operation was stabilized remarkably. The spec. of these instruments were described on instrument report, considering the maintenance in future.

There are several big and high grade rotating machines in this plant and they were maintained satisfactorily by skillful technicians. The preparation of suitable spare parts will be the future problem to be solved.

Further, synthesis gas compressor was stopped by the trouble of electrical sequence during our stay. The start-stop sequence of the motor had been investigated. In the last of our investigation we could not define the cause of the motor trip, and we estimated that the cause might be attributed to the flactuation of electric source regulating the sequence or the malfunction of the relay. The reason why we could not indentify the cause was the circuit drawings had not be kept sufficiently and also the circuit itself already remodeled without the revision of the drawings. In future the sequence should be rechecked synthetically. The detail of investigation was written in electricity report.

4-3-7 Urea synthesis plant

In this factory, the pipings of CO_2 compressor were destroyed by the explosion on May, 1978, and during our stay in Mae Moh, this plant had been operated only a week just before we left Mae Moh.

The biggest problem in this factory is the maintenance of reactors, i.e. the material for the coil in the first reactor and the lining in the second reactor is used special stainless steel and, for the repair of these material, special care is required. Since the header (mixer) of the coil and the shoulder portion of lining had been fabricated and repaired by technicians in Mae Moh without such the knowledge and so the conditions of the equipment were not satisfactory. In these days continuous inspection and repair are required and until 1980 these portion should be replaced under the supervision of the specialists.

Regarding the cause of CO_2 compressor piping explosion, we estimated that the mal-function of dampers in CO_2 drying unit had induced the explosion, i.e. at the time the damper to be opened was not opened and the damper to be switched over was not switched only just change its position a little, therefore the air,used for regeneration of drying agent, was sucked into CO_2 compressor instead of CO_2 and the air and lubricating oil made a combusible mixture in the discharge line of compressor, then the mixture was ignited by some of the shock in the machine and exploded. Survey team instructed to provice a divice which detect the mal-function of dampers and force to stop the compressor. As for the detail please refer the instrument report.

As for the maintenance of other equipment please refer the machine maintenance report.

4-3-8 Sulphuric acid plant

There are several problems caused by corrosion in this plant. These problems might be fate of sulphuric acid plant. Following equipment are the major problems of this plant.

(1) Waste heat boiler

(2) Shell of reactor

(3) Heat exchanger in reactor

(4) Absorber and drier

(5) Stack

The situation of damaged tower and vessels are discribed in machine maintenance report. The common problems of repairing among those equipment are as follows.

(i) They are big jobs.

The repairing machines in Mae Moh factory such as crane car has not enough capacity to perform the listed repairs.

(ii) They are special jobs.

Each job has contained some of speciallized technical problems. It is well understood in Mae Moh factory that these equipment are to be repaired, yet they had been idled because of they also understood the technical problems and the problems of repairing term, which is described next.

(iii) They require long terms for repairing.

Each job is big and moreover in this plant sulphure or sulphuric acid gas are treated which takes long time to sweep out from inside the equipment, therefore it is required 2 ∿ 2.5 months to repair the equipment including the days for start and stop the plant. The long term for repairing is one of the big problems for Mae Moh factory because of the demand of marketing sulphuric acid is very strong.

The problems of instruments are mainly existing in the lead pipes or lead wires for instruments. Usually the pipes and wires for instruments are connected putting in the ducts, from local to control room and vice versa, to eliminate the noise or corrosion of material.
However in this plant the ducts have been damaged already and the pipe and wires have been put disorderly around the equipment and they are in the condition easily to

be suffered the damage. They should be improved in full measure and this improvement would be also taken long term.

It will be big problem for Thailand that the repairing term shall be taken long term, because of the sulphuric acid from Mae Moh factory has been kept the important position in Thai chemical industries. Moreover, as described in later chapter of rehabilitation program, it is existing the possibility that the production of sulphuric acid would become to be the bottle neck of Mae Moh factory in future. Therefore the idea to install the new sulphuric acid plant and, after its complection, to carry out the repairing of existing plant, should be studied, taking the future demands of sulphuric acid in Thailand into consideration.

As for the repairing jobs, it is recommendable to invite the specialists to instruct the jobs, because if the repairing would be failed, the equipment might be suffered the serious damages.

4-3-9 Ammonia sulphate plant

There are no special problems in this plant. In this occasion, we have instructed the repairing of the centrifuge.

4-4 The organization and the technical level of Mae Moh factory

4-4-1 The number of workers and their technical level

The number of workers is reasonable, considering from our experience, or it is rather shorter. Although it should be discussed the correctness of the number of workers from the view points of the quantity and quality required to the workers, since there should be a lot of experiences and history before come to this condition, it is difficult to judge the correctness of the number of workers.

The technical level of operators is not bad. Their foundamental knowledge about the chemical and chemical engineering is not sufficient and required the further training in future. They are able to response rather correctly to the plant start up or shut down. Especially the shift leaders, they have the experiences more than ten years in Mae Moh, fairly response to the drastic change of operating conditions. The operators, who can and will response to the drastic change of plant conditions, are indifference to stabilize and to adjust the operating conditions strictly or to check carefully the machine or vessels during the normal operation. There might be not clear indications about those matter from the manager to them. Hence, on the operating conditions, the operational standards should be provided. The situation is same to technicians, they have the useful technique, observing them individually. However on actual repairing, they have been working without regarding the foundamental cautions on processes, equipment and repairing procedures. Moreover planning, careness and earnestness are insufficient on doing the jobs. The situation might be produced by the insufficient instruction and supervision from the managers.

4-4-2 Assistant manager

Assistant managers in each section of plant have their experiences more than 10 years long in Mae Moh, and enough knowledge on process and equipment. However it is regrettable that their experience and knowledge had not put to practical use. Assistant managers should utilize their knowledge themselves to educate and bring up the operators and technicians.

4-4-3 Engineers (Managers)

The number of the engineers and their technical level are not sufficient to keep the good operation of Mae Moh factory. Henceafter it is required to supplement the engineers and level up them.

During our stay in Mae Moh, we heard that the engineers will be recruited, yet the leading managers should understand that it will take at least 3 years long education before they will be brought up as skilled engineers,although they will be educated in the suitable circumstancies.

Survey team recommends to arrange at least one engineers for each plant, and especially for gasification plant and ammonia synthesis plant two engineers are recomendable, because of the troubles of Mae Moh factory were being concentrated in these 2 plants. Further at least two engineers are recommended for the machine workshop and instrument workshop respectively.

A good instructor should be provided to train the freshmen and existing engineers. Following subjects are expected to engineers.

(i) Management of every days operation

In present the operation data have been gathered, without utilizing them effectively. Henceafter to manage the plants adequately, the gathered data should be studied and fed back to plant operation.

(ii) Set up the operation standards

To stabilize the plant operation, the standards for operating conditions or procedures should be made clear and fixed by the managers (or engineers) after researching the past operation records and plant design conditions.

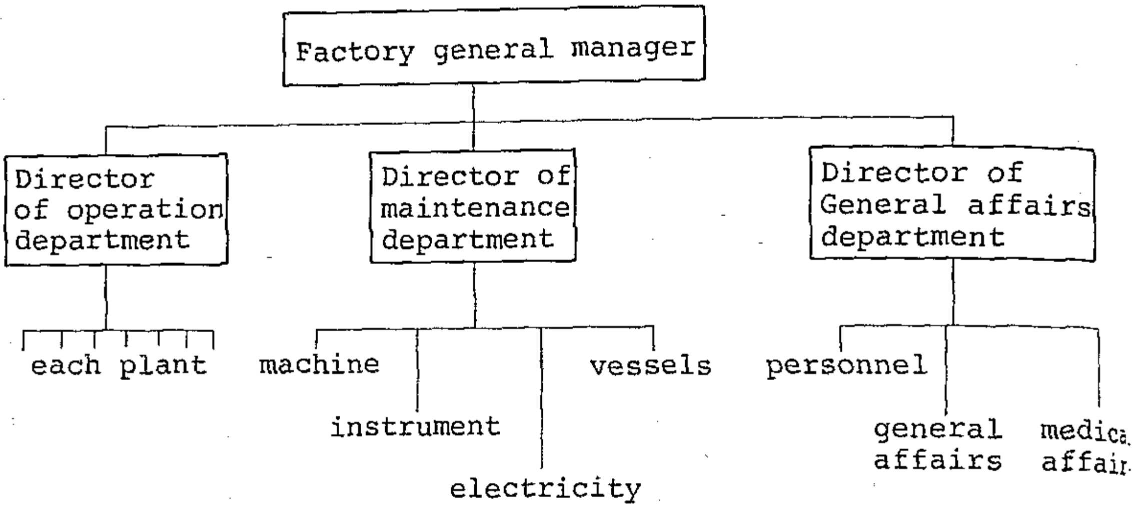
(iii) Analyse the plant problems and plan the countermeasures

Survey team are supposing that the plant problems and their countermeasures were wholly explained in this report. Therefore we are expecting to managers that they will study the detail of each job to put it in force.

4-4-4 Organization

Present organization of Mae Moh factory were too much expanded horizontally to keep the good communication among the plants and hence the communication troubles were disturbing the smooth operation.

We would like to recommend following organization.



The advantage of above described organization are:

(1) To make the simplified situation for the direction and the communication

(2) To make clear the each manager's responsibility

(3) To make the fine management of plant

(4) To make the good positions for engineers