5-4-10 Electrical Equipment

(1) Selection of Rated Voltage

The rated voltages of the various systems are to be as follows:

	300 MW x 1 unit		150 MW x 2 units	
	Sending End	Receiving End	Sending End	Receiving End
Transmission Line Voltage	132 kV	--	132 kV	—
Generator Output Voltage	18 kV	—	15k V	—
High-voltage Auxiliary Equipment Voltage	6.9 kV	6.6 kV	6.9 kV	6.6 kV
Low-voltage Auxiliary Equipment Voltage	460 V	440 V	460 V	440 V
Lighting Equipment Voltage	220 V	200 V	220 V	200 V
DC Auxiliary Equipment Voltage	110 V	100 V	110 V	100 V
DC Operating Circuit Voltage	110 V	—	110 V	—

(2) Generator Capacitor P_G

Calculated by

$$P_G = \frac{\text{Generator Rated Output (kW)}}{\text{Power Factor}}$$

the capacity was taken to be 353,000 kVA (in case of 300 MW x 1 unit) and 177,000 kVA (in case of 150 MW x 2 units).

(3) Capacity of Main Transformer

The capacity of the station service transformer was deducted with some allowance added, and the required capacity was calculated as given hereunder.

353,000 – 30,000 + 5,000 = 328,000 kVA
(in case of 300 MW x 1 unit)

177,000 – 15,000 + 3,000 = 165,000 kVA
(in case of 150 MW x 2 units)

(4) Capacity of Station Service Transformer

With an auxiliary power ratio of 8.5% and a power factor of 0.85, the capacity was taken to be 30,000 kVA (in case of 300 MW) and 15,000 kVA (in case of 150 MW), respectively.

(5) Capacity of Starting Transformer

Backing up by the station service transformer is considered, in addition to which the electric power required for trial operation of other units is considered and the capacity was made 50% larger [45,000 kVA (in case of 300 MW x 1 unit) and 22,000 kVA (in case of 150 MW x 2 units)] than the capacity of the station service transformer.

(6) Station Power Supply Structure

It was arranged to make it possible for high-voltage auxiliary equipment (6.6 kV) to be supplied from any one out of station service transformers, starting transformers and other units.

Low-voltage (440 V) auxiliary equipment is to be supplied from a power center divided into 4 parts which can be inter-connected. However, the coal transport facilities are to be provided independently.

(7) High-voltage Switchgear

Supply is to be made to large-capacity auxiliary equipment (about 200 kW or more) by 6.9-kV enclosed-type switchgear cubicles.

(8) Low-voltage Switchgear

Supply is to be made to auxiliary equipment of small capacity. The various control centers are to be located close to their loads.

(9) Direct-current Power Supply Facilities

The facilities are composed of charging equipment and batteries, and power is supplied for operation of auxiliary equipment, alarm issuing, protective interlocking and direct-current motors for emergencies.

(10) Emergency Power Supply Facilities

The facilities are composed of a diesel engine generator, and when the station service power supply is cut off due to reasons such as power station faulting, the aims will be:

1) Securing of power supply necessary for safety shutting down each unit

2) Securing of power supply necessary for re-starting units after clearing of fault

(11) Electronic Computer

The computer is made to memorize the operating condition with data typed out periodically and at demand times.

Data input of approximately 500 element/unit is considered.

(12) Telecommunications Facilities

The following are to be installed:

Automatic telephone apparatus inside power station premises	200 ch.
Telecommunications apparatus between power stations	5 ch.
Paging apparatus inside power station premises	70 speakers 130 telephone sets

5-4-11 Possibility of Operation of Turbine-Generator as Synchronous Condenser

It is considered technically possible for a turbine generator to be operated as synchronous condenser within the limits of the generating capability curve.

When a turbine-generator is operated as synchronous condenser, it must be separated from a steam-turbine. Several ways of "start-up" are conceivable. The start-up system by means of a synchronous induction motor would be realistic among said ways since it is most economical and has been used for a turbine-generator of small capacity.

In the event that a turbine-generator should be manufactured so that operation of a synchronous condenser can be made within the limits of the generating capacity curve, incremental costs of auxiliary equipment and start-up apparatus could be estimated at around 73 million Rupees. While installation of a synchronous condenser with the same capacity as that of reactive power of generator and installation of static condenser and shunt reactor will cost approximately 130 million Rupees and 135 million Rupees, respectively. Accordingly, operation of a turbine-generator as synchronous condenser would be more economical.

As described above, there exist actual records of having used turbine-generators of small capacity as synchronous condenser in the past.

However, the proposed turbine-generator will have a capacity of 300 MW for the project. Unfortunately, no actual records of having used such a big scaled turbine-generator as synchronous condenser have been observed. Therefore, it will be essential that WAPDA conduct careful and strict examinations prior to their finalization of employment of the turbine generator as synchronous condenser.

5-4-12 Powerhouse

The powerhouse as indicated in Figs. 5-10 to 5-12 is 3-story steel structure of building area 3,670 m^2 (300 MW x 1), 4,410 m^2 (150 MW x 2), and total floor area of 11,800 m^2 (300 MW x 1), 13,230 m^2 (150 MW x 2), with the building volume of machine hall 87,610 m^3 (300 MW x 1), 100,800 m^3 (150 MW x 2) – measuring by centers of columns.

The building is to be of dry construction in consideration of the advantages of lightening weight and shortening the construction period. In effect, the building is to be of steel construction with the exterior wall using steel sheets (with insulation material substrata).

The exterior wall up to the operations floor is to be reinforced concrete. The floor of each story is to be a reinforced concrete slab, but where opening is required for operation and maintenance, steel grating is to be provided. Partition walls in the interior are to be of reinforced concrete construction or brick walls depending on the degree of importance.

Windows are to have aluminum sashes, while accesses are to be provided with steel doors. Rooms accommodating precision equipment and rooms to be stationed by station personnel are to be provided with airconditioning facilities, and thermal insulation material is to be applied at surrounding walls of these rooms to minimize heat gain. Besides the above, lighting system, water supply and drainage system, sanitation system, fire extinguishing system, fire alarm system and ventilating system are to be provided the main power plant building.

In view of possible addition of Unit No. 2 in the future, the westside walls are to be made removable.

5-4-13 Foundations of Powerhouse and Major Facilities

The foundations of the powerhouse and major facilities such as the turbine-generators, boilers, induced draft fans, electrostatic precipitators, stacks, etc. should be supported from a layer of the ground which is sufficiently reliable from the standpoint of strength.

According to the present survey conducted by the JICA Survey Team, the power station site is covered by the Eocene Laki Limestone Formation, and it is judged to be possible to directly support the foundations of structures, and therefore reinforced concrete foundation is adopted.

However, since there is a strong possibility that this limestone formation has intercalations of marlstone and shale, it is suggested that a survey such as boring investigations and bearing capacity tests be carried out prior to the performance by WAPDA of definite design so that the results can be reflected in the detail design.

5-4-14 Administrative Building and Other Buildings

(1) Administrative Building

The administrative building, as shown in Figs. 5-14 and 5-15 is a 3-story reinforced concrete building having a reinforced concrete foundation.

The building area is 1,410 m^2 and the total floor area 4,230 m^2

The functions and uses of the administrative building consist of fuel testing & water analysis laboratory, security section office, storeroom, air-conditioning machinery room and clinic on the first floor, maintenance section, accounting section, drafting section and administration section offices, government labor, supervisor room, and training & coordination officer room on the second floor, and plant manager's office, deputy manager's office, telephone exchange room, data storage room, operations section offices (2 rooms), and conference rooms (3 rooms) on the third floor. Moreover, a connecting walkway is to be provided from the third floor to the main power plant building.

(2) Other Buildings

The buildings below are planned besides the above-mentioned administrative building.

The coal transport control building is to be a 2-story steel structure having total area of 1,200 m^2, the repair shop a single-story steel structure having a floor area of 1,800 m^2, and the water treatment plant and hydrogen generation apparatus house single-story reinforced concrete structures having floor areas of 300 m^2 and 150 m^2, respectively.The bulldozer house and the garage are to be single-story steel structures having floor areas of 300 m^2 and 280 m^2, respectively. The hazardous materials storehouses consist of two single-story steel construction buildings having a combined floor area of 380 m^2, while storehouses comprise four single-story steel structures of total floor area of 6,900 m^2. The guardhouse is a single-story reinforced concrete structure of floor area of 150 m^2. The gypsum storage is to be composed of two buildings of 1-story steel construction with a floor area of 3,000 m^2.

All the foundations of these buildings are reinforced concrete.

(3) Appurtenant Facilities of Buildings

Of the surrounding walls of the buildings, those of rooms accommodating precision instruments and of rooms where station personnel are stationed are all to be insulated thermally, and are to be provided with air-conditioning system.

Other than the above, lighting system, water supply & drainage system, sanitation system, fire extinguishing system, fire alarm system and ventilating system are to be provided.

5-4-15 Derrick Type Steel Stack

The types of stacks conceivable are reinforced concrete and steel stacks. Both have advantages and disadvantages with regard to constructability, economic nature, etc.

Generally, in case of a reinforced concrete stack, the following is said:

> When the ground conditions are favorable, there are many examples of construction up to around 100 m in height and there is no problem with respect to either economy or safety.

On the other hand, the drawbacks are said to be the following:

> The deterioration of concrete with time is greater than for steel, and in addition to inspection being difficult, it is not a simple matter to set up a measure to cope with the problem.
> It is difficult to collectivize a multiple number of stacks.
> It is difficult to line inside of the stack with insulation.

Where the ground conditions are poor, because of great weight and inferior earthquake resistance, the economy is poorer compared with steel.

The advantages of a steel stack are said to be the following:

Where the ground conditions are poor, it is easy to be earthquake resistant since weight including foundation is not so much as concrete stack.
Unlike with concrete, a steel stack can be directly lined.
Steel has little scatter in quality, and it is possible for parts erected in the field to be inspected and tested.
Discovery of and implementation of countermeasures against time-dependent deterioration and corrosion are easy.

The drawbacks are said to be:

The construction of superstructure is generally complicated and their construction period would be slightly longer.

The overall study of the aforementioned details has led to the conclusions that;

the proposed stacks are to be 150 m in height for minimizing the spreading of flue gas for prevention of possible air contamination in the case of Jamshoro site.

the steel towers for supporting the stacks are to be 14.0 m in height and stack shells 150 m in height, respectively. In the case of 300 MW x 1 unit, one stack shell will have a top diameter of 4.9 m and a bottom diameter of 5.4 m. When a scale of 150 MW x 2 units is adopted, two stack shells will be required and each of these shells will have a top diameter of 2.5 m and a bottom diameter of 3.5 m, respectively.

the lining of the stack shells will be provided with porcelain bricks in order to protect the surface of the stack shells from highly concentrated sulfuric oxides and will be sticked with acid-proof mortar.

and the foundations are of reinforced concrete.

5-5 Colony

As indicated in Fig. 5-16, a colonial area for WAPDA personnel (252,000 m^2) is to be provided adjacent to and south of the power station.

As the basic idea for the layout of the colony a public space is located at the center of it where the following are provided for convenience of daily life: 1 elementary school, 1 post office, 1 bank, 2 markets, 1 clinic, 1 mosque, 1 rest house, 1 garage, 1 clubhouse, 1 pump house.

For access to the colony, two access roads of 10 m width are provided from the national road (New Petaro Road). Roads (width 10 m or 6 m) which lead to the individual houses in the compound are provided with curves to avoid the monotony of a straight-line layout and to attempt to produce an appearance of the colony which is rich in variety.

The types of houses laid out are the following:

Type A	1 unit
Type B	7 units
Type C	25 units
Type D	43 units
Type E (Two rooms)	103 units
Type E' (Single room)	129 units
Type F	70 units
Total	378 units

It is assumed that the number of residential units to be constructed would be 60% of the number of power station personnel.

In consideration of the future extension (300 MW x 1 unit or 150 MW x 2 units), an additional space of 126,000 m^2 in the south of colony will be reserved.

Fig 5-1 GENERAL PLAN (300 MW)

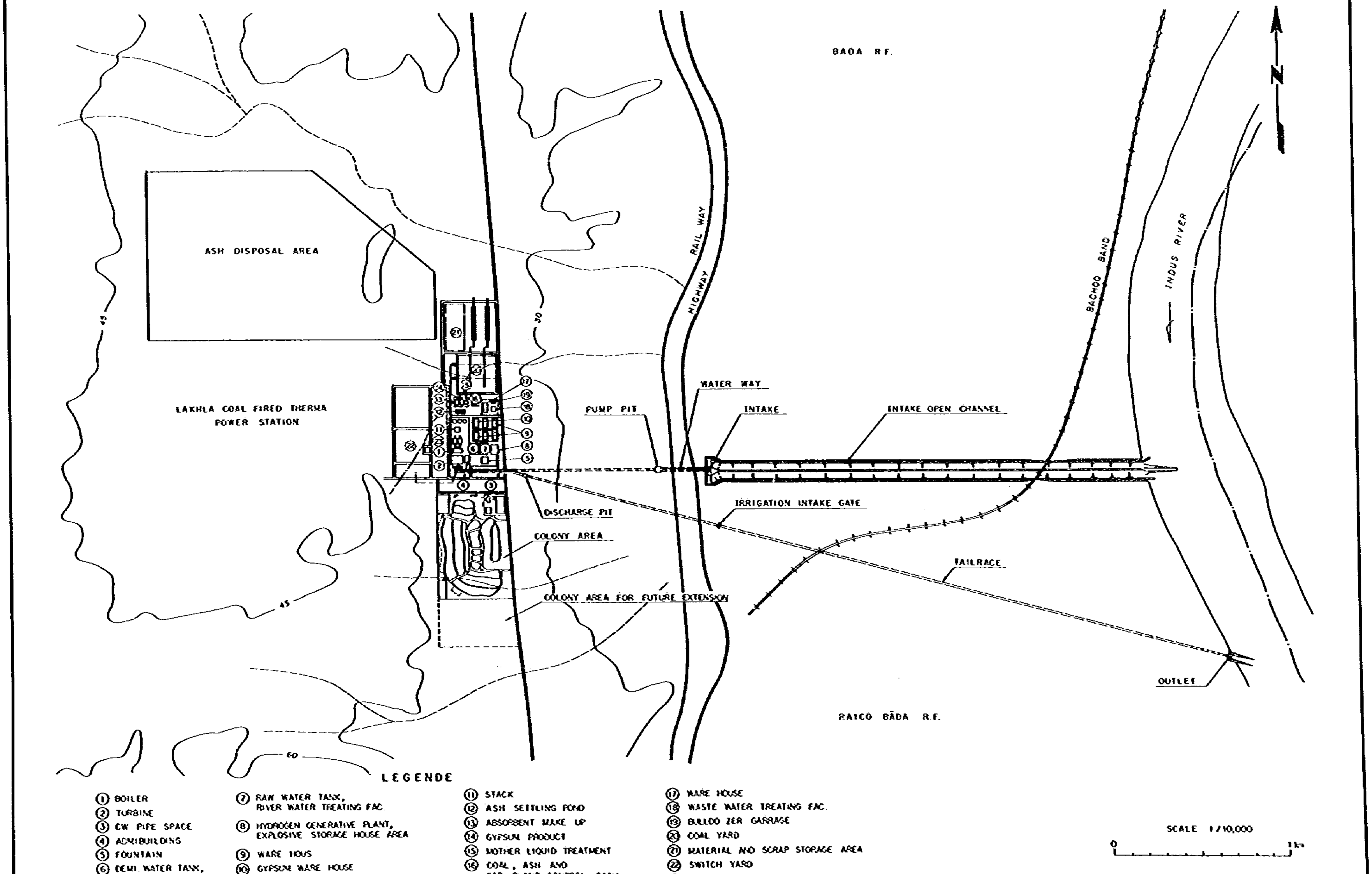
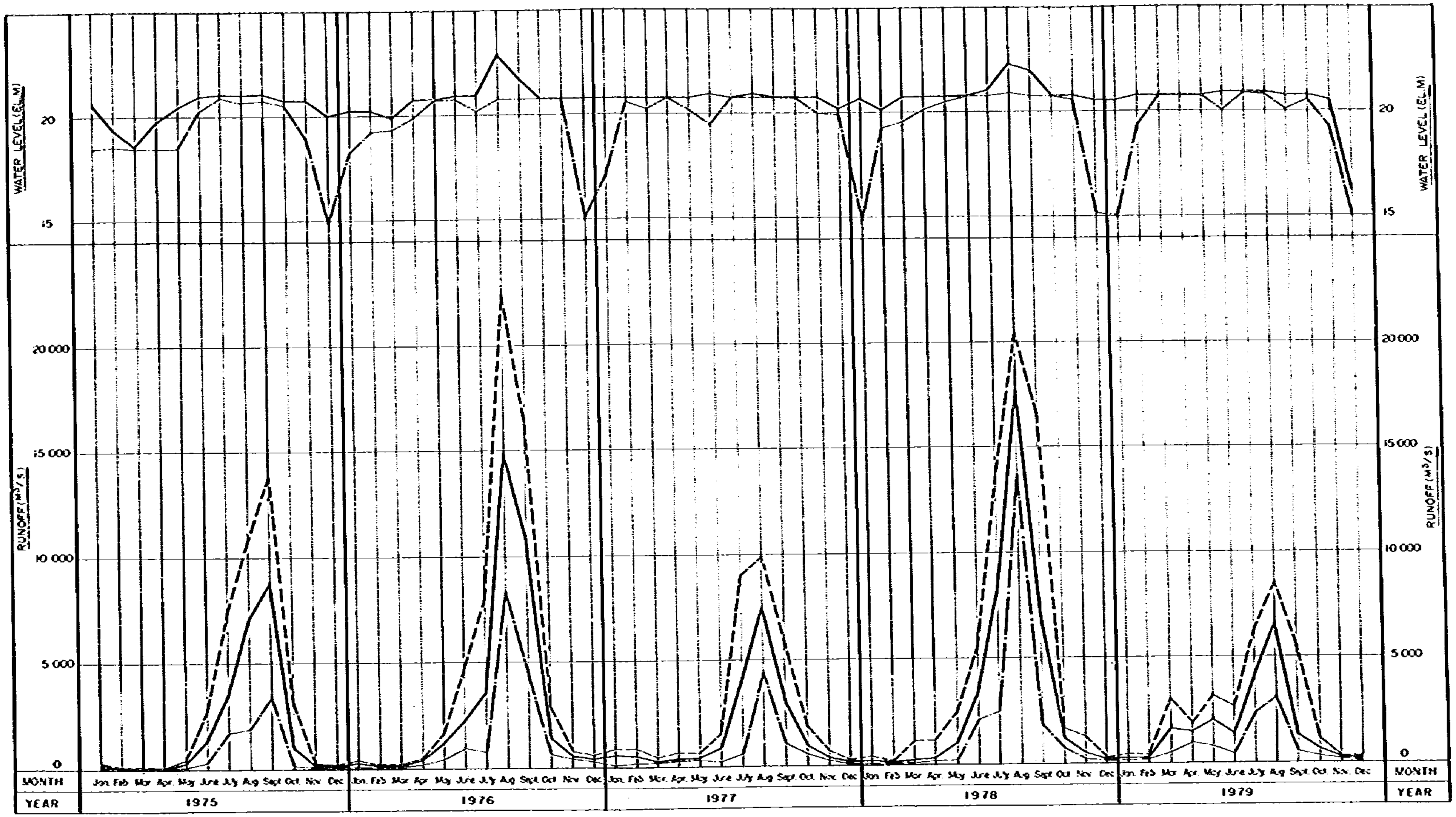


Fig 5-2 MONTHLY WATER LEVEL AND RUNOFF AT KOTRI BARRAGE



Note

Water Level	——	High Water Level	Max. Water Level = 23.73m
	–·–·	Low Water Level	Nor. High Water Level = 20.73m
Runoff	– – –	Maximum Runoff	Low Water Level = 14.84m
	——	Average Runoff	Crest Level of Kotri Barrage = 14.63m
	–·–·	Minimum Runoff	

Fig 5-3 CROSS SECTION OF INDUS RIVER

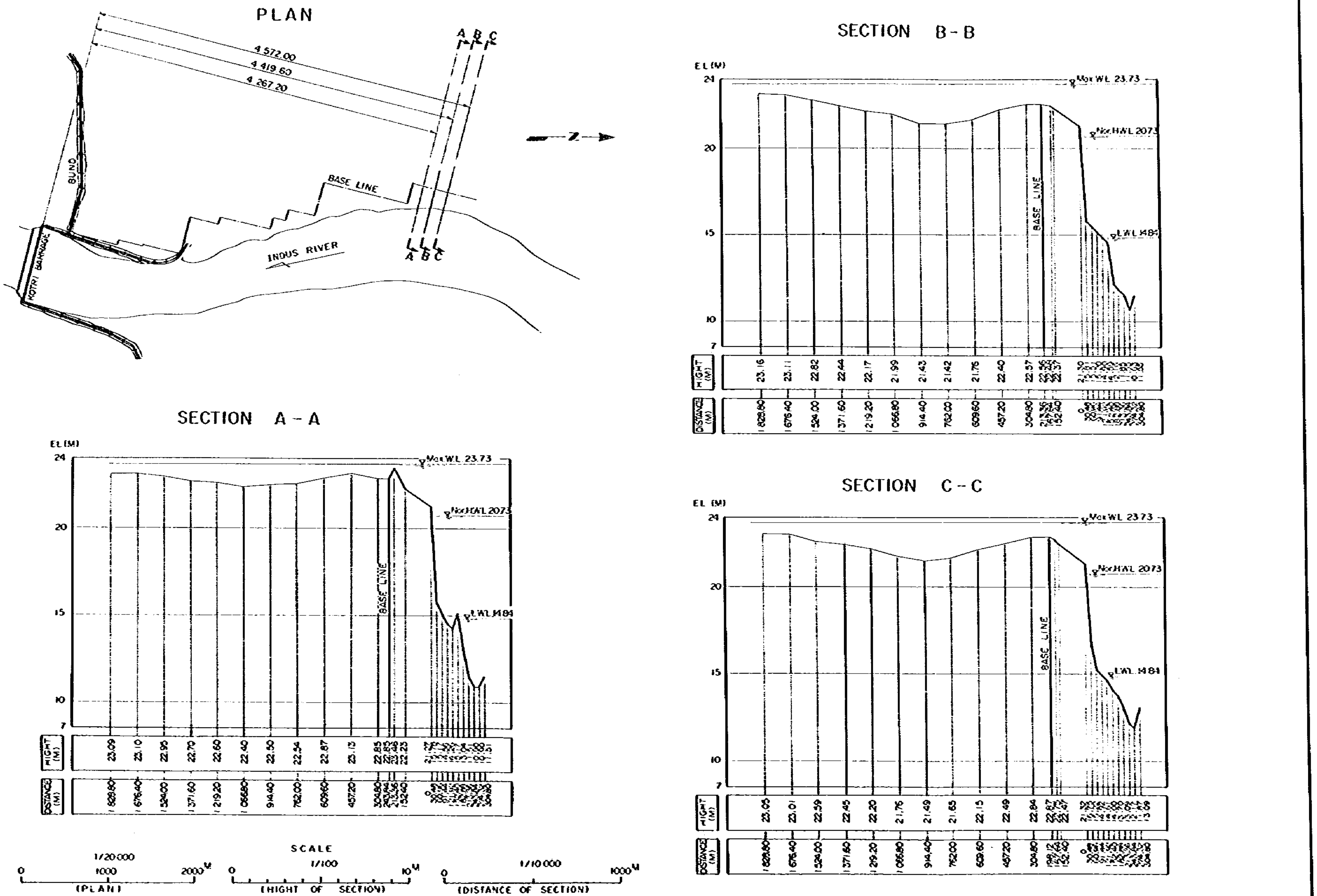
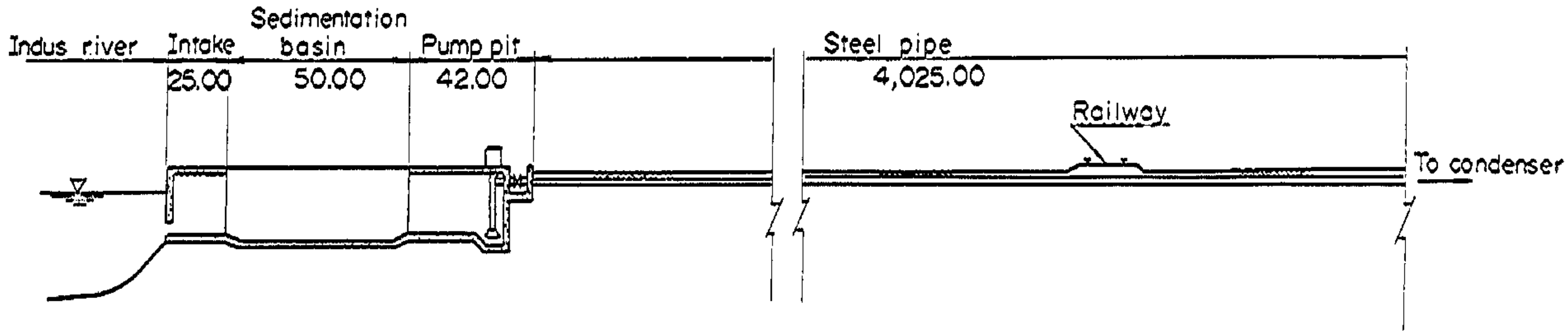


Fig. 5-4 CIRCULATING WATER SYSTEM

Case I



Case II

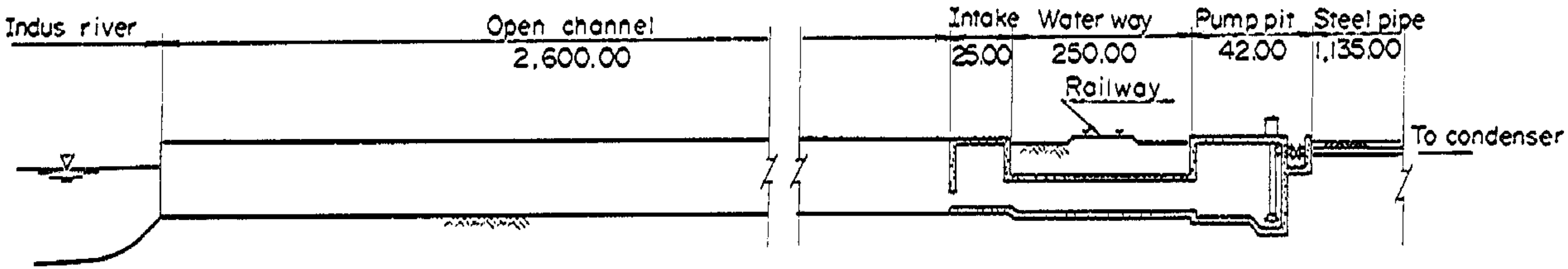


Fig 5-5 INTAKE OPEN CHANNEL

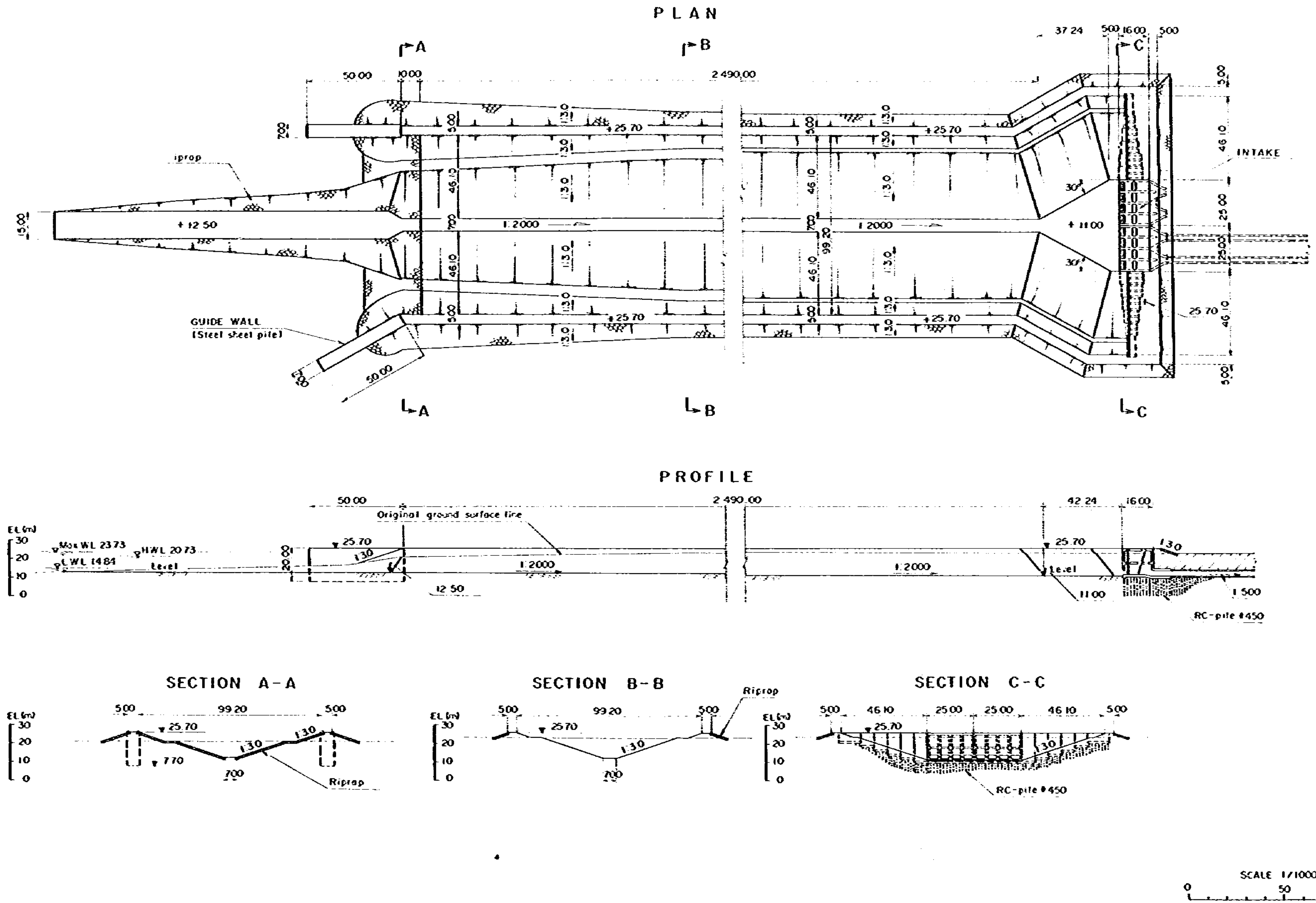


Fig 5 - 6 INTAKE, WATER WAY, PUMP PIT (300MW)

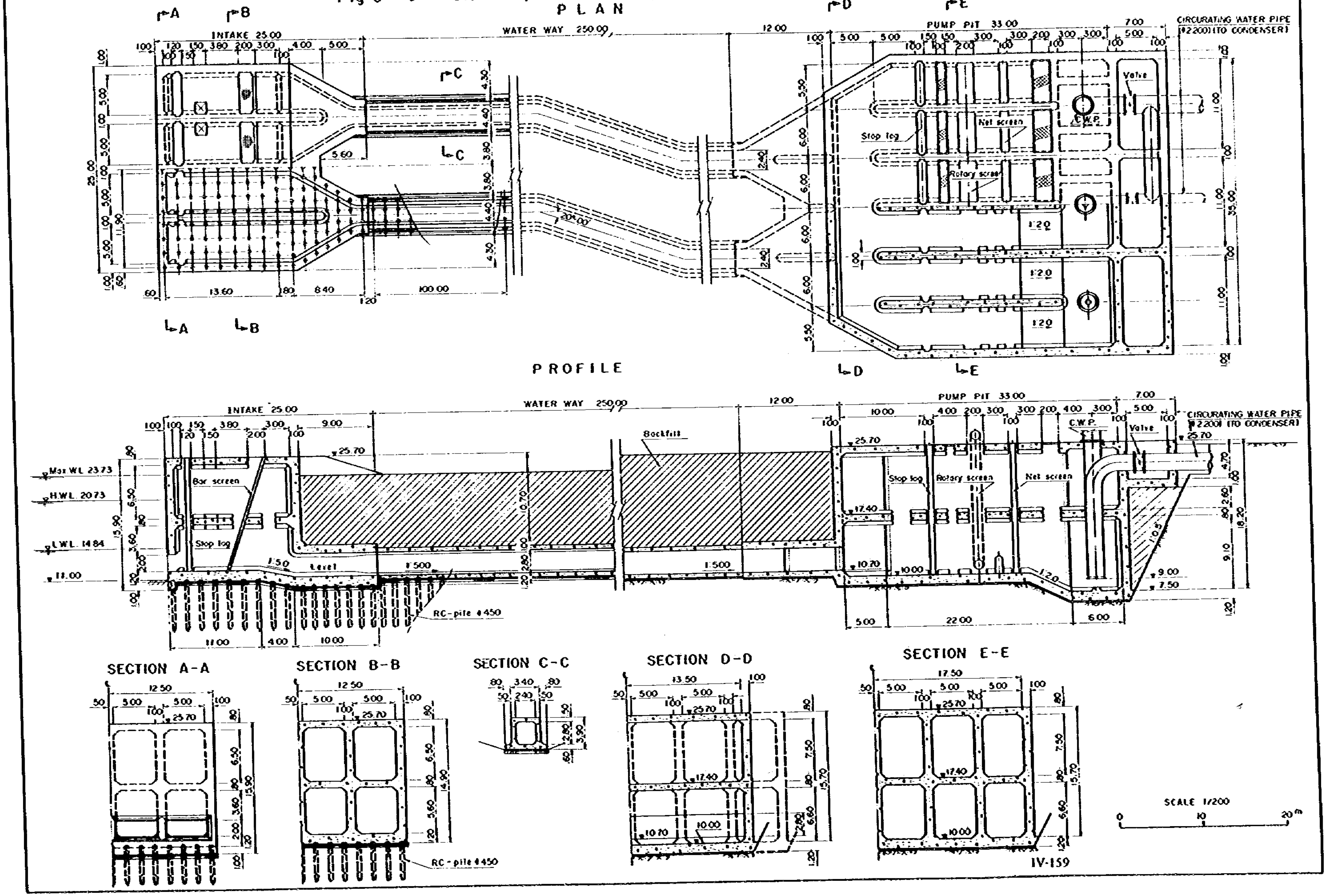


Fig 5 - 7 CIRCURATING WATER PIPE, DISCHARGE PIT, TAILRACE, IRRIGATION INTAKE, OUTLET (300MW)

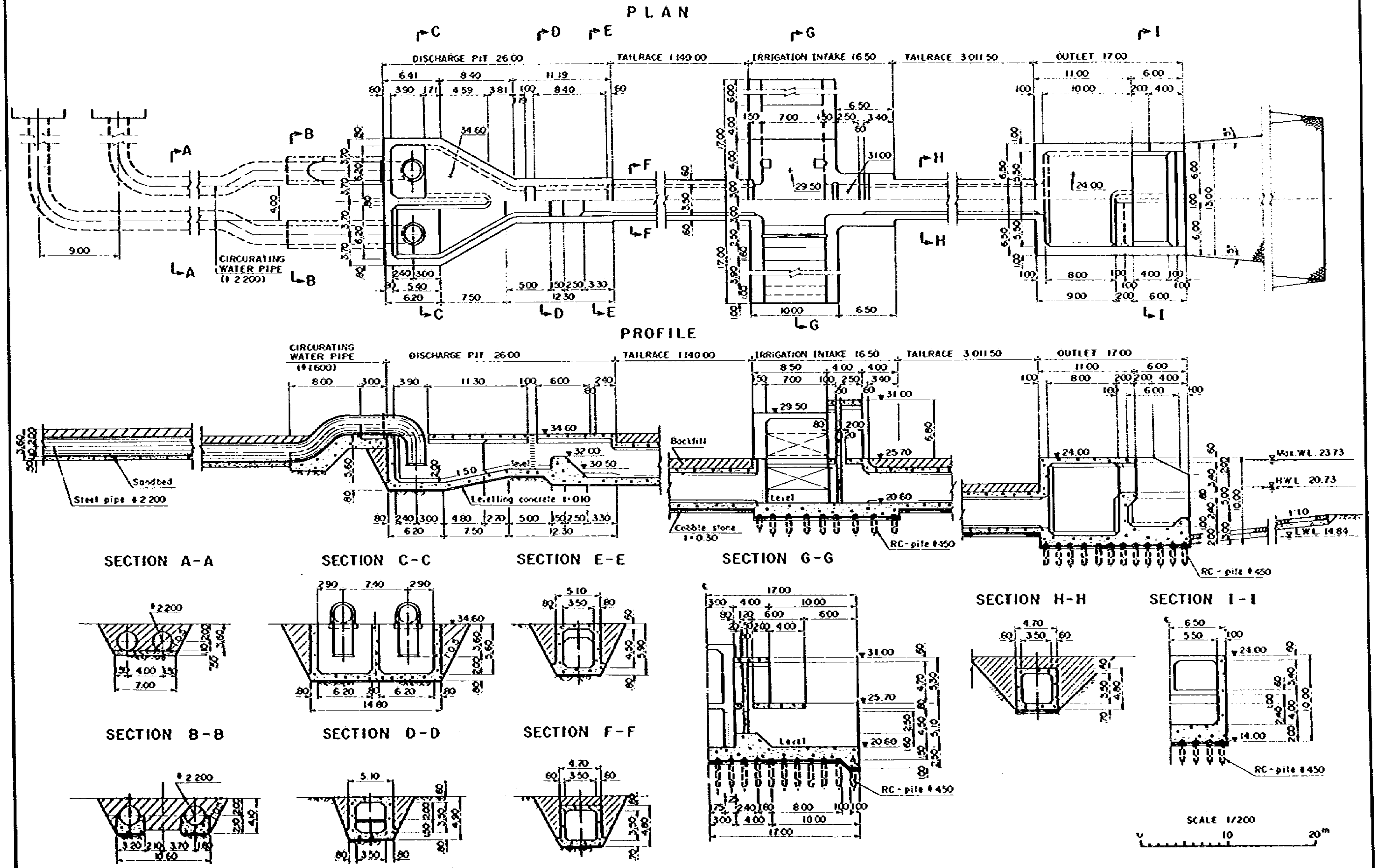


Fig 5-8 ASH DISPOSAL AREA

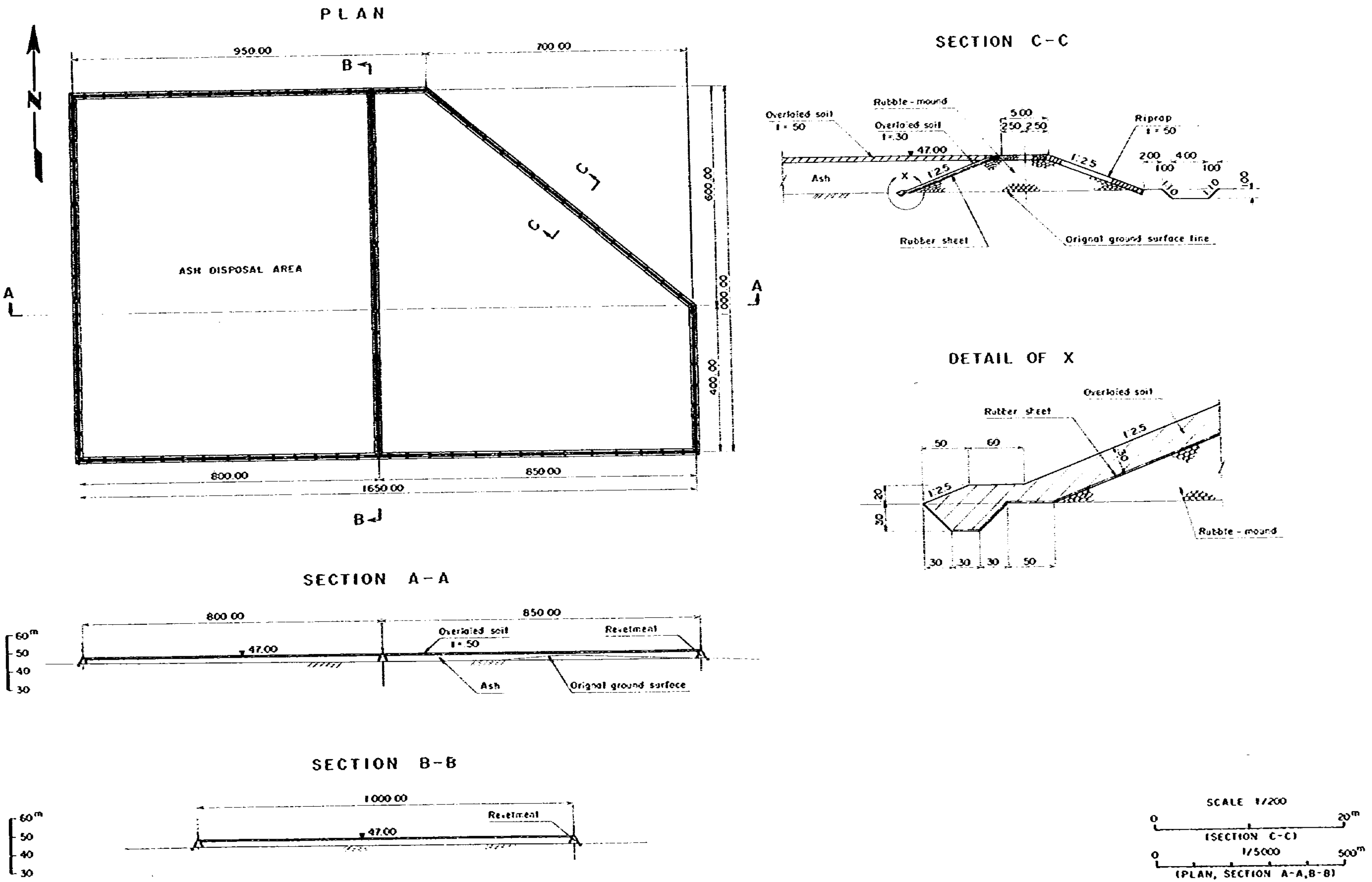


Fig. 5-9 LAYOUT OF LAKHRA COAL FIRED THERMAL POWER STATION (300 MW)

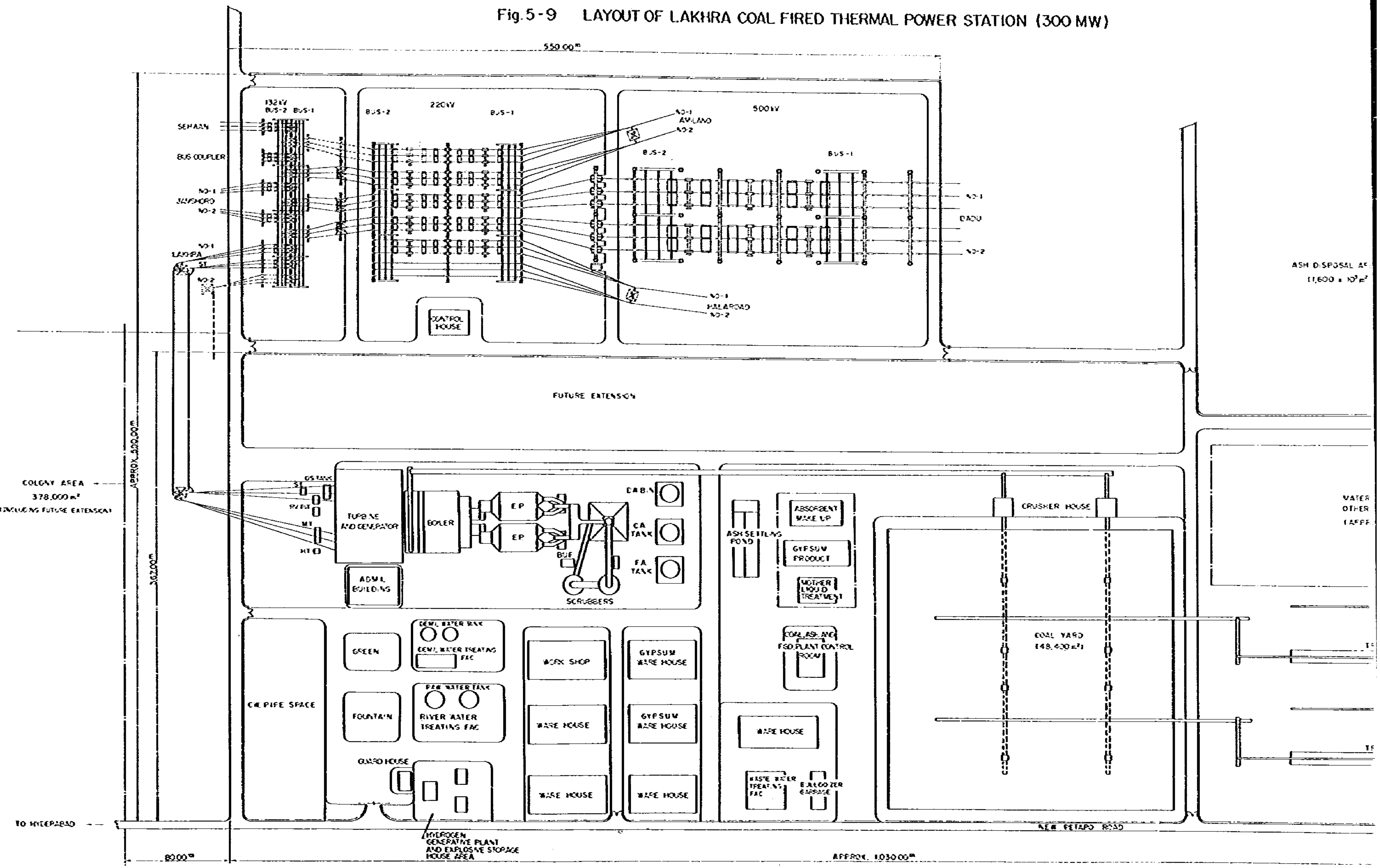


Fig. 5-9 LAYOUT OF LAKHRA COAL FIRED THERMAL POWER STATION (300 MW)

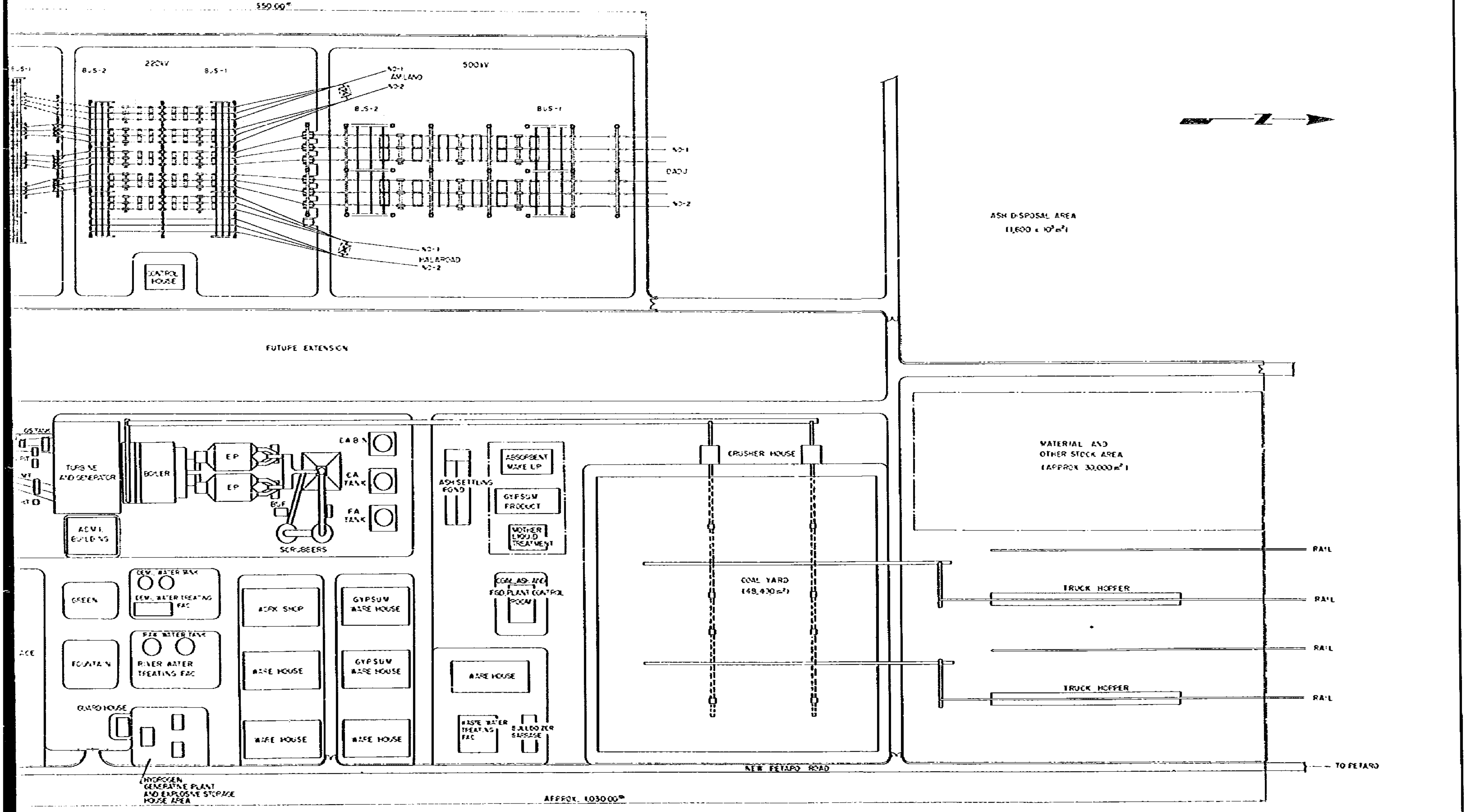


Fig. 5-10 GROUND FLOOR PLAN (300MW)

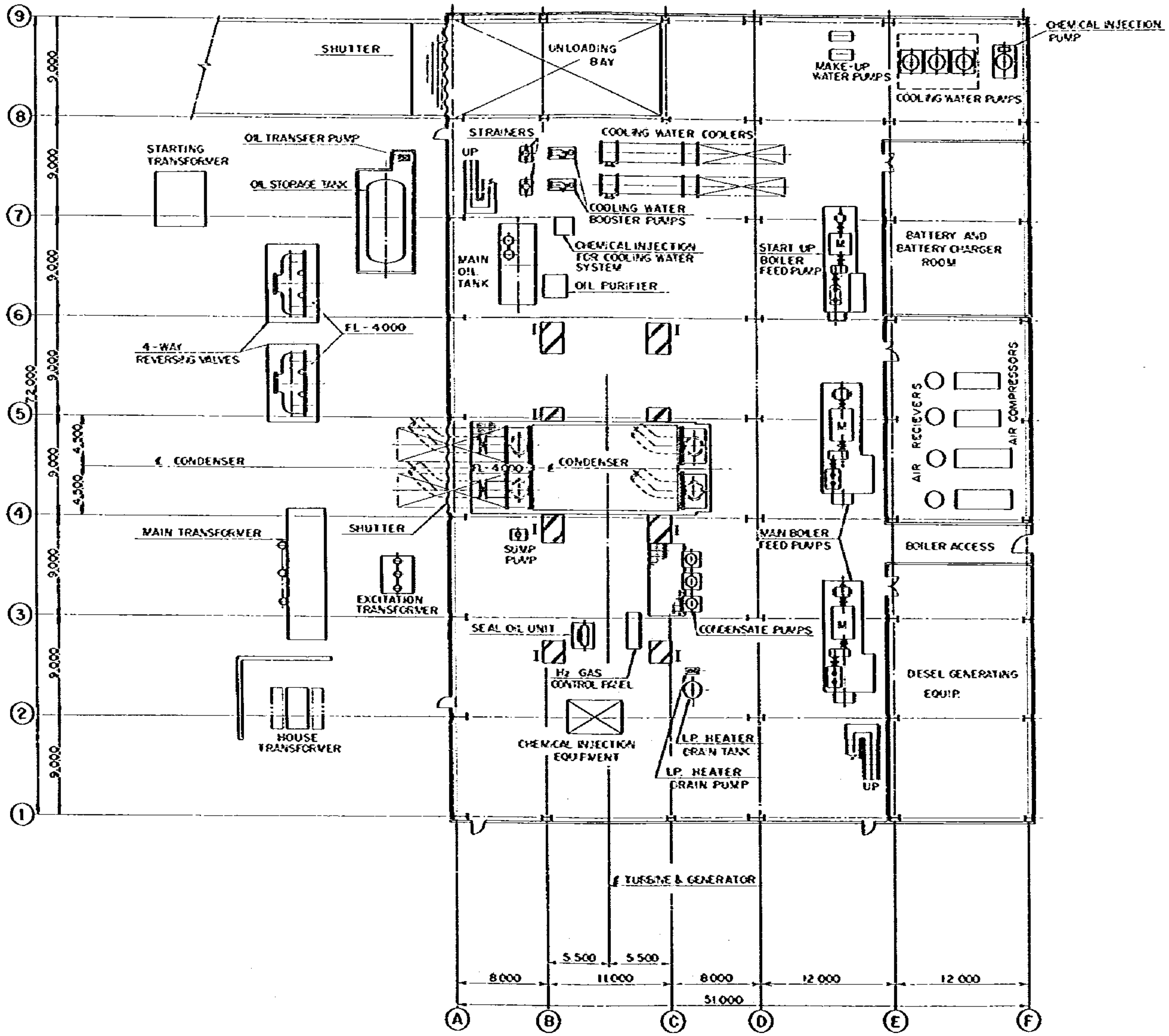


Fig. 5-11 MEZZANING FLOOR PLAN (300MW)

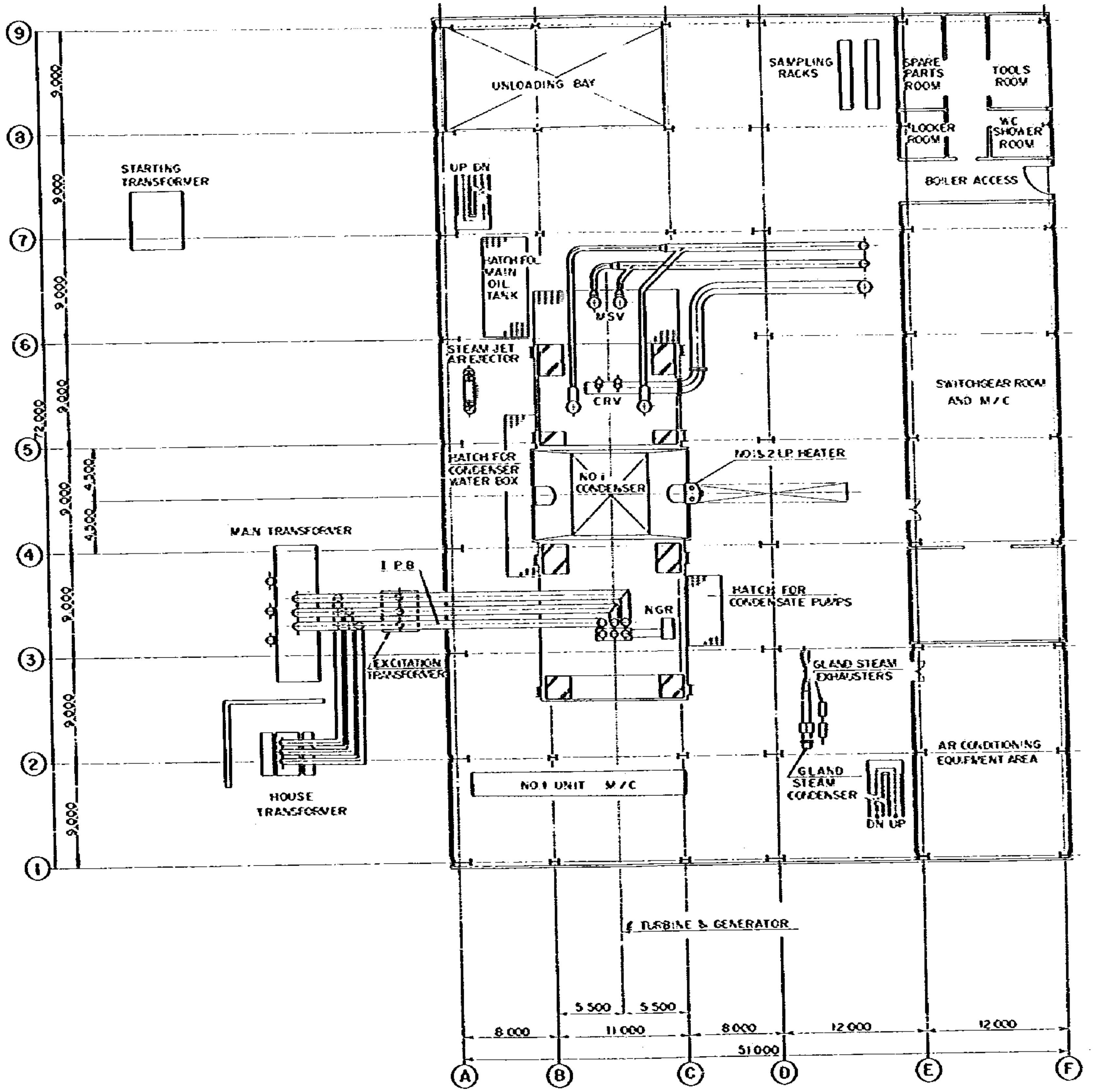


Fig. 5-12 BOILER TURBINE GENERATOR PLAN (300MW)

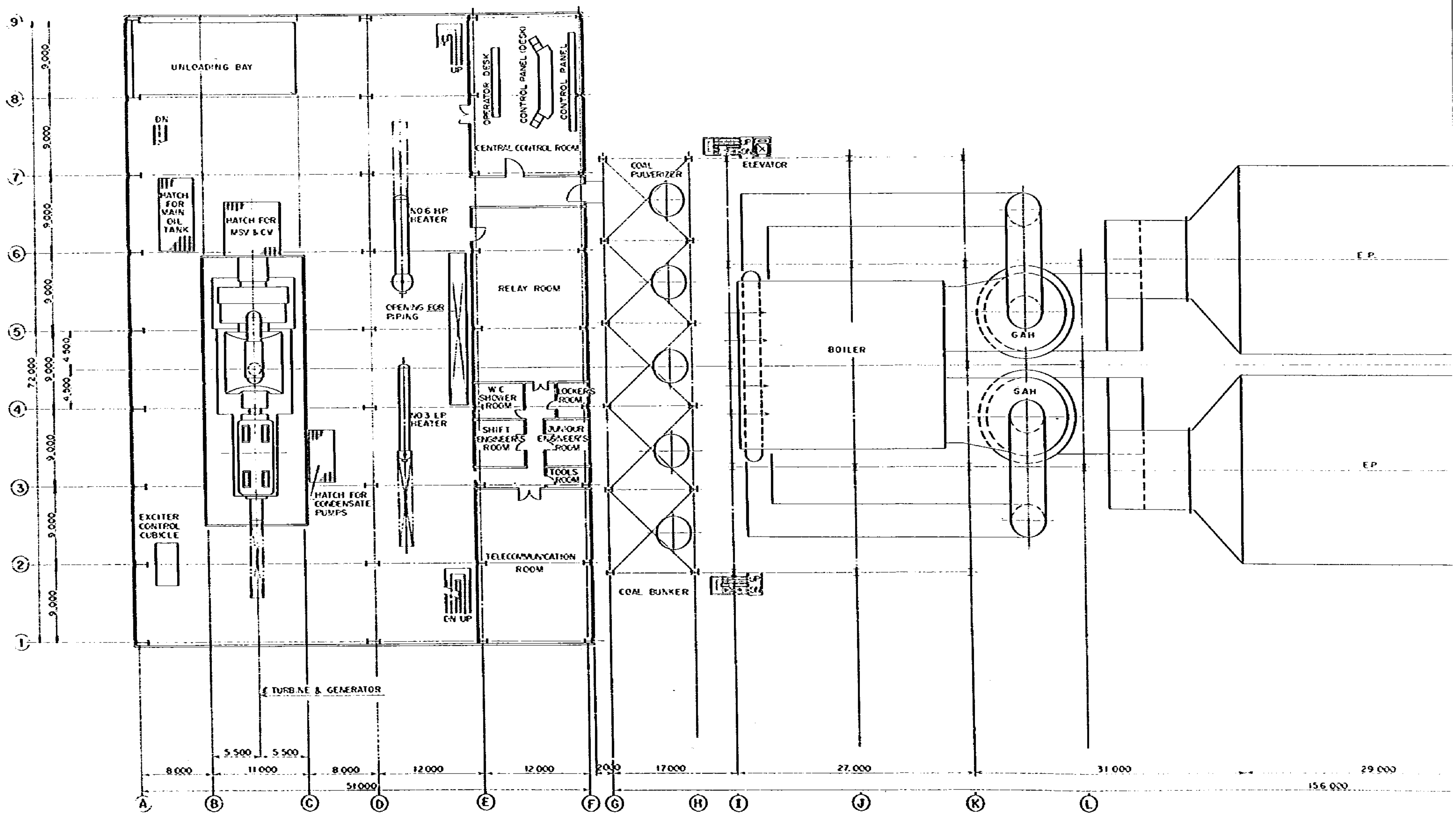


Fig. 5-12 BOILER TURBINE GENERATOR PLAN (300MW)

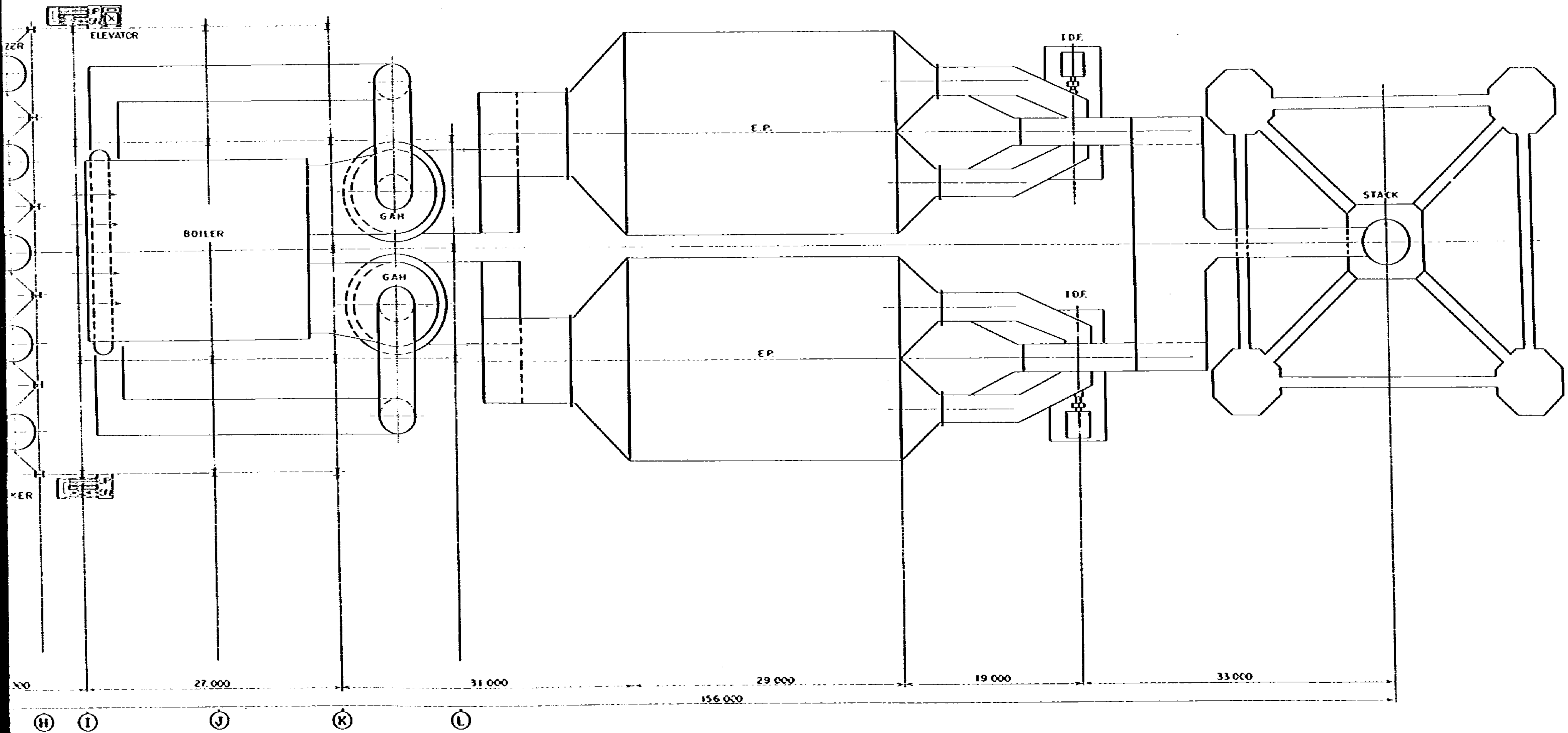


Fig. 5-13 SECTION OF POWER STATION (300MW)

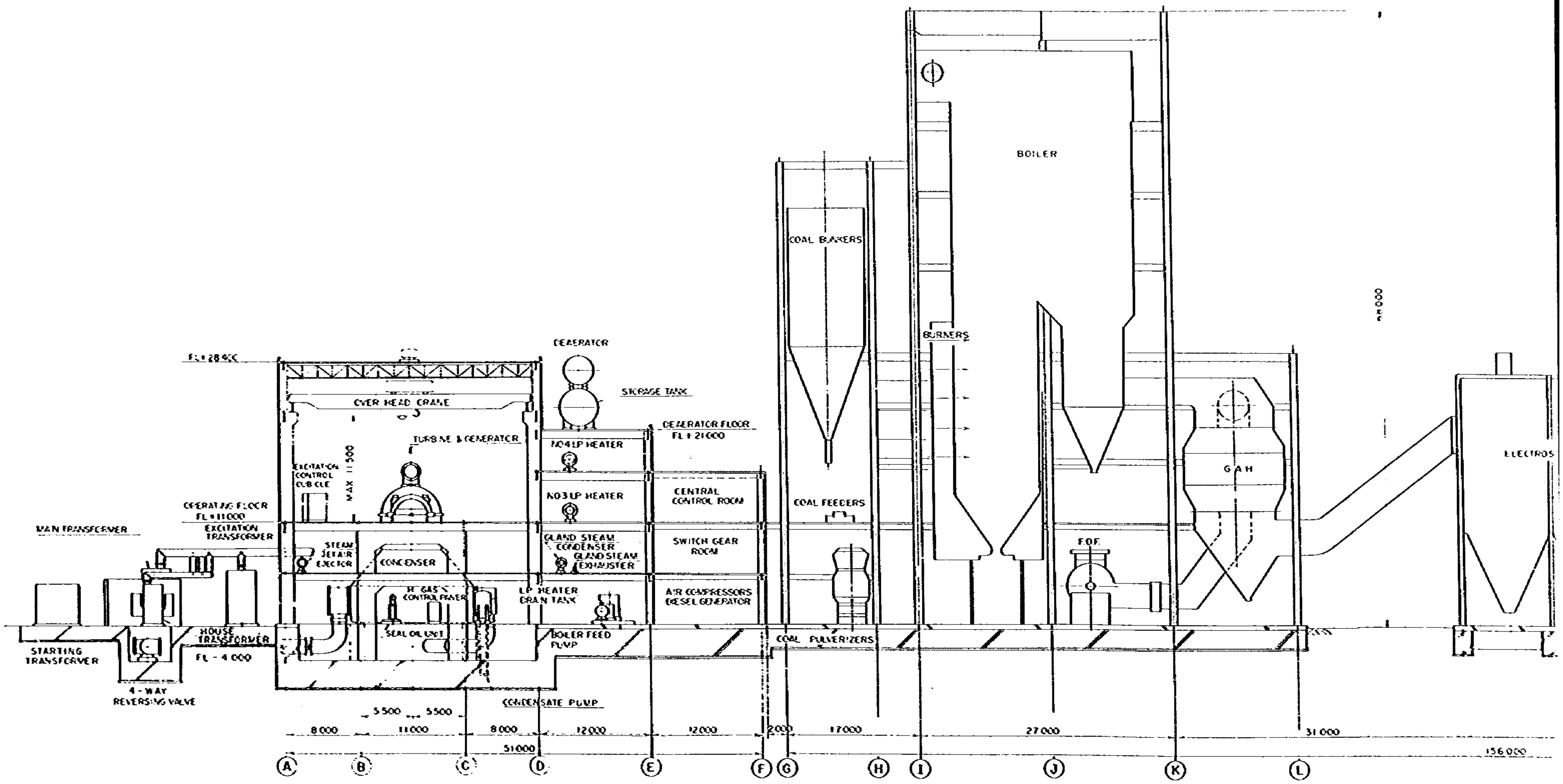


Fig. 5-13 SECTION OF POWER STATION (300MW)

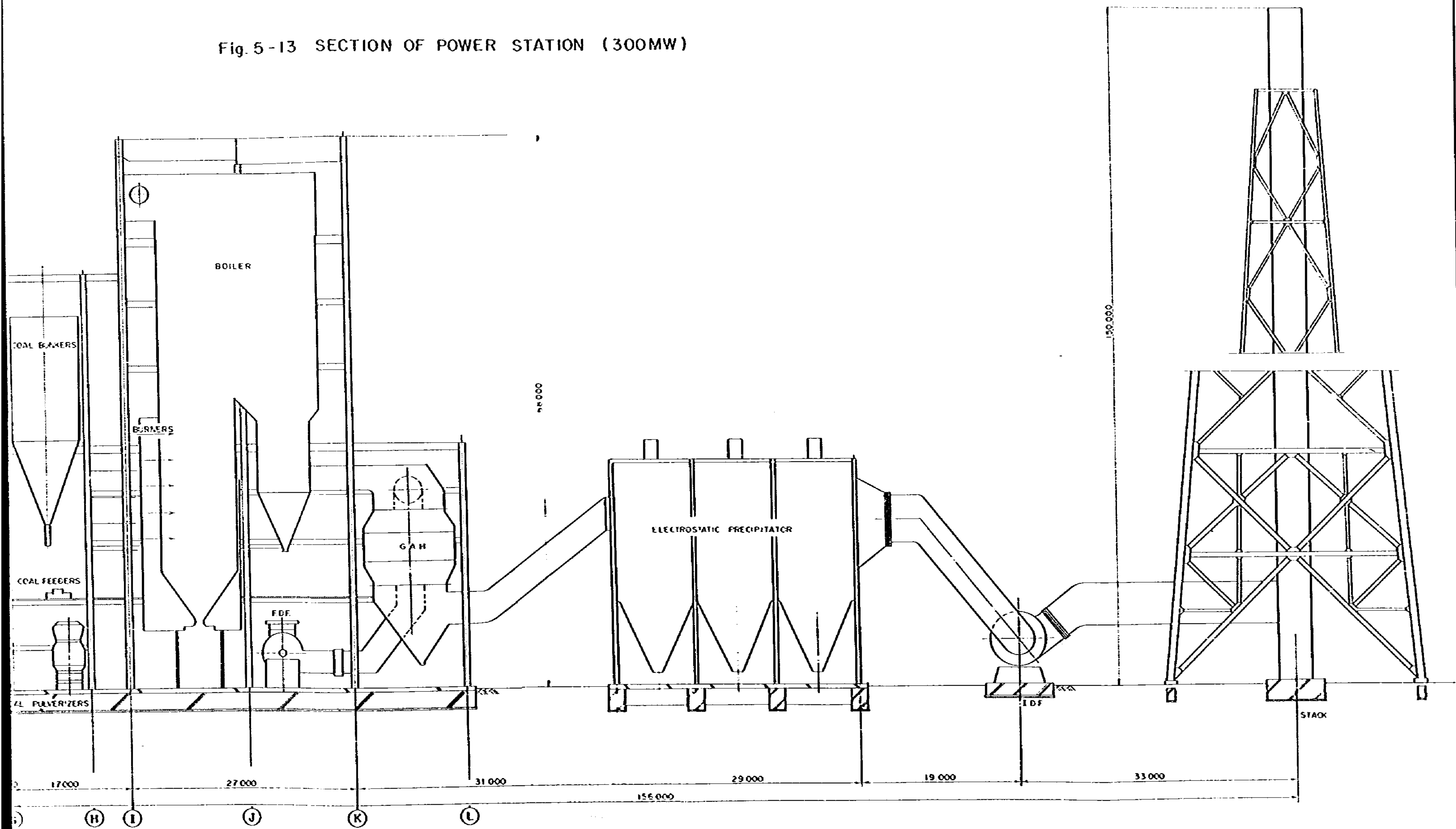


Fig. 5 - 14 ADMINISTRATION BUILDING PLAN

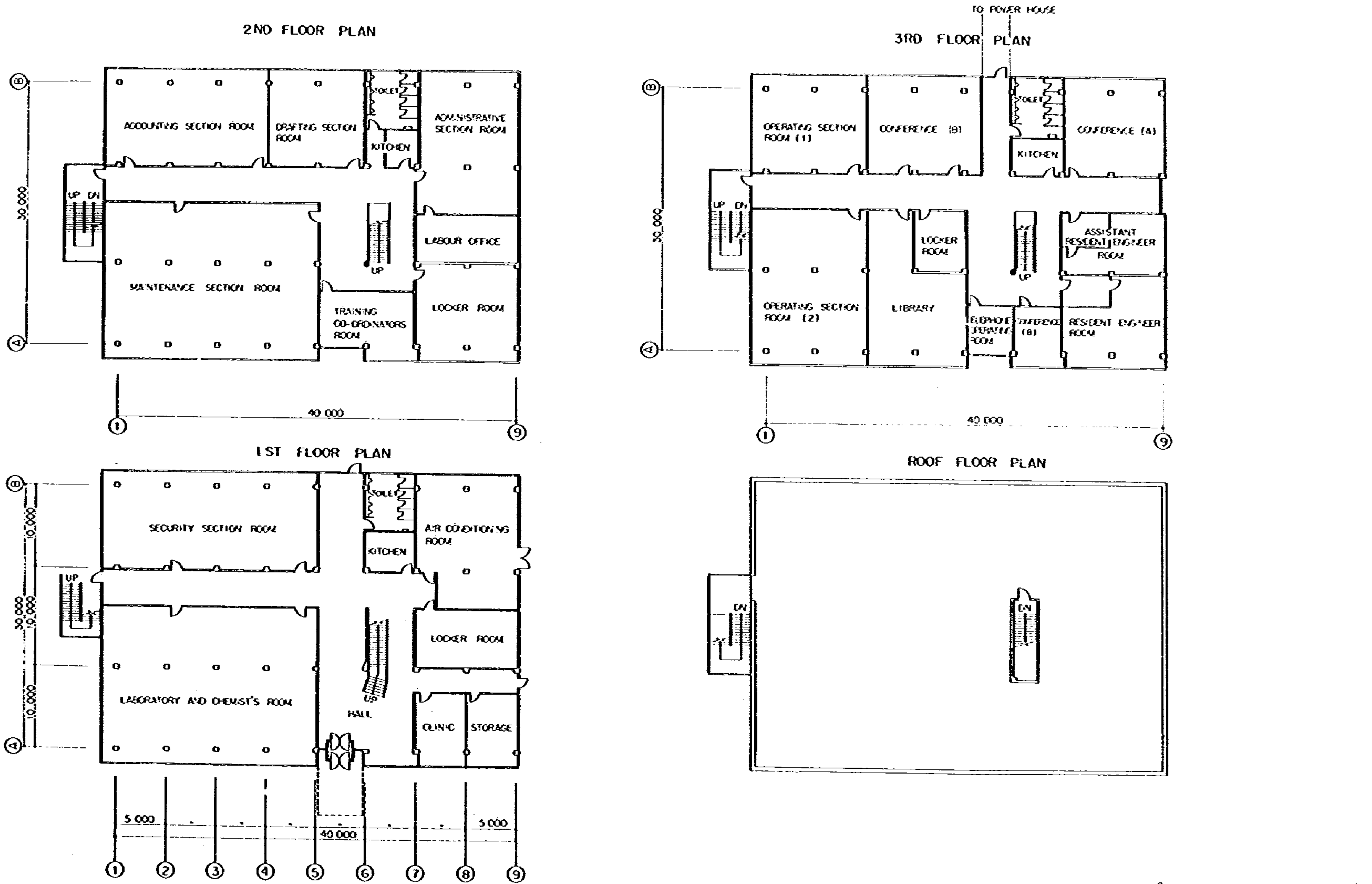
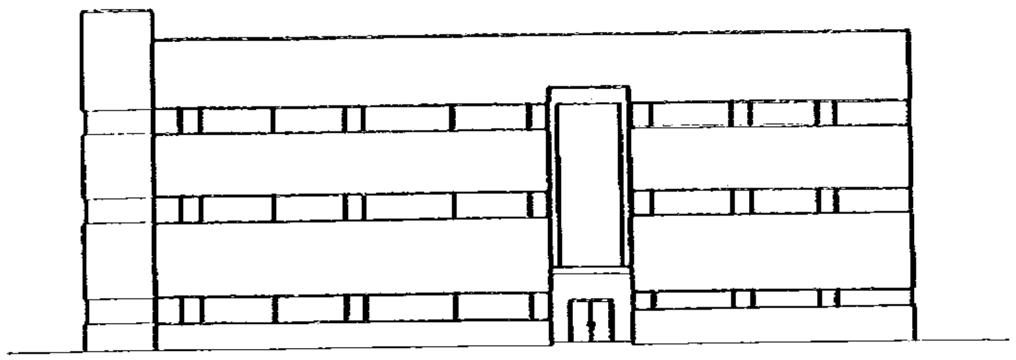
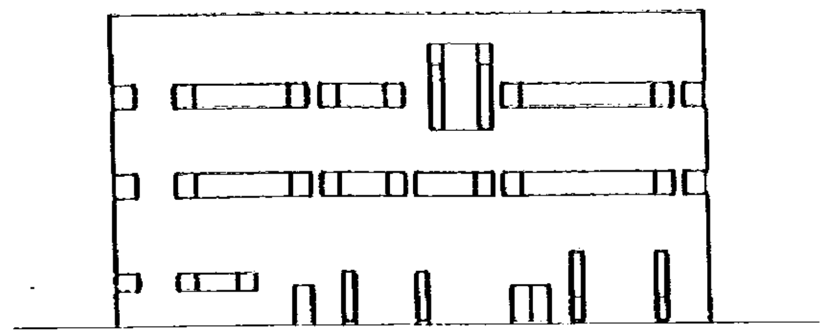


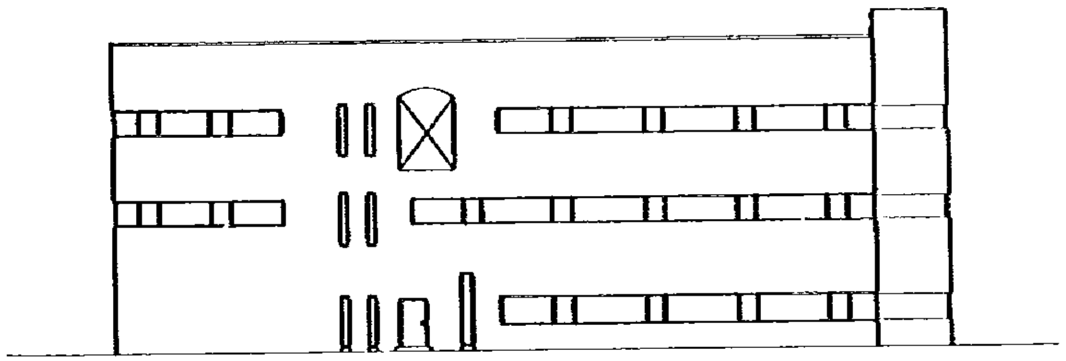
Fig. 5 -15 ADMINISTRATION BUILDING ELEVATION AND SECTION



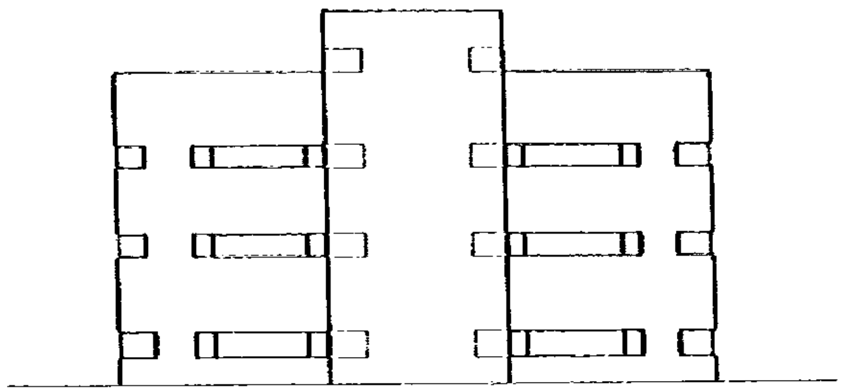
EAST ELEVATION



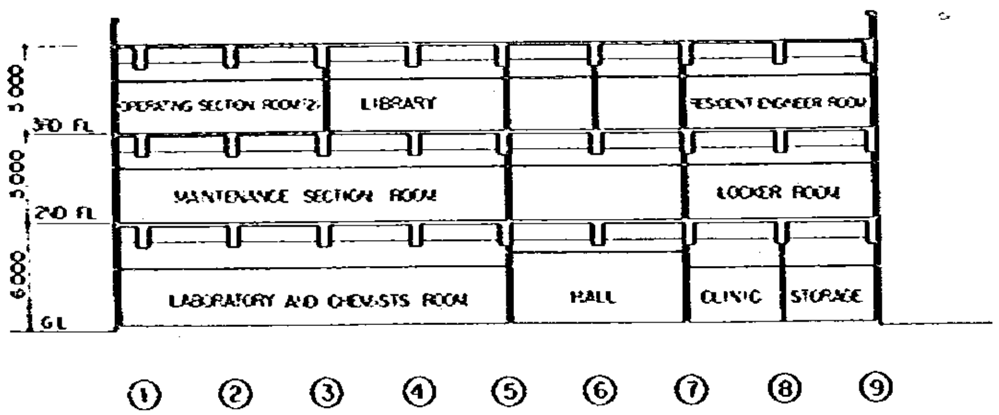
SOUTH ELEVATION



WEST ELEVATION



NORTH ELEVATION



SECTION

SCALE 1:200

Fig. 5 - 16 COLONY LAYOUT PLAN

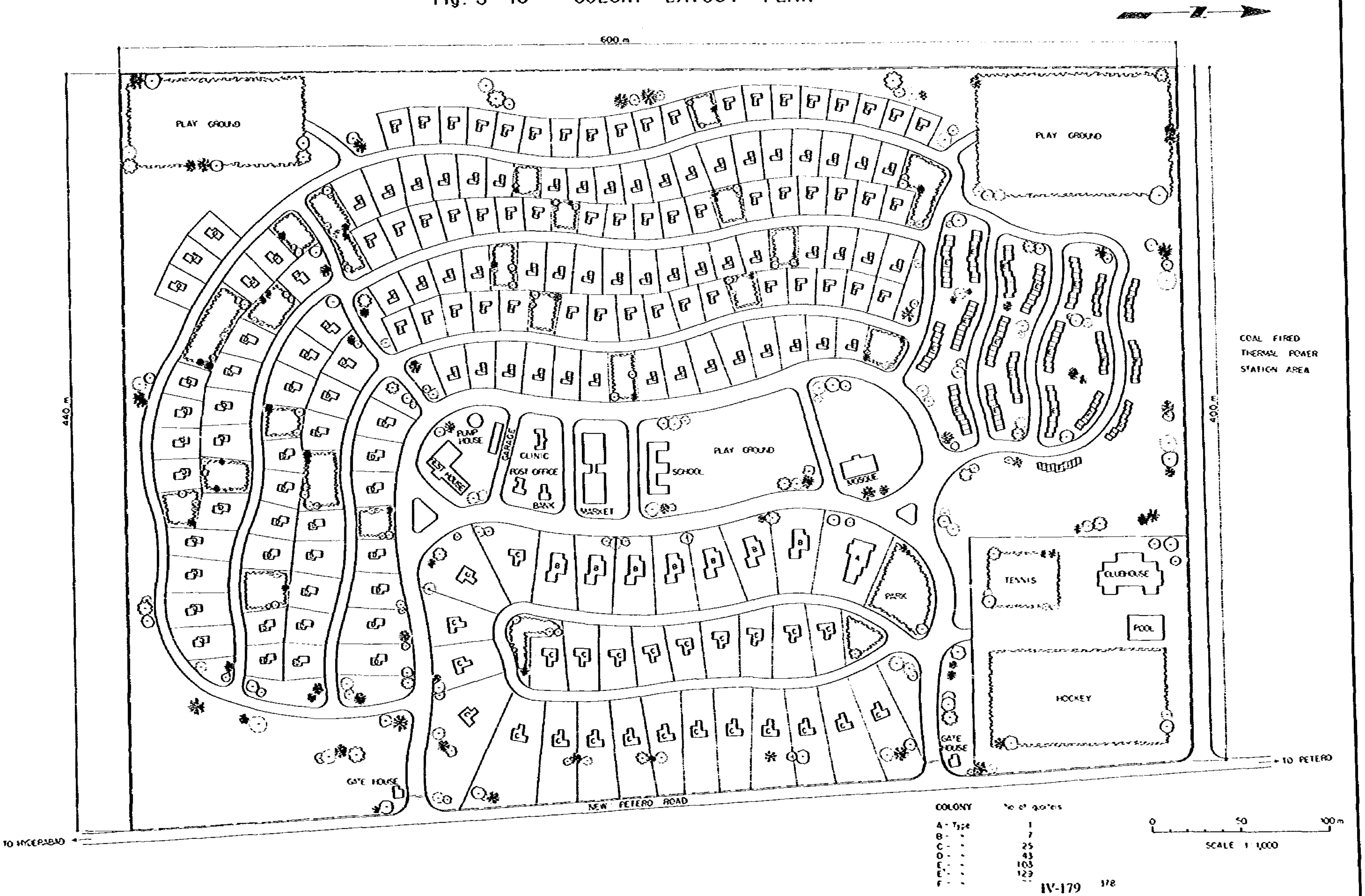


Fig. 5-17 FUEL GAS FLOW DIAGRAM (300MW)

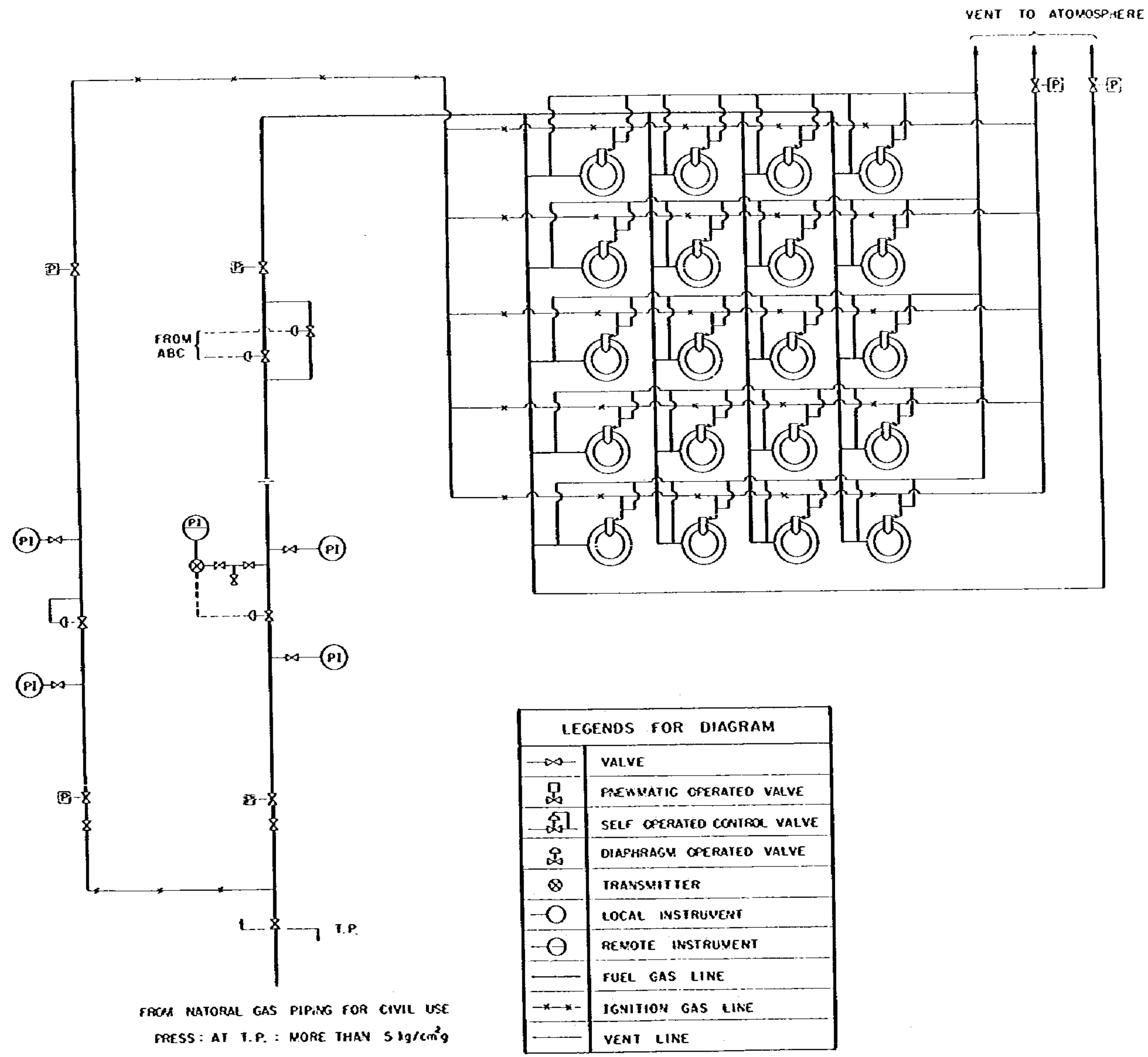


Fig. 5 - 18 AIR AND GAS FLOW DIAGRAM (300 MW)

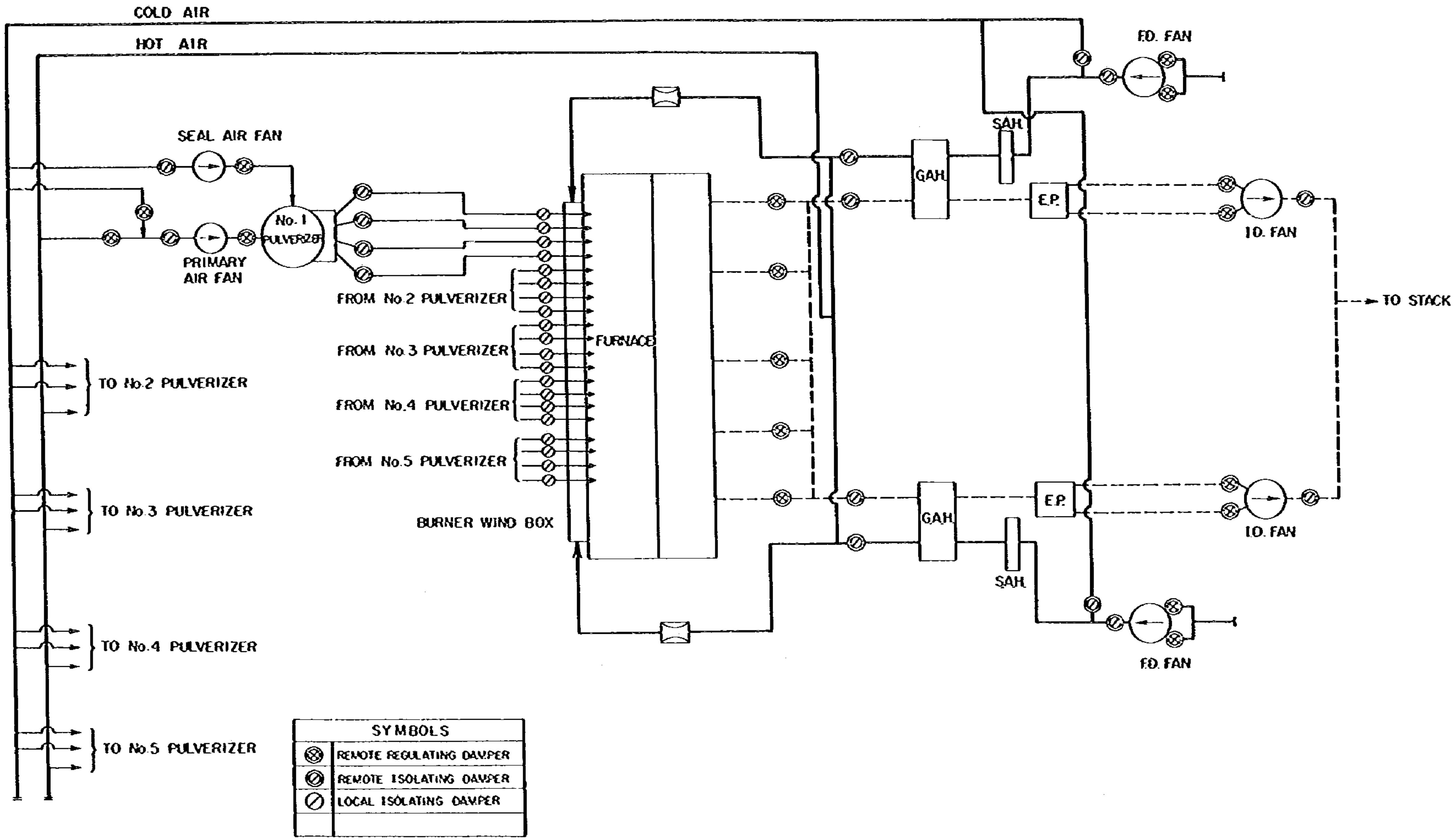
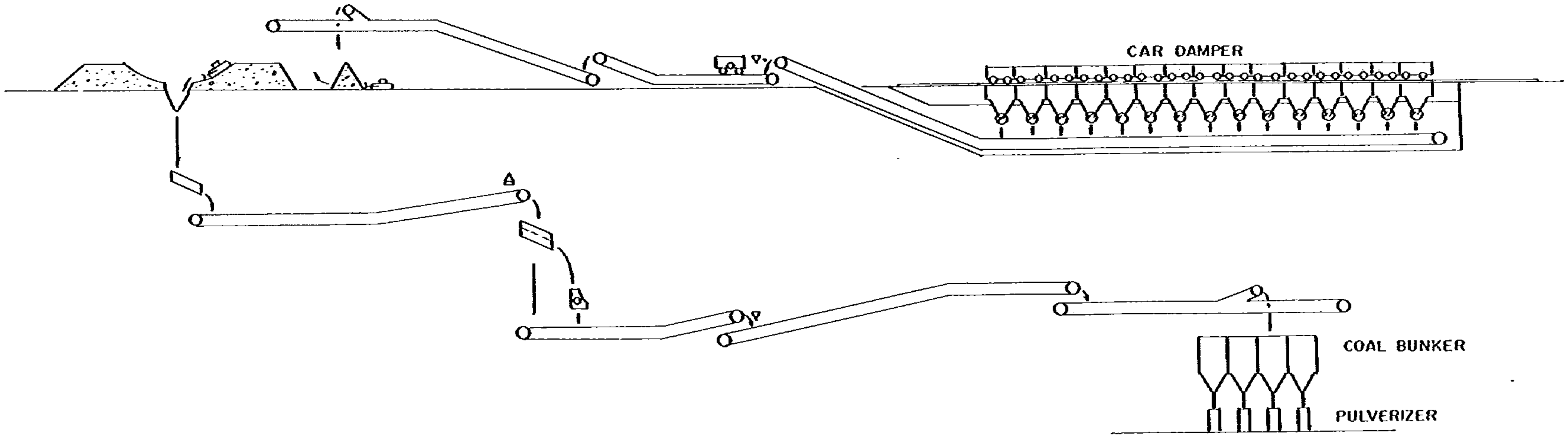


Fig. 5-19 COAL HANDLING SYSTEM FLOW DIAGRAM



SYMBOL	DISCRIPTION	SYMBOL	DISCRIPTION
	CAR DUMPER		MAGNET SEPARATOR
	HOPPER (ABOVEGROUND)		DUMPER CHUTE
	HOPPER (UNDERGROUND)		BULLDOZER
	VIBRATING FEEDER		BELT CONVEYOR
	SCREEN		TRIPPER CONVEYOR
	CRUSHER		STOCKPILE
	BELT SCALE		
	SAMPLER		

Fig. 5-20 ASH HANDLING SYSTEM FLOW DIAGRAM

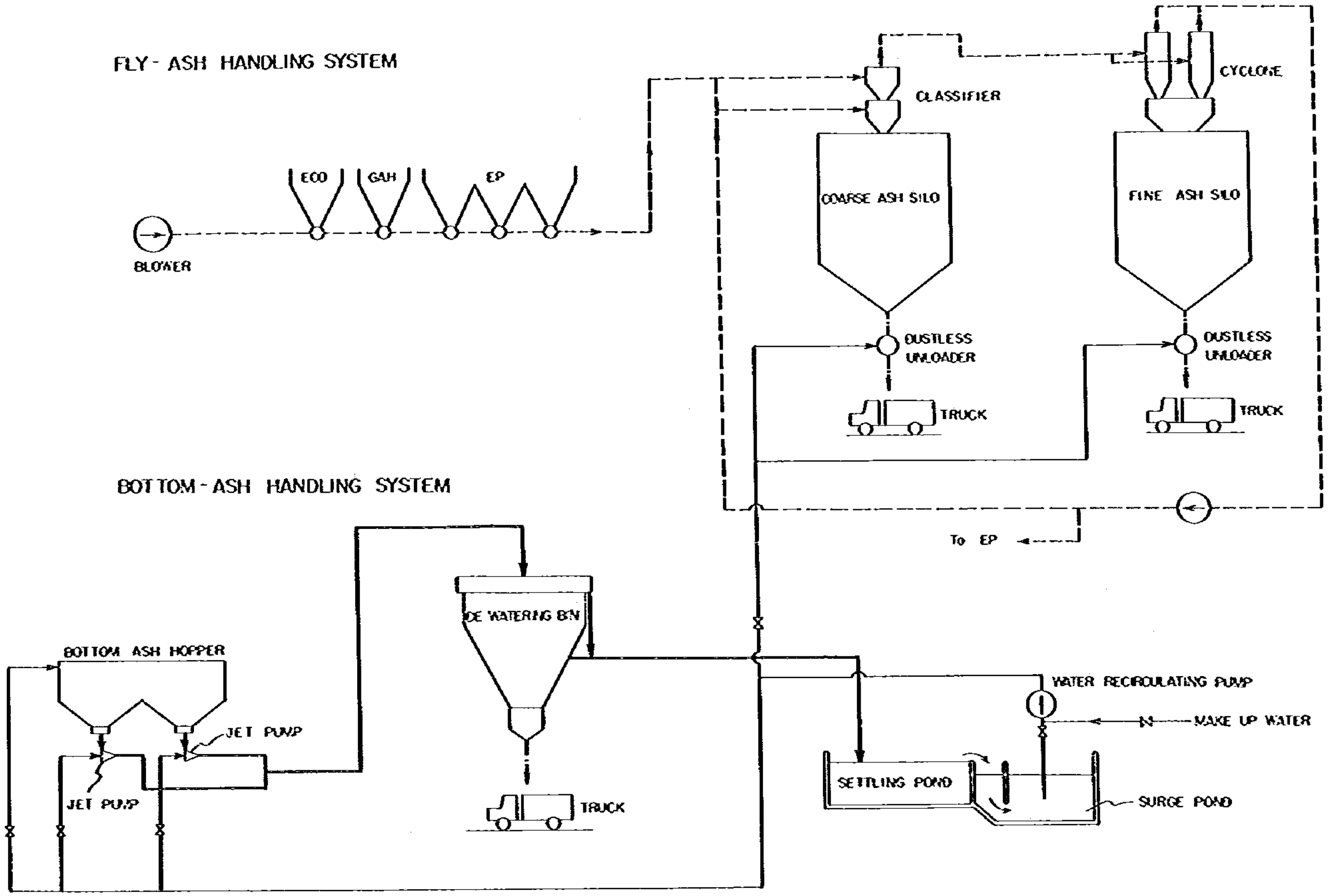


Fig. 5-21 WATER SUPPLY SYSTEM FLOW DIAGRAM

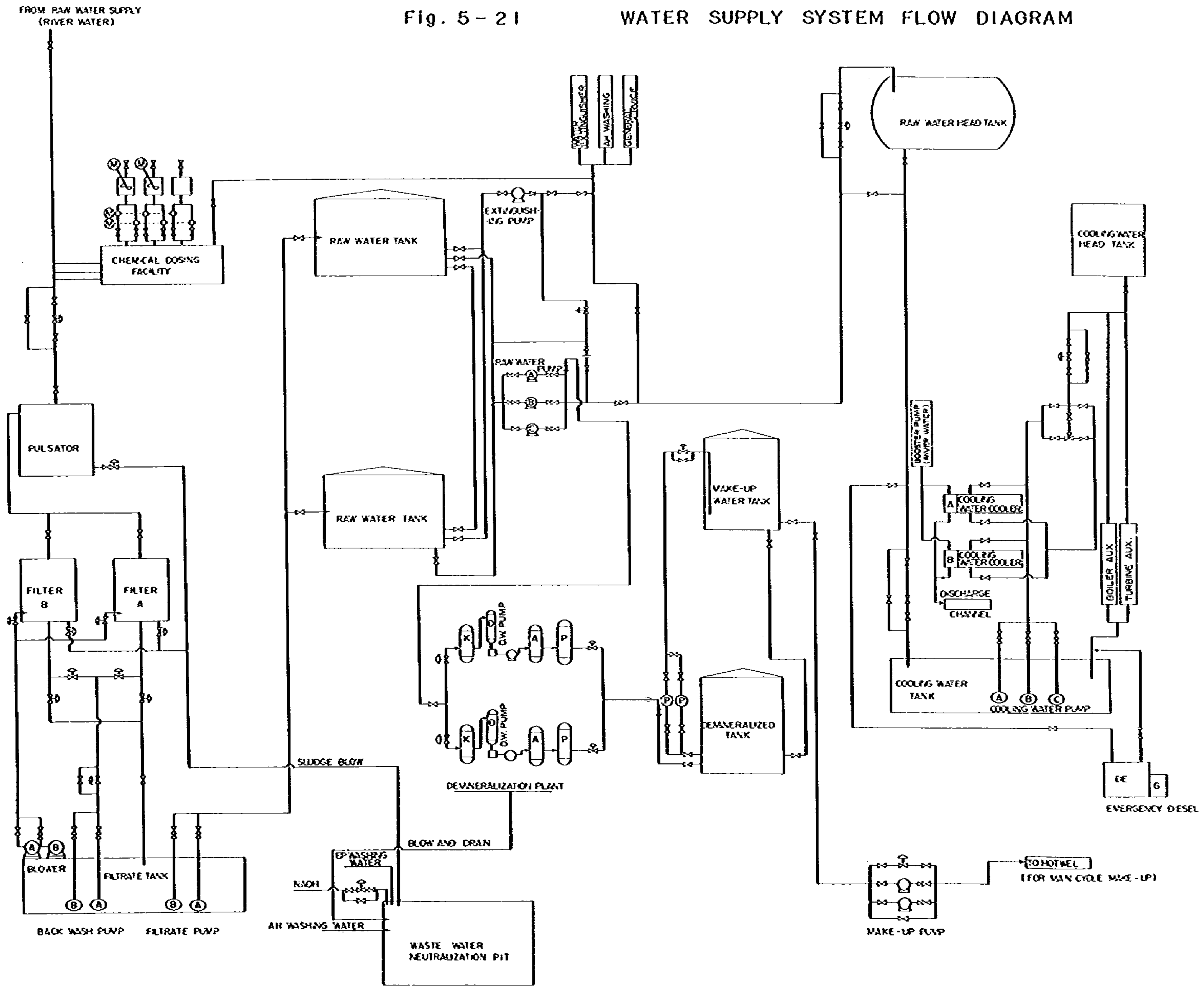


Fig. 5-22 COOLING WATER SYSTEM FLOW DIAGRAM

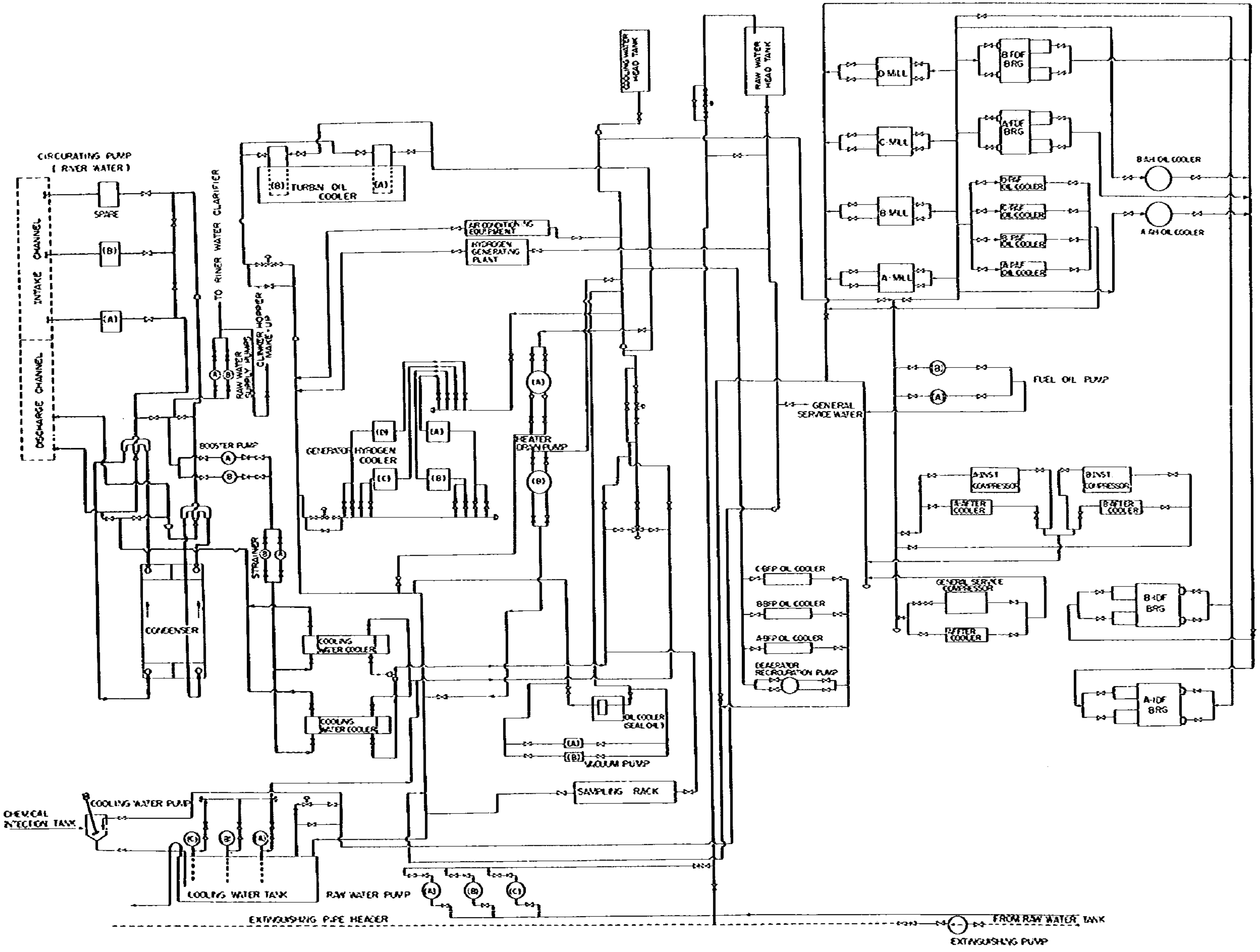
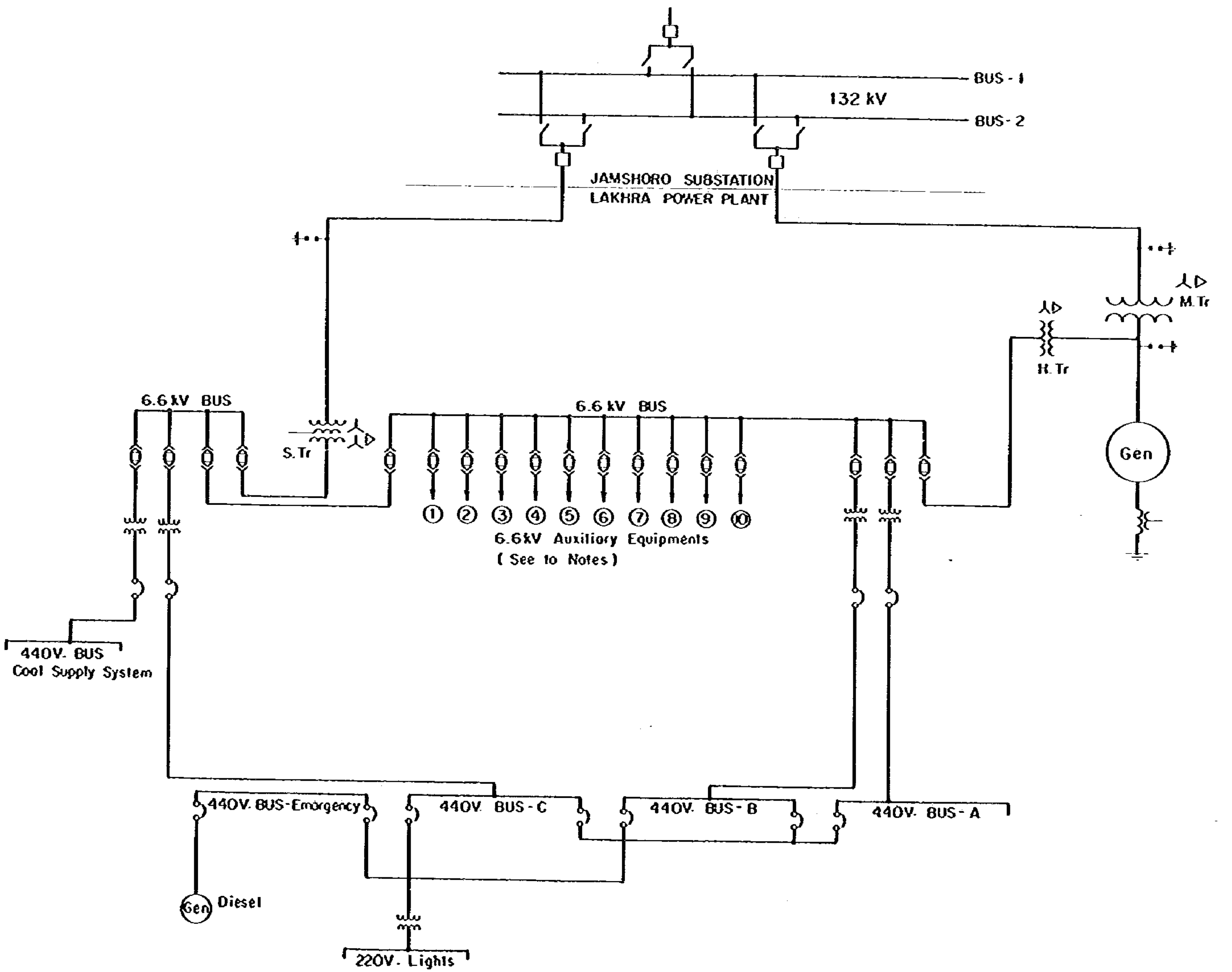


Fig. 5 - 23 BASIC SINGLE LINE DIAGRAM (300MW)

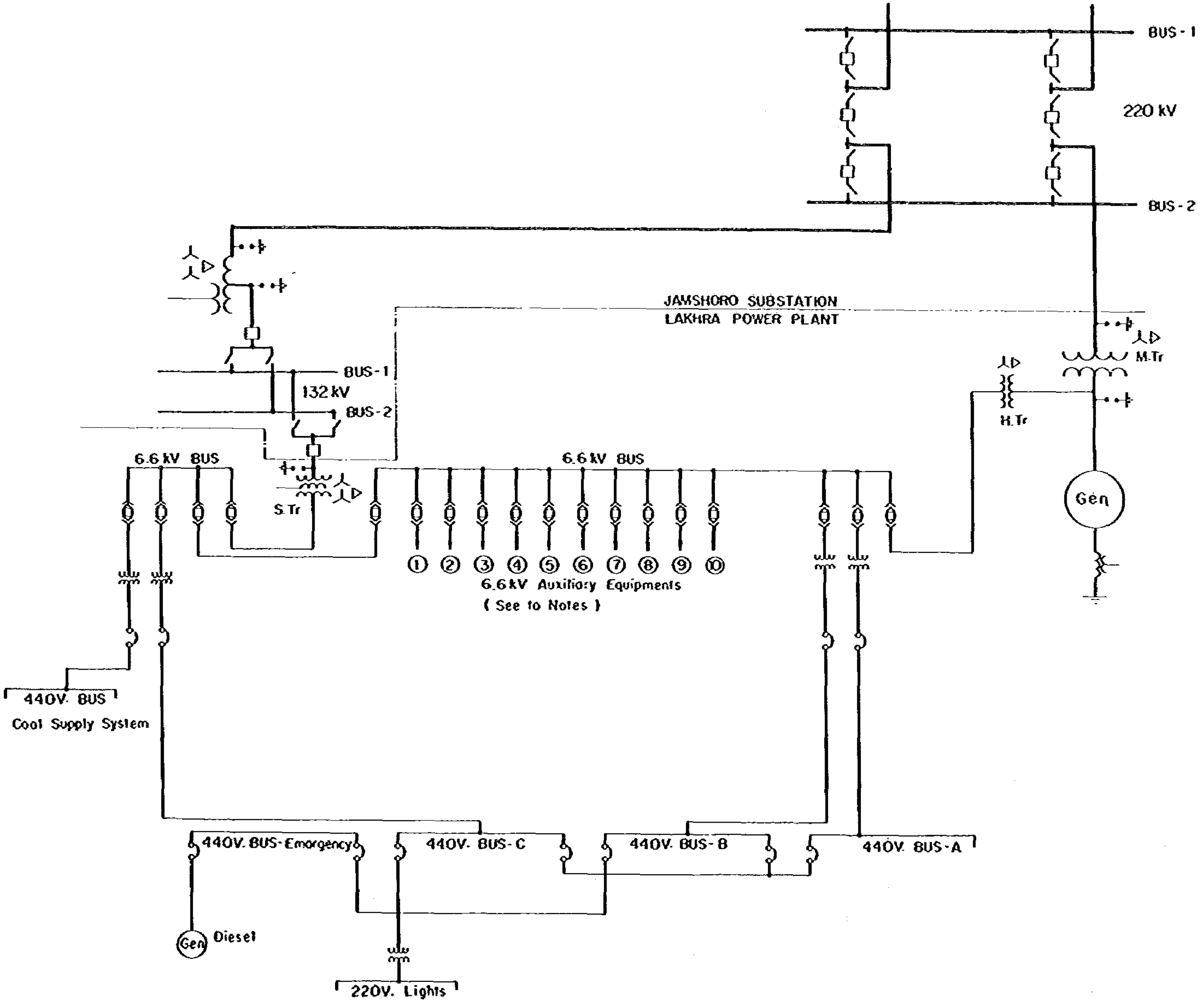


Notes.

6.6 kV Auxiliary Equipments

NAME OF MACHINE	300MW	150MW x 2 UNITS
1. Induced Draft Fan	2 sets	2 sets x2
2. Forced Draft Fan	2 sets	2 sets x2
3. Coal Pulveriger	5 sets	4 sets x2
4. Primary Fan	5 sets	4 sets x2
5. Coal Bunker Supply Conveyor	2 sets	1 sets
6. Ash Slucing Pump	3 sets	4 sets
7. Circulating Water Pump	3 sets	5 sets
8. Condensate Pump	3 sets	–
9. Boile Feed Water Pump	3 sets	3 sets x2
10. Cooling Water Pump	3 sets	3 sets x2

Fig. 5 - 24 BASIC SINGLE LINE DIAGRAM (Alternative of 220 kV Connection) (300 MW)



Notes.

6.6 kV Auxiliary Equipments

	NAME OF MACHINE	300MW	150MW x 2 UNITS
1.	Induced Draft Fan	2 sets	2 sets x2
2.	Forced Draft Fan	2 sets	2 sets x2
3.	Coal Pulneriger	5 sets	4 sets x2
4.	Primary Fan	5 sets	4 sets x2
5.	Coal Bunker Supply Conveyor	2 sets	1 sets
6.	Ash Slucing Pump	3 sets	4 sets
7.	Circulating Water Pump	3 sets	5 sets
8.	Condensate Pump	3 sets	—
9.	Boile Feed Water Pump	3 sets	3 sets x2
10.	Cooling Water Pump	3 sets	3 sets x2

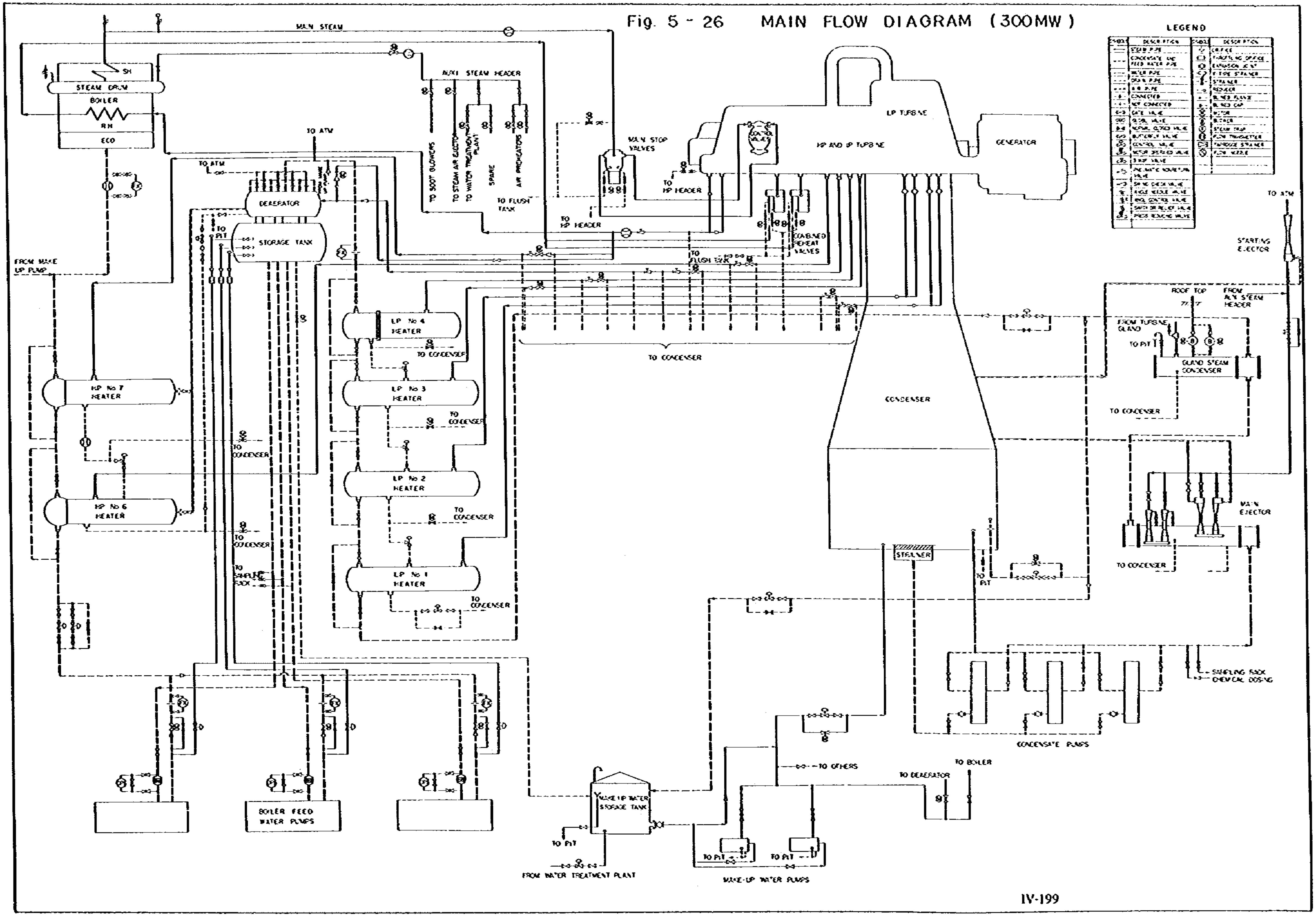


Fig. 5 - 26 MAIN FLOW DIAGRAM (300MW)

Fig 5-27 GENERAL PLAN (300 MW)

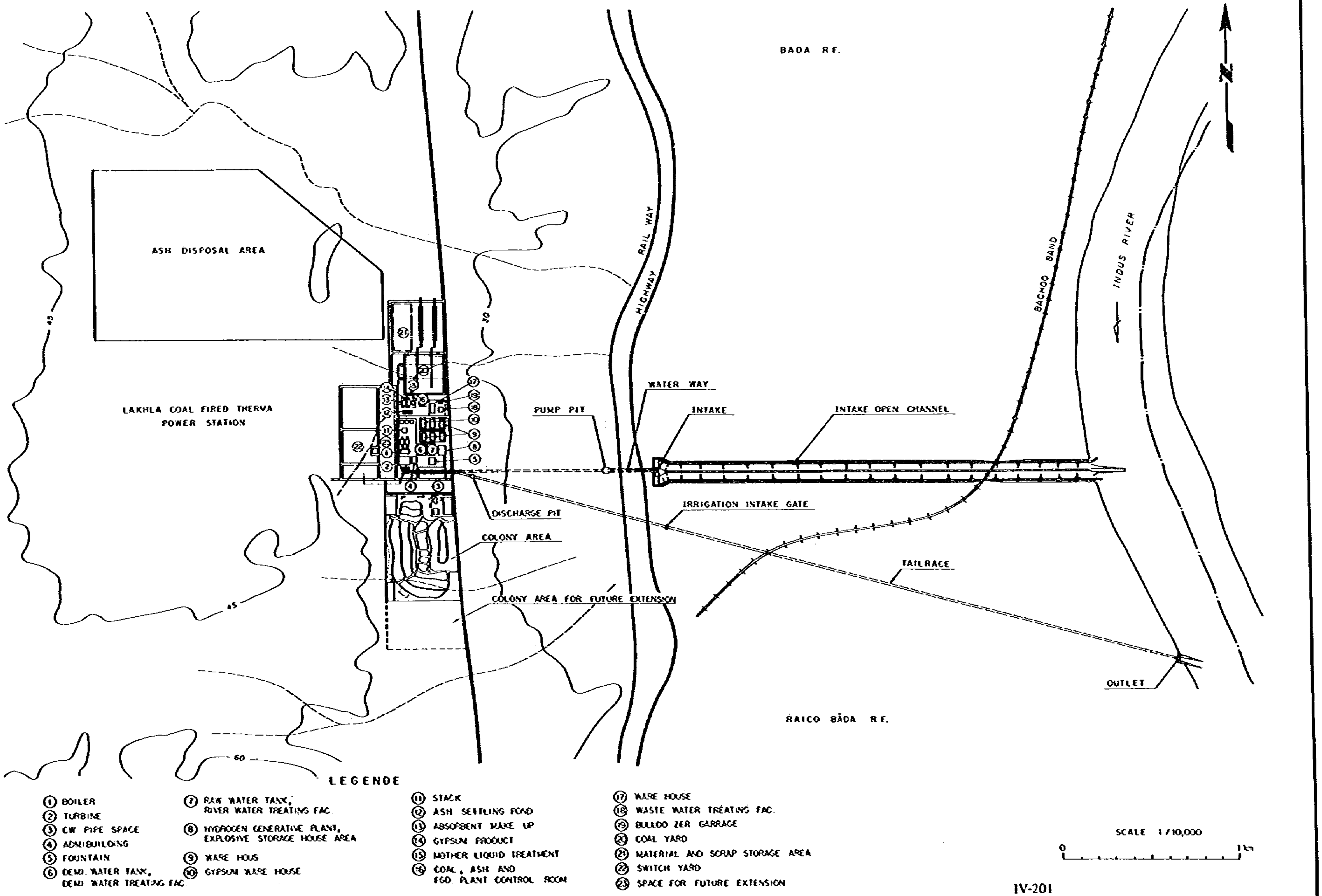


Fig 5-28 INTAKE, WATER WAY, PUMP PIT (150MW x 2)

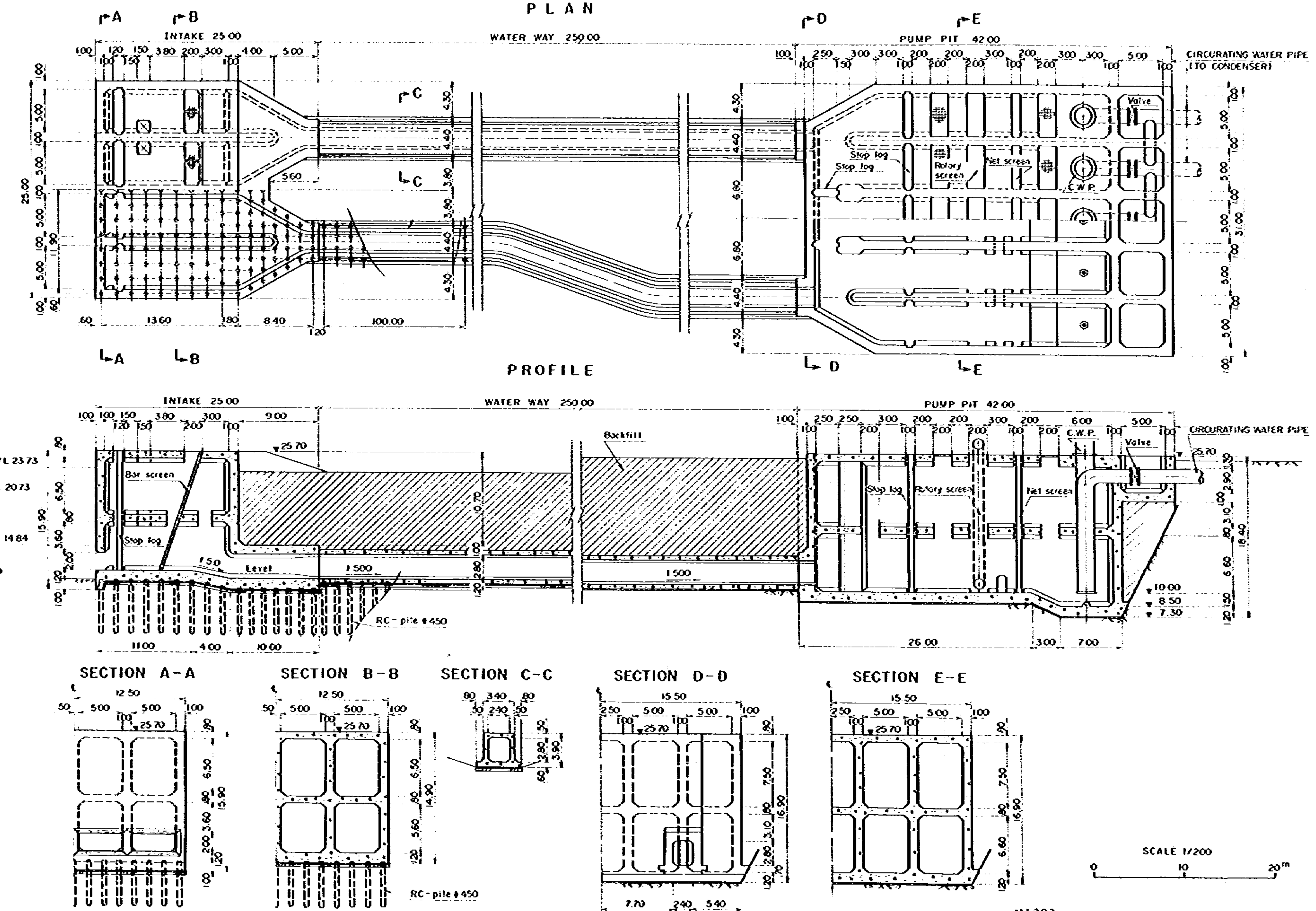


Fig 5-29 CIRCURATING WATER PIPE, DISCHARGE PIT, TAILRACE, IRRIGATION INTAKE, OUTLET (150MW x 2)

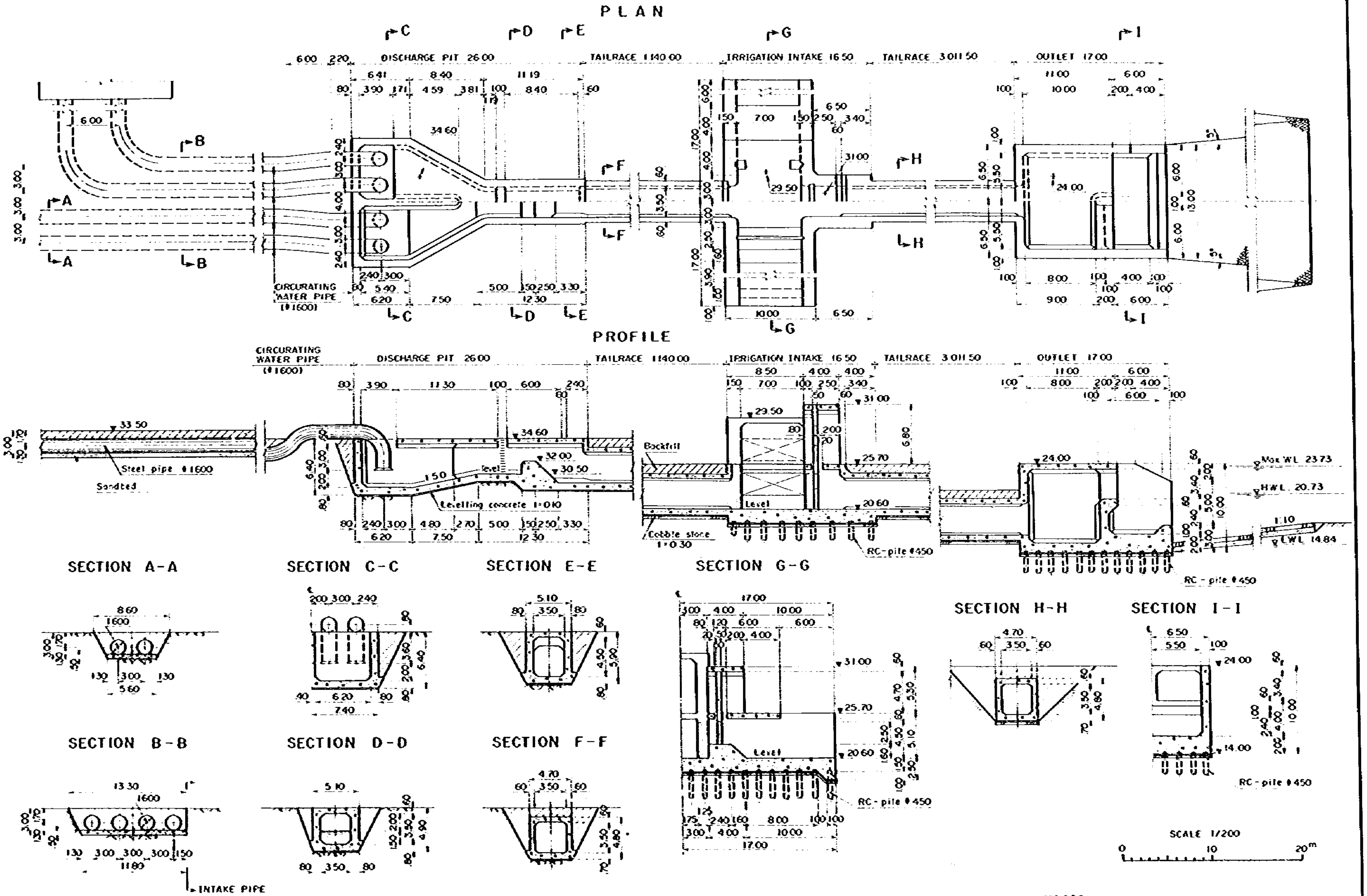


Fig 5 - 30 LAYOUT OF LAKHRA COAL FIRED THERMAL POWER STATION (150 MW x 2 UNITS)

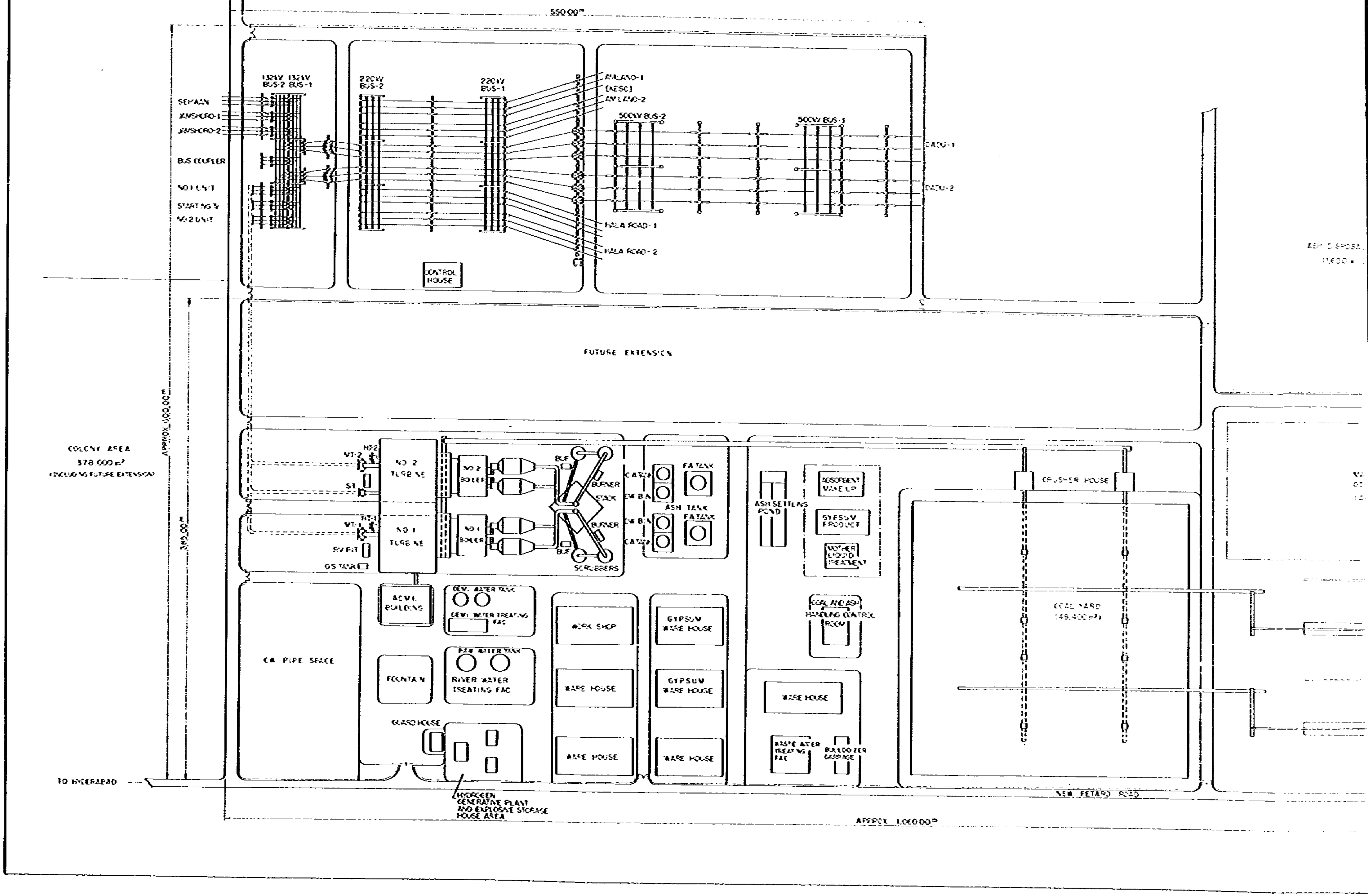


Fig. 5 - 30 LAYOUT OF LAKHRA COAL FIRED THERMAL POWER STATION (150 MW x 2 UNITS)

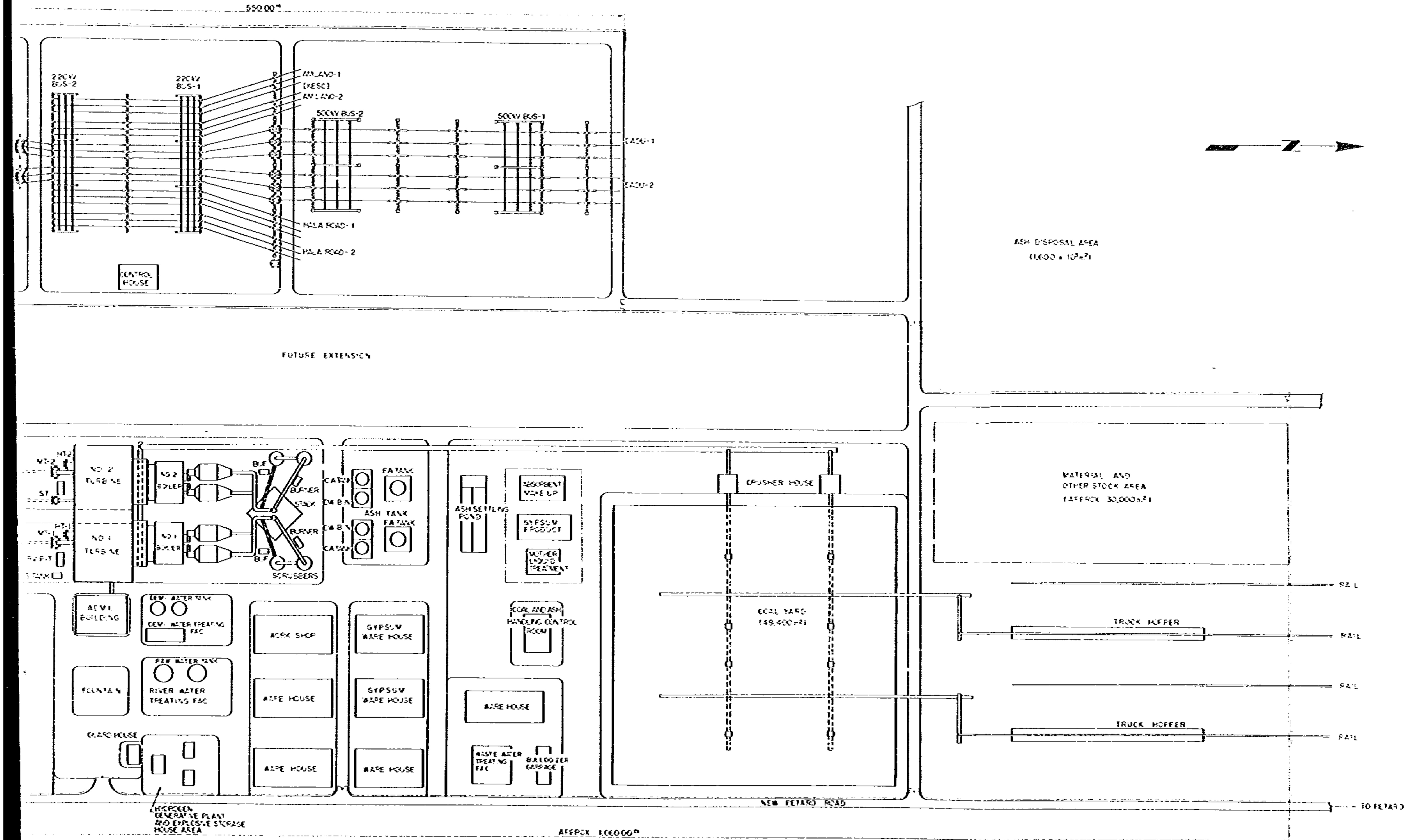


Fig. 5-31 GROUND FLOOR PLAN AND MEZZANING FLOOR PLAN (150MW x 2)

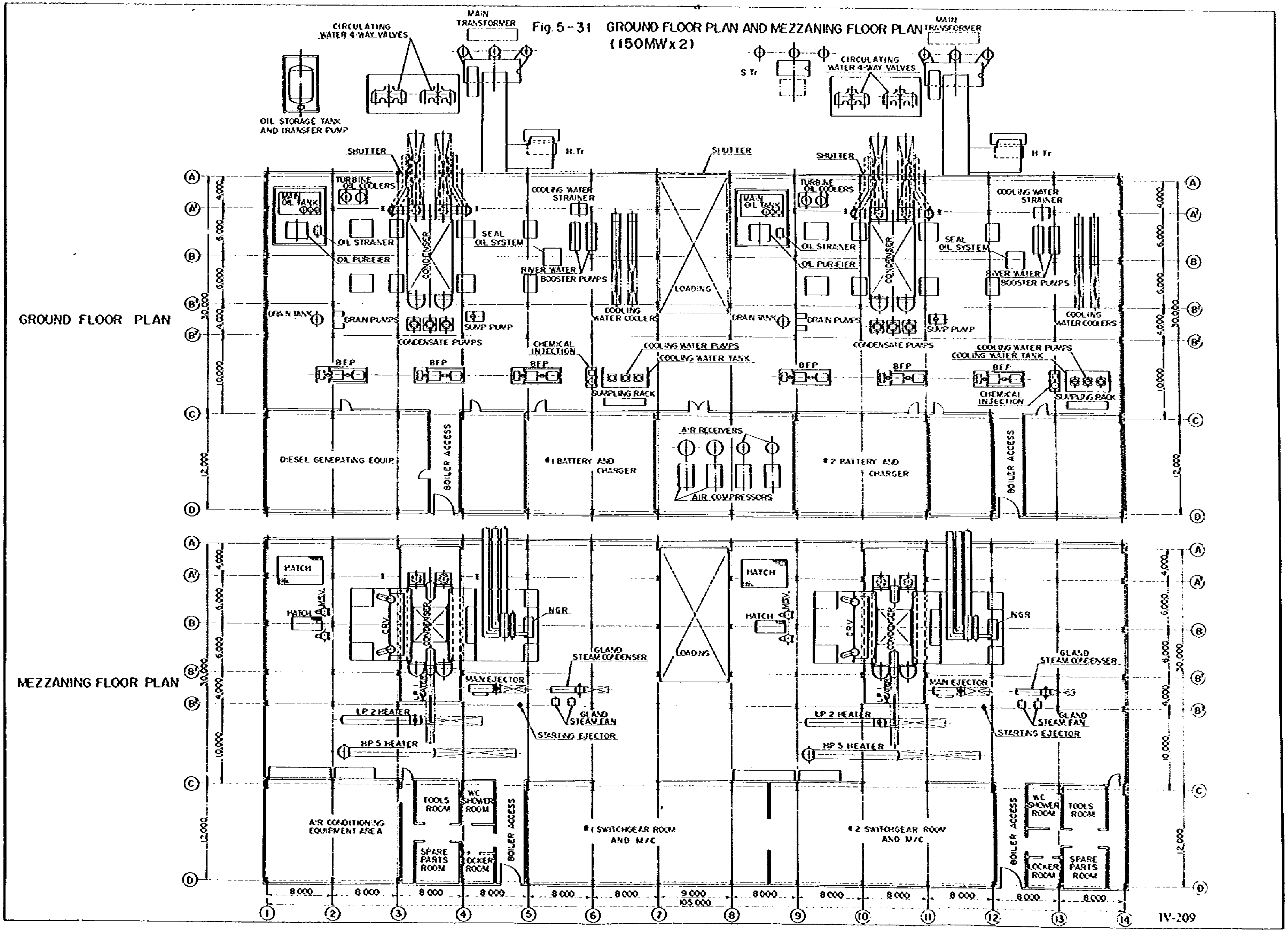
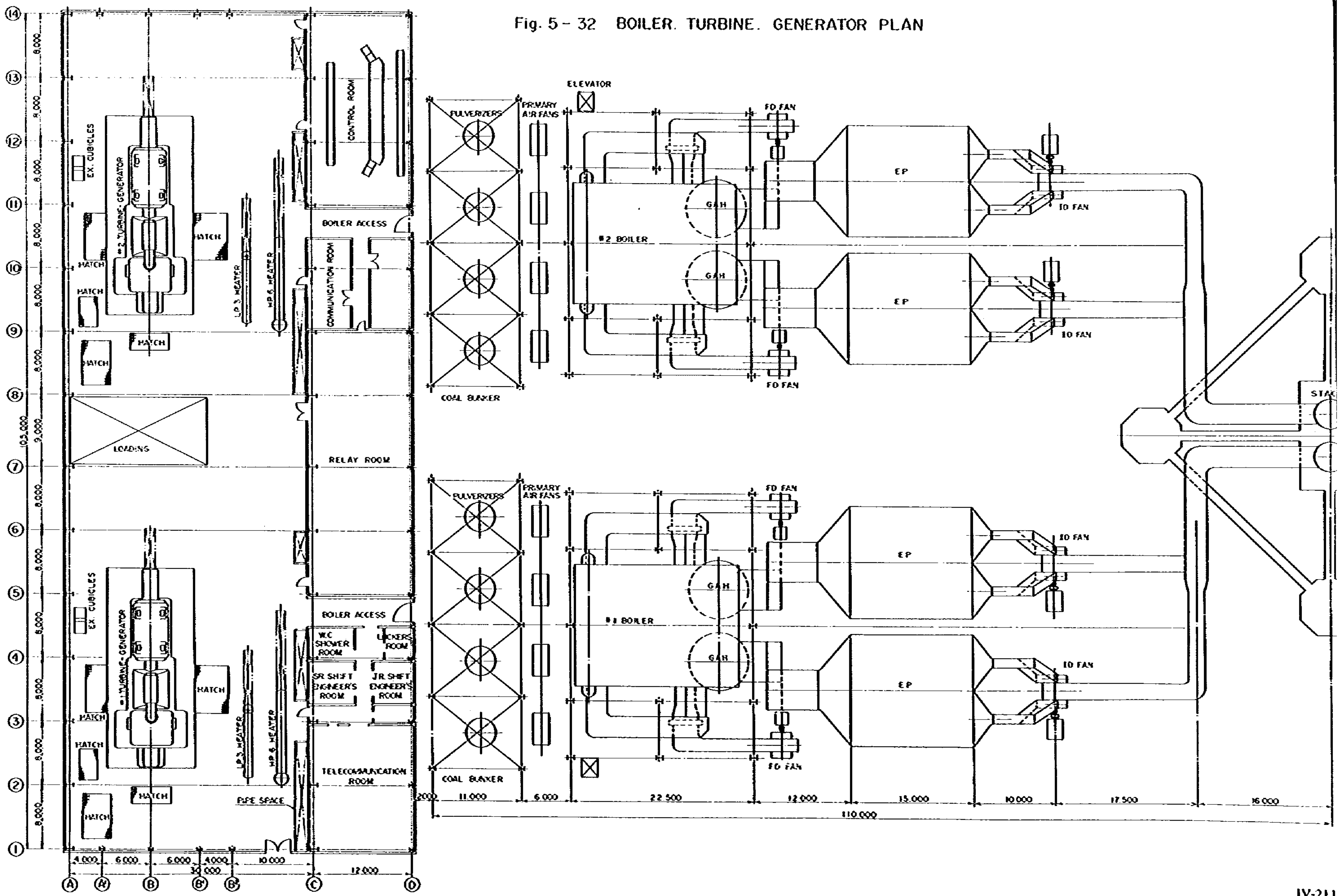


Fig. 5 - 32 BOILER. TURBINE. GENERATOR PLAN



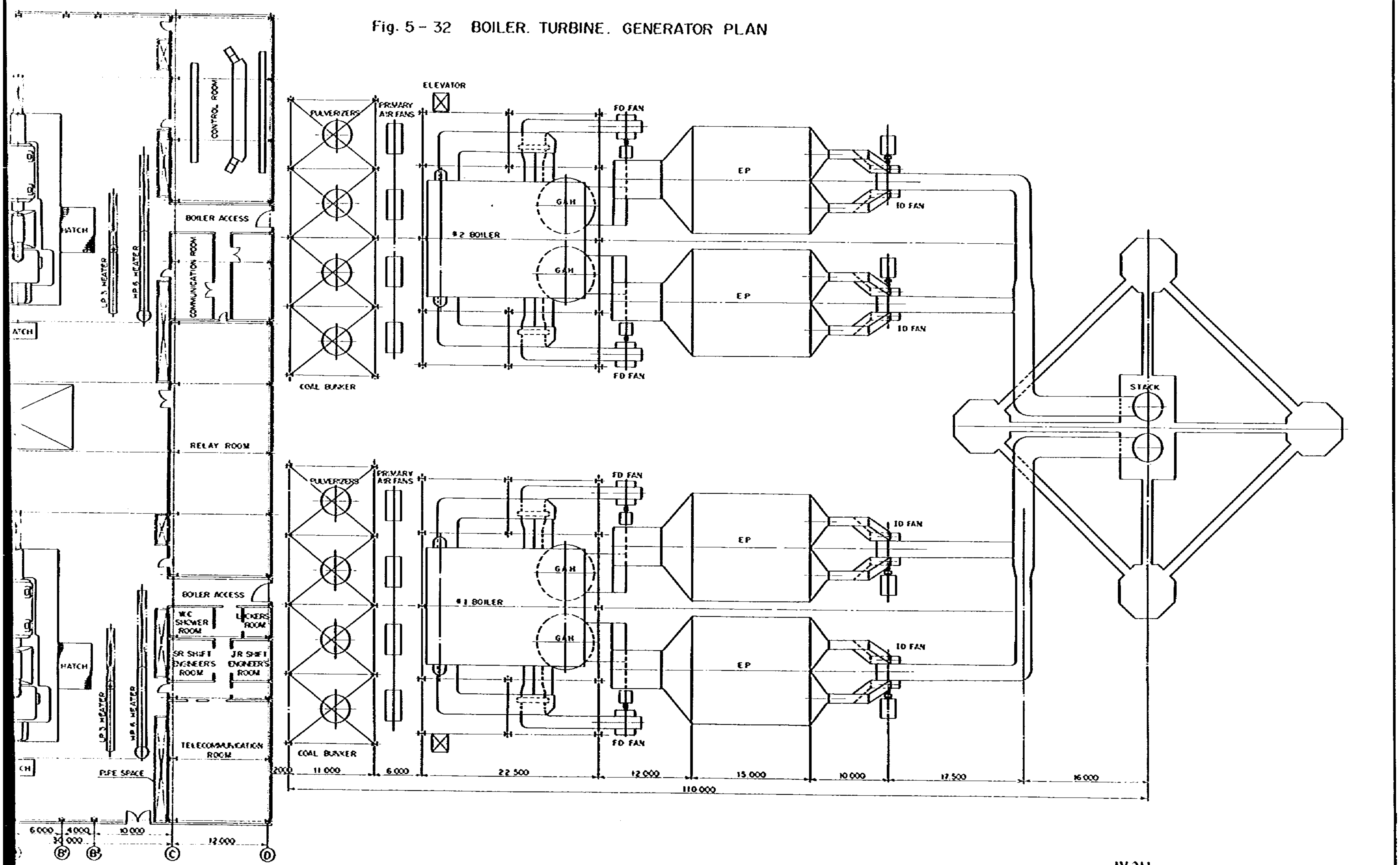


Fig. 5 - 32 BOILER. TURBINE. GENERATOR PLAN

Fig. 5 - 33 GENERAL ARRANGEMENT (SECTION) (150MW x 2)

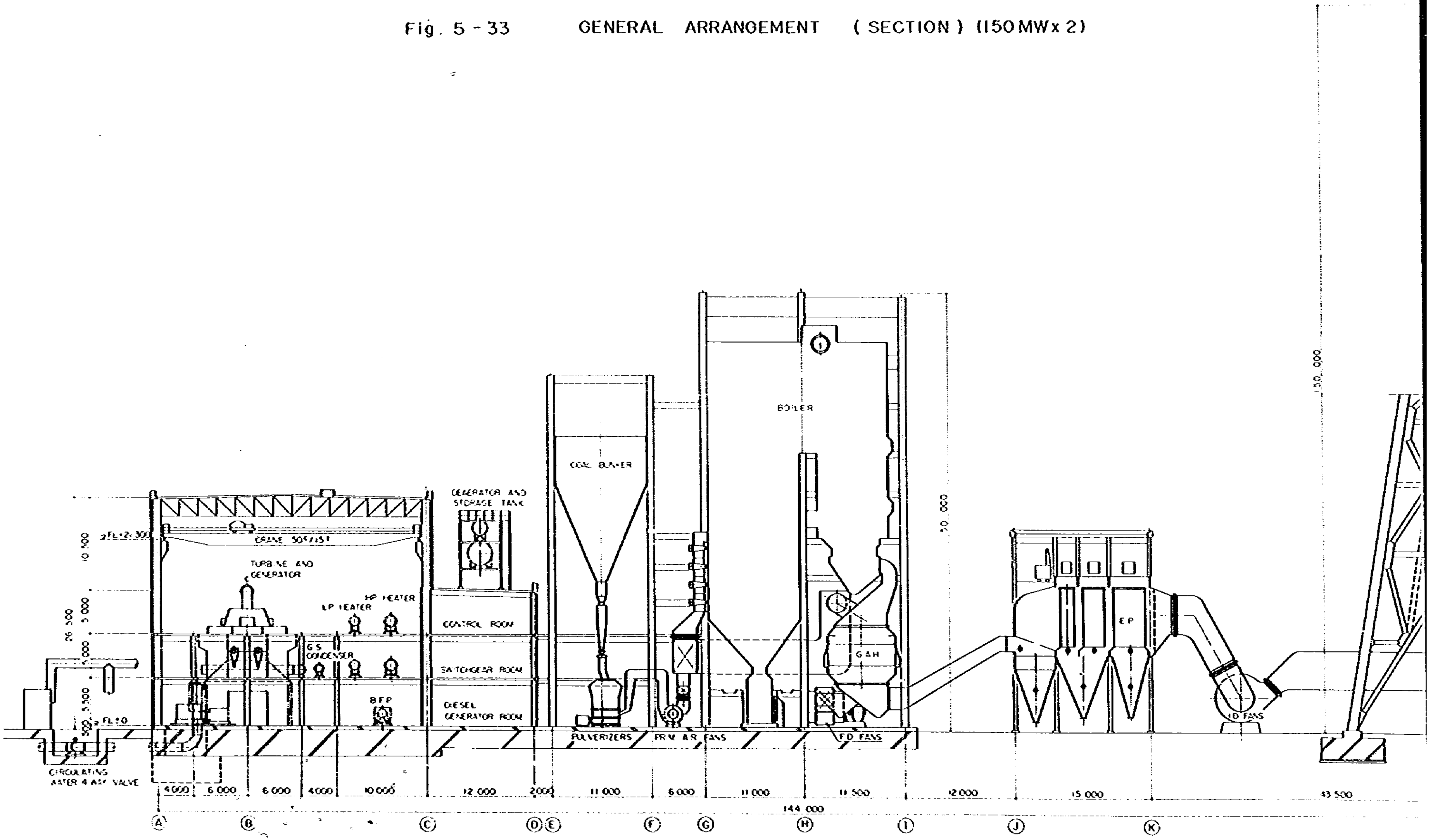


Fig. 5 - 33 GENERAL ARRANGEMENT (SECTION) (150 MW x 2)

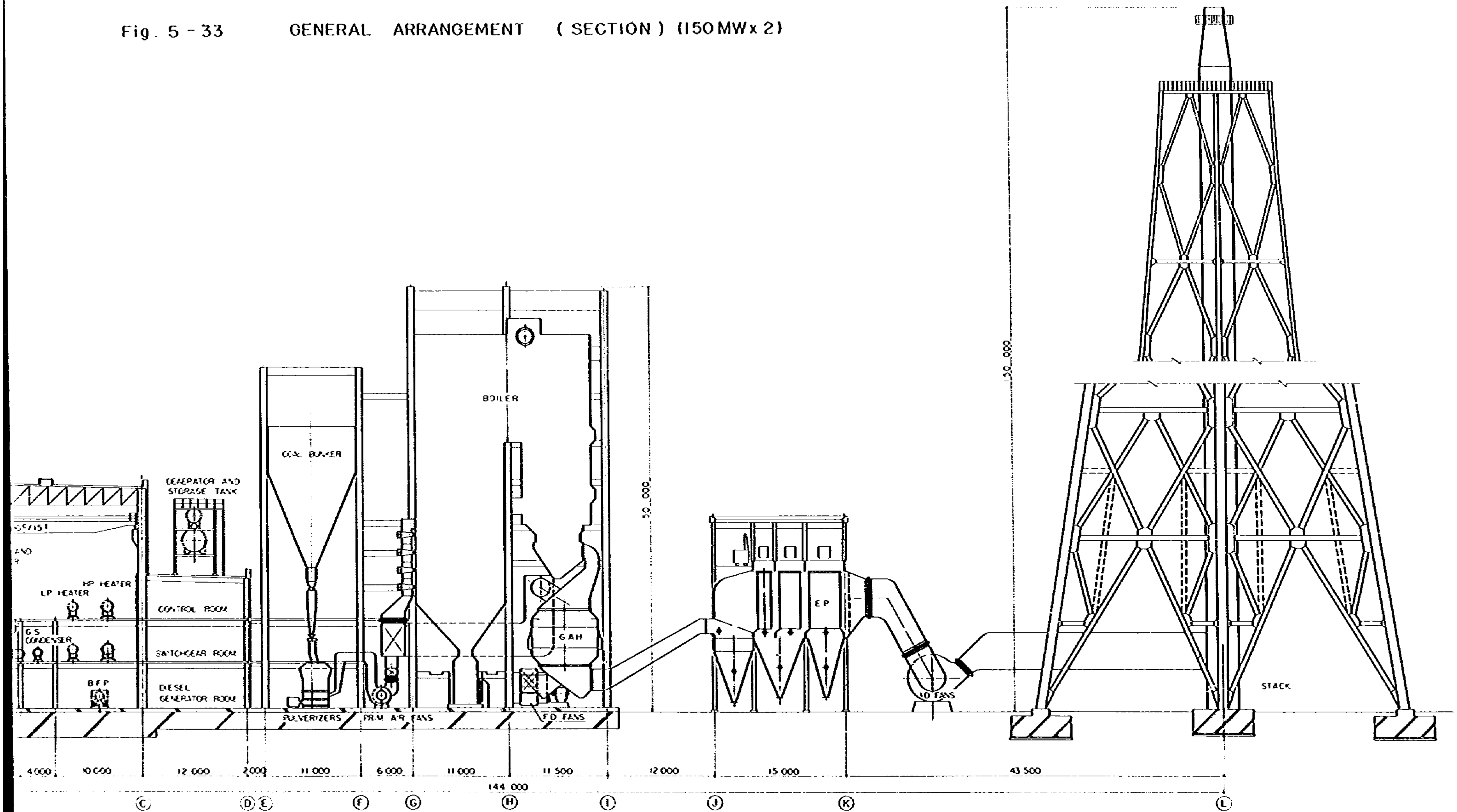


Fig. 5 - 34 MAIN POWER PLANT BUILDING (OPERATING FLOOR PLAN) (150MW x 2)

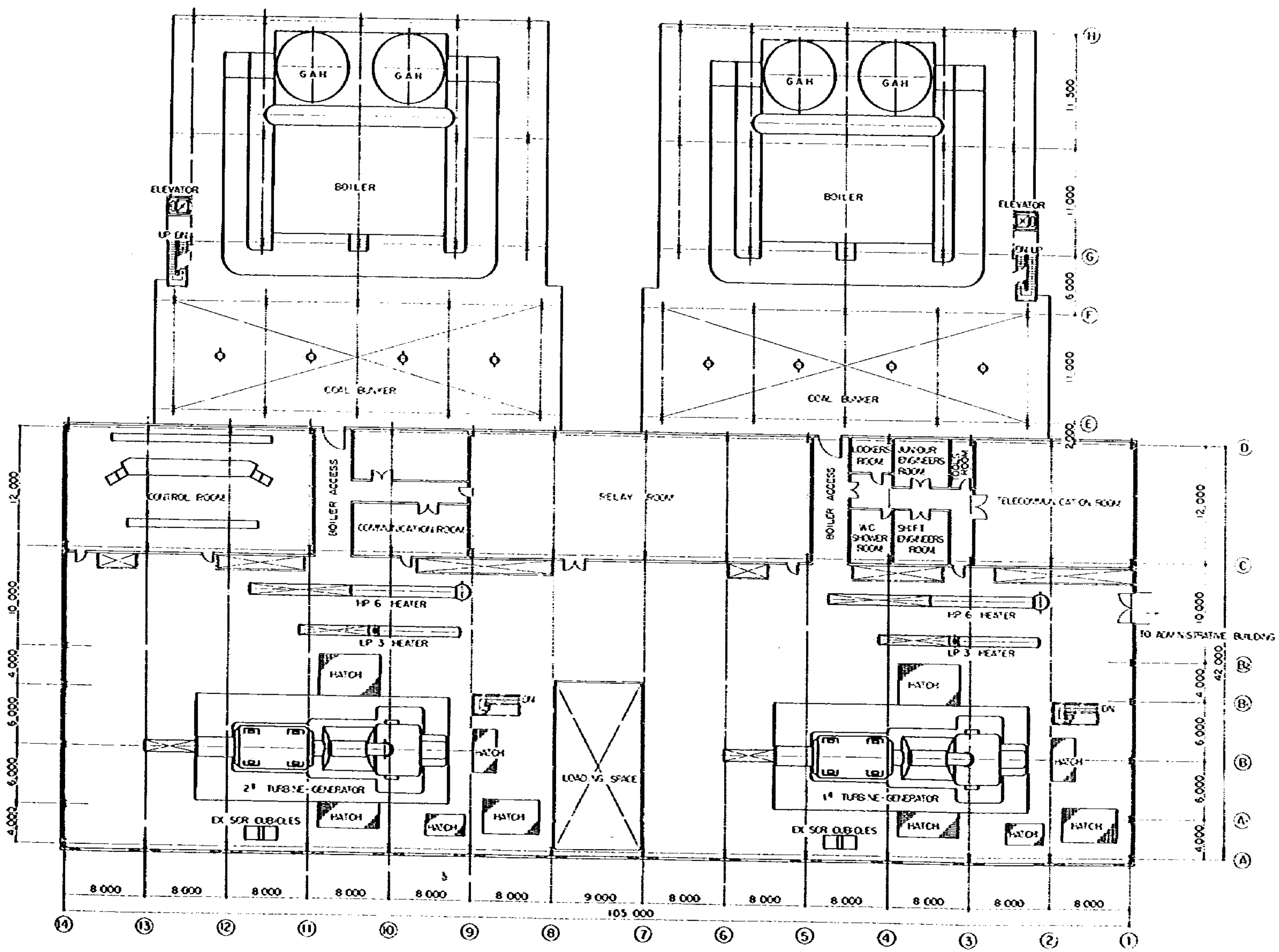


Fig. 5 - 35 FUEL GAS FLOW DIAGRAM (150 MW)

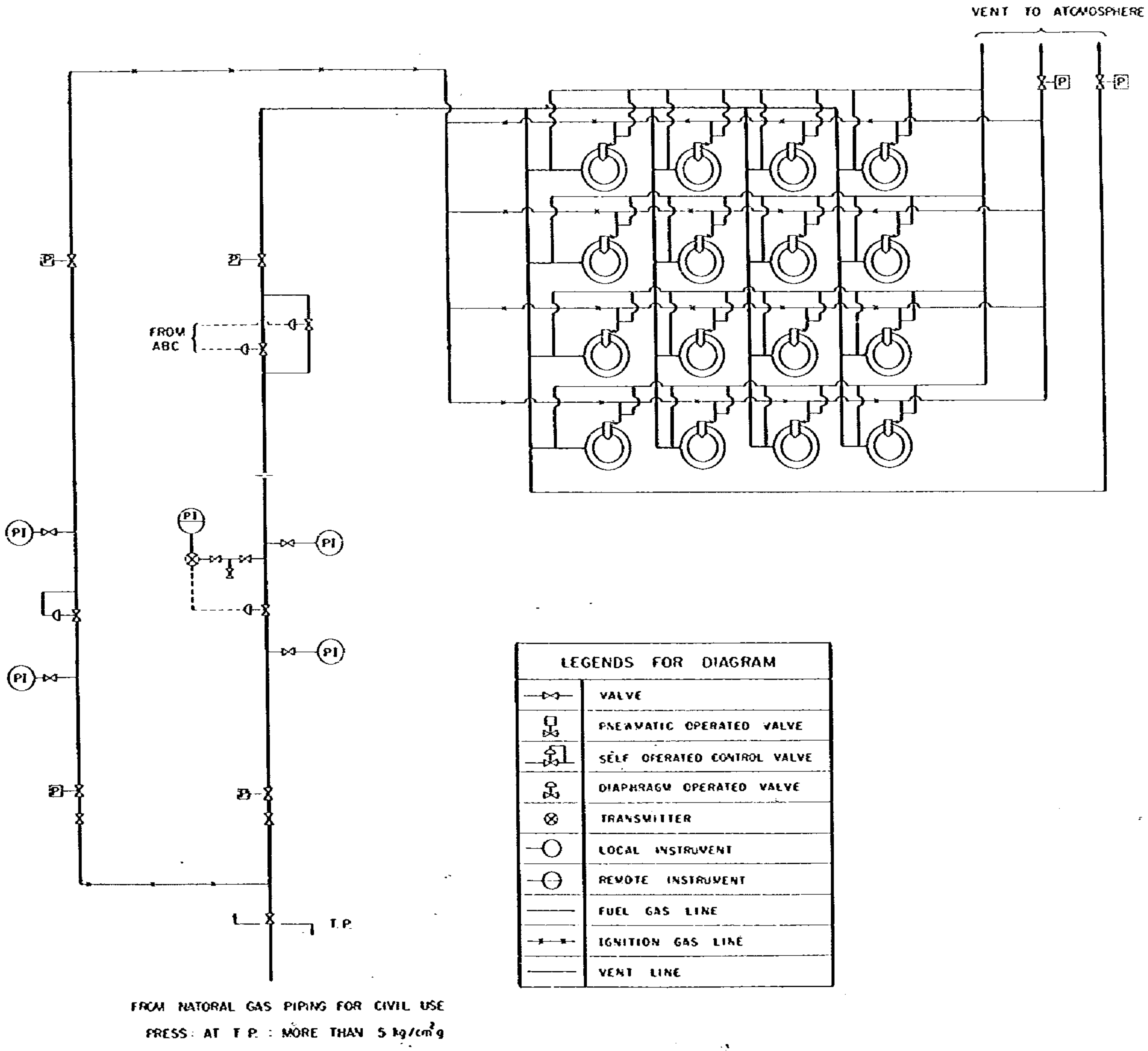
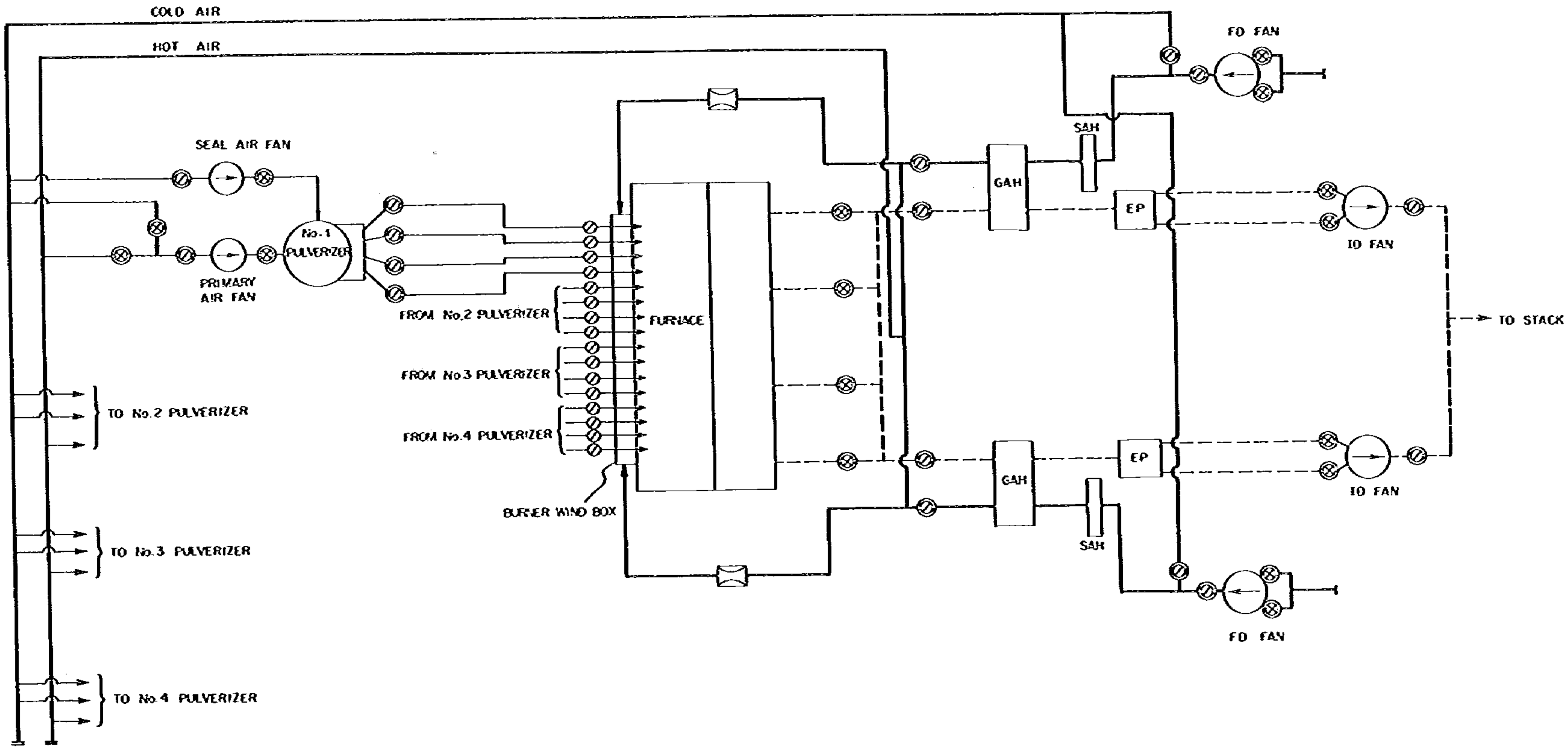
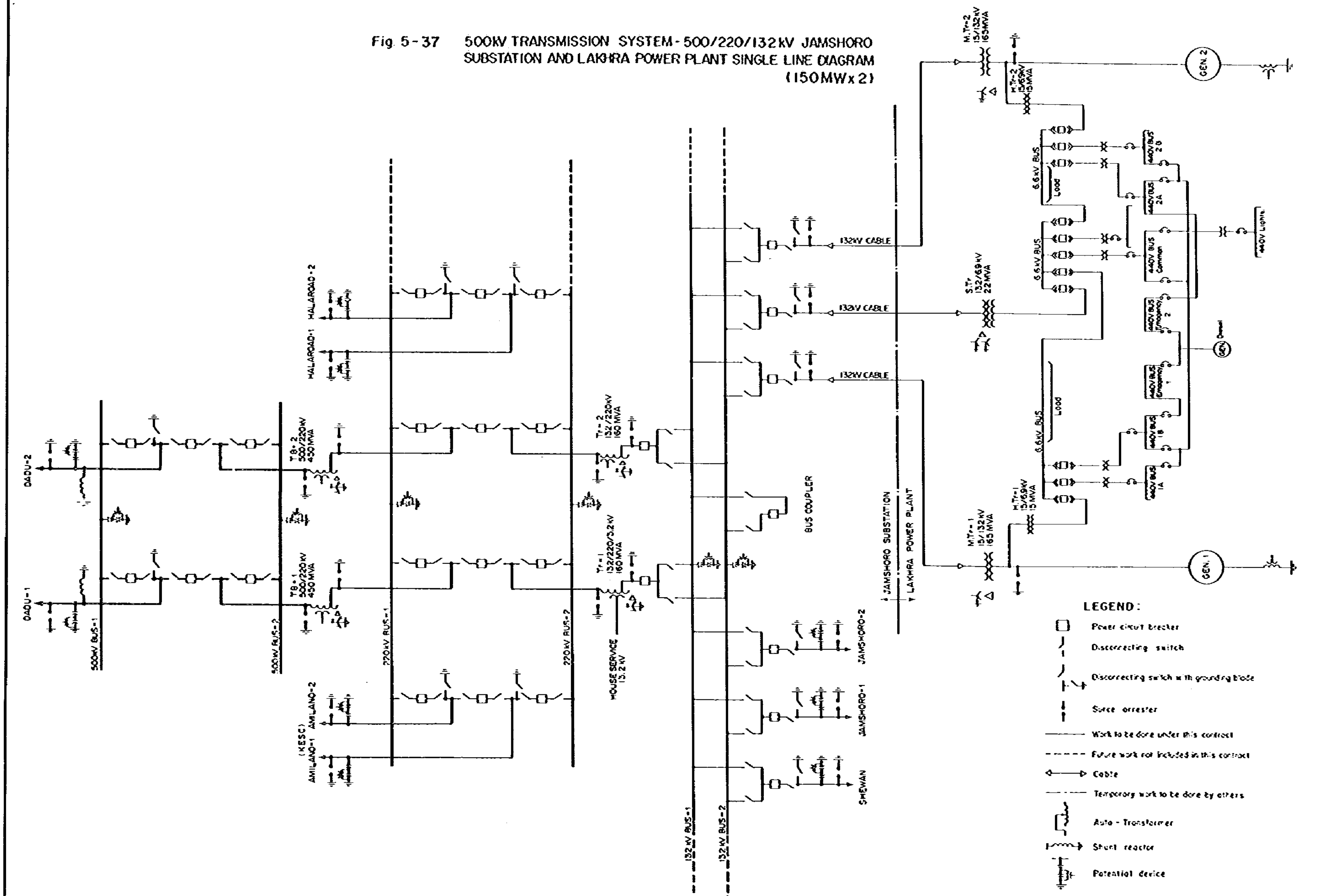


Fig. 5-36 AIR AND GAS FLOW DIAGRAM (150MW)



SYMBOLS	
⊗	REMOTE REGULATING DAMPER
⊘	REMOTE ISOLATING DAMPER
⊘	LOCAL ISOLATING DAMPER

Fig. 5-37 500kV TRANSMISSION SYSTEM - 500/220/132kV JAMSHORO SUBSTATION AND LAKHRA POWER PLANT SINGLE LINE DIAGRAM (150MWx2)



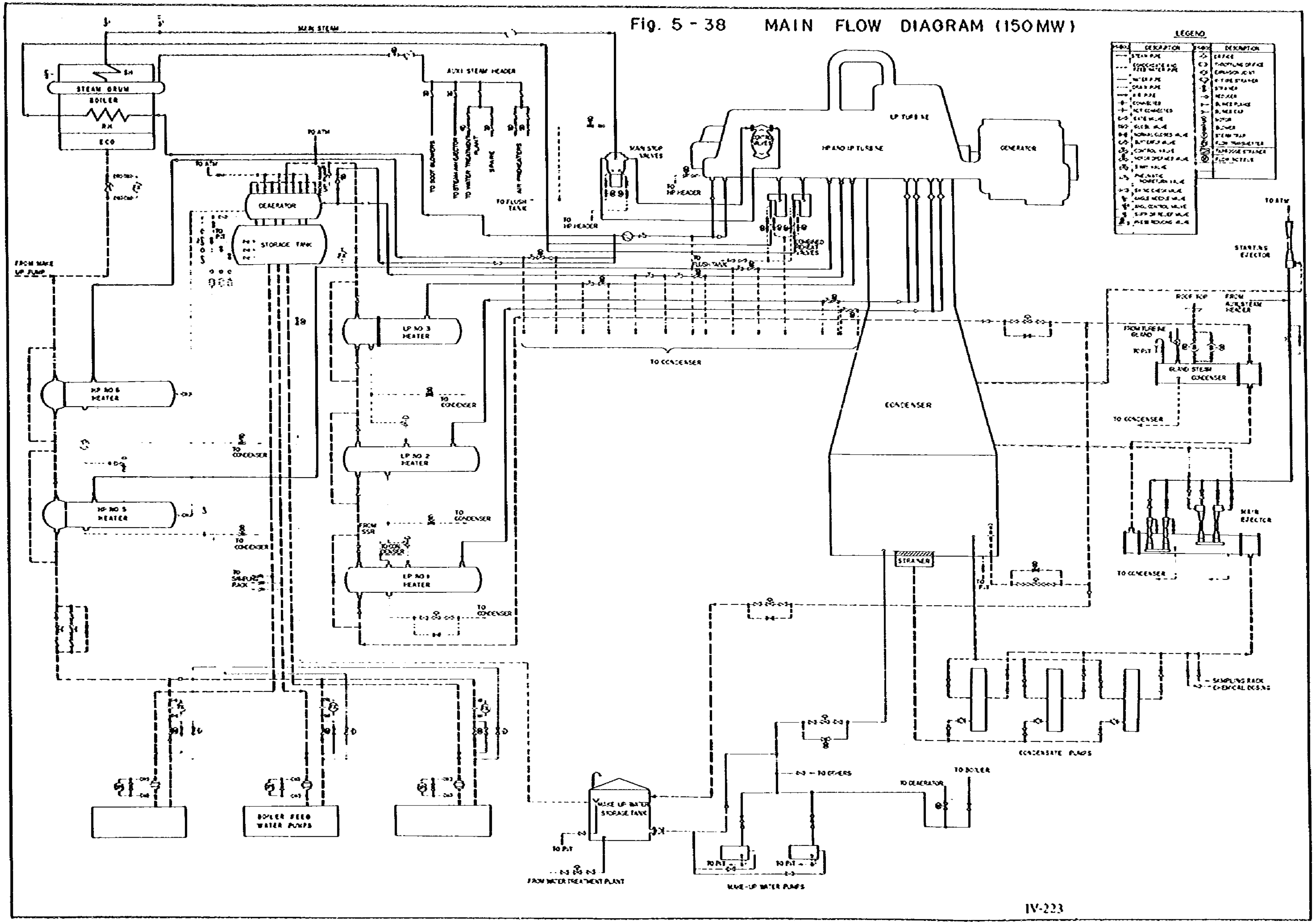


Fig. 5 - 38 MAIN FLOW DIAGRAM (150MW)

CHAPTER 6 POWER SYSTEM ANALYSIS

6-1 Method of Power Transmission for Lakhra Coal-fired Thermal Power Station

The voltage of electric power to be generated at Lakhra Coal-fired Thermal Power Station is to be increased to 132 kV by means of step-up transformers to be installed in the premises of the power station for transmission to the adjoining 500 kV Jamshoro Substation which is to be constructed as a terminal substation of the 500 kV Multan-Guddu-Jamshoro line.

The following are the reasons for selection of a voltage of 132 kV:

(1) WAPDA is contemplating to take in 500 kV, 220 kV and 132 kV lines to the 500 kV Jamshoro Substation, and the voltages of 132 kV and 220 kV are conceivable as transmission voltage for Lakhra Coal-fired Thermal Power Station.

(2) Economic comparison, however, has shown that 132 kV will be more advantageous than 220 kV as transmission voltage for Lakhra Power Station.

(3) There is almost no difference between the transmission voltages; 132 kV and 220 kV, in respect of power system stability. 300 MW could be sent from Lakhra Power Station in 1987, should there be no severe faults as three phase ground on the 500 kV transmission line.

(4) Breaker-and-a-half arrangement adopted for 220 kV buses has higher reliability than conventional double-bus bar arrangement adopted for 132 kV buses. However, the probability of occurrence of bus bar fault would be nearly zero and the annually planned shutdown of the power station for three months would give enough time for inspection, that would bring high reliability for 132 kV buses as well as for 220 kV buses.

(5) There is no difference between two methods, 132 kV transmission and 220 kV transmission, in the 220/132 kV transformation capacity of the 500 kV Jamshoro Substation, even if 600 MW should be the ultimate capacity of Lakhra Coal-fired Power Station because the capacity of the transformer is subject to power demand in the Hyderabad area during the high-water season.

Tables 6-1 and 6-2 show estimated construction costs of transmission facilities in every transmission scheme.

6-2 Power System Analysis

The power system in 1987, when the Lakhra Coal-fired Thermal Power Station is to be commissioned, was studied in respect of power flow and power system stability. The outline of the power system is as given in Fig. 6-1. Tarbela-Gatti 500 kV, 3 single-circuit lines, now under examination by WAPDA in connection with increase in the capacity of Tarbela, have been taken into account in the power system analysis dealing with Lakhra Power Station.

6-2-1 Power Flow

The voltages and power flows were studied for peak load hours in the low-water months of 1987. In power flow calculations, it was assumed that hydroelectric power stations are to be effectively utilized for meeting power demand and that the thermal power stations would supplement the hydro power stations in covering shortages of such power demand.

The data furnished by WAPDA were used for the outputs of the various hydroelectric power stations and the loads on the individual substations.

The outputs of the hydroelectric power stations will be greatly decreased during the low-water months. Accordingly, it will be necessary to operate a large gas turbine as well as steam power stations in this season.

The power flow diagram for peak load hours in the low-water months of 1987 is as given in Fig. 6-3. Regarding the power flows of 500 kV transmission lines, there will be flows outward, northward and southward, from the thermal power stations of the central areas of Pakistan, Multan and Guddu.

Since the power flows of the 500 kV transmission lines are relatively light, there is a tendency for the 500 kV bus voltages of the individual 500 kV substations to rise and shunt reactor capacities would be required for maintaining the 500 kV bus voltages of the substations at roughly 100%.

On the contrary, some 132 kV and 220 kV transmission lines might be overloaded and the voltages of 132 kV substations far from 500 kV substations will likely to decrease. Secondary transmission facilities consisting of 132 kV and 220 kV transmission lines and reactive power suppliers should be examined in detail by WAPDA.

If the 132 kV transmission line between the 500 kV Jamshoro Substation and the present 132 kV Jamshoro Grid Station are to be 132 kV, 2 cct (conductor used: LYNX) utilizing a part of the existing Jamshoro-Lakhra Line, it is considered that overloading will take place during shutdowns of the thermal units in the Hyderabad area. Such is the case in the high-water months. It is necessary for measures to be taken to increase the transmission capacity of the said present line; such as to use bundle conductors to be contemplated.

During the high-water months, all the thermal units in the South would be shut down and power required in the Hyderabad area would flow from the hydro power stations in the North. Therefore, the transmission lines to send power from the 500 kV Jamshoro Substation to the Hyderabad area and necessary equipment including 220 kV/132 kV transformers should have enough capacity to meet the full requirements of the area.

In case a 220 kV transmission line is constructed between the 500 kV Jamshoro Substation and Hala Road, considerations should be given to the operation of the power system in order that the power flows of the said 220 kV and existing 132 kV transmission lines can be properly distributed. If this transmission line is not constructed, the capacity of the 220/132 kV transformation will have to be provided for meeting the full requirements of the Hyderabad area.

6-2-2 Power System Stability

Transient stability calculations were made for the power flow conditions during peak load hours in the low-water months of 1987.

It was hypothesized that the faulting conditions in the transient stability calculations would be 3-phase line-to-ground faulting at the Jamshoro end of the 500 kV Dadu-Jamshoro Line with

circuit breakers of the said transmission line opened after 4 cycles following the occurrence of the fault.

The swing curves of calculation results are indicated in Fig. 6-4. The power system will be unstable in case of fault(s) at the Jamshoro end of the 500 kV Dadu-Jamshoro Line, and will not discharge functions against such faults.

In case double circuit is adopted for the 500 kV transmission line of Gatti-Multan Guddu-Jamshoro, the system will be stabilized, even when faults and/or accident(s) should occur on a single circuit of the 500 kV transmission line. The calculation results of transient stability are as shown in Fig. 6-5.

A second 500 kV Gatti-Multan-Guddu-Jamshoro Line would be necessary in order to maintain the interconnection of the 500 kV transmission line at all times.

6-2-3 Summarization of Results

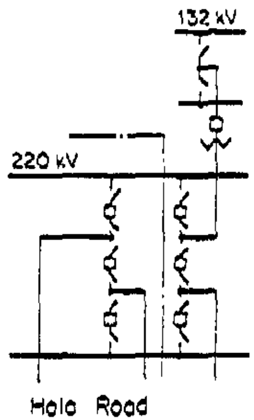
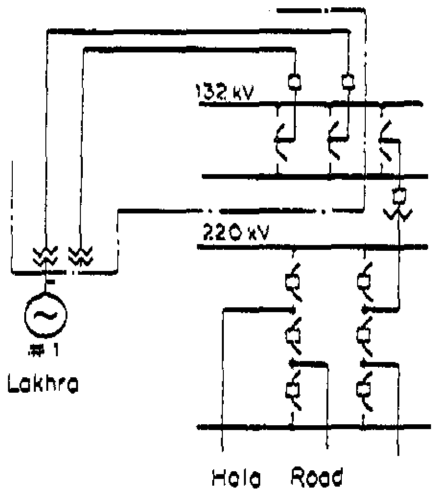
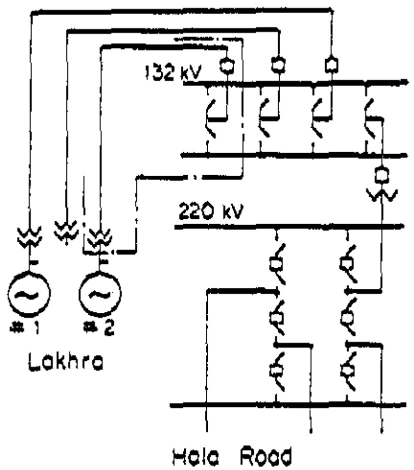
(1) It is considered more advantageous that Lakhra Coal-fired Thermal Power Station will be connected to a 132 kV bus of the 500 kV Jamshoro Substation from an economical point of view.

(2) It is desirable for a second 500 kV Gatti-Multan-Guddu-Jamshoro Line to be constructed to form a power system having high reliability in order to avoid step-out of any power stations against severe line fault(s).

(3) During the high-water months, power required in the Hyderabad area would be supplied by the hydro power stations in the North. Accordingly, the capacity of the transmission lines to send power from the 500 kV Jamshoro Substation and substation equipment including 220/132 kV transformers will have to be provided in order to meet the full requirements of the Hyderabad area.

Lakhra Coal-fired Thermal Power Station is to be shut down during the high-water season. Therefore, the analysis on the power system in this season was not performed in the feasibility study on the development of Lakhra Coal-fired Thermal Power Station.

Table 6-1 CONSTRUCTION COSTS OF FACILITIES OF 132kV TRANSMISSION SCHEME

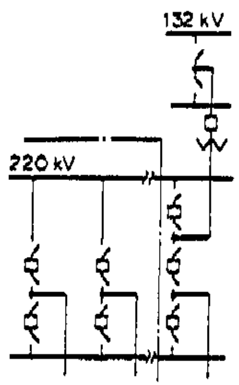
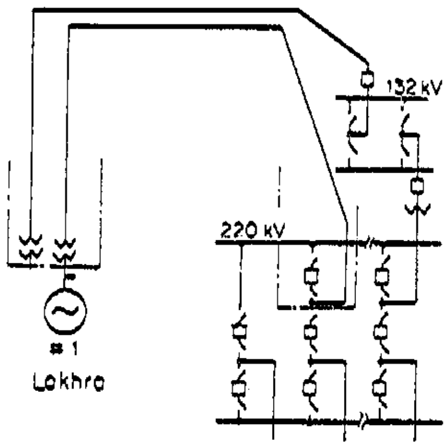
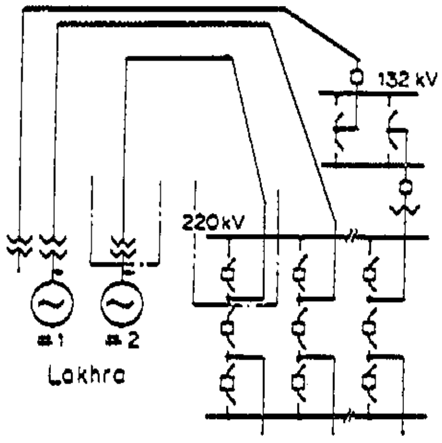
Year	Before 1987	1987	1991
Schedule for Addition of Facilities			
Construction Costs (10^6 Rs)	Switchyard equipment 12.2 Two bus section 0.7 Installation & erection 2.6 Total 15.5	Switchyard equipment 1.9 Two bus section 0.6 Transformer 25.0 Installation & erection 5.5 Transmission line 2.4 Total 35.4	Switchyard equipment 1.9 Transformer 25.0 Installation & erection 5.5 Transmission line 1.7 Total 34.1

Grand total 85.0 (10^6Rs)

Note) 1. The construction costs of equipment for the starting transformer circuit are excluded.

2. Costs include freight and marine cargo insurance premium.

Table 6-2 CONSTRUCTION COSTS OF FACILITIES OF 220kV TRANSMISSION SCHEME

Year	Before 1987	1987	1991
Schedule for Addition of Facilities			
Construction Costs (10^6 Rs)	Switchyard equipment 14.5 Four bus section 1.4 Installation & erection 3.1 Total 19.0	Switchyard equipment 3.3 Transformer 27.5 Installation & erection 6.2 Transmission line 2.0 Total 39.0	Switchyard equipment 3.3 Transformer 27.5 Installation & erection 6.2 Transmission line 1.4 Total 38.4

Grand total 96.4 (10^6 Rs)

Note) 1. The construction costs of equipment for the starting transformer circuit are excluded.

2. Costs include freight and marine cargo insurance premium.

Fig. 6-1 PAKISTAN ELECTRICITY GRID 1987

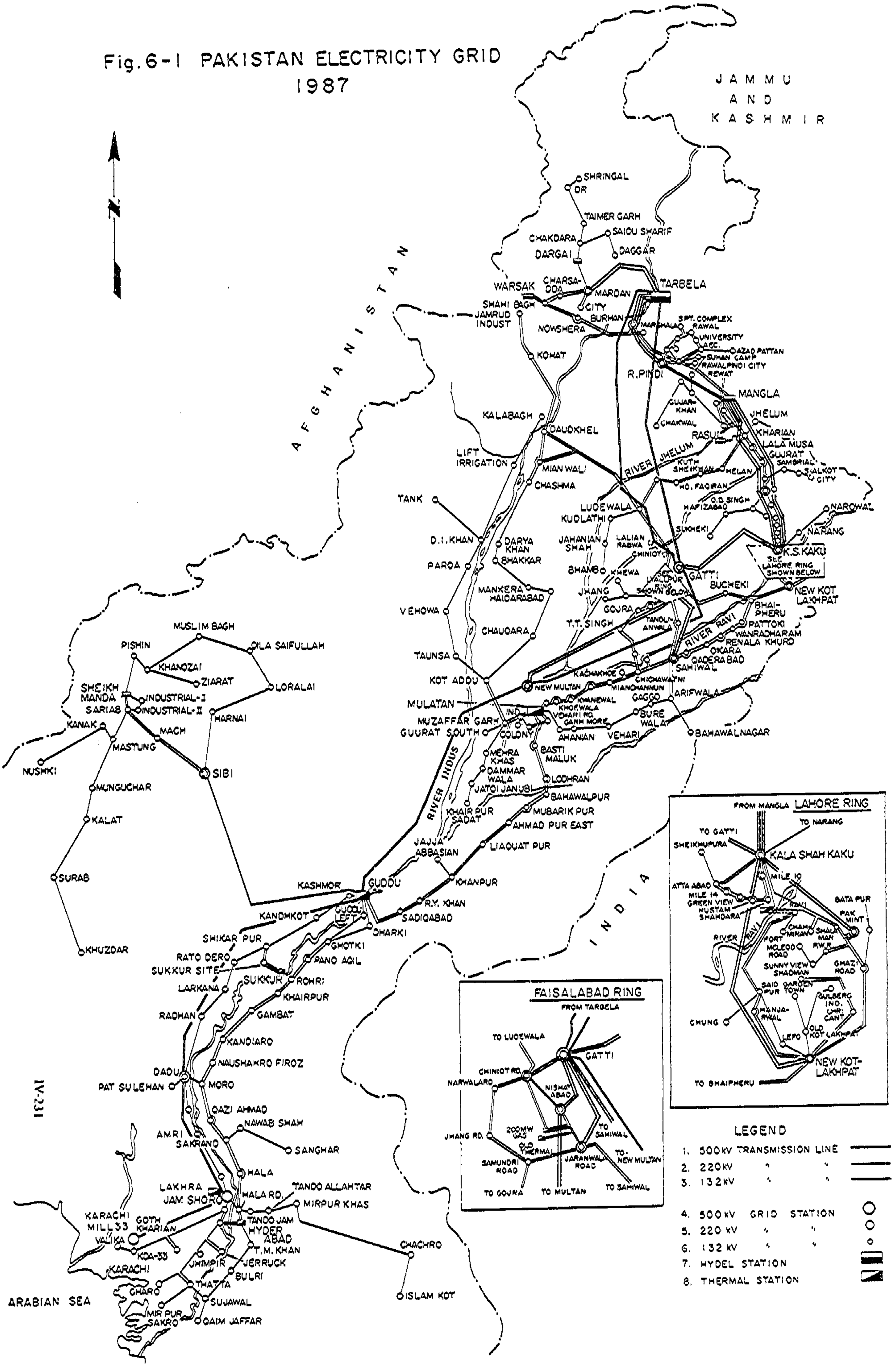


Fig. 6-2 IMPEDANCE MAP OF PAKISTAN ELECTRICITY GRID 1987

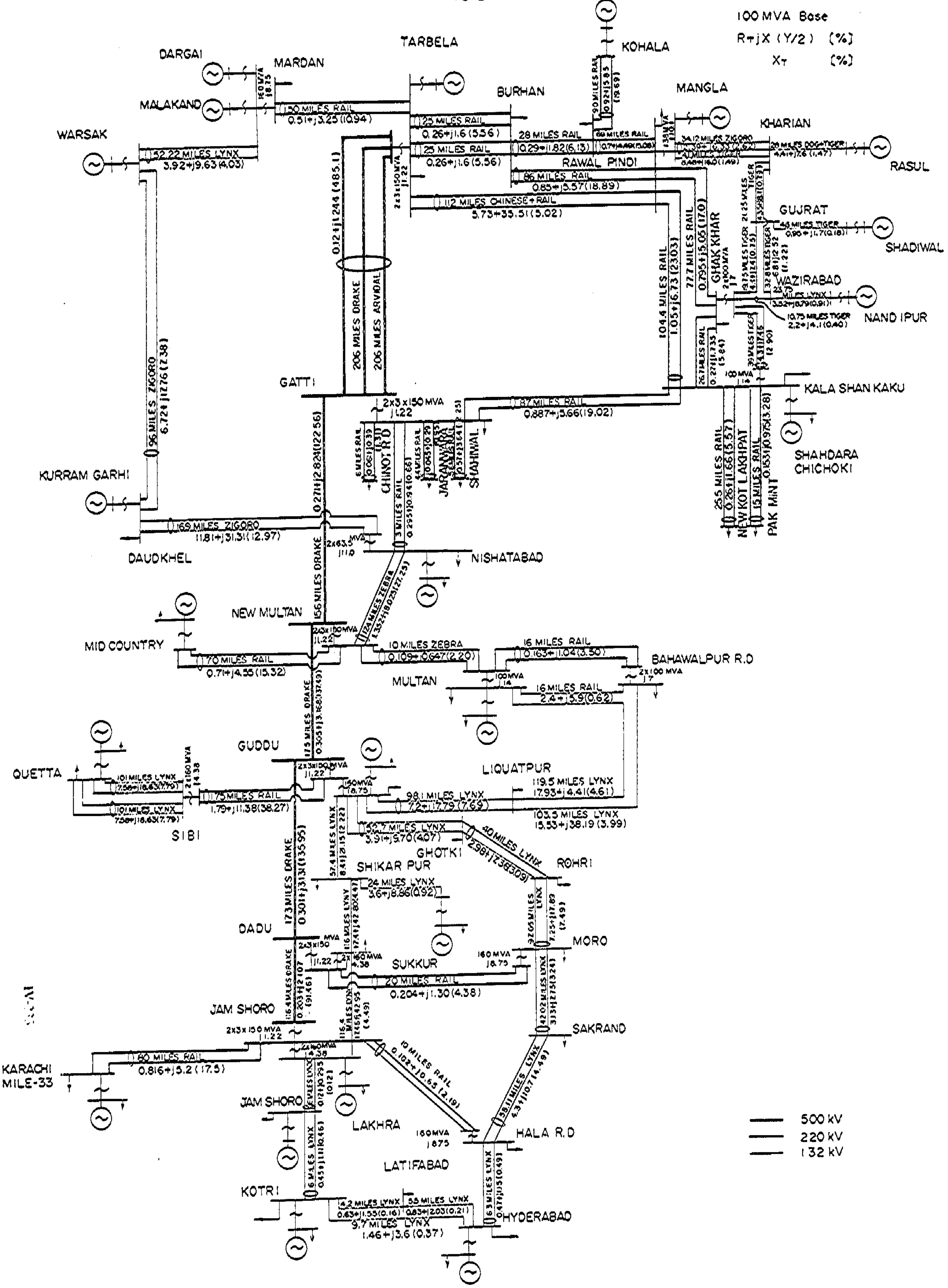
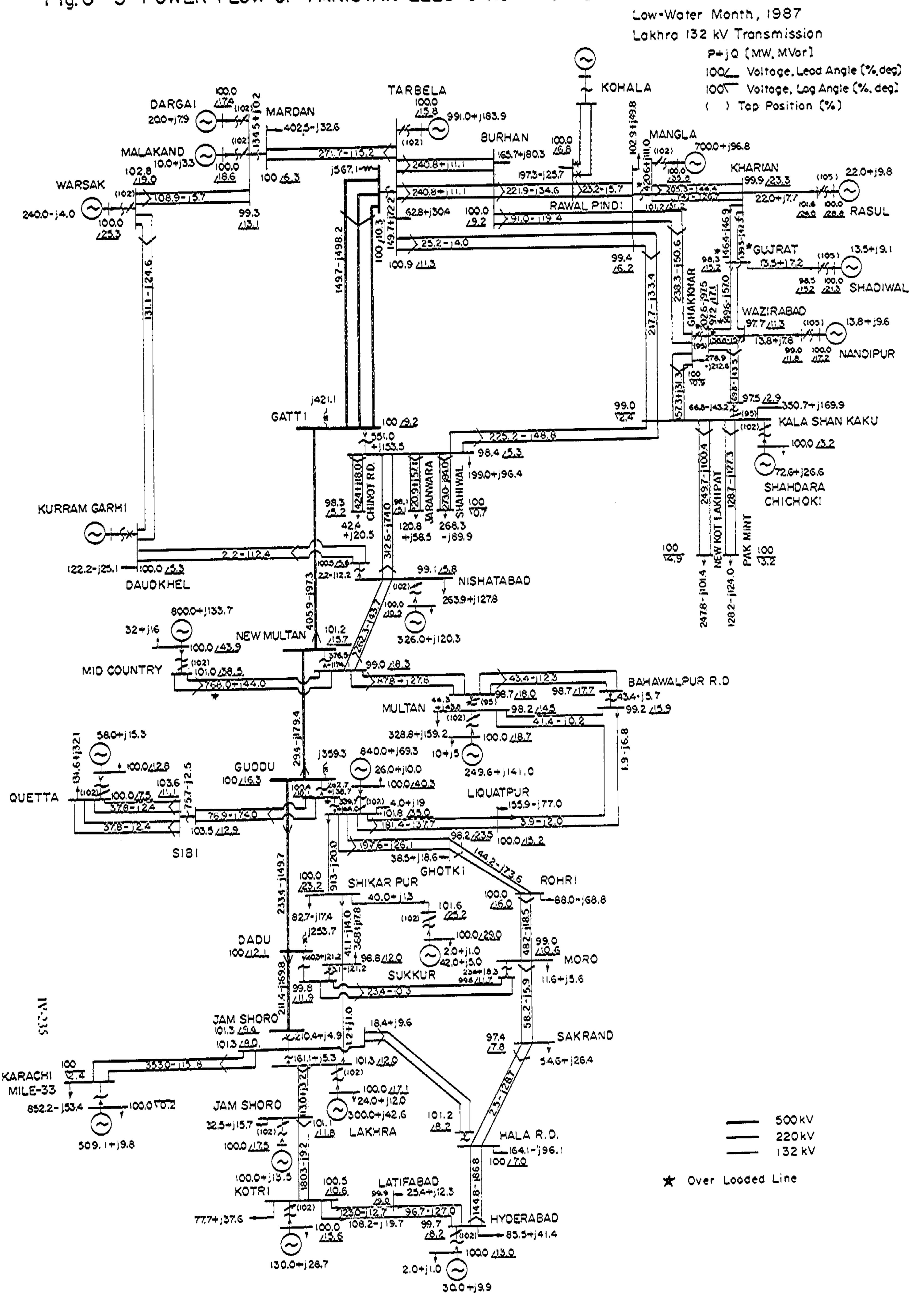
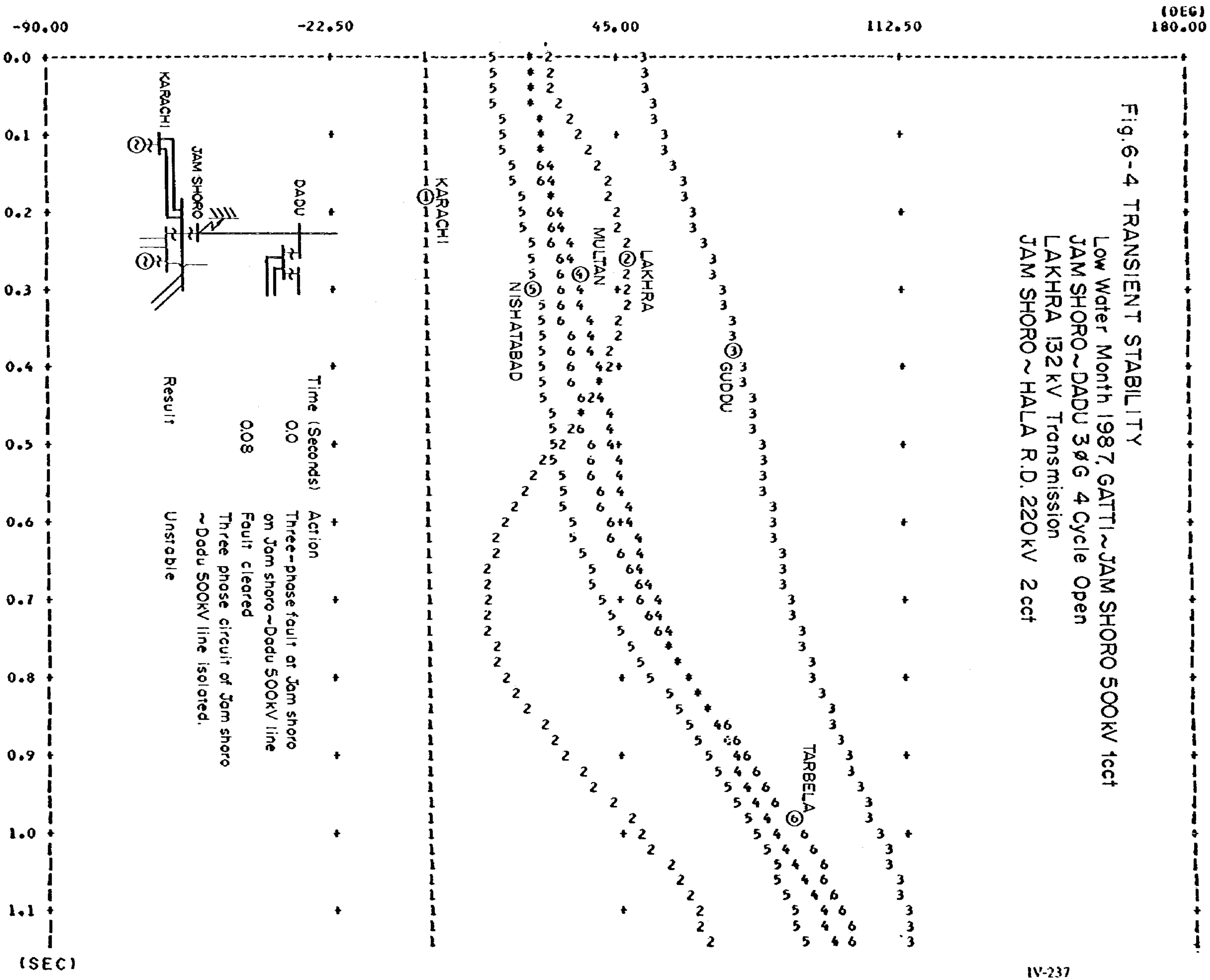


Fig. 6-3 POWER FLOW OF PAKISTAN ELECTORICITY GRID




(DEG)
-90.00
-22.50
45.00
112.50
180.00
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
(SEC)
KARACHI
JAM SHORO
DADU
KARACHI ①
NISHATABAD ⑤
MULTAN ④
LAKHRA ②
GUDDU ③
TARBELA ⑥
Time (Seconds) Action
0.0 Three-phase fault at Jam shoro on Jam shoro~Dadu 500kV line
0.08 Fault cleared
Three phase circuit of Jam shoro ~Dadu 500kV line isolated.
Result Unstable
Fig.6-4 TRANSIENT STABILITY
Low Water Month 1987, GATTI~JAM SHORO 500kV 1cct
JAM SHORO~DADU 3øG 4 Cycle Open
LAKHRA 132kV Transmission
JAM SHORO~HALA R.D. 220kV 2cct

JAMSHORO-DADU 3LG-0 BASE GENERATOR= 81

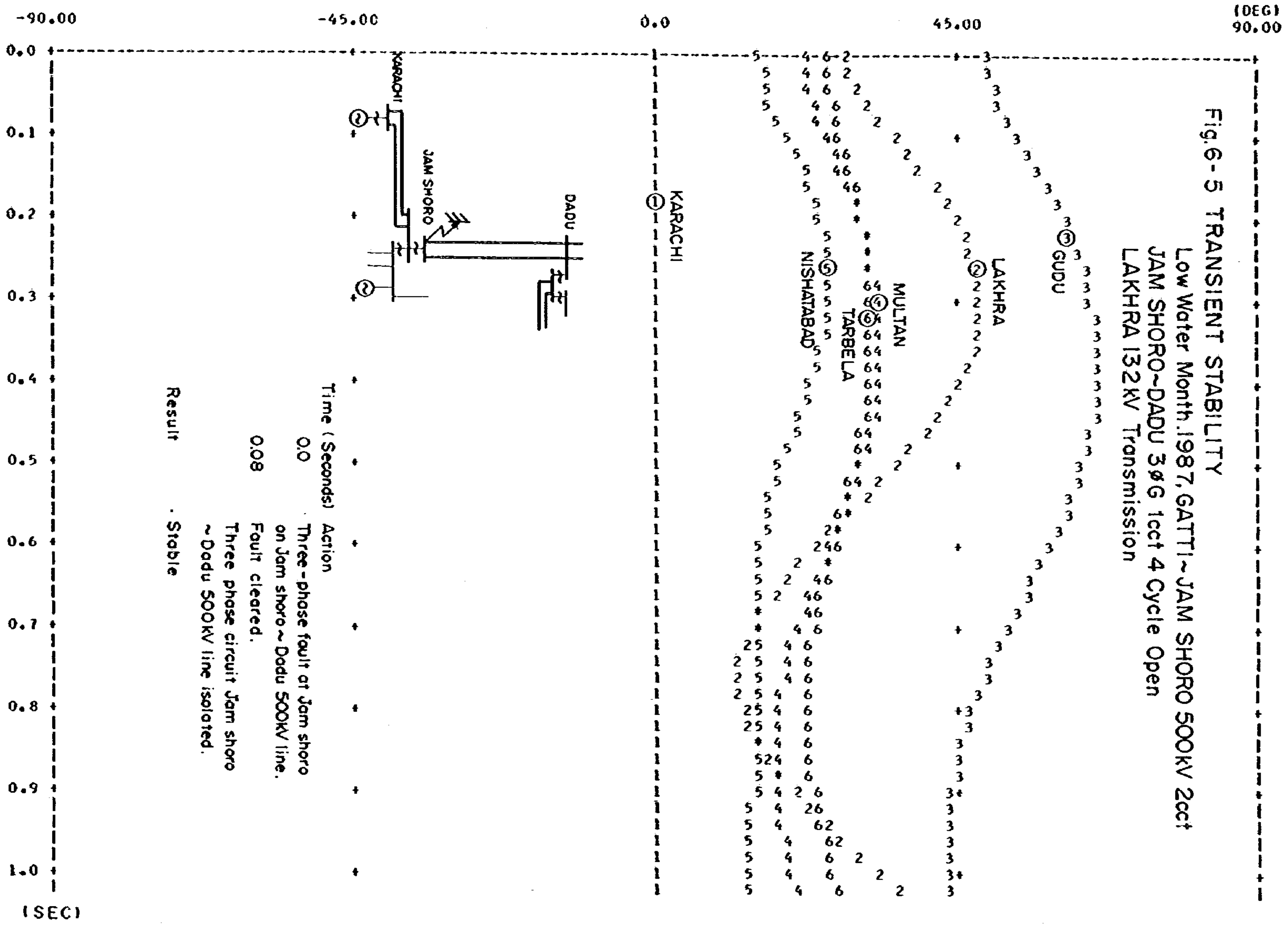


Fig.6-5 TRANSIENT STABILITY
Low Water Month.1987, GATTI~JAM SHORO 500kV 2cct
JAM SHORO~DADU 3φG 1cct 4 Cycle Open
LAKHRA 132kV Transmission

CHAPTER 7 CONSTRUCTION SCHEDULE FOR COAL-FIRED THERMAL POWER STATION

7-1 Scope of Construction Schedule Setup

In order to carry out the Project to construct a 300 MW Lakhra coal-fired thermal power station (300 MW x 1 unit or 150 MW x 2 units) as the alternative, the construction schedules shown in Figs. 7-1 and 7-2 start with submission of this feasibility study report.

These schedules have been prepared on the assumption that about 24 months are to be required for taking procedures from submission of this feasibility study report up to the commencement of the actual construction work and also about 47 mounths for the performance of construction work. Thus, about 71 months will be needed until the commissioning of the power plant.

7-2 Construction Work

Following receipt by the contractor(s) of an L/C to be opened within 24 months after submission of this feasibility study report, a contractor will be allowed 47 months for construction work which includes designing and manufacturing of necessary equipment by manufacturers, civil works, installation and erection, and trial operation of generating equipment. It is taken into consideration that workable days per month and working hours per day in Pakistan will be 23 days and 8 hours, respectively.

Details of construction process and necessary period are estimated as follows:

(1) Designing and Manufacturing

After a contractor receives an L/C, manufacturers are to start manufacture of equipment and supplies in accordance with approval drawings granted by WAPDA. About 19 months will be needed for manufacturing, shop tests and package of a turbine rotor, which requires the longest manufacturing time among generating equipment, and a generating rotor.

(2) Transportation

Upon completion of equipment, its shipment shall be effected by receiving an export license from the related authorities concerned of the exporter. 2 months are estimated necessary to cover transit from a foreign port to Karachi port and time needed for customs clearance and inland transportation.

(3) Civil and Structural Works

9 months are presumed necessary for preparatory work for construction of provisional facilities, temporary buildings and land reclamation.

29 months are allowed for water circulation works to install water intake and discharge facilities, and the related work should at the latest be completed before starting trial operation of auxiliary equipment and receiving electric power.

9 months are factored into estimated period necessary for foundation work for a main building and 27 months from frame erection to completion of a main building.

All civil and structural works including necessary modification work have been scheduled to be completed before steam admission to a turbine.

(4) Assembly, Installation and Trial Operation of Generating Equipment

Boiler assembly starts with drum lifting and assembly of portions to withstand pressure parts with a hydraulic test. Next, attachments will be installed and all necessary work shall be completed by the time a boiler is ignited. Time necessary for these jobs is estimated to be 16 months.

With the exception of wire grounding work to be conducted in parallel with foundation work for civil works, all electrical work including installation of a turbine, a generator and measuring instruments must be completed before steam admission to a turbine.

20 months are estimated necessary from drum lifting to completing these jobs. Trial operation of auxiliary equipment are to be conducted in turn after receiving electric power. A no-load test and a load test as well as adjustment to a plant should be made after steam admission to turbine and 3 months are allowed until commencement of commercial operation. Principal items of construction processes for the 300 MW x 1 unit and their timetable as well as a period from start of preparatory work are shown below;

Principal items	Time	Period
Start of preparatory work	April 1983	–
Start of foundation construction	October 1983	6 months
Frame erection (structural work)	July 1984	15 months
Drum lifting	April 1985	24 months
Boiler hydraulic static test	November 1985	31 months
Initial power receiving	March 1986	35 months
Initial boiler ignition (firing)	August 1986	40 months
Steam admission to turbine	December 1986	44 months
Start of commercial operation	March 1987	47 months

7-3 Final Disbursement after Completion of Construction

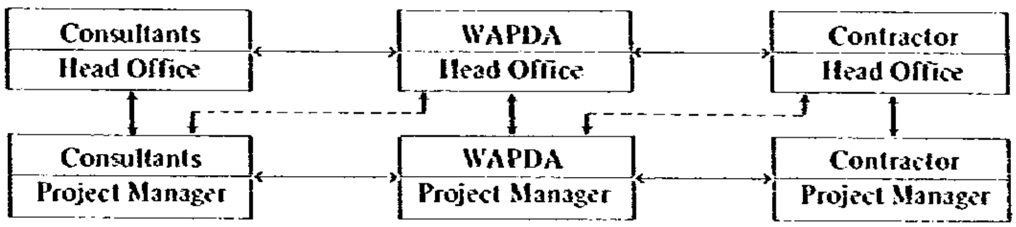
Acceptance tests will be made after construction is completed. Within about one month after WAPDA has approved test results, retention shall be released to a contractor(s) both in foreign and domestic currencies, resulting in full payment of monies for completion of the Project by December 1987.

7-4 Execution Organization and Work to be Performed

It is desired that WAPDA employ a consultant to receive his assistance in executing and managing this construction work.

Orders will be issued item by item and separately in order to cover each concrete and specific items of the work to be performed.

Organization chart showing relations between WAPDA, a consultant and a contractor is given below:



(1) Work to be Executed by WAPDA
The jobs to be conducted by WAPDA are as followers:

1) Preparatory work before starting construction
This is to make necessary arrangements for acquisition of required land, compensation for it, and supply of electricity and water to contractor(s) for the performance of construction works.

2) Examination of approval drawings and relevant documents
This is to examine and approve drawings and relevant documents submitted by contractor(s) for approval with the assistance of a consultant.

3) Decision on a basic policy of the Project
This is to work out and decide on a plan to maintain and organize necessary personnel for WAPDA's construction project and a construction plan, a test program as well as manner of acceptance tests.

4) Issuance of a certificate to justify completion of acceptance inspection
With the assistance of a consultant, WAPDA examines and approves methods, details and results of many tests conducted by a contractor and issues a certificate justifying the completion of acceptance inspection.

5) Command, adjustment and control of jobs related to project execution

6) Payment to a contractor

(2) Work to be Executed by a Consultant

The jobs to be conducted by a consultant are summarized as follows:

1) After an L/C has been established, a consultant reviews a feasibility study report and perform detailed studies.

2) Preparation of tender documents
A consultant will prepare Plans and Specifications including the general provisions, special provisions and technical provisions, bid forms, contract forms, etc. Such tender documents will be forwarded to WAPDA for its finalization.

3) Evaluation of tender documents
A consultant will examine tender documents submitted by each bidder according to the fixed formula, and prepares and submits to WAPDA reports on the results of his evaluation.

4) Assistance in conclusion of contract
A consultant will assist WAPDA in performing the work necessary for executing a contract with a contractor.

5) Assistance in examining drawings and relevant documents for approval
A consultant will examine drawings and relevant documents to be submitted by a contractor for approval and gives WAPDA appropriate comments thereon.

6) Assistance in witnessing factory inspection
A consultant renders technical assistance to WAPDA regarding a factory inspection to be witnessed by WAPDA staff.

7) Assistance in supervising construction work
A consultant gives technical assistance to WAPDA's supervisors at the construction site.

8) Assistance in making acceptance tests
A consultant gives WAPDA technical comments on the methods, details and results of various tests to be conducted by a contractor. In addition, a consultant extends technical assistance to WAPDA in issuing a certificate to a contractor to justify WAPDA's approval of the work completed as proved by satisfying inspection results.

9) Submission of monthly report
A consultant puts together comments on detailed and overall construction work executed by a contractor and submits to WAPDA a report thereon every month. A consultant also submits to WAPDA a comprehensive completion report when the construction has been completed.

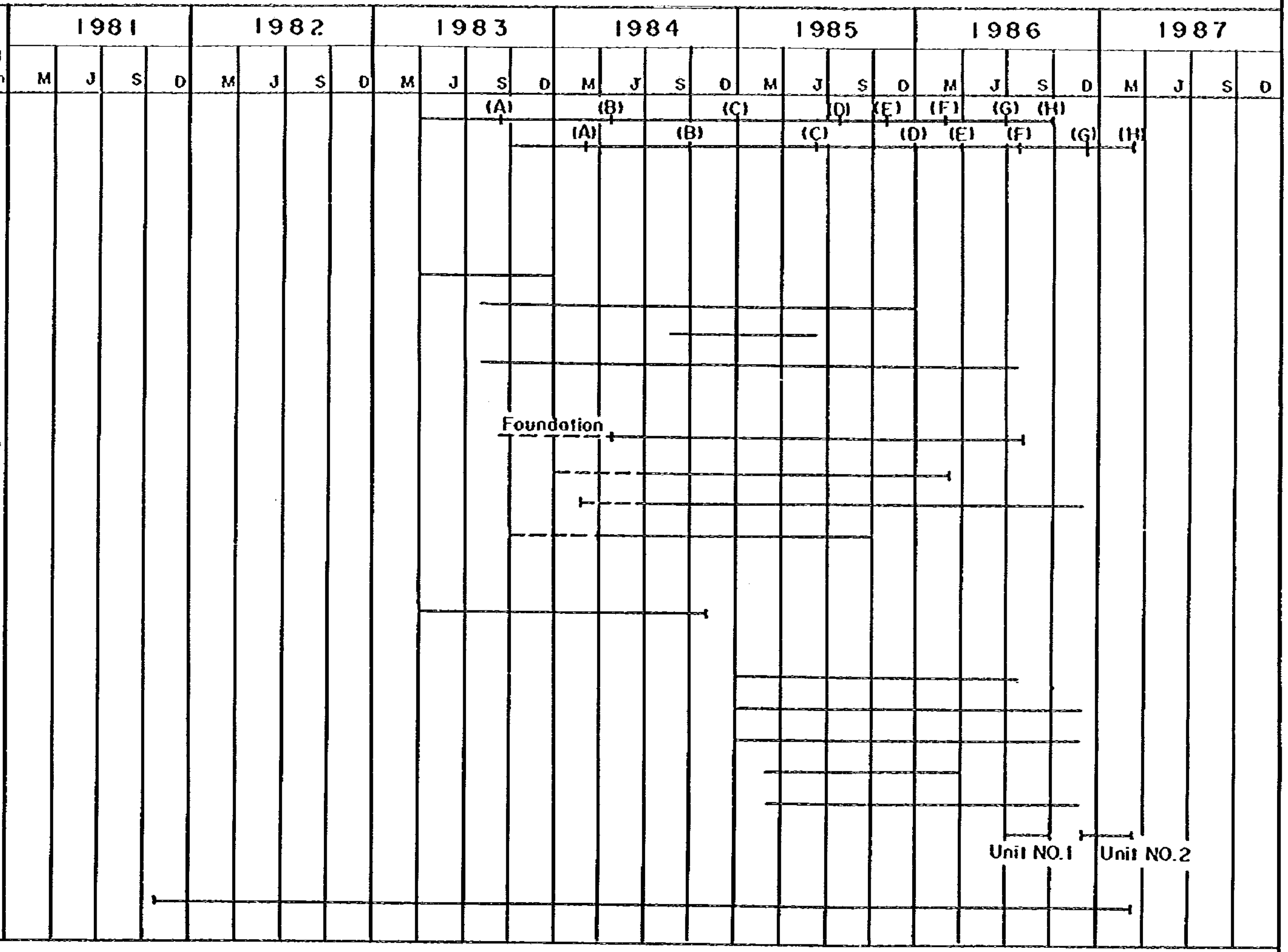
Fig. 7 – 1 Construction Schedule for Lakhro Coal – Fired Thermal Power Station (300 MW x 1 Unit)

Descriptions (Date: Year / Month 1981–1987)	Total Month
I. Major Events (A) (B) (C) (D) (E) (F) (G) (H) (I)	
II. Construction Schedule	
1. Civil Works	
1) Preparatory Works	9
2) Water Intake and Discharge	29
3) Coal Storage Yard	9
4) Other Works	36
2. Structural Works	
1) Power House	30
2) Service Building	26
3) Appurtenant House	33
4) Colony	24
3. Mechanical and Electrical Works	
1) Desigh and Fabrication	19
2) Installation	
– Boiler	16
– Turbine and Generator	20
– Electrical and Control Equipment	20
– Coal Handling Equipment	13
– Other Equipment	18
3) Tests	3
III. Consultancy Services	64

Note.
(A) Commencement of Foundation Works
(B) Commencement of Structural Works
(C) Drum Lifting
(D) Hydro Static Test
(E) Initial Power Recieve
(F) Initial Firing
(G) Steam Admission to Turbine
(H) Commissioning
(I) Final Disbursement

Fig. 7 - 2 Construction Schedule for Lakhra Coal - Fired Thermal Power Station (150 MW x 2 Units)

Descriptions	Total Month
I. Major Events — Unit NO. 1	
Unit NO. 2	
II. Construction Schedule	
1. Civil Works	
1) Preparatory Works	9
2) Water Intake and Discharge	29
3) Coal Storage Yard	9
4) Other Works	36
2. Structural Works	
1) Power House	35
2) Service Building	26
3) Appurtenant House	33
4) Colony	24
3. Mechanical and Electrical Works	
1) Desigh and Fabrication	19
2) Installation	
- Boiler	19
- Turbine and Generator	23
- Electrical and Control Equipment	23
- Coal Handling Equipment	13
- Other Equipment	21
3) Tests	6
III. Consultancy Services	64



Note.
- (A) Commencement of Foundation Works
- (B) Commencement of Structural Works
- (C) Drum Lifting
- (D) Hydro Static Test
- (E) Initial Power Recieve
- (F) Initial Firing
- (G) Steam Admission to Turbine
- (H) Commissioning
- (I) Final Disbursement

CHAPTER 8 CONSTRUCTION COST ESTIMATES

8-1 Scope of and Conditions for Estimates

The costs necessary to construct the coal-fired thermal power station specified in Chapter 5 are included in the scope of cost estimates. In accordance with the Construction Schedule shown in Chapter 7, moreover, costs are estimated at prices prevailing as of June, 1980 on the assumption that 300 MW unit will be commissioned in March 1987.

(1) Construction costs may be broken down as follows:

- Total construction costs
  - Direct costs
    - Generating facilities
    - Contingencies
  - Indirect costs
    - Administration cost
    - Engineering fee
    - Interest during construction (IDC)

(2) The construction costs are estimated in the foreign and Pakistani currency portions, respectively. Those belonging to the foreign currency portion include costs required for purchase of imported materials, equipment and supplies as spare parts thereof for five years' operation, ocean freightage thereof, salaries for foreign engineers, etc. Those to the latter include the salaries and wages for Pakistani personnel and workers and the costs for construction materials, such as cement, aggregates, etc. and construction machinery available in Pakistan, including the inland transportation cost of imported materials, equipment and supplies as well as spare parts thereof. Because of the previous practice observed in Pakistan and in accordance with the policy taken by the Pakistani Government, moreover, premium for marine cargo insurance is included in the domestic currency portion although such premium is usually quoted in the foreign currency portion.

(3) Requirements in foreign and Pakistani currencies are estimated under the following conditions:

1) Requirement in the foreign currency:
Obtained based on the prices prevailing in Japan as of June 1980 (on a C&F basis)

2) Requirement in the Pakistani currency:
Obtained, with prices prevailing in Pakistan as of June 1980 reckoned as a reference standard.

(4) Currency exchange rates adopted are as follows:

US$1 = Rs 10
US$1 = ¥220
Rs 1 = ¥ 22

(5) Customs duties

40% of the C&F prices of imported materials, equipment and supplies are reckoned as customs duties.

(6) Contingencies

5% of the costs for civil engineering, construction work and electrical equipment is reckoned as the contingencies which are to be applied to inevitable design modification(s) and to item(s) not taken into account upon estimation of prices.

(7) Administration Cost

4% of direct costs is reckoned as the administration cost covering those expenses necessary for WAPDA to undertake the Project, which will be incurred in head and field offices and in connection therewith.

(8) Engineering Fee

5% of direct cost is estimated as the engineering fee which includes personnel expenses, enumeration, overheads, travelling expenses, various communication expenses, etc. which will be incurred in employment of consultants. This fee, meanwhile, includes expenses necessary for WAPDA personnel to stay in a foreign country in connection with the performance of work related to the services of consultants which includes evaluation of bids.

(9) Interest during Construction (IDC)

In consideration of the Construction Schedule and conceivable terms and conditons of loans normally applied to the projects of WAPDA, IDC is calculated at 8.75% for a loan in the foreign currency portion and at 12.5% for that in the Pakistani currency portion, respectively.

(10) Assumptions

1) Construction costs estimated above include:
   - Construction of camps (contractors' offices, lodging, mess hall, canteen, etc.) necessary for the construction work, roadways for work, etc.
   - Fuel and chemicals necessary for acceptance tests

2) The following expenses, however, have been excluded from the present estimates:
   - Land procurement cost and compensation expenses of any nature
   - House, guest house, mosque, recreation facility and the like
   - Taxes imposed on engineering fee and income tax for foreign engineers

8-2 Estimated Construction Costs

Based on the scope of and the conditions for estimates as referred to above, the construction costs to be incurred on this Project are roughly estimated as shown in Table 8-1. These costs could be summarized by main item and by currency as follows:

8-3 Fund Requirement by Year

The fund requirement by year is estimated based on the Construction Schedule given in Chapter 7 on the conditions given on the next page.

(1) Civil engineering and construction works ...... progress payment

(2) Equipment cost (C&F)
- 10% of C&F value .... upon signing the contract
- 80% of C&F value .... upon shipment
- 10% of C&F value .... upon completion of acceptance test

(3) Installation work .... progress payment

(4) Contingencies .... proportional to the amount of annual direct work costs

(5) Administration
- Costs after the commencement of work are estimated in proportion to the annual payment of direct work costs

Work costs by year estimated under the above-mentioned conditions are as shown in Table 8-2.

8-4 Power Generating Cost

The power generating cost is estimated on a kWh basis at a power sending end in consideration of the power to be generated in the Lakhra Coal-fired Thermal Power Station and of the various expenses involved in the power station.

∘ Annual plant factor	70% (50%, 60% and 70%)
∘ Service life of plant	30 years
∘ Station use ratio	9%
∘ Depreciation	3.5%
∘ Operation and maintenance cost	3%
∘ Fuel cost	381 Rs/ton (As received basis)

Under the conditions above, the power generating cost is estimated at 93.5 paisas/kWh. A breakdown of this cost is given in Table 8-5.

Table 8-1 Construction Cost for Lakhra Coal-fired Thermal Power Station (300 MW x 1 unit)

(Unit: Rupees in million)

Item	Foreign Currency	Local Currency	Total
1. Equipment	1,727	–	1,727
2. Civil Works	295	300	595
3. Structural Works	144	266	410
4. F.G.D. Plant (Gypsum Recovery Process)	109	84	193
5. Installation	130	415	545
Sub-total	2,405	1,065	3,470
6. Contingency (5% of Sub-total)	121	53	174
Direct Cost	2,526	1,118	3,644
7. Customs Duties (40% of C&F Price)	–	905	905
8. Engineering Fee (5% of direct cost)	147	35	182
9. Administration (4% of direct cost)	–	146	146
Indirect Cost	147	1,086	1,233
Total	2,673	2,204	4,877
10. Interest during Construction			
Foreign Currency Portion	–	620	1,348
Local Currency Portion	–	728	
Grand Total	2,673	3,552	6,255

Interest during construction F.C, 8.75% D.C, 12.5%

Table 8-2 Annual Expenditure Requirements (300 MW x 1 unit)

(Unit: Rupees in million)

Item \ Year	Total			1981			1982			1983			1984			1985			1986			1987		
	F.C	D.C	Total	F.C	D.C	To-tal	F.C	D.C	To-tal	F.C	D.C	To-tal	F.C	D.C	Total	F.C	D.C	Total	F.C	D.C	Total	F.C	D.C	To-tal
1. Civil & Structural Works	439	566	1,005							44	57	101	176	220	396	110	140	250	65	92	157	44	57	101
2. Mechanical, Electrical Equipment & Installation	1,857	415	2,272							186	41	227	280	60	340	929	211	1,140	276	62	338	186	41	227
3. F.G.D. Plant (Gypsum Recovery Process)	109	84	193							11	8	19	16	14	30	55	42	97	16	12	28	11	8	19
Sub-total	2,405	1,065	3,470							241	106	347	472	294	766	1,094	393	1,487	357	166	523	241	106	347
4. Contingency (5% of Sub-total)	121	53	174							12	5	17	26	14	40	53	21	74	18	8	26	12	5	17
Direct Cost	2,526	1,118	3,644							253	111	364	498	308	806	1,147	414	1,561	375	174	549	253	111	364
5. Customs Duties (40% of C&F Price)	–	905	905							–	90	90	–	178	178	–	411	411	–	136	136	–	90	90
6. Engineering Fee (5% of Direct Cost)	147	35	182	30	6	36	44	11	55	17	4	21	17	4	21	17	4	21	17	4	21	5	2	7
7. Administration (4% of Direct Cost)	–	146	146	–	7	7	–	14	14	–	22	22	–	22	22	–	37	37	–	37	37	–	7	7
Indirect Cost	147	1,086	1,233	30	13	43	44	25	69	17	116	133	17	204	221	17	452	469	17	177	194	5	99	104
Total	2,673	2,204	4,877	30	13	43	44	25	69	270	227	497	515	512	1,027	1,164	866	2,030	392	351	743	258	210	468
8. Interest during Construction (F.C 8.75%, D.C 12.5%)	—	1,348	1,348	–	2	2	–	8	8	–	37	37	–	118	118	–	277	277	–	421	421	–	485	485
Grand Total	2,673	3,552	6,225	30	15	45	44	33	77	270	264	534	515	630	1,145	1,164	1,143	2,307	392	772	1,164	258	695	953

1 Rs = 22 Yen　1 US$ = 220 Yen

Exclude escalation
Price of June 1980

Table 8-3 Construction Cost for Lakhra Coal-fired Thermal Power Station (150 MW x 2 units)

(Unit: Rupees in million)

Item	Foreign Currency	Local Currency	Total
1. Equipment	1,860	–	1,860
2. Civil Works	320	320	640
3. Structural Works	150	290	440
4. F.G.D. Plant (Gypsum Recovery Process)	120	92	212
5. Installation	140	500	640
Sub-total	2,590	1,202	3,792
6. Contingency (5% of Sub-total)	130	60	190
Direct Cost	2,720	1,262	3,982
7. Customs Duties (40% of C&F Price)	–	980	980
8. Engineering Fee (5% of direct cost)	159	40	199
9. Administration (4% of direct cost)	–	159	159
Indirect Cost	159	1,179	1,338
Total	2,879	2,441	5,320
10. Interest during Construction			
Foreign Currency Portion	–	666	1,477
Local Currency Portion	–	811	
Grand Total	2,879	3,918	6,797

Interest during construction F.C, 8.75% D.C 12.5%

Table 8-4 Annual Expenditure Requirements (150 MW x 2 units)

(Unit: Rupees in million)

Item \ Year	Total			1981			1982			1983			1984			1985			1986			1987		
	F.C	D.C	Total	F.C	D.C	Total	F.C	D.C	Total	F.C	D.C	Total	F.C	D.C	Total	F.C	D.C	Total	F.C	D.C	Total	F.C	D.C	Total
1. Civil & Structural Works	470	610	1,080							47	61	108	188	244	432	118	152	270	70	92	162	47	61	108
2. Mechanical, Electrical Equipment & Installation	2,000	500	2,500							200	50	250	300	75	375	1,000	250	1,250	300	75	375	200	50	250
3. F.G.D. Plant (Gypsum Recovery Process)	120	92	212							12	9	21	18	15	33	60	44	104	18	15	33	12	9	21
Sub-total	2,590	1,202	3,792							259	120	379	506	334	840	1,178	446	1,624	388	182	570	259	120	379
4. Contingency (5% of Sub-total)	130	60	190							13	6	19	26	16	42	59	23	82	19	9	28	13	6	19
Direct Cost	2,720	1,262	3,982							272	126	398	532	350	882	1,237	469	1,706	407	191	598	272	126	398
5. Customs Duties (40% of C&F Price)	–	980	980							–	98	98	–	196	196	–	440	440	–	148	148	–	98	98
6. Engineering Fee (5% of Direct Cost)	159	40	199	32	8	40	48	12	60	18	5	23	18	5	23	19	4	23	19	4	23	5	2	7
7. Administration (4% of Direct Cost)	–	159	159	–	8	8	–	16	16	–	24	24	–	24	24	–	40	40	–	39	39	–	8	8
Indirect Cost	159	1,179	1,338	32	16	48	48	28	76	18	127	145	18	225	243	19	484	503	19	191	210	5	108	113
Total	2,879	2,441	5,320	32	16	48	48	28	76	290	253	543	550	575	1,125	1,256	953	2,209	426	382	808	277	234	511
8. Interest during Construction (FC 8.75%, D.C 12.5%)	–	1,477	1,477	–	2	2	–	9	9	–	41	41	–	129	129	–	304	304	–	461	461	–	531	531
Grand Total	2,879	3,918	6,797	32	18	50	48	37	85	290	294	584	550	704	1,254	1,256	1,257	2,513	426	843	1,269	277	765	1,042

Exclude escalation
Price of June, 1980

Table 8-5 Cost per Unit Sold

Items	Remarks		
1. Installed Capacity	300 MW		
2. Plant Factor (%)	70	60	50
3. Unit Generated (GWh)	1,839.6	1,576.8	1,314
4. Unit Consumed in Auxiliaries (9%)	165.6	141.9	118.3
5. Unit Sent Out (GWh)	1,674	1,434.9	1,195.7
6. Cost of Coal (Million Rs.) (381 Rs/ton as received base)	426.4	365.5	304.6
7. Interest			
F.C (Million Rs.) (8.75%)	328.5	328.5	328.5
L.C (Million Rs.) (12.5%)	405	405	405
8. Depreciation (Million Rs.) (3.5%)	217.9	217.9	217.9
9. Operation and Maintenance Cost (3%)	186.8	186.8	186.8
Total Cost (Million Rs.) (6 to 9)	1,564.6	1,503.7	1,442.8
Cost/Unit Sold (Paisas)	93.5	104.8	120.7

Exclude escalation
Price of June, 1980

Table 8-6 Details of Equipment Cost including Freitage
(Mechanical, electrical)

(Million Rupees)

Item	300 MW x 1	150 MW x 2
(1) Turbo-Generator		
1) Turbo-Generator and Acc.	197.7	212.3
2) Turbine Auxiliaries & Piping	172.3	185.0
3) Electric Equipment	136.4	144.5
4) Instrument & Control	68.2	73.2
5) Spare Parts	15.9	16.8
6) Cable & Installation Material	79.1	85.0
(2) Boiler		
1) Boiler	743.6	798.2
2) Boiler Feed Pump	23.6	25.0
3) Water Treatment Equipment	19.1	20.5
4) Ash Handling Equipment	46.4	50.5
5) Instrument & Control Equipment	43.6	46.8
6) Spare Parts	22.3	24.1
Sub-total	1,568.2	1,681.9
(3) Freight Charge	158.8	178.1
Total (C & F)	1,727.0	1,860.0

Table 8-7 Details of Installation Cost (300 MW x 1 Unit)

(Rupees in Million)

Foreign Currency Portion		Local Currency Portion	
Item	Amount	Item	Amount
(1) Cost of Deputing Manufacturer's Staff including Salaries, Overheads and Fees plus Direct Cost such as Air-fare, Postage and Telegram Expenses	120	(1) Salaries and Wages of Contractors Employees	130
(2) Cost of Lease of Temporary Facilities	10	(2) Insurance Premiums including Those for Marine Cargo Insurance and Other Local Insurance (3% of Equipment Prices – 1,568)	47
Sub-Total	130	(3) Cost of Lease of Equipment for Temporary Facilities	84
		(4) Cost of Purchase and Lease of Materials for Temporary Facilities	25
		(5) Cost of Inland Transportation including Loading, Unloading and Storage of Materials, Equipment and Supplies (7% of 545)	110
		(6) Miscellaneous	19
		Sub-Total	415
Total of Cost in Both Currency Portions 545			

Note: 327 Million Rupees or 60% and 218 Million Rupees or 40% of the Total (545 Million Rupees) given in the above Table can be allocated to Boiler and Turbine-Generator, respectively.

Table 8-8 Details of Construction Cost of Civil Works (300 MW x 1 Unit)

(Rupees in Million)

Item	Total	Foreign Currency Portion	Local Currency Portion
(1) Cooling Water System	281	145	136
(2) Discharge Water Way	186	89	97
(3) Coal Stock Yard	18	9	9
(4) Ash Disposal Area	30	14	16
(5) Ash Setting Pond	6	3	3
(6) Access Road to Pump Pit	3	1	2
(7) Site Preparation	71	34	37
Total	595	295	300

Table 8-9 Details of Construction Cost of Structural Works (300 MW x 1 Unit)

(Rupees in Million)

Item	Total	Foreign Currency Portion	Local Currency Portion
(1) Construction of Buildings			
Main Buildings	161.1	61.2	99.9
Administrative Building	30.2	4.8	25.4
Other Buildings	122.2	51.0	71.2
Sub-Total	313.5	117.0	196.5
(2) Foundation Works for Equipment			
Main Building	13.7	0.8	12.9
Other Buildings	40.5	3.5	37.0
Sub-Total	54.2	4.3	49.9
(3) Construction of Stacks			
Foundation	5.6	0.3	5.3
Stack	36.7	22.4	14.3
Sub-Total	42.3	22.7	19.6
Total	410.0	144.0	266.0

Note: The foreign exchange cost required for import of steel, special alloy and special bricks is included in (3) "Construction of Stacks" of the above Table.