No. 5

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR REHABILITATION OF KOTU POWER STATION IN THE REPUBLIC OF THE GAMBIA

DECEMBER 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to a request from the Government of the Republic of The Gambia, the Government of Japan decided to conduct a basic design study of the Project for Rehabilitation of the Kotu Power Station in the Republic of The Gambia, and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to The Gambia a basic design study team, headed by Mr. Takeshi Naruse, First Basic Design Study Division, Grant Aid Planning and Survey Department, JICA, from September 26 to October 16, 1988.

The basic design study team held discussions on the Project with officials concerned of the Government of The Gambia and conducted a field survey in the project area. After the study team returned to Japan, further studies were made. As a result, the present report was prepared.

I hope that this report will expedite implementation of the project, assist in improving power supply in The Gambia and contribute to the promotion of friendly relations between our two countries.

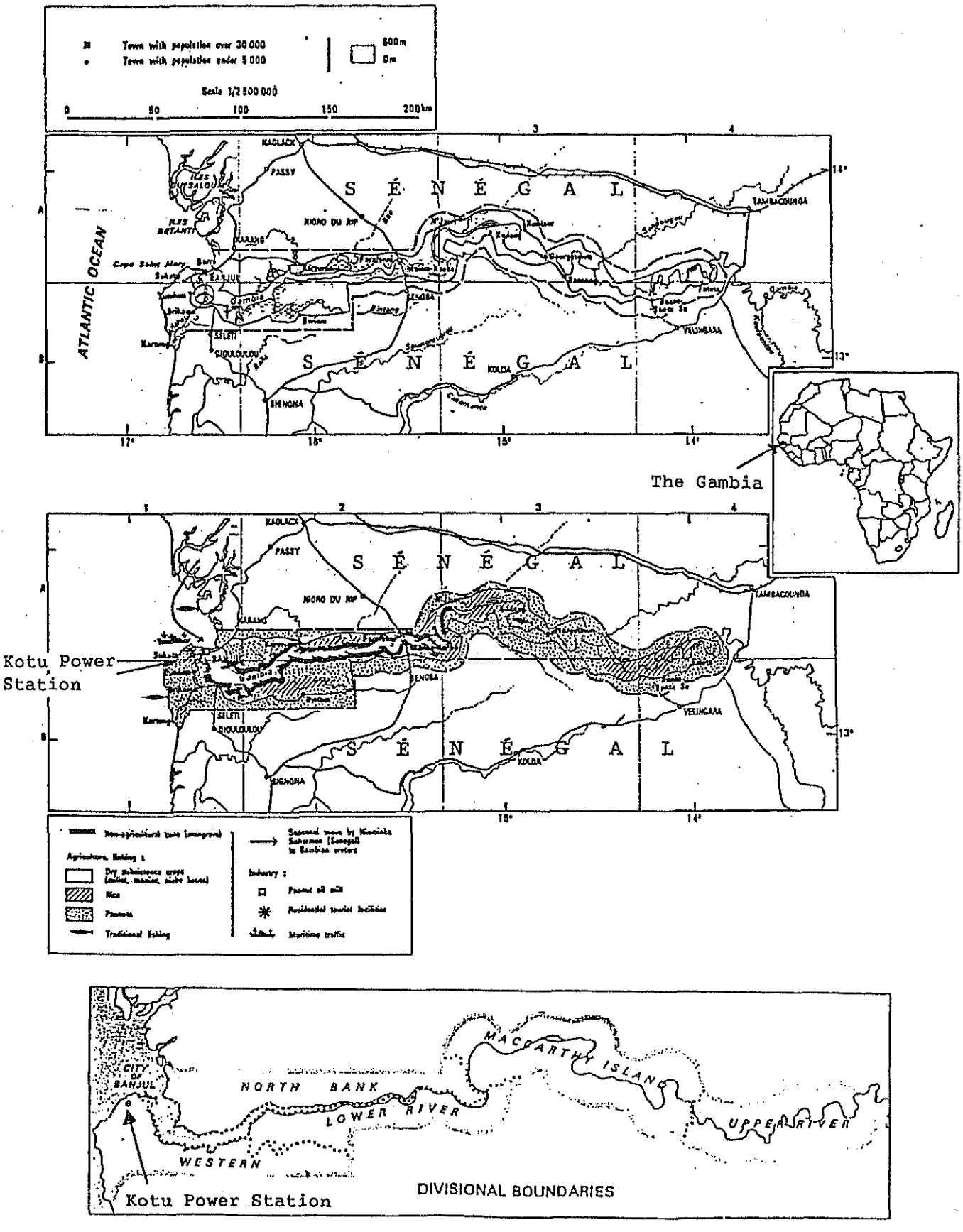
I wish to express my deep appreciation to the officials concerned of the Government of the Republic of The Gambia for their close cooperation extended to the study team.

December, 1988

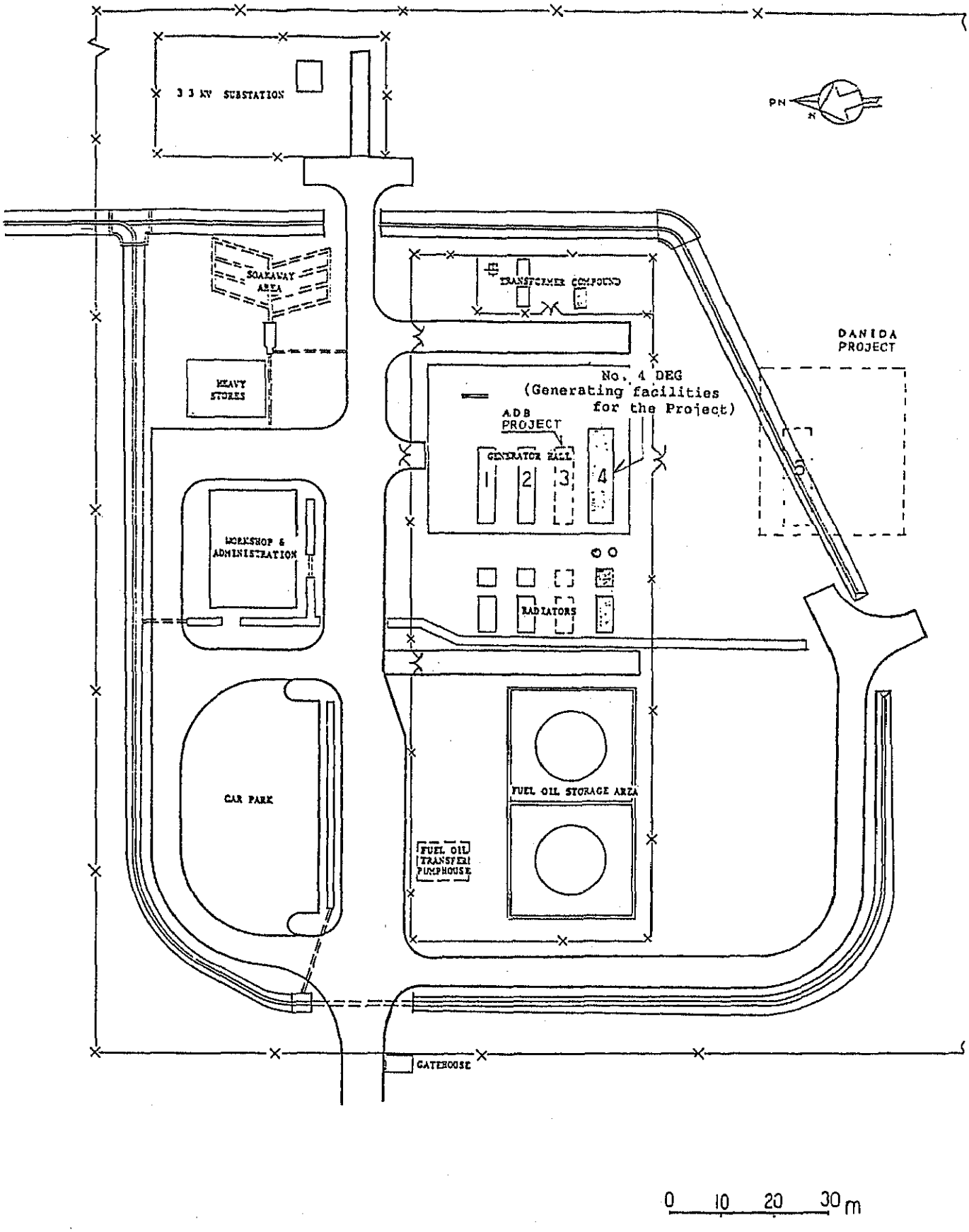
Kensuke YANAGIYA

President

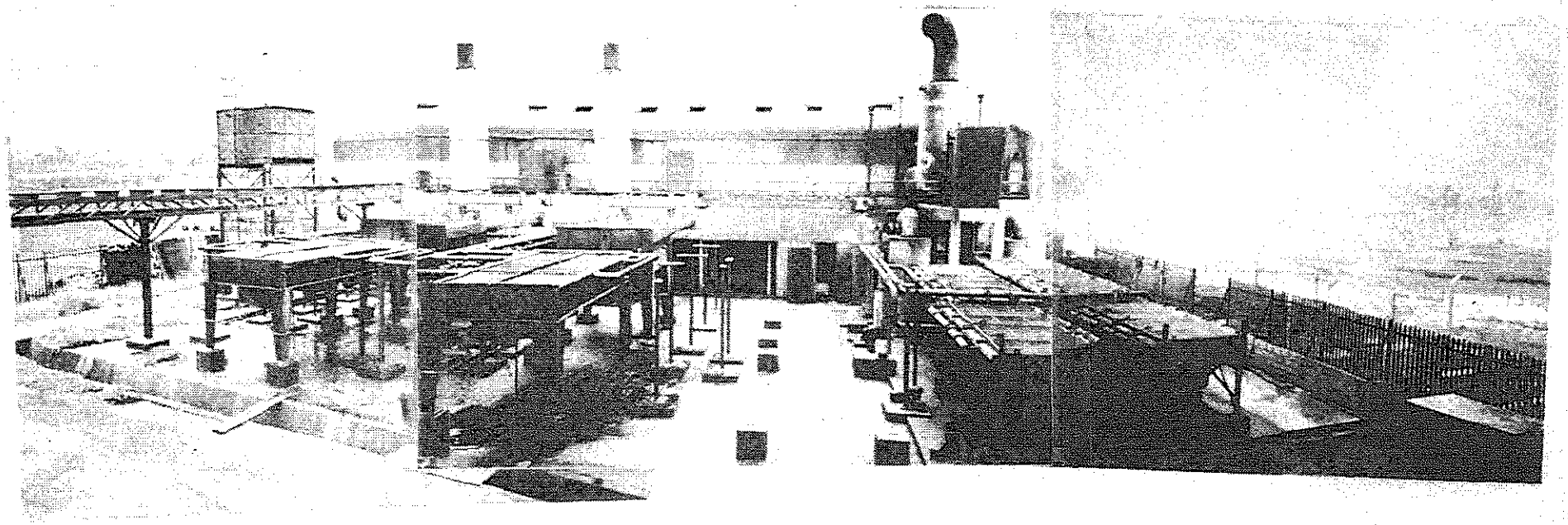
Japan International Cooperation Agency



Map of The Gambia



Plot Plan of Kotu Power Station



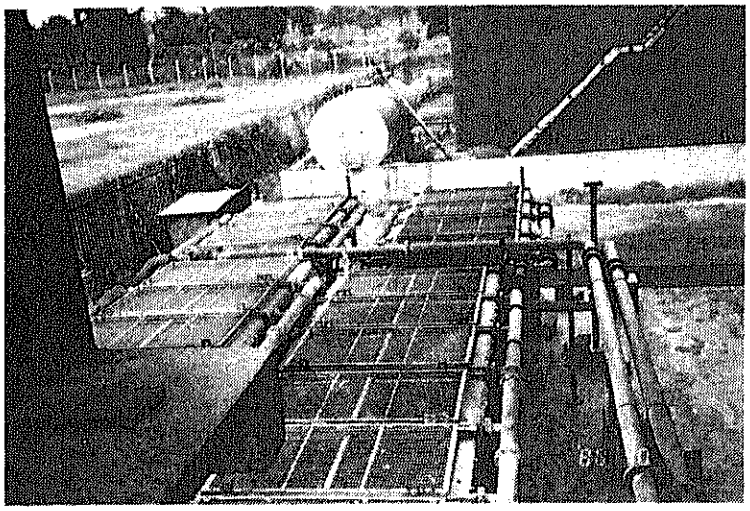
No. 1 Diesel Generating Facilities

No. 2 DEG

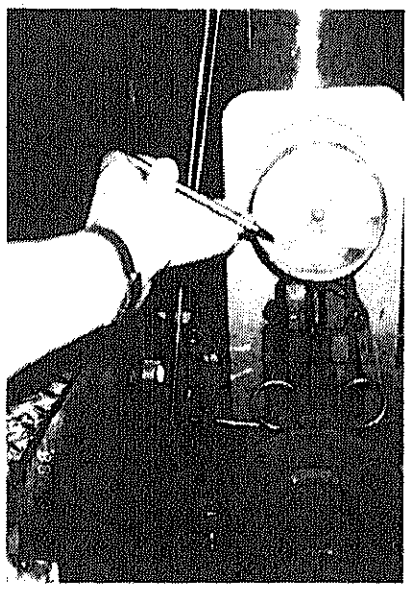
No. 3 DEG (Future)

No. 4 DEG (Generating facilities for the Project)

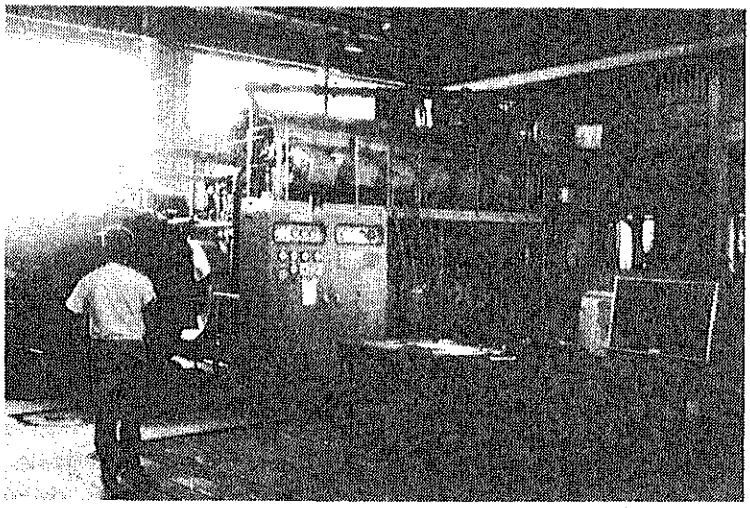
Overall View of Generating Facilities at Kotu Power Station



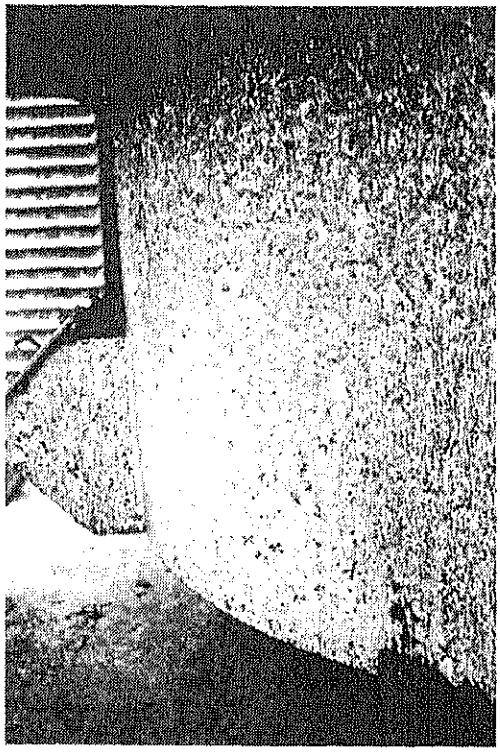
Radiator set for No. 1 and No. 2 DEG
(considerably strained by oil)



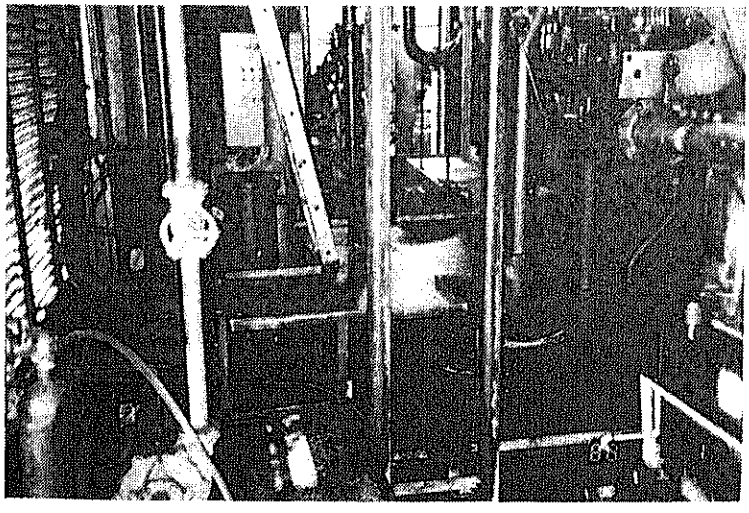
Pressure gauge damaged
(in use)



No. 4 DEG



Lower portion of an inlet filter
(strained by lubricating oil)



Engine Auxiliary Equipment

(oil strain resulted in difficulty in identifying a part of piping systems)

SUMMARY

SUMMARY

The Republic of The Gambia (hereinafter referred to as "The Gambia") is situated on the western side of the African continent and is bordered on three sides by the Republic of Senegal and by the Atlantic Ocean on the west. The country covers an area of approximately 11,295 square kilometers on both sides along the River Gambia which flows into the Atlantic Ocean.

Agriculture continues to be the mainstay of the country's economy, and the main agricultural product is groundnut and its processed goods. Since the great drought in 1973, production of groundnut has been continually decreasing. The country has made great efforts to diversify agricultural, commercial and other industries to attain self-reliance and strengthen exports of local products, with a view to emerging from its mono-economic structure that depends on the agricultural sector.

In view of this situation, the Government of the Republic of The Gambia planned to provide the existing Kotu Power Station (installed capacity: diesel generator 3 MW x 2 units) with a new diesel generating facility (6 MW, No. 4 Generator; hereinafter referred to as "No. 4 DEG") to meet the power demand in Greater Banjul Area including Banjul City and surrounding areas. No. 4 DEG was provided under Japan's grant aid in 1983.

Since its installation, No. 4 DEG had been operating for about 17,000 hours from the start of the commercial operation in January, 1985 to March, 1987 and had supplied within that period about 70 GWh of energy. Power cut previously occurring every day decreased to one time in ten days. As a result of its contribution to the stabilization of power supply, No. 4 DEG is highly appreciated among the people in The Gambia. The generated energy of Kotu Power Station in 1988 is about 58 GWh, occupying about 97% of the nation; Kotu Power Station is the largest station in The Gambia.

However, the generating output of No. 4 DEG has decreased to 5MW or less (as of September 24, 1988) for the following reasons:

- As the power demand has increased since 1985, continuous operation of No. 4 DEG has been made.

- Shortage of spare parts.

- Shortage of engineers who are familiar with maintenance control of No. 4 DEG.

Therefore, the existing power supply does not meet the present power demand.

During the study, No. 4 DEG at Kotu Power Station came to a stop due to mechanical breakdown. For this reason, Greater Banjul Area has fallen into the serious situation that only a half of power demand was supplied. Power cut was occurring every day, power stop was repeated and thus civic life and economic activities became stagnant.

To cope with this situation at an early stage, the Gambian Government formulated a rehabilitation plan of Kotu Power Station to secure stable civic life and economic activities through stabilization of power supply and cope with the future increase of power demand. The Gambian Government requested the Government of Japan for grant aid for Rehabilitation of Kotu Power Station (hereinafter referred to as "the Project") in The Gambia. This Project contains the following:

1) Overhaul work of No. 4 DEG
2) OJT related to O & M, and
3) Additional supply of spare parts for No. 4 DEG

In response to the request of the Gambian Government, the Government of Japan decided to conduct a basic design study on the Project, and JICA sent to The Gambia a basic design study team from September 26 to October 16, 1988.

The team had discussions on the Project with the officials concerned of the Gambian Government and conducted a field survey in Greater Banjul Area. After the team returned to Japan, the present report has been prepared in accordance with results of the field survey and discussions with the Gambian officials.

The scope of the Project is as follows:

Scope of the Project

Items	Rehabilitation work	Provision of spare parts	Conduct of OJT
1. Diesel engine			
1) Diesel engine	o	o	o
2) Radiator	o	o	o
3) Other auxiliary equipment	o	o	o
2. Generator	o	o	o
3. Electrical equipment			
1) Motor control center	-	o	-
2) Others	-	o	-

The executing agency of the Project in The Gambia is The Gambia Utilities Corporation (GUC).

If the Project is implemented under Japan's grant aid, principal undertakings for the Project of which the cost must be borne by the Gambian side are securing of sites for constructions, temporary office, etc. and appointment and assignment of OJT trainees. The cost necessary for these undertakings is roughly estimated to be about 7,500 D.

The rehabilitation work period including detailed design and tendering will be 11 months after the bilateral agreement; Exchange of Notes (hereinafter referred to as E/N).

The GUC, responsible organization for the Project implementation, shall undertake the acquisition of all necessary lands by the date as specified in Table 5-1, and make all possible efforts to maintain liaison and coordination with Ministries, agencies and other authorities concerned of the Gambian Government in cooperation with the Japanese side for smooth Project implementation.

It is expected that the implementation of this Project, the rehabilitation of No. 4 DEG and the transfer of O & M technology through conduct of OJT will maintain good functioning of No. 4 DEG in the future together with self effort of the Gambian side, and in effect contribute greatly to the stabilization and improvement of the living standard and the development of industries. Therefore, it is quite justifiable to implement this Project under Japan's grant aid.

As direct effects from the implementation of the Project, available capacity will be increased from the current value of about 5 MW to about 6 MW, and fuel consumption will be decreased from 0.288 ℓ/kWh to 0.281 ℓ/kWh.

In order to maintain good functioning of generating facilities for a long period, it is apparent that the Gambian side should cultivate specialized engineers, formulate an appropriate maintenance control plan and implement it at an earliest date.

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APPENDIX

LIST OF BASIC DESIGN DRAWINGS

LIST OF FIGURES AND TABLES

ABBREVIATIONS

ADB	African Development Bank
D	Dalasis
DANIDA	Danish International Development Agency
E/N	Exchange of Notes
GDP	Gross Domestic Product
GUC	Gambia Utilities Corporation
GWh	Giga Watt Hour (= 1,000 MWh = 1,000,000 kWh)
ha	hectare
IEC	International Electrotechnical Commission
ISO	International Standardization Organization
JEC	Japanese Electrotechnical Commission
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
O&M	Operation and Maintenance
OJT	On the Job Training

Glossary of Electrical Terms

Total installed capacity	:	Total capacity of installd generating facilities
Available capacity	:	Output of generating facilities decreases with aging. Therefore this term means available output of generating facilities at a certain time.
Peak demand	:	Maximum load during a certain period
Average demand	:	(Electric power during a certain period) ÷ (total hour during that period)
Generated energy	:	Electric energy at a generator terminal
Power demand	:	Average load at consumers during a certain period
Power loss	:	Power loss occurring in power supply system (i.e., transmission and distribution lines)
Base power supply	:	This term means capability of a generating facility which supplies continuous power for base load. From economical viewpoint, it is desirable that the generating facility has higher capacity factor and economical factors.

CHAPTER 1 INTRODUCTION

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Agriculture continues to be the mainstay of The Gambia's economy, and the main agricultural product is groundnut and its processed goods. Since the great drought in 1973, production of groundnut has been continually decreasing. The country has made great efforts to diversify agricultural, commercial and other industries to attain self-reliance and strengthen exports of local products, with a view to emerging from its mono-economic structure that depends on the agricultural sector.

In view of this situation, the Government of the Republic of The Gambia (hereinafter referred to as "the Gambian Government") planned to provide the existing Kotu Power Station (installed capacity: diesel generator 3 MW x 2 units) with a new diesel generating facility (6 MW, No. 4 Generator; hereinafter referred to as "No. 4 DEG") to meet the power demand in Greater Banjul Area including Banjul City and surrounding areas. No. 4 DEG was provided under Japan's grant aid in 1983.

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To cope with this situation at an early stage, the Gambian Government formulated a rehabilitation plan of Kotu Power Station to secure stable social life through stabilization of power supply and cope with the future increase of power demand. The Gambian Government requested the Government of Japan for grant aid for Rehabilitation on Kotu Power Station (hereinafter referred to as the "Project") in The Gambia. This Project contains the following:

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In response to the request of the Gambian Government, the Government of Japan decided to conduct a basic design study of the Project, and JICA sent to The Gambia a basic design study team from September 26 to October 16, 1988. (Refer to Appendix II for the members of the basic design study team.)

The objective of this study was to precisely understand the present condition of No. 4 DEG at Kotu Power Station, as requested by the Gambian side for Japan's grant aid, and examine the viability of the proposed project and the effects of Japan's grant aid.

The study team had discussions with Gambian officials regarding the background of the request and the objectives of the Project and carried out the field survey. The results of discussions are shown in Appendix I; Minutes of Discussions, Appendix V; Field Report, and Appendix VI; GUS's Acknowledge Receipt of Field Report.

The study team prepared this Basic Design Study Report on the basis of full consideration of the actual situation of the existing power supply system and the Project contents and scale.

CHAPTER 2 BACKGROUND OF THE PROJECT

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2-1 General

2-1-1 Geographical Location

The Gambia is located on the west coast of Africa along both banks of the River Gambia and surrounded on three sides by Senegal. It is a long and narrow country.

The country is very flat, with a maximum elevation of 40 meters above sea level. Kotu Power Station is situated in about 13 km west of Banjul City, and the Project site area has an elevation of about 12 meters above sea level.

2-1-2 Population and Land Area

According to the 1983 census, the population and land area of The Gambia are as follows:

Table 2-1 Population and Territorial Land Area

	The Gambia	Greater Banjul Area
Population	687,817 persons	234,698 persons
Population growth rate	3.4%/year	4.7%/year
Land area	11,295 km^2	750 km^2
Population density	60.9 persons/km^2	313 persons/km^2

Source: 1983 census, MEPID

2-1-3 Climate

The climate is subtropical, with a cooler dry season from November to April, and a hot season from May to June. The average temperature during the dry season is less than 27°C, and the temperature during the hot season varies between 28°C and 43°C. During the rainy season from July to October, the country has little rain, but has a high humidity. The country often suffers from droughts during that period. The dusty harmattan wind blows across the country from the Sahara between November and March.

2-1-4 Infrastructure Conditions

(1) Port

Banjul Port is deemed to be an appropriate place for unloading construction machinery and materials transported from Japan. Loading/unloading facilities are kept in a good condition, and unloading of such machinery and materials will not become a problem.

(2) Road

Less progress has been made in the building of city roads. Trunk roads in Banjul City are paved, but damaged considerably. Although there are several bridges between Banjul Port and the Project site, transportation of construction machinery and materials will not become a problem.

(3) Telecommunications

There are country-wide telecommunications facilities. Communications will not become a problem.

2-2 Socio-economic Condition in 1987

2-2-1 Economic Condition in The Gambia

Farming continues to be the backbone of the country's economy, and the farming population accounts for about 66% of the total population. Groundnut is one of the major agricultural products. Exports of groundnut products constitute 76% of domestic exports, as shown in Table 2-2.

Table 2-2 Exports of Domestic Products in 1987/88

	Amount of export (in millions of US dollars)	Percentage (%)
Groundnut	8,620	76
Fish	2,250	20
Hemp	490	4
Total	11,360	100

Source: UNDP, Development Co-operation Report, 1987

Industries other than farming products include fishing, tourism and import for re-export trade. In the tourism sector, the number of tourists to The Gambia was increased from about 70,000 in 1986 to about 83,500 in 1987 (tourism revenue: about US$34 million), and the tourism industry has grown steadily (UNDP, 1987 Report).

However, The Gambia had a trading deficit and was in a critical condition, as shown in Table 2-3.

Capital assistance is indispensable to the development of The Gambia's economy. As shown in Table 2-3, capital assistance in 1986/87 was about US$140 million; 2.2 fold increase over 1982/83 (about US$63 million).

Table 2-3 Trends in Flows of Development Assistance

(in thousands of US dollars)

	1982/83	1983/84	1984/85	1985/86	1986/87
CAPITAL ASSISTANCE:					
Loan	22,691	19,038	11,255	15,685	15,560
Grant	11,607	9,519	34,666	54,884	53,370
Food Commodity	3,295	2,876	3,604	3,607	8,280
Subtotal	41,955	31,433	49,525	74,176	77,210
TECHNICAL ASSISTANCE:					
Loan	-	-	-	-	-
Grant	16,015	15,593	27,929	22,274	26,051
Food/Commodity	14	-	-	15	-
Subtotal	16,029	15,593	27,929	22,288	26,051
STRUCTURAL ADJUSTMENT SUPPORT:					
Loan	-	-	-	17,500	23,584
Grant	-	-	-	8,608	12,933
Subtotal	-	-	-	26,108	36,517
HUMANITARING & RELIEF ASSISTANCE:					
Food/Commodities	4,899	11,803	7,215	2,134	1,040
Grant	42	122	1,856	14	-
Subtotal	4,941	11,925	9,071	2,148	1,040
TOTAL DEV. ASS'T.	62,925	58,951	86,525	124,720	140,818
OTHER CAPITAL FLOWS:					
Total imports, f.o.b. (A)	(91,735)	(97,812)	(80,246)	(86,557)	(91,438)
Total exports including re-exports, f.o.b. (B)	86,965	87,650	66,510	73,996	65,591
Freight and insurance (C)	(15,307)	(16,318)	(13,377)	(15,142)	(18,069)
Tourists' foreign exchange inflows (D)	15,850	18,692	19,780	24,717	34,473
Trade & Tourism Balance (A + C) - (B + D)	(4,227)	(7,788)	(7,333)	(2,986)	(9,443)
NET TOTAL	58,698	51,163	79,192	121,734	131,375

Source: UNDP, Development Co-operation Report, 1987

2-2-2 Financial Condition of GUC

The GUC consists of four divisions of electricity, water, sewerage and gas. Table 2-4 shows revenues and expenditures of the GUC from July, 1983 to June, 1988. The GUC's finance changed for the better in 1987, and this was due to increased revenue of electricity division (about 88% of the total revenue).

Table 2-4 Trends in Revenues and Expenditures (1984-1988)

(Unit: 10,000 D)

	1983/84	1984/85	1985/86	1986/87	1987/88
Revenue					
Electricity Division	15,157	18,232	23,759	30,863	38,680
Water Division	3,523	4,065	5,796	7,149	8,521
Sewerage Division	151	180	140	140	298
Gas Section	211	286	298	287	12
Sub total	19,051	22,763	29,993	38,439	47,511
Expenditure	25,390	29,059	32,368	37,224	44,054
Balance	-6,339	-6,296	-2,375	1,215	3,457

Source: GUC, Annual Report, 12th-16th

2-3 Power Condition

2-3-1 General Condition

(1) Power Condition in The Gambia

The Gambia's land is divided into five divisions. Although there are small-scale diesel power stations in major cities of each division that are operated by the GUC, they supply electricity through individual distribution network and electricity transmission and distribution network is not provided on a nation-wide scale. A look at power demand and supply in recent five years (from July, 1983 to June, 1988) in The Gambia shows that an average annual increase rate is 9.1% and the power demand is 11%.

Table 2-5 shows trends in power demand and supply in The Gambia.

Table 2-5 Transition of Power Demand and Supply in The Gambia (1983-1988)

Description		1983/84	1984/85	1985/86	1986/87	1987/88	Average annual increase rate (%)
Installed capacity	(MW)	11.9	16.1	15.5	15.5	14.7	-
Available capacity	(MW)	9.9	14.8	12.3	12.3	12.3	-
Peak demand	(MW)	8.5	9.5	10.4	10.8	12.0	9.1
Average demand	(MW)	4.6	4.8	5.4	6.0	6.8	10.1
Generated energy	(GWh)	40.5	41.8	47.7	52.2	59.5	10.2
Power demand	(GWh)	32.8	20.7	39.1	43.2	49.9	11.0
Power loss	(GWh)	7.7	21.1	8.6	9.0	9.6	5.8

Source: GUC Data

Table 2-6 indicates power plants and generated energy in 1987 operated by GUC.

Table 2-6 Names and Generated Energy of Power Stations Operated by GUC (1987)

No.	Name of Power Station	Division	Generated Energy (GWh)	
1	Kotu	Banjul City and Western	49.7	(95.2%)
2	Brikama	Western	0.6	(1.1%)
3	Mansakonko	Lower River	0.4	(0.8%)
4	Feratenni	North Bank	0.3	(0.6%)
5	George Town	Maccarthy Island	0.2	(0.4%)
6	Ban Sang	Maccarthy Island	0.6	(1.1%)
7	Basse Santa Su	Upper River	0.4	(0.8%)

Source: GUC data

Meter rate plus minimum rate are applied as electric charges. Unit price of average electric charges for general domestic (as of September, 1988) is 0.81 D/kWh. Table 2-7 indicates trends in electric charges during recent five years from January, 1984 to June, 1988.

Table 2-7 Trends in Electric Charges (1984-1988)

(Unit: D)

	1984	1985	1986	1987	1988
Domestic					
1) Minimum rate (0 - 30 kWh)	16.00	16.00	18.00	18.00	20.00
2) 31 - 100 kWh (per 1 kWh)	0.40	0.55	0.55	0.61	0.67
3) 101 - 1000 kWh (per 1 kWh)	0.48	0.66	0.66	0.74	0.82
4) 1001 kWh or more (per 1 kWh)	0.51	0.71	0.71	0.87	0.95
Hotels (per 1 kWh)	-	-	-	-	0.95
Commercial (per 1 kWh)	-	-	-	-	1.09

Source: MEPID data

Voltages and frequency for transmission and distribution systems adopted in The Gambia are as follows:

Transmission system: 33 kV, 50 Hz (Greater Banjul Area only)
Distribution system: 11 kV and 415/240 V, 50 Hz

(2) Power Condition in Greater Banjul Area

There are three power stations of Kotu, Half Die, and Brikama in Greater Banjul Area. Kotu Power Station (constructed in 1981) where No. 4 DEG are installed is one of the biggest ones in The Gambia. A total installed capacity and generated energy in 1988 at Kotu Power Station is 12 MW and about 58 GWh (occupying about 97% of the nation).

On the other hand, Half Die Power Station is not currently operated because of generator's failure, shortage of spare parts and so on. Brikama Power Station has small-scale diesel generating facilities. This power station presently stops, because 11 kV distribution line was connected to Kotu Power Station in 1987, and the relocation of this power station to other area is being studied.

Thus, the role of Kotu Power Station is very important in Greater Banjul Area.

The installed capacity of No. 4 DEG (6 MW) is 50% of the total installed capacity (12 MW) at Kotu Power Station. According to GUC's operation records in 1988, No. 4 DEG alone supplies generated energy of about 65% of Greater Banjul Area. Subsequently, No. 4 DEG stopped exerts a great influence on The Gambia's economic activities and the civic life in Greater Banjul Area. A look at power demand and supply in Greater Banjul Area during recent years from July, 1983 to June, 1988 shows that firm capacity (firm capacity equals installed capacity minus rating of largest set only) is less than peak demand at all times; unstable power demand and supply.

Table 2-8 shows transition of power demand and supply in Greater Banjul Area and Fig. 2-1 represents transition and forecast of that power demand and supply.

Table 2-8 Transition of Power Demand and Supply in Greater Banjul Area (1983-1988)

Description		1983/84	1984/85	1985/86	1986/87	1987/88	Average annual increase rate (%)
Installed capacity	(MW)	9.3	13.7	13.7	13.7	12.9	-
Available capacity	(MW)	8.0	12.8	11.0	11.0	11.0	-
Firm capacity	(MW)	6.3	7.7	7.7	7.7	6.9	-
Peak demand	(MW)	7.6	8.5	9.4	9.6	10.8	9.2
Average demand	(MW)	4.3	4.5	5.3	5.7	6.6	11.3
Generated energy	(GWh)	38.1	39.5	45.2	49.7	57.6	10.9
Power demand	(GWh)	31.0	29.7	37.2	41.5	47.7	11.4
Power loss	(GWh)	7.1	9.8	8.0	8.2	9.9	8.7

Source: GUC data

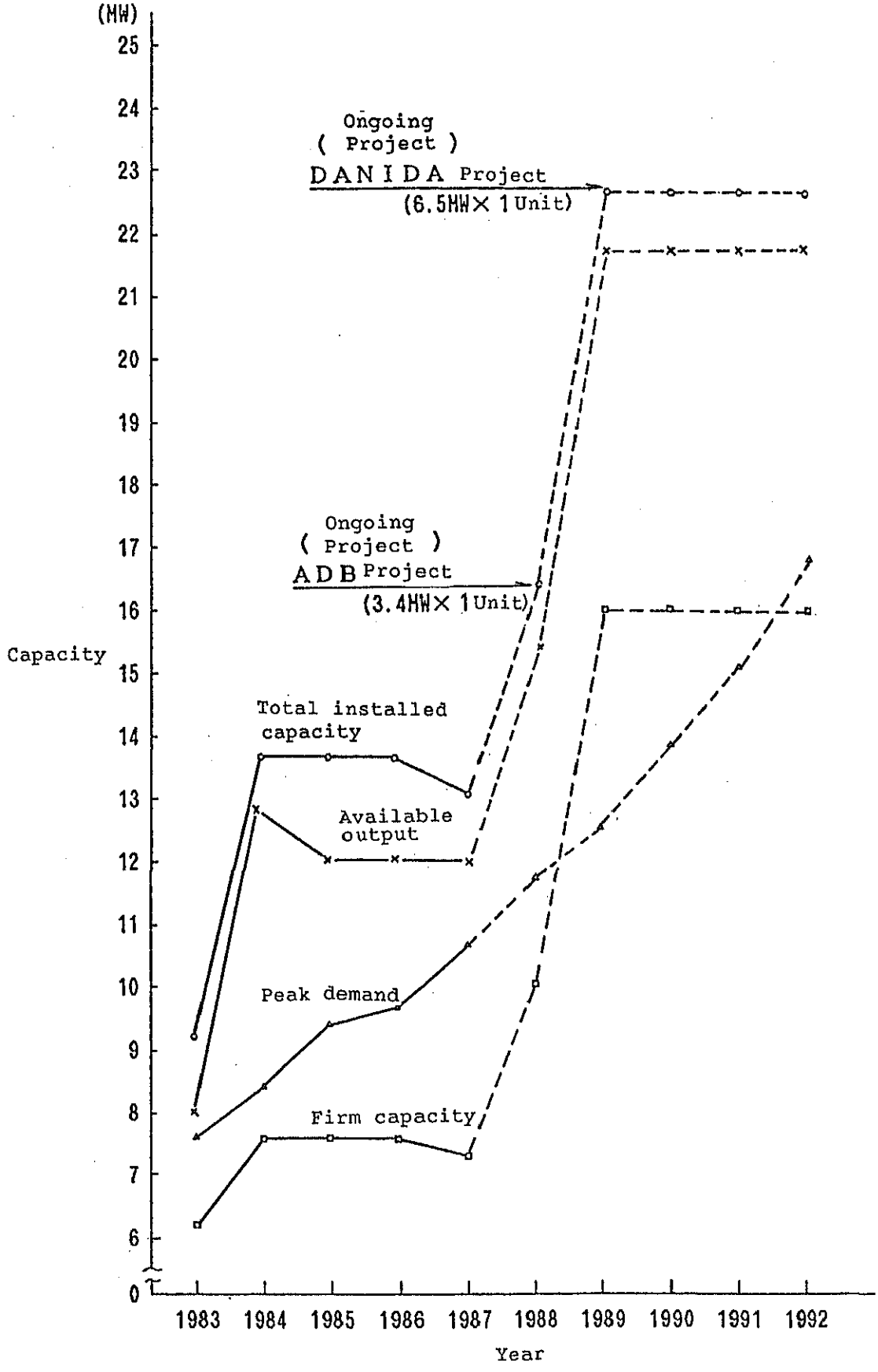


Fig. 2-1 Transition and Forecast of Power Demand and Supply in Greater Banjul Area

A look at power demand by consumer in 1987 indicates that power demand for domestic, commercial, hotels, government and GUC is 34%, 11%, 32%, 7% and 16% respectively.

Table 2-9 shows composition of power demand in Greater Banjul Area.

Table 2-9 Composition of Power Demand in Greater Banjul Area (1984-1987)

(Unit: GWh)

Classification of Consumer	1984 / 85	1985 / 86	1986 / 87	Average annual increase rate (%)
Domestic	11.6 (39%)	12.6 (34%)	14.1 (34%)	10.3
Commercial	2.9 (10%)	3.8 (10%)	4.3 (11%)	21.8
Hotels	10.3 (35%)	12.2 (33%)	13.4 (32%)	14.1
Government	1.9 (6%)	2.3 (6%)	2.9 (7%)	23.5
GUC	3.0 (10%)	6.3 (17%)	6.8 (16%)	50.5
Total	29.7(100%)	37.2(100%)	41.5(100%)	18.2

Source: GUC data

2-3-2 Present Condition of No. 4 DEG

The present condition of No. 4 DEG is as follows:

(1) Basic Specifications for Main Equipment

1) Diesel engine

Model:	12 ZV40
Manufacturer:	Hitachi Zosen Corp.
Output capacity:	9000 ps
Revolution:	600 rpm

2) Generator

Type:	Brushless, synchronous generator
Manufacturer:	Shinko Electric Co., Ltd.
Output capacity:	6 MW
Power factor:	0.8 (lag)
Voltage:	11.5 kV
Frequency:	50 Hz

3) Radiator

Type: Outdoor type

Manufacturer: COVRAD (UK)

4) Main transformer

Type: Oil-immersed air-cooled type

Manufacturer: Shihen Technical Corp.

Capacity: 8 MVA

(2) O & M Control Condition

1) Operation

No. 4 DEG started commercial operation in January, 1985, and its operation record up to the present time is as follows:

Running time: 28,597 hours

Total generated energy: 118,886 MWh

Average output of No. 4 DEG was about 4.4 MW as of September 23, 1988 prior to the conduct of this study. No. 4 DEG has been operated under base load, but suddenly tripped due to oil mist in a combustion chamber on September 24, 1988. After that, abnormal condition was observed in a lower part of cylinder (bearing cap) through inspection of a staff at Kotu Power Station.

Since it was impossible to repair that portion promptly, No. 4 DEG stopped during the study.

Engineers sent from CCM Sulzer in France inspected the cause of the bearing cap damaged to examine countermeasure against repairing.

As a result, the output at Kotu Power Station has reduced to 50% and thus electric power was supplied every six hours.

As the flow of tourists to The Gambia increases in November, it is strongly desired that operation of No. 4 DEG is re-started at an early date and stable power supply is realized.

It was clear from operation record (as shown in Appendix IX) that average annual operation factor of No. 4 DEG from the start of commercial operation up to the present time was about 86%. While, power consumption per unit output was 0.288 ℓ/kWh as of September, 1988, which was greater than that at the time of take-over.

2) Maintenance Control

a) Past records in maintenance control

Three years and eight months elapsed since the start of its commercial operation. During that period continuous operation was made. However, periodic inspection as specified in instructions manual prepared by a supplier has been conducted partially with bad timing much behind specified running hours because of insufficient technical level of maintenance control and increased power demand.

As shown in Fig. 2-2, periodic inspection was conducted five times. In accordance with the contract concluded between the Gambian side and a Japanese supplier concerning No. 4 DEG provided in 1983 under Japan's grant aid, periodic inspection was carried out four times every 2,000 hours under technical assistance of engineers dispatched from the Japanese supplier.

When running time reached 17,193 hours, CCM Sulzer performed the periodic inspection on a commercial basis during the period from March to May, 1987. Although CCM Sulzer conducted that inspection when running time reached 21,128 hours, they only replaced crank pin bearings and did not conduct overall inspection and maintenance of the diesel engine.

The Gambian side requested that CCM Sulzer inspected and maintained the diesel engine. However, inspection and maintenance of the whole generating facilities including auxiliary equipment were not made by CCM Sulzer because of scarcity of available engineers.

Under these situation, a part of auxiliary equipment was observed to be damaged, and thus needs to be repaired. Electrical equipment such as generators, control panel and the like were kept in a favorable condition, though some parts should be replaced. Powerhouse buildings, warehouse and so on were also maintained in a favorable condition.

b) Staff organization

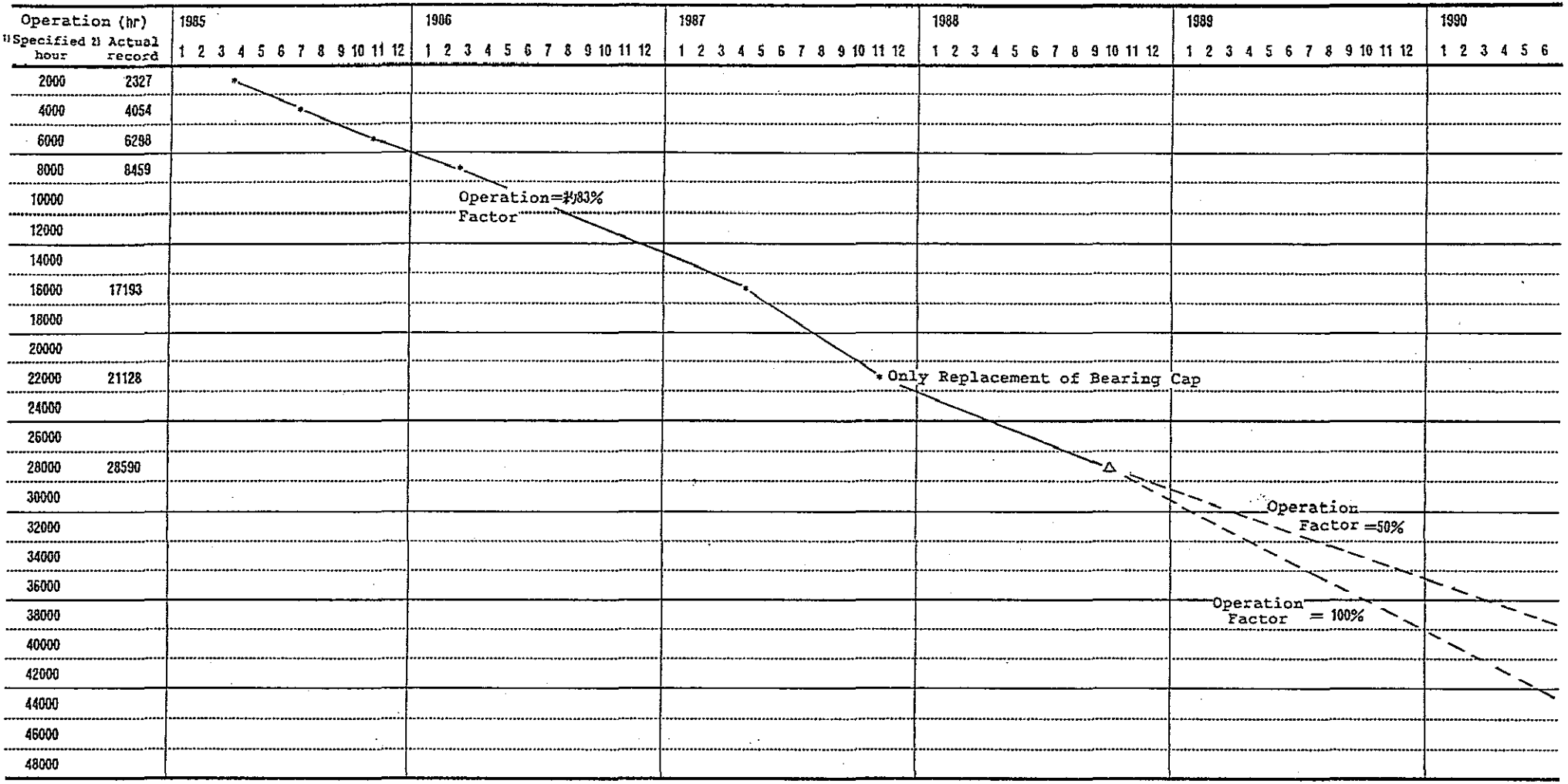
Staff members who are responsible for maintenance control of No. 4 DEG consist of 75 including one German adviser and one station engineer.

The present Kotu Power Station is operated in three shifts. Fig. 2-3 shows the organization chart of Kotu Power Station.

c) Maintenance control technology

Technology related to maintenance control was transferred during periodic inspection by the Japanese supplier (at the time of 8,000 hours) and inspection by CCM Sulzer. However, insufficient technology thus transferred impedes daily inspection and maintenance.

The Gambian side feels strongly the necessity of training engineers who will be responsible for maintenance, and hopes that technology will be transferred through OJT in the Project.



Note: * = Actual record

Δ = present operation hours

Fig. 2-2 Maintenance Record and Schedule of No. 4 DEG

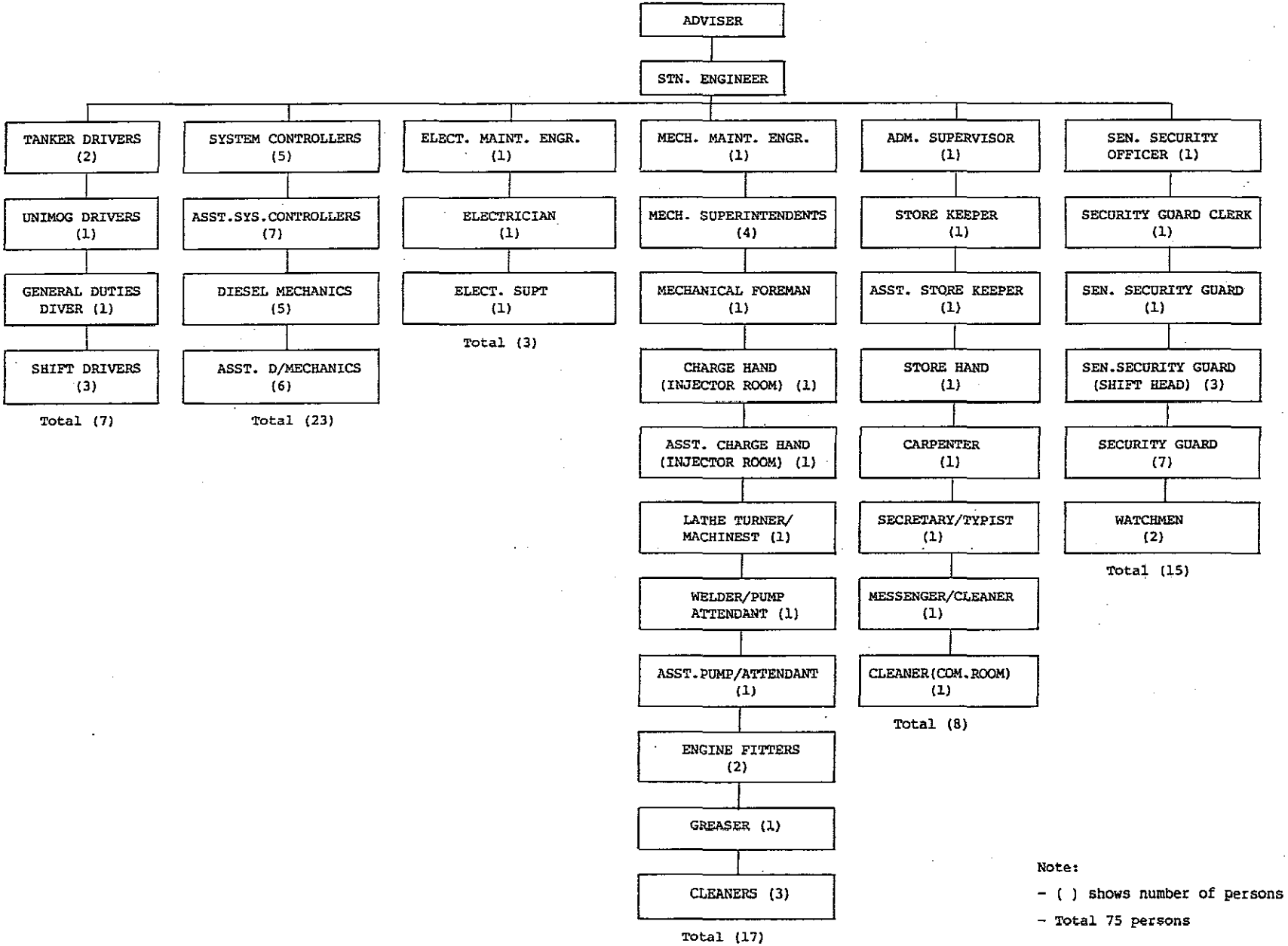


Fig. 2-3 Organization Chart of Kotu Power Station

(3) Problems in O & M Control

The results of the Study reveal that as the power demand increases, insufficient power supply becomes intensified, and No. 4 DEG faces a difficulty to stop generation and conduct periodic inspection. This point becomes a major problem in O & M control of No. 4 DEG. Following are other problems.

1) Cooling system

Oil leaked from No. 1 and No. 2 radiators installed in close proximity each other adheres to a radiator of No. 4 DEG, thereby affecting cooling capacity of the radiator.

Difficulty in identifying water and lubricating oil piping systems is attributable to oil adhering to the outside of the radiator.

2) Air intake and exhaust system

According to operation records obtained, the exhaust temperature increases as years elapse. Operation record in September 23, 1988 shows that exhaust gas temperature at the entrance of turbo charger is in the range of 630 to 650°C. This value is greater than that during take-over of No. 4 DEG (about 520°C). It is obvious from the visual inspection that this is attributed to 1) oil adhering to air inlet system, 2) reduction of air volume caused by unclean turbo charger and air cooler, and 3) increased back pressure due to contaminated exhaust system. If appropriate air volume is not secured, and engine is operated under a low combustion efficiency for a long period, excessive thermal stress develops in each part of the engine combustion chamber (cylinder liner, piston, cylinder head, exhaust value and the like), thereby being in danger of inducing a fatal accident.

Fig. 2-4 represents the present condition of contaminated air intake and exhaust system.

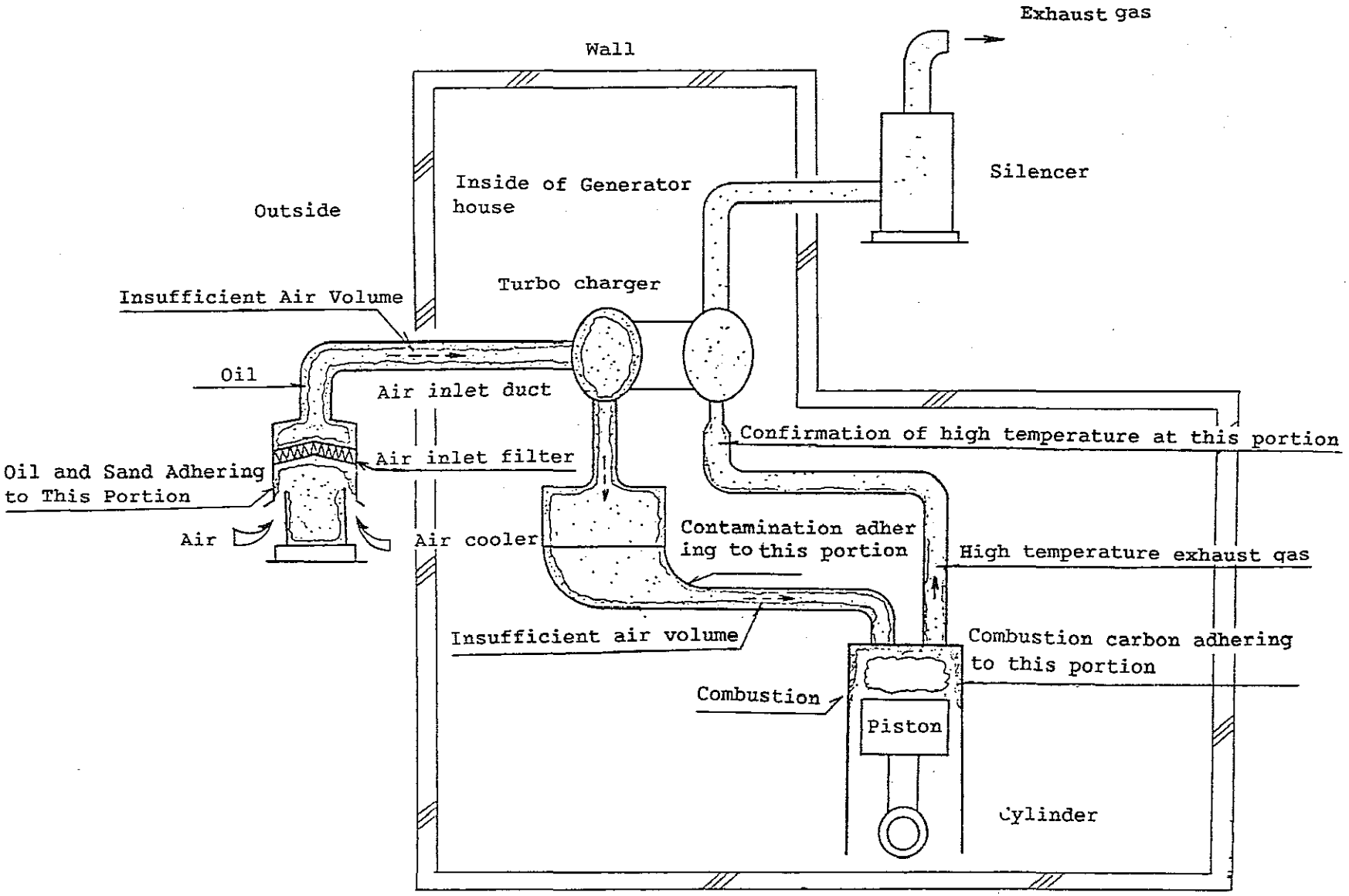


Fig. 2-4 Present Situation of Contaminated Air Intake and Exhaust System

3) Combustion chamber

According to the operation record in September 23, 1988, exhaust temperature of No. 2 cylinder (on the right bank) was 440°C; about 110°C lower value as compared with other cylinders (about 550°C), and big unbalance existed in engine's combustion system, which was due to malfunction of fuel injectors and the like.

4) Other problems

a) Periodic inspections are not conducted every specified time. Maintenance work is carried out only when accidents occur.

b) Skilled engineers who are responsible for maintenance control are shorthanded, and maintenance procedures and manual are not prepared. The GUC relies on technical assistance provided by outside engineers from CCM Sulzer and so on.

c) Since oil and sand adhere to the whole portion of generating facilities, it is difficult to identify piping systems and read out instruments' meter.

d) Data can not be precisely recorded and collected because of damaged instruments.

e) Inventory control of spare parts is insufficient and parts are not properly replaced with new ones.

f) Storage of tools is insufficient and some tools are missing.

g) Drain oil is discharged into a water canal near Kotu Power Station, which brings about environmental pollution.

h) Weeds around outdoor facilities such as transformers are not cut.

i) Deteriorated parts are not properly replaced because of shortage of spare parts.

j) Paint peels from equipment and oil and water piping.

k) Instead of damaged equipment (air compressors, etc.), equipment to be used for other project are temporarily used.

l) A part of damaged equipment (fuel oil gear pump, oil purifier, etc.) is temporarily repaired and used.

m) Most consumables for auxiliary equipment are not replaced.

(4) Causes for Output Drop

If assumption is made according to numerous data obtained such as operation records, etc., and O & M control condition, major causes for output drop are summarized in Table 2-10.

Table 2-10 Causes and Reasons for Output Drop

Cause	Reason
1. Decreased efficiency of air inlet and outlet system	- Clogged air inlet filter - Increased air inlet resistance caused by contaminated air inlet filter - Decreased efficiency of turbo charger and air cooler - Increased back pressure caused by contaminated exhaust system
2. Decreased cooling efficiency of radiator	- Adhering of lubricating oil and sand
3. Insufficient maintenance	- No adequate replacement of spare parts
4. Shorthanded maintenance specialists	- Insufficient training for maintenance

2-4 Outline of Related Development Projects

2-4-1 Five Year Plan

(1) Outline

The Gambian Government formulated the Second Five Year Plan for Economic and Social Development (1981/82-1985/86) as a development plan, and the Second Plan will continue the development process within the overall framework of goals and objectives of national development outlined in the First Plan. The Second Plan projected an average annual increase of 5.0% in the gross domestic product. Major goals and objectives of the Second Plan are as follows:

"The Plan initiated a comprehensive and intensive development effort aimed at transformation of the Gambian economy - from very low levels of output and income, dependence on export of one crop (groundnuts), with the consequent vulnerability to effects of changes in its output price and a need for large external assistance to support the nation's development effort, to an economy diversified, progressively self-reliant, and capable of sustained economic and social progress through development of its own natural, human, and material resources.

(2) Energy Resources Development

Main problem in the energy field in The Gambia that is the non-producing country and does not have fossil resources is the growing imports of fuel oil. In The Gambia's trade account in 1984/85, imports of fuel oil account for about 70% of exports of domestic products, which exert pressure upon The Gambia's economy.

For this reason, the Gambian side gropes for a potential to use alternative energy resources such as hydroelectricity, windmill, solar energy, instead of energy resource mainly obtained from the present diesel generating facilities. However, policy of alternative energy resources is not established.

On the other hand, the Gambian Government sets up the following development objectives as a philosophy of the Second Five Year Plan, and promotes economic and effective use of limited energy resources. Development objectives and strategy in the energy field of the Second Plan are as follows:

1) Development objectives:

a) to achieve efficient and judicious consumption of energy
b) to provide adequate and secure domestic and imported energy supplies for present and projected needs
c) to minimize the cost of energy to the economy, through reducing energy imports and increasing efficiency of investment
d) to ensure that the above objectives are met in an environmentally acceptable fashion

2) Strategy:

a) to encourage conservation by domestic, commercial, and institutional consumers
b) to accelerate feasibility studies for the development of renewable energy resources
c) to continue exploration for oil and other fossil fuels
d) to reduce the unit cost of electricity production by using heavy fuel oil and upgrading the transmission system
e) to provide limited expansion of generating capacity in the rural areas
f) to introduce solar water heaters into households, hotels, and factories using large amounts of low temperature heat
g) to promote use of energy saving vehicles, through appropriate policies and government regulations

2-4-2 Future Plan

Following two projects are being implemented by the GUC under loan and grant aid as mentioned below and these two sites for installing diesel generating facilities will be Kotu Power Station.

The Gambian Government requested the Government of Japan for grant aid of a new 6.6 MW diesel generating facility which will be installed by the year 1991.

Table 2-11 Power Supply Facilities Plan

No.	Project Name	Expected Completion Date	Financed by	Short Description of the Project
1	ADB Project	March, 1989	ADB's loan	- Installation of 3.4 MW diesel generating facilities on the foundation for No. 3 DEG at the existing power building (fuel: light oil)
2	DANIDA Project	Early month of 1990	Danish grant aid	- Installation of 6.5 MW diesel generating facilities on a new power building (fuel: heavy oil) - Heavy oil storage tank - Tank rolley - 33 kV transmission facilities (approx. 16 km long)
3	Japan's Grant Aid Project (now requesting)	1991	Japan's grant aid	- Installation of 6.6 MW diesel generating facilities (fuel: heavy oil) (Candidate site is not decided at the current stage.)

Source: GUC data

2-5 Contents of the Request

2-5-1 Course of Progress of the Request

The Gambian Government planned to provide the existing Kotu Power Station (3 MW x 2 units) with No. 4 DEG to meet the power demand in Greater Banjul Area including Banjul City and surrounding areas. No. 4 DEG was provided under Japan's grant aid in 1983.

Since its installation, No. 4 DEG had been operating for about 17,000 hours from the start of the commercial operation in January, 1985 to March, 1987 and supplied within that period about 70 GWh of energy. Power cut previously occurring every day decreased to one time in ten days. As a result of its contribution to the stabilization of power supply, No. 4 DEG is highly appreciated among the people in The Gambia.

However, the generating output of No. 4 DEG has decreased to 5MW or less (as of September 24, 1988) for the following reasons:

- As the power demand has increased since 1985, continuous operation of No. 4 DEG has been made.

- Shortage of spare parts.

- Shortage of engineers who are familiar with maintenance control of No. 4 DEG.

Therefore, the existing power supply does not meet the present power demand.

To cope with this situation at an early stage, the Gambian Government formulated a rehabilitation plan of Kotu Power Station to secure stable social life through stabilization of power supply and cope with the future increase of power demand. The Gambian Government requested the Government of Japan for grant aid for the Project in The Gambia covering items as described in 2-5-2.

2-5-2 Contents of the Request

Contents of the request confirmed according to discussions with officials concerned of the Government are as follows:

1) Overhaul work of No. 4 DEG
2) OJT related to O & M, and
3) Additional supply of spare parts for No. 4 DEG

The Gambian side also hopes for provision of maintenance tools.

CHAPTER 3 CONTENTS OF THE PROJECT

CHAPTER 3 CONTENTS OF THE PROJECT

3-1 Objecgtives and Contents

As described in Chapter 1, The Gambia is in a serious power condition, and generating capability and operating condition of No. 4 DEG have a great influence on economic activities in Greater Banjul Area.

The Project aims to accomplish the following items in order to upgrade the urban function of Banjul City, and secure stable living of the inhabitants and reliable power supply.

(1) Recovery of generating capability of No. 4 DEG

(2) Maintenance of function and performance of the whole facilities

(3) Transfer of technology related to O & M

3-2 Evaluation of the Request

As stated in 2-5-2, the contents of the request by the Gambian Government was a) rehabilitation of No. 4 DEG, b) provision of spare parts, and c) transfer of technology related to O & M.

On the basis of the request, the basic design study team confirmed and discussed the contents and examined the feasibility of the implementation of the request with the Gambian officials. The team examined the condition of existing No. 4 DEG on the basis of data and information collected locally, and considered it appropriate to implement rehabilitation work of No. 4 DEG, provide spare parts and transfer technology of O & M through OJT for stable operation of No. 4 DEG, as shown in Table 3-1. Detailed comparison of the rehabilitation work and provision of spare parts is shown in Appendix XI.

Table 3-1 Comparison of Contents of Request by The Gambia and Scope of the Project

Item	Contents of request by The Gambia			Scope of the Project		
	Rehabilitation work	Provision of spare parts	Conduct of OJT	Rehabilitation work	Provision of spare parts	Conduct of OJT
1. Diesel engine						
1) Diesel engine	o	o	o	o	o	o
2) Radiator	o	-	o	o	o	o
3) Other auxiliary equipment	-	o	-	o	o	o
2. Generator	o	o	o	o	o	o
3. Electrical equipment						
1) Motor control center	-	o	-	-	o	-
2) Others	-	-	-	-	o	-

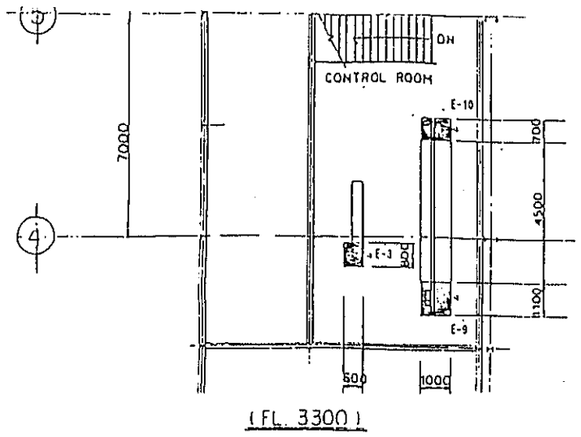
3-3 Outline of the Project

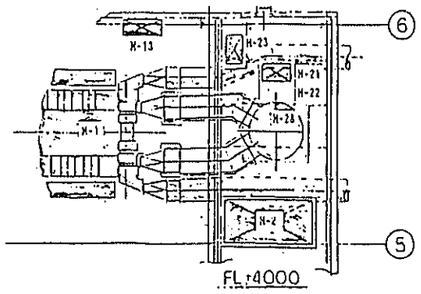
3-3-1 Executing Agency

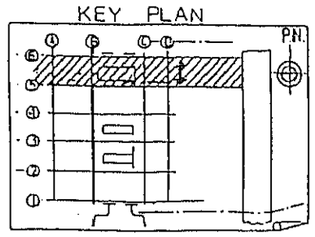
The executing agency of the Project in The Gambia is GUC.

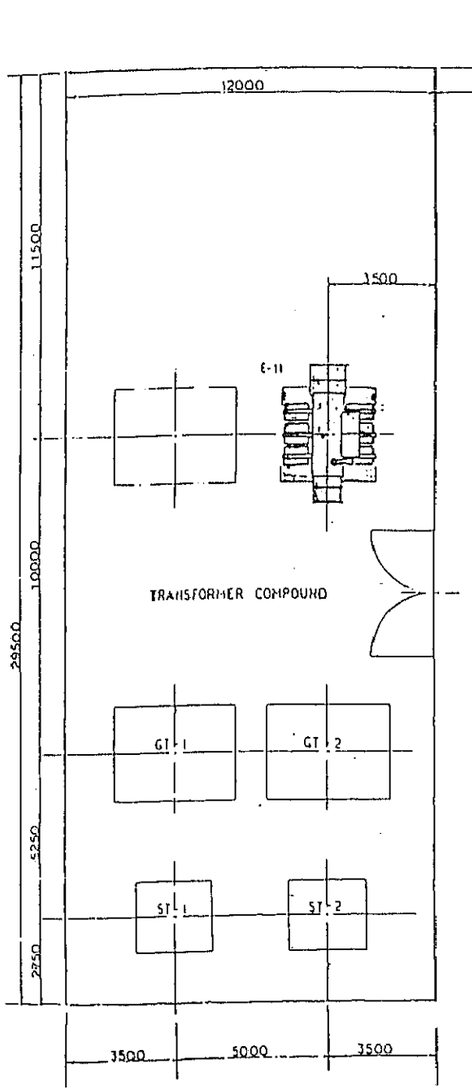
3-3-2 Generating Facilities for the Project

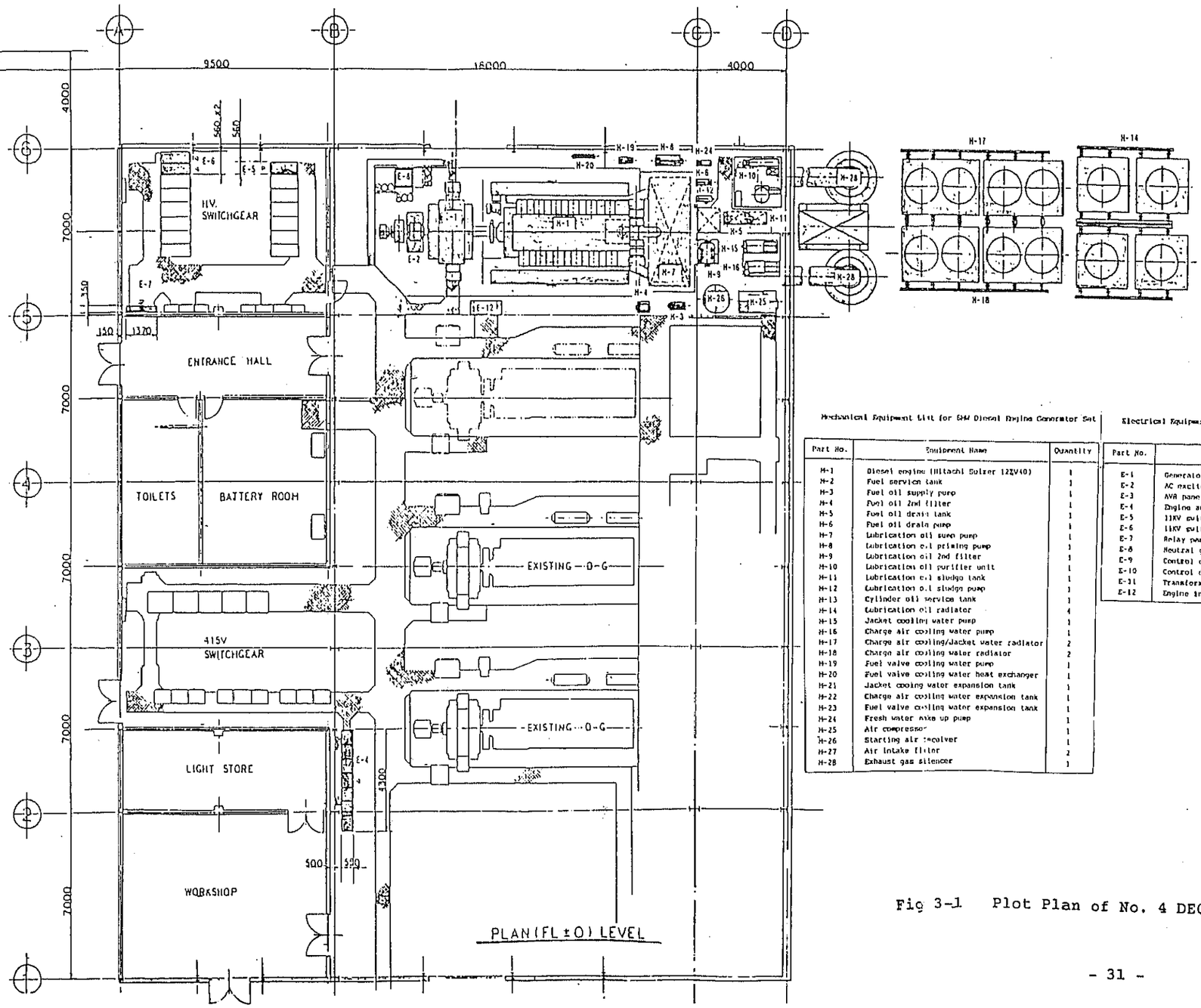
Generating facilities for the Project shall be No. 4 DEG at Kotu Power Station. Detailed equipment list for No. 4 DEG is shown in Figs. 3-1 and 3-2.

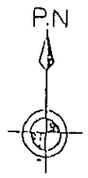












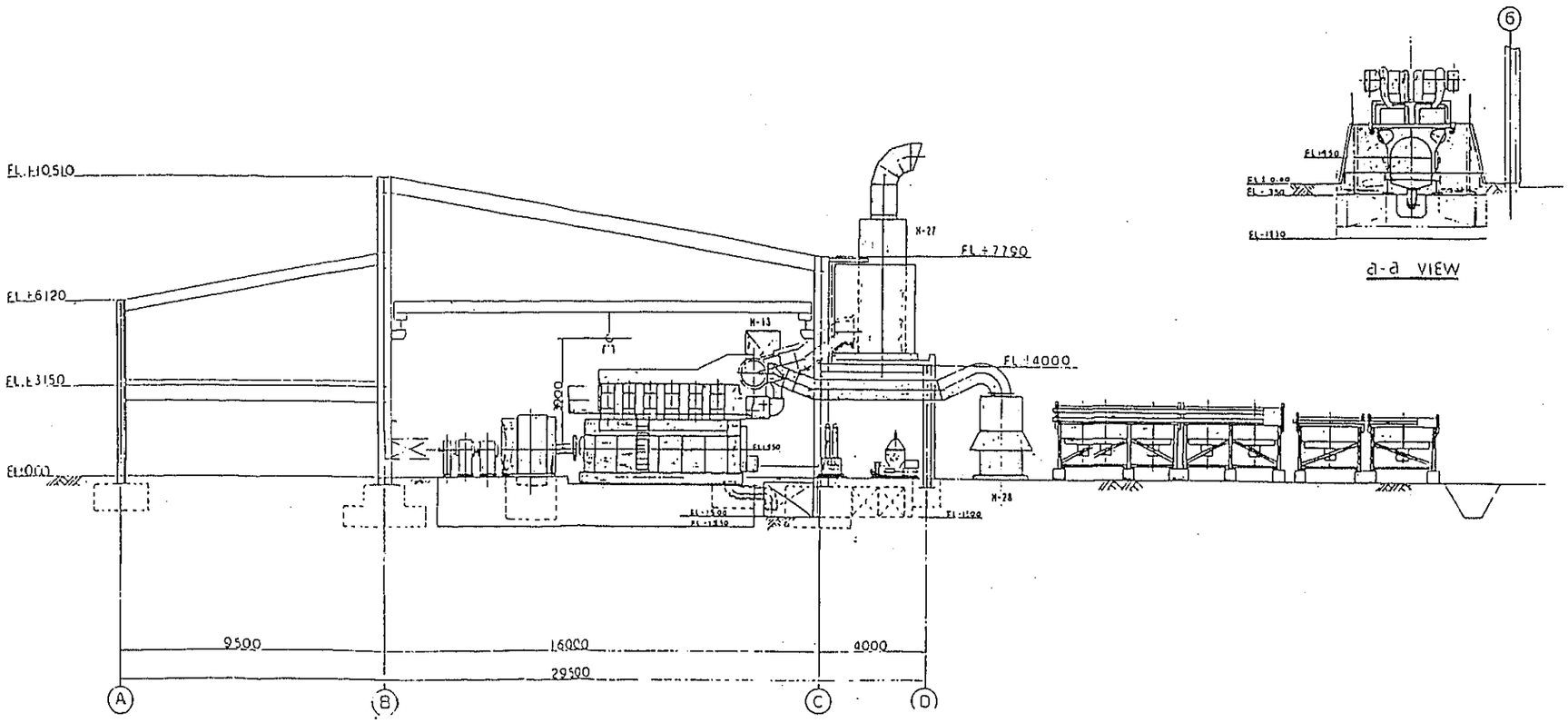
Mechanical Equipment List for 6MW Diesel Engine Generator Set

Part No.	Equipment Name	Quantity
M-1	Diesel engine (Hitachi Sulzer 12ZV40)	1
M-2	Fuel service tank	1
M-3	Fuel oil supply pump	1
M-4	Fuel oil 2nd filter	1
M-5	Fuel oil drain tank	1
M-6	Fuel oil drain pump	1
M-7	Lubrication oil sump pump	1
M-8	Lubrication oil priming pump	1
M-9	Lubrication oil 2nd filter	1
M-10	Lubrication oil purifier unit	1
M-11	Lubrication oil sludge tank	1
M-12	Lubrication oil sludge pump	1
M-13	Cylinder oil service tank	1
M-14	Lubrication oil radiator	4
M-15	Jacket cooling water pump	1
M-16	Charge air cooling water pump	1
M-17	Charge air cooling/Jacket water radiator	2
M-18	Charge air cooling water radiator	2
M-19	Fuel valve cooling water pump	1
M-20	Fuel valve cooling water heat exchanger	1
M-21	Jacket cooling water expansion tank	1
M-22	Charge air cooling water expansion tank	1
M-23	Fuel valve cooling water expansion tank	1
M-24	Fresh water make up pump	1
M-25	Air compressor	1
M-26	Starting air receiver	1
M-27	Air intake filter	2
M-28	Exhaust gas silencer	1

Electrical Equipment List for 6MW Diesel Engine Generator

Part No.	Equipment Name	Quantity
E-1	Generator 6000KW	1
E-2	AC exciter	1
E-3	AVR panel	1
E-4	Engine auxiliary panel (MEC)	1
E-5	11KV switchgear for generator	1
E-6	11KV switchgear for feeder	1
E-7	Relay panel for protection	1
E-8	Neutral grounding transformer panel	1
E-9	Control desk for generator	1
E-10	Control desk for feeder	1
E-11	Transformer 8000KVA	1
E-12	Engine instrument panel	1

Fig 3-1 Plot Plan of No. 4 DEG (Plan)



a-a VIEW

Fig 3-2 Plot Plan of No. 4 DEG (Side view)

3-3-3 Policy of the Project

(1) Basic Design Policy

The basic design of No. 4 DEG will be conducted considering that the Gambian side strongly desires prompt recovery of generating capability and transfer of technology related to O & M.

1) Rehabilitation plan of generating facilities:

   a) Recovery to adequate output
   b) Shortening of rehabilitation work period to minimize operation stop

2) Provision plan of equipment

   Materials and equipment such as spare parts, tools, etc. will be provided for stable operation of No. 4 DEG after the implementation of the Project.

3) OJT plan

   a) Overall procedures of O & M and positioning of maintenance work to be executed
   b) Practical training by an engineer sent from an implementation firm
   c) Provision of training materials for reviewing acquired technology

Although the Gambian side hopes for the training to be conducted in Japan, it is difficult to carry out the training under this Project in Japan as rehabilitation work, equipment and parts to be supplied for the Project are limited.

(2) Design Conditions

1) Site condition

Temperature	:	45°C (max.)
		15°C (min.)
Humidity	:	90% (max.)
Elevation	:	12 m above sea level
Other condition	:	Subtropical climate, and dusty harmattan

2) Voltage

High voltage	:	11 kV, 3-phase, 50Hz
Low voltage	:	415/240 V, 3-phase, 4-wire, 50Hz
DC	:	100V, 50V

3) Fuel

Light oil

4) Other considerations

a) Oil leakage from No. 1 and No. 2 radiators shall be prevented by the Gambian side, prevention of oil leakage will not affect No. 4 DEG after completion of this Project.

b) Load for operation test of No. 4 DEG shall be provided by the Gambian side.

c) Periodic inspection of No. 4 DEG shall be conducted by the Gambian side during the period from when running time reaches 24,000 hours up to the commencement of the Project.

d) Crank shaft damaged (on September 24, 1988) of No. 4 DEG, as stated in 2-3-2, shall be repaired by the Gambian side prior to the implementation of the Project, so as not to affect the operation of No. 4 DEG.

e) Spare parts and tools currently used for No. 4 DEG shall be used during the implementation of the rehabilitation work.

f) Any portion damaged shall be rehabilitated by the Gambian side.

(3) Applicable Standards and Codes

Following Japanese and international standards and codes shall be applied to the Project. Specifications for the existing generating facilities and standards shall be considered in the design of facilities for the Project.

- Japanese Industrial Standards (JIS)
- Japanese Electrotechnical Commission (JEC)
- The Standard of Japan Electrical Manufacturer's Association (JEM)
- Japan Cable Maker's Association Standard (JCS)
- International Electrotechnical Commission (IEC)
- International Standardization Organization (ISO)
- Other Relative Japanese Standards

3-3-4 Outline of the Project

An outline of facilities rehabilitation plan, provision plan of materials and equipment and OJT plan is as follows:

(1) Facilities Rehabilitation Plan

Judging from the present capability of maintenance control and operation records, it may be appropriate to overhaul and inspect the entire No. 4 DEG, and replace and adjust equipment and parts at an earliest date. In particular, functional recovery of air intake and exhaust system is indispensable for output recovery, and appropriate rehabilitation and improvement works are a pressing need.
Facilities rehabilitation plan is outlined below:

1) Inspection and adjustment of the whole generating facilities
2) Overhaul of diesel engine, replacement of parts for other facilities or overhaul of facilities
3) Dismantling, adjustment and cleaning of air intake and exhaust system (e.g., air intake filter, turbo charger, air cooler)
4) Removal of oil adhering to radiator, cleaning of radiator and replacement of parts
5) Replacement of deteriorated parts
6) Replacement of air compressor
7) Replacement and adjustment of instrument
8) Cleaning and touch-up painting of the whole generating facilities
9) Provision of high pressure cleaning pump for radiators

Although the Gambian side points out that it is difficult to clean radiators for No. 4 DEG from the lower portion because such radiators are installed in the lower position and these filters are liable to clogging caused by sand, it is deemed possible to clean radiators under this situation. Furthermore, oil leaked from radiators for No. 1 and No. 2 DEG adheres to radiators for No. 4 DEG.

If high pressure cleaning pump for radiators is provided and technology related to maintenance control for facilities is transferred, contamination to radiators due to oil leakage will be eliminated, and there is no matter affecting cooling capability of radiators. Therefore, the present installation level will remain as it is.

(2) Provision Plan of Materials and Equipment

1) Periodically replaced parts and consumables will be provided considering stocks and their life.

2) Since spare parts and tools stored by the GUC are not sufficient for maintenance work, necessary parts and tools will be provided.

3) Spare parts necessary until 12,000 hours of running time after the completion of the Project will be provided.

(3) OJT Plan

1) OJT will be conducted by engineers sent by a Japanese contractor for this Project.

2) Classroom training of O & M procedures and outline will be carried out for about one week.

3) Practical training of rehabilitation technology will be given for about two months during the implementation of the Project.

CHAPTER 4 BASIC DESIGN

CHAPTER 4 BASIC DESIGN

4-1 Facilities RehabilitationPlan

4-1-1 Basic Design

As stated in (3) of 2-3-2, No. 4 DEG had been operated under severe condition, because excessively contaminated air intake and exhaust system resulted in insufficient air volume. It became obvious through analysis of operation records of No. 4 DEG (refer to Appendix IX) that trip occurred in No. 4 DEG from 1985 to 1986 was attributed to high temperature of jacket cooling water, low pressure of lubricating oil, oil mist and shortage of lubricating oil for cylinder. However, trip only caused by overload and some trouble on the side of inter-connectors that occurred from June, 1987 onwards was reported.

It is assumed from the above situation that internal failure of generating facilities is discarded, and fuel amount is increased to increase the output, despite the fact that air volume is insufficient and effective output can not be obtained due to deteriorated fuel combustion parts of diesel engine.

As a result, exhaust temperature of diesel engine exceeds its permissible level, thermal load exerted on combustion chamber parts (e.g., cylinder liners, cylinder heads, etc.), exhaust pipes and turbo charger is assumed to be excessive.

Considering the above-mentioned matter, the rehabilitation plan of No. 4 DEG is to place emphasis on dismantling, inspection and overhaul of diesel engine and conduct the basic design.

The basic design is conducted with consideration given to 1) the contents of the request by the Gambian side, 2) field survey results, and 3) dismantling, cleaning, inspection, replacement of parts, assembling and total adjust- ment of the entire No. 4 DEG to be carried out at Kotu Power Station.

Details of rehabilitation work are as follows:

(1) Rehabilitation work of diesel engine for securing reliable generating facilities (i.e., maintenance work after 36,000 hours' operation and damaged parts)

(2) Rehabilitation work of cooling system for recovery of cooling efficiency

(3) Rehabilitation work of air intake and exhaust system for securing sufficient air volume

(4) Rehabilitation work of auxiliary equipment for No. 4 DEG (i.e., maintenance work after 36,000 hours' operation and damaged parts)

(5) Inspection and adjustment of electrical facilities

(6) Total adjustment for confirmation of the whole facilities

Table 4-1 shows the description of the rehabilitation work by work item.

Table 4-1 Description of Rehabilitation Work

1. Overhaul and Adjustment of Diesel Engine

Equipment and Part	Work to be carried out	Removal	Dismantling	Cleaning	Replacement	Adjustment	Assembling	Fitting
1) Fuel injector	Renewal of complete set	o	-	-	o	-	-	o
2) High pressure fuel pipe	- do -	o	-	-	o	-	-	o
3) Cylinder head	Removal and replacement	o	-	-	o	-	-	o
	Inspection of combustion surface/Grinding inlet and outlet valve seat	-	o	o	o	o	o	-
4) Inlet and outlet valve	Renewal of complete set	o	o	-	o	-	o	o
5) Inlet and outlet valve	Removal and replacement	o	-	-	o	-	-	o
rocker arm	Overhaul of bearing bush	-	o	o	o	o	o	-
6) Starting air valve	Renewal of complete set	o	-	-	o	-	-	o
7) Relief valve	- do -	o	-	-	o	-	-	o
8) Indicator valve	- do -	o	-	-	o	-	-	o
9) Piston	- do -	o	-	-	o	-	-	o
	Overhaul and inspection of cooling surface and spherical bearing	-	o	o	o	o	o	-

(cont'd)

Equipment and Part	Work to be carried out	Removal	Dismantling	Cleaning	Replacement	Adjustment	Assembling	Fitting
10) Cylinder liner	Wear measurement/Inspection of internal surface	-	-	o	-	o	-	-
11) Bottom end bearing	Overhaul and replacement	o	-	o	o	o	-	o
12) Crankshaft main locating bearing	- do -	o	-	o	o	o	-	o
13) Crankshaft	Inspection of crankjournal and crankpin/measurement of crankshaft deflection	-	-	o	-	o	-	-
14) Crankcase	Internal inspection	-	-	o	-	o	-	-
15) Camshaft	Overhaul of camshaft bearing and cam surface	o	-	o	o	o	-	o
16) Camshaft driving gear	Check of gear tooth backlash and bearing clearance	-	-	o	-	o	-	-
17) Valve actuating gear	Overhaul and inspection	o	o	o	o	o	o	o
18) Starting air distributor	- do -	o	o	o	o	o	o	o
19) Starting air stop valve	- do -	-	o	o	o	o	o	-
20) Exhaust gas pipe	Renewal of No.2 Cylinder exhaust pipe (K81105)	o	-	o	o	o	-	o
	Renewal of insulation on exhaust pipe	o	-	o	o	-	o	o
	Inspection and replacement of expansion joint	o	-	o	o	o	-	o

(cont'd)

Equipment and Part	Work to be carried out	Removal	Dismantling	Cleaning	Replacement	Adjustment	Assembling	Fitting
21) Fuel injection pump	Overhaul and inspection	o	o	o	o	o	o	o
22) Overspeed trip device	Overhaul and function check	o	-	-	o	-	-	o
23) pneumatic control valve	Check and adjustment of function	o	-	-	o	o	-	o
24) Cylinder lubricator	Flushing and adjustment	o	o	o	o	o	o	o
25) Governor/Governor drive	Request of overhaul and inspection to Governor manufactures	o	-	-	o	-	-	o
26) Lubricating oil pump	Overhaul and inspection/ Replacement of shaft	o	o	o	o	o	o	o
27) Pressure gauge, temperature gauge and instrument panel	Renewal and countermeasure for vibration	o	-	o	o	o	-	o
28) Oilmist detector	Overhaul/Replacement of part and adjustment	o	o	o	o	o	o	o
29) Foundation bolt	Check and tensioning	-	-	-	-	o	o	-

2. Repair for Cooling System

Equipment and Part	Work to be carried out	Removal	Dismantling	Cleaning	Replacement	Adjustment	Assembling	Fitting
1) Lubricating oil radiator	Chemical cleaning of cooling panel	o	-	o	o	-	-	o
2) Charge air cooling water radiator	- do -	o	-	o	o	-	-	o
3) Jacket cooling water radiator	- do -	o	-	o	o	-	-	o
	Installation of additional cooling panel/modification of piping	-	-	-	-	o	o	o
4) Charge air cooler	Chemical cleaning	o	-	o	o	o	-	o
5) Heat exchanger for fuel valve cooling water	Overhaul and inspection	o	-	o	o	o	-	o

3. Repair for Air Intake and Exhaust System

Equipment and Part	Work to be carried out	Removal	Dismantling	Cleaning	Replacement	Adjustment	Assembling	Fitting
1) Intake air filter	Cleaning/Replacement of element	o	o	o	o	o	o	o
2) Intake air duct (dia 650)	Internal cleaning	o	-	o	o	-	-	o
3) Exhaust gas turbocharger	Overhaul and inspection/ chemical cleaning	o	o	o	o	o	o	o
4) Exhaust gas system (dia 750) and exhaust gas silencer	Cleaning	o	-	o	o	-	-	o

4. Repair of Auxiliary Equipment

Equipment and Part	Work to be carried out	Removal	Dismanthing	Cleaning	Replacement	Adjustment	Assembbing	Fitting
1) Lubricating oil purifier	Overhaul and inspection	o	o	o	o	o	o	o
2) Electric driven pump	- do -	o	o	o	o	o	o	o
3) Oil filter	- do -	o	o	o	o	-	o	o
4) Instrument and piping	- do -	o	-	o	o	o	-	o

5. Check of Electric Equipment

Equipment and Part	Work to be carried out	Removal	Dismantling	Cleaning	Replacement	Adjustment	Assembling	Fitting
1) A.C. generator	Check and inspection	o	-	o	o	o	o	o
2) Control panel, switchgear	Inspection of part/check of function	o	-	o	o	o	o	o
3) Total check	Total check of function	o	o	o	o	o	o	o

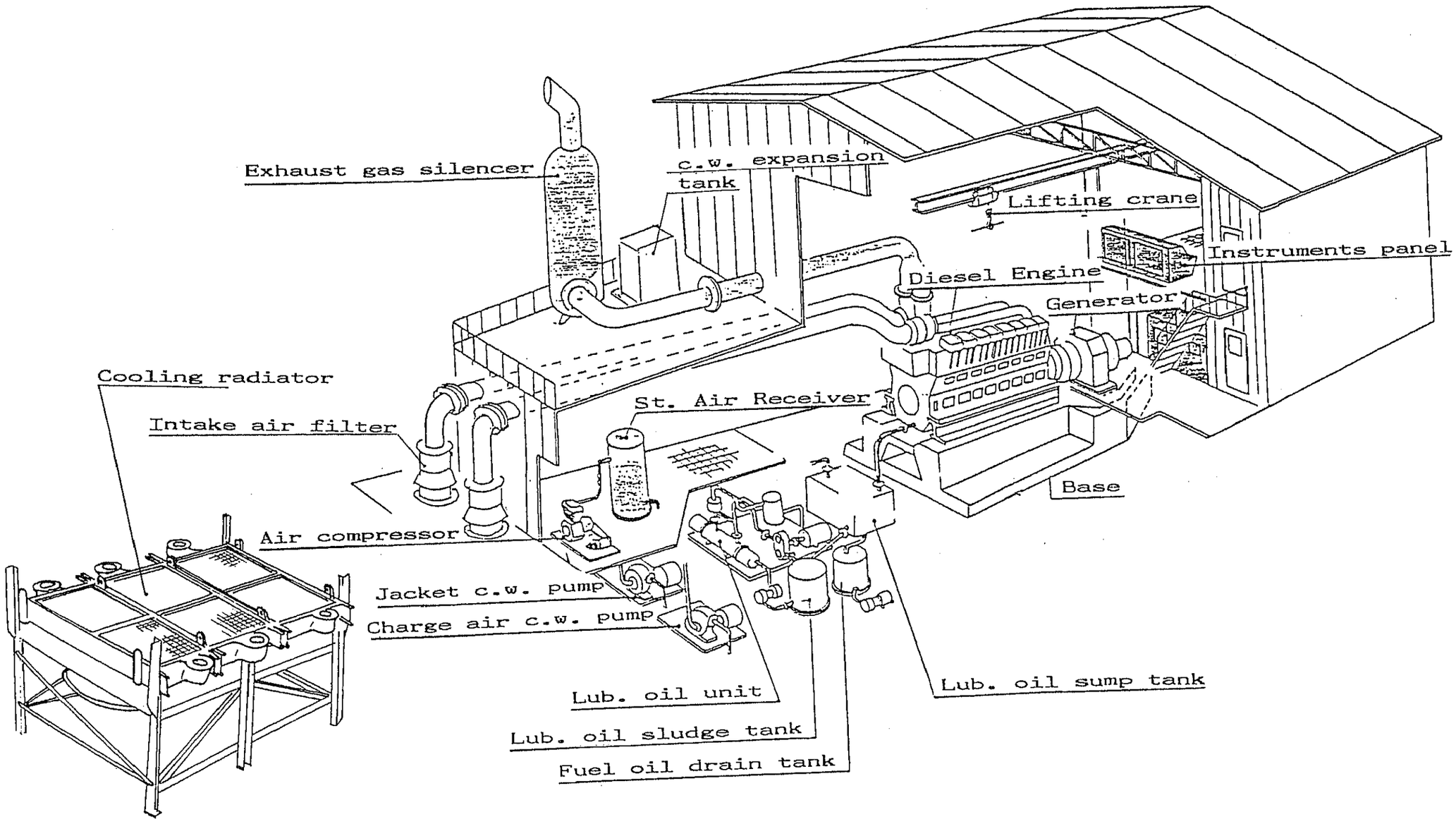
6. Total Adjustment

Equipment and Part	Work to be carried out	Removal	Dismanthing	Cleaning	Replacement	Adjustment	Assembbing	Fitting
1) Restoration	Check of function, oil flushing, water flushing	o	-	o	o	o	-	o
2) Trial run	Trial run	-	-	-	-	o	-	-

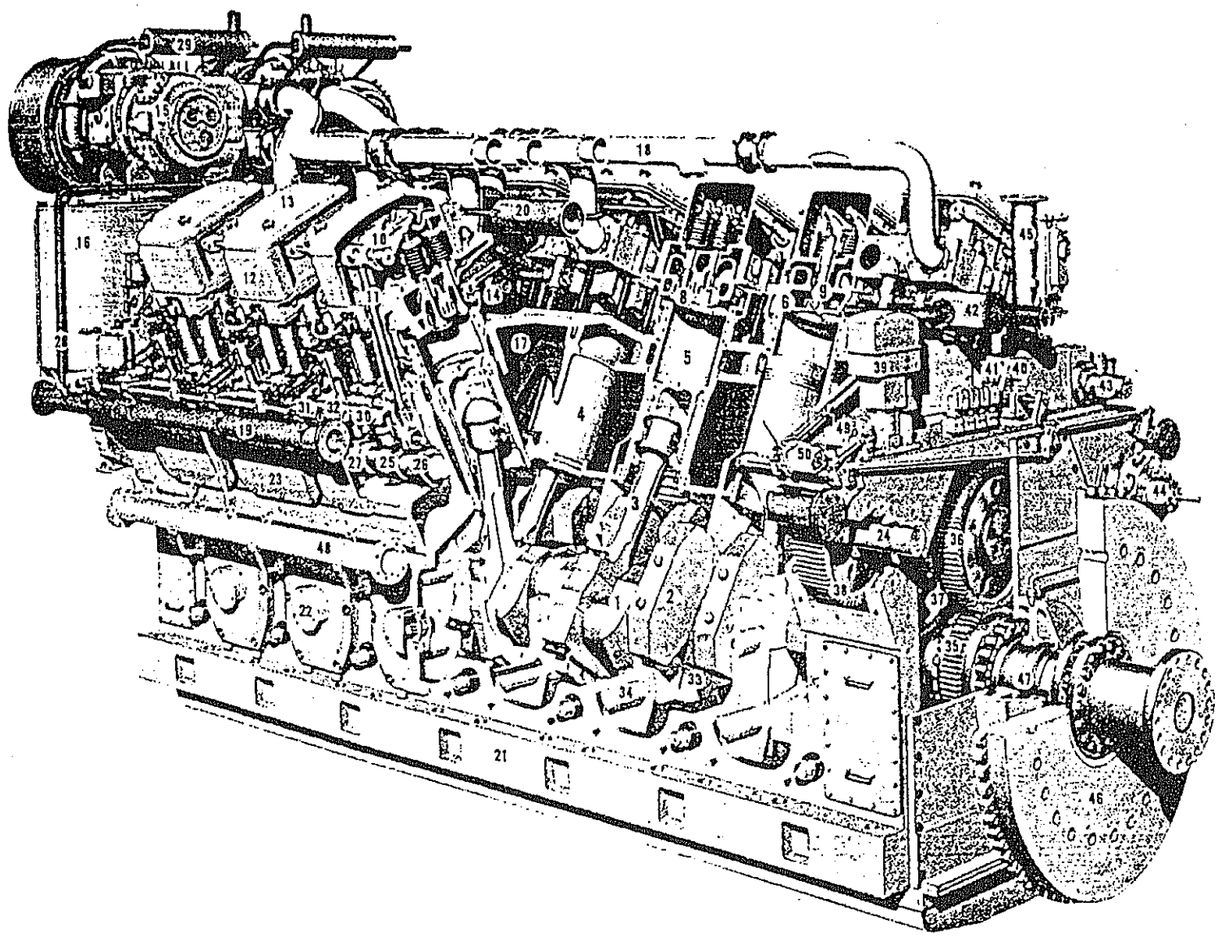
4-1-2 Basic Design Drawings

Plot plan No. 4 DEG is shown in Figs. 3-1 and 3-2 in Chapter 3.

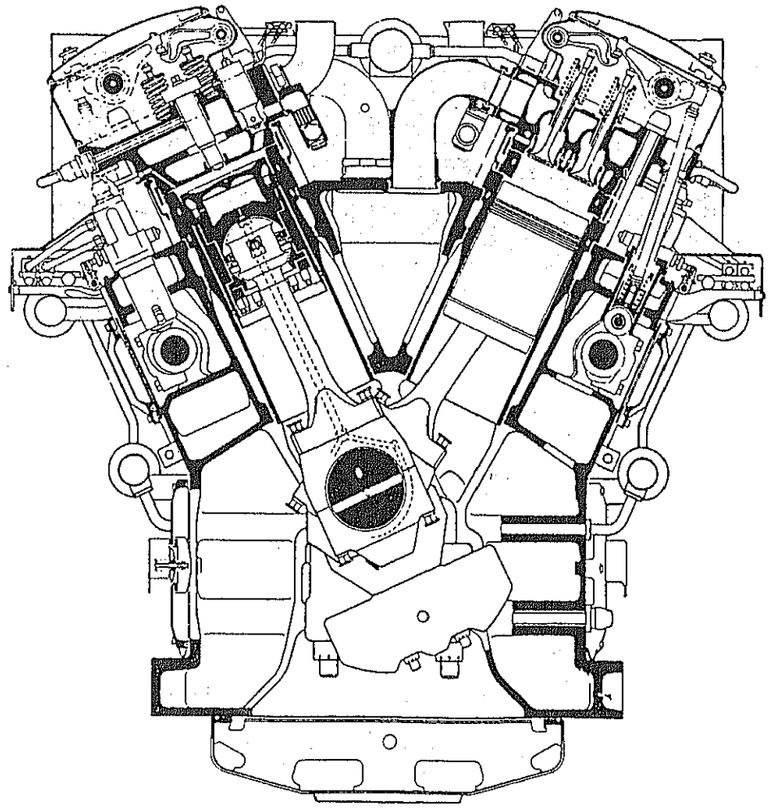
General descriptions of major items of rehabilitation work are shown in drawing Nos. GKR-01 through GKR-08.



THE REPUBLIC OF THE GAMBIA				SCALE: -
THE PROJECT FOR REHABILITATION OF KOTU POWER STATION				DWG. NO.
General Arrangement of Diesel Engine Generating Facilities				GKR-01
DATE	DESIGNED	CHECKED	APPROVED	REVISION
JAPAN INTERNATIONAL COOPERATION AGENCY				



ENGINE SECTION

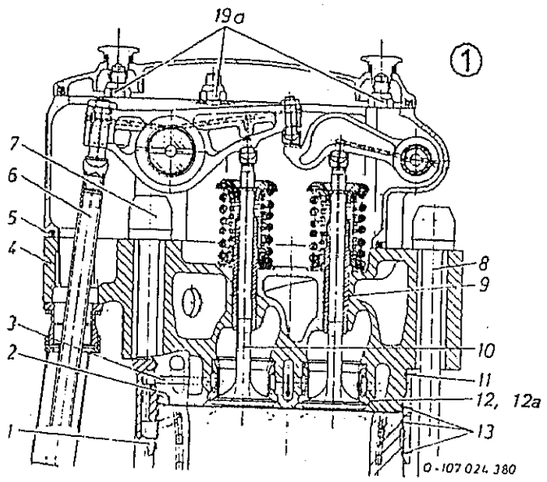


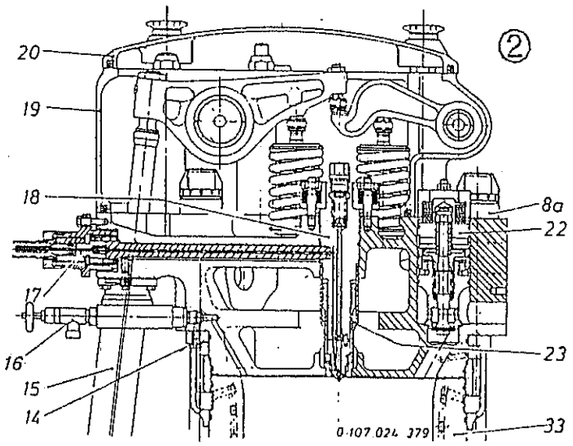
KEY TO ENGINE COMPONENTS

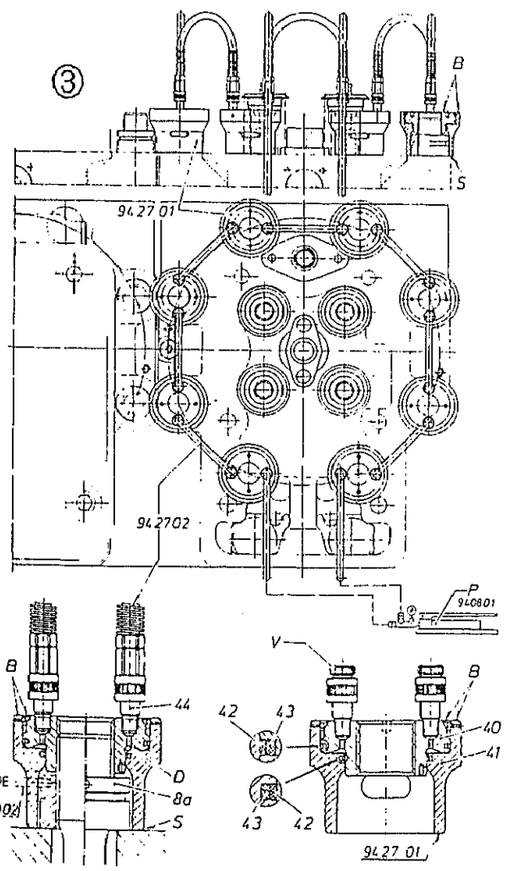
1 Crank shaft
2 Counter weight
3 Connecting rod
4 Piston
5 Cylinder liner
6 Cylinder head
7 Outlet valve
8 Inlet valve
9 Fuel injection valve
10 Rocker arm
11 Push rod
12 Rocker arm casing
13 Cover for Rocker arm
14 Starting air pipe
15 Exhaust turbocharger
16 Intercooler
17 Inlet air manifold
18 Exhaust branch piece
19 Cyl. C.W. inlet pipe
20 Cyl. C.W. outlet pipe
21 Cylinder frame
22 Crankcase relief valve
23 Camshaft casing
24 Camshaft
25 Outlet valve cam
26 Inlet valve cam
27 Fuel injection pump cam
28 T / C C.W. inlet pipe
29 T / C C.W. outlet pipe
30 Fuel regulating shaft
31 Fuel inlet pipe
32 Fuel outlet pipe
33 Main bearing
34 Side bolt
35 Cam shaft driving gear on crankshaft
36 Intermediate gear wheel(1)
37 Intermediate gear wheel(2)
38 Camshaft driving gear on camshaft
39 Governor
40 Overspeed trip device
41 Crankshaft locating bearing
42 Lubricating oil pipe
43 Cylinder lubricator driving pump
44 Indicator for fuel pump feed rate

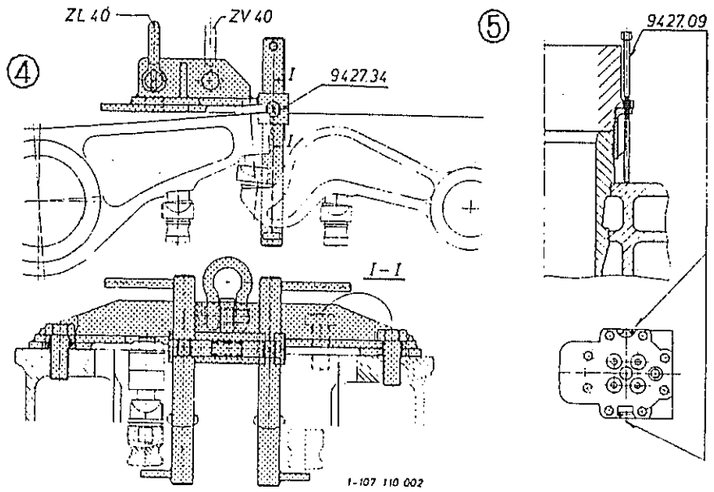
VIEWS OF DIESEL ENGINE TYPE OF 12ZV40

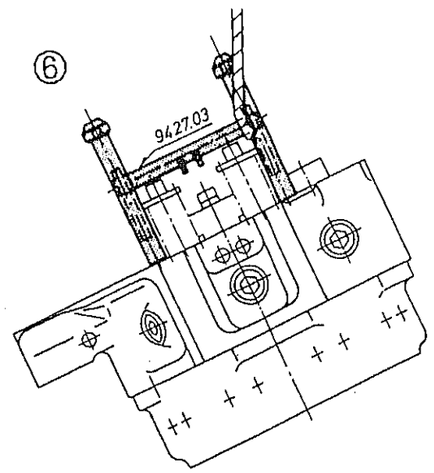
THE REPUBLIC OF THE GAMBIA		SCALE –
THE PROJECT FOR REHABILITATION OF KOTU POWER STATION		DWG. NO.
Detailed Drawing of Diesel Engine		GKR – 02
DATE	DESIGNED / CHECKED / APPROVED	REVISION
JAPAN INTERNATIONAL COOPERATION AGENCY		











Outline of cylinder Head Removal and Replacement

1 Preparation work

1) Drain the cylinder cooling water from the engine and shut the valve for fuel injector cooling water pipes.

2) Turn the crankshaft so that the respective piston is at T.D.C. on the firing stroke i.e. both inlet and outlet valves are closed.

2 Evenly slacken off the nuts 19a (①) of rocker gear cowling studs and lift off the cowling using lifting device (④).

3 Remove both push rods ⑥.

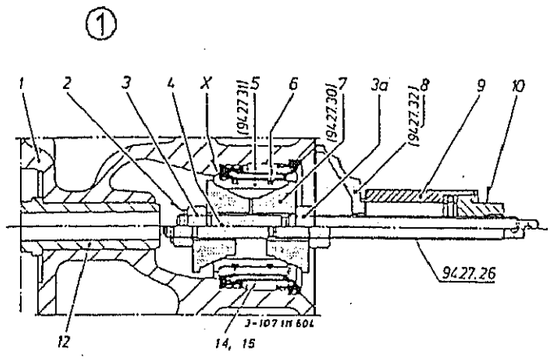
4 Remove the fuel high-pressure pipe and blank off the opening in the fuel injection pump as well as the pipe.
Also remove all the other pipe connections to the cylinder head (exhaust air, etc.).

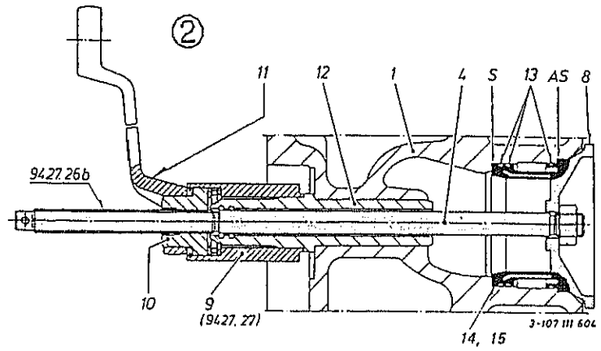
5 Slacken the cylinder head nuts using tensioning jack screwed onto the cylinder head studs (③).

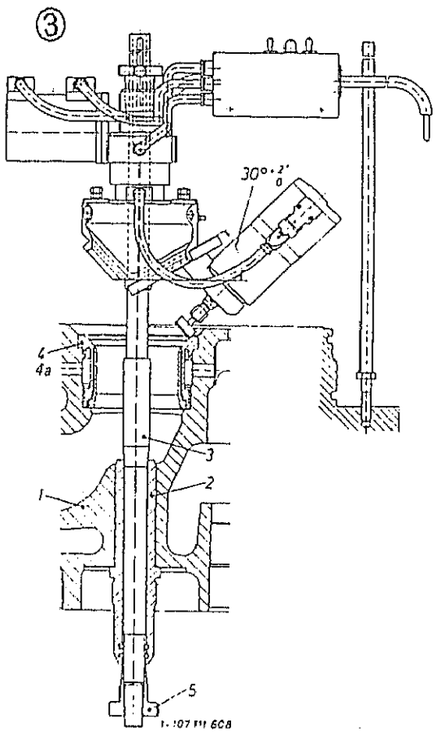
6 After all cylinder head nuts are removed, jack off the cylinder head together with the built in water guide ring from the cylinder liner using jacking screws (⑤).

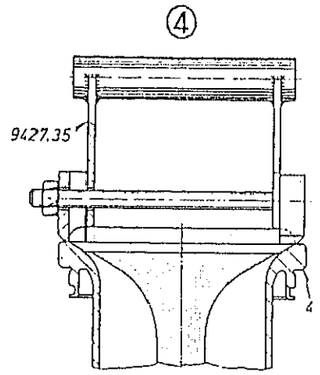
7 As soon as the cylinder head has come free, fit the lifting bracket and remove the cylinder head from the engine.

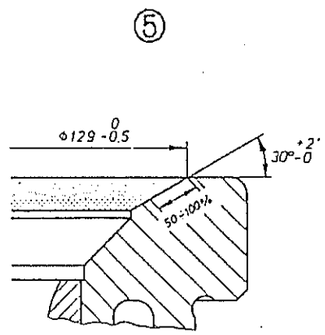
THE REPUBLIC OF THE GAMBIA				SCALE: -
THE PROJECT FOR REHABILITATION OF KOTU POWER STATION				DWG. NO.
Illustrative Drawing for Removal of Cylinder Head				GKR-03
DATE	DESIGNED	CHECKED	APPROVED	REVISION
JAPAN INTERNATIONAL COOPERATION AGENCY				

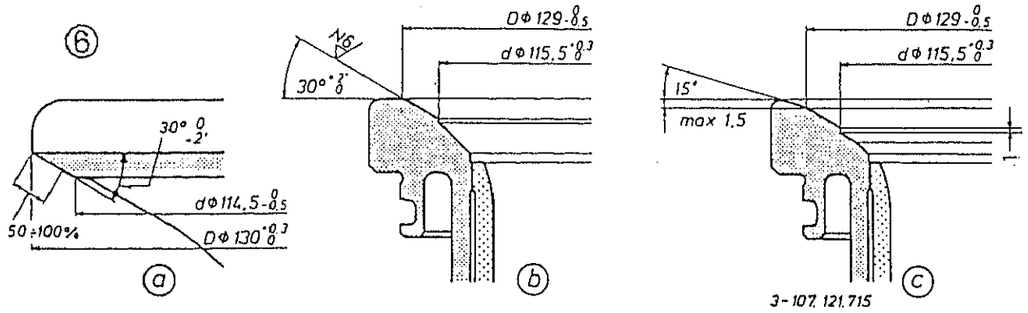












I I. Outline of Maintenance Work for Cylinder Head

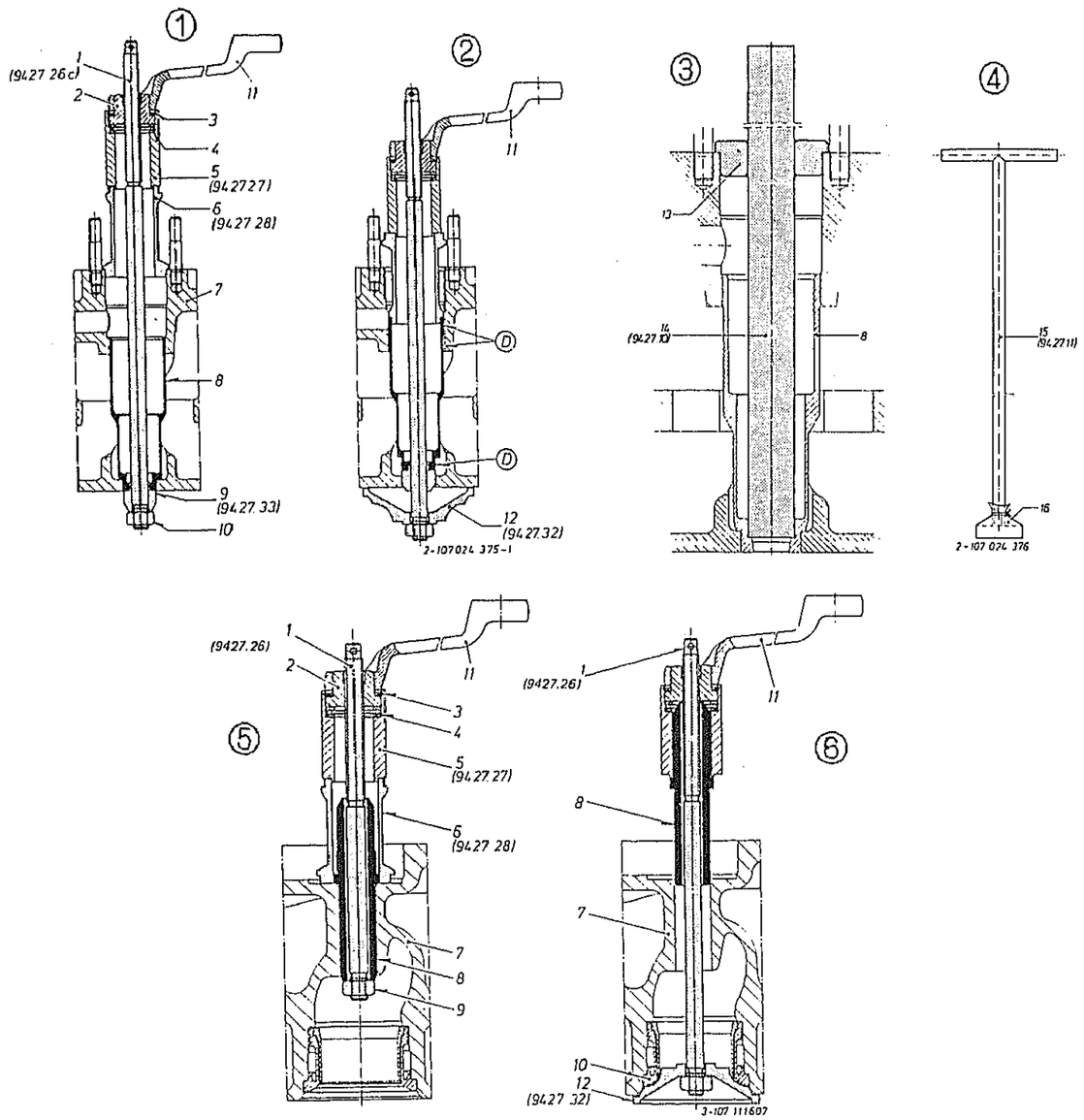
I I — 1 Replacement of Inlet/Outlet Valve Seats.

- Removal of valve seats: ①
- Fitting of valve seats: ②

I I — 2 Outline of Grinding Work for Inlet/Outlet Valve Seats

- Grinding of valve seats: ③
- Checking of valve seats: ④, ⑤, ⑥

THE REPUBLIC OF THE GAMBIA	SCALE: -
THE PROJECT FOR REHABILITATION OF KOTU POWER STATION	DWG. NO.
Illustrative Drawing for Repair of Cylinder Head (1/2)	GKR-04
DATE / DESIGNED / CHECKED / APPROVED / REVISION	
JAPAN INTERNATIONAL COOPERATION AGENCY	



I I — 3 Outline of Fuel Injector Bush Replacement and lapping seating surface

- Removal of Bush: ①
- Insert of Bush: ②
- Lapping of seating Surface: ③, ④

I I — 4 Outline of Replacement for Valve Guide of Inlet/Outlet Valves

- Removal of Valve Guide: ⑤
- Insert of Valve Guide: ⑥

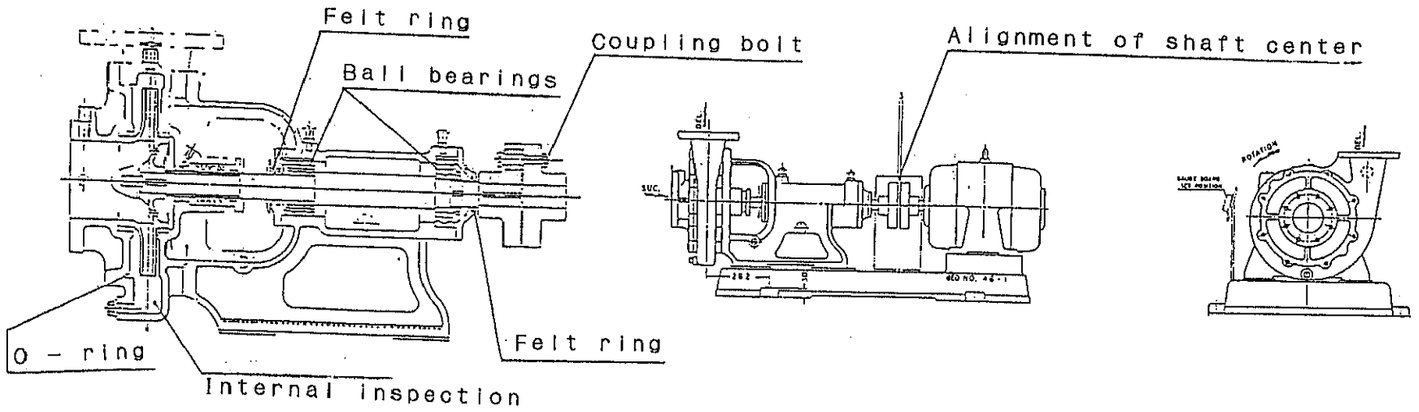
I I — 5 Outline of Pressure Testing for Cylinder Head Water Spaces

Water space remain tight at certain pressure held constant for about 15 minutes, ... ⑦, ⑧

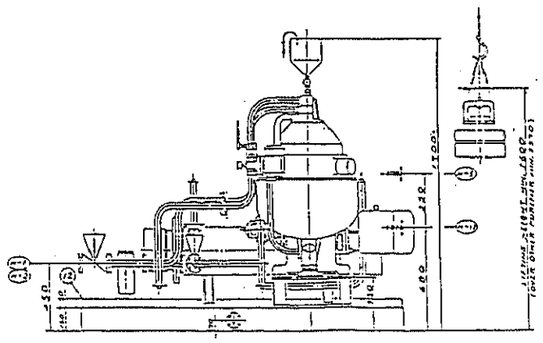
THE REPUBLIC OF THE GAMBIA				SCALE: -
THE PROJECT FOR REHABILITATION OF KOTU POWER STATION				DWG. NO.
Illustrative Drawing for Repair of Cylinder Head (2/2)				GKR-05
DATE	DESIGNED	CHECKED	APPROVED	REVISION
JAPAN INTERNATIONAL COOPERATION AGENCY				

I Motor-Driven Pumps

Maintenance and inspection points of centrifugal pump for CYL. C.W. as an example.

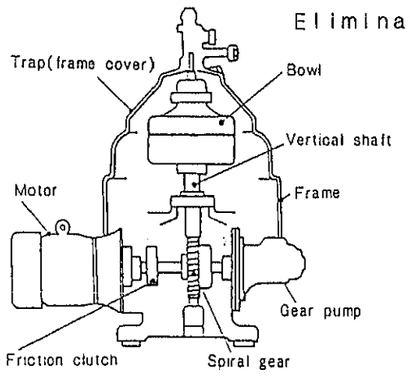


II Lubrication oil purifier unit

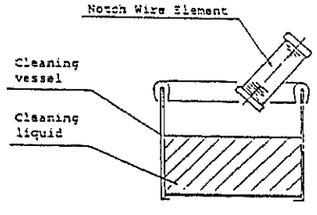


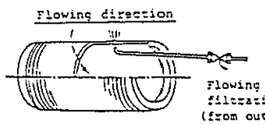
Overhaul Inspection/Maintenance

Elimination of oil leakage from the pipe system



III 2nd filter (FO - LO - CYL.OIL)





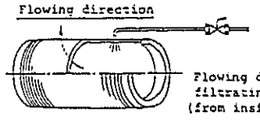
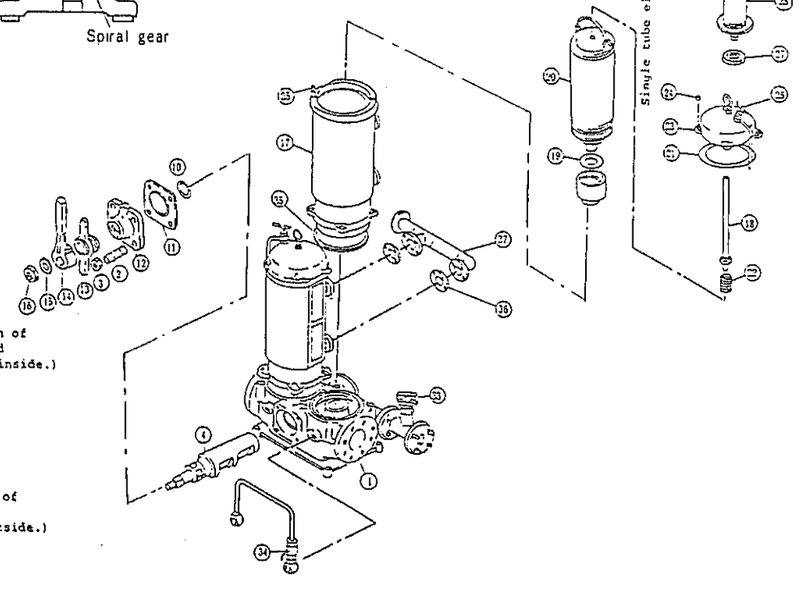


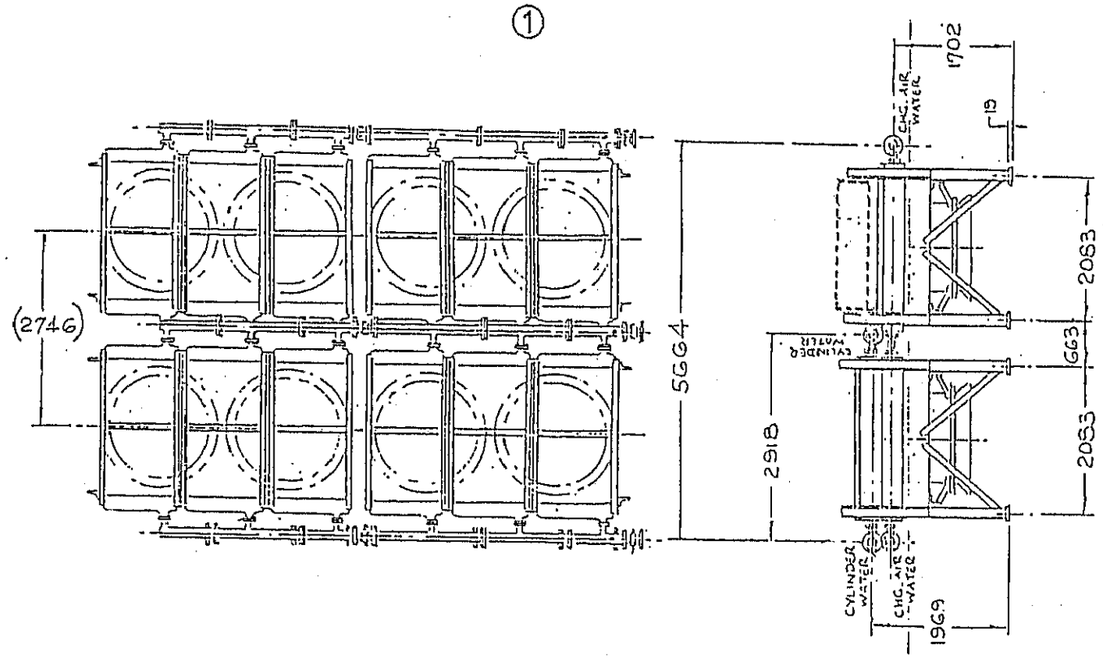
Fig. 13 Element cleaning method



Part No.	Part Name	Part No.	Part Name
(1)	Strainer main body	(24)	Tightening nut
(2)	Tightening stud	(25)	Stud
(3)	stud nut	(26)	Air plug (or cock)
(4)	Changeover cock	(27)	Element guide packing
(10)	Packing (O-ring)	(28)	Element (inner tube of double tubes)
(11)	Packing	(29)	Inner tube packing
(12)	Gland	(30)	Element (outer tube of double tubes)
(13)	Taking-off handle	(31)	Element hanger
(14)	Changeover cock handle	(32)	Wing nut
(15)	Washer	(33)	Drain valve (or cock)
(16)	Locknut	(34)	Fill-up cock
(17)	Casing	(35)	Casing packing
(18)	Shaft	(36)	Packing
(19)	Element guide packing	(37)	Steam vent
(20)	Element (single tube)		
(21)	Casing packing (O-ring)		
(22)	Spring		
(23)	Top cover		

THE REPUBLIC OF THE GAMBIA		SCALE -
THE PROJECT FOR REHABILITATION OF KOTU POWER STATION		DWG.NO.
Illustrative Drawing for Rehabilitation of Engine Auxiliary Equipment		GKR-06
DATE	DESIGNED / CHECKED / APPROVED	REVISION
JAPAN INTERNATIONAL COOPERATION AGENCY		

①



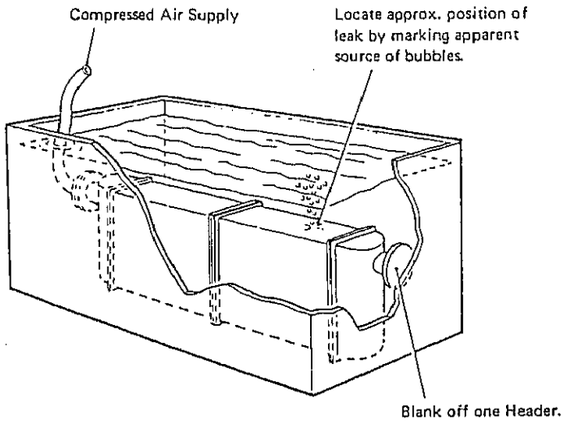
Outline of Maintenance Work of Radiator

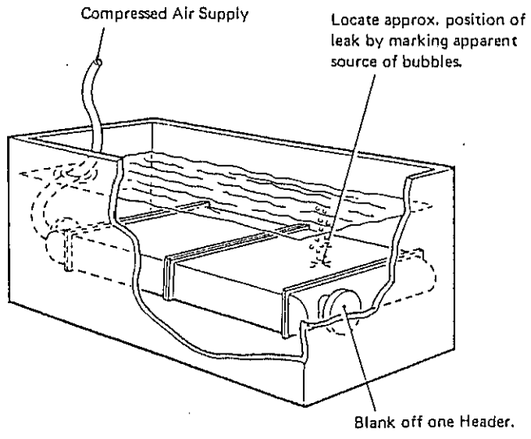
1) Remove the cooling panel from radiator frame using small lifting eyes and leave it into cleaning tank with suitable solvent for certain hours. After that, apply high pressure water jet cleaning on the treated surfaces forcing the material causing the fouling out from the heat exchanger.

2) In the case that scale deposite are present inside the water tubes of water cooler, internal cleaning to be aplied by connecting temporary circulation pump and circulation pipe to total matrix adding scale remover solution.

3) If any leaking from cooling tube appeared by compressed air testing, the cooling panel to be replaced or the cooling tube to be repaired in accordance with CRD's instruction.

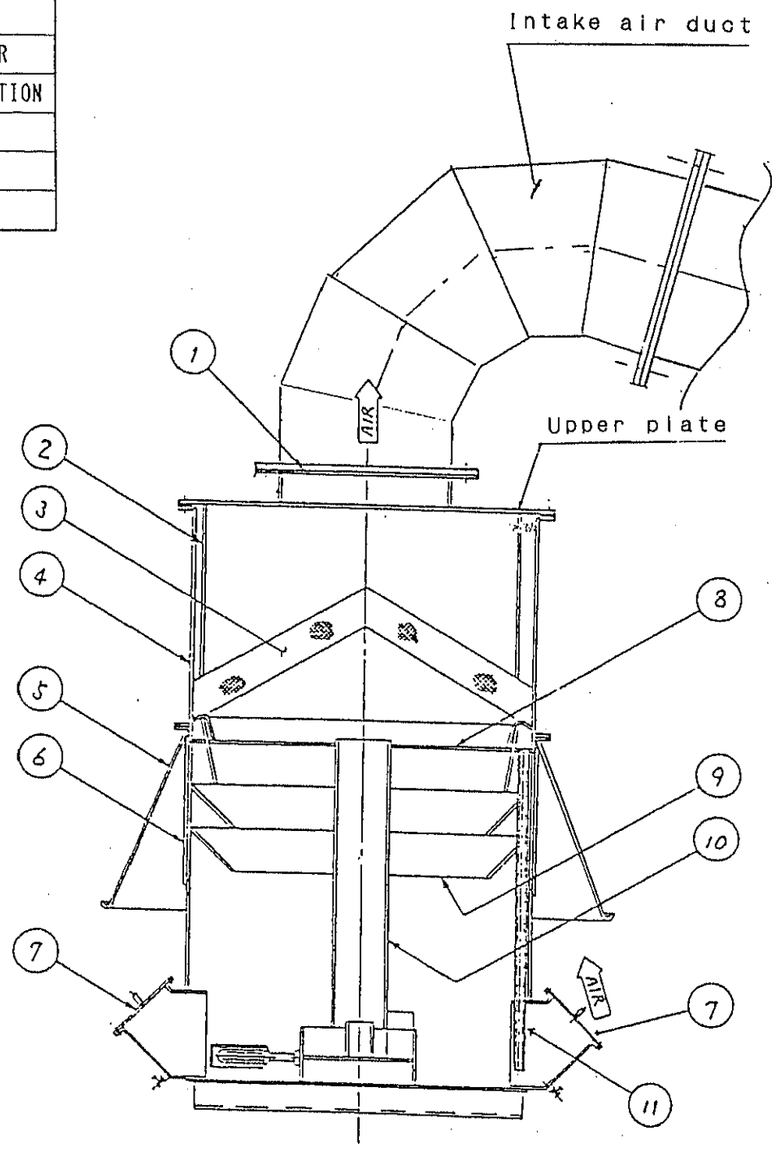
②





THE REPUBLIC OF THE GAMBIA				SCALE: -
THE PROJECT FOR REHABILITATION OF KOTU POWER STATION				DWG.NO.
Illustrative Drawing for Rehabilitation of Radiator				GKR-07
DATE	DESIGNED	CHECKED	APPROVED	REVISION
JAPAN INTERNATIONAL COOPERATION AGENCY				

PART NO.	PART NAME
1	OUTLET
2	SPACER
3	CONICAL ROD
4	CASING
5	RAIN SHIELD
6	INLET SCREEN
7	CLEANOUT DOOR
8	OIL DISTRIBUTION
9	BAFFLE
10	OIL LIFT
11	DRAIN PIPE



Outline of Maintenance Work for Intake Air Filter

1) Remove intake air duct and open the upper plate of the intake air filter.

2) Take out spacer ② and conical pad ③ of filter element.
Then, the inside of the filter body to be cleaned high pressure water jet.

3) The conical pad ③ and small element of oil inlet filter element to be replaced with new one.

THE REPUBLIC OF THE GAMBIA				SCALE –
THE PROJECT FOR REHABILITATION OF KOTU POWER STATION				DWG.NO.
Illustrative Drawing for Rehabilitation of Air Inlet Duct				GKR-08
DATE	DESIGNED	CHECKED	APPROVED	REVISION
JAPAN INTERNATIONAL COOPERATION AGENCY				

4-1-3 Execution Plan for Rehabilitation Work

(1) Conditions for the Execution Method

1) Instructions to be followed in execution of rehabilitation work.

The execution method should be decided by observing following particular instructions:

a) In executing work, execution methods, construction machinery, work hours, etc., should be carefully selected to avoid damage to the existing facilities.

b) To strictly meet the extremely short implementation period, several works should be executed simultaneously on a overlapped schedule.

2) Situation of local construction

Major points in the local construction relevant to execution of the Project are as follows:

a) In The Gambia specially trained engineers needed for this rehabilitation work can not be employed. The engineers should be employed from Japan.

b) Except for equipment and machines for special works of this rehabilitation work, ordinary construction equipment and machinery can be supplied from The Gambia.

c) Banjul Port will be selected as the port for unloading equipment and materials because it is the largest port in The Gambia.

d) For inland transportation from Banjul Port to the site, Serekunda Road will be selected.

(2) Method of Rehabilitation Work

1) Dismantling, cleaning, inspection, replacement of parts, adjustment, assembling of the entire No. 4 DEG should be made on the site.

2) Working group for each work division including Japanese engineers and the Gambian engineers or assistant staff shall be organized, and the implementation work shall be executed according to operation manual for each facility.

3) Several works shall be simultaneously executed on an overlapped schedule to shorten operation stoppage.

4) Special tools for rehabilitation work of No. 4 DEG, that are not possessed by the GUC, will be provided as a part of provision of materials and equipment, and used for the rehabilitation work.

(3) Construction Supervision Plan

To ensure that the construction work is to be conducted both positively and safely within the prescribed construction period, adequate construction supervision over the entire work needs to be carried out.

1) Management of work progress

a) The amount of completed work will be supervised by monitoring actual production and performance with the schedule at all times.

b) With regard to special materials and equipment, the guidance will be given to the contractor so as to promptly place orders with the makers to execute each stage of works on schedule and meet the delivery date under the Project.

2) Safety control

a) Guidance will be given to the contractor for all workers who will be employed for the Project are conscious about prevention of various accidents, and the foreman class will be trained to have the ability to prevent dangerous situations.

b) Efforts will be made to prevent accidents by always checking heavy equipment and machines such as cranes, wires and other critical items.

c) When transport vehicles, construction equipment, etc. travel within the construction site, slow driving will be strictly instructed and every caution will be taken to prevent traffic accidents which may cause injuries or death and damage to buildings, existing facilities, etc.

4-1-4 Procurement Plan of Materials and Equipment

All materials and equipment for this Project are not manufactured in The Gambia. All materials and equipment (except fuel oil) for this Project will be brought in from Japan or the third country.

As a result of comparative study from the viewpoint of standards, specifications, quality, time of supply and price, materials and equipment used for this Project will be procured as follows:

(1) Local procurement
- Fuel oil

(2) Procurement from Japan or third country
- Main engine parts
- Radiator parts

(3) Procurement from Japan

- Other engine parts
- Auxiliary equipment and spare parts for engine
- Generator parts
- Electrical equipment
- Consumables (lubricating oil, etc.) for the Project

4-2 Facilities Provision Plan

4-2-1 Plan for Provision of Materials and Equipment

According to the basic design policy as described in 3-3-3, provision of materials and equipment is classified into 1) spare parts for 12,000 hours' operation and 2) maintenance tools, and selection of them is conducted considering the contents of the request by the Gambian side and effective use at Kotu Power Station. Detailed provision of materials and equipment is shown in Appendix XI.

4-2-2 Major Specifications for Materials and Equipment

(1) Spare Parts

1) For diesel engine
Specifications: same as those of existing facilities

2) For auxiliary equipment for diesel engine
Specifications: same as those of the existing facilities or similarities

3) For generator
Specifications: same as those of the existing facilities

4) For electrical equipment
Specifications: same as those of the existing facilities or similarities

4-3 OJT Plan

4-3-1 Details of OJT Plan

According to the basic policy as stated in 3-3-3, OJT will be conducted as follows:

(1) Period for Conduct of OJT

Classroom training	:	about one week
Practice for rehabilitation work	:	about two months at the time of the rehabilitation work

(2) Trainer

One engineer will be sent by a Japanese contractor as a trainer.

(3) Trainees

Engineers who will be directly engaged in maintenance control of No. 4 DEG after the completion of the rehabilitation work, as appointed by the Gambian side, should participate in the training.

1) One total coordinator
2) Maintenance engineers
   - One mechanical engineer
   - One electrical engineer
3) Maintenance technicians
   - Three mechanical technicians
   - One electrical technician

(4) Detail of Training

1) Classroom training

a) Control technology
   - O & M schedule control (conception for preventive maintenance, functional analysis of facilities, effective scheduling for O & M work)

- Control of spare parts and tools
- Documents control for O & M

b) Technology related to rehabilitation of No. 4 DEG

2) Practice of rehabilitation work for No. 4 DEG

a) Maintenance of cylinder head
b) Dismantling and maintenance of fuel valve
c) Grinding finish of inlet and outlet valve
d) Dismantling and maintenance of piston
e) Overhaul and inspection of crank pin bearings
f) Maintenance of motor pump
g) Cleaning of air inlet filter, radiator filter and so on

(5) Training Method

1) Video system and training video tape will be provided and used at the classroom training so that the Gambian engineers may review technology acquired.
2) After the conduct of OJT, training materials will be provided to trainees for practical use as O & M.
3) O & M manual for No.4 DEG will be provided to use as practice related to maintenance and inspection.

4-3-2 Materials for OJT

Contents and quantity of OJT materials are as follows:

(1) Video System

25" color television set, video cassette tape deck, rack for video cassette tape deck

- One 25" color television set
- One video cassette tape deck
- One rack for video cassette tape deck
- One training video tape (30 minutes)

(2) Training Materials

1) Training materials: 20 copies

2) O & M manual for No. 4 DEG: 20 copies

CHAPTER 5 PROJECT IMPLMENTATION SYSTEM

CHAPTER 5 PROJECT IMPLMENTATION SYSTEM

5-1 Organization for Implementation

5-1-1 Overall Relationship

The overall relationship among the Implementing Organizations for the Project on the basis of Japan's grant aid is illustrated below:

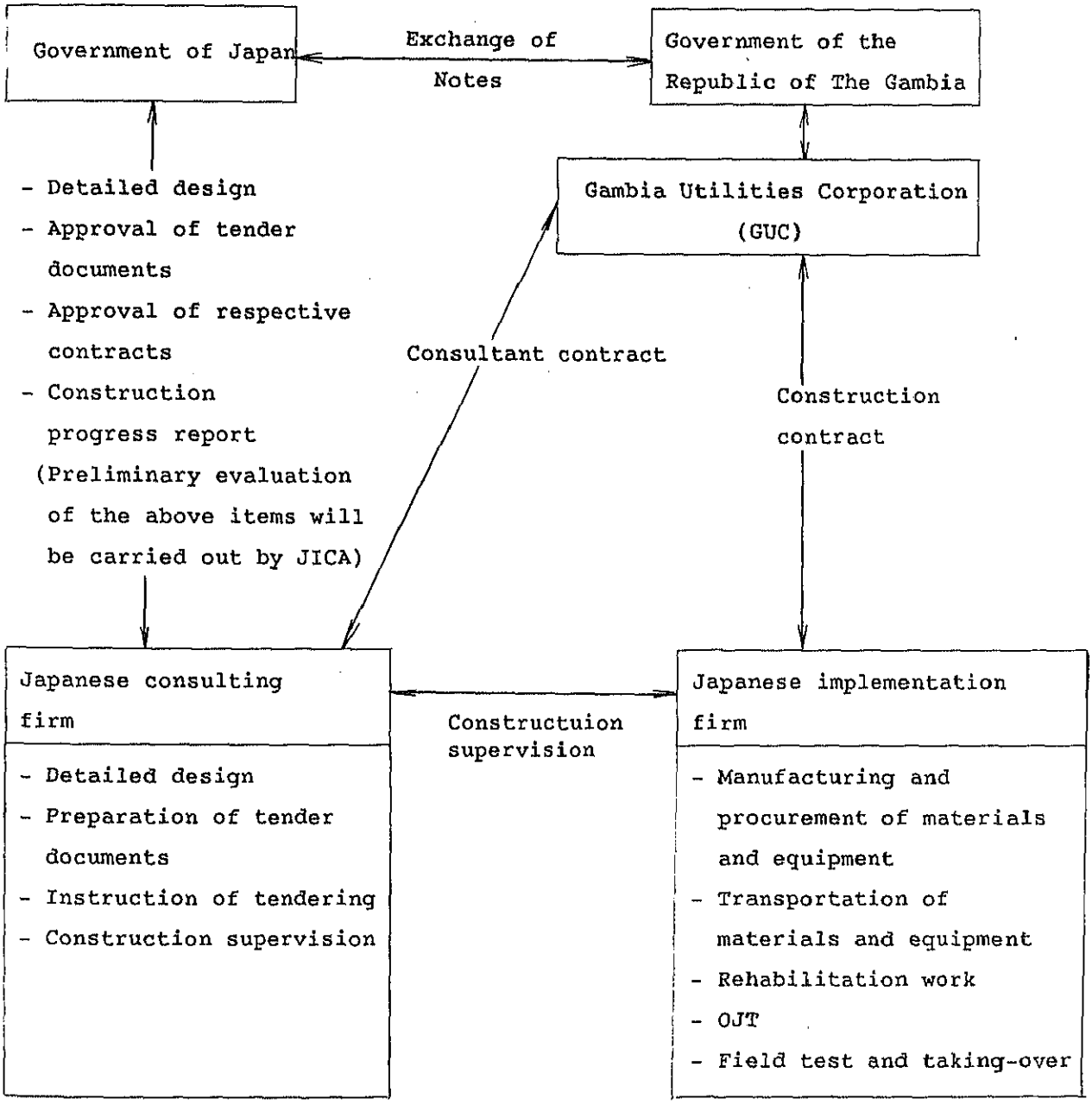
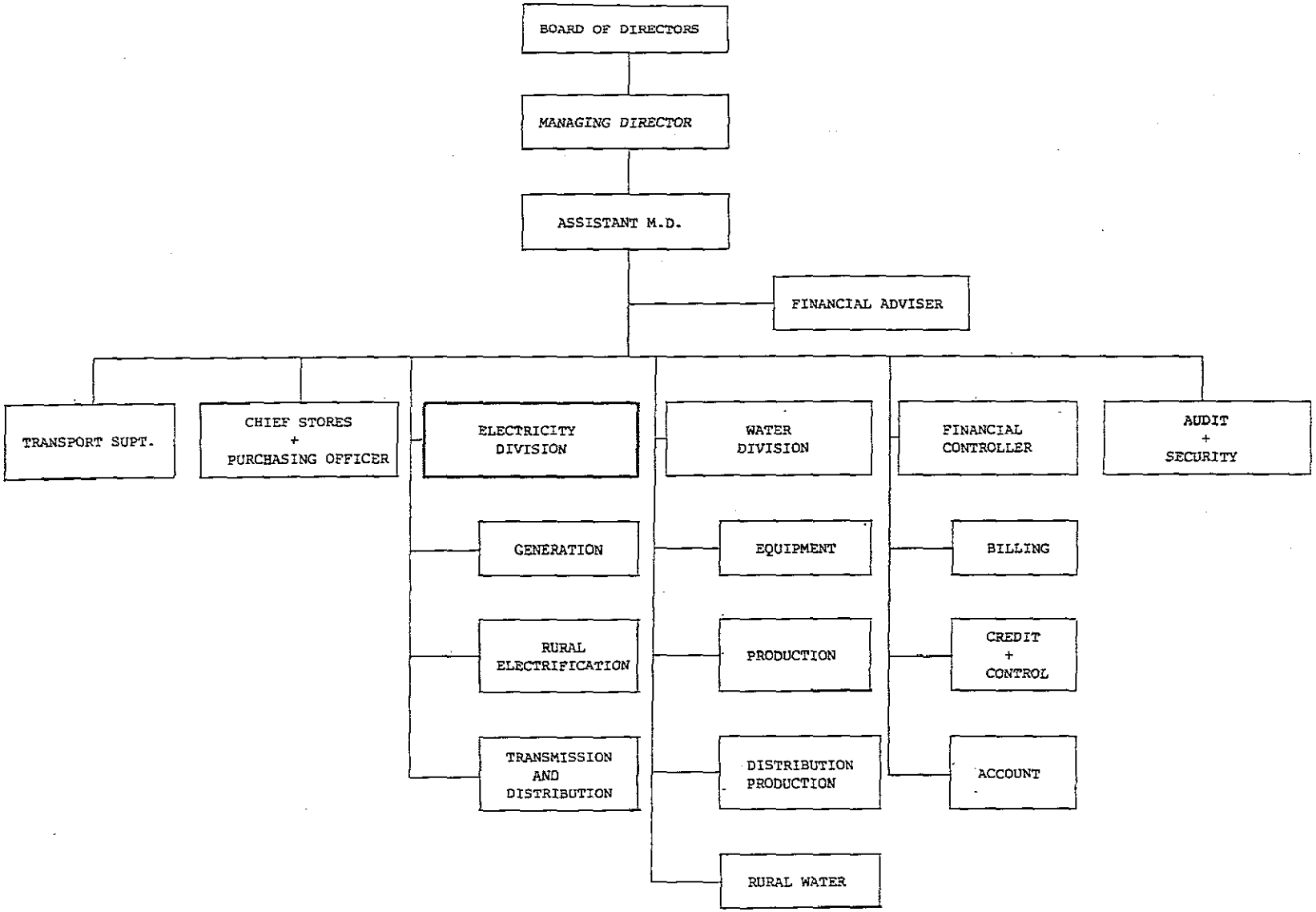


Fig. 5-1 Overall Relationship for the Project

5-1-2 Executing Agency

The GUC shall be responsible for the implementation of the Project. Fig. 5-2 shows the GUC Organization chart. In order to ensure the smooth implementation of the Project, the Gambian side needs to appoint a responsible person to be a full-time officer in charge of the Project so that he may maintain smooth liaison between the Japanese consultant, the Japanese contractor and the Gambian side concerned. The Japanese consultant will be responsible for the detailed design and supervision of construction. The rehabilitation work will be executed by a Japanese implementation firm who has been awarded with the contract for the Project.



Note:

- Total 770 persons (including 330 persons for electricity division)
- Bold line shows implementation division

Fig. 5-2 GUC Organization Chart

5-2 Scope of Work

5-2-1 Scope of Work to be borne by the Gambian Government

(1) To secure the stoppage of power supply of the 6 MW diesel engine generator during the rehabilitation period.

(2) To provide the land for temporary site office, warehouse and stock yard during the rehabilitation period.

(3) To ensure speedy unloading, tax exemption, customs clearance at port of disembarkation in The Gambia, of the products purchased under the grant aid.

(4) To give the permission required for all the works related to this project, e.g., entering into the existing Kotu Power Station, carrying out the inspection and maintenance work for No. 4 DEG, etc.

(5) To witness and confirm by the authorities concerned when the inspection and maintenance work are carried out.

(6) To carry out inspection and monitoring test of the existing equipment for basic and detailed design, if necessary.

(7) To provide the existing equipment and tools in Kotu Power Station, including electric power, compressor, fork lift, overhead crane, etc., during the rehabilitation period.

(8) To assign OJT trainees consisting of a total coordinator, maintenance specialists and technicians for the rehabilitation work, who is belonging exclusively to Kotu Power Station, during the rehabilitation period.

(9) To accord Japanese and other nationals whose services may be required in connection with the supply of the products and the services under the verified contract such facilities as may be necessary for their entry into The Gambia and stay therein for the performance of their work.

(10) The Japanese and other nationals involved in the project will not be subject to any customs duties, internal taxes, and other fiscal levies which may be imposed in The Gambia with respect to the supply of the products and services under the verified contract.

(11) To bear the following commissions to the Japanese foreign exchange bank for the banking services upon Banking Arrangement.
- Advising commission of Authorization to Pay
- Payment commission

(12) To bear all expenses, other than these to be borne by the grant, necessary for the execution of the grant.

(13) To provide necessary data and information for detailed design.

(14) To provide disposal places of waste water and oil discharged during the rehabilitation period.

(15) To take necessary actions to expedite the approval for execution of this Project by the Gambian Government.

(16) To obtain the permission required for inspection test at the time of detailed design, if necessary.

(17) To prevent the leakage of lubricating oil of radiators of No. 1 and No. 2 diesel engine generating facilities.

(18) To provide the necessary budget and personnel for proper and effective maintenance of No. 4 DEG after completion of the Project.

5-2-2 Scope of Work to be borne by the Government of Japan

(1) Rehabilitation work of No. 4 DEG

(2) Provision of spare parts

(3) Conduct of OJT

5-3 Implementation Schedule

5-3-1 Detailed Design and Construction Supervision

(1) Detailed Design and Tender Procedures

1) Detailed design and preparation of technical documents for tendering

For detailed design, after conclusion of E/N of the Project, the Japanese consultant will immediately conclude the consultant contract with the GUC and commence conducting the detailed design.

Based on results of surveys and confirmation regarding basic design, the consultant will complete detailed design and prepare tender documents in consultation with the GUC.

2) Tender and contract

Acting on behalf of the GUC, the consultant will invite tenders, accept and screen application for participation, hold tender briefings, and distribute tender documents. After a fixed period for tender preparation, the consultant will accept tenders, promptly evaluate them, and conclude the construction contract between the GUC and the successful Japanese implementation firm, incorporated under the law of Japan.

(2) Supervision of construction

Upon conclusion of the contract between the GUC and the Japanese implementation firm, the Project will proceed to the supervisory stage. The consultant will execute the construction supervision two times;

1) One time before commence of the rehabilitation work, the consultant will make preliminary arrangements with the Japanese implementation firm on execution of works, and guide and supervise them in transportation of equipment and materials to the site, execution methods, execution of works, etc.

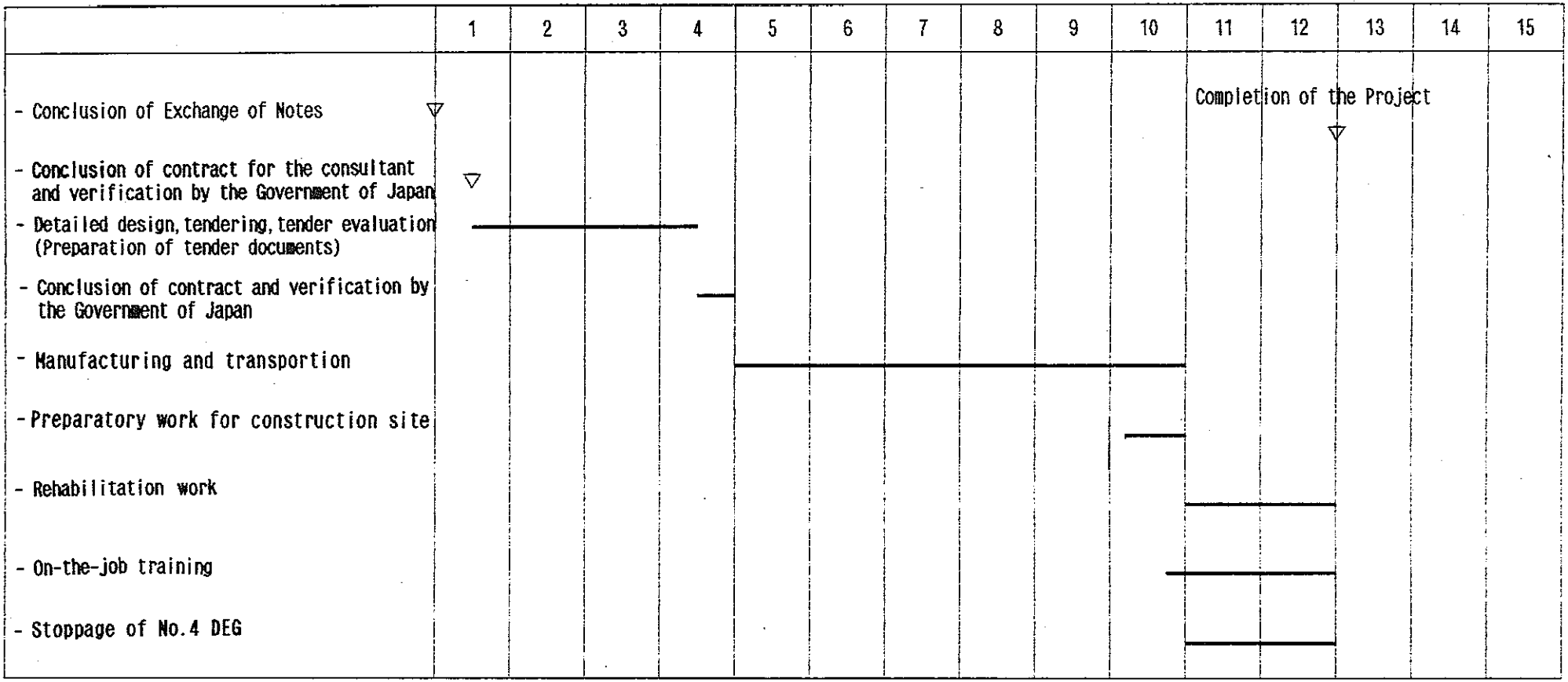
2) One time at the final stage of the rehabilitation work, the consultant will manage progress of works, perform quality control, and complete the contract within the period set forth in E/N.

5-3-2 Construction Period

The construction period for the Project after coming into effect of E/N is 11 months.

The tentative implementation schedule of the Project is shown in Table 5-1.

Table 5-1 Tentative Implementation Schedule



CHAPTER 6 MAINTENANCE CONTROL PLAN

CHAPTER 6 MAINTENANCE CONTROL PLAN

This chapter describes basic plan necessary for appropriate maintenance control of No. 4 DEG considering the present condition of No. 4 DEG and power condition in The Gambia as stated in 2-3.

6-1 Basic Policy

O & M and environmental protection of facilities are indispensable for stable power supply. In order to appropriately maintain performance and function of No. 4 DEG and supply stable power to Greater Banjul Area, maintenance control consisting of three targets as described in Fig. 6-1 is recommendable.

Fig. 6-1 shows basic conception for maintenance control.

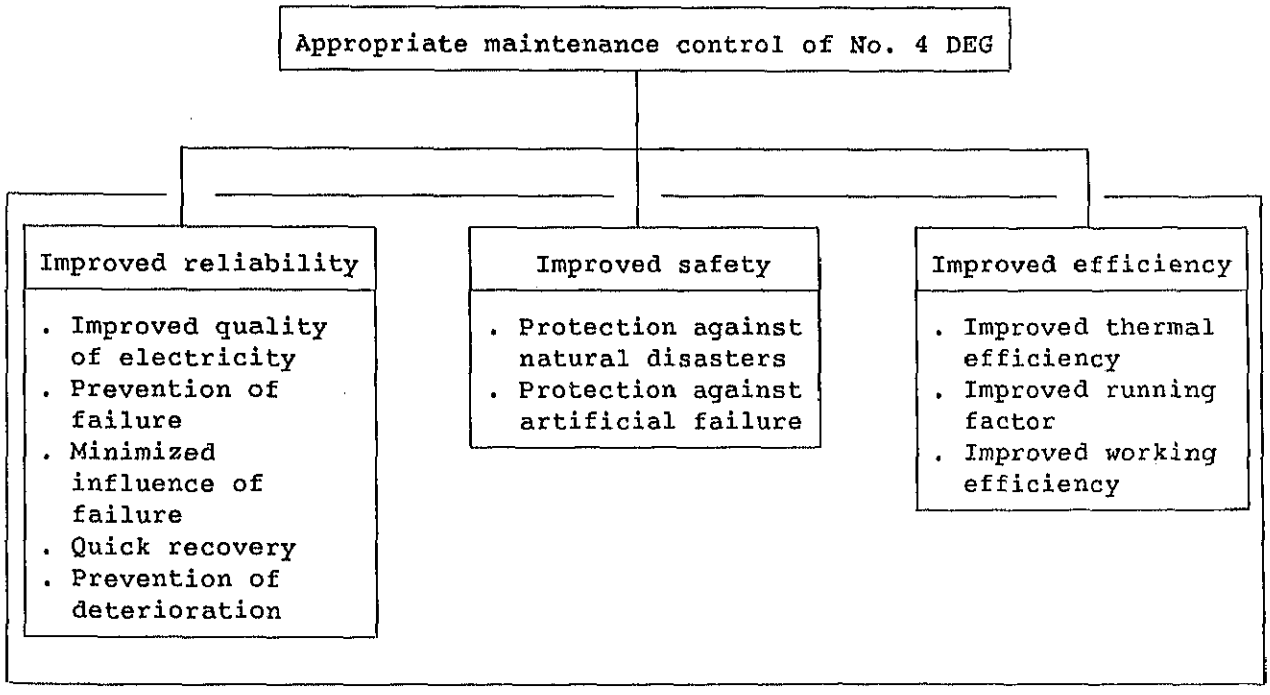


Fig. 6-1 Basic Conception for Maintenance Control of Generating Facilities