3.2.2 Routes of Transmission and Distribution Lines

By considering miscellaneous development projects which are covered by the Kilimanjaro Integrated Development Plan (KIDP), office of the Kilimanjaro regional development director, and headquareters of TANESCO, the routes have been selected to be the trunk lines for the region by connecting towns and villages located alongside the trunk roads of each district which have high potentials of electric power demand.

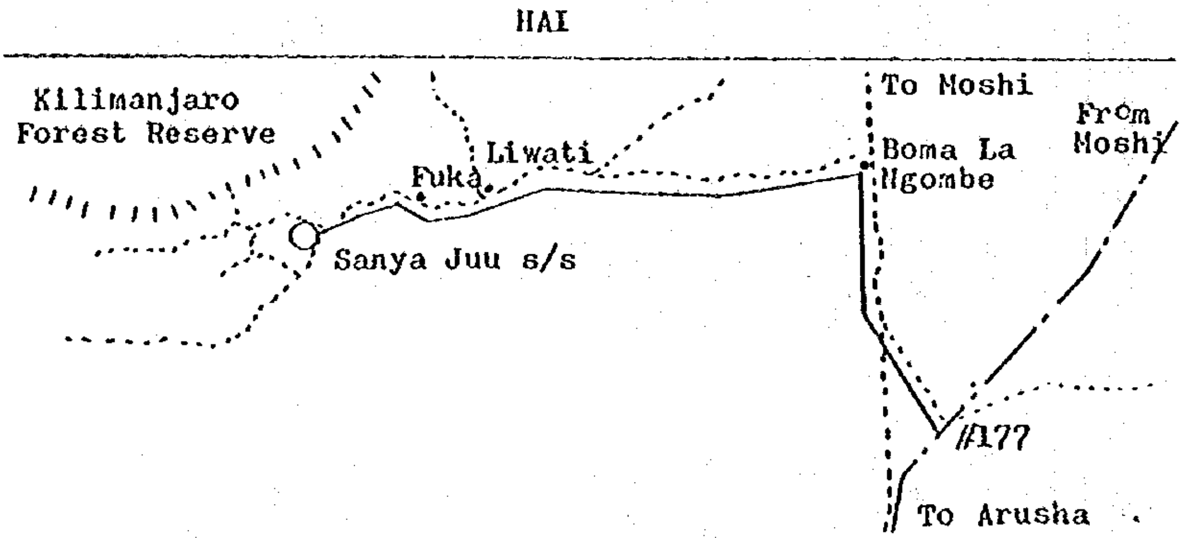
In determining the routes, necessary considerations are given to the following factors:

a. For the purposes of securing easy line maintenance as well as shortening required construction period, routes have been selected, whenever possible, to be alongside roads; avoiding long-span crossings of valley, glen, and etc.

b. Places where there is a fear of unfavorable ground conditions due to rains are avoided.

(1) Routes of Transmission and Distribution Lines in Hai District

(a) Transmission line Route (33 kV line up to Sanya Juu Substation)



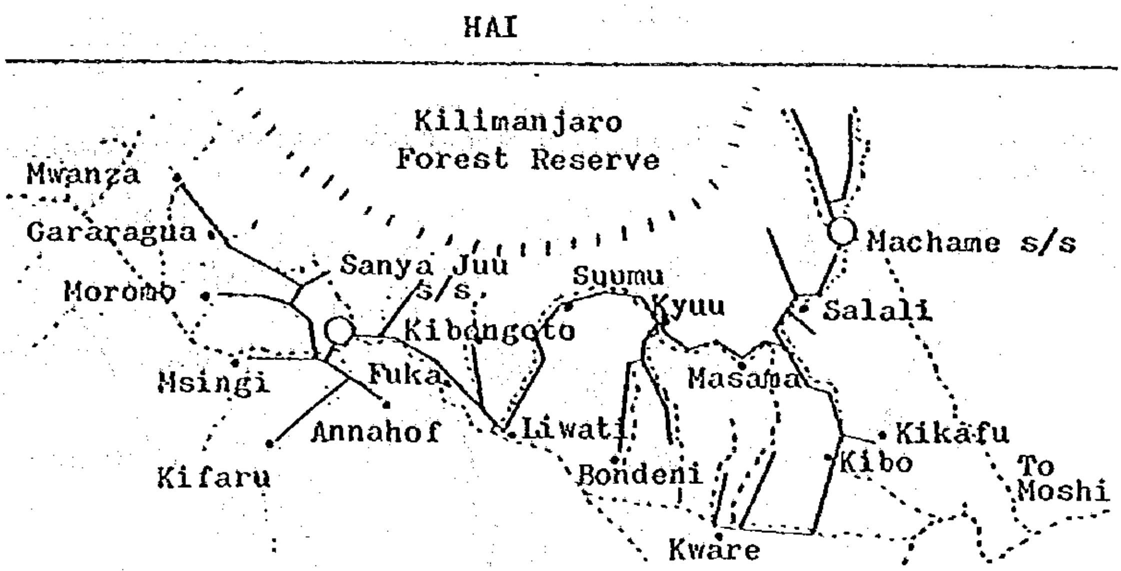
This 33 kV line to be newly constructed up to Sanya Juu substation is branched from Pole No. 177 of the existing 33 kV transmission line (Moshi–Arusha) which is running very near to the 33/11 kV substation to be newly constructed at Sanya Juu.

This branching point is located near the national highway from Moshi to Kilimanjaro International Airport, and line patrolling as well as materials transportation is very easy. From this branching point, the route runs about 10 km along the national road up to Boma La Ngombe where the new Hai DDD office is almost constructed and a new town project being progressed.

The route, after Boma La Ngombe, runs about 18.5 km up to Sanya Juu town via. Liwati and Fuka crossing fields alongside the regional road.

Construction work of this section is deemed comparatively easy, because the route from the branching point to Sanya Juu runs almost flat land without any glen crossing and trees to be cut.

(b) Distribution Line Route (11 kV distribution line route)



a. To West Hai (11 kV Line from Sanya Juu S.S)

This distribution line is constructed to supply electricity to many plantations located near the Sanya Juu town. There are two groups of plantations; one group is consisted of seven plantations including Gararagua and Molomo which are located north from the new Sanya Juu substation, while the other group of three plantations including Annahof which is located west from the first group.

The route runs about 17 km to the first group and then about 6 km to the second one, passing through coffee fields and some forests which are located alongside the road connecting those plantations.

b. To Central Hai (11 kV line from Sanya Juu substation to Machame Substation)

This route runs alongside the road running half-way up the Mt. Kilimanjaro connecting main villages and plantations scattered between Sanya Juu and Machame.

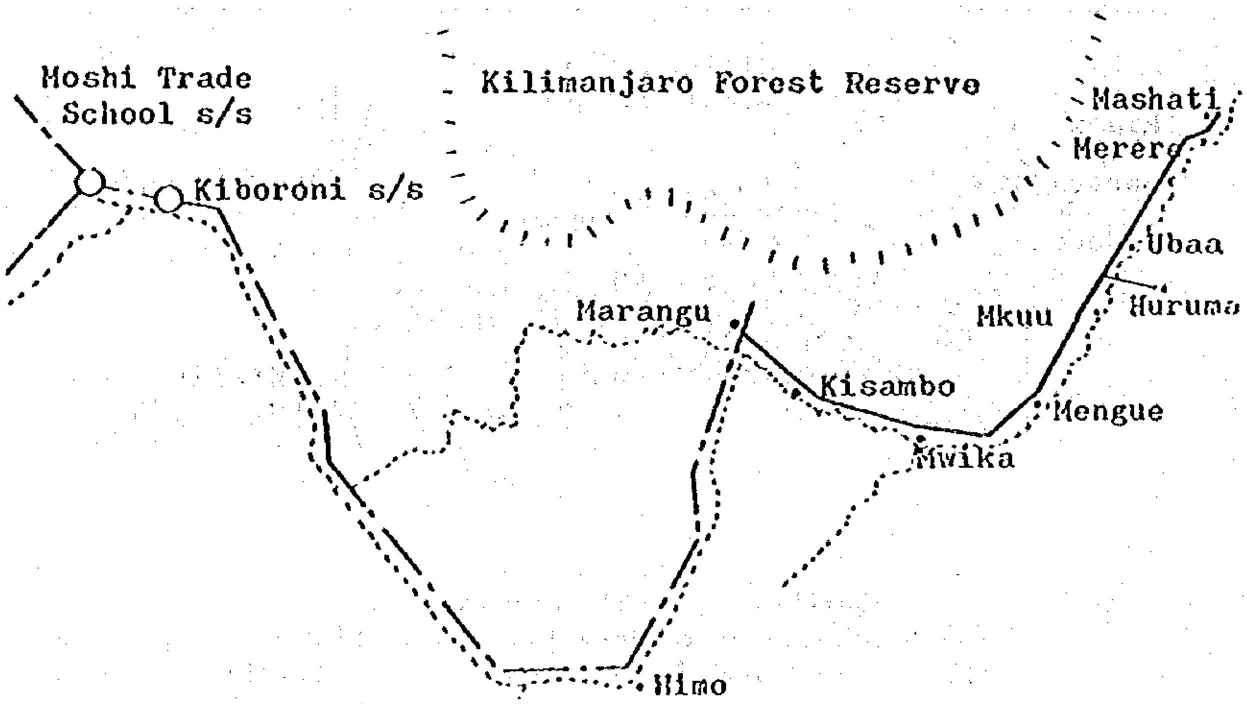
The route from Sanya Juu Substation to Liwati runs 7 km via Fuka, picking up the load of the Kibongoto Hospital on the way which is indespensable welfare facility, the electric service to which must be secured with high reliability.

After Liwati and up to Machame Substation, the route of about 22 km trunk line runs connecting Suumu–Kyuu–Lemira–Masama–Salali villages. On the way, the route has some branch lines : including one for Bondeni and Boloti plantations which are located south of Kyuu, one for the famous Kibo plantation and Kikaf plantation and up to Kware, the total of about 32 km lines run alongside roads in the area.

The above routes run through hilly and forestry sides requiring so much tree-cuttings, such as banana, and also have so much up-and-downs which require arranging wooden poles of various lengths in order to minimize steep fluctuations as much as possible.

(2) Routes of Distribution Line in Rombo District

ROMBO



A new distribution line is planned alongside the trunk road running half-way up the Mt. Kilimanjaro up to Tarakia near the national boundary, starting from the existing 33 kV line which comes to Marangu, one of the famous enterance to the mountain.

This route passes through coffee and banana fields and some other forest having complicated topographical conditions requiring many angle poles and several long-span crossings of 150–180 m.

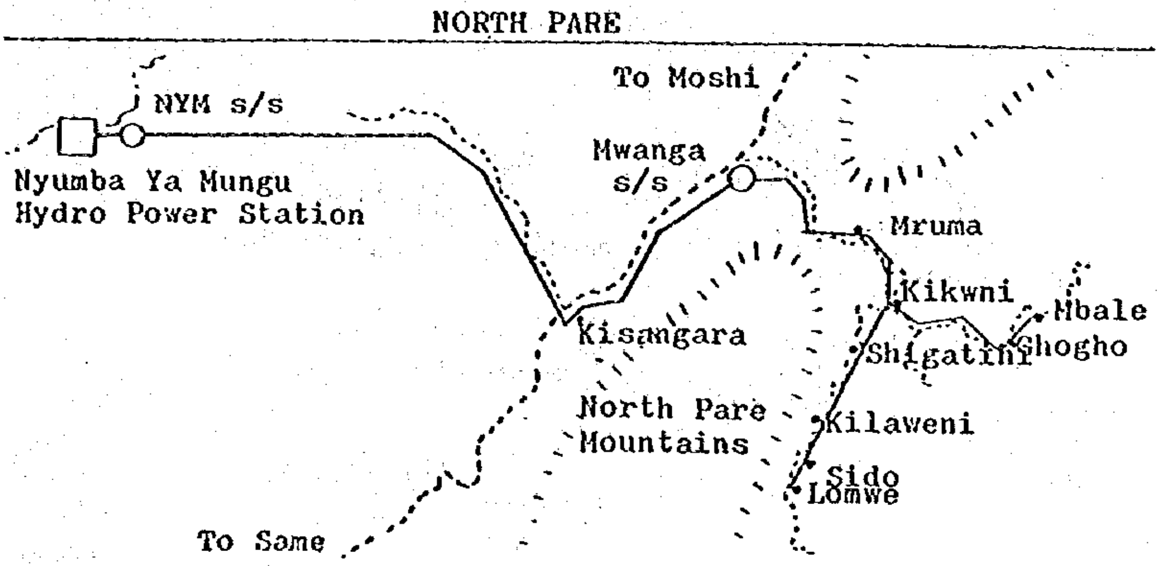
The trunk road as stated above is under planning of improvement, and we must be careful about timing adjustment with our Electrical Construction Work.

The route of this trunk line of about 31 km starts from Marangu to Mashati; connecting Kisambo, Mwika where light industries development plan is undergoing, Mengwe, Mkuu, Ubaa, and Merere. Especially, Merere has a regular open market of a considerable scale in that district, being estimated to have power demand increase in near future. 1 km east from Mkuu, there is Huruma where the Rombo DDD Office has been moved to and more public facilities would be constructed. Two branch lines including that for Huruma are planned out; total line length is about 2 km.

Almost all of the route passes through banana fields and other forests requiring tree cuttings to some extent for the purpose of securing route clearance and line maintenance.

The existing 33 kV line from Kiboroni Substation of 11/33 kV to Marangu is full of the present load, and the TANESCO has a plan to construct a new 33 kV line of about 10 km from Kiyungi Substation to Kiboroni; this plan is indespensable for our Project of this time, and must be realized in time for our Construction Work.

(3) Routes of Transmission and Distribution Lines in North Pare District



(a) Transmission Line Route

(33 kV Line from Nyumba Ya Mungu Hydro Power Station to Mwanga Substation)

Starting from a 11/33 kV substation to be constructed at the hydro power plant, the route runs about 17 km alongside a road in flat savanna up to the crossing point of the national highway from D'Salaam to Moshi, including one railway crossing. Moreover, the route runs about 9 km up to Mwanga Substation in the sisal plantations alongside the national highway. A branch line of about 1 km from the line is also planned to supply necessary electricity to the famous Kisangara Sisal Estate of large scale production.

Along this route from Nyumba Ya Mungu power station to Mwanga substation, there is no obstacles for construction work which will be completed easily by using the road in good condition.

(b) Distribution Line Route

(11 kV Line from Mwanga Substation to Sido and Ghogho)

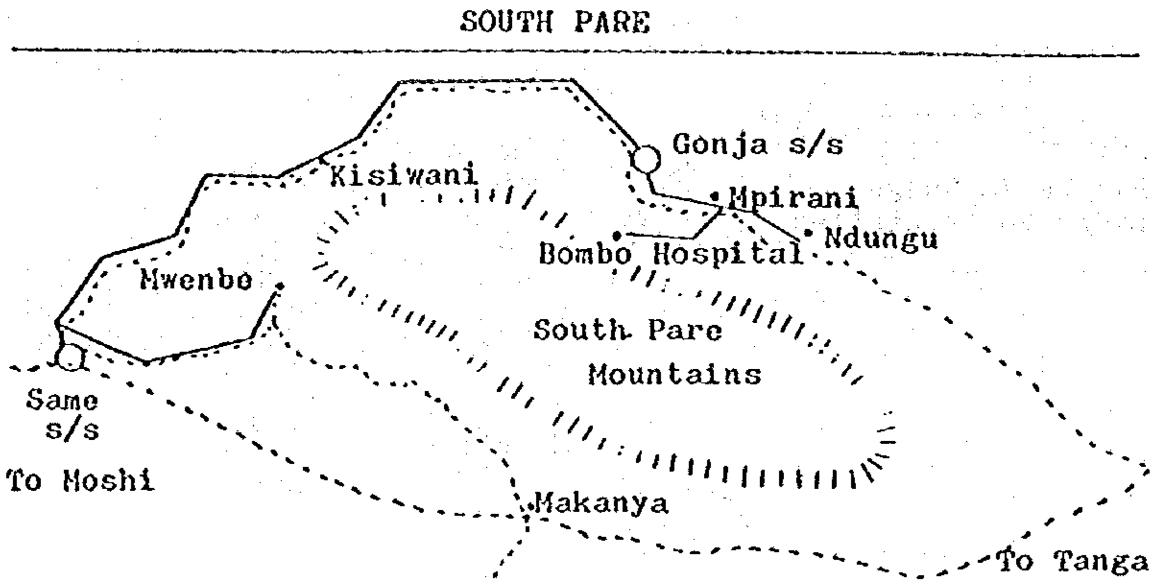
From Mwanga Substation the route runs to the east from the national highway forming T to the direction of North Pare hills; it is considerably difficult to design the route alongside a road, because there is a steep slope half-way up the hills. Also, it is not convenient for future maintenance to provide the route along the steep road, and consequently, the route has been designed on comparatively flat foot of the hills, and then go up straight to the half-way of the hills.

The route to Mruma village has been designed under the same idea to cross the hills straightly.

From Mruma up to Kikwni, about 9.5 km, the route is planned to run alongside the road which is running among the hills.

The route from Kikwni to Ghogho and Sido runs about 11.5 km making a short-cuts over some portions of snaking road. This route connects small but main villages passing alongside the road on the steep slope of the hills and through forests, banana and coffee plantations; this is the most tough route for construction of this time.

(4) Routes of Transmission and Distribution Lines in South Pare District



(a) Transmission Line Route

(33 kV Line from Same S.S to Gonja S.S)

The route runs 49 km up to Gonja village alongside the regional road running the edge of wide savanna area spreading from the eastern outskirts of the South Pare hills to the national border to Kenya.

Both Mukonga and Kisiwani villages and Kisiwani sisal plantation which are located almost at the middle point between Same and Gonja are also supplied electricity.

This route runs through forests of big trees at several places and plenty of tree-cutting is required for clearance and future maintenance of the lines.

By branching near the existing Same substation, another route runs about 16 km up to Mwenbe village, crossing a land of some up-and-downs which is not deemed to be any trouble for construction work.

(b) Distribution Line Route

(11 kV Line from Gonja Substation to Ndungu)

The route runs from a 33/11 kV substation to be constructed at Gonja alongside the regional road running the eastern outskirts of South Pare hills.

The route is consisted of two lines; 19 km from Gonja to Ndungu village which is located south of Gonja, and 8.5 km from Gonja to Bombo Hospital which is located north of Gonja and is the medical center of the district. The route from Gonja to Bombo Hospital runs along a very steep and narrow hillyside road, requiring considerable tree-cutting for clearance and short-cutting of the snaking road for securing the route.

3.2.3 Selection of Substation Location

a. Each location has been decided through our overall studies of location points which could be convenient for future additions and strengthenings under the TANESCO's long-term plan. Locations are marked by pegging at the sites.

b. Substation Locations

* Machame Substation

Suitable point near Baraza which is uncultivated land located 200 m south from the Machame Hospital is selected.

This point is the end of the existing 33 kV transmission line from Moshi Trade School substation to Machame.

Site Area (for 1st Phase) : 12.5 m x 18 m = 225 m^2

* Sanya Juu Substation

By laying emphasis on selection of 33 kV and 11 kV transmission and distribution line routes, the proposed site is an uncultivated land near the Christian Church located at the west end of Sanya Juu.

Site Area (for 1st Phase) : 12.5 m x 18 m = 225 m^2

* Gonja Substation

The site is an uncultivated land located 1 km north from Gonja streets.

Site Area (for 1st Phase) : 14.5 m x 8 m = 116 m^2

* Mwanga Substation

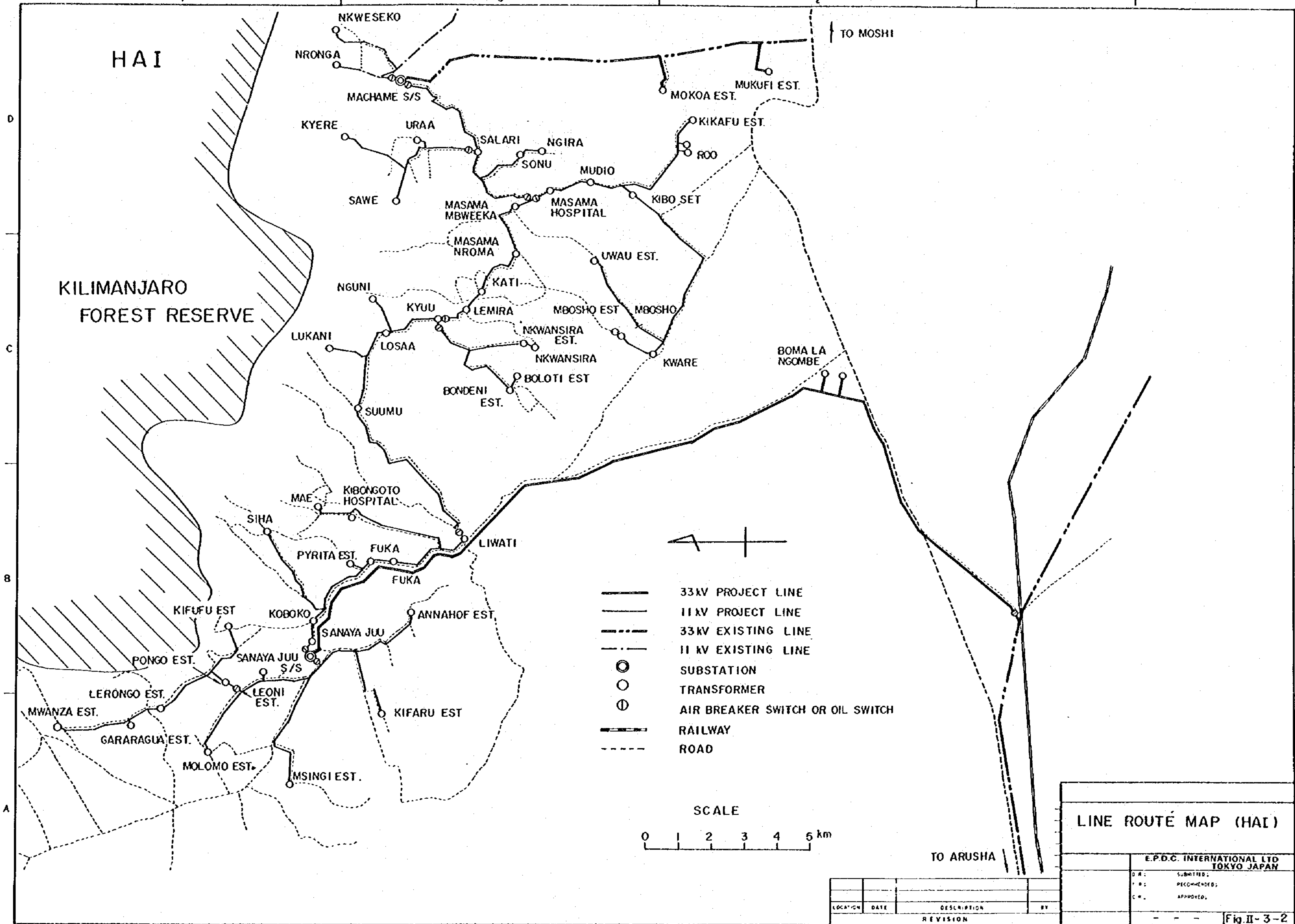
The site is selected at the southern outskirts of Mwanga.

Site Area (for 1st Phase) : 14.5 m x 8 m = 116 m^2

* Nyumba Ya Mungu Substation

The site is just adjacent to the outdoor substation of the Nyumba Ya Mungu Hydro Power Station.

Site Area : 16 m x 8 m = 128 m^2


HAI
KILIMANJARO FOREST RESERVE
NKWESEKO
NRONGA
MACHAME S/S
TO MOSHI
MOKOA EST.
MUKUFI EST.
KYERE
URAA
SALARI
NGIRA
SONU
KIKAFU EST.
ROO
SAWE
MUDIO
MASAMA MBWEEKA
MASAMA HOSPITAL
KIBO SET
MASAMA NROMA
UWAU EST.
KATI
NGUNI
KYUU
LEMIRA
MBOSHO EST
MBOSHO
LUKANI
LOSAA
NKWANSIRA EST.
NKWANSIRA
KWARE
BOMA LA NGOMBE
BOLOTI EST
BONDENI EST.
SUUMU
MAE
KIBONGOTO HOSPITAL
SIHA
LIWATI
PYRITA EST.
FUKA
FUKA
KIFUFU EST
KOBOKO
ANNAHOF EST.
SANAYA JUU
PONGO EST.
SANAYA JUU S/S
LERONGO EST.
LEONI EST.
MWANZA EST.
GARARAGUA EST.
KIFARU EST
MOLOMO EST.
MSINGI EST.
33 kV PROJECT LINE
11 kV PROJECT LINE
33 kV EXISTING LINE
11 kV EXISTING LINE
SUBSTATION
TRANSFORMER
AIR BREAKER SWITCH OR OIL SWITCH
RAILWAY
ROAD
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TO ARUSHA
LINE ROUTE MAP (HAI)
E.P.D.C. INTERNATIONAL LTD TOKYO JAPAN
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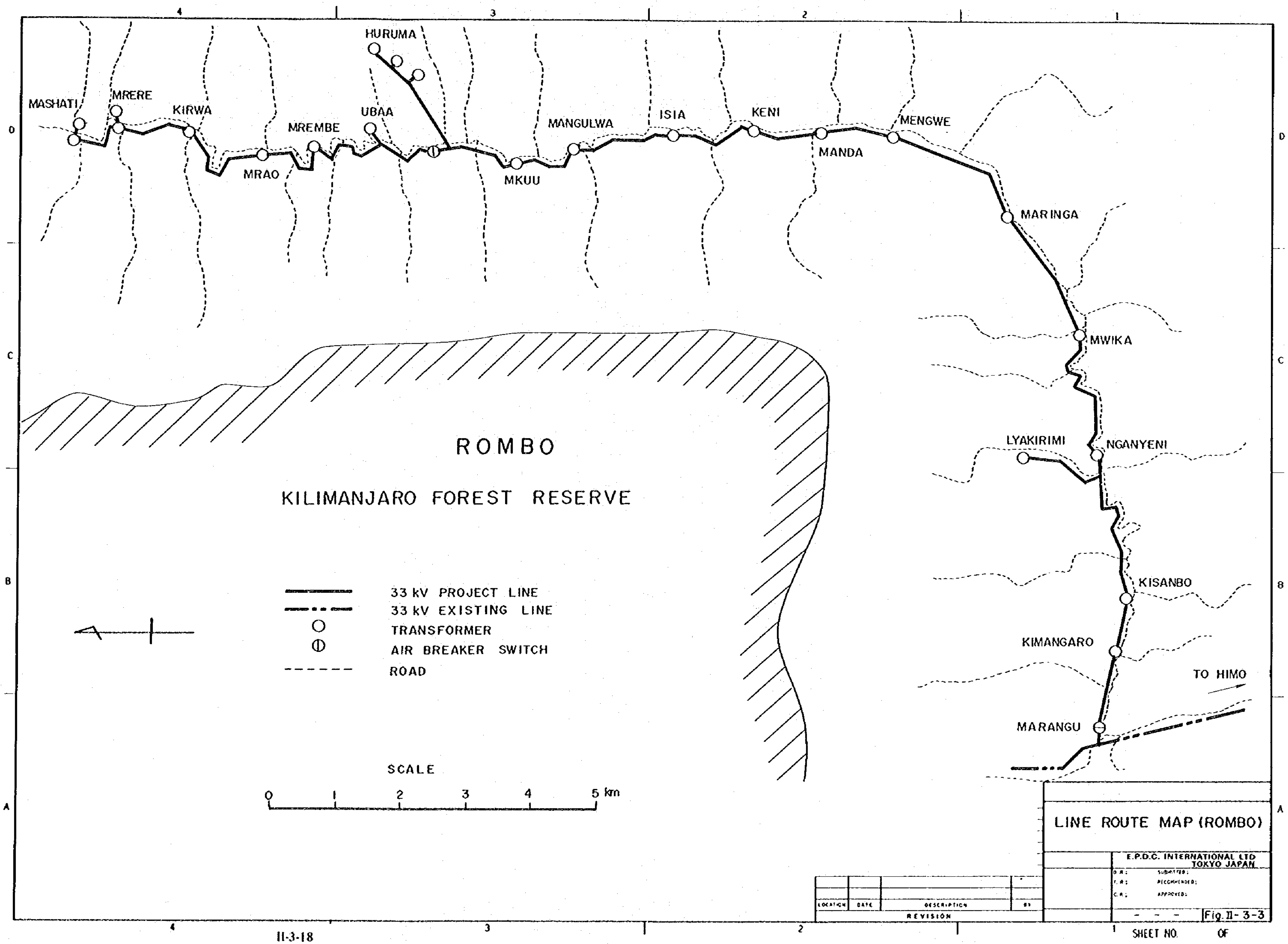
HURUMA
MASHATI
MRERE
KIRWA
MREMBE
UBAA
MRAO
MANGULWA
MKUU
ISIA
KENI
MANDA
MENGWE
MARINGA
MWIKA
LYAKIRIMI
NGANYENI
KISANBO
KIMANGARO
TO HIMO
MARANGU
ROMBO
KILIMANJARO FOREST RESERVE
33 kV PROJECT LINE
33 kV EXISTING LINE
TRANSFORMER
AIR BREAKER SWITCH
ROAD
SCALE
0 1 2 3 4 5 km
LINE ROUTE MAP (ROMBO)
E.P.D.C. INTERNATIONAL LTD
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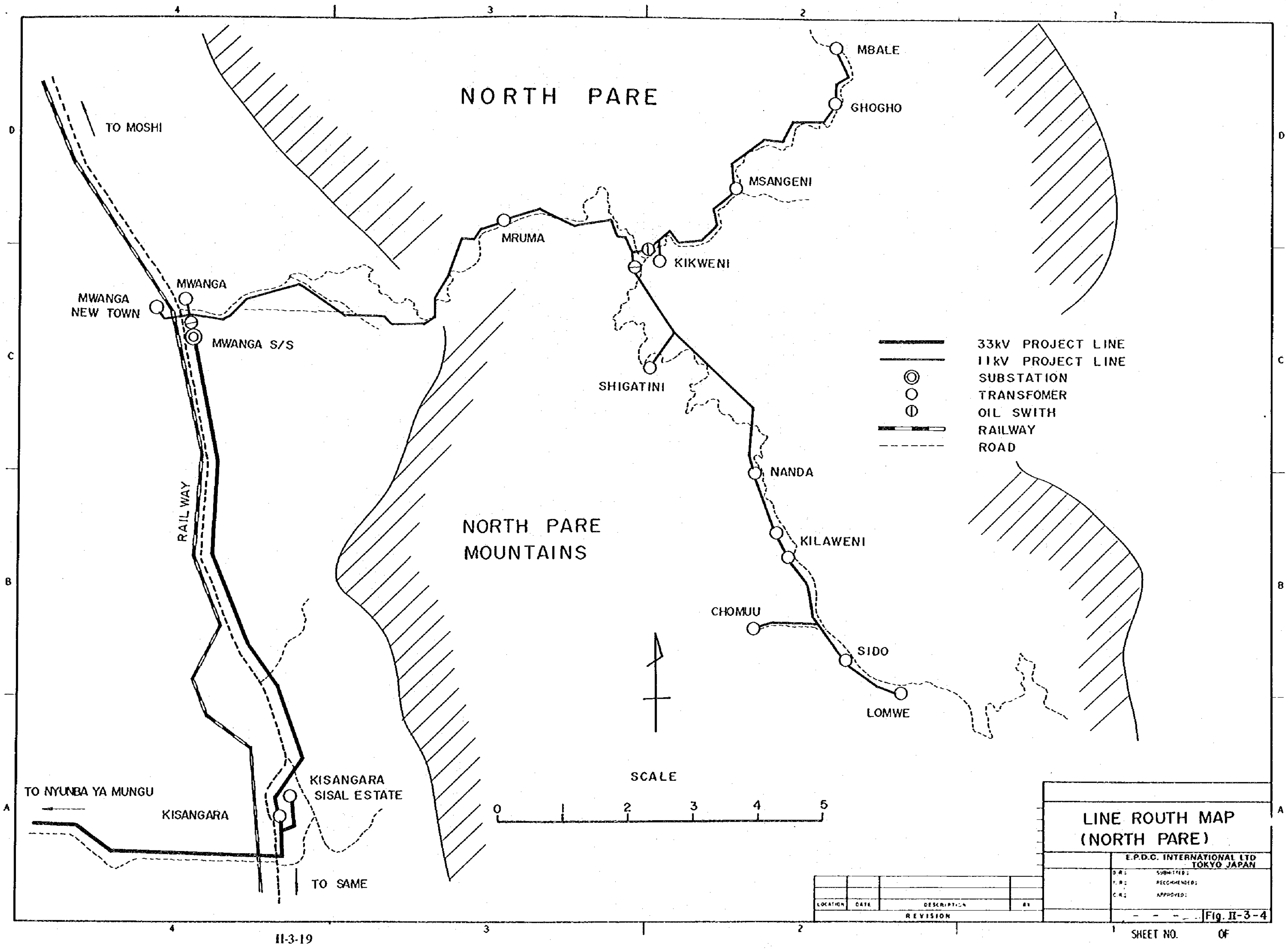
NORTH PARE
TO MOSHI
MBALE
GHOGHO
MSANGENI
MRUMA
KIKWENI
MWANGA
MWANGA NEW TOWN
MWANGA S/S
SHIGATINI
33kV PROJECT LINE
11kV PROJECT LINE
SUBSTATION
TRANSFOMER
OIL SWITH
RAILWAY
ROAD
NANDA
RAIL WAY
NORTH PARE MOUNTAINS
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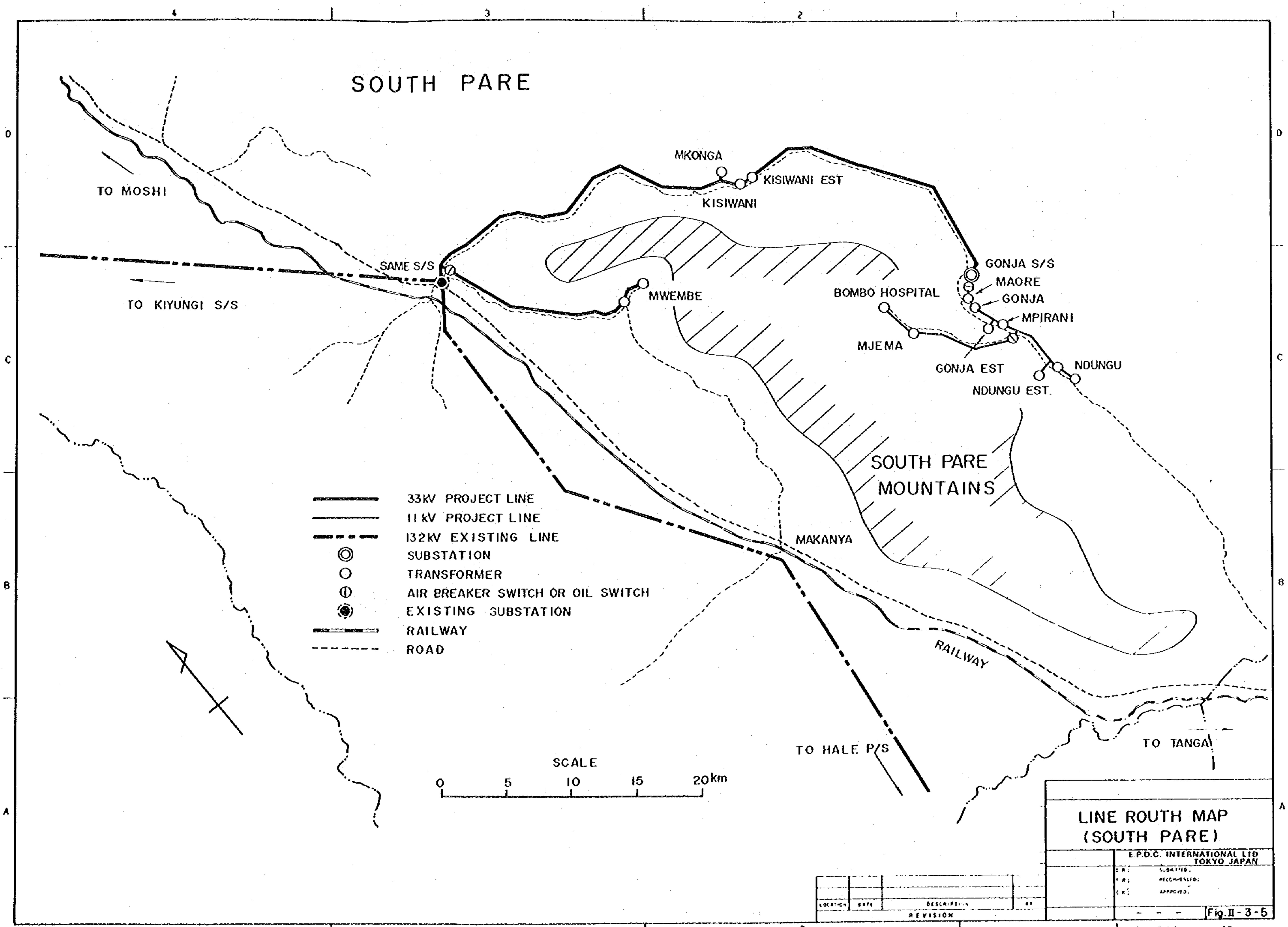
SOUTH PARE
TO MOSHI
TO KIYUNGI S/S
SAME S/S
MKONGA
KISIWANI EST
KISIWANI
MWEMBE
GONJA S/S
MAORE
GONJA
MPIRANI
BOMBO HOSPITAL
MJEMA
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NDUNGU EST.
SOUTH PARE MOUNTAINS
MAKANYA
RAILWAY
TO HALE P/S
TO TANGA
33kV PROJECT LINE
11 kV PROJECT LINE
132kV EXISTING LINE
SUBSTATION
TRANSFORMER
AIR BREAKER SWITCH OR OIL SWITCH
EXISTING SUBSTATION
RAILWAY
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LINE ROUTH MAP
(SOUTH PARE)
E.P.D.C. INTERNATIONAL LTD
TOKYO JAPAN
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3.2.4 Vehicles and Tools for Construction Work

Necessary vehicles and tools for construction work of this time are mentioned below.

	Hai	Rombo	North P.	South P.	Total
Pick-up Truck 2-tons	2	1	1	1	5
Truck, 7-tons	2	1	1	1	5
Crane Truck, 7-tons 3-tons-crane	2	1	1	1	5
Pole Carrier, 10-tons	1		1		2
Jeep		2			2
Hydraulic Compression Tool		10			10
Manual Compression Tool		25			25
Stringing Winch		50			50
Manual Winch		10			10
Metering Appar. & Others		one lot			one lot
Wireless Talkie		5			5

CHAPTER 4

DESIGN OF TRANSMISSION AND DISTRIBUTION LINE AND SUBSTATION FACILITIES

CHAPTER 4 DESIGN OF TRANSMISSION AND DISTRIBUTION LINE AND SUBSTATION FACILITIES

LIST OF FIGURE

CHAPTER 4 DESIGN OF TRANSMISSION AND DISTRIBUTION LINE AND SUBSTATION FACILITIES

4.1 DESIGN STANDARDS AND DESIGN CONDITIONS

4.1.1 Design Standards

The construction Project of transmission and distribution line and substation facilities are planned and designed according to the TANESCO's construction plans as well as results of investigation by the JICA feasibility study team, as follows:

(1) Nominal Voltage and Electric System

(a) Transmission Line

a.	Voltage	: 33 kV
b.	Transmission System	: 3-phase and 3-wire

(b) High Voltage Distribution Line

a.	Voltage	: 33 kV and 11 kV
b.	Distribution System	: 3-phase and 3-wire
c.	Type of Line	: Tree-Branch Type
d.	Limits of Voltage Drop	: 10%

(c) Low Voltage Distribution Line

a.	Voltage	: 400 V and 230 V
b.	Distribution System	: 3-phase and 4-wire 3-phase and 3-wire 1-phase and 2-wire
c.	Type of Line	: Tree-Branch Type
d.	Limits of Voltage Drop	: 4%

(d) Service Line

a.	Voltage	: 400 V and 230 V
b.	Distribution System	
	Motor	: 3-phase and 3-wire (400 V)
	Lighting	: 1-phase and 2-wire (230 V)

(e) Watt Hour Meter

One watt hour meter for each supply category

4.1.2 Design Conditions

As to the construction standards which shall be the basis for design, the present TANESCO's standards for operation and maintenance as well as that of Japan are referred to, as under-mentioned.

Applicable standards for main equipment and materials to be purchased under the foreign currency portion are mainly Japanese standards with some exceptions of the British Standards (BS) and American National Standards Institute (ANSI).

(1) Natural Conditions

(a) Altitude : 800 – 1,000 m (above sea level)
(b) Ambient Temp. : max. 40°C
min. 10°C
mean 32°C

(2) Safety Factor

The followings are adopted according to the TANESCO's standards:

Support : 4
Base for Support : 2.5
Wire : 3
Insulator : 3.5
Crossarm : 2.5
Guy Wire : 2.5

(3) Conductor Temperature

Mean Temp. of Conductor Use : 32°C
Allowable Temp. of Conductor : 90°C

(4) Wind Load

Under the condition of maximum wind velocity of 20 m/sec, the wind load shall be 50 kG/m^2.

(5) Height of Transmission and Distribution Lines from Ground Surface

The height of a overhead line are determined according to the TANESCO's standard as under-mentioned; as to low-voltage lines, the Japanese standards are adopted.

Item		33 kV	11 kV	L/T
Road way	Crossing	6.0 m	5.7 m	5.0 m
	Others	6.0	5.4	4.0
Pavement	Crossing	6.0	4.8	4.0
	Others	6.0	4.8	4.0
Above telecommunication wire		1.8	1.8	1.2
Above railway		9.0	9.0	9.0

4.2 DESIGNIGN OF TRANSMISSION AND DISTRIBUTION LINE FACILITIES

4.2.1 Design Criteria

(1) Basic Ideas in Designing

In designing the 33 kV and 11 kV transmission and distribution lines facilities for Kilimanjaro Region, necessary considerations are given to the following basic items as well as harmony and coordination with the TANESCO's existing facilities in the region:

(a) To be able to accommodation demand increase in future.
(b) To improve voltage fluctuation and service reliability.

(2) Improvement of Service Reliability

According to the statistics of troubles on transmission and distribution lines in Japan, although number of troubles is decresing year by year, such kinds of troubles as incomplete facilities (incomplete workmanship and construction), incomplete maintenance (natural decay and overload), natural phenomenon (obstacles flying due to storm and floods), obstacles contact (tree-branches, birds and beasts) and etc. occupy majority of causes of troubles.

Judging from the above, the following counterplans are worked out in order to improve the service reliability of lines; for minimizing blackouts due to troubles, adoption of Line Post insulators (hereinafter called LP insulator) for 33 kV transmission lines, adoption of channel steel crossarms, and adoption of driving-type anchors for strengthening stays. Moreover, adoption of surge arrestor for lightning surge, and adoption of sectional switches for minimizing black-out area are realized. Necessary oil circuit breakers are installed at substations, which shall be reclosed against line faults in order to improve service reliability.

(3) Voltage Regulation

Voltage fluctuation for low voltage consumers shall be kept ±5% by utilizing transformers with on-load tap changers to be installed at substations and pole mounted transformer taps of 5% and 2.5%.

(4) Insulation Coordination

(a) Insulation Design

In designing insulation for the purpose of equipment protection, insulation levels of lines and equipment are coordinated by covering whole band from lightning surge to power frequency, as follows:

a. Insulation performances of equipment themselves are protected against internal abnormal voltage (switching surge, sustained abnormal voltage, and etc.).
b. A surge arrestor is protected against external abnormal voltage (lightning surge).

(b) Kind of Insulator and Number of Insulator for String

Anti-lightning measures are designed on assumption that no flash-over due to internal abnormal voltage takes place. As to the internal abnormal voltage, the following values are assumed under the same way as applied to a transmission line:

Kind of Ground.	Multiple of Sustained Abnormal Voltage	Multiple of Abnormal Switching Voltage
Effective Grounding	0.8 Um	2.8 Um

(Um: Maximum allowable voltage of power system)

In determining insulation strength of an insulator, flash-over wet characteristics due to switching surge is used for switching abnormal voltage, and flash-over wet characteristics is used for sustained abnormal voltage.

Required insulation strength of an insulator which is computed from the switching abnormal voltage are as follows:

Nominal Voltage, kV	11	33
Max. Allow. Voltage, kV	12	36
Voltage Crest Value to Ground, kV	9.8	29.4
Multiple of Switching Abnormal Voltage	2.8	2.8
Switching Surge Voltage, kV	27.4	82.3
Insulation Degradat. Coefficient	1.2	1.2
Required Insul. Strength, kV	33	99

Required insulation strength computed from sustained abnormal voltage is as follows:

Nominal Voltage, kV	11	33
Max. Allow. Voltage, kV	12	36
Multiple of Extraord. Voltage	0.8	0.8
Sustained Abnormal Voltage	9.6	28.8
Insul. Degradat.	1.2	1.2
Required Insulat. Strength, kV	12	35

Electrical characteristics of insulator is as follows:

	Standard Surge	Switch. Surge (wet)		Power Frequency (wet)	
	50% flash-over Volt.	50% flash over Volt.	Withstand Volt.	Flashover Volt.	Withstand Volt.
250mm. Susp. Insul- one	125kV	85kV	75kV	45kV	40kV
Ditto. two-Discs/String	255	170	155	80	70
Ditto. three-Discs/String	345	245	220	115	105
L.P.Insul. (LP-30)	220	200	185	100	75
Special High Tension Pin-type, 11 kV	115	–	–	50	45

(notes)
1. Characteristics of 250 mm suspension insulator is referred to the Insulation Design Standard of Japan Electrical Association, 1966
2. LP insulator is referred to JIS C-3812.
3. Special high-tension pin-type insulator is referred to B S 137.

Judging from te comparisons between the above electrical characteristics and required strength of insulators, usable insulators, and their number of discs per string are determined, as stated below;

Voltage	Place of Use	L.P. Insul.	S.P. High Pin-type	Suspension Insulator
33 kV	non-dead-end	yes	–	–
	deadend	–	–	3 discs per string
11 kV	non-dead-end	–	yes	–
	deadend	–	–	One

(Note) The additional one suspension insulator for the dead-end pole of 33 kV transmission line is designed from the maintenance viewpoints.

(c) Determination of Basic Insulation Level (BIL)

BIL's are determined to be 30 A and 10 A for 33 kV and 11 kV system, respectively on the following grounds:

An arrestor is used against lightning surge as stated above, and accordingly, there is an necessity to select proper BIL of system which can endure switching surge and at the same time harmonize with protective performances of an arrestor; when the lightning surge protective allowance of arrestors and equipments to be protected is 20%, 100% spark-over voltage of an arrestor as well as BIL of more than 1.2 times of ceiling voltage are required. In the case of an arrestor of 5 kA for 33 kV system (JEC-156), 100% spark-over voltage is 135 kV and discharge voltage is 145 kV. Accordingly, required BIL = 145 kV x 1.2 = 174 kV, and selective BIL should be more than this value. Consequently, No. 30 B of BIL class are required, but No. 30 A (200 kV) should be finally adopted because the BIL class of 33 kV substation equipments is 30 A. Required BIL is determined to be No. 10 A for 11 kV distribution line.

(d) Anti-Lightning Design

Judging from the facts that accurate statistics of Isokeraunic Level (IKL) values are not available, and that overhead grounding wire are not installed except a part of sea-side areas, and that frequency of lightning is small throughout a year, necessary arrestors are installed on equipments in order to protect them against external abnormal voltage such as lightning surge.

(5) Supply System

According to the TANESCO's standards, it shall be as follows:

33 kV/400 and 230 V	Low-voltage direct stepping down
11 kV/400 and 230 V	Same as above

(6) Type of Line and Installation of Protective Switch

(a) Type of Line

The 33 and 11 kV distribution lines have a considerably large supply capacity, and necessary consideration shall be given to possible cases of line troubles as well as Off-load maintenance works.

However, in the case of this Project, power consumption areas extend in one and same direction with smaller density of power demand, the type of line shall be one circuit of tree-branches.

(b) Protective Switch

In order to realize effective and secure operation of a system, protective switches are installed at proper points on 33 and 11 kV lines, as follows:

a. 33 kV transmission Line

An air-circuit breaker is installed at T-branching point (pole No. 177) of a transmission line to Sanya Juu substation, and another T-branching point near Same substation extending to Mwembe, respectively, in order to minimize outage time given by system operation. This air-circuit breaker shall be operated under no-voltage condition in principle.

b. 33 kV Distribution Line

System protection shall be done by protective realys and oil circuit breaker which are installed at the existing Kiyungi substation. Accordingly, systems of protection and reclosing shall be the same as the existing ones.

c. 11 kV Distribution Line

Oil circuit breakers are installed at main branching points of long distribution lines in order to facilitate and minimize the system operations.

Power demands at Hai district shall be covered by both Machame and Sanya Juu substations, and accoringly, constant-opened switch is installed at Masama, while loop-operation of 11 kV trunk system at Hai district is not adopted. Switching of system shall be done by no-load operation; not by loop operation.

d. Low Tension Distribution Lines

Protection against troubles due to overload and short-circuit on low-tension lines and service lines shall be done as stated below;

* Against internal short-circuit troubles of a transformer itself, the primary cutout switch of a transformer shall be utilized for protection.

* Against troubles due to overload and short circuit, a switch on the secondary side of a transformer shall be utilized for protection.

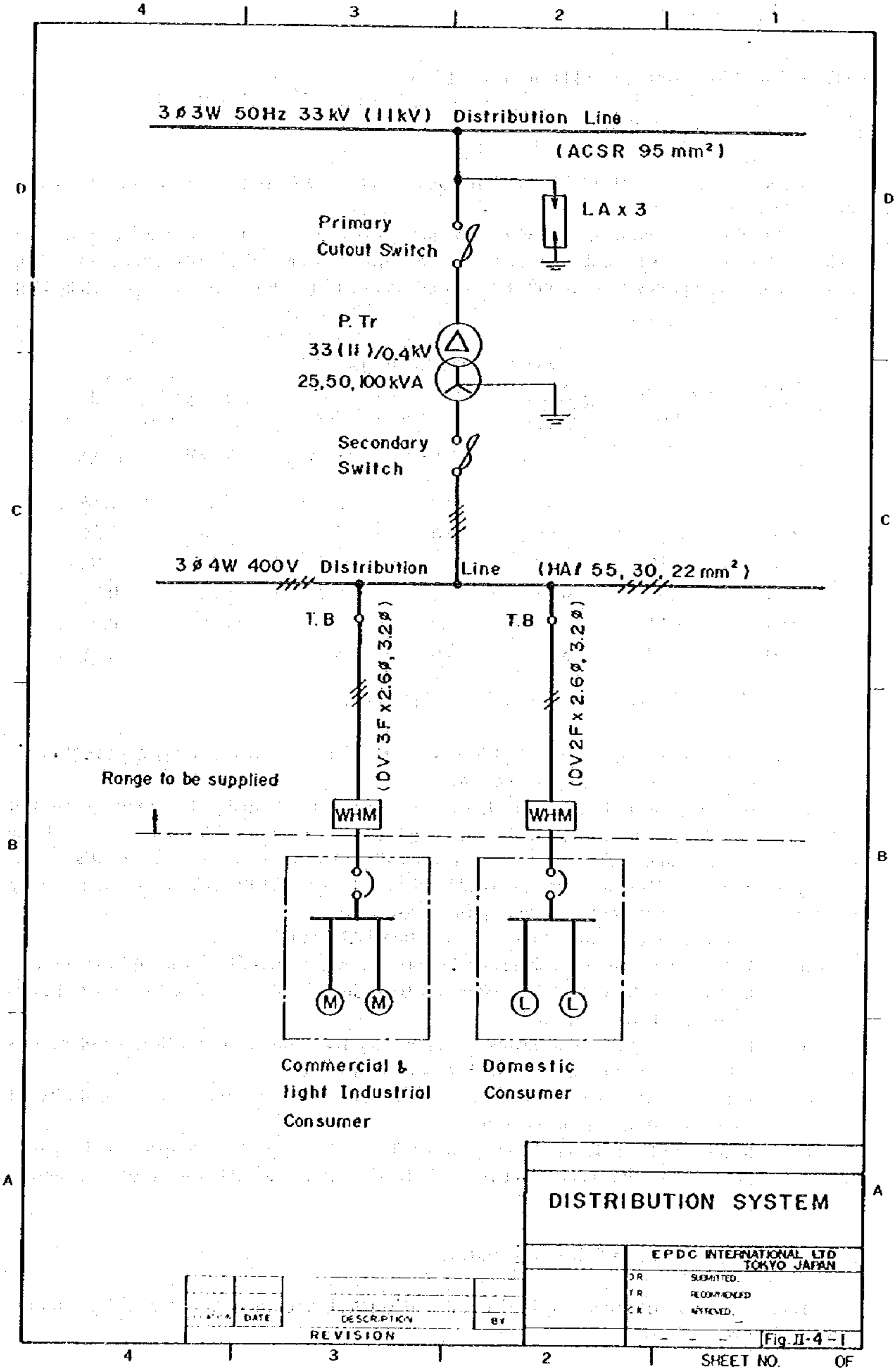
* On the switches as stated above, a fuse of proper size shall be installed judging from a transformer capacity and its load.

* For consumers of three-phase motor power, there is very rare case, in the past record, of troubles due to lack of a phase on the side of a distribution line. Installation of the protective device such as breakers is necessarily required to be prescrived in order to prevent consumer's equipments from accidents due to the line faults.

(7) Kind of Line

Routes of the lines of this Project run almost lands which are fields, farms, and hilly areas without dense-populated and/or urban areas, and use of insulated wire is not necessary; overhead lines with bare wire is adopted with due regards to economical construction.

Under-ground cable system is adopted for some outgoing ports of some substations, where overhead outgoing line can not be realized.



3ø3W 50Hz 33kV (11kV) Distribution Line
(ACSR 95 mm²)
LA x 3
Primary
Cutout Switch
P. Tr
33(11)/0.4kV
25,50,100kVA
Secondary
Switch
3ø4W 400V Distribution Line (HAl 55, 30, 22 mm²)
T.B
T.B
(DV 3F x 2.6ø, 3.2ø)
(DV 2F x 2.6ø, 3.2ø)
Range to be supplied
WHM
WHM
M
M
L
L
Commercial & light Industrial Consumer
Domestic Consumer
DISTRIBUTION SYSTEM
EPDC INTERNATIONAL LTD
TOKYO JAPAN
DATE
DESCRIPTION
BY
REVISION
Fig. II-4-1
SHEET NO.
OF

4.2.2 Design of Transmission and Distribution Lines

(1) Providing Standard Span

The standard span for 33 kV transmission and 11 kV distribution line is provided to be 100 meters on the ground as follows:

In this Project, conductor of ACSR 95 mm^2, wooden pole of 11 m, and the allowable maximum temperature of conductor of 90°C are adopted. Under these conditions, spanning, sagging, height of conductor above ground, and allowance to the design standards are computed as follows:

Span (m)	Sag at 90°C (m)	Height of Conductor (m)			Allowance to Design Standard (m)	
		Comput. Value	Design Standard			
			33 kV	11 kV	33 kV	11 kV
100	1.84	7.26	6.0	5.7	1.26	1.56
110	2.14	6.96	6.0	5.7	0.96	1.26
120	2.38	6.72	6.0	5.7	0.72	1.02
130	2.67	6.43	6.0	5.7	0.43	0.73
140	3.11	5.99	6.0	5.7	−0.07	0.29
150	3.32	5.78	6.0	5.7	−0.22	0.08

(Note) Sag Table is included in the Appendix.

Under the columns of 150 m and 140 m span, the height above ground is short in the case of 33 kV and has slight allowance in 11 kV case.

Under the column of 100 m span, there is allowance of 1.26 m and 1.56 m in the cases of 33 kV and 11 kV, respectivly. In the actual conditions, it is impossible to imagine that the maximum conductor allowable temperature is reached, and accordingly, allowance in the height above ground in the 100 m spanning could be said to be slightly larger. But, it is finally determined to be 100 meters by considering the following factors:

a. Harmony and coordination to the existing TANESCO's facilities.

b. With a long spanning of bare conductors, line short-circuit faults are apt to occur.

c. In a case of long spanning, after construction, irregular sags due to wind and rains are difficult to be adjusted.

d. Height of a pole must have some allowance for adjusting the difference of heights between adjacent poles in actual construction work.

e. L.T. Line is hang on a high tension pole, and also there is a possibility of communication line hanging, too.

f. In a case of a L.T. line hanging of a L.T. line hanging of 50 m span, auxiliary pole can be erected between two high tension poles to the effect of economical construction.

(2) Wire Arrangement and Pole Configuration

There are two arrangements, horizontal and vertical, and their merits and demerits are shown as follows:

Horizontal Arrangement

(merit)
* Pulling down lead-wires of equipments mounted on a pole is easy.
* Saving height of a pole is possible.

(demerit)
* Wiring space is bigger and inconvenient to have a good distance to buildings and trees.
* Horizontal swinging of wires due to short-circuit magnetic force and wind should be taken into consideration.

(applicable area)
* Applicable to a area where line occupying space is easily obtained.

Vertical Arrangement

(merit)
* Distance to buildings and trees can be easily obtained because of its narrower wiring space.
* Resistant to horizontal swinging of wires due to wind

(demerit)
* Difficult pulling down of lead wires of equipments mounted on a pole.
* Pole height is apt to be longer.

(applicable area)
* Suitable for densely built-up area where line occupying space is hardly obtained.

The horizontal arrangement is adopted by studying the above comparison, because the service areas are not densely built-up; with a merit of 1 m shorter height of a pole can be utilized with less costs of materials, labor and transportation in comparison with the vertical arrangement.

(3) Conductor

Kind and size of conductors to be used for 33 kV and 11 kV distribution lines should be determined with due consideration to the most economical load of circuits and voltage drops.

Under the conditions of voltage drop limits of 10 % of a high voltage line, the cases of ACSR 120 and 95 mm^2 are reviewed as follows:

(a) Maximum Load

As for ACSR 120 mm^2, the maximum economical current is about 350 A and the most economical load is about 6,700 kVA, while, as for ACSR 95 mm^2, the former is about 260 A and the latter about 5,000 kVA.

(b) Distribution Capacity

When the standard pattern of distribution lines of this Project is reviewed under the above conditions, the distribution capacity will be as follows:

Standard Pattern

Average Line Length	30 km
Load Distribution	uniform
Voltage Drop Limits	10%

Conductor of Trunk Line	Voltage	Constant Distrib. Capacity
ACSR 95 mm^2	11 kV	1,700 kVA
ACSR 120 mm^2	11 kV	2,100 kVA

(c) Selection of Conductor Wire

As to the distribution line from Sanya Juu substation to the Central Hai where the biggest power demand is located among the service areas of this Project, the maximum load per circuit will be estimated to be about 3,600 kVA for the coming thirty years.

The maximum loads of ACSR 120 and 95 mm² are 6,700 and 5,000 kVA respectively, and 120 mm² is too big to cover the above load. As to the matter of voltage drop, power capacitors and line boosters will be installed on the lines. Consequently, ACSR 95 mm² is determined to be the proper size of the conductor to be used.

(4) Electric Pole

A creothote-immersed pole is planned to be used, for the time being, in conjunction with the existing facilities, and however, in concrete designing for construction work, adoption of steel poles could be reviewed also.

(5) Insulator

According to the insulation coordination as stated in section 4.2.1 (4), the 33 and 11 kV lines use three suspension insulators and one suspension insulator (250 mm.), respectively, on their terminal poles.

The 33 kV transmission line and 11 kV distribution line will use solid core L.P. insulators and special high tension pin-type insulator, respectively, on their straight line poles.

(6) Cross-arm

(a) The cross-arms for 33 kV transmission line and 11 kV distribution line will be 2.8 m and 2.1 m, respectively, of channel steel (100 x 50 x 5 mm). Arm-tie of 750 mm will be used for both lines. Please refer to the Appendix for strength computation.

(b) The bolts to be used are M12; 150 mm, M16; 45 mm, 250 mm, 300 mm, and 350 mm.

(c) The straps to be used are:
Strain Point – Strain Strap 180 mm.
Double Arm Point – Strap 240 mm.

(7) Stay

(a) For single pole and H pole, the following stays are installed in order to bear a half of the wind load: (please refer to the Appendix for strength computation)

a. Straight Line
* Place where difference of adjacent two spans is big : one stay for both sides
* Four-directions Staying per 10 spans : 6

b. Angle Line

- * 1–15 degrees : 1
- * 15–45 : 2
- * 45–90 : 3

c. Section Pole : 6

d. Terminal Pole : 2

(b) Materials of Stay

Upper part of a stay is made of galvanized steel stranded wire 22 mm^2 with winding grip and turn-buckle. Its down-half has a driving-type anchor (2-tons).

(8) Pole Mounted Transformer

(a) Type : Outdoor, oil-immersed, self-cooling

(b) Use : Max. Ambient Temp. of 40°C
Mean Ambient Temp. of 32°C
Altitude of 1,000–1,800 m

(c) Rating

Rated Capacity : 25, 50, 100, 200, 300, 500 kVA
No. of Phase : 3
Rated Frequency : 50 Hz
Rated Voltage : 33 kV/ 400, 230 V
11 kV/ 400, 230 V

(d) Installation

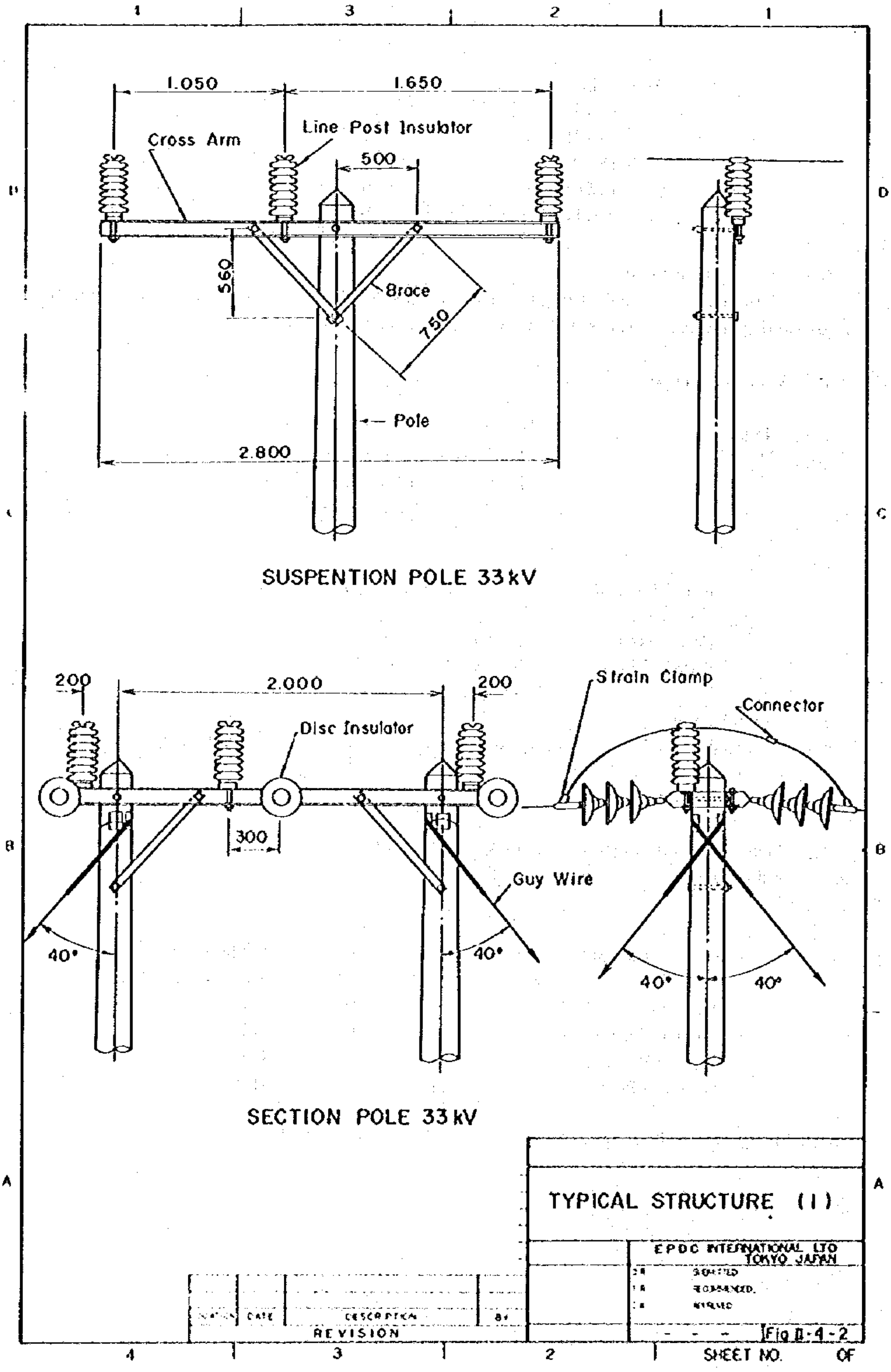
25 to 300 kVA transformers are installed on poles and 500 kVA on the ground.

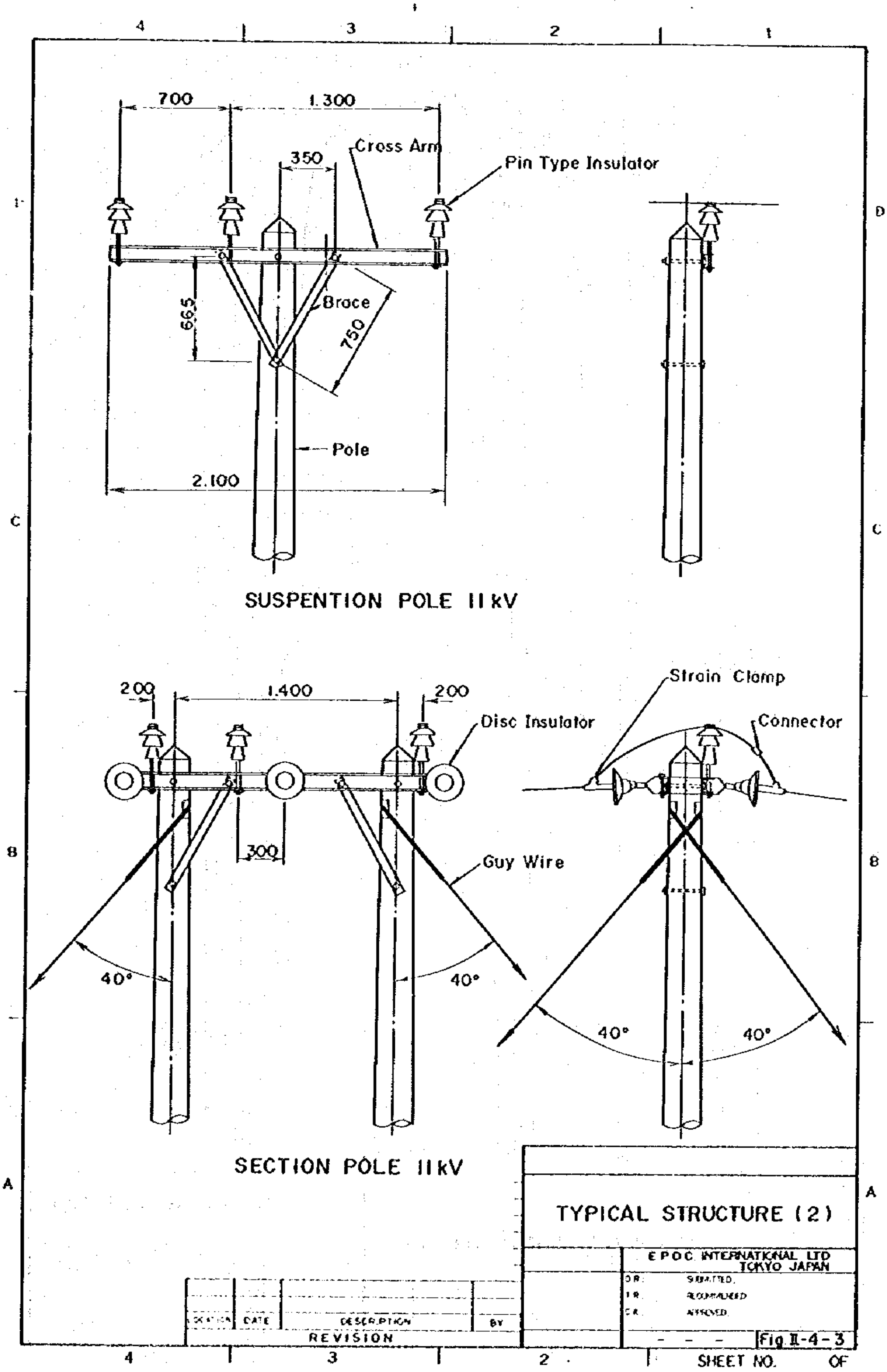
(9) Standard Pole Configurations

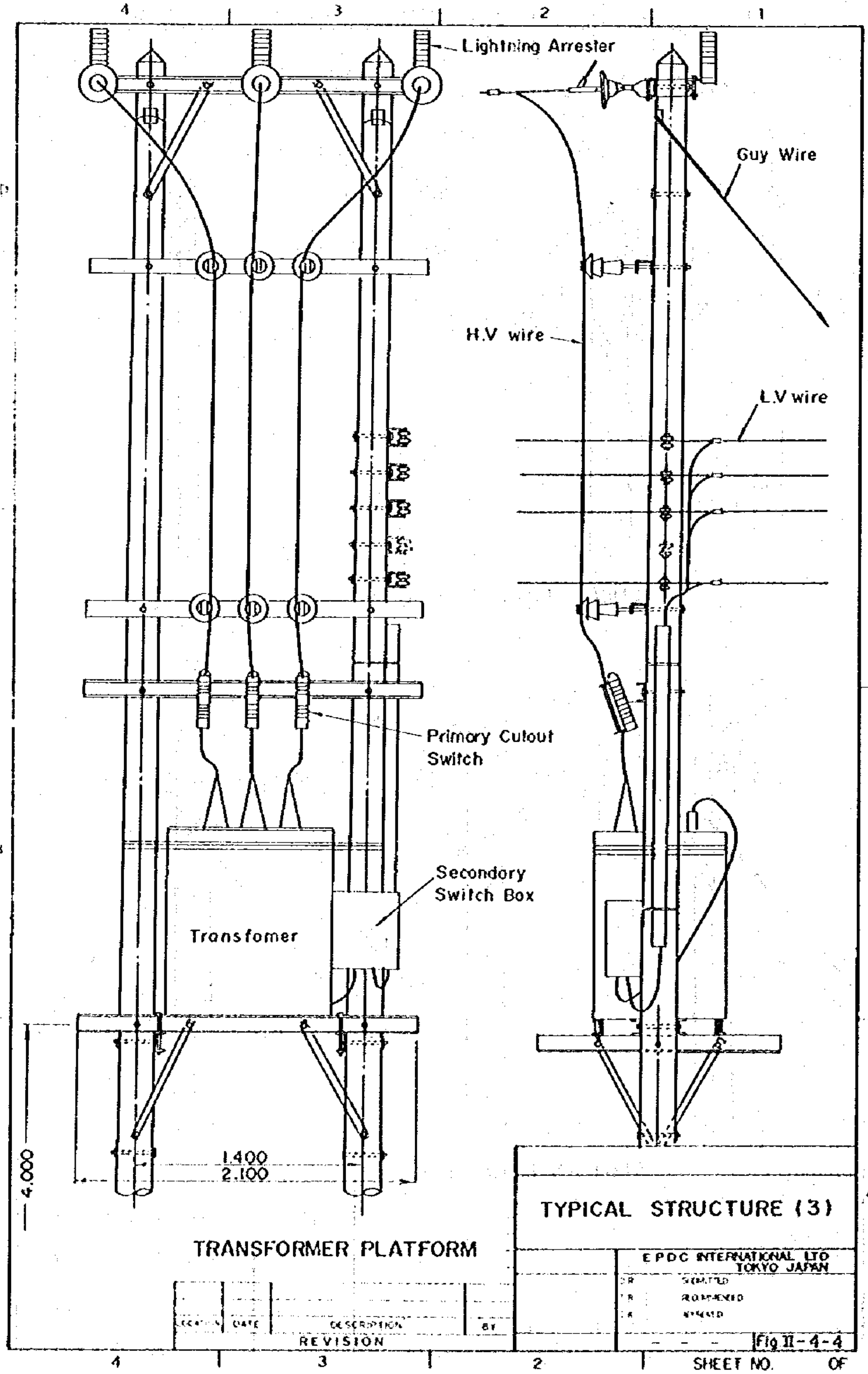
Standard pole configurations for 33 kV and 11 kV are applied, and their ratio in number are mentioned below:

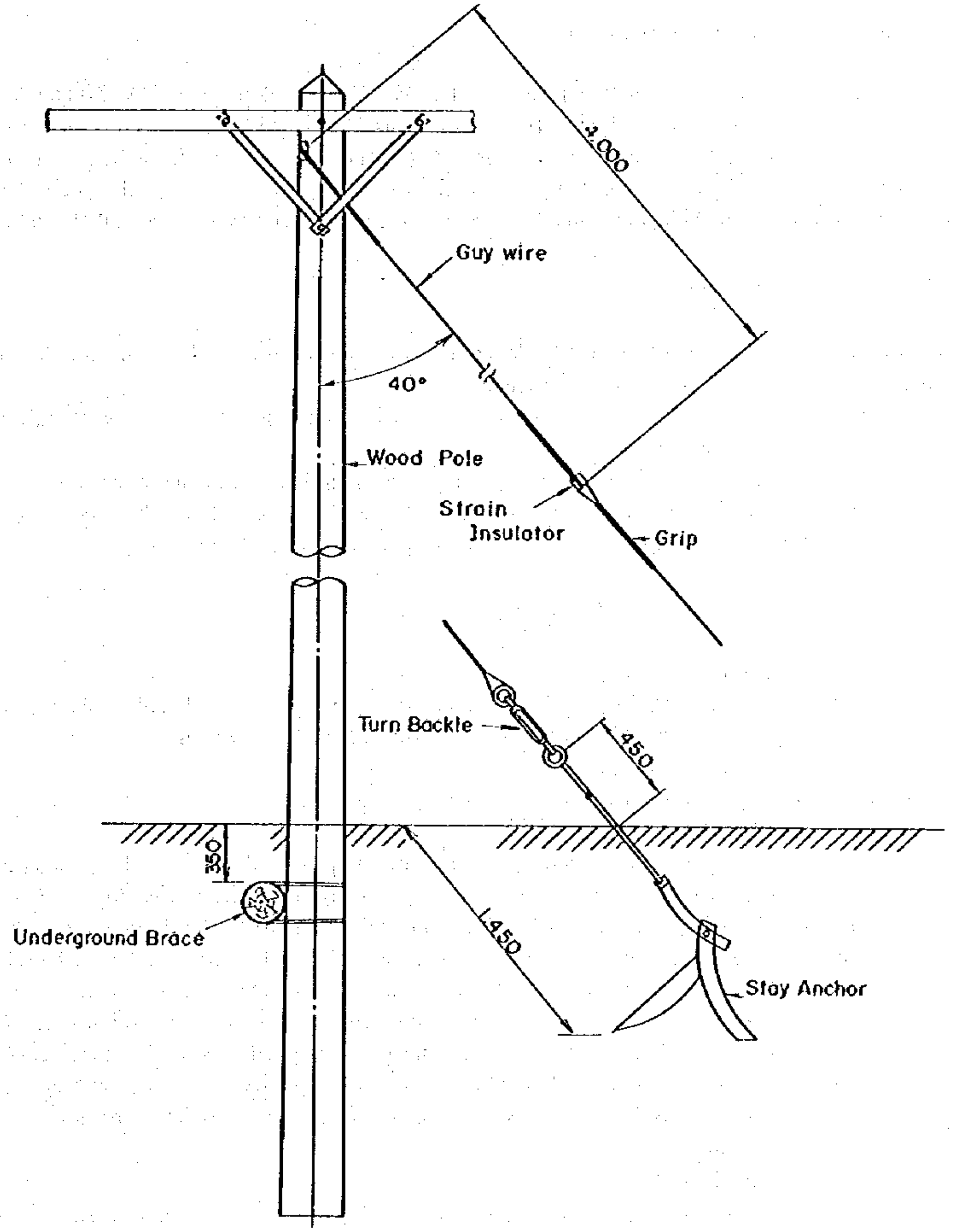
	33 kV	11 kV	
Suspension Pole	65%	45%	Single Pole
Angle Pole, 1–15 deg.	15	20	Single Pole
Angle Pole, 15–45	7	15	H Pole
Angle Pole, 45–90	5	13	H Pole
Section Pole	7	5	H Pole
Terminal Pole	1	2	H Pole

Standard configuration drawings are shown in Fig. II-4-2 to Fig. II-4-5.


1.050
1.650
Cross Arm
Line Post Insulator
500
560
Brace
750
Pole
2.800
SUSPENTION POLE 33kV
200
2.000
200
Strain Clamp
Connector
Disc Insulator
300
Guy Wire
40°
40°
40°
40°
SECTION POLE 33kV
TYPICAL STRUCTURE (1)
EPDC INTERNATIONAL LTD
TOKYO JAPAN
REVISION
Fig II-4-2
SHEET NO.
OF


700
1.300
350
Cross Arm
Pin Type Insulator
665
Brace
750
Pole
2.100
SUSPENTION POLE 11 kV
200
1.400
200
Strain Clamp
Disc Insulator
Connector
300
Guy Wire
40°
40°
40°
40°
SECTION POLE 11 kV
TYPICAL STRUCTURE (2)
E P O C INTERNATIONAL LTD
TOKYO JAPAN
DATE
DESCRIPTION
BY
REVISION
Fig II-4-3
SHEET NO.
OF


Lightning Arrester
Guy Wire
H.V wire
L.V wire
Primary Cutout Switch
Secondory Switch Box
Transfomer
1.400
2.100
4.000
TRANSFORMER PLATFORM
TYPICAL STRUCTURE (3)
EPDC INTERNATIONAL LTD TOKYO JAPAN
REVISION
SHEET NO. OF
Fig II-4-4



ANCHOR ASSEMBLY 11kV

TYPICAL STRUCTURE (4)

EPDC INTERNATIONAL LTD
TOKYO JAPAN

DR.	SUBMITTED.
TR.	RECOMMENDED.
CK.	APPROVED.

LOCATION	DATE	DESCRIPTION	BY
REVISION			

Fig. II-4-5

SHEET NO. OF

4.2.3 Capacity of Pole Mounted Transformer

(1) Standard Capacity of Transformer

Standard capacity of transformers are 3-phase 25 kVA, 50 kVA, 100 kVA, 200 kVA, 300 kVA and 500 kVA. 25 kVA and 50 kVA transformers are employed for the general load, that is, Load T1 (Domestic), T2 (Commercial), T3 (light industrial) and T5 (Public lighting), and 100 kVA transformers are employed for the combined load of spot demand and the general load. 200 kVA, 300 kVA and 500 kVA transformers mainly supply electricity to Load T4 (Industrial).

(2) Location of Transformer

The routes of the 33 kV and 11 kV distribution lines from each substation has been planned to run along the main roads of the villages.

The selection of the transformer's location has been made in accordance with following rules;

a. For demands alongside the feeder, transformers are located in the load centre.

b. For demands away from the feeder, high tension branch line is to be constructed up to the load centre, and transformers are to be located in the load center.

(3) Determination of Transformer Capacity

(a) Initial utilization Factor

Initial utilization factor has been determined to be 60%, and will be 100% in ten years, assuming that demands would increase at the rate of 6% per year.

(b) Determination of Transformer Capacity

a. General load

For the general demand, the maximum power demand and the maximum transformer capacity have been figured out assuming that, almost in all the cases, one transformer would be assigned in one village and that the diversity factor, the power factor and the utilization factor would be 1.3, 90% and 60% respectively. The load increase rate in future has been taken into consideration in working out the transformer capacity, and the suitable transformer capacity have been selected from the standard transformer capacities. In the case that suitable transformer capacities can not be found in the TANESCO's standard capacity series, or that capacities worked out exceeds 100 kVA, two transformers are to be installed on a pole for a efficient operation.

b. Special load

Large consumers such as plantations and hospitals with motive power demand are mainly in Hai District and are also in other districts. There are twenty four plantation consumers and three hospitals, and the average demand is 70 kW for a plantation and 72 kW for a hospital. For these consumers, exclusively used transformers are planned to be installed, and their capacities have been computed and selected provided that the power factor and the utilization are 90% and 40 to 80% respectively. And for plantation demand, transformers of at least 50 kVA have been selected to permit the demand increase, although the demand is small at present.

(4) Alignment of Transformers

Transformers sized from 25 kVA to 500 kVA are designed to be installed near load centres. Fig. II-4-6, II-4-7, II-4-8 and II-4-9 represent the detail of the transformer capacity and its location, and the number of transformers in each district is shown as follows.

unit: Nos.

District	Hai	Rombo	North P.	South P.	Total
25 kVA	10	9	9	7	35
50 kVA	36	11	5	3	55
100 kVA	7	3	1	1	12
200 kVA	0	0	0	2	2
300 kVA	0	0	1	1	2
500 kVA	1	0	0	0	1
Total quantity	54	23	16	14	107
Total capacity (kVA)	3250	1075	875	1125	6325

4.2.4 Specifications of Major Materials

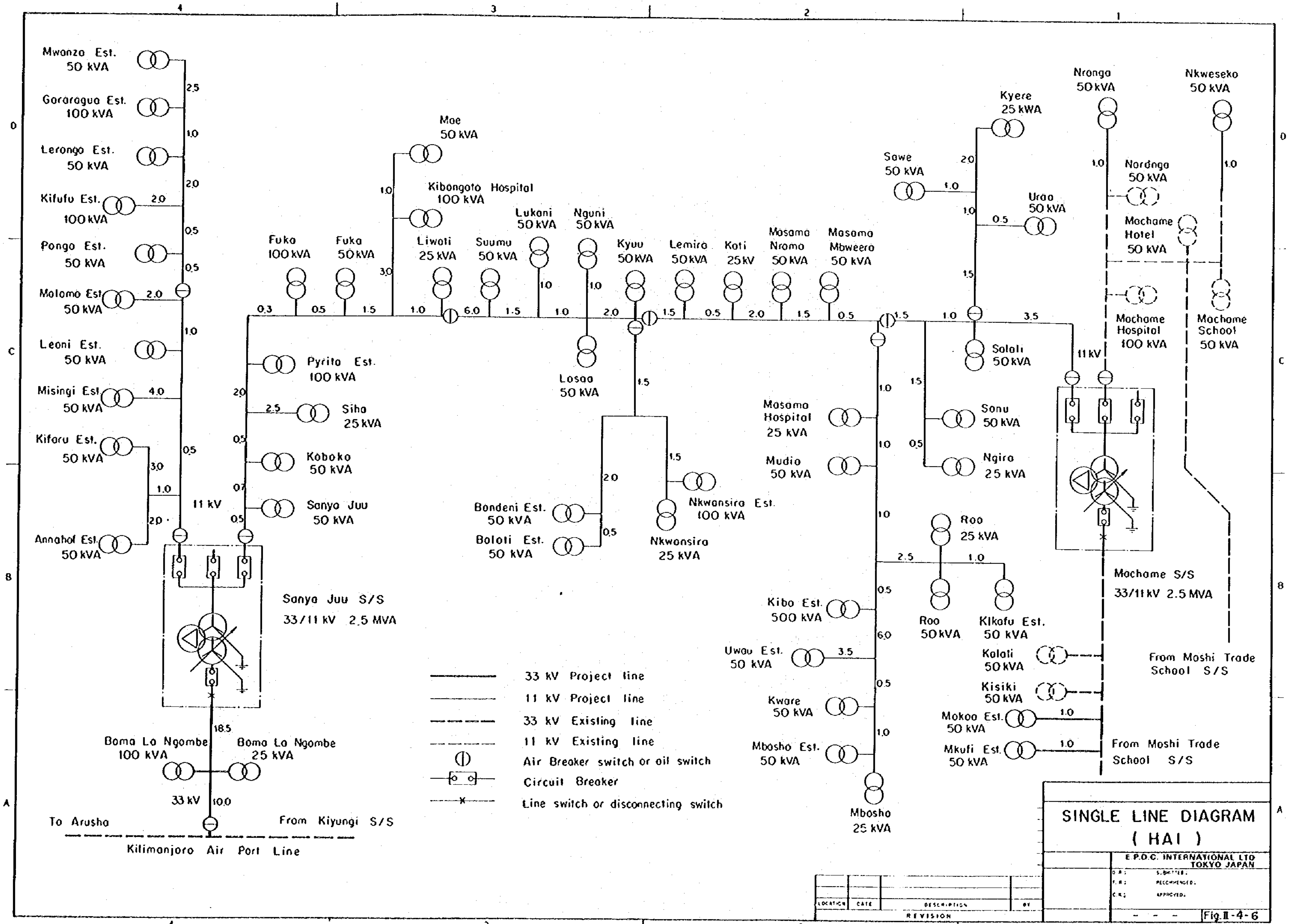
(1) Wooden Pole creosote treated

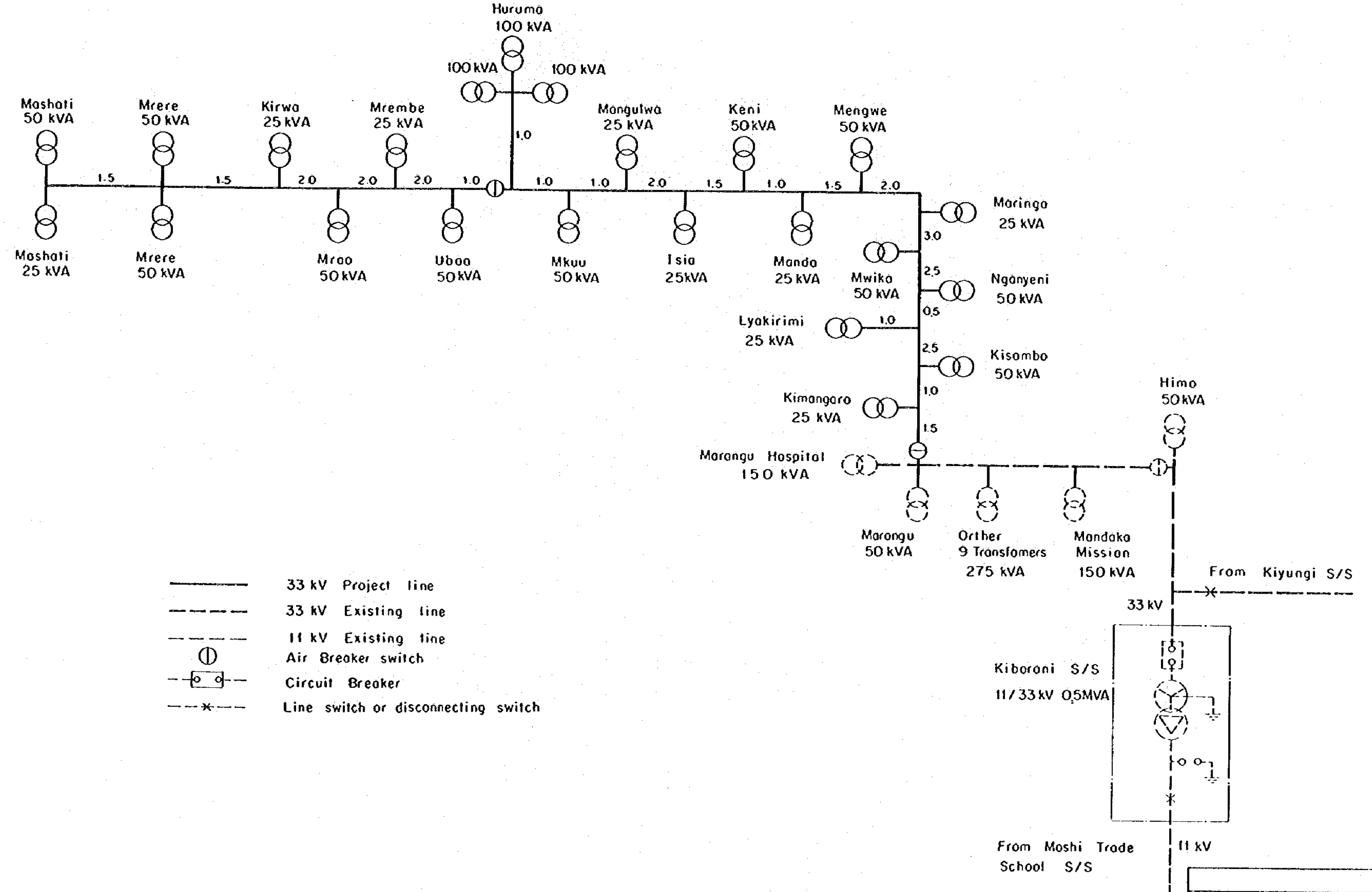
Material	Pine tree			
Length (m)	9	11	12	13
Dia. at top (mm)	180	190	190	200
Voltage (kV)	0.4 0.23	11	33	

(2) Conductor

(a) ACSR 95 mm^2 to be used for 33 kV and 11 kV transmission and distribution lines.

Nominal size (mm^2) :		95
Construction of conductor (No/mm) :	Aluminum :	6/4.5
	Steel :	1/4.5
Calculated sectional area (mm^2) :	Aluminum :	95.40
	Steel :	15.90
Tensile load (kG) :		3,180


Mwanzo Est. 50 kVA
Gararagua Est. 100 kVA
Lerongo Est. 50 kVA
Kifufu Est. 100 kVA
Pongo Est. 50 kVA
Molomo Est. 50 kVA
Leoni Est. 50 kVA
Misingi Est. 50 kVA
Kifaru Est. 50 kVA
Annahof Est. 50 kVA
11 kV
Moe 50 kVA
Kibongoto Hospital 100 kVA
Fuka 100 kVA
Fuka 50 kVA
Liwoti 25 kVA
Suumu 50 kVA
Lukani 50 kVA
Nguni 50 kVA
Kyuu 50 kVA
Lemira 50 kVA
Koti 25 kV
Masama Nromo 50 kVA
Masama Mbweera 50 kVA
Pyrito Est. 100 kVA
Siha 25 kVA
Koboko 50 kVA
Sanya Juu 50 kVA
Losaa 50 kVA
Bondeni Est. 50 kVA
Boloti Est. 50 kVA
Nkwansira Est. 100 kVA
Nkwansira 25 kVA
Sanya Juu S/S
33/11 kV 2.5 MVA
Boma La Ngombe 100 kVA
Boma La Ngombe 25 kVA
33 kV
To Arusha
From Kiyungi S/S
Kilimanjaro Air Port Line
33 kV Project line
11 kV Project line
33 kV Existing line
11 kV Existing line
Air Breaker switch or oil switch
Circuit Breaker
Line switch or disconnecting switch
Kyere 25 kWA
Sawe 50 kVA
Uraa 50 kVA
Nronga 50 kVA
Nkweseko 50 kVA
Nordnga 50 kVA
Machame Hotel 50 kVA
Machame Hospital 100 kVA
Machame School 50 kVA
Sololi 50 kVA
11 kV
Masama Hospital 25 kVA
Mudio 50 kVA
Sonu 50 kVA
Ngiro 25 kVA
Roo 25 kVA
Roo 50 kVA
Kikafu Est. 50 kVA
Kibo Est. 500 kVA
Uwau Est. 50 kVA
Kware 50 kVA
Mbosho Est. 50 kVA
Mbosho 25 kVA
Machame S/S
33/11 kV 2.5 MVA
From Moshi Trade School S/S
Kalali 50 kVA
Kisiki 50 kVA
Mokoo Est. 50 kVA
Mkufi Est. 50 kVA
From Moshi Trade School S/S
SINGLE LINE DIAGRAM
(HAI)
E.P.D.C. INTERNATIONAL LTD
TOKYO JAPAN
Fig. II-4-6
SHEET NO. OF

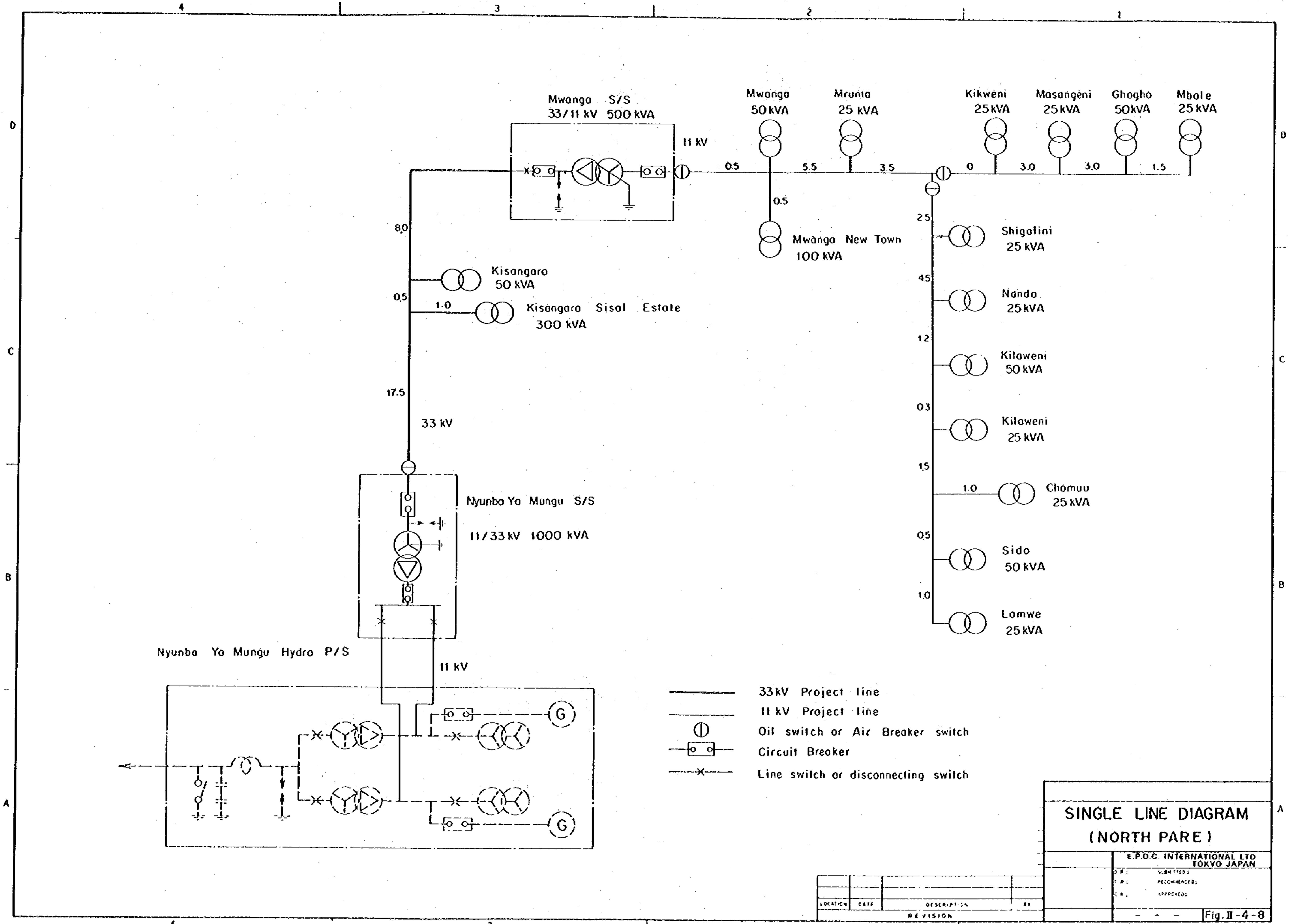


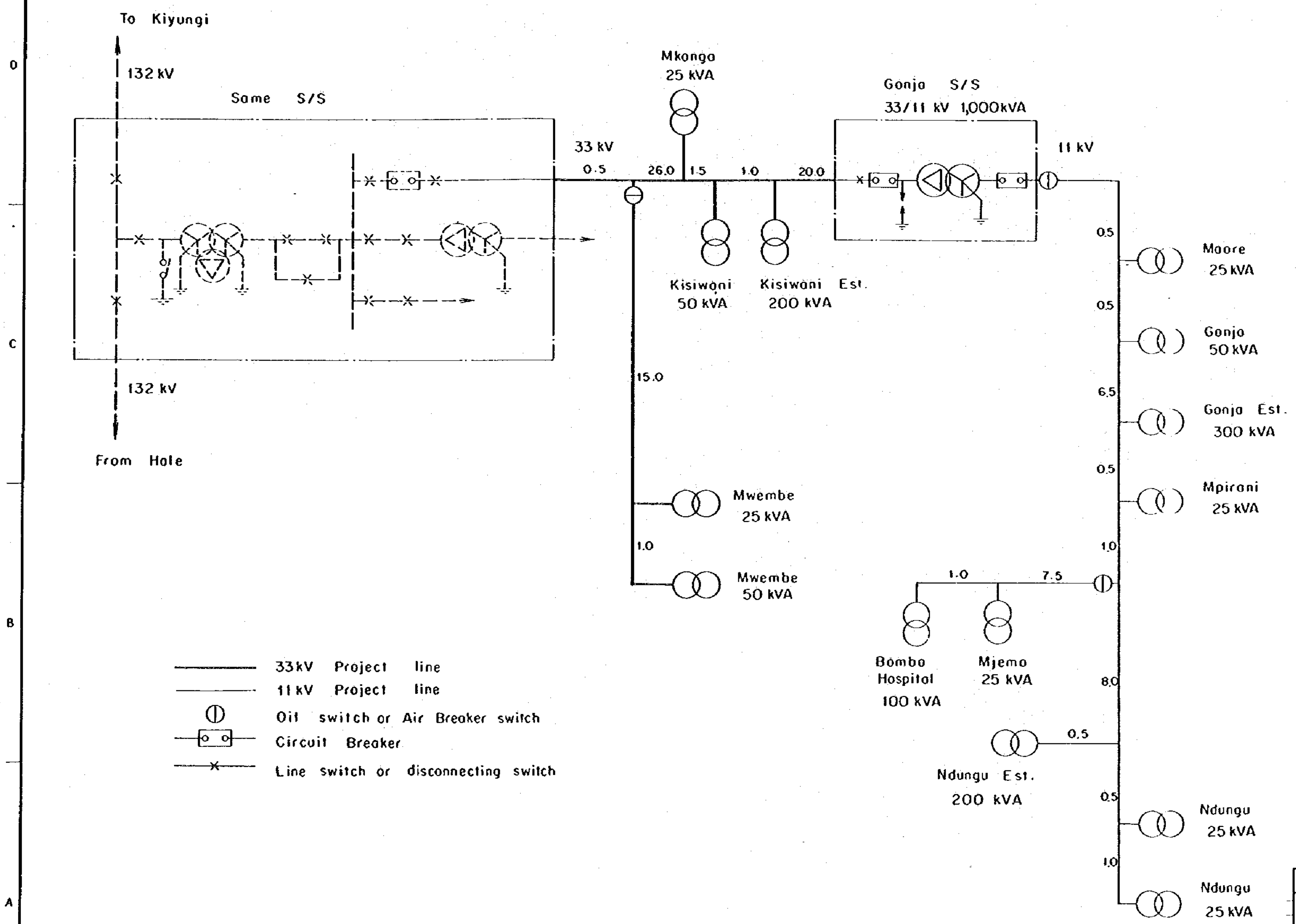
SINGLE LINE DIAGRAM
(ROMBO)

E.P.D.C. INTERNATIONAL LTD
TOKYO JAPAN

Fig. II-4-7

SHEET NO. OF


Mwanga S/S
33/11 kV 500 kVA
11 kV
Mwanga
50 kVA
Mrunia
25 kVA
Kikweni
25 kVA
Masangeni
25 kVA
Ghogho
50 kVA
Mbole
25 kVA
0.5
5.5
3.5
0
3.0
3.0
1.5
0.5
Mwanga New Town
100 kVA
8.0
Kisangara
50 kVA
0.5
1.0
Kisangara Sisal Estate
300 kVA
17.5
33 kV
2.5
Shigatini
25 kVA
4.5
Nanda
25 kVA
1.2
Kilaweni
50 kVA
0.3
Kiloweni
25 kVA
1.5
1.0
Chomuu
25 kVA
0.5
Sido
50 kVA
1.0
Lomwe
25 kVA
Nyunba Ya Mungu S/S
11/33 kV 1000 kVA
Nyunba Ya Mungu Hydro P/S
11 kV
G
G
33 kV Project line
11 kV Project line
Oil switch or Air Breaker switch
Circuit Breaker
Line switch or disconnecting switch
SINGLE LINE DIAGRAM
(NORTH PARE)
E.P.D.C. INTERNATIONAL LTD
TOKYO JAPAN
LOCATION
DATE
DESCRIPTION
BY
REVISION
Fig. II-4-8
SHEET NO.
OF



SINGLE LINE DIAGRAM
(SOUTH PARE)

E.P.D.C. INTERNATIONAL LTD
TOKYO JAPAN

Fig. II-4-9

Diameter of conductor (mm) :	Aluminum :	13.5
	Steel :	4.5
Weight of conductor (kG/km) :		385.2

(b) HAI 55,30 and 22 mm^2 to be used for low tension distribution lines.

Nominal size (mm^2)	55	30	22
Construction of conductor (No/mm)	7/3.2	7/2.3	7/2.0
Calculated sectional area (mm^2)	56.29	29.09	21.99
Tensile load (kG)	838	469	369
Diameter of conductor (mm)	9.6	6.9	6.0
Weight of conductor (kG/km)	153.80	79.48	60.09

(3) Pole Mounted Transformer

(a) Ratings

Rated capacity (kVA)	:	25, 50, 100, 200, 300, 500 kVA
Number of phase	:	3
Frequency (Hz)	:	50
Rated voltage	:	33 kV/400, 230 V 11 kV/400, 230 V
Tap voltage (%)	:	± 2.5, ± 5.0
Connections	:	H-v Delta
		L-v Wye with a neutral point brought out
Polarity	:	Subtractive polarity
Tempreture rise	:	Windings 55°C
		Oil 50°C

(b) Performancies (standard examples)

Capacity	Efficiency at full load	Exciting current	Voltage regulation
50 kVA	above 97.0%	below 6.5%	below 2.3%
100 kVA	above 97.2%	below 6.5%	below 2.0%
500 kVA	above 89.0%	below 5.0%	below 1.6%

(4) Insulator

(a)

Solid-Core Line Post Insulator (LP-30)	:	JIS C3812
Nominal voltage (kV)	:	30
Withstand voltage wet (kV)	:	75
Impulse withstand voltage (kV)	:	185
50% impulse flash-over voltage (kV)	:	220
Maximum working load (Bending) (kG)	:	280

(b)

Suspension Insulator (254 mm x 146 mm)	:	JIS C3840
Withstand voltage wet (kV)	:	40
Impulse withstand voltage (kV)	:	105
50% impulse withstand voltage (kV)	:	125
Maximum working tensile load (kG)	:	4000

(c) Special High Voltage Pin Type Insulator : BS 137 (1970)

Nominal voltage (kV)	:	10
Withstand voltage wet (kV)	:	45
50% impulse flash-over voltage (kV)	:	115
Failing load (Bending) (kG)	:	1100

(d) Low Tension Shackle Insulator : JIS C3845

Power-frequency withstand voltage (kV)	:	15
Tensile withstand load (kG)	:	1000

(5) Protection and Protective Devices

(a) Primary cut-out switch : ANSI C37-42-1969

This is for use of protection of the transformer.

Nominal voltage (kV)		:	11	33
Rated voltage (kV)		:	14.4	34.5
Rated current (A)		:	30	20
Frequency (Hz)		:	50	
Withstand voltage	Power frequency dry (kV)	:	35	95
	Power frequency wet (kV)	:	30	80
	Impulse (kV)	:	95	200

(b) Line Switch

a. 11 kV pole-mounted oil switch :

Rated voltage (kV)		:	12
Rated current (A)		:	100
Frequency (Hz)		:	50
Withstand voltage	Power frequency dry (kV)	:	36.4
	Impulse (kV)	:	117

b. 33 kV Air Breaker Switch

Rated voltage (kV)		:	34.5
Rated current (A)		:	200
Frequency (Hz)		:	50
Withstand voltage	Power frequency dry (kV)	:	95
	Power frequency wet (kV)	:	80
	Impulse (kV)	:	200

(c) Surge Arrestor : JEC-156 (1963)

Nominal voltage (kV)	:	11	33
Rated voltage (kV)	:	14	42
Power-frequency sparkover voltage (kV)	:	21	63
Nominal discharge current (kA)	:	5	5
Discharge voltage (kV)	:	50	145

4.3 SUBSTATION FACILITIES

4.3.1 Design Standards

(1) Basic Standards

Equipments and facilities for substations have been selected according to the following standards:

Japan Industrial Standards	(JIS)
Japanese Electrotechnical Committee Code	(JEC)
The Standards of Japanese Electrical Manufacturer's Association	(JEM)
Japan Cable Standards	(JCS)
Japan Electrical Association Code (Power Generation and Transformation) – for construction work, maintenance, and operation	(JEAC 5001-1978)

(2) Determination of Substation Capacity

In determining substation capacities, the following factors have been taken into consideration; growth rate of load density in each service area, voltage drop, voltage regulation, emergency steps, and overall economic analysis including distribution lines.

(a) Standard capacities of main transformers have been decided according to the TANESCO's standards, as follows:
3-phase, 500, 1,000, 2,500, 5,000 kVA

(b) Main transformer capacity of each substation has been selected according to the economic computation results, as follows:

a. Factors for Computation

Monetary Interest	8%
Physical Life of Transformer	15 years
Residual Value	10%
Period	25 years
Load Estimate	Forecast adopted this time
Load Power Factor	80%
Computation Method –	Method of Comparison of Annual Expenses vs. Present Value

(note) The following factors have been deleted from the computation, because they are common among patterns;
* Iron Loss, Copper Loss, and Maintenance Cost
* Purchasing Prices and Installation Cost of Equipments, other than main transformers.

b. Price of Main Transformer

The following assumption has been adopted.
* Transformer w/on-load tap changer
11/33 kV, 3-phase, outdoor, oil-immersed, self-cooling
(for Machame and Sanya Juu substations)

Capacity (kVA)	1,000	2,500	5,000
Price (10^3 YEN)	12,000	16,000	22,700

* Transformer w/off-load tap changer
  11/33 kV, 3-phase, outdoor, oil-immersed, self cooling
  (for Nymba Ya Mungu, Gonja, and Mwanga substation)

Capacity (kVA)	500	750	1,000	1,500
Price (10^3 YEN)	3,000	4,000	5,000	7,500

c. Computation Results

* For Machame and Sanya Juu substations

(unit : 10^3 YEN)

Capacity (kVA)		1,000	2,500	5,000
Annual Expense	Machame	30,603	20,876	27,418
Present Value	Sanya Juu	-	23,725	27,418

From the above, the size of 2,500 kVA is the most economical one.
(note) The initial load of Sanya Juu S.S is estimated to be about 1,000 kVA, and therefore no review was made on 1,000 kVA.

* For Nyumba Ya Mungu, Gonja, and Mwanga substations

(unit : 10^3 YEN)

Capacity (kVA)	500	750	1,000	1,500
Nyumba Ya Mungu	-	7,570	7,414	9,059
Gonja	6,255	6,252	6,645	9,059
Mwanga	4,969	5,127	6,039	9,059

From the above, the optimum capacity has been decided as follows:

– Nyumba Ya Mungu substation

The answer is 1,000 kVA, and the second transformer would be installed 15 years later.

– Gonja substation

According to the computation results, the first priority should be given to 750 kVA, and 500 kVA comes next. However, 750 kVA is out of the TANESCO's standards and should be deleted. In the case of 500 kVA, additional second one would be required within 5 years after installation of the first one, and accordingly, it could not be deemed most economical by requiring its installation cost as well as maintenance cost. Consequently, the answer must be 1,000 kVA, and the second one would be required 20 years later.

– Mwanga substation

According to the computation results, 500 kVA should be adopted, and the second one would be required 11 years later.

(3) Operation and Control System

(a) In designing the operation and control system of a substation, constant supervision is not be adopted by stationing no man at a substation, because density of power demand is smaller, and service reliability could be rather lower than those for urban

areas.
Such a system is equivalent to the Simple Supervisory System in Japan, which is adopted for a substation of less than 10 MVA.

(b) In the above Simple Supervisory System, an operator visits, whenever necessary, a substation from his station for the purpose of supervising, patrolling, as well as operation of equipments.
In the design of this time, the standard time which is required, when emergency, for a operator to reach a substation from the nearest operators' station is less than half an hour.

(c) Of the five substations to be newly constructed this time, the four substations except Nyumba Ya Mungu substation do not have clear definite schedules of their operators' locations. However, those locations of the four substations have been selected on assumption that any TANESCO's organization such as sub-branch offices would be provided in near future.

(d) Under the Simple Supervisory System, it is desirable to give an alarm to a operators' station in the cases as stated below. However, for the time being, we have no definite schedule of operators' stations, and accordingly, necessary alarm contacts are provided in design.
a. When a circuit breaker and disconnecting switch tripped.
b. When control circuit voltage lowered considerably.

(e) In order to prevent lowering of reliability under the Simple Supervisory System, an automatic recloser system is adopted at secondary side of each substation. And also, both Machame and Sanya Juu substations will have Load Ratio Control Transformer (LRT) for the purpose of automatic voltage regulation.

(4) Metering and Protective Apparatus

(a) The captioned apparatus for Machame and Sanya Juu substations are designed according to the Japanese Standard JEAC 5001 - 1978, while as to the both substations, Gonja and Mwanga, the metering apparatus are deleted from design, and the protective apparatus are minimum designed, because those two substations are just for stepping down 33 kV one circuit to 11 kV one circuit, being just similar to pole-mounted transformers of a distribution line.

(b) The outgoing port at the Nyumba Ya Mungu power station is designed to be from the generator main circuit, and necessary metering and protective apparatus are designed to be provided as fully as a typical substation in order to prevent effects of troubles on a substation and transmission line.

4.3.2 Equipments for Each Substation

(a) One Line Diagram and Equipments Layout Plan of each substation are shown on Fig. II-4-10 to Fig. II-4-16.

(b) Special considerations from the viewpoints of operation and maintenance are given as follows:

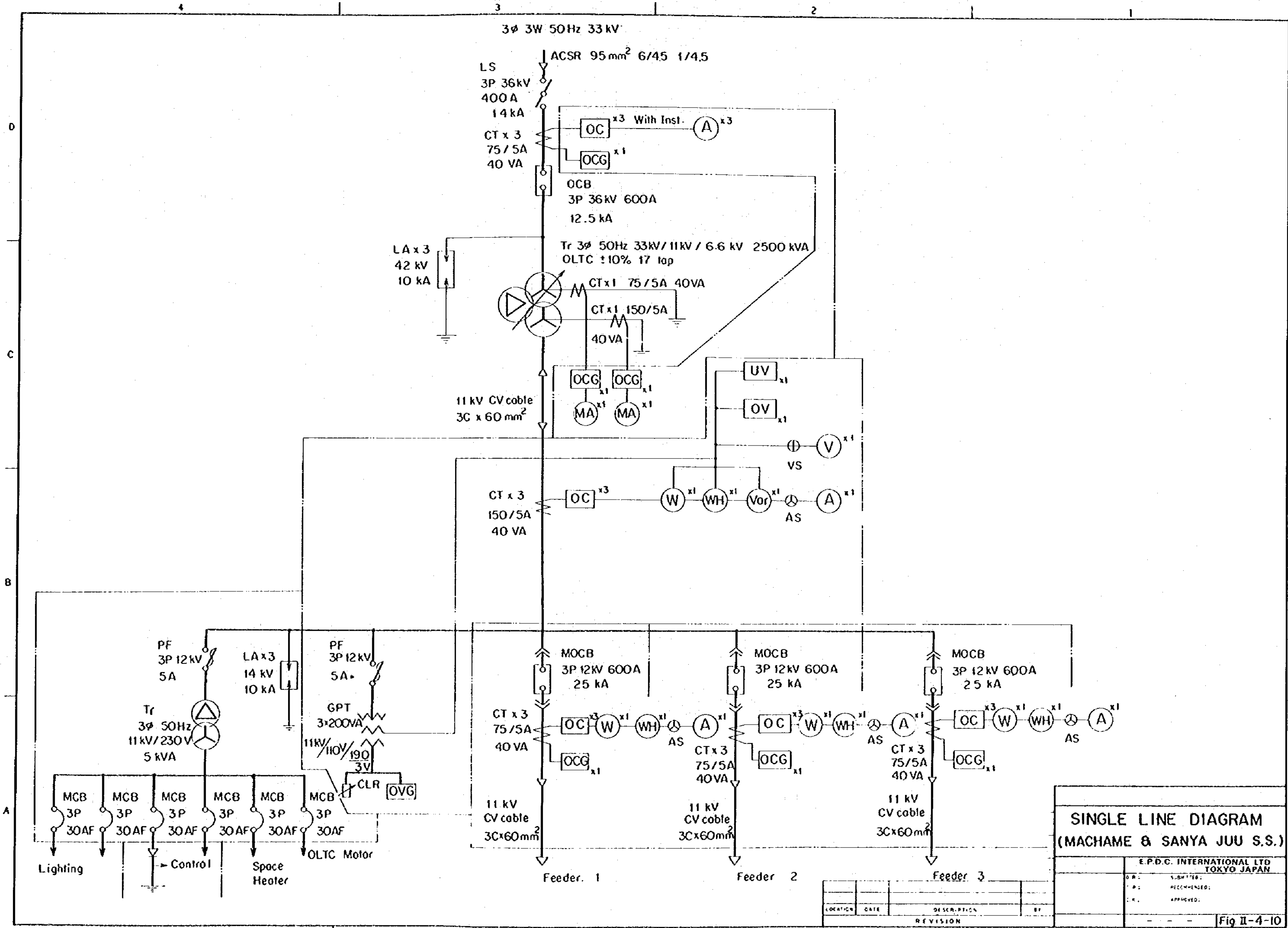
a. Equipments layout are standardized as much as possible for the purpose of prompt and proper operation of equipments.

b. All the 11 kV side equipments which are frequently operated are kept in cubicles which are arranged in a straight line.

c. Circuit breakers and disconnecting switches have their electrical and mechanical interlock for the purpose of preventing misperceiving as well as mis-operation.

d. The 33 kV disconnecting switches are mounted on stands for the convenience of maintenance and operation.

e. All the distribution boards and 11 kV switch-gear are designed to be contained in outdoor type cubicles; by saving construction of a building for this purpose.



SINGLE LINE DIAGRAM
(MACHAME & SANYA JUU S.S.)

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TOKYO JAPAN

LOCATION | DATE | DESCRIPTION | BY
REVISION

Fig II-4-10

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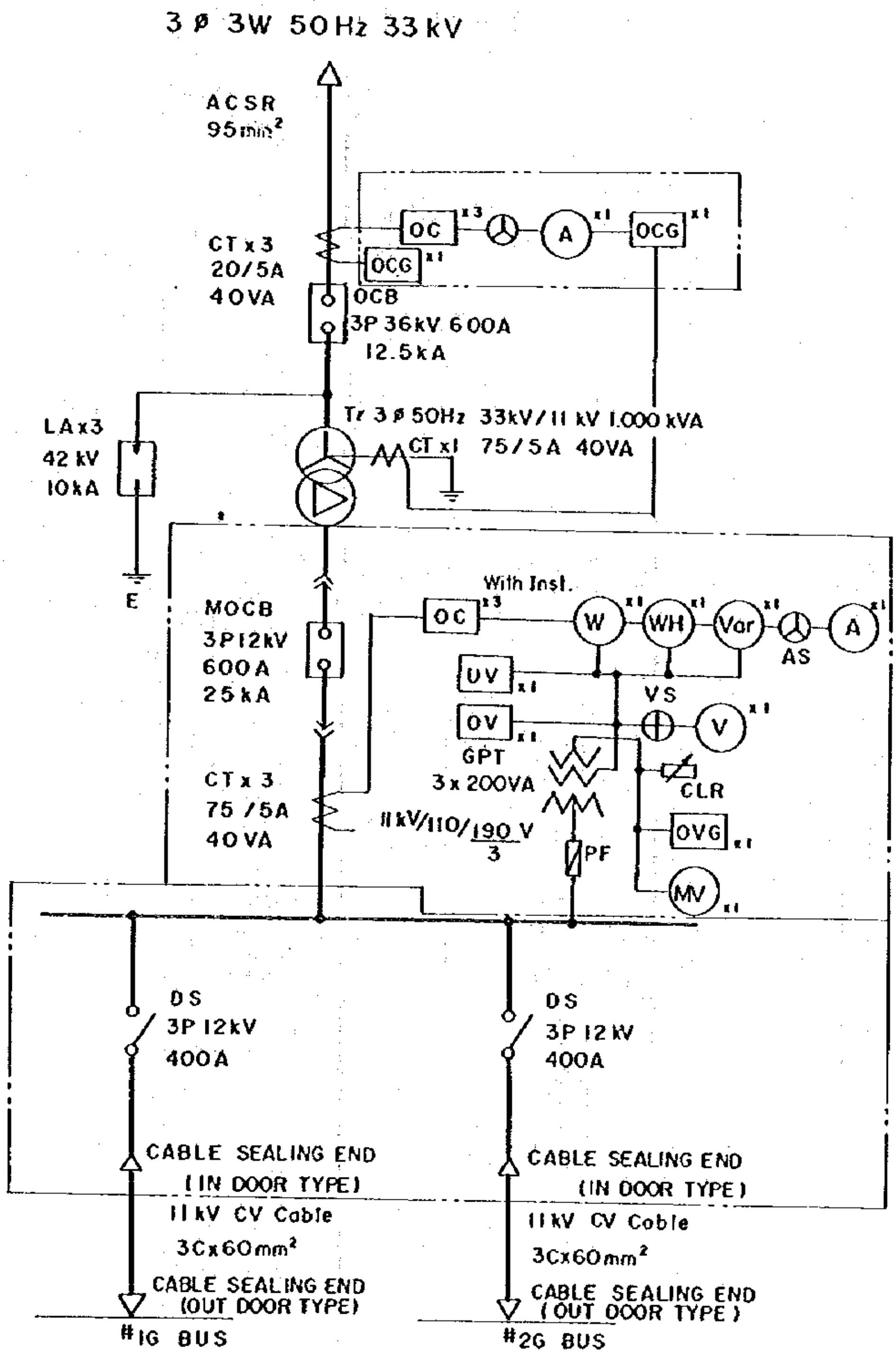


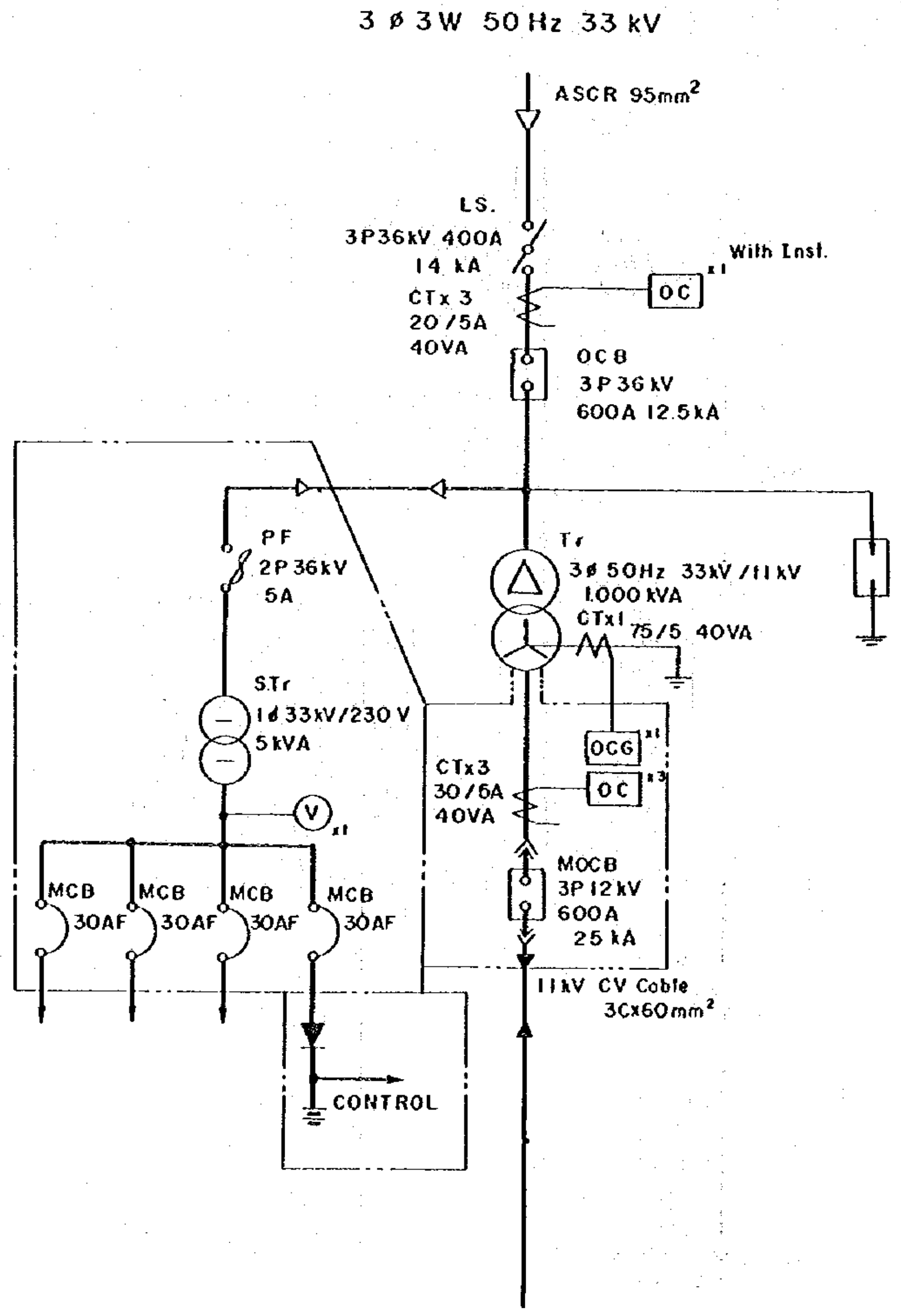
SINGLE LINE DIAGRAM
(NYUMBA YA MUNGU S.S)

EPDC INTERNATIONAL LTD
TOKYO JAPAN

LOCATION	DATE	DESCRIPTION	BY
REVISION			

Fig II-4-11

SHEET NO. OF



SINGLE LINE DIAGRAM (GONJA S.S)

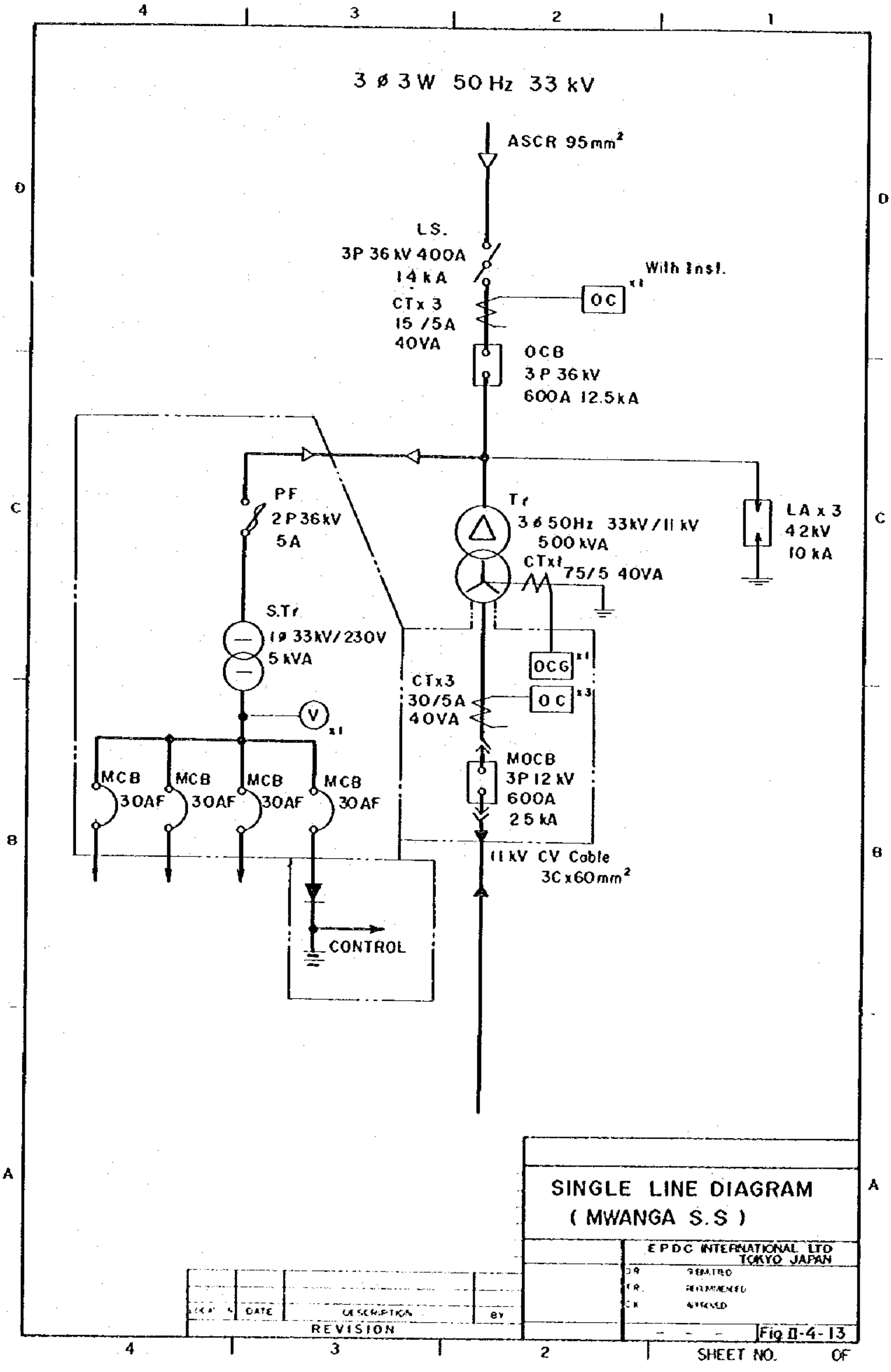
EPDC INTERNATIONAL LTD TOKYO JAPAN

LOCATION	DATE	DESCRIPTION	BY
REVISION			

DR. SUBMITTED
TR. RECOMMENDED.
CK. APPROVED

Fig. II-4-12

SHEET NO. OF


3 ø 3W 50Hz 33kV
ASCR 95mm²
LS.
3P 36kV 400A
14kA
With Inst.
OC
CTx 3
15 /5A
40VA
OCB
3P 36kV
600A 12.5kA
PF
2P 36kV
5A
Tr
3ø 50Hz 33kV/11kV
500kVA
CTx1 75/5 40VA
LA x 3
42kV
10kA
S.Tr
1ø 33kV/230V
5kVA
V
OCG
OC
CTx3
30/5A
40VA
MOCB
3P 12kV
600A
25kA
MCB
30AF
MCB
30AF
MCB
30AF
MCB
30AF
11kV CV Cable
3C x 60mm²
CONTROL
SINGLE LINE DIAGRAM
(MWANGA S.S)
EPDC INTERNATIONAL LTD
TOKYO JAPAN
DATE
DESCRIPTION
BY
REVISION
Fig II-4-13
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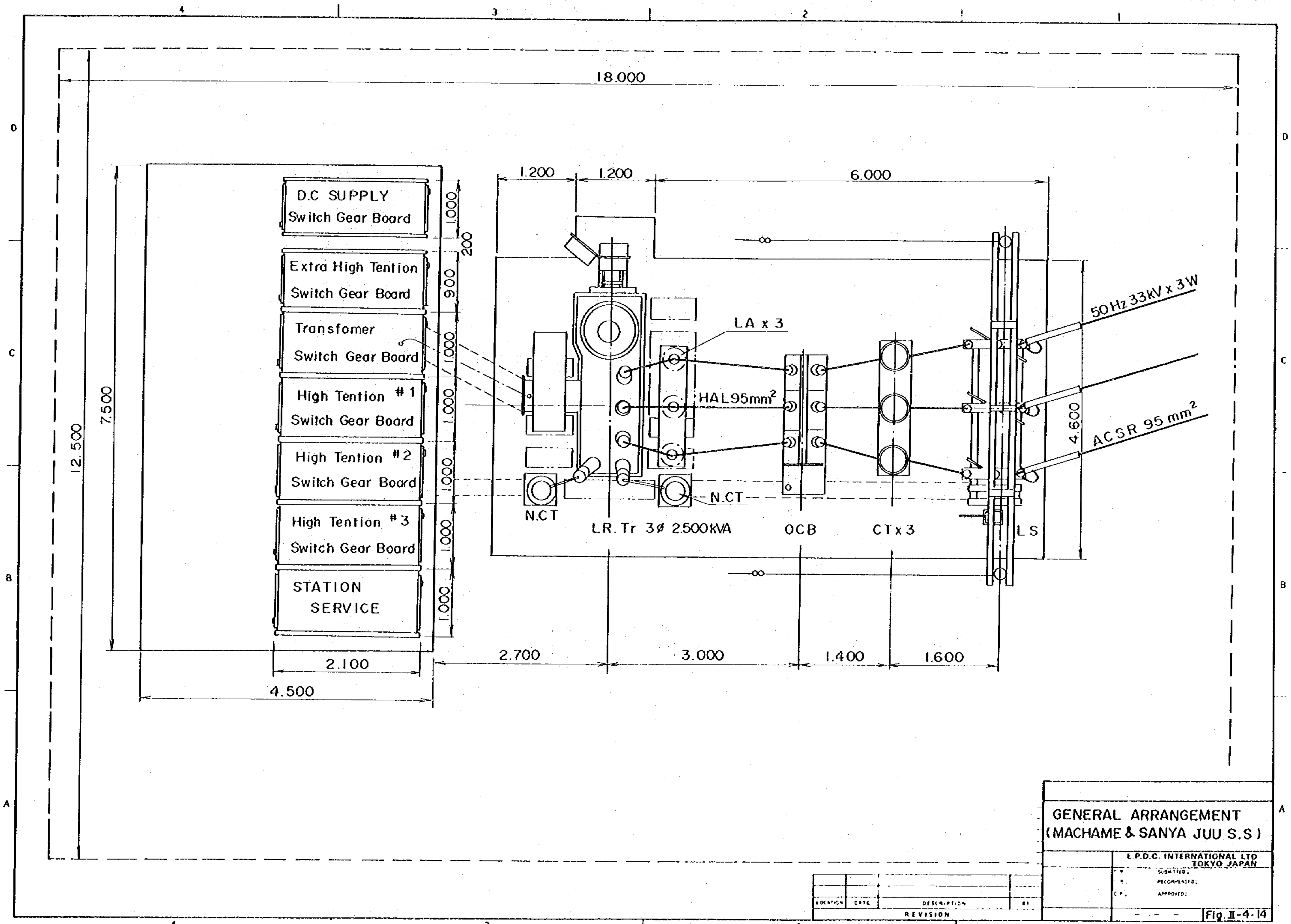
OF


18.000
12.500
7.500
D.C SUPPLY Switch Gear Board
Extra High Tention Switch Gear Board
Transfomer Switch Gear Board
High Tention #1 Switch Gear Board
High Tention #2 Switch Gear Board
High Tention #3 Switch Gear Board
STATION SERVICE
1.000
200
900
1.000
1.000
1.000
1.000
1.000
2.100
4.500
1.200
1.200
6.000
LA x 3
HAL95mm²
N.CT
N.CT
L.R.Tr 3ø 2.500KVA
OCB
CT x 3
LS
50Hz 33kV x 3W
ACSR 95 mm²
4.600
2.700
3.000
1.400
1.600
GENERAL ARRANGEMENT
(MACHAME & SANYA JUU S.S)
E.P.D.C. INTERNATIONAL LTD
TOKYO JAPAN
SUBMITTED:
RECOMMENDED:
APPROVED:
LOCATION
DATE
DESCRIPTION
BY
REVISION
Fig. II-4-14
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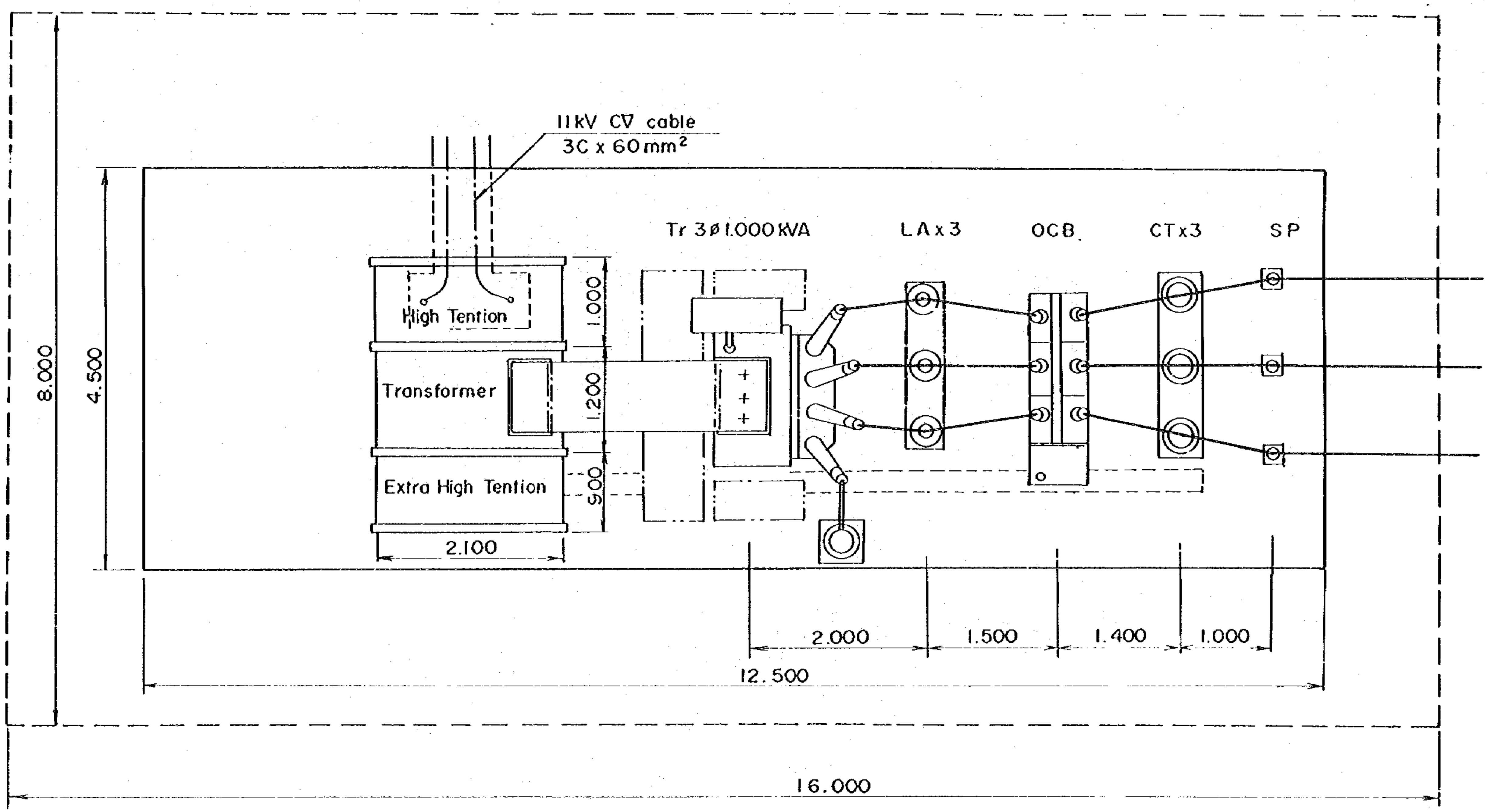
OF



GENERAL ARRANGEMENT
(NUMBAYA MUNGU S.S)

E.P.D.C. INTERNATIONAL LTD
TOKYO JAPAN

Fig. II-4-15

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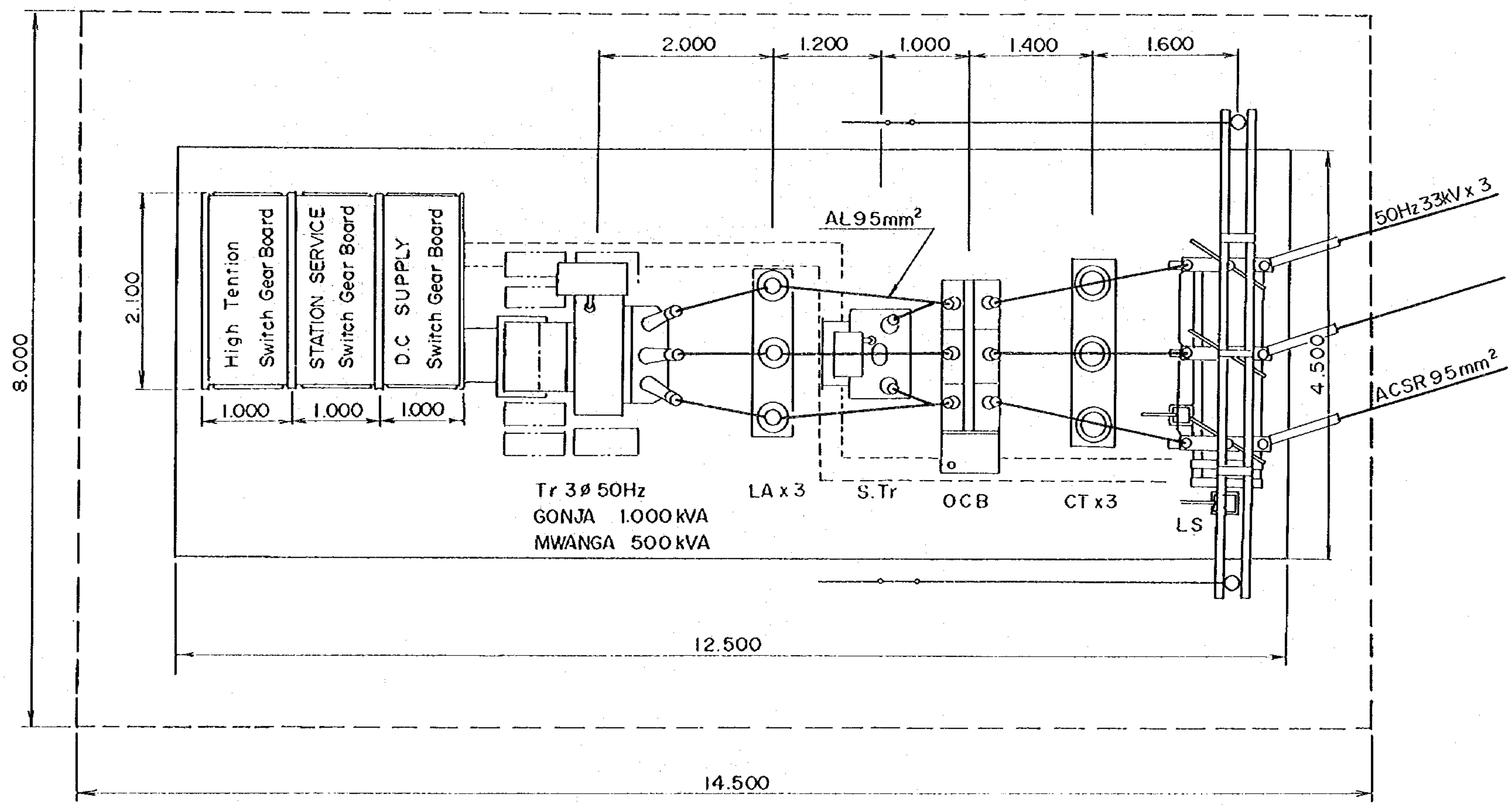


GENERAL ARRANGEMENT
(GONJA & MWANGA S.S)

E.P.D.C. INTERNATIONAL LTD
TOKYO JAPAN

LOCATION	DATE	DESCRIPTION	BY
REVISION			

D.R.: SUBMITTED:
C.R.: RECOMMENDED:
C.A.: APPROVED:

Fig. II-4-16

SHEET NO. OF

4.3.3 Specifications of Equipments

Specifications of main equipments are as follows:

(1) Main Transformer: JEC 168 – 1966 Transformer
JEC 186 – 1972 On-Load Tap Changer

Capacity, (kVA)	2,500		1,000		500	
Rating	continuous		continuous		continuous	
Phases	3		3		3	
Frequency (Hz)	50		50		50	
Cooling system	oil-immersed, self-cooling		oil-immersed, self-cooling		oil-immersed, self-cooling	
Rated Voltage	$33{,}000^V/11{,}000^V$		11,000V/ 33,000V	33,000V/ 11,000V	$33{,}000^V/11{,}000^V$	
Tap Voltage	±10% 17 taps		±5.0% 5 taps		±5.0% 5 taps	
Insulation Level	30A	10B	10B 30A	30A 10B	30A	10B
Connection, 1ry 2ry	Y Y	 3ry (Δ)	Δ Y	Δ Y	Δ Y	
Phase Displacement	0		330	30	30	
Polarity	subtractive		subtractive		subtractive	
Type of Use	outdoor		outdoor		outdoor	
Tap Changing	on-load		off-load		off-load	
Location Altitude	1000–1500m		1000–1500m		1000–1500m	
Number	2		1	1	1	

(2) Circuit Breaker: JEC 181 – 1971 A.C. Circuit Breaker

Rated Voltage	36 kV	12 kV
Insulation Level	30 A	10 B
Rated Current	600 A	600 A
Rated Frequency	50 Hz	50 Hz
Rated Breaking Current	12.5 kA	25 kA
Rated Breaking Time	5 cycle	5 cycle
Rated Closing Voltage	DC 110V (48V)	DC 110V (48V)
Rated Tripping Voltage	DC 110V (48V)	DC 110V (48V)
Standard Oper. Duty (class A)	0 – (1 min.) – co – (3 min.) – co	
Type of Use	outdoor	cubicle
Location Alt.	1000 – 500 m	
Max. Ambient Temp.	40°C	
Number	3	9

(3) Disconnecting Switch : JEC 165 – 1965 Disconnecting Switch

Rated Voltage	36 kV	12 kV
Insul. Level	30 A	10 B
Rated Current	400 A	400 A
Rated Short Time Current	14 kA	14 kA
Type of Use	outdoor	cubicle
Max. Temp.	40°C	40°C
Locat. Altitude	1000 – 1500 m	1000 – 1500 m
Operation	manual-remote	manual-remote
Number	5	2

(4) Current Transformer: JEC 143 – 1967 Current Transf.

Rated Voltage	33 kV	33 kV	33 kV
Insul. Level	30 A	30 A	30 A
Rated Current	75/5 A	20/5 A	15/5 A
Rated Burden	40 VA	40 VA	40 VA
Rated Over-current Strength	40	40	40
Accuracy Class	1.0	1.0	1.0
Number	6	3	6

(5) Arrestor: JEC 156 – 1963 Arrestor

Rated Voltage	42 kV	14 kV
Rated Frequency	50 Hz	50 Hz
Nominal Discharge Current	10,000 A	10,000 A
Max. Ambient Temperature	40°C	40°C
Location Altitude	1000 – 1500 m	1000 – 1500 m
Grounding System	solid ground.	solid ground.
Number	5	2

(6) Cubicle: JEM 1153 Cubicle

Rated voltage			11 kV		
Type of Use			Outdoor		
Max. Temp.			40°C		
Location Altitude			1,000 – 1,500 m		
Name of S.S	Machame	Sanya Juu	Nyumba Ya Mungu	Gonja	Mwanga
Name of Distrib. Board & Quantity					
Special High Tension	1	1	1		
Transformer	1	1	1		
High Tension	3	3	1	1	1
Station Power	1	1		1	1
Direct Current	1	1		1	1

4.4 DESIGN OF LOW TENSION DISTRIBUTION LINE

4.4.1 Design Standard

(1) Determination of Quantity of Low Tention Pole

(a) Load Forecast

Load forecast for the four districts resulted in 5624 customers and maximum power demand of 4308 kW including each tariff group of consumers, that is, T1 (Domestic), T2 (Commercial), T3 (Light industrial), T4 (Industrial) and T5 (Public lighting). Excluding demands covered by exclusively used transformers for use of power supply to plantations and so forth, the number of consumers and maximum power demand are reduced down to 5600 and around 2500 kW respectively.

(b) Load Density per Pole

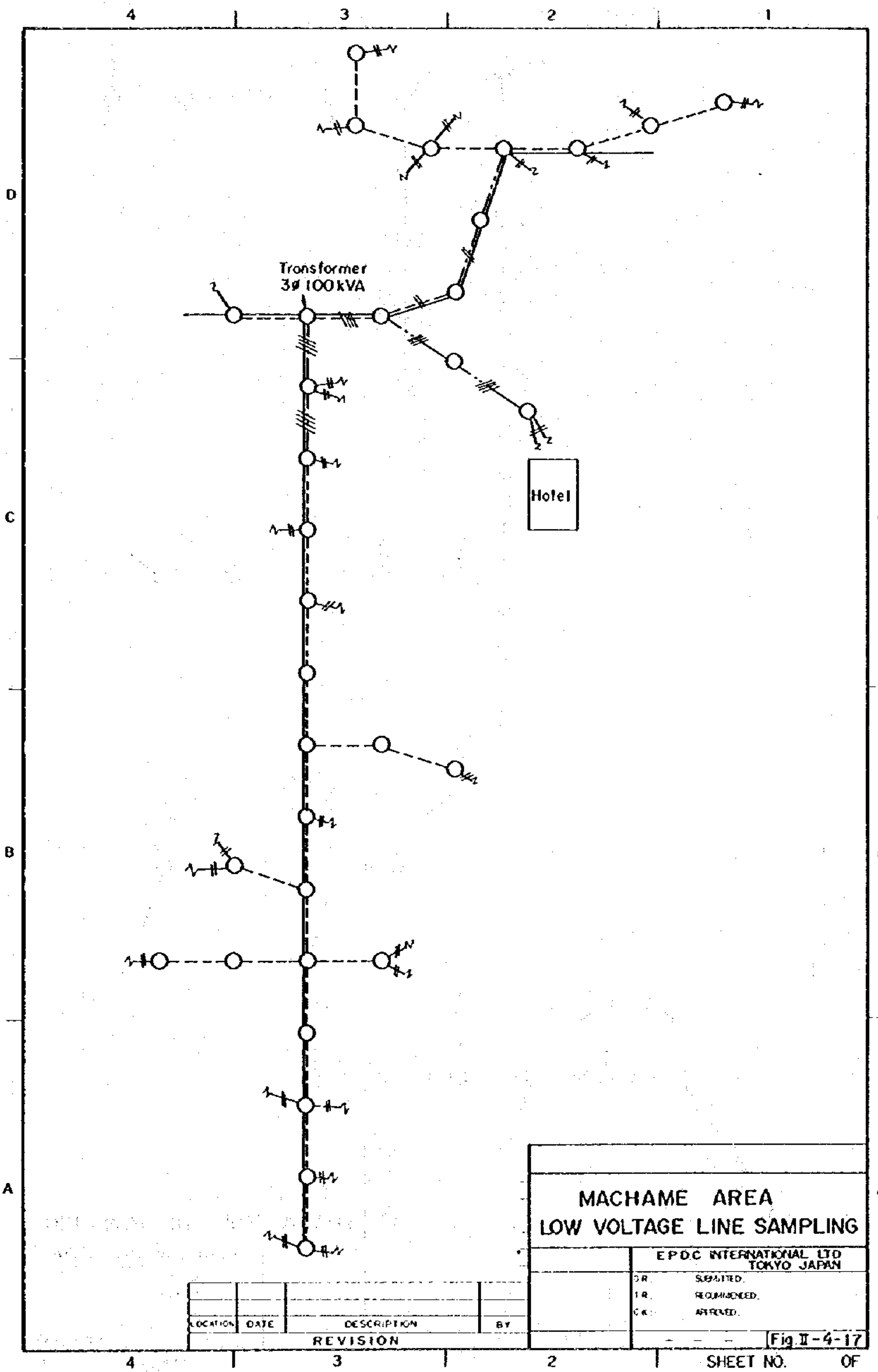
a. Load density per pole has been worked out based on data obtained from the investigation for an economical design.

b. As mentioned above, there are 5600 consumers with maximum power demand of around 2500 kW or 450 W per consumer. The average number of consumers per low tension pole has been computed to be 1.5 with expected demand increase and the result of the fact finding survey taken in to consideration. And the initial demand density has been computed to be 0.6 kVA per low tension pole on condition that the power factor and the diversity factor are 90% and 1.3 respectively (450 x 1/0.9 x 1/1.3 = 600 VA). A part of results of the fact finding survey is as follows;

Result of Fact Finding Survey

Area	Same	Machame
Transformer capacity	3ϕ 50 kVA	3ϕ 100 kVA
The number of consumers	Light 67 Power 2	Light 25 Power 2
Quantity of L/T pole	64	33
Maximum spans	25 spans	14 spans
Load distribution	Uniform	Uniform
Consumers per pole	1.08	0.82

Note: We deemed the actual capacity of the 100 kVA transformer installed near Machame Hotel to be 25 kVA because the remaining three-fourth of the transformer or 75 kVA is consumed by Machame Hotel.


Transformer
3ø 100kVA
Hotel
MACHAME AREA
LOW VOLTAGE LINE SAMPLING
EPDC INTERNATIONAL LTD
TOKYO JAPAN
LOCATION
DATE
DESCRIPTION
BY
REVISION
Fig.II-4-17
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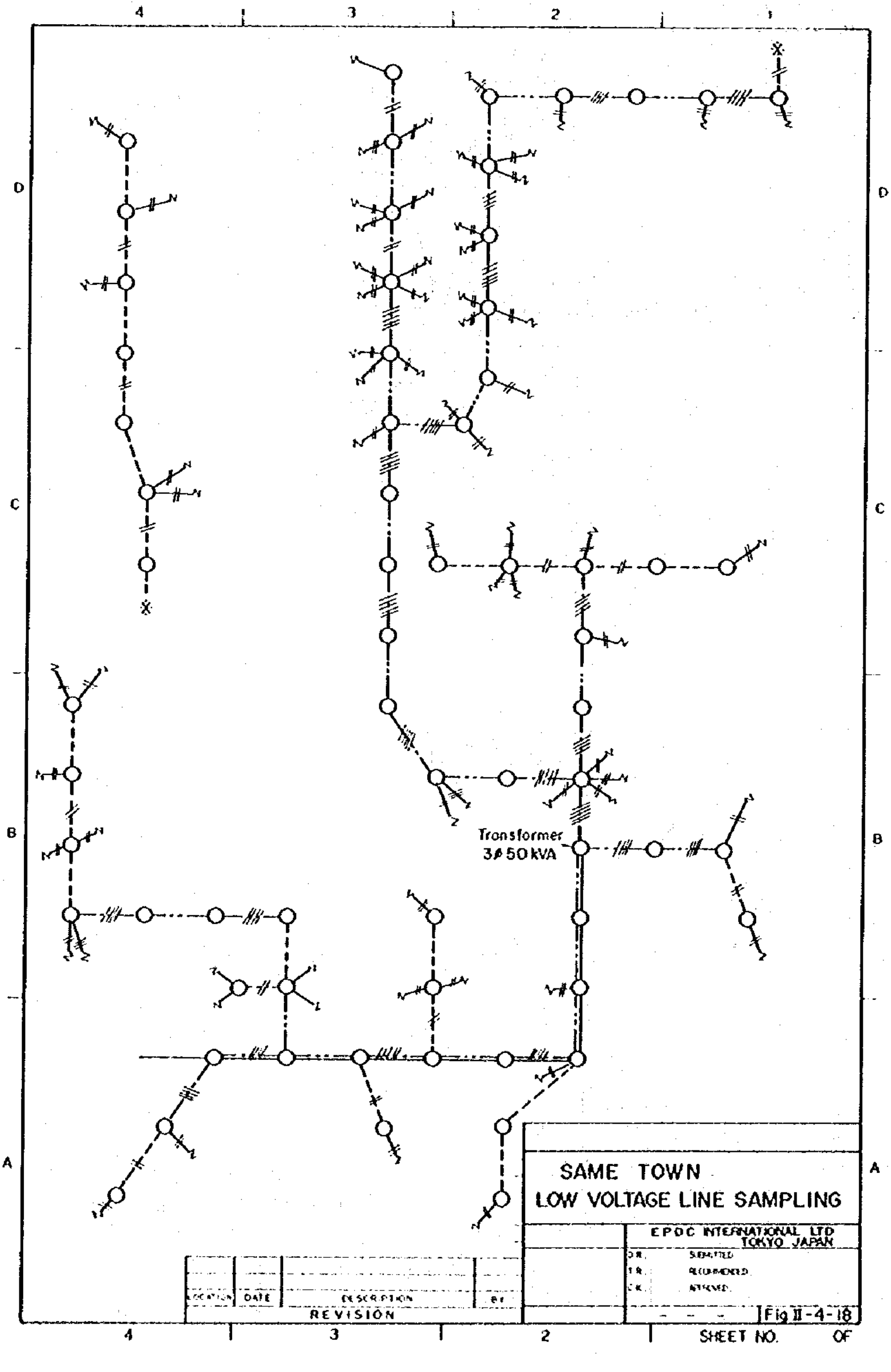


Transformer
3ϕ 50 kVA
SAME TOWN
LOW VOLTAGE LINE SAMPLING
EPDC INTERNATIONAL LTD
TOKYO JAPAN
REVISION
SHEET NO.
OF
Fig II-4-18

4.4.2 Scope of Low Tension Power Supply

(1) Power Supplying Scope of Transformer

The 25 kVA, 50 kVA and 100 kVA transformers which cover the general demands which require the secondary low tension distribution lines. The line length and the number of poles for the low tension distribution lines to supply the initial 5600 consumers with electric power have been computed from the demand density per pole and its growth rate. In addition, the initial utilization factor of transformers has been set up as 60%. The calculation of the power supplying scope of a transformer has been made for the 25 kVA and 50 kVA tranformers, which cover the ordinary consumers. For the 100 kVA transformers for combined use, we deemed the actual capacity to be 50 kVA because the remaining 50 kVA is to be consumed by large consumers located close to the poles.

The followings are calculations of power supplying scope of a transformer;

a. 25 kVA transformer

$$\frac{25\ \text{kVA} \times 0.6}{0.6\ \text{kVA /pole}} \fallingdotseq 24 \text{ poles or } 1.2 \text{ km (assume that one span is 50 m)}$$

b. 50 kVA transformer

$$\frac{50\ \text{kVA} \times 0.6}{0.6\ \text{kVA /pole}} \fallingdotseq 48 \text{ poles or } 2.4 \text{ km (assume that one span is 50 m)}$$

The outcome is that a 25 kVA transformer requires 24 poles and a 50 kVA transformer and a 100 kVA transformer for the conbined demands require 48 poles respectively.

(2) Required Number of Poles for Low Tension Line

Required number of poles for each transformer capacity is as follows;

Transformer capacity (kVA)	Nos.	Nos. of poles per trans.	Total Nos. of poles
25	35	24	840
50	40	48	1920
100	8	48	384
Total	83		3144

The total length of the low tension distribution lines for 3144 poles can be computed as below;

50 m/pole x 3144 poles = 157 km

In this Project, however, the total number of consumers has been deemed to be 1650, and the total line length to be 90 km that is about 60% of the calculated line length of 157 km. The total line length in each district is as follows;

District	Hai	Rombo	North P.	South P.	Total
Line length (km)	40	25	15	10	90

The total number of poles required for the line length of 90 km can be worked out as follows;

90 km ÷ 50 m/pole = 1800 poles

However, 25% of the above 1800 poles can be borne by high tension poles, therefore, the required number of poles for low tension distribution line is 1350.

(3) Number of Service Lines and WHM Installed

In the load forecast in Chapter 2, to estimate the demand of general domestic consumers, it was assumed that 8% of the present total number of households in the electrification area would be electrified taking into account various basic data, and the demand as a whole was grasped considering that this demand would materialize immediately after completion of the Project.

However, the number of general consumers estimated in this manner is 3,717, which makes up as much as 66% of the total number of consumers under this Project of 5,624. On the other hand, in the aspect of power demand, since the unit of demand is small, it amounts to only 15%. In effect, in computing the capacity of basic equipment, what are chiefly of influence are the large-capacity consumers who though small in number have large units of demand, in which case errors in the number of general consumers is not of consequence, but regarding facilities such as service lines and WHM which are required one to one for the number of customres, the accuracy of the number of general consumers has a direct influence.

Further, these types of facilities are of a nature that they would be installed by TANESCO upon applications by individual consumers after collecting installation cost charges, with the factor of the volition of individuals being large so that accurately grasping this is difficult both quantity-wise and timing-wise.

Therefore, as concrete quantities of service line and WHM facilities, separately from the figures deduced in a general manner in the load forecast, a more realistic way of thinking as described below is to be adopted and the number limited to that thought to be electrified without mistake.

T3, T4 Tariff	All 211 consumers
T2 Tariff	50% of 1,321 consumers, 660
(Note) Public facilities are included in the above, and roughly the entire number is thought to be covered by the above.	
T1 Tariff	20% of 3,717 consumers, 780

In effect, of the estimated total number of 5,624 consumers, the number to be budgeted this time is to be limited to 1,650, and the remaining 3,974 are considered to be installed by TANESCO on its own after completion of the Project on successively receiving applications.

4.4.3. Design of Low Tension Distribution Line

(1) Standard Span

The standard span length has been determined to be 50 m in accordance with the TANESCO's standard.

(2) Conductor Alignment

Vertical alignment of conductors has been employed on accounts of the following statements;

a. To reduce the frequency of short-circuit faults.

b. To make pole dressing simpler.

(3) Conductor for Use of Low Tension Distribution Line

As mentioned before, pole mounted transformers are located near the load centres. Two routes of the low tension distribution lines starting from one transformer have been designed to be constructed. Therefore, the conductor must have enough size to support half capacity of the transformer. The maximum voltage drop has been taken into consideration in selecting the following conductor sizes.

Capacity of trans.		25 KVA	50 KVA	100 KVA
Feeder 3ϕ 4W	Line	30 mm²	55 mm²	55 mm²
	Neutral	22 mm²	30 mm²	30 mm²
Branch	1ϕ 3W	22 mm²	30 mm²	30 mm²
	1ϕ 2W	22 mm²	30 mm²	30 mm²

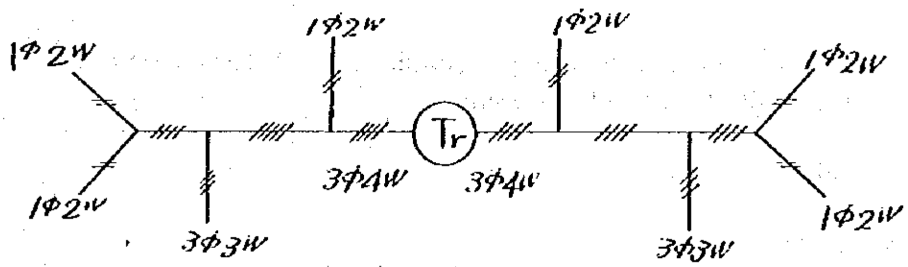
Conductor: Hard Aluminum Conductor

(4) The Line Length of Low Tension Feeder and Its Branch Line

The low tension distribution lines consist of feeders and their branch lines, and the proportion of the feeder length to the total line length is 50%. The 3ϕ 4-wire system for the feeder and the 3ϕ and/or 1ϕ 2-wire system for the branch line have been employed in this Project.

as per transformer

Transformer (kVA)		25	50	100	Amounts
Standard spans (Nos.)		14	28	28	1800
Standard line length (km)		0.7	1.4	1.4	90
Conductor length (km)	55 mm²		2.1	2.1	138
	30 mm²	1.05	3.5	3.5	93
	22 mm²	1.75			54



(5) Pole

Material : Pine tree
Length : 9 m
Dia. at top : 180 mm
Creosote treated

(6) Insulator

Shackle insulator: JIS C3845

(7) Hardware

D iron

(8) Stay

14 mm^2 galvanized steel strand wire: JIS G3537

(9) Bolt

M 12:100 mm, M 16:250 mm

The standard pole dressing is shown on Fig. II-4-19.

4.4.4 Design of Service Line and Street Lighting

(1) Electric System of Service Line

a. For lighting : 1ϕ 2-wire
b. For motor : 3ϕ 3-wire

(2) Conductor

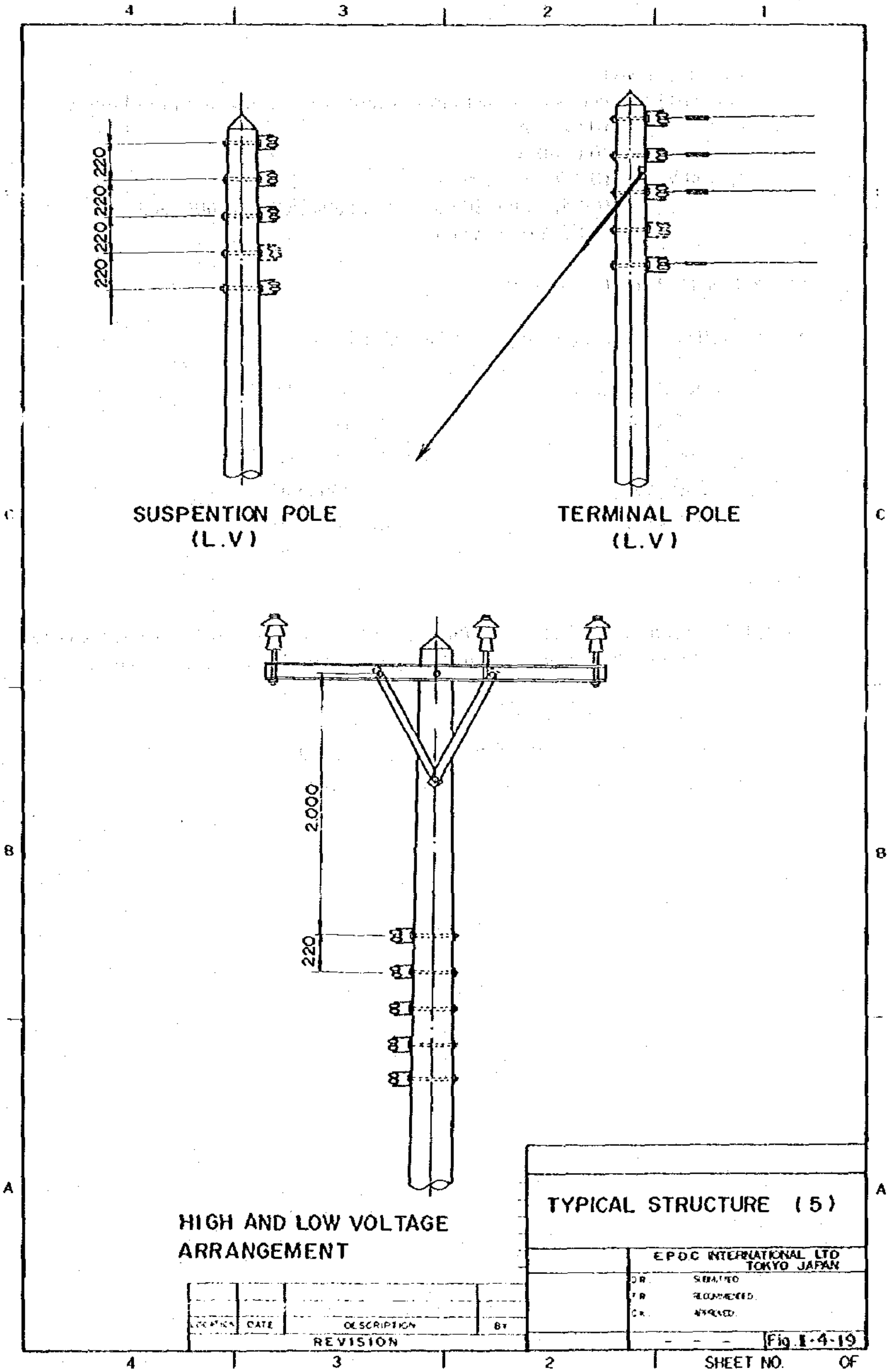
a. For lighting : 2.6 mm and 3.2 mm dia. DV wire
b. For motor : 2.6 mm and 3.2 mm dia. and 14 mm^2 DV wire
Note: DV is polyvinyl chloride insulated drop service wire.

(3) Length of Service Line

The average length of service wire per consumer has been determined to be 40 m in accordance with the result of the fact finding survey.

(4) Service Facilities

a. Service branch box
Service branch boxes to be secured on the D iron are to be provided to branch copper service wires off the low tension aluminum distribution lines to make T off constructions easy and secure.


SUSPENTION POLE
(L.V)
TERMINAL POLE
(L.V)
HIGH AND LOW VOLTAGE
ARRANGEMENT
220
2,000
TYPICAL STRUCTURE (5)
EPDC INTERNATIONAL LTD
TOKYO JAPAN
DATE
DESCRIPTION
BY
REVISION
Fig.II-4-19
SHEET NO.
OF

b. Watt-hour meter

The watt-hour meters with the following ratings are to be used in this Project.

1ϕ 230 V : 10 to 60 A
20 to 80 A

3ϕ 400 V : 10, 20, 25 and 50 A
100/5, 200/5, 300/5, 400/5, 500/5, 600/5, 700/5 and 800/5 A (with C.T.)

(5) Service Line for Large Consumers

The low voltage cable is to be employed for large consumers.

Transformer capacity	Size of cable
100 kVA	4C- 100 mm^2
200 kVA	4C- 150 mm^2
300 kVA	4C- 250 mm^2
500 kVA	4C- 400 mm^2

(6) Street Lighting

The lighting fixture employed in this Project for the street lighting has a 100 watts bulb, and this lighting fixture has been planned to be turned on and off by the timer switch.

The number of lighting fixtures

Hai	Rombo	North P.	South P.	Total
50	50	30	30	160

CHAPTER 5

CONSTRUCTION WORKS AND COST

CHAPTER 5 CONSTRUCTION WORKS AND COST

LIST OF TABLE

LIST OF FIGURE

CHAPTER 5 CONSTRUCTION WORKS AND COST

5.1 QUANTITY OF MATERIALS

The following Table II-5-2 represents material quantity required in the transmission and distribution line and substation construction works including the quantity of vehicles and so on for each district.

5.2 TRANSPORTATION AND CUSTODY OF MATERIALS

TANESCO is responsible for transportation and custody of materials for this Project except ocean freight. The transportation of these materials and arrangements of the local storehouses are requested to be done in a following manner.

5.2.1 Packing and Weight

Proper packing and crating are required to be done for freight and inland transportation. Water-tight sealed packing shall be necessarily required for meters, conductor connectors and so forth. The packing list of the major materials is represented in the following Table II-5-1.

5.2.2 Transportation of Materials

The total weight of all the materials used in this Project amounts to enormous weight of 3000 tons. Separate transportation of the materials into three times is necessary as construction schedule.

Pole carrier cars and trucks to be provided in this Project, railways and chartered large range trucks are necessary to be made avail of for the transportation between Dar-es-salaam and Moshi, 360 km. It probably takes three to six months in arranging railway service and large range trucks. The road between Dar-es-salaam to Moshi is paved all along the line and there will be no questions of bridges and so forth in the material transportation. While material transportation from storehouses in various districts to each site is planned to be done by construction vehicles provided in this Project, and it is desired to make access roads and/or to repair them, because there are some portion of the roads which are not paved.

5.2.3 Storehouse

Construction works are excuted simultaneously at each site. Stockyards must be constructed in each site for the purpose of keeping and arranging materials as the sites are far away with each other. The site offices and storehouses are planned to be constructed in the stockyards to keep materials, construction vehicles and tools. The stockyard shall be surrounded by fences. The following Table represents the area of each stockyard, which has been determined by judging the incoming material quantity.

District	Stockyard (m^2)	Storehouse (m^2)
Hai	2000	66
Rombo	1200	40
North Pare	1200	40
South Pare	1200	40

Table II-5-1 Weight of Materials

Item		Q'ty	Wt. tons	
Wooden Pole	9 m	1350 p.c.s.	303.8	Bare
	11 m	3190 〃	1158.0	
	12 m	400 〃	176.4	
	13 m	400 〃	236.0	
Conductor ACSR	95 mm²	947 km	451.0	Drum
Concuctor HA1	55 mm²	138 〃	26.6	
	30 mm²	93 〃	9.6	
	22 mm²	54 〃	4.4	
Wire DV	2.6 mm-F	43 〃	6.1	Bundle
	3.2 mm-F	5 〃	1.1	
	2.6 mm-F	10 〃	2.2	
	3.2 mm-F	9 〃	2.8	
Other Conductors		1 lot	5.0	
Pole Transformer		107 sets	67.9	Crate
Cross Arm	1500 mm	35 p.c.s.	0.5	Bundle
	2100 mm	2900 〃	58.0	
	2800 mm	2265 〃	72.5	
Insulator	LP-30 33 kV	4900 〃	78.4	Crate
	Pine 11 kV	4700 〃	23.5	
	Suspension	9200 〃	73.6	
	L-v Shackle	6510 〃	2.6	
Other Insulators		1 lot	2.4	
Arrestor	33 kV	102 p.c.s.	1.0	
	11 kV	219 〃	1.2	
A.B.S.	33 kV	5 sets	2.5	
O.S.	11 kV	16 〃	4.8	Crate
W.H.M.		1653 〃	6.9	
Other T/L materials		1 lot	50.0	
Main Transformer	2.5 MVA	2 sets	30.0	Bare
	1.0 MVA	2 〃	12.6	
	0.5 MVA	1 set	4.5	
Other S.S Materials		1 lot	33.7	Crate
Vehicle and Provisional Materials		1 〃	110.0	
	Total		3023.2 tons	

Table II-5-2 Power Equipment

Item	Specification			Hai	Rombo	North Pare	South Pare	Total
1. 33 kV Transmission line			km	30.5		27	65	122.5
2. 33 kV Distribution line			km		33			33
3. 11 kV Distribution line			km	95		30	27.5	152.5
4. 400/230 V L.T line			km	40	25	15	10	90
	33/.4/.23 kV	25 kVA		1	9		2	12
		50		2	11	1	2	16
		100		1	3			4
		200					1	1
		300				1		1
5. Pole mounted transformer	11/.4/.23 kV	25 kVA		9		9	5	23
		50		34		4	1	39
		100		6		1	1	8
		200					1	1
		300					1	1
		500		1				1
(Sub total)				(54)	(23)	(16)	(14)	(107)
6. Breaker switches	33 kV, 11 kV	100 A		12	2	4	3	21
7. Service lines with WHM				650	600	200	200	1,650
8. Street lights				50	50	30	30	160
	33/11 kV	2.5 MVA		2				2
9. Substation transformers	33/11 kV	0.5 MVA				1		1
	11/33, 33/11 kV	1 MVA				1	1	2
	Truck (7.0 ton)			$4^{2)*}$	$2^{1)*}$	$2^{1)*}$	$2^{1)*}$	$10^{5)*}$
10. Vehicles	Pickup type truck			2	1	1	1	5
	Pole carrier car			1		1		2
	Jeep				2			2

Note: * Truck with lifting crane.

5.3 WORKING PLAN

Inhabitant's longing for electrification is extremely strong and the earlier completion of this Project is strongly expected.

For the proper execution of this Project, the following means of construction and construction schedule are desired to be employed.

5.3.1 Method of Construction

This Project is executed under the direct management of TANESCO and carried out simultaneously in each district. The consultant assists and cooperates with TANESCO in procuring materials and promoting serial works concerning this Project such as specification writing work, tendering work, evaluation of tender documents, inspection at manufacturer's factories and after completion of this Project, adjusting delivery date of materials and supervision of the Project.

5.3.2 Project Organization

(1) Managing Formation

It is requested to assign a chief engineer, a site engineer to each site, an accountant and a store controller for a proper management. The Project organization is as shown in Fig. II-5-2. The chief engineer and site engineers are expected to solve the problem on the labour interchange, alignment of construction vehicles and procurement of materials and machinery for a smooth execution.

(2) Personel Affairs and Gang Constitution

Engineers and linesmen at Moshi Branch Office are engaged in another construction works and maintenance works in the Moshi Jurisdiction. And it is difficult to depend fully on them as man-power for this Project. Judging from the above situation, personel aid of engineers and labours from other districts must be taken into consideration. The number of staffs engaged in this Project is roughly estimated as follows;

Engineers	5
Foremen, linemen, mates	60
Casual labourers	150
Accountants, store controllers	10
Casual labourers for stockyard	10

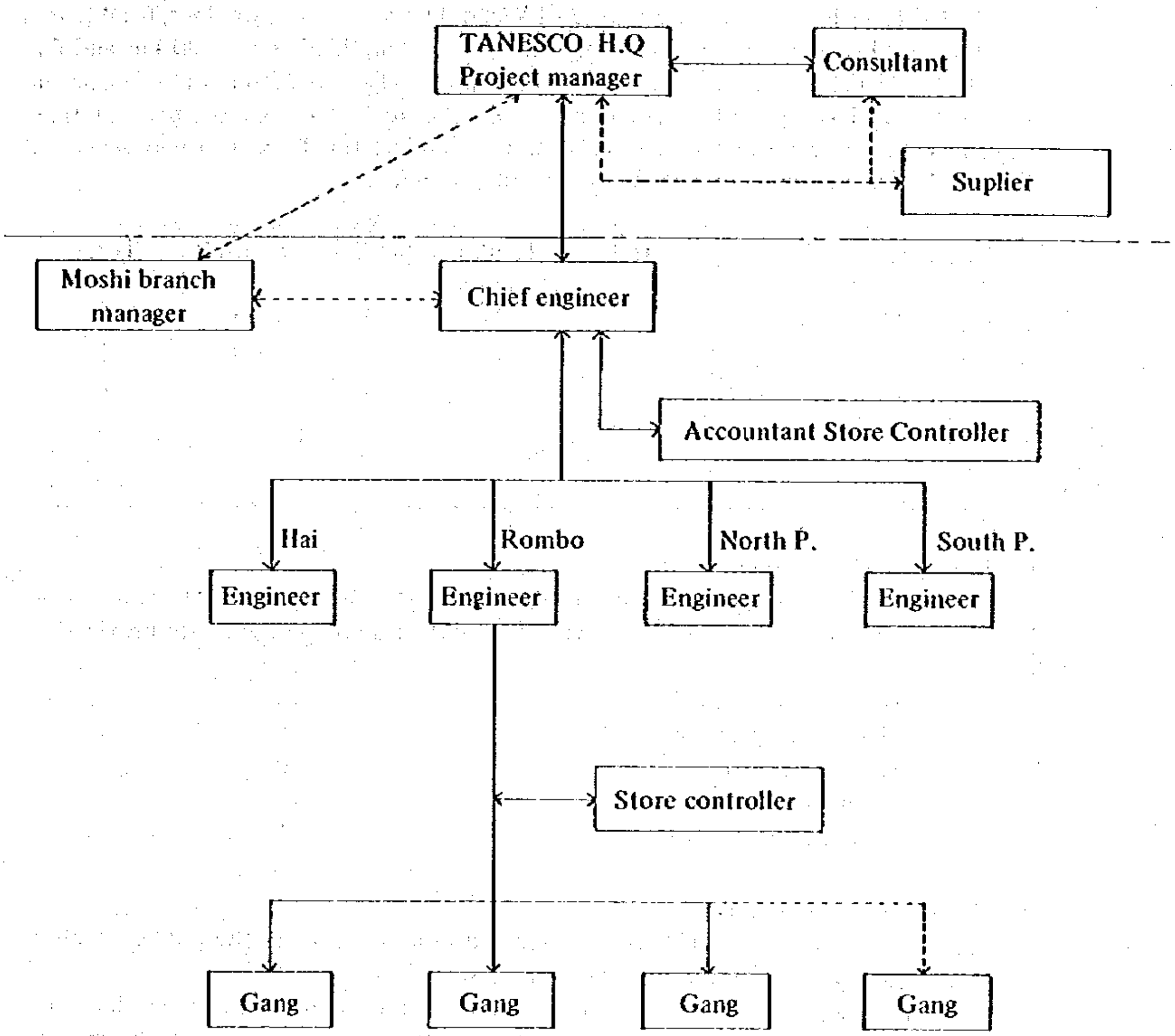
33 kV and 11 kV transmission lines are being executed under the direct management of TANESCO.

The standard gang constitution is as follows;

Constitution of a standard gang for T/L and D/L

Foreman	1
Linemen	4
Mates	4
Driver	1
Casual labourers	20

Fig. II-5-2 Project Organization



(3) Construction Vehicle and Tool

(a) Alignment of Vehicle

This Project has a large scale with 33 kV and 11 kV transmission lines, total length of around 300 km, low tension distribution lines, total length of around 90 km and five substations, and the weight of materials amounts up to 3000 tons. Material transportation, pole erection and equipment installation are planned to be machinized, because these works are of a major portion of this Project. To complete this Project in two years and three months, the following vehicles are necessarily provided.

<table>
<tr><th>District</th><th>Hai</th><th>Rombo</th><th>North P.</th><th>South P.</th><th>Total</th></tr>
<tr><td>Pick-up truck 2-tons</td><td>2</td><td>1</td><td>1</td><td>1</td><td>5</td></tr>
<tr><td>Truck 7-tons</td><td>2</td><td>1</td><td>1</td><td>1</td><td>5</td></tr>
<tr><td>Crane truck 7-tons with 3-tons-crane</td><td>2</td><td>1</td><td>1</td><td>1</td><td>5</td></tr>
<tr><td>Pole carrier 10-tons</td><td colspan="2">1</td><td colspan="2">1</td><td>2</td></tr>
<tr><td>Jeep</td><td></td><td colspan="2">2</td><td></td><td>2</td></tr>
</table>

(b) Provision of Construction Tool

Tools including stringing winches, handy manual winches, measuring instruments as well as compression joint tool which is vital for jointing aluminum wire are provided as follows:

1.	Hydraulic compression tool :	10
2.	Manual compression tool :	25
3.	Stringing winch :	50
4.	Manual winch :	10
5.	Metering appar. & others :	1

(c) Provision of Wireless Talkie

There seems to be no effective communication means such as the public telephone in the areas where this construction work is proceeded.

Therefore, wireless talkie for use of giving necessarily constructions are planned to be provided to secure communication means for an effective execution of the works. Five wireless talkie of 150 MHz and/or 400 MHz frequency bands are planned to be provided.

(4) TANESCO's Achievement of Similar Project

TANESCO has much experience of the similar electrification works such as electrification works in Same Town, about two years ago cooperated with by a German consultant and system rearrangement works in Arusha Town planned by TANESCO itself as well as electrification works in Moshi Town. Therefore, there are no fears in executing this Project.

5.3.3 Construction Schedule

As mentioned before, the earlier commencement and completion of this Project are desired by administrative authorities and inhabitants as well as TANESCO. The completion period is expected to be in the first half year in 1983. At this moment, the schedule of this Project is provisionally determined as shown in Table II-5-3.

5.4 CONSTRUCTION COST

Direct construction cost is computed, item by item, consisting of transmission lines, distribution lines, pole mounted transformers, low tension lines, service lines, street lighting facilities, substations, vehicles, tools, provisional equipments and spare parts as shown in Table II-5-4. Contingency, engineering fee and administrative expenses are added to the said direct cost to make the total construction cost for this Project.

5.4.1 Premise on Computation of Construction Cost

The followings have been regarded as conditions in working out the cost of major items such as material cost, labour cost, cost for inland transportation, contingency, engineering fee, administrative expenses, and CIF Dar es Sallam cost.

(1) Materials and Equipment Costs

A commodity price escalation of 13%/yr was taken into consideration and the costs were calculated for 1980 considered to be the time of contract award. The costs were calculated on the basis of CIF Dar es Salaam, and the costs of insurance and freight occupies 12% of the total costs. Import duties are not included.

(2) Labor Costs

Based on the prevailing standard estimation costs of TANESCO, the unit labor cost was set up taking into account escalation rate of 15% annually until the construction period, and compiling the required labor costs by type of work, the total was estimated.

Foreman	1,520 T.shs/month
Lineman	912 T.shs/month
Mate	760 T.shs/month
Driver	760 T.shs/month
Casual labour	26 T.shs/day

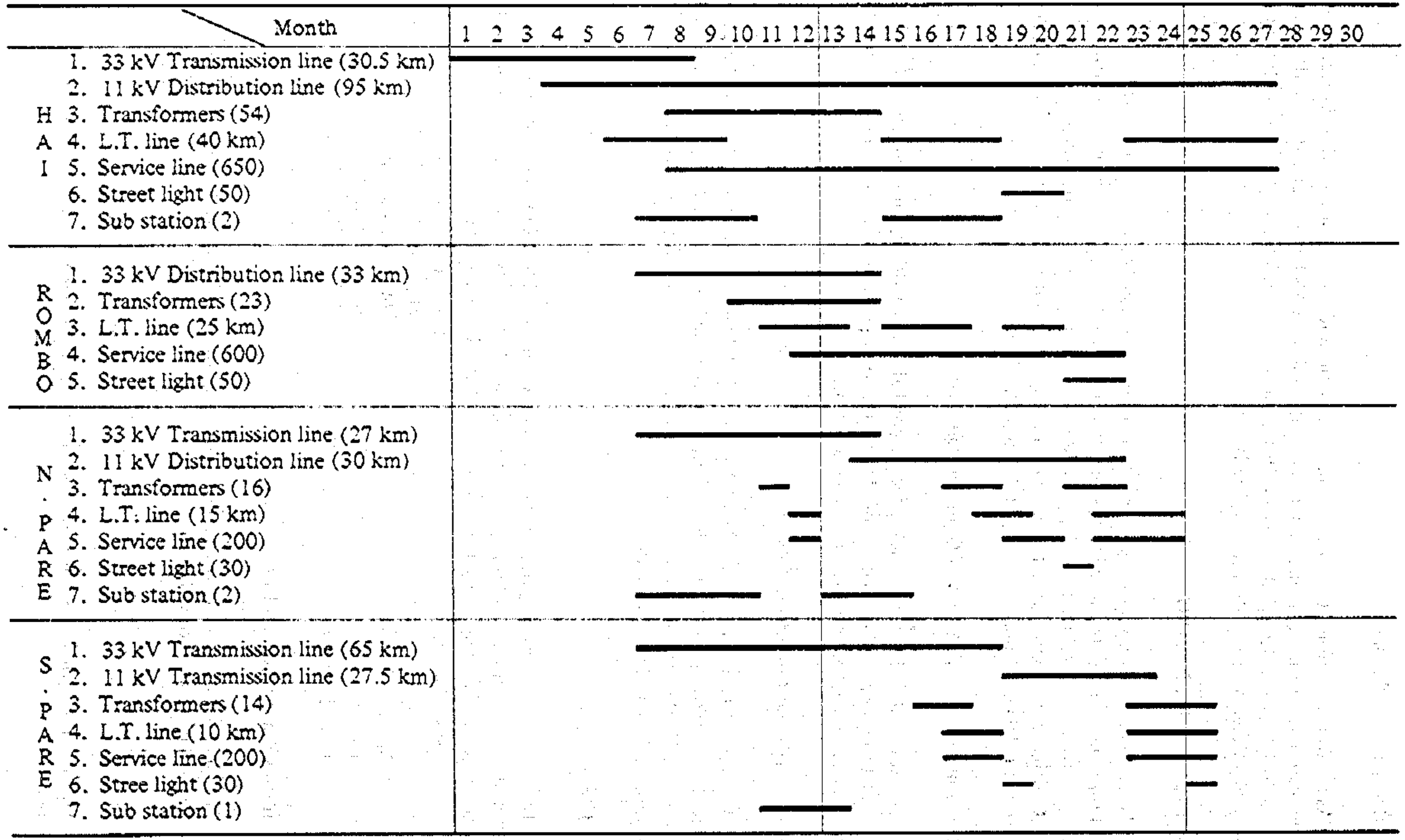
(3) Inland Transportation Costs

The inland transportation and insurance cost from unloading at Dar es Salaam Port to the site was calculated as 6% of CIF cost.

(4) Spare Parts

800 million yen has been estimated as spare parts cost for pole transformers and other apparatus.

Table II-5-3 Schedule of Construction



(5) Contingency Cost

The contingency cost was calculated as 10% for both of foreign currency portion and domestic currency portion.

(6) Engineering Fee

The engineering fee was calculated as 10% of total construction costs plus expenses of stay in Tanzania.

(7) Administrative Cost

Approximately 10% of the domestic currency portion of the direct construction cost was calculated.

(8) Conversion Rate ..... 1 T.sh = 25 Yen

5.4.2 Foreign Portion and Domestic Portion

The scope of foreign portion and domestic portion of the construction cost is as follows:

(1) Foreign Portion

(a) Materials
All the materials except underground brace, gravel, sand and cement
(b) Provisionnal equipment
Prefabricated office and storehouse
(c) Vehicles and tools
Major vehicles, special tools and measuring instruments
(d) Spare parts

(2) Domestic Portion

(a) Labour cost
(b) Cost for inland transportation
(c) Materials
Underground brace, gravel, sand and cement

(3) Indirect Cost

TANESCO's administrative expenses, engineering fee and constingency are necessarily separated into foreign portion and domestic portion, and are estimated as is required.

5.4.3 Total Construction Cost

The total construction cost are, as above-mentioned, computed by adding contingency, administrative expenses and engineering fee to the amount of direct construction cost. Table II-5-4 represents the result of the computation of the total construction.

Table II-5-4 Construction Cost (Total)

Item	Q'ty	Material		Construction		Inland Transport.	Total		
		F.C	D.C	F.C	D.C	D.C	F.C	D.C	Total
		10^6 Yen	10^3 T.shs	10^6 Yen	10^3 T.shs	10^3 T.shs	10^6 Yen	10^3 T.shs	10^6 Yen
33 kV Transmission Line	122.5 km	240			2,200	600	240	2,800	310
33 kV Distribution Line	33 km	83			660	200	83	860	105
11 kV Distribution Line	152.5 km	270	40		2,740	560	270	3,340	354
Pole Mounted Transformer	107	101			260	280	101	540	115
L.V Line	90 km	90			1,500	280	90	1,780	134
Service Line	1,650	25			250	80	25	330	33
Street Light	160	4			20		4	20	4
Substation	5	153			1,010	360	153	1,370	187
Vehicles & Tools		74					74		74
Temporary Facilities		5					5		5
Spare Parts		8					8		8
Survey & Measuring					3,140			3,140	79
Construction Administration					2,360			2,360	59
(Direct Cost)		(1,053)	(40)		(14,140)	(2,360)	(1,053)	(16,540)	(1,467)
Contingency							105	1,654	146
Engineering Fee							180	520	193
Administrative Expenses							20	1,000	45
(Total)		(1,053)	(40)		(14,140)	(2,360)	(1,358)	(19,714)	(1,851)

Note: a conversion rate of 1 T.shs = 25 yen was used for calculation.

CHAPTER 6

FINANCIAL ANALYSIS

CHAPTER 6 FINANCIAL ANALYSIS

LIST OF TABLE

CHAPTER 6 FINANCIAL ANALYSIS

When undertaking financial analysis, two points should be kept in mind. Firstly, it is to judge whether the proposed rural electrification plan is financially feasible through analysis on TANESCO's financial conditions for the last six years. It is apparent that expanded investment at times of financial difficulty worsens the financial conditions temporarily even though the investment may be profitable.

Secondly, it is to evaluate the proposed rural electrification plan whether it is profitable to TANESCO.

As a rule, project evaluation is carried out at several levels according to it purpose. Project evaluation discussed in this chapter is carried out at the level of an individual-profit-making enterprise, namely, TANESCO, therefore, all external effects are disregarded, and all goods and services are evaluated by the market price.

Project evaluation of an individual-profit-making enterprise, that is, financial analysis generally goes through the following process. First, i) the time series value of income and expenditure with market price denominations is estimated and ii) they are transformed into present values and iii) evaluated with one of the available appraisal standards. To be exact, the results obtained should be regarded as random variables because the figures used in calculation are based on several estimations. Therefore, the assessed value should also be understood as random variables and should not be considered as perfectly accurate. This creates need for iv) sensitivity analysis, which shows how the results change when a change occurs in the key parameter employed for simplification; and also for estimation and analysis on probability distribution of the assessed value, to be even more accurate. Finally, v) a fund (repayment) plan should be conceived if the Project depends on external funds.

In this chapter, the general analysis methods are followed in the process of analysis.

Here, it should be noted that the evaluation period of this Project is set to be for 25 years considering the durable years of the facilities.

6.1 ANALYSIS OF INCOME

(1) Demand for electricity

a. The results of electricity demand estimation in chapter 2 are quoted (Table II-2-7, 15).

b. Although the construction is still under way in 1982, 25% of 1985 demand is estimated for this year because there will be some areas with completed construction.

(2) Sales Unit Price

a. For the initial demand, the average unit price is calculated through a weighted average after calculating the potential load of planned districts (load forecast basic data) according to the tariff and the energy consumption.

Tariff	1 ;	1.45 T shs.	(0.48) T.shs.
	2 ;	2.10	(1.45)
	3 ;	0.80	(0.71)
	4 ;	0.65	(0.26)
	5 ;	0.75	(0.75)

* The figures in parentheses are the 1978 performance record at Moshi Branch.

b. For a later average unit price, some decrease is assumed as the energy consumption per consumer increases. Here, an average unit price is obtained by balancing the weight between the new subscriptions and present subscriptions through placing the average unit price of initial demand on the former and the average unit price varied according to the demand growth rate on the latter.

c. For the number of new subscriptions, 50% of the increase in energy consumption is assumed to be due to the new subscribers and their energy consumption per consumer to be always equivalent to the initial demand; therefore, the number of new subscriptions can be obtained at a certain time by:

$$\frac{\text{1/2 increase in energy consumption}}{\text{average energy consumption amount per consumer to initial demand}}$$

d. If R_{t-1} is set to be the demand growth rate during a certain period (t-1), the average energy consumption of present consumers at a certain time can be obtained through:

$$E_t = E_{t-1} \times \left(1 + \frac{R_{t-1}}{2}\right)$$

The average unit price of a certain period now can be obtained through cumulative calculation from the first year. The average unit price during n period is obtained by:

$$\frac{Co \cdot Nn + C_1 \cdot Nn\text{-}_1 + C_2 \cdot Nn\text{-}_2 + \ldots\ldots + C_n \cdot No}{No + N_1 + \ldots\ldots + N_n}$$

Note: Ni: number of new subscribers at the period i

Ci: average consumers' unit price after i years of electrification

e. Estimation will be carried out on a total basis not by a cumulative system after 1994; therefore, average unit prices after 1993 are left out.

f. Yearly sales unit prices obtained through above calculation are shown on Table II-6-1.

Table II-6-1 Yearly Sales Unit Price*

(Unit: T. shs.)

	T-1	T-2	T-3	T-4	T-5	Total
1982 ~ 85	1.45	2.10	0.80	0.65	0.75	
86	1.19	2.07	0.75	0.51	|	0.89
87	1.16	|	|	|	|	0.88
88	1.12	|	|	|	|	0.87
89	1.10	|	|	0.50	|	0.86
90	1.08	|	0.74	|	|	0.85
91	1.06	|	|	|	|	0.84
92	1.04	|	|	0.49	|	0.83
93	1.03	↓	↓	↓	↓	0.83
94						0.81
95						0.81
96						0.80
97						0.79
98						0.78
99						0.77
2000						0.76
1						0.75
2						0.74
3						0.73
4						0.72
5						0.71

*1978 Moshi Branch performance record ..... 0.57 T. shs./kWh

6.2 COST ANALYSIS

6.2.1 Construction Cost

(1) Initial Construction Cost

The construction cost of the proposed Project is assumed to be the initial construction cost and presented on Table II-5-4 in Chapter 5.

(2) Additional Construction Cost

As demand increases, facilities in the planned districts are assumed to be expanded. The cost required for the expansion is assumed to be additional construction cost and presented as follows.

a. Pole Mounted Transformers

–The capacity of transformers is determined to be 60% for the initial load, and the maximum capacity is assumed to be achieved in the 10th year. To meet the need likely to be presented by some of the transformers, 3% of the initial investment is estimated in the 7th year, 4% in the 8th year, and 5% in the 9th year as additional investment. After the 10th year, transformers with capacity to meet the increase in demand yearly are to be installed disregarding potential capacity.

–Average Unit Price of Transformers: 15 thousand yen/KVA.

b. Low-tension Line, Service Line

–Among items of initial potential demand, work for low-tension line 67km and service line of 3,652 consumers, is to be carried out in two years of 1983~84.

–For the later additional construction, facilities are to be expanded according to increase in demand (kW). The number of constructions is calculated using the following figures with assumption that 1/2 of increased kW is taken care of by the expansion of facilities.

(low-tension line)	0.027 km/increased kW
(service line)	increased kW/increased kW per consumer

We set increased kW per consumer as follows:

1985~1990	0.8 kW
1991~2000	0.9 kW
2001~2005	0.95 kW

–Construction unit prices used for calculation are as follows:

low-tension distribution line	1,330 thousand yen/km
service line and meter	18 thousand yen/consumer

c. Substations

Additional construction cost calculated based on the results of demand estimation for the year each substation achieves its maximum load is as follows:

Substation	Year of Expansion	Capacity	Additional Construction Cost
Mwanga	1992	500 kVA	21^6 Yen
Sanya Juu	1996	2,500 kVA	42^6 Yen
Gonja	2001	1,000 kVA	22^6 Yen
Nyumba Ya Mungu	2001	1,000 kVA	24^6 Yen
Machame	2003	2,500 kVA	42^6 Yen

d. Yearly additional construction cost obtained through above calculation methods is shown on Table II-6-2.

6.2.2 Operating Expenses

a. For administration cost, 1% of cumulative construction cost is estimated.

b. For maintenance repairs cost, 1.3% of cumulative construction cost is estimated from 1986 on.

c. Purchased Energy Cost

The proposed Project receives its power supply from the Coastal Grid System as its power source; 23 T.cents per 1 kwh is estimated as purchased energy cost according to the performance record of TANESCO's Financial Manager's Report and Utility rates in the Feasibility Study.

Table II-6-2 Yearly Additional Construction Cost

(Unit: 10^3 Yen)

Year	Pole Mounted Trans former	Low-tension line	Service Line	Substation	Total
1983		44,556	32,865		77,421
84		44,557	32,868		77,425
85		3,411	1,368		4,779
86		3,771	1,513		5,284
87	1,163	6,554	1,512		9,229
88	1,553	7,847	1,656		11,056
89	1,943	8,779	1,656		12,378
1990	1,725	4,489	2,034		8,248
91	1,875	4,848	2,214		8,937
92	2,025	4,666	2,124	21,000	29,815
93	1,952	5,206	2,359		9,517
94	2,175	5,387	2,447		10,009
95	2,250	5,746	2,593		10,589
96	2,400	5,925	2,701	42,000	53,026
97	2,475	5,925	2,680		11,083
98	2,475	6,643	3,025		12,143
99	2,775	6,823	3,115		12,713
2000	2,850	7,074	3,385		13,309
1	2,955	7,469	3,547	46,000	59,971
2	3,120	7,792	3,709		14,621
3	3,255	8,205	3,925	42,000	57,385
4	3,428	8,457	4,015		15,900

Table II-6-3 Income & Cost Flow by Year
(At market prices)

(Unit: 10^6 Yen)

	Construction Cost	Additional Construction Cost	Administration & Maintenance Repairs Cost	Purchased Energy C.	Sales Revenue
1980	514.5		5.1		
81	766.5		12.8		
82	531.6		18.1	11.2	48.5
83	38.4	77.4	19.3	32.7	129.3
84		77.4	20.1	38.7	161.5
85		4.8	20.1	44.6	193.8
86		5.3	46.4	48.0	186.2
87		9.2	46.6	51.0	196.0
88		11.1	46.8	54.2	206.0
89		12.4	47.1	57.7	216.3
90		8.3	47.3	61.4	227.2
91		8.9	47.5	65.4	239.8
92		29.8	48.2	69.7	252.1
93		9.5	48.4	74.2	266.8
94		10.0	48.6	79.1	280.2
95		10.6	48.9	84.3	295.0
96		53.0	50.1	89.7	310.1
97		11.1	50.4	95.4	326.0
98		12.1	50.6	101.5	342.6
99		12.7	50.9	108.0	360.0
2000		13.3	51.2	114.9	378.3
1		60.0	52.6	122.0	396.6
2		14.6	53.0	129.6	415.9
3		57.4	54.3	137.6	435.3
4		15.9	54.6	146.1	456.7

6.3 INTERNAL RATE OF RETURN

Currencies have time value. Income and expenditure brought about by a project have different points in time during the execution of the Project. Therefore, in order to indicate currency values of different points in time on the same scale, transformation of them into their present value by a proper discount rate is required.

The difference between the present value of benefit (income) and that of expenditure is termed as net present value; and the discount rate which sets net present value as zero is termed as internal rate of return (IRR).

Here, an internal rate of return is employed as the representative evaluation standard in examining profitability although tere are several evaluation standards for a project such as B/C ratio, payback period criteria as well as ones mentioned above.

The result of calculation for the internal rate of return of the proposed Project turned out to be 3.3%. The figure is lower than the interests on government securities of Tanzania (6.75% for 8-year bonds, 7.5% for 17-year bonds).

The results presented by financial analysis will show the nature of the Project. The rural electrification plan is a national project mainly geared for development of farming villages through introduction of various external economies by electrification.

6.4 SENSITIVITY ANALYSIS

Although it is better to estimate probability distribution of evaluation indicator and analyze expected value and distribution, sensitivity analysis as a simplified convenient method is employed to meet the problem of uncertainty.

Here, analysis is carried out by taking up some key parameters to see how an internal rate of return changes according to the changes in conditions under the supposition that other conditions are constant ceteris paribus.

6.4.1 Effects by Revision of Tariff and Construction Cost Change

(1) Revision of Tariff

The revision of Tariff has been carried out every two years, and the present one went into effect as of June, 1976; therefore, it is time for another revision. It has been reported that World Bank is asking for revision at the time of its investment for the KIDATU II Project, and TANESCO in itself is preparing for revision which is scheduled for this summer.

Here, the internal rates of return calculated in cases of a raise by 30% and 40% will be 9.8% and 11.1%, respectively.

(2) Change in Construction Cost

Some fluctuation for initial construction cost as well as for additional construction cost is anticipated depending on the level of inflation before the beginning of construction and on the change in conditions on which their estimation was also based. For initial construction cost, when the cost increases or decreases by 20% and 10%, the internal rate of return will have a range of 1.5% to 5.5%. As for additional construction cost, 20% and 10% change presents internal rate of return with a range of 2.8% to 3.6%. If 40% and 20% change is applied on administration and maintenance repairs cost, the internal rate of return will have a range of 2.1% to 4.3%. The results of calculation for internal rate of return with changes in sales revenue and construction cost are presented on Table II-6-6.

Table II-6-4 Financial Internal Rate of Return Estimation

CASH FLOW

YEAR	COST (I)	BENEFIT (I)
1	519.6	0.0
2	779.3	0.0
3	560.9	48.5
4	167.8	129.3
5	136.2	161.5
6	69.5	193.8
7	99.7	186.2
8	106.8	196.0
9	112.1	206.0
10	117.2	216.3
11	117.0	227.2
12	121.8	239.8
13	147.7	252.1
14	132.1	266.8
15	137.7	280.2
16	143.8	295.0
17	192.8	310.1
18	156.9	326.0
19	164.2	342.6
20	171.6	360.0
21	179.4	378.3
22	234.6	296.6
23	197.2	415.9
24	249.3	435.8
25	216.6	456.7
TOTAL	5231.8	6320.7

DIS. RATE (I) %	B/C RATIO (I) %	NET PV (I)	DIS. RATE (I) %	B/C RATIO (I) %	NET PV (I)
1	1.143	680.0	16	0.454	-1195.9
2	1.079	343.4	17	0.429	-1218.6
3	1.016	65.4	18	0.406	-1237.6
4	0.956	-164.9	19	0.385	-1253.2
5	0.898	-356.1	20	0.365	-1266.1
6	0.842	-515.3	21	0.347	-1276.6
7	0.790	-648.1	22	0.330	-1284.9
8	0.741	-759.2	23	0.315	-1291.5
9	0.695	-852.3	24	0.300	-1296.6
10	0.652	-930.3	25	0.287	-1300.3
11	0.612	-995.8	26	0.274	-1302.9
12	0.575	-1050.9	27	0.263	-1304.5
13	0.541	-1097.1	28	0.252	-1305.2
14	0.510	-1136.0	29	0.242	-1305.2
15	0.480	-1168.6	30	0.232	-1304.5

Table II-6-5 Change in Price Lists

(Unit: T. shs)

Tariff Group		Electricity Consumption (kwh)	Feb. '66	Sept. '72	Apr. '74*	July '76
No. 1	S 1	0 ~ 10	8.00	10.00	13.00	13.00
	2	10 ~ 20	–/80	–/80	1/05	1/05
	3	20 ~ 100	–/30	–/32	–/40	–/45
	4	100 ~ 500	–/18	–/20	–/25	–/35
	5	in excess of 500	–/12.5	–/15	–/20	–/30
No. 2	S 1	0 ~ 10	10.00	12.00	15.60	22.00
	2	10 ~ 20	1/00	1/20	1/55	2.25
	3	20 ~ 200	–/70	–/85	1/10	2.00
	4	200 ~ 1,000	–/50	–/65	–/85	1/50
	5	in excess of 1,000	–/25	–/40	–/50	1.00
No. 3	S 1	0 ~ 100	50.00	70.00	91.00	91.00
	2	100 ~ 500	–/50	–/60	–/80	–/80
	3	500 ~ 2,000	–/40	–/50	–/65	–/70
	4	2,000 ~ 5,000	–/25	–/35	–/45	–/65
	5	in excess of 5,000	–/15	–/25	–/35	–/55
No. 4	S 1	0 ~ 10,000	–/11	–/12	–/15	–/22
	2	10,000 ~ 20,000	–/10	–/11	–/15	–/20
	3	in excess of 20,000	–/ 9	–/10	–/15	–/18
No. 5						–/75

*Estimation of 30% raise in Sep. '72.

Table II-6-6 Change in Internal Rate of Return by Revision of Tariff and Construction Cost Change

Cost \ Sales Unit Price	Base	10% UP	20% UP	30% UP	40% UP
Base	3,259	4,745	6,166	7,403	8,546
Initial Construction Cost 20% DOWN	5,490	7,116	8,542	9,841	1,145
Initial Construction Cost 10% DOWN	4,306	5,815	7,276	8,543	9,719
Initial Construction Cost 10% UP	2,314	3,774	5,177	6,386	7,501
Initial Construction Cost 20% UP	1,451	2,887	4,287	5,471	6,562
Additional Construction Cost 20% DOWN	3,592	5,128	6,458	7,669	8,797
Additional Construction Cost 10% DOWN	3,428	4,885	6,314	7,537	8,672
Additional Construction Cost 10% UP	3,081	4,597	6,013	7,263	8,416
Additional Construction Cost 20% UP	2,825	4,445	5,795	7,120	8,283
Operation Cost 40% DOWN	4,339	5,730	7,074	8,259	9,363
Operation Cost 20% DOWN	3,758	5,289	6,594	7,789	8,904
Operation Cost 20% UP	2,619	4,245	5,625	6,870	8,119
Operation Cost 40% UP	2,102	3,711	5,217	6,513	7,699

6.4.2 Effects by Change in Demand

(1) Change in Growth Rate of Demand

a. Growth rates of demand are a parameter which affects cost, revenue, and various aspects of the proposed Project. Therefore, an internal rate of return, which is affected by growth rates of demand as well as its level of influence on construction cost, purchased energy cost, and sales revenue should be estimated.

b. For additional construction cost, since it depends on the maximum demand (kW), it is varied by variable factors. And as for load factors, the estimated rates are used as they are.

c. For administration and maintenance repairs cost is determined by cumulative construction cost, it is estimated according to the changes in additional construction cost.

d. For an average unit price, it is calculated according to the correlation found between the yearly average unit price, which were estimated upper the title of Analysis of Income (6.1), and energy consumption of that particular year.

e. The results of calculation on additional construction cost, purchased energy cost, total cost and sales revenue when the growth rate of demand increases or decreases by 10% and 20% according to the above method are shown on Table II-6-7~10. It is observed that as years go by, the ratio of change to initial estimated values become greater; on the average, when the rate of growth changes by 10%, there will be 5.6% change in additional construction cost, 6.7% in purchased energy cost, 2.9% in total cost and 5.1% in sales revenue.

f. As shown next, when the growth rate of demand increases by 10% and 20%, the internal rate of return will be 3.6%, 4.1%, respectively; and when it decrease by 10% and 20%, the IRR will be 2.8% and 2.4%.

Table II-6-7 Change in Internal Rate of Return by Change in Demand Growth Rate

Sales Unit Price / Demand Growth Rate	Base	10% UP	20% UP	30% UP	40% UP
Base	3,259	4,745	6,166	7,403	8,546
20% UP	4,065	5,560	6,877	8,188	9,329
10% UP	3,610	5,175	6,520	7,739	8,872
10% DOWN	2,804	4,396	5,734	7,036	8,192
20% DOWN	2,436	3,914	5,367	6,604	7,750

Table II-6-8 Change in Additional Construction Cost by Change in Demand Growth Rate

(Unit: 10^6 Yen)

Year	Base	20% DOWN	10% DOWN	10% UP	20% UP
1983	77.4	77.4	77.4	77.4	77.4
84	77.4	77.4	77.4	77.4	77.4
85	4.8	4.7	4.7	4.8	4.8
86	5.3	5.1	5.2	5.4	5.4
87	9.2	8.9	9.1	9.4	9.5
88	11.1	10.6	10.8	11.3	11.6
89	12.4	11.7	12.1	12.7	13.0
1990	8.3	7.7	7.9	8.6	8.9
91	8.9	8.2	8.6	9.3	9.7
92	29.8	27.0	28.4	31.3	32.9
93	9.5	8.5	9.0	10.1	10.6
94	10.0	8.8	9.4	10.6	11.3
95	10.6	9.2	9.9	11.3	12.1
96	53.0	45.7	49.3	57.0	61.5
97	11.1	9.4	10.2	12.0	13.0
98	12.1	10.2	11.2	13.2	14.4
99	12.7	10.6	11.6	13.9	15.3
2000	13.3	10.9	12.1	15.0	16.2
1	60.0	48.6	54.2	66.3	73.8
2	14.6	11.7	13.1	16.3	18.2
3	57.4	45.5	51.2	64.2	72.3
4	15.9	12.5	14.1	17.9	20.2

Table II-6-9 Change in Purchased Energy Cost by Change in Demand Growth Rate

(Unit: 10^6 Yen)

Year	Base	20% DOWN	10% DOWN	10% UP	20% UP
1982	11.2	11.2	11.2	11.2	11.2
83	32.7	32.7	32.7	32.7	32.7
84	38.7	38.7	38.7	38.7	38.7
85	44.6	44.6	44.6	44.6	44.6
86	48.0	47.3	47.6	48.3	48.7
87	51.0	49.7	50.4	51.7	52.4
88	54.2	52.2	53.2	55.3	56.4
89	57.7	54.9	56.3	59.1	60.7
1990	61.4	57.7	59.5	63.3	65.4
91	65.4	60.7	63.0	67.8	70.5
92	69.7	63.9	66.7	72.7	76.0
93	74.2	67.2	70.6	78.0	82.0
94	79.1	70.7	74.8	83.6	88.4
95	84.3	74.3	79.2	89.6	95.4
96	89.7	78.1	83.8	95.9	102.8
97	95.4	82.1	88.7	102.6	110.7
98	101.5	86.3	93.8	109.7	119.2
99	108.0	90.7	99.3	117.4	128.4
2000	114.9	95.3	105.0	125.6	138.3
1	122.0	100.1	110.9	134.2	148.5
2	129.6	105.1	117.1	143.3	159.5
3	137.6	110.3	123.6	153.1	171.3
4	146.1	115.8	130.5	163.5	184.0

Table II-6-10 Change in Total Cost by Change in Demand Growth Rate

(Unit: 10^6 Yen)

Year	Base	20% DOWN	10% DOWN	10% UP	20% UP
1980	519.6	519.6	519.6	519.6	519.6
81	779.3	779.3	779.3	779.3	779.3
82	560.9	560.9	560.9	560.9	560.9
83	167.8	167.8	167.8	167.8	167.8
84	136.2	136.2	136.2	136.2	136.2
85	69.5	69.4	69.4	69.5	69.5
86	99.7	98.8	99.2	100.1	100.5
87	106.8	105.2	106.1	107.7	108.5
88	112.1	109.6	110.8	113.4	114.9
89	117.2	113.7	115.5	118.9	120.9
1990	117.0	112.7	114.7	119.2	121.7
91	121.8	116.3	119.1	124.6	127.8
92	147.7	139.0	143.2	152.3	157.2
93	132.1	124.0	127.9	136.6	141.2
94	137.7	128.0	132.8	142.9	148.5
95	143.8	132.2	137.9	149.9	156.6
96	192.8	173.5	183.0	203.2	214.8
97	156.9	141.1	149.0	165.2	174.5
98	164.2	146.7	155.4	173.8	184.8
99	171.6	151.7	161.6	182.5	195.2
2000	179.4	156.9	168.1	192.2	206.4
1	234.6	200.5	217.3	253.6	275.9
2	197.2	168.9	182.7	213.1	231.7
3	249.3	208.9	228.5	272.2	299.3
4	216.6	181.7	198.6	236.7	260.3

Table II-6-11 Change in Sales Revenue by Change in Demand Growth Rate

(Unit: 10^6 Yen)

Year	Base	20% DOWN	10% DOWN	10% UP	20% UP
1982	48.5	48.5	48.5	48.5	48.5
83	129.3	129.3	129.3	129.3	129.3
84	161.5	161.5	161.5	161.5	161.5
85	193.8	193.8	193.8	193.8	193.8
86	186.2	182.9	184.1	186.4	187.5
87	196.0	190.8	193.1	197.3	199.7
88	206.0	199.0	202.5	209.0	212.5
89	216.3	207.7	212.2	221.2	226.1
1990	227.2	216.7	222.5	234.2	240.4
91	239.8	226.1	233.1	247.9	255.6
92	252.1	235.8	244.4	262.3	271.8
93	266.8	245.9	256.3	277.5	288.9
94	280.2	256.3	268.4	293.4	307.0
95	295.0	267.1	281.2	310.0	325.9
96	310.1	278.0	294.2	327.1	345.5
97	326.0	289.4	307.7	345.0	366.3
98	342.6	301.1	321.6	363.8	388.3
99	360.0	313.2	336.3	383.7	411.7
2000	378.3	325.8	351.4	404.7	437.0
1	396.6	338.5	366.8	426.6	463.3
2	415.9	351.7	382.9	449.9	492.1
3	435.8	365.1	399.4	475.1	523.7
4	456.7	379.4	417.0	502.6	559.3

6.5 FINANCIAL CONDITION OF TANESCO

(1) Financial Condition According to Balance Sheet

Balance sheet according to TANESCO's annual report (1977) is as follows.

Table II-6-12 TANESCO's Balance Sheet (1977)

	T. shs.	%
Assets (Debtor)	1,531,677,533	100.00
Current Assets	193,395,214	12.63
Cash in Hand and at Bank	2,488,914	0.16
Stock of Stores	60,945,698	3.98
Debtors	81,094,989	5.29
Prepayment and Deposits	671,198	0.04
Investments in Short Term Deposits	48,194,415	3.15
Fixed Asset	1,129,505,148	73.74
Capital Work in Progress	208,777,171	13.63
Liabilities + Capital (Creditor)	1,531,677,533	100.00
Liabilities	803,282,144	52.44
Current Liabilities	137,501,487	8.98
Sundry Creditors	112,436,794	7.34
Current Maturities of Long Term Loans	20,703,854	1.35
Taxation	4,360,839	0.28
Fixed Liabilities		
Deferred Taxation	90,904,000	5.93
Long Term Loans	595,590,511	38.88
Less Current Maturities of Long Term Loans	20,703,854	1.35
Capital	728,395,389	47.56
Share Capital	436,843,540	28.52
Advance Towards Share Capital	159,644,581	10.42
Capital Reserve	127,689,739	8.34
Currency Revaluation Reserve	--	--
Surplus	4,217,529	0.28

When the current ratio (current assets/ current liabilities) is studied it shows a percentage of 141, which is greater than that of Japanese power industry. The fixed assets ratio (fixed assets/ capital) shows 184%, which is smaller than that of Japanese power industry. The ratio of fixed assets to long-term capital (fixed assets/capital+fixed liabilities) shows 96%, which is less than 100%, therefore, is fairy in sound condition.

The ratio of capital to liabilities (capital/liabilities) has a percentage of 91; although it is not 100% but close to it. As for the ratio of current assets to fixed assets (current assets/fixed assets), it shows a percentage of 14.5, whose number is quite low but is at the level of Japanese power industry. The ratio of share capital to capital (share capital/capital) is 60%.

Table II-6-13 shows a balance sheet in time series. The quick ratio of quick assets to current liabilities is observed to be very low. Fixed assets grows from the year 1974 on. And capital work in progress has big figures especially in 1973 and in '74 due to the Kidatu Hydro Project phase I, which contributes to the growth of fixed assets after 1975. Growth of fixed liabilities is great also, and the figure for long-term loans grew 2.5 times in the last five years although its ratio to the whole grew smaller. As for capital, it grew 2.9 times in the last five years; share capital grew 3.4 times and its ratio to the whole grew some also.

Table II-6-13 TANESCO's Yearly Change in Balance Sheet

(1972 ~ 1977)	1972	1973	1974	1975	1976	1977
CURRENT ASSETS						
Cash in Hand and Bank	5,663,384	4,686,541	4,455,518	5,181,990	7,058,985	2,488,914
Stock of Stores	35,198,500	34,701,435	46,902,879	65,586,768	72,041,353	60,945,698
Debtors	19,629,012	22,051,108	31,173,757	40,391,886	62,264,837	81,094,989
Prepayment and Deposits	217,548	903,553	55,326	1,682,293	723,126	671,198
Investments in Short-term Deposits		6,476,600		15,862,000	13,360,950	48,194,415
	60,708,444	68,819,237	82,587,480	128,704,937	155,449,251	193,395,214
CURRENT LIABILITIES						
Sundry Creditors	23,352,214	40,689,653	84,659,158	62,710,964	86,731,168	112,436,794
Current Maturities of Long-term Loans			4,733,526	13,650,435	21,815,051	20,703,854
Bank Overdraft			7,596,868			
Taxation	15,698,404	17,113,443	6,681,512	2,786,922	2,542,579	4,360,839
	39,050,618	57,803,096	103,671,064	79,148,321	111,088,798	137,501,487
NET CURRENT ASSETS	21,657,826	11,016,141	21,083,584	49,556,616	44,360,453	55,893,727
FIXED ASSETS	254,003,850	257,178,031	259,982,657	1,021,631,870	1,007,966,090	1,129,505,148
CAPITAL WORK IN PROGRESS	254,066,356	415,969,754	706,718,572	112,428,510	204,679,950	208,777,171
	529,728,032	684,163,926	945,617,645	1,183,616,996	1,257,006,493	1,394,176,046
FINANCED BY:						
SHARE CAPITAL	126,528,080	181,164,040	249,452,580	336,941,680	379,767,540	436,843,540
ADVANCE TOWARDS SHARE CAPITAL	44,164,968	43,988,557	107,646,262	174,188,975	177,427,893	159,644,581
CAPITAL RESERVE	77,226,409	93,146,959	99,044,958	103,152,899	101,325,680	127,689,739
CURRENCY REVALUATION RESERVE	5,544,019	5,934,739	1,711,458			
SURPLUS	1,121,143	837,196	697,544	721,485	1,031,583	4,217,529
	254,584,619	325,071,491	458,552,802	615,005,039	659,552,696	728,395,389
SHAREHOLDER'S FUND						
DEFERRED TAXATION	32,227,000	35,226,000	41,909,500	59,909,500	67,000,000	90,904,000
LONG TERM LOANS	242,916,413	323,866,435	449,888,869	522,352,893	552,268,848	595,580,511
LESS CURRENT MATURITIES OF LONG TERM LOANS			4,733,526	13,650,435	21,815,051	20,703,854
			445,155,343	508,702,457	530,453,797	574,876,657
	529,728,032	684,163,926	945,617,645	1,183,616,996	1,257,006,493	1,394,176,046

Unit: T.shs.

(2) Financial Condition According to Income Statement

Income statement according to TANESCO's annual report (1977) is as follows.

Table II-6-14 TANESCO's Income Statement (1977)

	T. shs.	%
Sales of Energy	248,859,584	100.0
Cost of Sale	113,629,608	45.7
Administrative Expenses	46,534,518	18.7
Directors Fees	42,000	0.0
Auditors Remuneration	206,221	0.1
Interest	37,309,584	15.0
Exchange (Gain) Loss	(1,091,687)	0.4
Preinvestment Study Expenses	910,967	0.4
Non Operating Income	1,756,944	0.7
Non Operating expenses	5,985,371	2.4
Net Revenue before Taxation	47,089,946	18.9
Taxation	23,904,000	9.6
Net Revenue after Taxation	23,185,946	9.3
Provision for Development	20,000,000	8.0
Balance Brought Forward	1,031,583	0.4
Dividend	0	--
Surplus Carried Forward	4,217,529	1.7

Collective view of this is presented in Table II-6-15.

Table II-6-15 TANESCO's Yearly Change in Income Statement (1972 ~ 1977)

	1972	1973	1974	1975	1976	1977
SALE OF ENERGY	95,814,365	112,777,953	141,044,292	154,848,939	197,726,189	248,859,584
Less: COST OF SALES	38,895,025	46,507,322	90,881,580	85,084,385	94,813,952	113,629,608
GROSS INCOME	56,919,340	66,270,631	50,162,712	69,764,554	102,912,237	135,229,976
Less:						
ADMINISTRATIVE EXPENSES	14,136,883	17,611,963	25,926,979	35,447,730	39,823,572	46,534,518
DIRECTORS FEES	60,000	54,045	66,000	38,200	38,000	42,000
AUDITORS REMUNERATION	120,000	130,000	180,000	180,000	200,000	206,221
Interest	5,961,870	5,412,266	5,226,166	12,905,701	36,316,321	37,309,584
Exchange (Gain) Loss for Year	–	–	–	2,890,905	18,636,807	(1,091,687)
Pre-investment study Expenses written off	–	–	–	–	–	910,967
	20,278,753	23,208,274	31,399,145	51,462,536	95,014,700	83,911,603
OPERATING INCOME	36,640,587	43,062,357	18,763,567	18,302,018	7,897,537	51,318,373
Non Operating Income	1,517,734	3,332,665	813,687	2,150,357	2,910,082	1,756,944
Less: Expenses	–	(568,864)	(1,710,382)	–	(3,407,021)	(5,985,371)
	1,517,734	2,763,801	(896,695)	2,150,357	(496,939)	(4,228,427)
NET REVENUE BEFORE TAXATION	38,158,321	45,826,158	17,866,872	20,452,375	7,400,598	47,089,946
TAXATION:						
Provision for the Year	13,497,840	16,754,955	6,323,024	–	–	–
Deferred Taxation	2,224,000	2,999,000	6,683,500	18,000,000	7,090,500	23,904,000
Adjustments for pervious years	463,660	(252)	–	2,428,434	–	–
	16,185,500	19,753,703	13,006,524	20,428,454	7,090,500	23,904,000
NET REVENUE AFTER TAXATION	21,972,821	26,072,455	4,860,348	23,941	310,098	23,185,946
Less: Provision for Development	(14,000,000)	(15,000,000)	(5,000,000)	–	–	(20,000,000)
Add: Balance Brought Forward	1,583,527	1,121,143	837,196	697,544	721,485	1,031,583
LESS: Dividend	(8,435,205)	(11,356,402)				
SURPLUS CARRIED FORWARD	1,121,143	837,196	697,544	721,485	1,031,583	4,217,529

Unit: T.shs.

Financial condition of 1977 has been considerably improved and the sales grew 26%. This owes a lot to the revision of charges in June of previous year. Net revenue before taxation grew six times of the previous year, but this is due to the fact that the one in 1975 and 1976 was characteristically low; and it only menas recovery to the 1972, 1973 state.

Profit rates before taxation presented 40% in 1972, showed 4%, which was the worst record, in 1976 and recovered to 21% in 1977. Profit rates after taxation presented 23% in 1972, 0.2% in 1976, and recovered to 10% in 1977.

A comparison index of capital and sales shows 0.16 for turnover ratio of total sales and capital (sales amount/liability and capital); 0.34 for turnover ratio of total sales and capital (sales amount/capital). The figures show recovery from the worst period of 1975. The turnover ratio of total sales and fixed assets (sales amount/fixed asset) presents 0.19 indicating recovery to 1972 level. These turnover ratios are very low compared to those of Japanese power industry, and the fact indicates inefficiency of capital and assets.

World Bank sets 7% for rate of return (operating income to average net fixed asset in operation) as a condition for investment. The rate recorded below 7% in 1974–76 but recovered to 7.9% in 1977.

Table II-6-16 TANESCO's Yearly Change in Financial Ratios (1972 ~ 77)

	1972	1973	1974	1975	1976	1977
Net Revenue Before Taxation / Sales Amount	40%	41%	13%	13%	4%	19%
Net Revenue After Taxation / Sales Amount	23%	23%	3%	0%	0%	9%
Sales Amount / Liability and Capital	0.17	0.15	0.13	0.12	0.15	0.16
Sales Amount / Capital	0.38	0.35	0.31	0.25	0.30	0.34
Sales Amount / Fixed Asset	0.19	0.17	0.15	0.14	0.16	0.19
Sales Amount / Share Capital	0.76	0.62	0.57	0.47	0.52	0.57
Net Revenue Before Taxation / Share Capital	30%	25%	7%	6%	2%	11%
Rate of Return	11.7%	13.4%	6.4%	4.7%	4.3%	7.9%
Time Interest Charges	2.4	1.4	0.5	0.7	1.2	2.3

There is an index termed as "times interest charges covered by operating income" for interests in repayment plans. And we have a figure 2.3 in 1977 which indicates recovery.

The sources for TANESCO's investment funds can be classified as:

(1) Share Capital
(2) Advance Towards Share Capital
(3) Grants
(4) Loans
(5) Deffered Taxation
(6) Consumer's Contribution
(7) Surplus

The flow of the funds can be presented as:

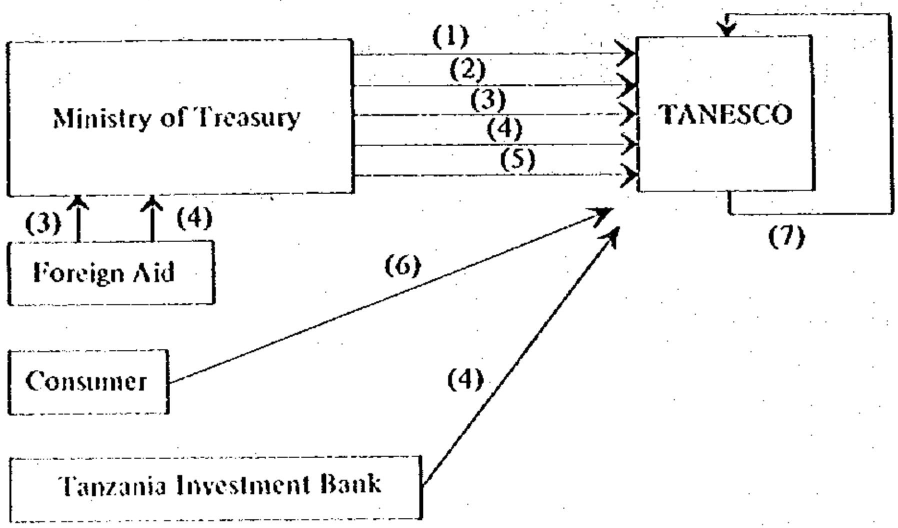


Table II-6-17 TANESCO's Fixed Liabilities (1977)

Name	Total Amount	Moratorium	Repayment due	Finance charges	Outstanding at 1977 T. shs.	Repayment in 1978 T. shs.
1. Foreign Loans						
(1) Commonwealth Development Corporation	STG £ 3,000,000	5	1969 ~ 1985	I = 7.25	19,979,895	2,686,270
(2) IBRD Loan 518-TA	US$ 5,200,000	3	1971 ~ 1988	I = 6 Commt. = 0.375	32,855,566	2,107,423
(3) IBRD Loan 715-TA	US$ 35,000,000	5	1976 ~ 1996	I = 7.25 Commt. = 0.25	313,718,145	7,236,811
(4) Kingdom of Sweden Through Govt.	SW. KR. 83,000,000	5	1976 ~ 1996	I = 7.25	147,276,663	7,067,575
(5) Govt. of Canada Through Govt.	CAN $ 2,000,000	–	1977 ~ 1992	I = 3.25	15,409,127	969,245
(6) IBRD Loan 1306-TA	US$ 30,000,000		1983 ~ 2001	I = 8.5	24,952,349	–
(7) Kingdom of Sweden	S.W. KR. 80,000,000	5	1982 ~ 2001	I = 6.3	16,644,793	–
(8) K.F.W. Loan Kidatu II Loan	D.M. 60,000,000	5	1982 ~ 2001	I = 8.5	13,934,919	–
(9) K.F.W. Loan Rural Electrification Loan	D.M. 13,500,000	10	1987 ~ 2001	I = 6	4,699,620	–
2. Local Loans						
(1) Govt. for Sub Economic Branches	T. shs. 982,700	–	1968 ~ 1988	I = 6.25	416,355	59,610
(2) Tanzania Investment Bank	T. shs. 7,500,000	2	1976 ~ 1989	I = 9 Commt. = 1	5,693,079	576,920
					595,580,511	20,703,854

TANESCO's long-term loans are as shown in Table II-6-17, and considerable amount is scheduled for repayment from 1982.