JAPAN INTERNATIONAL [illegible]
THE UNITED REPUBLIC OF [illegible]
[illegible] ELECTRIC [illegible]

[illegible] PLAN [illegible] STUDY

DAR ES SALAAM [illegible]

THE UNITED [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

JAPAN INTERNATIONAL COOPERATION AGENCY
THE UNITED REPUBLIC OF TANZANIA
TANZANIA ELECTRIC SUPPLY CO.,LTD.

MASTER PLAN STUDY AND PRE-FEASIBILITY STUDY ON DAR ES SALAAM POWER SUPPLY SYSTEM EXPANSION IN THE UNITED REPUBLIC OF TANZANIA

FINAL REPORT

VOLUME II

(PRE-FEASIBILITY STUDY)

MARCH, 1994

ELECTRIC POWER DEVELOPMENT CO.,LTD.
TOKYO, JAPAN

Contents

Final Report - Volume II

Page

CHAPTER 10

PRELIMINARY DESIGN

Chapter 10 Preliminary Design

Page

CHAPTER 10 PRELIMINARY DESIGN

10.1 PURPOSE OF DESIGN

In this study, the preliminary design is prepared based on the short-term plan (five years) of the master plan study with regard to the power supply system, i.e. the transmission and distribution line facilities and substation facility and moreover the purposes of the works thereof are as shown below:

10.1.1 Facility reinforcement needed for power supply system expansion

(1) Construction of new 132 kV and 33 kV transmission lines

(2) Construction of new 11 kV distribution line

(3) Construction of new distribution substation

(4) Additional installation and modification of grid and secondary substations

10.1.2 *Repair of old facilities and improvement of existing facilities*

(1) Replacement with new ones and additional installation of main *transformers*

(2) Replacement of 33 kV transmission line with a new one

(3) Replacement of 11 kV distribution line with a new one

(4) Replacement with new ones and additional installation of substation equipment

10.1.3 Facility reinforcement for enhancement of power supply reliability

(1) Additional installation of section switch to the existing 11 kV distribution line as a part of enhancement of the power supply reliability.

(2) To make the design of the system and the working plans aiming at reinforcing the transmission line and distribution line in order to secure power supply routes at the time of an emergency or during scheduled shutdown, the following items must fully be taken into account after due consideration being given to the local situations in Tanzania:

- To aim at the most economical design to fully satisfy the requirements from the customer with an eye to the simple and strong structure to match the actual situations in Tanzania.

- To observe the standards and technical criteria or the like presently used by TANESCO so that the standardization will never be obstructed.

- To avoid an complex and sensitive design as far as possible and moreover to avoid too much advanced design as compared to the existing design so that the design matches the existing TANESCO's facilities and technical level and therefore the maintenance and operation of the system will never be impeded.

- To give due consideration to the shortest scheduled shutdown of power supply during the construction work.

  The target areas of the present expansion plan are the urban districts where the electrification is already fully completed and thus it is impossible to cut power supply for a long time in wide areas during the construction work. Under the circumstances, it is indispensable to make such work and facility plans as allow the shortest scheduled shutdown of power supply during the construction work.

- Environmental problem

  Since the newly constructed 132 kV and 33 kV transmission lines pass through the urban and residential districts, all possible attention must be paid to ensure the public safety. In addition, the plan shall be such that the environmental destruction such as too much felling of the trees lining the roads or the like shall never be brought about.

- Since transportation of heavy cargo is included in the construction work, the work plan must be formed by fully taking into account it.

10.2 DESIGN CONDITIONS

In this study, the design for the improvement and reorganization of the transmission, substation and distribution lines is prepared in accordance with the TANESCO's current standards and criteria as well as the standard methods in Japan. As for the applicable standards for the equipment and materials, Japanese standards are mostly applied with ANSI (American standards) and BS (British standards) being partly applied.

10.2.1 Design Conditions

(1) Environmental conditions

a. Elevation : 1,000m or under
b. Atmospheric temperature : Max. 40°C, Min. 10°C

(2) Wind load

From TANESCO design criteria; maximum wind velocity is 38.3 m/s and wind pressure load to be imposed shall be taken for 92 kg/m^2 for the strung wire and 73 kg/cm^2 for wooden pole.

(3) Height of transmission and distribution lines from the ground

Height of the strung wires from the ground level shall be taken as shown in Table 10.2-1.

Table 10.2-1 Height of strung wire

Item	132 kV	33 kV	11 kV
In general places	6.7 m	5.0 m	4.8 m
In places crossing roads			
Roads with vehicle traffic	8.0 m	6.7 m	6.0 m
Roads without vehicle traffic		6.0 m	4.8 m
Over railroads	9.0 m	9.0 m	9.0 m
Over telephone wires		1.8 m	1.8 m

10.3 INSULATION DESIGN

(1) Insulation design

The insulation design is made by taking into account the following as well as aiming at fully protecting the facilities in the whole range from the lightning surge to the commercial frequency by making the coordination of insulation levels of lines and equipment.

a. Equipment shall be protected from the internal abnormal voltage (lightning surge, continuous abnormal voltage) by its own insulation coordination.

b. Equipment shall be protected from the external abnormal voltage (lightning surges) by lightning arrester and arcing horn

(2) Determination of type of insulators and number to be connected

As stated above, the basic design concept for the insulation design is such that the measures are taken against the lightning stroke presuming that no flash over will takes place regardless of the internal abnormal voltage. As for the internal abnormal voltage, the conventional design concept to be used for the transmission line is adopted.

a. Class of earthed neutral system : direct earthed system

b. Continuous abnormal voltage multiple: 0.8 Um (Um: maximum permissible voltage of the system)

c. Switching abnormal voltage multiple: 2.0 Um

To determine the dielectric strength of the insulator, the flash over characteristics of the switching surge with the water injection are used for the switching abnormal voltage while those of the commercial frequency with the water injection for the continuous abnormal voltage. The necessary dielectric strength and electric characteristics of the insulator for the internal abnormal voltage are as shown in Table 10.2-2 to 10.2-6:

Table 10.2-2 Required dielectric strength of insulators obtained from switching abnormal voltage

a. Nominal voltage (kV)	132	33	11
b. Permissible maximum voltage Um (kV)	144	36	12
c. Peak value of voltage to ground $\frac{\sqrt{2}}{\sqrt{3}}$ Um (kV)	118	29.4	9.8
d. Switching surge multiple n times	2.8	2.8	2.8
e. Switching surge voltage $\frac{\sqrt{2}}{\sqrt{3}}$ Um x n (kV)	329	82.3	27.4
f. Dielectric strength deterioration coefficient	1.1	1.1	1.1
g. Required dielectric strength of insulator (kV)	362	90.5	30.2

Table 10.2-3 Electric Characteristics of insulator

	Standard surge	Switching surge (with water injection)		Commercial frequency (with water injection)	
	50% flash over voltage (kV)	50% flash over voltage (kV)	Withstand voltage (kV)	50% flash over voltage (kV)	Withstand voltage (kV)
Suspension insulator:					
1 insulator	140	85	75	45	40
2 insulator string	240	170	55	80	70
3 insulator string	330	245	20	115	105
33 kV Pin insulator	290	-	-	95	-
11 kV Pin insulator	130	-	-	35	-

(3) Minimum insulation clearance

The clearance for the insulators to withstand switching surges and short-term over voltages respectively is taken as the minimum insulation clearance. Table 10.2-4 give the minimum insulation clearances.

Table 10.2-4 Minimum insulation clearance

Nominal voltage (kV)	132	33	11
Maximum permissible voltage Um (kV)	144	36	12
Voltage to ground peak value (kV)	118	29.4	9.8
Switching surge multiple (times)	2.8	2.8	2.8
Switching surge peak value (kV)	329	82.3	27.0
Required withstand voltage (kV)	362	90.5	29.7
Required clearance (cm)	76	13	5
Minimum insulation clearance (cm)	75	15	5

(4) Insulation clearance in an abnormal conditions

Check shall be done as to the maximum permissible voltage (Um) of the line in respect of the presumed maximum wind speed with the water injection. The insulation clearance in an abnormal condition shall be as shown in Table 10.2-5.

Table 10.2-5 Insulation clearance in abnormal conditions

Nominal voltage (kV)	132	33	11
Maximum permissible voltage (kV)	144	36	12
Maximum permissible voltage (to ground) (kV)	83.1	20.8	6.92
Required withstand voltage (kV)	91.5	22.9	7.62
Insulation distance in an abnormal condition (cm)	34	8	3

(5) Minimum insulation clearance between wires

The minimum insulation clearance between wires is defined as the minimum insulation clearance between wires to withstand switching surges. These clearances are given in Table 10.2-6.

Table 10.2-6 Minimum clearance between wires

1. Nominal voltage (kV)	132	33	11
2. Miaximum permissible voltage (kV)	144	36	12
3. Voltage to ground peak values of the above (kV)	118	29.4	9.8
4. Switching surge multiple	2.8	2.8	2.8
5. Switching surge peak wave	329	82.3	27.0
6. Required withstand voltage (kV)	362	90.5	29.7
7. Required clearance (cm)	76	13	5
8. Minimum insulation clearance (cm)	75	15	5

(6) Lightning resistant design

In the present survey, the exact statistics of IKL (Isokeraunic Level) could not be obtained but instead it was known that IKL 60 is recorded as an actual example.

It was also known that the arresters are provided for respective substations while the overhead ground wires are respective substations, 132 kV and 33 kV transmission lines. Nonetheless, it is conceivable that the lightning takes place rather less frequently throughout the year.

Despite the situations, it is concluded that in order to prevent the external abnormal voltage such as lightning surge, etc., an arrester should be provided for the major transformers of substations, equipment installed in the transmission and distribution lines, and both ends of cables, and in addition, an overhead wire for an appropriate position on the premises of substations and transmission lines.

10.4 TRANSMISSION LINE

10.4.1 Transmission Line Route

(1) 132 kV Transmission Line

Construction program of 132 kV transmission lines in the short-term plan is as follows.

1) In 1994

Ubungo - Ilala Line (Overhead line)
Line length: 7 km
This transmission line route is shown in Fig. 5.3-7 of Volume III.

2) In 1996

Ubungo - FZ III Line (Overhead line)
Line length: 8.6 km
This transmission line route is shown in Fig. 5.3-8 of Volume III.

(2) 33 kV Transmission Lines

Construction program of 33 kV transmission lines in the short-term plan is as follows.

1) In 1994

(a) Tandale Line (Overhead line)

- Upgrade (double circuit pole assembly)	:	1.2 km
- New construction (single circuit pole assembly)	:	3.3 km
- Road-crossing	:	1 span
- Total line length	:	4.5 km

(b) Chang'ombe Line (Overhead line)

- Line length (single circuit pole assembly)	:	2.0 km
- Road-crossing	:	2 spans

Total line length planned in 1994	:	6.5 km

Above transmission line routes are shown in Fig. 5.3-7 of Volume III.

2) In 1996

(a) Kunduchi Line (Overhead Line)

- Line length (single circuit pole assembly) : 2.8 km
- Valley-crossing : 1 span

The employment of steel tower is assumed at Valley-crossing span at present.

(b) Kariakoo Line (Overhead line and underground line)

- Underground line : 0.5 km
- Overhead line (single circuit pole assembly) : 1.6 km
- Total line length : 2.1 km

(c) Mbagala Line (Overhead line)

- Line length (single circuit pole assembly) : 8.5 km
- Railway-crossing : 1 span
- Road-crossing : 2 spans

The employment of steel towers is assumed at railway- and Valley-crossing span at present.

(d) Tabata Line

p-connection of 2 circuits of existing transmission lines to Tabata S/S.

Above transmission line routes are shown in Fig. 5.3-8 of Volume III.

10.4.2 Basic Items

(1) Applicable Standards

In the design of this transmission line, basically standards applied in Japan such as JEAC and JEC are applied.

(2) Height of Line Conductors

The height of line conductors is as follows according to clause 5.3.1 of Master Plan Study.

		132 kV (m)	33 kV (m)
a.	Ordinary places	6.7	5.0
b.	Road	8.0	6.7
c.	Railway	9.0	9.0
d.	Waterways	10.0	10.0

(3) Wind Load

Wind load on steel tower is as follows according to clause 5.3.1 of Master Plan Study.

a. Wind load on steel tower : 266 kg/m^2
b. Wind load on conductors : 92 kg/m^2
c. Wind load on wooden pole, concrete pole : 73 kg/m^2
d. Temperature at the worst condition : 10°C

(4) Natural Condition

a.	Height above sea level	:	1,000 m or less	
b.	Ambient temperature	:	Maximum	40°C
			Minimum	10°C
			Average (EDS)	20°C
c.	Solar radiation	:	1,000 W/m^2	

(5) Number of Circuits of 132 kV Transmission Line

The supports of both Ubungo - Ilala and Ubungo - FZ III Line are designed for double circuits, and single circuit is strung due to the following reason.

- Double circuits transmission line is recommended from the view point of system reliability since Dar Es Salaam is the biggest city in TANZANIA.
- Securing the right of way for the construction of new transmission line for future load growth may be difficult.
- Effective utilization of right of way

(6) *Selection of Conductors*

a. 132 kV Transmission Line

Mainly, 150 mm² ACSR is used for 132 kV transmission lines at present, and the future load growth should be taken into consideration at the standardization process of conductors. Especially, the employment of bigger size conductor is recommended in the high load density area.

As stated above, in this planning, 240 mm² ACSR having approx. 1.3 times current capacity of 150 mm² ACSR and employed in the Pangani Falls Line which is being constructed at present is employed.

(7) Supports

a. Steel towers is employed as supports of 132 kV transmission lines.

b. Following supports is employed for 33 kV transmission line according to the application condition.

- Wooden poles
- Steel towers
- Concrete poles

(8) Tower Foundation of 132 kV Transmission Lines

Foundations employed for steel tower of transmission line are classified as follows.

1) Standard foundation

(a) Spread foundation
- Concrete foundation
- Steel grillage foundation

2) Special Foundation

(a) Pile foundation
- Steel pipe pile foundation
- Precast concrete pile foundation
- Cast-in-place pile foundation

(b) Pier foundation
(c) Anchor foundation

As for the foundation type of steel towers for 132 kV transmission line, load from upper structures of steel tower, corrosion of foundation members of steel grillage foundation and ground condition at site are taken into consideration, following foundations are estimated.

- Steel pipe pile foundation is employed for three towers constructed in the swamp area near Ilala substation.

- In the towers other than above three towers, concrete foundation is employed.

10.4.3 Supports

(1) 132 kV Transmission Line

Steel towers are employed as supports for 132 kV transmission line, and steel towers are designed in accordance with JEC-127.

a. Safety Factor and Allowable Stress of Steel

Steel towers for transmission lines shall have the strength for the stress on each part of structures due to the load which is estimated in accordance with JEC-127.

Loading condition	Multiples for stress due to estimated load
Normal condition	Not less than 1.0
Abnormal condition	Not less than 1/1.5 (not less than 1.0 for arm members)

Allowable stress of structural steel for design stress at normal and working condition is as follows, and this allowable stress should be 1.5 times of the figures below for the design stress at the strong wind loading condition.

- Allowable tensile stress : $\frac{\sigma_Y}{1.5}$ or $\frac{0.7}{1.5}\sigma_B$
- Allowable compressive stress: $\frac{\sigma_Y}{1.5}$
- Allowable bending stress : $\frac{\sigma_Y}{1.5}$
- Allowable shear stress : $\frac{\sigma_Y}{1.5\sqrt{3}}$ or $\frac{0.7\sigma_B}{1.5\sqrt{3}}$
- Allowable bearing stress : $1.1\sigma_Y$
- Allowable buckling stress : To be calculated for each case.

where,

: Yield stress of steel (kg/cm²)

: Tensile strength of steel (kg/cm²)

b. Number of continuous suspension tower

Number of continuous suspension tower is not greater than 10.

c. Slenderness ratio of compression member

Slenderness ratio of compression member is as follows.

Members	Slenderness Ratio
Main post (including arm member)	Not greater than 200
Compression member other than main post	Not greater than 220
Supplement member	Not greater than 250

d. Minimum thickness of members

Minimum thickness of members is as follows.

Main post, arm member : Not less than 5.0 mm
Other members : Not less than 3.0 mm

e. Anti-climbing guard

Anti-climbing guard is installed on the steel towers.

f. Burying of counterpoise

Counterpoise is buried to reduce grounding resistance of steel towers.

And, typical drawing of steel towers is shown in Fig.10.4-1.

(2) 33 kV Transmission Line

Wooden poles, concrete poles and steel towers are employed as supports for 33 kV transmission lines.

a. Safety factor of supports

Supports	Loading condition	Multiples for stress due to estimated load
Concrete pole	Normal condition	Not less than 1.0
Wooden pole	Normal condition	Not less than 2.0

b. Safety factor of guy

Supports	To be used at	Safety factor
Wooden pole Concrete pole	- Places where difference of span length of both sides is big - Places with horizontal deviation angle - Places where dead-end type is required	Not less than 1.5
	Other places	Not less than 2.5

And, drawings of typical pole assembly is shown in Fig. 10.4-2.

Fig. 10. 4-1 STEEL TOWERS

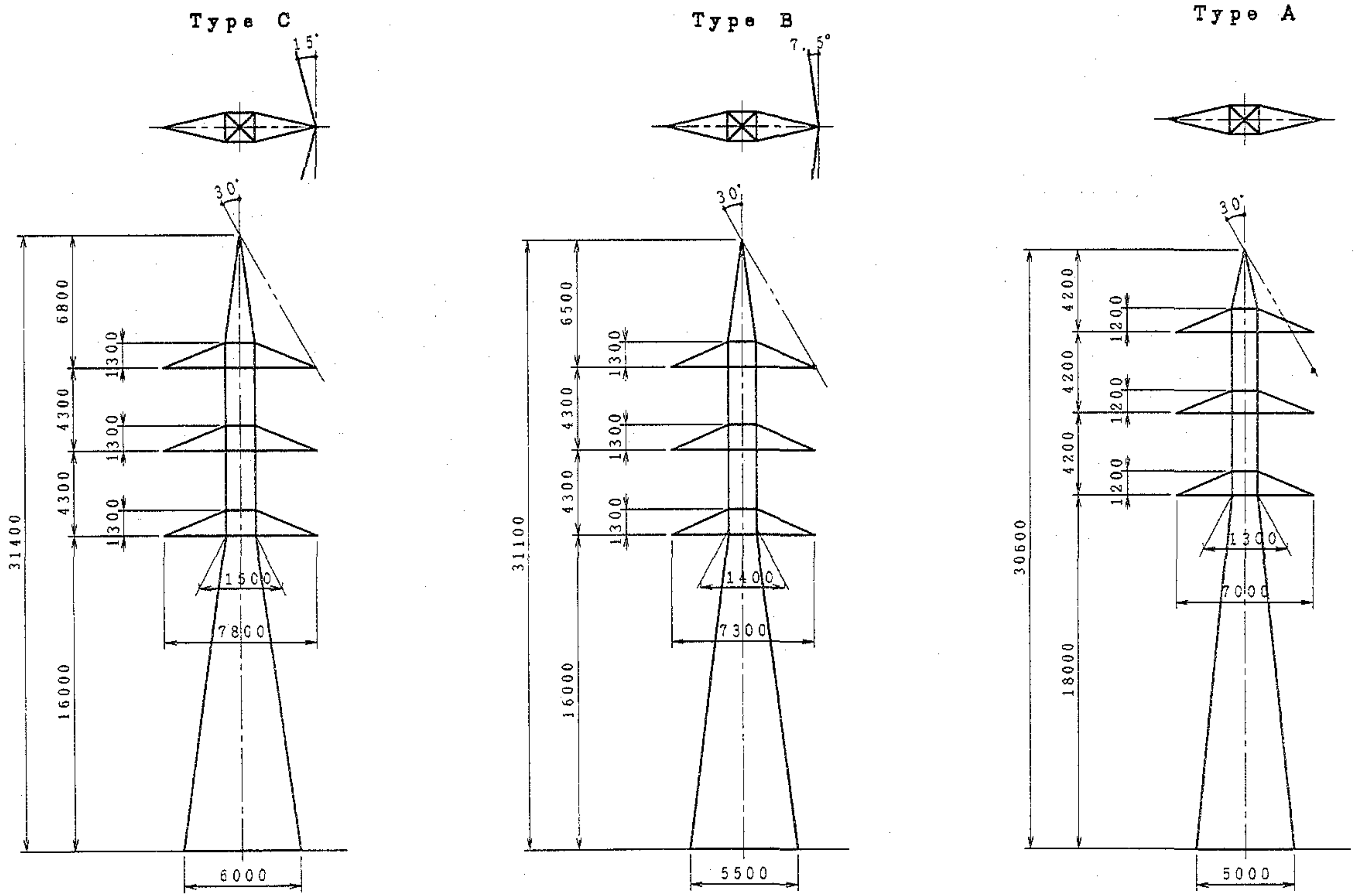
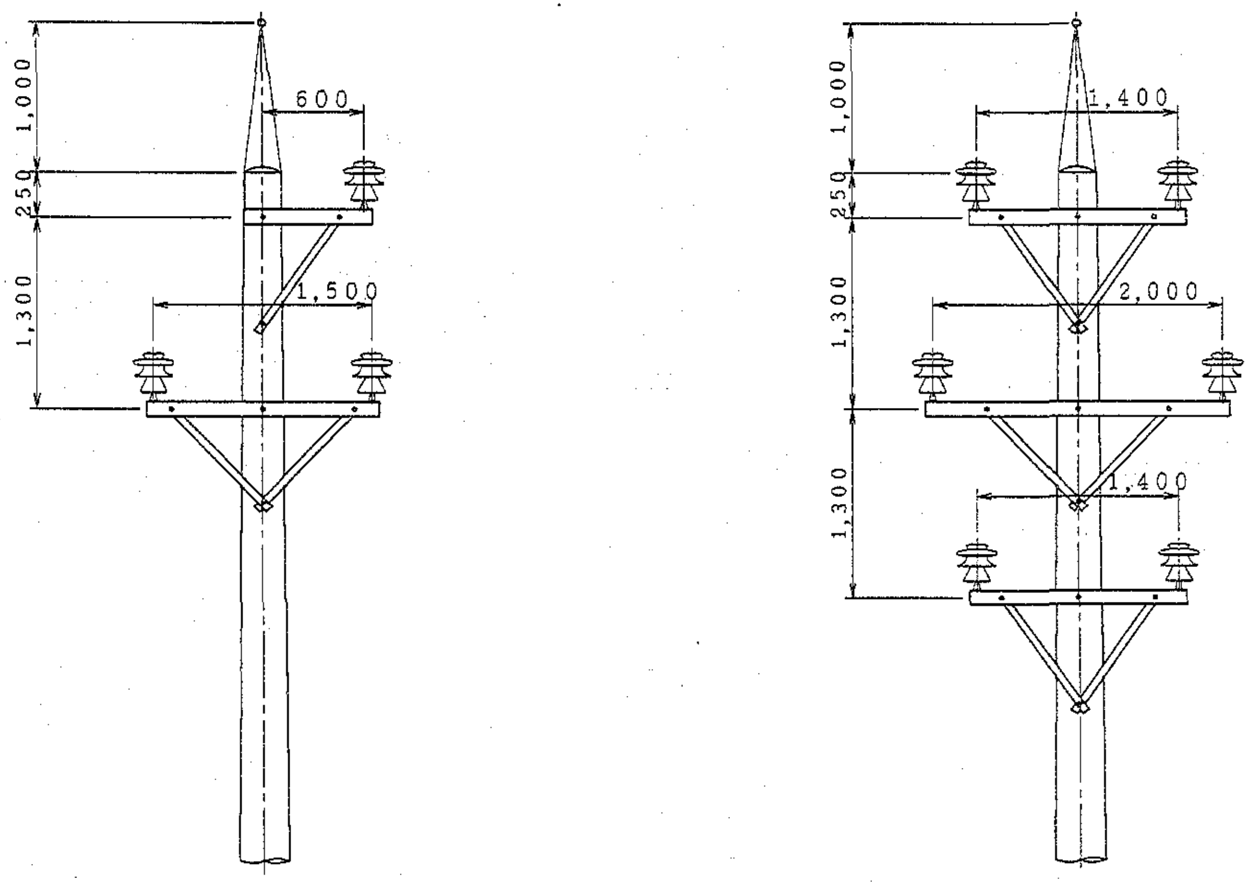


Fig. 10. 4-2 POLE ASSEMBLY



10.4.4 Foundation

(1) 132 kV Transmission Line

1) Foundation Type

Concrete foundation (pad and chimney type foundation) and steel pipe pile foundation are employed as foundation for 132 kV transmission line towers.

2) Design Load of Foundation

Load for foundation design consists of compressive force, tensile force and horizontal force which are transferred from the upper structures of steel tower.

3) Safety Factor of Tower Foundation

Safety factor of tower foundation is as follows.

Safety factor of tower foundation:

Normal condition	Not less than 2.0
Abnormal condition	Not less than 2.0/1.5

4) Bearing Capacity Calculation of Foundation

a. Bearing capacity of concrete foundation is calculated in accordance with formula (Design calculation formula-I for pad and chimney type foundation) specified in JEC-127, design data of ground is follows.

Type of ground	Class A	Class B
Effective angle of soil for tensile force θ (°)	30	20
Unit weight of soil $\gamma(t/m^3)$	1.6	1.5
Compressive proof stress (t/m^2)	60	40

b. Steel Pipe Pile Foundation

Bearing capacity of steel pipe pile foundation is calculated in accordance with JEC-127, and design data of ground is based on the geological survey at tower site.

(2) 33 kV Transmission Line

The condition of steel tower for 33 kV transmission line is according to item (1) above. Wooden poles and concrete poles are constructed with embedment depth shown below.

a. Embedment depth of wooden pole

Pole length	Embedment depth
Not more than 15 m	Not less than 1/6 of pole length
More than 15 m	Not less than 2.5 m

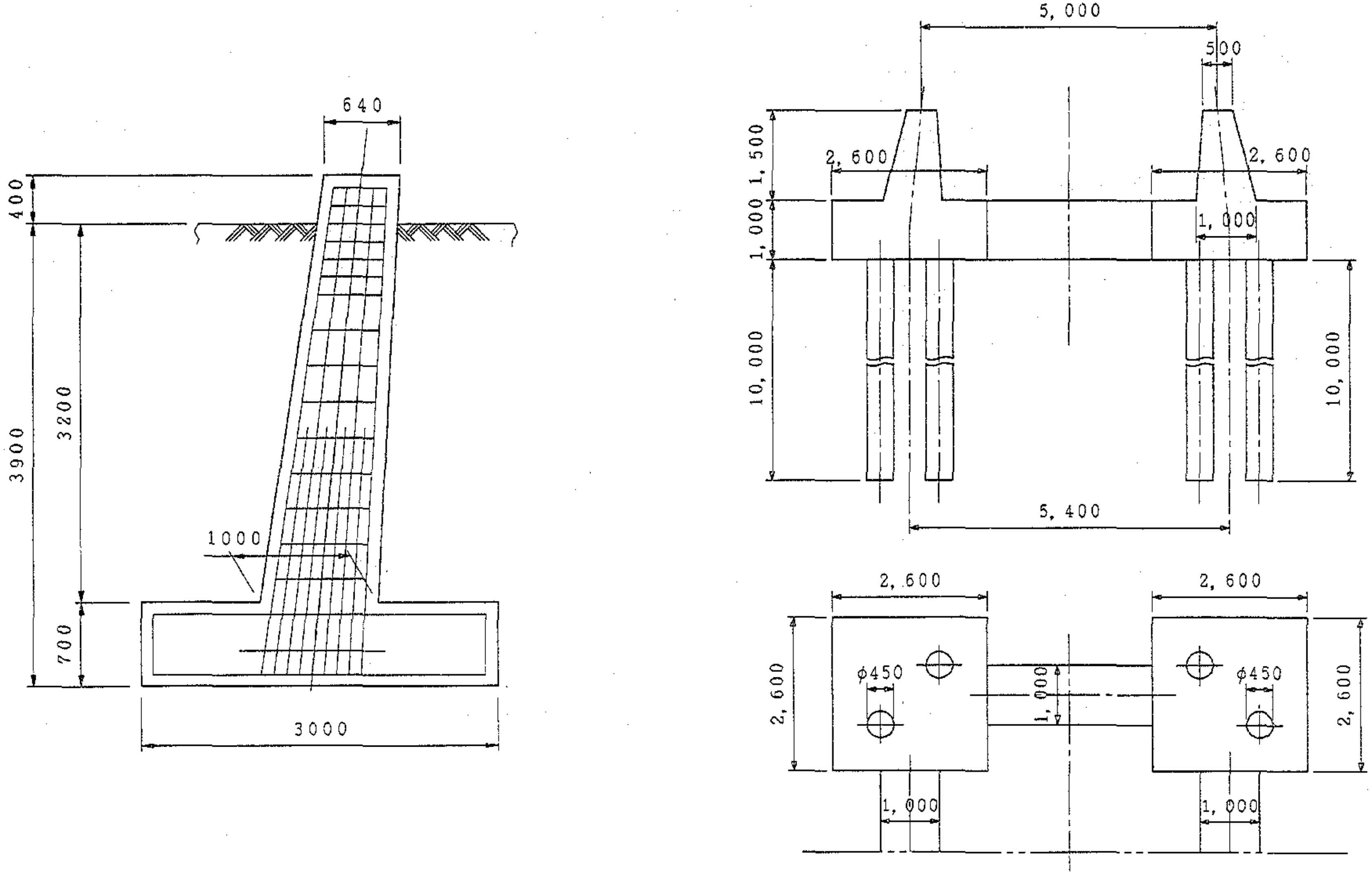
b. Embedment depth of concrete pole

Design load	Pole length	Embedment depth
Not more than 700 kgf	Not more than 15 m	Not less than 1/6 of pole length
Not less than 700 kgf and not more than 1,000 kgf	Not less than 14 m and not more than 15 m	Not less than (L/6+30cm)
Not less than 1,000 kgf and not more than 1,500 kgf	Not less than 14 m and not more than 15 m	Not less than (L/6+50cm)

where, L : pole length

Drawings of typical concrete foundation and steel pipe pile foundation are shown in Fig.10.4-3 for reference.

Fig. 10. 4-3 FOUNDATION OF STEEL TOWERS



10.4.5 Line Conductor

Line conductors to be employed are as follows:

132 kV transmission line : 240 mm² ACSR/AS (Hawk)
33 kV transmission line : 150 mm² ACSR (Wolf)

To prevent the reduction of conductor strength due to the corrosion of core wire of ACSR (Hawk), alminium-clad strand is employed as core wire of ACSR, since the life span of 132 kV transmission line is 30 - 40 years.

(1) Design Condition of Stringing

Design condition of stringing of line conductors is as follows:

Temperature: 10°C
Wind load : 92 kg/m²

(2) Safety Factor

Safety factor of conductor at the supporting point under the design condition of stringing is not less than 2.5.

(3) Every Day Stress (EDS)

Every day stress of line conductor is not more than 20% of breaking load.

(4) Specification of Conductors

Specification of conductors to be employed is as follows:

		240 mm² ACSR/AW (Hawk)	150 mm² ACSR (Wolf)
a.	Applicable standard	ASTM B 232-78	BS 215-2.70
b.	Nominal sectional area (MCM, mm²)	477 (236.9)	150
c.	Calculated area (mm²)		
	- Aluminum	241.5	158.1
	- Steel wire	39.34	36.88
	- Total	280.8	194.9
d.	Number and diameter of wires (No./mm)		
	- Aluminum	26/3.439	30/2.59
	- Steel	7/2.675	7/2.59
e.	Diameter (mm)	21.78	18.13
f.	Weight (kg/m)	0.9294	0.726
g.	Breaking load (kgf)	8,586 (84.2 kN)	7,056
h.	D. C. electrical resistance (Ω/km at 20°C)	0.1133	0.1828

(5) Employment of Armor Rods and Vibration Dampers

To prevent fatigue of conductors due to vibration and fusing of conductors at the supporting point, armor rods are fixed on suspension type steel towers of 132 kV transmission line. And, to prevent fatigue and damage of conductors due to aeolian vibration, vibration dampers are fixed.

(6) Sag and Tension of Conductors

Sag and max. working tension of conductors (Hawk) in the standard span length of 132 kV transmission line are studied based on the design condition described above. And conductors, which will be employed for 33 kV transmission line, are studied based on the following conditions.

a. At long span section

As described in 10.4.3, in the:

- Railway- and road-crossing points of Mbagala line, and
- Valley-crossing point of Kunduchi line,
  steel towers are employed as supports. And, sag and max. working tension of conductors are studied based on the estimation that standard span length is to be 150 m.

b. Ordinary places

Working tension of conductors at 20°C and no wind condition is studied and the sag of conductors is to be 1.5% of span length.

10.4.6 Overhead Ground Wire

(1) 132 kV Transmission Line

Alminum-clad steel strand (ACS 55 mm^2) is employed as overhead ground wire for 132 kV transmission line, and ACS (30 mm^2) is employed for 33 kV transmission line.

(2) Sag of Overhead Ground Wire

To prevent in-span back flashover by the lightning striking, sag of overhead ground wire is adjusted to be 80% of conductor sag in the standard span length at minimum temperature and no wind condition.

(3) Other Conditions

Design condition of stringing and safety factor are according to clause 10.4.5.

(4) Specification of Overhead Ground Wire

Specification of overhead ground wire employed is as follows:

	55 mm^2 ACS	30 mm^2 ACS
a. Applicable standard	JEC	JEC
b. Nominal sectional area (mm^2)	50	30
c. Calculated area (mm^2)	56.29	27.09
d. Number and diameter of wires (No./mm)	7/3.2	7/2.3
e. Diameter (mm)	9.6	6.9
f. Weight (kg/m)	0.3565	0.1918
g. Min. tensile load (kgf)	6,620	3,530
h. D.C. electrical resistance (Ω/km at 20°C)	1.34	2.94

10.4.7 Insulators

The insulator string used for transmission line are studied based on the clause 10.2 Design Condition and basic condition shown below. These conditions are in accordance with "The Guideline of Insulation Design for Overhead Transmission Lines".

1) Basic condition

a.	Nominal voltage	(kV)	132	33
b.	Max. allowable voltage	(kV)	144	36
c.	Voltage to ground	(kV)	83.1	20.8
d.	Normal voltage to ground max. value	(kV)	79.7	19.9
e.	Height above sea level		Not more than 1,000 m	

Following studies are executed based on the specification of 250 mm suspension insulator disk.

1) Switching surge design

Required insulation strength for switching surge is as follows according to clause 10.2 Design Condition.

Nominal voltage	(kV)	132	33
Required insulation strength	(kV)	362.1	90.5
No. of discs for withstand voltage		6	2
Insulator disc for maintenance		1	1
Required No. of disks		7	3

2) Design for pollution of insulator

Command of withstand voltage	(kV)	79.7	19.9
Withstand voltage per one disc	(kV)	7.7	7.7
Required No. of discs		11	3

(Note: Withstand voltage of a polluted insulator disk is estimated to be 7.7 kV)

3) Lightning protection design (132 kV transmission line)

To protect the insulators from lightning striking and to prevent back flashover between conductors and steel tower, arcing horns are fixed on insulator string.
Arcing horn clearance is estimated as follows based on the figures of existing facilities.

Arcing horn clearance	(mm)	1,440
No. of insulator discs		11
Length of insulator string	(mm)	1,606

4) Standard insulation clearance

Standard insulation clearance is such clearance that flashover is occurred only between arcing horns and not between conductors and steel tower.

$$L' = 1.115 \times Z + 0.021$$

where,

L' : Standard insulation clearance (m)

Z : Arcing horn clearance (m)

Accordingly,

L' : 1,630 (mm)

5) 33 kV transmission line

As studied in 1) and 2) above, tension insulator string used for 33 kV transmission lines is designed to withstand the same level of insulator pollution for 132 kV transmission line.

On the other hand, fault due to salt contamination on pin-type insulator is reported on the 33 kV transmission line which connects Oyster Bay S/S and Msasani S/S. Therefore, salt contamination on insulator is considered in the insulation design of 33 kV transmission line which is constructed in the areas close to the sea.

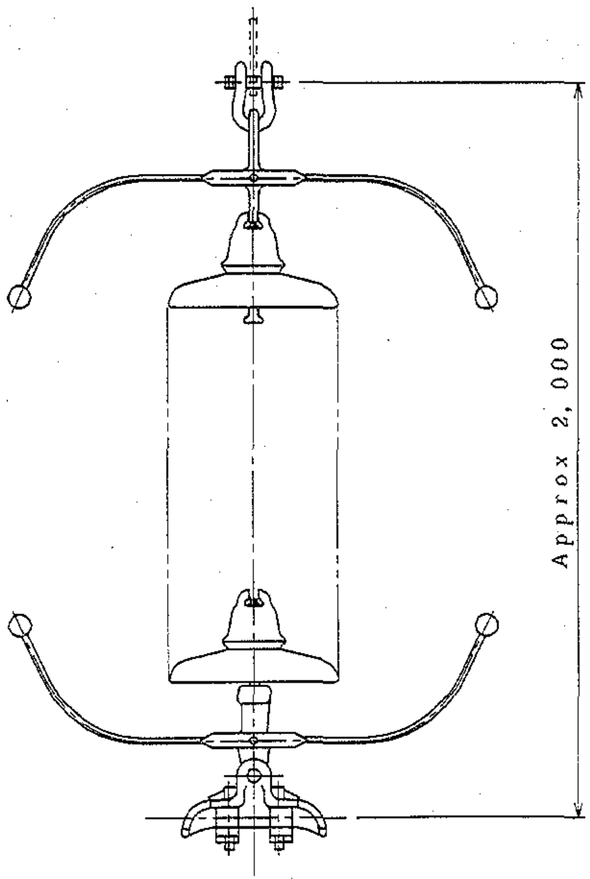
6) Safety factor

Safety factor of insulator discs and insulator string is not less than 2.5.

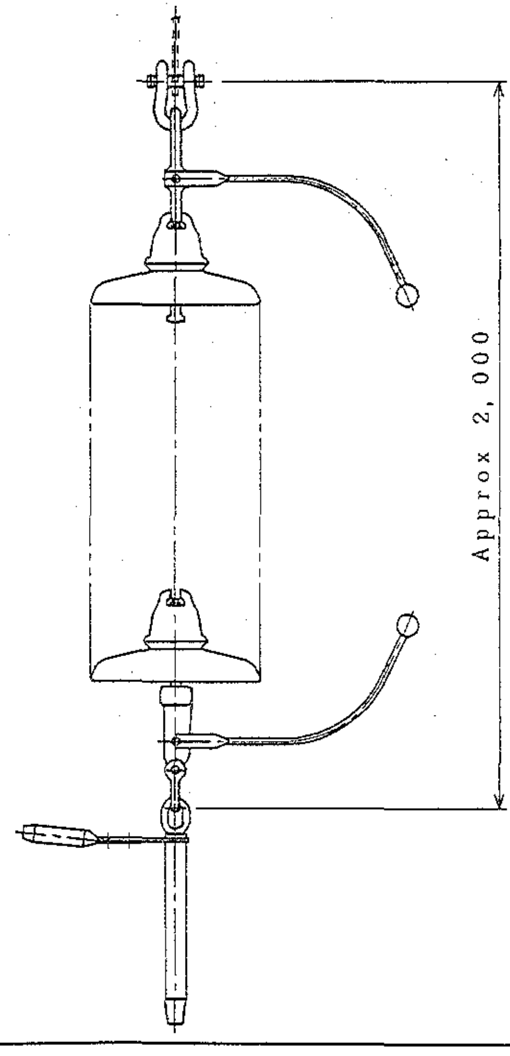
Typical drawings of insulator string are shown in Fig.10.4-4 for reference.

Fig. 10.4-4 INSULATOR STRINGS

Suspension Type



Tension Type



10.5 SUBSTATION

In this study, the power supply system expansion for Dar Es Salaam City, the preliminary design of the substations and transmission and distribution lines, are performed in accordance with the short-term plan (5 years) that is particularly taken up out of the 15 year master plan study of Volume I.

In the construction works of substations and transmission and distribution lines, construction of new substations and additional installation and modification of the existing substations, as well as construction of new 132 kV and 33 kV transmission lines and 11 kV distribution line and additional installation and expansion of incoming and outgoing facilities are scheduled to be carried out thereby enhancing the reliability of the system.

The single line connection diagram and equipment layout drawing of each substation are as shown in Fig. 10.5-8-1 to 10.-11-2, as well as in Fig. 5.4-12-1 to 5.4-21-2 of Volume III.

10.5.1 Expansion and modification works

(1) Additional installation and modification works of the existing substations to be implemented in 1994 are as shown below: (see Table 10.5-1)

No. 1 Ilala secondary substation

At Ilala substation, additional installation of 33/11 kV, 15 MVA transformer x 1 unit and related equipment installation must be carried out.

No. 2 Ilala secondary substation

Additional installation and modification of the switchyard must be carried out so that the 132 kV transmission line, which is planned to be constructed between Ubungo and Ilala, can be taken out of it. In addition, additional installation of 132/33 kV, 45 MVA transformer x 1 unit must also concurrently be carried out.

No. 6 Kurasini substation

Kurasini substation is already equipped with 33/11 kV, 15 MVA transformer x 1 unit. However, the switching facility for the 33 kV incoming line is in failure, which must be repaired. Concurrently, construction of 1 bay of new switching facility for Chang'ombe substation must also be carried out.

No. 7 Mbezi substation

Mbezi substation is also already equipped with 33/11 kV, 7.5 MVA transformer x 1 unit. However, in consideration of the demand increase and overage and deteriorated existing transformer, additional installation of new 15 MVA transformer x 1 unit as well as additional installation and modification of other various equipment on the premises and buses must also be carried out. In addition, expansion works of the existing building and construction of new indoor 11 kV cubicles and removal of the existing cubicles to other places must also be carried out.

(2) Additional installation and modification works of the existing substations to be implemented in 1996 are as shown below: (See Table 10.5-1)

No. 13 Factory Zone III substation

Factory Zone III substation is already equipped with 33/11 kV distribution substation facilities. However, in compliance with the power supply system expansion plan, additional installation of 45 MVA transformer x 2 units to be used for 132/33 kV receiving facility and additional installation and modification works of related various facilities must be carried out.

No. 14 Ubungo substation

Construction of new 132 kV transmission line, 1 circuit, between Ubungo substation to Ilala substation and construction of 1 bay of switching facilities on the premises of those substations, by making good use of available vacant space, must be carried out. In addition, additional installation and modification of the related various facilities must also be carried out.

No. 16 Ilala substation

In the above No. 1 and No. 2 works that are planned to be implemented in 1994, additional installation work of buses and additional installation and modification works of related various facilities are carried out in connection with the additional installation of transformers. In succession to it, additional installation of outgoing switching facility for 33 kV transmission line which is required as a result of construction of new Kariakoo distribution substation described later in No. 15 must be carried out.

No. 18 Kurasini substation

In the above No. 6 work that is planned to be implemented in 1994, additional installation of 1 bay of 33 kV outgoing transmission line switching facility for Chang'ombe substation is carried out. In this No. 18, additional installation of 1 bay of outgoing transmission line switching facility for new Mbagala substation, which is planned to be constructed successively, and additional installation and modification works of related various facilities must be carried out.

10.5.2 Construction of New Substations and Selection of Sites

(1) New construction work

1) Construction of new substations that are planned to be implemented in 1994 are as shown below: (See Table 10.5-1)

No. 4 Tandale substation

Tandale district comprises the residential area and industrial area mixedly and thus it has an average load density. The power supply to this district is presently done from Ilala (D10), Oyster Bay (04), Mikocheni (MK2) and Ubungo (U2) and thus it is known that the distribution lines for this district are already in the worst condition due to very bad voltage drop, power loss, etc. To solve these problems, construction of new distribution substation in Tandale district must be carried out. This substation is planned to be equipped with 15 MVA transformer x 1 unit and 33 kV transmission line incoming facility as well as related various facilities. To supply power to this substation, 33 kV transmission line branching off in a T branch from the nearest point on the Ubungo to Ilala transmission lines, Friendship-No.I or II, is planned to be constructed.

No. 5 Chang'ombe substation

Presently, power supply to the Chang'ombe district is done to such areas as are located along the Pugu Road. In order to cope with this existing distribution line load, as well as such loads as are needed for the port access distribution lines and for the industrial use for glassworks, etc. located in this district, construction of new distribution substation in the Chang'ombe district must be carried out. This substation is planned to be equipped with 15 MVA transformer x 1 unit and 33 kV transmission line incoming and outgoing facilities as well as related various facilities.

2) Construction of new substations that are planned to be implemented in 1996 are as shown below: (See Table 10.5-1)

No. 12 Kunduchi Substation

Kunduchi district is located on the northwest side of Msasani Bay with a cement factory and a number of tourist hotels being situated along its seashore. The power supply to this district is already in the worst condition due to bad voltage drop and power loss caused by the progress of urbanization in this district and moreover because of the anticipated future increase in demand. In order to improve this condition, construction of new distribution substation must be carried out in an appropriate place in the vicinity of 132 kV transmission line to Zanzibar substation. This substation is planned to be equipped with 15 MVA transformer x 1 unit and 33 kV transmission line incoming facility as well as related various facilities. The power supply 33 kV transmission line is connected to the 132/33 kV transmission line to Tegeta substation to be constructed in other project.

No. 15 Kariakoo substation

Kariakoo district includes the commercial city area and thus the high load level is always called for. Nonetheless, this district presently badly suffers from the lack of alternative power resources to enable sufficient power supply. To cope with it, construction of new distribution substation in Kariakoo district must be carried out. This substation is planned to be equipped with 15 MVA transformer x 1 unit and 33 kV transmission line incoming facility as well as related various facilities. The power supply via 33 kV transmission line is done from Ilala secondary substation.

No. 17 Mbagala substation

Power supply to the residential district and industrial district of the Mbagala district, which are located in the areas along Kilwa Road, is undertaken by Kurasini substation. However, since the transmission distance is too long to cover the voltage drop and power loss, the power supply to this district is already in the worst condition. To cope with this situations, construction of new distribution substation in this district must be carried out. This substation is planned to be equipped with 15 MVA transformer x 1 unit and 33 kV transmission line incoming facility as well as related various facilities. The power supply via 33 kV transmission line is done from Kurasini substation.

No. 19 Tabata substation

Power supply to Tabata district is presently done from Ubungo S/S substation. However, since it is known from the long-term demand forecast that the load is further on the increase in the future, construction of new distribution substation in this district must be carried out. This substation is planned to be equipped with 5 MVA transformer x 1 unit and 33 kV transmission line incoming and outgoing facilities as well as related various facilities. To supply power to this substation, 33 kV transmission line branching off in a π branch from the existing 33 kV transmission line between Ubungo to Factory Zone III is planned to be constructed.

Table 10.5-1 A List of the Substations to be installed in the Short Term after 1994

No.	Year	Name of Substation		Voltage	Capacity (Newly/Expansion capacity)		Classification
1	1994	Ilala	Secondary Substation	33/11 kV	45 MVA	(15 MVA × 1 Ex.)	Expanshion
2		Ilala	ditto	132/33 kV	135 MVA	(45 MVA × 1 Ex.)	ditto
3		Ubungo	Grid Substation	132 kV	Switchyard	(1 bay Ex.)	ditto
4		Tandale	Distribution Substation	33/11 kV	15 MVA	(15 MVA × 1)	Newly Installation
5		*Chang'ombe*	ditto	33/11 kV	15 MVA	(15 MVA × 1)	ditto
6		Kurasini	ditto	33 kV	Switchyard	(1 bay Ex.)	Expansion
7		Mbezi	ditto	33/11 kV	22.5 MVA	(15 MVA × 1 Ex.)	Expansion
8		Oyster Bay	Distribution Substation	33/11 kV	25 MVA	(15 MVA × 1 Ex.)	Expand by Phase Ⅲ
9		Factory Zone Ⅰ	ditto	33/11 kV	25 MVA	(15 MVA × 1)	ditto
10		Msasani	ditto	33/11 kV	15 MVA	(15 MVA × 1)	Construct by Phase Ⅲ
11		Sokoine	ditto	33/11 kV	15 MVA	(15 MVA × 1)	ditto
12	1996	Kunduchi	Distribution Substation	33/11 kV	15 MVA	(15 MVA × 1)	Newly construct
13		Factory Zone Ⅲ	Secondary Substation	132/33 kV	90 MVA	(45 MVA × 2)	Newly construct
14		Ubungo	Grid Substation	132 kV	Switchyard	(1 bay Ex.)	Expansion
15		Kariakoo	Distribution Substation	33/11 kV	15 MVA	(15 MVA × 1)	Newly construct
16		Ilala	ditto	33 kV	Switchyard	(1 bay Ex.)	Expansion
17		Mbagala	ditto	33/11 kV	15 MVA	(15 MVA × 1)	Newly construct
18		Kurasini	ditto	33 kV	Switchyard	(1 bay Ex.)	Expansion
19		Tabata	ditto	33/11 kV	5 MVA	(5 MVA × 1)	Newly construct

(2) Selection of location of substation

It is known that construction of new substations is needed in the Dar Es Salaam City region and thus discussions are made with TANESCO's staff in order to select the locations of the substations by taking into account the following:

- To harmonize with the existing facilities
- To be located in the vicinity of future consuming zones
- To cope with the increase in demand and improve voltage and power losses
- To enhance reliability of power supply
- Incoming and outgoing arrangement of transmission and distribution lines

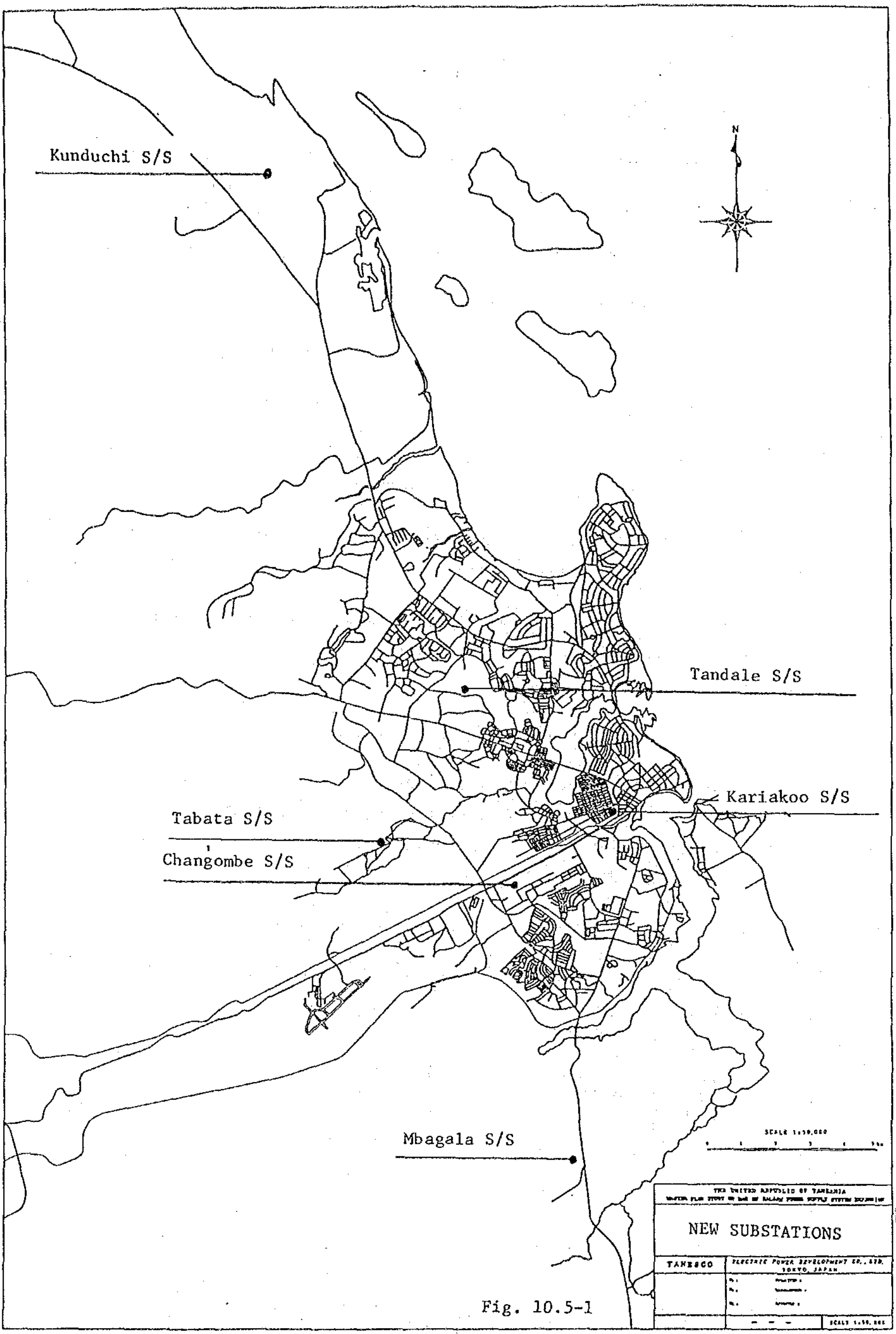
Those points are comprehensively reviewed to determine the necessary construction areas as shown below. The locations of the substations are shown in Fig. 10.5-1 to 10.5-7.

1) Site for construction of new substation

The construction sites for these new substations are as mentioned in the minutes of meeting prepared by TANESCO and JICA on October 10, 1993. The summary of the site areas are as shown in Table 10.5-2.

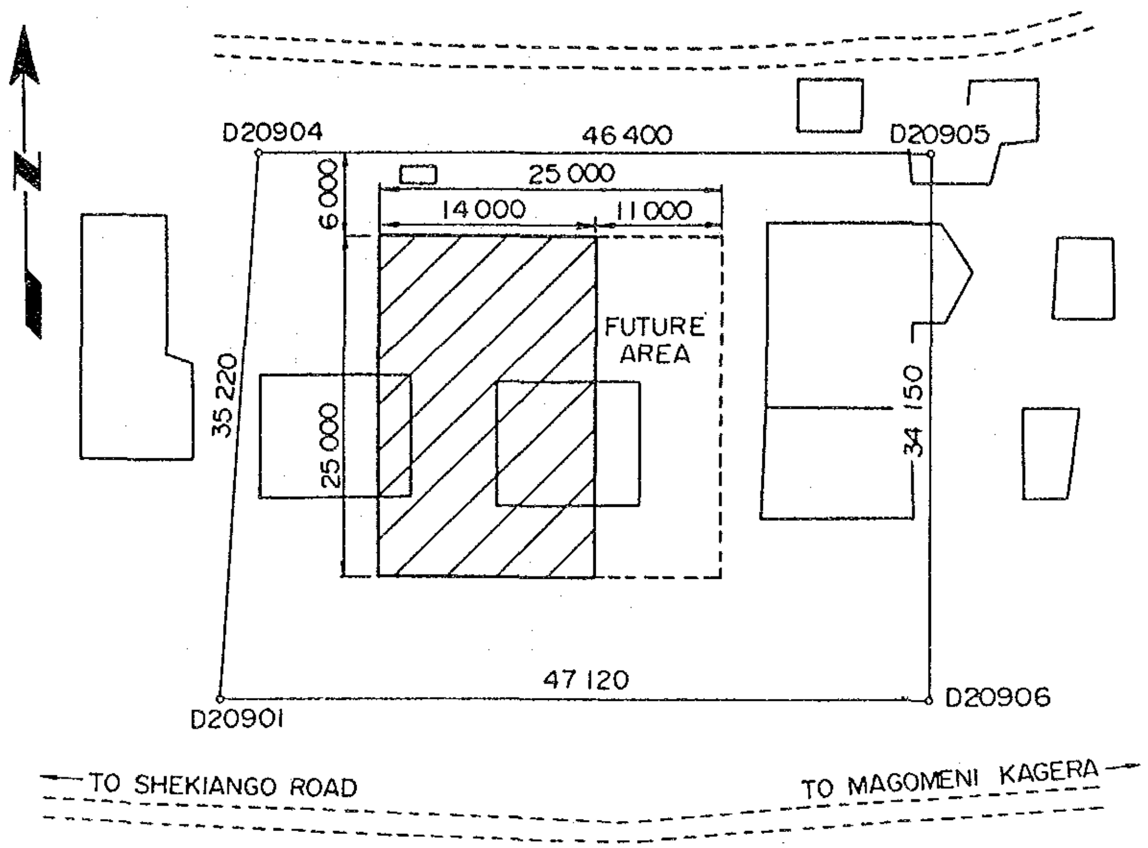
Table 10.5-2 Site areas for Substation

No.	Substation name	Site area (m x m)	Remarks
4	Tandale	30 x 40	
5	Chang'ombe	40 x 30	
12	Kunduchi	40 x 20	
15	Kariakoo	90 x 20	
17	Mbagala	40 x 80	
19	Tabata	35 x 30	



Kunduchi S/S
N
Tandale S/S
Kariakoo S/S
Tabata S/S
Changombe S/S
Mbagala S/S
NEW SUBSTATIONS
TANESCO

Fig. 10.5-1



THE UNITED REPUBLIC OF TANZANIA

MASTER PLAN STUDY ON DAR ES SALAAM POWER SUPPLY SYSTEM EXPANSION

LOCATION MAP OF TANDALE SUBSTATION

TANESCO

ELECTRIC POWER DEVELOPMENT CO., LTD. TOKYO JAPAN

D. R.: SUBMITTED:

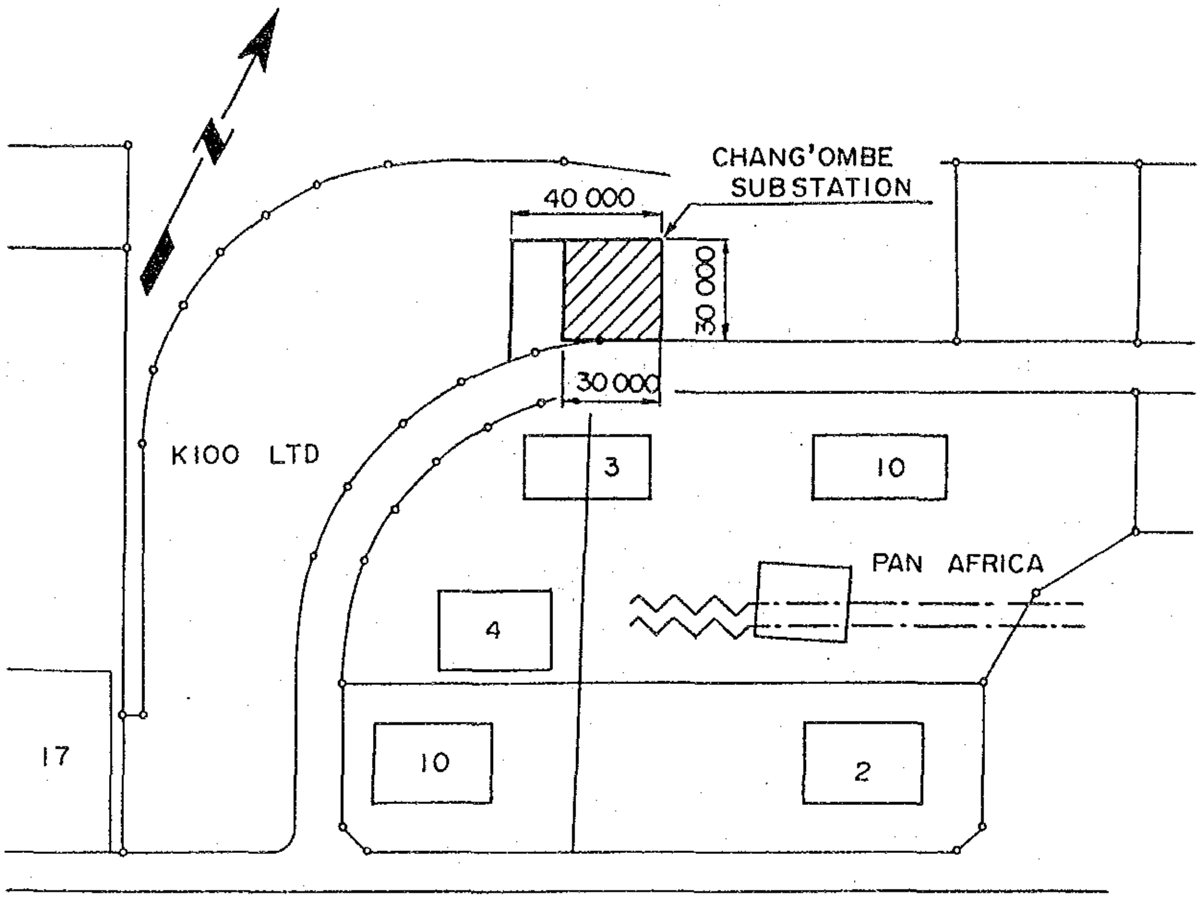
T. R.: RECOMMENDED:

C. K.: APPROVED:

LOCATION	DATE	DESCRIPTION	BY
REVISION			

SHEET NO. OF

Fig. 10.5-2



LOCATION	DATE	DESCRIPTION	BY
REVISION			

THE UNITED REPUBLIC OF TANZANIA
MASTER PLAN STUDY ON DAR ES SALAAM POWER SUPPLY SYSTEM EXPANSION

LOCATION MAP OF CHANG'OMBE SUBSTATION

TANESCO | ELECTRIC POWER DEVELOPMENT CO., LTD. TOKYO JAPAN

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

Fig. 10.5-3

SHEET NO. OF

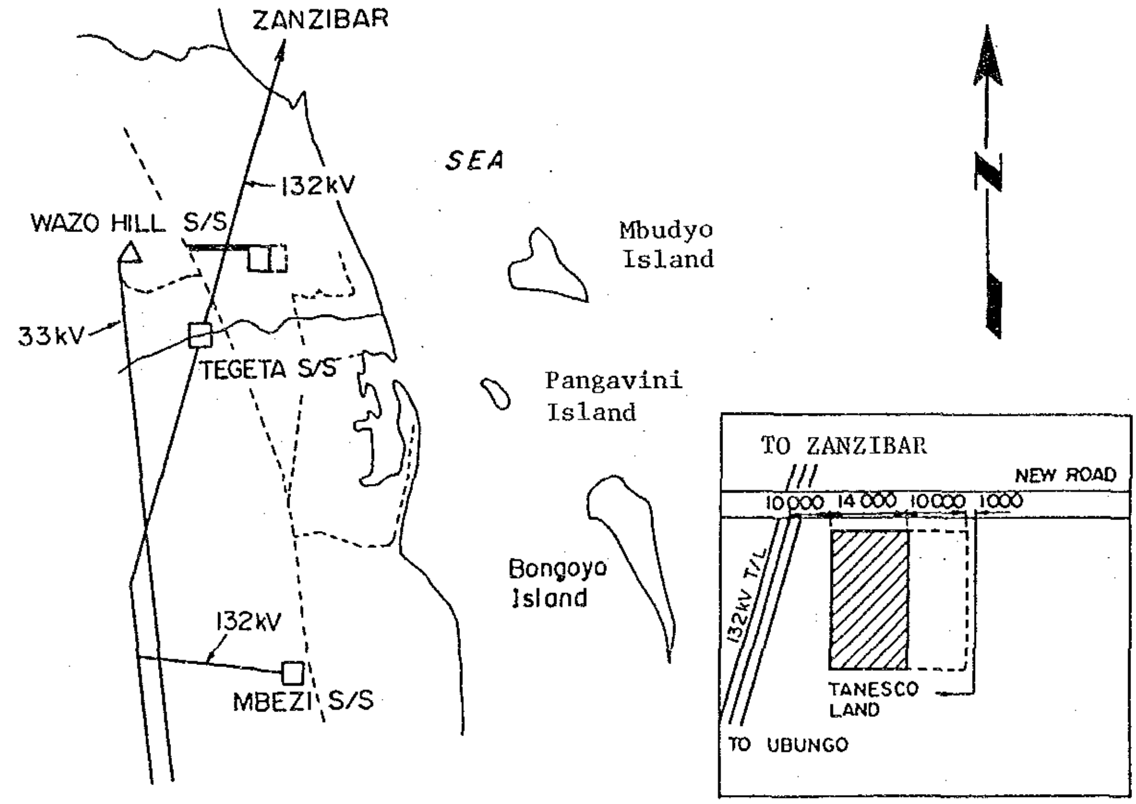


Fig. 10.5-4

THE UNITED REPUBLIC OF TANZANIA
MASTER PLAN STUDY ON DAR ES SALAAM POWER SUPPLY SYSTEM EXPANSION

LOCATION MAP OF KUNDUCHI SUBSTATION

TANESCO	ELECTRIC POWER DEVELOPMENT CO., LTD. TOKYO JAPAN
	D.R.: SUBMITTED:
	T.R.: RECOMMENDED:
	C.K.: APPROVED:

LOCATION	DATE	DESCRIPTION	BY
REVISION			

SHEET NO. OF

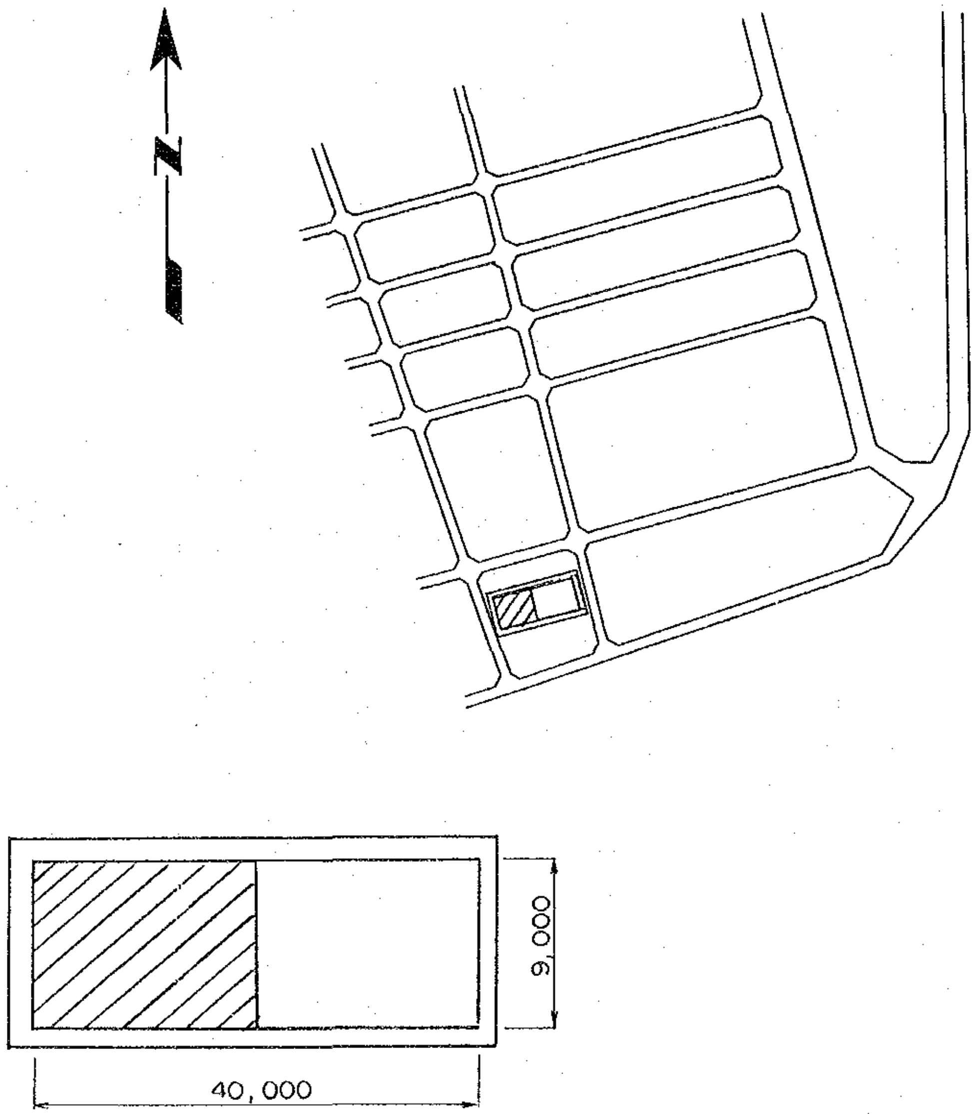


Fig. 10.5-5

THE UNITED REPUBLIC OF TANZANIA

MASTER PLAN STUDY ON DAR ES SALAAM POWER SUPPLY SYSTEM EXPANSION

LOCATION MAP OF KARIAKOO SUBSTATION

TANESCO

ELECTRIC POWER DEVELOPMENT CO., LTD. TOKYO JAPAN

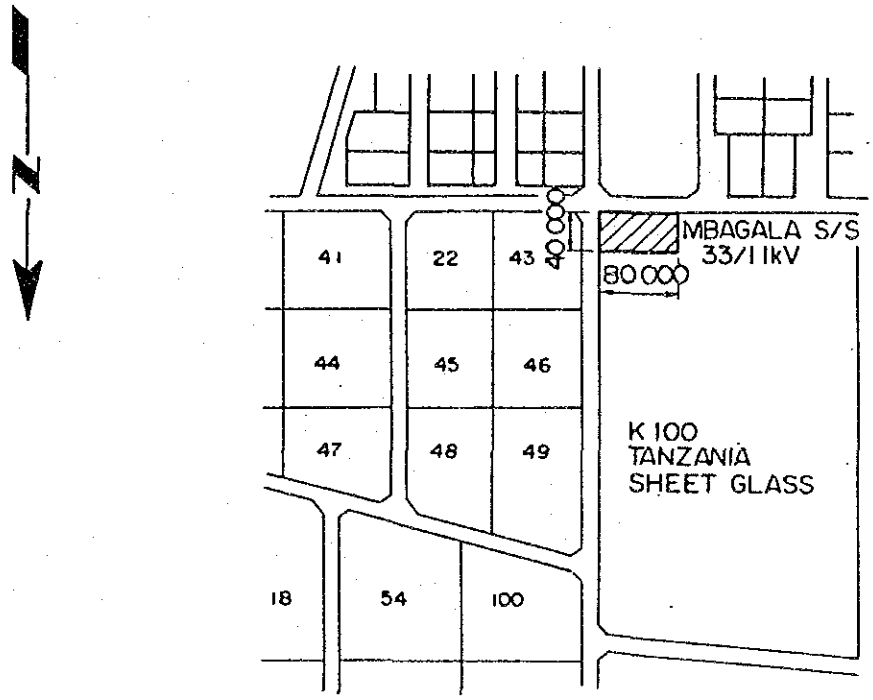
D.R.: SUBMITTED:

T.R.: RECOMMENDED:

C.K.: APPROVED:

LOCATION	DATE	DESCRIPTION	BY
REVISION			

SHEET NO. OF

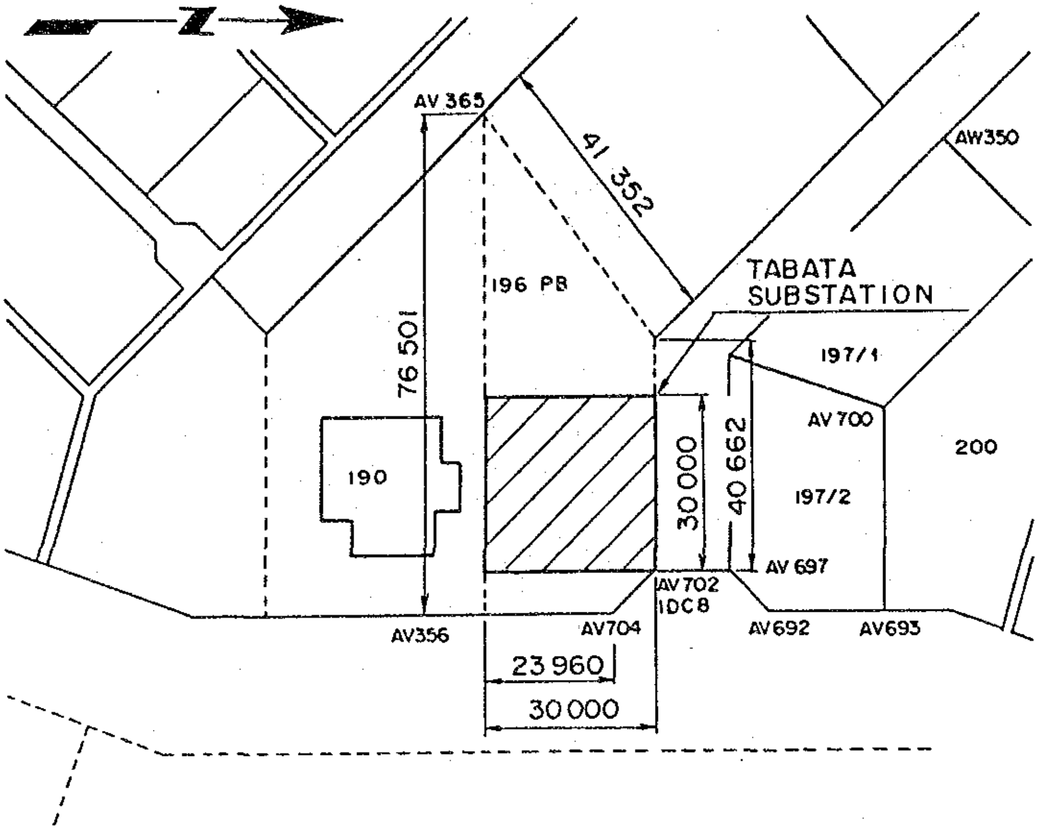


THE UNITED REPUBLIC OF TANZANIA MASTER PLAN STUDY ON DAR ES SALAAM POWER SUPPLY SYSTEM EXPANSION	
LOCATION MAP OF MBAGALA SUBSTATION	
TANESCO	ELECTRIC POWER DEVELOPMENT CO., LTD. TOKYO JAPAN
	D. R.: SUBMITTED: T. R.: RECOMMENDED: C. R.: APPROVED:

Fig. 10.5-6

LOCATION	DATE	DESCRIPTION	BY
REVISION			

SHEET NO. OF



THE UNITED REPUBLIC OF TANZANIA
MASTER PLAN STUDY ON DAR ES SALAAM POWER SUPPLY SYSTEM EXPANSION

LOCATION MAP OF TABATA SUBSTATION

TANESCO	ELECTRIC POWER DEVELOPMENT CO., LTD. TOKYO JAPAN
	D.R.: SUBMITTED:
	T.R.: RECOMMENDED:
	C.K.: APPROVED:

Fig. 10.5-7

LOCATION	DATE	DESCRIPTION	BY
REVISION			

SHEET NO. OF

(3) Unitization of new substation facilities

In consideration of the economic efficiency and maintainability of the new substations, an unit type substation (an unit automated substation) is adopted in which 33 kV equipment are placed outdoors and 11 kV equipment are contained in a cubicle thus eliminating the housing structures.

Advantages of the unit substation are as follows:

- To standardize and simplify the substation design.
- To eliminate housing structures to contain switchboards and equipment thus allowing the substation to be built even in a narrow space.
- To enable compact design of the transformer on its secondary side as well as allow use of shorter power cables and moreover substantially save the length of the control cables.
- To implement easy installation and shorten the work period.
- To enable additional installation and removal to other places.
- To enable easy operation and maintenance and moreover save the maintenance cost.
- To save the total construction cost.

(4) Method of connection

The method of connection to apply to the new substations is reviewed in such a way that it should be as simple as possible while satisfying the following to the extent that it does not damage the power supply functions:

- Operational conditions of the system
- Frequency of inspection of equipment and failure rate (In recent years, the reliability of the cables and transformers is much enhanced.)

- Responsibility for power supply

- To secure the construction site

(5) Pollution design

1) Applicable division of pollution zone

As for the applicable division of pollution zones to the Dar Es Salaam City region, it is necessary to make the pollution design coordination with the existing facilities currently owned by TANESCO. In general, the design must first be made by comprehensively taking into account such factors as the local weather conditions, distances from the seashore, ambient geographical features, existence of any shields, actual results of past pollution in the region, and others and then by estimating the equivalent salt deposit based on them to determine the division finally.

In Tanzania, the monsoon can be regarded as being equivalent to the typhoon or seasonal wind in Japan but it differs in that it is effective in washing down the salt deposit from the insulators. This is probably because it rains more during the monsoon than in the typhoon. Hence, it is presumable that the insulators are in rather good condition in Tanzania than in Japan. This may also be verified by the fact that the corona discharge increases at the time of the monsoon due to the winds that blow just before and after it and moreover from the fact that the insulators are not provided with any washing devices despite the close location of the existing substations from the seashore, that is only 10 km or less. For that reason, it is decided that the pollution division which a rank lower than that to be determined from the ordinary design concept for the pollution division may be applicable.

It is well known that it takes a very long time to obtain the exact local pollution measurement data and thus it is difficult to make the strict pollution design. However, the applicable division is set out for the time being as shown in Table 10.5-3.

Table 10.5-3 Applicable Division of Pollution

Pollution division	Degree of pollution equivalent salt deposit density		Applicable division	Tanzania	Japan	
				For Dar es Salaam City areas	Distance from seashore (km)	
	Suspension insulator	Long-rod station post			For typhoon	Seasonal wind
A	0.063	0.03	Ordinary		50 or over	1 or over
B	0.125	0.06	Light salt damage		10 - 50	3 - 10
C	0.25	0.12	Medium salt damage	o	3 - 10	1 - 3
D	0.5	0.35	Heavy salt damage		0.3 - 3	0.1 - 1

Distances from the new substations to the seashore are as shown in Table 10.5-4.

Table 10.5-4 Distance to Seashore

Name of Substations	Distance (km)
Tandale	4.8
Chang'ombe	3.8
Kunduchi	2.1
Kariakoo	0.9
Mbagala	5.4
Tabata	7.5
Temeke	4.1
Mburahati	5.4
Kitunda	8.6
Yombo	7.5
Upanga	0.9

2) Design pollution withstand voltage

As for the selection of the design withstand voltage value for the insulators, various design concepts are available presently. However, as a result of the actual review of the performance of the existing facilities being used by TANESCO, it is known that the continuous abnormal voltage rarely occurs in the circuit despite their effectively earthed systems. Accordingly, it is decided that the normal voltage to ground of the line should be taken up and that the design of the insulators should be such that they can fully withstand this voltage even under the worst possible condition thereby enabling good coordination with the existing facilities.

The maximum value of the normal voltage to ground is given by the following equation:

$$V = (\text{nominal voltage}) \times \frac{1.15}{1.1} \times \frac{1}{\sqrt{3}} \ (\text{kV})$$

(132 kV)

$$V_{132} = 132 \times \frac{1.15}{1.1} \times \frac{1}{\sqrt{3}}$$
$$= 79.674$$

(33 kV)

$$V_{33} = 33 \times \frac{1.15}{1.1} \times \frac{1}{\sqrt{3}}$$
$$= 19.919$$

(11 kV)

$$V_{11} = 11 \times \frac{1.15}{1.1} \times \frac{1}{\sqrt{3}}$$
$$= 6.640$$

3) Number of suspension insulators to be installed

The standard pollution withstand voltage per insulator of the proven 254 x 146 mm suspension insulators that are successfully delivered to TANESCO in the past is as shown in Table 10.5-5.

Table 10.5-5 Pollution withstand voltage of insulator

(kV)

Withstand voltage /suspension insulator (kV) \ Equivalent salt deposit (mg/cm²)	0.0625	0.125	0.25	0.5
254 x 146 mm	9.4	7.5	6.9	6.4

Based on the above data, necessary number of suspension insulators by each nominal voltage can be calculated as shown in Table 10.5-6.

Table 10.5-6 Number of suspension insulators

(Piece)

Nominal voltage (kV) \ Equivalent salt deposit (mg/cm2)	0.0625	0.125	0.25	0.5	Number of insulators presently installed	Remarks
132	9 (8.5)	11(10.1)	12(11.5)	13(12.4)	9.11.12	
33	3 (2.1)	3 (2.5)	3 (2.9)	4 (3.1)	3	
11	1 (0.7)	1 (0.8)	1 (1.0)	1 (1.0)	2	

Note: ( ) shows the calculated values.

4) Pollution withstand voltage of station post insulator

The pollution withstand voltage of the standard SP insulators put under review this time is as shown in Table 10.5.-7.

Table 10.5-7 Withstand voltage of SP insulator

Equivalent salt deposit (mg/cm2) / Insulator	0.03 (kV)	0.06 (kV)	Insulator specifications	
			Average diameter (mm)	Leakage distance (mm)
SP - 10	18	15	89	360
SP - 30	37	30	115	830
SP-850A + SP-850B	108	97	152	3,240

The surface leakage distance of the insulators in respect of the pollution withstand voltage is taken for the ordidnary value of 40 mm/kV or over.

10.5.3 Operation Control System

1) As for the operation control system, the same simple monitor system as that of the existing distribution substations is applied to the new substations.

2) The above system is applicable in Japan to those substations as with 100 kV or over and 10 MVA or under of capacity. In this case, the monitoring, patrolling and operation of equipment of the substation is done by technicians staying at a control station who visit the substation as necessary.

3) As for the operation of on load tap changer, the same LTC and LDC control system as that of the existing distribution substations are applied to the newly construct substations.

4) It is desirable that in the case of simple monitor system, alarms should be displayed at Ilala S/S, the station of the technicians, and thus a VHF device is provided this time for this purpose. For details, see [Feeder maintenance communications system].

5) In the 11 kV distributions feeder's cubicles at the newly construct distributing substations should be equipped with the

current recorders in addition to the necessary meters in order to observe the load current variation for the consumers associated.

10.5.4 Number of Banks

Presently, various methods are widely used to determine necessary number of banks to be provided for distribution substations. With the demand for a substation being kept constant, the number of banks are changed from 2 to 3 and then to 4. It is known from it that both the transmission line construction cost and distribution line construction cost out of the total construction costs remain unchanged regardless of the change of number of banks. On the other hand, when a case is taken up were one transformer is in failure, it is also known that the load must be supplied by the remaining other sound banks, and hence, in consideration of the overload limit of transformers, the less is the number of banks, the more becomes the capacity of the facilities of the substation. This is disadvantageous. Consequently, the basic number of banks is taken for two including the additional installation in future. This is because less number of banks is generally more advantageous for the large-scale substations.

10.5.5 Unit Capacity of Transformer

To select the unit capacity of transformers, it is necessary to estimate beforehand the future demand density of the region covering 10 years or more. In general, the optimum unit capacity to match the estimated future demand capacity is determined by minimizing the integrated construction costs for the transmission, substation and distribution facilities with the scale of the substation being used as the parameter. However, in consideration of the actual unit capacity of 5, 7.5 and 15 MVA and moreover of the circumstances in Tanzania, it is decided that 15 MVA should be taken for the standard capacity through it might pose a little challenge.

10.5.6 Bus System

The bus system of the existing distribution substations is of a simple single bus arrangement type. The single bus system is often used for one circuit, T branching power receiving as well as one circuit, π branching power receiving and thus this system should be used.

10.5.7 Protective Relay System

(1) Countermeasures to be taken for existing substations

As stated in [5.1.2 (5) Present State of Protection System], the present protective relay systems pose no problems but as for the condition of installation of the protective relays, however, temperature control and dustproof protection are needed at all distribution substation.

To put it concretely:

- To close up tightly the entrance and exit, windows, etc. to prevent infiltration of dust and dirt from the outside.
- To install an air-conditioner to prevent high temperature or temperature change in the room.

Those two countermeasures must promptly be taken for the distribution substations giving priority to those located in the vicinity of the seashore.

(2) Countermeasures to be taken for New Substations

Since present protective relay systems for transmission and distribution lines, buses and transformers have so far posed no problems at all, it is recommended that the same protective relays as those presently in use at each existing substation should be used hereafter as well. Those systems are of almost the same type as that used by the power companies in Japan.

As for the type of the relay, the same electromagnetic type as that presently in use at the existing substations should be used by taking into account the maintainability.

a) Protection system of transmission and distribution lines

Voltage \ Fault / Protection	Main protection		Backup protection	
	Short-circuit	Grounding	Short-circuit	Grounding
220 kV Transmission line	DZ x 3 (*1)	DG (*1)	OC x 3	OCG
132 kV Transmission line	DZ x 3	DG	OC x 3	OCG
33 kV Transmission line	OC x 3	OCG	-	-
11 kV Distribution line	OC x 2	OCG	-	-

* 1: The phase-reversal relay system is used for the main protection of 220 kV transmission line.

Where; DZ : Short-circuit distance relay
DG : Ground power directional relay
OC/OCG : Overcurrent/ground overcurrent relay

b) Method of protection of bus

Voltage	Method of protection	Remarks
132 kV	Voltage differential relay system	220, 132 kV substation
33 kV	Overcurrent relay system	220, 132 kV substation
11 kV	Overcurrent relay system	33 kV substation

As for the 33 kV bus of the distribution substation, the bus protection is not applicable to it but instead it is included in the 33 kV transmission line protection.

c) Method of protection of transformer

Voltage	Electrical protection							Mechanical protection
	Short-circuit			Grounding			Inter-nal fault	
	High-tension winding	Low-tension winding	Tertiary winding	High-tension winding	Low-tension winding	Tertiary winding		
220/ 132kV	OC*3	OC*3	-	OCG	OCG	-	RDf*3	Pr T(winding) (oil tem-perature)
LTC	-	-	-	-	-	-	-	Pr
132/33kV	OC*3	OC*3	-	OCG	OCG	-	RDF*3	Pr T(winding) (oil tem-perature)
LTC	-	-	-	-	-	-	-	Pr
33/11kV (over 5 MVA)	-	OC*3	-	OCG	OCG	-	RDf*3	Pr T(winding) (oil tem-perature)
LTC	-	-	-	-	-	-	-	Pr
33/11kV (under 5 MVA)	-	OC*2	-	-	OCG	-	RDf	Pr T(winding) (oil tem-perature)
LTC	-	-	-	-	-	-	-	Pr

Where; RDf : Ratio differential relay
Pr : Pressure relay
T : Temperature relay
LTC : On-load tap changer

10.5.8 Telecommunications System

(1) Summary of telecommunications system

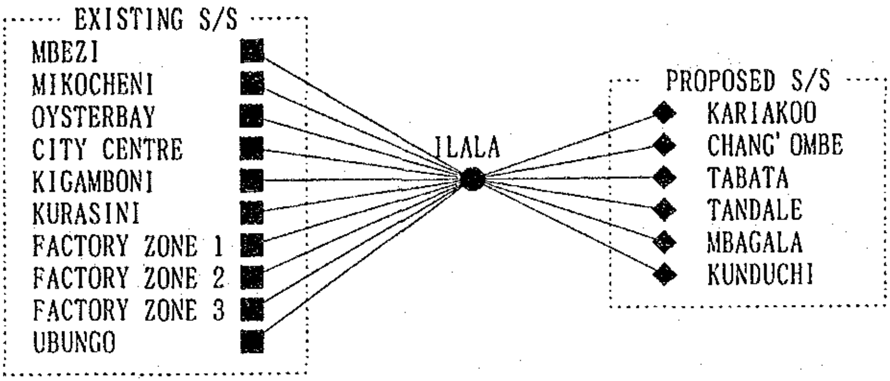
As for the new telecommunications systems to be connected to the six substations that are scheduled to be constructed in the short-term five year plan, the most suitable way to set up them should be by making good use of the existing systems. This is recommended from the point of view of the consistency with the existing facilities and moreover the economic efficiency as shown below in detail.

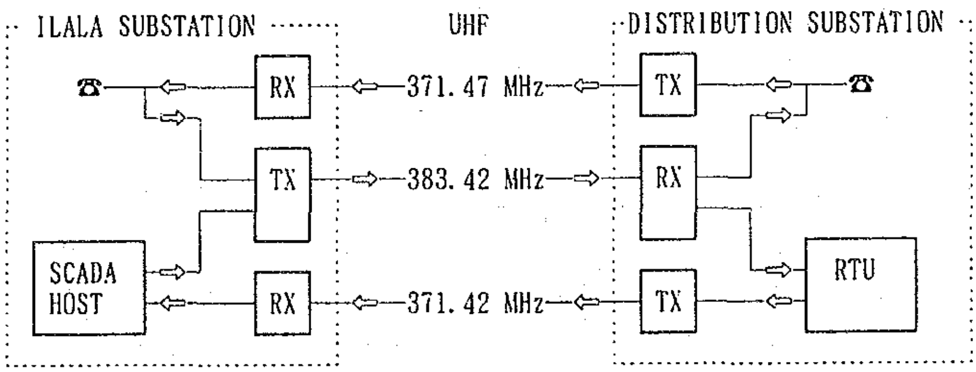
(a) Consistency with existing telecommunications system

These six new planned substations are scheduled to be monitored from Ilala S/S via telecommunications systems (including SCADA). It is known however that the existing type of systems can well deal with them. In view of it and moreover from the point of view of the facility setup, installation space, routine works of the operators, as well as that presently in use at the existing substations.

(b) Economic efficiency

Since the SCADA system is included in the Ilala telecommunications systems, relevant software and hardware concerning the new substations must newly be added to it, but it should be noted herewith that no additional installation is needed for new whole devices. As in the case of the existing substations, the new substations are also provided with the same kinds of facilities as the existing ones as shown in the following diagram. It is known form the diagram that because of the systems being set up by making good use of the existing facilities, the necessary costs are only limited to those related to the new substations thus offering the economic design.

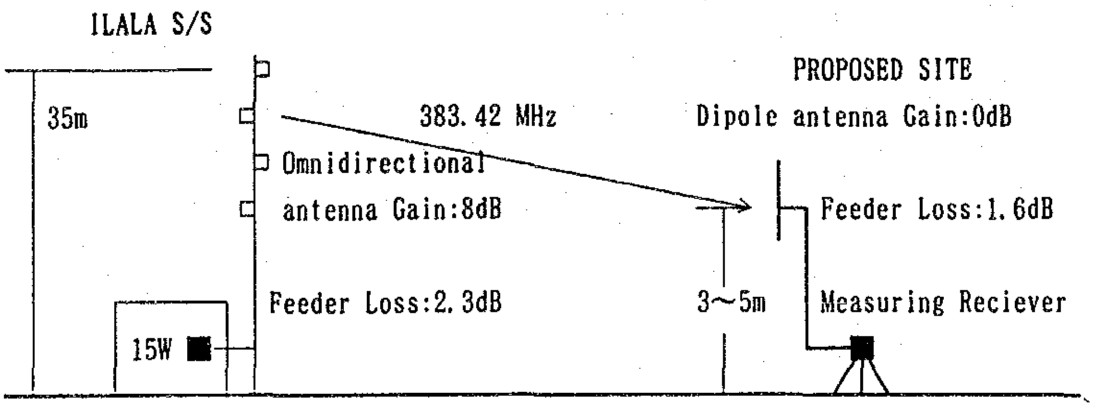




LEGEND ●: MASTER STATION SCADA HOST RTU: REMOTE TERMINAL UNIT
■: EXISTING DISTRIBUTION SUBSTATION
◆: PROPOSED DISTRIBUTION SUBSTATION
TX: TRANSMITTER RX: RECEIVER ☎: TELEPHONE HANDSET

(2) As to received input voltage and S/N

To check whether the wireless circuit can be formed between the planned construction site and Ilala substation, the received input electric field is measure as follows:



Transmit Power 41.8dBm(15W)

Measuring Reciever:ANRITSU ML522C
Dipole antenna:ANRITSU MP534B

On the other hand, the received electric field strength (calculated value) can be obtained from the following equation. In this event, however, since uncertain factors are still included in the design conditions, the diffraction loss is excluded from the calculation.

$$Pr = \underbrace{[Pt - (Lft + Lst) + Gat]}_{\text{Transmitter}} - \underbrace{[Lo + Ld + Lg]}_{\text{Propagation}} + \underbrace{[Gar - (Lfr + Lsr)]}_{\text{Receiver}}$$

$$= [41.8 - (2.3) + 8.0] - [Lo + Ld + 20.0] + [0.0 - (1.6)]$$

$$= 25.9 - [Lo + Ld] \quad \text{(LLst, Lsr eliminated)}$$

Pt :	Transmitting Power	41.8	(dBm)	Transmitter at ILALA S/S
Lst:	Circuit Loss	-	(dB)	
Lft:	Feeder Loss (LDF1/2 50m)	2.3	(dB)	
Gat:	Antenna Gain (RMV4)	8.0	(dB)	
Lo :	Free Space Loss	-	(dB)	Propagation
Ld :	Diffraction Loss	-	(dB)	
Lg :	Land Factor	20.0	(dB)	
Gar:	Antenna Gain (Dipole)	0.0	(dB)	Receiver at the SITE
Lfr:	Feeder Loss (RG55/u 10m)	1.6	(dB)	
Lsr:	Circuit Loss	-	(dB)	
Pr :	Received Power	-	(dBm)	
Vo :	Received Voltage	-	(dBμV)	

On the other hand, the received electric field strength (calculated value) can be obtained from the following equation. In this event, however, since uncertain factors are still included in the design conditions, the diffraction loss is excluded from the calculation.

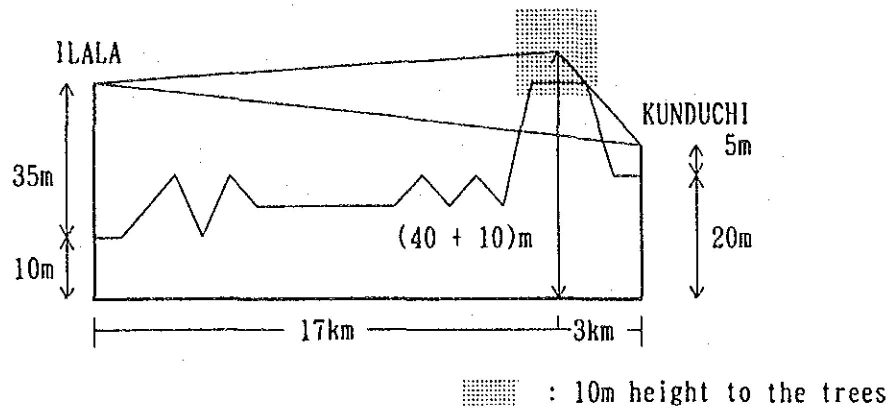
Site	Distance from ILALA (km)	Free Space Loss (dB)	Land Factor (dB)	Received Voltage (dBμV)				S/N (dB)			
				Cal.	Mea.	Act.	Sta.	Cal.	Mea.	Act.	Sta.
KARIAKOO	1.3	86.4	20	53	47	56	over 25	60	54	63	over 35
CHANG'OMBE	2.9	93.4	20	46	55	64		53	62	71	
TABATA	5.4	98.8	20	40	33	42		47	40	49	
TANDALE	4.4	97.0	20	42	34	43		49	41	50	
MBAGALA	10.3	104.4	20	35	26	35		42	33	42	
KUNDUCHI	20.0	110.1	20	29	13	22		36	20	29	

Cal.: Calculated Data
Mea.: Measured Data and its Antenna Gain (Dipole) 0.0 dB
Act.: Actual Data (Calculated by the measured data) and its Antenna Gain (6el YAGI) 8.5 (dB)
6el YAGI is standard of the SCADA SYSTEM

(3) As to the measured results

It is said that in the case of a 400 Hz band telemeter station, the received input voltage should be 25 dBμ V or over and S/N 35 dB or over. Accordingly, the physical circuits of the existing substations are reviewed based on these standards. As a result, it is known that all KARIAKOO, CHANG'OMBE, TABATA, TANDALE, MBAGALA substations, except for KUNDUCHI, fully satisfy these standards and thus it is decided, together with taking into account the actual condition of the planned sites found during the site survey, that the new facilities being set up in the same way as the existing facilities may pose no problems at all in the future.

As for the KUNDUCHI substation that fails to satisfy the standards, a detailed study is further conducted as follows:



Frequency : 383.42 MHz

Free Space Loss : L0 = 20log(F*D)+32.44=20log(383.42*20)+32.44 = 110.1dB

Diffraction Loss :Ld

rs = 547.72 √ [(D1 * D2)/(D1 + D2) • 1/F]

= 547.72 √ [(17 * 3)/20 • 1/383.42]

= 44.67 m

C = hs - [h1 - D1/D * (h1 - h2) - d1 * d2/(d * K * a)]

rs:Radius 1st = 50 - [45-17/20*(45-25)-17,000*3,000/(2*8.49×E6)]

Fresnel Zone = 25 m (for K=4/3)

x = C / rs

C :Clearance = 25 / 44.67

= 0.56

Ld = 8 x + 8

= 8 * 0.56 + 8

= 12.5dB

Land Factor 20dB

Propagation Loss(Total) = 110.1dB + 12.5dB + 20dB = 142.6dB

In the case of KUNDUCHI, the calculated values of the received input voltage largely differ from those of the actual measurement. In order to find out the cause, the geographical features that lie in the wave propagation route and may probably exert the influences on the measured values on the way from ILALA to KUNDUCHI were reviewed during the actual site survey as well as with the help of the map. As the result of it, it is confirmed that the land height is coming up from the point in front of the planned KUNDUCHI substation construction site towards the ILALA substation. Hence, it is concluded that the diffraction loss due to the above sloped land may have largely affected the measured results.

Accordingly, the detailed calculation is performed as follows including the effect of the diffraction loss.

As the result of the calculation, it is found that the diffraction loss comes to 12.5 dB when the antenna height is therefore calculated again to obtain 17 dBμ V this time. As compared to 13 dBμ V of measured value, it is convinced that the diffraction loss has exerted a large influence on the received input voltage.

Accordingly, it is found out that in order to obtain the necessary received input voltage as well as S/N value at Kunduchi substation, the following three countermeasures should be taken:

(a) To raise antenna height

Antennas must be installed in a higher position to reduce the diffraction loss. The variations in the received input voltage due to change of the antenna height are as shown in the following table:

Antenna Height KUNDUCHI	X C/rs	Diffraction Loss (dB)	Propagation Loss(Total) (dB)	Recieved Voltage (dBμV)		
				Calculated	Measured	Actual
5 m	0.56	12.5	142.6	16.3	13.0	21.5
10 m	0.47	11.7	141.8	17.1	13.8	22.3
15 m	0.36	10.4	140.5	18.4	15.1	23.6
20 m	0.27	9.3	139.4	19.5	16.2	24.7
25 m	0.18	8.2	138.3	20.6	17.3	25.8
30 m	0.09	7.1	137.2	21.7	18.4	26.9

(b) To increase number of elements of antenna

It is also necessary to improve the gain itself and thus the received input electric field by increasing the number of elements of the antenna.

ANTENNA TYPE	GAIN	REMARKS
3 E L YAGI	8.0dB	EXISTING SUBSCRIBER S/S (6EL YAGI 8.5dB)
4 E L YAGI	10.0dB	
5 E L YAGI	11.0dB	
6 E L YAGI	13.0dB	

(c) To enlarge transmitter output at KUNDUCHI

In view of the actual result of the received input electric field that is rather low, it is also put under review that the transmitter output at KUNDUCHI should be raised.

In the present system, the transmitter output of the ILALA master station is 15W (41.8 dBm) while at the slave existing substations, the 6W (37.8 dBm) transmitters are commonly used

(c) To enlarge transmitter output at KUNDUCHI

In view of the actual result of the received input electric field that is rather low, it is also put under review that the transmitter output at KUNDUCHI should be raised.

In the present system, the transmitter output of the ILALA master station is 15W (41.8 dBm) while at the slave existing substations, the 6W (37.8 dBm) transmitters are commonly used as the standard type. Nonetheless, if this standard transmitter (6W) is used at KUNDUCHI, the received input voltage at ILALA comes to only 9 dB which is still more lower by 4 dB than the above mentioned 13.0 dBμ V of the measured received input voltage at KUNDUCHI.

Since it is difficult to raise the transmitter output at ILALA in consideration of the total even balance, it may inevitably be necessary and important to increase the transmitter output at KUNDUCHI to 10W (40.0 dB) thereby increasing the input voltage to ILALA.

(4) Conclusion

As the result of the above review, it is concluded herewith that the necessary telecommunications systems at each substation in the short-term 5 year plan are as shown in the following table.

KARIAKOO	Received input voltage : S/N : Environmental condition: Facility to be used :	Favorable (56 dBμV), Favorable (63 dB) In a vacant lot in the center of the city next to an about 30m high building. The existing communications system is planned to be introduced.
CHANG'OMBE	Received input voltage : S/N : Environmental condition: Facility to be used :	Favorable (64 dBμV), Favorable (71 dB) Surrounded by factories. The existing communications system is planned to be introduced.
TABATA	Received input voltage : S/N : Environmental condition: Facility to be used :	Favorable (42 dBμV), Favorable (49 dB) In a residential district next to the Tanzania Post and Telecommunications Public Corporation. The existing communications system is planned to be introduced.
TANDALE	Received input voltage : S/N : Environmental condition: Facility to be used :	Favorable (43 dBμV), Favorable (50 dB) In a residential district. The existing communications system is planned to be introduced.
MBAGALA	Received input voltage : S/N : Environmental condition: Facility to be used :	Favorable (35 dBμV), Favorable (42 dB) Next to a factory. The existing communications system is planned to be introduced.
KUNDUCHI	Received input voltage : S/N : Environmental condition: Facility to be used :	Below the standard level before improvement (22 dBμV), but favorable after improvement (30 dBμV). Below the standard level before improvement (29 dB) but favorable after improvement (37 dB) In a farmland with a hill in front of it thus causing a large diffraction loss. In the case of KUNDUCHI, a 10W transmitter and 20m high Yagi antenna with eight elements are ploanned to be secured, which improve as much as by 8dB on KUNDUCHI side and by 10 dB on ILALA side thus posing no problems at all.

The received input voltage and S/N shown in the above table are calculated based on the measured values at each substation and in addition, presuming that the similar facilities as the existing ones will be introduced again.

10.5.9 Number of Feeders and Outgoing Arrangement

In general, the single bus system based on a unit transformer is widely used for the outgoing arrangement of the secondary feeders and in addition, in order to divide the secondary bus, there is such a system in which the bus is divided into two together with two transformers. In this study, however, these systems are further systematically combined to make into an advanced system in which the load change-over at the time of the transformer failure can suitably be done to match the actual situation of the distribution system.

As for the number of feeders, five feeders each are planned to be provided for respective new distribution substations to meet the load demand.

10.5.10 Incoming Arrangement for Transmission Line

As for the incoming arrangement of the transmission lines, the design concepts for the wire connection vary according to the inclusion or exclusion of the circuit breakers and disconnectors. In this study, the line CB and transformer CB system that facilitates T branching and π branching is used for the new distribution substations. In this system, which is applicable both to T branching receiving and π branching receiving, the wire connection includes the circuit breakers both for the transformer primary and power receiving lines.

10.5.11 Particular Specifications of Transformer

1) Neutral point grounding system

As stated in the single line diagrams, all existing 220 kV, 132 kV, 33 kV and 11 kV circuits are directly earthed at the neutral point of the transformers.

Likewise in this study, the neutral point grounding system is adopted both for the protection system and equipment facilities in order to match the design concept with that of the existing facilities.

2) Method of wire connection

In this study, the grounding system and the phase difference between the primary and secondary voltage of the transformers are made matched with those of the existing facilities so that they can appropriately be diverted if needed to other installation or modification purposes in the future and hence to the transformers, Y - Y - D connection is applied.

3) L.T.C and others

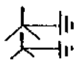
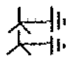
The L.T.C attached to each transformer is made matched with the existing tap width and moreover it is placed on the high-tension side from the economical point of view. This arrangement also enables the parallel operation, if any, in the future with the existing transformers without posing any problems at all.

10.5.12 Specification of Main Equipment

Summarise of the main equipment to be newly or additionally installed in this study in connection with the substation-related works are as follows:

(1) Main transformer

Applicable Standards:	JEC 204-1978	Transformer
	JEC 186-1972	On-load tap changer

Capacity	45,000 kVA	15,000 kVA
Rating	Continuous	Continuous
Number of phase	3 phase	3 phase
Frequency	50 Hz	50 Hz
Method of cooling	Oil-immersed and self-cooled	Oil-immersed and self-cooled
Rated voltage (primary/secondary)	132,000V/33,000V	33,000V/11,000V
Tap voltage (HV)	+5%, -15% 17 Tap	±10% 17 Tap
Insulation class (No.)	120/30A	30A/10A
Wire connection Primary Secondary	 Tertiary(Δ)	 Tertiary(Δ)
Angular displacement	0°	0°
Polarity	Subtractive polarity	Subtractive polarity
Condition of use	Outdoors	Outdoors
Tap-changing mechanism	On-load tap-changing	On-load tap-changing
Elevation	1,000m or under	1,000m or under

(2) Circuit breaker

Applicable Standards: JEC 181-1975 Circuit Breaker

Rated voltage	145 kV	36 kV	36 kV
Insulation class (No.)	120	30 A	30 A
Rated current	800 A	1,200 A	600 A
Rated frequency	50 Hz	50 Hz	50 Hz
Rated breaking current	12.5 kA	12.5 kA	12.5 kA
Rated breaking time	5 cycle	5 cycle	5 cycle
Rated closing operation voltage	DC 100 V	DC 100 V	DC 100 V
Rated tripping voltage	DC 100 V	DC 100 V	DC 100 V
Standard operating duty	A CO-(1 min)-CO CO-(3 min)-CO	B CO-(15 sec)-CO	
Condition of use	Outdoors		
Elevation	1,000m or under		
Maximum ambient temperature	40°C		

Rated voltage	12 kV	12 kV
Insulation class (No.)	10 A	10 A
Rated current	1,200 A	600 A
Rated frequency	50 Hz	50 Hz
Rated breaking current	25 kA	25 kA
Rated breaking time	5 cycle	5 cycle
Rated closing operation voltage	DC 100 V	DC 100 V
Rated tripping voltage	DC 100 V	DC 100 V
Standard operating duty	B CO-(15 sec)-CO	
Condition of use	Contained in a cubicle	
Elevation	1,000m or under	
Maximum ambient temperature	40°C	

(3) Disconnector

Applicable Standards: JEC 196-1975 Disconnector

Rated voltage	145 kV	36 kV	36 kV
Insulation class (No.)	120	30 A	30 A
Rated current	800 A	1,200 A	800 A
Rated short-time current(standard value)	14 kV	14 kV	14 kV
Condition of use	Outdoors		
Elevation	1,000m or under		
Maximum ambient temperature	40°C		
Manual operation	Manual operation		

Rated voltage	36 kV	36 kV
Insulation class (No.)	30 A	30 A
Rated current	600 A	600 A
Rated short-time current(standard value)	14 kA	14 kA
Condition of use	Outdoors	
Elevation	1,000m or under	
Maximum ambient temperature	40°C	
Method of operation	Manual operation	
Accessory	Earthing device	-

(4) Current transformer

Applicable Standards: JEC 190-1974 Current transformer

Rated voltage	132 kV	132 kV	33 kV
Insulation class (No.)	BCT	BCT	BCT
Rated current	800/5A	400/5A	1200/5A
Rated burden	40 VA	40 VA	40 VA
Rated overcurrent intensity	40	40	40
Class	1.0	1.0	1.0

Rated voltage	33 kV	33 kV	11 kV
Insulation class (No.)	BCT	BCT	BCT
Rated current	600/5A	400/5A	1200/5A
Rated burden	40 VA	40 VA	40 VA
Rated overcurrent intensity	40	40	40
Class	1.0	1.0	1.0

Rated voltage	11 kV	11 kV
Insulation class (No.)	10 A	10 A
Rated current	1200/5A	600/5A
Rated burden	40 VA	40 VA
Rated overcurrent intensity	40	40
Class	1.0	1.0

(5) Instrument transformer

Applicable Standards: JEC 190-1974 Instrument transformer

Rated voltage	$\frac{132\ KV}{\sqrt{3}} / \frac{110\ V}{\sqrt{3}}$
Rated frequency	50 Hz
Insulation class (No.)	120
Rated burden	200 VA
Class	1.0

(6) Lightning arrester

Applicable Standards: JEC 208-1978 Lightning arrester

Rated voltage	126 kV	42 kV	33 kV
Rated frequency	50 Hz		
Nominal discharge current	10 kA		
Elevation	1,000 m or under		
Maximum ambient temperature	40°C		
Earthed system	Direct grounding at neutral point		

(7) Enclosed switchboard

Applicable Standards: JEM 1153 Enclosed switchboard

Rated voltage	11 kV
Condition of use	Outdoors
Elevation	1,000 m or under
Maximum ambient temperature	40°C

(8) List of new substation facilities

Main equipment to be newly or additionally installed in the substation expansion plan are as shown in Table 10.5-8.

Table 10.5-8 (1/2)

Main facilities		Substation name									
		Ilala S/S		Ubungo S/S	Tandale S/S	Chang'ombe S/S	Kurasini S/S	Mbezi S/S	Kunduchi S/S	FZ-III S/S	
Main transformer	Capacity	45 MVA	15 MVA		15 MVA	15 MVA		15 MVA	15 MVA	45 MVA	
	Number of phase	3	3		3	3		3	3	3	
	Frequency	50 Hz	50 Hz		50 Hz	50 Hz		50 Hz	50 Hz	50 Hz	
	Rated voltage	132/33 kV	33/11 kV		33/11 kV	33/11 kV		33/11 kV	33/11 kV	132/33 kV	
	Wire connection										
	Tap changer	On-load tap-changing	On-load tap-changing		On-load tap-changing	On-load tap-changing		On-load tap-changing	On-load tap-changing	On-load tap-changing	
	Required quantity	1	1		1	1		1	1	1	
Circuit breaker	Rated voltage	145 kV	36 kV	145 kV	36 kV	36 kV	36 kV	36 kV	36 kV	145 kV	36 kV
	Rated current										
	Rated breaking current	12.5 kA	12.5 kA	12.5 kA	12.5 kA	12.5 kA	12.5 kA	12.5 kA	12.5 kA	12.5 kA	12.5 kA
	Required quantity	4	4	1	1	3	1	4	1	3	1
	Rated voltage										
	Rated current										
	Rated breaking current	E.S	E.S								
	Required quantity	1	2								
Disconnector	Rated voltage	145 kV	36 kV	145 kV	36 kV	36 kV	36 kV	36 kV	36 kV	145 kV	36 kV
	Rated current										
	Required quantity	4	4	3		3	1	4		3	2
	Rated voltage	145 kV	36 kV	145 kV	36 kV						
	Rated current										
	Accessory	E.S	E.S	E.S	E.S	E.S	E.S	E.S	E.S	E.S	E.S
	Required quantity	1	2	2	2	2	1	2	1	1	2
Instrument transformer (C.T and P.T)	Rated voltage	132 kV	33 kV	132 kV	33 kV	33 kV	33 kV	33 kV	33 kV	132 kV	33 kV
	Insulation class										
	Rated current	800/5A, 400/5A	1200/5A, 400/5A	800/5A, 400/5A							
	Required quantity	3	3	3						3	
	Rated voltage			132 kV							
	Insulation class										
	Rated current										
	Required quantity	6		3				3		3	9
11 KV feeder Enclosed switchboard	Required quantity	0	C. 8 (10 panels)	0	8	7	1 (Panel)	10	8	12 (Panels)	

Table 10.5-8 (1/2)

Main facilities		Ubungo S/S	Kariakoo S/S	Ilala S/S	Mbegala S/S	Kurasini S/S	Tabata S/S	Remarks
		Substation name						
Main transformer	Capacity		15 MVA		15 MVA		5 MVA	45 MVA x 3 = 135
	Number of phase		3		3		3	15 MVA x 8 = 120
	Frequency		50 Hz		50 Hz		50 Hz	
	Rated voltage							
	Wire connection							
	Tap changer		On-load tap-changing		On-load tap-changing		On-load tap-changing	
	Required quantity		1		1		1	
Circuit breaker	Rated voltage	145 kV	36 kV	36 kV	36 kV	36 kV	36 kV	145 kV x 9
	Rated current							36 kV x 25
	Rated breaking current	12.5 kA	12.5 kA	12.5 kA	12.5 kA	12.5 kA	12.5 kA	
	Required quantity	1	1	1	1	1	3	
	Rated voltage							
	Rated current							
	Rated breaking current							
	Required quantity							
Disconnector	Rated voltage	145 kV	36 kV	36 kV	36 kV	36 kV	36 kV	145 kV x 13
	Rated current							36 kV x 19
	Required quantity	3		1		1	3	
	Rated voltage							E.S.
	Rated current							145 KV x 4
	Accessory	E.S	E.S	E.S	E.S	E.S	E.S	36 kV x 17
	Required quantity	1	1	1	1	1	2	
Instrument transformer (C.T and P.T)	Rated voltage	132 kV	33 kV	33 kV	33 kV	33 kV	33 kV	
	Insulation class							
	Rated current							
	Required quantity	3						
	Rated voltage							
	Insulation class							
	Rated current							
	Required quantity	3						
Enclosed switchboard	Required quantity	C. 2 (Panels)	8	C. 2 (Panels)	8	C. 1 (Panel)	6	

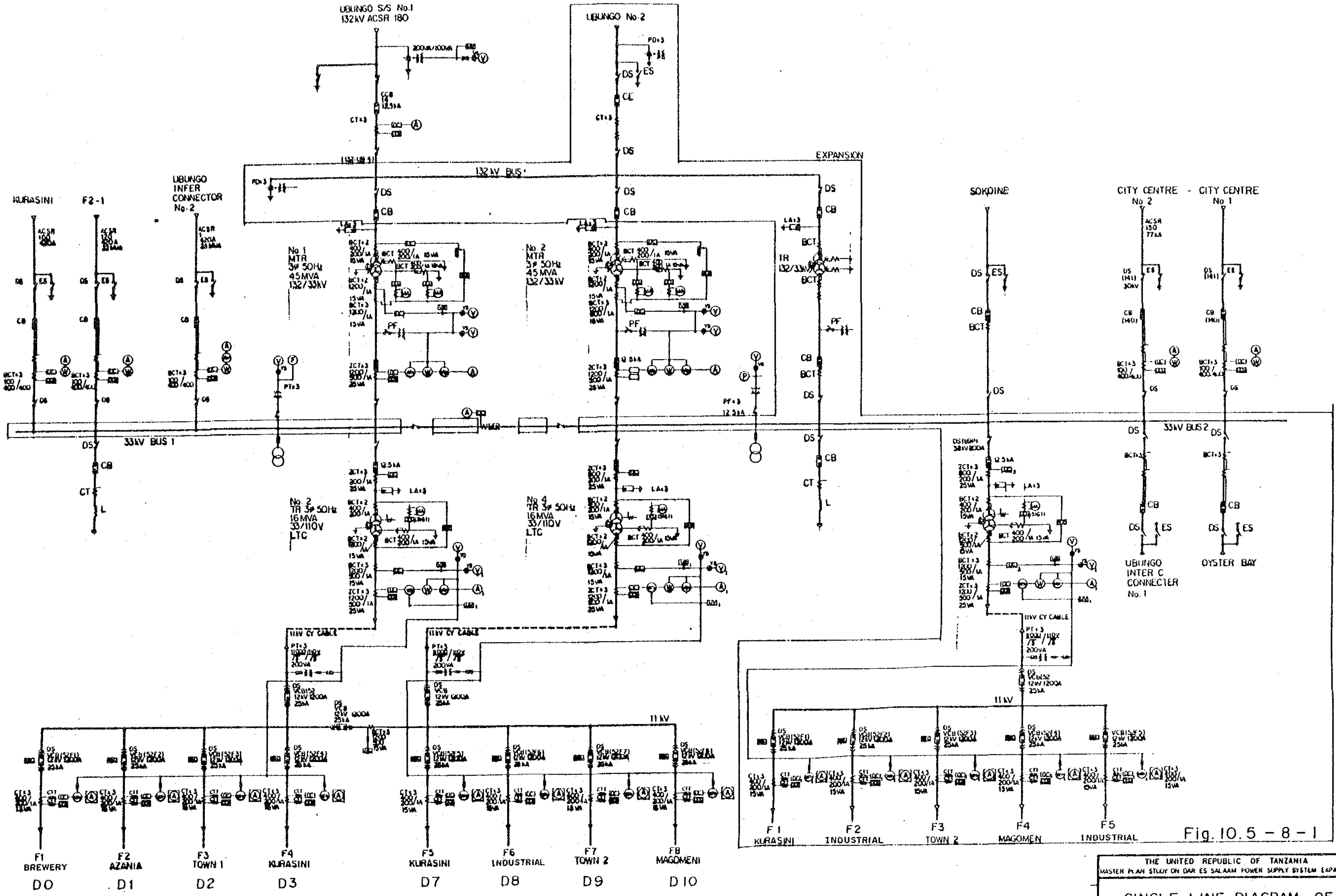


Fig. 10.5 - 8 - 1

THE UNITED REPUBLIC OF TANZANIA
MASTER PLAN STUDY ON DAR ES SALAAM POWER SUPPLY SYSTEM EXPANSION

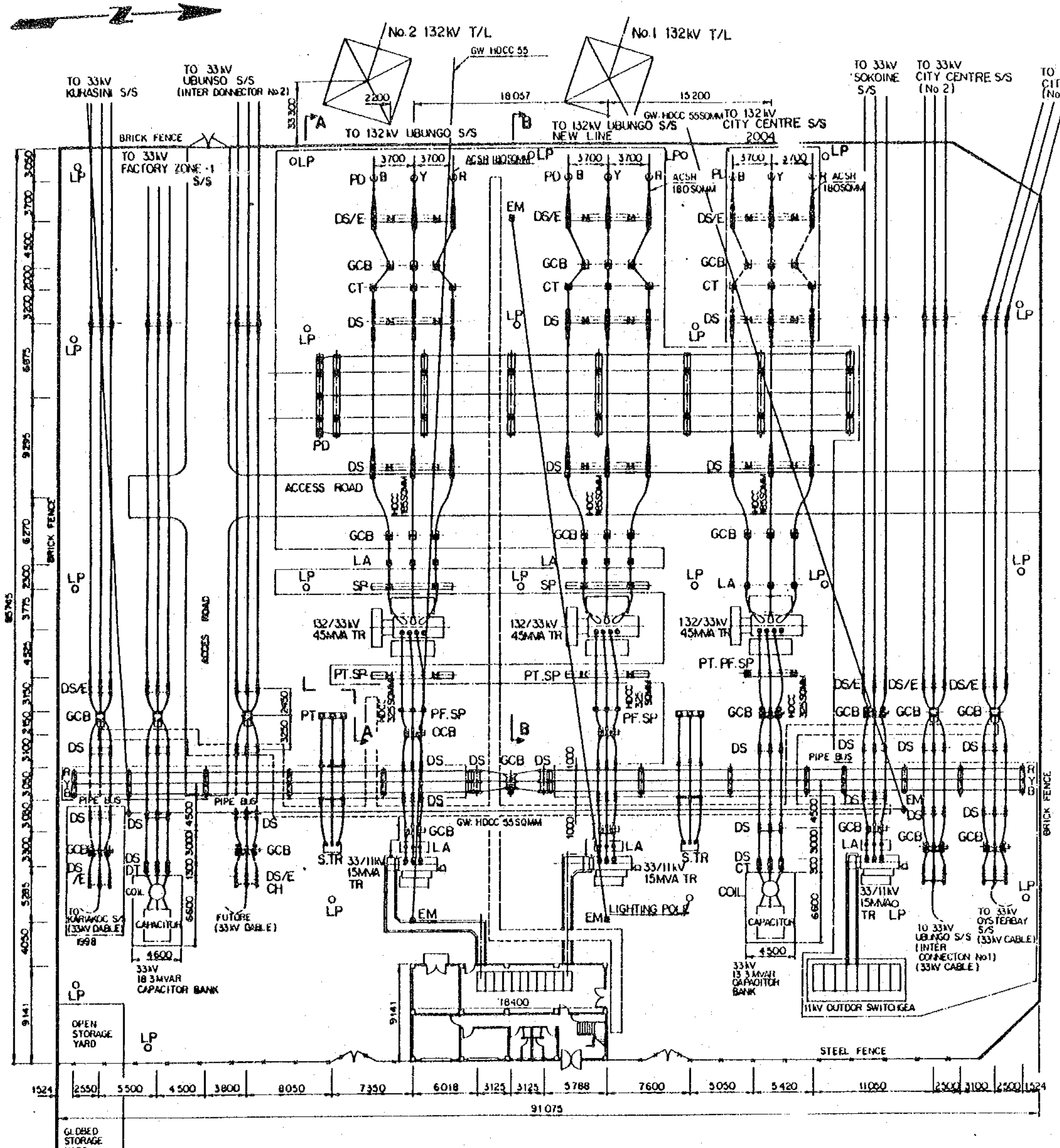
SINGLE LINE DIAGRAM OF
ILALA SUBSTATION

TANESCO

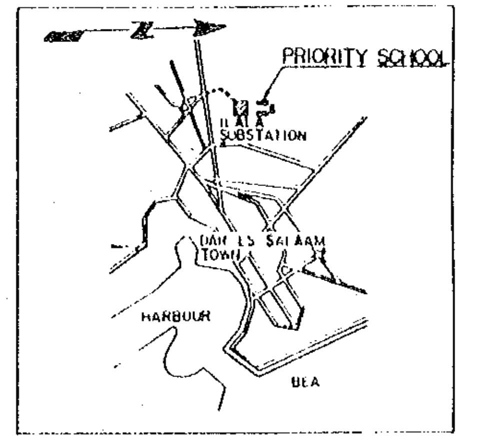
ELECTRIC POWER DEVELOPMENT CO. LTD.
TOKYO, JAPAN

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

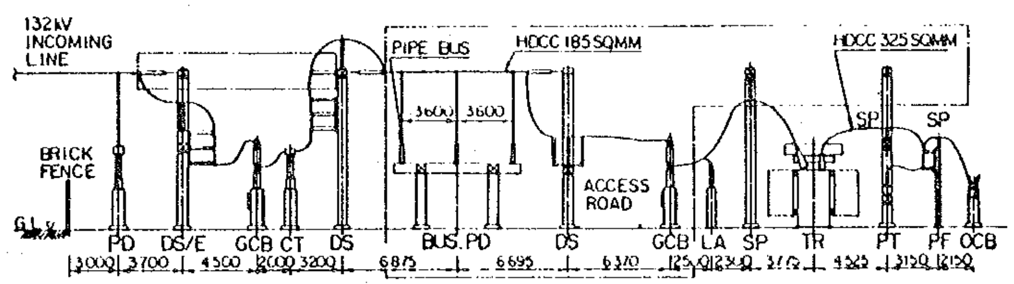
LOCATION	DATE	DESCRIPTION	BY
REVISION			



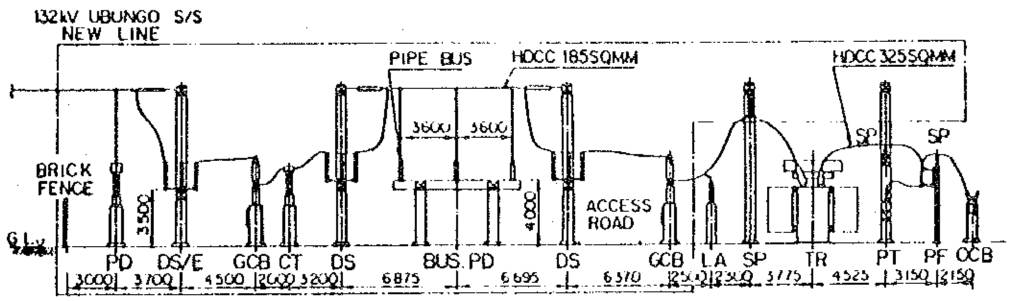
PLAN



LOCATION MAP (NONE SCALE)



SECTION A-A



SECTION B-B

LEGEND

- DS/E : DISCONNECTING SWITCH WITH EARTHING DEVICE
- CB : CIRCUIT BREAKER
- LA : LIGHTNING ARRESTER
- LP : LIGHTING POLE
- PF : POWER FUSE
- S.TR : STATION TRANSFORMER
- EM : EARTH MAST
- PD : POTENTIAL DEVICE
- DS : DISCONNECTING SWITCH
- CT : CURRENT TRANSFORMER
- PT : POTENTIAL TRANSFORMER

NOTE

1. [ ] : EXPANSION AND REHABILITATION AREA
2. [ ] : FUTURE EXPANSION AREA

Fig. 10.5-8-2

THE UNITED REPUBLIC OF TANZANIA
MASTER PLAN STUDY ON DAR ES SALAAM POWER SUPPLY SYSTEM EXPANSION

LAYOUT OF ILALA SUBSTATION

TANESCO

ELECTRIC POWER DEVELOPMENT CO., LTD. TOKYO, JAPAN

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

LOCATION	DATE	DESCRIPTION	BY

REVISION

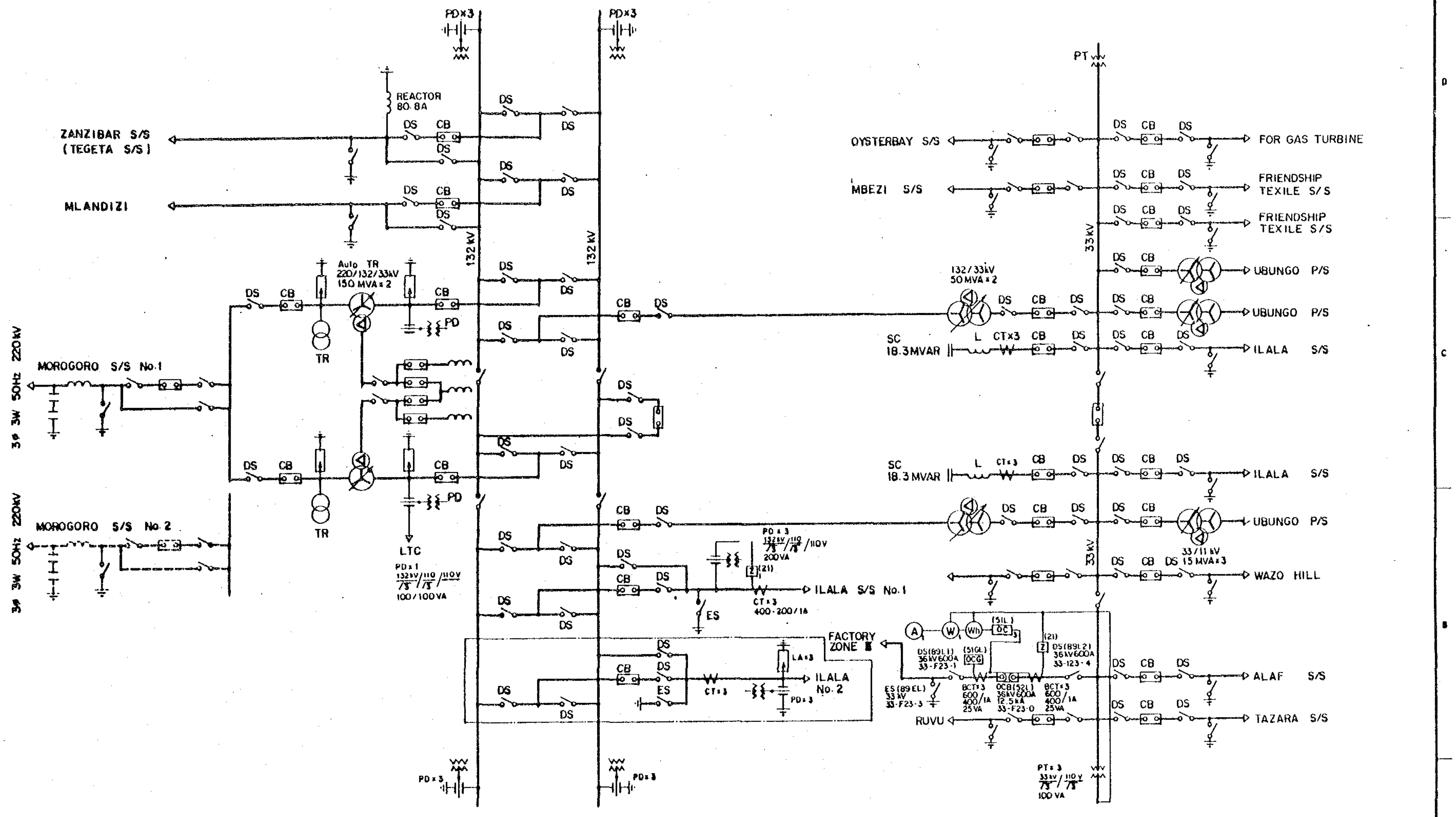


Fig. 10.5 – 9 – 1

THE UNITED REPUBLIC OF TANZANIA
MASTER PLAN STUDY ON DAR ES SALAAM POWER SUPPLY SYSTEM EXPANSION

SINGLE LINE DIAGRAM OF UBUNGO SUBSTATION

TANESCO

ELECTRIC POWER DEVELOPMENT CO., LTD. TOKYO, JAPAN

LOCATION	DATE	DESCRIPTION	BY
REVISION			

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

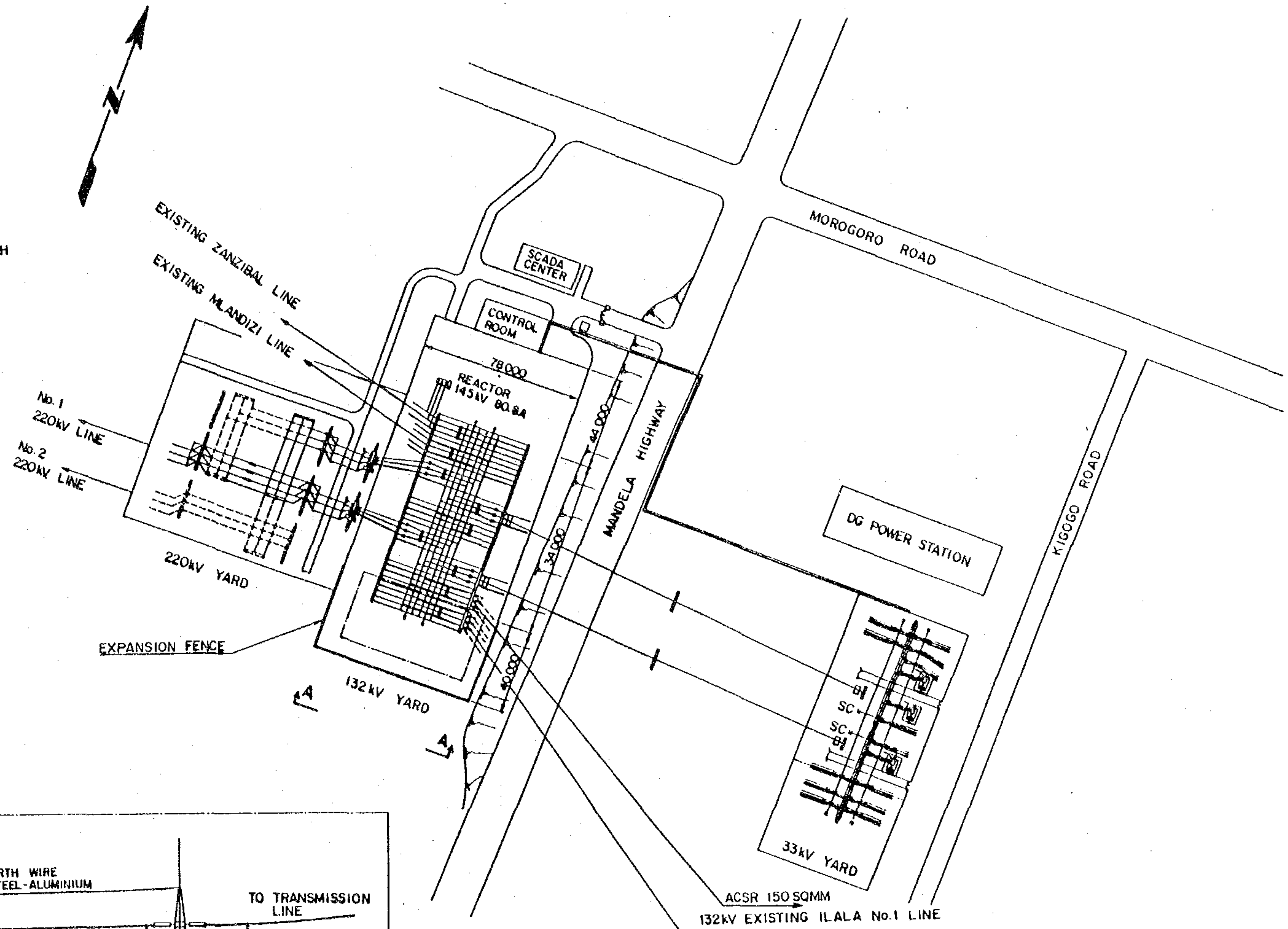
SHEET NO OF

LEGEND

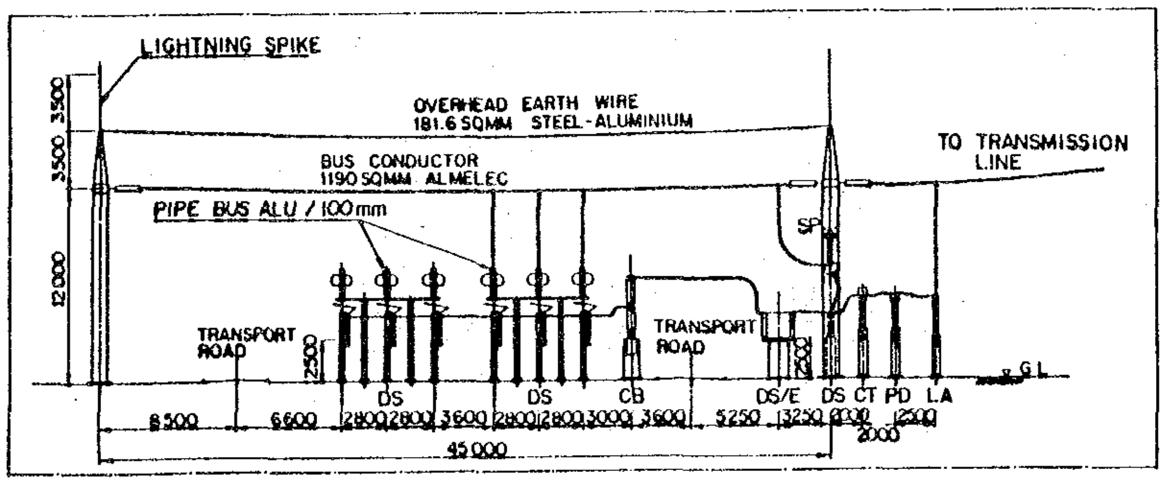
DS/E : DISCONNECTING SWITCH WITH EARTHING DEVICE
CB : CIRCUIT BREAKER
LA : LIGHTNING ARRESTER
PD : POTENTIAL DEVICE
DS : DISCONNECTING SWITCH
CT : CURRENT TRANSFORMER

NOTE

132kV FEEDER EXPANSION AREA



PLAN



SECTION A-A

Fig. 10.5 - 9 - 2

THE UNITED REPUBLIC OF TANZANIA
MASTER PLAN STUDY ON DAR ES SALAAM POWER SUPPLY SYSTEM EXPANSION

LAYOUT OF UBUNGO SUBSTATION

TANESCO

ELECTRIC POWER DEVELOPMENT CO., LTD.
TOKYO, JAPAN

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

LOCATION	DATE	DESCRIPTION	BY

REVISION

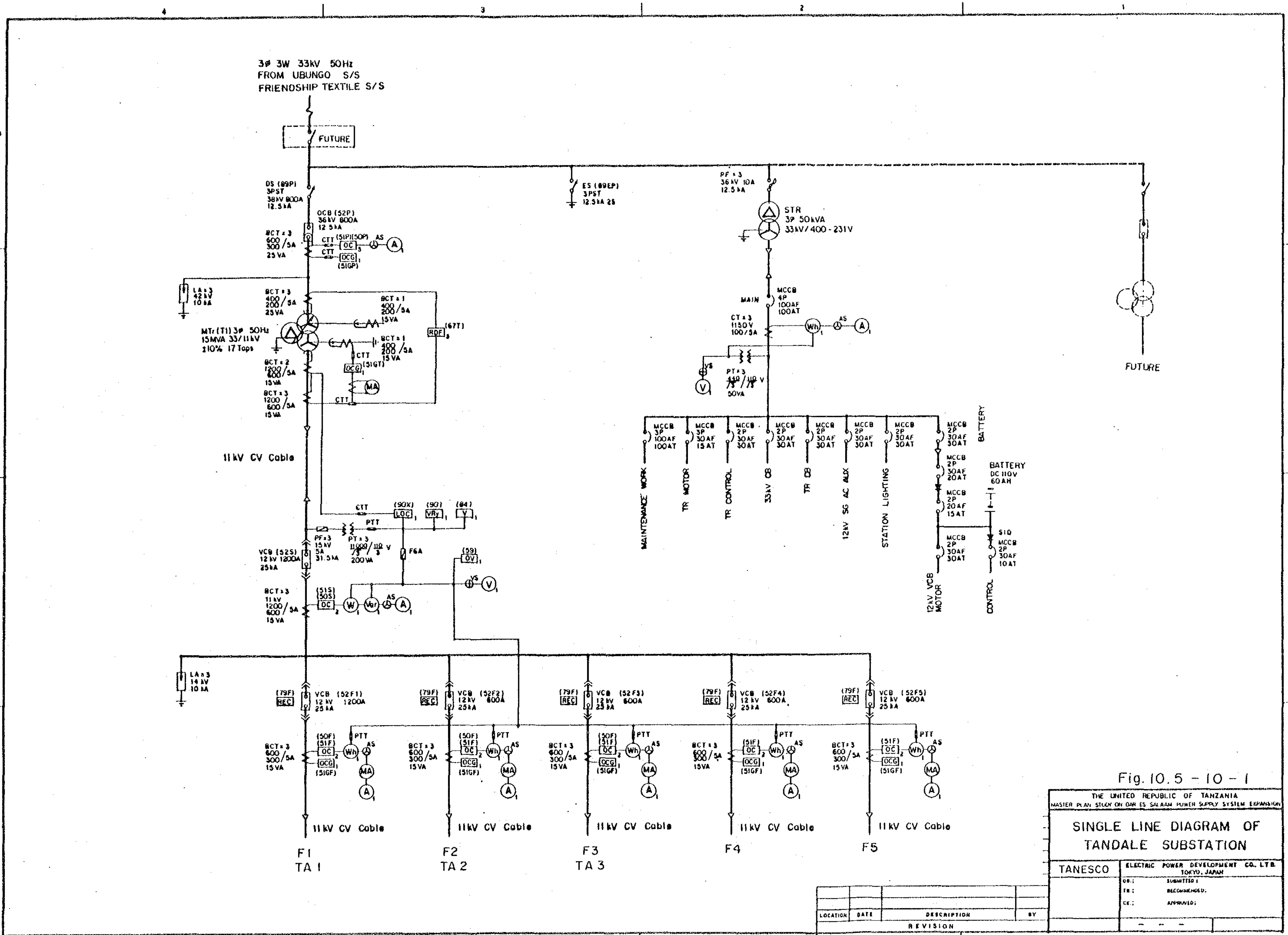


Fig. 10.5 - 10 - 1

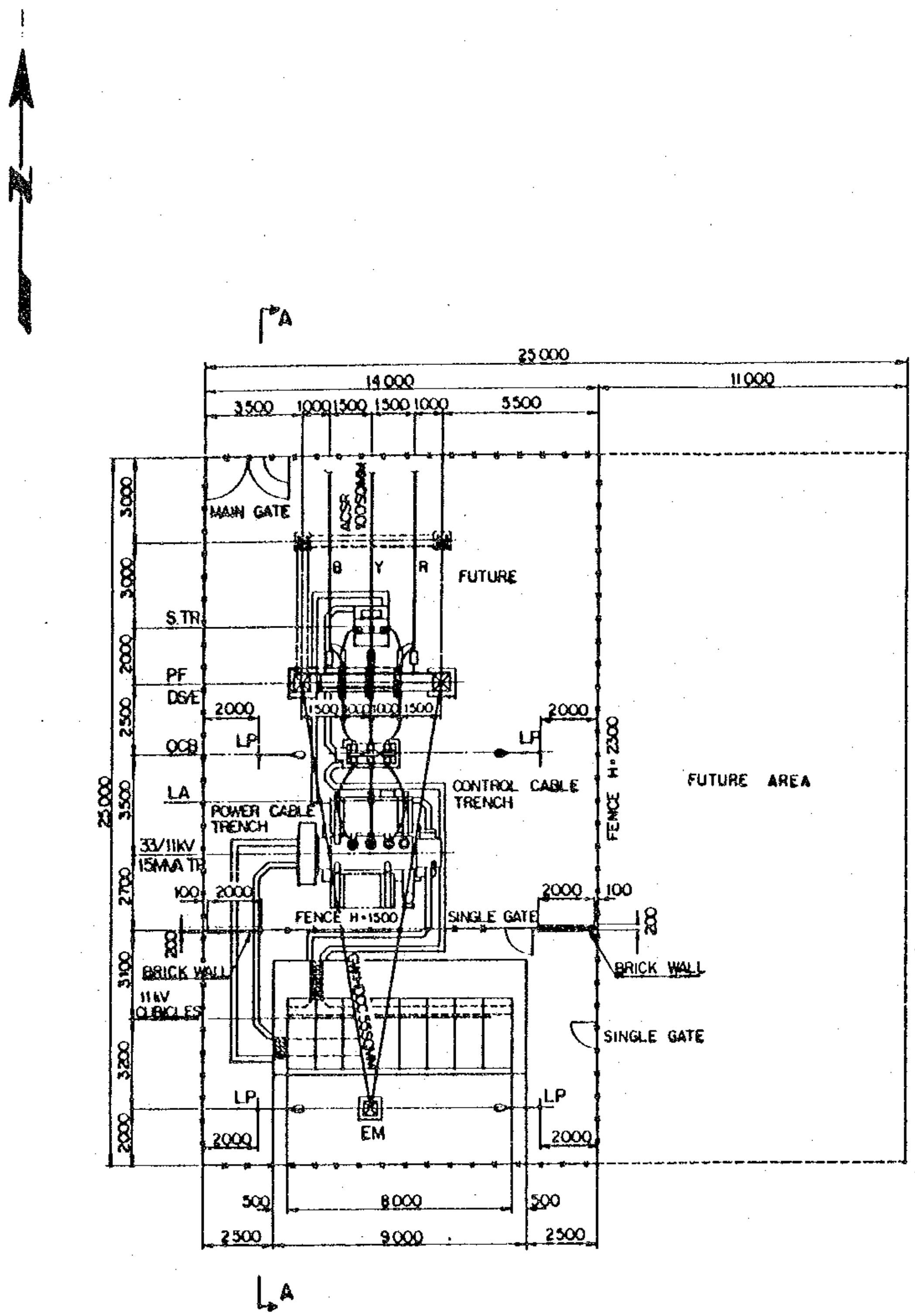
THE UNITED REPUBLIC OF TANZANIA
MASTER PLAN STUDY ON DAR ES SALAAM POWER SUPPLY SYSTEM EXPANSION

SINGLE LINE DIAGRAM OF TANDALE SUBSTATION

TANESCO | ELECTRIC POWER DEVELOPMENT CO., LTD. TOKYO, JAPAN

LOCATION | DATE | DESCRIPTION | BY

REVISION



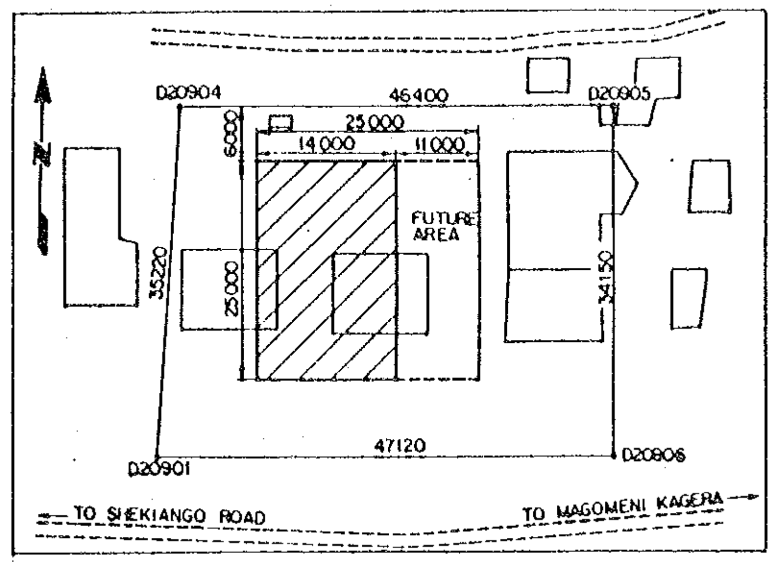
PLAN

LEGEND

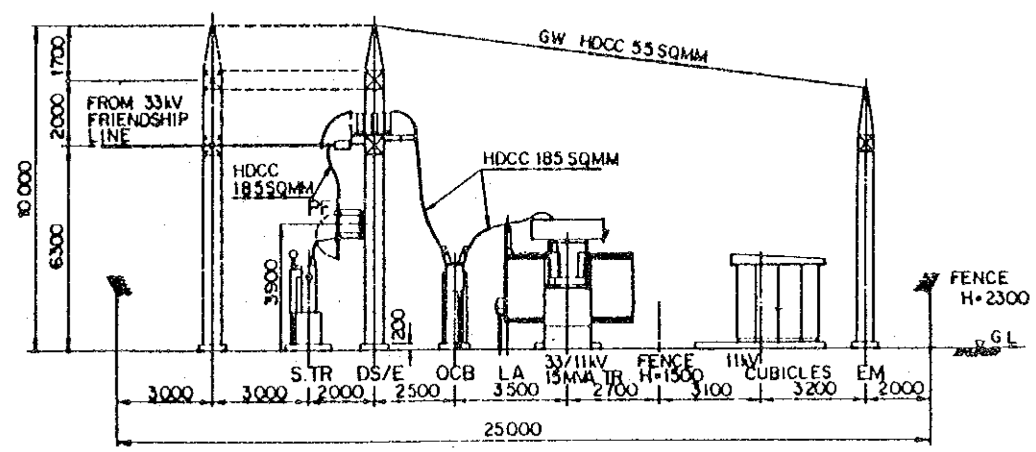
DS/E : DISCONNECTING SWITCH WITH EARTHING DEVICE
CB : CIRCUIT BREAKER
LA : LIGHTNING ARRESTER
TR : 15 MVA MAIN TRANSFORMER
LP : LIGHTING POLE
PF : POWER FUSE
S.TR : STATION TRANSFORMER
EM : EARTH MAST

NOTE

----- FUTURE EXPANSION



LOCATION MAP (NONE SCALE)



SECTION A-A

Fig. 10.5 - 10 - 2

THE UNITED REPUBLIC OF TANZANIA
MASTER PLAN STUDY ON DAR ES SALAAM POWER SUPPLY SYSTEM EXPANSION

LAYOUT OF TANDALE SUBSTATION

TANESCO

ELECTRIC POWER DEVELOPMENT CO., LTD. TOKYO, JAPAN

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

LOCATION	DATE	DESCRIPTION	BY
REVISION			

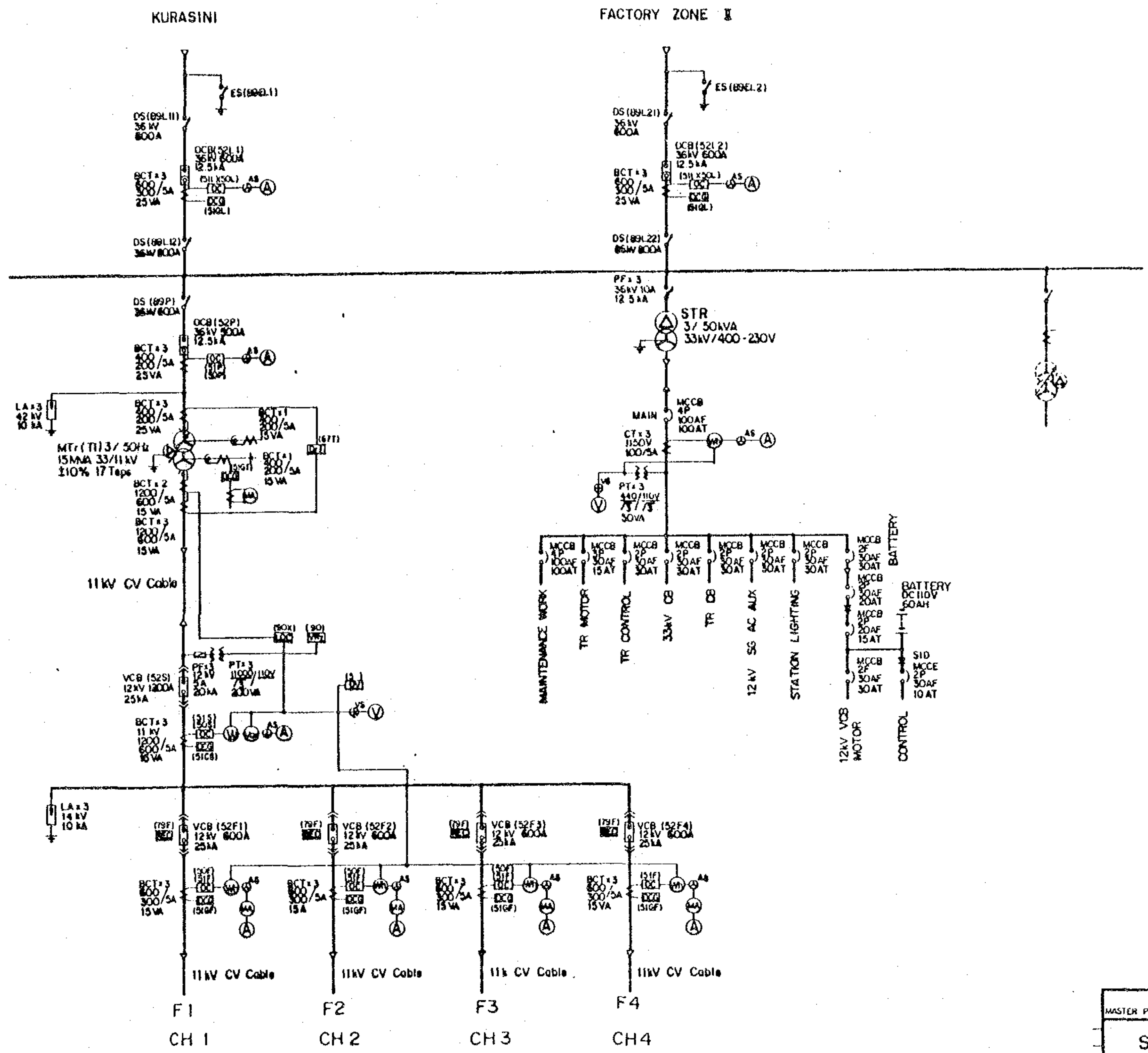


Fig. 10.5 - 11 - 1

THE UNITED REPUBLIC OF TANZANIA

MASTER PLAN STUDY ON DAR ES SALAAM POWER SUPPLY SYSTEM EXPANSION

SINGLE LINE DIAGRAM OF CHANG'OMBE SUBSTATION

TANESCO

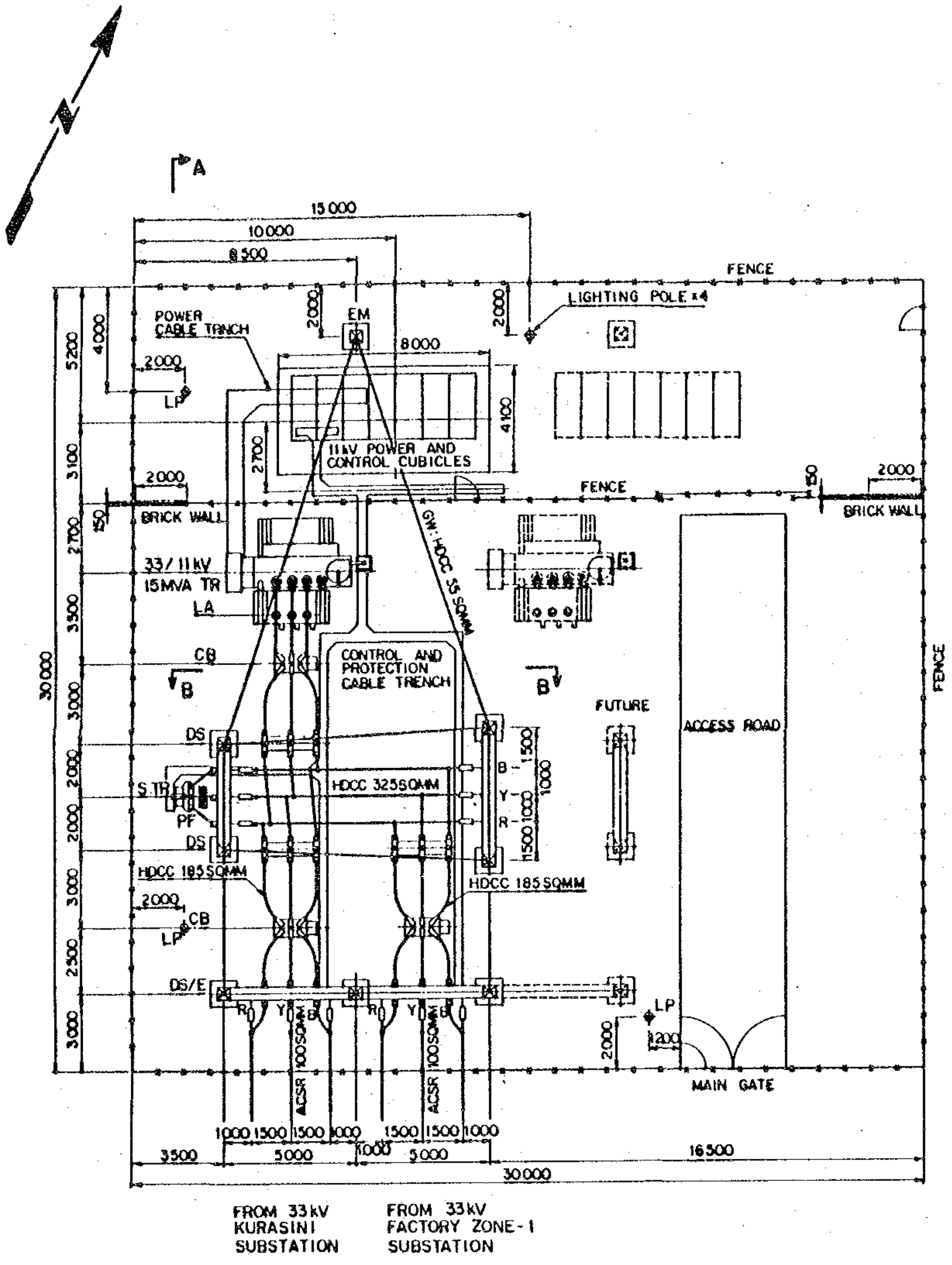
ELECTRIC POWER DEVELOPMENT CO., LTD. TOKYO, JAPAN

DR.: SUBMITTED:

TR.: RECOMMENDED:

CK.: APPROVED:

LOCATION	DATE	DESCRIPTION	BY
REVISION			



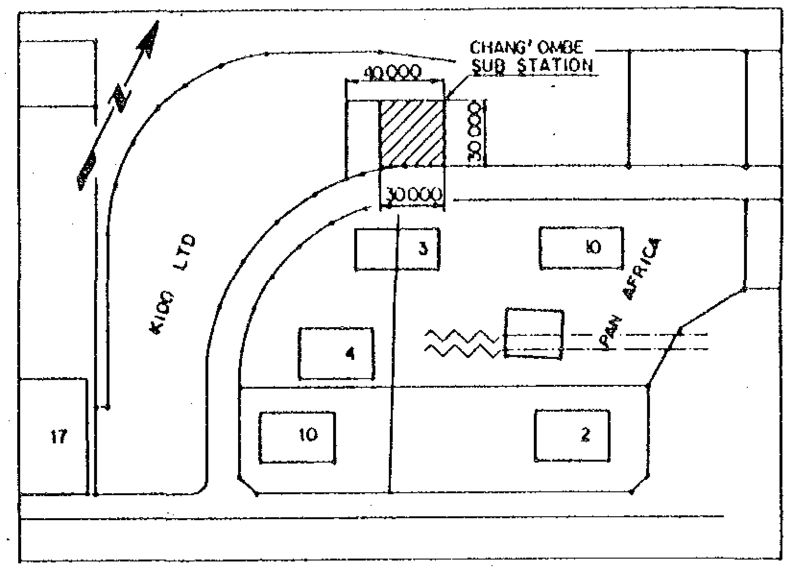
PLAN

LEGEND

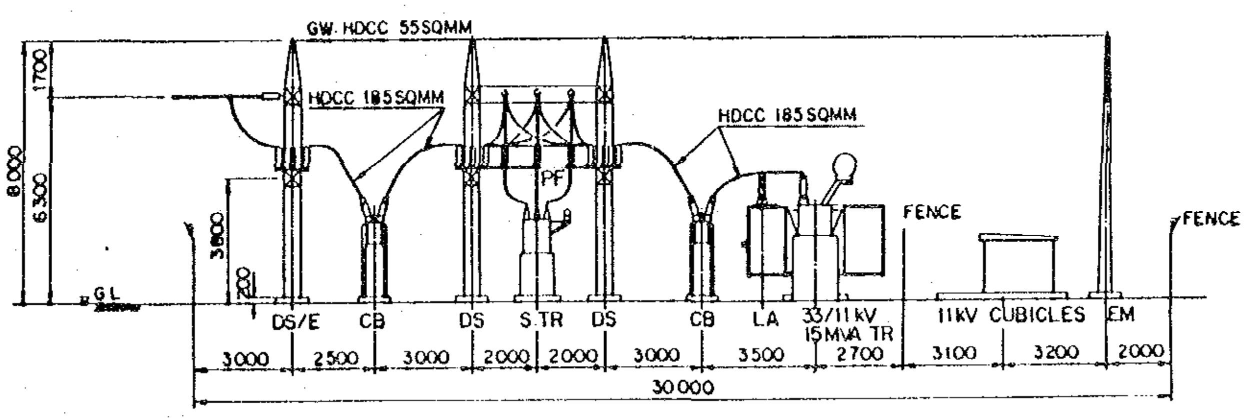
DE/E : DISCONNECTING SWITCH WITH EARTHING DEVICE
DS : DISCONNECTING SWITCH
CB : CIRCUIT BREAKER
LA : LIGHTNING ARRESTER
TR : 15MVA MAIN TRANSFORMER
LP : LIGHTING POLE
PF : POWER FUSE
S.TR : STATION TRANSFORMER
EM : EARTH MAST

NOTE

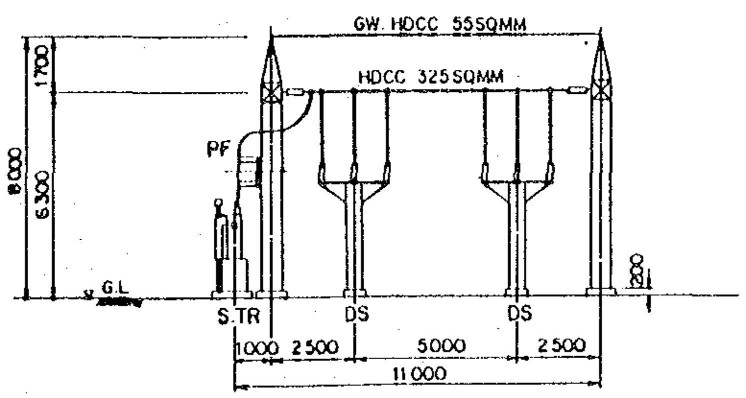
---- FUTURE EXPANSION



LOCATION MAP (NONE SCALE)



SECTION A - A



SECTION B - B

Fig. 10.5 - 11 - 2

THE UNITED REPUBLIC OF TANZANIA
MASTER PLAN STUDY ON DAR ES SALAAM POWER SUPPLY SYSTEM EXPANSION

LAYOUT OF CHANG'OMBE SUBSTATION

TANESCO	ELECTRIC POWER DEVELOPMENT CO., LTD. TOKYO, JAPAN
DR.:	SUBMITTED:
TR.:	RECOMMENDED:
CK.:	APPROVED:

LOCATION	DATE	DESCRIPTION	BY
REVISION			

SHEET NO. OF

10.6 11 KV DISTRIBUTION LINE

Summary of expansion of distribution facilities

Summary of expansion of distribution facilities in accordance with the distribution substation 33/11 kV bank new construction and additional installation and expansion of existing banks are as shown in Table 10.6-1 and 10.6-2.

Table 10.6-1 Summary of expansion of distribution facilities

Year	Construction of new feeders (cct)	Overhead line distance (km)		Installation of new switches (set)	Underground line (km)	Remark (Construction of new substations, additional installation and expansion of existing substations
		Construction of new lines	Replacement with new lines			
1994	7	7.6		(1) 22	1.8	New construction: 2 places Expansion : 2 places
1996	13	8.1	15.6	(1) 24	2.4	New construction: 4 places
Short-term subtotal (5 years)	20	15.7	15.6	(2) 46	4.2	New construction: 6 places Expansion : 2 places
1998	4	4.0		10	0.4	Expansiion : 2 places
2000	10	10.0		25	1.0	New construction: 3 places Expansion : 1 place
2002	4	4.0		10	0.4	Expansion : 2 places
2003	3	3.0		8	0.3	Expansion : 1 place
2004	8	8.0		20	0.8	New construction: 1 place Expansion : 2 places
2005	3	3.0		8	0.3	Expansion : 1 place
2006	2	2.0		5	0.2	Expansion : 1 place
Total (15 years)	54	49.7	15.6	(2) 132	7.6	New construction:10 places Expansion :12 places

(Notes) 1. ( ) shows the multi-circuit switch to be otherwise shown.

2. Estimate for 1998 onward is based on the following:
Construction of new overhead line (distance) : 1 km/cct
Replacement of existing overhead line (distance) : Applicable places
Installation of new switch : 2.5 units/cct
Construction of underground line : 0.1 km/cct

Table 10.6-2 Details by substations

Year	New substation related-works		Bank additional installation and expansion related-works	
	Substation name	Distribution line plan	Substation name	Distribution line plan
1994	Tandale 15 MVA x 1 Chang'ombe 15 MVA x 1	3 cct new construction 4 cct new construction	Ilala (15 MVA x 2) 15 MVA x 1 Mbezi (7.5 MVA x 1) 15 MVA x 1	2 cct replacement between banks with new ones 3 cct replacement between banks with new ones
1996	Kunduchi 15 MVA x 1 Kariakoo 15 MVA x 1 (Ilala Mbagala 15 MVA x 1 Tabata 5 MVA x 1	4 cct new construction 3 cct new construction 1 cct) new construction) 3 cct new construction 2 cct new construction		
1998			Mikocheni (15 MVA x 1) 15 MVA x 1 Kigamboni (5 MVA x 1) 5 MVA x 1)	3 cct new construction 1 cct new construction
2000	Temeke 15 MVA x 1 Mburahati 5 MVA x 1 Kitunda 5 MVA x 1	4 cct new construction 2 cct new construction 2 cct new construction	FZ-II (5 MVA x 1) 5 MVA x 1	2 cct new construction
2002			Kariakoo (15 MVA x 1) 15 MVA x 1 Kigamboni (5 MVA x 2) 5 MVA x 1	3 cct new construction 1 cct new construction
2003			Oyster Bay (15 MVA x 1 5 MVA x 2) 5 MVA x 1 EX. 15 MVA	3 cct new construction
2004	Upanga 15 MVA x 1	3 cct new construction	Mikocheni (15 MVA x 2) 15 MVA x 1 Mbezi (7.5 MVA x 1 15 MVA x 1) 7.5 MVA x 1 EX. 15 MVA	3 cct new construction 2 cct new construction
2005			FZ-III (15 MVA x 1) 15 MVA x 1	3 cct new construction
2006			Msasani (15 MVA x 1) 15 MVA x 1	2 cct new construction

10.6.1 Basic Design Concept for Outgoing Arrangement for Feeders

The design of the new 11 kV feeders must basically be such that it enables the stable power supply over a long period as well as efficient operation of the facilities while keeping harmony with the functions of the existing facilities.

To achieve it, the importance must be attached to the maintenance of the adequate voltage and gradual enhancement of the power supply reliability while keeping an eye to the following for the detailed implementation of the design.

It should be noted herewith that in view of the background of this study and the purpose of this survey, the preliminary design premises only that it should take up the 11 kV distribution line but exclude the pole transformers, low-tension distribution lines or the like.

(1) System setup of 11 kV distribution line

The standard system setup must be of a 3-division and 3-interconnection system.

The design must basically be such that the section switch must be installed at places where outgoing feeder arrangement starts or riser cable arrangement is done.

(2) Applicable division of overhead and underground distribution lines

As a rule, the overhead distribution line must be used except where the underground distribution line is more advantageous as a whole in consideration of the harmonization with the existing facilities or the regional environment as well as economic efficiency. As for the laying of the distribution line for the substations located in the center of the cities, it is preferable that the outgoing arrangement by means of duct lines should be set up by taking into account the development of the urbanization. Nonetheless, in order to avoid the enormous investment needed for such facilities, the present direct underground laying system is again adopted in this study.

(3) Type of voltage and current

Nominal voltage : 11 kV

Distribution system: 3 phase, 3 wires (neutral point direct grounding system)

Line arrangement : Branch System

Voltage drop limit :

	Area	Voltage drop limit (V)
Normal	A area	500
	B area	1,000

(Note) A Area: Districts covering major government and municipal offices and important installations

B Area: Other districts than the above.

(4) Capacity of distribution line

Main line standard capacity: Maximum 300 A

(5) Lightning stroke resistant facility

A lightning arrester must be installed at places where the section switch is provided or riser cable arrangement is done.

As before, the installation of the overhead ground wires are omitted from this study in consideration of:

1) The overhead ground wires have not been used for existing lines except for such lines as are originally designed for use as the 33 kV line but are actually in use as the 11 kV line.

2) The overhead ground wires, if actually installed, lack the suspension strength. This is because the existing lines