6-3-7 Designing of Steel Structure, equipment structure and foundation design

(1) Steel Structure

The steel structure will be angle truss frames. The foundation of steel structure will be anchor bolt type.

The designed load for the steel structure and equipment structure will be as follows:

(a) Wind Pressure of Tower: 270 kg/m^2

(b) Wind Pressure of Overhead Wires

- Overhead ground wires: 90 kg/m^2
- Conductor : 81 kg/m^2

(c) Wind Pressure on Insulator Strings: 114 kg/m^2

(d) Earthquake Strength: Co=0.2 G

(2) Equipment Structure

In the case of the equipment structure, the angle-joined structure will be employed. Regarding structural use of pipe bus supporting and SP insulator supporting, employment of pipes will be also considered.

As in the case of the equipment structure, the foundation will also be anchor bolts type.

(3) Foundation Designing

The foundation design will be similar to the foundation design for transmission line towers. Its details will be as follows:

(a) Designed Details of the Foundation

Foundations for steel structures and equipment structure in the substation will be directly-supported ones. Basic soil data used for foundation design will be as follows:

Designed Details of Soil

Item	Details
Kind of ground	Earth and sand
Earth resistance angle against over turning (degrees)	20
Unit volume weight of earth (kg/m^3)	1,400
Soil compression bearing (kg/m^3)	30,000
Unit volume weight of concrete (kg/m^3)	2,400
Underground water level	Lower than the foundation base

(b) Shape of Foundation

The shape of the foundation will be so designed as to be the mat-floor foundation directly supported by the ground. If the supporting bearing force is in short, piles will be used to reinforce the supporting strength.

(c) Concrete

The whole of the equipment foundation will be reinforced concrete one, with the synthetic strength of concrete to be 180 kg/cm^2 (material age: 28 days).

The tolerable stress and reinforcing bar strength will be similar to those of the foundation for the transmission line.

(d) Stability of Foundation

Dimensions of the steel structure equipment structure and foundation of the transformer will be so fixed that the bearing capacity of soil will be less than 30 t/m^2, while they will be set so as not to be floated in the case of horizontal force.

The bottom surface of the foundation concrete will be set at an identical level to the utmost possible extent. The foundation concrete, which possibly could develop cable trench cracks, etc. will be reinforced with iron bars in case of need.

6-3-8 Buildings in Substation

(1) Control Building

The Sharpevale substation to be newly constructed will have the Control building. It will be such a building with a control room, a 33 kV switchgear chamber, a telecommunication machinery room and a store room as shown in Fig. 6-16.

In view of the importance of the building, it will be of the reinforced concrete frame structure with strong antiseismic nature, while its walls will be made of Grade A brick composition. The roof will be of the wooden truss assembly structure, with the height of the ceiling set at 3.0 m.

With regard to the Control Building, air conditioning equipment will be installed in the 33 kV switchgear room and the telecommunication equipment room, while a ventilation device will be installed in the battery room and an electric water boiler in the mess room.

(2) Guardsman's Room

At the entrance of the substation, a brick guardsman's room with a floor area of 3 m^2 will be established.

(3) Store Room

A brick store room with a floor space of 50 m^2, for storage of spare parts for transmission line and substation equipment, will be established.

(4) Garage

An open-type garage capable of accommodating 5 patrol cars will be established.

(5) Water Supply and Discharge Facilities

A water supply pump chamber and a water storage tank will be set up.

A purification tank for waste and discharge water treatment will be established.

(6) Fence, Paving of Switchyard, etc.

Along the substation border line, a spiked mental fence 1.8 m high and a gate will be established.

Gravel will be laid around the equipment in the switchyard while other parts of the ground will be paved with asphalt, with rain water drainage ditches to be formed.

6-4 Expansion Plans for Existing Power Station/Substation

6-4-1 Existing Power Station/Substation to be Expanded

In order to terminate the transmission line of This Project, the following Power Station and Substation will be expanded:

- Nkula B Power station	Equipment for terminating one 132 kV circuit
- Lilongwe B Substation	Equipment for terminating one 132 kV circuit

As for the circuit configuration at the expansion part, see Fig. 6-8, Fig. 6-9, Fig. 6-14, and Fig. 6-15.

(1) Circuit Configuration of the Expansion Part

The single line diagram for expansion parts of the Nkula B Power Station and the Lilongwe B Substation will be as shown in Fig. 6-8 and Fig. 6-14.

(2) General Equipment Layout for Expansion Part

The equipment layout plan for expansion parts of Nkula B Power Station and the Lilongwe B Substation will be as shown in Fig. 6-9, and Fig. 6-15.

6-4-2 Coordination with Existing Facilities

(1) Nkula B Power Station

At the switchyard in the Nkula B Power Station, a line bay has been formed so as to allow the termination of a transmission line under This Project, with the 132 KV equipment installed. Since the terminal equipment for the transmission line will be provided in package, these devices are to be furnished under This Project. However, the equipment and facilities that can be used will be utilized as far as possible, with replacement to be made only if the equipment will not match the equipment specifications under This Project (circuit breaker and CT fall under the category of replacement equipment).

As installing the steel structure for terminating the transmission line and stringing of conductor are finished, the structure and strung wires should be utilized as far as possible.

The 132 KV line protection relay has already been installed in the relay room of the Power Station as it is mounted on the panel there. If the manufacturer of the relay to be purchased under This Project is different, however, the replacement of the relay in a panel-mounted form will be studied.

Since the control and meter panel for the line has already been fitted with such equipment and installed, employment of usable circuits and meters will be studied.

Since the equipment foundation and cable duct have been completed, they will be utilized as far as possible.

(2) Lilongwe B Substation

The line bay for the transmission line under This Project has already been secured. Since part of the outdoor steel structure (one post and one beam) has already been installed, the designing in the event of expansion will be required to take such a part of the steel structure into consideration.

Within the control house, the space for the transmission line protection relay and control meter board has already been secured.

New establishment of the equipment foundation and a cable duct will be implemented in case of necessity.

6-5 Preliminary Design of Telecommunications System

6-5-1 Outline of Facilities

Outline of telecommunications facilities to be installed under This Project are as follows:

Model	Specifications	Nkula B	Sharpevale	Lilongwe B
Power line carrier equipment (PLC)	2Ch, 40 dBm	2 units	4 units	2 units
Blocking coil	600Ω, 800 A	2 units	6 units	2 units
Carrier relay signal transmission equipment	200-baud transmitting/ receiving equipment	1 unit	2 units	1 unit
Fault locator	C-type	--	1 unit	--
Automatic exchange (PAX)	50 circuits	1 unit	--	--
"	20 circuits	--	1 unit	1 unit
VHF base station	100 W	--	1 unit	--
VHF, car mounted	80 W		2 units	
VHF, portable	1 W	--	4 units	--
Telemeter	Terminal equipment	1 pair	1 pair	1 pair

6-5-2 Circuit Configuration

The telecommunications circuits required for load dispatching, and maintenance under this Project are to be composed as follows:

The telecommunication circuit diagram, see Fig. 6-19 and the power line carrier protective relaying system diagram, see Fig. 6-20.

(1) Telephone Circuits related to Load Dispatching

One each telephone circuit for load dispatching use will be installed between the Nkula B Power Station and the Sharpevale Substation, between the Nkula B power Station and the Lilongwe A Substation, and between the Sharpevale Substation and the Lilongwe A Substation.

(2) Business Purpose Telephone Circuit

While a 50-circuits automatic exchange will be installed in the Nkula B Power Station, a 20-circuits automatic exchange each will be installed in the Sharpevale substation and the Lilongwe substation, with the network to be constituted by linking Nkula B power Station and Sharpevale Substations, and Sharpevale and Lilongwe Substations by means of 2 channel power line carrier circuits each.

(3) Signal Transmission Circuit for Transmission Line Proteciton

A carrier relay system by means of directional comparison impedance type protection will be installed to pick up, clear the fault and reclosing the transmission line. For this purpose, a signal transmission channel as well as telephone channels will be formed within the power line carrying equipment and will constitute signal transmission circuit as a portion of line protection system.

(4) VHF Telephone Circuit for Maintenance of Transmission Line

For the maintenance of the transmission line, a 30 MHz band, VHF base station will be established within the Sharpevale Substation, and 2 corresponding, car-mounted radio communication devices and 4-portable radio communication devices will be provided.

(5) Fault Locator

For speedier line restoration from any fault, the C-type fault locator will be installed in the Sharpevale Substation to pinpoint the place of any fault in transmission lines between the Sharpevale Substation and the Nkula B Power Station and also between the Sharpevale Substation and the Lilongwe B Substation.

(6) Telemetry

A supervisory system for the substation equipment to be newly installed this time will be added to the earlier established telemetry system of the SCADA system centered on the load dispatching center in Chichiri Power Station.

Table 6 - 1 CLIMATIC DATA IN THE PROJECT AREA

Item			Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Temperature (℃)	Average		LILONGWE	22.0	23.0	21.5	20.3	18.0	15.8	15.5	16.9	19.6	22.4	23.3	22.6	19.6
			DEDZA	19.0	19.1	19.0	18.0	16.5	14.2	13.9	15.4	18.0	20.0	20.6	19.5	17.7
			MANGOCHI	25.7	25.5	25.3	24.5	22.2	20.2	20.1	21.6	24.3	27.2	27.7	26.4	24.2
			CHILEKA	24.0	23.9	23.5	22.3	20.6	18.5	18.3	20.1	23.1	25.3	25.6	24.5	22.4
			CHICHIRI	21.6	21.5	21.0	20.1	18.5	16.2	15.8	17.6	20.2	22.3	22.4	21.9	19.9
	Highest		LILONGWE	30.5	30.0	31.6	30.5	31.1	29.4	28.8	31.1	34.4	35.5	36.1	35.0	36.1
			DEDZA	26.6	26.1	26.6	25.5	26.6	23.8	23.8	25.0	29.4	30.5	29.4	28.8	30.5
			MANGOCHI	36.1	34.4	35.5	35.0	33.3	31.6	31.1	33.8	37.2	40.0	39.4	37.2	40.0
			CHILEKA	32.7	32.2	33.3	31.6	33.3	30.0	30.0	31.6	36.1	37.2	37.7	36.1	37.7
			CHICHIRI	30.5	29.4	30.5	30.5	30.5	27.7	27.7	29.4	31.1	34.4	35.0	32.2	35.0
	Lowest		LILONGWE	12.7	13.8	9.4	4.4	2.7	0.5	0.0	0.5	1.6	7.7	11.1	10.5	0.0
			DEDZA	11.6	11.6	10.5	7.7	6.6	5.0	1.6	5.0	5.5	6.1	9.4	12.7	1.6
			MANGOCHI	17.2	17.2	14.4	11.6	7.2	4.4	4.4	5.5	9.4	13.3	16.6	17.7	4.4
			CHILEKA	16.1	16.6	14.4	12.2	10.5	9.4	7.7	10.0	10.5	12.7	13.8	16.6	7.7
			CHICHIRI	13.3	14.4	12.7	11.1	7.2	4.4	3.8	6.6	7.7	9.4	11.6	12.2	3.8
Relative Humidity (%)			LILONGWE	84.0	85.0	82.0	79.0	72.0	68.0	64.0	58.0	53.0	51.0	62.0	78.0	70.0
			DEDZA	84.0	85.0	83.0	81.0	72.0	69.0	66.0	61.0	56.0	55.0	64.0	79.0	71.0
			MANGOCHI	79.0	79.0	76.0	73.0	69.0	66.0	62.0	57.0	52.0	49.0	57.0	72.0	66.0
			CHILEKA	80.0	81.0	79.0	76.0	69.0	66.0	64.0	57.0	51.0	50.0	61.0	75.0	67.0
			CHICHIRI	85.0	86.0	86.0	85.0	77.0	74.0	72.0	63.0	57.0	57.0	68.0	81.0	74.0
Rainfall	Total (mm)		LILONGWE	215.3	202.9	133.8	41.9	8.8	1.0	1.0	1.0	3.3	6.0	66.2	166.3	847.5
			DEDZA	247.3	199.8	122.6	53.5	12.1	5.5	3.3	1.5	3.5	7.8	53.0	195.3	905.2
			MANGOCHI	215.1	188.4	135.6	41.6	5.3	4.5	3.5	1.7	5.9	11.9	57.1	153.9	823.6
			CHILEKA	205.7	173.2	135.1	40.8	10.1	3.3	2.5	1.2	3.3	21.8	84.8	175.7	857.5
			CHICHIRI	258.8	207.2	190.5	72.3	17.2	13.9	13.2	4.8	2.2	19.8	102.3	219.9	1122.1
	Most of days for each of classes of rainfall (day) — Each of class (mm) or more	0.03	LILONGWE	20	18	14	7	2	1	0	0	1	1	7	16	7
		0.1		17	14	10	6	1	0	0	0	0	1	6	16	6
		10.0		7	6	4	1	0	0	0	0	0	0	2	2	2
		0.03	DEDZA	22	20	15	8	2	2	2	1	1	2	8	18	9
		0.1		19	17	12	6	2	1	1	1	0	2	7	15	7
		10.0		9	7	3	1	1	0	0	0	0	0	2	7	3
		0.03	MANGOCHI	18	16	14	6	2	2	1	0	1	1	6	13	6
		0.1		16	13	12	5	1	1	1	0	1	1	6	13	6
		10.0		6	6	4	1	0	0	0	0	0	0	2	5	2
		0.03	CHILEKA	17	16	14	7	2	2	2	1	1	3	10	15	8
		0.1		15	13	10	6	1	1	1	0	0	2	7	13	6
		10.0		6	5	3	2	0	0	0	0	0	1	3	6	2
		0.03	CHICHIRI	21	18	18	11	7	6	5	2	1	3	11	18	10
		0.1		18	15	14	9	4	3	3	2	1	3	8	16	8
		10.0		9	7	6	2	0	0	0	0	0	1	3	7	3
Thunderstorm (day)			LILONGWE	27	22	22	13	2	0	0	0	1	6	16	28	137
			DEDZA	21	17	15	6	1	0	0	0	1	6	14	21	102
			CHILEKA	24	21	20	7	1	0	0	0	1	8	17	23	122
			Monkey Bay	27	24	22	8	1	0	0	0	0	6	18	25	131

T max 40℃ IKL max. 140
Average 20℃ Ave. 123
Min. 0℃ Min. 102

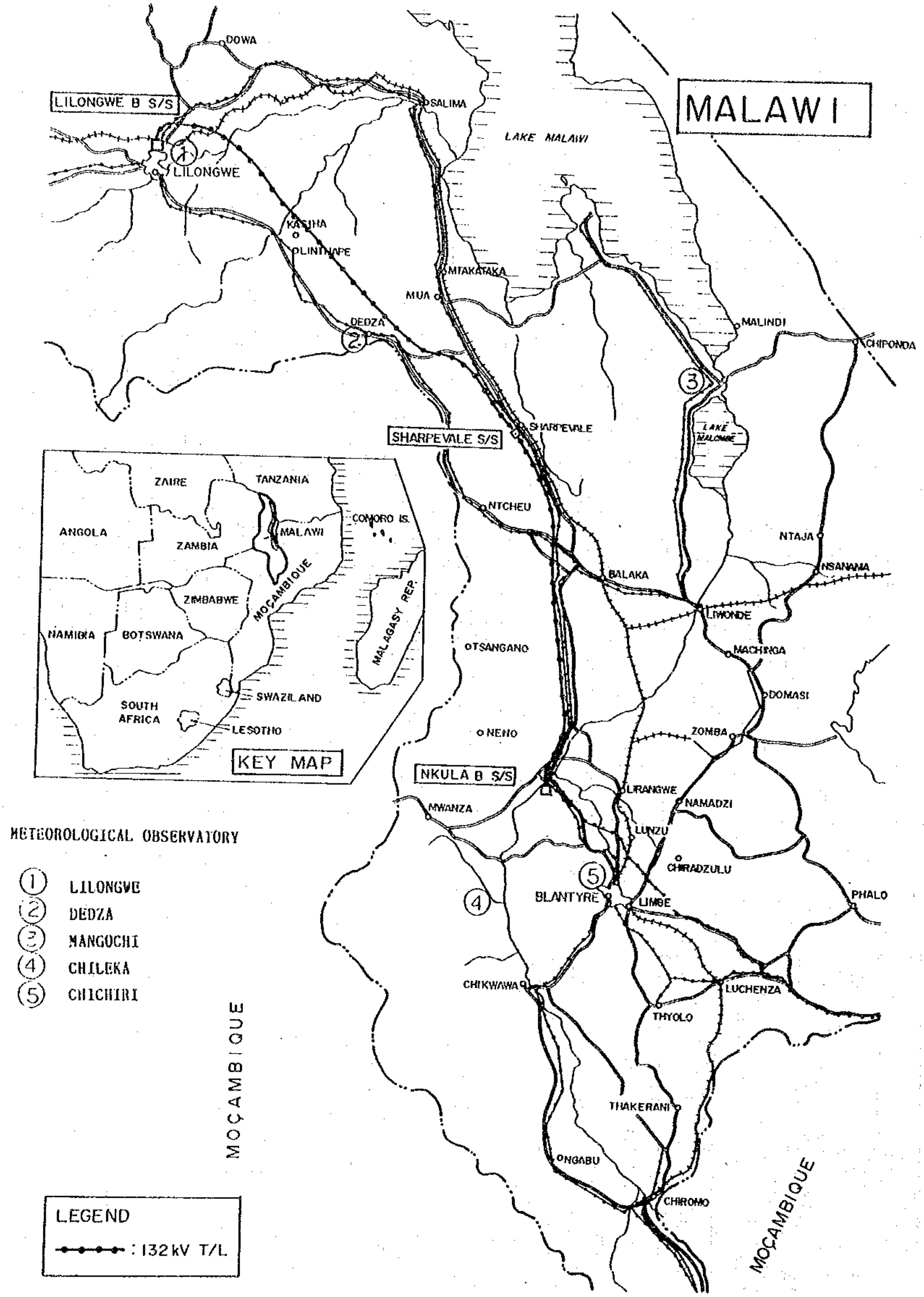


Fig 6－1 Meteorological Observatory

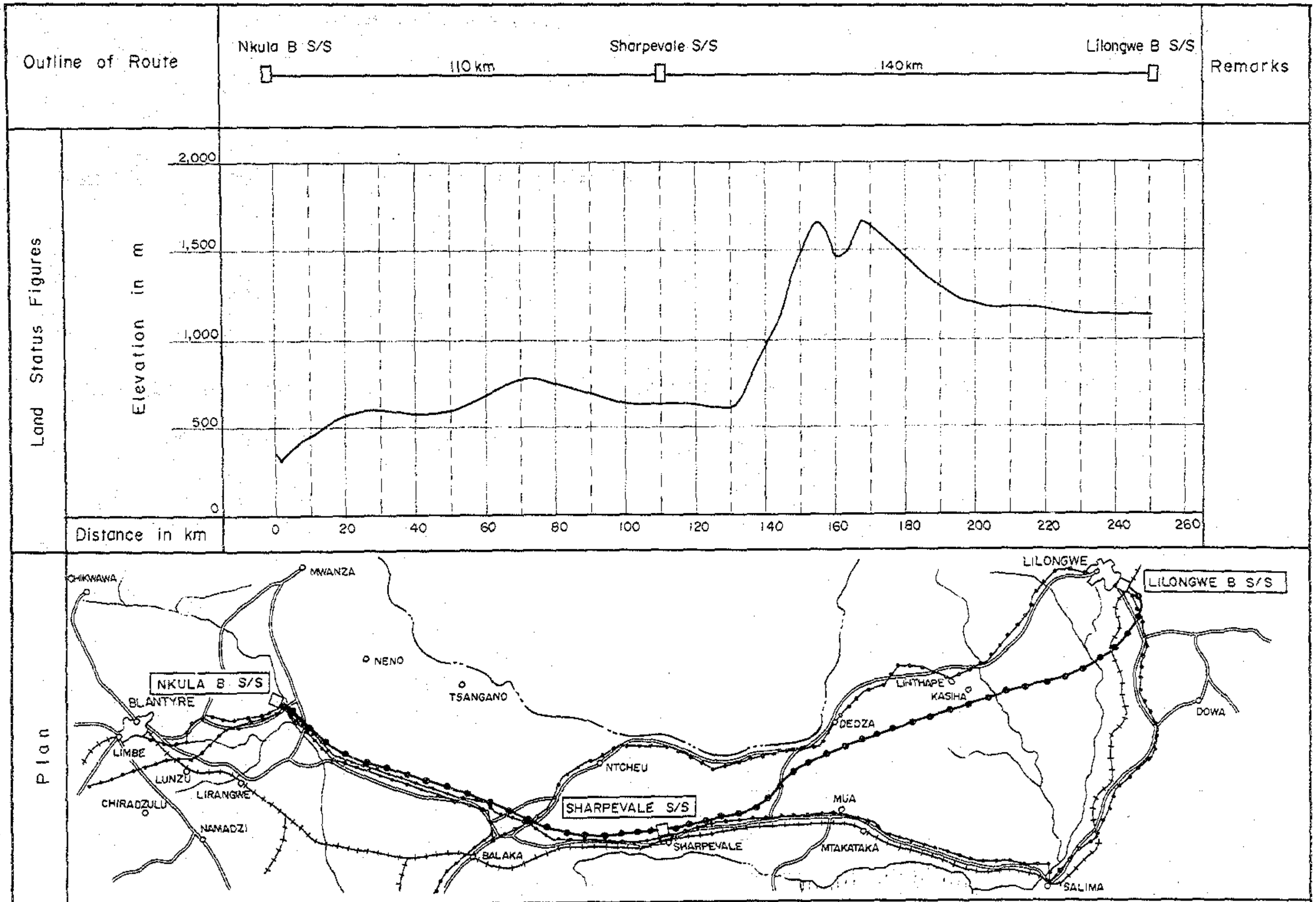


Fig 6 — 2 OUTLINE OF NKULA B — LILONGWE B TRANSMISSION CONSTRUCTION PROJECT

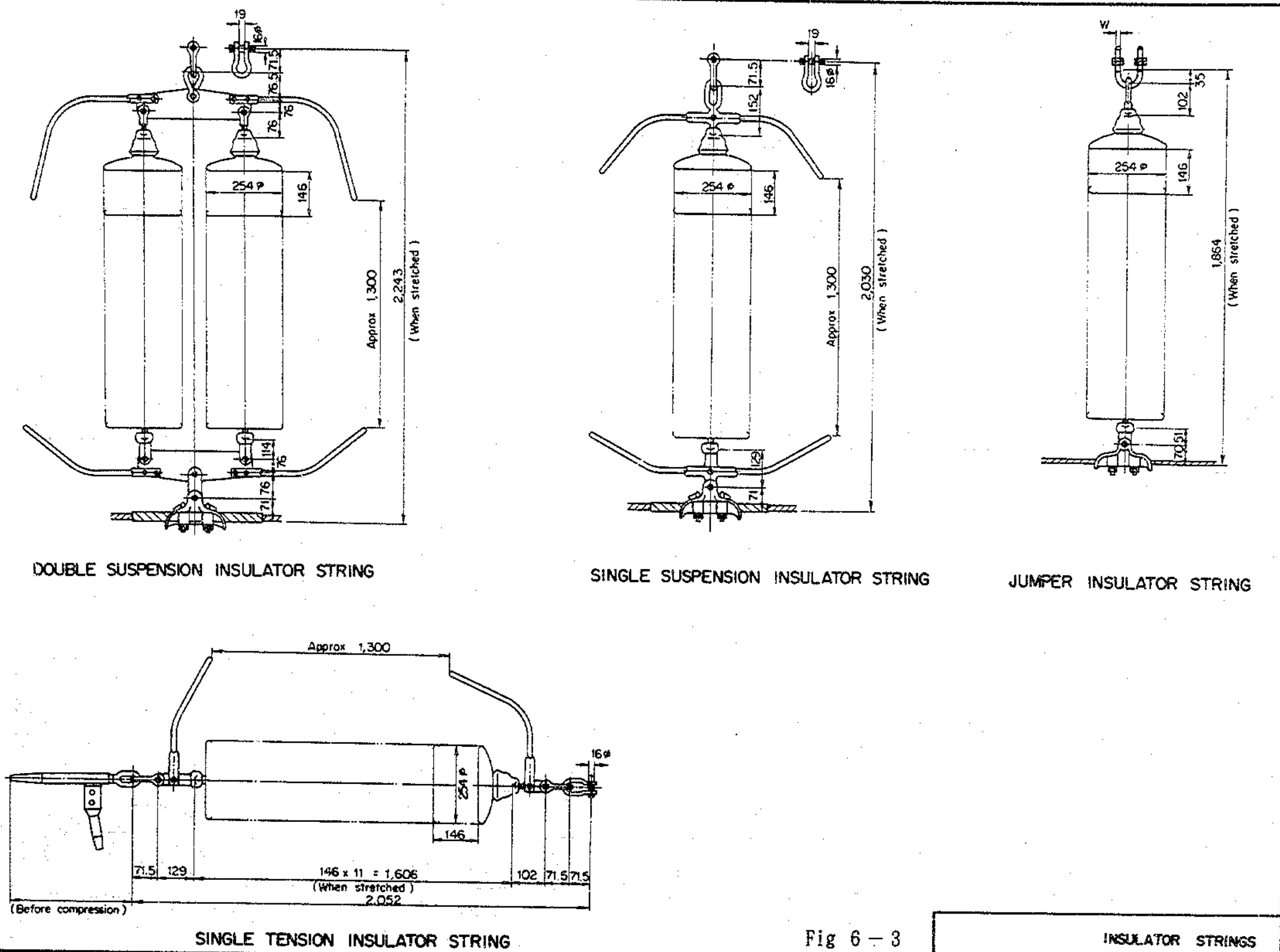


Fig 6 − 3 INSULATOR STRINGS

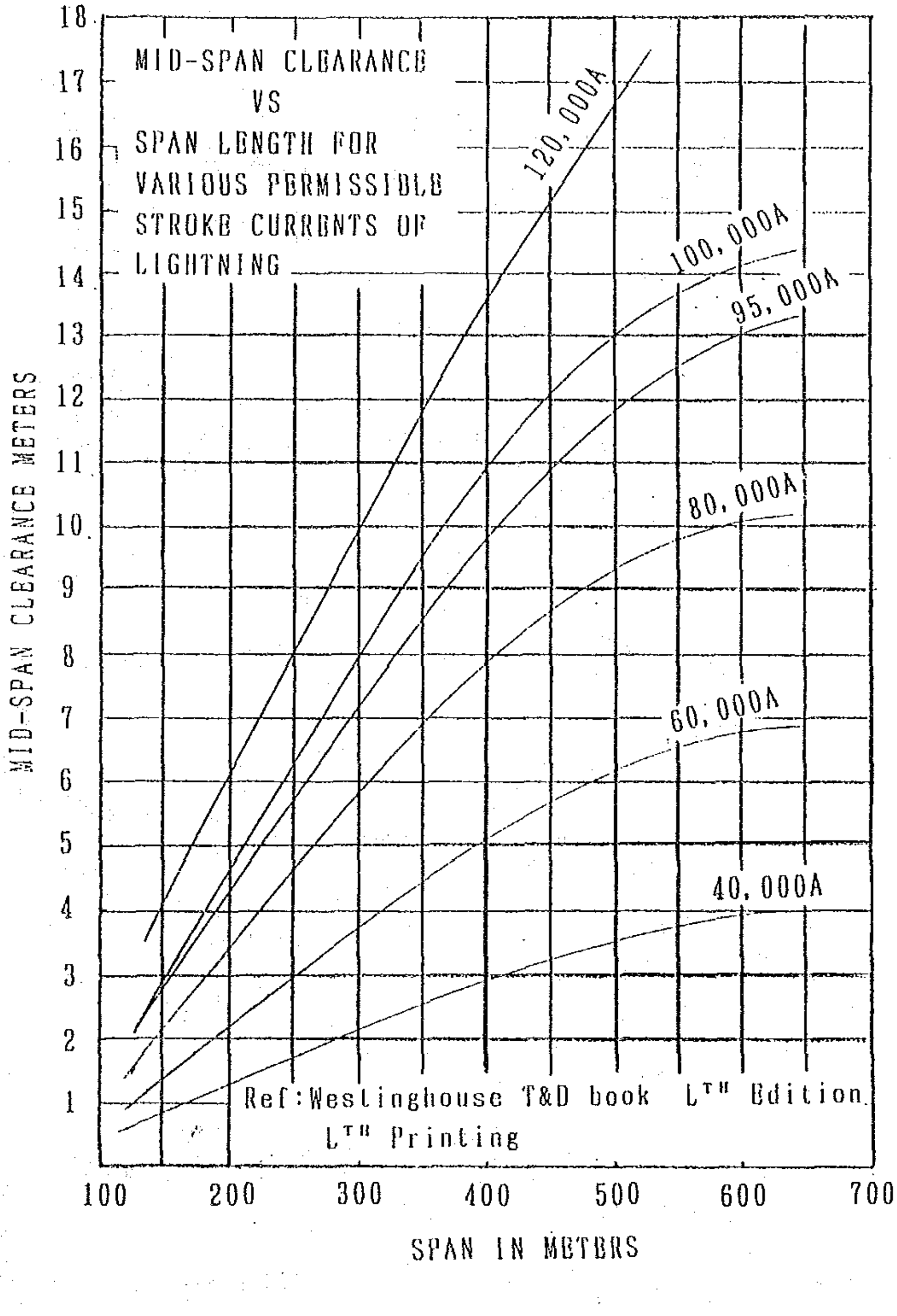


Fig 6 — 4 MIDSPAN CLEARANCE FOR LIGHTNING

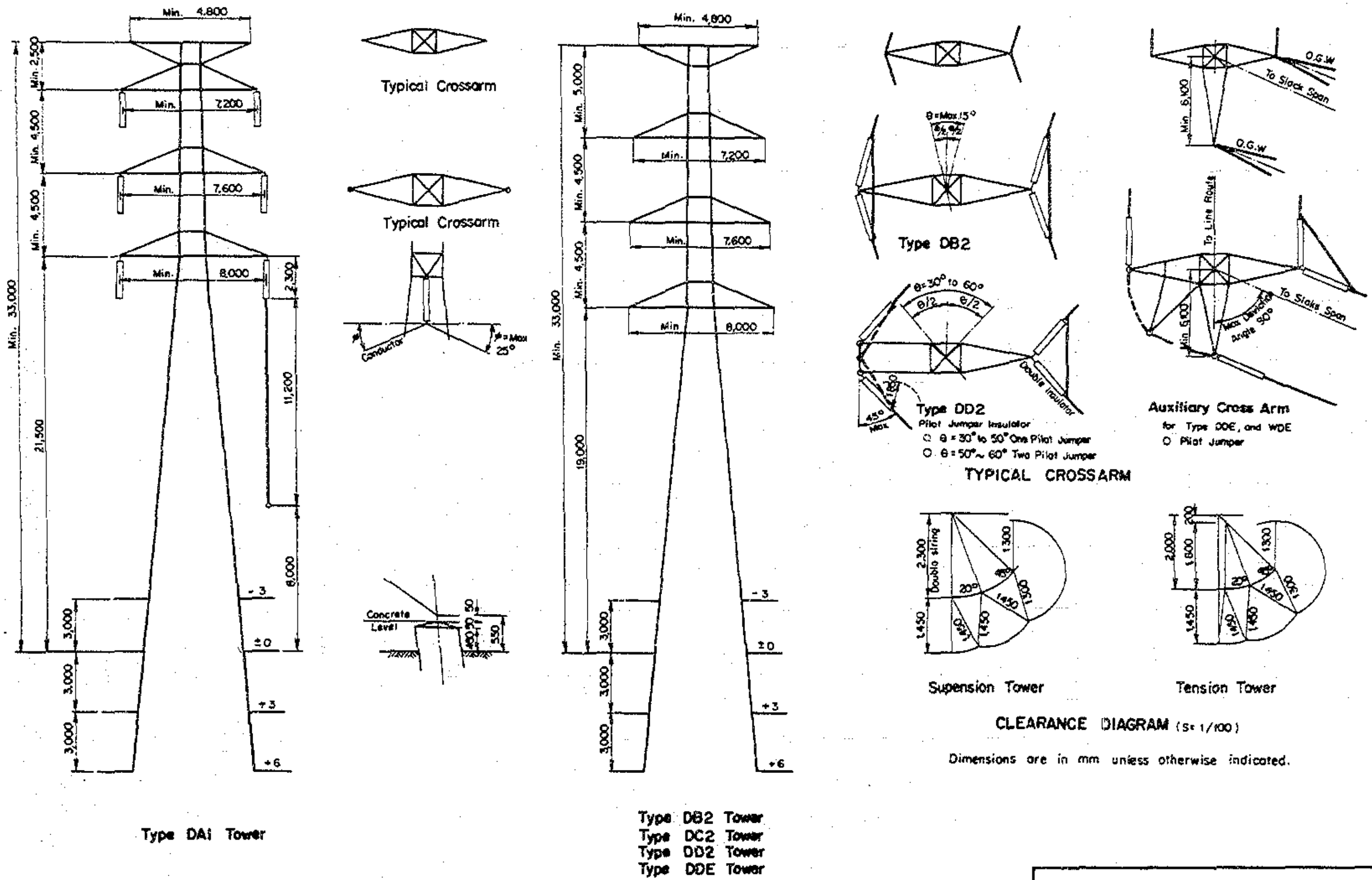
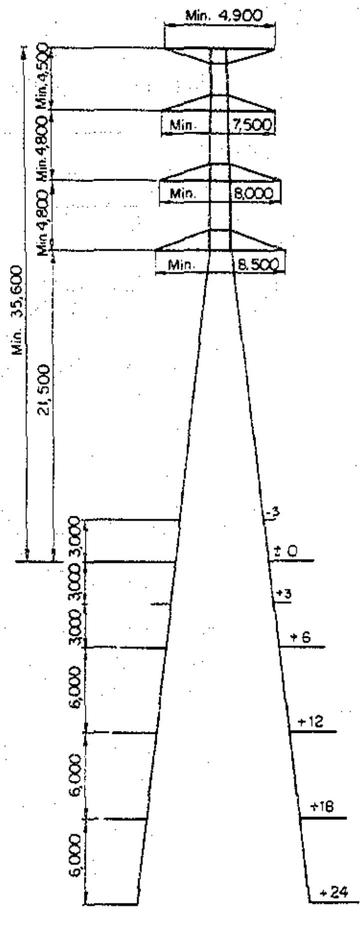
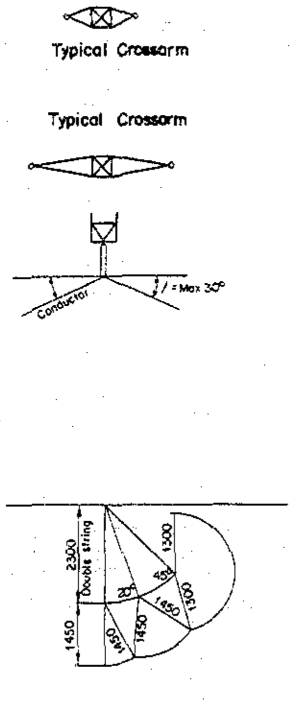


Fig 6 — 5

PRINCIPAL DIMENSION OF TOWER (1/2)



Type LDAI Tower



Suspension Tower

CLEARANCE DIAGRAM

ELECTRICAL AND GROUND CLEARANCES

1. Sag Shall be as follows

Description	Basic Span (m) 350	600
Overhead Ground Wire AC 55 Sqmm (St 7 / 3.2)		
Sag at 0 °C Temp and 90 x 60 % kg/sqm Wind	8.13	26.07
at 0 °C Temp and No Wind	6.44	24.37
at Every Day Stress 20 °C Temp and No Wind	7.07	25.07
at Max. Operating Temp 45 °C and No Wind	7.84	25.92
Conductor 605 MCM ACSR (Al 24 / 4.034 St 7 / 2.69)		
Sag at 0 °C Temp and 81 x 60 % kg/sqm Wind	9.15	28.11
at 0 °C Temp and No Wind	8.51	27.46
at Every Day Stress 20°C Temp and No Wind	9.36	28.37
at Max. Operating Temp 65 °C and No Wind.	11.13	30.34

2. Tower Design Shall provide at least the following electrical clearance

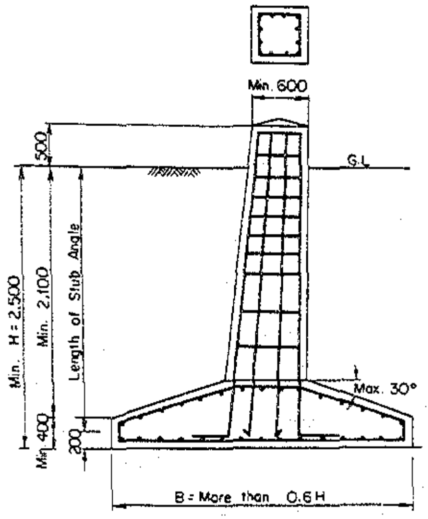
Description	Min. Clearance
Insulator and Jumper Loop Swing Angle	
Still air 0° to 20°	Min. 1.45 m
Wind air 20° to 45°	Min. 1.30 m

3. Overhead ground wire shall provide protective zone as follows

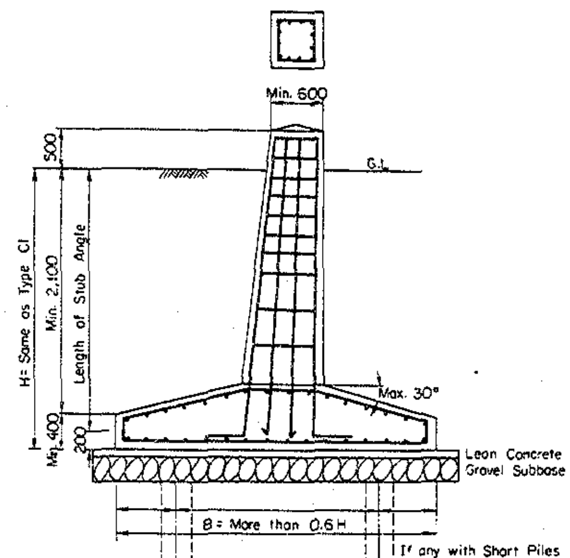
Section	Conductor	Protective Angle ( ) ※
Nkulu B - Lilongwe B S/S	605 MCM x 1	Max. 15°

4. Dimensions are in mm unless otherwise indicated

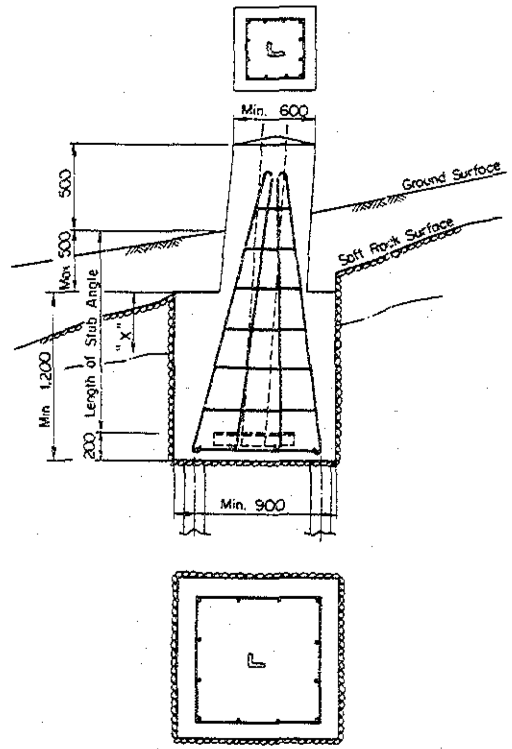
Fig 6 — 5 PRINCIPAL DIMENSION OF TOWER (2/2)



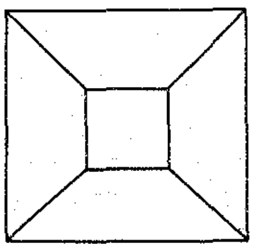
CONCRETE PAD FOUNDATION
FOR SOIL TYPE C1.C2



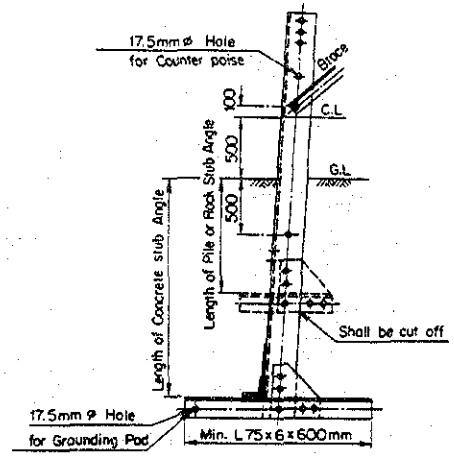
CONCRETE PAD FOUNDATION
FOR SOIL TYPE C3



SOFT ROCK FOUNDATION
TYPE R



PLAN OF FOOTING



DETAILS OF STUB ANGLE

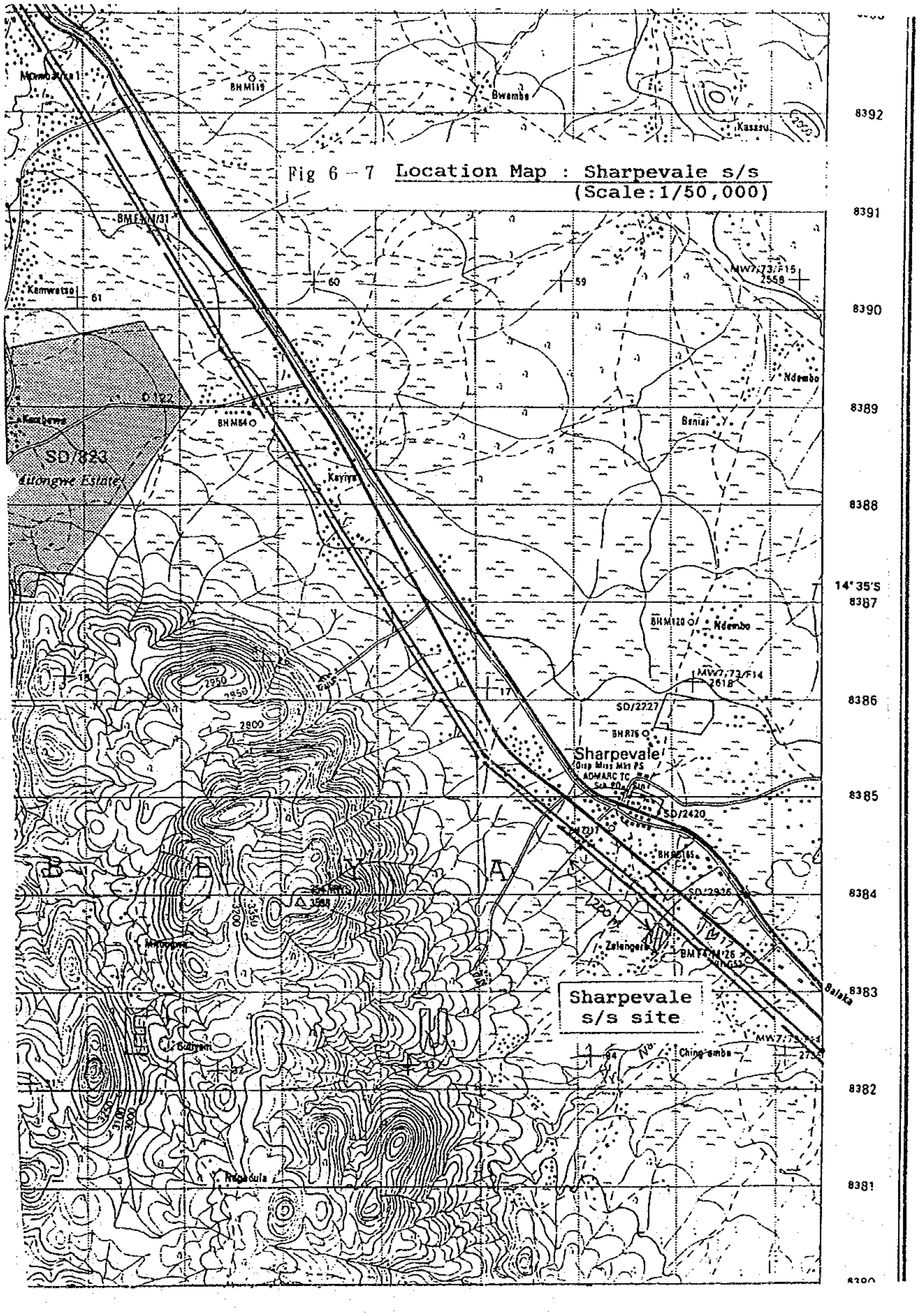
NOTE

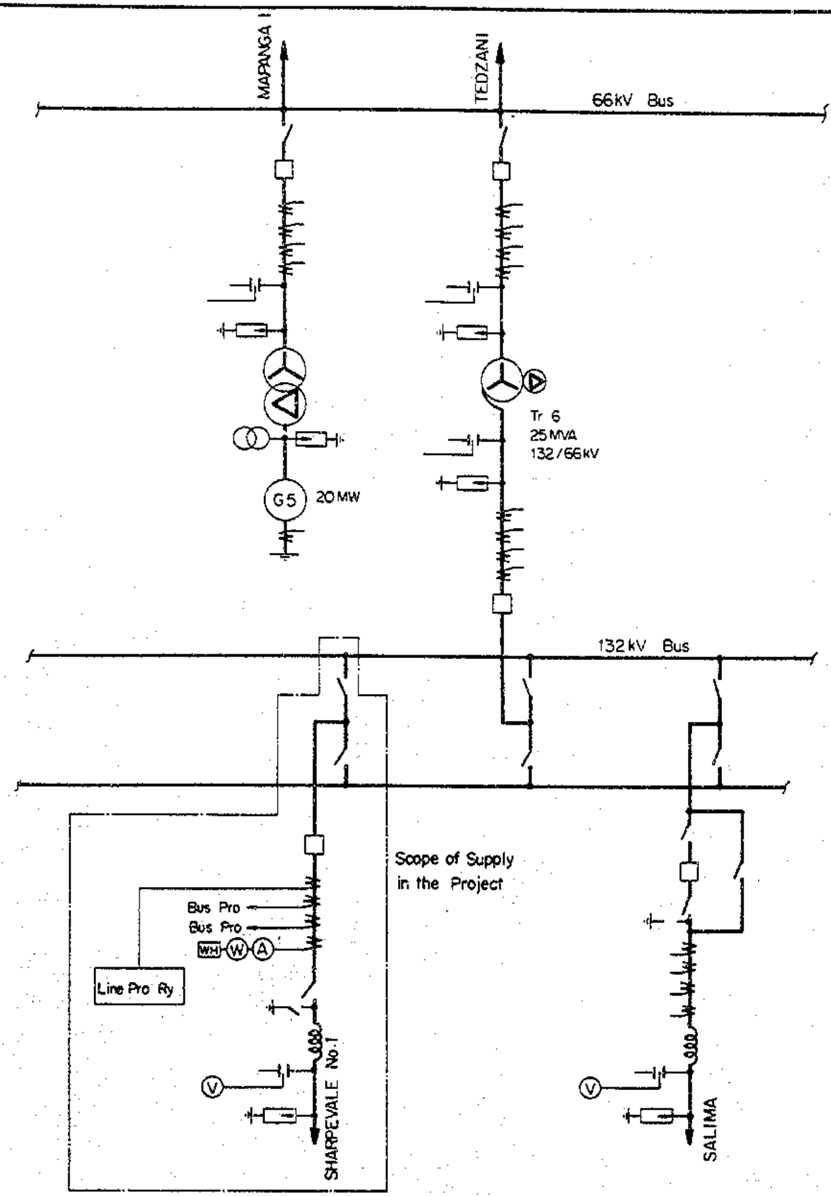
1) Reinforcement Bar
   The reinforcement bar size shall not be less than 16mm φ for reinforcement and 8mm φ for stirrup.
2) Rock Friction
   Rock skin friction in inverted perimeter of rock footing excluding 30cm ("X") depth from the rock surface.
3) Rock Excavation Hole
   Rock excavation hole shall be filled with concrete and there shall be no void
4) Anchor Rod
   Minimum size of anchor rod shall be D-24mm diameter.
5) Anchor Hole
   Diameter of drilled hole for anchor rod shall be at least 5 times that of anchor rod.
6) All dimensions are in mm unless otherwise indicated.

Fig 6 — 6

DETAILS OF FOUNDATIONS

Fig 6 − 7 Location Map : Sharpevale s/s
(Scale:1/50,000)





LEGEND

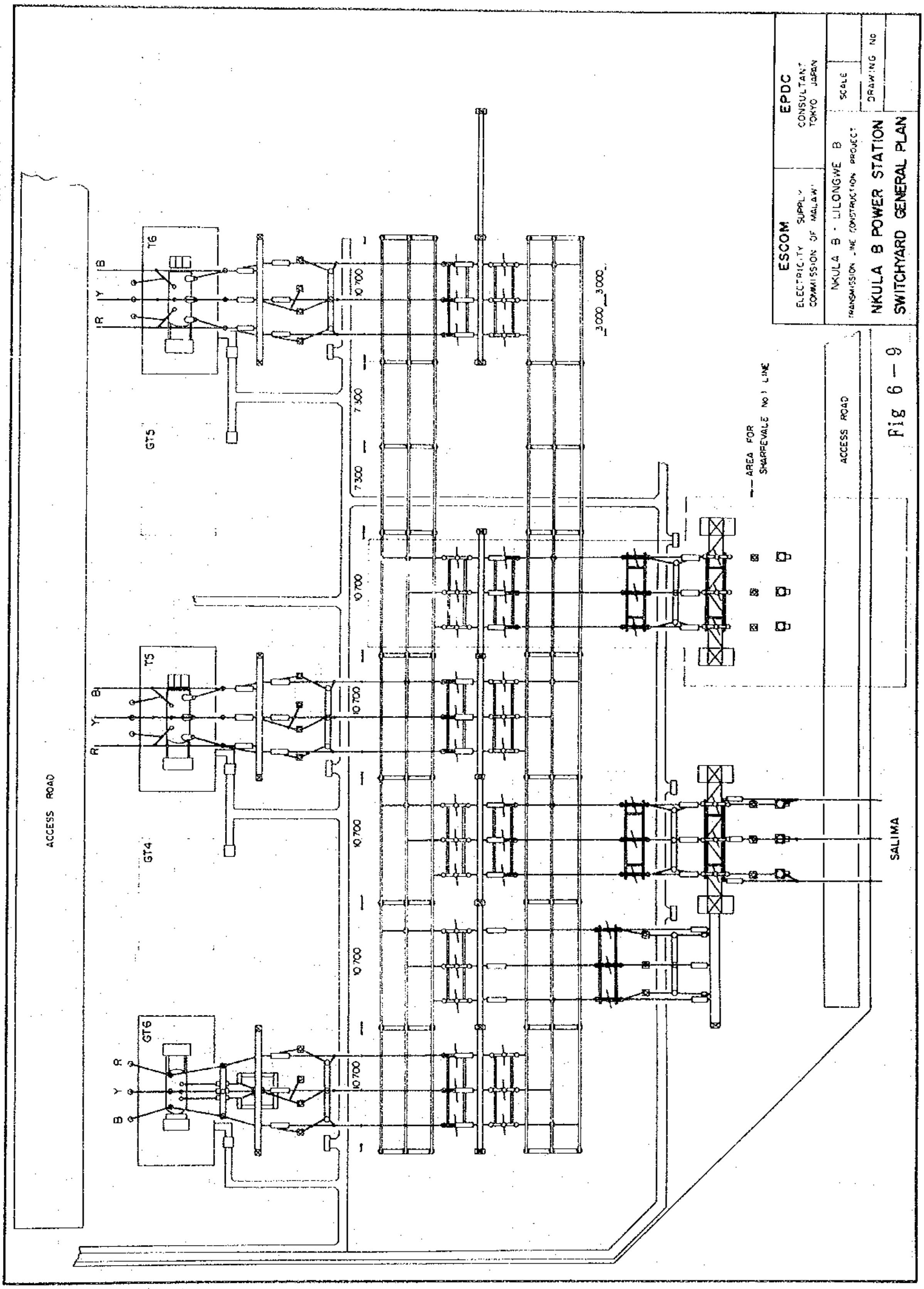
- Circuit breaker
- Disconnector
- Surge arrester
- Capacitor voltage transformer
- Potential transformer

NOTE

This single line diagram indicates one new transmission line (to LILONGWE (B)) which is to be constructed by the project and not indicates whole circuit connection in NKULA B power station.

ESCOM ELECTRICITY SUPPLY COMMISSION OF MALAWI	EPDC CONSULTANT TOKYO JAPAN
NKULA B - LILONGWE B TRANSMISSION LINE CONSTRUCTION PROJECT	SCALE
NKULA B POWER STATION SINGLE LINE DIAGRAM	DRAWING No.

Fig 6 — 8



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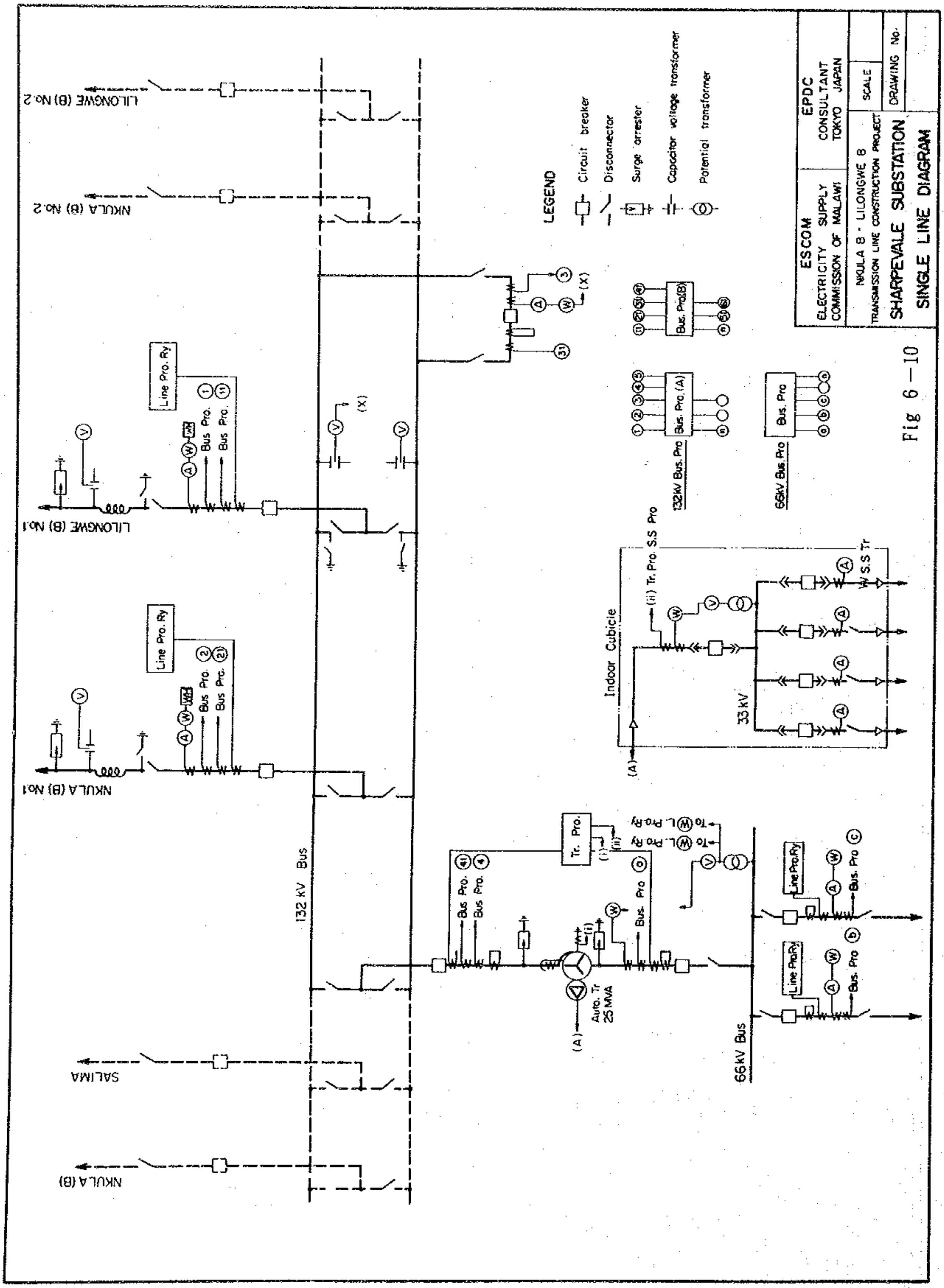
ELECTRICITY SUPPLY COMMISSION OF MALAWI
EPDC
CONSULTANT TOKYO JAPAN
NKULA B - LILONGWE B
TRANSMISSION LINE CONSTRUCTION PROJECT
SCALE
DRAWING No
NKULA B POWER STATION
SWITCHYARD GENERAL PLAN
ACCESS ROAD
ACCESS ROAD
AREA FOR SHARPEVALE No1 LINE
SALIMA
T6
T5
GT6
GT5
GT4
R
Y
B
10700
7300
7300
3000
3000

Fig 6 — 9


ESCOM
ELECTRICITY SUPPLY COMMISSION OF MALAWI
EPDC
CONSULTANT TOKYO JAPAN
NKULA B - LILONGWE B
TRANSMISSION LINE CONSTRUCTION PROJECT
SCALE
DRAWING No.
SHARPEVALE SUBSTATION
SINGLE LINE DIAGRAM
LEGEND
Circuit breaker
Disconnector
Surge arrester
Capacitor voltage transformer
Potential transformer
LILONGWE (B) No.2
NKULA (B) No.2
LILONGWE (B) No.1
NKULA (B) No.1
SALIMA
NKULA (B)
132 kV Bus
66kV Bus
33 kV
Indoor Cubicle
(ii) Tr. Pro. S.S Pro
S.S Tr
Auto. Tr
25 MVA
Tr. Pro.
Line Pro. Ry
Bus Pro.
Bus. Pro (A)
Bus. Pro (B)
132kV Bus. Pro
66kV Bus. Pro
To W L. Pro. Ry
Fig 6 − 10

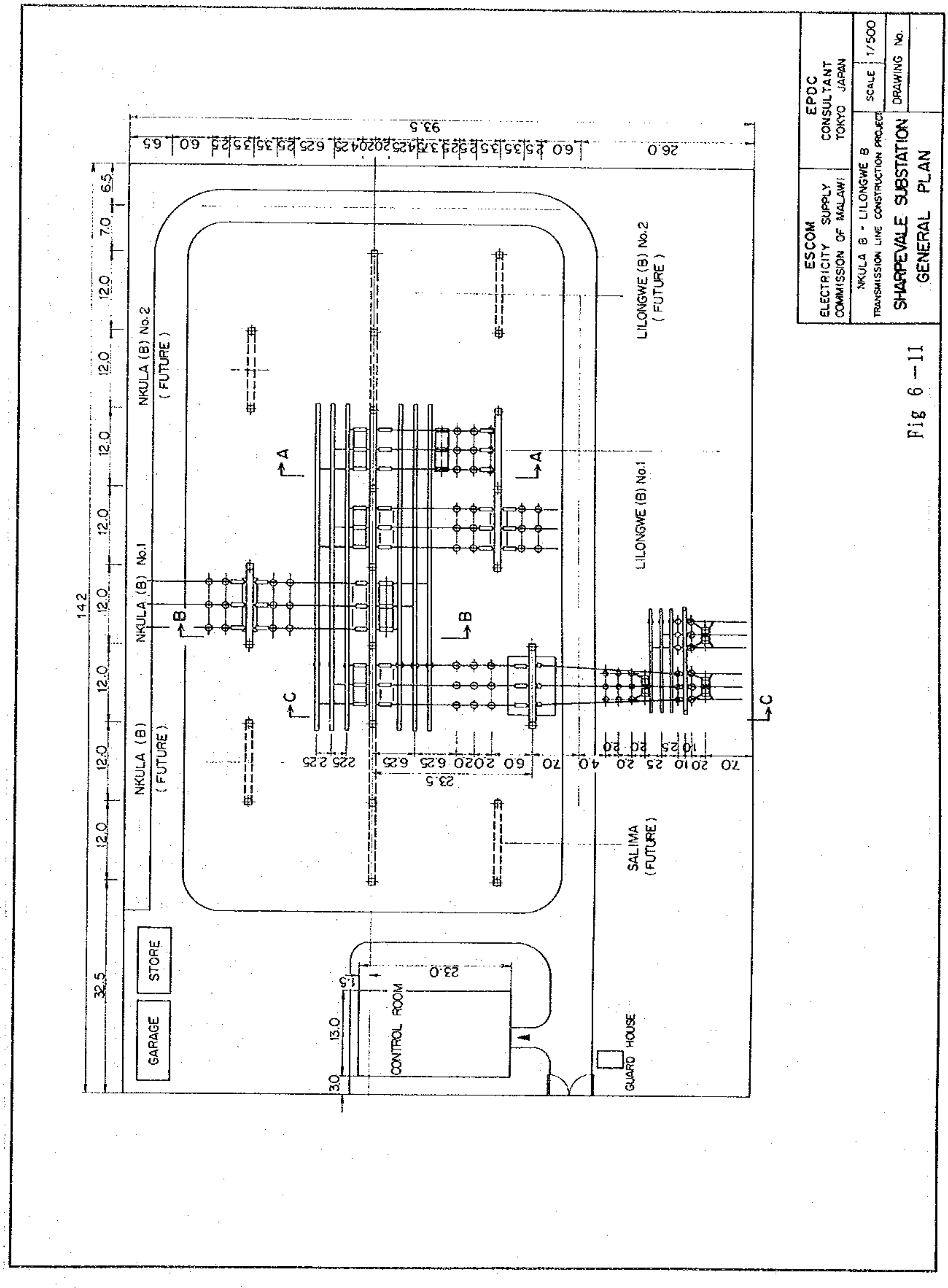
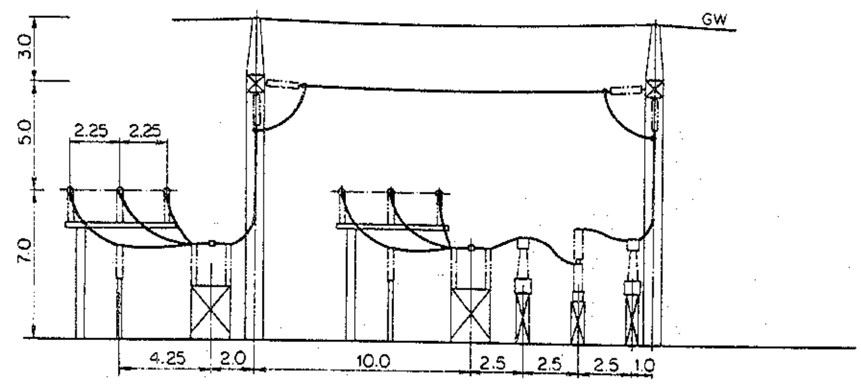

ESCOM
ELECTRICITY SUPPLY
COMMISSION OF MALAWI
EPDC
CONSULTANT
TOKYO JAPAN
NKULA B - LILONGWE B
TRANSMISSION LINE CONSTRUCTION PROJECT
SCALE 1/500
DRAWING No.
SHARPEVALE SUBSTATION
GENERAL PLAN
NKULA (B) No.2
(FUTURE)
NKULA (B) No.1
NKULA (B)
(FUTURE)
LILONGWE (B) No.2
(FUTURE)
LILONGWE (B) No.1
SALIMA
(FUTURE)
GARAGE
STORE
CONTROL ROOM
GUARD HOUSE

Fig 6 -11

SECTION A-A (BUS TIE)



SECTION B-B (132kV LINE)

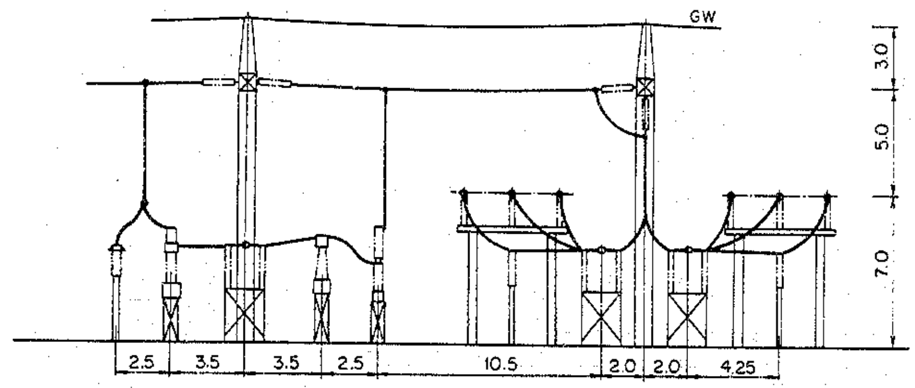


Fig 6 —12

ESCOM ELECTRICITY SUPPLY COMMISSION OF MALAWI	EPDC CONSULTANT TOKYO JAPAN	
NKULA B - LILONGWE B TRANSMISSION LINE CONSTRUCTION PROJECT	SCALE	1/200
SHARPEVALE SUBSTATION	DRAWING No.	
SECTION (1/2)		

SECTION C-C

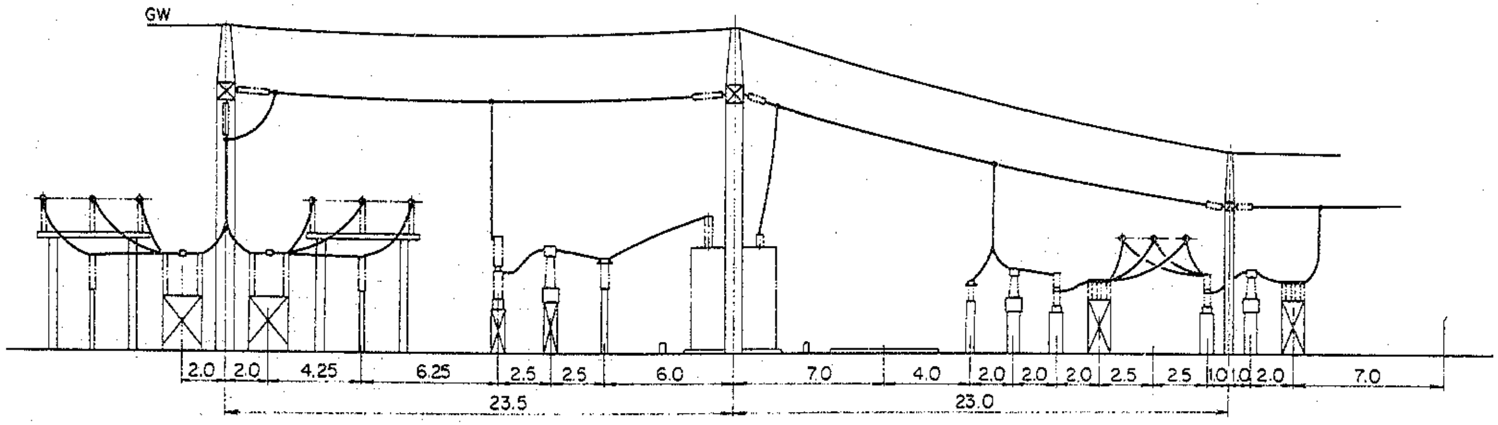


Fig 6 −13

ESCOM ELECTRICITY SUPPLY COMMISSION OF MALAWI	EPDC CONSULTANT TOKYO JAPAN		
NKULA B - LILONGWE B TRANSMISSION LINE CONSTRUCTION PROJECT		SCALE	1/200
SHARPEVALE SUBSTATION SECTION (2/2)		DRAWING No.	

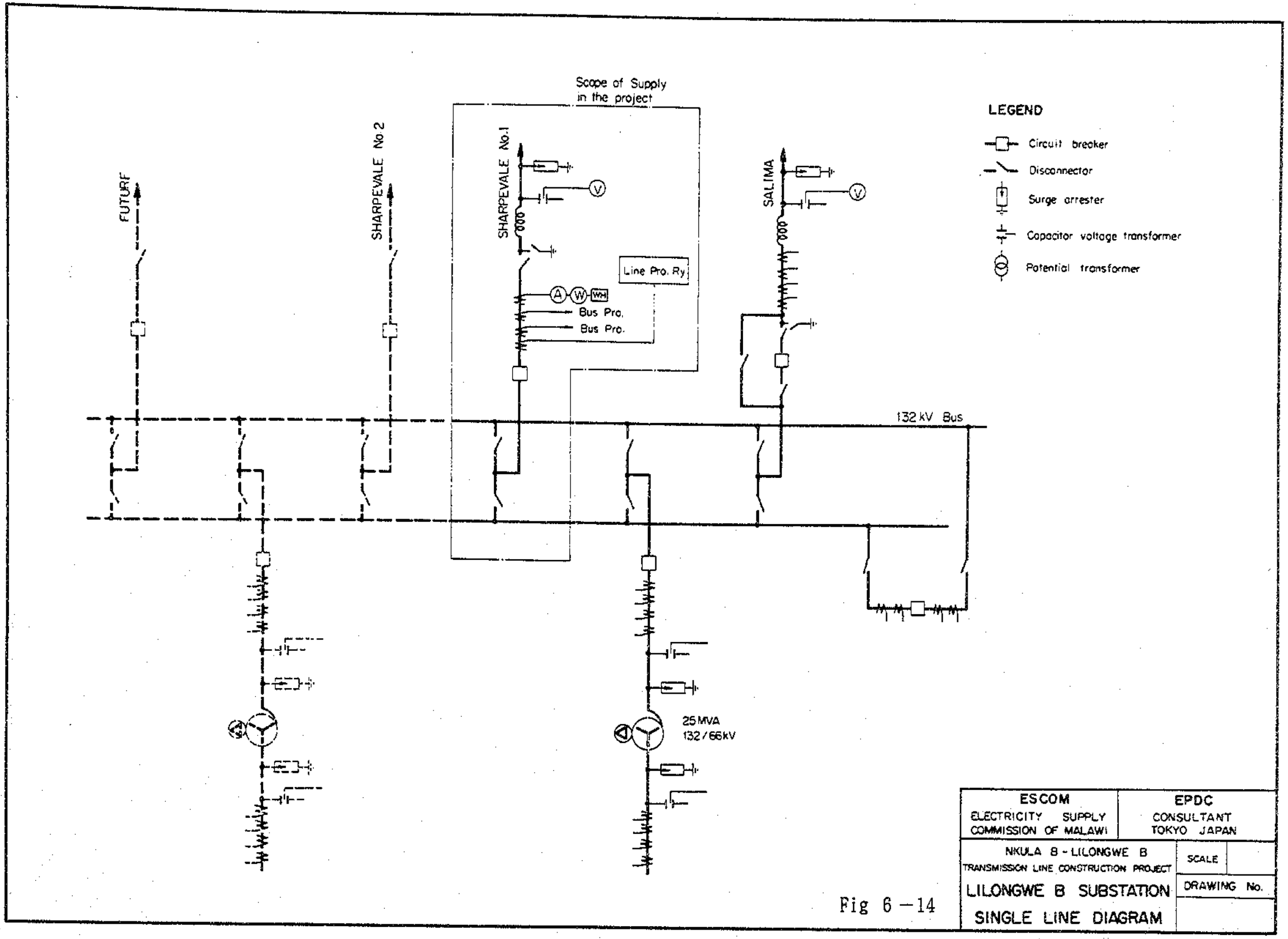

Scope of Supply
in the project
LEGEND
Circuit breaker
Disconnector
Surge arrester
Capacitor voltage transformer
Potential transformer
FUTURE
SHARPEVALE No 2
SHARPEVALE No.1
SALIMA
Line Pro. Ry
A
W
WH
Bus Pro.
Bus Pro.
V
132 kV Bus
25 MVA
132 / 66kV
ESCOM
ELECTRICITY SUPPLY
COMMISSION OF MALAWI
EPDC
CONSULTANT
TOKYO JAPAN
NKULA B - LILONGWE B
TRANSMISSION LINE CONSTRUCTION PROJECT
SCALE
LILONGWE B SUBSTATION
SINGLE LINE DIAGRAM
DRAWING No.

Fig 6 —14

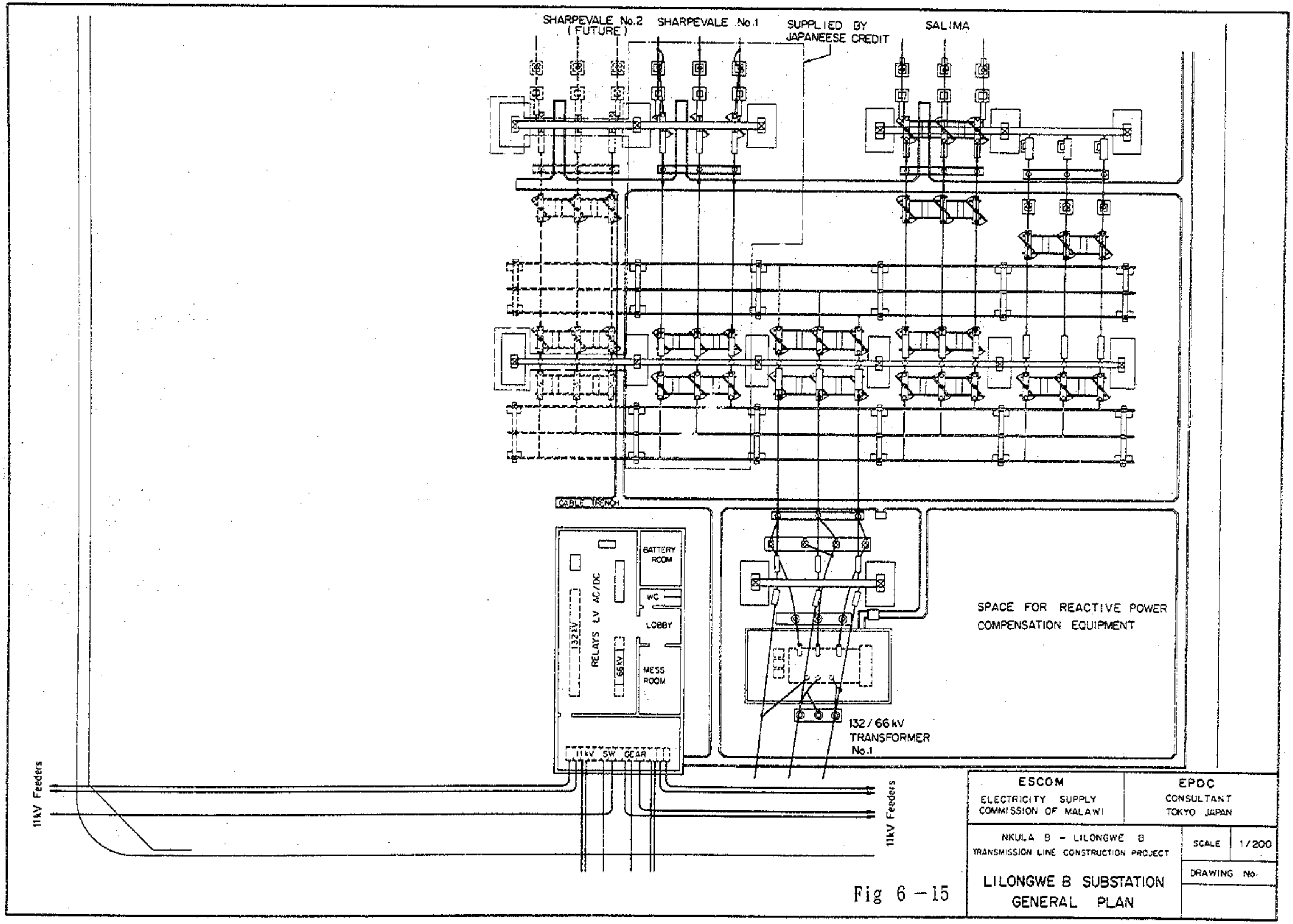
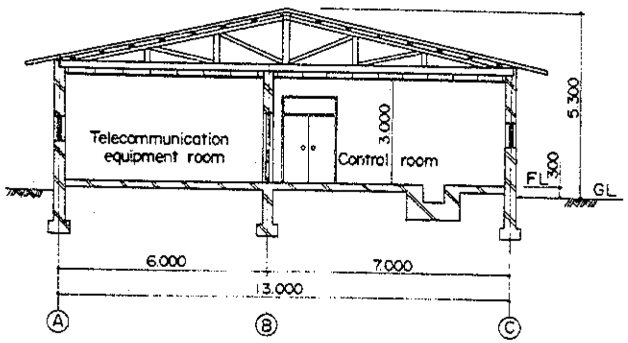
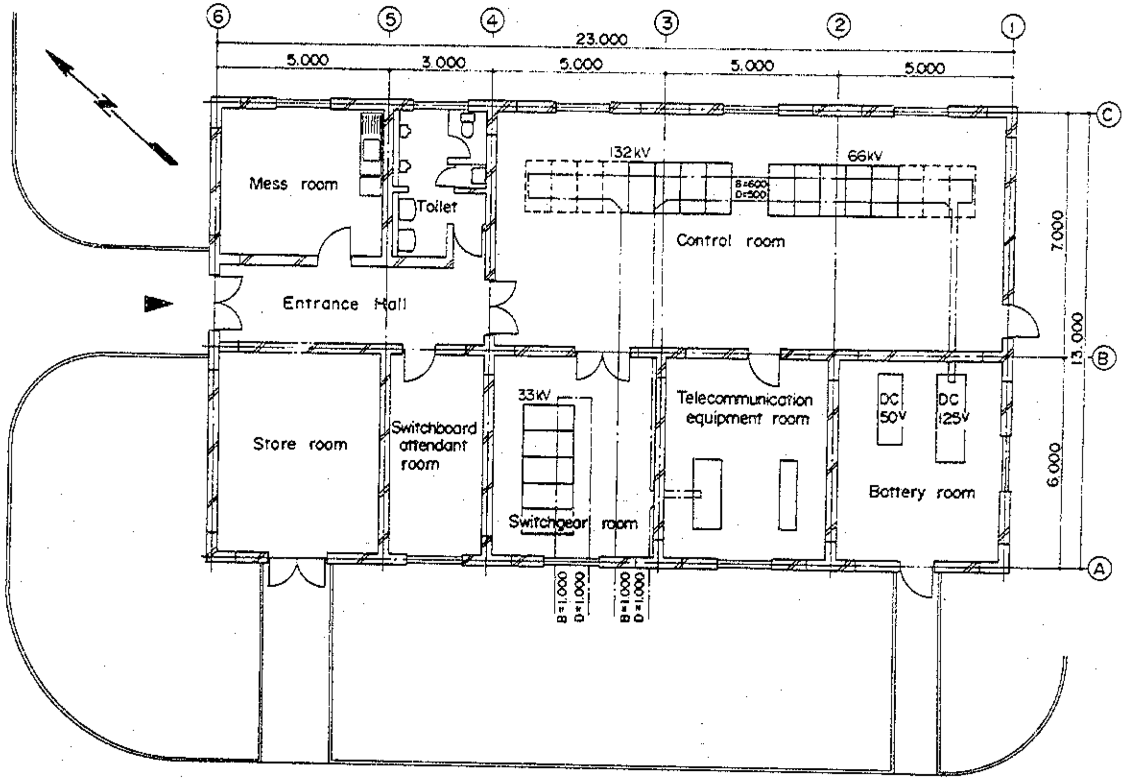

SHARPEVALE No.2 (FUTURE)
SHARPEVALE No.1
SUPPLIED BY JAPANEESE CREDIT
SALIMA
CABLE TRENCH
BATTERY ROOM
WC
LOBBY
MESS ROOM
RELAYS LV AC/DC
132kV
66kV
11kV SW GEAR
SPACE FOR REACTIVE POWER COMPENSATION EQUIPMENT
132/66kV TRANSFORMER No.1
11kV Feeders
11kV Feeders
ESCOM
ELECTRICITY SUPPLY COMMISSION OF MALAWI
EPDC
CONSULTANT
TOKYO JAPAN
NKULA B - LILONGWE B
TRANSMISSION LINE CONSTRUCTION PROJECT
SCALE
1/200
DRAWING No.
LILONGWE B SUBSTATION GENERAL PLAN

Fig 6 -15



SECTION



PLAN

Fig 6 –16 SHARPEVALE SUBSTATION CONTROL BUILDING

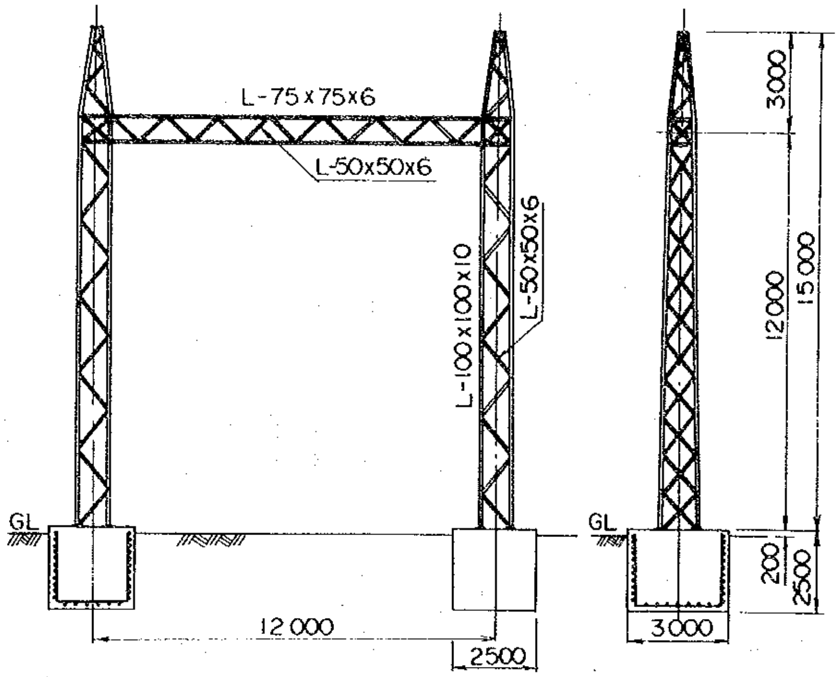
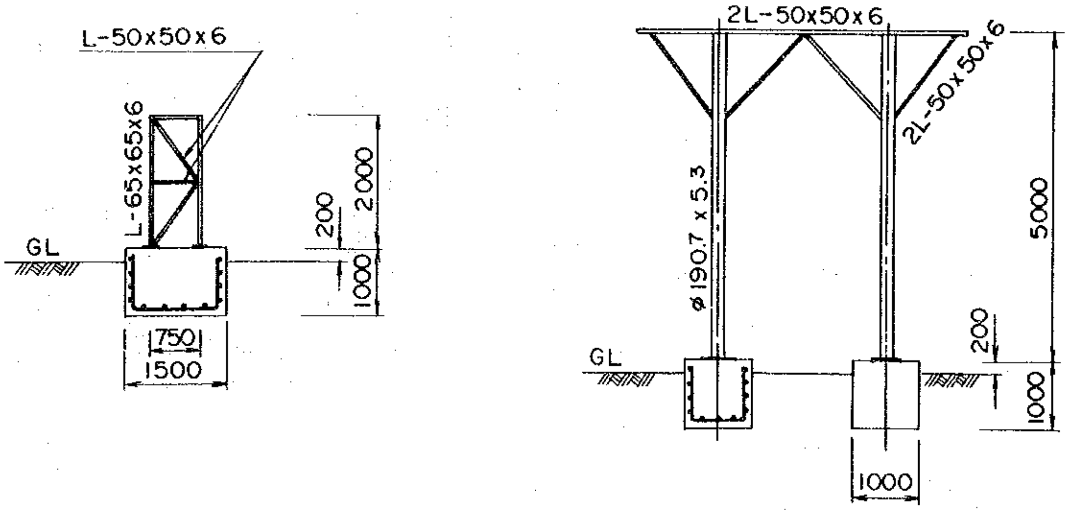


Fig 6 −17 STEEL STRUCTURE (132kV)



STRUCTURE for CT· CVT· SA

STRUCTURE for PIPE BUS

Fig 6 −18 SUPPORT STRUCTURE for INSTALLATIONS at SHARPEVALE SUBSTATION

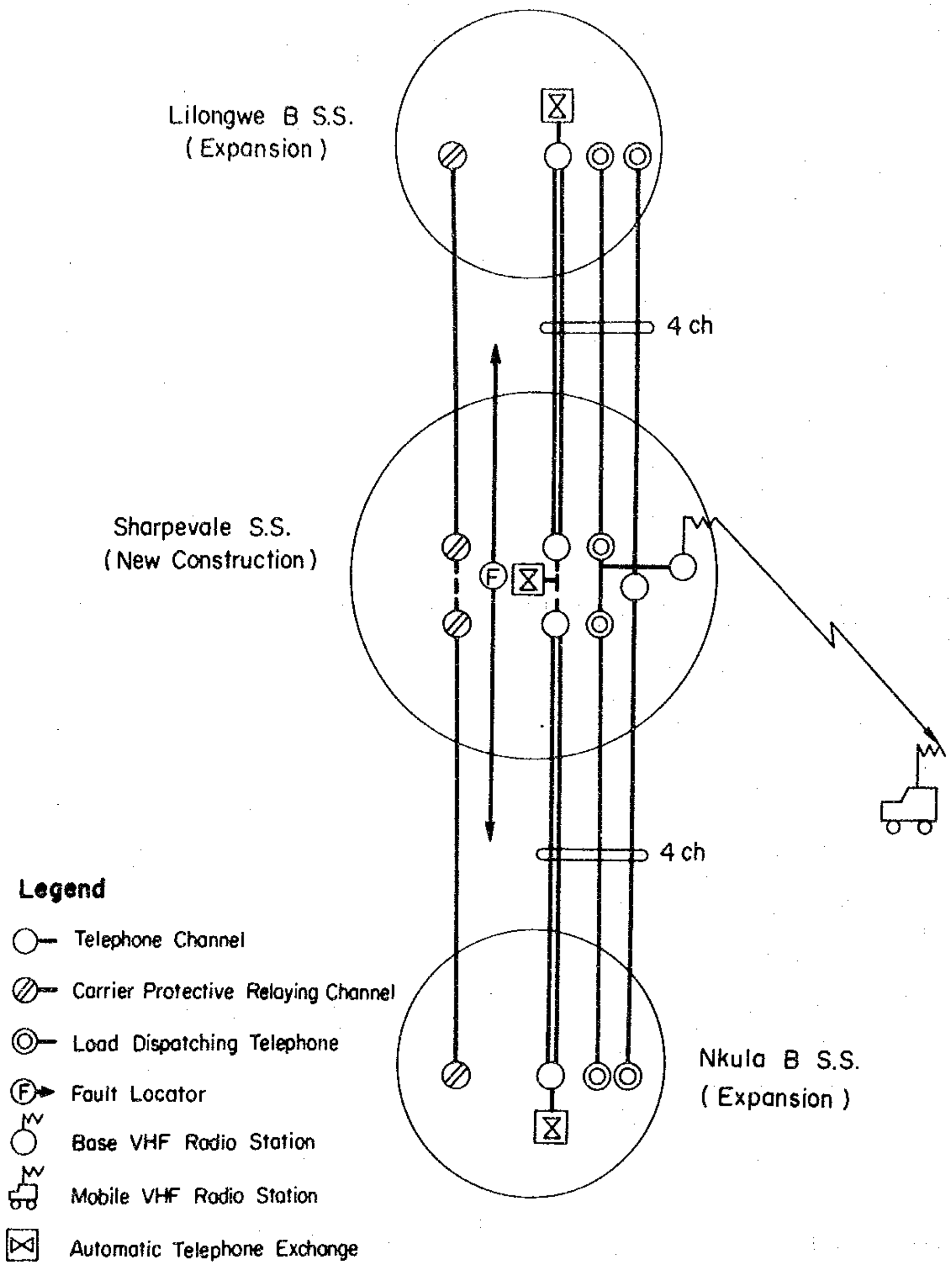


Fig 6 −19 **Telecommunication Circuit Diagram**

NKULA B − LILONGWE B : TRANSMISSION LINE CONSTRUCTION PROJECT

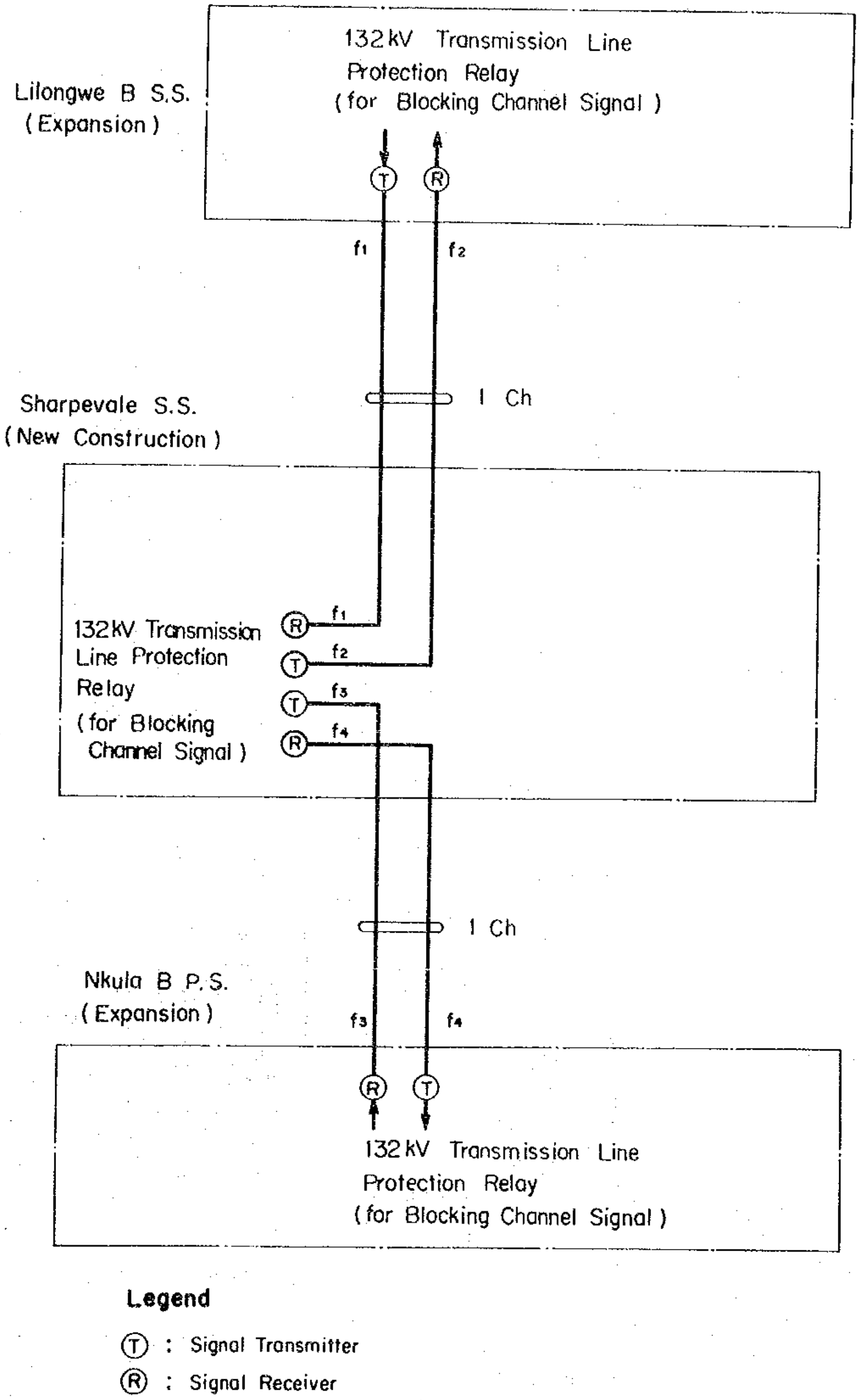


Fig 6 – 20 **Power Line Carrier Protective Relaying System Diagram**

NKULA B – LILONGWE B : TRANSMISSION LINE
CONSTRUCTION PROJECT

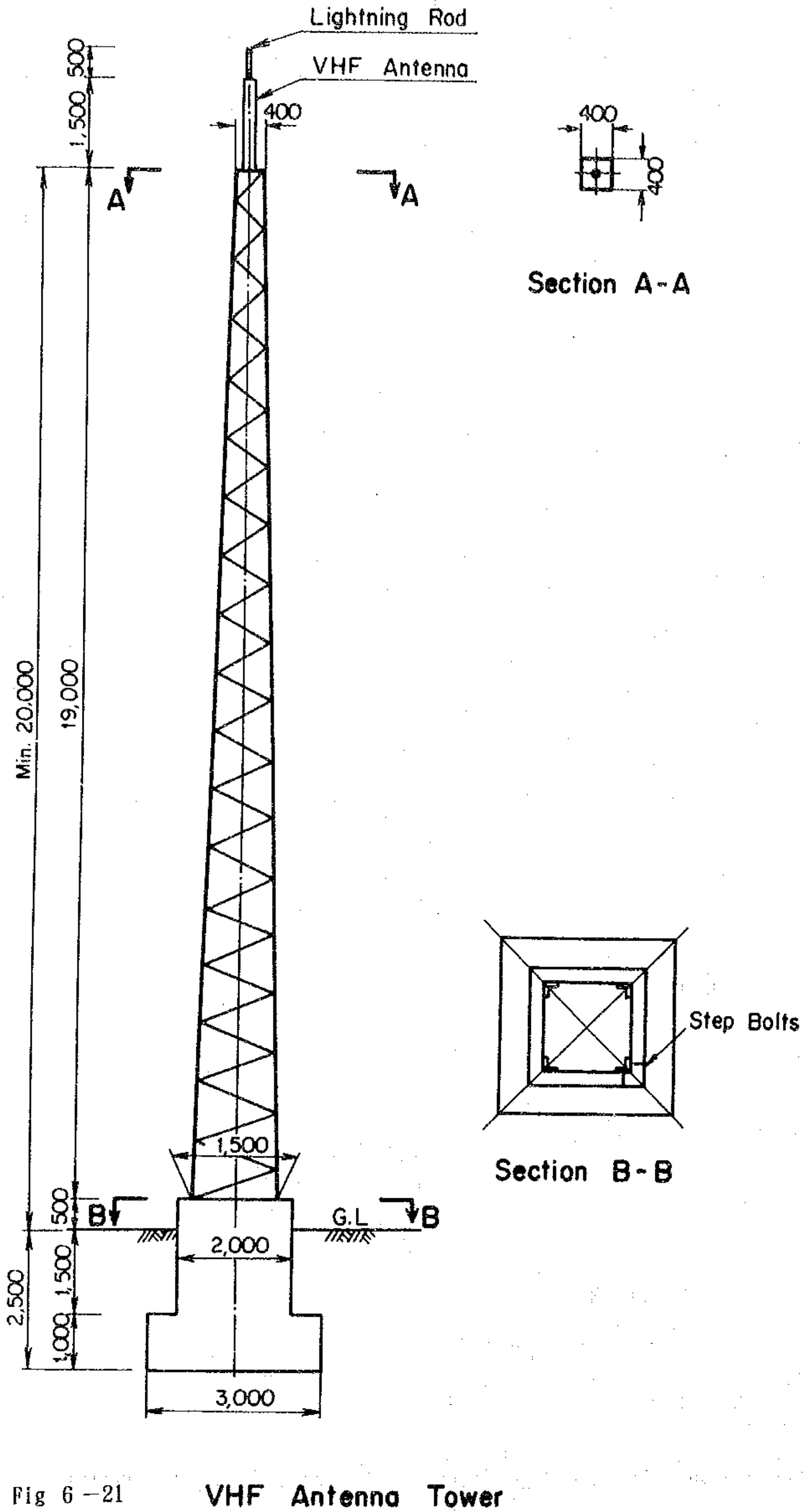
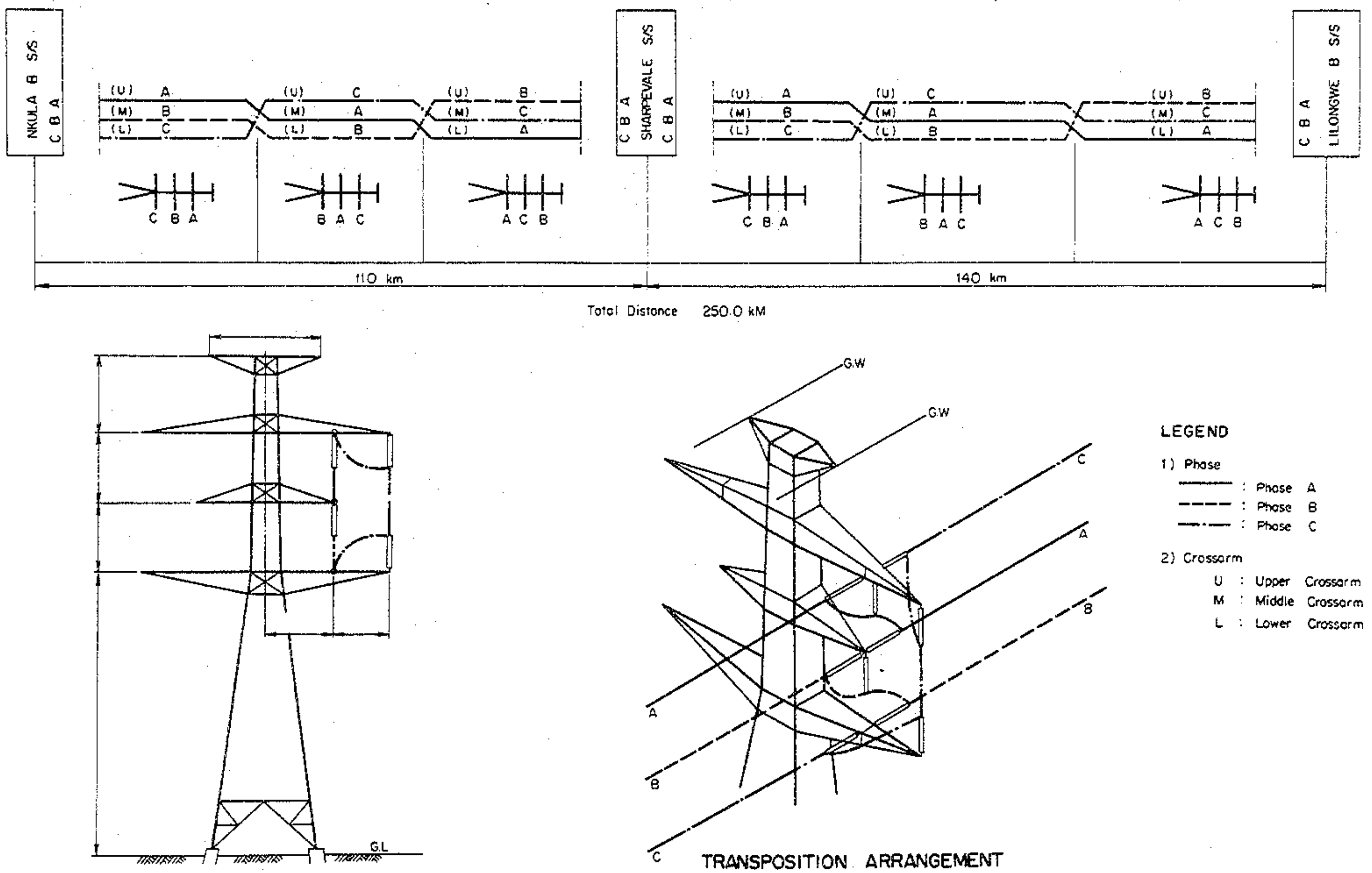


Fig 6 -21 **VHF Antenna Tower**

NKULA B - LILONGWE B : TRANSMISSION LINE CONSTRUCTION PROJECT

PHASE ROTATION



TRANSPOSITION STRUCTURE
Mounted on Type DB2 Tower

TRANSPOSITION ARRANGEMENT

Fig 6 −22

TRANSPOSITION SYSTEM

CHAPTER 7 POWER SYSTEM ANALYSIS

CHAPTER 7 POWER SYSTEM ANALYSIS

Based on the transmission line plan described in Chapter 6-2, examinations were made of the power flow, stability, short-circuit capacity as well as the countermeasures for the improvement of voltage stability which are detailed below. It can be concluded that linking the power source area in the south and the central power system with the transmission line for which this study is conducted will permit the intended transmission of the power (30 MW) by a 1 circuit transmission line (stringing for 1 circuit and designed for 2 circuits) and that there are no specific problems with either the stability or the short-circuit capacity.

Regarding the retaining of voltage, the result of a system analysis indicates the possibility of voltage drop at Chichiri Power Station.

7-1 Preconditions for Power System Analysis

Presented below is the fundamental data used for the power system analysis:

- Year analysed: 1992, 1994, 1997, 1999, 2005

- Commissioning year of generators and transmission lines in the system:

1992: 132 kV 1 circuit transmission line will be completed between Nkula B - Sharpevale - Lilongwe B.

No. 7 generator (20 MW) of Nkula B Power Station will be completed.

1994: Generators, 2 x 25MW, will be completed at Tedzani III Power Station.

Voltage up to 132 kV between Salima - Chintheche will be completed.

1997: Kapichira, 2 x 25MW, will be completed.
New 66 kV transmission line between Blantyre West and Mapanga will be completed.

1999: Additional three units of 25 MW generator will be completed at Kapichira.
New 66 kV transmission line between Blantyre West and Chichiri will be completed.

Additional stringing of 1 circuit to 132 kV transmission line will be completed between Nkula B - Sharpevale - Lilongwe B.

- Configuration of power system analysed

During the power system analysis, the power stations, transmission lines and substation facilities on the 132 kV, 66 kV and 33 kV lines were simulated as shown in Figs. 7-1, 7-2 and 7-3.

- Power demand at substation level

Peak load: Refer to Figs. 7-4 through 7-8.

- Load power factor: 0.9

- Equipment constant: Refer to Table 7-1 and Table 7-2.

- Line constant: Refer to Table 7-3.

- Standard voltage

The voltage at each power station was calculated by assuming the output voltage of the generator at Tedzani Power Station is 105% constant.

7-2 Power Flow Calculation

The peak power flow was calculated based on demand forecast for the years, 1992, 1994, 1997, 1999 and 2005. The obtained results are shown in Figs. 7-4 to 7-8.

(1) Power Flow

(a) In 1992

At peak, power of approximately 18.3 MW to 15.9 MW will flow from Nkula B Power station to Lilongwe B Substaion on the project transmission line. The heaviest power flow will be approximately 21.2 MW from the Nkula Power Station to the Chichiri Power Station.

(b) In 1994

The completion of Tedzani III Power Station (25 MW x 2 units) will boost the power flow through the project transmission line to levels between 26.1 MW and 22.7 MW.

The heaviest power flow of approximately 24.9 MW will be found in the same section between Nkula A Power Station and the Chichiri Power Station. At that point in time, the power flow through the 66 kV line between Nkula A and Lilongwe A will increase to 10.5 MW, creating a condition of overload.
Refer to Fig. 7-9.

By that point in time, therefore, the line between Dedza and Lilongwe A will have to be opened. For the power flow chart after the opening, refer to Fig. 7-5.

In this year, existing 66 kV transmission line between Salima - Nkhotakota - Chintheche will be voltage up to 132 kV.

(c) In 1997

With the completion of the Kapichira Power Station (25 MW x 2 units), the power flow through the project transmission line will increase to levels between 32.5 MW and 28.2 MW. The section with the heaviest power flow will still be the one between the Nkula A Power Station and the Chichiri Power Station, at approximately 26.6 MW.

(d) In 1999

This being the year in which additional units for the Kapichira Power Station (25 MW x 3 units) are to be completed, the second circuit will be string to the project transmission line to improve the reliability of power transmission. The power flow through the project transmission line after the said stringing will amount to levels between 47.2 and 42.4 MW (23.6 to 21.2 MW per a line).

(e) In 2005

The power source development plan of 1999 ends with addition of the No. 5 generator for Kapichira in 1999. The total installed capacity as of that year will be 319 MW.

According to the demand forecast, the demand as of the year 2003 will be 305.5 MW. Taking into consideration the transmission loss of 21 MW (approximately 7%) of all the system, the required total generation will be 326 MW, hence a shortage. The power flow calculation of the project transmission line this time was performed assuming that the output at the Kapichira Power Station can be increased to cover the power requirement and transmission loss in 2005. The power flow through the project transmission line using this assumption has amounted to levels between 89.2 and 79.4 MW (44.6 to 39.7 MW per line).

(2) The Bottleneck in the Power Flow

(a) Transmission Line

i) There will be no overloaded transmission line as of 1992.

ii) From 1994, however, the 66 kV transmission line from the Nkula A Power Station to Dedza will be overloaded so that the linkage between Dedza and Lilongwe A will have to be separated.

iii) As of 1999, the expansion of Kapichira Power Station will be completed. The transmission lines for transferring the generated power of Kapichira Power Station, 132 kV line of between Kapichira - Blantyre West - Chichiri will be overloaded.

(b) Transformer

An examination was made of the transformers for each substation to see whether they will be overloaded under the normal power flow conditions. It was found that none of transformers in any of the substations will experience any overload during the period from 1992 to 1999.

(3) Voltage Regulation

The purpose of voltage regulation is the regulation of the balance of reactive power. Voltage regulation is performed with generator, phase modifying equipment, and the tap of the transformer.

Since the Lilongwe B Substaion which will receive power through the project transmission line has no source of reactive power to maintain voltage and that the 66 kV transmission line to which the substation will be connected suffers a large voltage drop, the 66 kV bus bar voltage was found low.

However, in 1992 when the project transmission line will be commissioned and the transmission will carry a small amount of power, so that the voltage drop at the Lilongwe B will show the carefree value, influenced by the capacitance of the transmission line. But the voltage drop will be occured following with load increase at Chichiri Power Station, so there will be a growing necessity to install power condensers with an adequate capacity and to reconsider the new transmisison line to Chichiri Power Station.

In the northern power system, the voltage condition will be improved largely due to voltage up from the existing 66 kV line to 132 kV. It will be occuring some cases necessary to regulate the bus voltage by transformer tap at light load in the night on Nkhotakota and Chintheche substations.

To maintain the 66 kV bus bar voltage of the following substations at 95% level for each year, the installation of power modifying equipment shown below should be examined.

Power Modifying Equipment

(MVar)

Substation \ Year	1992	1994	1997	1999
Lilongwe B (66 kV Bus)	* 11.5	* 2.3	2.9	0.1
Chichiri (66 kV Bus)	10.6	18	24	14.2
Nkhotakota (66 kV Bus)	* 5.5	* 9	* 11	9
Mtunthawa (66 kV Bus)	2.5	3.3	4.1	5
Dwangwa (33 kV Bus)	0.8	1.0	1.2	1.7
Chintheche (66 kV Bus)	* 1.1	* 9.6	* 9.5	* 10.5
Chibaka (33 kV Bus)	0.8	1.1	1.5	1.8
Chikangawa (66 kV Bus)	1.7	2.3	2.9	3.7
Mzuzu (66 kV Bus)	1.7	2.3	2.9	3.6
Nkota Bay (33 kV Bus)	2.8	3.6	4.4	5.4

Note: * means Shunt Reactor capacity

7-3 Stability Calculation

(1) The stability calculation was made for 1999 when the power flow through the project transmission line will culminate. The calculation was made on the assumption that faults will occur in sections of 132 kV transmission lines between Tedzani 3 and Nkula B as well as between Sharpevale and Lilongwe B; the assumed faults are 3-phase short circuit faults in each transmission line. The operation was considered stable if the faults are removed within five cycles after the occurrence of the fault and 3-second transitory stability calculation show that all the generators do not step out.

(2) Result of Stability Calculation

The result of the stability calculation is shown in the swing curves in Figs. 7-10 and 7-11. The results show stability in either case of fault at both sections and that the generators at each power station will be able to perform stable operations.

7-4 Short Circuit Level

(1) Shown in Fig. 7-12 is the 3-phase short circuit level at the 1999 peak. The calculations were performed using xd" for the generator reactance and assuming that all generators are incorporated in the system.

(2) Calculation Result of Short Circuit Level

An examination of obtained results shows that the short circuit level on the 132 kV side bus of the 132 kV substation is 757 MVA (approximately 3.67 kA), while on the 66 kV side bus bar and the 66 kV substation bus bar it is below 665 MVA (6.4 kA).

It can be concluded from the above that there is an ample allowance if the breaking current of the circuit breaker adopted in the project were:

132 kV circuit breaker : 20 kA (IEC standard 145 kV), and
66 kV circuit breaker : 12.5 kA (IEC standard 72.5 kV).

7-5 Timing of Additional Stringing for the Project Transmission Line

With the conductor planned at present for the first circuit, it is possible to transmit upto about 62.8 MW if voltage improvement is made by installing a power condenser (approximately 57 MVar) on the 66 kV bus bar at Lilongwe B. However, the voltage drop at the receiving end is 11.8%. (Fig. 7-13).

Since the project transmission line is the trunk line of Malawi, it is imperative that it should maintain high reliability for power transmission. It will be necessary to string the second circuit at the soonest possible date, considering overloading of the existing 66 kV transmission line between Nkula A and Lilongwe A and aging of first 132 kV transmission line between Nkula B and Lilongwe B.

Shown in Figs. 7-14 and 7-7 are the power flow through the first and second circuits of the project transmission line assuming that the Kapichira Power Station (3 x 25 MW) listed in the power source development plan will be completed by 1999.

As can be seen from the power flow chart (Fig. 7-14), the 66 kV transmission line between Nkula A and Lilongwe A will be overloaded, so that it will have to be separated at Dedza. The power flow in case of separation between Dedza and Lilongwe A can be seen on Fig. 7-5.

Under the condition of the first circuit shown in Fig. 7-14, 33.0 MW power flows through Lilongwe B and, the voltage drop between Nkula B and Lilongwe B is 8.0%. Under normal practice, the transmission line is operated by regulating the voltage drop at the receiving end within 10%. It can be said, therefore, that the transmission line is nearing its limit.

Fig. 7-7 shows the power flow amounting to 23.6 MW each on the project transmission line. If a fault occurs on either circuit of the line and this failed circuit is opened, the remaining line will have a power flow amounting to 38.2 MW, which can be transmitted discussed before.

Based on the result of these calculations, it is wise to string the second circuit by 1999 at the latest.

7-6 Reduction of Transmission Loss and Countermeasures for Voltage Improvement

(1) Measure for Reduction of Transmission Losses

Since the project transmission line is as long as 250 km and forms the trunk line of Malawi, due consideration was given to minimize the transmission losses taking into account constant heavy power flow.

The majority of transmission losses through a transmission line consists of resistance loss and corona loss. In the case of the project transmission line, the voltage is as low as 132 kV, so corona loss is not worth considering. The major technique required for achieving the goal of reducing the transmission losses is to lower resistance loss.

It will serve for the purpose of reducing resistance loss if a conductor of less resistance, that is, a larger size conductor, is used when the materials are the same. Examining the size of the conductor from the transmission capacity (30 MW) alone, approximately 159 MCM (Guina) will be required. The AC resistance of such a conductor will be 0.3583 ohm/km.

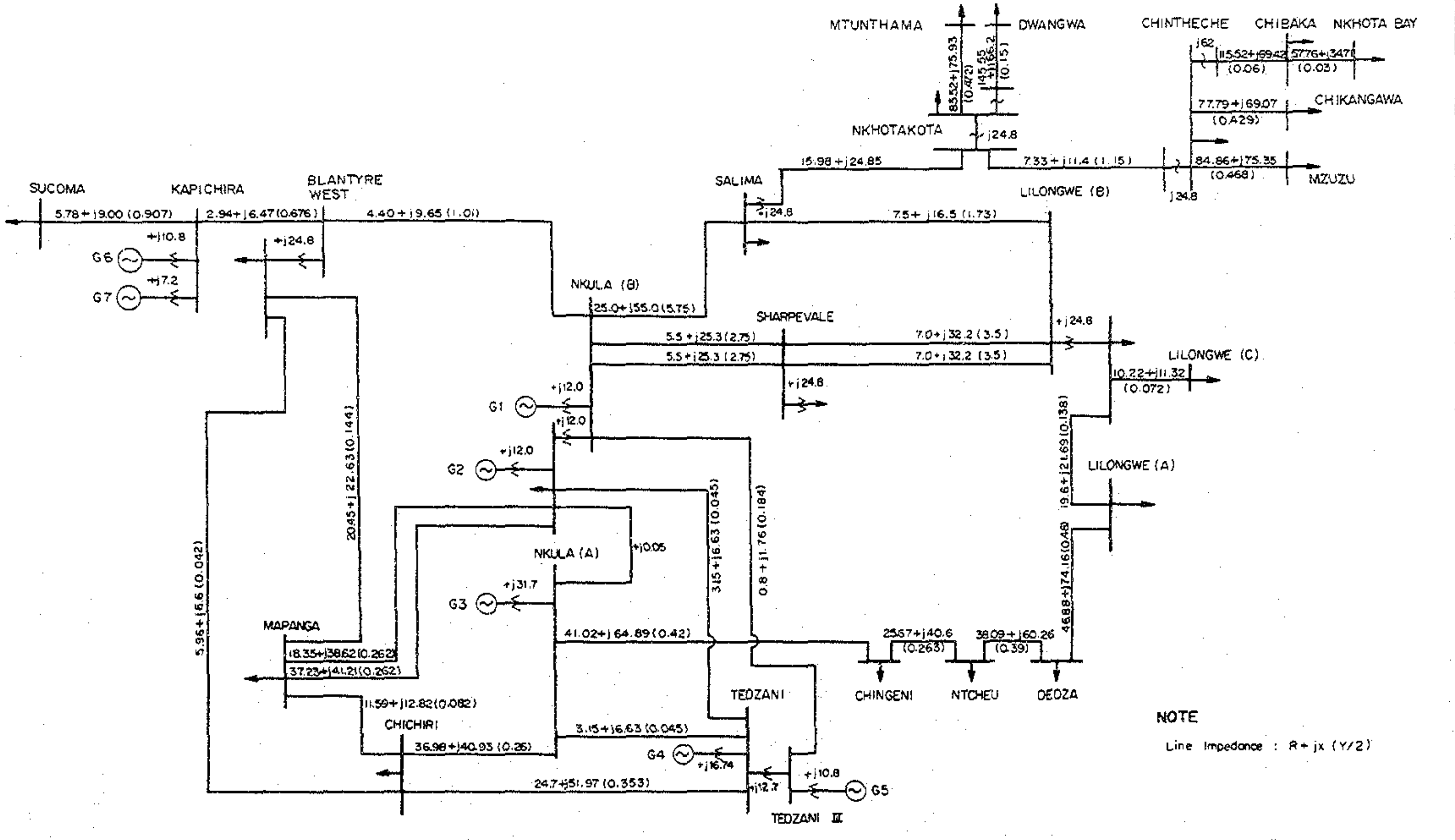
As described in Chapter 6, the transmission losses can be reduced to about a quarter (1/4) comparing with the case using Guina if the conductor (peacock, 605 MCM) planned for adoption at present is used.

(2) Countermeasures for Voltage Improvement

- The 66 kV bus bar voltage at the Lilongwe B will become rather higher. Therefore, it will be a growing necessity to regulate the bus voltage by 132 kV/66 kV transformer tap at light load in the night.

- For the 66 kV bus bar at the Chichiri power station, the voltage will become lower and lower in proportion to the load increasing and gathering in spite of constructing new 66 kV transmission line between Blantyre West - Chichiri. Therefore, the installation of power condensers will be necessary for improvement of voltage. The relevent figures are shown in Paragraph 7-2 (3).

- In the northern power system, the voltage condition will be improved by the voltage up of the existing transmission line between Salima - Chintheche from 66 kV to 132 kV in 1994.



ESCOM ELECTRICITY SUPPLY COMMISSION OF MALAWI	EPDC CONSULTANT TOKYO JAPAN
NKULA B - LILONGWE B TRANSMISSION LINE CONSTRUCTION PROJECT MALAWI POWER SYSTEM IMPEDANCE MAP (100MVA BASE)	SCALE DRAWING No.

Fig 7 — 1

MALAWI 1992 PEAK

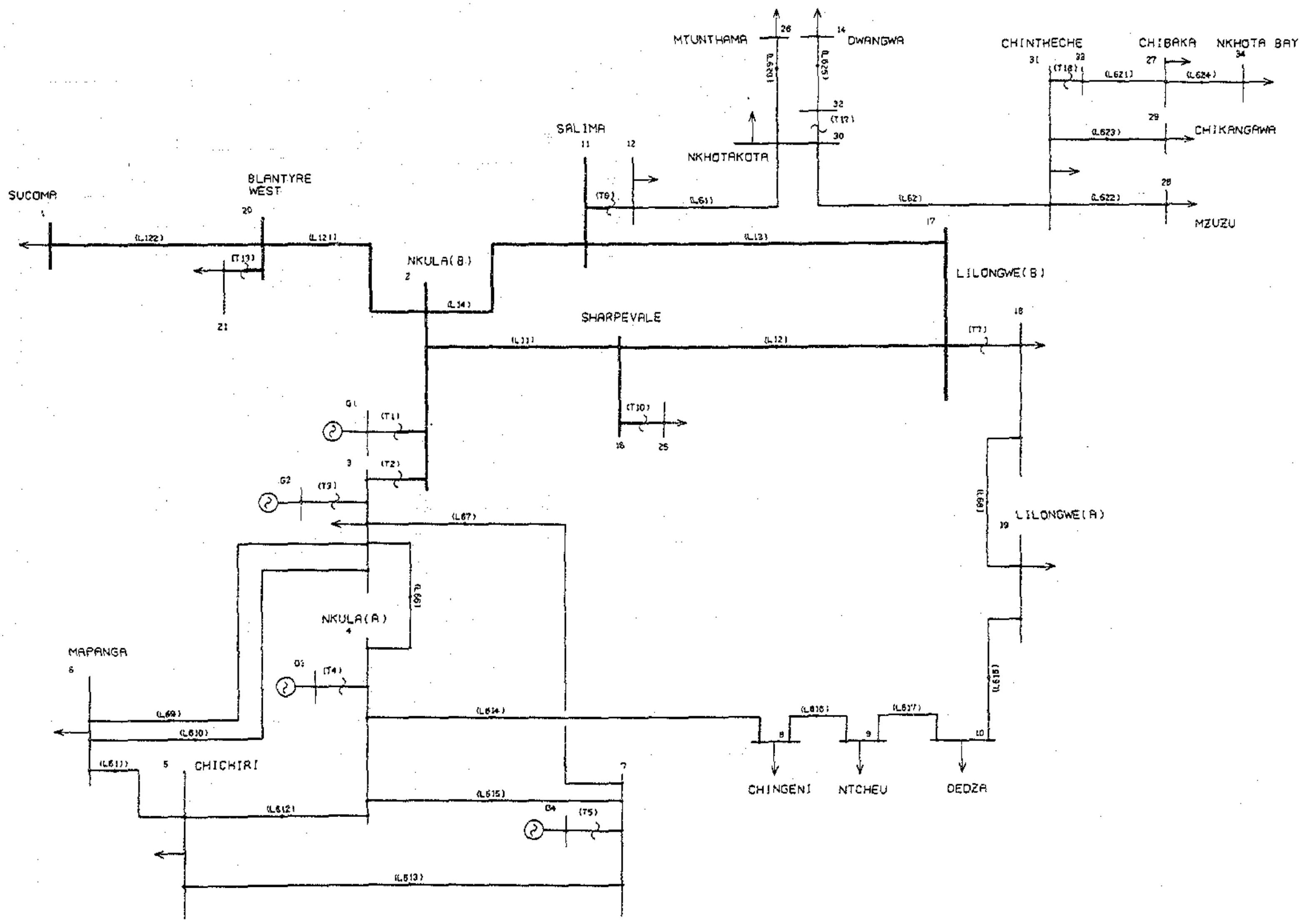


Fig 7−2 Node Blanch in 1992 Peak

MALAWI 1999 PEAK CASE-1

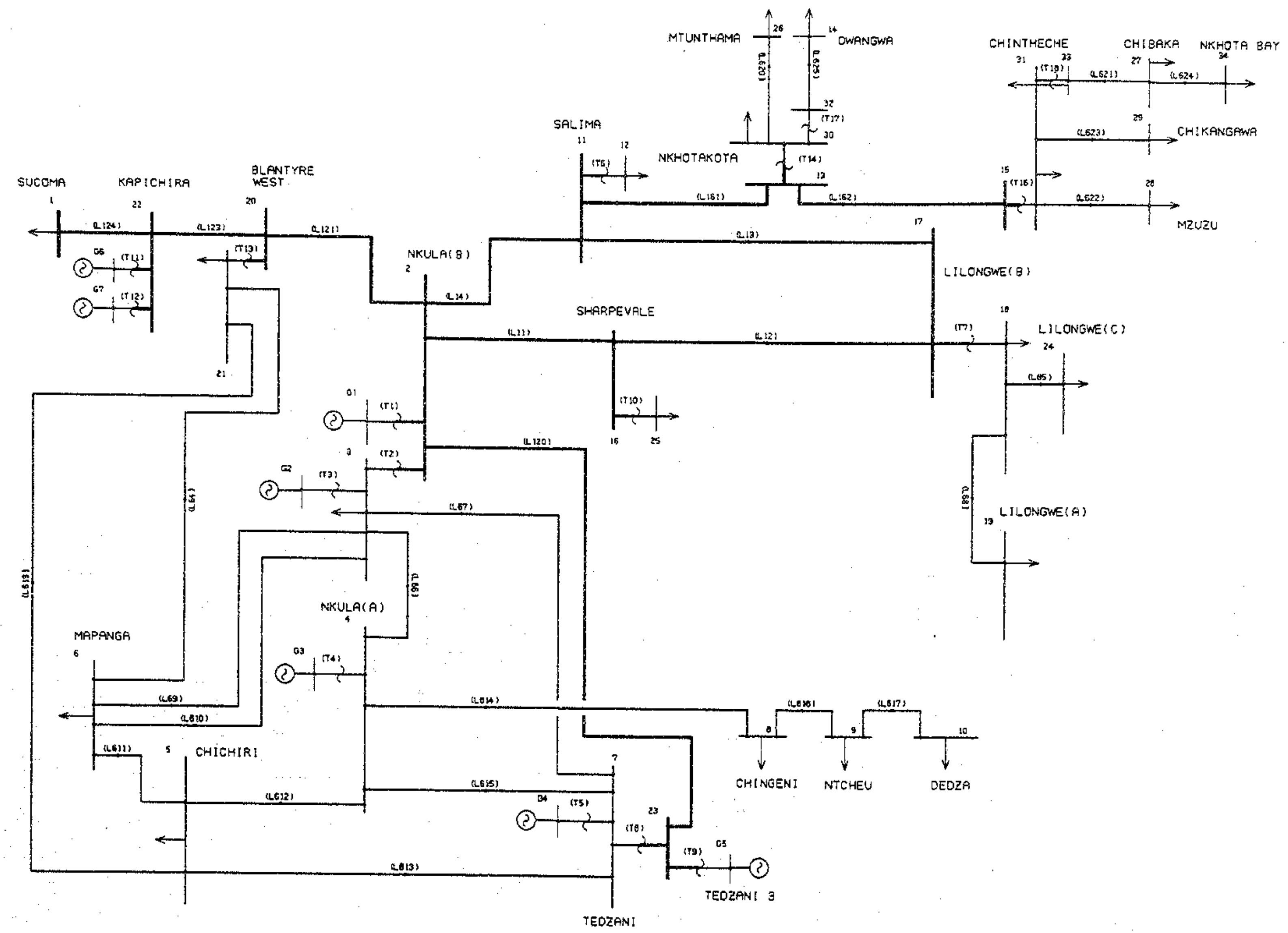


Fig 7−3 Node Blanch in 1999 Peak Case−1

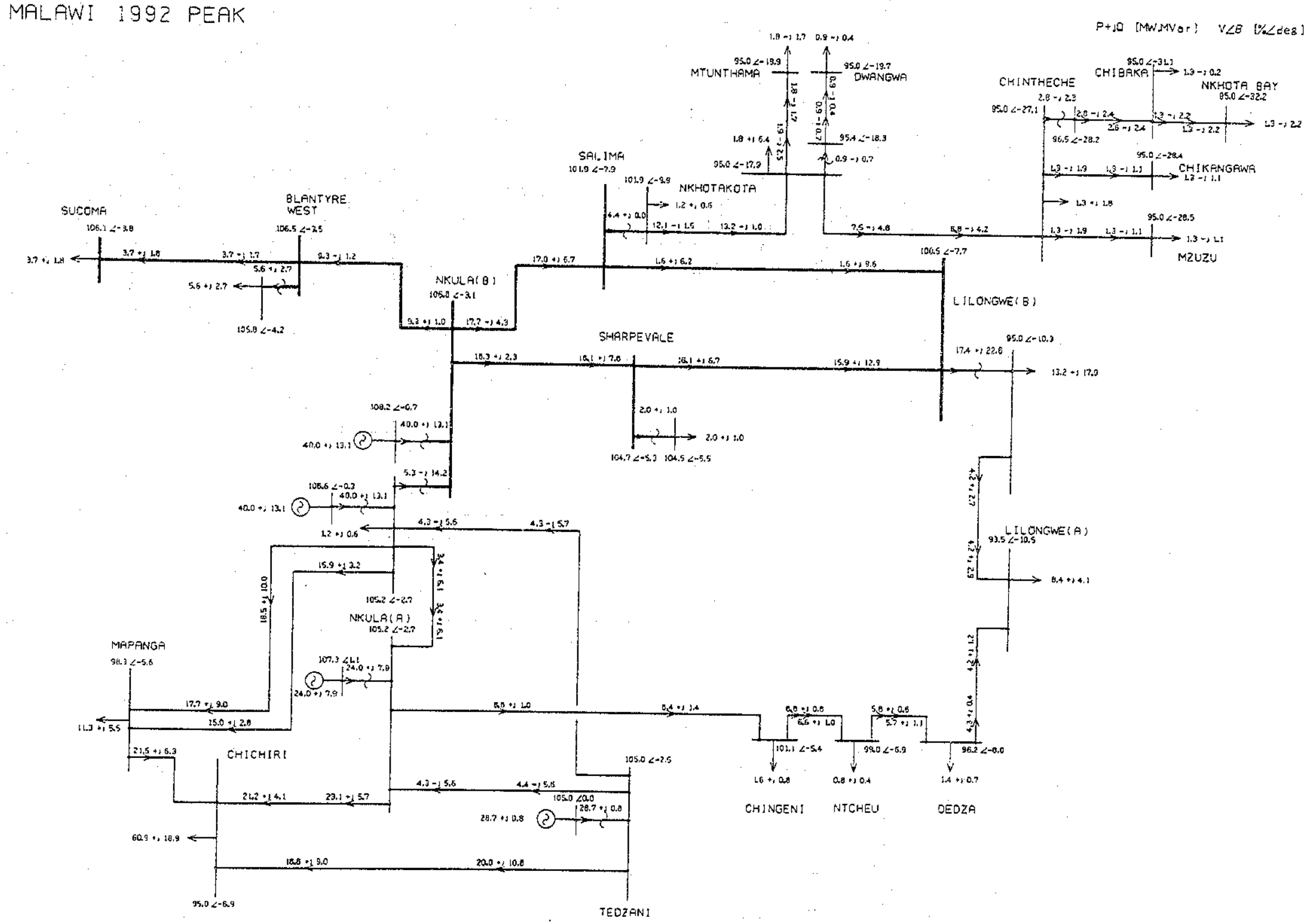


Fig 7−4 Power Flow in 1992 Peak

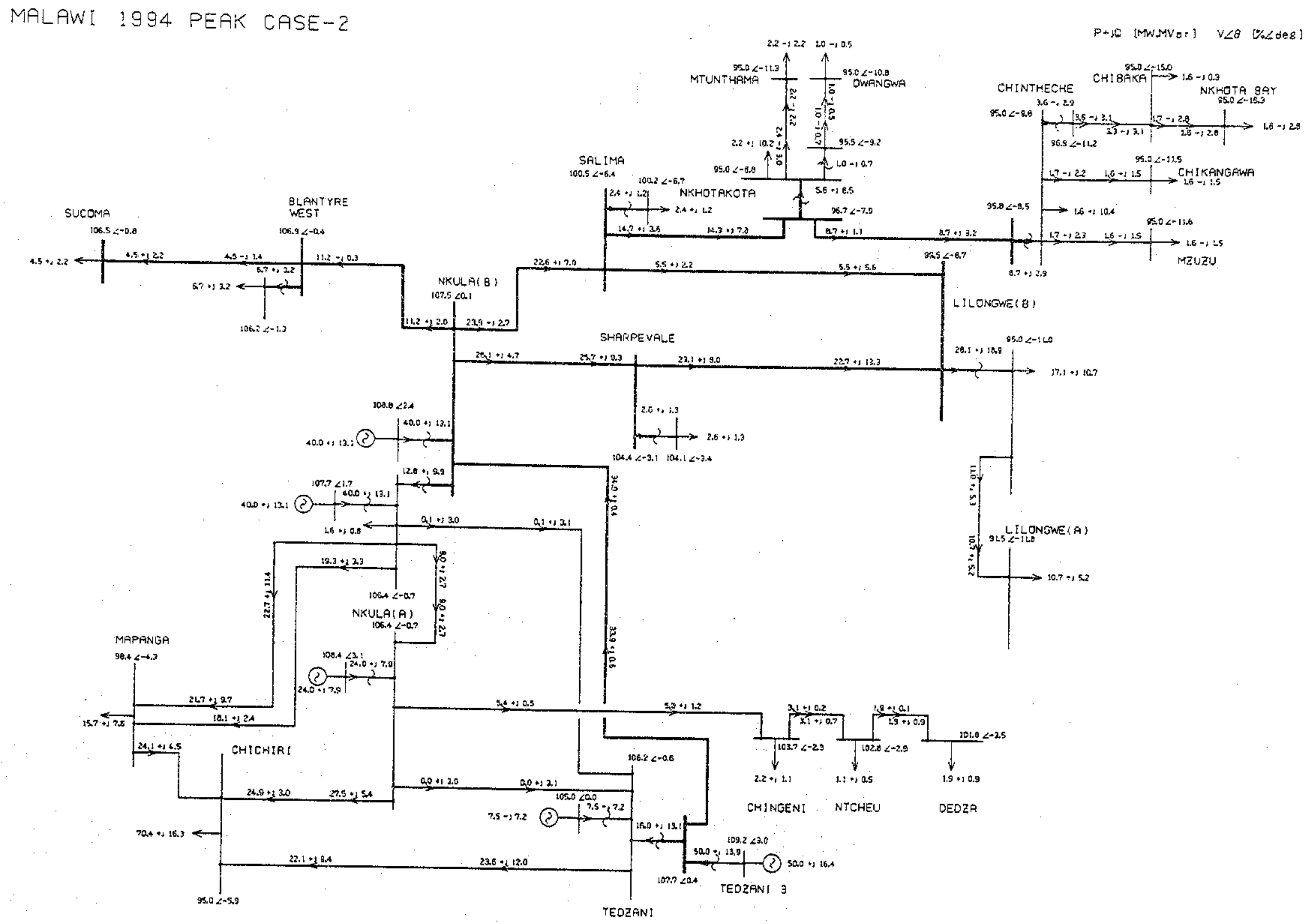


Fig 7−5 Power Flow in 1994 Peak Case−2

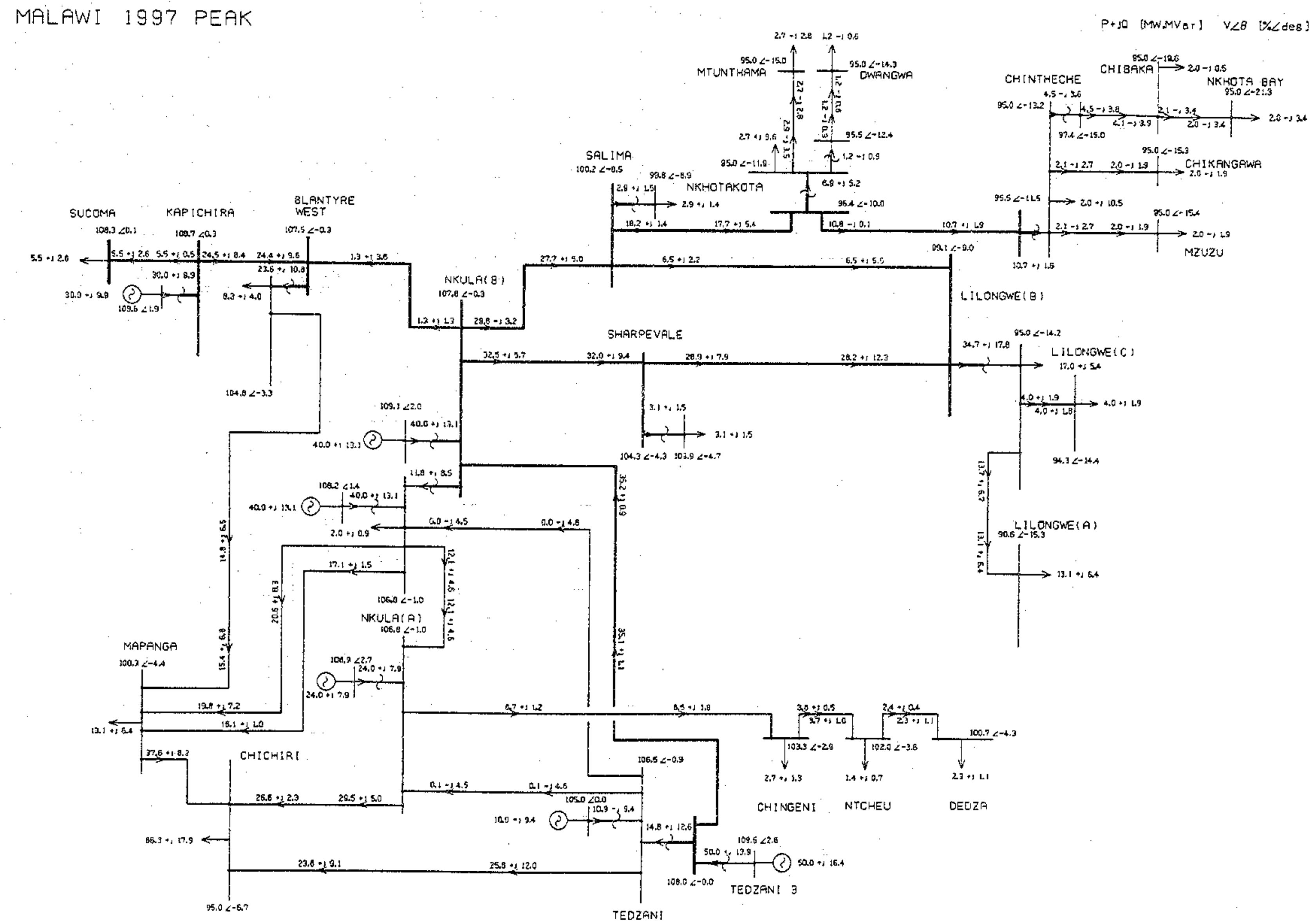


Fig 7−6 Power Flow in 1997 Peak

MALAWI 1999 PEAK CASE-2

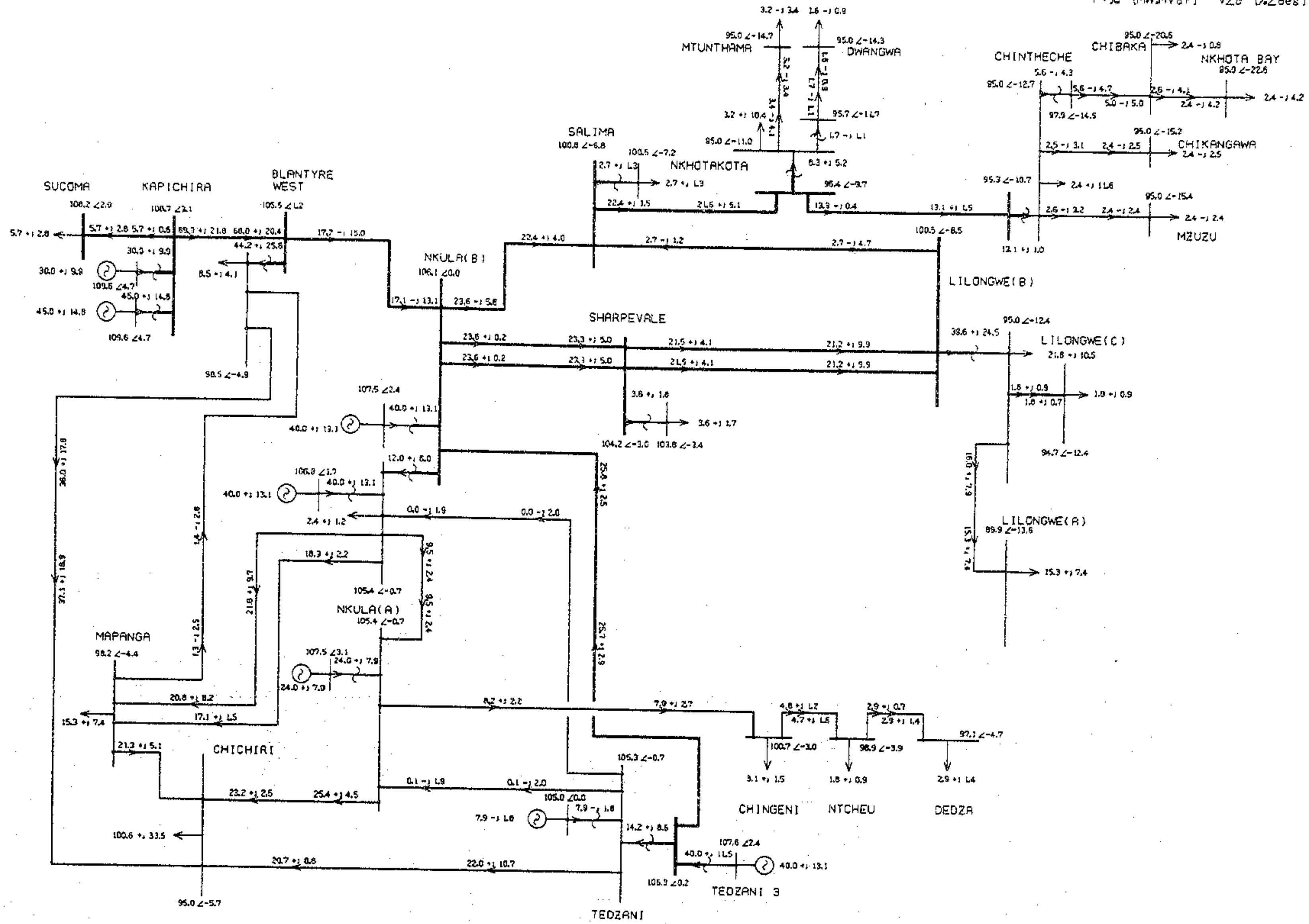


Fig 7−7 Power Flow in 1999 Peak Case−2

MALAWI 2005 PEAK CASE-2

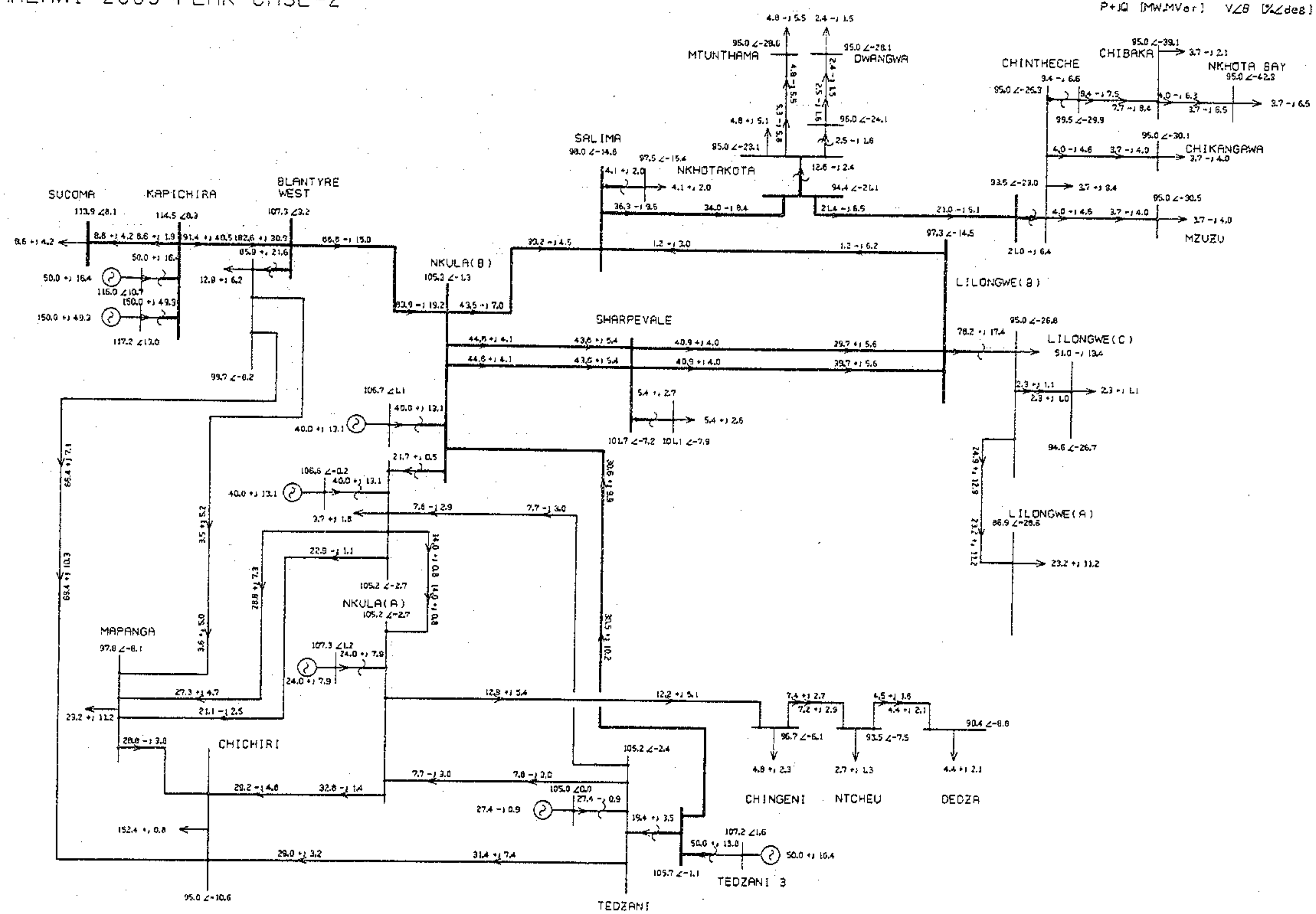


Fig 7−8 Power Flow in 2005 Peak Case−2

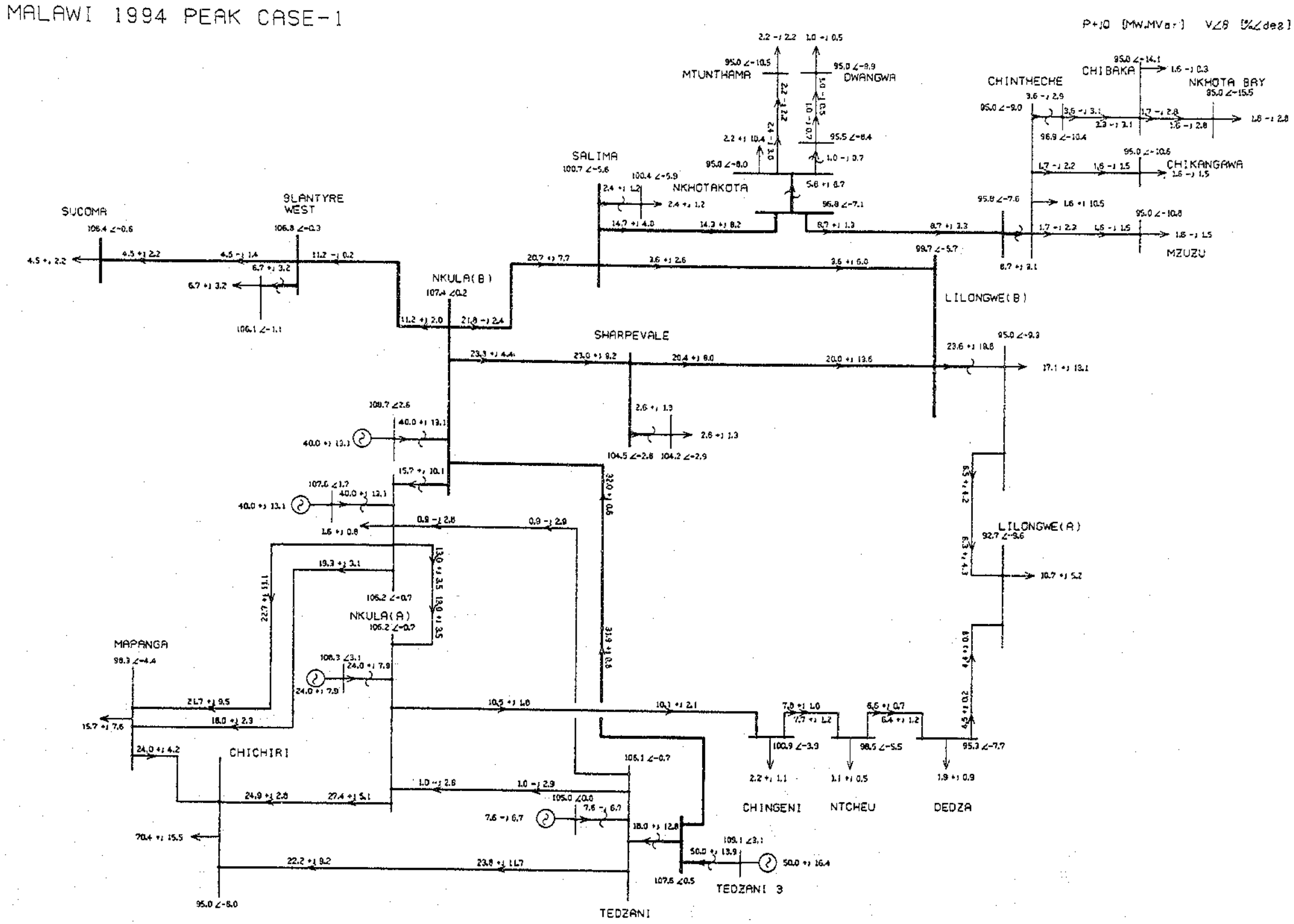


Fig 7−9 Power Flow in 1994 Peak Case−1

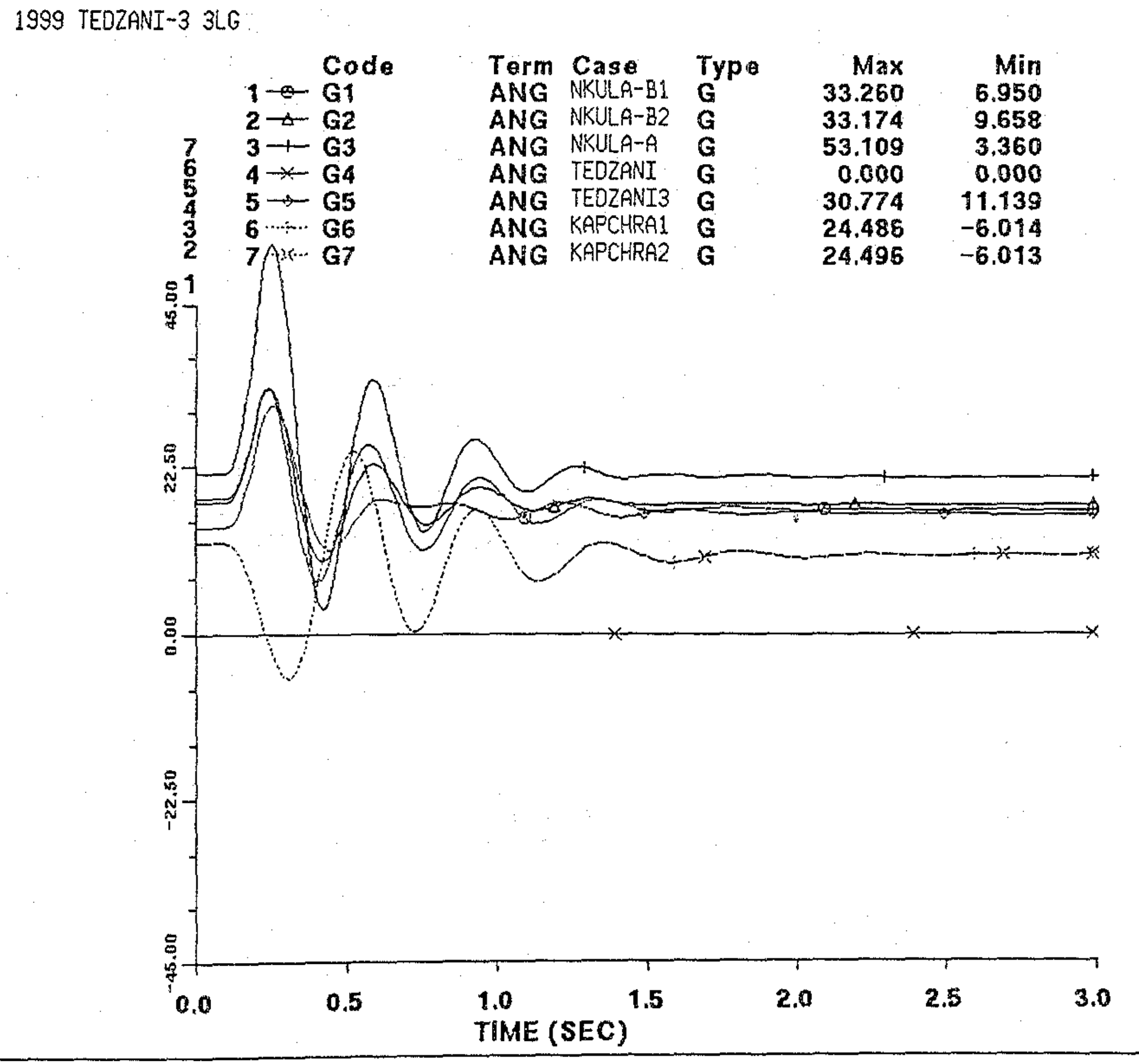

1999 TEDZANI-3 3LG
Code Term Case Type Max Min
1 G1 ANG NKULA-B1 G 33.260 6.950
2 G2 ANG NKULA-B2 G 33.174 9.658
3 G3 ANG NKULA-A G 53.109 3.360
4 G4 ANG TEDZANI G 0.000 0.000
5 G5 ANG TEDZANI3 G 30.774 11.139
6 G6 ANG KAPCHRA1 G 24.486 -6.014
7 G7 ANG KAPCHRA2 G 24.496 -6.013
45.00
22.50
0.00
-22.50
-45.00
0.0
0.5
1.0
1.5
2.0
2.5
3.0
TIME (SEC)

Fig 7 −10

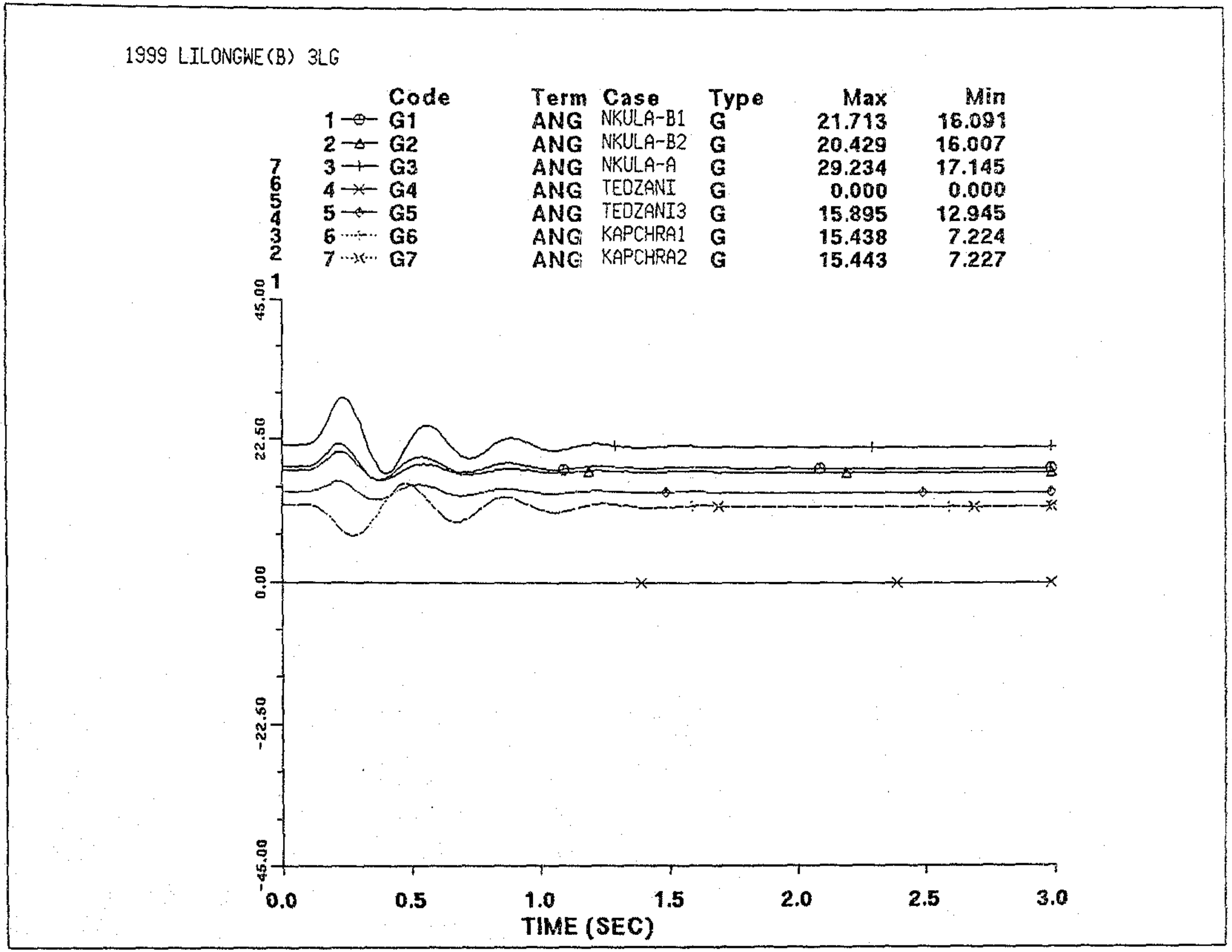

1999 LILONGWE(B) 3LG
Code Term Case Type Max Min
1 G1 ANG NKULA-B1 G 21.713 16.091
2 G2 ANG NKULA-B2 G 20.429 16.007
3 G3 ANG NKULA-A G 29.234 17.145
4 G4 ANG TEDZANI G 0.000 0.000
5 G5 ANG TEDZANI3 G 15.895 12.945
6 G6 ANG KAPCHRA1 G 15.438 7.224
7 G7 ANG KAPCHRA2 G 15.443 7.227
45.00
22.50
0.00
-22.50
-45.00
0.0 0.5 1.0 1.5 2.0 2.5 3.0
TIME (SEC)

Fig 7 −11

MALAWI 1999 PEAK CASE-2

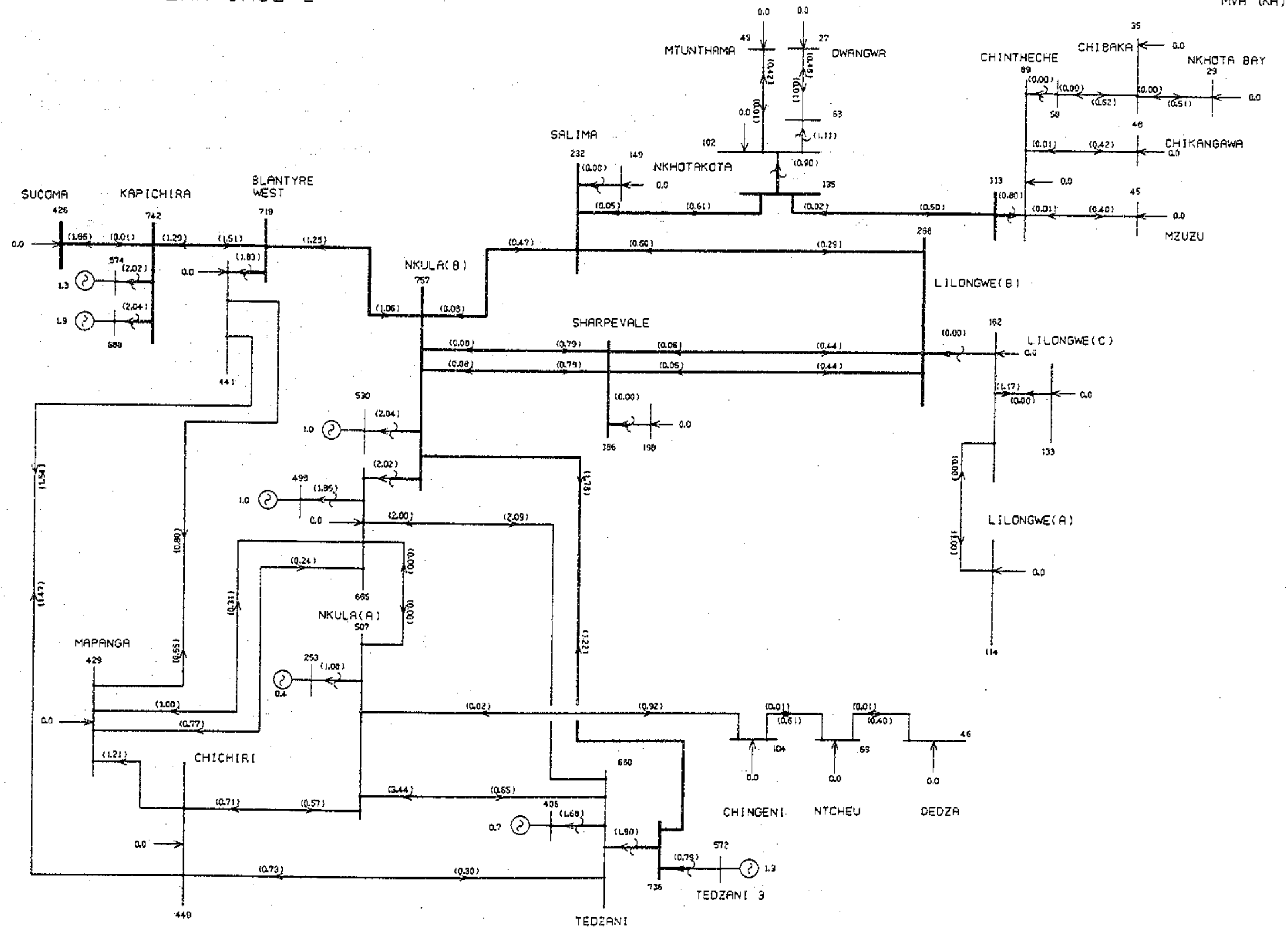


Fig 7−12 Short Circuit Capacity in 1999 Peak Case−2

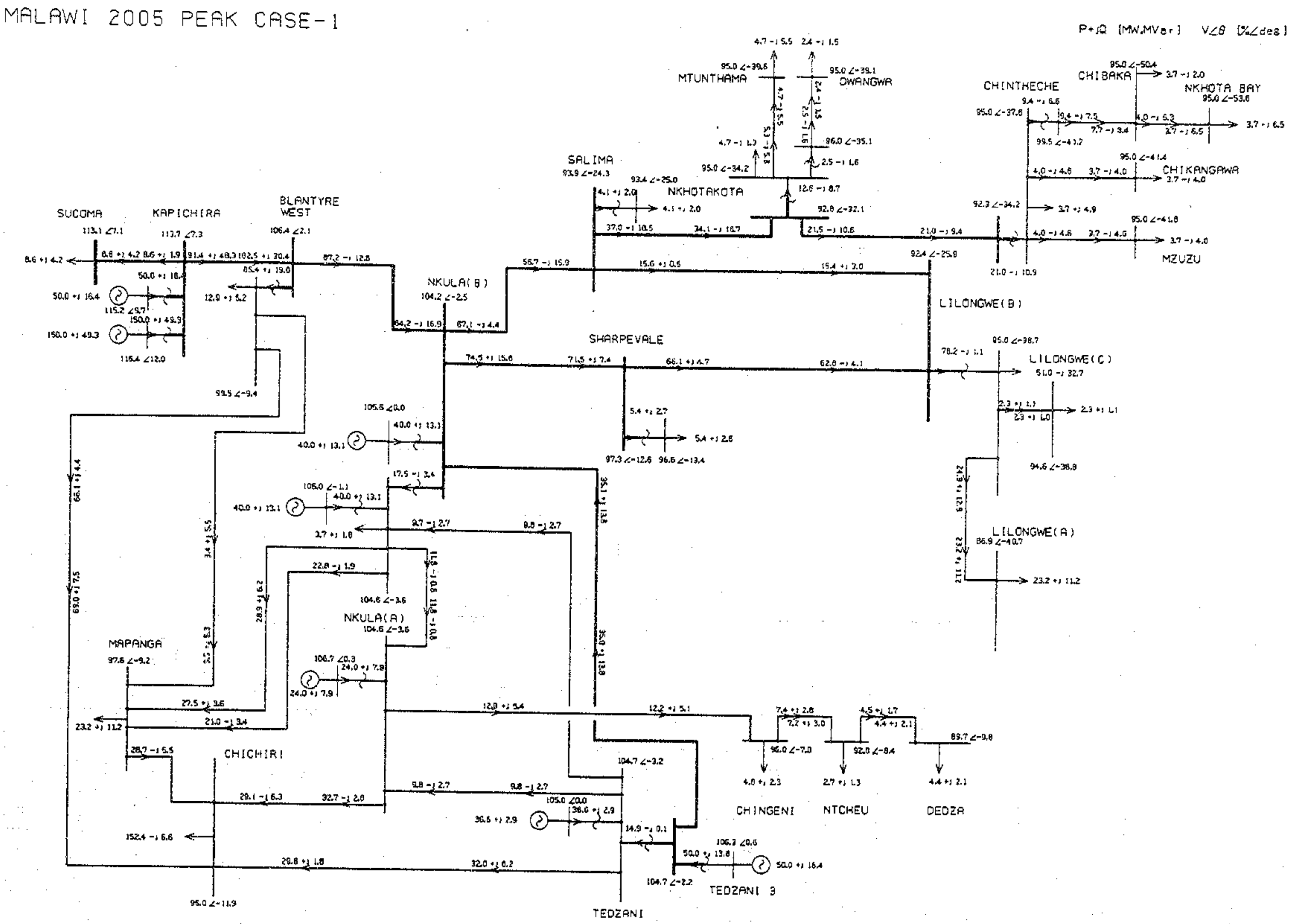


Fig 7—13 Power Flow in 2005 Peak Cose—1

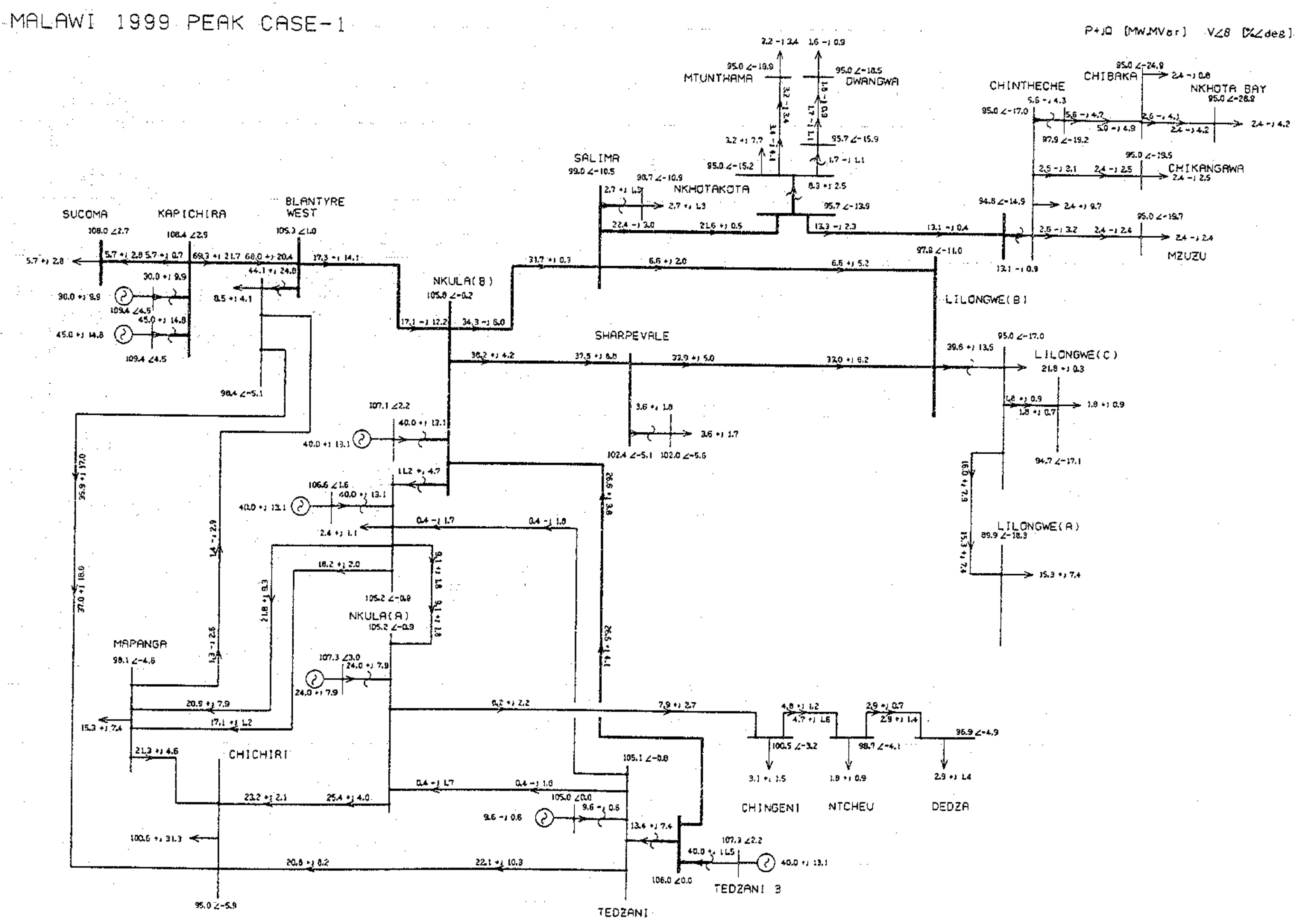


Fig 7−14 Power Flow in 1999 Peak Cose−1

Table 7－1 CONSTANT OF GENERATOR AND TRANSFORMER

NORD No	STATION	No	CONSTANT	NOTE
G 1	Nkula (B)	6 7	MW = 20 MVA = 22.2 Xq = 60 Xd = 100 Xd' = 25 Xd" = 17.6 Xℓ = 15 X₂ = Xd" F = 50 Xo = 10 M = 3 Tdo' = 4.0 Tdo" = 0.05 Tqo" = 0.1 To = 0.1 kV = 11	1992 No7 Ge completion
G 2	〃	4 5		
G 3	Nkula (A)	1 2	MW = 8 F = 50 Xq = 70 Xd = 110 Xd' = 40 Xd" = 30 Xℓ = 25 X₂ = Xd" MVA = 8.8 kV = 11 Xo = 18 M = 2 Tdo' = 3.0 Tdo" = 0.05 Tqo" = 0.1 To = 0.1	
		3	MW = 10 F = 50 Other constants are same as G 3 MVA = 11.1 kV = 11	
G 4	Tedzani	1 2 3 4	MW = 10 MVA = 11.11 Xq = 70 Xd = 100 Xd' = 40 Xd" = 30 Xℓ = 25 X₂ = Xd" F = 50 Xo = 18 M = 2 Tdo' = 3.0 Tdo" = 0.05 Tqo" = 0.1 To = 0.1 kV = 11	
G 5	Tedzani Ⅲ	1 2	MW = 25 F = 50 Other constants are same as G 1 MVA = 28 kV = 11	1994 No1, No2 Ge completion
G 6	Kapichira	1 2	Same as G 5	1997 No1, No2 Ge completion
G 7	〃	3 4 5	Same as G 5	1999 No3, No4, No5 Ge completion
T 1	Nkula (B)	6	Step up Tr. 25MVA, 11kV/132kV, Xps = 6% Xst = 8% Xtp = 9%	
T 2	〃	-	Tie Tr. 25MVA, 132kV/66kV, Xps = 6% Xst = 3% Xtp = 3%	
T 3	〃	5 4	Step up Tr. 25MVA, 11kV/66kV, Xps = 6% Xst = 8% Xtp = 9%	
T 4	Nkula (A)	1 2 3	Step up Tr. 10MVA, 11kV/66kV, Xps = 9.5% Xst = 8% Xtp = 9%	
T 5	Tedzani	1 2 3 4	Step up Tr. 11.5MVA, 11kV/66kV, Xps = 7.7% Xst = 3.8% Xtp = 3.8%	

Table 7 — 2

NORD No	STATION	No	CONSTANT	NOTE
T 6	Salima	-	Tie Tr, 25MVA, 6.2% 132/66/11kV, Xps = 6.2% Xst = 7% Xtp = 7%	
T 7	Lilongwe (B)	-	Tie Tr, 25MVA, 6.2% 132/66/11kV, Xps = 6.2% Xst = 7% Xtp = 7%	
T 8	Tedzani Ⅲ	-	Tie Tr, 55MVA, 7 % 132/66/11kV, Xps = 6.5% Xst = 7% Xtp = 7%	
T 9	〃	1 2	Step up Tr. 30MVA, 6.5% 11/132kV, Xps = 6.5% Xst = 3.25% Xtp = 3.25%	
T 1 0	Sharpevale	1	Tie Tr, 25MVA, 6.5% 132/66/33kV, Xps = 6.5% Xst = 7% Xtp = 7%	1992 completion
T 1 1	Kapichira	1 2	Step up Tr. 30MVA, 6.5% 11/132kV, Xps = 6.5% Xst = 3.25% Xtp = 3.25%	1997 completion
T 1 2	Kapichila	3	Step up Tr. 30MVA, 6.5% 11/132kV, Xps = 6.5% Xst = 3.5% Xtp = 3.5%	1999 completion
T 1 3	Blantyre West	1	Tie Tr, 25MVA, 6.2% 132/66/11kV, Xps = 6.2% Xst = 7% Xtp = 7%	
T 1 4	Nkotakota	1	— 〃 —	
T 1 5			Missing number	
T 1 6	Chintheche	1	Tie Tr, 25MVA, 6.2% 132/66/11kV, Xps = 6.2% Xst = 7% Xtp = 7%	
T 1 7	Nkotakota	1	Tie Tr, 10MVA, 6.2% 66/33kV, Xps = 9.5% Xst = 8% Xtp = 9%	
T 1 8	Chintheche	1	Tie Tr, 10MVA, 6.2% 66/33kV, Xps = 9.5% Xst = 8% Xtp = 9%	

Table 7－3 CONSTANT OF TRANSMISSION LINE

BRANCH	SECTION		VOLTAGE kV	DISTANCE km	CONDUCTOR SIZE	%Z (Pos. phase) 100MVA base R + j X, $(Y_1/2)$ %/Km	NOTE
L 1 1	Nkula (B) #1	Sharpevale #1	132	110	605 MCM ACSR	0.05 + j 0.23 (0.025)	1992 completion
1 2	Sharpevale #1	Lilongwe (B) #1	〃	140	〃	〃	〃
1 3	Salima	〃	〃	75	175mm^2 AAAC	0.1 + j 0.22 (0.023)	
1 4	Nkula (B)	Salima	〃	250	〃	〃	
1 5	Missing number						
1 6	〃						
1 7	Kapichira	Blantyre West	〃	79	〃	〃	1997 completion
1 8	Nkula (B) #2	Sharpevale #2	〃	110	605MCM ACSR	0.05 + j 0.23 (0.025)	1998 completion
1 9	Sharpevale #2	Lilongwe (B) #2	〃	140	〃	〃	〃
1 2 0	Nkula (B)	Tedzani Ⅲ	〃	8	175mm^2 AAAC	0.1 + j 0.22 (0.023)	
1 2 1	Nkula (B)	Blantyre West	〃	43.98	〃	〃	
1 2 2	Blantyre West	Sucoma	〃	68.49	125mm^2 AAAC	0.1466+ j 0.228 (0.023)	
1 2 3	〃	Kapichira	〃	29.4	175mm^2 AAAC	0.1 + j 0.22 (0.023)	
1 2 4	Kapichira	Sucoma	〃	39.45	125mm^2 AAAC	0.1466+ j 0.228 (0.023)	
1 6 1	Salima	Nkhotakota	〃	109	〃	〃	
1 6 2	Nkhotakota	Chintheche	〃	156	〃	〃	
6 1	Salima	Nkhotakota	66	109	125mm^2 AAAC	0.586 + j 0.927 (0.006)	} 1994 completion (voltage up to 132kV)
6 2	Nkhotakota	Chintheche	〃	156	〃	〃	
6 3	Missing number						
6 4	Blantyre West	Mapanga	〃	24	100mm^2 ACSR	0.852 + j 0.943 (0.006)	
6 5	Lilongwe (B)	Lilongwe (C)	〃	12	〃	〃	1995 completion
6 6	Nkula (A)	Nkula (B)	〃	-	-		Very short section
6 7	Nkula (A)	Tedzani	〃	7.5	175mm^2 ACSR	0.42 + j 0.8838 (0.006)	
6 8	Lilongwe (B)	Lilongwe (A)	〃	23	100mm^2 ACSR	0.852 + j 0.943 (0.006)	
6 9	Nkula (B)	Mapanga	〃	43.7	175mm^2 AAAC	0.42 + j 0.8838 (0.006)	
6 1 0	〃	〃	〃	〃	100mm^2 ACSR	0.852 + j 0.943 (0.006)	
6 1 1	Chichiri	〃	〃	13.6	〃	〃	
6 1 2	Nkula (A)	Chichiri	〃	43.4	〃	〃	
6 1 3	Chichiri	Tedzani	〃	58.8	175mm^2 ACSR	0.42 + j 0.8838 (0.006)	
6 1 4	Nkula (A)	Chingeni	〃	70	125mm^2 ACSR	0.586 + j 0.927 (0.006)	
6 1 5	Nkula (A)	Tedzani	〃	7.5	175mm^2 ACSR	0.42 + j 0.8838 (0.006)	
6 1 6	Chingeni	Ntcheu	〃	43.8	125mm^2 ACSR	0.586 + j 0.927 (0.006)	
6 1 7	Ntcheu	Dedza	〃	65	〃	〃	
6 1 8	Lilongwe (A)	Dedza	〃	80	〃	〃	
6 1 9	Chichiri	Blantyre West	〃	7	100mm^2 ACSR	0.852 + j 0.943 (0.006)	1997 completion
6 2 0	Nkhotakota	Ntunthama	〃	78.6	75mm^2 AAAC	1.088 + j 0.966 (0.006)	
6 2 1	Chintheche	Chibaca	33	20	50mm^2 AAAC	5.776 + j 3.471 (0.003)	
6 2 2	Chintheche	Mzuzu	66	78	75mm^2 AAAC	1.088 + j 0.966 (0.006)	
6 2 3	Chintheche	Chikangawa	〃	71.5	75mm^2 AAAC	〃	
6 2 4	Chibaca	Nkhotakota	33	10	50mm^2 AAAC	5.776 + j 3.471 (0.003)	
6 2 5	Nkhotakota	Dwangwa	〃	50	100mm^2 AAAC	2.911 + j 3.324 (0.003)	

CHAPTER 8 QUANTITY OF EQUIPMENT AND MATERIALS

CHAPTER 8 QUANTITY OF EQUIPMENT AND MATERIALS

8 − 1 Quantity of Materials, Spare materials and Maintenance tools for Transmission line

8 − 1 − 1 Summary of Item and Quantity

Item No.	Description
A	Preliminary Works
B	Tower Foundations Works
C	Supply and Erection of Towers
D	Insulator String and O.H.G Wire Attachments
E	Supply and Stringing, Conductor and O.H.G. Wire
F	Line Accessories
G	Miscellaneous Works
H	Spare Materials
I	Maintenance Tools

8 − 2 − 2 Breakdown of Item and Quantity

(1) Item A. Preliminary Works (1/1)

Item No.	Description	Unit	Quan-tity
A − 1	Final survey and Staking tower location	Km	250
A − 2	Clearing of right-of-way and danger trees	Km	250
A − 3	Subsoil investigation		
A − 3 − 1	Subsoil test with penetration tests to 5 meters depth from ground level	bore	715
A − 3 − 2	86mm ϕ boring with standard penetration tests, soil sampling and tests	m	720
A − 3 − 3	Ground bearing test	spot	7

(2) Item B. Tower Foundations works (1/2)

Item No.	Description	Unit	Quantity
B－1	Foundation for tower type DA1		
B－1－1	Concrete pad foundation type class Ⅰ	tower	372
B－1－2	Concrete pad foundation type class Ⅱ	tower	155
B－1－3	Concrete pad foundation type class Ⅲ	tower	95
B－1－4	Soft rock foundation type R-1	tower	1
B－2	Foundation for tower type LDA1		
B－2－1	Concrete pad foundation type class Ⅰ	tower	5
B－2－2	Concrete pad foundation type class Ⅱ	tower	7
B－2－3	Concrete pad foundation type class Ⅲ	tower	10
B－2－4	Soft rock foundation type R-1	tower	－
B－3	Foundation for tower type DB2		
B－3－1	Concrete pad foundation type class Ⅰ	tower	20
B－3－2	Concrete pad foundation type class Ⅱ	tower	8
B－3－3	Concrete pad foundation type class Ⅲ	tower	6
B－3－4	Soft rock foundation type R-1	tower	－
B－4	Foundation for tower type DC2		
B－4－1	Concrete pad foundation type class Ⅰ	tower	10
B－4－2	Concrete pad foundation type class Ⅱ	tower	6
B－4－3	Concrete pad foundation type class Ⅲ	tower	2
B－4－4	Soft rock foundation type R-1	tower	－

(2) Item B. Tower Foundations works (2/2)

Item No.	Description	Unit	Quantity
B－5	Foundation for tower type DD2		
B－5－1	Concrete pad foundation type class Ⅰ	tower	9
B－5－2	Concrete pad foundation type class Ⅱ	tower	3
B－5－3	Concrete pad foundation type class Ⅲ	tower	2
B－5－4	Soft rock foundation type R-1	tower	－
B－6	Foundation for tower type DDS		
B－6－1	Concrete pad foundation type class Ⅰ	tower	2
B－6－2	Concrete pad foundation type class Ⅱ	tower	2
B－6－3	Concrete pad foundation type class Ⅲ	tower	－
B－6－4	Soft rock foundation type R-1	tower	－
B－7	Furnishing and driving concrete pile 70 cm minimum effective perimeter (continuous single length pile)	m	4,900
B－8	Pile bearing (compression) test and uplift (tension) with test equipment and hold piles	spot	4
B－9	Earth excavation and backfilling including dewatering	m^3	5,700
B－10	Solid rock excavation and backfilling including dewatering	m^3	2,900
B－11	Close timbering	m^2	1,400
B－12	Concrete work including forms	m^3	600
B－13	Steel reinforcing bars	ton	60
B－14	Wet masonry walling	m^3	250
B－15	Galvanized steel work	ton	35
B－16	Paint with two coats of bituminous paint	m^3	84

(3) Item C. Supply and Erection of Tower (1/2)

Item No.	Description	Unit	Quantity
C − 1	Tower type DA1		
C − 1 − 1	Tower type DA1-3	tower	91
C − 1 − 2	Tower type DA1±0	tower	250
C − 1 − 3	Tower type DA1+3	tower	188
C − 1 − 4	Tower type DA1+6	tower	94
B − 2	Tower type LDA1		
B − 2 − 1	Tower type LDA1-3	tower	−
B − 2 − 2	Tower type LDA1±0	tower	−
B − 2 − 3	Tower type LDA1+3	tower	1
B − 2 − 4	Tower type LDA1+6	tower	5
B − 2 − 5	Tower type LDA1+12	tower	5
B − 2 − 6	Tower type LDA1+18	tower	10
B − 2 − 7	Tower type LDA1+24	tower	1
C − 3	Tower type DB2		
C − 3 − 1	Tower type DB2-3	tower	10
C − 3 − 2	Tower type DB2±0	tower	24
C − 3 − 3	Tower type DB2+3	tower	−
C − 3 − 4	Tower type DB2+6	tower	−
C − 4	Tower type DC2		
C − 4 − 1	Tower type DC2-3	tower	5
C − 4 − 2	Tower type DC2±0	tower	10
C − 4 − 3	Tower type DC2+3	tower	−
C − 4 − 4	Tower type DC2+6	tower	−
C − 5	Tower type DD2		
C − 5 − 1	Tower type DD2-3	tower	4
C − 5 − 2	Tower type DD2±0	tower	12
C − 5 − 3	Tower type DD2+3	tower	−
C − 5 − 4	Tower type DD2+6	tower	−

(3) Item C. Suppy and Erection of Towers (2/2)

Item No.	Description	Unit	Quan-tity
C－6	Tower type DDE		
C－6－1	Tower type DDE-3	tower	－
C－6－2	Tower type DDE±0	tower	4
C－6－3	Tower type DDE+3	tower	－
C－6－4	Tower type DDE+6	tower	－
C－7	Additional galvanized steel work for lame leg extension	ton	175
C－8	Auxiliary crossarms for type DDE tower	tower	－
C－9	Crossarm of transposition tower for type DB2 tower	tower	4
C－10	Painting for aeronautical sign of steel tower	tower	4
C－11	Testing tower for load tests and destruction test including supply of test towers	test	6

(4) Item D. Insulator Strings and Overhead Ground Wire Attachments (1/1)

Item No.	Description	Unit	Quan-tity
D－1	Single string suspension insulator assemblies with armor rod for 605 MCM ACSR single conductor (without insulator)	set	1,881
D－2	Double string suspension insulator assemblies with armor rod for 605 MCM ACSR single conductor (without insulator)	set	48
D－3	Single string tension insulator assemblies for 605 MCM ACSR single conductor (without insulator)	set	438
D－4	Single bypass string suspension insulator assemblies for 605 MCM ACSR single conductor (without insulator)	set	48
D－5	Transposition bypass string insulator assemblies for 605 MCM ACSR single conductor for single circuit (without insulator)	tower	4
D－6	Porcelain or glass insulator discs 12,000kg (IEC Type U 120BS)	piece	27,269
D－7	Overhead ground wire suspension assembly attachments for AC 55 mm^2	set	1,286
D－8	Overhead ground wire tension assembly attachments for AC 55 mm^2	set	296
D－9	Special overhead ground wire tension assembly attachments for AC 55 mm^2 at structure	set	16

(5) Item E. Supply and stringing, Conductor and Overhead Ground Wire (1/1)

Item No.	Description	Unit	Quantity
E－1	605 MCM ACSR Conductor		
E－1－1	Furnishing conductor for 605 MCM ACSR (750 Km plus 2%)	Km	765
E－1－2	Stringing Single circuit for 605 MCM ACSR single conducotr	Km	250
E－2	55 mm^2 AC overhead ground wire		
E－2－1	Furnishing overhead ground wire for AC 55 mm^2 (500 Km plus 2%)	Km	510
E－2－2	Stringing AC 55 mm^2 for two overhead ground wires	Km	250

(6) Item F. Line Accessories (1/1)

Item No.	Description	Unit	Quantity
F − 1	Midspan joint sleeve for 605 MCM ACSR conductor	piece	255
F − 2	Midspan joint sleeve for AC 55 mm^2 overhead ground wire	piece	165
F − 3	Dead end clamp for 605 MCM ACSR conductor	piece	24
F − 4	Dead end clamp for AC 55 mm^2 overhead ground wire	piece	16
F − 5	Vibration damper for 605 MCM ACSR conductor (12Lbs)	piece	8,650
F − 6	Vibration damper for AC 55 mm^2 overhead ground wire (3Lbs)	piece	5,750
F − 7	Special Jumper socket clamp for 605MCM ACSR Conductor	piece	24

(7) Item G. Miscellaneous works (1/1)

Item No.	Description	Unit	Quantity
G－1	L50×6×1.2m copperweld ground angle with connection wires	piece	2,860
G－2	Counterpoise No 2/0 AWG alumoweld wire or (2×30m wires with connectors)	set	570
G－3	Number plate on tower	piece	715
G－4	Aerial patrol plates on towers	piece	715
G－5	Phase plates on towers	piece	145
G－6	Danger plates on towers	piece	570
G－7	Boundary posts (meters) along boundary lines of right-of-way	piece	1,430
G－8	Anti Climbing device for Tower	Tower	715

(8) Item H. Supply of Spare Materials (1/2)

Item No.	Description	Unit	Quantity
H − 1	Tower type DA1 + 6 body extension with concrete stub angle	tower	4
H − 2	Tower type DB2 + 6 body extension with concrete stub angle	tower	4
H − 3	Tower type DC2 + 6 body extension with concrete stub angle	tower	3
H − 4	Tower type DD2 + 6 body extension with concrete stub angle	tower	2
H − 5	605 MCM ACSR conductor	m	7,500
H − 6	AC 55 mm² overhead ground wire	m	5,000
H − 7	Tension joint sleeve for 605 MCM ACSR conductor	piece	60
H − 8	Repair sleeve for 605 MCM ACSR conductor	piece	12
H − 9	Tension joint sleeve for AC 55 mm² overhed ground wire	piece	40
H − 10	Repair sleeve for for AC 55 mm² overhead ground wire piece	piece	6
H − 11	Vibration dampers for MCM ACSR conductor (12Lbs)	piece	90
H − 12	Vibration dampers for AC 55 mm² overhead ground wire (3Lbs)	piece	60
H − 13	Single string suspension insulator assemblies with armor rod for 605 MCM ACSR single conductor (without insulator)	set	12
H − 14	Double string suspension insulator assemblies with armor rod for 605 MCM ACSR single conductor (without insulator)	set	6

(8) Item H. Supply of Spare Materials (2/2)

Item No.	Description	Unit	Quantity
H－15	Single bypass string suspension insulator assemblies for 605 MCM ACSR single conductor (without insulator)	set	6
H－16	Single string tension insulator assemblies for 605 MCM ACSR single conductor (with insulator)	set	6
H－17	Porcelain or glass insulator discs 12,000kg, (IEC) (Type U 120Bs)	piece	420
H－18	Overhead ground wire suspension assembly attachments for AC 55 mm^2	set	6
H－19	Overhead ground wire tension assembly attchments for AC 55 mm^2	set	2
H－20	Danger plate set	piece	100
H－21	L50×50×6×1.2m copperweld ground angle with connectors	piece	20
H－22	Counterpoise 1×30m No 2/0 AWG alumoweld wire with terminal bolts and nuts	set	10

(9) Item I. Maintenance Tools (1/2)

Item No.	Description	Unit	Quantity
I − 1	4 wheel drive vehicle with 5 seats, and tools	set	2
I − 2	4 wheel drive pick-up type vehicle with 4 seats, winch and tools	set	2
I − 3	4 wheel drive 7-tons lorry type vehicle with crane and tools	set	1
I − 4	Compressor, 100 ton, hand operated type with tools and 10 m remote control tubes	set	1
I − 5	Compression die sets for 605 MCM ACSR	set	2
I − 6	Compression die sets for 55 mm^2 AC	set	2
I − 7	Insulator exchanger 12,000 kg (IEC Type U 120BS)	set	2
I − 8	Hotline tools for 132 KV	set	1
I − 9	Megger 2,000 V 0-5,000 M ohm	set	2
I − 10	Specific earth resistance tester with lead wires and rods (type 3244 YEW)	set	2
I − 11	Portable winch (1,500 kg - allowable pulling tension)	set	1
I − 12	single conductor car with distance meter and brake for one lineman	set	2
I − 13	Come-along clamp set for 8.0 tons working load with wedge for 605 MCM ACSR conductor	set	2
I − 14	Come-along clamp set for 3.5 tons working load with wedge for 55 mm^2 AC	set	2

(9) Item I. Maintenance Tools (2/2)

Item No.	Description	Unit	Quan-tity
I －15	Turn-buckle for 7.0 tons working load and stroke 550 mm	set	3
I －16	Stringing ladder of aluminum alloy, for 5 m length, 2 men	set	2
I －17	Vibration recorders for 7 days for 605 MCM ACSR conductor with record paper use 2 years	set	1
I －18	Earthing equipment	set	1
I －19	Field meter	set	1
I －20	Portable compression testing machine (Soil Test Model CT-650M)	set	1
I －21	Concrete test cylinder with tools (ASTM Standard)	set	6
I －22	Concrete strength test hammer	set	1
I －23	Sieve-analysis tester	set	1
I －24	pH-tester	set	1
I －25	Galvanized thickness meter	set	1
I －26	Hand vane tester	set	1
I －27	Proving ring penetrometer	set	1

8 − 2 Quantity of Materials, Maintenance tools, Spare Equipment and Spare Parts for Substation

8 − 2 − 1 Items of spare equipment, materials and spare parts

(1) 132 kV equipment

(2) 66 kV equipment

(3) Equipment for station service circuit

(4) Control board and protection relay

(5) Steel structure

(6) Bus

(7) Insulator and wiring materials

(8) Conductor and cables

(9) Miscellaneous

(10) Spare parts

(11) Maintenance tools

8 − 2 − 2 Number

(1) 132 kV equipment (1/1)

Name	Rating	Sharpevale	Nkula B	Lilongwe B
Circuit breaker	145kV, 800A	4	1	1
Disconnector	145kV, 800A	10	3	3
CVT (Phase)	4000PF, $\frac{132kV}{\sqrt{3}}/\frac{110V}{\sqrt{3}}$	12	3	3
CT (Phase)	300/150/5A	15	3	3
Surge arrestor (Phase)	120kV	9	3	3
Line trap	800A	4	2	2
Transformer	25MVA, 132/66/33kV	1	-	-

(2) 66 kV equipment (1/1)

Name	Rating	Sharpevale	Nkula B	LilongweB
Circuit breaker	72kV, 800A	3	-	-
Disconnector	72kV, 800A	3	-	-
CVT (Phase)	$\frac{66kV}{\sqrt{3}} / \frac{110V}{\sqrt{3}}$	3	-	-
CT (Phase)	300/150/5A	9	-	-
Surge arrestor	60kV	3	-	-

(3) Equipment for station service circuit (1/1)

Name	Rating	Sharpevale	Nkula B	LilongweB
Indoor cubicle	33kV metalclad	1	-	-
S.S transformer	300kVA	1	-	-
DC power source set	200AH battery and charger	1 set	-	-

(4) Control board and protection relay board (1/1)

Name	Rating	Sharpevale	Nkula B	LilongweB
Control board		3	1	1
Bus Pro. Ry.board		1 set	-	-
132kV T/L Pro.Ry board		2 sets	1 set	1 set
66kV T/L Pro.Ry board		2 sets	-	-
Tr.Pro.Ry. board		1 set	-	-
Station service board	with relay	1 set	-	-
AC board		1	-	-
DC board		1	-	-

(5) Steel structure (1/1)

Name	Rating	Sharpevale	Nkula B	Lilongwe B
132kV post		10	-	4
〃 beam		8	-	4
66kV post		3	-	-
〃 beam		2	-	-

(6) Bus (1/1)

Name	Rating	Sharpevale	Nkula B	Lilongwe B
132kV pipe bus	with SP insulator, support structure	1 set	-	1 set
66kV pipe bus	ditto	1 set	-	-

(7) Insulator and wiring materials (1/1)

Name	Rating	Sharpevale	Nkula B	Lilongwe B
132kV insulator strings	10"insulator, 12/string	24	6	9
66kV insulator strings	10"insulator, 6/strings	6	-	-
Terminals		1 set	1 set	1 set
Phase I.D plate		1 set	1 set	1 set

(8) Conductor and cables (1/1)

Name	Rating	Sharpevale	Nkula B	Lilongwe B
AL conductor	330 mm	500m	20m	140m
Ground wire	80mm² Cu wire	260m	-	50m
Earth wire	38mm² Cu wire	3500m	100m	400m
33KV CV cable etc	with cable head	65m	-	-
Control,600V cable		1 set	1 set	1 set

(9) Miscellaneous (1/1)

Name	Rating	Sharpevale	Nkula B	Lilongwe B
Switchyard illumination		1 set	-	-
Clock, Paging set		1 set	1 set	1 set
Outdoor AC box		1	-	-

(10) Spare parts (1/3)

Name	Rating	Sharpevale	Nkula B	Lilongwe B
1) Transformer				
a) 132kV bushing		1	-	-
b) 66kV 〃		1	-	-
c) 33kV 〃		1	-	-
d) Neutral 〃		1	-	-
e) Cooler (fin)		1	-	-
f) Thermometer	with alarm contact	1	-	-
g) Temp. relay		1	-	-
h) Valve	1 each kind	1 set	-	-
i) Silicagel container		1	-	-
2) 132kV circuit breaker				
a) Circuit breaker	1 complete phese	1	-	-
b) Contact	move/fix contact	1	-	-
c) Trip coil		2	-	-
d) Control box		1	-	-
e) Valve		1 set	-	-
3) 66kV circuit breaker				
a) Contact	move/fix contact	1	-	-
b) Trip coil		1	-	-
c) Control box		1	-	-
d) Valve		1 set	-	-

⑩ Spare parts (2/3)

Name	Rating	Sharpevale	Nkula B	Lilongwe B
4) 132kV disconnector				
a) Disconnector	1 complete phase	1	-	-
b) Blade	1 phase	1	-	-
c) SP insulator		3	-	-
d) Control box		1	-	-
5) 66kV disconnector				
a) Blade	1 phase	1	-	-
b) SP inslator		1	-	-
c) Control box		1	-	-
6) 132kV CVT				
a) CVT	1 phase	1	-	-
7) Surge arrestor				
a) 120kV surge arrestor	1 phase	1	-	-
b) 60kV surge arrestor	1 phsae	1	-	-
8) CT				
a) 132kV CT	1 phase	1	-	-
b) 66kV CT	1 phase	1	-	-
9) Indoor cubicle				
a) C.B contact		1	-	-
b) C.B trip coil		1 set	-	-
10) D.C power-source set				
a) Battery cell		2	-	-
b) SCR stack	1 component	1	-	-
c) Meter	V, A meter	1	-	-

(10) Spare parts (3/3)

Name	Rating	Sharpevale	Nkula B	LilongweB
11) Control board, protection relay board				
a) Meter	1 each kind	1 set	-	-
b) Control switch	2 each kind	1 set	-	-
c) Protection relay	1 each type	1 set	-	-
d) Transducer	1 each type	1 set	-	-
e) NFB	1 each kind	1 set	-	-
f) Lamp	1 each of 200%	1 set	-	-
g) Fuse	1 each of 100%	1 set	-	-
12) Bus				
a) 132kV SP insulator		1	-	-
b) 66kV SP insulatou		1	-	-
c) Metal device	1 each kind	1 set	-	-
13) Inslator and wiring materials				
a) 132kV insulator strings		1	-	-
b) 66kV insulator strings		1	-	-
c) Terminals	1 each kind	1 set	-	-
14) Conductor and cable				
a) 33kV CV cable		25m	-	-
b) 33kV CV C.H		1	-	-
15) Miscellaneous				
a) Mercury lamp		10	-	-
b) Clock		1	-	-

(11) Maintenance tools (1/7)

Name	Rating	Sharpevale	Nkula B	Lilongwe B
1) Insulation oil treatment set		1 set	-	-
• Oil degassing Equipment	4 kl/h			
• Oil filter	1 kl/h			
• Vacuum pump	7.5 kl/min			
• Vacuum gauge	Macleod type			
• Dry air generator	1 l/min			
• Dew point meter	-80° C - 20° C			
• Water content measure	Digital type			
• Hygrometer	0 - 100%			
• Oil storage tank (Portable type)	60 kl			
• Accessories Vinyl hose 2 pcs. 32mm diameter 15m length with coupling flange				
Coupling adaptor, change-over valve Filterpaper drier				
Necessary tools				
Filter paper 5000 sheets				
2) Oil tester	60kV/2.5mm gap	1 set	-	-
3) SF_6 gas transfer set		1 set	-	-
• SF_6 gas compressor	760ℓ/min			
• Vacuum pump	1500ℓ/min			
• Storage tank	100kg capacity			

(11) Maintenance tools (2/7)

Name	Rating	Sharpevale	Nkula B	Lilongwe B
• Gas cylinder with 50kg SF_6 gas				
• Gas leak detector				
• Oxygen density meter				
4) Tools				
Steel wire rope	9mm diameter, 6m length with loop attachment ends	2	-	-
Wire rope cutter	For 100mm-60mm HDCC manual operation type	2	-	-
Wire rope cutter	For Hydraulic type	1	-	-
Engine winch	Maximum 5 ton 3.5 - 7.0 m/sec.	1	-	-
Ratchet spanner set with tool box	Ratchet change-over type w/ 30cm length knob×1	2	-	-
• 10mm×12mm • 12mm×14mm • 16mm×18mm	1 pc. 1 pc. 1 pc.			
Step ladder	Aluminum alloy, more than 1 m length	2	-	-
Ladder	Aluminum alloy, 4m length folded into two, available for stringing work	1	-	-
Ladder	Aluminum alloy, 6m length folded into two, available for stringing work	1	-	-
Safety-belt set		3	-	-
• Body belt	Nylon webbing 1,200mm length 45mm width			

(11) Maintenance tools (3/7)

Name	Rating	Sharpevale	Nkula B	Lilongwe B
・Life rope	3-stranded, 2-twisted nylon rope with chroniumplating coated swivel snap hook and adjustable fittings, 2,000 kg tensile strenght, 16mm diameter, 2000 mm length			
・Working sack	Canvas sack sewn with waxing yarn			
・Multi-hanging	Oxhide, for cutting piler, screw driver and knife, etc.			
Oil compressor	Capacity 200 ton with hose and head for 330mm² with the dices	1	-	-
Terminal press tool kit with tool box		2	-	-
・Press tool	For 2mm² - 38mm² conductors, manual operation type			
・Stripper	Remover of vinyl insulation of 2mm² -8mm² conductors, spring return type			
・Cable sheath remover	For cutting cable sheath in the sectional and axial directions for PVC cable (3.5mm² ×2C -22 mm² ×2C)			
Home kit with tool box		2	-	-
・Drill chuck				
・Bench saw				
・Planner				
・Sander				
・Grinder				

(11) Maintenance tools (4/7)

Name	Rating	Sharpevale	Nkula B	LilongweB
• Balk cutter				
• Jig saw				
• Wool bonnet				
• Motor	1 ϕ AC 220V 50 Hz 300W			
• Spare drill				
3.5mm diameter	10 pcs.			
5.0mm diameter	10 pcs.			
7.0mm diameter	10 pcs.			
10.0mm diameter	10 pcs.			
• Spare carbon brushes	6 sets			
Cleaner	Single-phase, 240V 1kW, suction capacity of $3m^3$/minute, dust bucket capacity of 10 liters	2	-	-
Electroscope	Windmill type for 132kV	1	-	-
Electroscope	Neon lamp type for 33-11kV	1	-	-
Electroscope	Neon lamp type for 4 kV	1	-	-
Portable type earth device	Separable type, with 5m length insulated copper conductor of $38mm^2$ covered by vinyl tube, bolt clamping type clamp, hung type head			
	132 kV	9	-	-
	10-35 kV	9	-	-
Colored-nylon rope	9mm in diameter 50m length	2	-	-
5) Meter				
Volt/ampere meter of AC	Accuracy class 0.5 13 range 0-30A, 0-750V, portable type	3	-	-

(11) Maintenance tools (5/7)

Name	Rating	Sharpevale	Nkula B	LilongweB
Volt/ampere meter of DC	Accuracy class 0.5 17 range, with shunt resistor 0-30A, 0-1,000V, portable type	3	-	-
Volt/ampere meter	Transistor, portable type voltage range … 3-300mV, 1.2-300V 11 range ampere range…… 1.2-60mA, 0.3-12A 12 range	3	-	-
Phase meter	Transistor, portable type voltage range … 3-24 V, 7 range input impedance … 0.6-50k, 7 range ampere range…… 0.1-10A measuring phase … 0-360°, 4 range frequency …… 45-2,000 Hz error allowance … within ±3%	1	-	-
Variable sliding resistor	Metalic double slide type 1,000 1A in series connection	2	-	-
Variable sliding resistor	Metalic double slide type 110 3.0 A in series connection	2	-	-
Variable sliding resistor	Metalic double slide type 40 5.0 A in series connection	2	-	-

(11) Maintenance tools (6/7)

Name	Rating	Sharpevale	Nkula B	Lilongwe B
Circuit tester	Resistance 2/300/20,000 K DC voltage 0.3/1.2/3/12/30/ 120/300/1,200 V DC current 3/12/39/120/300/ 1,200 mA Accuracy less than 4% of full scale value Accessories portable cases	3	-	-
Watt meter	150V 5A, single phase, AC	3	-	-
Rotation meter	150V 3 phase	1	-	-
Oscillograph	6 elements portable pen writing type	1	-	-
Lux meter	Portable type 300/1,000/3,000 lux	1	-	-
Megger (Battery type)	250V/50 MΩ	1	-	-
Megger (Battery type)	500V/1,000 MΩ	1	-	-
Megger (Battery type)	1,000V/2,000 MΩ	1	-	-
Noise meter	30-130 db (A)	1	-	-
Soil resistivity meter	L-10 type YEW	1	-	-
Relay tester		1 set	-	-
3 phase 240V 50 Hz 3 kVA (including simulating circuit breaker relay)				
· AC voltage output	3 phase 0-240V 600 VA 0-360 ° variable			

(11) Maintenance tools (7/7)

Name	Rating	Sharpevale	Nkula B	LilongweB
· AC current output	3 phase 0-50A 300 VA 0-360 ° variable			
· DC voltage output	0-240 V			
· DC current output	0-10A			
· Volt meter	0-300V 0.5 class 4 range			
· Ammeter	0-5A 0.5 class			
· Phase meter	0-360° 120V/5A, ±3 ° accuracy			
· Second meter	0.1 - 999999.9 milli-second			
Connector drum	Single-phase AC 480V 10A with 30m length cabtype cable	2	-	-
Primary injector test set	CT : 100-1000A	1 set	-	-

8 − 3 Quantity of Equipment, Materials and Spare parts for Telecommunication

8 − 3 − 1 Breakdown of Item and Quantity

(1) Item A Telecommunication Equipments (1/1)

Item No.	Description	Unit	Quan-tity
A − 1	Power Line Carrier Telephone Terminal Equipment (2 CH, 40dBm)	set	8
A − 2	Line Trap	set	10
A − 3	Teleprotection Equipment	set	4
A − 4	Fault Locator (C Type)	set	1
A − 5	Coupling filter	set	5
A − 6	Separation filter	set	2
A − 7	Automatic Exchange (50 Line with Telephone sets)	set	1
A − 8	Automatic Exchange (20 Line with Telephone sets)	set	2
A − 9	VHF Radio Base Station (100W)	set	1
A − 10	VHF Radio Mobile Station (80W)	set	2
A − 11	VHF Radio Portable set (1W)	set	4
A − 12	Telemetering Equipment	set	6
A − 13	VHF Radio Antenna tower	set	1
A − 14	VHF Radio Antenna with cable	set	1
A − 15	Battery for DC 48V	set	1
A − 16	Charger for DC 48V	set	1

(2) Item B Supply of Spare Materials (1/1)

Item No.	Description	Unit	Quantity
B − 1	Spare material		
B − 1 − 1	Spare of celles for Battery	cell	4
B − 1 − 2	Line trap	unit	1

CHAPTER 9 SCHEDULE AND COSTS FOR PROJECT

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9-1 Construction Plan

The total capacity of all electric power generation facilities in ESCOM as of December 1988 is 169 MW, of which 144.6 MW (86%) in occupied by hydraulic power generation, and on the balance 24.4 MW (14%) by the power generation of 15 MW gas turbine generator and 20 units of small-scale diesel-engine generators.

All the hydraulic power stations are concentrated along the Shire River basin in the south of Malawi, and the electric power generated there is being supplied to all over the country.

In Malawi which depends on import for entire supply of all oil and gas, the government gives a priority to develope its potential hydraulic energy as the national energy policy for the purpose of decreasing the imports of oil and others and saving the foreign currency consumption. Thus, various studies are being made for proceeding of hydraulic power development in the Republic of Malawi.

In parallel with the above hydraulic power development plan, the expansion plan of national power supply system (transmission and transformer facilities) is being advanced as the measure for future increase in power demand and for the stable supply of power.

At the present time, the power consumed in the Capital City Lilongwe is being supplied from Nkula-A Power Station through single circuit 66 kV transmission line and, from Nkula B Power Station through single circuit 132 kV transmission line.

In the event of power supply cut due to accident to 132 kV transmission line between Nkula B power station and Salima substation or to 66 kV transmission line between Salima substation and Lilongwe B substation, countermeasure is taken by switching the failed line to one 66 kV transmission line between Nkula A Power Station and Lilongwe B substation with a distance of about 260 km as well as operating emergency diesel-engine generators with overall output of 5,400 kW. However, in the above case, the power supply capacity is restricted to less than 10 MW.

Moreover, in case that the expansion plan for Lilongwe B substation is not put into practice, there is a concern in Lilongwe B substation terminal that the voltage drop at a peak load exceeds the maximum allowable voltage drop in 1991.

In this connection, it is anticipated that the voltage drop through 132 kV transmission line of Nkula - Salima - Lilongwe will be 13.2% at a peak load, that is, almost the allowable limit for the maximum tap of transformers.

The government of the Malawi should, in fear of the future prospect as noted above, plan to put the construction project into practice by the end of 1992, giving top priority to the construction plan of single circuit of 132 kV transmission line on double circuit steel tower between Nkula B Power Station and Lilongwe B substation for the sake of stable supply of power and voltage support.

9-2 Construction Schedule

Preparation and construction of this project should be advanced in accordance with the construction schedule in Fig. 9-1 aiming at startup at the end of March 1992. For the above purpose, the finance agreement should be made at the end of September 1989. Since the implementation design and preparation of tender specification will take fairly long period of time, it is necessary to start design work, and preparation of specification in October, 1989 and to complete final design and technical specification at the end of February, 1990.

The supposed international tender will be required at least six (6) months for tender proceeding, term of tender and examination of proposals and quotation. Hence, the above procedures need to be smoothly advanced.

The required term of the construction work for the transmission lines will be twenty-four (24) months in total taking into consideration the site survey with field measurement, detailed design, fabrication, transport, site installation work and field test.

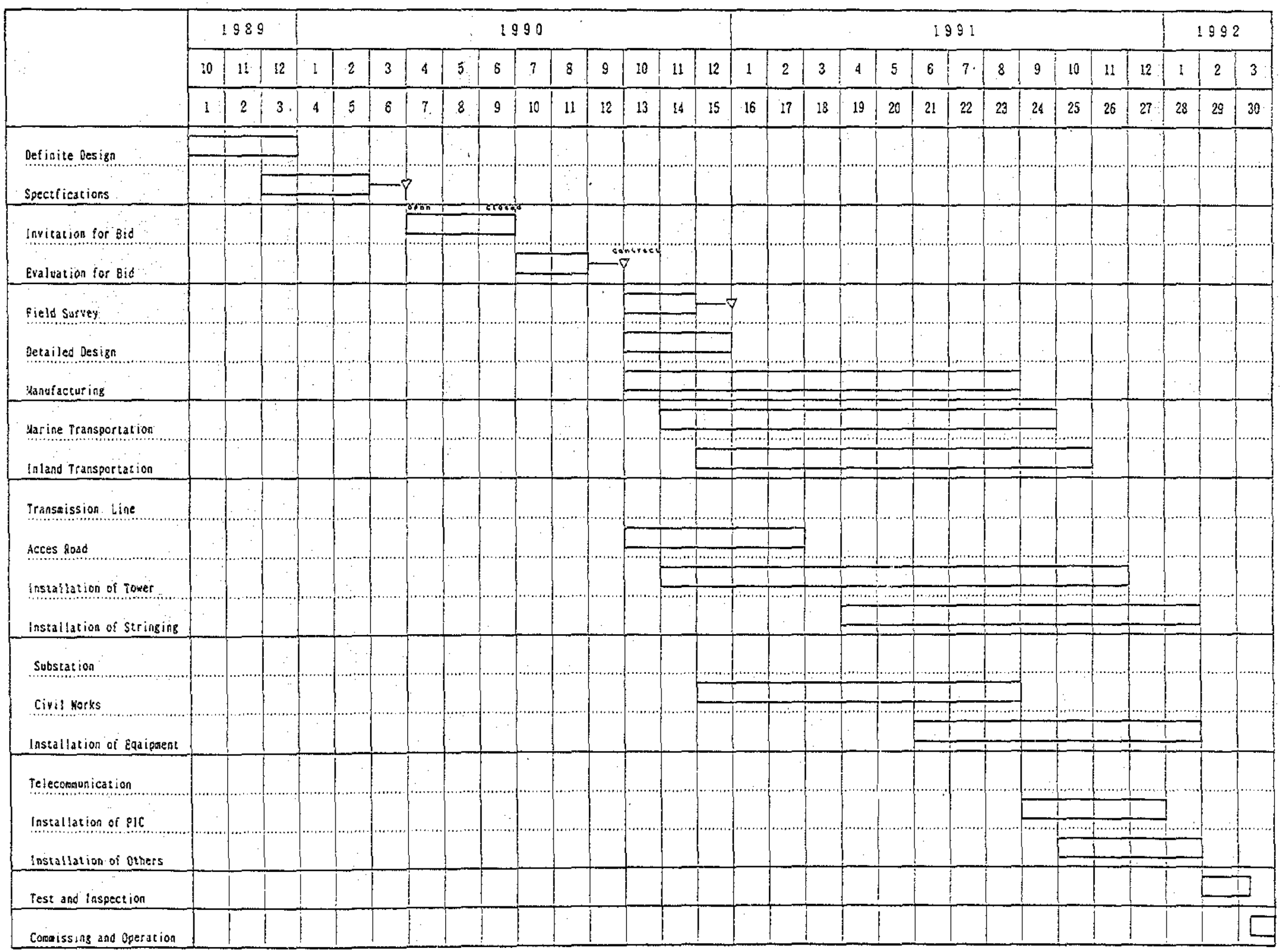

Fig 9-1 CONSTRUCTION SCHEDULE OF NKULA B-LILONGWE B TRANSMISSIOIN LINE

9-3 Construction Cost

On the basis of the preliminary design, we made a calculation for the quantity of construction including spare materials and maintenance tools, and further for the total construction cost as shown in Table 9-1, taking site situation into consideration with teams and conditions as described hereunder:

(1) Scope of Work

The construction cost of the transmission lines is estimated as follows with the scope of work:

(a) Transmission Line

Between Nkula B Power Station and Lilongwe B Substation (via Sharpevale Substation)

(b) Substation

i) Outgoing equipment for Nkula B Power Station

ii Sharpevale Substation

iii) Outgoing equipment for Lilongwe B Substation

(c) Communication Equipment

Communication equipment relating to the equipment under planning

(2) Compensation Cost, etc.

Site acquisition cost, compensation cost, cost of ancillary facilities such as ESCOM permanent employee's accommodation and cost of auxiliary equipment are not included for the construction cost. However the compensation for the transfer of buildings that are under the transmission lines, etc. is taken in consideration.

(3) Procurement of Equipment and Materials

(a) It has been decided that the following equipments and materials shall be imported from foreign countries.

- Steel towers
- Conductor
- Overhead ground wires
- Insulators
- Major transformers
- Disconnecting
- Switchgear
- Current transformers for instrument

(b) The materials for the works such as portland cement and reinforcing bars shall be locally procured in Malawi.

(4) Contractor

All the 132 kV transmission line construction shall be executed by a contractor in Malawi on a turn-key basis. The materials and equipment to be used in the works shall be supplied by the Contractor, and the installation works at site shall be executed by local workers.

(5) Conversion Rate

The conversion rate for used this project is of unit rate as of the end of February, 1989 and conversion rate as one (1) Japanese Yen is 0.0212 Malawi Kwacha and One (1) US Dollar is 2.6695 Malawi Kwacha and 125.92 Yen.

(6) Customs Duty and Tax

Subject to confirmation by Malawi government, the customs duty for the equipment and materials to be used in this project, the tax duty for engineering fee, and the income tax for foreign engineers have not been earmarked for the construction works on the basis of assumption that they are exempted from taxation.

(7) The Year on which the Estimation is based

The construction costs relating to this project have been estimated on the basis of unit cost as of the end of February, 1989.

(8) Fund Procurement for the Construction Works

The fund for the project shall be procured by the Soft Loan credit for all domestic and foreign currencies, with annual interest rate of one percent (1.0%) for both domestic and foreign currencies during the construction works.

Table 9－1 Project Construction Costs

Unit : 10^3 US Dollar

Descriptions	Foreign Currency	Domestic Currency	Total
a) Transmission line	12,954	6,489	19,443
b) Substations	3,414	3,502	6,916
c) Communication facilities	1,079	228	1,307
Ⅰ. Sub-Total of Direct Cost	17,447	10,219	27,666
d) Compensation of House and other	0	199	199
e) Maintenance Equipment	635	0	635
f) Administration Expense	0	238	238
g) Engineering fee	2,382	596	2,978
h) Contingency	2,046	1,125	3,171
Ⅱ. Sub-Total of Indirect Cost	5,063	2,158	7,221
Ⅲ. Construction Cost (Ⅰ＋Ⅱ)	22,510	12,377	34,887
Ⅳ. Interest during the Construction	360	198	558
Ⅴ. Total Project Cost (Ⅲ＋Ⅳ)	22,870	12,575	35,445

Note : 1) Ratio of Contingency is 10%.

2) Ratio of Interest during the construction is 1.0%.

Table 9 − 2 Fund Requirement of Nkula B-Lilongwe B Transmission Line Construction Project

Unit : 10^3 US Dollar

Description	Construction Cost			Annual Fund Requirement			
	Material Cost (Foreign Currency)	Installation cost (Domestic Currency)	Total Cost	1989	1990	1991	1992
Transmission Line cost Materials Cost	12,954	0	12,954	0	1,049	10,610	1,295
Installation Cost	0	6,489	6,489	0	818	5,022	649
Sub-Total	12,954	6,489	19,443	0	1,867	15,632	1,944
Substation Cost Nkula B Substation	335	159	494	0	0	445	49
Sharpevale Substation	2,681	3,015	5,696	0	0	5,126	570
Lilongwe B Substation	398	328	726	0	0	654	72
Sub-Total	3,414	3,502	6,916	0	0	6,225	691
Telecommunication Facilities Cost Nkula B Substation	232	35	267	0	0	240	27
Sharpevale Substation	639	162	801	0	0	721	80
Lilongwe B Substation	208	31	239	0	0	215	24
Sub-Total	1,079	228	1,307	0	0	1,176	131
Total of Direct Cost	17,447	10,219	27,666	0	1,867	23,033	2,766
Compensation Cost of House & Others	0	199	199	79	60	60	0
Maintenance Equipment Cost	635	0	635	0	635	0	0
Administration Expenses	0	238	238	24	95	95	24
Engineering Fee	2,382	596	2,978	413	1,209	966	390
Contingency	2,046	1,125	3,171	52	387	2,415	317
Total of Indirect Cost	5,063	2,158	7,221	568	2,386	3,536	731
Construction Cost	22,510	12,377	34,887	568	4,253	26,569	3,497
Interest during the Construction	360	198	558	1	27	181	349
Grand Total Project Cost	22,870	12,575	35,445	569	4,280	26,750	3,846

Note : 1) Ratio of Contingency is 10%.
2) Ratio of Interest during the construction is 1.0%.

9-4 Procedure of Construction Work

In principle, construction works for this project shall be contracted on turn key basis. The construction works have been planned as follows:

9-4-1 Transmission-line Construction Work

This project is roughly divided into the following two (2) works:

(1) Structure Construction Work

(2) Stringing Work

The content of each work is described below:

(1) Structure Construction Work

After the site application design for the types of steel towers and foundations is completed on the basis of the site survey and the preparation for the works such as arranging the materials and site for transmission line work, the construction of the supports shall be started. The construction shall start from final survey and include temporary facilities building work, foundation work, steel tower erection work, ground levelling work, grounding work, etc. The block flow charts for the order of the work are shown in Fig. 9-2 and Fig. 9-3.

(a) Final Survey

Final survey shall be made to confirm whether or not the detailed design is adopted to the site conditions and the survey stakes are in right position and also confirm the route and position of towers with the vertical section and plane view drawings. The existence or non existence of crossing at important places, and to review the detailed design.

(b) Survey on Transport Road

One of the most important works in planning transmission line construction project is to prepare transport plan having a great influence on the term of work, as well as construction cost. Sufficient care should be exercised of the transport roads for materials and tools (from harbor to inland transport route) as well as transport means (truck, railway, etc.).

(c) Excavation for Foundation

In principle, the excavation for steel tower foundation has been planned on the basis of manual job with man power. The back hoe shovels shall be used in construction of the tower foundation where possible for the purpose of shortening the term of the work. In addition, spring water, if any, shall be drained by a submersible pump.

(d) Installation of Foundation Stub Materials

Installation of foundation stub materials for steel towers has been planned so as to use setting templates to minimize the dimensional errors in installing font materials for foundations.

(e) Concrete Placing

Concrete placing has been planned so as to use a bagger mixer in the site of steel towers locations. Local materials shall be used for concrete, and ordinary portland cement shall be used. The sand to be used shall be river sand, and crashed stones shall be used as gravel. Concrete strength test shall be carried out by means of slamp test and confirmation of strength with concrete test samples. In case of underwater concrete placing, the amount of cement to be used shall be increased as high as 120%.

The mold forms to be used shall be made of steel.

(f) Backfilling

Being one of the most important elements in stabilizing the support, backfilling for steel tower foundations shall be carried out in every spacing of about 30 cm by means of tamping with a vibration rammer.

(g) Grounding

Grounding angles shall be put under the ground at the foot of each steel tower foundation. In case of earth resistance being ten (10) ohm or more, additional grounding wire (30 m per strand) shall be buried in a depth of fifty (50) cm so as to attain an earth resistance of not more than ten (10) ohms.

(2) Structure Erection

(a) Transporting Steel Tower Materials

Steel tower materials have been planned to be transported from a material yard to the site of steel tower by use of a midget truck and human shoulders. In case of placing steel tower materials on the site, those shall be placed on wooden blocks instead of directly on the ground.

(b) Steel Tower Erection

In principle, steel tower shall be erected by "Gin-Pole Method". However, truck crane method shall be used for the place where favorable access road is available in order to shorten the term of works.

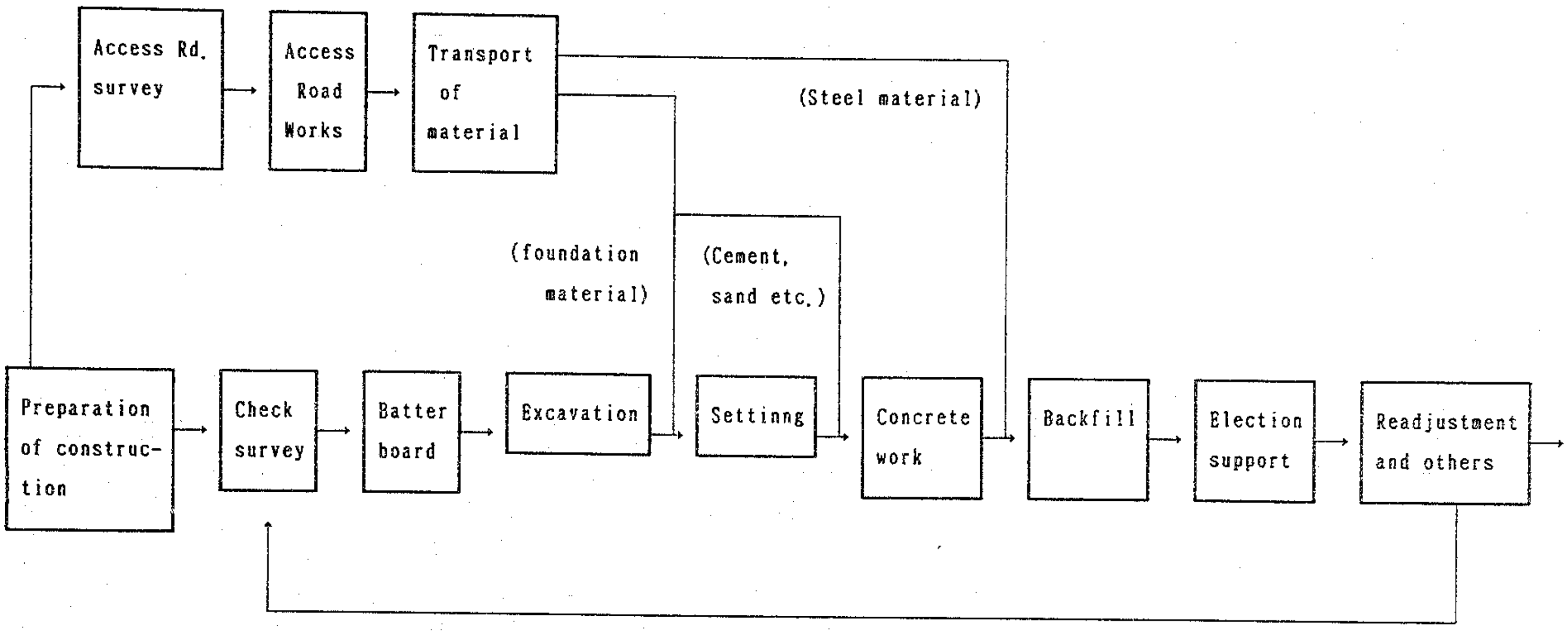

Fig 9-2 Flow Chart diagram of outline of construction of support (steel tower)

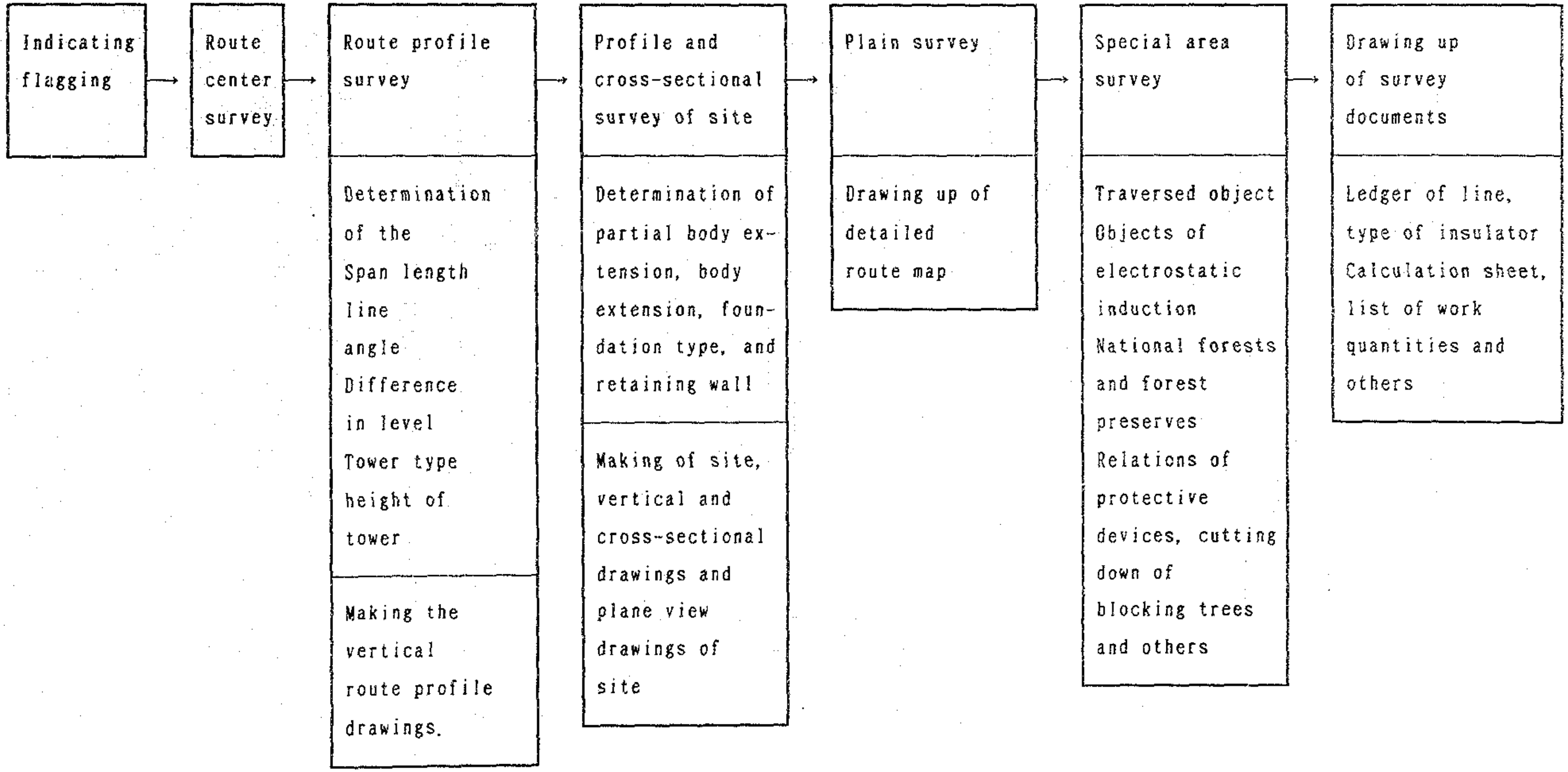

Fig 9-3 Outline of Survey Order

(c) Tightening Bolts and Nuts

All bolts and nuts shall be tightened to the prescribed torque.

(d) Fixing Steel Tower Accessories

After the steel tower fabrication is completed, all accessories shall be attached to the towers with number tags, danger sign board and frame tags.

(3) Stringing Work

Completion of structure construction works is followed by stringing work, the block flow chart of which is shown in Fig. 9-4.

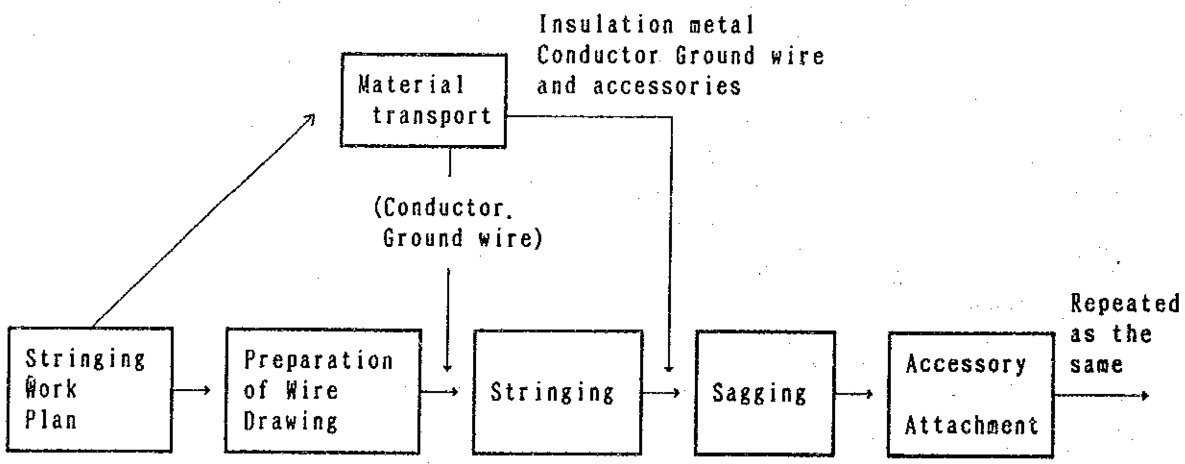

Fig 9-4 Flow Chart of stringing work

The stringing work is classified into the works of preparation of wire drawing, stringing, sagging and accessory attachment, each being described as follows:

(a) Preparation of Stringing Work

The fundamentals of stringing work preparation is to formulate the stringing work plan including the following items, etc.

i) Determining stringing section, drum yard and engine yard.

ii) Determing the places of scaffolding installation and scaffolding design.

iii) Planning arrangement of personnel, materials and tools.

iv) Preparing construction schedule for stringing work items.

v) Planning transport of line materials and tools.

Because of variation in the place of job in the stringing sections as well as many kinds of the tools to be used, the proper arrangement of personnel and tools is the most important element which improves the efficiency of the work leading to the possible shortening of the term of work. Saying it differently, the arrangement of personnel and tools should be planned so as to minimize the arrangement plan itself.

In the planning, each distance from an engine yard to a drum yard was taken as from 3.5 to 4.0 km. Major tools are as follows:

i) Tensioner

The capstan diameter shall be not less than 1.2 m.

ii) Stringing Winch

To be equipped with an engine of at least 45 HP.

iii) Stringing Block

To be lifting pulley made of aluminium with a groove diameter of not less than 450 mm.

iv) Messenger Wire

To be wire-rope with a minimum diameter of 12 mm.

(b) Stringing Work

The stringing work to be applied shall be of tension stringing system. Protective scaffoldings shall be temporarily install at facilities over which the 132 kV transmission line clive is to pass, such as other objects, if necessary with care being taken to prevent proximity with stringing lines.

(c) Sagging Work

The completion of stringing work shall be followed by sagging work which is in accordance with the prescribed sag calculation. In this case, the length of sag shall be calculated to meet the prescribed sag, measurement made with a sag scale and thereafter, tensioning shall be completed by compressing to compression clamps of insulators.

(d) Accessory Attachment

After the completion of the sagging work followed by attaching armor rods, the conductor shall be clamped in to the suspension type insulator string. After that damper shall be attached on conductor.

(4) Inspection for Transmission Lines

After the completion of the 132 kV transmission line construction works, visual inspection shall be made for all supports and sections with sampling inspection, when required.

After the confirmation of the completion of all lines in accordance with the specification, the following test shall be made to confirm the performance of the transmission lines:

(1) Line Insulation Test

(2) Phasing Test

(3) Line Trial Charging Test

9-4-2 Substation Construction Works

The main items of the substation construction work shall be proceeded mutatis mutandis in accordance with the 132 kv transmission line construction works.

The construction and transportation of heavy equipment item among the substation construction works, shall be carried out in the following manner:

(1) Transport of Heavy Equipment

Heavy equipment shall be unloaded at the port of unloading by use of a 100 ton barge crane, and subjected to inland transportation with a bottom trailer. Investigation shall be made in advance in planning transport into the limit to load, minimum turning radium, effective tunnel height, etc. depending upon transport roads.

The transfer in the premise of the substation has been planned. So as to transfer to the position of installation using sleepers and rollers.

(2) Installation of Heavy Equipment

The heavy equipment such as main transformers shall be completely tightened with locking bolts after installation in place.

(3) Grounding Work

Because of importance to be attached to the grounding work in view of protection of the electrical equipment in the substation, grounding cables and wires shall be buried in a depth of 100 cm in parallel crosses, and connection shall be made with compression clamps.

(4) Inspection on Completion of Works

On completion of the works in the substation, performance tests shall be made on the equipment concerned, mutatis mutandis in accordance with the inspection procedures for the transmission line including loss test specifically for main transformers for the confirmation of the discrepancy, if any, from the specification.

9-4-3 Telecommunication Equipment Installation Work

Telecommunication equipment installation work shall be performed mutatis mutandis in accordance with the substation work with cares to be taken as described hereunder:

(1) Installation of the Telecommunication Equipment

Telecommunication equipment shall be installed correct positions following with drawings.

(2) Connection with Existing Equipment

Because of importance to be attached to cooperation with the existing equipment, the telecommunication equipment shall be subjected to electrical wiring in accordance with the wiring connection diagrams.

(3) Inspection for Telecommunication Equipment

On completion of the telecommunication equipment work, countertest shall be made to test the cooperation with the existing equipment and to confirm the discrepancy, if any, from the requirements of the specification.

CHAPTER 10 ECONOMIC ANALYSIS AND FINANCIAL ANALYSIS

CHAPTER 10 ECONOMIC ANALYSIS AND FINANCIAL ANALYSIS

10-1 Basic Concept of Economic/Financial Analyses

In the economic analysis, the relative economy of this Project is evaluated by comparing the total present worth cost of this Project with that of an Alternative Project. The Alternative Project is a hypothetical gas turbine power plant, having an output equal to the receiving end power of this project, which is assumed to be constructed near Lilongwe.

In the financial analysis, the financial soundness of this Project is evaluated by calculating the discount rate with which the present worth of the total operating revenues of this Project (the energy sales revenue) becomes equal to that of the total expenses of this Project, or the financial internal rate of return.

10-2 Parameters Used in Economic/Financial Analyses

10-2-1 Construction Cost of This Project

The construction cost of this Project is the cost calculated in Chapter 9. The plant life is assumed to be 35 years.

10-2-2 Parameters of Alternative Project

The sending end output of the alternative gas turbine power plant is assumed to be equal to the receiving end output of this Project. By taking into account the reduction of gas turbine power plant output due to the station service rate, repair/shutdown rate and peripheral temperature, the installed capacity of the gas turbine power plant is assumed to be 42 MW. The major parameters of the gas turbine power plant are presented below.

Installed capacity	:	42 MW
Station service rate	:	0.7%
Repair/shutdown rate	:	15.5%
Output reduction rate	:	14% (at 35°C)

Thermal efficiency (sending end)	:	26%
Light oil calorific value	:	8,900 kcal/l
Fuel consumption rate (sending end)	:	0.372 l/kWh
Unit construction cost	:	390 US$/kW
Plant life	:	25 years

Note:

Based on the definition that:
required installed capacity x (1 - station service rate) x (1 - repair/shutdown rate) x (1 - output reduction rate) = 30 MW

We obtain:
required installed capacity = 30/[(1 - 0.007)(1 - 0.155)(1 - 0.14)]
= 41.6 ≒ 42 MW

10-2-3 Construction Cost of Alternative Project

The construction cost of the alternative gas turbine plant can be calculated as below based on the parameters defined in 10-2-2.

42,000 x 390 = 16.38 million US$ (43.73 million M.Kw)

The capital expenditure for construction of this plant is assumed to be 20% of the total for the first year and 80% for the second year. That is:

Expenditure for the first year : 3.28 million US$ (8.76 million M.Kw)

Expenditure for the second year : 13.10 million US$ (34.97 million M.Kw)

10-2-4 O&M Cost

The O&M cost (including administration expenses) of this Project is assumed to be 2.5% of the construction cost. The O&M cost (including administration expenses) of the Alternative Project is assumed to be 5% of the construction cost.

10-2-5 Fuel Cost

ESCOM's purchase price of light oil, which will be used as fuel for the gas turbine plant of the Alternative Project, was 1.556 M.Kw/ℓ according to the actual purchase record in March, 1989. Converting this price to US$ at a rate of 0.3746 US$/M.Kw, we obtain 0.583 US$/ℓ. Multiplying this figure by the fuel consumption rate (at sending end), we obtain the sending end fuel cost of 0.2168 US$/kWh.

10-2-6 Cost of Supplied Power

It is assumed that the electric power from hydroelectric power plants in the southern part of Malawi will be supplied to the Lilongwe area after this Project is completed. The cost of such power has been calculated as presented below based on the financial data of ESCOM for 1988.

The total electricity sales in 1988 was 477.46 GWh, the operating expenses 25.69 million M.Kw, and the interest payment 9.26 million M.Kw. As almost all electricity sales by ESCOM is sustained by hydroelectric power, we defined the supplied power cost of this Project as the sum of the above operating expenses and interest payment divided by the total electricity sales, which was:

$$\begin{aligned}(25.69 + 9.26)/447.46 &= 0.0732 \text{ M.Kw/kWh} \\ &= 0.0732 \times 0.3746 \\ &= 0.0274 \text{ US\$/kWh}\end{aligned}$$

10-2-7 Unit Electricity Price

The average unit price of electricity sold, as assumed by ESCOM for the year 1992 when this Project is commissioned to commercial operation, that is, 0.1347 M.Kw/kWh = 0.0505 US$/kWh, was used as the unit electricity price with which the operating revenues from this Project is calculated.

10-3 Economic Analysis

10-3-1 Comparison by Levelized Costs

The relative economic advantage between this Project and the Alternative Project was compared in terms of the levelized costs, assuming the social discount rate of 10% which is generally adopted as the opportunity cost of capital. Here, the year 1989 was selected as reference and it was assumed that the two projects will be commissioned to commercial operation in 1992. The evaluation was performed for a period ending in 2026 on this Project, and a period ending in 2016 on the alternative Project.

The O&M costs are calculated as below based on the assumptions in 10-2-4.

This Project	:	34.88 x 0.025 = 0.872 million US$/year
Alternative Project	:	16.38 x 0.05 = 0.819 million US$/year

The power received by the loads in Lilongwe area was assumed to be 30 MW with a load factor of 60%, that is, 1.577×10^8 kWh/year. In reality, this figure should change from year to year, but such changes have negligible effect as discussed in Section 10-3-2. Therefore, the fuel cost can be estimated as $1.577 \times 10^8 \times 0.2168 =$ 34.19 million US$/year, and the power supply cost as $1.577 \times 10^8 \times 0.0274 = 4.32$ million US$/year.

The results of this evaluation are presented in Tables 10-1 and 10-2. The levelized annual costs are 8.83 million US$ (23.57 million M.Kw) for this Project and 36.85 million US$ (98.37 million M.Kw) for the Alternative Project. The Alternative Project is 28.02 million US$ more expensive, or 4.17 times, than this Project. That is, this Project is far more economical.

10-3-2 Effect of Transmission Power on Project Economy

As discussed in 10-3-1, the economy of this Project is much superior, but this superiority is heavily dependent on the high price of light oil (which price was 0.25 US$/ℓ according to the purchase records of nine electric utilities of Japan in 1987, or only 43%). Therefore, we examined how much the transmission power from this Project can be reduced while maintaining its economic superiority.

The levelized power supply cost and fuel cost are 4.32 million US$ and 34.19 million US$ respectively, and these values are proportional to the transmission power, P MW (assuming that the load factor of 60% does not change with transmission power). Therefore, the levelized annual cost of this Project is less than that of the Alternative Project with transmission power PMW when the following equation is sustained.

$$(8.83 - 4.32) + 4.32 \times P/30 \leqq (36.85 - 34.19) + 34.19 \times P/30$$

This equation can be transformed as:

$$29.87 \times P/30 \geqq 1.85$$

Therefore, we obtain:

$$P \geqq 0.0619 \times 30 = 1.9 \text{ MW}$$

That is, this Project has a superior economy if the amount of power received from this Project is no less than 1.9 MW (at load factor of 60%).

The actual amount of power to be received will be around 20 MW in the year of commissioning, and will exceed 30 MW within 5 years, as discussed in Chapter 7. Therefore, the high economy of this Project should be proved if the economy of the Project is evaluated on the actual amount of power received.

Table 10-1 Levelized Annual Costs of This Project

(in Million US$, with 10% discount rate)

No.	Year	Construction Cost	O&M	Power Supply Cost	Total
	1989	0.57			0.57
	90	4.25			4.25
	91	26.57			26.57
1	92	3.49	0.872	4.32	8.69
2	93		0.872	4.32	5.19
3	94		0.872	4.32	5.19
4	95		0.872	4.32	5.19
5	96		0.872	4.32	5.19
6	97		0.872	4.32	5.19
7	98		0.872	4.32	5.19
8	99		0.872	4.32	5.19
9	2000		0.872	4.32	5.19
10	01		0.872	4.32	5.19
11	02		0.872	4.32	5.19
12	03		0.872	4.32	5.19
13	04		0.872	4.32	5.19
14	05		0.872	4.32	5.19
15	06		0.872	4.32	5.19
16	07		0.872	4.32	5.19
17	08		0.872	4.32	5.19
18	09		0.872	4.32	5.19
19	10		0.872	4.32	5.19
20	11		0.872	4.32	5.19
21	12		0.872	4.32	5.19
22	13		0.872	4.32	5.19
23	14		0.872	4.32	5.19
24	15		0.872	4.32	5.19
25	16		0.872	4.32	5.19
26	17		0.872	4.32	5.19
27	18		0.872	4.32	5.19
28	19		0.872	4.32	5.19
29	20		0.872	4.32	5.19
30	21		0.872	4.32	5.19
31	22		0.872	4.32	5.19
32	23		0.872	4.32	5.19
33	24		0.872	4.32	5.19
34	25		0.872	4.32	5.19
35	26		0.872	4.32	5.19
Total Present Worth:		26.38	6.33	31.30	64.01

Levelized total annual costs = 8.83

Note: The levelized total annual costs can be obtained by multiplying the total present worth costs by capital recovery factor at 10% discount rate for 35 years of 0.10369, and 1.1^3 which is a coefficient to convert the figures based on the reference year to those based on the commissioning year.

Table 10-2 Levelized Annual Costs of Alternative Project

(in million US$, with 10% discount rate)

No.	Year	Construction Cost	O&M	Power Supply Cost (Fuel)	Total
	1989				0
	90	3.28			3.28
	91	13.10			13.10
1	92		0.819	34.19	35.01
2	93		0.819	34.19	35.01
3	94		0.819	34.19	35.01
4	95		0.819	34.19	35.01
5	96		0.819	34.19	35.01
6	97		0.819	34.19	35.01
7	98		0.819	34.19	35.01
8	99		0.819	34.19	35.01
9	2000		0.819	34.19	35.01
10	01		0.819	34.19	35.01
11	02		0.819	34.19	35.01
12	03		0.819	34.19	35.01
13	04		0.819	34.19	35.01
14	05		0.819	34.19	35.01
15	06		0.819	34.19	35.01
16	07		0.819	34.19	35.01
17	08		0.819	34.19	35.01
18	09		0.319	34.19	35.01
19	10		0.819	34.19	35.01
20	11		0.819	34.19	35.01
21	12		0.819	34.19	35.01
22	13		0.819	34.19	35.01
23	14		0.819	34.19	35.01
24	15		0.819	34.19	35.01
25	16		0.819	34.19	35.01
Total Present Worth:		12.55	5.58	233.15	251.28

Levelized total annual costs = 36.85

Note: The levelized total annual costs can be obtained by multiplying the total present worth costs by capital recovery factor at 10% discount rate for 25 years of 0.11017, and 1.1^3 which is a coefficient to convert the figures based on the reference year to those based on the commissioning year.

10-3-3 Economy of Double Circuit Tower

In this Project, it is planned to construct a transmission line of double circuit tower design, on which a single circuit is strung first, and then another circuit is to be strung to deal with the future increase of power demand in Lilongwe area. In this section, it is discussed from economical point of view why this plan has been adopted instead of constructing two transmission lines of single circuit tower design step by step for meeting the demand growth.

In these two plans (double circuit design and single circuit design), the annual project expenditure will be as given in Tables 10-3 and 10-4 respectively. The project expenditure for the double circuit design, up to the time when only one circuit is strung, is given in Chapter 9. This figure is also used as the basis in calculating the indirect costs of stringing the second circuit and constructing the single circuit transmission line.

Table 10-3 Construction Cost of Double Circuit Transmission Line with One Circuit Strung at a Time

(in million US$)

Cost Item	Total	First Circuit				Second Circuit
		#1	#2	#3	#4	
Transmission Line	19.44	--	1.87	15.63	1.95	10.32
Right of Way	0.20	0.08	0.06	0.06	--	--
Administration	0.24	0.02	0.10	0.10	0.02	0.08
Engineering	2.98	0.41	1.21	0.97	0.39	0.99
Contingency	3.17	0.05	0.39	2.41	0.32	1.14
Total	26.02	0.56	3.62	19.16	2.68	12.54

Total Construction Cost: 26.02 + 12.54 = 38.56 million US$

Table 10-4 Construction Cost of Two Single Circuit Lines in Sequence (Cost of one circuit)

(in million US$)

Cost Item	Total	#1	#2	#3
Transmission Line	17.47	7.86	7.86	1.75
Right of Way	0.20	0.10	0.10	--
Administration	0.16	0.07	0.07	0.02
Engineering	1.99	0.90	0.90	0.20
Contingency	1.99	0.90	0.90	0.20
Total	21.80	9.83	9.81	2.16

Total Construction Cost: 21.80 x 2 = 43.60 million US$

The relative economic advantage of the two plans (double circuit vs. single circuit) can be compared in terms of the total present worth with the year 1989 as reference. It is assumed that the second circuit will be commissioned in the n'th year, with the first year being 1992, or the year this Project is commissioned.

(1) Double Circuit Tower with One Circuit Strung at a Time (in million US$)

$$0.56/1.1 + 3.62/1.1^2 + 19.16/1.1^3 + 2.68/1.1^4 = 19.73$$
(for the first circuit)

$$12.54/1.1^{n+2}$$
(for the second circuit)

(2) Single Circuit Towers Constructed in Sequence (in million yen)

$$9.83/1.1^2 + 9.81/1.1^3 + 2.16/1.1^4 = 16.97$$
(for the first circuit)

$$16.97/1.1^{n-1}$$
(for the second circuit)

The condition that (1) is more economical than (2) is given by the equation:

$$19.73 + 12.54/1.1^{n+2} \leq 16.97 + 16.97/1.1^{n-1}$$

Solving this equation, we have:

$$1.1^{n+2} \leq 10.05/2.76 = 3.63605$$

$$n + 2 \leq \log 3.63605/\log 1.1 = 13.54$$

Therefore:

$$n \leq 11.5$$

This proves that the plan of constructing double circuit tower line, with one circuit strung at each time, is more economical if the second circuit is to be strung within 11.5 years after the commissioning of the first circuit. As indicated by the annual power flows presented in chapter 7, the second circuit is required by 1999, which is the 8th year after commissioning of the Project.

Therefore, it has been decided to construct a double circuit transmission line for this Project and to string one circuit at a time.

10-4 Financial Analysis

10-4-1 Financial Internal Rate of Return

The financial internal rate of return (FIRR) means the value of discount rate with which the total present worth of revenues and expenses of a project becomes equal.

The annual electric power supplied by this Project (at receiving end) can be obtained from the annual power flows given in Chapter 7. The total power cost and the revenue can be calculated by multiplying these values by the unit costs given in 10-2-6 and 10-2-7. These values are presented in Table 10-5 (with the load factor assumed to be 60% for the whole period of calculation).

Table 10-5 Annual Power Supply Cost and Revenue

Year	Power Supplied (MW)	Energy Supplied (10^6 kWh)	Supply Cost (Million US$)	Revenue (Million US$)
1992	20	105.1	2.88	5.30
1993	23	121.9	3.34	6.15
1994	27	141.9	3.89	7.16
1995	30	157.7	4.32	7.95
1996	34	178.7	4.90	9.01
1997	38	199.7	5.47	10.07
1998	40	210.2	5.76	10.60
1999	42	220.8	6.05	11.13
2000	42	220.8	6.05	11.13
-	--	--	--	--
-	--	--	--	--
-	--	--	--	--
2026	42	220.8	6.05	11.13

Using the same construction cost and O&M cost as in the economic analysis, we can calculate the FIRR as given in Table 10-6.

According to this calculation results, the FIRR of this Project is 9.1%. Therefore, it can be said that this Project is sufficiently economical in terms of financial internal rate of return.

Table 10-6 Calculation Table of Financial Internal Rate of Return

(in million US$)

No.	Year	Revenue	Expense			
			Construction Cost	O&M	Power Supply Cost	Total
	1989		0.57			0.57
	90		4.25			4.25
	91		26.57			26.57
1	92	5.30	3.49	0.87	2.88	7.25
2	93	6.15		0.87	3.34	4.22
3	94	7.16		0.87	3.89	4.76
4	95	7.95		0.87	4.32	5.19
5	96	9.01		0.87	4.90	5.77
6	97	10.07		0.87	5.47	6.35
7	98	10.60		0.87	5.76	6.63
8	99	11.13		0.87	6.05	6.93
9	2000	11.13		0.87	6.05	6.93
10	01	11.13		0.87	6.05	6.93
11	02	11.13		0.87	6.05	6.93
12	03	11.13		0.87	6.05	6.93
13	04	11.13		0.87	6.05	6.93
14	05	11.13		0.87	6.05	6.93
15	06	11.13		0.87	6.05	6.93
16	07	11.13		0.87	6.05	6.93
17	08	11.13		0.87	6.05	6.93
18	09	11.13		0.87	6.05	6.93
19	10	11.13		0.87	6.05	6.93
20	11	11.13		0.87	6.05	6.93
21	12	11.13		0.87	6.05	6.93
22	13	11.13		0.87	6.05	6.93
23	14	11.13		0.87	6.05	6.93
24	15	11.13		0.87	6.05	6.93
25	16	11.13		0.87	6.05	6.93
26	17	11.13		0.87	6.05	6.93
27	18	11.13		0.87	6.05	6.93
28	19	11.13		0.87	6.05	6.93
29	20	11.13		0.87	6.05	6.93
30	21	11.13		0.87	6.05	6.93
31	22	11.13		0.87	6.05	6.93
32	23	11.13		0.87	6.05	6.93
33	24	11.13		0.87	6.05	6.93
34	25	11.13		0.87	6.05	6.93
35	26	11.13		0.87	6.05	6.93

Total present worth with discount rate of:						Revenue - Expense
9%	77.57	27.10	7.13	42.17	77.43	+0.15
10%	68.07	26.38	6.33	37.00	69.71	-1.64

FIRR = 9 + 0.15/(0.15 + 1.64) = 9.1%

Note: Construction cost is excluding interest during construction.

10-4-2 Some Financial Tables

The loan repayment program of this Project is presented in Table 10-7. All project fund is to be borrowed by the following terms.

Interest rate	:	1%
Reimbursement term	:	35 years (with a 10 year grace period)
Reimbursement method	:	Equal installment of principal and interest

The statement of profit and loss for this Project is given in Table 10-8. The gross construction cost of 35.10 million US$ (93.69 million M.Kw), which is the sum of the net construction cost of 34.89 million US$ (93.13 million M.Kw) and the interest during construction of 0.21 million US$ (0.56 million M.Kw), is to be depreciated in 35 years by a straight line method (no salvation).

According to this program, the interest during construction of 0.21 million US$ for the construction period of 3 years is incurred as loss, but we judge that this can be financed by ESCOM itself. The profit increases satisfactorily after commissioning as the sales revenue increases. The interest rate with which the total net profit becomes zero is 95.885/6.42 = 14.9%.

The debt/service ratio is given in Table 10-9. This is the ratio of the payable amount which is the repayment of interest and principal to the internal financing which is operating revenue plus depreciation, and is 3.32 in the final year, being well over 1, thereby indicating the financial soundness of this Project.

Table 10-7 Loan Repayment Program

(in Million US$)

No.	Year	Construction Cost	Interest	Principal	Principal & Interest	Loan Balance
	1989	0.57	0.002		0.002	0.57
	90	4.25	0.027		0.027	4.82
	91	26.57	0.181		0.181	31.39
1	92	3.49	0.349		0.349	34.89
2	93		0.349		0.349	34.89
3	94		0.349		0.349	34.89
4	95		0.349		0.349	34.89
5	96		0.349		0.349	34.89
6	97		0.349		0.349	34.89
7	98		0.349		0.349	34.89
8	99		0.349	1.58	1.93	33.30
9	2000		0.333	1.60	1.93	31.70
10	01		0.317	1.62	1.93	30.09
11	02		0.300	1.63	1.93	28.45
12	03		0.284	1.65	1.93	26.81
13	04		0.268	1.67	1.93	25.14
14	05		0.251	1.68	1.93	23.46
15	06		0.234	1.70	1.93	21.76
16	07		0.217	1.72	1.93	20.04
17	08		0.200	1.73	1.93	18.31
18	09		0.183	1.75	1.93	16.56
19	10		0.165	1.77	1.93	14.79
20	11		0.148	1.79	1.93	13.01
21	12		0.129	1.80	1.93	11.20
22	13		0.111	1.82	1.93	9.38
23	14		0.094	1.84	1.93	7.54
24	15		0.075	1.86	1.93	5.69
25	16		0.056	1.88	1.93	3.81
26	17		0.038	1.89	1.93	1.91
27	18		0.019	1.91	1.93	0
Total		34.89	6.42	34.89	41.31	

Table 10-8 Statement of Profit and Loss

(in Million US$)

No.	Year	Operating Revenue	Operating Expense O&M	Operating Expense Power Cost	Operating Expense Depreciation	Operating Expense Total	Operating Income	Interest	Net Income
	1989							0.00	-0.00
	90							0.03	-0.03
	91							0.18	-0.18
1	92	5.30	0.87	2.88	1.00	4.76	0.54	0.35	0.19
2	93	6.15	0.87	3.34	1.00	5.22	0.93	0.35	0.58
3	94	7.16	0.87	3.89	1.00	5.77	1.39	0.35	1.04
4	95	7.95	0.87	4.32	1.00	6.20	1.75	0.35	1.40
5	96	9.01	0.87	4.90	1.00	6.78	2.24	0.35	1.89
6	97	10.07	0.87	5.47	1.00	7.35	2.72	0.35	2.37
7	98	10.60	0.87	5.76	1.00	7.63	2.97	0.35	2.62
8	99	11.13	0.87	6.05	1.00	7.93	3.21	0.35	2.86
9	2000	11.13	0.87	6.05	1.00	7.93	3.21	0.33	2.87
10	01	11.13	0.87	6.05	1.00	7.93	3.21	0.32	2.89
11	02	11.13	0.87	6.05	1.00	7.93	3.21	0.30	2.91
12	03	11.13	0.87	6.05	1.00	7.93	3.21	0.28	2.92
13	04	11.13	0.87	6.05	1.00	7.93	3.21	0.27	2.94
14	05	11.13	0.87	6.05	1.00	7.93	3.21	0.25	2.96
15	06	11.13	0.87	6.05	1.00	7.93	3.21	0.23	2.97
16	07	11.13	0.87	6.05	1.00	7.93	3.21	0.22	2.99
17	08	11.13	0.87	6.05	1.00	7.93	3.21	0.20	3.01
18	09	11.13	0.87	6.05	1.00	7.93	3.21	0.18	3.02
19	10	11.13	0.87	6.05	1.00	7.93	3.21	0.17	3.04
20	11	11.13	0.87	6.05	1.00	7.93	3.21	0.15	3.06
21	12	11.13	0.87	6.05	1.00	7.93	3.21	0.13	3.08
22	13	11.13	0.87	6.05	1.00	7.93	3.21	0.11	3.09
23	14	11.13	0.87	6.05	1.00	7.93	3.21	0.09	3.11
24	15	11.13	0.87	6.05	1.00	7.93	3.21	0.08	3.13
25	16	11.13	0.87	6.05	1.00	7.93	3.21	0.06	3.15
26	17	11.13	0.87	6.05	1.00	7.93	3.21	0.04	3.17
27	18	11.13	0.87	6.05	1.00	7.93	3.21	0.02	3.21
28	19	11.13	0.87	6.05	1.00	7.93	3.21		3.21
29	20	11.13	0.87	6.05	1.00	7.93	3.21		3.21
30	21	11.13	0.87	6.05	1.00	7.93	3.21		3.21
31	22	11.13	0.87	6.05	1.00	7.93	3.21		3.21
32	23	11.13	0.87	6.05	1.00	7.93	3.21		3.21
33	24	11.13	0.87	6.05	1.00	7.93	3.21		3.21
34	25	11.13	0.87	6.05	1.00	7.93	3.21		3.21
35	26	11.13	0.87	6.05	1.00	7.93	3.21		3.21
Total		367.99	30.57	200.01	35.10	265.68	102.31	6.42	95.89

Table 10-9 Debt/Service Ratio

(in million US$)

		Internal Financing				Repayment				Debt/ Service Ratio
No.	Year	Operating Income	Depre- ciation	Total	Cumula- tive (A)	Interest	Princi- pal	Total	Cumulative (B)	(A)/(B)
	1989					0.00		0.00	0.00	
	90					0.03		0.03	0.03	
	91					0.18		0.18	0.21	
1	92	0.54	1.00	1.54	1.54	0.35		0.35	0.56	
2	93	0.93	1.00	1.93	3.47	0.35		0.35	0.91	
3	94	1.39	1.00	2.39	5.86	0.35		0.35	1.26	
4	95	1.75	1.00	2.76	8.62	0.35		0.35	1.60	
5	96	2.24	1.00	3.24	11.86	0.35		0.35	1.95	6.07
6	97	2.72	1.00	3.72	15.58	0.35		0.35	2.30	
7	98	2.97	1.00	3.97	19.55	0.35		0.35	2.65	
8	99	3.21	1.00	4.21	23.76	0.35	1.58	1.93	4.58	
9	2000	3.21	1.00	4.21	27.97	0.33	1.60	1.93	6.52	
10	01	3.21	1.00	4.21	32.18	0.32	1.62	1.93	8.45	3.81
11	02	3.21	1.00	4.21	36.39	0.30	1.63	1.93	10.38	
12	03	3.21	1.00	4.21	40.52	0.28	1.65	1.93	12.31	
13	04	3.21	1.00	4.21	44.73	0.27	1.67	1.93	14.25	
14	05	3.21	1.00	4.21	52.51	0.25	1.68	1.93	16.18	
15	06	3.21	1.00	4.21	53.14	0.23	1.70	1.93	18.11	2.93
16	07	3.21	1.00	4.21	57.35	0.22	1.72	1.93	20.05	
17	08	3.21	1.00	4.21	61.56	0.20	1.73	1.93	21.98	
18	09	3.21	1.00	4.21	65.77	0.18	1.75	1.93	23.91	
19	10	3.21	1.00	4.21	69.98	0.17	1.77	1.93	25.85	
20	11	3.21	1.00	4.21	74.19	0.15	1.79	1.93	27.78	2.67
21	12	3.21	1.00	4.21	78.40	0.13	1.80	1.93	29.71	
22	13	3.21	1.00	4.21	82.61	0.11	1.82	1.93	31.64	
23	14	3.21	1.00	4.21	86.82	0.09	1.84	1.93	33.58	
24	15	3.21	1.00	4.21	91.03	0.08	1.86	1.93	35.51	
25	16	3.21	1.00	4.21	95.24	0.06	1.88	1.93	37.44	2.54
26	17	3.21	1.00	4.21	99.44	0.04	1.89	1.93	39.38	
27	18	3.21	1.00	4.21	103.65	0.02	1.91	1.93	41.30	
28	19	3.21	1.00	4.21	107.86				41.30	
29	20	3.21	1.00	4.21	112.07				41.30	
30	21	3.21	1.00	4.21	116.28				41.30	2.81
31	22	3.21	1.00	4.21	120.49				41.30	
32	23	3.21	1.00	4.21	124.70				41.30	
33	24	3.21	1.00	4.21	128.91				41.30	
34	25	3.21	1.00	4.21	133.12				41.30	
35	26	3.21	1.00	4.21	137.33				41.30	3.32

ANNEX 1 DATA AND DOCUMENTS

ANNEX 1 Data and Documents

(1)	PROPOSED ENERGY I PROJECT CO-FINANCING BRIEF (1988)	Office of the President and Cabinet
(2)	POWER DEVELOPMENT STUDY PHASE I : LEAST COST SOLUTION VOLUME II : ANNEXES	ESCOM (1985)
(3)	POWER DEVELOPMENT STUDY PHASE II : KAPICHIRA PROJECT VOLUME I : MAIN REPORT	ESCOM (1980)
(4)	PRELIMINARY ESCOM CAPACITY UTILIZATION STUDY	ESCOM (1987)
(5)	MALAWI ELECTRICAL NETWORK REINFORCEMENT STUDY SITE INVESTIGATION REPORT	ESCOM (1984)
(6)	PROJECT REPORT FOR NKULA FALLS HYDROELECTRIC SCHEME STAGE II	ESCOM (1975)
(7)	ECONOMIC REPORT 1985	Office of the President and Cabinet Economic Planning Div.
(8)	FINANCIAL STATEMENT 1988/89 (Budget Document No.3)	Government of Malawi (1987)
(9)	STUDY TO UPDATE ESCOM'S LEAST COST DEVELOPMENT PROGRAM FINAL REPORT - Volume 1 - Volume 2	Office of the President and Cabinet Dept. of Economic Planning and Development (1988)
(10)	A WATER RESOURCES EVALUATION OF LAKE MALAWI AND THE SHIRE RIVER, C.H.R. KIDD UNDP PROJECT MLW/77/012	UNDP (1983)
(11)	INTERNATIONAL CONFERENCE OF PARTNERS IN ECONOMIC DEVELOPMENT PROJECT ABSTRACTS VOLUME II (POWER)	MALAWI GOVERNMENT (1983)
(12)	MAIN GENERATION STATIONS, TRANSMISSION LINES AND POWER REQUIREMENTS ( )	ESCOM (1983)
(13)	TRANSMISSION ROUTE MAP (1/50,000, 12)	ESCOM (1984) (1988)

1334	D4	LILONGWE
1334	C3	CHIWERE
1434	A1	LINTHIPE
1434	A2	CHITUNDU
1434	A4	DEDZA
1434	B3	GOLOMOTI
1434	D1/C2	SHARPEVALE
1434	D2	PHIRILONGWE
1434	D4	BALAKA
1534	B2	KANGANKUNDE
1534	B4	MATOPE MISSION
1534	D2	CHILEKA

(14) STATEMENT OF DEVELOPMENT POLICIES 1987-1996	Office of the President and Cabinet Dept. of Economic Planning and Development
(15) MID-YEAR ECONOMIC REVIEW 1987-88	〃
(16) BUDGET STATEMENT 1988	Minister of Finance
(17) ANNUAL REPORT 1986	ESCOM
(18) PROJECT ABSTRACTS (POWER) ・ KAPICHILA FALLS HYDRO-ELECTRIC PROJECT ・ 132 KV STEEL TOWER TRANSMISSION LINE ・ RURAL ELECTRIFICATION-PHASE (1) ・ 〃 (2) ・ 〃 (3)	Office of the President and Cabinet
(19) TENDER SPECIFICATION FOR 132 KV SABSTATION EQUIPMENT AT NKULA "B", SHARPEVALE & LILONGWE "B"	ESCOM (Oct. 1988)
(20) TENDER SPECIFICATION FOR 132 KV OVERHEAD TRANSMISSION LINE FROM NKULA "B" TO LILONGWE "B" THROUGH SHARPEVALE	ESCOM (Oct. 1988)
(21) LILONGWE (B) substation connection diagram	ESCOM
(22) NUKLA (B) power station single line diagram	ESCOM
(23) Sequence network of impeadance map	ESCOM
(24) NUKLA(B)-SALIMA 132KV overhead line-1989 date on outages for pole replacement	ESCOM
(25) Protection rely catalogue (Reclose, Time, Ground-OC, Bus-pro, Z, OC, Voltage-regulation, Synchronizer)	ESCOM
(26) 132KV feeder protection	ESCOM
(27) Maximum wind gust at different return periods for a few selected station in MALAWI	W. station
(28) Climatological table for MALAWI	W. station
(29) ESCOM ANNUAL REPORT 1969-1986	ESCOM
(30) PERFORMANCE EVALUATION-FINANCIAL	ESCOM
(31) MALAWI INVESTMENT PROGRAM	ESCOM
(32) ESCOM DEBT SCHEDULE	ESCOM
(33) PRICE OF DIESEL SINCE 1979-KARONGA	ESCOM
(34) HISTORY OF TARIFF INCREASE 1979-1988	ESCOM
(35) DEVALUATIONS 1982-1988	ESCOM
(36) ELECTRICITY (SUPPLY) REGURATIONS IN MALAWI	ESCOM