KINGDOM OF THAILAND

MASTER PLAN REPORT

OF

ELECTRIC DISTRIBUTION SYSTEM

IN

BANGKOK

(1982 – 2001)

LONG RANGE PLAN

AUGUST 1982

JAPAN INTERNATIONAL COOPERATION AGENCY

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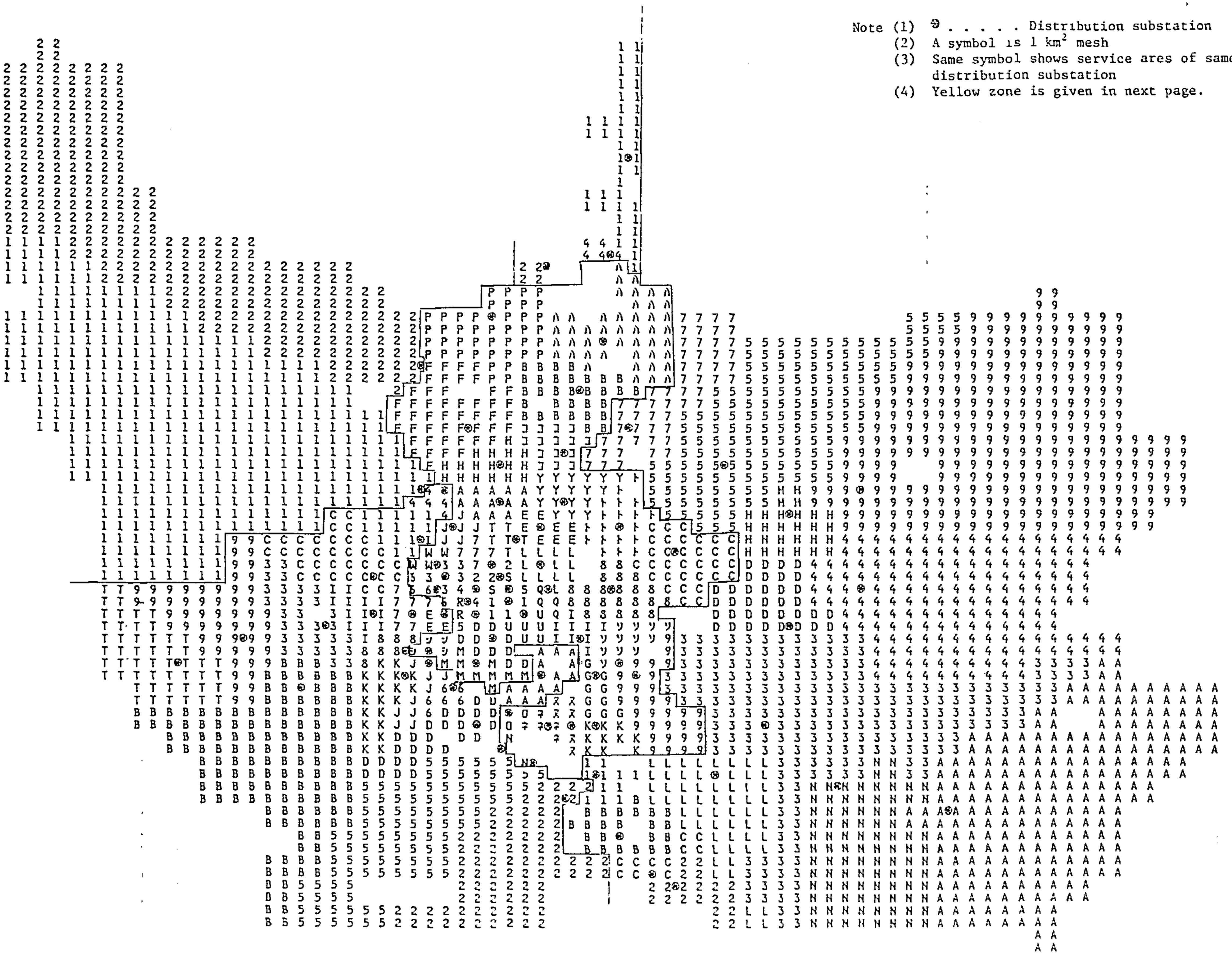
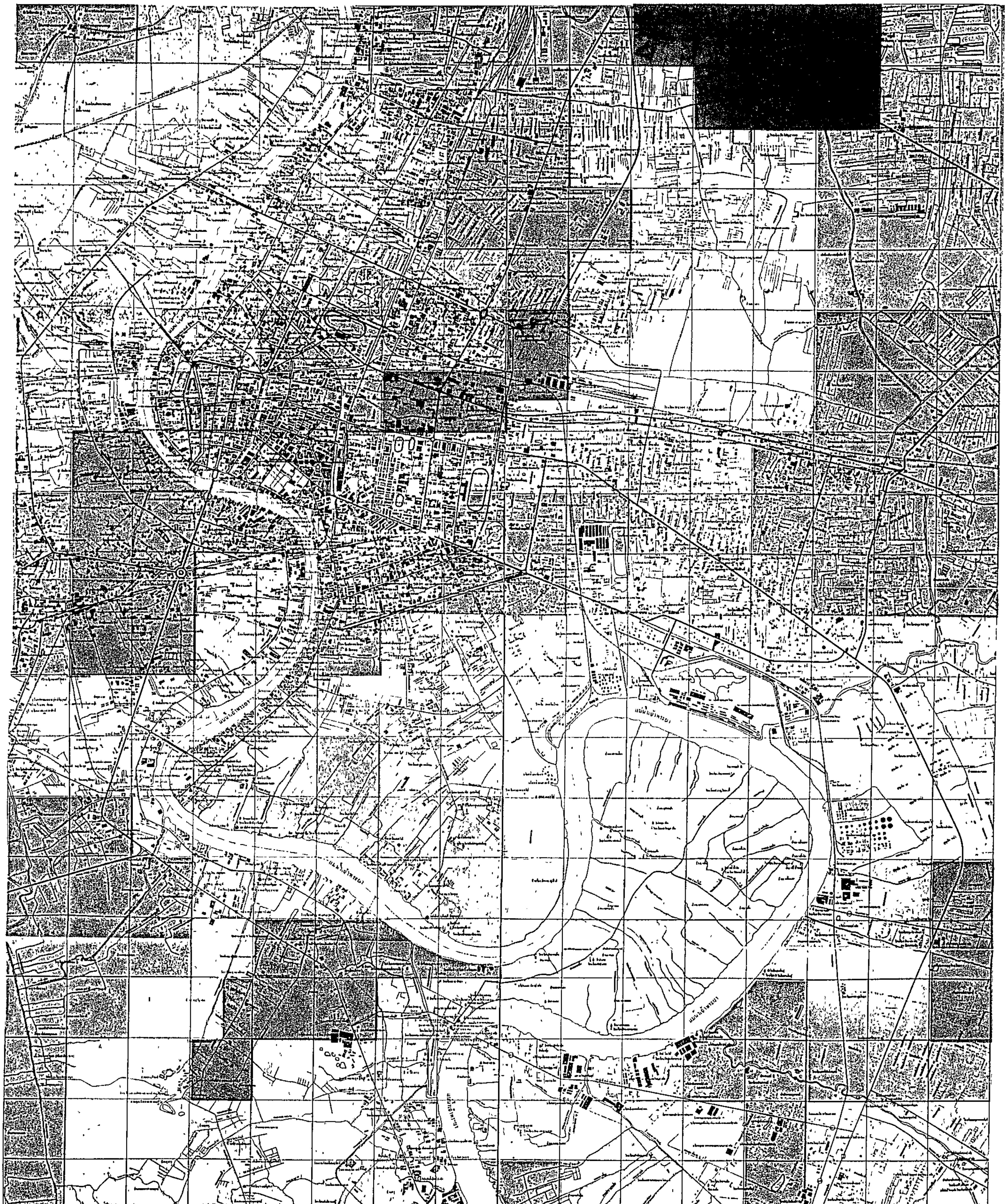
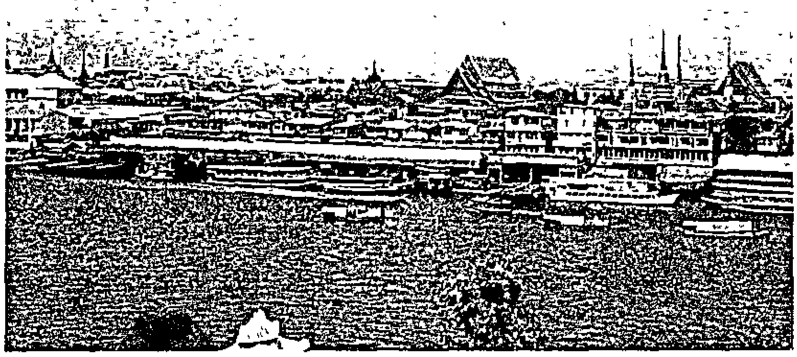
SERVICE AREA OF DISTRIBUTION SUBSTATION IN 2001 (WHOLE)

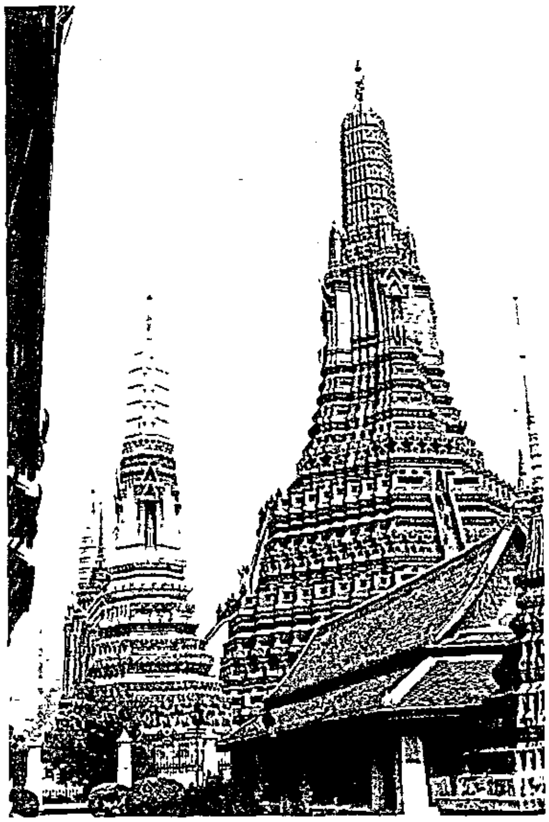
Note (1) ⊕ . . . . . Distribution substation
(2) A symbol is 1 km^2 mesh
(3) Same symbol shows service ares of same distribution substation
(4) Yellow zone is given in next page.

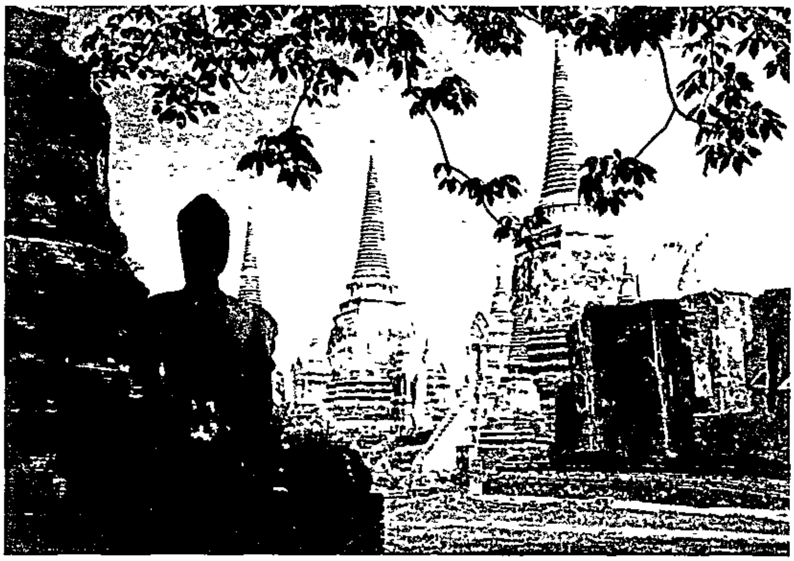


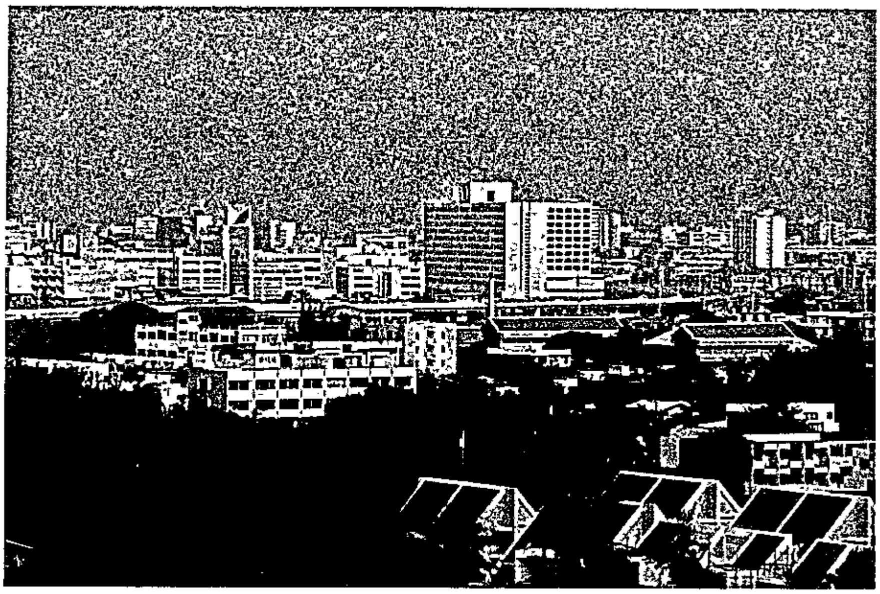
SERVICE AREA OF DISTRIBUTION SUBSTATION IN 2001 (DETAIL)











CONTENTS

I. INTRODUCTION

I. INTRODUCTION

In response to a request of the Government of the Kingdom of Thailand, the Japan International Cooperation Agency (JICA) undertook a study to prepare a 20-Year Master Plan for the Distribution System of Metropolitan Electricity Authority (MEA). In March, 1980, JICA organized and sent to MEA a team of 5 engineers. The team studied the existing condition of MEA's distribution system and collected a voluminous amount of data. After six months of study and analysis of existing conditions, a criterion for planning the master plan was established and computations were made by using a large capacity electronic computer inputting data on load and power installations. Printed output data from the computer were carefully reviewed and checked to finalize the master plan which is compiled in this report.

The members of the team who worked on this study are as follows:

Leader	Mr. Toshinori Homma	Electrical engineer	EPDC INTERNATIONAL
Member	Mr. Haruki Watanabe	Electrical engineer (Distribution)	YONDEN ENGINEERING
Member	Mr. Hiromichi Akamatsu	Electrical engineer (Distribution)	YONDEN ENGINEERING
Member	Mr. Takumi Miyako	Electrical engineer (Substation)	EPDC INTERNATIONAL
Member	Mr. Kikuo Hashimoto	Electrical engineer (Transmission)	EPDC INTERNATIONAL
Member	Mr. Takashi Kimishima	Computer system engineer	EPDC INTERNATIONAL
Member	Mr. Rikio Soeda	Computer system engineer	EPDC INTERNATIONAL
Member	Mr. Tetsuro Kobayashi	Economist	EPDC INTERNATIONAL

I-1 Objective of the Study

Generally, the goal of this project is to lay down definite but flexible guidelines for the improvement and expansion of MEA's power system 20 years in advance, so that it be properly included and in coordination with other goals of various sectors set forth in the National Economic and Social Development Plan.

The study was made for this purpose including followings:

1. To develop a technically sound and economically feasible distribution system for MEA from the year of 1982 to 2001 on the basis of the load forecast completed by MEA.

2. To investigate and possibly develop computer programs for use in the distribution system planning as widely employed in developed countries.

3. To find out the optimum construction program of MEA's distribution facilities during 1982 – 2001.

4. To review and develop Engineering and Construction Standards of the MEA.

5. To prepare the training program and schedule of MEA's selected engineers for proceeding this project.

I-2 Scope of Work

The detailed plan or project activities can be described in consequential stages as follows:

1. Collecting necessary data which will be used for the study.

2. Analyzing the existing system to determine the adequacy of the MEA's existing distribution system to serve future loads and serve as a base for the additional studies and to determine early corrective action if found necessary.

3. Where appropriate, alternative solutions will be considered with emphasis on these solutions which have the greatest long-range technical and economical benefits.

4. Developing the Near-term System to cover the 10-year period (1982 – 1991) – The plan thus developed must indicate on an annual basis the requirements for terminal stations, subtransmission lines, distribution substations and general requirements for distribution system.

5. Load flow studies will be prepared each year over the period of 10 years (1982 – 1991) and fault studies for the first, fifth and tenth year. Corrective action will be determined to cope with rising fault levels.

6. A system protection analysis will be developed adequate for the system up to the tenth year.

7. Projected budget costs will be prepared for each year up to the tenth year.

8. If and when necessary, the plan will outline methods of transition to different transmission and distribution voltages and systems.

9. Developing the Far-term System to cover the last 10-year period (1992 – 2001) – The plan thus developed will indicate requirements for terminal stations, subtransmission lines and distribution substations. Alternatives will be included and evaluated. Load flow and fault level studies will be made for the fifteenth and twentieth year including methods of coping with rising fault levels. Approximate investment cost will be prepared.

1-3 Scope of the Report

The report embodies the following subjects:

1. Summary of studies and recommendations in respect of the implementation of the master plan.

2. An optimum program for the expansion of MEA's distribution system and the required amount of investment that are based on the load forecast for a 20 years period prepared by MEA.

3. The procedures of review of technical and economic aspects in establishing the optimum program by using an electronic computer are as follow:

(1) Load forecast by each mesh for a 20 years period

(2) Facilities criteria which are the basis for planning, and economic and technical conditions for the purposes of calculations

(3) Calculation method and results of case calculations

A diagram of the review procedures is given in Fig. I-1.

Note:

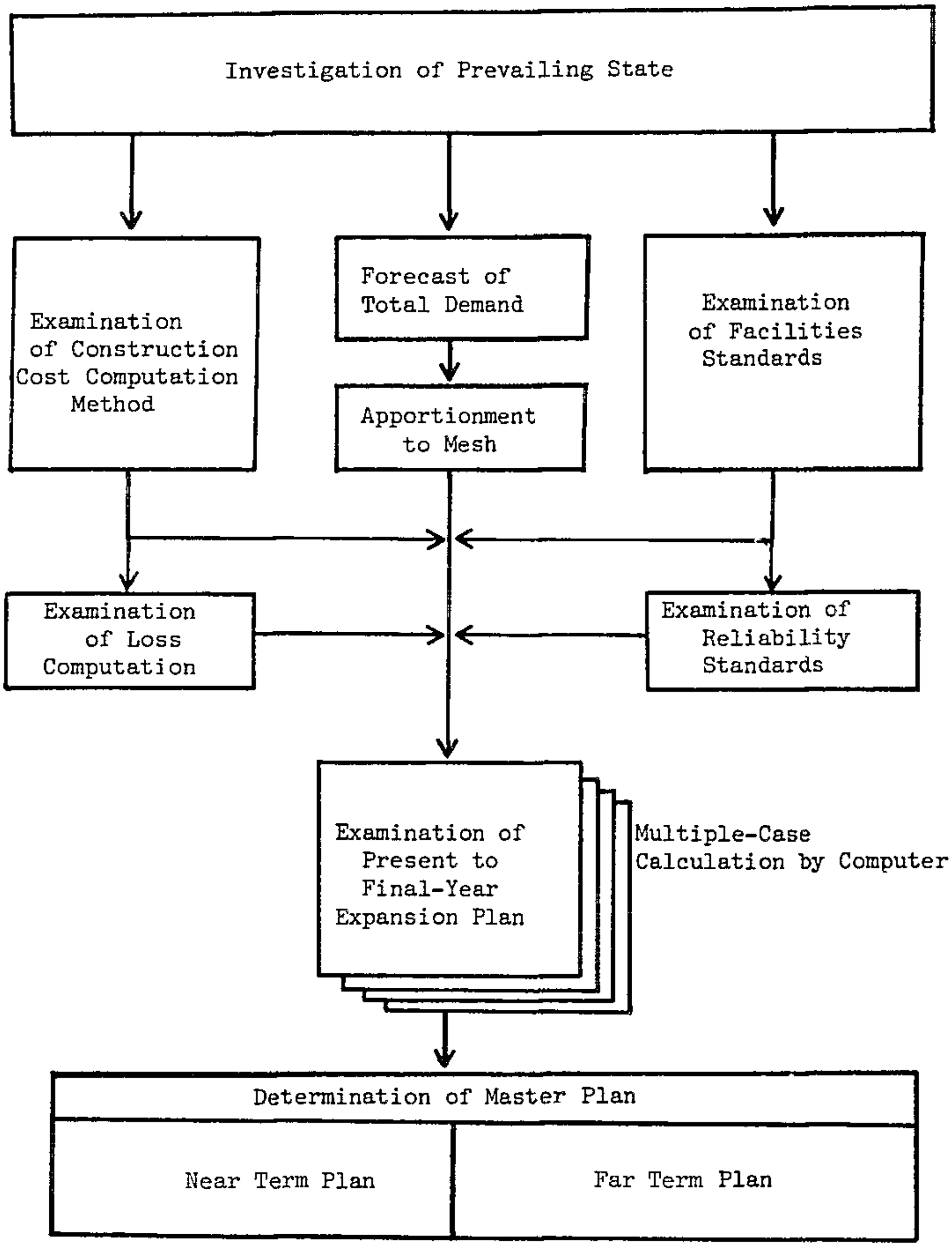
This report does not include studies on the following matters.

(1) Results of analysis of existing condition of MEA

(2) Results of review of MEA's construction standards and design criteria

Studies on items (1) and (2) above are included in the following report.
– Report on Existing Condition – August, 1982

Fig. I-1   Outline of Work Operation Procedure



II. SUMMARY OF STUDIES AND RECOMMENDATIONS

II. SUMMARY OF STUDIES AND RECOMMENDATIONS

II-1 Summary of Studies

1. Demand Forecast by Each Mesh

In accordance with difference of load density, MEA's supply territory was divided into meshes of 0.5 km x 0.5 km (for A area), 1 km x 1 km (for B area) and 2 km x 2 km (for C area), and then distribution load forecast was made.

The projected load density is compared with the present value as shown in Table II-1.

Table II-1 Average Load Density

(KW/Km²)

Area	in 1979	in 2001
A area	8,200	21,200
B area	1,100	4,100
C area	80	320

(1) Averaged load density of respective area has big difference from another (A to C).

(2) High load density meshes are concentrated in the metropolitan area (A area).

(3) Value of total load including big customers will reach to about 3.5 times of present load during a 20 years period. (See Paragraph V-2.)

2. Technical Criteria and Economic Conditions

(1) Technical criteria

a. Composition of subtransmission line

A area ...... Normally open π loop type and feeder transformer type
B area ...... Normally open π loop type
C area ...... Normally open π loop type and double circuit T-branch type

b. Limitation of utilization factor of transformer in distribution substation

A area ...... 85% Max.
B area ...... 80% Max.
C area ...... 65% Max.

c. Unit capacity and number of transformers in a distribution substation

Table II-2 Transformer Installation Criteria in a Distribution Substation

	[Capacity of transformer] x [Number of bank]	Number of bank at initial phase of operation
Case 2	40 MVA x 3 & 20 MVA x 3	2
Case 3	〃 〃	1
Case 4	40 MVA x 2 & 20 MVA x 2	2
Case 5	〃 〃	1
Case 6	30 MVA x 3 & 20 MVA x 3	2
Case 7	〃 〃	1

Note: Case 1 is trial case for using of computer program.
(See Paragraph VI-1.)

(2) Economic conditions

The following economic conditions are applied in the investment calculations.

a. Price escalation 8%
b. Rate of interest 8.5%
c. Price conversion into present value .... Value in 1979 (See Paragraph VI-2.)

3. Summary of Result

Of the 6 cases studied, Case 2 gives the smaller amount of investment and amount of expense converted into present values (in 1979) over the 20 years period.

Table II-3 Comparison of Amount of Investment and Expense in 20 Years Period

Unit: Million Baht

	Investment converted into present value	Expense converted into present value
Case 2	21,510	22,270
Case 3	22,430	22,910
Case 4	21,980	22,450
Case 5	22,320	22,780
Case 6	21,980	22,590
Case 7	22,750	23,090

Note:

a. Amount of investment includes the following:

   i) Investment in expansion of facilities
      – Investment in expansion of distribution system, including distribution substation, subtransmission line and high voltage distribution line
      – Investment in expansion of upper stream system, including terminal substation, sub-terminal substation and 230 kV transmission line
      – Investment in expansion of lower stream system, including distribution transformer, low voltage distribution line and other facilities

   ii) Policy guided investment
      Investment in semi-insulated conductor for distribution feeders

   iii) Investment in renewal of function of facilities

   iv) Other investment
      Vehicle, testing equipment, etc.

b. Annual expense

   In order to evaluate the difference in the amount of investments for each facility, amounts of expense were calculated.

   Amounts of expense consist of depreciation, interest charge, operation and maintenance costs (excluding salary and wages) arising from the investment in facilities.

   Amounts of expenses are computed by multiplying fixed rates to accumulated amount of investments in a certain year. In the comparison of amount of expenses calculated energy losses were multiplied by an evaluated unit price and the results were included.

   Calculation of amount of expenses and evaluation of energy loss were made for each year, and then converted to present value of a base year (1979).

The factor that will greatly influence investment and expense is the number of distribution substations that must be constructed in the next 20 years period. (See Paragraph VII-2.)

Table II-4 Number of Distribution Substations
to be Constructed in 20 Years Period

	Present	1982 ~ 2001	2001
Case 2	46	+ 30	76
Case 3	46	+ 57	103
Case 4	46	+ 46	92
Case 5	46	+ 60	106
Case 6	46	+ 40	86
Case 7	46	+ 63	109

4. Selection of Optimum Program

(1) Trend of amount of investment

Investments for the optimum program indicate that in the near term (1982 – 1991), the amount of investment is small and it is greater in the far term (1992 – 2001). The reason for this phenomena is that there is a margin of reserve in facilities due to low utilization factor.

The amount of investment over the 20 years period is 61,840 million Bahts (21,510 million Bahts converted into present value).

Table II-5 Investment in the 20 Years

Unit: Million Baht

	Investment	Present value of investment
Expansion of distribution system	13,570	4,490
Expansion of upper system	5,420	1,870
Expansion of lower system	32,480	11,420
Restringing distribution lines with semi-insulated conductor	520	180
Renewal of function of facilities	6,420	2,320
Vehicle & equipment	3,430	1,230
Amount	61,840	21,510

(2) Supply of power to center of city in the far term

The existing Chidlom terminal substation located in the metropolitan area will carry a load up to its capacity of 500 MVA at the end of the near term. Therefore, in the far term another terminal substation will have to be constructed inside the metropolitan area. (See Paragraph III-1, 4.)

(3) Variation of projected load

If variation occurs to projected load, and in the year 2001, the set value of the upper limit of load variation is plus 16.6% and the lower limits of load variation is minus 14.7%, then –

a. Case 8 which is the program for the upper limit of load variation, 8 additional substations are required in comparison to Case 2, the program for the projected load (construction will be advanced by about 2 years).

b. Case 9 which is the program for the lower limit of load variation, 8 substations will not be required in comparison to Case 2, the program for the projected load (construction will be deferred by about 2 years).

Table II-6 If Variation occurs to Projected Load

	No. of Substations in 2001	Present value of amount of investment in million B	Present value of amount of expense in million B
Case 2	76	21,510	22,270
Case 8	84 (+8)	24,560 (+3,050)	25,040 (+2,770)
Case 9	68 (–8)	18,570 (–2,940)	19,330 (–2,940)

Note: Figures in ( ) are in comparison to Case 2.
(See Paragraph IV-4.)

5. Training

Formal class and on-the-job trainings have been held at MEA office and two selected MEA engineers were despatched to be trained in Japan for a period of one month.

II-2 Recommendations

As a result of the studies, the following recommendations are made.

1. Investment

(1) In the near term

a. Decrease the number of additional distribution substation and improve the utilization factor of facilities by appropriate implementation of the Master Plan.

b. Acquire land for new substations which are required in future.

c. If permitted in financial situation, invest in facilities to improve reliability. Some examples are:

i) Use of semi-insulated conductors for distribution feeders

ii) Relocate circuit breaker to primary side of bus bar in distribution substation in order to adopt automatic switch-over in case of fault.

iii) Adopt new type of switches for distribution lines.

(2) In the far term

a. Since the number of required distribution substation increases so much, make effective use of land for distribution substation (adopt 3 bank system).

b. Acquire land for terminal substation and 230 KV transmission lines in advance.

2. Technical Matters

(1) In the near term

a. Adopt TAAC for subtransmission lines in order to increase transmitting capacity.

b. As outgoing distribution lines from distribution substation will grow in number in the future, subjects of technical and economic nature should be made matters of continuing studies.

c. Adopt distribution transformer management system effectively in order to decrease the amount of investment in lower system.

d. Make up various statistics in order to invest effectively for level up of reliability.

(2) In the far term

a. Adopt advanced technique for underground lines which are anticipated to increase for transmission and distribution lines.

b. Measures to increase short circuit capacity corresponding to growth and expansion of power source. This is a matter which requires the coordinated planning by MEA and EGAT on a national basis.

III. NEAR TERM PLAN

III. NEAR TERM PLAN

III-1 Facilities Expansion Program

1. Distribution Substation Expansion Program

Table III-1 gives the distribution substation expansion program for the near term.

In the near term, 11 new substations are scheduled to be constructed, and out of those number, the construction of 6 substations is firm and decided. The 5 remaining substations were selected as needed as a result of optimum load allocation by computer. These substations are identified as 4349, Bangbor, 39184, 44091 and 32231. The need of these new stations were revealed in the comparative studies of all cases, and detail studies leading to definite studies for implementation should be performed.

The service area of each substation in each year is given in detail in the output prints of computer. The service areas in 1982 and 1991 which are output prints of computer are attached as Fig. III-1 and Fig. III-2.

2. Subtransmission Line Expansion Program

Subtransmission line expansion program for the near term is given in Table III-2. The expansion of subtransmission lines is to be implemented in association with the construction of new or expansion of existing distribution substations described in detail in the chapter VII. An important matter which must be pointed out in this connection is that all new subtransmission lines and restringing of conductors of existing lines have been planned to be thermal resistant all aluminum conductor for the reasons given later in this report. (See Page VI-9)

The process in the expansion of subtransmission lines are shown in Fig. III-3 to Fig. III-11, subtransmission line route map.

In this expansion program, tie transmission line and electrical facilities to connect to customer's substation are not included. However, in the power flow calculations which will be given in III-3 of this report, the load of customer's substation are included.

3. Distribution Line Expansion Program

High voltage distribution line expansion program for the near term is given in Table III-3. This table gives the growing trend in the number of distribution feeders. At present (1981), the number of feeder which is 345 will increase by 142 to 487 feeders in 1991.

This number of feeders is within the allowable load current as determined in the planning criteria, and this number was calculated so that the voltage drop is within the range determined in that criteria.

Where the average voltage drop exceeds the allowable voltage drop, calculations have been made to include lines which require renovation. The last item in Table III-3 which reads "additional length of conductor (km)" is to cover additional line length to supply loads of a service area and to perform renovation work for voltage improvement.

4. Terminal Substation Expansion Program

The expansion program for terminal substations is shown in Table III-4. In the near term, additional transformers are to be installed in stages at terminal substations along EGAT's loop transmission line corresponding to growth of load. Unit capacity of transformers of terminal substations are to be 300 MVA instead of the present 200 or 250 MVA in consideration of future load growth.

The load of the existing Chidlom Substation, located in the metropolitan area, which has a transformer capacity of 500 MVA, will grow to 426 MVA in 1989 reaching the ultimate capacity (utilization factor 85%). Therefore, some of distribution substations receiving power from Chidlom Substation must be connected to another terminal substation. (See Fig. III-12) Around the end of the near term, as the next step, a second terminal substation in the urban area must be planned and construction should be started.

Comparative studies of types of terminal substation in the urban area were made as follows:

(1) Case study

The following 3 cases of types of terminal substations in the metropolitan area were studied.

Case "A" – 230 kV terminal substation and
230 kV underground transmission line
Case "B" – 69 kV sub-terminal substation and
69 kV underground transmission line
Case "C" – 69 kV sub-terminal substation and
69 kV overhead transmission line

(2) Results of comparison

Table III-5 which gives the results of comparison indicate that Case "C" is the most economical. However, it would be impossible in the 10 years future to construct 6 circuits of 69 kV overhead transmission lines into the center of the city. Case "B" is the most costly. This is due to the fact that a number of 69 kV underground cables must be installed. Therefore, the most practicable solution would be Case "A".

(3) Conclusion

In the far term, construction of terminal substations in the urban area will become necessary. The suitable type would be the Chidlom pattern, that is, 230 kV indoor substation. It would be therefore necessary to perform concrete studies in the later part of the near term.

5. Protection System Expansion Program

Protection system for the near term is to be arranged by equipping standard as follows:

(1) Subtransmission line protection system

a. Normally Open π-loop (two incoming lines) System

i) Terminal substation
Distance relay
Overcurrent relay }
Earth fault relay } for back up

ii) Distribution substation
Directional overcurrent relay
Directional earth fault relay
Automatic restorator

b. Double Circuit T-branch System

i) Terminal substation
Distance relay
Overcurrent relay }
Earth fault relay } for back up

ii) Distribution substation
Selective circuit relay
(Current balance type & Zero phase current balance type)

c. Feeder Transformer System

i) Terminal substation
Overcurrent relay
Earth fault relay

ii) Distribution substation
Any relays are not necessary.

(2) Transformer Protection System

Distribution substation
Differential relay
Overcurrent relay

(3) Distribution Line Protection System

Distribution substation
Overcurrent relay
Earth fault relay
Under-frequency relay

Table III-1 DISTRIBUTION SUBSTATION EXPANSION PROGRAM - NEAR TERM (Case 2)

Unit : No. x MVA

Bloc No.	Substation	Existing	Expansion											Capacity in 1991	Remark
			'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	TTL		
10	North BKK	1x40												1x40	
	Klongkred	1x20												1x20	
20-1	Bangkok Noi	2x20				+1x20			+1x40 -1x20				+1x40	1x40 2x20	+: Addition
20-2	Bangyekhan	2x40												2x40	
	Pechkasem	3x20			*+1x40 -1x20								+1x40 -1x20	1x40 2x20	*: Fixed
	North BKK	2x20												2x20	
	Rasburana	2x40												2x40	
	Thonburi	2x40												2x40	
	Taksin	2x40												2x40	
	Pran Nok			new *1x40									+1x40	1x40	
	32231									new 2x40			+2x40	2x40	
20-3	Klong Sanpsamit	2x20												2x20	
	Prapradaen	2x40												2x40	
	Bangbon			new *1x40	*+1x40								+2x40	2x40	
20-4	Bangkrajao	2x10												2x10	
30-1	Rangsit	2x40												2x40	
30-2	Klong Rangsit	1x40						+1x40					+1x40	2x40	
40-1	Bangpood	2x20												2x20	
	43491				new 2x40								+2x40	2x40	
40-2	Donmuang	2x40												2x40	
	Nontaburi	2x20												2x20	
	Prachacuen	2x40												2x40	
40-3	Bangkapi	2x40												2x40	
	Bangsue	1x10												1x10	
	Klong Jan	2x40												2x40	
	Mochit	2x40												2x40	
	Prakanong	2x40												2x40	
	Samsen	2x40												2x40	
	Sansab	2x40												2x40	
	Sukhumvit	1x40	*+1x40										+1x40	2x40	

DISTRIBUTION SUBSTATION EXPANSION PROGRAM - NEAR TERM (Case 2)

Unit : No. x MVA

Bloc No.	Substation	Existing	Expansion											Capacity in 1991	Remark
			'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	TTL		
40-3	Paholyotion		new *1x40	*+1x40									+2x40	2x40	
40-4	Lumpini	2x40												2x40	
	Makasan	2x40												2x40	
	Sapandam	4x40												4x40	
	Pathumwan	2x40												2x40	
	Silom	2x40												2x40	
	Watlieb	2x40												2x40	
	Yothee	2x40												2x40	
	Sipraya		new *1x40	*+1x40									+2x40	2x40	
	Chidlom			new *2x40									+2x40	2x40	
	Klongtoey			new *2x40									+2x40	2x40	
40-5	Mahamek	2x40												2x40	
	Satupradit	1x40	*+1x40										+1x40	2x40	
40-6	Bangna	2x40												2x40	
	Plywood	1x20												1x20	
	Samrong	2x40												2x40	
	South BKK	1x20												1x20	
	Tangkung	2x40												2x40	
	39184								new 2x40				+2x40	2x40	
50-1	Ramintra	2x40												2x40	
	Ladplakao	1x40												1x40	
50-2	Bangplee	1x40												1x40	
	Onnuj	2x40												2x40	
50-3	Paknam	2x40												2x40	
	Bangpu	2x40												2x40	
	Bangbor					new 2x20		+1x20					+3x20	3x20	
	44091								new 2x40				+2x40	2x40	
	Total No. of substation	46	+2	+4	+1	+1			+2	+1			+11	57	
	Total capacity (MVA)	2,990	+160	+320	+140	+60		+60	+180	+80			+1,000	3,990	

DISTRIBUTION SUBSTATION EXPANSION PROGRAM - NEAR TERM (Case 2)

Unit : No. x MVA

Bloc No.	Substation	Existing	Expansion '82	'83	'84	'85	'86	'87	'88	'89	'90	'91	TTL	Capacity in 1991	Remark
	Capacity in each year (MVA)	2,990	3,150	3,470	3,610	3,670	3,670	3,730	3,910	3,990	3,990	3,990		3,990	
	Total load in each year (MVA)		1,448	1,541	1,636	1,737	1,835	1,946	2,064	2,176	2,299	2,432		2,432	
	Utilizing factor (%)		46.0	44.4	45.3	47.3	50.0	52.2	52.8	54.5	57.6	60.9		60.9	

Fig. III-1 Service Area of Distribution Substation (1982)

Note (1) ⊛ ..... Distribution substation

(2) A letter is 1 km^2 mesh

(3) Same letter shows service area of same distribution substation

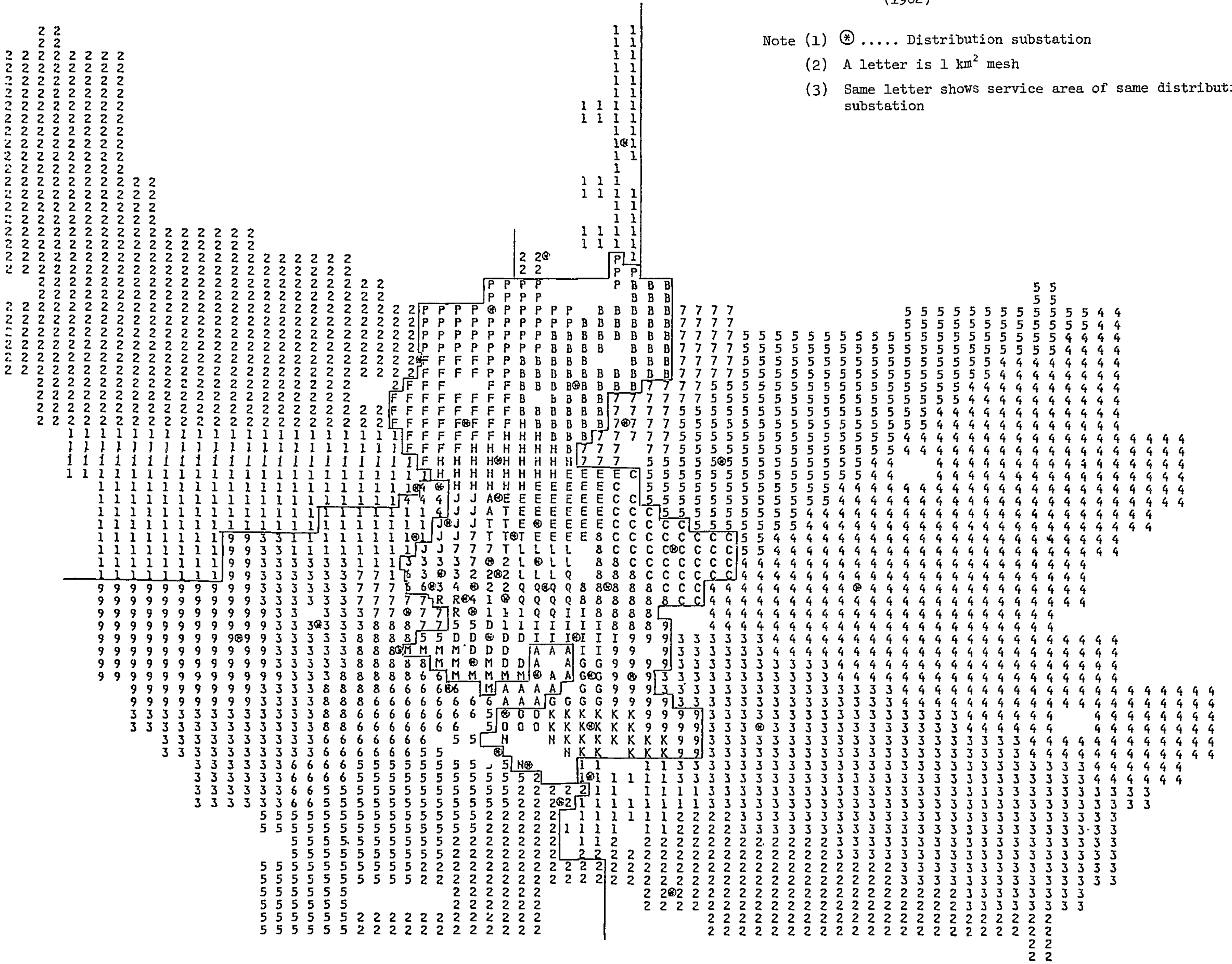


Fig.III-2 Service Area of Distribution Substation (1991)

Nore (1) ⊗ ..... Distribution substation

(2) A letter is 1 km^2 mesh

(3) Same letter shows service area of same distribution substation

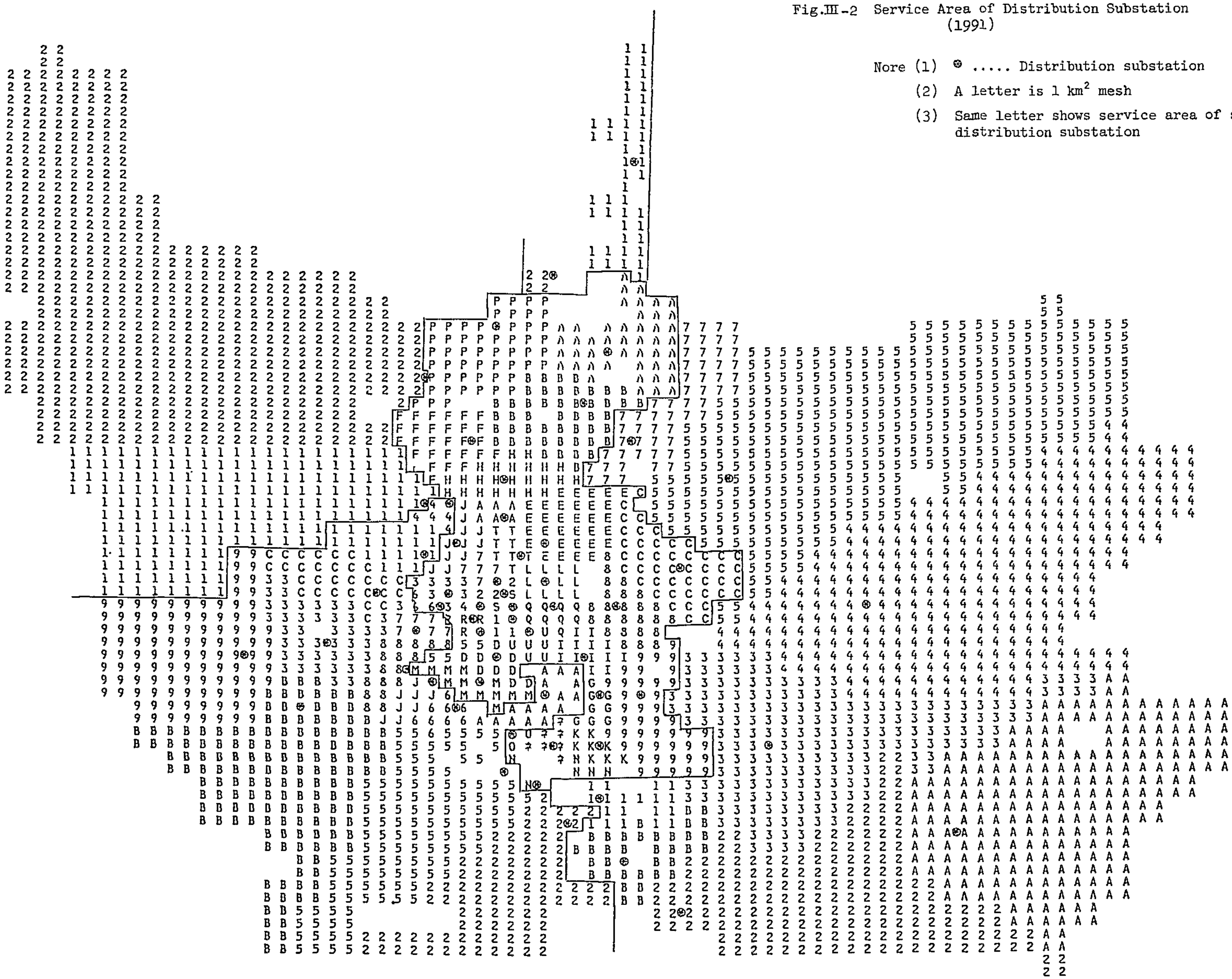


Table III-2 Subtransmission Line Expansion Program - Near Term (Case 2)

Year	Voltage (KV)	Section	Length (km)	Existing facility	New by TAAC constructed	Remark
'82	69	near Paholyotin	1.8		UGC	
"	"	"	1.0		OHS	
"	69	near Sipraya	1.2		OHS	
"	"	"	3.0		UGC	
'83	69	Prannok π connection	0.2		OHS	
"	"	North BKK to Bangyeekhan	5.5	OHB	OHB	
"	69	Bangborn to Bangkok Noi	7.2		OHS x 2cct	
"	69	Klongtoey π connection	0.1		OHS	
'84	69	Pechkasen to Bangkok Noi	6.0	OHB	OHB	
"	69	near Klong Ransit	6.7		OHS	for 43491
'85	115	Bangbor	20.0		OHS x 2cct	
'88	69	39184 to South BKK	7.2		OHB	

(Note) OHS . . . . . . Overhead single conductor
OHB . . . . . . Overhead bundle conductor
UGC . . . . . . Underground cable

(Case 2)

Subtransmission Line Expansion Program - Near Term

Year	Voltage (KV)	Section	Length (km)	Existing facility	New by TAAC constructed	Remark
'88	115	44091 to Paknam	8.4		OHB	
"	"	Paknam to South BKK	4.8	OHB	OHB	
"	"	44091 to South BKK	12.6	OHS, OHB	OHB	
'89	69	32231 π connection	0.2		OHB	
"	"	near South BKK	9.0	OHS, OHB	OHB	

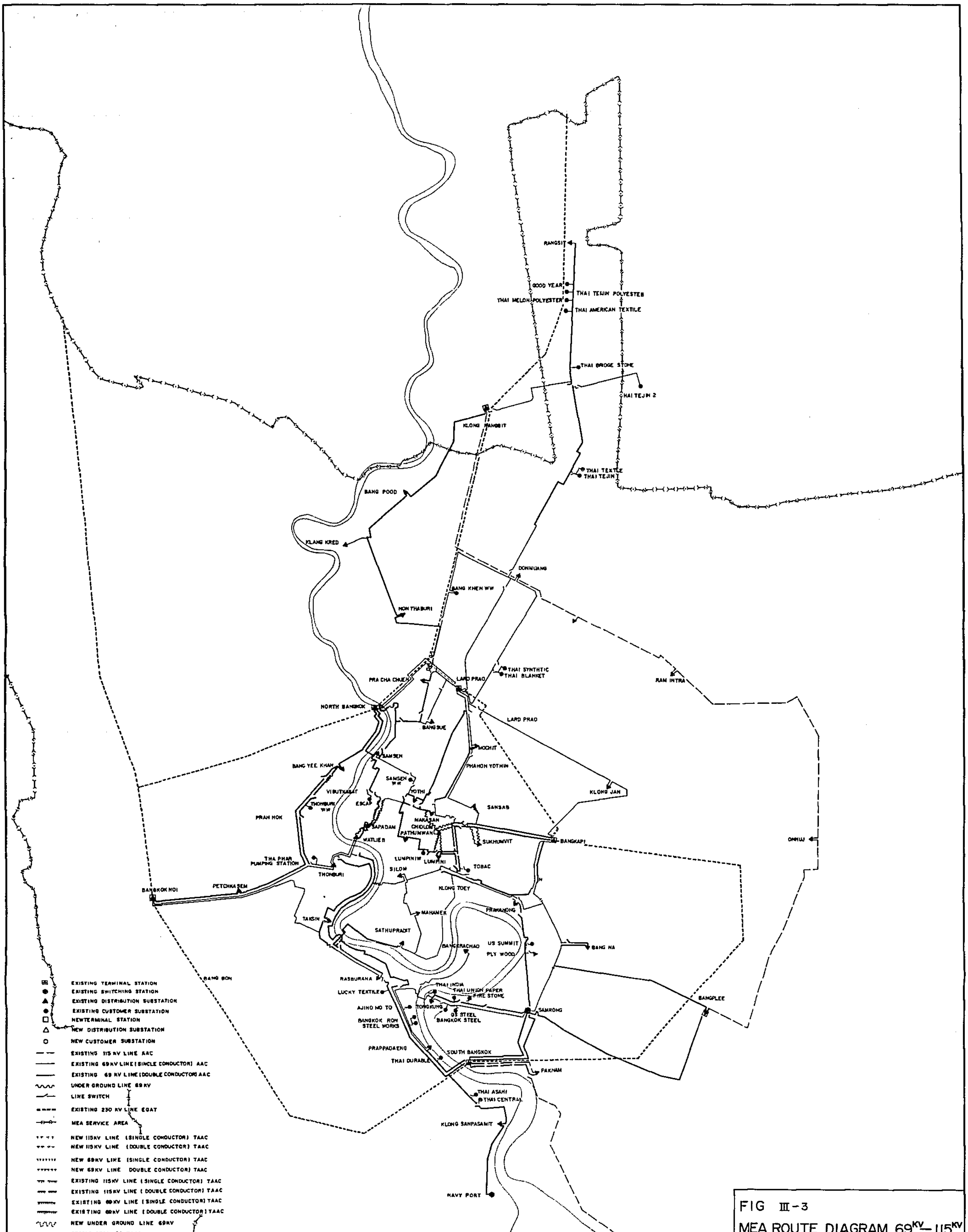


FIG Ⅲ-3
MEA ROUTE DIAGRAM $69^{KV}-115^{KV}$
(1981)

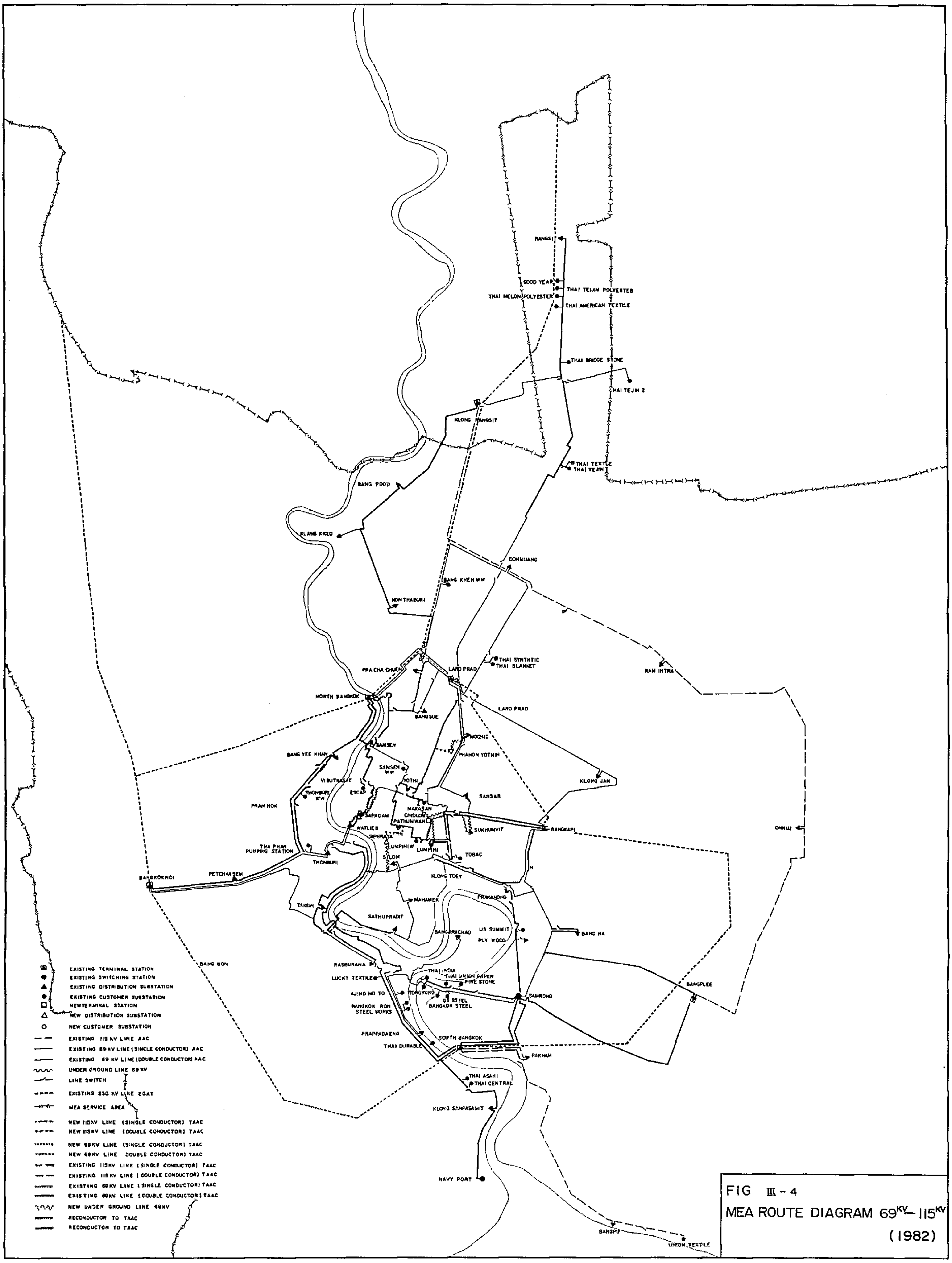


FIG III-4
MEA ROUTE DIAGRAM 69KV–115KV
(1982)

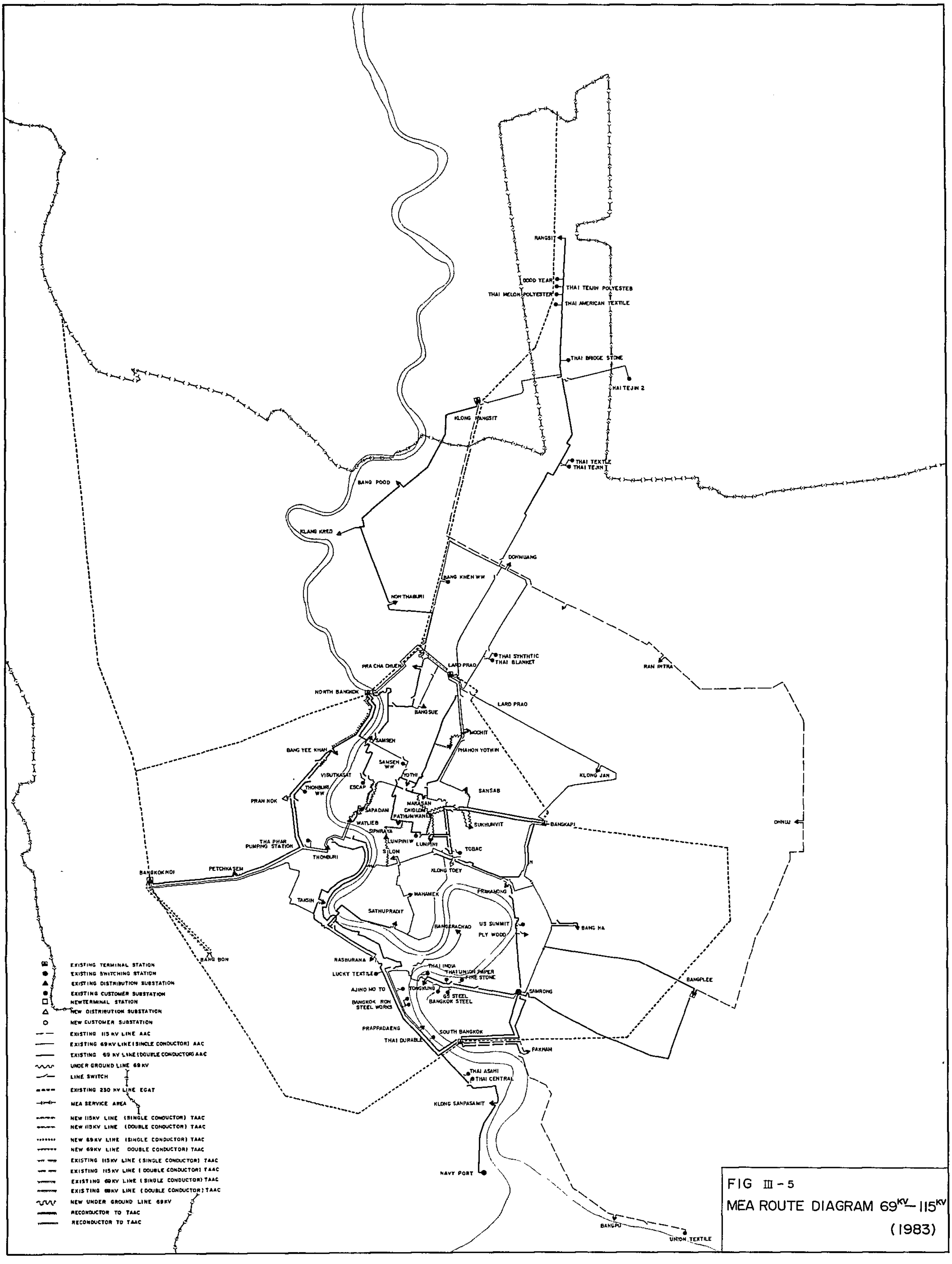


FIG III - 5
MEA ROUTE DIAGRAM 69KV – 115KV
(1983)

FIG III-6
MEA ROUTE DIAGRAM 69kV–115kV
(1984)

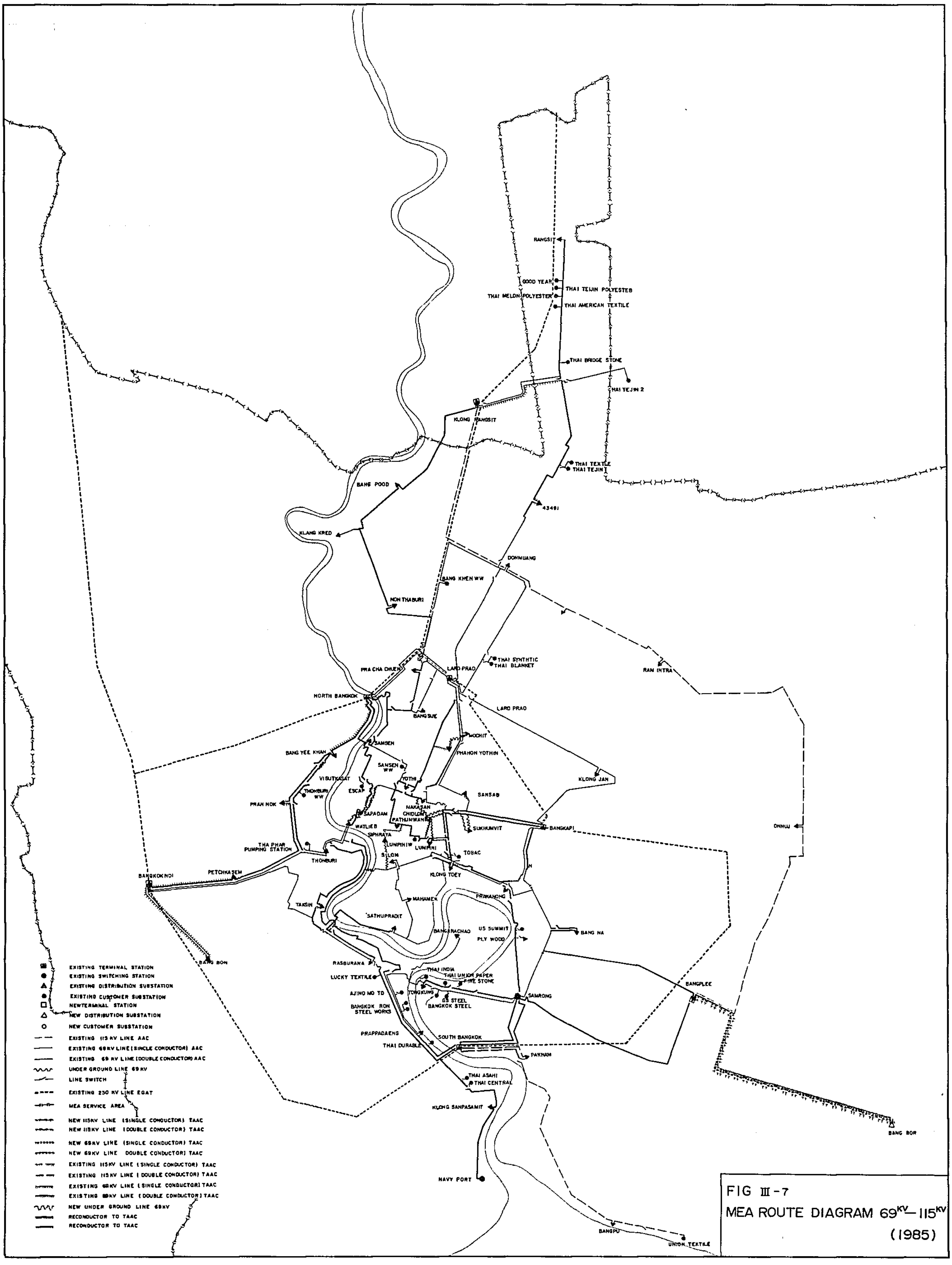


FIG III-7
MEA ROUTE DIAGRAM 69KV–115KV
(1985)

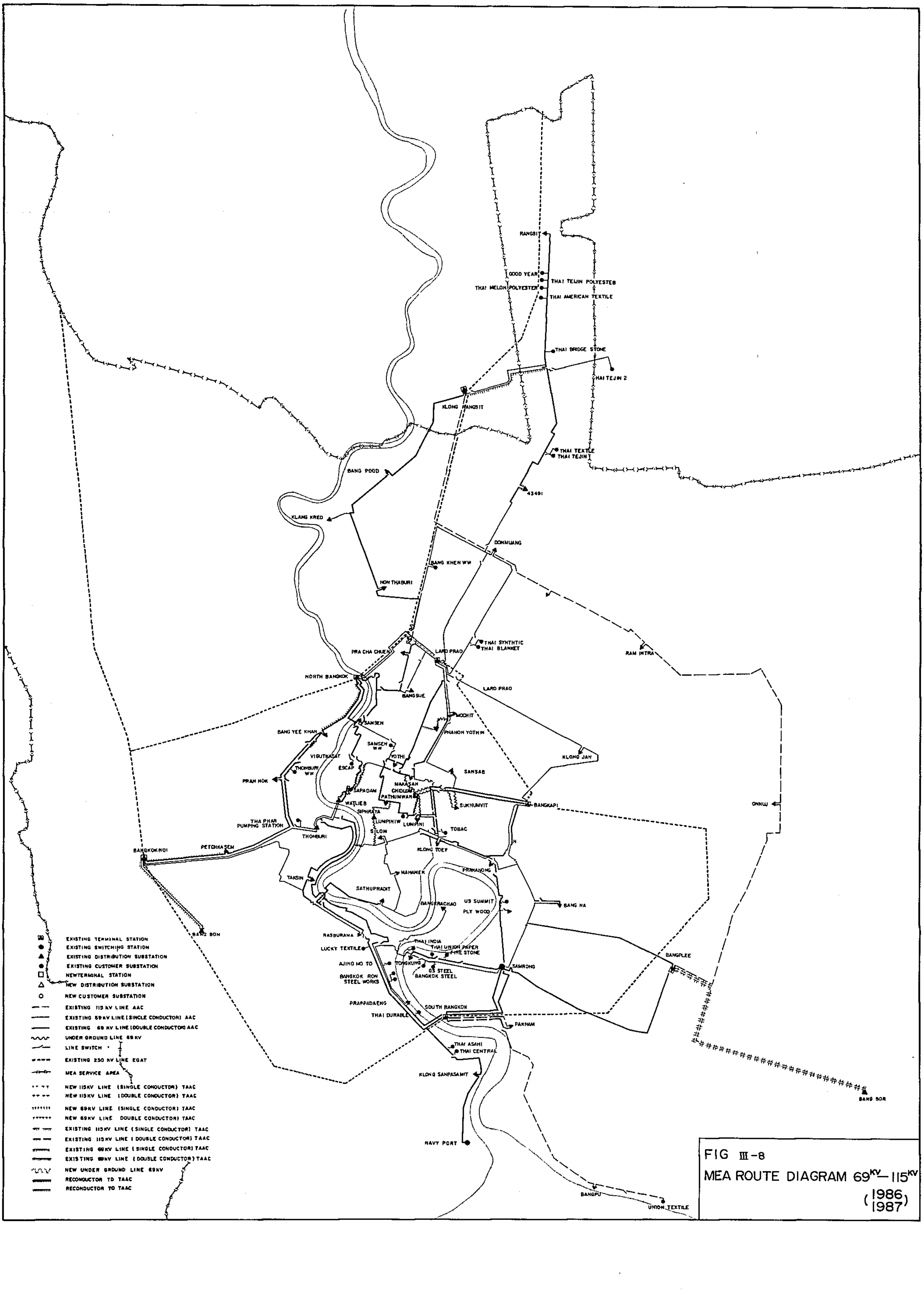


FIG III-8
MEA ROUTE DIAGRAM 69KV–115KV (1986/1987)

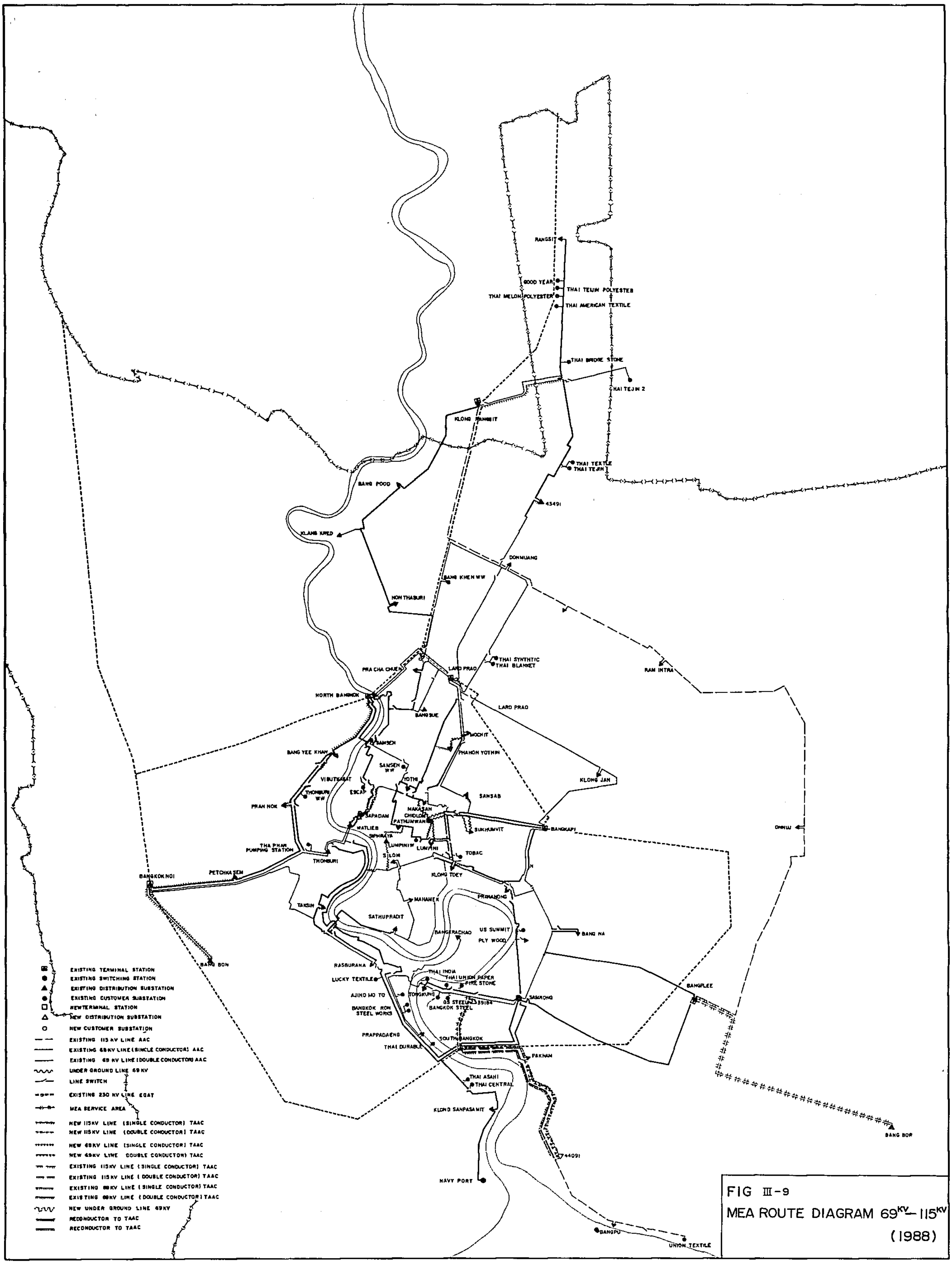


FIG III-9
MEA ROUTE DIAGRAM 69^{KV}–115^{KV}
(1988)

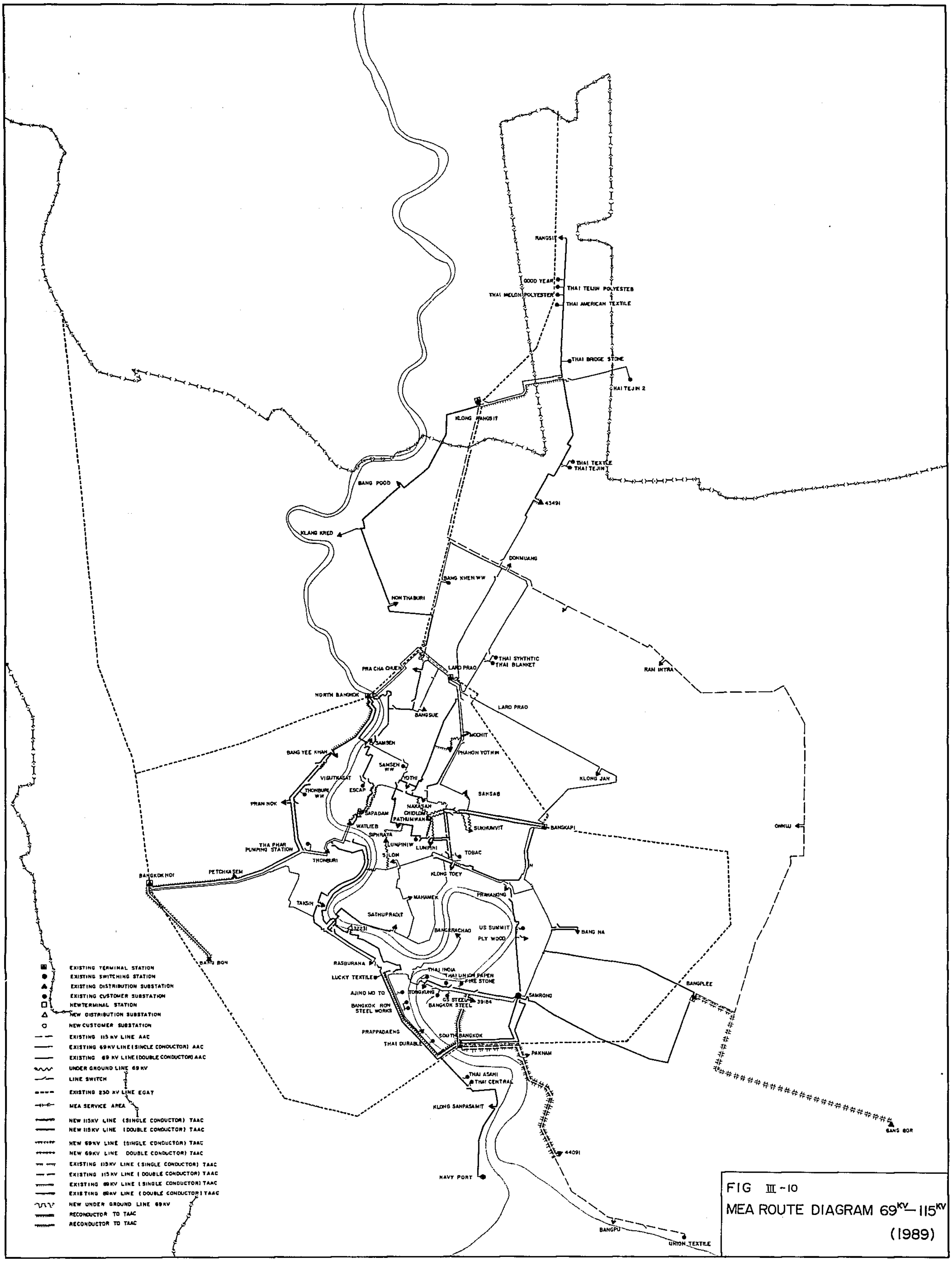


FIG III-10
MEA ROUTE DIAGRAM 69KV–115KV
(1989)

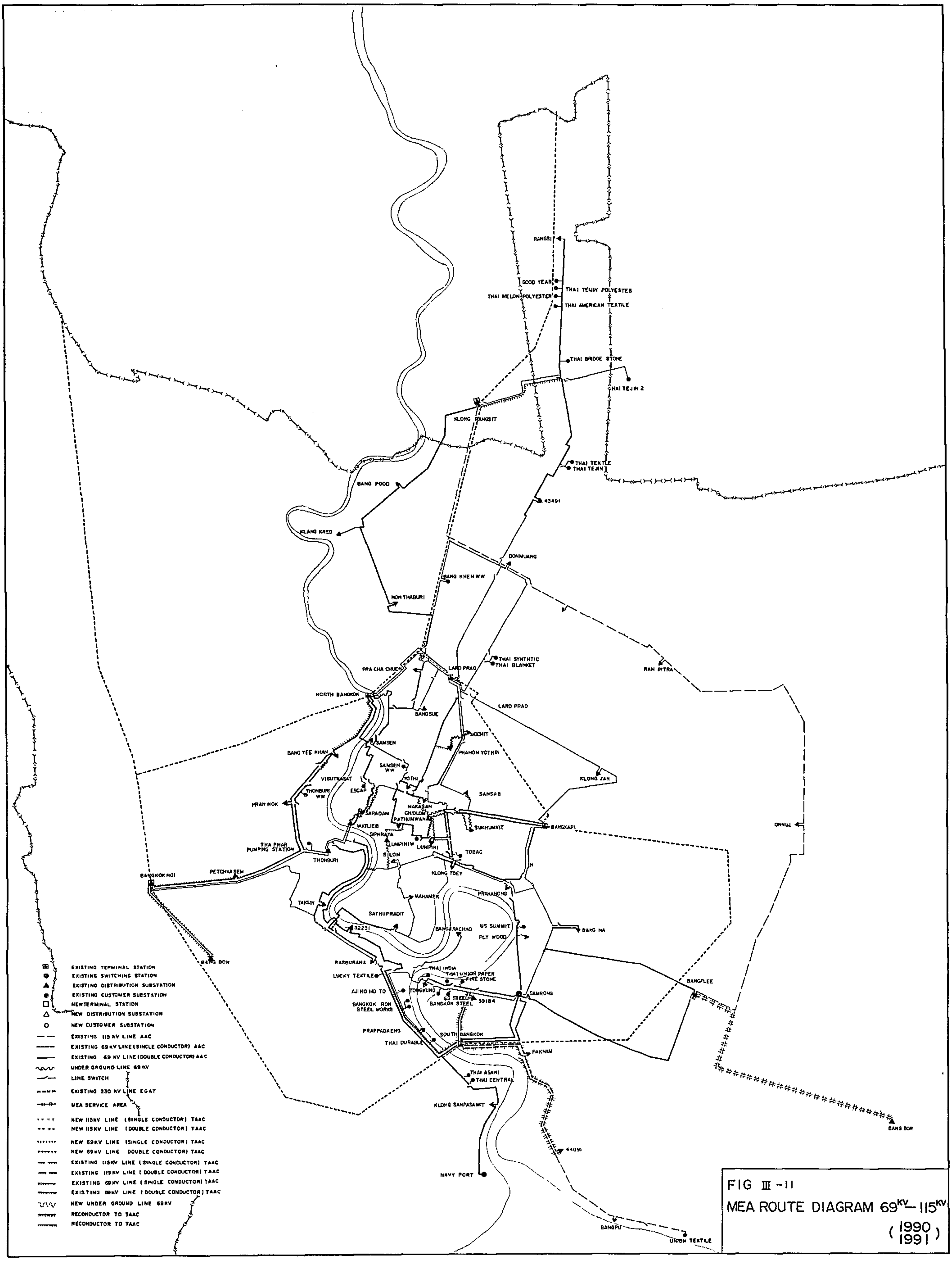


FIG III-11
MEA ROUTE DIAGRAM $69^{KV}-115^{KV}$
(1990
1991)

Table III-3 DISTRIBUTION FEEDER EXPANSION PROGRAM - NEAR TERM (Case 2)

Unit : No. of feeder

Bloc No.	Substation	Existing	Expansion											No. of feeder in 1991	Remark
			'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	TTL		
10	North BKK	3												3	
	Klongkred	1												1	
20-1	Bangkok Noi	5										+1	+1	6	
20-2	Bangyekhan	6	+1										+1	7	
	Pechkasem	9	+1				+1	+3	+4				+9	18	
	North BKK	4												4	
	Rasburana	9	+1										+1	10	
	Thonburi	10												10	
	Taksin	12								+1	+1	+1	+3	15	
	Pran Nok			+4	+1								+5	5	
	32231									+10			+10	10	
20-3	Klong Sanpsamit	5												5	
	Prapradaen	8						+1	+2				+3	11	
	Bangbon			+2			+1						+3	3	
20-4	Bangkrajao	4												4	
30-1	Rangsit	6									+1		+1	7	
30-2	Klong Rangsit	5												5	
40-1	Bangpood	6												6	
	43491				+3			+1				+1	+5	5	
40-2	Donmuang	9	+2	+2								+1	+5	14	
	Nontaburi	5	+1	+1		+1							+3	8	
	Prachacuen	5	+4	+2	+1	+1	+1	+1	+1	+1			+12	17	
40-3	Bangkapi	10									+1	+1	+2	12	
	Bangsue	3												3	
	Klong Jan	12												12	
	Mochit	10					+1		+1	+1	+1	+1	+5	15	
	Prakanong	9												9	
	Samsen	10												10	
	Sansab	12												12	
	Sukhumvit	5	+2					+1		+1		+1	+5	10	

DISTRIBUTION FEEDER EXPANSION PROGRAM - NEAR TERM (Case 2)

Unit : No. of feeder

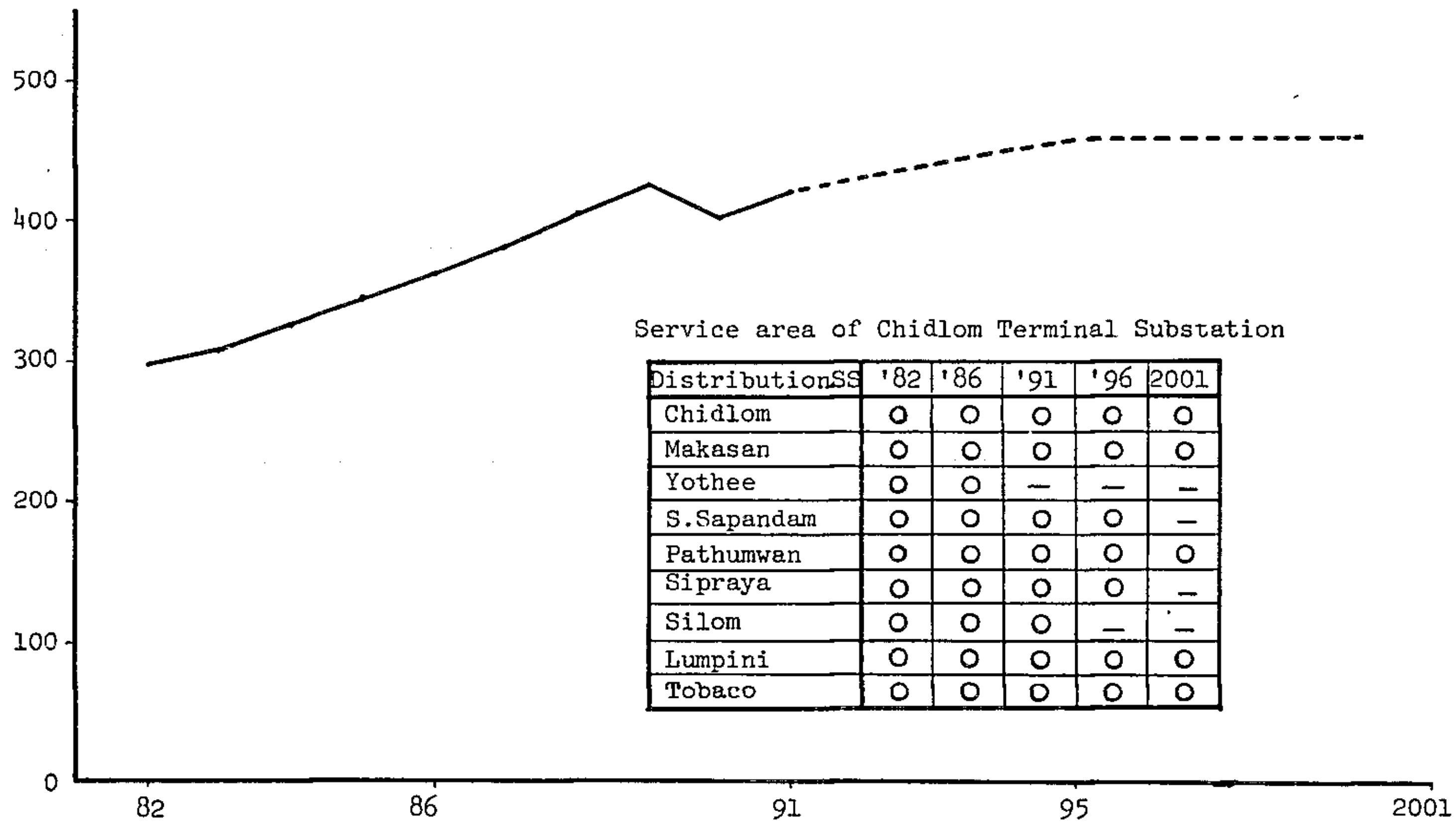
Bloc No.	Substation	Existing	Expansion '82	'83	'84	'85	'86	'87	'88	'89	'90	'91	TTL	No. of feeder in 1991	Remark
40-3	Paholyotion		+5	+1		+1			+1	+1			+9	9	
40-4	Lumpini	12												12	
	Makasan	10												10	
	Sapandam	17						+1	+1	+1	+1	+1	+5	22	
	Pathumwan	9												9	
	Silom	10								+1		+1	+2	12	
	Watlieb	8												8	
	Yothee	12												12	
	Sipraya		+5	+1	+1			+1		+1		+1	+10	10	
	Chidlom			+6		+1				+1			+8	8	
	Klongtoey			+3	+1				+1				+5	5	
40-5	Mahamek	10												10	
	Satupradit	4	+2	+1	+1		+1	+1		+1		+1	+8	12	
40-6	Bangna	12									+1	+2	+3	15	
	Plywood	3												3	
	Samrong	12												12	
	South BKK	3					+1						+1	4	
	Tangkung	10												10	
	39184								+9	+1			+10	10	
														7	
50-1	Ramintra	7												7	
	Ladplakao	3												3	
50-2	Bangplee	5												5	
	Onnuj	5												5	
	54264														
50-3	Paknam	5												5	
	Bangpu	5												5	
	Bangbor					+1	+1		+1				+3	3	
	44091								+3			+1	+4	4	
	Total of feeder	345	+24	+25	+8	+5	+7	+10	+24	+21	+6	+14	+142	487	
	Additional Length of Conductor (km)		+153	+113	+41	+37	+68	+78	+138	+115	+62	+109	+914		

Table III-4 Terminal Substation Expansion Program - Near Term

Unit : MVA

Substation	Existing	Expansion										Capacity in 1991
		'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	
North BKK	438											438
BKK Noi	200			+200				+300				700
S.BKK (69KV)	400			+200			+300					900
" (115KV)	200											200
Bangplee(69KV)	200											200
" (115KV)					new 200							200
K.Rangsit(69KV	200					+300						500
" (115KV			new 200									200
Lard Prao	200				+200						+300	700
Bangkapi	200					+200						400
Chidlom	500											500
TTL	2,538		+200	+400	+400	+500	+300	+300	-	-	+300	4,938

Fig.Ⅲ-12 Load of Chidlom Terminal Substation



Service area of Chidlom Terminal Substation

DistributionSS	'82	'86	'91	'96	2001
Chidlom	O	O	O	O	O
Makasan	O	O	O	O	O
Yothee	O	O	—	—	—
S.Sapandam	O	O	O	O	—
Pathumwan	O	O	O	O	O
Sipraya	O	O	O	O	—
Silom	O	O	O	—	—
Lumpini	O	O	O	O	O
Tobaco	O	O	O	O	O

Table III-5 Comparison of Construction Cost of Terminal Substation and Sub-terminal Substation

Case	Installation	Estimated Cost (10^6 B)
A	Substation – indoor (Chidlom type) Voltage – 230 kV Transformer – 300 MVA, 3 banks	200
	Transmission line – underground cable installed in pipe duct, 10 km Voltage – 230 kV Conductor – 800 mm² and 1200 mm² OF cable, 4 circuits	550
	Total	750
B	Substation – distribution substation combined with 69 kV switching station	100
	Transmission line – underground cable installed in pipe duct, 10 km Voltage – 69 kV Conductor – 800 mm² PEX cable, 12 circuits	1,260
	Total	1,360
C	Substation – same as Case "B"	100
	Transmission line – overhead line strung on concrete pole, 10 km Voltage – 69 kV Conductor – 795 MCM TAAC, bundle, 6 circuits	154
	Total	254

III-2 Amount of Investment and Expense

1. Classification of Investment

Investment is divided into purpose and object as summarized below.

(1) Investment in expansion of facilities

a. Investment in expansion of distribution system which includes distribution substation, subtransmission line and high voltage distribution line.

b. Investment in expansion of upper stream system which includes terminal substation, sub-terminal substation and 230 kV transmission line.

c. Investment in expansion of lower stream system which includes distribution transformer, low voltage distribution line and other facilities.

(2) Policy guided investment

Investment in improvement of reliability and aesthetic purpose which depend on policy decision of management, for examples.

(3) Investment in renewal of function of facilities

Renewal or repair of facilities for deterioration of function.

(4) Other investment

Vehicle and testing equipment, etc.

2. Amount of Investment

(1) Investment in expansion of facilities

a. Investment in expansion of distribution system

Investment in expansion of distribution system is obtained by computer calculation of a program developed for expansion of distribution system. Table III-6 gives the amount of investment (including price escalation of 8% annually), and Table III-7 gives the present value (at 1979 price) of the amount of investment.

Investment in expansion of distribution system is divided into as below.

- Distribution substation
- Subtransmission line
- High voltage distribution line

This investment seems to be small compared to the amount of investment. The reason is a small number of distribution substation to be constructed in the near term.

b. Investment in expansion of upper stream system

In the near term, new transformers of terminal substation are to be built on EGAT's loop transmission line, and this will not entail any investment by MEA. However, some advance investment will be required on terminal substations to be constructed in the metropolitan area by MEA in the far term. The investment for this purpose is given in Tables III-6 and III-7.

c. Investment in expansion of lower stream system

This investment covers a number of small components forming an installation, and it is difficult to segregate and add up the investment in each component. Therefore, the method adopted is to make a macro analysis of past trends of investment and to proportion it to growth of demand or to growth in number of customers.

As shown in Tables III-6 and III-7, this investment amounts to a sizable sum, and investment of distribution transformers, low voltage overhead lines and meters hold big portion in this amount. It means that improvement of load management for distribution transformers is very important matter, as recommended previously in the Existing Condition Analysis Report.

(2) Policy guided investment

Examples of policy guided investments are as follows:

a. investments to improve reliability
b. advance investments for acquisition of land
c. investments for aesthetic and environmental purposes
d. other investments

In the near term, as policy guided investment, investment is semi-insulated conductor to reduce distribution line fault is added. This amount is taken as 100% of the annual increase in quantity of conductors of distribution feeders which is calculated by computer. This type of investment is given in Tables III-6 and III-7.

(3) Investment in renewal of function of facilities

Investment in renewal of distribution substations is calculated in proportion to growth of number of distribution substation using average amount of MEA's recent year program, and that of subtransmission lines is to growth of length of subtransmission lines. And that of distribution facilities is included in above paragraph (1)-C. Those are shown in Tables III-6 and III-7.

(4) Other investment

Investment of vehicle and testing equipment, etc. is calculated in proportion to growth of number of customers using average amount of MEA's recent year program.

This investment is given in Tables III-8 and III-9.

(5) Amount of investment

The amount of investment in a former 10 years period is approximately 13,470 million Bahts, and approximately 8,230 million Bahts converted into present value (at 1979 price). (See Tables III-8 and III-9.)

3. Amount of Expense

Amount of expense corresponding to the abovementioned investment is given in Tables III-10 to III-13.

Table III-6 Amount of Investment - Near Term (Detail)

Unit : Million Baht

Year	Substation			Transmission line			Distribution line		
	Distribution SS	Upper system	Renewal	Sub-TL	Upper system	Renewal	High voltage DL	Lower system DL	Semi-insulated DL
'82	89		76	69		17	112	484	(51) 13
'83	194		85	33		29	176	556	(38) 10
'84	106		100	27		31	94	609	(14) 4
'85	72		118	91		11	34	682	(12) 4
'86	4		122			60	32	716	(23) 8
'87	35		135			26	77	764	(26) 10
'88	246		151	120		42	171	861	(46) 19
'89	99		159	21		121	149	920	(38) 17
'90	5		175			49	45	1,046	(21) 10
'91	12	167	189		563	17	90	1,197	(36) 18
TTL	861	167	1,311	360	563	403	978	7,836	(306) 113

SS : Substation, TL : Transmission line, DL : Distribution line

( ) : Semi-insulated conductor length in cct·km

Table III-7 Present Value of Amount of Investment - Near Term (Detail)

Unit : Million Baht

Year	Substation			Transmission line			Distribution line		
	Distribution SS	Upper system	Renewal	Sub-TL	Upper system	Renewal	High voltage DL	Lower system DL	Semi-insulated DL
'82	82		71	63		17	103	446	12
'83	164		73	28		24	149	472	9
'84	83		78	21		25	74	476	3
'85	52		85	66		8	24	493	3
'86	3		81			40	21	477	5
'87	21		83			16	47	468	6
'88	139		85	68		23	96	487	11
'89	52		82	11		63	78	479	9
'90	2		84			24	22	502	5
'91	5	74	84		249	7	40	529	8
TTL	603	74	806	257	249	246	654	4,830	70

Present value : in 1979

Table III-8 Amount of Investment - Near Term

Unit : Million baht

Year	Substation	Transmi-ssion line	Distribution line	Vehicle & equipment	TTL
'82	165	86	609	52	912
'83	279	62	742	58	1,142
'84	206	58	707	64	1,036
'85	190	102	720	72	1,084
'86	126	60	756	80	1,021
'87	170	26	851	89	1,135
'88	397	162	1,051	99	1,708
'89	258	142	1,086	110	1,595
'90	180	49	1,101	122	1,452
'91	368	580	1,305	136	2,389
TTL	2,339	1,326	8,927	880	13,472

Table III-9 Present Value of Amount of Investment - Near Term

Unit : Million baht

Year	Substation	Transmi-ssion line	Distribution line	Vehicle & equipment	TTL
'82	153	80	561	48	841
'83	237	53	630	49	969
'84	161	46	553	50	811
'85	137	74	520	52	783
'86	84	40	503	53	679
'87	104	16	521	54	696
'88	224	91	594	56	965
'89	134	74	566	57	831
'90	86	24	529	59	697
'91	163	256	577	60	1,056
TTL	1,483	752	5,554	538	8,327

Table III-10 Amount of Expense - Near Term (Detail)

Unit : Million Baht

Year	Substation			Transmission line			Distribution line		
	Distribution SS	Upper system	Renewal	Sub-TL	Upper system	Renewal	High voltage DL	Lower system DL	Semi-insulated DL
'82	13		12	9		2	17	76	2
'83	42		25	13		6	44	163	4
'84	58		40	17		10	60	258	4
'85	69		58	28		12	65	365	5
'86	70		76	29		19	70	477	6
'87	76		96	28		23	81	597	8
'88	113		119	44		28	109	731	11
'89	128		143	47		44	133	875	13
'90	128		170	47		50	139	1,039	15
'91	131	25	198	47	73	52	153	1,226	18
TTL	829	25	936	310	73	246	872	5,807	85

SS : Substation, TL : Transmission line, DL : Distribution line

Table III-11 Present Value of Amount of Expense - Near Term (Detail)

Unit : Million Baht

Year	Substation			Transmission line			Distribution line		
	Distribution SS	Upper system	Renewal	Sub-TL	Upper system	Renewal	High voltage DL	Lower system DL	Semi-insulated DL
'82	12		11	8		2	16	70	2
'83	36		21	11		5	38	138	3
'84	46		31	13		8	47	202	3
'85	50		42	21		8	47	263	4
'86	47		50	19		13	47	317	4
'87	46		59	17		14	50	366	5
'88	64		67	25		16	62	413	6
'89	66		75	24		23	69	456	7
'90	62		81	23		24	67	499	7
'91	57	11	88	21	32	23	67	542	8
TTL	487	11	525	183	32	136	510	3,266	48

Present value : in 1979

Table III-12 Amount of Expense - Near Term

Unit : Million baht

Year	Substation	Transmi-ssion line	Distribution line	Vehicle & equipment	Distribu-tion loss	TTL
'82	25	11	95	12	49	192
'83	67	19	211	24	56	378
'84	98	27	322	39	67	553
'85	127	40	435	54	80	736
'86	146	48	553	72	91	910
'87	172	51	686	92	109	1,109
'88	232	72	851	114	120	1,388
'89	271	91	1,021	138	132	1,651
'90	298	97	1,193	165	156	1,909
'91	354	172	1,397	195	184	2,302
TTL	1,790	629	6,764	903	1,044	11,129

Table III-13 Present Value of Amount of Expense - Near Term

Unit : Million baht

Year	Substation	Transmi-ssion line	Distribution line	Vehicle & equipment	Distribu-tion loss	TTL
'82	23	10	88	11	45	177
'83	57	16	179	21	48	321
'84	77	21	252	30	52	433
'85	92	29	314	39	57	531
'86	97	32	368	48	61	605
'87	105	31	421	56	67	680
'88	131	41	481	64	68	784
'89	141	47	532	72	69	860
'90	143	47	573	79	75	916
'91	156	76	617	86	81	1,017
TTL	1,023	351	3,824	506	622	6,325

III-3 Power Flow, Short Circuit Capacity and Reliability Studies

1. Power Flow Studies

Results of power flow calculations for the near term (10 years) are given in Fig. III-13 to Fig. III-22. In the power flow calculation, distribution substations receive power from the closest terminal substation. However, in certain years when problems on power flow are encountered, changes have been made in the connection of distribution substation, but calculation results reveal no problem.

The following problems encountered in the course of the power flow calculations require attention.

That is problem of connection methods of underground cable of subtransmission line. Fig. III-23 gives examples of the connection methods. As in the case of Examples 1 to 4, if connection is made to pass the line current through the underground cable, the connection point will become a bottleneck of power flow in the future as the current carrying capacity of the underground cable is small.

In the case of Example 5, there will be no problem as the load (current) of 1 substation will pass through the underground cable.

2. Short Circuit Capacity Studies

Short circuit capacity studies of MEA's power system were made for the years 1982, 1986 and 1991. Fig. III-24 to III-26 are impedance maps of the power system for the above mentioned years.

As the basis of calculation, the impedance of the power source side was calculated from data of EGAT's power development program. According to the calculation, the short circuit capacity at the 69 kV side of each terminal substation is a maximum of 4,400 MVA.[1] (See Table III-14) The short circuit capacity at the 69 kV side of each distribution substation is smaller than the value at the terminal substation. (See Table III-15)

Note:[1] The impedance of new transformers (230 kV/69 kV) installed in terminal substations is 4.63% on a 100 MVA basis.

3. Reliability Studies

(1) Outage of subtransmission lines and substations

Average service interruption time to customers by outage of 1 bank of transformer in distribution substation caused by fault of distribution substation, subtransmission line and terminal substation was calculated.

a. Input data

On the basis of actual data of 1 bank fault in MEA's power system in the past, the following values were used as input data.

i) 1 bank fault

- service restored by switching operation at the substation in case of fault of subtransmission lines
  - occurrence of fault – 4.066 times/bank·year
  - average interruption time – 6 minutes per fault
- service restored by supplying power from another substation
  - occurrence of fault – 0.303 times/bank·year
  - average interruption time – 150 minutes per fault

ii) time required for outside help at time of fault

"A" area – 30 minutes
"B" area – 45 minutes
"C" area – 60 minutes

b. Output

One bank fault under the above mentioned conditions results in an annual average service interruption to customer of 0.635 hour/year in the year 1982. Calculation results as shown in Table III-16 indicate very little change annually in the said value until 1991. This result means that;

i) the current flow and the voltage drop in the distribution line were within the determined limits, and therefore no change takes place in the frequency (interchange factor) of receiving power from another distribution at time of fault of 1 bank of transformer,

ii) loading (maximum utilization factor) of 1 bank of transformer in the substation is according to the predetermined value.

In other words, the power system expansion program can be said to be properly calculated by computer, and the program which is the output of the computer is one that will not result in degradation of reliability.

Table III-17 gives the interchange factor of each substation. It will be noted that interchange of power is the least in the substations of "C" area.

(2) Outage of distribution feeders

a. Calculation method of average service interruption time per customer

Length of distribution line per feeder	:	ℓ (cct. km/feeder)
Number of faults annually per distribution line	:	n (no./cct. km)
Service interruption time per fault	:	t (minute)
Total number of feeders	:	F
Total number of customers	:	C
Average total service interruption time per customer	:	ΣHC

$$\Sigma HC = \frac{\ell \times n \times C/F \times F \times t}{C}$$

$$= \ell \times n \times t \text{ min./year·customer}$$

$$= \frac{\ell \times n \times t}{60} \text{ hour/year·customer}$$

b. Data

Length of distribution line per feeder .... calculated from computer output

Number of faults annually per circuit .... 112.6/100 cct. km

Service interruption time per fault
(Feeder interruption time) .... 4.2 minutes

c. Average annual service interruption time to customer

Year	Circuit length per feeder ℓ(cct. km/f)	Average service interruption time to customer (H/year.customer)
1982	14.1	1.11
83	13.6	1.07
84	13.4	1.05
85	13.4	1.05
86	13.3	1.05
87	13.2	1.04
88	12.8	1.01
89	12.4	0.98
90	12.4	0.98
91	12.3	0.97

Note:

(a) In the calculations, the effect of increased number of feeders according to the distribution line expansion plan is calculated.

(b) An attempt has been made to find some kind of method of countermeasure to reduce outage rate and to evaluate it's effect, but this was not possible because the service interruption statistics (distribution) compiled by MEA give data only according to primary causes (Unknown 42%, rain storm 20%, etc.)
In the future statistics of outage, a cross statistics giving primary cause and facilities damaged (insulator, cross arm, conductor, transformer, etc.) should be compiled in order to be able to perform studies on countermeasures to prevent reoccurrence of fault and to know the effects by the implementation of countermeasures.

(c) Service interruption time per fault
According to MEA's statistics of faults, 2 kinds of service interruption are recorded.

- One is feeder interruption time .... 4.2 minutes.
- Another is disturbance time .... 57.8 minutes.

Feeder interruption will cause service interruption to all customers served by that feeder, at each occurrence, and therefore, average total service interruption time to customers can be calculated by the above given calculation formula.
In the case of disturbance time, statistics on time (minutes) of service interruption to some of the customers served by the feeder out-of-service due to fault are available, but the magnitude of the number of customers interrupted with service is neglected, these data cannot be used for calculation of average service interruption time to customers. Therefore, it is recommended that statistics be compiled with an indicator of number of customers x service interruption time.
In MEA's statistics emphasis is placed on service outage load (MW), and data are compiled to give an indicator of MW-minutes (energy loss). However, as load (MW) fluctuates from time to time of a day, the above statistics are not good as an indicator for reliability because the calculation of actual outage power (MW) and study of future plan will be complicated.

(3) Countermeasure to Improve Reliability

As countermeasures to improve reliability, the following 3 kinds were considered.

a) Countermeasures to reduce frequency of occurrence of faults
b) Countermeasures to reduce continuation time of faults
c) Countermeasures to confine area affected by faults

a. Countermeasures to reduce frequency of occurrence of faults

First, analysis should be made of the cause of fault and the facilities damaged, and then find the vulnerable facility to establish an effective countermeasure. For example, if non-insulated conductors are replaced with semi-insulated conductors on a distribution line, how many percent of the number of faults can be reduced, the adoption of semi-insulated conductors in what portion of distribution line will bring the best results, etc.

b. Countermeasures to reduce continuation time of faults

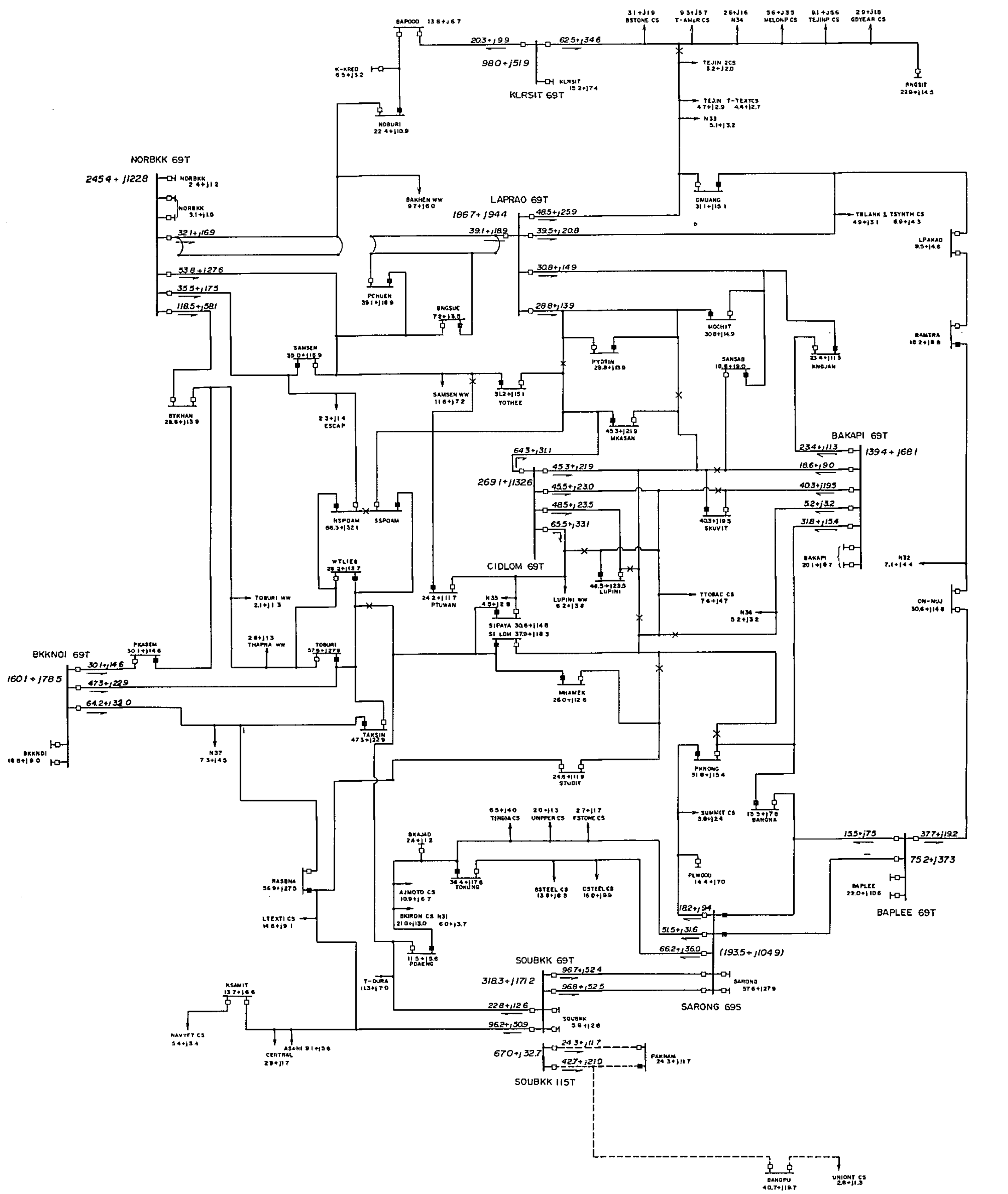
The MEA has already introduced radio telephone cars for restoration work of faults. In our experience, we find that with the growth of volume of traffic in cities, the maneuverability of radio telephone cars will not be as one desires. In such case, the most effective service restoration mean is to adopt remote control switches and automatic switches. The adoption of remote control switches and automatic switches will bring about the results given in the following paragraph, and the adoption of these switches should be made a matter of a separate detail study.

c. Countermeasures to confine area affected by faults

If the area of service interruption can be confined at the time of fault, this will reduce the number of customers affected by service interruption. For this subject, the following countermeasures are necessary.

- 2 power sources for every substation
- multi-banks of transformers,
- maintenance of maximum utilization factor of transformers in substations
- adoption of section switches for distribution lines (See note below).

Note: Section switches for distribution lines employed by MEA are single pole disconnecting switches, and the operation of these switches is not convenient. It is recommended that 3 pole load break switches be adopted at the earliest.



LEGEND

SYMBOL	DESCRIPTION
■, X	NORMALLY OPEN
□	NORMALLY CLOSE

FIG. III-13

POWER FLOW DIAGRAM YEAR 1982

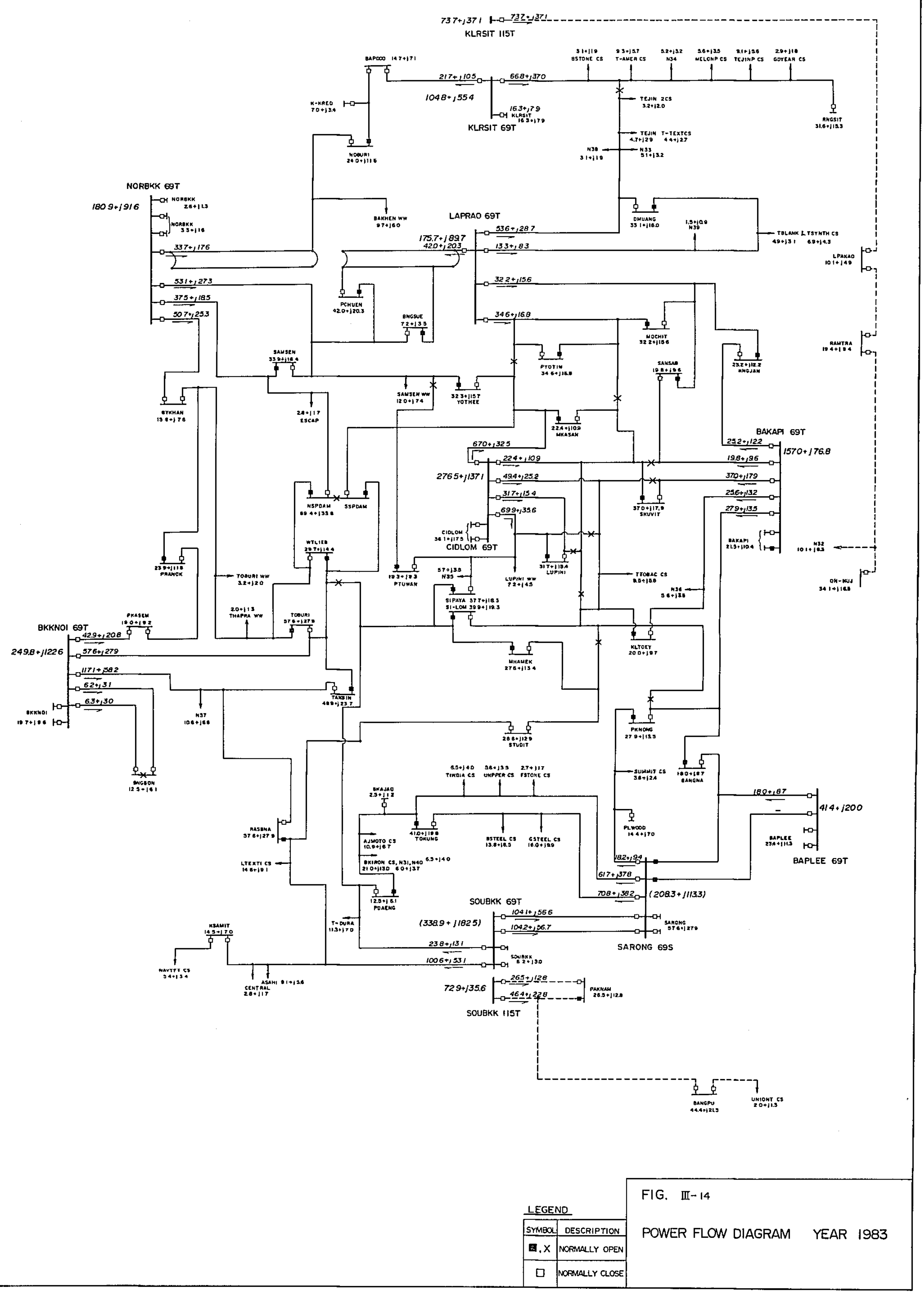


FIG. III-14

POWER FLOW DIAGRAM YEAR 1983

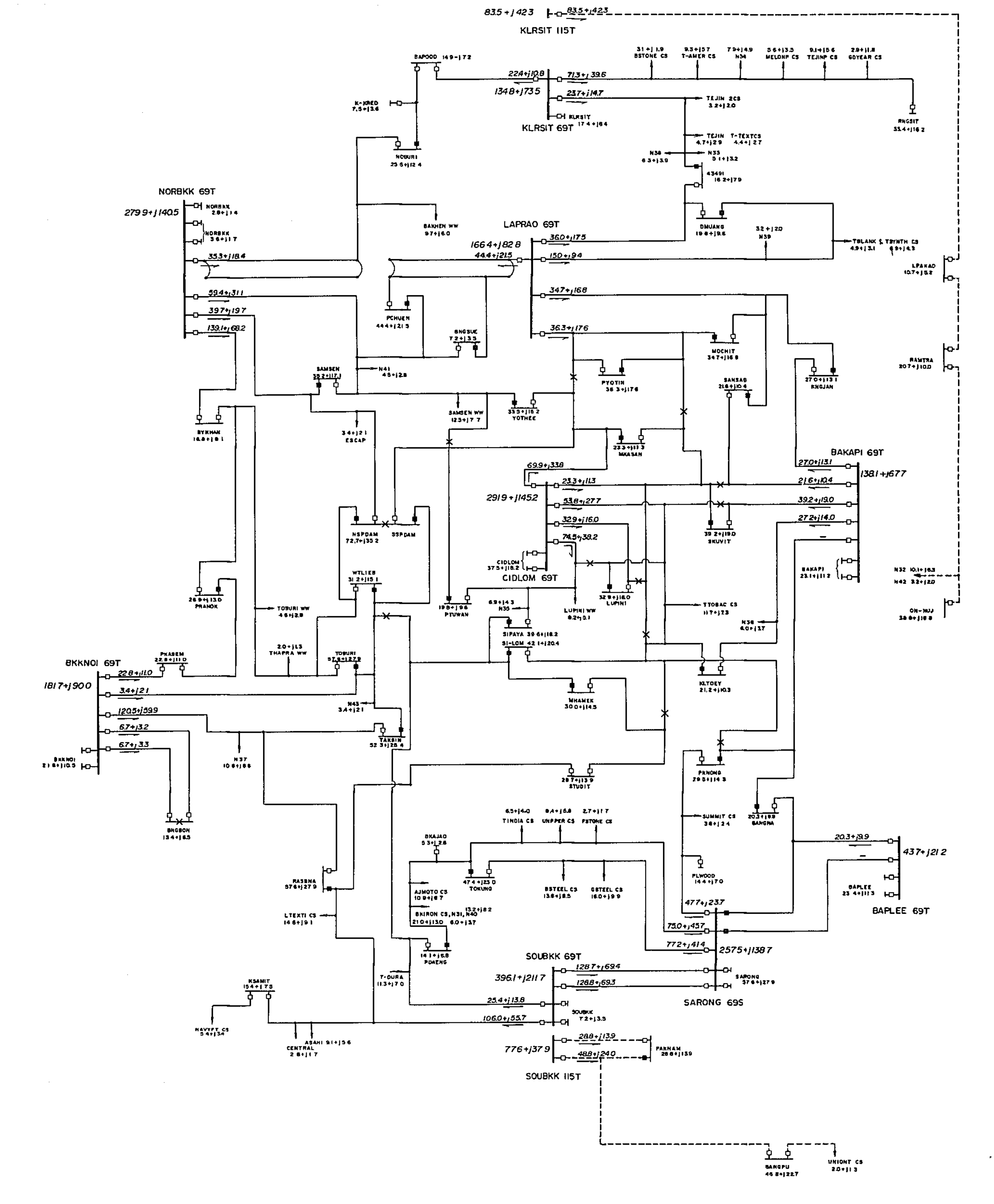
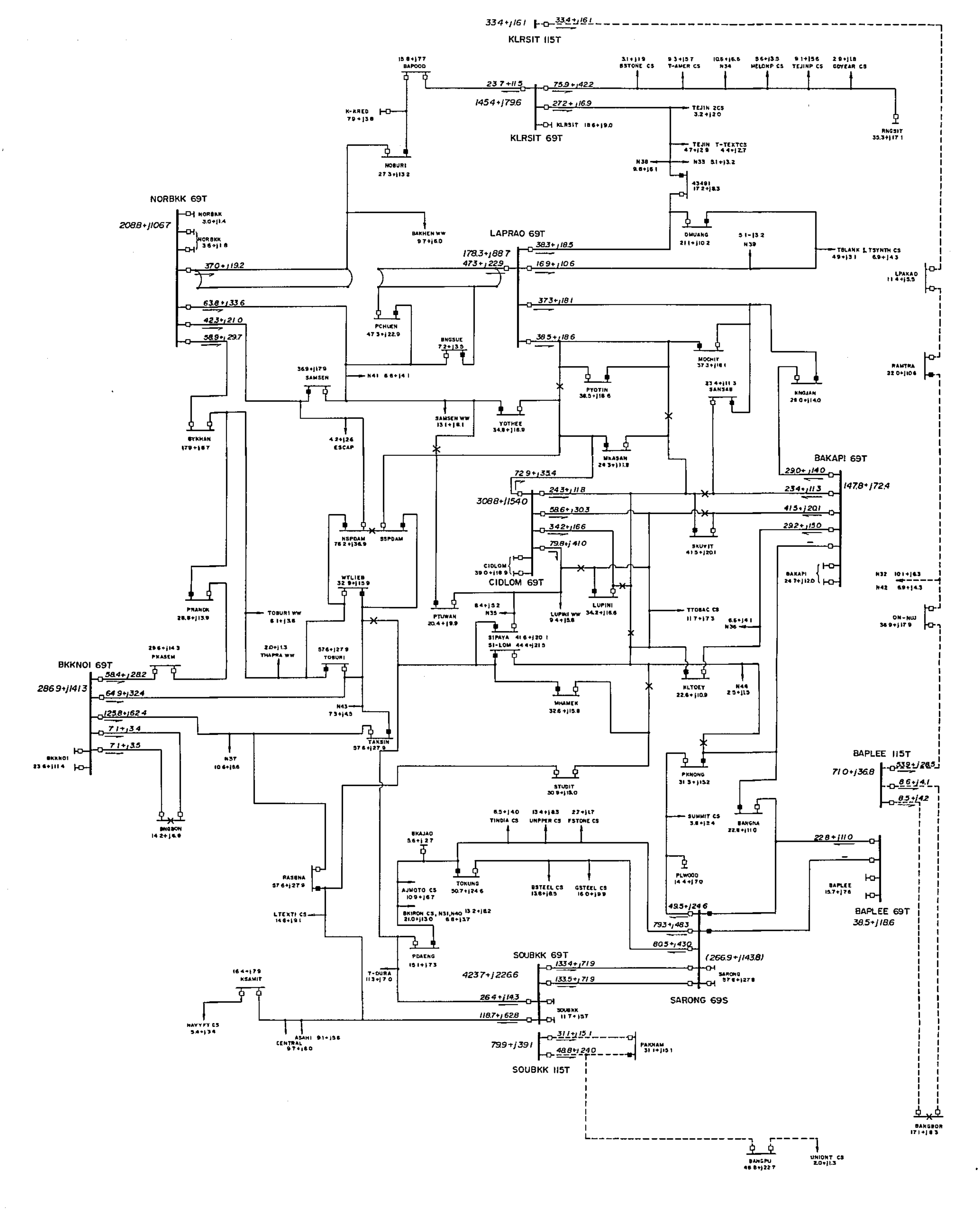


FIG. III-15

POWER FLOW DIAGRAM YEAR 1984

LEGEND

SYMBOL	DESCRIPTION
■ , X	NORMALLY OPEN
□	NORMALLY CLOSE

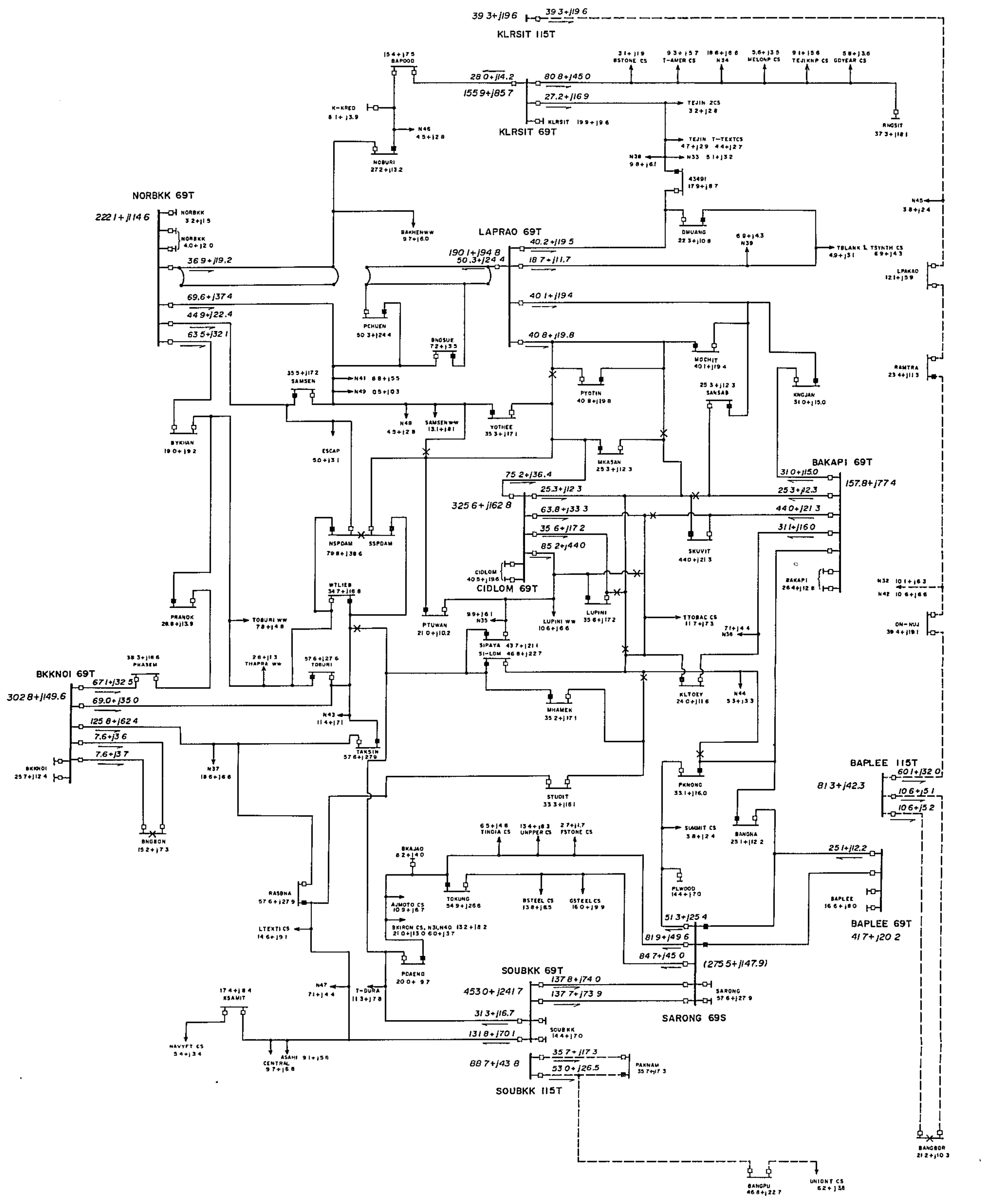


LEGEND

SYMBOL	DESCRIP TION
■, X	NORMALLY OPEN
□	NORMALLY CLOSE

FIG. III-16

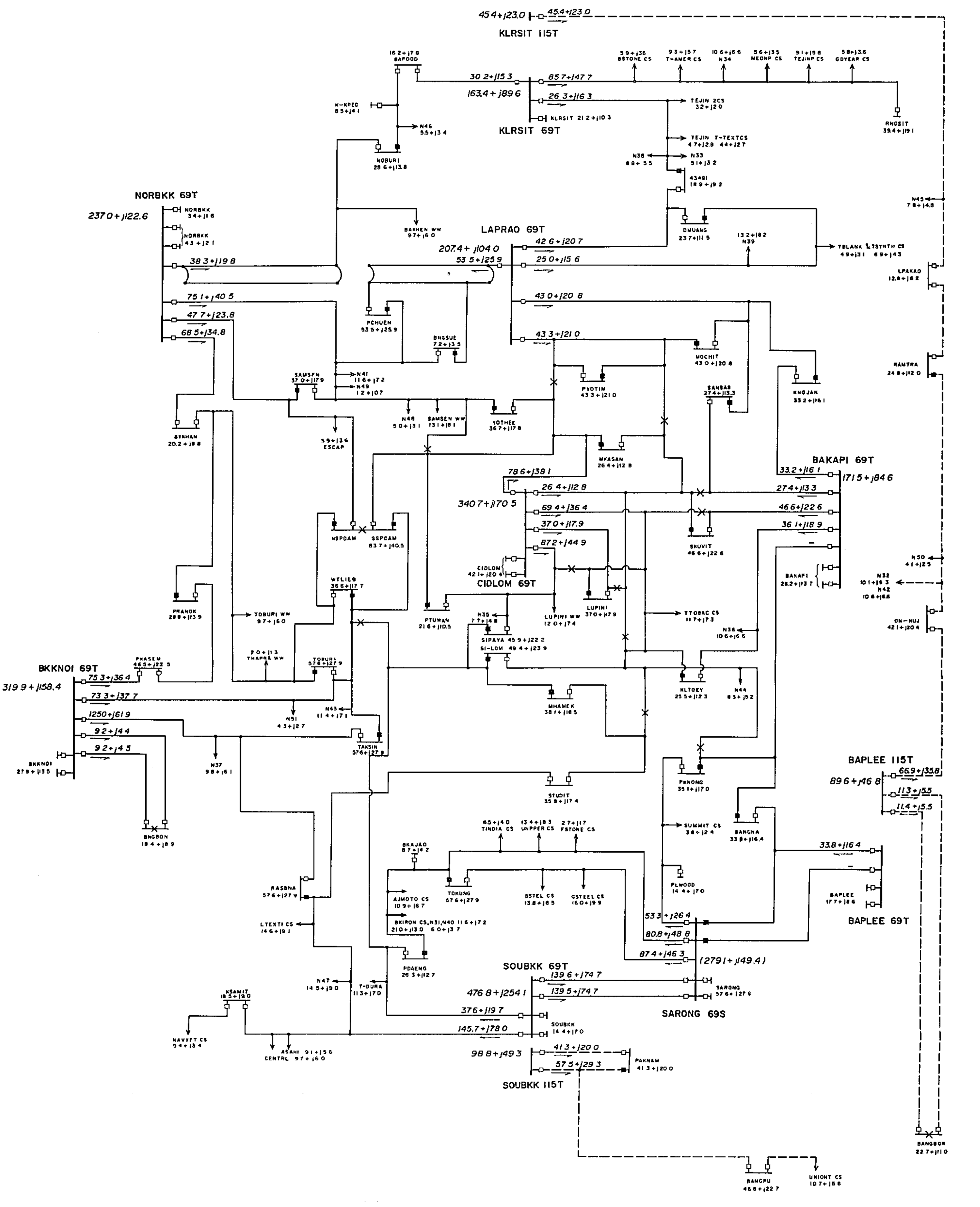
POWER FLOW DIAGRAM YEAR 1985



SYMBOL	DESCRIPTION
■, X	NORMALLY OPEN
□	NORMALLY CLOSE

FIG. III-17

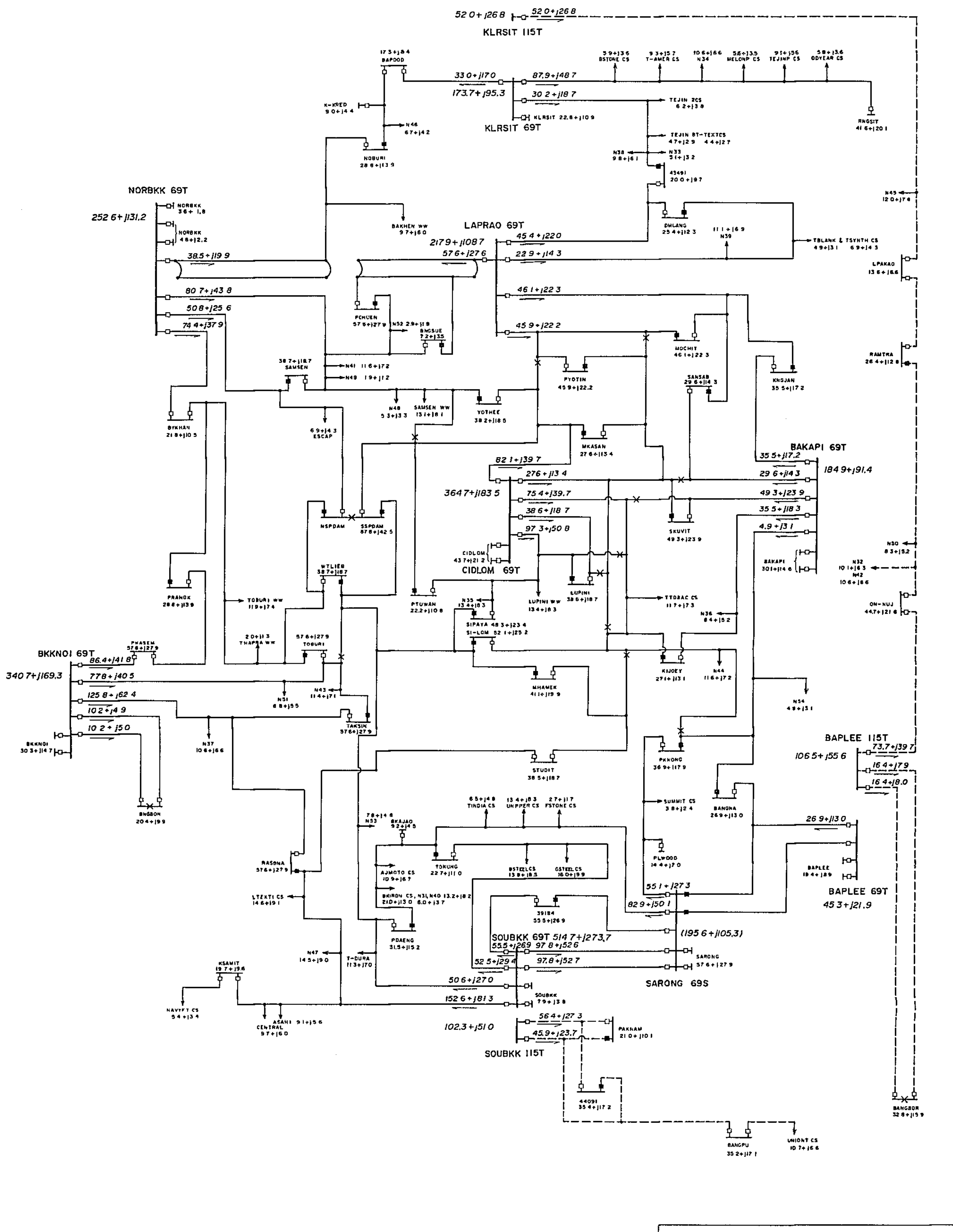
POWER FLOW DIAGRAM YEAR 1986



LEGEND	
SYMBOL	DESCRIPTION
■, X	NORMALLY OPEN
□	NORMALLY CLOSE

FIG. III - 18

POWER FLOW DIAGRAM YEAR 1987

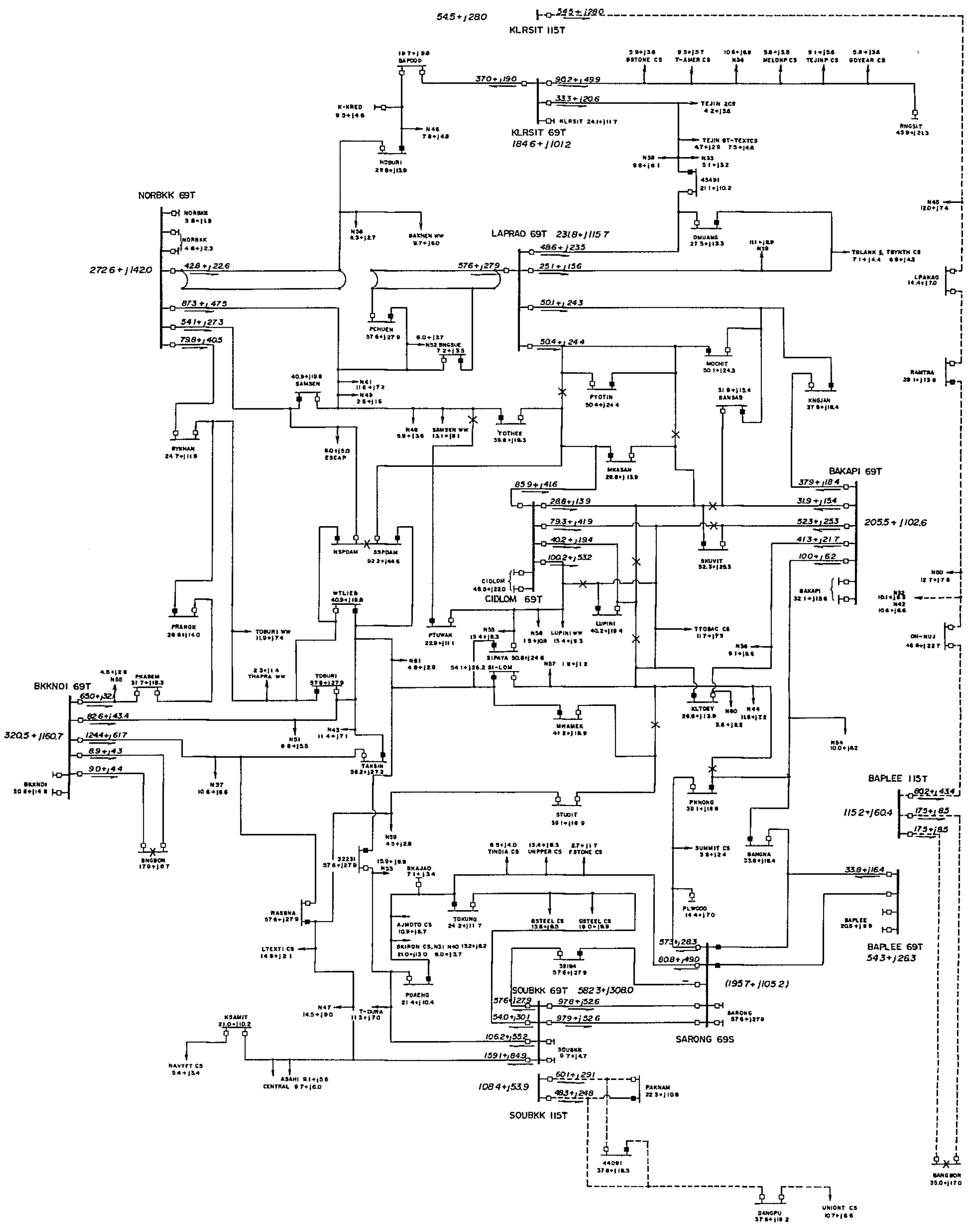


SYMBOL	DESCRIPTION
■, X	NORMALLY OPEN
□	NORMALLY CLOSE

LEGEND

FIG. III-19

POWER FLOW DIAGRAM YEAR 1988

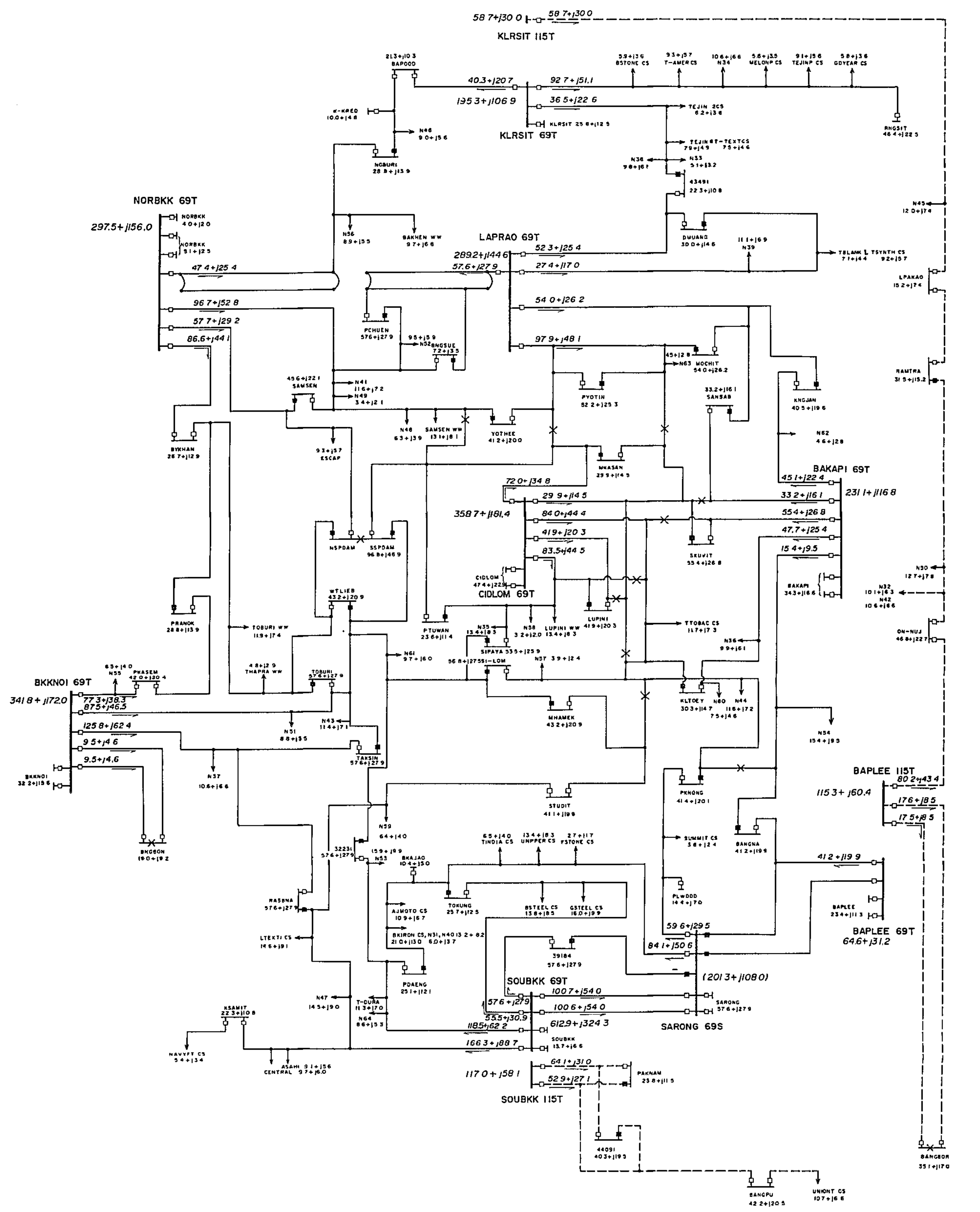


LEGEND

SYMBOL	DESCRIPTION
■, X	NORMALLY OPEN
□	NORMALLY CLOSE

FIG. III-20

POWER FLOW DIAGRAM YEAR 1989



LEGEND

SYMBOL	DESCRIPTION
■, X	NORMALLY OPEN
□	NORMALLY CLOSE

FIG. III-21

POWER FLOW DIAGRAM YEAR 1990

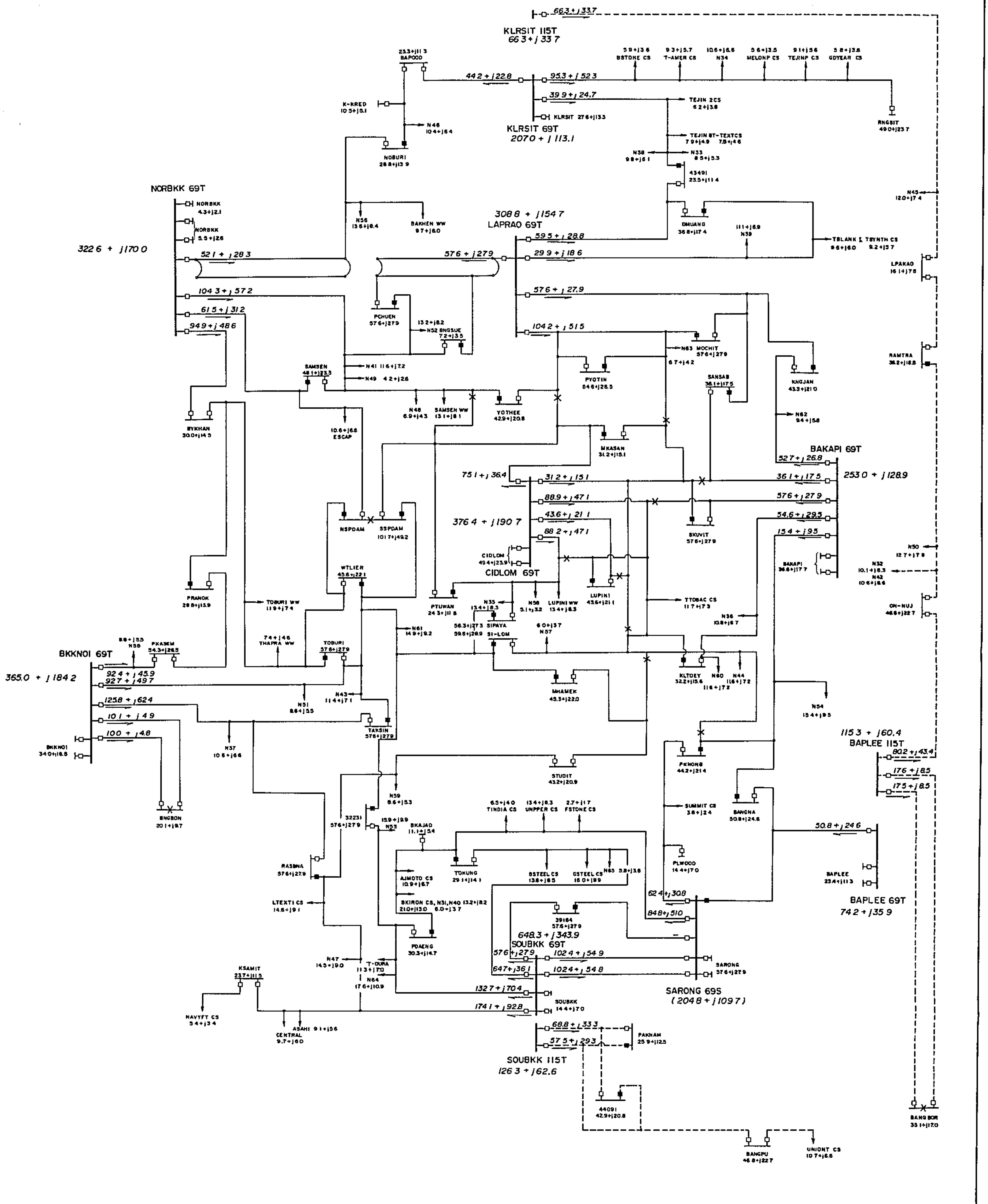


FIG. III-22

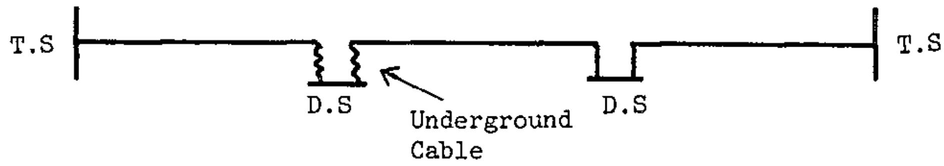
POWER FLOW DIAGRAM YEAR 1991

LEGEND

SYMBOL	DESCRIPTION
■ X	NORMALLY OPEN
□	NORMALLY CLOSE

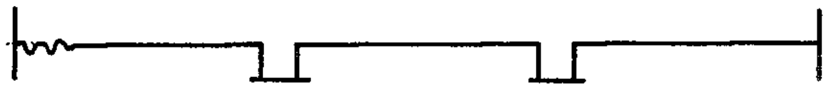
Fig. III-23 Connection of Underground Cable
(Subtransmission Line)

(Exsample 1)

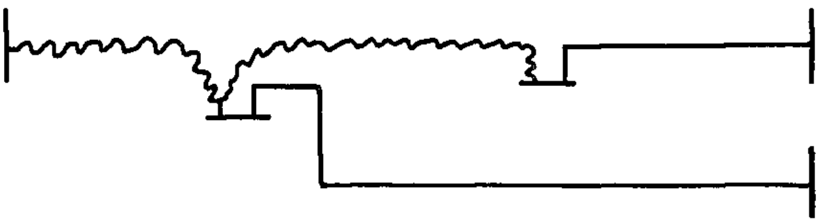


(Exsample 2)

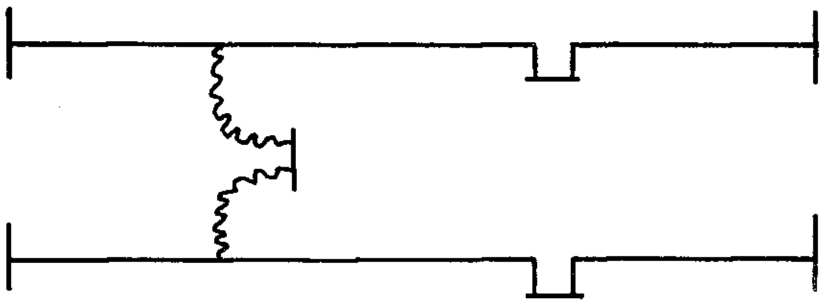
(Exsample 3)



(Exsample 4)



(Exsample 5)



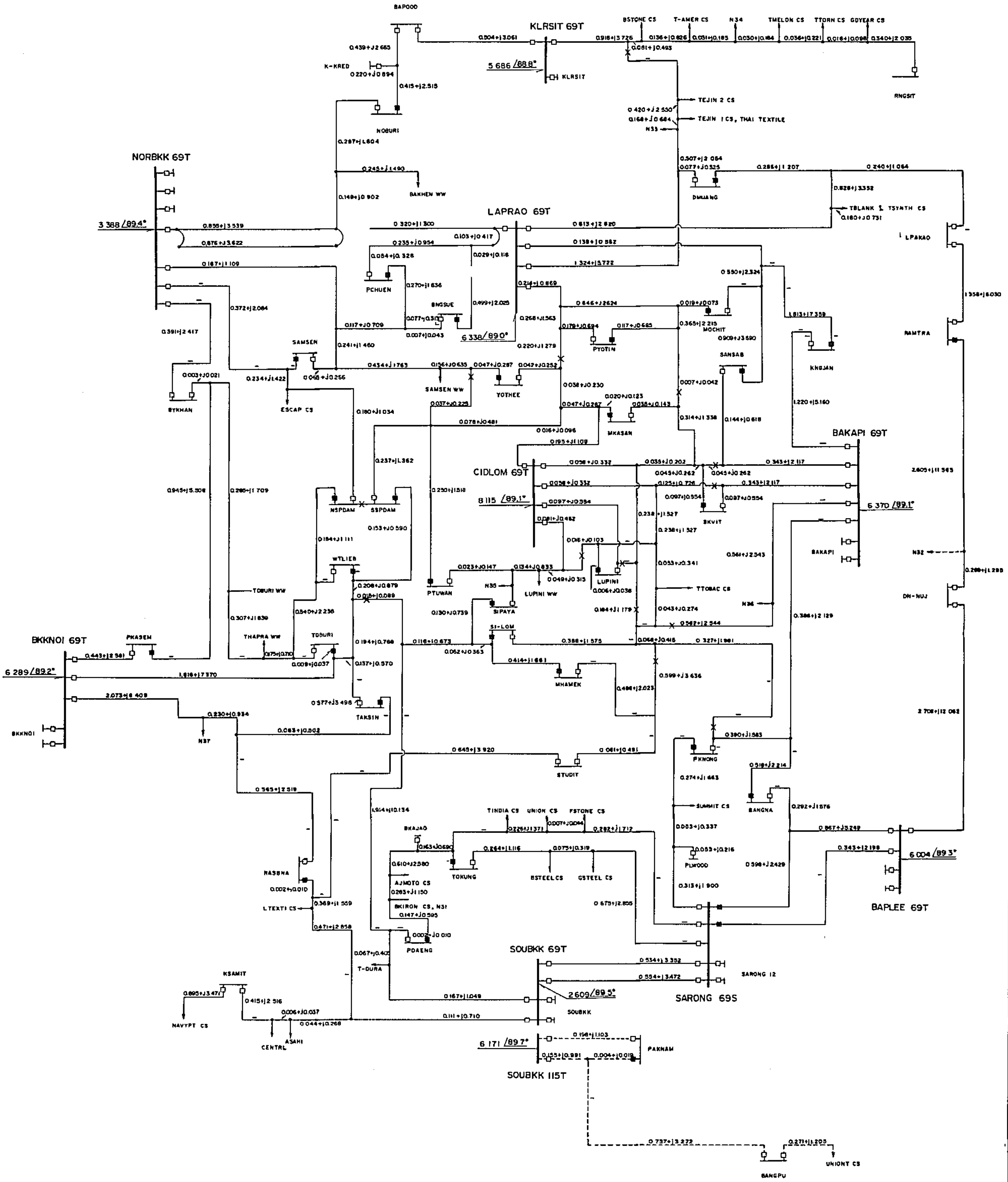


FIG. III - 24

IMPEDANCE DIAGRAM YEAR 1982

POSITIVE PHASE BASED ON 100MVA %

LEGEND

SYMBOL	DESCRIPTION
■ X	NORMALLY OPEN
□	NORMALLY CLOSE

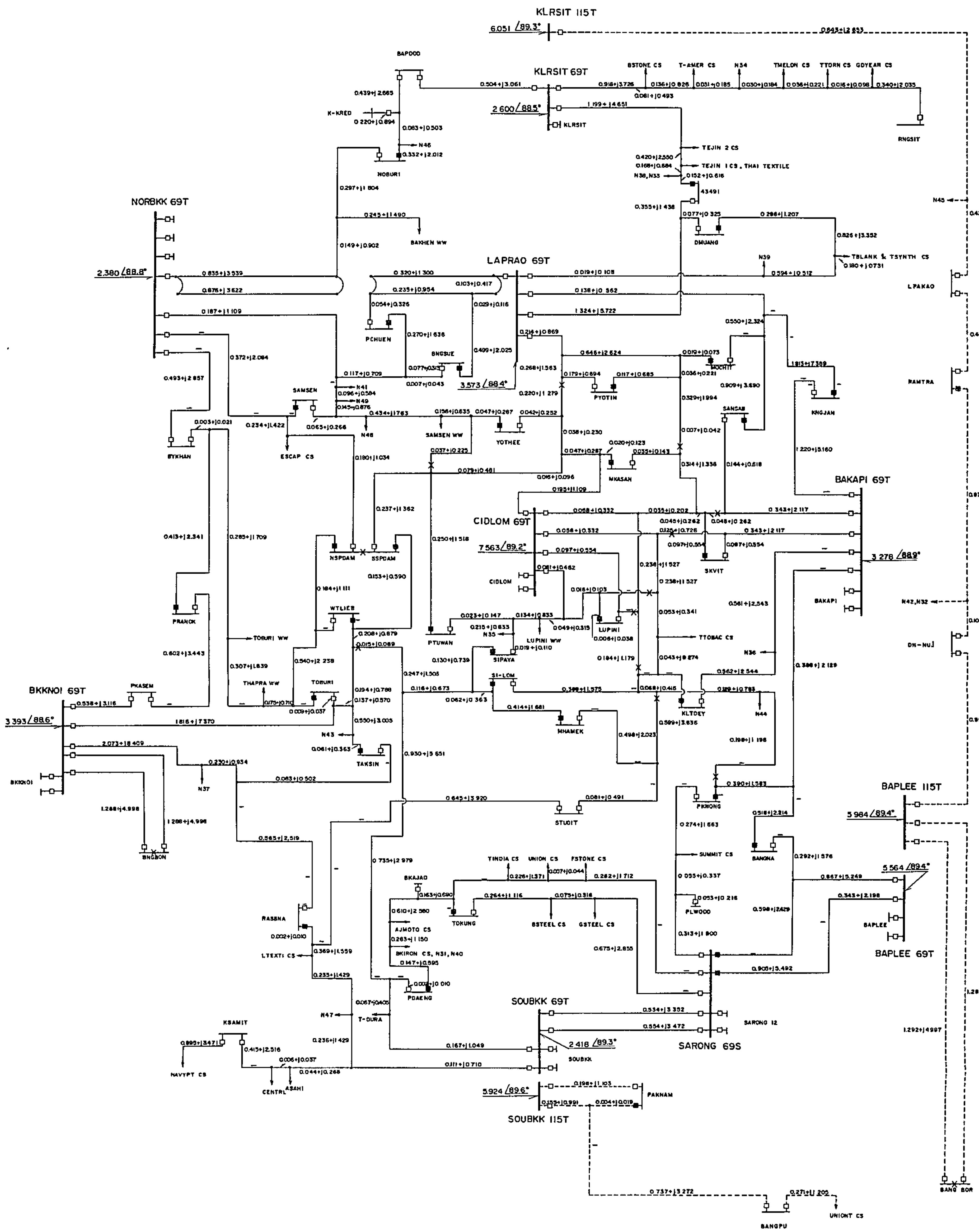


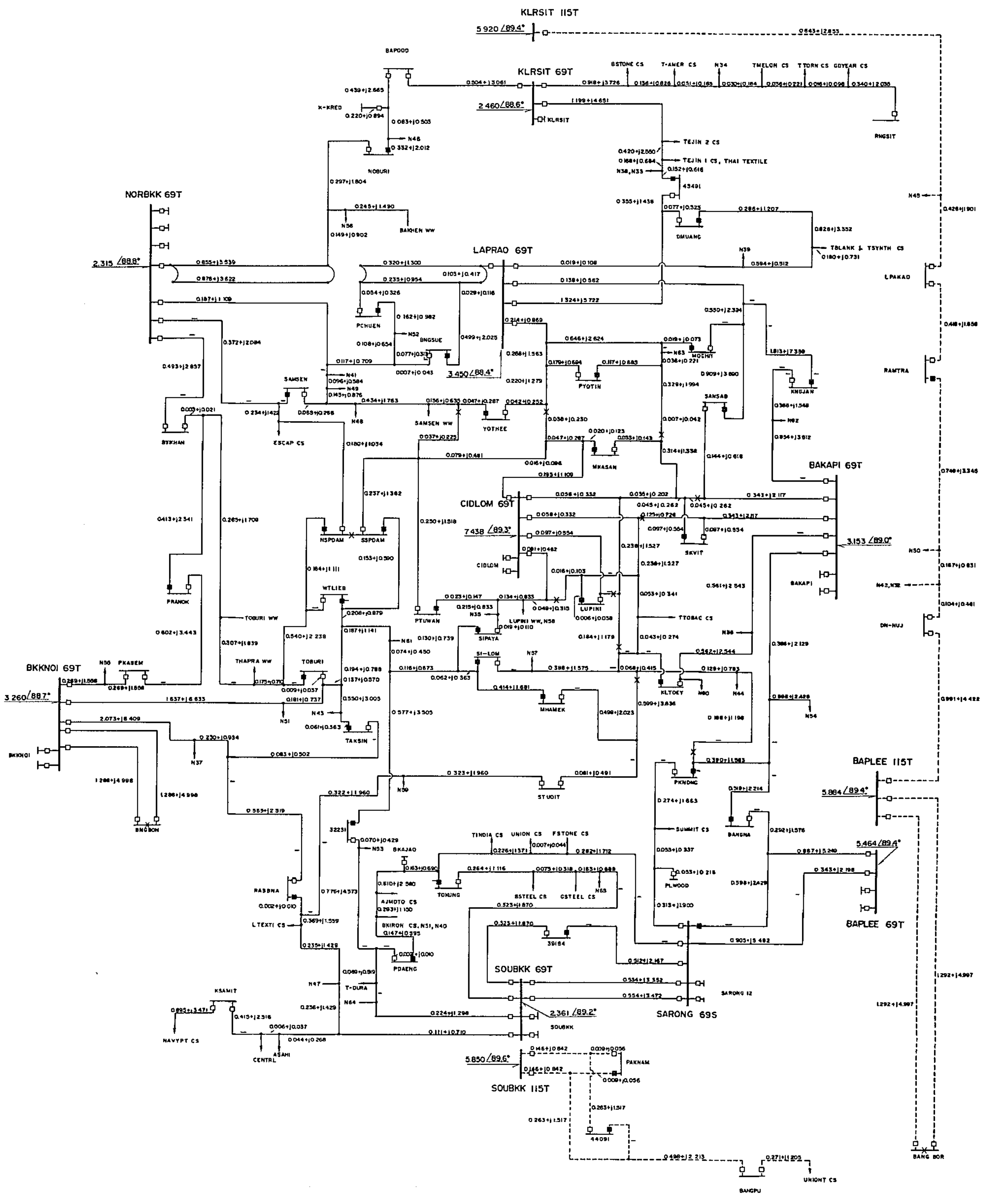
FIG. III - 25

IMPEDANCE DIAGRAM YEAR 1986

POSITIVE PHASE BASED ON 100 MVA %

LEGEND

SYMBOL	DESCRIPTION
■ ×	NORMALLY OPEN
□	NORMALLY CLOSE



LEGEND

SYMBOL	DESCRIPTION
■ ×	NORMALLY OPEN
□	NORMALLY CLOSE

FIG. III - 26

IMPEDANCE DIAGRAM YEAR 1991

POSITIVE PHASE BASED ON 100MVA %

Table Ⅲ-14

Fault Level at Terminal Substation - Near Term

Unit : MVA

Substation	'82	'86	'91	Remark
North BKK	2,953	4,200	4,318	
BKK Noi	1,590	2,947	3,067	
S. BKK (69KV)	3,834	4,135	4,235	
" (115KV)	1,620	1,690	1,710	
Bangplee (69KV)	1,666	1,797	1,830	
" (115KV)	—	1,670	1,700	
K.Rangsit (69KV)	1,760	3,845	4,065	
" (115KV)	—	1,650	1,690	
Lard Prao	1,580	2,800	2,900	
Bangkapi	1,570	3,050	3,172	
Chidlom	1,230	1,322	1,345	

(Note) Three phase fault

Table III-15 Fault Level at Distribution Substation - Near Term

Unit : MVA

Substation	'82	'86	'91	Remark
North BKK	2,953	4,200	4,318	
Bangyeekhan	1,718	1,899	1,923	
Klong Sanpasamit	1,621	1,672	1,688	
Pechkasem	1,126	1,530	1,561	
North BKK	2,953	4,200	4,318	
Prapradaen	2,450	2,569	2,380	
Rasburana	544	643	649	
Thonburi	981	912	923	
Taksin	558	743	750	
Bangkok Noi	1,590	2,947	3,067	
Bangkrajao	1,221	1,249	1,252	
Bangbon	-	1,176	1,195	
Pran Nok	-	997	1,010	
32231	-	-	1,080	
Rangsit	738	1,000	1,014	
Klong Ransit	1,760	3,845	4,065	
Lumpini	1,153	1,226	1,251	
Makasan	986	1,042	1,056	
Sapandam	1,255	1,434	1,448	
Pathumwan	1,012	1,072	913	
Silom	820	858	868	
Watlieb	804	840	845	
Yothee	1,000	1,058	1,340	
Bangkapi	1,570	3,050	3,172	
Bangna	776	803	809	
Bangsue	1,793	2,185	2,217	
Donmuang	802	1,027	1,040	
Klong Jan	862	1,171	1,189	

(Note) Three phase fault

Fault Level at Distribution Substation - Near Term

Unit : MVA

Substation	'82	'86	'91	Remark
Mahamek	695	706	709	
Mochit	1,080	1,537	1,566	
Nontaburi	1,260	1,441	1,454	
Plywood	1,547	1,593	1,608	
Prachacuen	1,363	2,185	2,245	
Prakanong	988	1,237	1,246	
Samsen	1,601	1,907	1,931	
Samrong	2,313	2,418	2,452	
Sansab	1,096	1,656	1,691	
Satupradit	850	863	868	
South BKK	3,834	4,135	4,235	
Tangkung	1,149	1,174	1,560	
Bangpood	1,140	1,757	1,802	
Sukhumvit	1,104	1,674	1,711	
Sipraya	936	986	999	
Chidlom	-	1,322	1,345	
Paholyotin	1,054	1,497	1,510	
Klongtoey	-	1,183	1,201	
39184	-	-	2,355	
43491	-	919	930	
Paknam	1,374	1,422	1,481	
Bangpu	955	977	955	
Bangplee	1,666	1,797	1,830	
Onnuj	547	956	965	
Ramintra	509	783	792	
Ladplakao	712	920	931	
Bangbor	-	903	912	
44091	-	-	1,216	
Klongkred	808	1,075	1,091	

Table III-16 Annual Average Time of Interruption - Near Term

Unit : hour

Substation	Annual Average Time										Remark
	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	
North BKK	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	
Bangyekhan	0.64	0.63	0.63	0.63	0.63	0.63	0.64	0.64	0.64	0.64	
Klong Sanpasamit	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	
Pechkasem	0.64	0.64	0.64	0.64	0.63	0.63	0.63	0.64	0.64	0.64	
North BKK	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	
Prapradaen	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	
Rasburana	0.64	0.64	0.64	0.64	0.64	0.63	0.63	0.64	0.64	0.63	
Thonburi	0.63	0.63	0.63	0.63	0.63	0.62	0.62	0.62	0.62	0.62	
Taksin	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	
Bangkok Noi	0.70	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	
Bangkrajao	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	
Bangbon		0.66	0.65	0.65	0.65	0.65	0.65	0.66	0.66	0.66	
Pran Nok		0.67	0.68	0.68	0.68	0.67	0.68	0.68	0.68	0.69	
32231								0.63	0.63	0.63	
Rangsit	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	
Klong Ransit	0.90	0.90	0.90	0.90	0.90	0.71	0.71	0.71	0.71	0.71	
Lumpini	0.57	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	
Makasan	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	
Sapandam	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	
Pathumwan	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	
Silom	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	
Watlieb	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	
Yothee	0.60	0.60	0.60	0.60	0.59	0.59	0.59	0.59	0.59	0.59	
Bangkapi	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	
Bangna	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	
Bangsue	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	
Donmuang	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	
Klong Jan	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	
Mahamek	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	
Mochit	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	
Nontabri	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.63	0.63	0.63	

Annual Average Time of Interruption - Near Term

Unit : hour

Substation	Annual Average Time										Remark
	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	
Plywood	0.63	0.63	0.64	0.64	0.64	0.64	0.63	0.64	0.64	0.64	
Prachacuen	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	
Prakanong	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	
Samsen	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	
Samrong	0.65	0.65	0.65	0.65	0.64	0.64	0.64	0.64	0.64	0.64	
Sansab	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	
Satupradit	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	
South BKK	0.71	0.71	0.69	0.65	0.65	0.66	0.72	0.69	0.67	0.67	
Tangkung	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	
Bangpood	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.70	
Sukhumvit	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	
Sipraya	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	
Chidlom		0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	
Paholyotin	0.64	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	
Klongtoey		0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	
39184							0.63	0.63	0.63	0.63	
43491			0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	
Paknam	0.65	0.65	0.65	0.65	0.65	0.65	0.66	0.66	0.66	0.66	
Bangpu	0.69	0.69	0.69	0.69	0.69	0.70	0.71	0.71	0.71	0.71	
Bangplee	0.78	0.80	0.80	0.73	0.72	0.72	0.73	0.73	0.74	0.73	
Onnuj	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	
Ramintra	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	
Ladplakao	0.67	0.67	0.67	0.66	0.67	0.67	0.67	0.67	0.67	0.67	
Bangbor				0.71	0.71	0.71	0.71	0.71	0.71	0.71	
44091							0.65	0.65	0.65	0.65	
Klongkred	0.97	0.97	0.97	0.97	0.98	0.98	0.98	0.99	0.99	0.99	
TTL	0.634	0.635	0.635	0.634	0.634	0.635	0.635	0.635	0.635	0.635	

Table III-17 Interchange Factor at 1 Transformer Fault - Near Term

Substation	Interchange factor										Remark
	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	
North BKK	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	
Bangyekhan	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Klong Sanpasamit	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Pechkasem	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
North BKK	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Prapradaen	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Rasburana	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Thonburi	1.0	1.0	1.0	1.0	1.0	0.98	0.93	1.0	1.0	1.0	
Taksin	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Bangkok Noi	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Bangkrajao	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Bangbon		0.76	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Pran Nok		0.57	0.52	0.50	0.52	0.54	0.55	0.50	0.47	0.46	
32231								1.0	1.0	1.0	
Rangsit	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Klong Ransit	0.2	0.2	0.2	0.2	0.2	1.0	1.0	1.0	1.0	1.0	
Lumpini	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Makasan	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Sapandam	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Pathumwan	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Silom	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Watlieb	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Yothee	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Bangkapi	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Bangna	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Bangsue	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Donmuang	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Klong Jan	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Mahamek	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Mochit	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Nontabri	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	

Interchange Factor at 1 Transformer Fault - Near Term

Substation	Interchange factor										Remark
	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	
Plywood	0.96	0.95	0.92	0.90	0.87	0.85	0.94	0.93	0.92	0.93	
Prachacuen	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.98	0.98	0.98	
Prakanong	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Samsen	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Samrong	0.71	0.71	0.72	0.72	0.77	0.77	0.80	0.86	0.88	0.84	
Sansab	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Satupradit	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
South BKK	0.38	0.38	0.44	0.63	0.65	0.59	0.35	0.43	0.55	0.55	
Tangkung	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Bangpood	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Sukhumvit	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Sipraya	0.85	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Chidlom		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Paholyotin	0.82	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Klongtoey		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
39184							1.0	1.0	1.0	1.0	
43491			1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Paknam	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Bangpu	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Bangplee	0.44	0.38	0.37	0.66	0.75	0.73	0.67	0.61	0.57	0.64	
Onnuj	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Ramintra	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Ladplakao	0.71	0.67	0.69	0.74	0.72	0.69	0.69	0.70	0.67	0.66	
Bangbor				1.0	1.0	1.0	1.0	1.0	1.0	1.0	
44091							1.0	1.0	1.0	1.0	
Klongkred	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.12	

IV. FAR TERM PLAN

IV. FAR TERM PLAN

IV-1 Facilities Expansion Program

1. Distribution Substation Expansion Program

Far term distribution substation expansion program is given in Table IV-1.

In the far term program (1991 to 2001), 19 new substations and installation of additional transformers in 26 existing substations will be necessary. What must be kept in mind in the far term is that acquisition of land for substations may become increasingly difficult due to progress of urbanization of Bangkok. For this season it would be advisable to acquire required land, in the near term, for the new stations and for addition of transformers to existing substations.

The locations of substations and service areas in the year 2001 which are output print of computer is given in Fig. IV-1.

2. Subtransmission Line Expansion Program

The far term subtransmission line expansion program is given in Table IV-2.

Subtransmission lines will have to be expanded corresponding to the construction of new substations and addition of transformers in existing substations. In the far term it is anticipated that acquisition of right-of-way for transmission lines will become increasingly difficult, therefore, existing lines of ACC conductors are to be restrung with thermal resistant all aluminum conductors in order to increase the line capacity. The trend in the expansion of subtransmission lines is given in Fig. IV-2 to IV-4.

3. Distribution Line Expansion Program

The far term (1991 to 2001) high voltage distribution line expansion program is given in Table IV-3. The number of feeders will drastically grow, in relation to the increase in the number of substations.

4. Terminal Substation and Sub-Terminal Substation Expansion Program

The far term (1991 – 2001) terminal substation expansion program is given in Table IV-4. Corresponding to growth of load, addition of transformers will take place in the terminal substations located on EGAT's loop transmission line encircling Bangkok.

In the far term, 2 terminal substations are required in the metropolitan area. The second terminal substation to be located in the metropolitan area, identified as T. Sathupradit, is to be constructed in the southern side of the metropolitan area. T. Sathupradit substation will go into service in the first half of the far term and at the end of the long term the load will build up to the maximum of the 300 MVA 2 banks installation.

The third terminal substation in the metropolitan area is to be located in the northern side of the metropolitan. This substation is identified as T. Visuthasat. As this substation is located near the center of the metropolitan, the subtransmission lines are all underground cables. T. Visuthasat substation will go into service in the later part of the far term.

With the growth in the number of distribution substations in the Thonburi district on the west bank of Chao Phraya River, sub-terminal substation is to be constructed in the first half of the far term. This substation will be equipped with switching facilities to permit switching to other power system in case of transmission line fault and line maintenance.

230 kV transmission line system at 2001 is given in Fig. IV-5.

Table IV -1 Distribution Substation Expansion Program - Far Term (Case 2)

Unit : No. x MVA

Bloc No.	Substation	Capacity in 1991	Expansion			Capacity in 2001
			'92 ~ '96	'97 ~ 2001	TTL	
10	North BKK	1x40				1x40
	Klongkred	1x20				1x20
20-1	Bangkok Noi	1x40 2x20				1x40 2x20
	16232		new 2x20		+2x20	2x20
20-2	Bangyekhan	2x40				2x40
	Pechkasem	1x40 2x20				1x40 2x20
	North BKK	2x20				2x20
	Rasburana	2x40	+1x40		+1x40	3x40
	Thonburi	2x40	+1x40		+1x40	3x40
	Taksin	2x40	+1x40		+1x40	3x40
	Pran Nok	1x40	+1x40		+1x40	2x40
	Samray			new 3x40	+3x40	3x40
	28272			new 2x40	+2x40	2x40
	32231	2x40	+1x40		+1x40	3x40
	30224			new 2x40	+2x40	2x40
20-3	Klong Sanpsamit	2x20				2x20
	Prapradaen	2x40				2x40
	Bangbon	2x40				2x40
	Suksawad			new 2x40	+2x40	2x40
20-4	Bangkrajao	2x10				2x10
30-1	Rangsit	2x40		+1x40	+1x40	3x40
	43564		new 2x20	+1x20	+3x20	3x20
30-2	Klong Rangsit	2x40		+1x40	+1x40	3x40
40-1	Bangpood	2x20		+1x20	+1x20	3x20
	43491	2x40				2x40
40-2	Donmuang	2x40				2x40
	Nontaburi	2x20	+1x40 -1x20	+2x40 -1x20	+3x40 -2x20	3x40
	Prachacuen	2x40	+1x40		+1x40	3x40
	40402			new 2x40	+2x40	2x40
40-3	Bangkapi	2x40		+1x40	+1x40	3x40

Distribution Substation Expansion Program - Far Term (Case 2)

Unit No. x MVA

Bloc No.	Substation	Capacity in 1991	Expansion			Capacity in 2001
			'92 ~ '96	'97 ~ 2001	TTL	
40-3	Bangsue	1x10	+2x40 -1x10	+1x40	+3x40 -1x10	3x40
	Klong Jan	2x40	+1x40		+1x40	3x40
	Mochit	2x40	+1x40		+1x40	3x40
	Prakanong	2x40				2x40
	Samsen	2x40				2x40
	Sansab	2x40		+1x40	+1x40	3x40
	Sukhumvit	2x40				2x40
	Paholyotion	2x40				2x40
	Lardprao			new 2x40	+2x40	2x40
	44341			new 3x40	+3x40	3x40
40-4	Lumpini	2x40		+1x40	+1x40	3x40
	Makasan	2x40				2x40
	Sapandam	4x40				4x40
	Pathumwan	2x40		+1x40	+1x40	3x40
	Silom	2x40				2x40
	Watlieb	2x40		+1x40	+1x40	3x40
	Yothee	2x40				2x40
	Sipraya	2x40				2x40
	Chidlom	2x40				2x40
	Klongtoey	2x40				2x40
	Visutkasat			new 2x40	+2x40	2x40
40-5	Mahamek	2x40	+1x40		+1x40	3x40
	Satupradit	2x40		+1x40	+1x40	3x40
	32243			new 2x40	+2x40	2x40
40-6	Bangna	2x40				2x40
	Plywood	1x20	+1x40 -1x20	+1x40	+2x40 -1x20	2x40
	Samrong	2x40				2x40
	BKK	1x20		+1x40 -1x20	+1x40 -1x20	1x40
	Tangkung	2x40		+1x40	+1x40	3x40
	44233			new 2x40	+2x40	2x40
	41183		new 3x40		+3x40	3x40
	39184	2x40		+1x40	+1x40	3x40

Distribution Substation Expansion Program - Far Term (Case 2)

Unit No. x MVA

Bloc No.	Substation	Capacity in 1991	Expansion			Capacity in 2001
			'92 ~ '96	'97 ~ 2001	TTL	
50-1	Ramintra	2x40				2x40
	Ladplakao	1x40				1x40
	Minburi		new 2x20		+2x20	2x20
	54352			new 2x20	+2x20	2x20
50-2	Bangplee	1x40		+1x40	+1x40	2x40
	Onnuj	2x40				2x40
	54264		new 2x20	+1x20	+3x20	3x20
50-3	Paknam	2x40				2x40
	Bangpu	2x40				2x40
	Bangbor	3x20				3x20
	44091	2x40	+1x40		+1x40	3x40
	46063			new 3x20	+3x20	3x20
	50141			new 3x20	+3x20	3x20
	57134		new 2x20	+1x20	+3x20	3x20
	Total No. of substation	57	+6	+13	+19	76
	Total capacity MVA	3,990	+830	+1,720	+2,550	6,540
	Capacity in each year (MVA)	3,990	'96 4,820	2001 6,540		6,540
	Total load in each year (MVA)	2,432	'96 3,210	2001 4,261		4,261
	Utilizing factor (%)	60.9	'96 66.6	2001 65.1		65.1

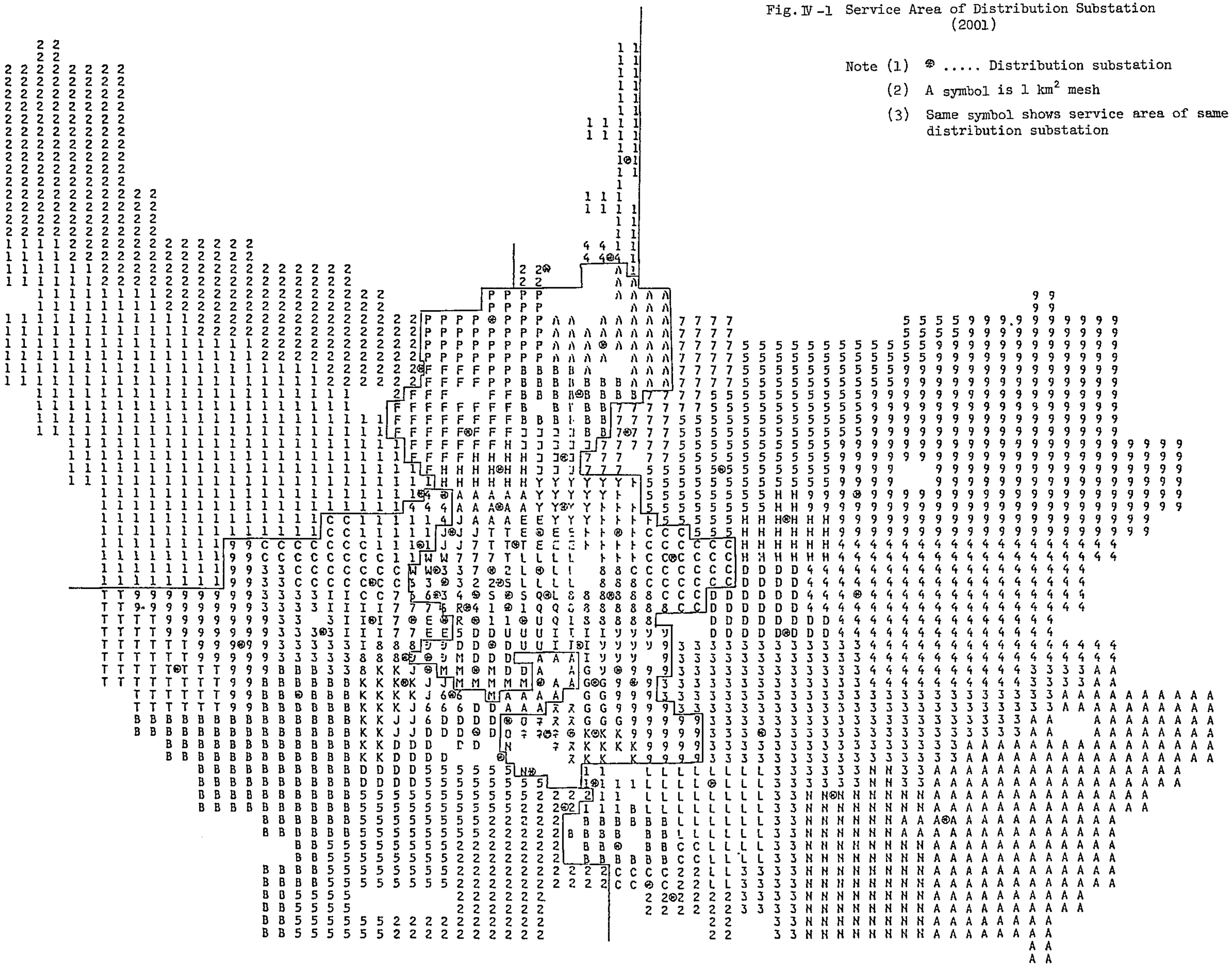


Fig. Ⅳ-1 Service Area of Distribution Substation (2001)

Note (1) ⊛ ..... Distribution substation

(2) A symbol is 1 km^2 mesh

(3) Same symbol shows service area of same distribution substation

Table IV-2 Subtransmission Line Expansion Program - Far Term (Case 2)

Year	Voltage (KV)	Section	Length (km)	Existing facility	New by TAAC constructed	Remark
'92~'96	69	Thonburi to Bangkok Noi	13.8	OHS	OHB	
	"	near Thonburi	1.8	OHS	OHB	
	"	near North BKK	3.6	OHB	OHB	
	"	near Bangyeekhan	2.4		OHB	
	"	near South BKK	1.4	OHB	OHB	
	"	Bangkok Noi to near Taksin	16.2	OHS	OHB	
	"	near Taksin	2.2		OHB	
	"	near Taksin to Rasburana	4.1	OHB	OHB	
	"	16232 to Bangkok Noi	5.4		OHS x 2cct	
	"	near Taksin	0.6		UGC	
	"	near Taksin	1.2	OHB	OHB	
	"	43564 to Klong Ransit	6.7	OHS	OHB	

(Note) OHS . . . . . Overhead single conductor
OHB . . . . . Overhead bundle conductor
UGC . . . . . Underground Cable

(Case 2)

Subtransmission Line Expansion Program - Far Term

Year	Voltage (KV)	Section	Length (km)	Existing facility	New by TAAC constructed	Remark
'92∿'96	69	Bangsue to Ladprao	4.8	OHS	OHB	
	"	Prachacuen to Ladprao	3.6	OHS	OHB	
	"	Mochit to Ladprao	8.8	OHS	OHB	
	"	Klong Jan to Bangkapi	8.2	OHS	OHB	
	"	Mahamek to new Terminals	4.6		OHB	
	"	Mahamek to Sathupradit	4.2	OHS	OHS	
	"	41183 to Samrong	1.9	OHS	OHB	
	"	Samrong to South BKK	8.2	OHB	OHB	
	"	Plywood π connection	0.1		OHB	
	"	Samrong to South BKK	7.8	OHB	OHB	
	115	near 54264	4.8		OHS x 2cct	
	"	near Minburi	1.5		OHB	

Subtransmission Line Expansion Program - Far Term

(Case 2)

Year	Voltage (KV)	Section	Length (km)	Existing facility	New by TAAC constructed	Remark
'92~'96	115	57134 π connection	0.2		OHS	
'97~2001	69	near Smray	1.4		UGC	
	"	30224 π connection	1.2		OHS	
	"	28272 π connection	0.2		OHB	
	"	Suksawad π connection	0.2		OHB	
	"	near 32231	1.2	OHB	OHB	
	"	near 43564	7.0	OHB	OHB	
	"	Nontabri to North BKK	10.8	OHB, OHS	OHB	
	"	Klong Ransit to Bangpood	9.0	OHB	OHB	
	"	40402 to Lardprao	5.2	OHS	OHB	
	"	44341 to Lardprao	7.8	OHS	OHB	
	"	near Lardprao	1.2		OHB	

Subtransmission Line Expansion Program - Far Term

(Case 2)

Year	Voltage (KV)	Section	Length (km)	Existing facility	New by TAAC constructed	Remark
'97~2001	69	Sansab to Bangkapi	6.6	OHB, OHS	OHB	
	"	Lardprao (D.S) to Lardprao	3.6		OHB	
	"	Visutkasat to Sapandam	4.8		UGC	
	"	near Satupradit	1.2	OHB	OHB	
	"	Watlieb to Visutkasat	3.6		UGC	
	"	Sukhumvit to Bangkapi	5.4	OHB	OHB	
	"	near Silom to new Terminals	3.0		UGC	
	"	32243 π connection	0.2		OHB	
	"	Tangkung to 39184	3.0	OHS	OHB	
	"	44233 to Bangkapi	10.0	OHS, OHB	OHB	
	"	50141 π connection	2.0		OHB	
	115	54352 π connection	3.0		OHS x 2cct	

Subtransmission Line Expansion Program - Far Term (Case 2)

Year	Voltage (KV)	Section	Length (km)	Existing facility	New by TAAC constructed	Remark
'97~2001	115	46063 to 44091	4.4		OHS	

FIG IV-2
MEA ROUTE DIAGRAM 69KV–115KV
(1992 ~ 1996)

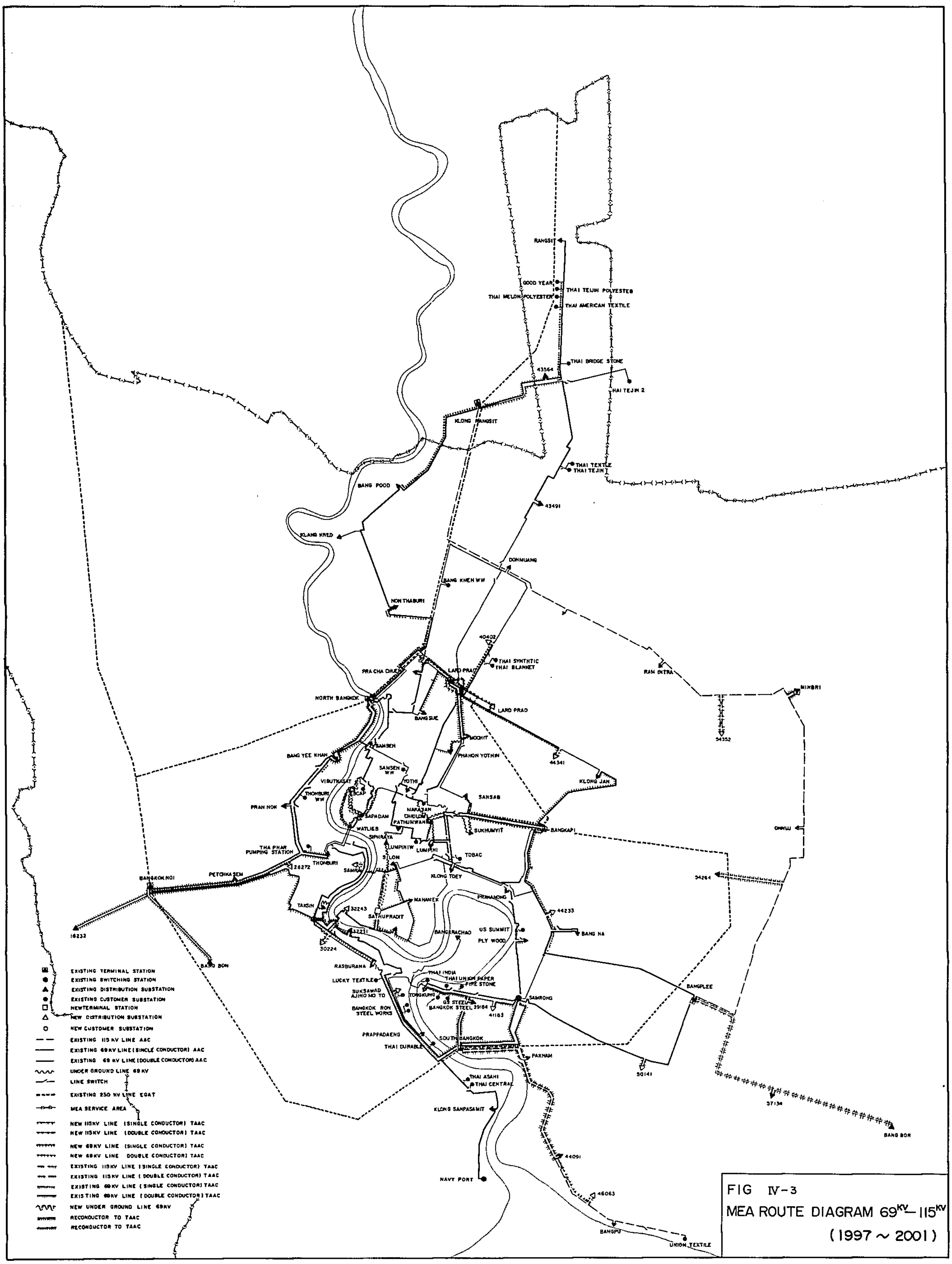


FIG IV-3
MEA ROUTE DIAGRAM 69^{KV}—115^{KV}
(1997 ~ 2001)

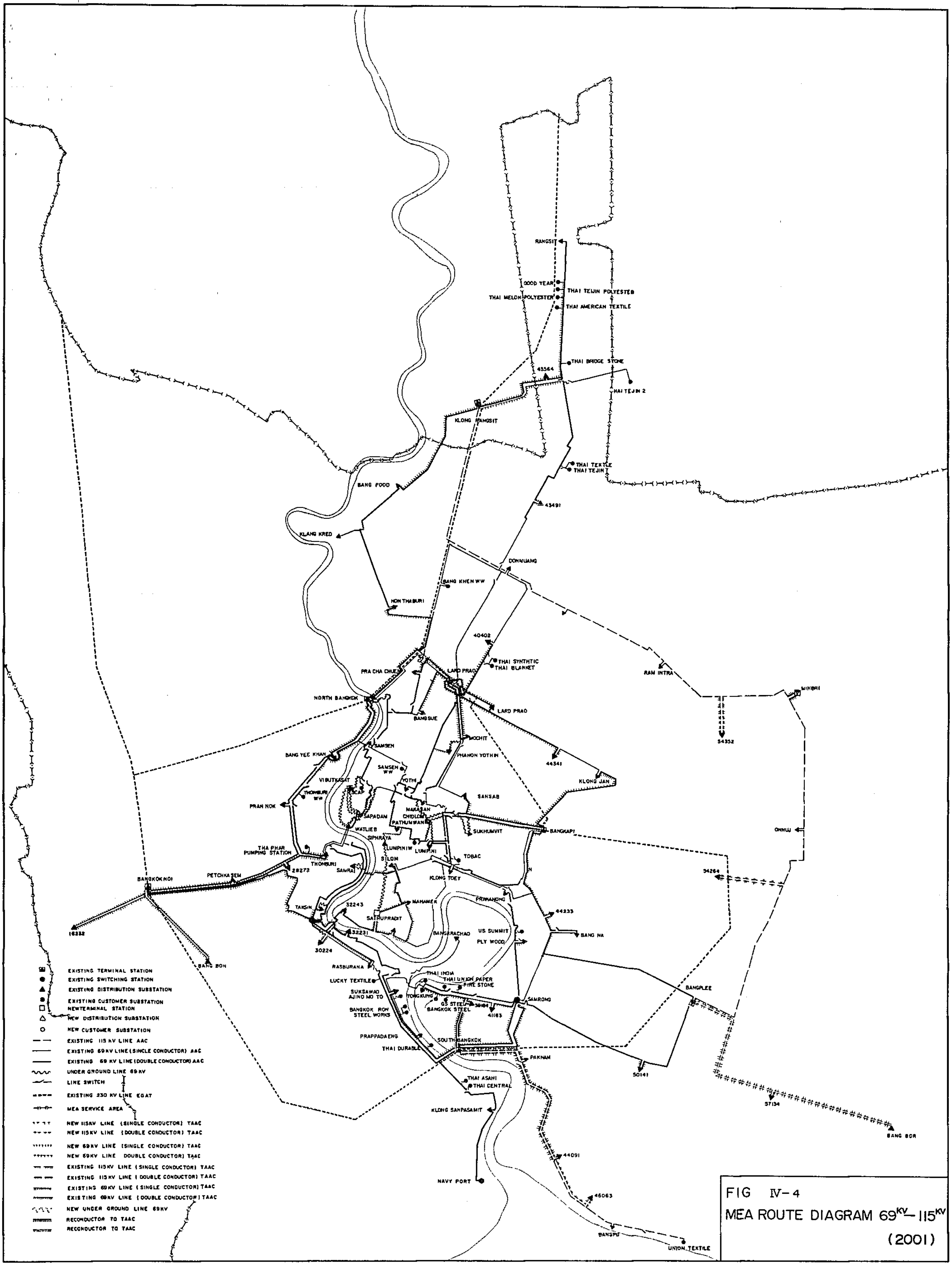


FIG IV-4
MEA ROUTE DIAGRAM 69KV – 115KV
(2001)

Table IV-3 Distribution Feeder Expansion Program - Far Term (Case 2)

Bloc No.	Substation	Capacity in 1991	Expansion			No. of feeder in 2001
			'92 ∿ '96	'97 ∿ 2001	TTL	
10	North BKK	3				3
	Klongkred	1				1
20-1	Bangkok Noi	6	+1		+1	7
	16232		+3	+1	+4	4
20-2	Bangyekhan	7	+1		+1	8
	Pechkasem	18				18
	North BKK	4				4
	Rasburana	10	+5		+5	15
	Thonburi	10	+5		+5	15
	Taksin	15	+1		+1	16
	Pran Nok	5	+6		+6	11
	Samray			+11	+11	11
	28272			+8	+8	8
	32231	10	+5		+5	15
	30224			+10	+10	10
20-3	Klong Sanpsamit	5	+1		+1	6
	Prapradaen	11	+2	+5	+7	18
	Bangbon	3	+2	+1	+3	6
	Suksawad			+10	+10	10
20-4	Bangkrajao	4		+1	+1	5
30-1	Rangsit	7				7
	43564		+2	+1	+3	3
30-2	Klong Rangsit	5				5
40-1	Bangpood	6				6
	43491	5	+1	+3	+4	9
40-2	Donmuang	14	+6		+6	20
	Nontaburi	8	+5	+5	+10	18
	Prachacuen	17	+7		+7	24
	40402			+10	+10	10

Distribution Feeder Expansion Program - Far Term (Case 2)

Bloc No.	Substation	Capacity in 1991	Expansion			No. of feeder in 2001
			'92 ∿ '96	'97 ∿ 2001	TTL	
40-3	Bangkapi	12	+5		+5	17
	Bangsue	3	+5	+4	+9	12
	Klong Jan	12	+2		+2	14
	Mochit	15	+3		+3	18
	Prakanong	9	+1		+1	10
	Samsen	10	+1		+1	11
	Sansab	12		+2	+2	14
	Sukhumvit	10				10
	Paholyotion	9	+1		+1	10
	Lardprao			+9	+9	9
	44341			+10	+10	10
40-4	Lumpini	12		+8	+8	20
	Makasan	10				10
	Sapandam	22	+5		+5	27
	Pathumwan	9		+2	+2	11
	Silom	12				12
	Watlieb	8	+3	+3	+6	14
	Yothee	12				12
	Sipraya	10				10
	Chidlom	8	+2		+2	10
	Klongtoey	5	+3	+2	+5	10
	Visutkasat			+10	+10	10
40-5	Mahamek	10	+2	+2	+4	14
	Satupradit	12	+4	+6	+10	22
	32243			+7	+7	7
40-6	Bangna	15		+2	+2	17
	Plywood	3	+2	+7	+9	12
	Samrong	12				12
	South BKK	4				4
	Tangkung	10				10
	44233	-		+10	+10	10
	41183		+15		+15	15
	39184	10		+5	+5	15

Distribution Feeder Expansion Program - Far Ferm (Case 2)

Bloc No.	Substation	Capacity in 1991	Expansion			No. of feeder in 2001
			'92 ~ '96	'97 ~ 2001	TTL	
50-1	Ramintra	7				7
	Ladplakao	3				3
	Minburi		+2		+2	2
	54352			+2	+2	2
50-2	Bangplee	5				5
	Onnuj	5	+1		+1	6
	54264		+2	+1	+3	3
50-3	Paknam	5				5
	Bangpu	5				5
	Bangbor	3				3
	44091	4	+2	+2	+4	8
	46063			+3	+3	3
	50141			+2	+2	2
	57134		+2	+2	+4	4
	.					
	Total number of feeder	487	+116	+167	+283	770
	Additional length of conductor (km)	+914	+753	+785	+1538	+2452

Table IV-4 Terminal Substation Expansion Program - Far Term

Unit : MVA

KV	Substation	Existing	Expansion			Capacity in 2001
			'92~'96	'97~2001	TTL	
69	North BKK	437	+300		+300	737
69	BKK Noi	700	+300		+300	1,000
69	South BKK	900	+300		+300	1,200
115	"	200		+300	+300	500
69	Bangplee	200			-	200
115	"	200			-	200
69	Klong Rangsit	500			-	500
115	"	200			-	200
69	Lardprao	700		+300	+300	1,000
69	Bangkapi	400	+300		+300	700
69	Chidlom	500			-	500
69	T. Satupradit		new 600		+600	600
69	Visutkasat			new 600	+600	600
115	Minburi		new 300		+300	300
	TTL	4,938	+2,100	+1,200	+3,300	8,238

Fig. Ⅳ-5 230 KV Transmission System in 2001