添　　付　　B

220kV 母線の設計（アルミニウム・パイプ導体）

220kV母線の設計（アルミニウム・パイプ導体）

1. 220kV母線の設計条件

	記　号	主母線	支持母線
回路電圧	V	220kV	220kV
最大電流	I_C	※1 4,000A	※2 2,000A
短絡電流	I_S	※3 40kA	※3 40kA
母線導体間隔	D	4m	4m
母線支持間隔	S	16m	125m

註　※1　ブスタイ用220kVガス遮断器の定格電流と同値

※2　送電線用220kVガス遮断器の定格電流と同値

※3　220kVガス遮断器の遮断容量と同値

2. アルミニウム・パイプ導体

	Notation	Main Bus	Branch Bus
導体寸法	D x t	180mmx10mm	120mmx8mm
電流容量		4420 Amp.	2810 Amp.
断面積	A	5340 mm^2	2815 mm^2
単位重量	W	14.42 kg/m	7.6 kg/m
断面係数	Z	215.0 cm^3	73.93 cm^3
断面二次モーメント	I	1936 cm^4	443.6 cm^4
弾性係数	E	7000 kg/mm^2	7000 kg/mm^2
線膨脹係数	α	$23x10^{-6}$ 1/℃	$23x10^{-6}$ 1/℃
耐力	ρ	17 kg/mm^2	17 kg/mm^2
風圧荷重	Fw	6 kg/m	9 kg/m

3. 算定式

(1) アルミニウム・パイプの固有振動 : f_o

$$f_o = \frac{\lambda^2}{2\pi S^2} \cdot \sqrt{\frac{g \cdot E \cdot I}{W}} \quad (Hz)$$

Basic value, $f_o \geqq 3$ Hz

Where,

λ : Modulus of Horizontal Vibration of bar = 3.93

S : Interval of Bus support (m)

g : Acceleration of gravity = 9.8

E : Modulus of elasticity (kg/mm^2)

I : Moment of ineatia (cm^4)

W : Per unit weight of pipe (kg/m)

1) 主　母　線

$$f_o = \frac{3.93^2}{2\times3.14\times16^2}\cdot\sqrt{\frac{9.8\times7000\times10^6\times1936\times10^{-8}}{14.42}}$$

$$= 3 \quad (\text{Hz}) \qquad \text{O.K}$$

2) 分 岐 母 線

$$f_o = \frac{3.93^2}{2\times3.14\times12.5^2}\cdot\sqrt{\frac{9.8\times7000\times10^6\times443.6\times10^{-8}}{7.6}}$$

$$= 3.14 \quad (\text{Hz}) > 3 \quad (\text{Hz}) \qquad \text{O.K}$$

(2) 短絡電流による電磁力 : F_S

$$F_S = \frac{\sqrt{3}}{2}\cdot\frac{2.05 \times K \times I_S^2 \times 10^{-8}}{D} \qquad (\text{kg/m})$$

Where,

Is : Short circuit current = 40 kA

D : Interval of Bus conductor = 4 m

K : Factor of average electromagnetic force = 3

1) 主　母　線

$$F_S = \frac{\sqrt{3}}{2}\cdot\frac{2.05 \times 3 \times (40\times10^3)^2 \times 10^{-8}}{4} = 21.3 \qquad (\text{kg/m})$$

2) 分 岐 母 線

$$F_S = \frac{\sqrt{3}}{2}\cdot\frac{2.05 \times 3 \times (40\times10^3)^2 \times 10^{-8}}{4} = 21.3 \qquad (\text{kg/m})$$

(3) アルミニウム・パイプ母線にかかる総 : T
合荷重

$$T = \sqrt{W^2 + (F_S + F_W)^2} \qquad (\text{kg/m})$$

Where,

W : Per unit weight of pipe (kg/m)

Fs : Electromagnetic force of short circuit (kg/m)

Fw : Wind load (kg/m)

1) 主　母　線

$$T = \sqrt{14.42^2 + (21.3 + 6)^2} = 30.9 \quad (kg/m)$$

2) 分 岐 母 線

$$T = \sqrt{7.6^2 + (21.3 + 9)^2} = 31.2 \quad (kg/m)$$

(4) アルミニウム・パイプ母線にかかる応力

Shearing force $Q_p = \frac{5 \cdot T \cdot S}{8} \cdot \frac{1}{A}$ (kg/cm)

Bending stress $M_p = \frac{T \cdot S^2}{8} \cdot \frac{100}{Z}$ (kg/cm)

Basic safety factor $>$ 2.0

Where,

T : Total force of Aluminum pipe (kg/m)

S : Interval of Bus support (m)

A : Cross-section area of Aluminum pipe (mm^2)

Z : Modulus of section (cm^3)

1) 主　母　線

$$Q_p = \frac{5 \times 30.9 \times 16}{8} \times \frac{1}{5340 \times 10^{-2}} = 5.8 \quad (kg/cm^2)$$

Safety factor $S_q = \frac{P}{Q_p} = \frac{17 \times 10^2}{5.8} = 293 > 2.0$ O.K

$$M_p = \frac{30.9 \times 16^2}{8} \times \frac{100}{215.0} = 460 \quad (kg/cm^2)$$

Safety factor $S_m = \frac{P}{M_p} = \frac{17 \times 10^2}{460} = 3.7 > 2.0$ O.K

2) 分 岐 母 線

$$Q_p = \frac{5 \times 31.2 \times 12.5}{8} \times \frac{1}{2815 \times 10^{-2}} = 8.7 \quad (kg/cm^2)$$

Safety factor $S_q = \frac{P}{Q_p} = \frac{17 \times 10^2}{8.7} = 195 > 2.0$ O.K

$$M_p = \frac{31.2 \times 12.5^2}{8} \times \frac{100}{73.93} = 824 \quad (kg/cm^2)$$

Safety factor $S_m = \frac{P}{M_p} = \frac{17 \times 10^2}{824} = 2.1 > 2.0$ O.K

(5) アルミニウム・パイプ母線の撓み

Deflection is based on pipe weight : δ_1

$$\delta_1 = \frac{W \cdot S^4 \cdot 10^6}{185 \cdot E \cdot I} \quad (\text{cm})$$

Deflection is based on fixed contact of pantograph type Disconnecting switch : δ_2

$$\delta_2 = 0.009317 \cdot \frac{W \cdot S^3}{E \cdot I} \times 10^6 \quad (\text{cm})$$

Total Deflection $\delta = \delta_1 + \delta_2$ (cm)

Basic value, Total deflectio $<$ Diameter of pipe $\times \frac{1}{2}$

Where,

W : Per unit weight of pipe (kg/m)

S : Interval of Bus support (m)

E : Modulus of elasticity (kg/mm^2)

I : Moment of inertia (cm)

w : Weight of fixed contact of pantograph type disconnecting switch = 90 kg

1) 主 母 線

$$\delta_1 = \frac{14.42 \times 16^4 \times 10^6}{185 \times 7000 \times 10^2 \times 1936} = 3.8 \quad (\text{cm})$$

$$\delta_2 = 0.009317 \cdot \frac{90 \times 16^3 \times 10^6}{7000 \times 10^2 \times 1936} = 2.5 \quad (\text{cm})$$

$$\delta = \delta_1 + \delta_2 = 6.3 \text{ cm} < 18 \times \frac{1}{2} \text{ cm} \quad \text{O.K}$$

2) 分 岐 母 線

$$\delta_1 = \frac{7.6 \times 12.5^4 \times 10^6}{185 \times 7000 \times 10^2 \times 443.6} = 3.2 \quad (\text{cm})$$

$$\delta_2 = 0$$

$$\delta = 3.2 \text{ cm} < 12 \times \frac{1}{2} \text{ cm} \quad \text{O.K}$$

(6) アルミニウム・パイプ母線の延び

$$\Delta S = S \cdot \alpha \cdot t \cdot 10^2 \quad (\text{cm})$$

Basic strech $\Delta S < 2.5$ cm

Where,

S : Interval of Bus support (m)

α : Coefficient of linear expansion (1/°C)

t : Temperature rise = 60 °C

1) 主 母 線

$S = 16 \times 23 \times 10^{-6} \times 60 \times 10^{2} = 2.2 \text{ cm} < 2.5 \text{ cm}$

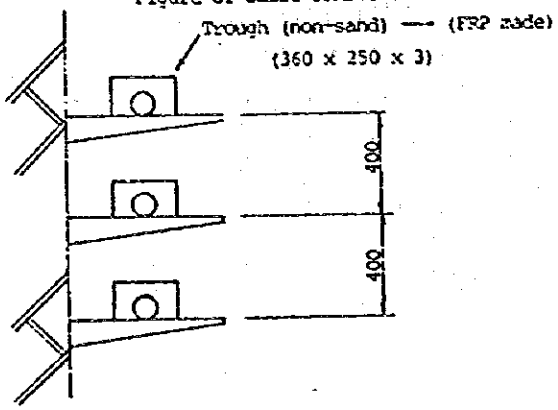
2) 分 岐 母 線

$S = 12.5 \times 23 \times 10^{-6} \times 60 \times 10^{2} = 1.7 \text{ cm} < 2.5 \text{ cm}$

添　　付　　C

AHMED HANDI トンネル用 OF ケーブル温度上昇の検討

Figure of cable construction



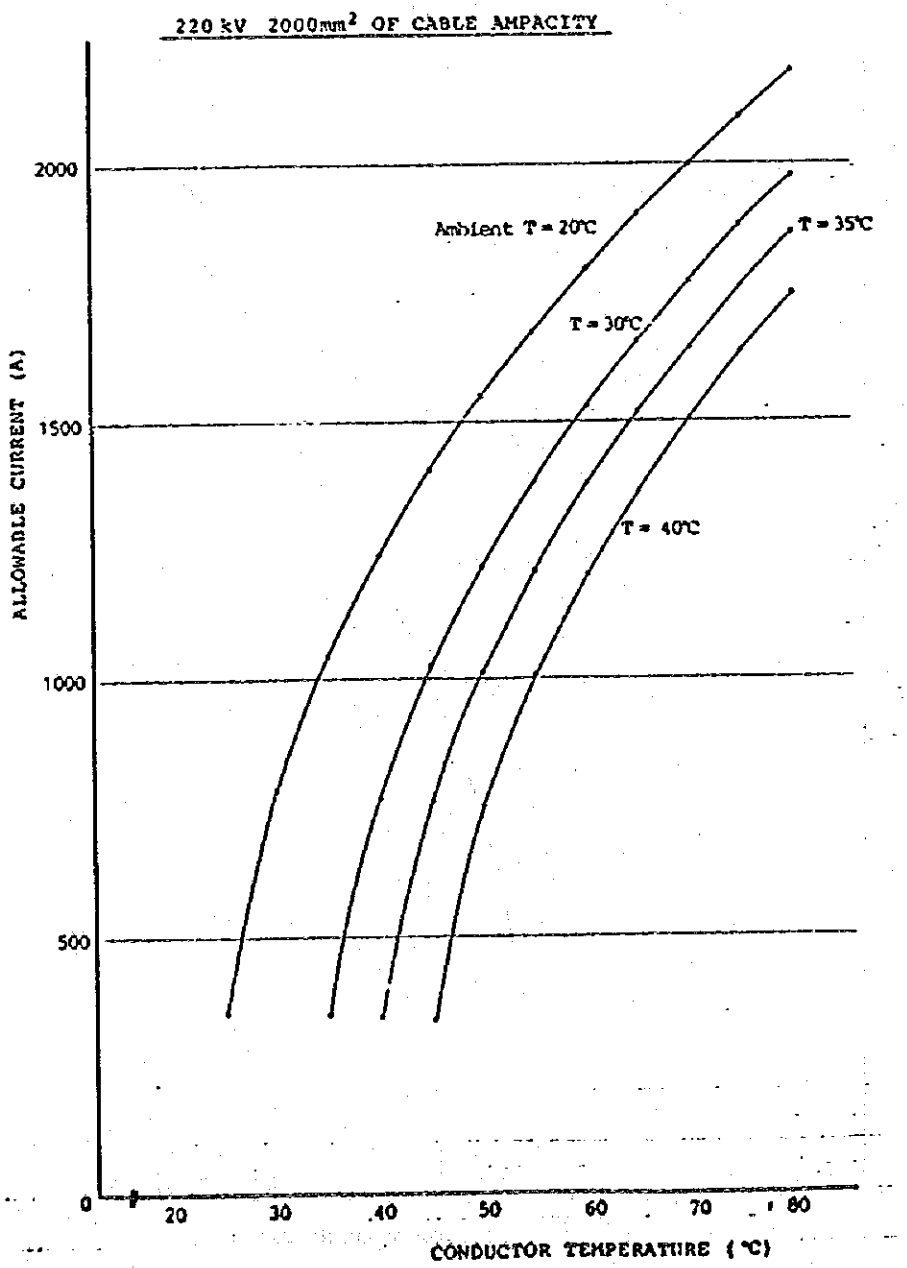
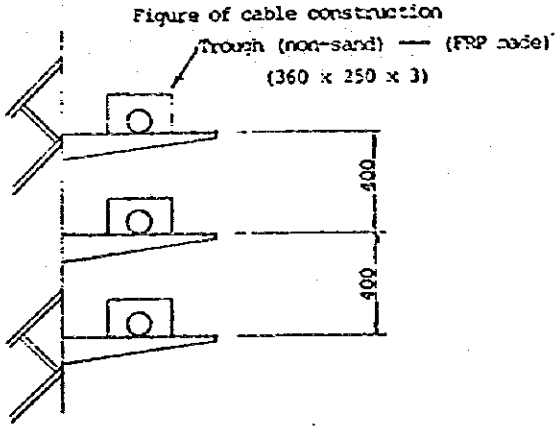
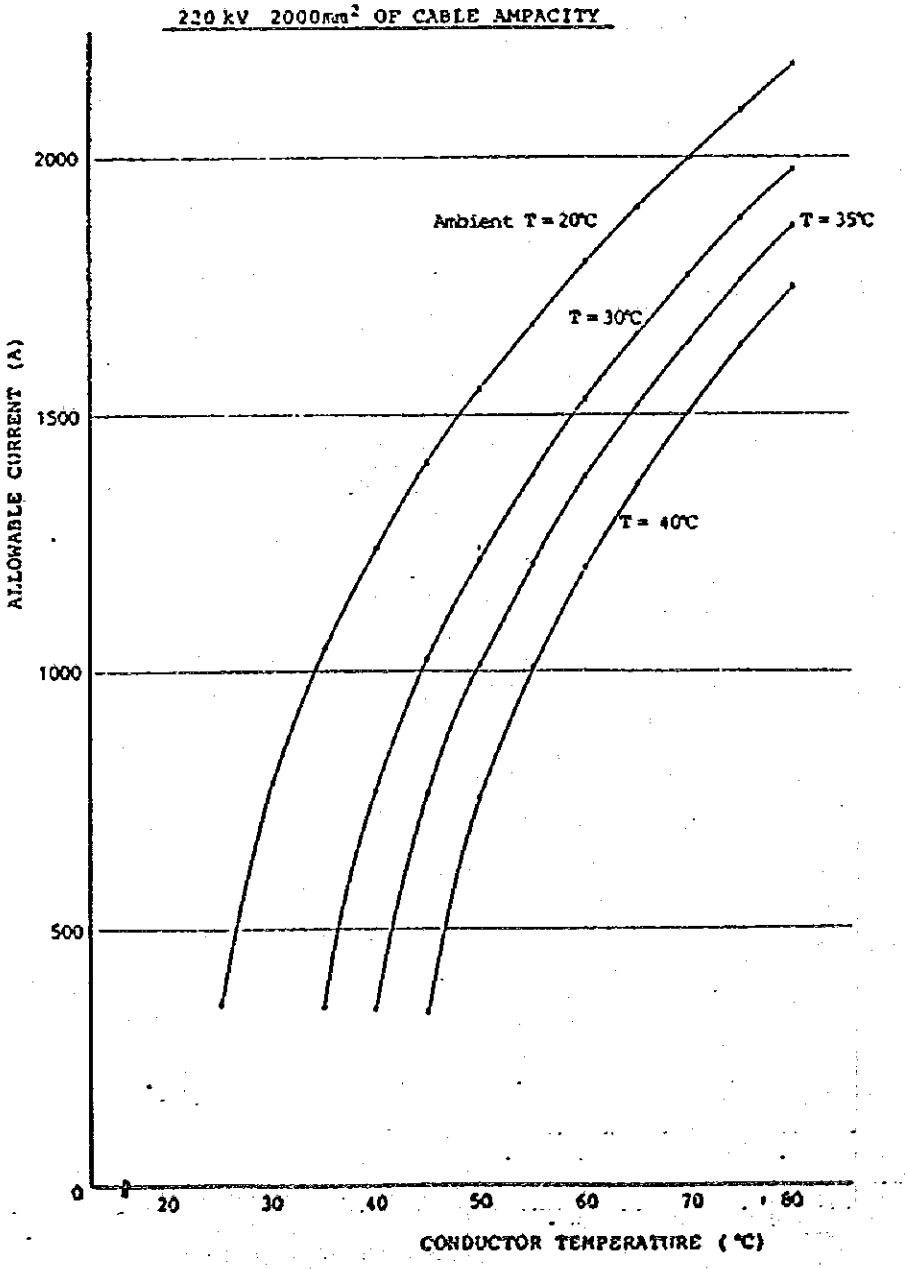


Figure of cable construction





添　付　D

1989 － 1990 年に於ける潮流検討

GENERATOR LIST

1/2

Node No.	NAME of SUBSTATION	No.of Gene x Out put	Rated Out put (MW)	Possib. Out put (MW)	Year of Operate	Out put operation 1 9 9 0 (MW)		
THERMAL POWER						P	D.T.	M.N.
659	AYUN MUSA	1 x 600	600	600	1990	570	570	570
562	EL KRIMAT	1 x 600	600	600	1990	570	570	570
562	EL KRIMAT	1 x 300	300	300	1989	285	285	285
562	EL KRIMAT	1 x 300	300	300	1989	285	285	285
659	AYUN MUSA	1 x 300	300	300	1988	285	285	285
659	AYUN MUSA	1 x 300	300	300	1988	285	285	285
652	DAMANHOUR	1 x 300	300	300	1986	285	285	285
556	SHOBURA	1 x 300	300	300	1986	285	285	285
656	ISHARIA	1 x 150	150	150	1986	142	142	107
556	SHOBURA	1 x 300	300	300	1985	285	285	285
556	SHOBURA	1 x 300	300	300	1985	285	285	285
651	DOUWER	1 x 110	110	110	1985	105	105	28
657	EL SUEZ	1 x 300	300	300	1985	285	285	285
651	DOUWER	1 x 110	110	110	1984	105	105	28
657	EL SUEZ	1 x 150	150	150	1984	142	142	107
657	EL SUEZ	1 x 150	150	150	1984	142	142	107
656	ISHARIA	1 x 150	150	150	1983	142	142	107
753	ABU QIR	1 x 150	150	150	1984	142	142	107
753	ABU QIR	1 x 150	150	150	1984	142	142	107
656	ISHARIA	1 x 150	150	150	1983	142	142	107
753	ABU QIR	1 x 150	150	150	1983	142	142	107
753	ABU QIR	1 x 150	150	150	1983	142	142	107
656	ISHARIA	1 x 150	150	150	1982	142	142	107
651	DOUWER	2 x 110	220	220	1980	210	210	56
552	CAIRO WEST	1 x 87.5	87.5	61.3	1979	55	46	--
552	CAIRO WEST	3 X 87.5	262.5	183.8	1966	165	46	--
652	DAMANHOUR	3 x 65	195	163.8	1968	147	--	--
653	EL SUIF	2 x 33	66	60	1969	54	--	--
654	TALKHA	3 x 30	90	73.8	1966	66	--	--
854	ASSIOUT	3 x 30	90	55	1966	50	--	--
658	SUEZ O	4 x 25	100	75	1965	67	--	--
557	CAIRO SOUTH	1 x 60	60	45	1965	40	--	--
653	EL SUIF	2 x 26	52	47	1961	42	--	--
652	DAMANHOUR	2 x 15	30	25	1960	22	--	--

GENERATOR LIST

2/2

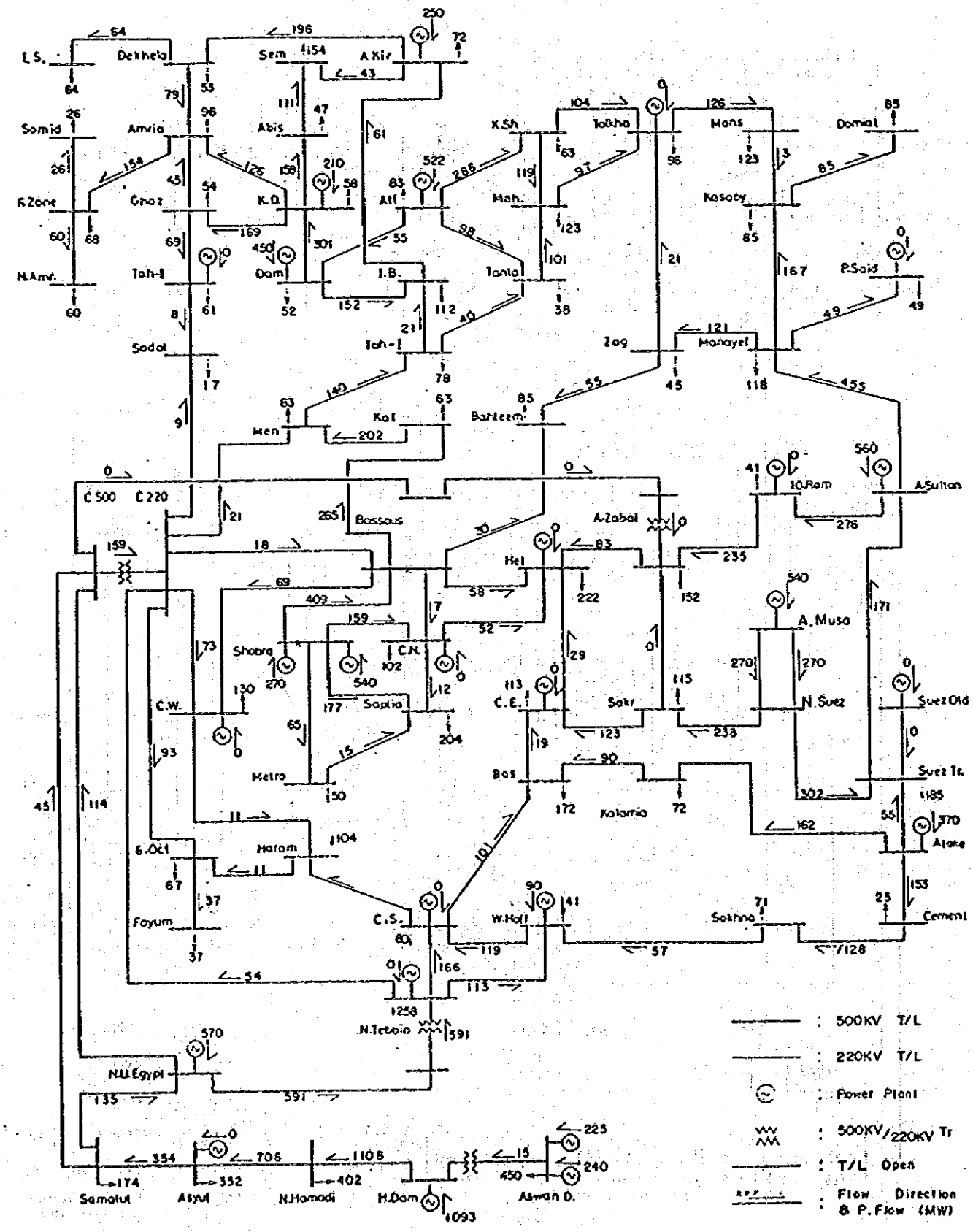
Node No.	Name of Substation	No. of Gen. x Out put	Rated Out Put	Possible Out put	Year of Operate	Out put Operation 1 9 9 0 (MW)		
GAS POWER						P	D.T.	M.N.
652	DAMANHOUR	2 x 50	100	100	1984	95	--	--
560	WADI HOFF	3 x 33.3	100	100	1984	--	--	--
653	EL SUIF	3 x 33.3	100	100	1983	95	--	--
653	MOHMOUDIA	8 x 25	200	200	1983	190	--	--
653	EL SUIF	2 x 33.3	66.6	66	1982	63	--	--
653	MOHMOUDIA	1 x 50	50	50	1982	48	--	--
653	MOHMOUDIA	4 x 50	200	200	1981	--	--	--
561	EL SHABAB	3 x 33.3	100	100	1982	--	--	--
653	EL SUIF	1 x 33	33	33	1981	--	--	--
653	EL SUIF	1 x 33	33	30	1980	--	--	--
559	N. TEBBIN	2 x 25	50	45	1980	--	--	--
654	TALKHA	2 x 24.2	48.4	43	1980	--	--	--
558	HELWAN	5 x 24.2	121	110	1980	--	--	--
554	HELIOPOLIS	3 x12.5	37.5	35	1980	--	--	--
555	CAIRO EAST	2 x 25	50	45	1980	--	--	--
655	PORT SAID	2 x 20	40	36	1979	--	--	--
654	TALKHA	6 x 24.2	145.2	130.7	1979	--	--	--
553	CAIRO NORTH	1 x 20	20	18	1979	--	--	--
751	EL MATAMIA	1 x 23	23	20	1978	--	--	--
656	ISMARIA	1 x 22	22	15	1977	--	--	--
658	SUEZ O	1 x 17	17	15	1976	--	--	--
753	EL MAX	2 x 14	28	24	1966	--	--	--
HYHDORO POWER						P	O.P	N
851	ASWAN DAM	7 x 46	322	322	1960	199	199	199
852	ASWAN II	4 x 75	300	300	1983	205	205	155
853	ASWAN HIGHDA	10 x 175	1750	1750	1967 ~1970	1616	650	354

TOTAL OUT PUT (A)	8764	6691	5595
POSSIBLE OUT PUT CAPACITY (B)	9305	8117	7944
SPINING RESERVE CAPACITY (B)-(A)	541	1426	2349
%	6.1	21,3	42.0

1989 Flow NO.3

Load Flow in 1989 (Day Time) Case L-89-2

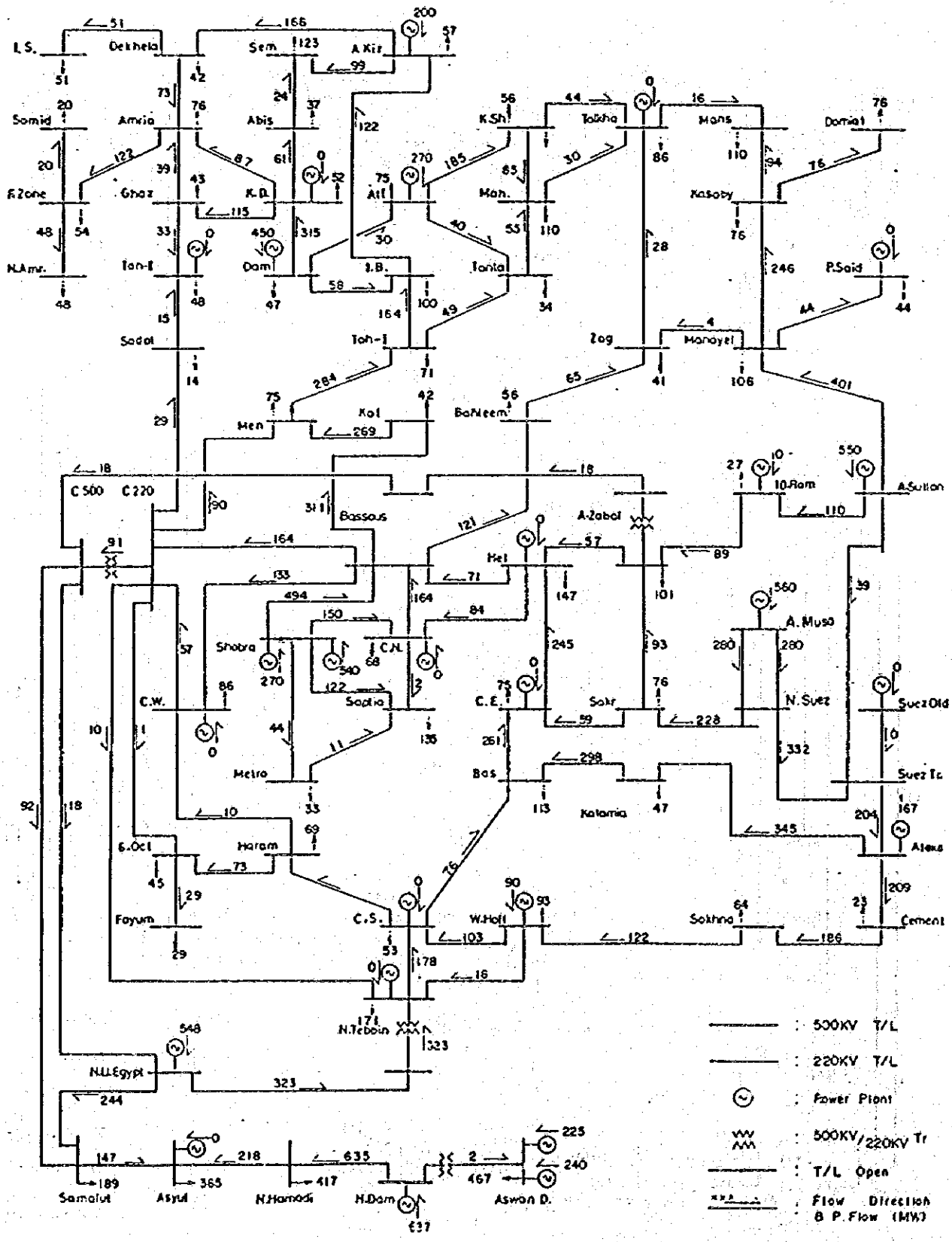
Conditions : 1) All Loop



1989 Flow NO.4

Load Flow in 1989 (Mid Night) Case L-89-3

Conditions : 1) All Loop



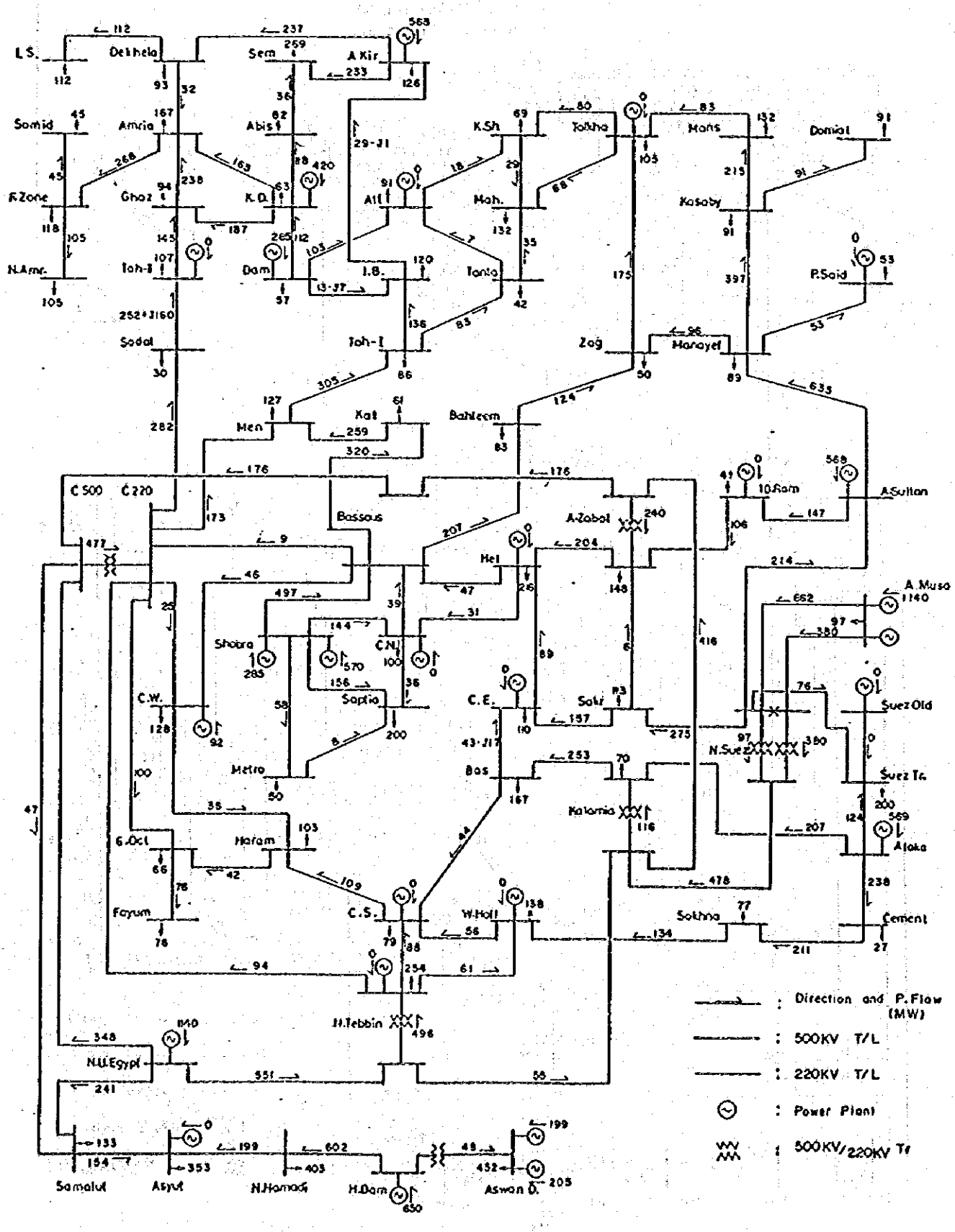
1990 Flow NO.6

Load Flow in 1990 (Day Time) Case L-90-2

Conditions : i) All Loop

ii) N.Suez 220KV Bus Separate

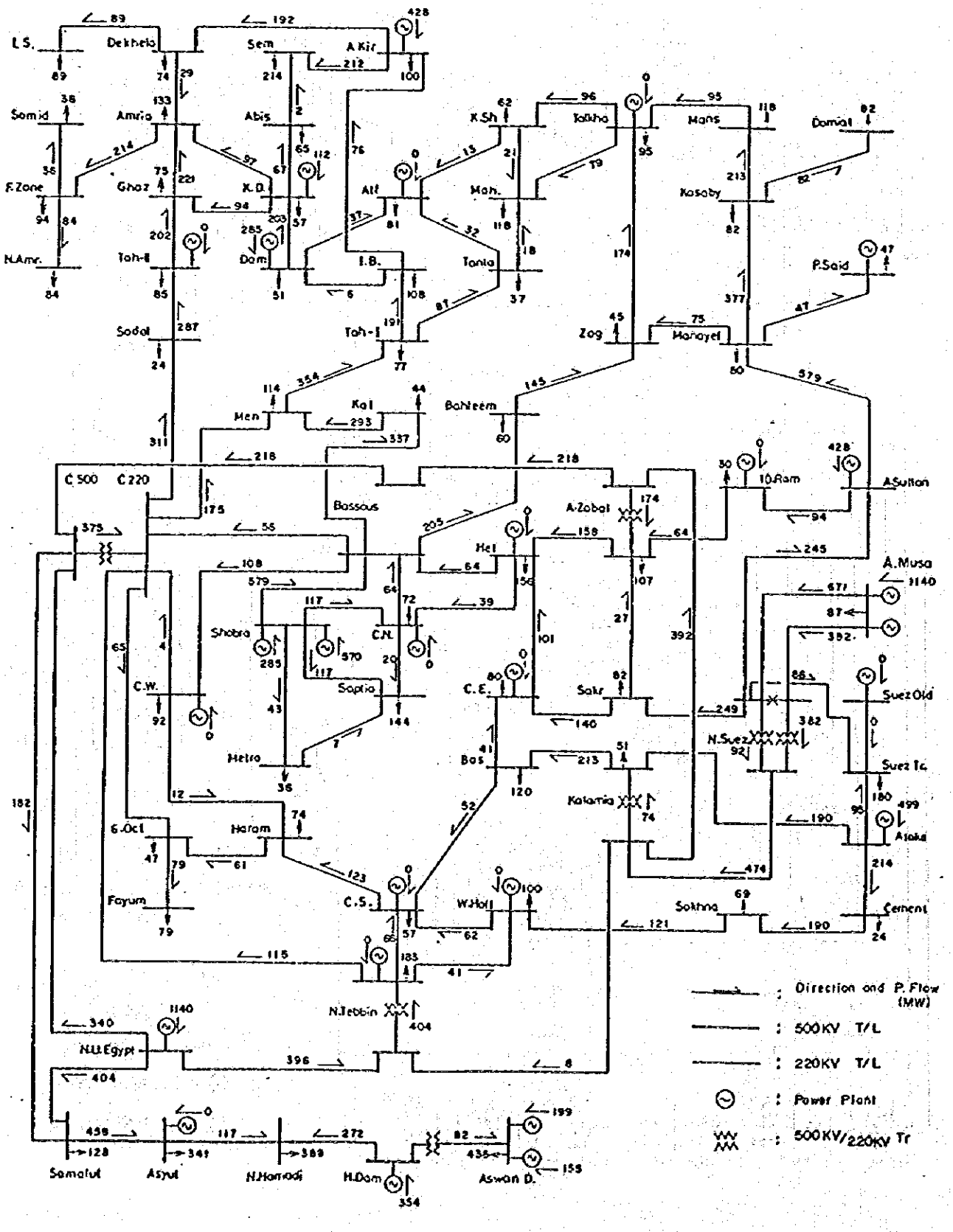
iii) Reference Bus is C.500



1990 Flow NO.7

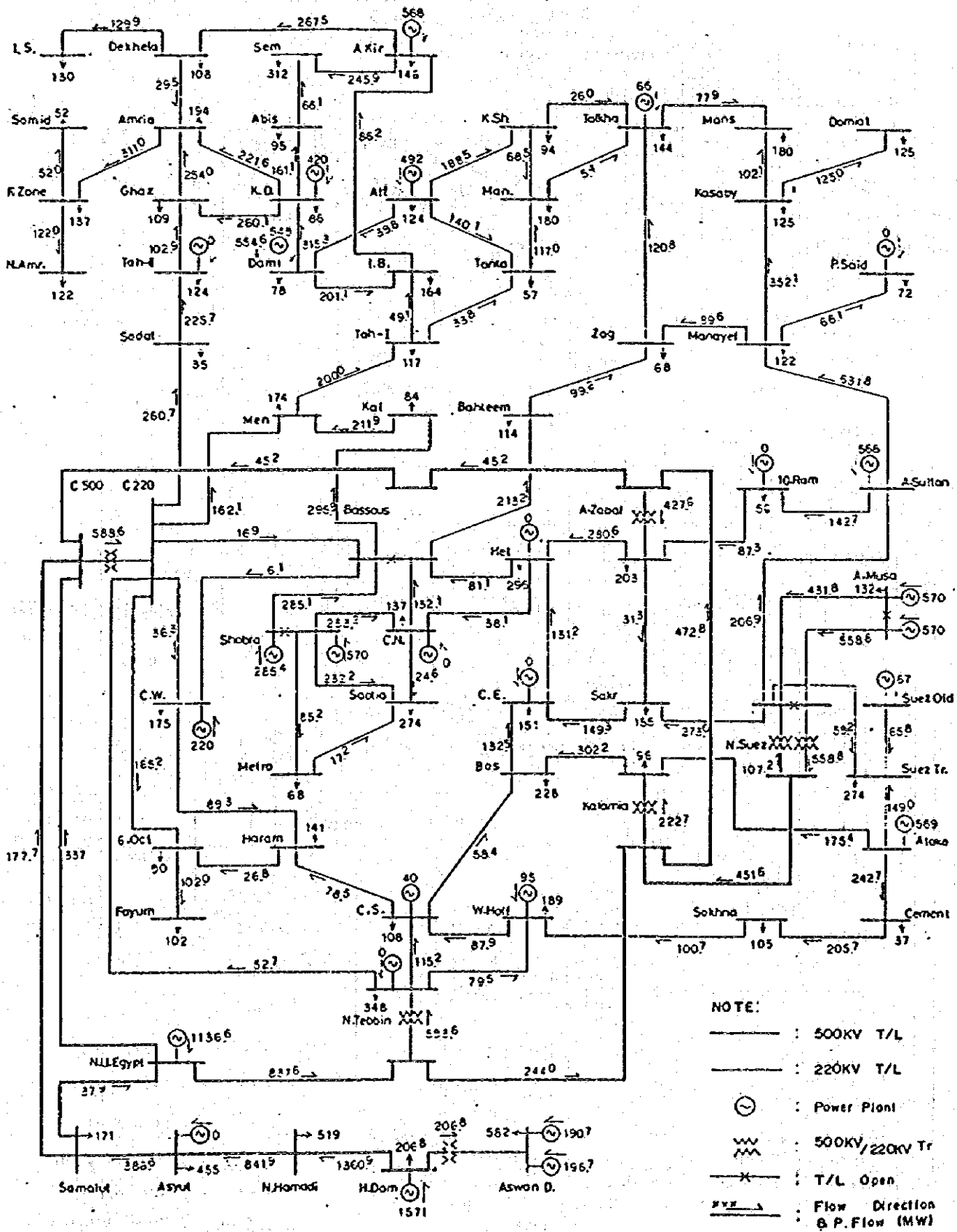
Load Flow in 1990 (Mid Night) Case L-90-3

Conditions : i) All Loop
ii) N. Suez 220KV Bus Seperate
iii) Reference Bus is C.500



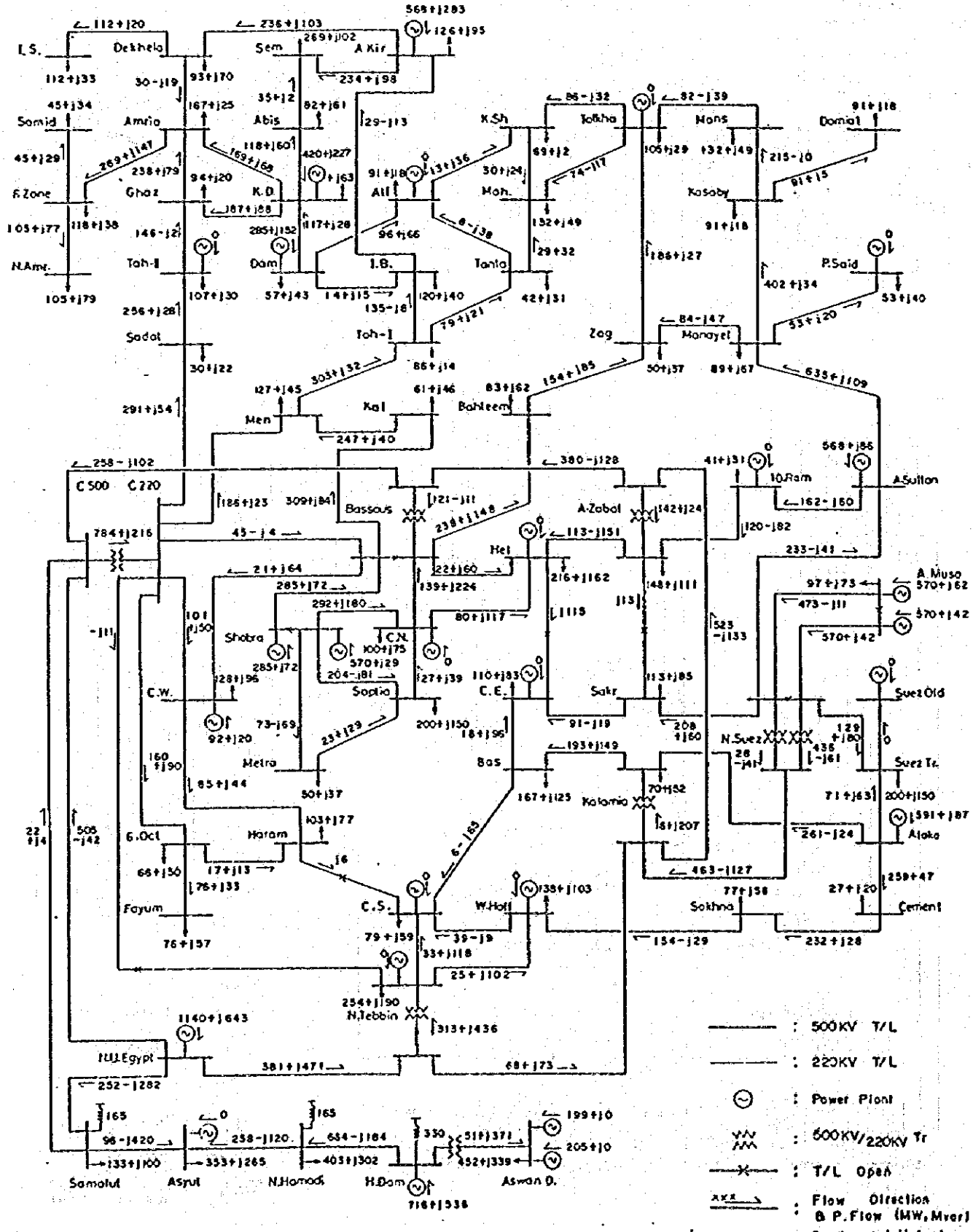
Load Flow 1990 (Peak) case L-90-3

Conditoins : i) Bassous, Shobra Bus Separate
ii) New Suez 220 kv Bus Separate



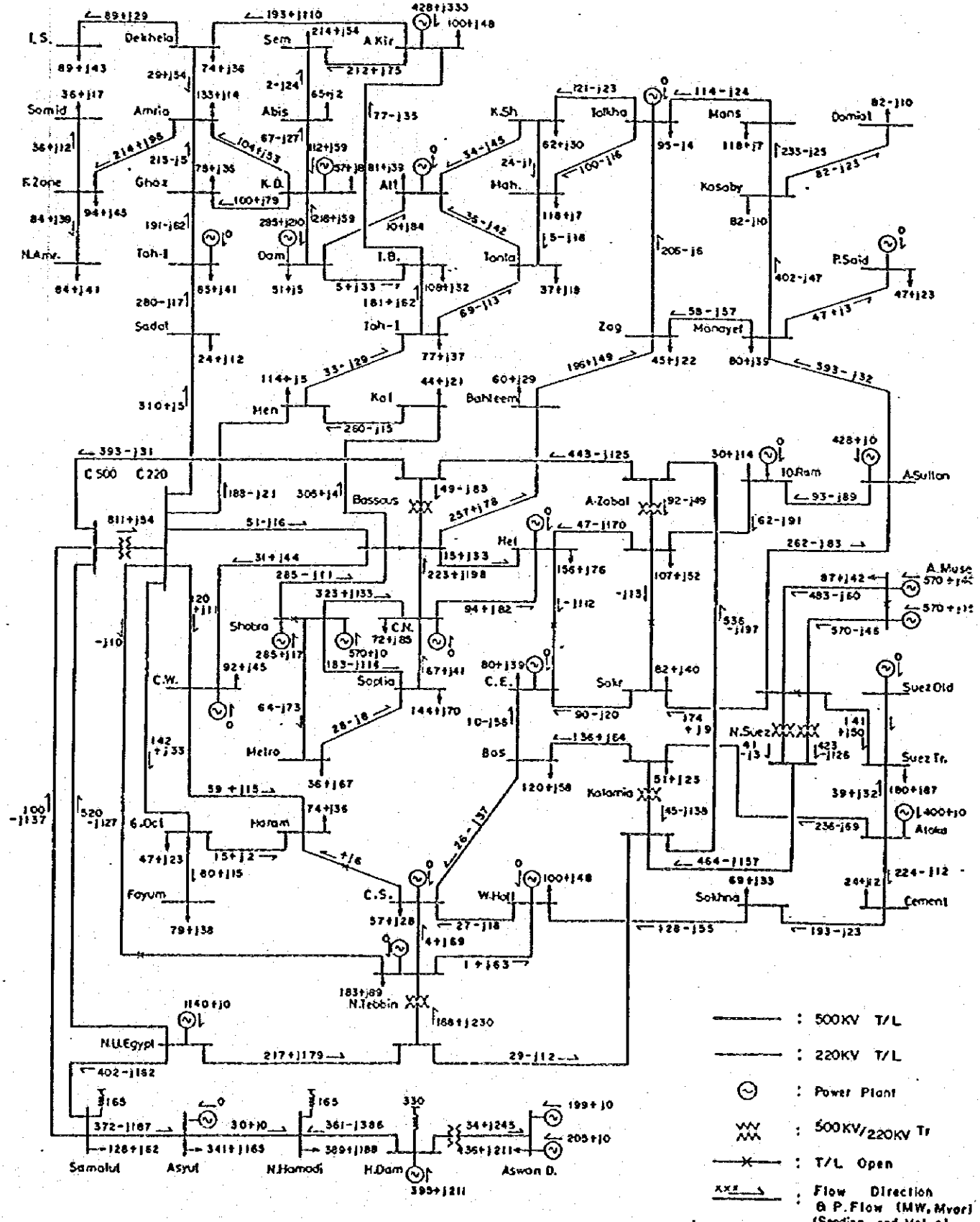
Load Flow in 1990 (Day Time) Case L-90-6

Conditions
(I) Bassous, Shobra Bus Separate.
(II) C200-N.Tebbin, Haram-C.S, Hel-C.E, A.Zabal-Sakr Lines Open
(III) Bassous 500/220KV Step Down Tr. Is installed.
(IV) N.Suez 220KV Bus Separate.



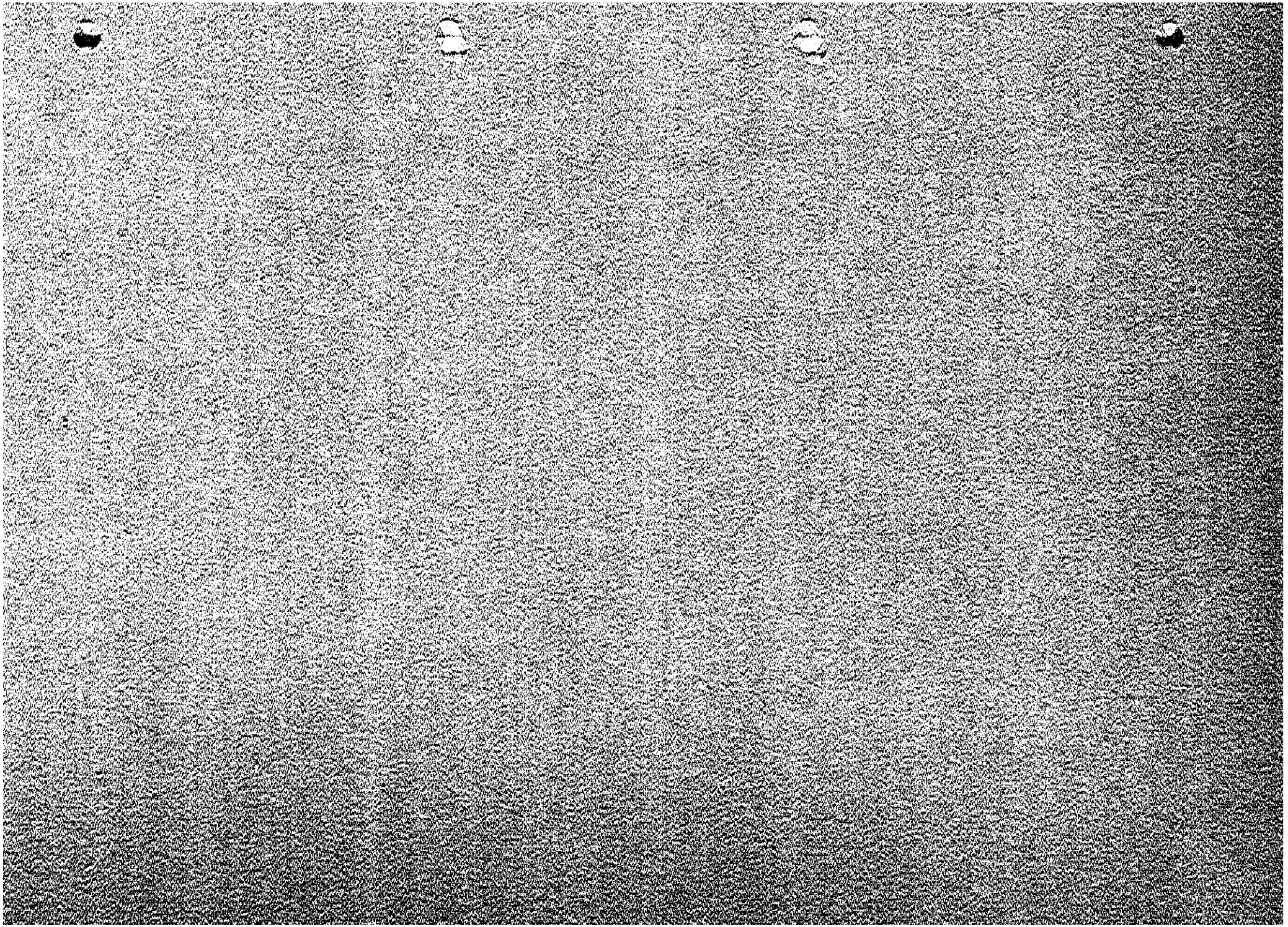
Load Flow in 1990 (Mid Night) Case L-90-7

Conditions
I) Bassous, Shobra Bus Separate.
II) C200-N.Tebbin, Horam-C.S, Hel-CE, A.Zobal-Sakr Lines Open
III) Bassous 500/220KV Step Down Tr. is Installed.
IV) N.Suez 220KV Bus Separate.



添付E

日本における事故率実績



Outage Rate in Japan

The forced outage rate in Japanese thermal power plants are tabulated in the following table. The calculation of reserve capacity was made with this table as the reference.

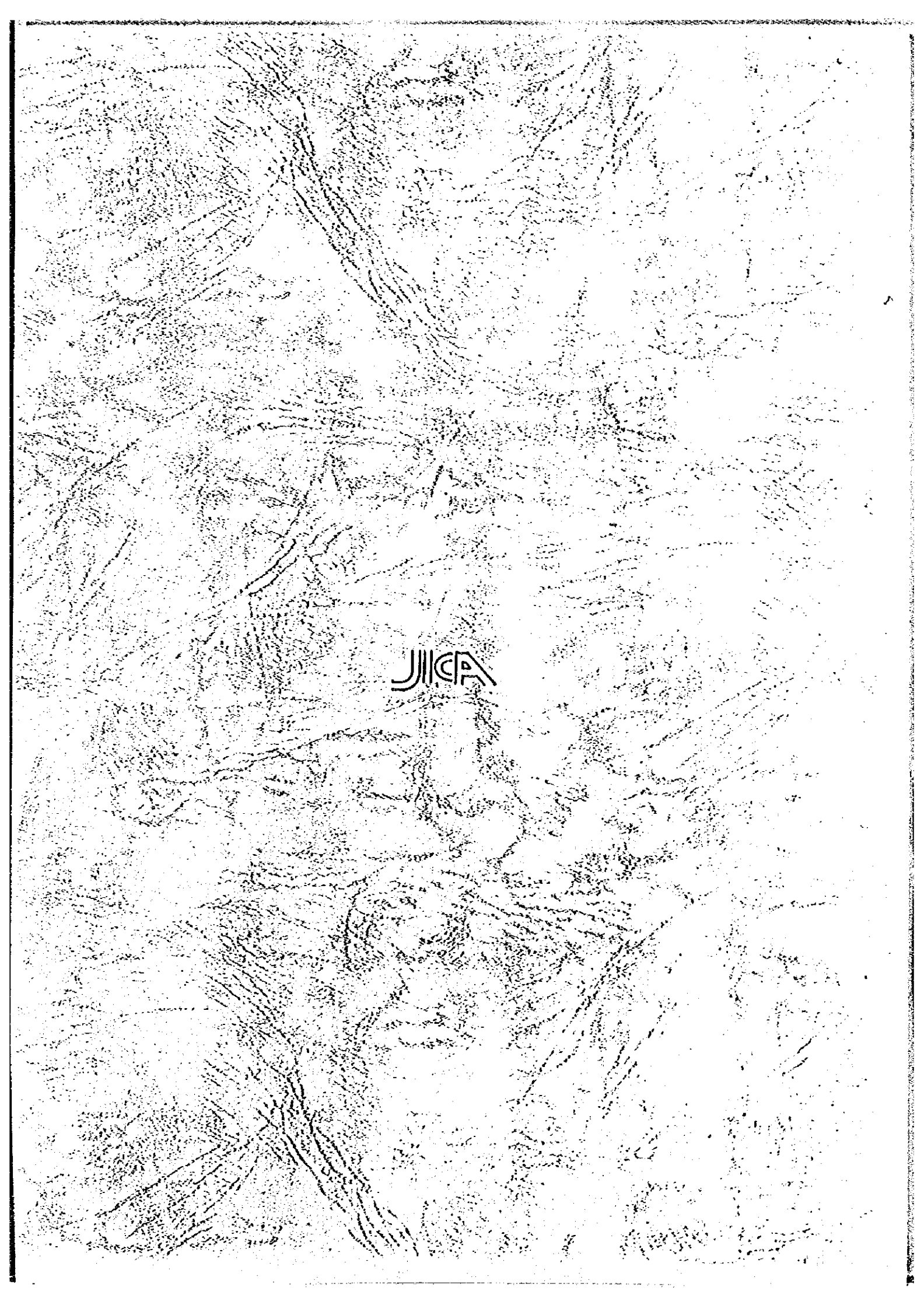
Forced Outage Rate of Thermal Power Plant in Japan (1955 ~ 1977)

第III－21表　昭和30年度～52年度の火力停止率(平日)の推移

	Class	Output		Unit	Result of Study (1955 ~ 1973)																										Result of Study (1974 ~ 1977)					Four 23 years
					1st Period				2nd Period				3rd Period				4th Period				5th Period				6th Period				for 19 years	7th period					
					1955	1956	1957	3 years	1958	1959	1960	for 3 years	1961	1962	1963	for 3 years	1964	1965	1966	1967	for 4 years	1968	1969	1970	for 3 years	1971	1972	1973	for 3 years		1974	1975	1976	1977	for 4 years	
Opreating days (A)	(I)	75MW	運転日数(A)	Days	7,371.5	9,763.0	11,695.0	28,829.5	13,049.0	15,781.5	19,625.0	47,573.5	14,716.0	16,106.0	14,933.0	45,755.0	12,941.5	14,213.5	11,317.5	12,618.5	47,091.0	13,138.5	14,184.5	13,781.5	41,303.5	8,867.0	7,844.0	8,134.5	24,845.5	226,540.0	6,720.5	6,881.5	6,842.5	7,128.5	26,760.0	282,100.0
Forced outage days (B)		1	計画外停止日数(B)	Days	996.0	536.5	533.0	1,573.5	653.5	566.5	453.0	1,673.0	775.5	292.5	371.5	897.5	283.5	265.5	306.5	855.5	999.0	244.5	176.5	140.5	561.5	141.0	246.0	103.5	490.5	5,763.0	112.5	117.5	126.5	140.5	501.0	6,460.0
Forced outage rate (A)/((A)+(B))		125MW	停止率 $\frac{(B)}{(A)+(B)}$	(%)	6.4	5.2	4.5	5.2	3.6	3.4	2.3	3.0	1.8	1.5	2.4	1.9	1.9	2.3	2.7	1.5	2.1	1.8	1.2	1.0	1.3	1.6	2.7	1.3	1.8	2.4	1.6	1.8	1.9	1.9	1.8	2.4
Opreating days (A)	(II)	156MW	運転日数(A)	Days	-	-	-	-	95.0	1,496.5	3,198.5	4,790.0	4,128.0	6,772.5	9,618.0	19,518.5	11,734.5	13,068.0	15,243.5	17,470.0	57,788.0	19,121.0	21,228.5	22,720.0	63,069.5	23,649.5	23,564.0	22,993.5	70,971.0	214,737.0	19,312.0	18,126.5	19,173.0	20,224.0	77,016.0	291,853.0
Forced outage days (B)		1	計画外停止日数(B)	Days	-	-	-	-	1.5	88.5	95.0	184.5	169.0	233.5	374.5	677.0	263.5	321.0	258.5	349.0	1,192.0	281.0	367.5	349.0	997.5	392.5	636.0	574.5	1,603.0	4,652.5	314.0	271.5	336.0	196.0	1,179.5	5,832.0
Forced outage rate (A)/((A)+(B))		265MW	停止率 $\frac{(B)}{(A)+(B)}$	(%)	-	-	-	-	1.6	6.0	2.9	3.8	3.9	3.6	2.3	3.0	3.0	2.7	2.3	2.0	2.4	1.4	1.7	1.4	1.5	1.6	2.8	2.5	2.3	2.2	1.6	2.0	1.6	0.9	1.6	2.0
Opreating days (A)	(III)	375MW	運転日数(A)	Days	-	-	-	-	-	-	-	-	-	-	-	-	877.5	1,332.5	2,070.5	2,640.5	6,920.0	3,799.5	6,322.5	5,929.5	16,050.5	7,857.0	11,428.5	12,997.5	32,284.0	56,440.6	15,723.0	17,219.5	17,691.0	19,297.0	69,930.5	126,370.0
Forced outage days (B)		1	計画外停止日数(B)	Days	-	-	-	-	-	-	-	-	-	-	-	-	41.5	81.5	92.5	77.5	293.0	95.5	168.5	177.5	541.5	306.0	361.5	474.5	1,141.0	1,975.5	425.0	377.5	296.0	346.5	1,444.0	3,419.5
Forced outage rate (A)/((A)+(B))		1,000MW	停止率 $\frac{(B)}{(A)+(B)}$	(%)	-	-	-	-	-	-	-	-	-	-	-	-	4.6	5.9	4.6	2.8	3.6	2.5	2.7	2.1	2.3	3.7	3.1	3.5	3.3	3.1	2.6	2.2	1.7	1.8	2.0	2.0
Opreating days (A)	Total	75MW	運転日数(A)	Day	7,371.5	9,763.0	11,695.0	28,829.5	13,104.0	17,196.0	21,921.5	52,221.5	18,844.0	22,878.5	24,551.0	66,273.5	25,345.5	29,719.0	28,941.5	32,729.0	116,735.0	36,741.0	39,735.5	42,867.0	118,823.5	40,191.5	41,284.5	44,104.5	127,580.5	504,777.5	41,756.5	41,414.5	43,634.5	46,629.5	173,435.0	678,689.0
Forced outage days (B)		1	計画外停止日数(B)	Days	996.0	536.5	533.0	1,573.5	654.5	645.0	528.0	1,827.5	944.5	694.0	746.0	1,584.5	547.5	728.0	717.5	815.0	2,808.0	621.0	692.5	667.0	1,980.5	839.5	1,243.5	1,154.5	3,237.5	12,536.5	851.5	867.5	798.5	690.5	3,178.0	15,821.5
Forced outage rate (A)/((A)+(B))		1,000MW	停止率 $\frac{(B)}{(A)+(B)}$	(%)	6.4	5.2	4.5	5.2	3.6	3.6	2.4	3.4	2.8	2.7	2.9	2.3	2.5	2.7	2.5	1.8	2.3	1.7	1.6	1.4	1.6	2.0	2.8	2.5	2.5	2.4	2.0	2.0	1.7	1.4	1.8	2.3

Source: Explanation of Methods of Electric Power Demand Forecast and Electric Power Supply Program Employed in the Japan Electric Power Survey Report, November, 1982, Japan Electric Power Research Committee

* Adopted Forced Outage Rate for Decision of Unit Capacity of This Project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