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APPENDICES

APPENDIX A

PERFORMANCE DATA
OF THE SOUTH BANGKOK THERMAL PLANT

A.1 Station Net Heat Rates

Figure A-1.1 : Unit-1

Figure A-1.2 : Unit-2

Figure A-1.3 : Unit-3

Figure A-1.4 : Unit-4

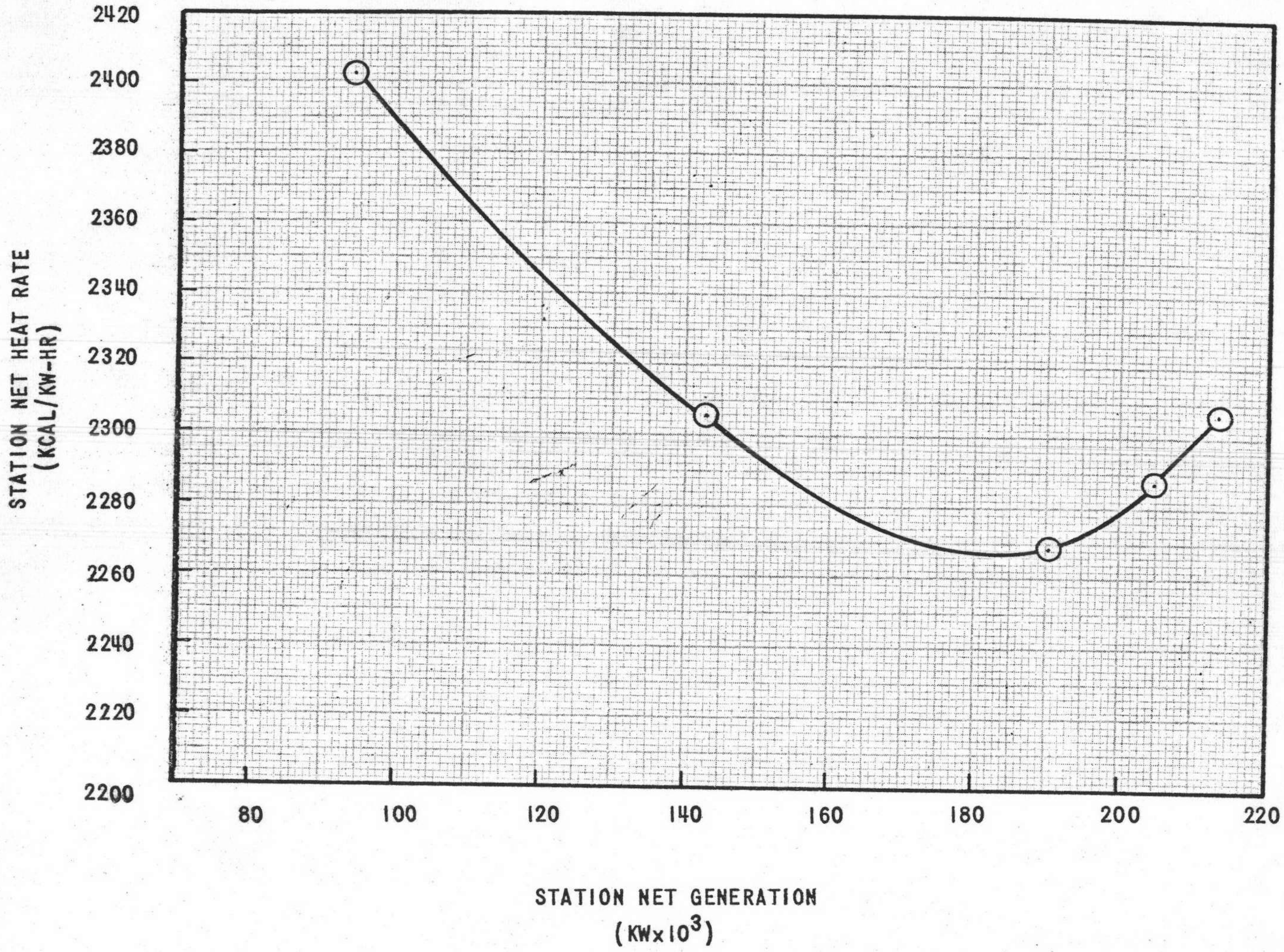
A.2 Station Auxiliary Power

Figure A-2.1 : Unit-1

Figure A-2.2 : Unit-2

Figure A-2.3 : Unit-3

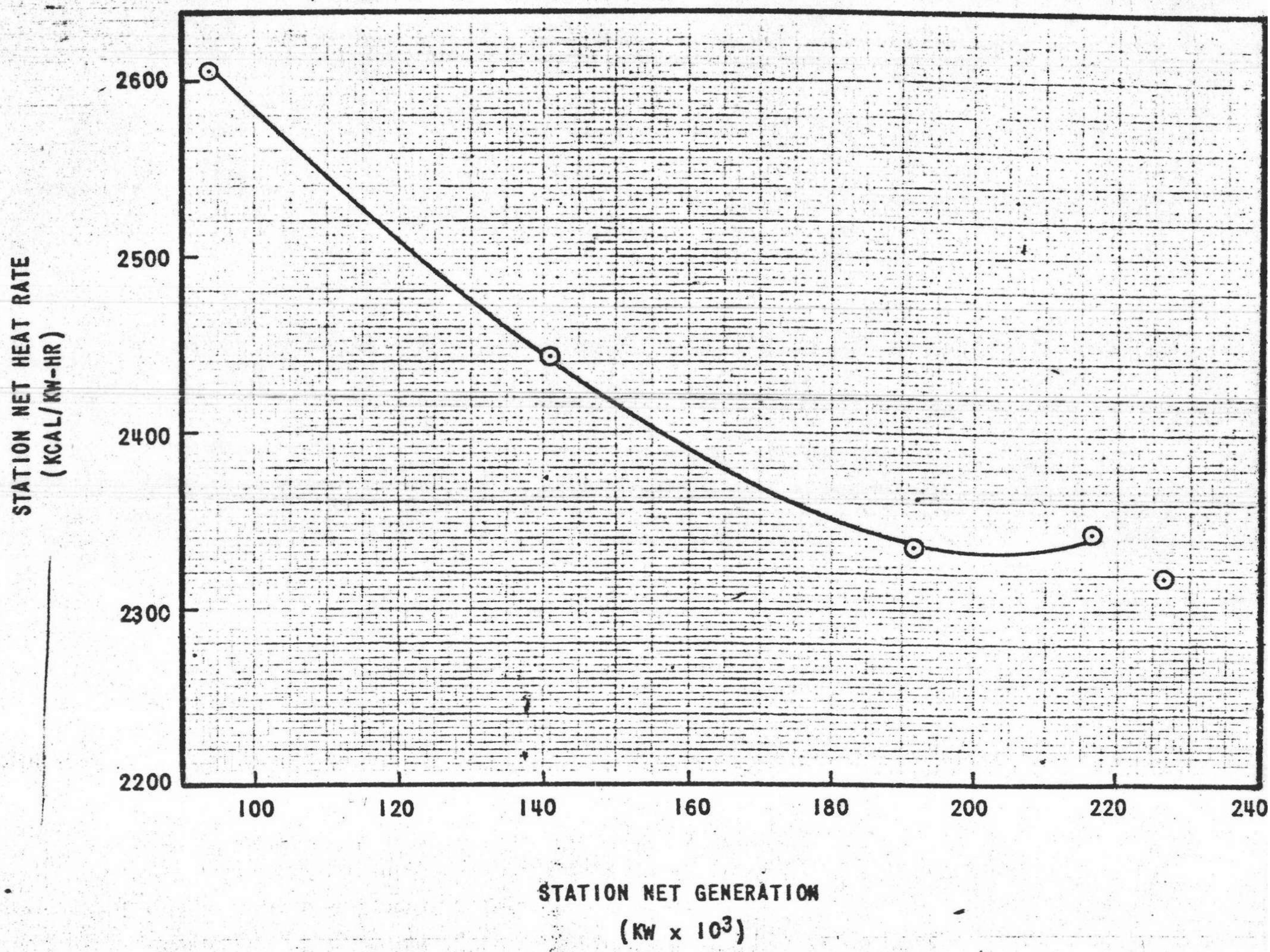
Figure A-2.4 : Unit-4



* HEAT RATES CORRECTED TO
76 MMHgA BACKPRESSURE

ELECTRICITY GENERATING AUTHORITY OF THAILAND
SOUTH BANGKOK UNIT I
STATION NET HEAT RATES

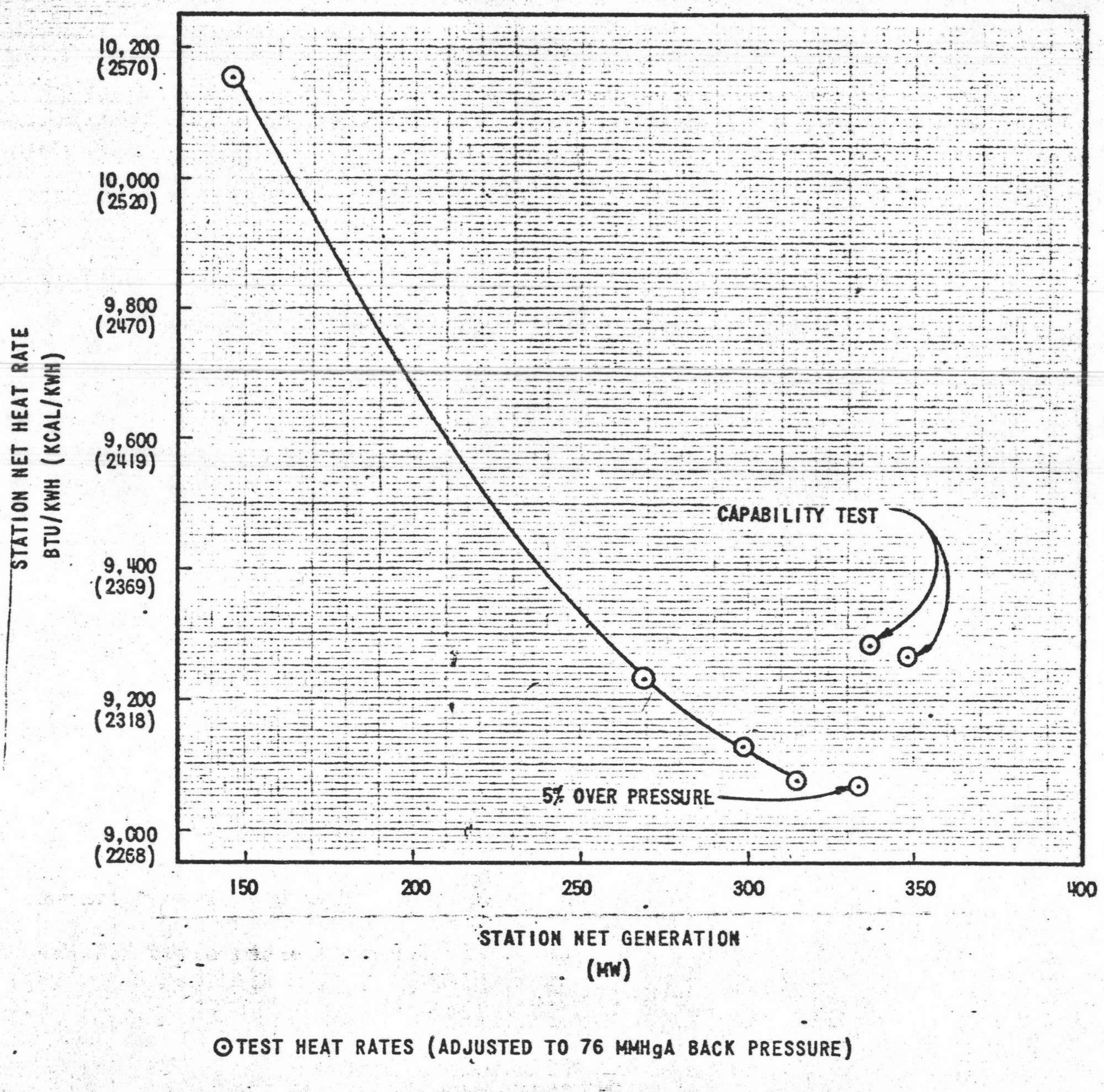
FIGURE A-1.1



* HEAT RATES CORRECTED TO
76 MMH_gA BACK PRESSURE

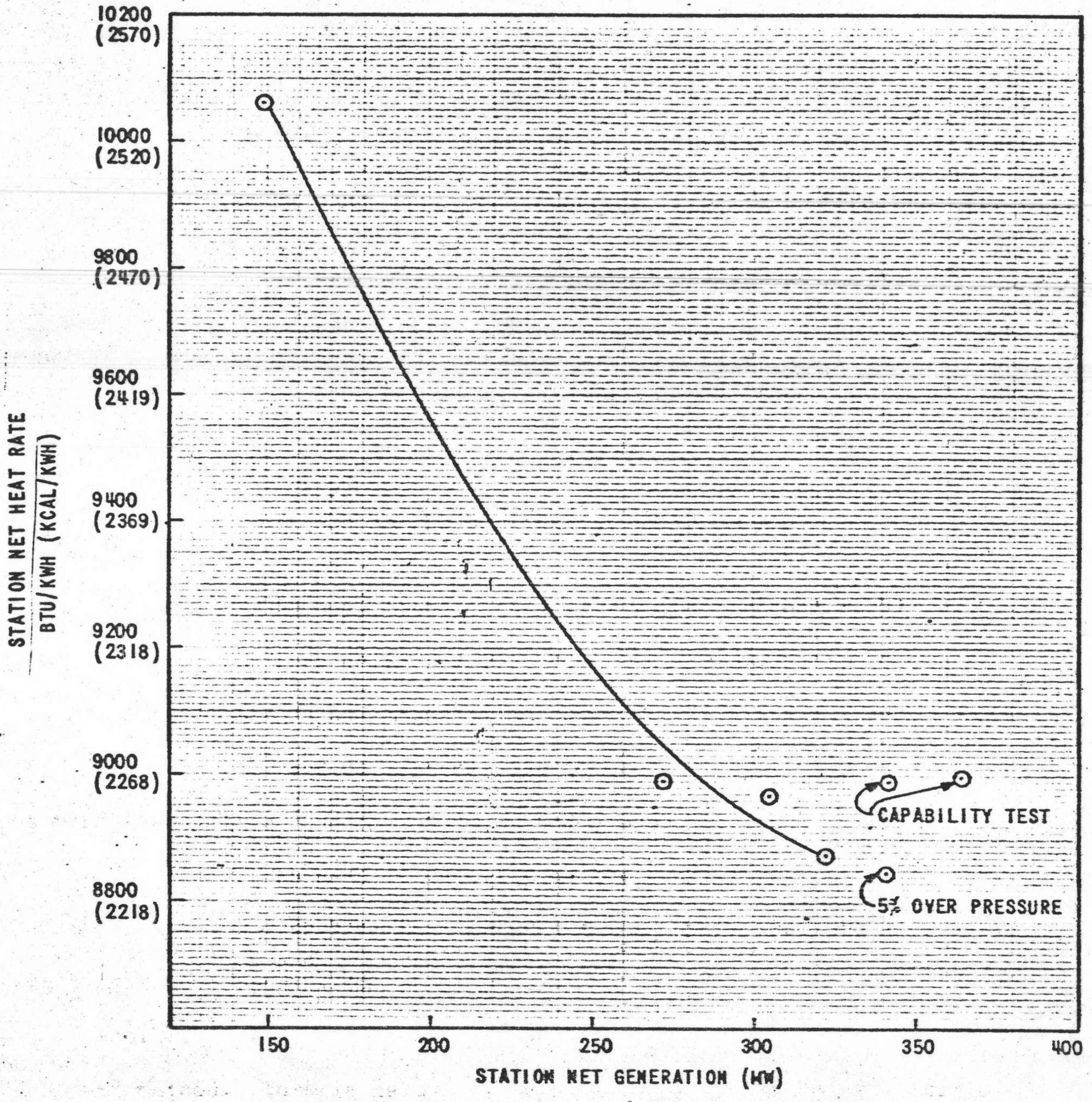
ELECTRICITY GENERATING AUTHORITY OF THAILAND
SOUTH BANGKOK UNIT 2
STATION NET HEAT RATES

FIG. A-1.2



ELECTRICITY GENERATING AUTHORITY OF THAILAND
SOUTH BANGKOK UNIT 3
STATION NET HEAT RATES

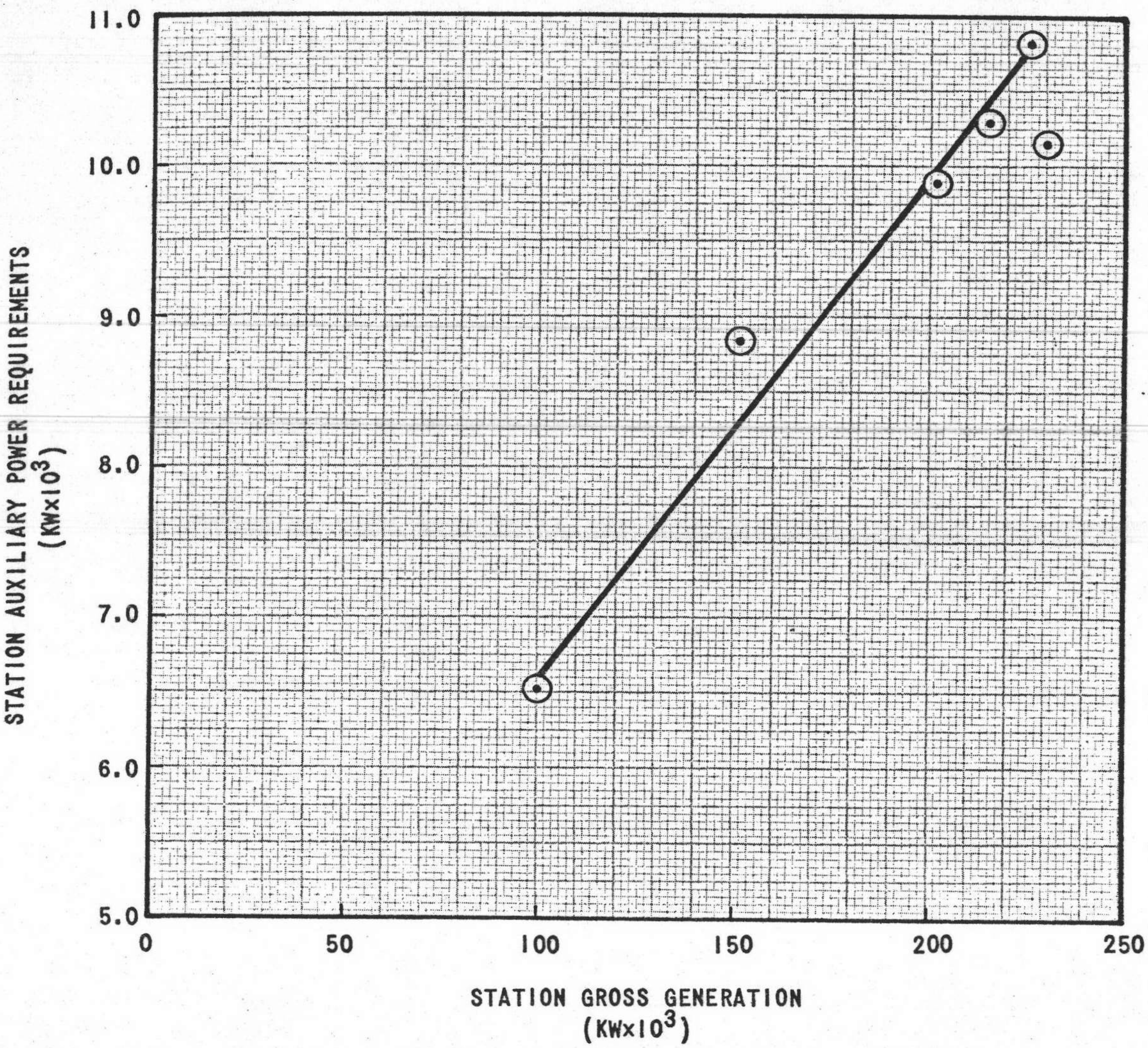
FIG. A-1.3



⊙ TEST HEAT RATES (ADJUSTED TO 76 MMHgA BACK PRESSURE)

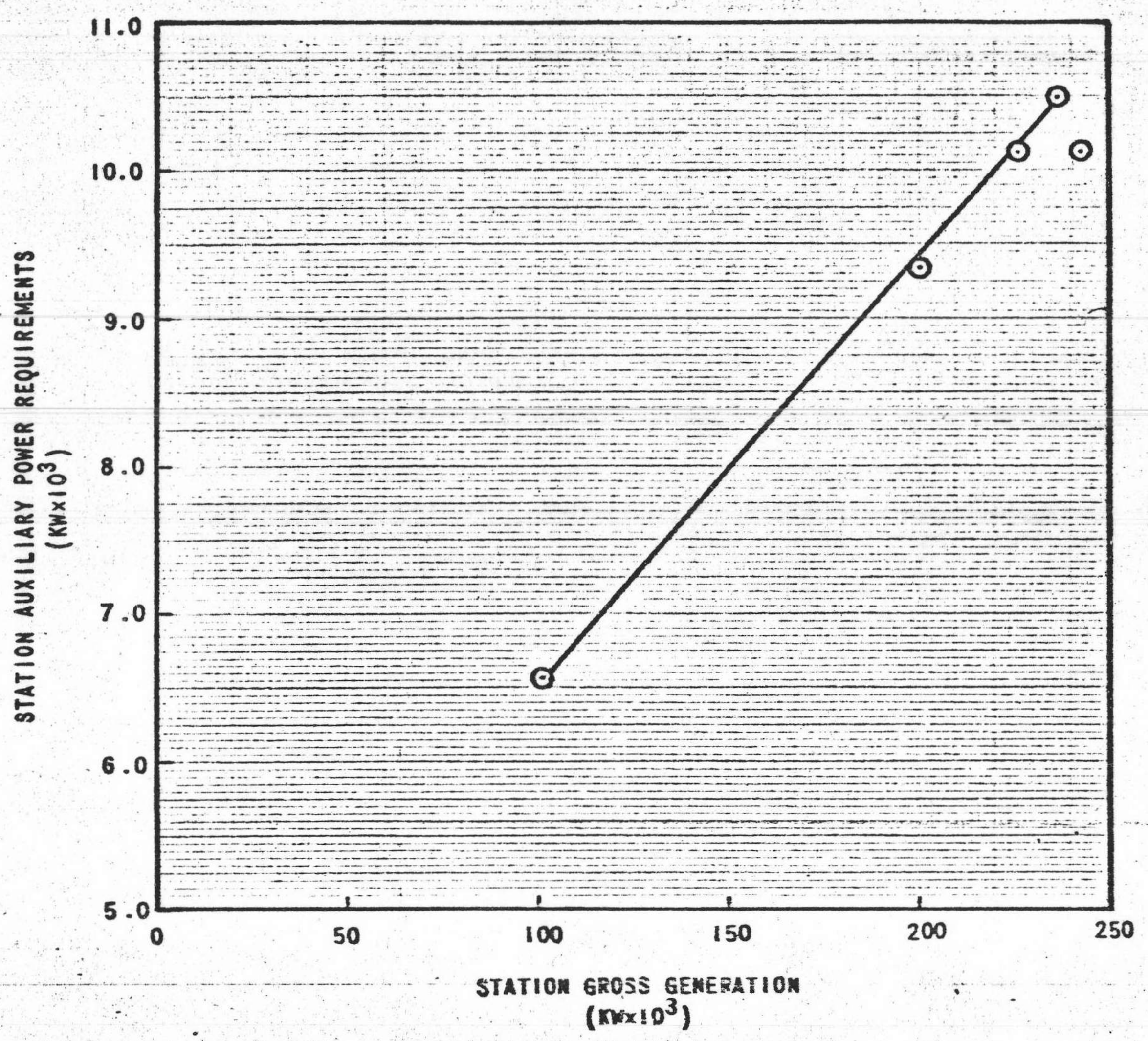
ELECTRICITY GENERATING AUTHORITY OF THAILAND
SOUTH BANGKOK UNIT 4
STATION NET HEAT RATES

FIG. A-1.4



ELECTRICITY GENERATING AUTHORITY OF THAILAND
SOUTH BANGKOK UNIT I
STATION AUXILIARY POWER

FIGURE A-2.1

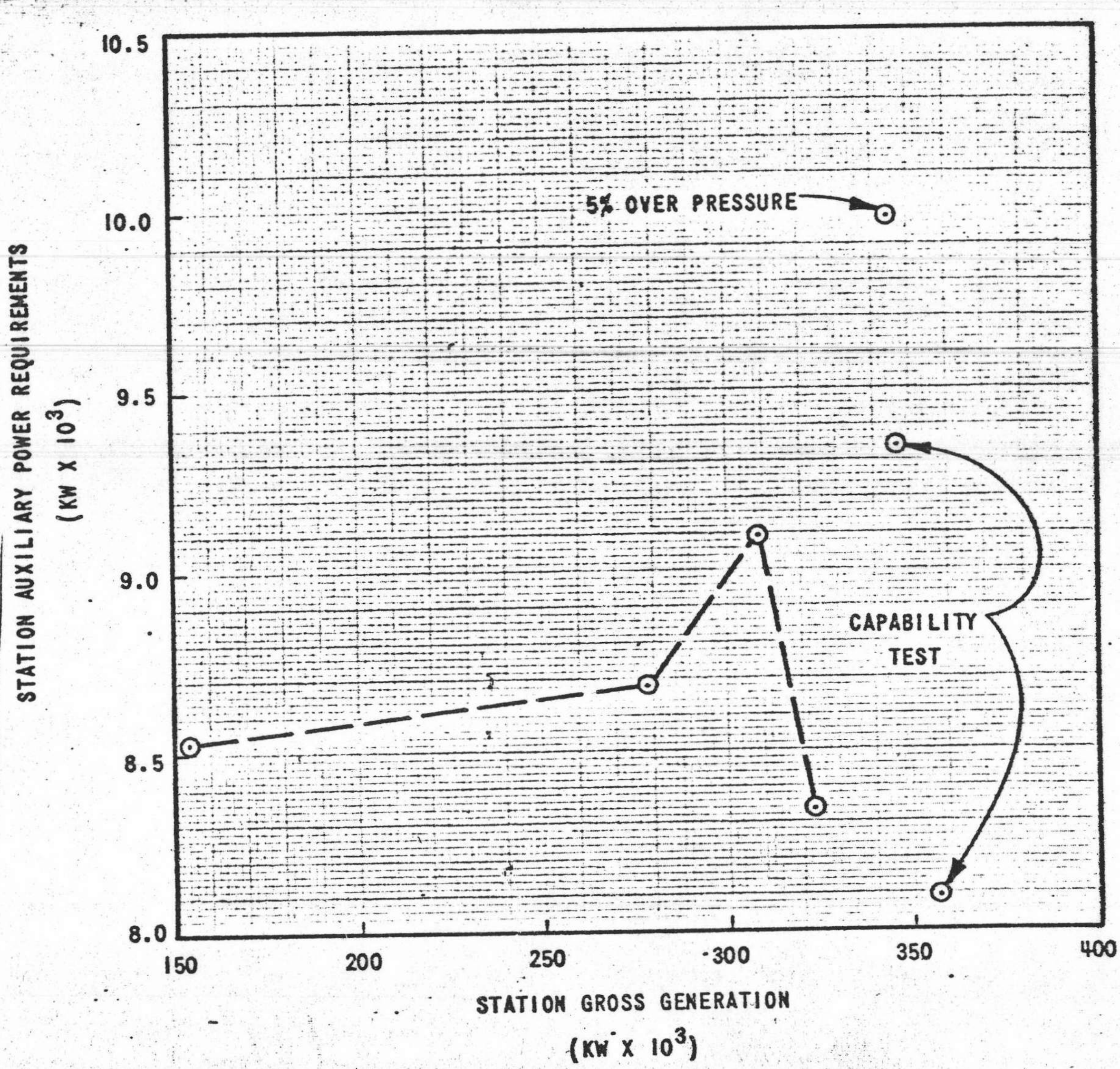


ELECTRICITY GENERATING AUTHORITY OF THAILAND

SOUTH BANGKOK UNIT 2

STATION AUXILIARY POWER

FIG. A-2.2

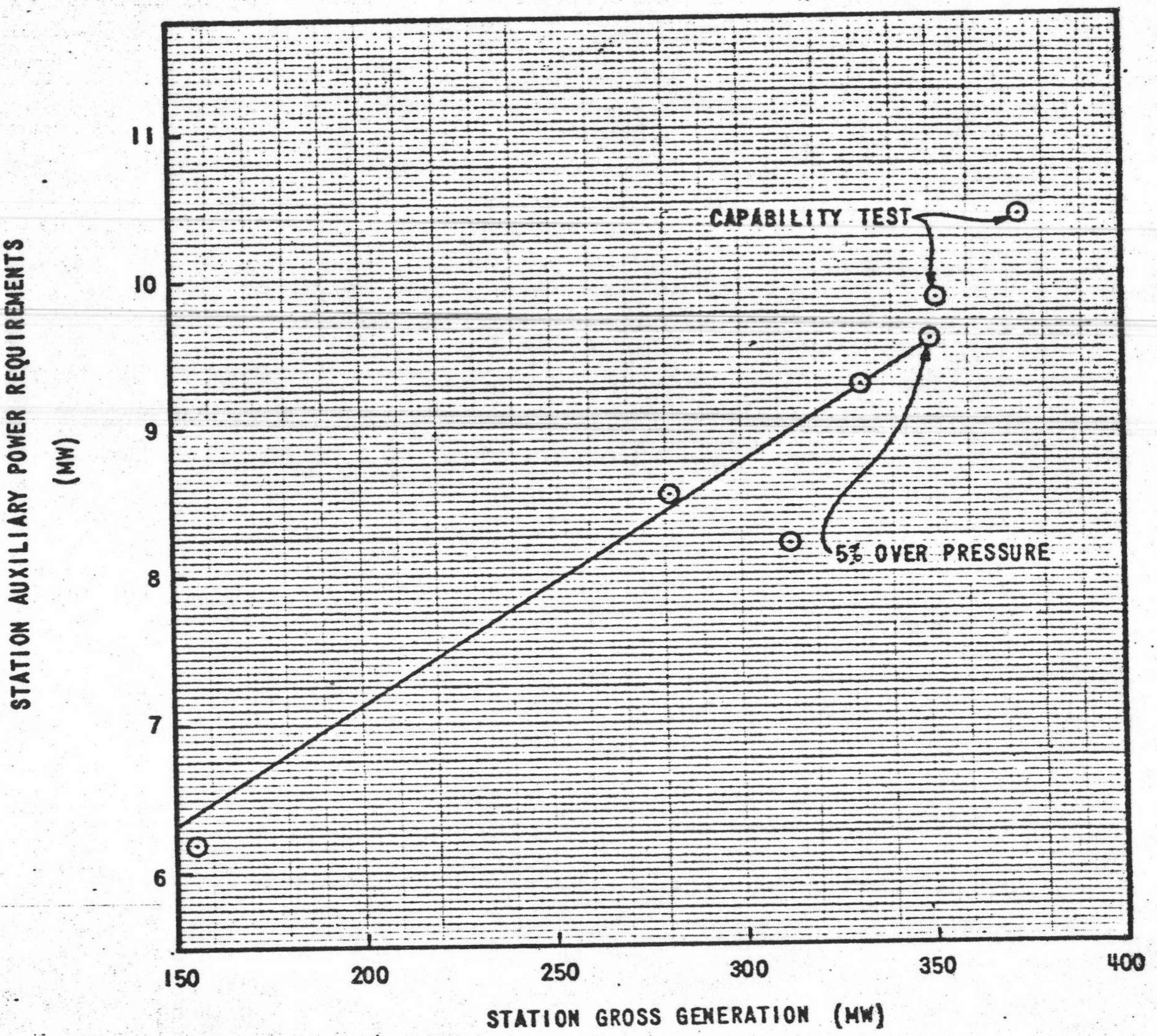


NOTE: VARIATIONS IN AUX. POWER REQUIREMENTS

LOAD	OPERATING MDBFP 32	OPERATING MDBFP 33	OPERATING CWP 31
155	YES	YES	NO
280	YES	YES	NO
310	YES	YES	NO
325	NO	NO	NO
345	YES	NO	YES
350	NO	NO	NO
360	NO	NO	YES

ELECTRICITY GENERATING AUTHORITY OF THAILAND
SOUTH BANGKOK UNIT 3
STATION AUXILIARY POWER

FIG. A-2.3



NOTE: VARIATIONS IN AUX. POWER REQUIREMENTS

LOAD	OPERATING CWP #1	#2	#3
155	YES	YES	NO
280	YES	YES	YES
310	YES	YES	NO
330	YES	YES	YES
350	YES	YES	YES
352	YES	YES	YES
370	YES	YES	YES

ELECTRICITY GENERATING AUTHORITY OF THAILAND
SOUTH BANGKOK UNIT 4
STATION AUXILIARY POWER

FIG. A-2.4

APPENDIX B

LEAST-SQUARES CURVE FITTING

It is a smooth curve which does not pass through each of a number of given points, but which passes near each of them in a plane.

Normal Equation for Curve Fitting

This is the problem of fitting a given number of function values (x_i and y_i, $i=1,\ldots,n$) by a straight line in the form

$$Y = a_o + a_1 x. \tag{B-1}$$

The coefficients a_o and a_1 are determined by using the least-squares criterion which requires that $S = \sum (Y_i - y_i)^2$ be a minimum, where Y_i is evaluated from Eq.(B-1). The values $Y_i - y_i$ are called **residuals.**

To obtain the minimum value of S, which is a function of two variables: a_o and a_1, the following two first partial derivatives are set to zero:

$$\frac{\partial S}{\partial a_o} = 0 \quad \text{and} \quad \frac{\partial S}{\partial a_1} = 0.$$

This yields the two simultaneous linear equations

$$\frac{\partial S}{\partial a_o} = \sum_{i=1}^{n} \frac{\partial}{\partial a_o}(a_o + a_1 x_i - y_i)^2 = \sum_{i=1}^{n} 2(a_o + a_1 x_i - y_i) = 0, \tag{B-2a}$$

and

$$\frac{\partial S}{\partial a_1} = \sum_{i=1}^{n} \frac{\partial}{\partial a_1}(a_o + a_1 x_i - y_i)^2 = \sum_{i=1}^{n} 2x_i(a_o + a_1 x_i - y_i) = 0. \tag{B-2b}$$

From Eq.(B-2a)

$$\sum_{i=1}^{n} y_i = na_o + a_1 \sum_{i=1}^{n} x_i , \quad \text{(B-3a)}$$

and from Eq.(B-2b)

$$\sum_{i=1}^{n} x_i y_i = a_o \sum_{i=1}^{n} x_i + a_1 \sum_{i=1}^{n} x_i^2 \quad \text{(B-3b)}$$

Thus, the Eqs.(B-3a) and (B-3b) represent two conditions which must be met in order to obtain the best fit of the straight line, based on the least-squares criterion. The values of a_o and a_1 can be solved easily by these two linear equations.

The m^{th} Degree Polynomials

The procedure is quite similar to the straight-line case. Basically, a minimum value of S will be found, where

$$Y = a_o + a_1 x + a_2 x^2 + \ldots + a_m x^m , \quad \text{(B-4a)}$$

and

$$S = \sum_{i=1}^{n} (Y_i - y_i)^2 = \sum_{i=1}^{n} (a_o + a_1 x_i + a_2 x_i^2 + \ldots + a_m x_i^m - y_i)^2 . \quad \text{(B-4b)}$$

To obtain the minimum value of S, which is now a function of $m+1$ variables $a_o, a_1, \ldots, a_m$, the following $m+1$ first partial derivatives are set to zero:

$$\begin{aligned} \frac{\partial S}{\partial a_o} &= \sum_{i=1}^{n} 2(a_o + a_1 x_i + a_2 x_i^2 + \ldots + a_m x_i^m - y_i) = 0, \\ \frac{\partial S}{\partial a_1} &= \sum_{i=1}^{n} 2x_i (a_o + a_1 x_i + a_2 x_i^2 + \ldots + a_m x_i^m - y_i) = 0, \quad \text{(B-5)} \\ &\vdots \\ \frac{\partial S}{\partial a_m} &= \sum_{i=1}^{n} 2x_i^m (a_o + a_1 x + a_2 x_i^2 + \ldots + a_m x_i^m - y_i) = 0. \end{aligned}$$

Then the m+1 simultaneous linear, or normal, equation

$$
\begin{aligned}
a_o n &+ a_1\Sigma x_i &+ a_2\Sigma x_i^2 &+\dots+ a_m\Sigma x_i^m &- \Sigma y_i &= 0,\\
a_o\Sigma x_i &+ a_1\Sigma x_i^2 &+ a_2\Sigma x_i^3 &+\dots+ a_m\Sigma x_i^{m+1} &- \Sigma x_i y_i &= 0,\\
a_o\Sigma x_i^2 &+ a_1\Sigma x_i^3 &+ a_2\Sigma x_i^4 &+\dots+ a_m\Sigma x_i^{m+2} &- \Sigma x_i^2 y_i &= 0,\\
&\vdots\\
a_o\Sigma x_i^m &+ a_1\Sigma x_i^{m+1} &+ a_2\Sigma x_i^{m+2} &+\dots+ a_m\Sigma x_i^{m+m} &- \Sigma x_i^m y_i &= 0,
\end{aligned}
\qquad \text{(B-6)}
$$

are obtained. The symbol Σ implies summation of i from 1 to n.

It is convenient to express Eq.(B-6) in the following matrix notation,

$$[\underline{X}][\underline{a}] = [\underline{Y}], \qquad \text{(B-7)}$$

where

$$
[\underline{X}] = \begin{bmatrix} n & \Sigma x_i & \Sigma x_i^2 & \dots & \Sigma x_i^m \\ \Sigma x_i & \Sigma x_i^2 & \Sigma x_i^3 & \dots & \Sigma x_i^{m+1} \\ \vdots & & & & \\ \Sigma x_i^m & \Sigma x_i^{m+1} & \Sigma x_i^{m+2} & \dots & \Sigma x_i^{2m} \end{bmatrix},
$$

is a symmetric matrix, and

$$
[\underline{a}] = \begin{bmatrix} k_o \\ k_1 \\ \vdots \\ k_m \end{bmatrix} \qquad [\underline{Y}] = \begin{bmatrix} \Sigma y_i \\ \Sigma x_i y_i \\ \vdots \\ \Sigma x_i^m y_i \end{bmatrix} .
$$

It is noted that the column matrix $[\underline{a}]$ can be readily obtained by the Gauss-Jordan elimination method or some other well-known methods.

Case Study Data Fit Curve

From the performance data curves shown in Appendix A, the numerical equation of these curves can be obtained by the least-squares curve fitting method described in the previous section. The straight line of the relation of station service and gross load in MW of each unit within a plant will be fitted into the form

$$L_A = m_s L_G + c \qquad \text{(B-8)}$$

where L_A represents the station service auxiliary power (MW) which is Y in Eq. (B-1)

L_G represents the gross generated load which is x in Eq. (B-1),

m_s is the slope of the line or a_1 in Eq. (B-1), and

c is the constant value or a_o in Eq. (B-1).

For convenience, Fig. 3-2 in Chapter III could be illustrated again

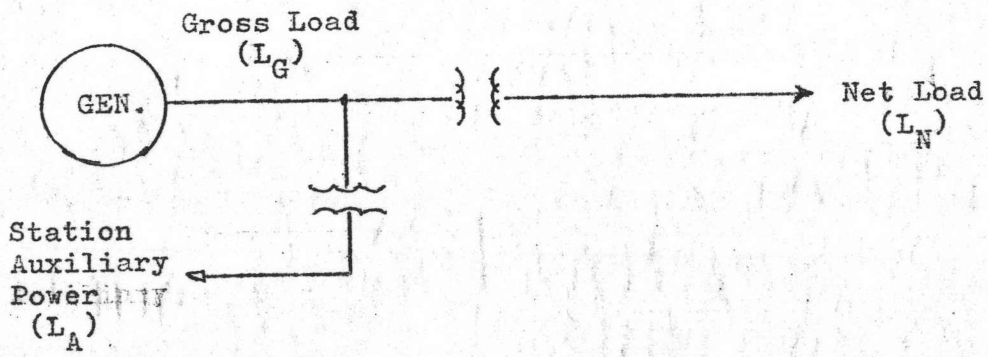


FIG. 3-2 Simplificated one line diagram for each unit of power plant.

From this Fig. 3-2, it can be seen that

$$L_G = L_N + L_A \tag{B-9}$$

Substitute Eq. (B-8) into Eq. (B-9)

$$L_G = L_N + m_s L_G + c$$

then

$$L_G = \frac{L_N + c}{1 - m_s} \tag{B-10}$$

Since heat-rate H_R is the ratio of input per output value, the relation can be written in the following form:

$$H_R = \frac{I}{L_G}$$

or

$$I = H_R \cdot L_G \tag{B-11}$$

where I represents the energy input,

and H_R represents the heat-rate.

Thus, the net heat rate performance data (L_N - H_R relation) shown in Appendix A can be transformed to the input-output relation by the Eqs. (B-10) and (B-11), then the polynomial equation of this relation will be fit by the least-squares curve fitting method into the form.

$$I = a_o + a_1 L_G + a_2 L_G^2 + a_3 L_G^3 + \ldots + a_m L_G^m. \tag{B-12}$$

Eq. (B-12) is similar to Eq. (B-4a) where I is Y and L_G is x. This equation will be used in the computer program for the case study of the load distribution problem. The results of numerical calculation to receive the values of $a_o, a_1, \ldots, a_m$ in Eq. (B-12) are shown in Table B-1 and B-2.

TABLE B-1

STATION SERVICE CURVE FIT

This is the table for finding the values of m_s and c of the Eq.(B-8)

$$L_A = m_s L_G + c$$

by using the least-squares criterion. Appendix A is used as the data.

UNIT-1

L_G (MW*10)	L_A (MW*10)	RESULTS
10.00 15.10 20.20 21.50 22.60	0.500 0.885 0.990 1.030 1.080	$m_s = 0.4271*10^{-1}$ $c = 0.1334$
$m_sL_G+ c$	RESIDUALS $(L_A-(m_sL_G+c))$	SQ. OF RES. $(L_A-(m_sL_G+c))^2$
0.560480	$-0.6048*10^{-1}$	$0.365783*10^{-2}$
0.778300	0.1067	$0.113848*10^{-1}$
0.996077	$-0.6077*10^{-2}$	$0.369290*10^{-4}$
1.051590	$-0.2159*10^{-1}$	$0.466128*10^{-3}$
1.098570	$-0.1857*10^{-1}$	$0.344844*10^{-3}$
	S =	$0.158906*10^{-1}$

UNIT-2

L_G (MW*10)	L_A (MW*10)	RESULTS
10.2	0.656	$m_s = 0.2906*10^{-1}$
20.0	0.935	
22.6	1.012	$c = 0.3582$
23.6	1.050	

$m_s L_G + c$	RESIDUALS $(L_A-(m_s L_G+c))$	SQ.OF RES. $(L_A-(m_s L_G+c))^2$
0.654595	$0.1405*10^{-2}$	$0.197402*10^{-5}$
0.939406	$-0.4406*10^{-2}$	$0.194128*10^{-4}$
1.014968	$-0.2968*10^{-2}$	$0.880902*10^{-5}$
1.044030	$0.5970*10^{-2}$	$0.356409*10^{-4}$

	S =	$0.658367*10^{-4}$

UNIT-3

L_G (MW*10)	L_A (MW*10)	RESULTS
15.4	0.853	$m_s = 0.121*10^{-2}$
27.8	0.868	$c_s = 0.8344$
27.8	0.868	$m_s = 0.1323*10^{-1}$
30.9	0.909	$c_s = 0.5003$
30.9	0.909	$m_s = -0.5357*10^{-1}$
32.3	0.834	$c_s = 2.564$

$m_s L_G + c$	RESIDUALS $(L_A-(m_s L_G+c))$	SQ.OF RES. $(L_A-(m_s L_G+c))^2$
0.8530003	$-0.3576*10^{-6}$	$0.127877*10^{-12}$
0.8680003	$-0.3576*10^{-6}$	$0.127877*10^{-12}$
	S =	$0.255755*10^{-12}$
0.8679994	$0.596*10^{-6}$	$0.355216*10^{-12}$
0.9089994	$0.596*10^{-6}$	$0.355216*10^{-12}$
	S =	$0.710432*10^{-12}$
0.909	0.	0.
0.8339998	$0.1192*10^{-6}$	$0.142086*10^{-13}$
	S =	$0.142086*10^{-13}$

UNIT-4

L_G (MW*10)	L_A (MW*10)	RESULTS
15.5	0.620	$m_s = 0.1727*10^{-1}$
28.1	0.854	
33.2	0.925	$c = 0.3562$
35.0	0.957	

m_sL_G+c	RESIDUALS $(L_A-(m_sL_G+c))$	SQ.OF RES. $(L_A-(m_sL_G+c))^2$
0.623958	$-0.3958*10^{-2}$	$0.156657*10^{-4}$
0.841590	$0.1241*10^{-1}$	$0.154008*10^{-3}$
0.929679	$-0.4679*10^{-2}$	$0.21893*10^{-4}$
0.960770	$-0.3770*10^{-2}$	$0.142129*10^{-5}$
	S =	$0.205779*10^{-3}$

TABLE B-2

INPUT-OUTPUT CHARACTERISTICS CURVE FIT

This is the table for finding the values of $a_1, a_2, \ldots, a_m$ of the Eq.(B-12)

$$I = a_o + a_1 L_G + a_2 L_G^2 + \ldots + a_m L_G^m$$

which is similar to the Eq.(B-4a)

$$Y = a_o + a_1 x + a_2 x^2 + \ldots + a_m x^m$$

by using the least-squares criterion. Appendix A and Table B-1 is used as the data.

UNIT-1

L_N (MW*10)	(x) $L_G = \frac{L_N+c}{1-m_s}$ (MW*10)	H_R ($\frac{KCAL}{KW*hr}*10^3$)	(y) $I = H_R \cdot L_G$ ($\frac{KCAL}{hr}*10^7$)
9.40	9.959	2.402	23.92
14.30	15.08	2.360	35.58
19.00	19.99	2.268	45.33
20.50	21.55	2.287	49.29
21.35	22.44	2.306	51.75

DEG.	RESULTS	F(x)	RESIDUALS	S
2	$a_2= 0.2285*10^{-2}$	24.04	-0.1220	0.7228701
	$a_1= 2.114$	35.16	0.4188	
	$a_o= 2.761$	45.93	-0.6048	
		49.38	-0.09081	
		51.35	0.3982	
3	$a_3= 0.9115*10^{-2}$	23.92	$-0.1251*10^{-2}$	$0.354712*10^{-2}$
	$a_2=-0.4388$	35.58	$0.3075*10^{-2}$	
	$a_1= 8.917$	45.36	$-0.2673*10^{-1}$	
	$a_o=-30.37$	49.24	$0.4568*10^{-1}$	
		51.78	$-0.2711*10^{-1}$	
4	$a_4=-0.5788*10^{-4}$	23.90	$0.1670*10^{-1}$	$0.272629*10^{-1}$
	$a_3= 0.1307*10^{-1}$	35.53	$0.4504*10^{-1}$	
	$a_2=-0.5373$	45.28	$0.5437*10^{-1}$	
	$a_1= 9.969$	49.16	0.1312	
	$a_o=-34.42$	51.68	$0.6918*10^{-1}$	

UNIT-2

L_N (MW*10) (x)	$L_G = \frac{L_N+c}{1-m_s}$ (MW*10)	H_R $(\frac{KCAL}{KW*hr}*10^3)$	(y) $I = H_R \cdot L_G$ $(\frac{KCAL}{hr}*10^7)$
9.40	10.05	2.604	26.17
14.10	14.89	2.444	36.39
19.20	20.14	2.336	47.06
21.60	22.62	2.344	53.01

DEG.	RESULTS	F(x)	RESIDUALS	S
2	$a_2 = 0.8157*10^{-2}$	26.24	-0.06924	0.186569
	$a_1 = 1.849$	36.17	0.2158	
	$a_0 = 6.831$	47.38	-0.3229	
		52.83	0.1759	
3	$a_3 = 0.4386*10^{-2}$	26.17	$0.3357*10^{-3}$	$0.641141*10^{-5}$
	$a_2 = -0.2056$	36.39	$-0.8621*10^{-3}$	
	$a_1 = 5.167$	47.06	$-0.2357*10^{-2}$	
	$a_0 = -9.448$	53.01	$0.7629*10^{-5}$	

UNIT-3

L_N (MW*10)	(x) $L_G = \frac{L_N+c}{1-m_s}$ (MW*10)	H_R $(\frac{KCAL}{KW*hr}*10^3)$	(y) $I = H_R \cdot L_G$ $(\frac{KCAL}{hr}*10^7)$
14.6	15.4	2.558	39.39
26.9	27.8	2.326 2.326	64.66
29.9	30.9	2.300	71.07
31.5	32.3	2.287	73.87

GEG.	RESULTS	F(x)	RESIDUALS	S
2	$a_2= 0.5694*10^{-3}$	39.39	$0.1099*10^{-2}$	$0.294537*10^{-2}$
	$a_1= 2.015$	64.68	$-0.1697*10^{-1}$	
	$a_0= 8.227$	71.03	$0.4367*10^{-1}$	
		73.90	$-0.2737*10^{-1}$	
3	$a_3=-0.8878*10^{-3}$	39.38	$0.6180*10^{-2}$	$0.858728*10^{-3}$
	$a_2= 0.6729*10^{-1}$	64.66	$0.1907*10^{-2}$	
	$a_1= 0.4080$	71.05	$0.2084*10^{-1}$	
	$a_0= 20.38$	73.85	$0.1956*10^{-1}$	

UNIT-4

L_N (MW*10)	(x) $L_G = \frac{L_N+c}{1-m_s}$ (MW*10)	H_R ($\frac{KCAL}{KW*hr}*10^3$)	(y) $I = H_R.L_G$ ($\frac{KCAL}{hr}*10^7$)
14.9	15.52	2.535	39.35
27.2	28.04	2.266	63.54
30.5	31.40	2.259	70.93
32.2	33.13	2.237	74.11
34.1	35.06	2.229	78.15

DEG.	RESULTS	F(x)	RESIDUALS	S
2	$a_2= 0.5981*10^{-2}$ $a_1= 1.688$ $a_o= 11.70$	39.34 63.73 70.60 74.19 78.15	$0.1415*10^{-1}$ -0.1911 0.3328 $-0.7512*10^{-1}$ $-0.8003*10^{-1}$	0.159523
3	$a_3=-0.1628*10^{-2}$ $a_2= 0.1348$ $a_1=-1.5580$ $a_o= 37.130$	39.34 63.56 70.74 74.30 78.08	$0.5959*10^{-2}$ $-0.2184*10^{-1}$ 0.1861 -0.1922 $0.7106*10^{-1}$	$0.77136*10^{-1}$
4	$a_4= 0.8796*10^{-3}$ $a_3=-0.1000$ $a_2= 4.1600$ $a_1=-72.330$ $a_o= 482.90$	39.40 63.86 71.40 74.67 78.44	$-0.4716*10^{-1}$ -0.3243 -0.4692 -0.5600 -0.2870	0.7235121

It can be seen that the best degree to obtain the least value of S is 3 in every unit.

APPENDIX C

COMPUTER PROGRAM

Program Description

The program consists only of one main program. All array and vector sizes are specified in DIMENSION statements, which may be altered for the particular problem. The program is designed for a minimum total fuel use of a plant by distributing the given generation load. The final result will show the best operating point of all the units within the plant. The total generation load can be set via the reading input or initialize the value in the main program.

Description of the Parameters

A(I,J) : The coefficients of x^j of the polynomial I/O equation of the i^{th} unit within a plant.

AO(I) : The constant value of the polynomial I/O equation of the i^{th} unit within a plant.

C : Constant value for reducing r and S in each iteration. In the most cases $C < 10$.

DXI(I) : The i^{th} value of increment of initial feasible solution $\Delta x_i(i)$.

EPS : Epsilon ϵ, the tolerance value.

F : The objective function which is the total fuel use of the plant.

FS	:	The value of F corresponding to the successive value of P.
G(I)	:	The $i^{\underline{th}}$ inequality constraint which is the generting capacity of each unit within a plant.
INV	:	Inverse direction of the step size vector S if it equals to 1.
IPN	:	I + n
ISC	:	If ISC = 1, it means there is some success at least one direction.
JJ	:	Co-ordinate number. If JJ $<$ n it is exploratory move. If JJ = n, it is pattern search. If JJ $>$ n, the tolerance value is checked out and the iteration is started again.
M	:	Maximum degree of the polynomial equations.
N	:	The number of units within a plant.
N1	:	n-1, number of the independent variables.
NN	:	n+n = 2n; number of the inequality constraint g.
NT	:	Row number of the tables. There are NTT rows in each table.
NTBL	:	The number of table.
P	:	The augmented objective function.
PO	:	The original augmented objective function during the step-size vector $\underline{S}$.
PR	:	The memory augmented objective function during the iteration of r.

PS	:	The successive augmented objective function.
R	:	The penalty factor. The initial value is set to make the penalty equal to 10 per cent of the objective function F.
S(I)	:	The i^{th} value of the step-size vector $\underline{S}$
SM	:	Maximum value of S_i.
SO	:	Magnitude of the step-size vector $\underline{S}$.
SUMG	:	Summation of the penalty function $\sum_{i=1}^{2n} \ln g_i$.
SUMGS	:	The value of SUMG corresponding to the successive value of P.
X(I)	:	Gross load generated by the i^{th} unit.
XI(I)	:	The i^{th} initial feasible solution.
XL	:	Total gross load of the plant given by CDC (Central Dispatching Center).
XLMN	:	Minimum value of total gross load of the plant.
XLMX	:	Maximum value of total gross load of the plant.
XLS	:	The last value of XL.
XMAX(I)	:	Maximum load generated by the i^{th} unit.
XMIN(I)	:	Minimum load generated by the i^{th} unit.
XO(I)	:	The i^{th} original feasible solution of the step-size $\underline{S}$.
XS(I)	:	The i^{th} successive feasible solution.
Y(I)	:	Fuel consumption of the i^{th} unit.

Flow Chart

The flow chart is divided into four sub-flow charts as follows:

SUB-FLOW CHART (A) : Read the input data and change the value of given total load XL, for making the table.

SUB-FLOW CHART (B) : Setting the initial value of r, (i.e., r_o), to make the penalty term equal to 10 per cent of the objective function F.

SUB-FLOW CHART (C) : Find the direction and reduce the magnitude of the step-size vector $\underset{\sim}{S}$ and tolerance check out, or reduce the weighting coefficient r of the penalty function.

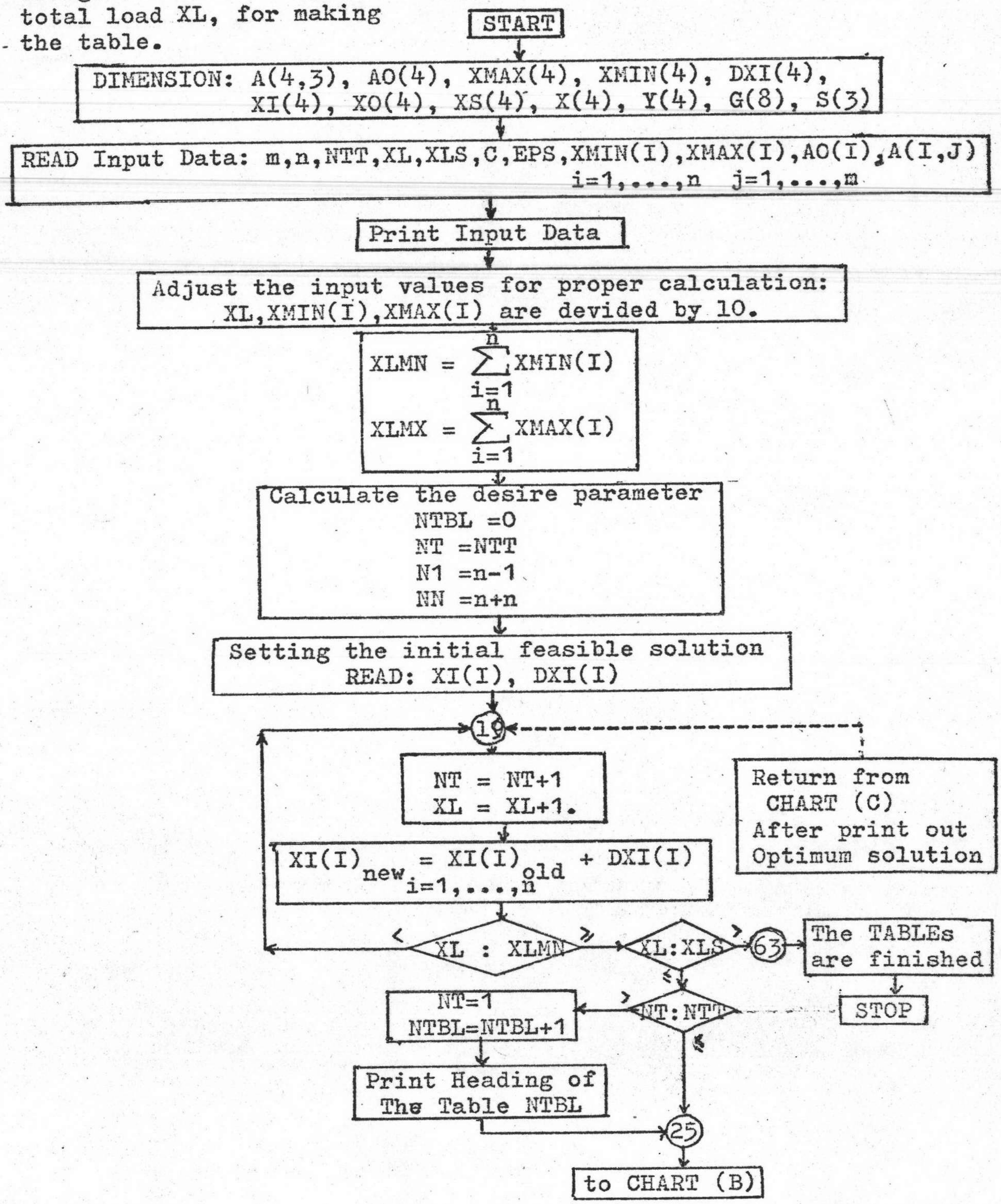
SUB-FLOW CHART (D) : Find the optimum value of $\underset{\sim}{x}$ with the step-size vector $\underset{\sim}{S}$ to minimize the objective function P.

Computer Source List

The computer source list is shown coding in the FORTRAN IV language.

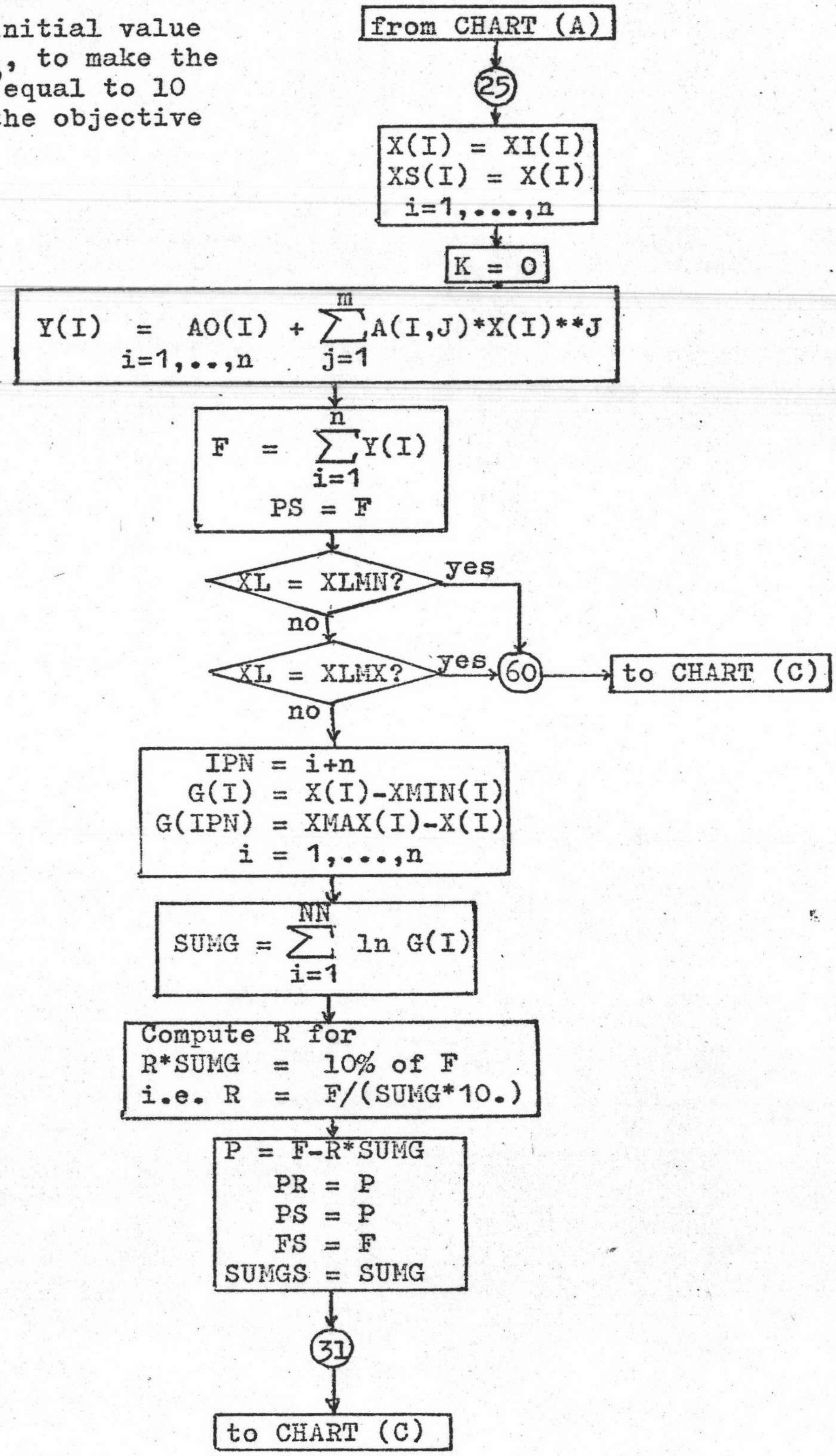
SUB-FLOW CHART (A)

Read the input data and change the value of given total load XL, for making the table.



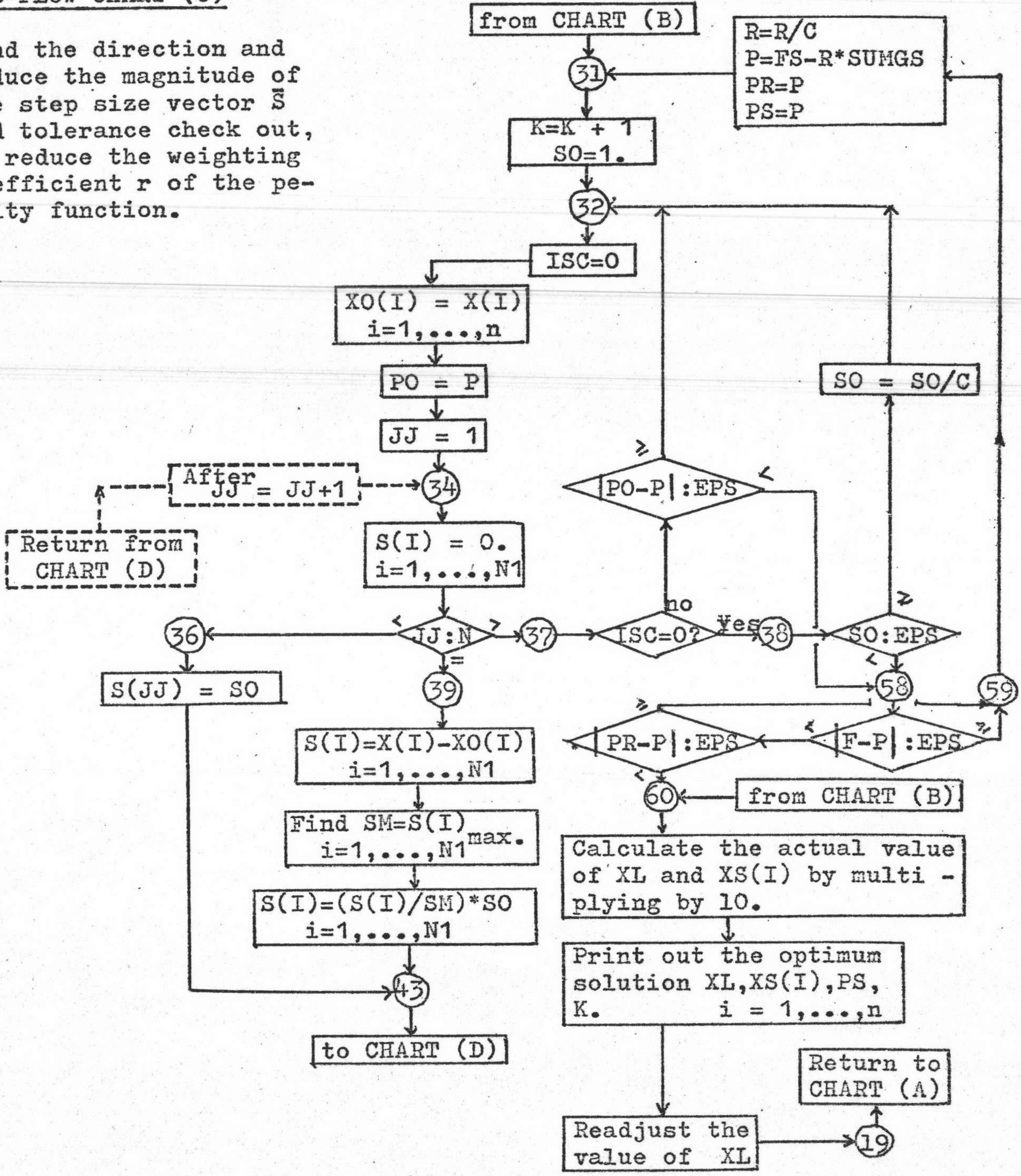
SUB-FLOW CHART (B)

Setting the initial value of r, i.e., r_o, to make the penalty term equal to 10 per cent of the objective function F.



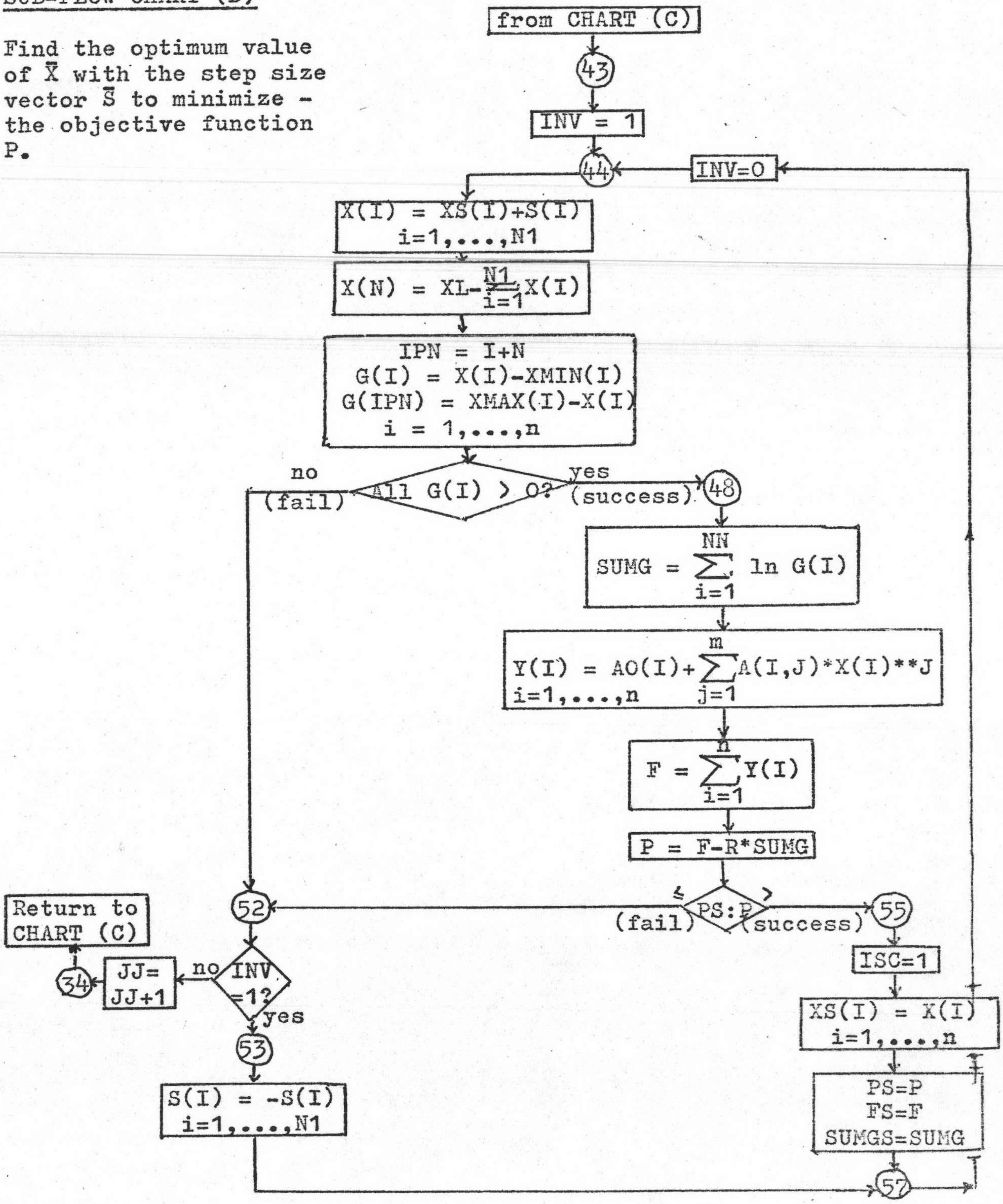
SUB-FLOW CHART (C)

Find the direction and reduce the magnitude of the step size vector $\bar{S}$ and tolerance check out, or reduce the weighting coefficient r of the penalty function.



SUB-FLOW CHART (D)

Find the optimum value of $\bar{X}$ with the step size vector $\bar{S}$ to minimize - the objective function P.



```
C     THIS IS A GENERAL COMPUTER PROGRAM IN FORTRAN IV
C     TO SOLVE A LOAD DISTRIBUTION PROBLEM OF N UNIT PLANT.
C     THIS NEW DIRECT SEARCH METHOD DEVELOPED FOR THE SUMT.
C
      DIMENSION A(4,3),AO(4),XMAX(4),XMIN(4),DXI(4),XI(4),
     1          XO(4),XS(4),X(4),Y(4),G(8),S(3)
C
C     READ INPUT DATA
C
      READ (5,1) M,NTT,C,EPS,N,XL,XLS
    1 FORMAT (I2,I3,F3.0,F7.4,I3,2F5.0)
      READ (5,2) (XMIN(I),I=1,N)
      READ (5,2) (XMAX(I),I=1,N)
    2 FORMAT (4F5.0)
      READ (5,3) (AO(I),I=1,N)
    3 FORMAT (4F7.3)
      DO 5 I=1,N
      READ (5,4) (A(I,J),J=1,M)
    4 FORMAT (F6.3,F8.5,F10.7)
    5 CONTINUE
C
C     PRINT INPUT DATA
C
      WRITE (6,6)
    6 FORMAT (1H1,//////////,37X,'=  INPUT   DATA  ='///)
      WRITE (6,7)
    7 FORMAT (40X,'UNIT-1',6X,'UNIT-2',6X,'UNIT-3',6X,'UNIT-4'///)
      WRITE (6,8) (XMIN(I),I=1,N)
    8 FORMAT (10X,'MINIMUM GENERATIVE LOAD',4F12.0,6X,'MW'/)
      WRITE (6,9) (XMAX(I),I=1,N)
    9 FORMAT (10X,'MAXIMUM GENERATIVE LOAD',4F12.0,6X,'MW'///)
      WRITE (6,10) (AO(I),I=1,N)
   10 FORMAT (19X,'A(0)',7X,'=     ',4F12.3/)
      DO 12 J=1,M
      WRITE (6,11) J,(A(I,J),I=1,N)
   11 FORMAT (19X,'A(',I1,')',7X,'=      ',4F12.7/)
   12 CONTINUE
      WRITE (6,13)
   13 FORMAT (//,10X,'WHERE OUTPUT    Y  =  A(0) + A(1)*X ',
     1        '+ A(2)*X**2 + A(3)*X**3')
      WRITE (6,14)
   14 FORMAT (/,10X,' AND  INPUT     X  =  GENERATIVE LOAD',
     1        ' (MW) OF EACH UNIT.')
      WRITE (6,15)
   15 FORMAT (///,28X,36('*'))
C
C     ADJUST THE INPUT VALUES FOR PROPER CALCULATION
C
      XLMN = 0.
      XLMX = 0.
      DO 16 I=1,N
      XMIN(I)=XMIN(I)/10.
      XMAX(I)=XMAX(I)/10.
      XLMN = XLMN+XMIN(I)
      XLMX = XLMX+XMAX(I)
   16 CONTINUE
C
C     CALCULATE THE DESIRE PARAMETERS
C
```

```
      NT = NTT
      N1 = N-1
      NN = N+N
C
C     SETTING THE INITIAL FEASIBLE SOLUTIONS
C
      READ (5,17) (XI(I),I=1,N)
   17 FORMAT (4F6.2)
      READ (5,18) (DXI(I),I=1,N)
   18 FORMAT (4F5.2)
C
   19 NT=NT+1
      XL=XL+1.
      DO 20 I=1,N
   20 XI(I)=XI(I)+DXI(I)
      IF (XL.LT.XLMN) GO TO 19
      IF (XL.GT.XLS) GO TO 63
      IF (NT.LE.NTT) GO TO 25
      NT=1
      NTBL=NTBL+1
      WRITE (6,21)
   21 FORMAT (1H1,//////////,
     131X,'=  THE TABLE OF LOAD DISTRIBUTION  ='///)
      WRITE (6,22) NTBL
   22 FORMAT (45X,'TABLE NO.',I2////)
      WRITE (6,23)
   23 FORMAT (15X,'TOTAL LOAD',4X,'UNIT-1',3X,'UNIT-2',
     13X,'UNIT-3',3X,'UNIT-4',4X,'OPTIMUM',4X,'NUMBER  OF')
      WRITE (6,24)
   24 FORMAT (18X,'(MW)',8X,'(MW)',5X,'(MW)',5X,'(MW)',
     15X,'(MW)',6X,'VALUE',5X,'ITERATIONS'///)
   25 DO 26 I=1,N
      X(I) =XI(I)
      XS(I)=X(I)
   26 CONTINUE
C
C     COMPUTE THE INTIAL VALUE OF R
C
      K=0
      DO 27 I=1,N
      Y(I)=A0(I)
      DO 27 J=1,M
      Y(I)=Y(I)+A(I,J)*X(I)**J
   27 CONTINUE
      F=0.
      DO 28 I=1,N
   28 F=F+Y(I)
      PS=F
      IF (XL.EQ.XLMN) GO TO 60
      IF (XL.EQ.XLMX) GO TO 60
C
C     COMPUTE INEQUALITY CONSTRAINTS G(I)
C
      DO 29 I=1,N
      IPN=I+N
      G(I)=X(I)-XMIN(I)
      G(IPN)=XMAX(I)-X(I)
   29 CONTINUE
C
C     COMPUTE THE PENALTY FUNCTION
```

```
C
      SUMG=0.
      DO 30 I=1,NN
   30 SUMG=SUMG+ALOG(G(I))
C
C     COMPUTE R FOR R*SUMG=10 PERCENTS OF F
C
      R = F/(SUMG*10.)
C
      P = F-R*SUMG
      PR= P
      PS=P
      FS=F
      SUMGS=SUMG
C
C     FIND THE DIRECTION AND REDUCE THE MAGNITUDE OF
C     THE STEP SIZE VECTOR S,AND TOLERANCE CHECK OUT
C
   31 K =K+1
      SO=1.
C
C     SET THE ORIGINAL FEASIBLE SOLUTION
C
   32 ISC=0
      DO 33 I=1,N
   33 XO(I)=X(I)
      PO=P
C
C     SET THE STEP SIZE VECTOR S, AND TOLERANCE CHECK OUT
C
      JJ=1
   34 DO 35 I=1,N1
   35 S(I)=0.
      IF (JJ-N) 36,39,37
   36 S(JJ)=SO
      GO TO 43
   37 IF (ISC.EQ.0) GO TO 38
      IF (ABS(PO-P)-EPS) 58,32,32
   38 IF (SO.LT.EPS) GO TO 58
      SO=SO/C
      GO TO 32
   39 DO 40 I=1,N1
   40 S(I)=X(I)-XO(I)
C
C     FIND SM=S(I)MAX.
C
      SM=0.
      DO 41 I=1,N1
      IF (SM.GE.S(I)) GO TO 41
      SM=S(I)
   41 CONTINUE
C
      DO 42 I=1,N1
   42 S(I)=(S(I)/SM)*SO
C
C     FIND X WITH THE STEP SIZE VECTOR S TO MINIMIZE P
C
   43 INV = 1
   44 X(N)=XL
```

```
      X(I)=XS(I)+S(I)
      X(N)=X(N)-X(I)
   45 CONTINUE
C
C     COMPUTE THE INEQUALITY CONSTRAINTS G(I)
      DO 46 I=1,N
      IPN = I+N
      G(I)=X(I)-XMIN(I)
      G(IPN)=XMAX(I)-X(I)
   46 CONTINUE
C
C     CHECK IF ALL CONSTRAINTS ARE SATISFIED
C
      II=1
   47 IF (G(II).LE.0.) GO TO 52
      IF (II.GE.NN) GO TO 48
      II=II+1
      GO TO 47
C
C     COMPUTE AUGMENTED OBJECTIVE FUNCTION P
C
   48 SUMG=0.
      DO 49 I=1,NN
   49 SUMG=SUMG+ALOG(G(I))
      DO 50 I=1,N
      Y(I)=A0(I)
      DO 50 J=1,M
      Y(I)=Y(I)+A(I,J)*X(I)**J
   50 CONTINUE
      F=0.
      DO 51 I=1,N
   51 F=F+Y(I)
      P=F-R*SUMG
C
C     CHECK FOR DECREASING VALUE OF P OR NOT
C
      IF (PS.GT.P) GO TO 55
C
C     SINCE P FAIL TO DECREASE, FIND NEW DIRECTION OF S
C
   52 IF (INV.EQ.1) GO TO 53
      JJ=JJ+1
      GO TO 34
C
C     REVERSE DIRECTION OF STEP SIZE VECTOR S
C
   53 DO 54 I=1,N1
   54 S(I)=-S(I)
      GO TO 57
C
C     P SUCCESS TO DECREASE
C
   55 ISC=1
      DO 56 I=1,N
   56 XS (I)=X(I)
      PS=P
      FS=F
      SUMGS=SUMG
   57 INV=0
```

```
   58 IF (ABS(F-P).GE.EPS) GO TO 59
      IF (ABS(PR-P).LT.EPS) GO TO 60
   59 R=R/C
      P=FS-R*SUMGS
      PR=P
      PS=P
      GO TO 31
C
C     PRINT OUT THE OPTIMUM SOLUTIONS
C
   60 XL=XL*10.
      DO 61 I=1,N
   61 XS(I)=XS(I)*10.
      WRITE (6,62)XL,(XS(I),I=1,N),PS,K
   62 FORMAT (15X,F8.2,3X,4F9.2,F11.3,I10/)
      XL=XL/10.
      GO TO 19
   63 WRITE (6,65)
   65 FORMAT (31X,36('*'),/////////)
      STOP
      END

END OF COMPILATION          NO  DIAGNOSTICS.
```

APPENDIX D

ECONOMIC OPERATION ON THE NORMAL CONDITION

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 1

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
510.00	100.00	100.00	130.33	179.67	128.455	10
520.00	100.00	100.00	136.20	183.80	130.184	10
530.00	100.00	100.00	142.16	187.84	131.949	10
540.00	100.00	100.00	148.13	191.87	133.749	10
550.00	100.00	100.00	154.07	195.93	135.582	10
560.00	100.00	100.00	160.04	199.95	137.447	10
570.00	100.00	100.00	166.10	203.90	139.341	9
580.00	100.00	100.00	172.16	207.84	141.264	9
590.00	100.00	100.00	178.27	211.73	143.212	10
600.00	100.00	100.00	184.43	215.57	145.184	9

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 2

TOTAL LOAD (Mw)	UNIT-1 (Mw)	UNIT-2 (Mw)	UNIT-3 (Mw)	UNIT-4 (Mw)	OPTIMUM VALUE	NUMBER OF ITERATIONS
610.00	100.00	100.00	190.63	219.37	147.179	10
620.00	100.00	100.00	196.93	223.07	149.195	9
630.00	100.00	100.00	203.33	226.67	151.230	10
640.00	100.00	100.00	209.91	230.09	153.281	10
650.00	100.00	161.27	177.50	211.24	155.719	17
660.00	100.00	166.59	180.40	213.02	157.682	17
670.00	100.00	170.72	184.02	215.25	159.657	17
680.00	180.24	100.00	184.28	215.48	162.273	16
690.00	181.92	100.00	189.43	218.65	164.265	17
700.00	183.35	100.00	194.82	221.83	166.276	16

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 3

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
710.00	184.62	100.00	200.39	224.99	168.303	9
720.00	177.52	154.71	176.98	210.80	170.849	17
730.00	177.94	162.48	178.05	211.52	172.805	18
740.00	178.99	167.00	180.77	213.24	174.770	17
750.00	180.17	170.71	183.95	215.18	176.746	18
760.00	181.32	173.79	187.44	217.45	178.734	17
770.00	182.45	176.41	191.33	219.81	180.735	17
780.00	183.57	178.68	195.60	222.14	182.750	17
790.00	184.53	180.83	199.89	224.76	184.777	18
800.00	185.44	182.66	204.60	227.30	186.818	17

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 4

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
810.00	186.28	184.34	209.57	229.81	188.870	19
820.00	187.11	185.85	214.67	232.36	190.934	10
830.00	187.77	187.06	220.28	234.88	193.009	18
840.00	188.37	188.26	226.11	237.25	195.094	17
850.00	188.86	189.15	232.56	239.43	197.187	14
860.00	189.31	189.96	239.60	241.14	199.288	17
870.00	189.54	190.28	247.81	242.38	201.393	16
880.00	189.56	190.37	257.71	242.35	203.501	16
890.00	188.94	189.18	272.25	239.63	205.605	16
900.00	184.53	180.86	309.99	224.62	207.669	10

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 5

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
910.00	186.22	184.19	310.00	229.59	209.715	17
920.00	187.82	187.19	310.00	234.99	211.783	10
930.00	189.24	189.77	310.00	240.99	213.875	10
940.00	190.52	192.03	310.00	247.46	215.988	15
950.00	191.55	193.81	310.00	254.64	218.119	9
960.00	192.36	195.16	310.00	262.48	220.267	12
970.00	192.80	195.92	310.00	271.29	222.425	10
980.00	192.79	195.80	310.00	281.42	224.587	9
990.00	191.99	194.62	310.00	293.39	226.743	11
1000.00	189.65	190.54	309.99	309.82	228.873	9

*THESE TABLES ARE THE NORMAL CONDITIONS OF PLANT (NO UNIT SHUTDOWN).

APPENDIX E

ECONOMIC OPERATION
ON THE SHUTDOWN UNIT CONDITION

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 1

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
410.00	-	100.00	130.35	179.65	104.420	8
420.00	-	100.00	136.22	183.78	106.149	8
430.00	-	100.00	142.17	187.83	107.914	9
440.00	-	100.00	148.12	191.88	109.714	9
450.00	-	100.00	154.11	195.89	111.547	9
460.00	-	100.00	160.07	199.93	113.412	8
470.00	-	100.00	166.10	203.90	115.306	9
480.00	-	100.00	172.18	207.82	117.228	9
490.00	-	100.00	178.29	211.71	119.177	9
500.00	-	100.00	184.43	215.57	121.149	9

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 2

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
510.00	-	100.00	190.62	219.38	123.144	9
520.00	-	100.00	196.96	223.04	125.160	9
530.00	-	100.00	203.40	226.60	127.195	9
540.00	-	100.00	209.90	230.10	129.246	9
550.00	-	161.02	177.70	211.29	131.684	17
560.00	-	166.68	180.30	213.02	133.647	18
570.00	-	170.76	184.02	215.23	135.622	17
580.00	-	174.12	188.13	217.75	137.612	16
590.00	-	176.99	192.59	220.41	139.616	16
600.00	-	179.53	197.26	223.20	141.635	17

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 3

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
610.00	-	181.77	202.26	225.98	143.668	20
620.00	-	183.78	207.49	228.73	145.715	17
630.00	-	185.38	213.05	231.57	147.775	18
640.00	-	186.78	218.95	234.27	149.847	17
650.00	-	188.05	225.14	236.81	151.930	16
660.00	-	189.06	231.67	239.27	154.022	14
670.00	-	189.81	239.03	241.16	156.122	15
680.00	-	190.30	247.29	242.41	158.228	15
690.00	-	190.31	257.29	242.40	160.335	15
700.00	-	189.41	270.56	240.03	162.440	15

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 4

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
710.00	-	184.81	294.85	230.34	164.526	10
720.00	-	182.74	310.00	227.26	166.561	10
730.00	-	186.45	310.00	233.55	168.622	10
740.00	-	189.61	310.00	240.39	170.709	9
750.00	-	192.09	310.00	247.91	172.822	9
760.00	-	194.07	310.00	255.93	174.956	9
770.00	-	195.34	310.00	264.66	177.106	12
780.00	-	196.02	310.00	273.98	179.266	9
790.00	-	195.73	310.00	284.27	181.427	9
800.00	-	194.13	310.00	295.88	183.580	9

*THESE TABLES ARE THE SHUTDOWN UNIT CASE (UNIT NO.1 SHUTDOWN).

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 1

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
410.00	100.00	-	130.34	179.66	102.407	9
420.00	100.00	-	136.23	183.77	104.136	8
430.00	100.00	-	142.14	187.86	105.901	9
440.00	100.00	-	148.10	191.90	107.701	10
450.00	100.00	-	154.08	195.92	109.534	10
460.00	100.00	-	160.11	199.89	111.399	9
470.00	100.00	-	166.13	203.87	113.293	9
480.00	100.00	-	172.18	207.82	115.215	8
490.00	100.00	-	178.26	211.74	117.164	8
500.00	100.00	-	184.47	215.53	119.136	9

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 2

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
510.00	100.00	-	190.69	219.31	121.131	9
520.00	100.00	-	196.99	223.01	123.147	8
530.00	100.00	-	203.39	226.61	125.182	9
540.00	170.85	-	165.64	203.50	128.446	14
550.00	173.94	-	169.77	206.30	130.361	16
560.00	176.37	-	174.42	209.21	132.296	17
570.00	178.46	-	179.24	212.30	134.251	16
580.00	180.28	-	184.27	215.46	136.225	16
590.00	181.92	-	189.50	218.59	138.217	17
600.00	183.33	-	194.88	221.79	140.228	16

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 3

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
610.00	184.64	-	200.40	224.96	142.255	18
620.00	185.73	-	206.16	228.11	144.298	18
630.00	186.68	-	212.15	231.16	146.356	16
640.00	187.57	-	218.30	234.13	148.426	15
650.00	188.28	-	224.89	236.82	150.508	15
660.00	188.86	-	231.89	239.25	152.601	15
670.00	189.24	-	239.59	241.17	154.701	13
680.00	189.56	-	248.09	242.34	156.807	14
690.00	189.53	-	258.09	242.39	158.914	14
700.00	189.02	-	270.98	239.99	161.018	14

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 4

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
710.00	187.22	-	290.10	232.68	163.106	10
720.00	184.78	-	309.98	225.24	165.147	9
730.00	187.22	-	309.99	232.79	167.201	9
740.00	189.25	-	310.00	240.75	169.288	10
750.00	190.82	-	310.00	249.18	171.403	9
760.00	191.94	-	310.00	258.06	173.541	13
770.00	192.63	-	310.00	267.37	175.694	13
780.00	192.82	-	310.00	277.18	177.856	10
790.00	192.49	-	310.00	287.51	180.016	10
800.00	191.42	-	310.00	298.58	182.164	9

*THESE TABLES ARE THE SHUT-DOWN UNIT CASE (UNIT NO.2 SHUTDOWN).

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 1

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
320.00	100.00	100.00	-	120.00	.000	0
330.00	100.00	100.00	-	130.00	86.164	10
340.00	100.00	100.00	-	140.00	87.355	10
350.00	100.00	100.00	-	150.00	88.679	10
360.00	100.00	100.00	-	160.00	90.126	10
370.00	100.00	100.00	-	170.00	91.686	10
380.00	100.00	100.00	-	180.00	93.350	10
390.00	100.00	100.00	-	190.00	95.107	10
400.00	100.00	100.00	-	200.00	96.949	10
410.00	100.00	100.00	-	210.00	98.865	10

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 2

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
420.00	100.00	100.00	-	220.00	100.845	10
430.00	100.00	100.00	-	230.00	102.880	10
440.00	100.00	100.00	-	240.00	104.960	10
450.00	100.00	100.00	-	250.00	107.076	10
460.00	100.00	147.74	-	212.26	109.416	9
470.00	100.00	159.07	-	210.93	111.372	9
480.00	100.00	166.88	-	213.12	113.333	9
490.00	100.00	173.09	-	216.91	115.314	9
500.00	181.74	100.00	-	218.26	117.931	16
510.00	184.73	100.00	-	225.27	119.949	9

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 3

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
520.00	187.20	100.00	-	232.80	122.004	9
530.00	189.21	100.00	-	240.79	124.091	18
540.00	190.80	100.00	-	249.20	126.206	18
550.00	177.70	161.14	-	211.16	128.458	13
560.00	179.11	167.53	-	213.35	130.421	12
570.00	180.90	172.58	-	216.53	132.401	13
580.00	182.72	176.95	-	220.33	134.402	15
590.00	184.50	180.83	-	224.68	136.424	17
600.00	186.25	184.19	-	229.56	138.469	16
610.00	187.83	187.16	-	235.01	140.538	16

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 4

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
620.00	189.27	189.79	-	240.94	142.630	10
630.00	190.48	192.05	-	247.47	144.742	13
640.00	191.54	193.82	-	254.64	146.874	14
650.00	192.28	195.15	-	262.57	149.021	14
660.00	192.80	195.94	-	271.26	151.179	10
670.00	192.80	195.88	-	281.32	153.342	10
680.00	192.04	194.57	-	293.39	155.497	10
690.00	189.58	190.47	-	309.95	157.628	10
700.00	193.15	196.85	-	310.00	159.766	10

*THESE TABLES ARE THE SHUT-DOWN UNIT CASE (UNIT NO.3 SHUTDOWN).

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 1

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
320.00	100.00	100.00	120.00	-	83.515	0
330.00	100.00	100.00	130.00	-	85.189	10
340.00	100.00	100.00	140.00	-	86.928	10
350.00	100.00	100.00	150.00	-	88.727	10
360.00	100.00	100.00	160.00	-	90.581	10
370.00	100.00	100.00	170.00	-	92.484	10
380.00	100.00	100.00	180.00	-	94.431	10
390.00	100.00	100.00	190.00	-	96.417	10
400.00	100.00	100.00	200.00	-	98.437	10
410.00	100.00	100.00	210.00	-	100.484	10

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 2

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
420.00	100.00	100.00	220.00	-	102.554	10
430.00	100.00	100.00	230.00	-	104.642	10
440.00	100.00	162.12	177.88	-	106.938	10
450.00	100.00	168.39	181.61	-	108.903	10
460.00	100.00	173.23	186.77	-	110.886	9
470.00	181.59	100.00	188.41	-	113.504	13
480.00	183.71	100.00	196.29	-	115.515	15
490.00	185.42	100.00	204.58	-	117.550	9
500.00	186.88	100.00	213.12	-	119.607	17
510.00	187.98	100.00	222.02	-	121.682	18

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 3

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
520.00	188.82	100.00	231.18	-	123.771	20
530.00	179.46	168.70	181.84	-	125.992	15
540.00	180.99	172.81	186.20	-	127.974	15
550.00	182.42	176.32	191.26	-	129.973	14
560.00	183.82	179.39	196.79	-	131.989	14
570.00	185.16	182.04	202.80	-	134.023	17
580.00	186.27	184.27	209.46	-	136.073	17
590.00	187.30	186.25	216.45	-	138.139	16
600.00	188.19	187.84	223.97	-	140.218	17
610.00	188.89	189.10	232.02	-	142.310	10

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 4

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
620.00	189.40	190.03	240.57	-	144.411	16
630.00	189.59	190.37	250.04	-	146.517	14
640.00	189.54	190.22	260.24	-	148.625	13
650.00	189.04	189.28	271.68	-	150.728	12
660.00	187.78	187.07	285.15	-	152.818	10
670.00	185.02	181.86	303.12	-	154.881	10
680.00	185.94	184.11	309.96	-	156.917	8
690.00	189.32	190.68	309.99	-	158.998	9
700.00	193.27	196.73	310.00	-	161.136	10

*THESE TABLES ARE THE SHUT-DOWN UNIT CASE (UNIT NO.4 SHUTDOWN).

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 1

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
310.00	-	-	130.33	179.67	78.372	10
320.00	-	-	136.21	183.79	80.101	10
330.00	-	-	142.14	187.86	81.866	10
340.00	-	-	148.11	191.89	83.666	10
350.00	-	-	154.08	195.92	85.499	10
360.00	-	-	160.08	199.92	87.364	10
370.00	-	-	166.09	203.91	89.258	10
380.00	-	-	172.17	207.83	91.180	10
390.00	-	-	178.25	211.75	93.129	10
400.00	-	-	184.45	215.55	95.101	10

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 2

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
410.00	-	-	190.69	219.31	97.096	10
420.00	-	-	196.96	223.04	99.112	10
430.00	-	-	203.40	226.60	101.147	10
440.00	-	-	209.92	230.08	103.198	10
450.00	-	-	216.68	233.32	105.265	10
460.00	-	-	223.64	236.36	107.345	10
470.00	-	-	231.02	238.98	109.436	10
480.00	-	-	238.86	241.14	111.535	10
490.00	-	-	247.55	242.45	113.641	10
500.00	-	-	257.49	242.51	115.748	10

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 3

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
510.00	-	-	269.63	240.37	117.853	10
520.00	-	-	285.07	234.93	119.945	10
530.00	-	-	305.16	224.84	122.005	10
540.00	-	-	309.99	230.01	124.043	9
550.00	-	-	310.00	240.00	126.123	9
560.00	-	-	310.00	250.00	128.238	9
570.00	-	-	310.00	260.00	130.378	9
580.00	-	-	310.00	270.00	132.535	9
590.00	-	-	310.00	280.00	134.697	9
600.00	-	-	310.00	290.00	136.855	9

*THESE TABLES ARE THE SHUTDOWN UNIT CASE (UNIT NO.1&2 SHUTDOWN).

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 1

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
220.00	-	100.00	-	120.00	61.080	0
230.00	-	100.00	-	130.00	62.129	10
240.00	-	100.00	-	140.00	63.320	9
250.00	-	100.00	-	150.00	64.644	9
260.00	-	100.00	-	160.00	66.091	9
270.00	-	100.00	-	170.00	67.651	9
280.00	-	100.00	-	180.00	69.315	9
290.00	-	100.00	-	190.00	71.072	9
300.00	-	100.00	-	200.00	72.914	9
310.00	-	100.00	-	210.00	74.830	8

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 2

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
320.00	-	100.00	-	220.00	76.810	8
330.00	-	100.00	-	230.00	78.845	9
340.00	-	100.00	-	240.00	80.925	9
350.00	-	100.00	-	250.00	83.041	9
360.00	-	147.77	-	212.23	85.381	10
370.00	-	159.10	-	210.90	87.337	10
380.00	-	166.90	-	213.10	89.298	10
390.00	-	173.05	-	216.95	91.278	10
400.00	-	178.30	-	221.70	93.283	10
410.00	-	182.70	-	227.30	95.316	10

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 3

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
420.00	-	186.44	-	233.56	97.376	10
430.00	-	189.60	-	240.40	99.464	10
440.00	-	192.11	-	247.89	101.577	10
450.00	-	194.11	-	255.89	103.710	10
460.00	-	195.34	-	264.66	105.860	10
470.00	-	195.99	-	274.01	108.020	10
480.00	-	195.67	-	284.33	110.182	10
490.00	-	194.11	-	295.89	112.334	10
500.00	-	190.44	-	309.56	114.462	10

*THESE TABLES ARE THE SHUT-DOWN UNIT CASE (UNIT NO.1&3 SHUTDOWN).

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 1

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
220.00	-	100.00	120.00	-	59.480	0
230.00	-	100.00	130.00	-	61.154	10
240.00	-	100.00	140.00	-	62.893	10
250.00	-	100.00	150.00	-	64.692	9
260.00	-	100.00	160.00	-	66.546	9
270.00	-	100.00	170.00	-	68.449	9
280.00	-	100.00	180.00	-	70.397	8
290.00	-	100.00	190.00	-	72.382	8
300.00	-	100.00	200.00	-	74.402	8
310.00	-	100.00	210.00	-	76.449	9

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 2

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
320.00	-	100.00	220.00	-	78.519	9
330.00	-	152.92	177.08	-	80.947	10
340.00	-	162.23	177.77	-	82.902	10
350.00	-	168.34	181.66	-	84.868	10
360.00	-	173.21	186.79	-	86.851	10
370.00	-	177.22	192.78	-	88.854	10
380.00	-	180.57	199.43	-	90.876	10
390.00	-	183.40	206.60	-	92.918	10
400.00	-	185.75	214.25	-	94.979	10
410.00	-	187.54	222.46	-	97.055	10

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 3

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
420.00	-	188.99	231.01	-	99.145	10
430.00	-	189.92	240.08	-	101.245	10
440.00	-	190.37	249.63	-	103.351	10
450.00	-	190.32	259.68	-	105.459	10
460.00	-	189.44	270.56	-	107.563	10
470.00	-	187.75	282.25	-	109.656	10
480.00	-	184.39	295.61	-	111.728	10
490.00	-	180.03	309.97	-	113.768	9
500.00	-	190.00	310.00	-	115.832	10

*THESE TABLES ARE THE SHUTDOWN UNIT CASE (UNIT NO.1&4 SHUTDOWN).

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 1

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
220.00	100.00	-	-	120.00	59.067	0
230.00	100.00	-	-	130.00	60.116	10
240.00	100.00	-	-	140.00	61.307	10
250.00	100.00	-	-	150.00	62.631	9
260.00	100.00	-	-	160.00	64.078	9
270.00	100.00	-	-	170.00	65.638	9
280.00	100.00	-	-	180.00	67.302	9
290.00	100.00	-	-	190.00	69.059	9
300,00	100.00	-	-	200.00	70.901	9
310.00	100.00	-	-	210.00	72.817	9

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 2

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
320.00	100.00	-	-	220.00	74.797	9
330.00	100.00	-	-	230.00	76.832	9
340.00	100.00	-	-	240.00	78.912	9
350.00	100.00	-	-	250.00	81.028	9
360.00	160.61	-	-	199.39	84.170	10
370.00	168.30	-	-	201.70	86.052	10
380.00	173.77	-	-	206.23	87.960	10
390.00	178.18	-	-	211.82	89.903	10
400.00	181.76	-	-	218.24	91.883	10
410.00	184.74	-	-	225.26	93.901	10

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 3

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
420.00	187.19	-	-	232.81	95.956	10
430.00	189.21	-	-	240.79	98.043	10
440.00	190.81	-	-	249.19	100.158	10
450.00	191.95	-	-	258.05	102.295	10
460.00	192.63	-	-	267.37	104.449	10
470.00	192.85	-	-	277.15	106.610	10
480.00	192.46	-	-	287.54	108.771	10
490.00	191.42	-	-	298.58	110.918	10
500.00	190.05	-	-	309.95	113.041	9

*THESE TABLES ARE THE SHUT-DOWN UNIT CASE (UNIT NO.2&3 SHUTDOWN).

****

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 1

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
220.00	100.00	-	120.00	-	57.467	0
230.00	100.00	-	130.00	-	59.141	10
240.00	100.00	-	140.00	-	60.880	9
250.00	100.00	-	150.00	-	62.679	9
260.00	100.00	-	160.00	-	64.533	9
270.00	100.00	-	170.00	-	66.436	9
280.00	100.00	-	180.00	-	68.383	9
290.00	100.00	-	190.00	-	70.369	9
300.00	100.00	-	200.00	-	72.389	9
310.00	100.00	-	210.00	-	74.436	9

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 2

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
320.00	100.00	-	220.00	-	76.506	9
330.00	167.73	-	162.27	-	79.683	10
340.00	172.46	-	167.54	-	81.586	10
350.00	176.15	-	173.85	-	83.514	10
360.00	179.16	-	180.84	-	85.471	10
370.00	181.56	-	188.44	-	87.456	10
380.00	183.73	-	196.27	-	89.467	10
390.00	185.46	-	204.54	-	91.502	10
400.00	186.86	-	213.14	-	93.559	10
410.00	188.00	-	222.00	-	95.634	10

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 3

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
420.00	188.83	-	231.17	-	97.723	10
430.00	189.37	-	240.63	-	99.824	10
440.00	189.57	-	250.43	-	101.930	10
450.00	189.52	-	260.48	-	104.038	10
460.00	189.05	-	270.95	-	106.141	10
470.00	188.14	-	281.86	-	108.234	10
480.00	186.72	-	293.28	-	110.309	10
490.00	184.51	-	305.49	-	112.359	10
500.00	190.00	-	310.00	-	114.411	10

*THESE TABLES ARE THE SHUTDOWN UNIT CASE (UNIT NO.2&4 SHUTDOWN).

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 1

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
210.00	100.00	110.00	-	-	52.384	10
220.00	100.00	120.00	-	-	54.564	10
230.00	100.00	130.00	-	-	56.648	9
240.00	100.00	140.00	-	-	58.663	9
250.00	100.00	150.00	-	-	60.635	9
260.00	100.00	160.00	-	-	62.591	9
270.00	100.00	170.00	-	-	64.556	9
280.00	180.00	100.00	-	-	67.172	9
290.00	190.00	100.00	-	-	69.214	9
300.00	200.00	100.00	-	-	71.418	10

= THE TABLE OF LOAD DISTRIBUTION =

TABLE NO. 2

TOTAL LOAD (MW)	UNIT-1 (MW)	UNIT-2 (MW)	UNIT-3 (MW)	UNIT-4 (MW)	OPTIMUM VALUE	NUMBER OF ITERATIONS
310.00	191.96	118.04	-	-	73.693	9
320.00	181.42	138.58	-	-	75.750	10
330.00	177.61	152.39	-	-	77.721	10
340.00	177.91	162.09	-	-	79.676	10
350.00	179.92	170.08	-	-	81.644	10
360.00	182.79	177.21	-	-	83.639	10
370.00	186.11	183.89	-	-	85.672	10
380.00	189.61	190.39	-	-	87.753	10
390.00	193.28	196.72	-	-	89.891	10
400.00	200.00	200.00	-	-	92.110	0

*THESE TABLES ARE THE SHUTDOWN UNIT CASE (UNIT NO.3&4 SHUTDOWN).

VITA

Mr Vatchara Noomahan was born on March 2, 1952 in Bangkok, Thailand. He graduated in Electrical Engineering (2nd Honour) from Kasetsart University in 1972. He now works in the Electricity Generating Authority of Thailand as an engineer of the South Bangkok Thermal Plant.