P.O. BOX 529100 MIAMI, FLA 33152

FLORIDA POWER & LIGHT COMPANY

Reference 11

April 4, 1978
L-78-118

Office of Nuclear Reactor Regulation
Attention: Mr. A. Schwencer, Chief
Operating Reactors Branch #1
Division of Operating Reactors
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Schwencer:

Re: Florida Power & Light Company (FPL)
Docket Nos. 50-250, 50-251, and 50-335
Request for Additional Information

Your letter of March 16, 1978 requested additional information regarding the FPL system distrubance which occurred on May 16, 1977. Our responses to your additional questions are attached.

Very truly yours,

Robert E. Uhrig
Vice President

REU/MAS/mb

Attachment

cc: Mr. James P. O'Reilly, Region II
Harold F. Reis, Esquire

80021504 83

ATTACHMENT

Re: Florida Power & Light Company (FPL)
Docket Nos. 50-250, 50-251, and 50-335
Request for Additional Information

QUESTION 1

The response to request 1.3 gives limitations on the line based on long-term operation. Please provide any operational guidance that may exist such as "The line may be operated at above x amperes but not exceeding y amperes for a time not to exceed z minutes," where z is a number small enough to provide operational guidance.

Line sag is computed for two different temperatures, but no indication is given as to what the temperature of the line was when it relayed open. Please provide any recorded data on the line current over this 16-minute period (10:08-10:24) from which a temperature profile could be determined.

RESPONSE 1

There is no guide for overloading conductors in the form of X ≤ Y for Z minutes.

There is no recording of the load on the Fort Myers-Ranch lines. The loading was computed from other charts. The sag figures were included to show that even under extreme conditions of ambient temperature and light wind that, it is highly improbable that the conductor would have sagged enough to contact some object to cause the phase to ground fault.

Re: Florida Power & Light Company (FPL)
Docket Nos. 50-250, 50-251, and 50-335
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QUESTION 2

The power estimates given in response to request 1.6 are not supported by the data on which they were based. Please provide the 16-minute (10:08-10:24) record of each variable that was used in making this power calculation and a sample of how the calculation was made.

A reference is made in this response to past histroy of division of the load (between the two Ft. Myers-Ranch lines). Please provide any records of such a division of transmission on these lines at approximately 500-600 MW total power.

In a dynamic situation such as the system was then experiencing would the relative loading of the two lines be expected to oscillate so that an average relative loading would not reflect peak conditions on one? If so please discuss the details.

In the response to 1.6, oscillogram records from Ringling are included; oscillogram records from Broward and Midway are cited but not included. Please, furnish copies of the Broward and Midway oscillogram records.

Since oscillogram records at locations remote from a fault cannot be interpreted without some knowledge of the intervening circuitry, particularly transformer coupling, please furnish the indicated intervening circuitry description for Ringling, Broward, and Midway.

RESPONSE 2

The line flows from Fort Myers to Ranch were computed as follows:

a) Power available to the Western Division is the sum of the output of the plants in the Western Division minus the tie flows to Tampa Electric Company (flows into Florida Power & Light are negative numbers). These values are obtained from the various strip charts for the time period under consideration. (Charts were previously transmitted.) An additional chart "Area Loads" is attached to verify the 'before' load. (Appendix C)

b) Load in the Western Division: Load prior to the disturbance is obtained from the strip chart showing the area loads. After the initial disturbance, the area load chart showed

a load in the Western Division which, if true, would have indicated a reduction in line flows from Ft. Myers to Ranch. The known deficit of generation in the south, the observation by plant personnel at Fort Myers and the alarm signal from the West Palm computer, all indicate that the power flows from Fort Myers to Ranch did indeed increase. There was no interruption of feeders in the Western Division but during this period the area substation load would increase; any other change in area load is due to a change in the transmission line losses in the Western Division. An estimate of the total load in the Western Division was made.

c) The total power flow from Fort Myers to Ranch is the power available to the Western Division (a) above) minus the load in the Western Division (b) above).

d) The division of power flow on the Fort Myers-Ranch 240kV line and on the Fort Myers-Ranch 138kV line, for analysis purposes, may be treated in two steps. (1) The division of power flow to satisfy the load requirement of the substations served between Fort Myers and Ranch (all such substations are connected to the 138kV line). This total power flow equals the sum of the load at the served substations. (2) The division of all other power flow in excess of (1). Both of these divisions must obey Kirchhoff's laws and can be combined using the superposition theorem to give an estimate of the individual line flows. As the total flow from Fort Myers to Ranch increases, the division will more nearly be that of (2). Using a D. C. analog calculating board set up to represent the reactances of the transmission lines and transformers, the (2) division was determined to be 75% on the Fort Myers-Ranch 240kV line and 25% on the Fort Myers-Ranch 138kV line.

The attached table (Appendix C) shows the values of the Fort Myers-Ranch 240kV line flows for significant times during the disturbance on Florida Power & Light Company's system of May 16, 1977.

There are no records showing the division of load on these two lines at approximately 500 - 600 MW total power.

In a dynamic situation, the relative loading of the two Fort Myers-Ranch lines would be expected to vary together according to Kirchhoff's laws with no oscillation between the two circuits.

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The oscillograms for Broward and Midway are attached (Appendix C). Please note that all traces on the Broward oscillogram are from the 138kV side of the station. The 138kV and 240 kV sections are connected through Wye connected autotransformers, solidly grounded.

A diagram of the transmission system is attached (Appendix C). Generator transformers have been omitted to reduce clutter. All generators are connected to the system through delta wye transformers. The high side is wye, solidly grounded. A schematic drawing is also included.

Re: Florida Power & Light Company (FPL)
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QUESTION 3

The response to request 2 "We have concluded that the Turkey Point trip could not by itself, have caused the line to relay" is not supported. Please furnish any supporting analyses with a full description.

RESPONSE 3

The conclusion that the system was stable at 10:24 a.m., May 16, 1977, was based on the following:

1) The system continued to operate for 16 minutes following the loss of Turkey Point No. 3.

2) Oscillograms from Ringling show no sign of instability before loss of Fort Myers-Ranch circuit.

3) Oscillograms from Midway show no sign of instability before the loss of Fort Myers-Ranch circuit.

4) Oscillograms from Broward show no sign of instability before the loss of the Fort Myers-Ranch circuit.

5) Total generation was increasing. Copy of total generation chart attached (Appendix D).

6) There were no reports from operators that voltage, watts or vars were oscillating.

7) The Fort Myers-Ringling 240kV circuit tripped at both ends. Since the relays are directional, only one end would trip for an overload condition. Only an internal fault could cause infeed from both ends. There were ground targets at Ranch and at Fort Myers. Circuits tripping from an unstable condition will trip with phase targets. Since all three phases must swing together, the swing is balanced and therefore there is no ground current to operate ground relays.

8) From ratings furnished by conductor manufacturers, we have obtained conductor temperatures for various conditions of loading and ambient temperature. From the

SCADA alarm log from West Palm Beach, we can determine that the watt loading was near or slightly above the alarm setpoint of 418MW, and that the VAR loading was below the setpoint of 147MVAR. This loading is such that it is highly unlikely that the conductor would sag enough to contact some object and cause a phase-to-ground fault. The loadings are reasonably confirmed by taking the change in ties, change in generation, and change in west coast load to determine the total power flow at the time of loss.

9) The line loading of the Fort Myers-Ranch line was well under the tripping value.

Setting sheets are attached (Appendix D) with a plot of the relay characteristic in terms of R & X and a plot in terms of watts and vars.

Re: Florida Power & Light Company (FPL)
Docket Nos. 50-250, 50-251, and 50-335
Request for Additional Information

QUESTION 5

The response to request 6 is not clear in some respects. Is our understanding that Southern Co. and Florida Power and Light Company have not yet entered an agreement for a 500 kV Georgia-Florida tie correct? Is our understanding that 800 MW interchange capability from Georgia to Florida (which was, according to referenced FP&L reports, to be ready in 1976) is not yet available correct?

RESPONSE 5

The load growth and the generation/transmission expansion plans of both Florida and Georgia were revised to reflect the slower economic growth of the nation. The need for additional transmission tie lines between Florida and Georgia was altered accordingly. Thus, the in-service date for the 500 kV tie is now conceived by both Florida and Georgia to fall into the late 1980's (possibly as late as 1990). Therefore, no agreement with Georgia has been reached. This will be monitored closely by the Federal Energy Regulatory Commission, SERC, FCG, Florida Public Service Commission, Georgia Power Company, and Florida Power & Light Company.

A January 1980 in-service date for a 240 kV line from Yulee (Florida) to Kingsland (Georgia) has been agreed to by Georgia Power Company and Florida Power & Light Company with additional supportive facilities to establish a transmission interconnection.

Re: Florida Power & Light Company (FPL)
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Request for Additional Information

QUESTION 6

The reply to request 7.3 is not fully responsive. Please provide the discussion requested.

RESPONSE 6

Turkey Point, Unit 4 was removed from service to perform scheduled refueling, maintenance, and inspections of nuclear and non-nuclear systems on May 9, 1977. Maintenance and refueling are occurrences which are normal and anticipated. Generating capacity available was sufficient to meet anticipated loads with adequate reserve margins. Because periodic maintenance of generating facilities is a routine procedure, and had begun seven days prior to the disturbance on May 16, there was no need for a specific discussion of this event within the referenced report. A status of all installed capacity at 10:08 a.m., May 16, 1977, was included in the report as Figure 5.

The Andytown-Orange River 500 kV line had been operating at 230 kV since 1974. Conversion to 500 kV was scheduled for 1977 and construction had begun in 1976 to accomplish this. On May 9, 1977, the line was removed from service on a continuous clearance for final line work. The line was temporarily energized at 500 kV on May 14. On Sunday night, May 15, the line was removed from service in accordance with a clearance scheduled on May 16, to permit final calibration of protective systems. Removal of transmission facilities from service from time to time to facilitate construction or maintenance is a normal practice. For these reasons it was not necessary to discuss this within the referenced report. The status of the Andytown-Orange River 500 kV line on May 16, 1977, is clearly indicated on Figures 2 and 4.

The "Report on System Disturbance, May 16, 1977" was prepared to address the disturbance and provide an analysis of those events directly related to it. The Report and Exhibits taken as a whole, clearly establish the initial condition of the system on May 17, 1977. A discussion of events, prior to that time, was not intended since the system was operating within limits on the morning of May 16.

APPENDIX A

ORIDA ELECTRIC POWER COORDINATING GROUP (FCG)
2 REO STREET, SUITE 214 • TAMPA, FLORIDA 33609 • (813) 877-5301

July 27, 1977

SYSTEM PLANNING COMMITTEE:

Mr. J. S. Bell, Florida Power & Light Company
Mr. R. T. Bowles, Florida Power Corporation
Mr. Larry Gawlik, Gainesville/Alachua County Regional Utilities Board
Mr. M. W. Howell, Gulf Power Company
Mr. R. T. Dyer, Jacksonville Electric Authority
Mr. R. E. Arnold, Lake Worth Utilities Authority
Mr. R. W. Cochran, Lakeland Department of Electric & Water Utilities
Mr. D. E. Moore, Orlando Utilities Commission
Mr. R. W. Claussen, Seminole Electric Cooperative, Inc.
Mr. G. T. Lawrence, City of Tallahassee Electric Department
Mr. R. E. Proctor, Tampa Electric Company

SUBJECT: OFF-PEAK TRANSIENT STABILITY STUDY FOR 1977

The 1977 Transient Stability Task Force was assigned to investigate the transient response of the State Bulk Power System for various contingencies which may occur during off-peak operating conditions. These contingencies are set forth in SERC Guidelines, Number 3, "Criteria for Reliability in System Planning." The recommendations of this study will assure that cascading outages will not result from any foreseeable contingencies.

This study was the combined effort of individuals in every member company of the System Planning Committee. During the months of January and February, the Task Force spent two weeks in St. Petersburg, Florida, in order to expedite this study.

Respectfully submitted,

Gerald L. Hofacker

1977 Transient Stability Task Force:
G. L. Hofacker, Chairman (FPL)
A. N. Darlington (TEC)
G. F. Erickson (OUC)
C. N. Hansen (FPC)
H. D. Powell (JEA)

GLH/ds

INTRODUCTION

The System Planning Committee commissioned the 1977 Off-Peak Transient Stability Task Force to analyze certain transient stability phenomena of the Interconnected Generation/ Transmission System proposed to be in service during 1977. System planning personnel from the following utilities either worked on the Task Force or provided data to produce the results stated in this report:

Florida Power Corporation

Florida Power & Light Company

Gainesville-Alachua County Regional Utilities Board

Jacksonville Electric Authority

Lakeland Department of Electric & Water Utiliities

Orlando Utilities Commission

City of Tallahassee

Tampa Electric Company

The general study categories are listed below:

1. Generation Losses

   A three-part analysis associated with:

   a. The transient effects associated with single nuclear generator contingency outages.

   b. The transient effects associated with multiple generator contingency outages.

   c. The transient effects associated with single nuclear generator contingency outages on a fragmented transmission system.

2. <u>Transmission Losses</u>

An analysis of the transient effects on the system resulting from a three-phase, delayed-clearing fault.

These studies were run on Florida Power Corporation's IBM System 370 Computer, utilizing the Philadelphia Electric Company (PECO) Load Flow and Transient Stability programs--the latter modified by Florida Power Corporation.

The Task Force met during the last week of January 1977 and the last two days of February 1977 in St. Petersburg, Florida, to run and analyze cases. All case studies were completed on the computer by the end of April 1977.

The features incorporated in the modified version of the Transient Stability program include:

1. Provision to model underfrequency relays allowing three independent set points and intentional relay time delay settings at each bus with separate and independent breaker time.
2. Provision to model most transmission line relays which may operate due to positive sequence transients.
3. Relay representations included the following types:
   - a. Impedance
   - b. Reactance
   - c. Underfrequency
   - d. Directional Comparison Carrier Blocking

   Each distance relay could be modeled with three separate distance and time settings and independent breaker trip and reclose time specification.

4. Summary Reports for:

   a. Load damping for selected areas.

   b. Turbine response for selected areas.

   c. Line flow change for selected lines.

   d. Line flow for selected lines.

   e. Machine frequency and angle for all units.

PURPOSE

The purpose of these studies was to analyze the 1977 State system to provide an understanding of the transient response during off-peak conditions. The primary interests were to:

1. Simulate selected single unit generation outages under two circumstances; with complete transmission system and fragmented transmission system.
2. Determine if emergency reactor coolant pump operation would be initiated on nuclear generating units.
3. Determine the underfrequency relay response in the State for the 1977 time period such that no firm load would be shed for the loss of the largest unit.
4. Determine if the response of the Florida bulk power system to the contingencies studied would result in any cascading from the Peninsular Florida Subregion into the Southern Company Subregion.
5. Provide a report to be used as a guide for future studies on the subject.

PERIOD OF STUDY

This study was done considering certain significant generation and transmission facilities to be in service. These facilities were (1) the Andytown - Orange River 500 kV line, and (2) Crystal River Unit 3, St. Lucie Unit 1, and Port Manatee Unit 1.

The task force used the published Florida Load Duration Curves for 1974 to determine the value for the off-peak load level. The load value was plotted as a function of the duration of that particular load level during the year 1974. The peak of this curve was selected as a starting point and the duration of each load point above and below the center point was summed to determine the percent load range that represented 50 percent of the time. The recommended load level is that load level which falls mid-way in this range. This value compares very closely with the composite load duration curves published in the subject report. The load level chosen was 55 percent of the 1977 estimate of summer peak load of each utility. Adjustments to this figure were made by Florida Power Corporation and Tampa Electric Company, reflecting industrial load. It was assumed that a high power factor would be in effect at this load level; hence, no transmission compensation was required.

The load level and spinning reserve used in the Base Case Load Flow is tabulated below:

Utility		Load and Losses (MW)	Spinning Reserve (MW)
Florida Power Corporation	(FPC)	2,417	340
Florida Power & Light Company	(FPL)	4,634	486
Gainesville-Alachua County RUB	(GVL)	101	21
Jacksonville Electric Authority	(JEA)	709	181
City of Lakeland	(LAK)	131	37
Orlando Utilities Commission	(OUC)	259	101
City of Tallahassee	(TAL)	139	68
Tampa Electric Company	(TEC)	1,125	207
State of Florida Total		9,515	1,441
Southern Company Equivalent		11,414	0
TOTAL		20,929	1,441

CASE TSS-77-4A2

LOSS OF TURKEY POINT UNIT 4 (700 MW) WITH FRAGMENTED TRANSMISSION SYSTEM

This case simulation was chosen in order to observe the transient response of the system for the loss of a large generating unit in extreme southern Florida during a time period when certain transmission circuits considered vital to maintain system integrity have been removed. This condition is analogous to having these circuits removed for maintenance.

The transmission lines selected for removal were the Andytown - Orange River 500 kV circuit, the Midway - Indiantown 230 kV circuit, and the Central Florida - Clermont East 230 kV circuit.

Specific items of interest are:

1) The transient response of the state for the loss of a significant percentage of dispatched system generation during off-peak conditions.
2) The resulting frequency and voltage response which may cause the operation of emergency reactor coolant pumps.
3) To determine if underfrequency load shedding will occur.
4) To observe any tendency toward cascading.

RESULTS AND OBSERVATIONS

The loss of this unit resulted in the frequency decline of the other units in the state. Turkey Point Unit 3 reached a minimum frequency of 59.58 Hz at approximately T = 0.35 second. This frequency represented the lowest that occurred on any State of Florida generating unit. Frequency deviations from 60.00 Hz on those units progressively removed from Turkey Point were smaller and occurred later in simulation time (see Figure 4A2-2).

System response recovered the 700 MW loss by T = 0.7 second. The largest initial contribution was from load damping, followed respectively by tie line flows and turbine response (see Figure 4A2-1). The load damping peak was 697 MW at T = 1.7 seconds; turbine response peaked 0.1 second later at 243 MW.

Tie lines were exporting approximately 3 MW of power when the unit outage occurred (see Figure 4A2-3). These tie lines were composed of the following circuits:

1) Suwannee-Archer 230 kV
2) Ft. White-Inglis 115 kV
3) Ft. White-Newberry 115 kV
4) Ft. White-High Springs 69 kV

Net power flow over these tie lines reversed at T = 0.2 second, increasing to a peak of 515 MW at T = 2.4 seconds to the south. No transmission line relays operated during the course of the study.

A voltage profile for selected buses throughout the state reveals the following excursions from initial conditions:

TABLE I: VOLTAGE PROFILE (PERCENT)

Bus			Initial Voltage	Minimum Voltage	Difference	Voltage @ T=4.0
Turkey Point	230 kV	(FPL)	105.7	96.5	-9.2	104.9
Andytown	230 kV	(FPL)	105.1	92.2	-12.9	102.6
Ft. Myers	230 kV	(FPL)	104.9	92.2	-12.7	101.7
Midway	230 kV	(FPL)	105.6	94.6	-11.0	101.8
Volusia	230 kV	(FPL)	104.4	100.6	-3.8	103.7
Suwannee	230 kV	(FPC)	102.3	94.6	-7.7	103.5
Crystal River	230 kV	(FPC)	105.7	101.3	-4.4	106.1
Gannon	230 kV	(TEC)	104.7	101.7	-3.0	103.8
Pebbledale	230 kV	(TEC)	101.8	97.9	-3.9	100.4
Northside	230 kV	(JEA)	101.7	100.3	-1.4	101.3
Indian River	230 kV	(OUC)	105.7	101.1	-4.6	105.0
Larsen	69 kV	(LAK)	102.7	98.2	-4.5	100.2
Hopkins	230 kV	(TAL)	100.7	98.3	-2.4	101.7
Parker Road	230 kV	(GVL)	103.7	94.7	-9.0	103.1

The lowest frequency and terminal voltage occurring on the three remaining nuclear generating units are tabulated below:

TABLE II: NUCLEAR GENERATING UNIT DATA

Unit	Lowest Frequency (Hz)	Lowest Terminal Voltage (Percent)
Turkey Point 3	59.58	92.4
St. Lucie 1	59.77	89.8
Crystal River 3	59.80	100.1

CONCLUSIONS

Based on the assumptions included in this study, the following conclusions can be stated:

1) There will be no separation of Peninsular Florida from the north for the loss of this unit.
2) The resulting frequency and voltage response of the three nuclear units connected to the system is such that emergency reactor coolant pump operation will not be initiated.
3) No load shedding will occur.
4) No transmission line relay operations will occur from the loss of this unit.
5) No tendency toward cascading was observed.

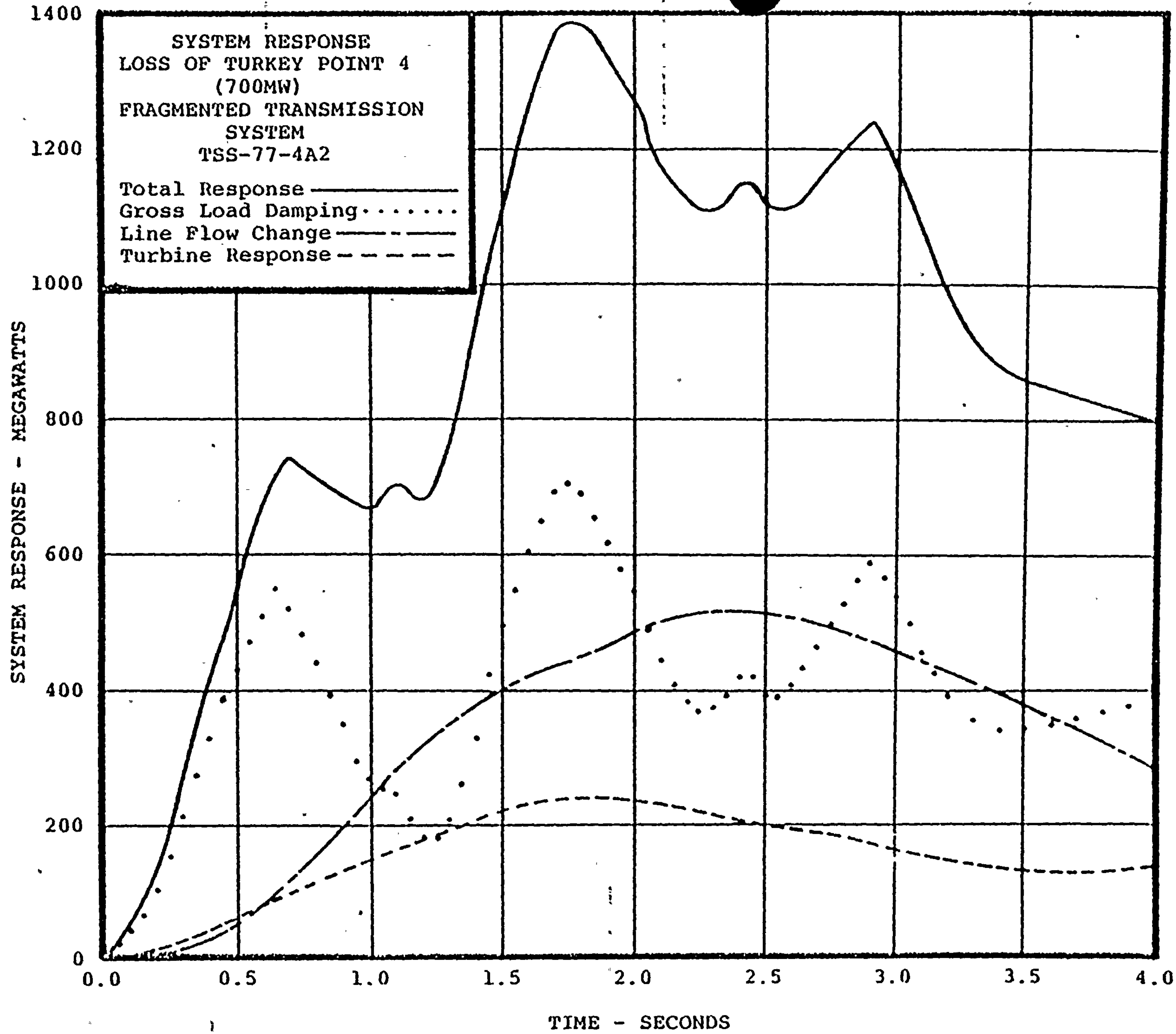

SYSTEM RESPONSE
LOSS OF TURKEY POINT 4
(700MW)
FRAGMENTED TRANSMISSION
SYSTEM
TSS-77-4A2
Total Response
Gross Load Damping
Line Flow Change
Turbine Response
SYSTEM RESPONSE - MEGAWATTS
1400
1200
1000
800
600
400
200
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
TIME - SECONDS

FIGURE 4A2-1

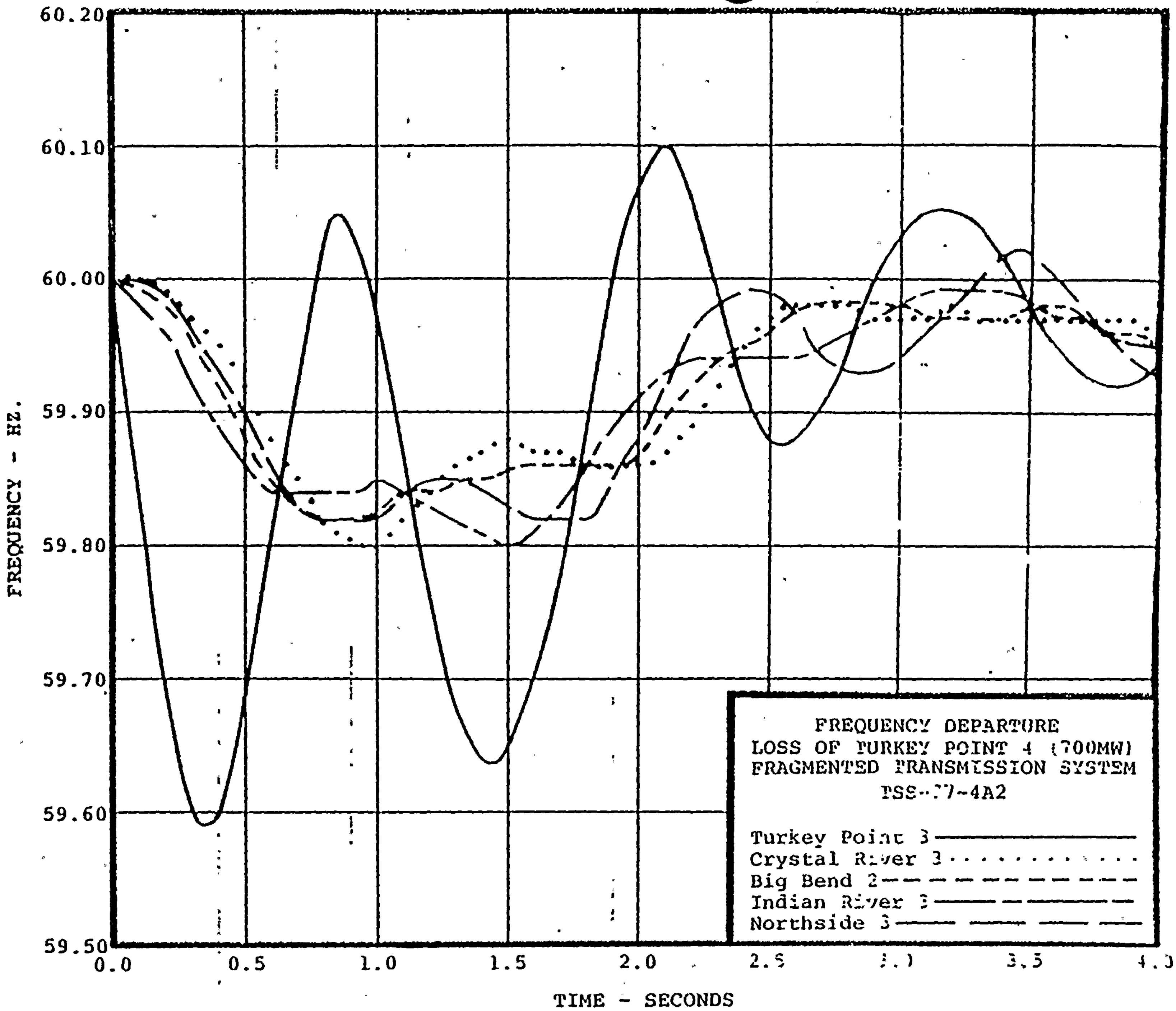
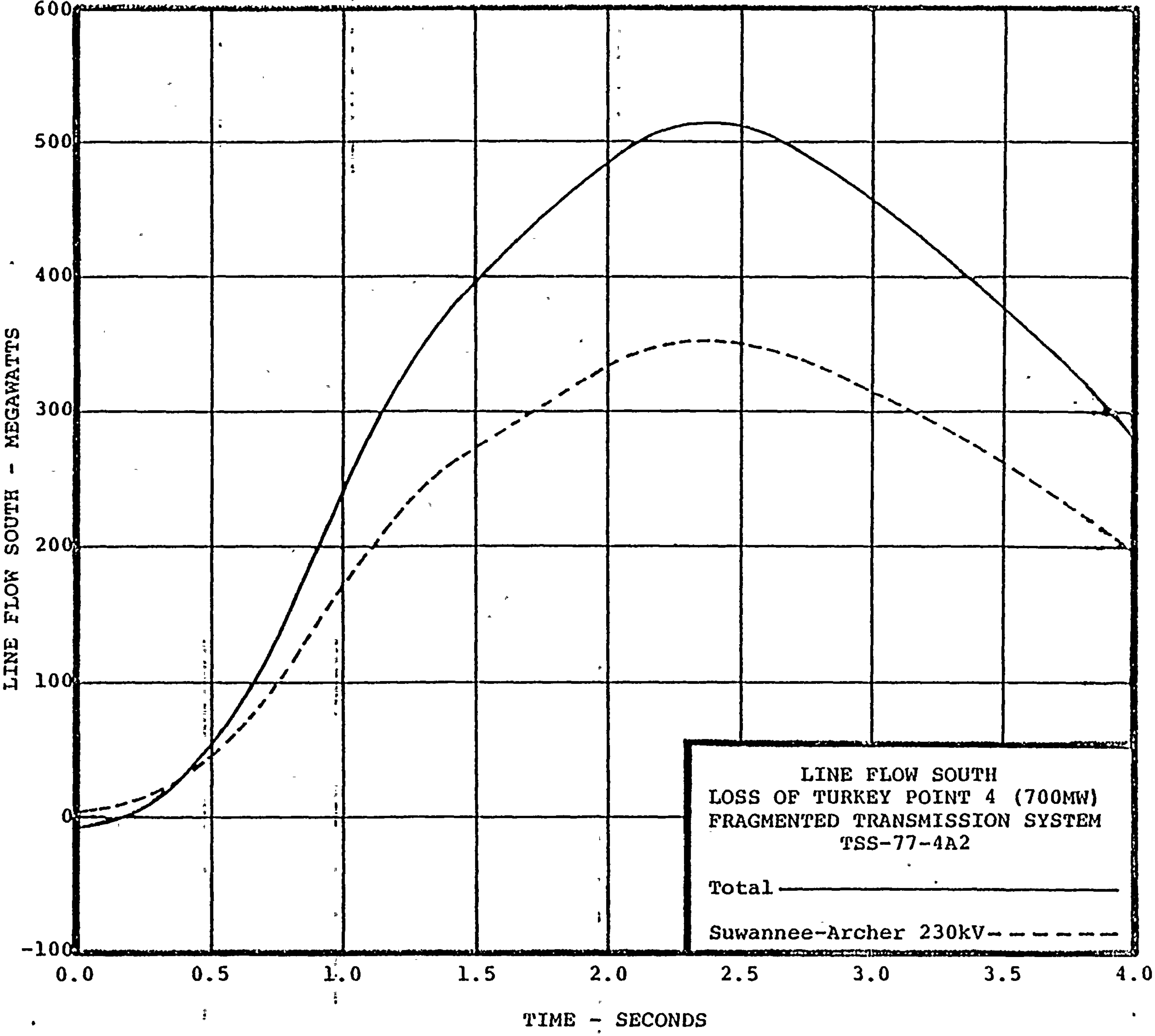

FREQUENCY DEPARTURE
LOSS OF TURKEY POINT 4 (700MW)
FRAGMENTED TRANSMISSION SYSTEM
TSS-77-4A2
Turkey Point 3
Crystal River 3
Big Bend 2
Indian River 3
Northside 3
FREQUENCY - HZ.
TIME - SECONDS
60.20
60.10
60.00
59.90
59.80
59.70
59.60
59.50
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0

FIGURE 4A2-2



LINE FLOW SOUTH
LOSS OF TURKEY POINT 4 (700MW)
FRAGMENTED TRANSMISSION SYSTEM
TSS-77-4A2
Total
Suwannee-Archer 230kV
LINE FLOW SOUTH - MEGAWATTS
600
500
400
300
200
100
0
-100
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
TIME - SECONDS

FIGURE 4A2-3

APPENDIX B

FPC REPORTS ON ELECTRIC POWER DISTURBANCES DURING THE SECOND QUARTER OF 1977 APRIL 1 - JUNE 30, 1977

The Federal Power Commission (FPC) requires all electric utilities to report electric power disturbances under Order No. 331-1. The reports are classified into three categories; bulk power supply interruptions which result in loss of ultimate customer load, load reduction measures which do not necessarily result in disconnection of customer load, and events which constitute an unusual hazard to bulk electric power supply. The second quarter of 1977 reported disturbances are briefly summarized for each classification in attached Tables I, II, and III. The major disturbances are described in greater detail below:

Bulk Power Supply Interruptions

During the second quarter of 1977, the nation's electric utility systems reported eight bulk power supply interruptions to FPC.

FPC Order No. 331-1 requires electric systems to report all interruptions of bulk power supply caused by the outage of any generating unit or electric facility operating at a nominal voltage of 69 kilovolts or higher and resulting in a load loss for 15 minutes or longer of at least 100 megawatts. Smaller systems must report if one-half or more of the annual system peak load is involved. The major interruptions are described below.

Florida Power and Light Co. - May 16, 1977

The largest bulk electric power interruption in terms of customers and load occurred on May 16, 1977, when 1,300,000 customers, representing 3,227 megawatts of load, were deprived of service for periods up to four hours and 36 minutes during an outage on Florida Power & Light Company's (FP&L) system. During this period, three separate incidents of system disturbance occurred, which are categorized as:

1. Forced outage of Turkey Point Unit No. 3, a 666-megawatt nuclear unit.

2. Loss of the Ft. Myers-Ranch 240-kilovolt transmission line; and

3. Loss of the Andytown-Orange River 500-kilovolt line.

At 10:08 a.m. Turkey Point Unit No. 3 experienced a reactor and turbine trip as the result of a false relay signal which caused the loss of 684 megawatts in generation. The north-south lines in the State of Florida relayed, isolating the Peninsula from the north. The combined spinning reserves of the Florida system were sufficient to cover the loss and arrest the frequency decline at 59.59 hertz, and no customer service was affected. At 10:14 a.m. the interconnection to the north was re-established and the frequency returned to 60 hertz. However, with the loss of Turkey Point No. 3, the system transmission line loadings were such that the Ft. Myers-Ranch 240-kilovolt line was loaded to its maximum thermal rating.

Ten minutes later, a second outage, which extended from Fort Pierce southward along the East Coast to the Florida Keys, was triggered when the heavily loaded (west to east flow) Ft. Myers-Ranch 240-kilovolt line tripped because of a phase-to-ground fault. This caused heavy north to south flows tripping other key transmission lines. This division of the transmission system resulted in the St. Lucie Plant of the eastern area being tied only to the northern system area, the Riviera Plant being islanded with part of the eastern system area load, and creation of an isolated southern area.

In the southern area, Port Everglades Units 1 and 3 and Turkey Point Units 1 and 2 were generating a total of 1,003 megawatts to supply approximately 2,950 megawatts of load. This load-generation imbalance caused a rapid decrease in frequency to below 56 hertz. Underfrequency relays operated to shed approximately 1,544 megawatts of load. The four units operating at Port Everglades and Turkey Point Plants became overloaded and tripped out due to underspeed protection. The isolated eastern area's Riviera Plant was shut down because of excess generation and subsequent operational problems following rapid unloading.

The other FP&L system islands (north and west) went into overfrequency from excess generation causing the St. Lucie Unit 1 operator to manually trip the nuclear unit due to rapid unloading to an unsatisfactory level. Shortly the frequency in the north and west recovered to normal, which permitted re-establishment of the north-south FP&L system ties and reconnection to other Florida systems. The total number of customers affected by this series of events was 1,300,000, representing 3,227 megawatts of load. Restoration of the south and eastern areas began and most of the load was re-established by 12:03 p.m., after one hour and 39 minutes.

During this initial restoration at 12:03 p.m. the third incident occurred when the Andytown-Orange 500-kilovolt line tripped because of the misoperation of a fault pressure relay on the "A" phase of the 240/500-kilovolt autotransformer at Andytown. This initiated a power swing which resulted in the separation of the entire eastern and southern areas at Malabar. Generation in the affected area was again separated by under-frequency generator protection and overcurrent relay operation. The total amount of load lost was 2,025 megawatts. Service restoration again proceeded immediately. Gas turbines quickly picked up load in the isolated areas and were synchronized with the northern system. Service was restored to all but a few small isolated areas by 3:00 p.m. the same day.

Tennessee Valley Authority - May 2, 1977

In terms of load, the second largest bulk electric power interruption occurred on May 2, 1977, on the Tennessee Valley Authority's (TVA) system when the loss of two Electric Energy Inc. 161-kilovolt transmission lines supplying load to the Energy Research and Development Administration (ERDA) in Paducah, Kentucky, caused the loading and tripping of a TVA 161-kilovolt circuit to the ERDA load center. Following loss of the TVA circuit from its Shawnee plant, three of the plant's units tripped, resulting in a power interruption which lasted for five hours and 29 minutes and a load loss totaling 1,084 megawatts. Only one industrial customer, ERDA, was affected by the outage.

APPENDIX C

Sample Calculation

Area Load Chart

Transmission System Breaker Diagram 4/1/77 (8 sheets)

Transmission System Schematic Diagram

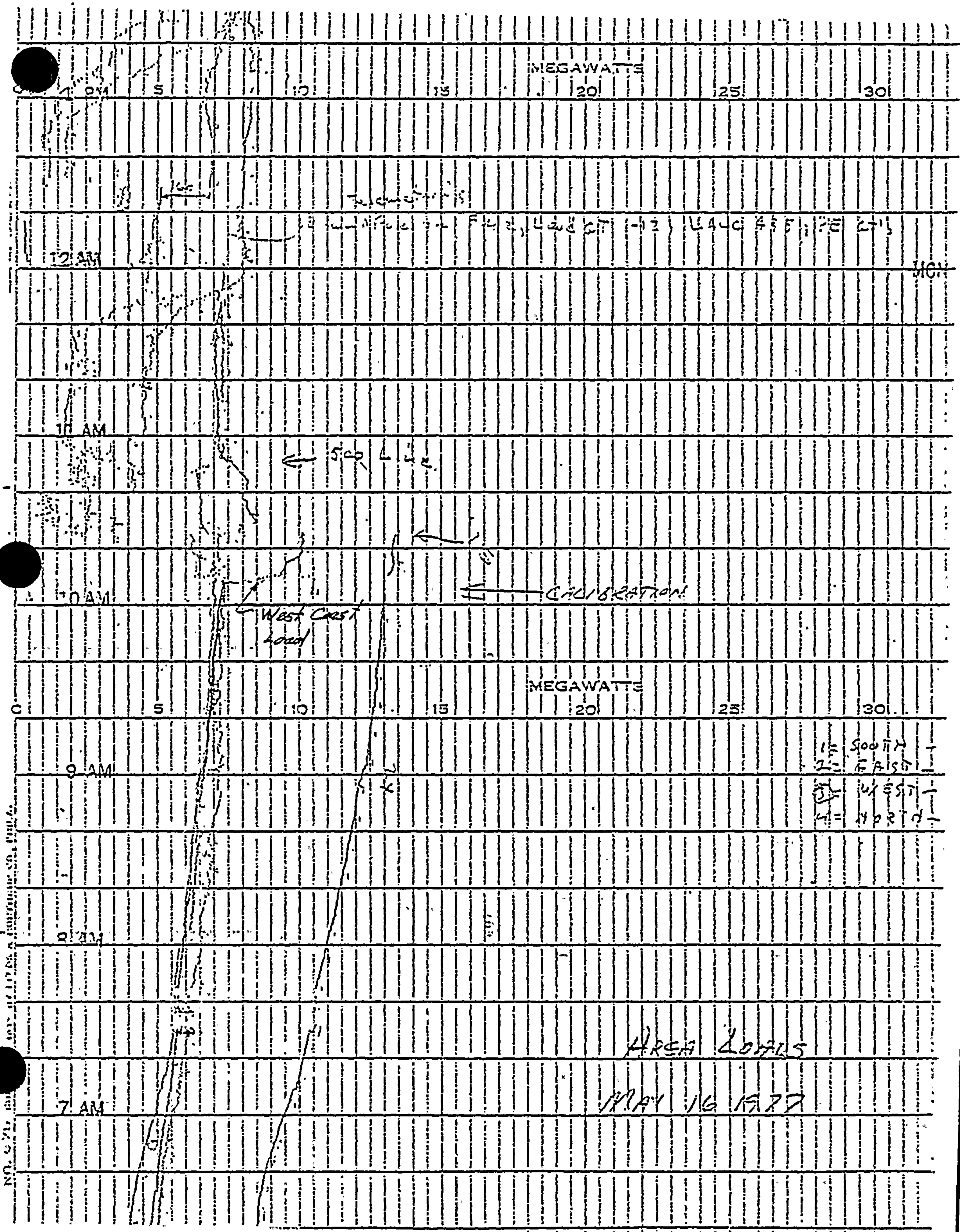
Oscillograms - Broward (1 roll)

Oscillograms - Midway (1 roll)

CNW:sh
3/30/78

SAMPLE OF CALCULATION OF
FT. MYERS-RANCH 240kV LINE LOADING

APPROXIMATE TIME	TAMPA TIES #1	TAMPA TIES #2	MANATEE #1	FT. MYERS #1	FT. MYERS #2	FT. MYERS GT	POWER AVAILABLE	AREA LOAD	FORT MYERS - RANCH FLOWS TOTAL	FORT MYERS - RANCH FLOWS 240kV LINE
10:07	-70	105	585	108	337	0	995	705	290	191
10:08	-180	20	638	128	346	0	1272	710	562	395
10:23	-180	20	677	128	365	5	1335	740	595	420
10:24	70	250	570	107	310	5	672	672	0	0



MEGAWATTS
0
5
10
15
20
25
30
12 AM
MON
10 AM
500 Line
CALIBRATION
West Coast Load
9 AM
8 AM
7 AM
1= SOUTH
2= EAST
3= WEST
4= NORTH
AREA LOADS
MAY 16 1977

TRANSMISSION SYSTEM BREAKER DIAGRAM (8 sheets) is being duplicated.

TRANSMISSION SYSTEM SCHEMATIC DIAGRAM is being duplicated.

OSCILLOGRAMS: BROWARD.

(only 1 roll will be sent to NRC).

OSCILLOGRAMS — MIDWAY

(only 1 roll will be sent to NRC)

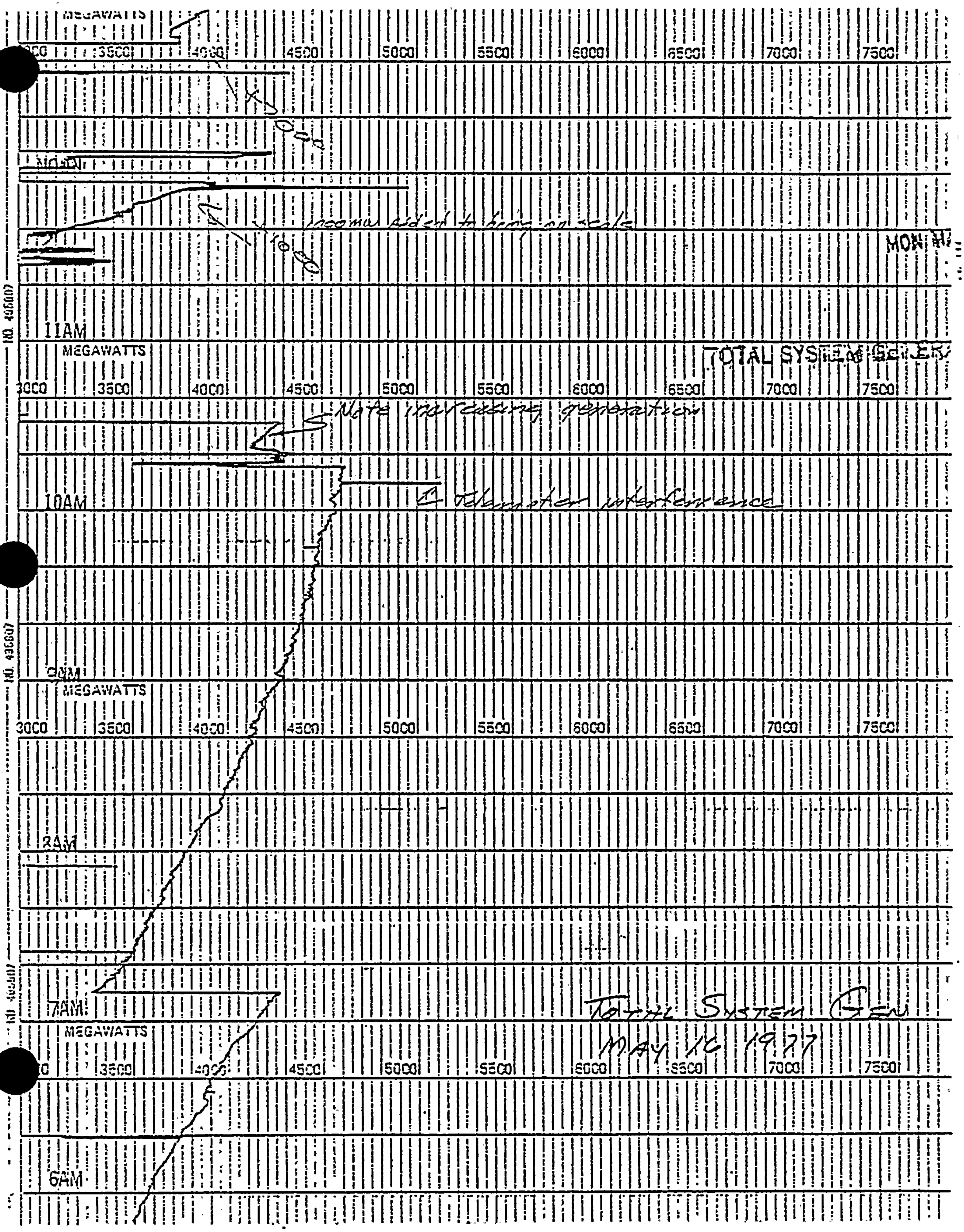
APPENDIX D

Total Generation Chart

Relay Settings (Fort Myers - Ranch)

R-X Diagram Phase Relays (Fort Myers - Ranch)

Watt-Var Diagram Phase Relays (Fort Myers - Ranch)


MEGAWATTS
3000 3500 4000 4500 5000 5500 6000 6500 7000 7500
NOON
MON
11AM
TOTAL SYSTEM GEN
Note increasing generation
10AM
Telemeter interference
9AM
8AM
7AM
6AM
Total System Gen
MAY 16 1977

FLORIDA POWER & LIGHT COMPANY

PROTECTIVE RELAY SETTINGS

DATE	PANEL
12/10/76	PL-435
STATION	
FT. MYERS	
CIRCUIT	
FT. MYERS-RANCH 240kV	
COMPANION PANEL	
PB-128	

*Indicates change from specified settings dated 5-16-75

Circuit Impedance: 11.17 +j 77.27 Ohms

* BCT Ratio: 2000/5
PT Ratio: 2000/1

Carrier Channel Frequency: 106 kHz

CLPG Relay is DUAL Polarized

CEY Phase Carrier Tripping Relay
Model Number: 12CEY54A1D
Range: 1 - 30 Ohms
Settings:
Basic Tap: 3 Ohms
* Approximate Restraint Tap: 18 %
* Reach: 20.0 Ohms
Angle: 75°

CEB Phase Carrier Blocking Relay
Model Number: 12CEB52A1D
Range: 1 - 30 Ohms
Settings:
Basic Tap: 3 Ohms
* Approximate Restraint Tap: 12%
* Ohms Reach: 0.5 Angle: 90°
* Ohms Reach: 23.75 Angle: 240°
* Ohms Reach: 23.60 Angle: 270°

CHC Phase Carrier Fault Detector Relay
Model Number: 12CHC12A2A
Range: 2 - 8 Amps
Pickup: 2 Amps

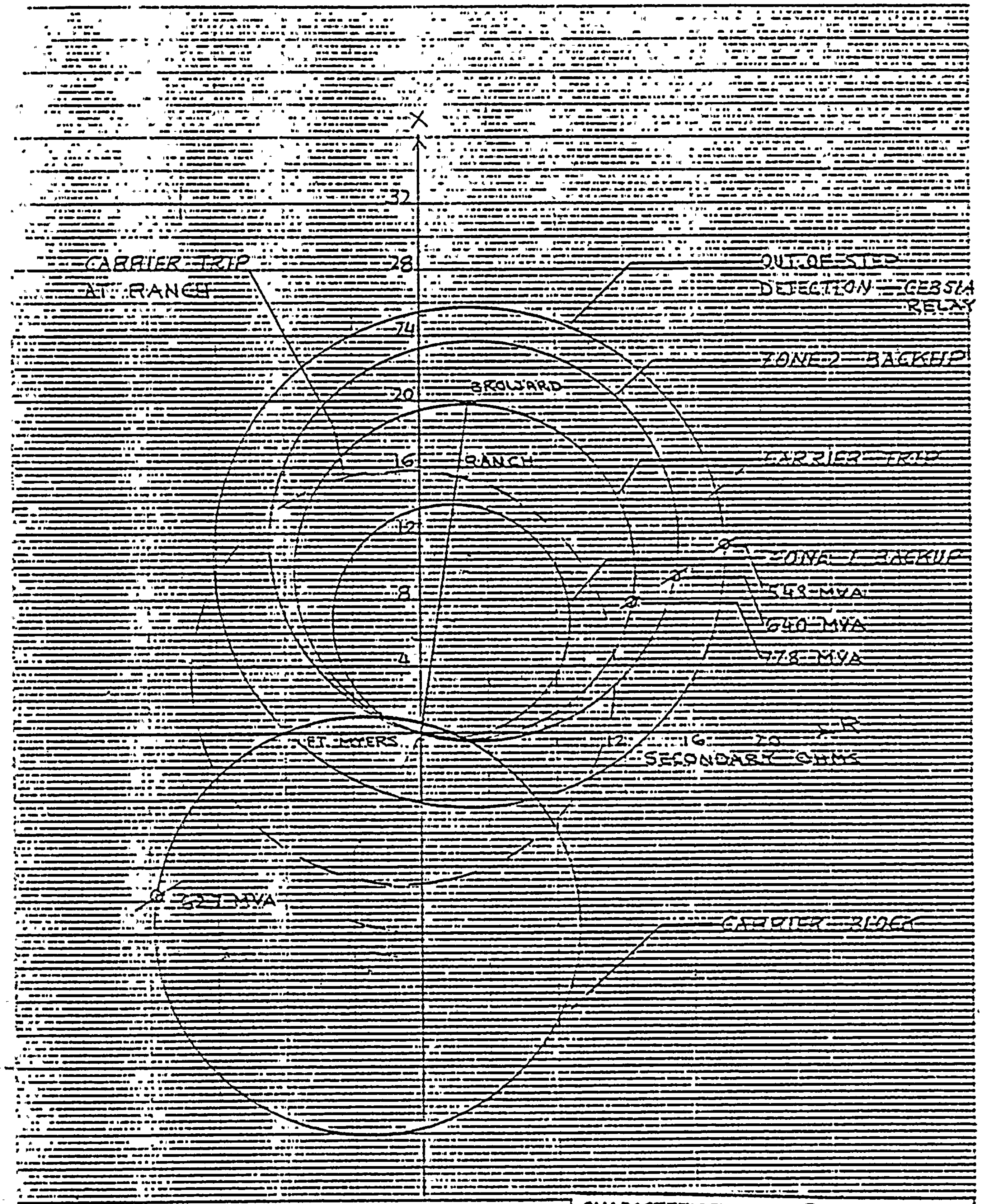
CLPG Ground Carrier Relay
Model Number: 12CLPG12C1A
Range: G1 0.4 - 1.6 Amps
G2 0.5 - 2.0 Amps
Settings:
* G1 Pickup: 0.4 Amps
* G2 Pickup: 0.6 Amps
GD Pickup: 0.25 IxI, 3.6 ExI
GD Test Amps With Coil in Series: 0.5
GD Test VA @ Unit Power Factor: 20.7

CEB Out-Of-Step Detection Relay
Model Number: 12CEB51A3A
Range: 3-30 Ohms @ 75°
Settings:
* Approximate Restraint Tap: 10%
* Forward Reach: 26.0 Ohms
Angle: 75°
Backward Reach: 4.0 Ohms
Angle: 255°

RELAYS SET AS SPECIFIED

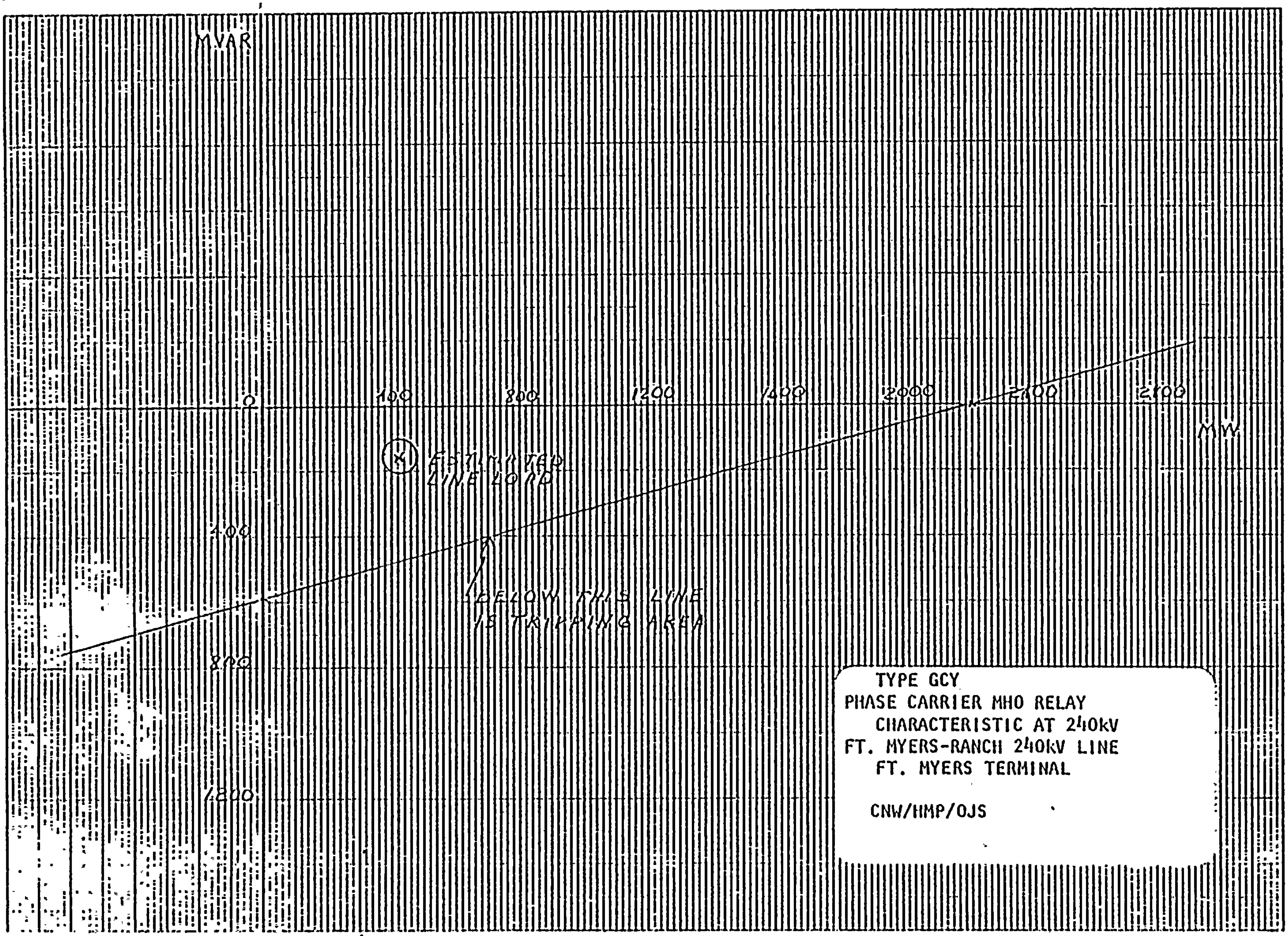
By__________ Date __________

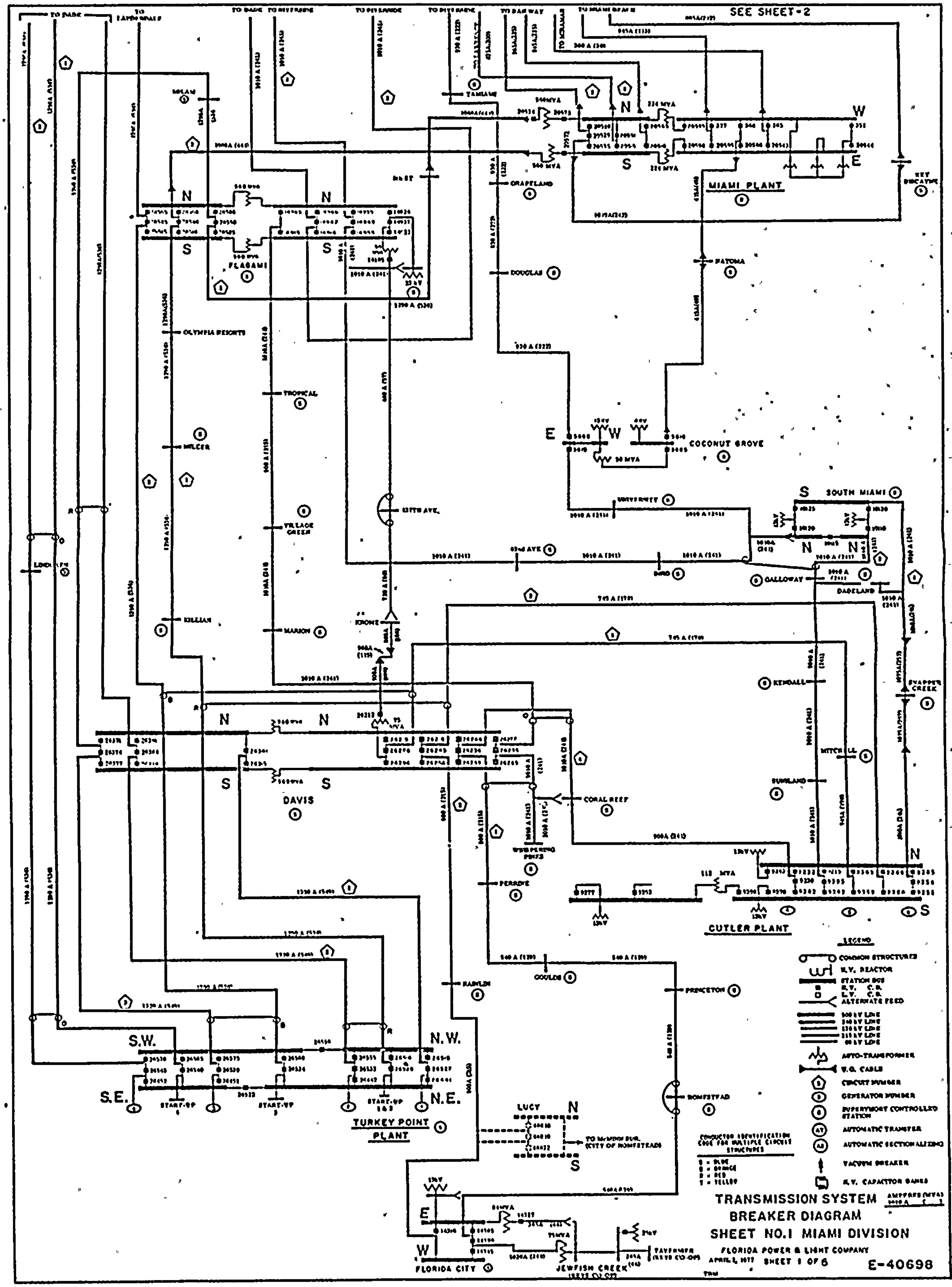
FORM 3102 REV. 3/75



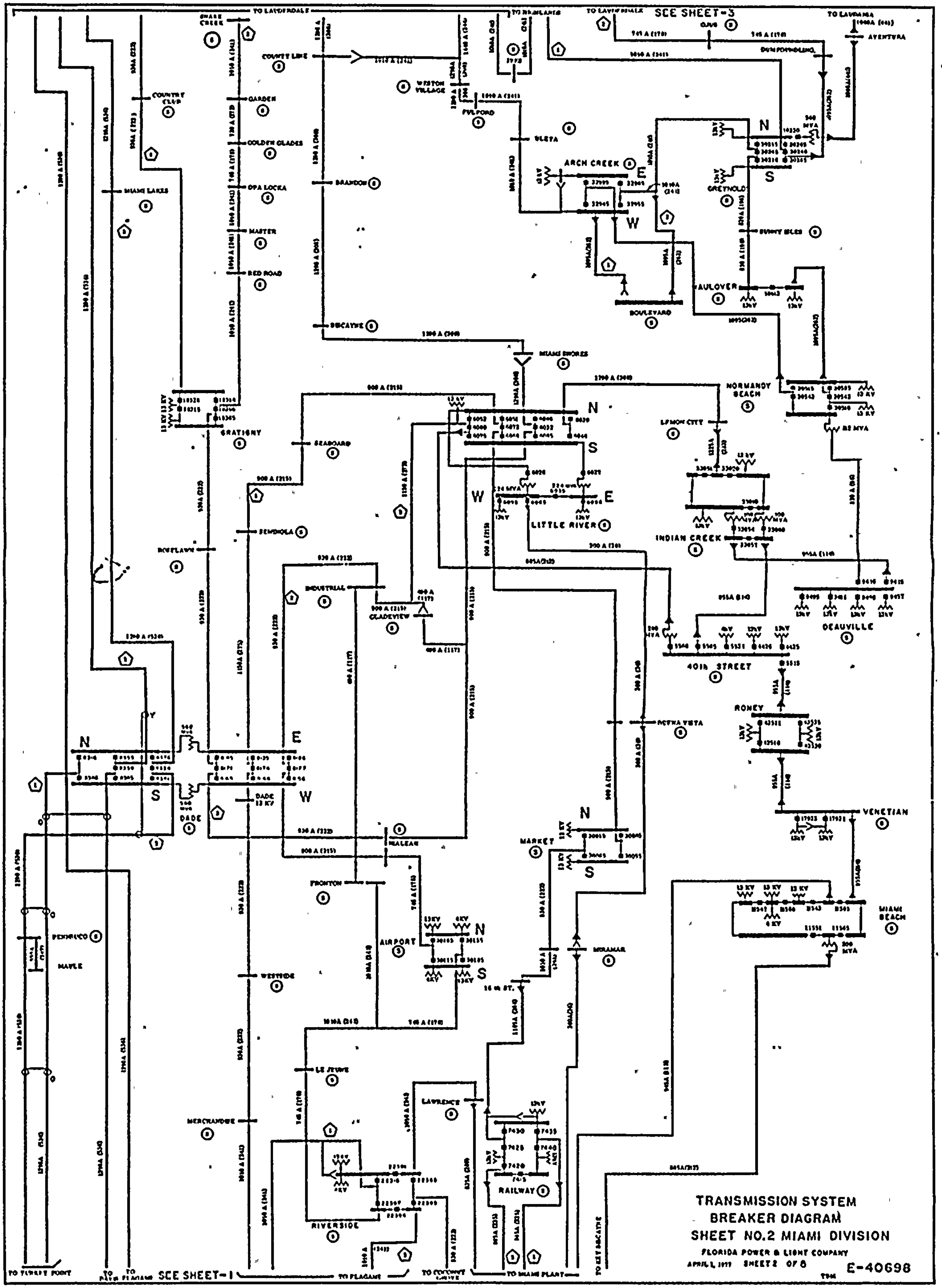
CHARACTERISTICS FOR PHASE RELAYS
LINE FT MYERS - RANCH 240 KV
TERMINAL FT MYERS
BASED ON SETTINGS DATED 12-10-76
DRAWN BY A.S.

K&E 20 X 20 TO THE INCH 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 1242





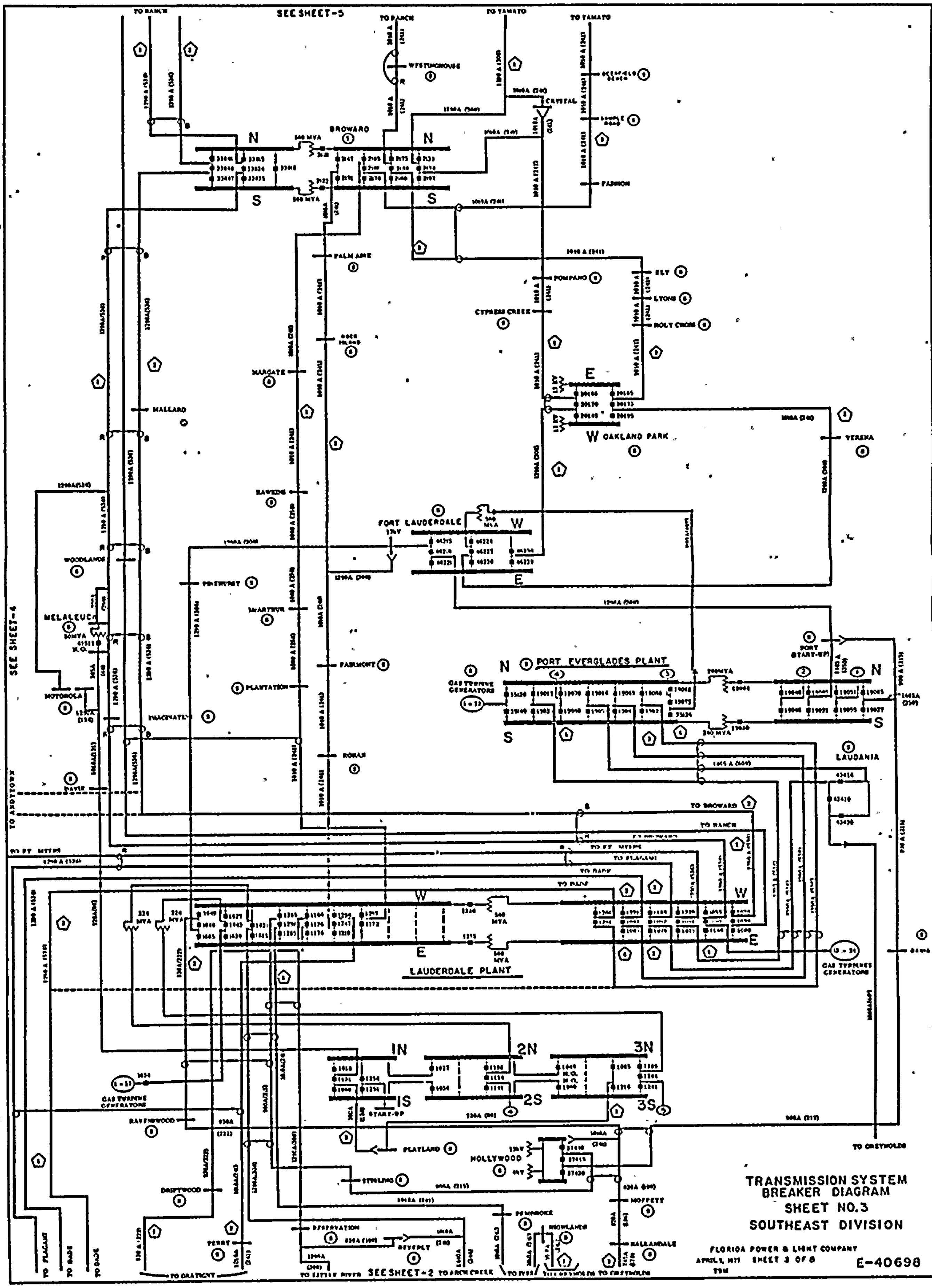
SEE SHEET-2
MIAMI PLANT
FLAGAMI
COCONUT GROVE
SOUTH MIAMI
DAVIS
CUTLER PLANT
TURKEY POINT PLANT
LUCY
FLORIDA CITY
JEWFISH CREEK
S.W.
N.W.
S.E.
N.E.
LEGEND
COMMON STRUCTURES
CONDUCTOR IDENTIFICATION CODE FOR MULTIPLE CIRCUIT STRUCTURES
AUTOMATIC TRANSFER
AUTOMATIC SECTIONALIZING
VACUUM BREAKER
TRANSMISSION SYSTEM
BREAKER DIAGRAM
SHEET NO.1 MIAMI DIVISION
FLORIDA POWER & LIGHT COMPANY
SHEET 1 OF 6
E-40698



TRANSMISSION SYSTEM
BREAKER DIAGRAM
SHEET NO.2 MIAMI DIVISION

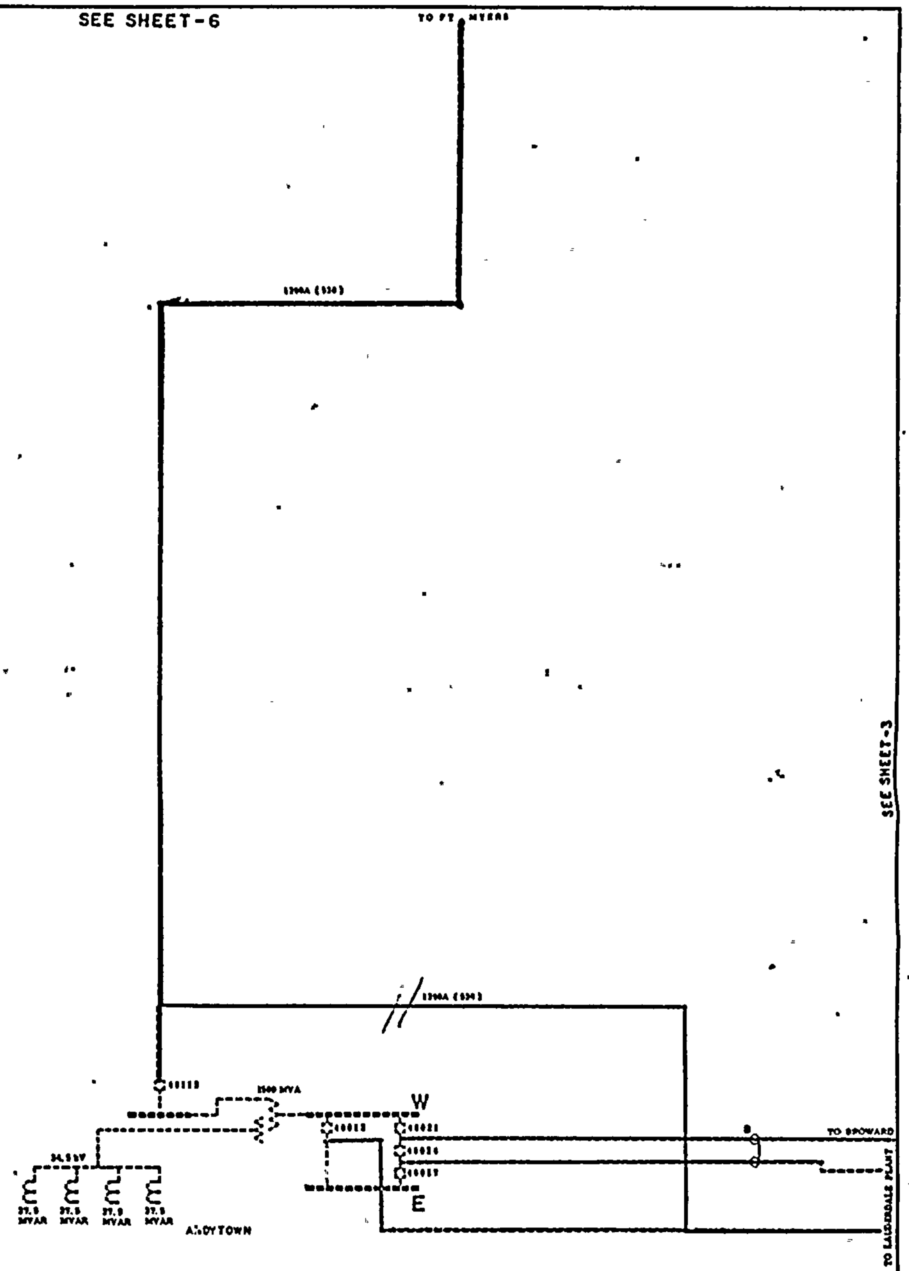
FLORIDA POWER & LIGHT COMPANY
APRIL 1, 1977 SHEET 2 OF 8

E-40698



SEE SHEET-5
TO RANCH
TO YAMATO
WESTINGHOUSE
CRYSTAL
BROWARD
N
S
FASHION
PALM AIRE
POMPANO
CYPRESS CREEK
ELY
LYONS
HOLY CROSS
MARGATE
MALLARD
OAKLAND PARK
E
W
VERENA
SAWGRASS
FORT LAUDERDALE
WOODLANDS
MELALEUCA
MOTOROLA
SEE SHEET-4
MCARTHUR
FAIRMONT
PLANTATION
ROHAN
DAVIE
TO ANDYTOWN
TO FT. MYERS
PORT EVERGLADES PLANT
GAS TURBINE GENERATORS
LAUDANIA
TO BROWARD
TO RANCH
TO FLAGAMI
TO DADE
LAUDERDALE PLANT
IN
2N
3N
IS
2S
3S
START-UP
RAVENSWOOD
PLAYLAND
HOLLYWOOD
STERLING
DRIFTWOOD
PEMBROKE
HIGHLANDS
MOFFETT
HALLANDALE
RESERVATION
BEVERLY
PERRY
TO FLAGAMI
TO DADE
TO DADE
TO GRATIGNY
TO LITTLE RIVER
SEE SHEET-2
TO ARCH CREEK
TO GREYNOLDS
TRANSMISSION SYSTEM
BREAKER DIAGRAM
SHEET NO.3
SOUTHEAST DIVISION
FLORIDA POWER & LIGHT COMPANY
E-40698

SEE SHEET-6

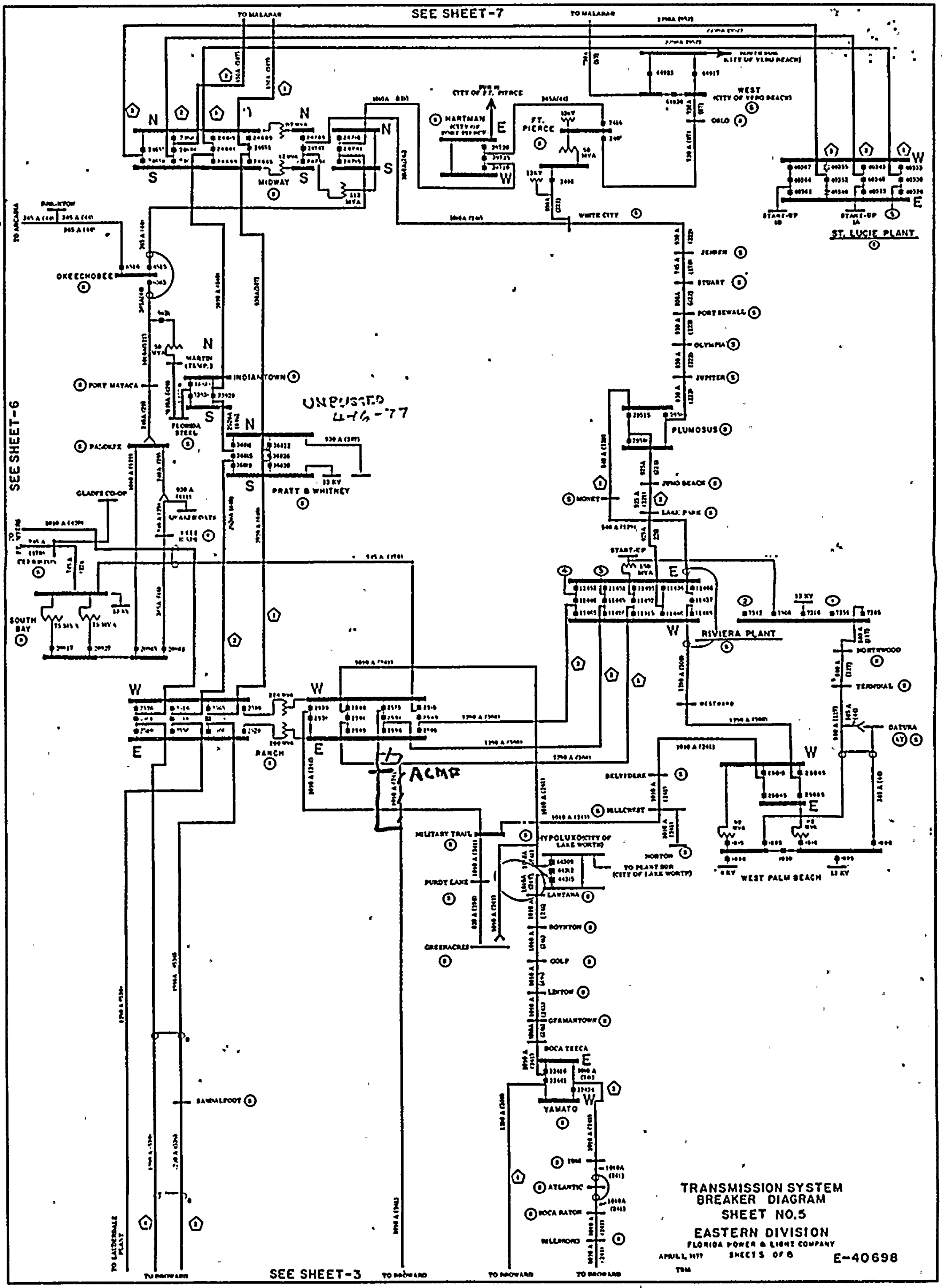


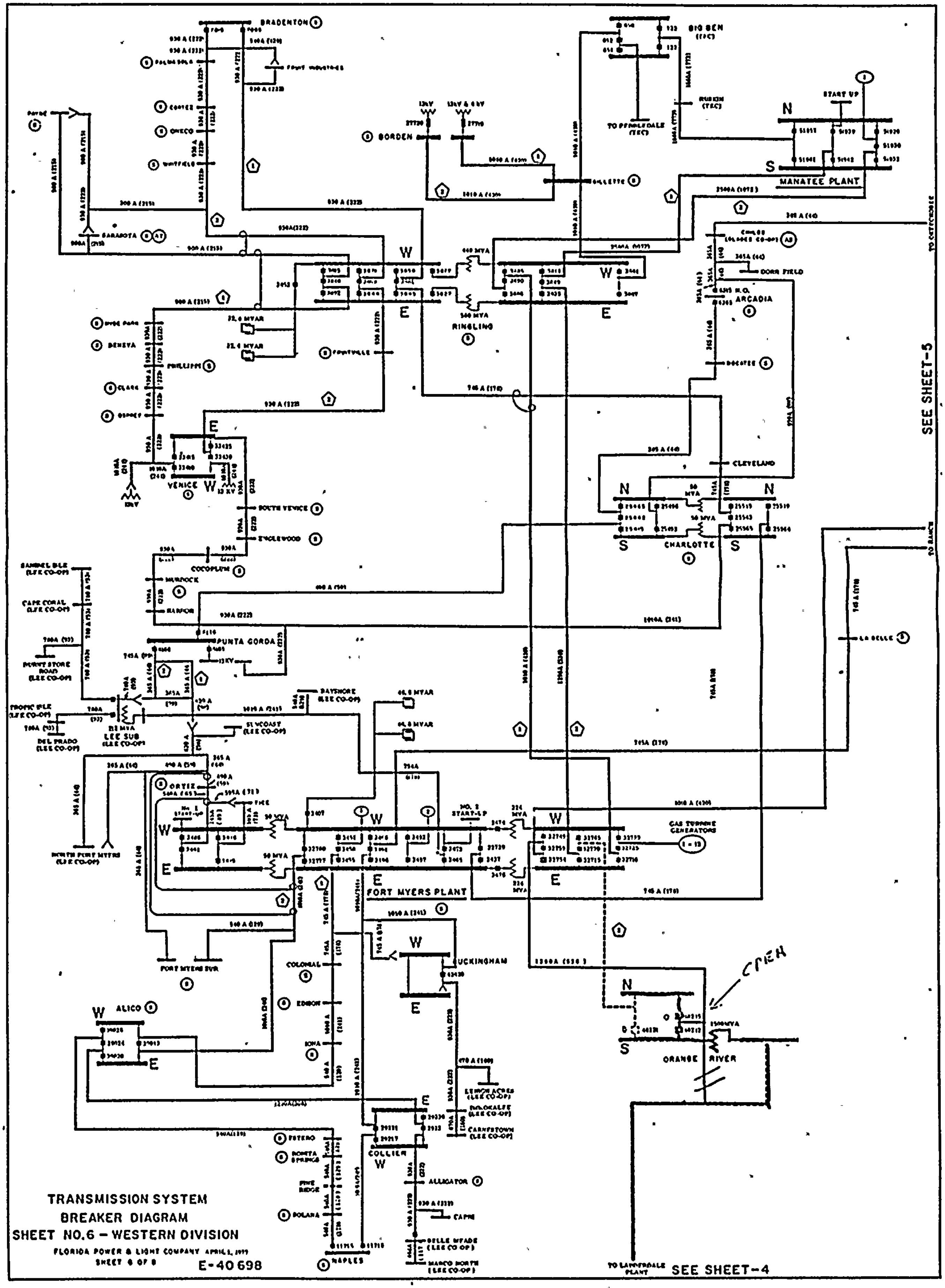
SEE SHEET-3

TRANSMISSION SYSTEM
BREAKER DIAGRAM
SHEET NO.4
SOUTHEAST DIVISION

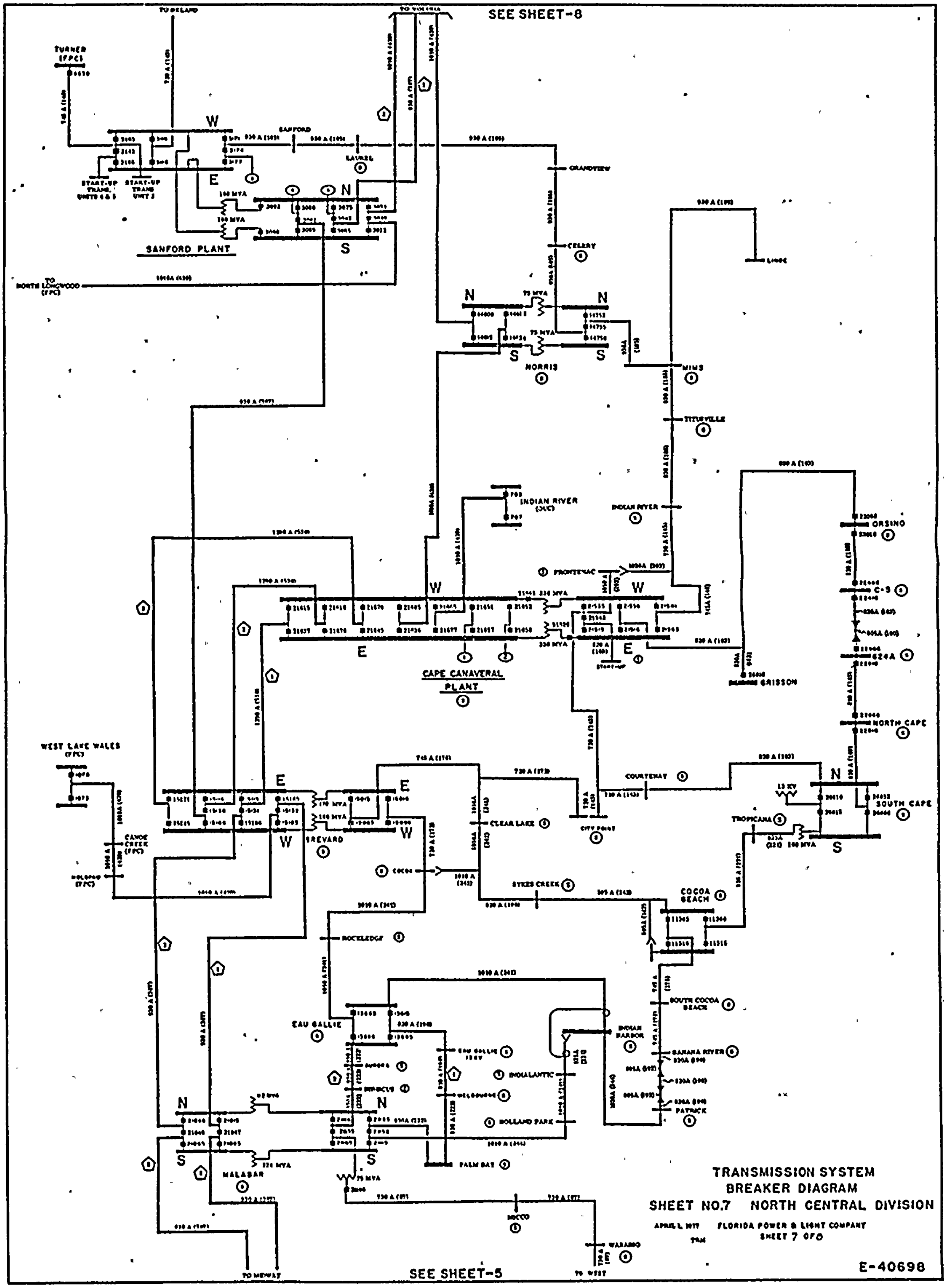
FLORIDA POWER & LIGHT COMPANY

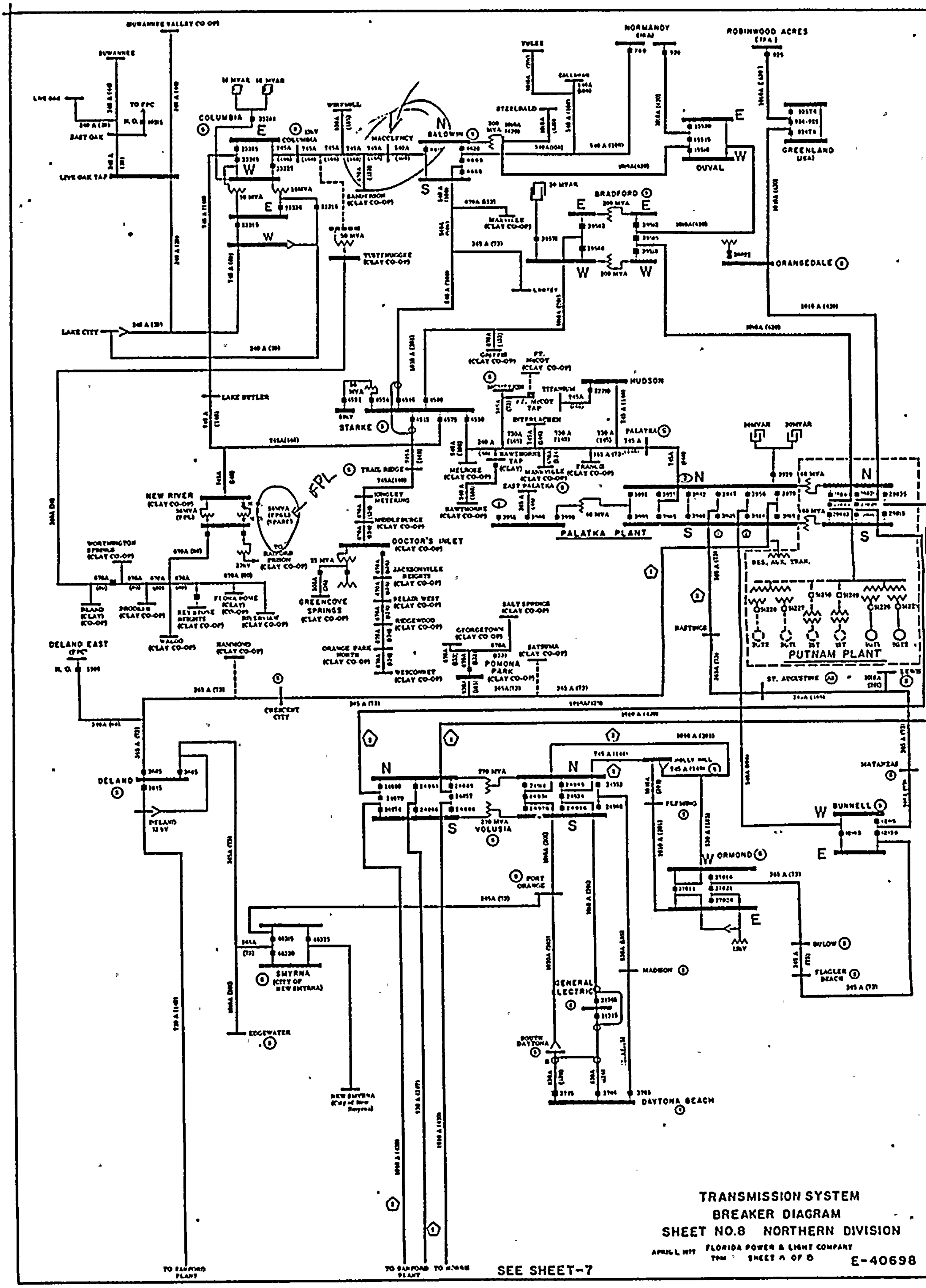
E-40 698 SHEET 4 of 8


SEE SHEET-7
TO MALABAR
SEE SHEET-6
SEE SHEET-3
MIDWAY
HARTMAN
FT. PIERCE
WHITE CITY
ST. LUCIE PLANT
OKEECHOBEE
PORT MAYACA
INDIANTOWN
MARTIN
FLORIDA STEEL
PAHOKEE
PRATT & WHITNEY
GLADES CO-OP
SOUTH BAY
JENSEN
STUART
PORT SEWALL
OLYMPIA
JUPITER
PLUMOSUS
JUNO BEACH
MONET
LAKE PARK
RIVIERA PLANT
NORTHWOOD
TERMINAL
DATURA
WEST PALM BEACH
BELVEDERE
HILLCREST
NORTON
MILITARY TRAIL
HYPOLUXO
PURDY LANE
LANTANA
BOYNTON
GREENACRES
GOLF
LINTON
GERMANTOWN
BOCA TEECA
YAMATO
ATLANTIC
BOCA RATON
HILLSBORO
RANCH
SAMPALFOOT
TO BROWARD
TO LAUDERDALE PLANT
UNBUSSED 4-26-77
ACME
TRANSMISSION SYSTEM
BREAKER DIAGRAM
SHEET NO.5
EASTERN DIVISION
FLORIDA POWER & LIGHT COMPANY
SHEET 5 OF 6
E-40698



BRADENTON
BIG BEN
RUSKIN
BORDEN
START UP
MANATEE PLANT
GILLETTE
SARASOTA
RINGLING
ARCADIA
CLEVELAND
CHARLOTTE
VENICE
SOUTH VENICE
ENGLEWOOD
COCOPLUM
MURDOCK
HARBOR
PUNTA GORDA
LEE SUB
BAYSHORE
ORTIZ
FORT MYERS PLANT
GAS TURBINE GENERATORS
BUCKINGHAM
COLONIAL
EDISON
IONA
ALICO
ALLIGATOR
COLLIER
NAPLES
ORANGE RIVER
SEE SHEET-5
SEE SHEET-4


SEE SHEET-8
TO DELAND
TURNER (FPC)
SANFORD
LAUREL
SANFORD PLANT
TO NORTH LONGWOOD (FPC)
GRANDVIEW
CELERY
LINDE
NORRIS
MIMS
TITUSVILLE
INDIAN RIVER (OUC)
INDIAN RIVER
FRONTENAC
ORSINO
C-5
624A
CAPE CANAVERAL PLANT
GRISSON
NORTH CAPE
WEST LAKE WALES (FPC)
CANOE CREEK (FPC)
BREVARD
CLEAR LAKE
CITY POINT
COURTENAY
SOUTH CAPE
TROPICANA
COCOA
SYKES CREEK
COCOA BEACH
ROCKLEDGE
EAU GALLIE
SOUTH COCOA BEACH
INDIAN HARBOR
BANANA RIVER
PATRICK
INDIALANTIC
MELBOURNE
HOLLAND PARK
PALM BAY
MALABAR
SECCO
WABASSO
TO MIDWAY
TO WEST
SEE SHEET-5
TRANSMISSION SYSTEM
BREAKER DIAGRAM
SHEET NO.7 NORTH CENTRAL DIVISION
FLORIDA POWER & LIGHT COMPANY
SHEET 7 OF 8
E-40698



TRANSMISSION SYSTEM
BREAKER DIAGRAM
SHEET NO.8 NORTHERN DIVISION

APRIL 1977 — FLORIDA POWER & LIGHT COMPANY

E-40698