REPUBLIC OF PERU

LIMA-CHIMBOTE INTERCONNECTING TRANSMISSION LINE PROJECT

FEASIBILITY REPORT

JULY 1971

prepared for

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

by

ELECTRIC POWER DEVELOPMENT CO., LTD.

PREFACE

In response to a request of the Government of the Republic of Peru, the Government of Japan agreed to conduct a feasibility study of a transmission line interconnecting Lima and Chimbote in Peru as a part of its technical cooperation program, and entrusted the Overseas Technical Cooperation Agency (OTCA) to perform the said study.

In view of the great importance of this project in expediting rehabilitation programs in the earthquake disaster area in Peru, OTCA organized an engineering team composed of four members headed by Mr. K. Shimada of the Electric Power Development Co., Ltd.. The team visited Peru for a period of 45 days from January 15 through February 28, 1971 in order to conduct field surveys.

After their return to Tokyo, the team made detail studies of the project, based upon the results of the field studies and data obtained during the field investigations. An interim report giving the tentative results of the studies was submitted to the Peruvian Government in July 1971, and the final report of the study was recently completed.

It is my sincere hope that this report will be of great help to the implementation of the project which we believe is essential for emergency source of power in the event of earthquake disaster and for the assured supply of electricity for the promotion of industries, thereby contributing to the improvement of the livelihood of the people of Peru.

On behalf of OTCA, I would like to take this opportunity to express my deepest gratitude for the hospitality and kind cooperation which officials of the Government of the Republic of Peru and associated organizations extended to the team during their stay in Peru.

Keiichi TATSUKE

Director General
Overseas Technical
Cooperation Agency

July 1971

LETTER OF TRANSMITTAL

Mr. Keiichi Tatsuke, Director General
Overseas Technical Cooperation Agency

Sir :

Submitted herewith is a Feasibility Report on the Lima-Chimbote Interconnecting Transmission Line Project in the Republic of Peru. The Overseas Technical Cooperation Agency (OTCA), for the purpose of feasibility studies of the above Project, sent an investigation team consisting of four experts of Electric Power Development Co., Ltd. (EPDC) to the Republic of Peru.

The investigation team stayed in Peru for one and a half months from January 15, 1971 to investigate the topography, geology, climatic conditions, power industry, earthquakes in the project area and to collect data required to prepare the report.

Upon return to Japan the investigation team, after analyzing the results of the investigations performed and data collected in Peru, prepared the present feasibility report in cooperation with engineers of EPDC.

The Interconnecting Transmission Line Project has been proposed to interconnect the systems in Lima and Chimbote by constructing new Chimbote Substation in the suburbs of Chimbote, a 425 km long transmission 220 kV in nominal voltage between New Chimbote Substation and San Juan Substation now under construction by Mantaro Corporation near Lima City and New Paramonga Substation midway between New Chimbote and San Juan substations, to interconnect the systems with Paramonga Power System. The transmission line herein proposed will have double circuit towers and single circuit strung with a transmitting capacity of 150 MW.

It is our belief that, when completed, the transmission line will serve to supply stable energy to Chimbote, at the same time, to consume effectively surplus energy to be produced in the Central Power System, and thereby it will contribute to the promotion of stabilization and enhancement of people's livelihood in the central and northern Peru.

In consideration of the necessity to resume the normal conditions of the devastated Chimbote and the timing of commercial operation of Mantaro Project, the present transmission line project should be implemented as early as practicable.

It is estimated that the construction period of the project will require a minimum of three years and two months including detailed survey and designs, and the total construction cost of the first stage program will be US$14,598,000.

In closing, it is wished to express the heartiful gratitude to the Government of the Republic of Peru, the Ministry of Energy and Mining, the Weather Bureau, the Geological Survey Station, the Mantaro Corporation, the Santa Corporation, Lima Electric Company and OTCA Japan for their great assistance and cooperation in carrying out the investigations.

Respectfully submitted,

K. Shimada

Kiyoshi Shimada, Chief
Investigation Team
Lima - Chimbote Interconnecting
Transmission Line Project

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CHAPTER 1.

INTRODUCTION

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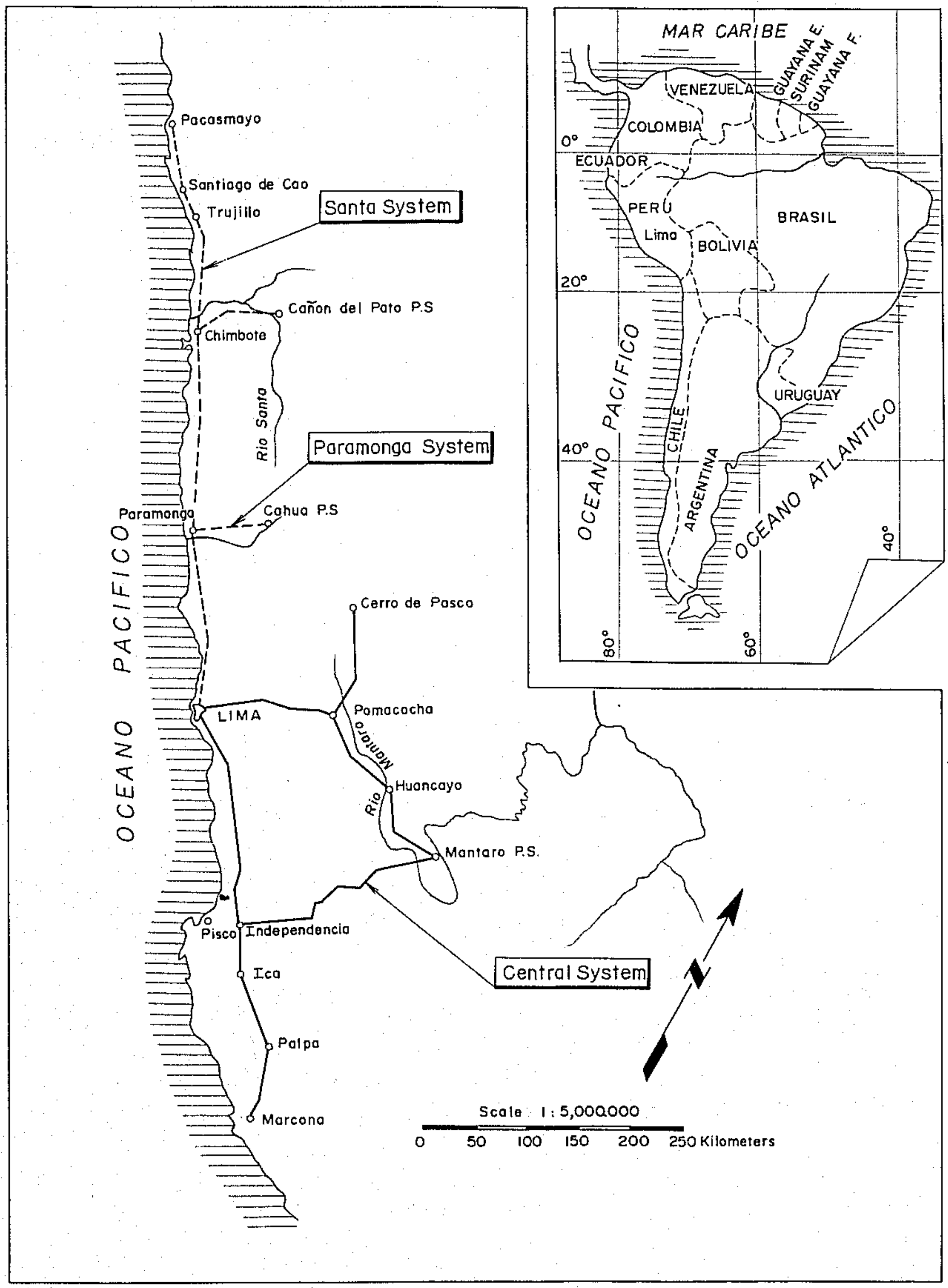
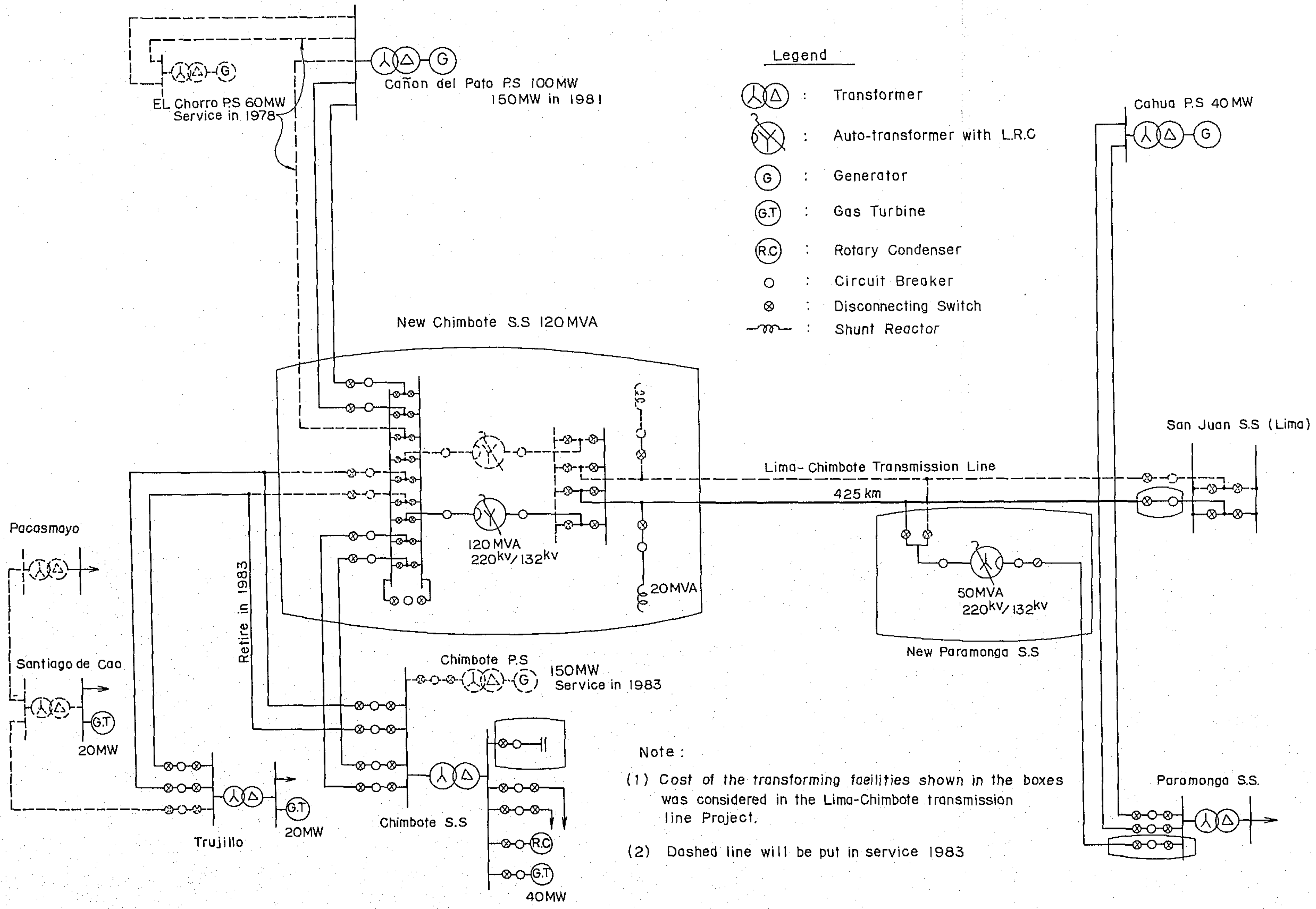


Fig. 1-2 Single Line Diagram related with Lima-Chimbote Transmission Line



Note :

(1) Cost of the transforming facilities shown in the boxes was considered in the Lima-Chimbote transmission line Project.

(2) Dashed line will be put in service 1983

CHAPTER 1. INTRODUCTION

1.1 Antecedents

On May 31, 1970 the Chimbote region in the northern part of the Republic of Peru was struck by a severe earthquake and suffered tremendous damage. Cañon del Pato Power Station which is the principal hydroelectric power station in the region also suffered damage and stopped to function. Consequently, the disaster area was placed in a serious condition with respect to power supply for a considerably long period.

Due to such circumstances, the Government of the Republic of Peru, based on "Informe Preliminar sobre la Línea de Interconexión a 220 kV de Lima a Chimbote," requested the Government of Japan in December 1970 for economic cooperation in early realization of an interconnecting transmission line to secure electricity in the disaster area, and also to cope with possible damages by earthquake in the future.

The Government of Japan, in response to this request immediately dispatched through the Overseas Technical Cooperation Agency a survey team comprised of four engineers of the Electric Power Development Co., Ltd. to the Republic of Peru from the middle of January to the end of February 1971 to investigate the feasibility of the transmission line and a report thereof was prepared upon return of the team to Japan.

1.2 Prupose and Scope of Study

This survey report is on the investigations and studies of the interconnecting transmission line project between Lima and Chimbote and related substation facilities.

The scope of the investigations cover the Central Power System area cenered around Lima, the Santa Power System area centered around Chimbote and the Paramonga Power System centered around Paramonga.

1.3 Investigation and Study

The team resided in the Republic of Peru for one and one-half months from January 15, 1971, and conducted discussions with the Ministerio de Energia y Minas, Junta de Asistencia Nacional Corporación de Mantaro, Corporación de Santa, etc. in regard to the surveys and plans, carried out field investigations and collected necessary information.

The team upon returning to Japan prepared this Report at the Electric Power Development Co., Ltd. under the direction of the Company's Chief Engineer and with the cooperation of specialists in the fields concerned, study of load projection, transmission line and substation plans, further making analysis of preliminary design, construction cost estimates, economic studies, financing plans, etc. based on the information collected in the field.

1.4 Basic Information

The basic information used in formulation of the Project were made availabble to the team while residing in the Republic of Peru from the Ministerio de Energía y Minas, the Meteorological Agency, Geological Survey Institute, Mantaro Corporation, Santa Corporation, Lima Light and Power Company, etc. and the listed in Appendix 6.

1.5 Composition of Survey Team

The team was comprised of the engineers of the Electric Power Development Co., Ltd. listed below.

Chief	Kiyoshi Shimada	Power Transmission Engineer
Member	Tatsuo Tomabechi	System Analysis Engineer
Member	Yosuke Sunada	Power Transforming Engineer
Member	Tadahisa Namura	Power Transmission Engineer

CHAPTER 2.
CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 2. CONCLUSIONS AND RECOMMENDATIONS

2.1 Conclusions

The conclusions obtained through the investigation and study are as follows:

(1) This interconnecting transmission line project, in addition to the power interchange between the interconnected areas, provides an effective facility as an emergency power source which is necessary for restoration in case of fault or other calamities.

(2) Cañon del Pato Power Station, the largest power station in the Santa Power System supplying electric power to the Chimbote area, suffered damage in the last earthquake and power generation was stopped for a long period hindering greatly the early recovery of the area from the earthquake disaster. There have been similar cases a number of times in the past, while there is great possibility of power stoppage in the future due to earthquakes and abnormal floods. This greatly endangers the stability of power supply to the Chimbote area. In order to eliminate this danger, it is necessary to construct a transmission line to interconnect with the Central Power System which is capable of supplying power instantaneously in a stable manner. Therefore, top priority should be given to the implementation of this tie line project.

(3) The net construction cost of the interconnecting transmission line would be US$6,180,000 if designed for single circuit steel towers and US$7,540,000 for double circuit with one circuit installed. The difference is US$1,360,000, but since this interconnecting transmission line is judged to become an important transmission line between the central area of Peru and the northern regions, and considering that this would be made a double-circuit line in the near future because of importance of its reliability, a double-circuit design with one circuit initially installed was adopted.

(4) It was determined that the scale of the interconnecting transmission line should be as indicated below in view of the load forecasts, the present conditions of power generating facilities and future development plans in the Central Power System, Santa Power System and Paramonga Power System, the probable complete stoppage of Cañon del Pato Power Station in the future and the power flow conditions ensuring from the stoppage as well as the considerations of (3) above.

Section:	From San Juan Substation, Mantaro Corp. to New Chimbote Substation, Santa Corp.
Length:	425 km

Voltage: 220 kV

Electric Supply System: 3 phase, 3 wire, 60 Hz

Transmission Capacity: 150 MW per cct

Number of Circuits: 1 circuit initially (2-cct design)

Conductor: 330 mm^2 ACSR (corrosion-proof)

Insulator: 10-in. fog-type insulator, 21 discs per string

Support: Steel tower (atomospheric corrosion resisting rolled steel)

(5) According to the load forecasts, the total demand at peak hours in 1974 of the Central Power System, Santa Power System and the Paramonga Power System will be approximately 1,000 MW and as much as 2,360 MW in 1984, the growth rate being an average of about 9.0%.

To meet the above load forecasts, the interconnecting transmission line should be put in operation in 1974 with the first circuit and if no additional thermal power station (150 MW x 1) is constructed in the Chimbote area by 1983 the second circuit should be installed in 1983.

(6) The interconnection point with Lima system would be San Juan Substation now under construction by the Mantaro Corporation, and with Chimbote system, it would be New Chimbote Substation proposed at a site approximately 10 km northeast of Chimbote City. Also, New Paramonga Substation not included in Informe Preliminar was newly planned to be provided for interconnection with the Paramonga Power System.

(7) In designing the interconnecting transmission line, it will be necessary to provide facilities, to prevent salt pollution bothe electrically and mechanically.

(8) The construction period of this Project is calculated to require 24 months from start of construction in January 1973 to completion in December 1974. The construction cost required for execution of this Project will be US$14,598,000 including interest during construction. The domestic and foreign currency requirements are as follows:

Foreign currency: US$10,178,000 (interest during construction, $497,000)

Domestic currency: US$4,420,000 (interest during construction, $216,000)

The annual interest rate applied was 3.5%.

(9) By interconnecting the Central Power System with the Santa Power System, it will be possible to curtail the installed capacity in each system that would be required if the power systems are operated independently. The amount of these savings is

evaluated at US$15,600,000.

Also, Mantaro Power Station which will start commercial operation in 1973 will initially have surplus energy and through the interconnection this surplus energy will be made effective, the value of this being US$5,438,000.

Besides the above, with the increase in scale of the power system, there are such effects as improvement in stability and reductions in fluctuations of voltage and frequency which are difficult to evaluate in monetary terms.

Further, as stated in (6), the degree of utilization of this interconnecting transmission line is heightened through the construction of New Paramonga Substation, which will, in turn, contribute greatly to the development of various industries and agriculture in the Paramonga area.

2.2 Recommendations

From the above conclusions, the team makes the following recommendations in regard to this Project.

(1) Since there will be a shortage in power supply capability in 1974, this interconnecting transmission line should be completed by the end of 1974 at the latest.

Through this transmission line, the shortage up to 1980 can be filled in great part by the surplus energy of Mantaro Power Station now under construction and scheduled to be put into operation in 1973 (First and Second Stages, 684 MW).

(2) For the effective operation of this interconnecting transmission line, New Paramonga Substation should be provided for interconnection with the Paramonga Power System.

(3) For execution of this Project, the Government of Peru should immediately make various preparations such as establishment of an agency for construction and making provisions for construction funds.

(4) A preparation work (concrete selection of transmission line route, surveying and determination of locations of steel towers) should be commenced in accordance with the schedule suggested in Fig. 6-1.

(5) After 1980, the annual expense of this interconnecting transmission line including depreciation of facilities cannot be covered with income from sale of the energy passing through this transmission line and there will be an accumulation of

deficits. However, as will be stated in Chapter 7, Economic Evaluation, there will be economic benefits such as savings in power generation facilities and consumption of surplus energy accompanying the interconnection, which are benefits to be obtained by the Republic of Peru as a whole, and it is considered that the amount corresponding to the deficit seen in the cash balance of Chapter 8, Funding Plan, should be shared by the Government of Peru and the beneficiaries, Mantaro Corporation and Santa Corporation if their financial conditions permit from revenues of Mantaro Power Station and Cañon del Pato Power Station or by the Government of Peru only as a subsidy.

CHAPTER 3.

LOAD FORECAST

CHAPTER 3. LOAD FORECAST

3.1 Areas Concerned

The areas which the load forecast covers may be divided into the Central Power System centered around Lima supplied by the Mantaro Project, the Santa Power System centered around Chimbote and the Paramonga Power System. These three power systems are at present individually structured with the peak load of 605 MW, 85 MW and 40 MW respectively as of 1970.

(1) Central Power System

The three major power systems of the Central Power System; Empresas Electricas Asociadas, Cerro de Pasco Corporation and Marcona Mining Company presently being operated independently will be operated as an interconnected power system through a 995 km long 220-kV transmission line, when the First Stage of the Mantaro Project, 342 MW in installed capacity, starts commercial operation.

The power generation facilities of this Central Power System as of 1970 consist of 600 MW hydro and 116.5 MW thermal or a total of 716.5 MW.

(2) Santa and Paramonga Power Systems

The Santa and Paramonga power systems located in the northern part of Peru are centered around Chimbote and cover the industrial area of the northern part of Peru, the industry comprising of the state-owned SOGESA steel mill, fish meal plants, sugar factories and paper mills. The power generation facilities of the Santa Power System for industry as of 1970 comprised only 100 MW in hydro.

As a note, the power generation facilities of the Paramonga Power System consist of 40 MW hydro and 21 MW thermal for a total of 61 MW.

3.1.1 Outline of Santa Power System

a) Chimbote Area

The Chimbote area comprises the largest industrial district northern part of Peru in which the largest steel mill of Peru, the state-owned steel mill, SOGESA (Sociedad Siderúrgica de Chimbote, S.A.), is located. The major loads of SOGESA are those of electric furnaces consisting of two 10-MW scrap furnaces and two 7.5-MW iron ore furnaces. (Production of reinforcing steel bar, etc. is 270,000 tons meeting the demand within Peru.) The maximum load of SOGESA is 63 MW, but there is much fluctuation because of the electric furnaces, there being a range of fluctuation of 15 - 30 MW causing the quality of electricity to be poor with much flickering of electric lights. The power factor is also very low being 75% on the secondary side of the Chimbote Sub-station transformer.

For improve of power factor, a rotary condensar (15 MVA) was installed in Chimbote Substation but it is under overhaul now.

The power demand other than at the steel mill amounts to 23 MW of which 19 MW are for fish meal plants and are almost completely stopped except in the fishing season.

The power demand of the Chimbote area described above depends greatly on Cañon del Pato Hydroelectric Power Station (100 MW) which in the past has been forced to stop operation repeatedly due to earthquakes and abnormal floods.

Also, although Cañon del Pato Power Station has 25 MW x 4 units, because of the high content of sand in the water, erosion of turbine runners and nozzles is severe and one unit is always under repair. Therefore, the dependable firm output should be considered as 75 MW. At present, a gas turbine plant (20 MW x 2 units) is being constructed at Chimbote Substation, which will be for peak hours and emergencies and is scheduled to be completed in 1971.

b) Trujillo Area

The Trujillo area comes under the Liberta Corporation and in this area sheet-metal works, galvanization works, vehicle parts factories and an automobile assembly plant are scheduled to be constructed soon. Besides these, a new city plan is being considered, and the future growth in power demand will be high at an annual average of 16.6% in industrial load sector. The peak load before the earthquake of May 1970 was 7,200 kW. The power supply to the Trujillo area is being carried out from Cañon del Pato Power Station through the 132 kV, 1-cct, Chimbote-Trujillo Interconnecting Transmission Line. At present, a 20 MW gas turbine is being installed at the industrial complex while it is scheduled for one circuit to be added by the end of 1972. Further, Viru Substation is located between Chimbote and Trujillo.

c) Santiago de Cao and Pacasmayo Areas

The total power demand in these two areas is slightly larger than the Trujillo areas. At present, there are cement and other plants, but all have their own private power generating facilities even supplying power to the city area. As a note, there is no interconnecting line between Santiago de Cao and Pacasmayo and each is of an independent power system.

3.1.2 Paramonga Power System

The power demand of the Paramonga area is almost entirely industrial. Of this load approximately 37.5 MW is consumed by electric boilers at sugar refineries.

At Pativilca, Barranca and Supe adjoining Paramonga, lighting demands are main and the maximum load is about 3 MW.

This area is flat with fertile farm land where there is active cultivation of sugar cane serving as raw materials for sugar refining and paper manufacturing. Power supply to the Paramonga area depends heavily on Cahua Hydroelectric Power Station (40 MW) 63 km east of Paramonga. Besides this, most of the sugar refineries and paper mills have their own power generating facilities.

Cahua Power Station is carrying out full generation at the installed capacity of 40 MW while load regulation is being performed at the consumer end through regulation of the electric boilers of sugar refineries.

3.2 Load Forecast

The load forecast in "Informe Preliminar sobre la Línea de Interconexión a 220 kV de Lima a Chimbote, Corman 1970" prepared by Comisión Mixta de Funcionarios de la O.P. del M.E.M., C.P.S y Corman in May 1970 and in "Report on the Feasibility of the El Chorro Hydroelectric Plant" by the J.G. White Engineering Corporation (U.S.A) and Piazza y Valdez Ingenieros S.A. (Peru) in June 1968 were reviewed and judged to be reasonable.

Therefore, these load forecasts were adopted for the reasons that the time allowed for investigation in Peru and for study and analysis perfomed in Japan was limited, in addition to shortage of basic information. The followings are the outline of the forecast and the results of the study made by the team.

Since the chief aim of the Lima-Chimbote Interconnecting Transmission Line is to supply power to the Santa and Paramonga power systems, the load forecast for the Central Power System was limited to confirmation of the supply capability to the Santa and Paramonga power systems after forecasting kW demand and examining the appropriateness of proposed power development plans.

3.2.1 Central Power System

The Central Power System covers 221,000 sq.km, approximately 17% of the total area of Peru, where 40% of the population of the country live, and 90% of industrual production and

70% of mine development are centered.

As shown in Table 3-1, the installed capacity of the Central Power System has shown an increase of 9.5% annually from 1960 to 1968 while electric energy production has grown 10% annually.

In forecasing future loads, the trend of power demand in the future should be estimated taking duly into account actual performances in the past of power demand and economic growth, while microscopically, it should be forecast by use or by industry.

In the load forecast for the Central Power System, the load was divided into the 4 major power systems and only the maximum power in the future was forecast.

(1) Gran Lima Power System (EE.EE.AA.)

The Gran Lima Power System, when adding Callao City, the political and economic center of Peru, serves a population of approximately 2.0×10^6. The concentration of population in the cities has become marked of recent, although not clear in number due to lack of census, but it is said the population increase at Lima has exceeded 3%.

In forecasting the load in the future, it was decided that the estimate would be made from the past trend (8.9%), but in consideration of the sharp increase in population a value of 9.5% was adopted as the annual growth rate.

(2) Cerro de Pasco Power System

Cerro de Pasco Power System is a system with the main purpose of supplying power for ore mining at copper mines and copper refining, but also supplies power to the neighboring communities. Considering the growth rate in power demand in the past and taking into account the future development plans of the copper mines, the future growth rate in power demand was taken to be 8.0%. However, when new copper refining facilities are constructed, the power demand will become greater still.

(3) Marcona Mining Co.

The Marcona Mining Co. Power System is a power system with the main purpose of supplying power for iron ore mining. The statistics on electric power in the past are not known clearly, but the maximum power load in 1968 was 40 MW. In 1973, when a planned expansion program is completed, the maximum power will reach 50 MW. For 1973 and thereafter, an annual growth rate of 8.0%, the same as considered for Cerro de Pasco Mines, was adopted. The growth rate in power demand from 1968 through 1980 will be 6.6%.

(4) CSE Power System (Comañia de Servicios Eléctricos)

The CSE Power System supplying power to the cities of Ica, Pisco and Chincha recorded an output of 8,900 kW in 1968. The statistics on electric power demand in the past are not clear, but at present, from the fact that power generation facilities are inadequate, it is thought there is a fair amount of potential demand. On one hand, there is a considerable amount of private power generating facilities in this area (the private power generating facilities in Ica Department in 1967 not including the facilites of Marcona Mining amounted to approximately 30 MW), and it is possible for 50% of these power loads to be supplied in the future from the Central Power System. Based on these considerations, the same value of power damand growth rate as taken for the Gran Lima Power System, 9.5%, was adopted.

Combining the growth rates of the four electric power systems described above, the average annual growth rate of the Central Power System up to 1980 will be 9.0%.

The growth rate in power demand described above, when reviewed macroscopically from the standpoint of the closely related economic growth rate will be as follows:

As shown in Fig. 3-1, taking the example of any country, the rate of growth in power demand is always greater than that of economic growth.

In other words,

$$\text{Electric Power Elasticity Value} = \left(\frac{\text{Demand Growth Rate}}{\text{Economic Growth Rate}}\right)$$

is always larger than 1.

If the economic growth rate * of the Central Power System area is taken to be 8% (with population growth rate of 3%, the real economic growth rate will be 5%), the power demand growth rate will be 13.5% at the upper limit and 9.0% at the lower limit. Parenthetically, the growth rate of 9.0% in the power demand of the Central Power System would be the minimum from the viewpoint of the economic growth rate.

According to the United Nations Statistical Yearbook, the growth rate between 1955 and 1965 was 11% (7.9% taking population increase into consideration). From the most recent trends of economic indices of Peru, it is certain that in 1970 there will have been a real growth of 5% or more in the economy. (Further, it is thought that the economic growth rate of the Central Power System area is higher than the national average)

*Economic Growth Rate of Peru

3.2.2 Santa Power System

The power systems which will be the objectives of the Lima-Chimbote Interconnecting Transmission Line are the Santa Power System and the Paramonga Power System.

There have been many load forecasts made for the Santa Power System and the results of studies of these are indicated below.

National Survey of 1957

The results of load forecast for the Santa River Basin made by a French consulting engineer in 1957 was a growth rate of a minimum 7%, maximum 12% and average of 10%.

Estimate of 1961

According to the report prepared by Rader and Associates (U.S.A.) made in 1971 for the construction of Cañon del Pato Power Station, it was forecast that the growth rate in power demand from 1961 to 1975 would be 10%.

Estimate of 1963

In 1963, the abovementioned Rader and Associates reviewed the power demand of the Santa Corporation, in which the growth rate from 1963 to 1976 was approximately 15%, far higher than the forecast in 1961.

Pancitos Report (1965)

A detailed load forecast for the supply area of the Santa Corporation, was made by The J.G. White Engineering Corporation (U.S.A.) and Piazza y Valdez Ingenieros S.A. (Peru) and according to their report the growth rate in power demand during the 20-year period from 1965 to 1985 was forecast at 7.1%.

The 20-MW gas turbines now being installed at Chimbote and Trujillo are a result of the load forecast in this report.

(1) Load Forecast

The power demand in the Santa Power System is overwhelmingly industrial demand as shown in Table 3-3 and Table 3-4. Namely, the industrial demand of SOGESA, the fish meal factory and the paper mill comprise 79% in 1970 and 72% in 1980. (The ratio of SOGESA is 52% in 1970 and 57% in 1980.)

As indicated in the above, in making a load forecast for the Santa Power System, the future development plans of major industrial consumers are absolutely needed, and in this sense, it is necessary to estimate the aggrigate power demand by the sector.

The team carried out investigations based on the previously mentioned Pancitos Report, and taking into consideration the expansion plans of SOGESA, the conclusions given in Table 3-3 and Table 3-4 were obtained. According to these, the growth rate in peak demand will be 10.1% while the growth rate in electric energy will be 13.3%. The annual load factors in 1970 and 1980 are 0.38 and 0.51 respectively.

Further, the power demand in 1974 of the Pacasmayo and Santiago de Cao areas will be approximately 30 MW of which 81% will be taken up by Papelera Trujillo S.A. and Cía de Cemento Pacasmayo S.A. These two consumers are securing their power supplies through their own private generating facilities, but it will be possible to take them into the Santa Power System in the future by construction of 132 kV, 90 km transmission line from Trujillo. However, considering the uncertainty of procurement of funds to carry out the transmission line work by 1974 and the construction period necessary, it was judged unrealistic to include these loads in the Santa Power System demand in 1974. On the other hand, it was considered that Pacasmayo and Santiago de Cao would be interconnected with the Santa Power System to become a part of the power demand in the latter in 1983 when a thermal power plant will be constructed in Chimbote district or the Lima-Chimbote Interconnecting Transmission Line will become a reliable double-circuit line.

3.2.3 Paramonga Power System

The power demand of the Paramonga Power System, as stated in 3.1.1 d) is almost entirely industrial. As a result of field investigations and based on the growth in power demand in the past, a growth rate of 6.5% was considered for the Pativilca-Barranca-Supe area.

On one hand, for other districts, considering the poor conditions in recent years of the fish meal industry, the growth rate in power demand as a whole was taken to be 5.9%.

Further, in regard to the annual load factor of the Paramonga Power System, since the load factor of industrial demand is high, it is 0.68 in 1970 and 0.60 in 1980.

On combining the Santa Power System and Paramonga Power System described above, the growth rate in power demand for these areas will be 9.5% with the growth rate in energy demand being 10.2%.

3.3 Power Demand and Supply Balance

In study of the balance of power demand and supply, studies were made for the Central Power System, Santa Power System and Paramonga Power System for the cases with and without the Lima-Chimbote Interconnecting Transmission Line.

3.3.1 Central Power System

The electric power development program of the Central Power System would be determined by the growth in power demand within the Central Power System regardless of whether or not an interconnecting transmission line is to be built. As a result of study, it was assumed that a thermal station of 150 MW proposed to be built in the Central Power System in 1983 has been moved to Chimbote with the purpose of improving the power flow of the interconnecting line.

As a result, the future development program of the Central Power System would be as shown in Table 3-5.

In other works, at the end of 1980, due to the growth in power demand, there will be a shortage in supply capability with the existing power development plans. Therefore, as supply capability to meet the shortage, it was assumed that EE.EE.AA. would build a thermal power plant of 150 MW x 5 units, while in 1984, a 300 MW facility would be added through the Mantaro Third Stage Project.

It is noted that through the Mantaro First and Second Stage projects, total 684 MW, going into operation in 1973, there would be produced surplus energy in the Central Power System until 1980. The power development program of the Central Power System in the case the Lima-Chimbote Interconnecting Transmission Line is not to be built is as shown in Table 3-6 and Fig. 3-2. (The difference point is that the 150 MW thermal to be provided would be constructed instead within the Central area.)

3.3.2 Santa and Paramonga Power Systems

The future power development plans in the case the Lima-Chimbote Interconnecting Transmission Line is completed is as shown in Table 3-7. In regard to the power development program of the Santa Power System indicated in Table 3-7, the feasibility report on the El Chorro Hydro-electric Plant prepared by the J. G. White Engineering Corporation (U.S.A.) was referred to.

Further, studies were made of the timing for construction of the Colcas Pondage or securing firm output at the existing Cañon del Pato Power Station and an upstream reservoir on the Rio Santa.

As for the case of the Santa and Paramonga power systems not being connected by the interconnecting Transmission Line and being structured as independent power systems, it was considered that electric power development would be carried out to correspond with the growth in power demand of each as shown in Table 3-8.

3.3.3 Demand and Supply Balance of Interconnected Power Systems

(1) *Demand and Supply Balance*

As indicated in Table 3-9 and Table 3-10, on the completion of the Lima-Chimbote Interconnecting Transmission Line, because of the ineffective output of the Central Power System and the diversity factor between the two power systems, the generating facilities of the Santa Power System are expected to be saved by 78,300 kW in 1974 and 123,300 kW in 1985 as compared to the case of it being an independent system. The demand and supply balance of the interconnected power systems is shown in Fig. 3-3.

Further, the dependable firm output suppliable from the Central Power System to the Santa and Paramonga power systems is shown in Table 3-11.

(2) Power flow of the Interconnecting Transmission Line

As shown in Fig. 3-4 and Fig. 3-5, the power supply capabilities of the Santa Paramonga power systems were allocated in the load duration curves by year based on the electric power development plan in the case the Interconnecting Transmission Line was completed, and the energy transmission and maximum power of the interconnecting line were calculated accordingly. The results are given in Table 3-12. Gas turbine, 60 MW, of the Santa area was considered as reserve capacity.

(3) Electric Power Development Plan of Santa Power System after Completion of the Interconnecting Transmission Line

As the dependable firm output of the Central Power System, the team adopted a figure of 90% not including the Marcona Power System (the figure was adopted in Informe Preliminar). However, in regard to dependable firm output, since this would govern the future power development program of the Santa Power System, it is necessary to confirm the dependable firm output of the Central Power System including the timing of development of Mantaro Third Stage and the construction of the thermal power station to be provided within the Central Power System.

Table 3-1 Installed Capacity and Energy Production in Central Electric Power System

Year	Installed Capacity (MW)	Energy Production (GWh)	Remarks
1960	513.6	1,731.3	
1961	-	1,919.2	Including installed
1962	567.2	2,085.7	capacity and energy
1963	-	2,438.6	production in
1964	660.6	2,629.6	Pativilca.
1965	837.1	2,823.5	
1966	928.5	3,125.7	
1967	969.5	3,398.0	
1968	1,049.4	3,671.0	
Increase (%)	9.5	10.0	

From "Informe Preliminar sobre la Línea de Interconexión a 220 kV de Lima a Chimbote, Corman 1970"

Table 3-2 Historical Peak Demand and Load Forecast

(1) Historical Load Demand — Unit = MW

Year	Gran Lima	Cerro de Pasco	Marcona Mining Co.	CSE	Total
1960	173.0	67.4			
1961	192.1	79.3			
1962	208.5	87.3			
1963	221.5	91.9	No available data		
1964	239.5	98.0			
1965	260.0	103.0		No available data	
1956	291.0	116.2			
1967	319.0	118.0			No available data
1968	338.0	124.0			
Increase (%)	8.9	8.0			

(2) Load Forecast up to 1980 — Unit = MW

Year	Gran Lima	Cerro de Pasco	Marcona Mining Co.	CSE	Total
1968	338.0	124.0	40.0	8.9	510.9
1969	370.1	133.9	42.0	9.7	555.7
1970	405.3	144.5	44.0	10.7	604.5
1971	443.8	156.1	46.0	11.7	657.6
1972	485.9	168.5	48.0	12.8	715.2
1973	532.1	181.9	50.0	14.0	778.0
1974	582.6	196.5	54.0	15.3	848.4
1975	637.9	212.2	58.3	16.8	925.2
1976	698.6	229.2	62.9	18.4	1,009.1
1977	764.9	247.5	68.0	20.1	1,100.5
1978	837.6	267.3	73.4	22.0	1,200.3
1979	917.2	288.7	79.3	24.1	1,309.3
1980	1,004.3	311.8	85.6	26.4	1,428.1
Increase (%)	9.5	8.0	6.6	9.5	9.0

From "Informe Preliminar sobre la Línea de Interconexión a 220 kV de Lima a Chimbote, Corman 1970"

Table 3-3 Load Forecast of Stanta System (Peak Demand in kW)

Unit: kW

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Increase (%)
1. Santa Power System Peak Demand												
(1) Trujillo Sub-station												
Trujillo City	10,400	11,600	14,400	16,000	18,100	20,100	22,000	24,200	26,600	29,300	32,200	12.0
Industry	-	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	5,500	6,000	16.6
Total	10,400	13,100	16,400	18,500	21,100	23,600	26,000	28,700	31,600	34,800	38,200	13.9
(Coincidence Factor)	(1.000)	(0.956)	(0.953)	(0.953)	(0.954)	(0.950)	(0.947)	(0.948)	(0.946)	(0.946)	(0.946)	(-)
Total Coincident	10,400	12,500	15,620	17,630	20,100	22,400	24,600	27,200	29,900	32,900	36,100	13.3
(2) Viru Sub-station												
Total Coincident	100	1,400	1,600	2,000	2,100	2,100	2,100	2,100	2,200	2,200	2,300	5.7
(3) Chimbote Sub-station												
SOGESA	44,000	57,000	57,000	57,000	57,000	77,900	98,000	105,400	112,800	120,200	127,600	11.2
ENSA	4,700	4,700	4,700	4,700	4,700	5,300	5,300	5,300	5,300	5,300	5,300	1.3
Fishing Industry	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	0
Chimbote City	4,700	5,700	6,900	8,200	9,700	11,300	13,300	15,300	17,500	19,900	22,500	17.0
Total	71,400	85,400	86,600	87,900	89,400	112,500	134,600	144,000	153,600	163,400	173,400	9.3
(Coincidence Factor)	(0.947)	(0.967)	(0.967)	(0.968)	(0.968)	(0.968)	(0.968)	(0.968)	(0.968)	(0.968)	(0.968)	(-)
Total Coincident	67,600	82,600	83,800	85,000	86,500	109,000	130,300	139,500	149,000	158,300	168,000	9.5
(4) Casma Sub-station												
Fishing Industry	-	-	-	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	0
Casma City	-	-	-	1,100	1,200	1,300	1,400	1,600	1,800	2,000	2,200	11.0
Total	-	-	-	2,500	2,600	2,700	2,800	3,000	3,200	3,400	3,600	5.4
(Coincidence Factor)	(-)	(-)	(-)	(0.900)	(0.900)	(0.900)	(0.900)	(0.900)	(0.900)	(0.900)	(0.900)	(-)
Total Coincident	-	-	-	2,250	2,300	2,430	2,520	2,700	2,880	3,060	3,240	5.4
(5) Huallanca Sub-station												
Mines	1,500	2,400	2,400	3,000	3,000	3,500	3,500	4,000	4,000	4,500	4,500	11.6
Huaylas Valley	2,000	2,000	2,400	2,400	2,500	2,800	2,900	3,000	3,100	3,200	3,300	5.2
Total	3,500	4,400	4,800	5,400	5,500	6,300	6,400	7,000	7,100	7,700	7,800	8.3
(Coincidence Factor)	(0.900)	(0.900)	(0.900)	(0.900)	(0.900)	(0.900)	(0.900)	(0.900)	(0.900)	(0.900)	(0.900)	(-)
Total Coincident	3,150	3,960	4,320	4,860	4,950	5,670	5,760	6,300	6,400	6,900	7,000	8.3
(6) Cañon del Pato Sub-station (including Huallanca, Huaylas Mato & Die districts)												
Total Coincident	800	800	800	900	900	900	900	900	900	900	900	1.2
Total Peak Demand												
at Sub-station End	82,100	101,300	106,100	112,600	116,900	142,500	166,200	178,700	191,300	204,300	217,500	10.1
(Coincidence Factor)	(0.970)	(0.970)	(0.970)	(0.970)	(0.970)	(0.970)	(0.970)	(0.970)	(0.970)	(0.970)	(0.970)	(-)
at Generating End	85,200	105,100	110,100	116,900	121,300	148,000	172,500	185,500	198,600	212,000	225,700	(10.1)
2. Paramonga Sub-station Total Coincident	35,300	36,800	38,300	40,400	43,300	45,900	48,600	51,900	55,700	59,200	62,500	5.9
Total Peak Demand (1+2)	120,500	141,900	148,400	157,300	164,600	193,900	221,100	237,400	254,300	271,200	288,200	9.1
(Coincidence Factor)	(0.950)	(0.950)	(0.950)	(0.950)	(0.950)	(0.950)	(0.950)	(0.950)	(0.950)	(0.950)	(0.950)	(-)
Total Coincident	114,500	134,800	141,000	149,400	156,400	184,200	210,000	225,500	241,600	257,600	273,600	(9.1)

From "Informe Preliminar sobre la Línea de Interconexión a 220 kV de Lima a Chimbote, Corman 1970"

Table 3-4 Load Forecast of Santa System (Energy Demand in MWh)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Increase (%)
1. Santa Power System Energy Demand												
(1) *Trujillo* Sub-station												
Trujillo City	44,900	46,300	58,000	64,700	74,800	83,400	92,500	102,200	112,500	124,500	137,300	11.7
Industry	-	3,000	4,800	7,600	8,600	9,900	11,300	12,800	14,300	15,800	17,300	19.2
Total	44,900	49,300	62,800	72,300	83,400	93,300	103,800	115,000	126,800	140,300	154,600	13.2
(Load Factor)	(0.493)	(0.450)	(0.460)	(0.468)	(0.473)	(0.476)	(0.481)	(0.483)	(0.485)	(0.487)	(0.489)	(-)
(2) Viru Sub-station												
Total	315	3,700	4,400	5,500	5.600	5,700	5,900	6,070	6,360	6,380	6,660	6.8
(Load Factor)	(0.370)	(0.302)	(0.314)	(0.314)	(0.304)	(0.310)	(0.321)	(0.330)	(0.330)	(0.331)	(0.331)	(-)
(3) Chimbote Sub-station												
SOGESA	130,000	243,000	249,000	250,000	252,000	345,000	415,000	479,900	513,900	548,100	581,600	16.1
ENSA	15,000	20,300	24,300	28,300	28,300	30,400	30,400	32,400	34,500	36,600	38,600	9.9
Fishing Industry	48,200	48,200	48,200	48,200	48,200	48,200	48,200	48,200	48,200	48,200	48,200	0
Chimbote City	17,800	21,300	25,500	29,800	34,900	40,400	46,300	52,500	59,400	67,100	75,600	15.5
Total	211,000	332,800	346,700	356,300	363,400	464,000	539,900	613,000	656,000	700,000	744,000	13.4
(Load Factor)	(0.358)	(0.460)	(0.473)	(0.478)	(0.480)	(0.486)	(0.472)	(0.503)	(0.504)	(0.505)	(0.506)	(-)
(4) Casma Sub-station												
Fishing Industry	-	-	-	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900	0
Casma City	-	-	-	2,820	3,000	3,500	3,770	4,700	5,350	6,150	6,970	9.5
Total	-	-	-	5,720	5,900	6,400	6,670	7,600	8,250	9,050	9,870	5.6
(Load Factor)	(-)	(-)	(-)	(0.291)	(0.293)	(0.301)	(0.303)	(0.322)	(0.328)	(0.338)	(0.348)	(-)
(5) Huallanca Sub-station												
Mines	8,750	13,550	14,250	16,800	17,000	19,650	19,800	22,150	22,300	24,350	24,600	9.4
Huaylas Valley	5,000	5,000	6,000	6,000	6,200	6,950	7,200	7,450	7,700	7,950	8,200	5.1
Total	13,750	18,550	20,250	22,800	23,200	26,600	27,000	29,600	30,000	32,300	32,800	9.1
(Load Factor)	(0.499)	(0.536)	(0.536)	(0.536)	(0.536)	(0.536)	(0.536)	(0.536)	(0.536)	(0.536)	(0.536)	(-)
(6) Cañon del Pato Sub-station												
Total	223	223	223	390	400	410	525	440	455	470	485	8.1
(Load Factor)	(0.466)	(0.476)	(0.486)	(0.496)	(0.509)	(0.521)	(0.540)	(0.569)	(0.578)	(0.598)	(0.616)	(-)
Total at Sub-station End	270,188	404,573	434,373	466,520	481,900	596,410	683,795	771,710	827,865	888,500	948,415	13.3
Transmission Loss (5%)	13,510	21,580	21,720	23,330	24,100	29,820	34,190	38,590	41,390	44,430	47,420	(-)
Total at Generating End	283,698	426,153	456,093	489,850	506,000	626,230	717,985	810,300	869,255	932,930	995,835	13.3
(Load Factor)	(0.380)	(0.463)	(0.473)	(0.478)	(0.476)	(0.483)	(0.475)	(0.499)	(0.500)	(0.503)	(0.505)	(-)
2. Paramonga Sub-station	209,700	219,000	225,600	235,000	246,300	259,800	273,400	286,000	297,600	312,000	325,600	4.5
(Load Factor)	(0.677)	(0.680)	(0.672)	(0.663)	(0.649)	(0.645)	(0.641)	(0.630)	(0.610)	(0.602)	(0.595)	(-)
3. Total Energy Demand (1+2)	466,400	602,000	638,300	678,200	704,100	826,400	923,000	1,019,100	1,084,100	1,156,100	1,226,600	10.2
(Load Factor)	(0.467)	(0.508)	(0.516)	(0.518)	(0.514)	(0.512)	(0.502)	(0.517)	(0.514)	(0.512)	(0.511)	(-)

From "Informe Preliminar sobre la Línea de Interconexión a 220 kV de Lima a Chimbote, Corman 1970"

Table 3-5 Generating Facilities in Central System

System	Name of Power Plants	Installed Capacity (kw)	Remarks
Gran Lima System	Callahuanca	67,750	Hydro
(EE. EE. AA)	Moyopampa	63,000	Hydro
	Huanpani	31,400	Hydro
	Huinco	258,400	Hydro
	Santa Rosa	11,000	Retire in 1981 (Steam)
	Santa Rosa	53,600	" " (Gas)
	Matsucana	120,000	Service in 1971
		600,000	Service in 1980 (Steam)
		1,205,150	
Mantaro System	Mantaro (1st stage)	342,000	Service in 1973
	" (2nd stage)	342,000	" 1977
	" (3rd stage)	300,000	" 1984
		984,000	
Cerro de Pasco System	La Oroya	5,000	Thermal
	La Oroya	9,000	Hydro
	Pachachaca	12,000	Hydro
	Yaupi	105,000	Hydro
	Malpaso	54,000	Hydro
		100,000	Service in 1981 (Thermal)
		285,000	
Mancona Mining System	Marcona	46,500	Diesel & Steam
		25,000	Service in 1972 (Thermal)
		71,500	
Central System		716,650	Existing
		1,979,000	Service in future
		2,545,650	

Table 3-6 Supply Balance of Central Power System (Before interconnection)

Year	Peak Demand (MW)	EE. EE. AA. Existing (MW)	EE. EE. AA. Construction (MW)	Cerro de Pasco (MW)	Marcona Mining (MW)	Mantaro (MW)	Total of Installed Capacity (MW)	Total of Dependable Firm Output (MW)
1968	510.9	486.8	0.0	185.0	46.5	-	718.3	649.6
1969	555.7	"	0.0	"	"	-	718.3	649.6
1970	604.5	"	0.0	"	"	-	718.3	649.6
1971	657.6	546.8	0.0	"	"	-	778.3	703.6
1972	715.2	606.8	0.0	"	71.5	-	863.3	782.6
1973	778.0	"	0.0	"	"	228.0	1,091.3	987.8
1974	848.4	"	0.0	"	"	342.0	1,205.3	1,091.5
1975	925.2	"	0.0	"	"	"	"	1,091.5
1976	1,009.1	"	0.0	"	"	"	"	1,091.5
1977	1,100.5	"	0.0	"	"	456.0	1,319.3	1.193.5
1978	1,200.3	"	0.0	"	"	570.0	1,433.3	1,296.5
1979	1,309.3	"	0.0	"	"	684.0	1,547.3	1,399.5
1980	1,428.1	"	150.0	"	"	"	1,697.3	1,534.5
1981	1,558.4	542.2	300.0	285.0	"	"	1,882.7	1,706.5
1982	1,701.7	"	450.0	"	"	"	2,032.7	1,841.5
1983	1,857.7	"	600.0	"	"	"	2,182.7	1,976.5
1984	2,027.0	"	"	"	"	984.0	2,482.7	2,246.5
1985	2,210.0	"	750.0	"	"	"	2,632.7	2,381.5

Note : Dependable firm output means a summation of the installed capacity of Marcona Mining System and the 90% of installed capacity in other system.

Table 3-7 Generating Facilities in Santa and Paramonaga Power System

System	Name of Power Plant	Installed Capacity (kW)	Remarks
Paramonga	Cahua	40,000	Existing (Hydro)
Santa	Cañon del Pato	100,000	Existing (Hydro)
	Gas Turbine	60,000	Service in 1971
	El Chorro	* 60,000	Service in 1978 (Hydro)
	Cañon del Pato	50,000	Service in 1981 (Hydro)
	New Thermal	150,000	Service in 1983
	El Chorro	* 60,000	Service in 1985 (Hydro)
Total		520,000	

Note; * Addition

Table 3-8 Santa and Paramonga Power System Development Scheme *(Independent)*

Year	Santa Power System							Paramonga Power System					System Total		
	Peak Demand	Power Source				Installed Capacity	7/ Dependable Firm Power	Peak Demand	Cahua	Gas Turbine	Installed Capacity	Dependable Firm Power	Peak Demand	Installed Capacity	Dependable Firm Power
		Gas Turbine	C.del Pato	El Charro	Hydro C-2										
	(kW)	(kW)	(kW)	(kW)	(kW)	(kW)	(kW)	(kW)	(kW)	(kW)	(kW)	(kW)	(kW)	(kW)	(kW)
1969	53,400		2/ 100,000			100,000	75,000	34,100	40,000		40,000		87,500	140,000	115,000
1970	85,200		100,000			100,000	75,000	35,300	40,000		40,000		120,500	140,000	115,000
1971	105,100	1/ 60,000	100,000			160,000	135,000	36,800	40,000		40,000		141,900	200,000	175,000
1972	110,100	60,000	100,000			160,000	135,000	38,300	40,000	5/ 20,000	60,000		148,400	220,000	195,000
1973	116,900	60,000	100,000			160,000	135,000	40,400	40,000	20,000	60,000		157,300	220,000	195,000
1974	121,300	60,000	100,000	60,000		220,000	195,000	43,300	40,000	20,000	60,000		164,600	280,000	255,000
1975	148,000	60,000	100,000	60,000		220,000	195,000	45,900	40,000	20,000	60,000	ditto	193,900	280,000	255,000
1976	172,500	60,000	100,000	60,000		220,000	195,000	48,600	40,000	20,000	60,000		221,100	280,000	225,000
1977	185,500	60,000	100,000	90,000		250,000	225,000	51,900	40,000	20,000	60,000		237,400	310,000	285,000
1978	198,600	60,000	3/ 150,000	90,000		300,000	250,000	55,700	40,000	40,000	80,000		254,300	380,000	330,000
1979	212,000	60,000	150,000	90,000		300,000	250,000	59,200	40,000	40,000	80,000		271,200	380,000	330,000
1980	225,700	60,000	150,000	90,000		300,000	250,000	62,500	40,000	40,000	80,000		288,200	380,000	330,000
1981	240,100	60,000	4/ 150,000	90,000		300,000	275,000	66,300	40,000	40,000	80,000		306,400	380,000	355,000
1982	254,500	60,000	150,000	90,000		300,000	275,000	70,200	40,000	60,000	100,000		324,700	400,000	375,000
1983	6/ 305,600	60,000	150,000	120,000	65,000	395,000	370,000	74,300	40,000	60,000	100,000		379,900	495,000	470,000
1984	326,800	60,000	150,000	120,000	65,000	395,000	370,000	78,800	40,000	60,000	100,000		405,600	495,000	470,000
1985	349,700	60,000	150,000	120,000	65,000	395,000	370,000	83,500	40,000	60,000	100,000		433,200	495,000	470,000

Note

1/ 20 MW x 2 units in Chimbote, 20 MW x 1 unit in Trujillo.

2/ Dependable firm output of Cañon del Pato Power Station is 75 MW up to 1977.

3/ Dependable firm output increases to 100 MW after construction of Colcas Pondage and additional installation of 2 units of 25 MW Turbine Generator.

4/ Dependable firm output of Cañon del Pato Power Station increases to 125 MW by construction of dam with water storage capacity of 86 x 10^6 m^3 at the upriver of Rio Santa in 1981

5/ Considering addition of 20 MW Gas Turbine for shortage of installed capacity in Paramonga Power System.

6/ Interconnecting Santiago de Cao and Pacasmayo Systems to Santa Power System at the end of 1983.

Table 3-9 *Demand & Supply Capability in the Interconnected System*

Year	Santa & Paramonga System			Central System (2)			Isolated System Total (1)+(2)			Interconnected system			Installed Capacity	
	Peak Demand (kW)	Installed Capacity (kW)	Dependable Firm Power (kW)	Peak Demand (kW)	Installed Capacity (kW)	Dependable Firm Power (kW)	Peak Demand (kW)	Installed Capacity (kW)	Dependable Firm Power (kW)	Peak Demand (kW)	Installed Capacity (kW)	Dependable Firm Power (kW)	Installed Capacity Saving by Interconnection (kW)	(%)
1969	87,500	140,000	115,000	555,700										
1970	120,500	140,000	115,000	604,500										
1971	141,900	200,000	175,000	657,600										
1972	148,400	220,000	195,000	715,200										
1973	157,300	220,000	195,000	778,000	1,091,300	987,800	935,300	1,309,600	1,182,800	911,000				
1974	164,600	280,000	255,000	848,400	1,205,300	1,091,500	1,013,000	1,483,600	1,346,500	997,000	1/ 1,405,300	2/ 1,266,500	78,300	5.27
1975	193,900	280,000	255,000	925,200	1,2053,00	1,091,500	1,119,100	1,483,600	1,346,500	1,099,000	1,405,300	1,266,500	78,300	5.27
1976	221,100	280,000	255,000	1,009,100	1,205,300	1,091,500	1,230,200	1,483,600	1,346,500	1,209,000	1,405,300	1,266,500	78,300	5.27
1977	237,400	310,000	285,000	1,100,500	1,319,300	1,193,500	1,337,900	1,627,600	1,478,500	1,315,000	1,519,300	1,368,500	108,300	6.66
1978	254,300	380,000	330,000	1,200,300	1,433,300	1,296,500	1,454,600	1,811,600	1,626,500	1,430,000	1,693,300	1,531,500	118,300	6.53
1979	271,200	380,000	330,000	1,309,300	1,547,300	1,399,500	1,580,500	1,925,600	1,729,500	1,554,000	1,807,300	1,634,500	118,300	6.15
1980	288,200	380,000	330,000	1,428,100	1,697,300	1,534,500	1,716,300	2,011,000	1,864,500	1,688,000	1,957,300	1,769,500	53,700	2.67
1981	306,400	380,000	355,000	1,55[illegible],400	1,882,700	1,706,500	1,864,800	2,261,000	2,061,500	1,835,000	2,192,700	1,966,500	68,300	3.02
1982	324,700	400,000	375,000	1,701,700	2,032,700	1,841,500	2,026,400	2,431,000	2,216,500	1,996,000	2,342,700	2,101,500	88,300	3.63
1983	379,900	495,000	470,000	1,857,700	2,182,700	1,976,500	2,237,600	2,676,000	2,446,500	2,170,000	2,492,700	2,236,500	183,300	6.85
1984	405,600	495,000	470,000	2,027,000	2,482,700	2,246,500	2,432,600	2,976,000	2,716,500	2,360,000	2,792,700	2,506,500	183,300	6.17
1985	433,200	495,000	470,000	2,210,000	2,632,700	2,381,500	2,643,200	3,126,000	2,851,500	2,564,000	3,002,700	2,701,500	123,300	4.15

Note: 1/ 2/ Brakedown of this figures is indicated in the Table 3-9

Table 3-10 Installed Capacity & Dependable Firm Power in the Interconnected System

		1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Installed Capacity	Santa & Paramonga System												
	Trujillo (Gas)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
	Chimbote (Gas)	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
	Cañon del Pato (Hydro)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	1/ 150.0	150.0	150.0	150.0	150.0
	El Chorro (Hydro)	-	-	-	-	60.0	60.0	60.0	60.0	60.0	60.0	60.0	2/ 120.0
	Hydro C-2												
	Thermal	-	-	-	-	-	-	-	-	-	3/ 150.0	150.0	150.0
	Cahua (Hydro)	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
	Paramonga (Gas)	0	0	0	0	0	0	0	0	0	0	0	0
	Sub-total	(200)	(200)	(200)	(200)	(260)	(260)	(260)	(310)	(310)	(460)	(460)	(520)
	Central System												
	EE. EE. AA (Small Hydro)	162.2	162.2	162.2	162.2	162.2	162.2	162.2	162.2	162.2	162.2	162.2	162.2
	" " " (Gas & Thermal)	64.6	64.6	64.6	64.6	64.6	64.6	214.6	300.0	450.0	450.0	450.0	600.0
	Huinco (Hydro)	260.0	260.0	260.0	260.0	260.0	260.0	260.0	260.0	260.0	260.0	260.0	260.0
	Matucana (Hydro)	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0
	Mantaro (Hydro)	342.0	342.0	342.0	456.0	570.0	684.0	684.0	684.0	684.0	984.0	984.0	984.0
	Cerro de Pasco (Hydro & Thermal)	185.0	185.0	185.0	185.0	185.0	185.0	185.0	185.0	285.0	285.0	285.0	285.0
	Marcona	71.5	71.5	71.5	71.5	71.5	71.5	71.5	71.5	71.5	71.5	71.5	71.5
	Sub-total	(1,205.3)	(1,205.3)	(1,205.3)	(1,319.3)	(1,433.3)	(1,547.3)	(1,697.3)	(1,882.7)	(2,032.7)	(2,032.7)	(2,332.7)	(2,482.7)
	Interconnected System Total	1,405.3	1,405.3	1,405.3	1,519.3	1,693.3	1,807.3	1,957.3	2,192.7	2,342.7	2,492.7	2,792.7	3,002.7
Dependable Firm Power	Santa & Paramonga System												
	Trujillo (Gas)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
	Chimbote (Gas)	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
	Cañon del Pato (Hydro)	75.0	75.0	75.0	75.0	75.0	75.0	75.0	1/ 100.0	100.0	100.0	100.0	100.0
	El Chorro (Hydro)					60.0	60.0	60.0	60.0	60.0	60.0	60.0	2/ 120.0
	Hydro C-2										135.0	135.0	135.0
	Thermal												
	Cahua (Hydro)	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
	Paramonga (Gas)	0.0	0	0	0	0	0	0	0	0	0	0	0
	Sub-total	(175.0)	(175.0)	(175.0)	(175.0)	(235.0)	(235.0)	(235.0)	(260.0)	(260.0)	(395.0)	(395.0)	(455.0)
	Central System												
	EE. EE. AA. (Small Hydro)	146.0	146.0	146.0	146.0	146.0	146.0	146.0	146.0	146.0	146.0	146.0	146.0
	" " " (Gas & Thermal)	58.0	58.0	58.0	58.0	58.0	58.0	193.0	270.0	405.0	405.0	405.0	540.0
	Huinco (Hydro)	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0	234.0
	Matucana (Hydro)	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0
	Mantaro (Hydro)	308.0	308.0	308.0	410.0	513.0	616.0	616.0	616.0	616.0	616.0	886.0	886.0
	Cerro de Pasco (Hydro & Thermal)	166.0	166.0	166.0	166.0	166.0	166.0	166.0	261.0	261.0	261.0	261.0	261.0
	Marcona	71.5	71.5	71.5	71.5	71.5	71.5	71.5	71.5	71.5	71.5	71.5	71.5
	Sub-total	(1,091.5)	(1,091.5)	(1,091.5)	(1,193.5)	(1,296.5)	(1,399.5)	(1,534.5)	(1,706.5)	(1,841.5)	(1,841.5)	(2,111.5)	(2,246.5)
	Interconnected System Total	1,266.5	1,266.5	1,266.5	1,368.5	1,531.5	1,634.5	1,769.5	1,966.5	2,101.5	2,236.5	2,506.5	2,701.5

Note 1/ Dependable firm output increases to 100 MW by the completion of Colcas Pondage and the additional installation of 2 units of 25 MW Turbine Generator
2/ Construction of dam with water storage capacity of 86 x 10^6 m^3 at the upriver of Rio Santa
3/ Construction of 150 MW Thermal Power Station at Chimbote instead of same station planned in Liwa

Table 3-11. Dependable Firm Output Suppliable to Santa and Paramonga Systems from Central Power System

Year	Dependable Firm(1) (MW)	Peak Demand(2) (MW)	Deference (1)-(2)=(3) (MW)	By Utility 1/ of Load Diversity(4) (MW)	Total (3)+(4) (MW)	Deficiency in Santa & Paramonga (MW)
1975	1,091.5	925.2	166.3	20.1	186.4	78.9
1976	1,091.5	1,009.1	82.4	21.2	103.6	106.1 2/
1977	1,193.5	1,100.5	93.0	22.9	115.9	122.4 3/
1978	1,296.5	1,200.3	86.5	24.6	111.1	79.3
1979	1,399.5	1,309.3	90.2	25.1	115.3	96.2
1980	1,534.5	1,428.1	106.4	28.1	134.5	113.2
1981	1,706.5	1,558.4	148.1	29.8	177.9	106.6
1982	1,841.5	1,701.7	139.8	30.4	170.2	127.0
1983 3/	1,841.5	1,857.7	2/ -16.2	67.6	51.4	47.6
1984	2,111.5	2,027.0	84.5	72.6	157.1	75.3
1985	2,246.5	2,210.0	36.5	78.2	114.7	48.5

Notes: 1/ There is a diversity factor of 1.03 between the Central Power System and the Santa and Paramonga power systems.

2/ Suppliable from the Santa Power System.

3/ It was considered that the 150 MW thermal to be constructed in the Central Power System would be built at Chimbote in order to improve the current of the interconnected transmission line.

Table 3-12 Receiving Peak Power and Energy from the Interconnecting Transmission Line in Santa and Paramonga Power System

Year	Paramonga Energy (MWh)	Paramonga Power (kW)	Santa Energy (MWh)	Santa Power (kW)	Total Energy (MWh)	Total Power (kW)
1975	1,000	5,900	91,200	73,000	92,200	78,900 1/
1976	2,500	8,600	169,700	97,500	172,200	106,100 1/
1977	5,100	11,900	212,500	110,500	217,600	122,400 1/
1978	9,500	15,700	29,900	63,600	39,400	79,300 1/
1979	14,500	19,200	48,800	77,000	63,300	96,200 1/
1980	22,600	22,500	70,100	90,700	92,700	113,200 1/
1981	32,500	26,500	44,900	80,100	77,400	106,600
1982	48,800	32,500	72,000	94,500	120,800	127,000
1983	65,500	37,000	1,000	10,600	66,500	47,600
1984	89,500	43,500	13,000	31,800	102,500	75,300
1985	115,000	48,500	0	0	115,000	48,500

Note 1/ Receiving energy from 1975 up to 1980 is supplied by surplus energy of Mantaro Power Station.

Fig. 3-1 Relation between Economic Growth Rate and Elasticity

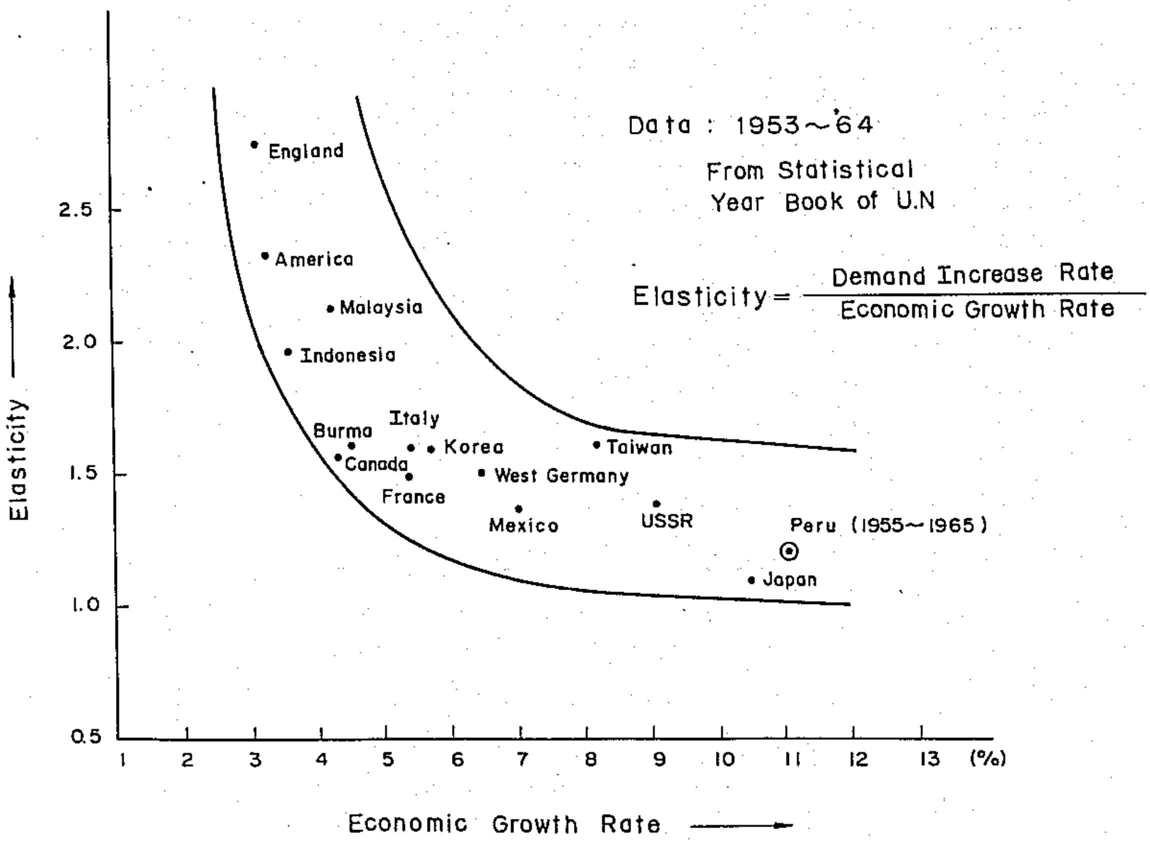


Fig. 3-2 Load Forecast of Central and Santa Power System (Independent)

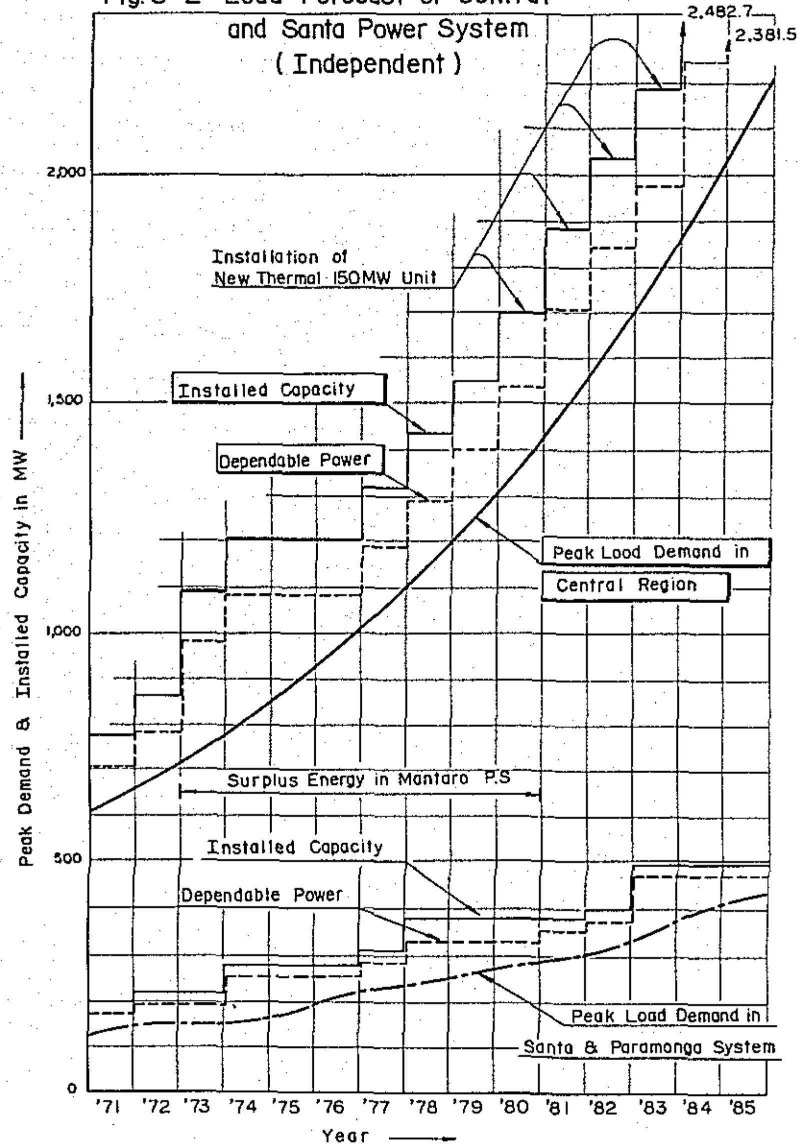


Fig.3-3 Interconnected Power System (Santa-Paramonga-Central Region)

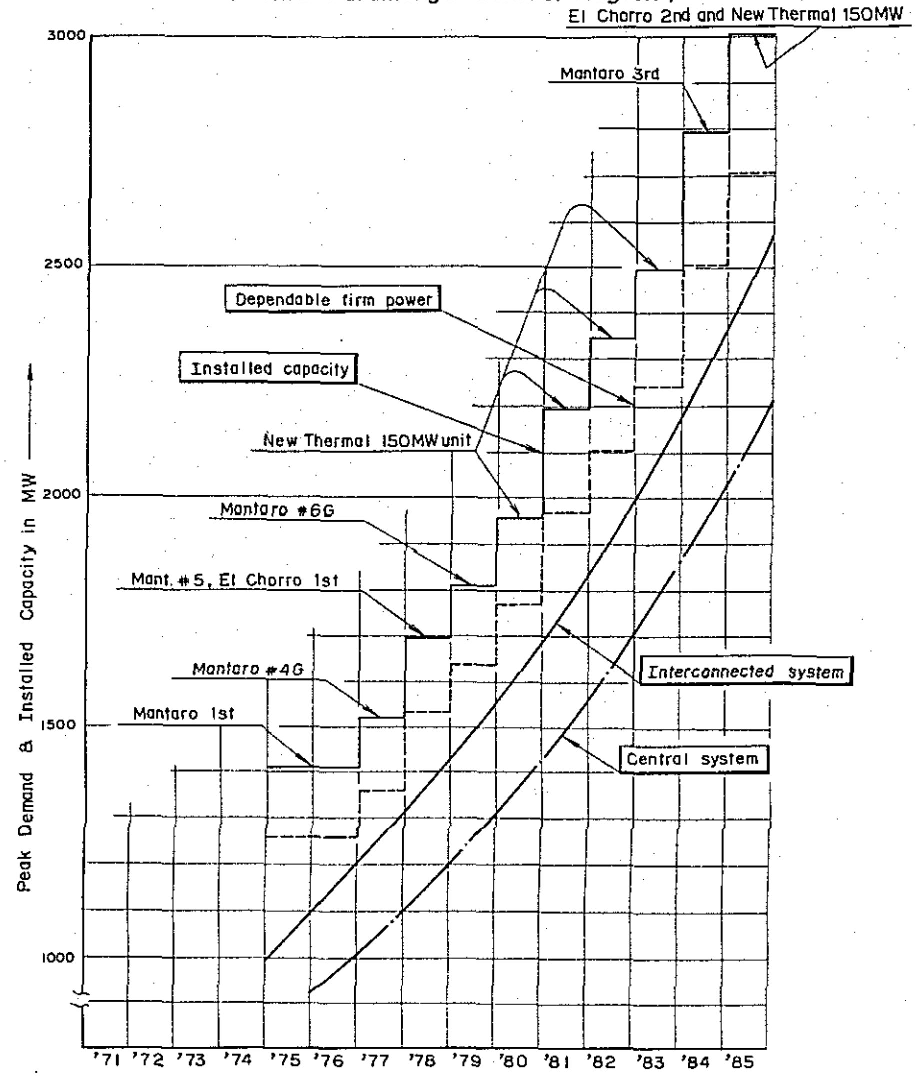
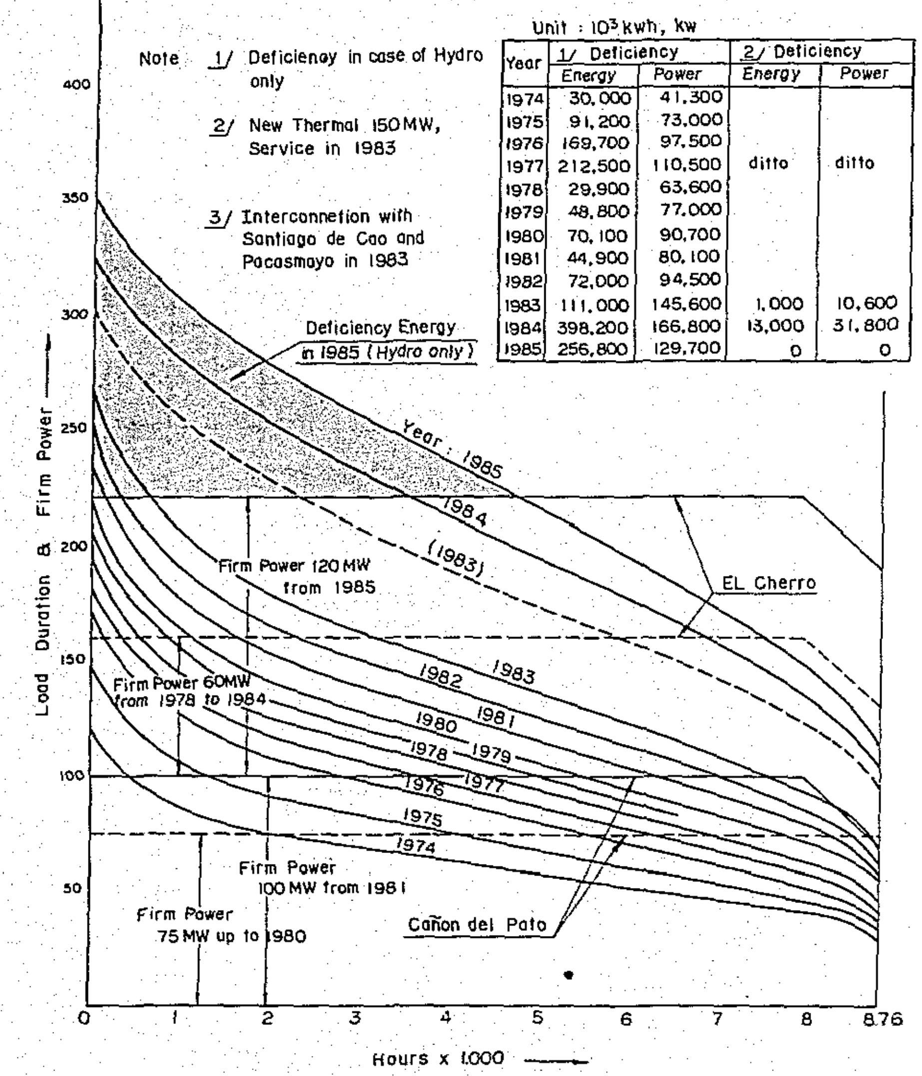


Fig.3-4 Load Duration Curve in Santa System



Note 1/ Deficiency in case of Hydro only

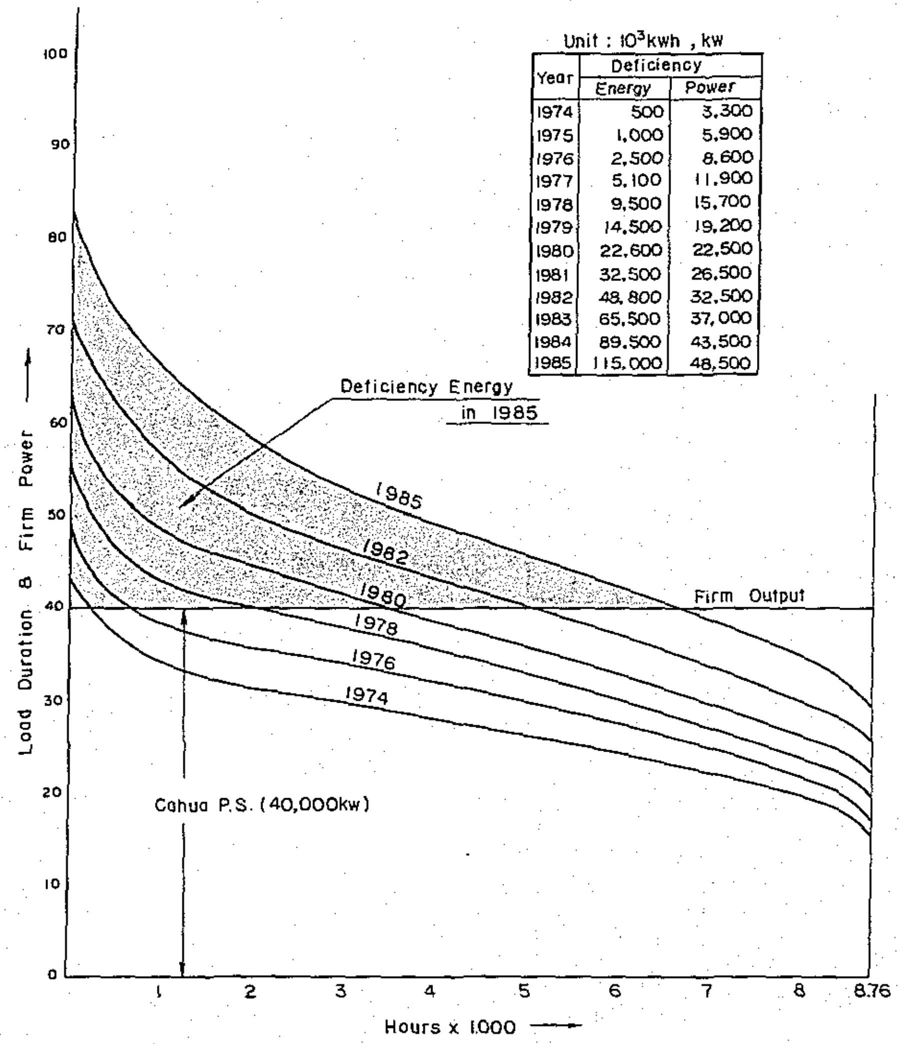
2/ New Thermal 150 MW, Service in 1983

3/ Interconnetion with Santiago de Cao and Pacasmayo in 1983

Unit : 10^3 kwh, kw

Year	1/ Deficiency		2/ Deficiency	
	Energy	Power	Energy	Power
1974	30,000	41,300		
1975	91,200	73,000		
1976	169,700	97,500		
1977	212,500	110,500	ditto	ditto
1978	29,900	63,600		
1979	48,800	77,000		
1980	70,100	90,700		
1981	44,900	80,100		
1982	72,000	94,500		
1983	111,000	145,600	1,000	10,600
1984	398,200	166,800	13,000	31,800
1985	256,800	129,700	0	0

Fig.3-5 Load Duration Curve in Paramonga System



Unit : 10^3 kwh , kw

Year	Deficiency	
	Energy	Power
1974	500	3,300
1975	1,000	5,900
1976	2,500	8,600
1977	5,100	11,900
1978	9,500	15,700
1979	14,500	19,200
1980	22,600	22,500
1981	32,500	26,500
1982	48,800	32,500
1983	65,500	37,000
1984	89,500	43,500
1985	115,000	48,500

CHAPTER 4.

OUTLINE OF INTERCONNECTING TRANSMISSION LINE

CHAPTER 4. OUTLINE OF INTERCONNECTING TRANSMISSION LINE

4.1 Outline of Project

4.1.1 Outline of Interconnecting Transmission Line

The Lima-Chimbote Interconnecting Transmission Line is designed for a transmission voltage of 220 kV, 330 mm^2 ACSR, double circuits design with one circuit to be initially installation. The time of start of operation is to be the end of 1974 for the first circuit and the end of 1983 for the second circuit, if a thermal power plant is not constructed in Chimbote district.

The point of interconnection of this transmission line on the Lima side is to be the San Juan Substation being constructed by the Mantaro Corporation, while that on the Chimbote side is to be the New Chimbote Substation to be newly constructed at a point approximately 10 km northeast of Chimbote City as desired by the Santa Corporation.

At Paramonga, roughly midway along the interconnecting transmission line, New Paramonga Substation is to be newly constructed and interconnection made with the Paramonga Power System by a T-branch.

Further, the 132 kV transmission line connected to as far as Trujillo is to be extended northward in 1983 for interconnection to Santiago de Cao and Pacasmayo.

4.1.2 Outlines of Substations

The terminal of the interconnecting transmission line on the Lima side is to be San Juan Substation capable of directly receiving the power generated at Mantaro Power Station.

The power receiving terminal on the Chimbote side is to be on the outskirts of Chimbote City since the existing Chimbote Substation is too small and there is fear of contamination.

The transformers to be installed at New Chimbote and New Paramonga substations are both to be autotransformers for voltages of 220 kV/132 kV with on-load tap changer. The capacities are to be 120 MVA at New Chimbote Substation and 50 MVA at New Paramonga Substation, and in 1983, when the second circuit is to be added to the interconnecting transmission line, an additional 120 MVA unit is to be installed at New Chimbote Substation.

4.1.3 Need for New Paramonga Substation

In "Informe preliminar," switchyard or substation is not considered on the Interconnecting Transmission Line for the line is intended to extend to Chimbote directly, but it is judged by EPDC for the three reasons given below that a substation (New Paramonga Substation) should be provided at Paramonga simultaneously with start of operation (1974).

(1) Cahua Power Station now supplying power to the Paramonga area is carrying out full-load operation at all times (2 generators). The load regulation of the system is being performed by electrode regulation (40 MW, constant) of an electric boiler at the consumer end, and by interconnection with the Interconnecting Transmission Line, it will become unnecessary for such troublesome regulation and the "quality" of the electricity would be improved.

(2) The demand growth in the Paramonga area (including Pativilca, Barranca and Supe) is high. The area with its favored geographical features has sugar refineries, fish meal plants, etc., and these plants are being supplied partly with private power generation, while it is expected that such plants will be increased even more in the future.

(3) The New Paramonga Substation should be provided in order to improve the economics of the Interconnecting Transmission Line.

Even if stoppage of one unit at Cahua Power Station is not considered, the load will increase from 1974 and power will need to be received from the interconnecting transmission line. The power flow between Lima and Paramonga will become heavy compared with the power flow between Paramonga and Chimbote, but this will increase the utilization factor of the Interconnecting Transmission Line to improve the economics Naturally, the utilization factor should be increased only within the limits that emergency power can be added at time of outage of a power source due to a disaster in the north.

The 220 kV, 2 circuits transmission line will not raise any question in this connection.

4.1.4 Outline of Telecommunication

The telecommunication facilities in this Project are to be provided for the purpose of smooth operation of the power system and will be composed of telephone channels for load dispatching, communication channels for line maintenance, and carrier relay channels for system protection. Load dispatching channels and carrier relay channels are required to have high reliability as they have a great effect on operation stability, and as the transmission method although either a microwave system or a power line carrier system is conceivable, it is decided to compose the channels by the power line carrier system which is the most economical.

As line maintenance telecommunication channels, since it is necessary to make conversation possible with the various substations from the field any where along the Interconnecting transmission line for liaison in transmission line maintenance work, the structure will be of UHF equipment and power line carrier equipment, while fault locaters will be installed for quick restoration of faults in the Interconnecting transmission line.

4.2 System Plan

In preparation of a transmission and transforming plan the level of reliability is an important factor. If this level were to be low, the capital investment will be reduced, but stable power transmission cannot be looked forward to. Conversely, if the level of reliability is made high, the investment will be increased. Therefore, the level of reliability must be determined taking into consideration the quality required of electricity and the amount of capital investment. In designing the Interconnecting Transmission Line, the following reliability level was established as criterion.

(1) Outage of Power Source

In outage of a power source, the largest-capacity unit within the object power system is normally considered, but in this case the largest power station in the Chimbote area, Cañon del Pato* was assumed to fall out due to earthquake disaster.

This power station will be of a scale of 25 MW x 4 units in 1974, but because of the high content of sand in the water, it was assumed that one unit would be under repairs of runner and nozzles at all times so that the outage in this case would be 25 MW x 3 units.

Further, in 1981, the installed capacity will become 25 MW x 6 units and the outage was considered to be 25 MW x 5 units = 125 MW.

In 1983, a thermal power station (150 MW) which is largest station in the northern Peru will be constructed, therefore the outage was considered to be 150 MW.

*Cañon del Pato Power Station has been forced to stop for long periods 3 times in the last 10 years. Therefore, it is thought it would not be unnatural to consider stoppage of the entire power station.

(2) Prevention of Power Stoppage

Needless to say, there are many harmful effects produced by a power stoppage and when this occurs on a large scale, danger of social unrest will be caused.

However, in order to completely obviate power stoppages, a considerable amount of capital investment would be necessary. In this Project the following measures are to be taken to cope with power stoppage.

a. With outage of a power source, the transformer of New Chimbote Substation would become overloaded and this is to be detected by an overload relay and the feeders supplying power to the furnace and other consumers from Chimbote Substation are to be restricted.

In other words, until there is no more overloading of the transfomer, load-restriction is to be performed. The transformer overloading will be roughly 15% in the initial year. (As a note, overloading of the transformer is permissible if for a short period of time.)

b. Simultaneously with detection of transformer overloading, gas turbines (Chimbote 20 MW x 2 units, Trujillo 20 MW x 1 unit, Santiago de Cao 20 MW x 1 unit, provided however that Santiago de Cao will be from 1983) will be started at full load.

c. With full load operation of gas turbines, the feeder circuits previously restricted will be successively brought back in.

d. The approximate values of power passing through the interconnecting transformer of New Chimbote Substation in the above order will undergo the changes indicated in Table 4-1. (Power factor of 85% and estimated transmission loss not taken into consideration)

e. Likewise, the approximate values of power passing the transmission line between New Paramonga Substation and San Juan Substation will vary as shown in Table 4-2. (Power factor of 85% and estimated transmission loss not taken into consideration)

Table 4-1. Power of New Chimbote Substation Transformer

Unit : MVA

Year	New Chimbote Transformer Installed Capacity (MVA)	New Chimbote Transformer Power: Firm (peak)	Instant of Cañon del Pato Outage	After Paralleling Gas Turbine	Remarks
1974	120	49.4	138.0	67.0	
1975	120	79.5	168.0	92.0	
1976	120	108.0	196.0	126.0*	*6 MVA load restriction required at transformer
1977	120	120.0	210.0	140.0*	*20 MVA load restriction required at transformer
1978	120	66.2	155.0	83.9	Operation of El Chorro 60 MW
1979	120	81.2	170.0	99.1	
1980	120	97.0	185.5	115.0	
1981	120	55.0	202.0	131.0	Cañon del Pato increased 75 MW → 125 MW
1982	120	72.8	220.0	149.0*	*29 MVA load restriction required at transformer
1983	240	164.0	311.0	168.0	Transmission line increased to 2 circuit
1984	240	191.0	337.0	244.0*	*4 MVA load restriction required at transformer

Each figure in the list are very severe condition for the Interconnecting Transmission Line and are valve in 1983 when the second circuit of the Interconnecting Transmission Line is installed

Table 4-2 Power on New Paramonga Station - San Juan Substation Transmission Line

Unit: MVA

Year	New Paramonga - San Juan Transmission Line Power			Remarks
	Firm (Peak)	Instant of Cañon del Pato Outage	Time of Paralleling Gas Turbine	
1974	54.1	143.0	71.8	
1975	110.0	198.0	128.0	
1976	118.0	206.0	136.0	6 MVA load restriction required due to transformer overloading, 136 → 130 MVA
1977	134.0	222.0	151.0	20 MVA load restriction required due to transformer overloading, 151 → 131 MVA
1978	84.7	173.0	102.0	Operation of El Chorro 60 MW
1979	104.0	192.0	121.0	
1980	135.0	224.0	153.0	
1981	86.0	233.0	162.0	Cañon del Pato increased 75 MW → 125 MW
1982	109.0	256.0	185.0	29 MVA load restriction required due to transformer overloading, 185 → 156 MVA
1983	205.0	352.0	258.0	Transmission line increased to 2 circuits
1984	236.0	383.0	290.0	4 MVA load restriction required due to transformer overloading, 290 → 286 MVA
1983*	31.2	226.0	122.0	In case of Operation of Chimbote Thermal 150 MW.
1984*	66.0	261.0	157.0	

*Outage of Chimbote Thermal Plant

(3) Selection of the Interconnecting Transmission Line Voltage

It is conceivable for the transmission line voltage to be either one of three, 132 kV, 220 kV and 380 kV, but in the 132 kV case the transmission capacity would be small (Surge Impedance Loading = 44 MW/cct) and it is obvious there will be a lack of capacity only a few years after construction.

With a 380 kV line the transmission capacity would be excessively large (Surge Impedance Capacity = 360 MW/cct) and the construction cost would be extremely high. However, in the case of the intermediate 220 kV proposal, the transmission capacity is of a suitable value (Surge Impedance Capacity = 120 MW/cct) and this voltage is therefore adopted with following reasons.

a. In considering the interconnection capacity requirement between Lima and Chimbote for about 10 years from 1974, there will be adequate transmission capacity with 220 kV, 1 circuit.

b. Since the existing power system for Huinco Power Station of EE.EE.AA. and the Mantaro Power system now under construction are to be operated at 220 kV, the same voltage should be adopted. Parenthetically, when interconnections with existing power systems are to be considered, there would be the merits that expensive interconnecting transformers and accessory switching facilities would become unnecessary, that the substation bus line would not have to be provided separately and that the site of the substation can be made small.

c. The voltage of 220 kV is at present the highest in Peru and is a voltage which is suitable for using as a part of the interconnecting lines of the entire Pacific Coast area of Peru in the future.

As a reference, the various patterns for 220 kV 132 kV and 380 kV lines are shown in Table 4-3 for comparison purpose.

(4) Stability of the Interconnecting Transmission Line

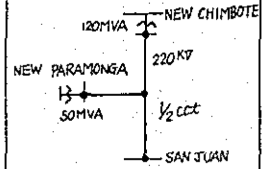
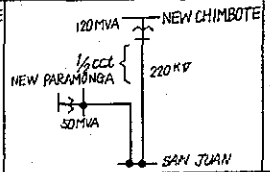
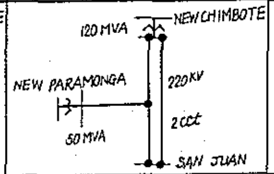
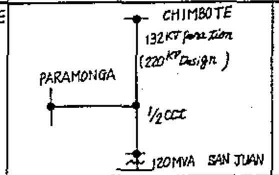
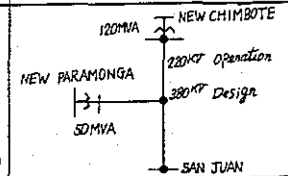
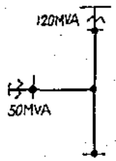
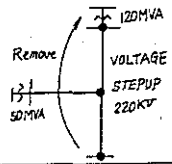
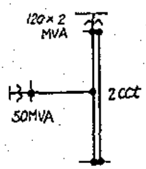
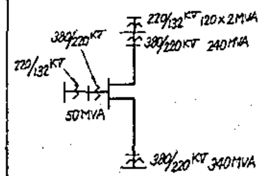
From the standpoint of stability, with 220 kV and a single circuit, 150 MW would be the limit. (see Appendix-2, Transient Stability)

(5) The Interconnecting Transmission Line Protection

With a long distance transmission line as in this Project, high speed, single-phase reclosure would be technically difficult and while single circuit operation is perfomed high speed reclosure will not be carried out. After the line has become double circuits, three phase reclosure will be performed.

The method of protection of the transmission line is to be a power line carrier transmission system.

Table 4-3 Comparisons of Patterns for the Interconnecting Transmission Line

Comparison Item		Pattern A 220 kV, 1 cct	Pattern B 220 kV	Pattern C 220 kV, 2 cct	Pattern D 132 kV Operation	Pattern E 380 kV, 1 cct
Year	1974					
	1979		Same as above	Same as above		Same as above
	1983		Same as Pattern A	Same as Pattern A	Same as Pattern A	
Current	Firm Current (1974 ~ 1984)	No problem (S.I.L = 2.5 x 220² = 120MW)	No problem	No problem	Transmission impossible at 132 kV (SIL = 2.5 x 132² = 44 MW)	No problem (SIL = 2.5 x 380² = 360 MW)
	Cañon del Pato Out	Some power source restriction in 1976, 1977, 1982	Same as left	No problem		No problem
Transmission Loss (I^2R only)		2.06 MW (1974)	Slightly less than Pattern	Slightly less than Pattern B	Maximum	Minimum
Construction Cost (Rough Estimate)		$15,000,000	$18,000,000	$21,000,000	$14,000,000	$25,000,000
Overall Judgement		Short power stoppage at outage of of power source.	System emphasized Paramonga. Short power stoppage at outage of power similar to Pattern A.	High reliability level not permitting power stoppage for one instant.	Power transmission impossible even at normal times.	Extremely costly compared to 220-kV patterns and not advantageous.

(6) Number of Circuits of the Interconnecting Transmission Line

From the results of the above studies, up to 1982 when outage of a power source should occur, the transmission line power flow could be held to within 130 MW by a small amount of countermeasures so that a single circuit would be adequate.

In 1983, because of increases in loads, the case of the said thermal power plant is not constructed in Chimbote area, the second circuit should be added in 1983. Though the thermal power station would be constucted in Chimbote, this line will become an important transmission line between central part of Peru and northern part of Peru in near future. Therefore, from the standpoint of reliability, it was judged that the Interconnecting Transmission Line should be planned with two circuit design.

(7) New Chimbote Substation Interconnecting Transformer Capacity

The capacity of the transformer would be adequate at 120 MVA until 1982, but after that it will be insufficient if the thermal power plan will not be installed in Chimbote district.

In other words, additional installation of transformers must be simultaneous to additional installation of second circuit of the line.

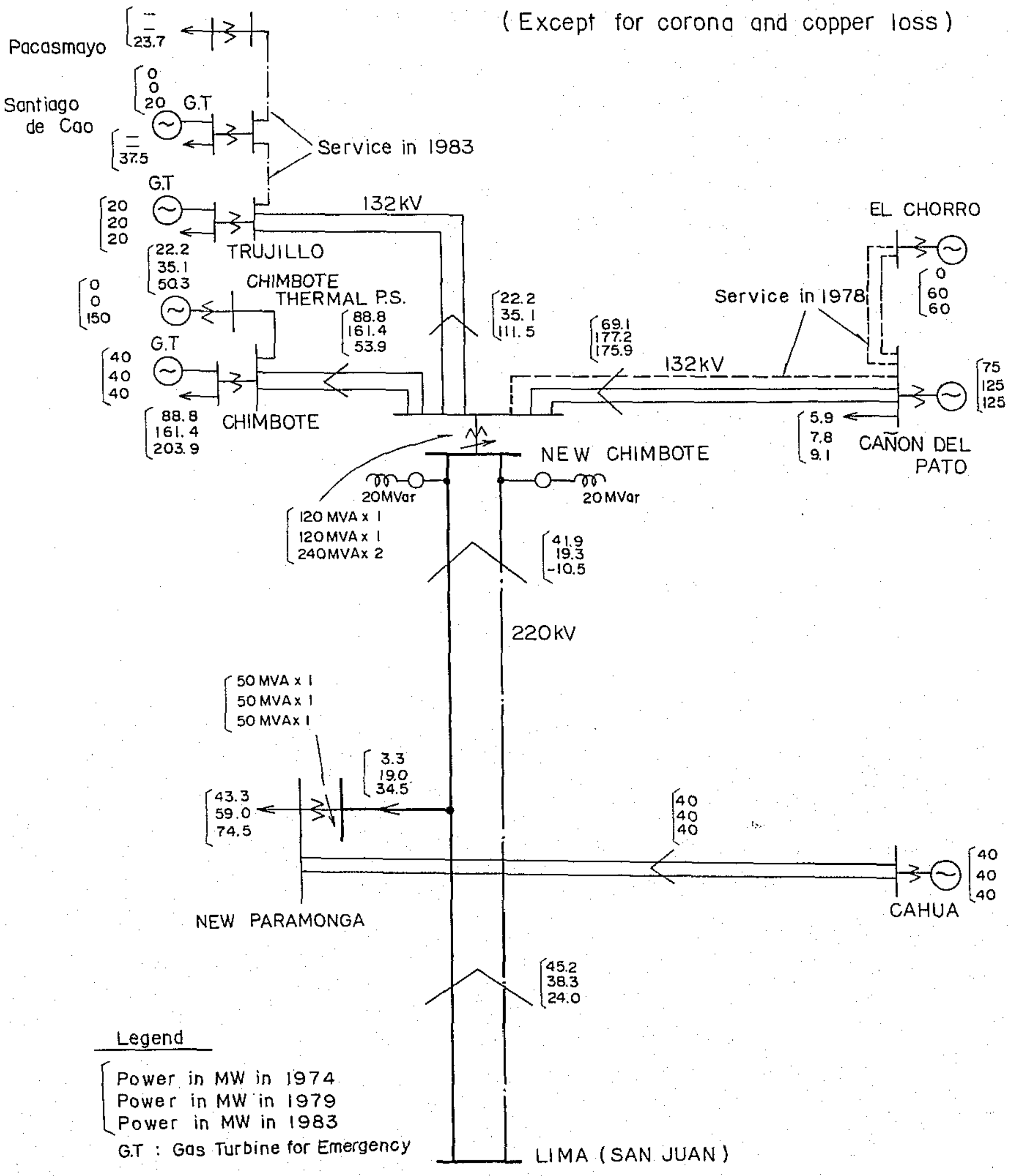
The various problems in regard to voltage regulation should be referred to in Appendix-1, "Voltage Regulation."

(8) New Paramong Substation Interconnecting Transformer Capacity

When considering stoppage of one of the generating units of Cahua Power Station there will be some overloading (10% or less) in 1982 and 1983, but a 50 MVA transformer would be adequate.

Fig. 4-1 Peak Power Flow of Santa System Related with Chimbote Transmission Line

(Except for corona and copper loss)



CHAPTER 5.

PRELIMINARY DESIGN

CHAPTER 5. PRELIMINARY DESIGN

5.1 Preliminary Design of Transmission Line

5.1.1 Outline of Facilities

The transmission line of this Project would be as listed below.

(1) 220 kV Transmission Line

Section:	San Juan Substation (Lima) to New Chimbote Substation (Chimbote)
Length:	425 km
Voltage:	220 kV
Electric Supply System:	3 phase, 3 wire, 60 Hz
Number of Circuits:	1 circuit initially (2 circuit design)
Conductor:	330 mm^2 ACSR (corrosion proof)
Overhead Ground Wire:	None
Insulator:	254 mm dia., fog-type, 21 discs per string
Supports:	Steel tower (atmospheric corrosion resisting rolled steel)
Grounding System	Neutral point direct grounding system

(2) 132 kV Transmission Line

	Paramonga Area	Chimbote Area
Section:	New Paramonga to Paramonga Substation	New Chimbote Substation Callahuanca - Chimbote Line
Length :	5 km	3.5 km x 2 routes
Voltage:	132 kV	132 kV
Electric Supply System:	3 phase, 3 wire, 60 Hz	3 phase, 3 wire, 60 Hz
Number of Circuits:	1	2
Conductor:	120 mm^2 ACSR, (corrosion proof)	120 mm^2 ACSR, (corrosion proof)
Overhead Ground Wire:	None	None
Insulator:	254 mm, fog-type, 13 discs per string	254 mm, fog-type, 13 discs per string

Support:	*1 circuit type steel tower*	*2 circuit type steel tower*
Grounding System:	Neutral point direct grounding system	Neutral point direct grounding system

5.1.2 Design Conditions

(1) Transmission Line Route

The transmission line of this Project starts from San Juan Substation located at the southeastern part of Lima and passes through the Costa Region between the Pacific Coast line and the Andes Mountain Range to a newly planned substation at the city of Chimbote where is industrial center of the Northern Peru.

The route of the Interconnecting Transmission Line near Anchon - Chancay, Paramonga - Huarmey and Huarmey - Casma passes through mountainous areas which close in on the coast, but generally runs across a flat desert land and elevation in less than 600 m. In the capital area, in order to avoid areas which are becoming urbanized, a detour route is taken as a result of which a number of relatively high ridges would need to be crossed.

In this area, there are winds blowing in constantly from the ocean and soil is a salinous sandy soil so that in order to alleviate salt pollution the route should be selected to pass inland while to make construction and maintenance easy the route should pass over comparatively flat areas.

Although it is unavoidable for inductive interference to be produced in telecommunication lines neighboring extra-high voltage transmission line, when such interference is expected, the telecommunication facilities should be reviewed in detail and necessary protective equipment should be taken.

The geology is generally that of marine volvanic deposits of the Cretaceous Period and sand-gravel widely distributed, while towards the Andes Mountain Range, the rocks are igneous rocks such as granite and diorite.

Bearing strength of soil is stable. Partially, there are rocksalt strata.

The route of the Interconnecting Transmission Line is indicated in an annexed map Fig. 5-1.

(2) Meteorological Conditions

The meteorological data studied of the project area were for the past 10-year period. The temperature shows a tendency to be slightly higher the farther north, the maximum is 35°C and the minimum 5°C.

Regarding wind direction, it is indicated that southerly and southwesterly winds are most frequent although there are a few northeasterly and northwesterly winds. The mean wind velocity is 4 - 6 m/sec and maximum wind velocity 15 - 16 m/sec.

There is extremely little precipitation, the average precipitation being 30 mm. The precipitation is slightly greater in the winter during which period it is estimated there is much misty rainfall not appearing in precipitation records. This condition is exceedingly unfavorable in connection with corona phenomena. There are hardly lightning phenomena in the surroundings of the route and no observation data of lightning is available.

From the foregoing, the meteorological conditions in design are taken to be the following:

Temperature:	Maximum : 40°C Mean: 20°C Minimum: 0°C
Wind Pressure:	Wind pressure equivalent to wind velocity of 25 m/sec
IKL:	Zero

5.1.3 Preliminary Design

(1) Insulation

The elevation of the route is taken to be 1,000 m or lower with IKL being zero. The maximum voltage of the system was taken to be 240 kV and insulation design was carried out considering switching surge voltages for a direct grounding system and commercial frequency abnormal voltages.

The number of insulators to be strung is determined from the design for salt pollution and dust troubles and to be 21 discs. The standard insulating distance and minimum insulating distance are to be 1,800 mm and 1,300 mm respectively. These are equivalent or more than No. 170 insulation level.

Salt pollution design was carried out for equivalent salt deposity of 1.0 mg/sq. cm based on the conditions in the field and measurement results of sample insulators. In this case, from the salt pollution design voltage of 165 kV and withstanding voltage per unit unsulator of 7.9 kV, it is suitable to adopt a 21 discs insulator string.

Regarding salt pollution, further investigations should be made to assure perfection in salt pollution design.

(2) Conductor

The rated current corresponding to a transmission capacity of 150 MW is approximately 470 A. Conductors having such a current capacity would be 120 mm^2 ACSR or larger, and for this transmission line, corona phenomena were taken into account and 330 mm^3 ACSR was selected. In the case of a 330 mm^2 ACSR transmission line at 220 kV, the potential gradient of the conductor surface is approximately 16 kV/cm which is a suitable figure.

Using 330 mm^2 ACSR as demanded by consideration of corona phenomena was compared in economically with using 410 mm^2 ACSR which increase construction cost but decrease line loss, and even as the result of comparisons, it is adequate to use 330 mm^2 ACSR.

From the corrosion conditions of the environment of the route, the conductor should be corrosion-proof type ACSR. By use of this type, it can be expected that adequate corrosion resistance of the conductor can be secured in an economical manner.

In design of conductor installation, it is necessary to use every day stress (EDS) of the conductor as a basis. Here, considering the mechanical fatigue of the conductor, the EDS is held to 18% and the maximum working tension is 2,600 kg.

For vibration-proof design, dampers are to be fastened at points of support of the conductor.

(3) Supports

This Interconnecting Transmission Line is to be a single-circuit line initially (1974), but is required to be a double-circuit line in the near future (1983).

For this reason, the three alternatives below were compared, as a result of which only double-circuit type supports were decided to be designed.

a) A single-circuit line to be constructed initially with an additional separate route single-circuit line to be provided in the future.

b) A double-circuit design from the beginning with a single-circuit installation initially and an additional circuit to be installed in the future.

c) A double circuit to be provided from the beginning.

Upon trial calculations of construction costs, and taking into account the investment difference in comparison of the above alternatives, if the time at which a double circuit facility would be required is about 10 years after initially starting operation of the installation, Case b) would be of advantage. In the case of this Project, since it is assumed that the time at which two circuits will become necessary is 1983 and the initial investment will not be excessive, double circuit steel towers with a single circuits installation irritially should be adopted.

Regarding the type of support, steel towers and concrete poles were compared. In the case of concrete poles, it is not mechanically suitable for two circuits of 220 kV class transmission lines to be installed so that they can be used only for Case a). For this reason, it would be possible to adopt concrete poles for a single circuit plan. In the case of this Project, investment efficiency can be raised by the two circuit design one circuit installation plan, so that comprehensively, steel tower supports are of advantage. Adoption of steel towers would not only be of advantage economically, but also would provide greater mechanical reliability.

In regard to the spacing of conductors, earthing distance at points of support at steel towers and distance between conductors at mid-points of spans were studied. As a result, for standard steel tower, the horizontal spacing between lines was decided to be more than 7.8 m and the vertical spacing 6.0 m.

For standard spans, a length of 400 m would be suitable. To improve corrosion resistance, atomospheric corrosion resisting rolled steel is to be used for members of steel towers.

Atomospheric corrosion resisting rolled steel, through action of the ingredient alloy elements, is caused to form an oxidized membrane at the surface which allows progress of corrosion to be stopped effectively, and thereby possesses 2 - 4 times the corrosion reistance of ordinary steel.

The standard steel tower is indicated in an attached drawing Fig. 5-10.

5.2 Preliminary Design of Substations

5.2.1 Outline of Facilities

The substation facilities of this Project would be as listed below.

(1) San Juan Substation

220 kV transmission line outgoing equipment	1 circuit
Circuit breaker, 240 kV, 5 GVA	1 unit
Disconnecting switch, 240 kV	3 units

(2) New Chimbote Substation

220 kV transmission line incoming equipment (including shunt reactor)	1 circuit
Main transformer	1 bank
132 kV transmission line outgoing equipment	4 circuits
132 kV bus-tie equipment	1 circuit
Main transformer, 220 kV/132 ± 13.2 kV/66 kV, 120 MVA auto-transformer	1 unit
Shunt reactor, 240 kV, 20 MVA	1 unit
Circuit breaker, 240 kV, 5 GVA	3 units
Circuit breaker, 144 kV, 2.5 GVA	6 units
Disconnecting switch, 240 kV	4 units
Disconnecting switch, 144 kV	16 units
Area required	30,000 m^2

(3) Chimbote Substation

13.8 kV phase modifier (static condeser)	1 bank
Static condenser, 13.8 kV, 35 Mvar	1 bank
Circuit breaker, 14.4 kV	1 unit
Disconnecting switch, 14.4 kV	1 unit

(4) New Paramonga Substation

Main transformer	1 bank
Main transformer, 220 kV/ 132 ± 13.2 kV/22 kV, 50 MVA, auto transformer	1 unit
Circuit breaker, 240 kV, 5 GVA	1 unit
Disconnecting switch, 240 kV	1 unit
Disconnecting switch, 144 kV	1 unit
Area required	6,000 m^2

(5) Paramonga Substation

132 kV transmission line outgoing equipment	1 circuit
Circuit breaker, 144 kV, 2.5 GVA	1 unit
Disconnecting switch, 144 kV	3 units

The details are as shown in the annexed drawings.

5.2.2 Locations and Environments of Substations

(1) Lima Side Outgoing Point

As the Lima side outgoing point of this Interconnecting Transmission Line, either San Juan Substation of the Mantaro Corporation or Chavarria Substation of EE.EE.AA. is conceivable, but from the fact that the power produced at Mantaro Power Station can be directly received, while the time of construction of the 220 kV ring system around Lima planned by EE.EE.AA. is not known for certain at present, San Juan Substation of the Mantaro Corporation has been selected.

(2) Chimbote Side Side incoming Point

To serve as the incoming point on the Chimbote side of the Interconnecting Transmission Line, the existing 132 kV Chimbote Substation is not suitable as it is located in the compounds of the state-owned steel mill, SOGESA, and order to provide a 220 kV substation it would be necessary to remove and relocate existing distribution lines, while it is difficult to secure adequate land for the purpose. Also, besides salt pollution from the sea wind blowing in from Chimbote Bay, there is risk of smoke and dust trouble from the steel mill. Further, from the standpoint of aseismatic design, it is desirable for the site to have sound ground. For this Project, since there is the expressed wish of the Santa Corporation, New Chimbote Substation is to be constructed at a new site at the foot of Mt. Tambo approximately 10 km northeast of Chimbote City.

(3) Interconnection Point with Paramonga System

Regarding the interconnection point with the existing Paramonga System, in order to protect the transmission and substation facilities of this Project from salt pollution and to keep away the transmission line route from passing through cultivated land, the route will be made to pass approximately 5 km inland from the present Paramonga Substation with an interconnecting substation newly provided directly under the Interconnecting Transmission Line and connecting with the existing Paramonga substation by a 132 kV transmission line.

5.2.3 Composition of Substation

(1) New Chimbote Substation

a. Land Required for Substation

The ultimate scale of this substation is considered to be as follows:

220 kV transmission line	4 circuits
Main transformer	2 banks
132 kV transmission line	7 circuits
132 kV bus tie	1 circuit

Further, as the site of the new substation is on a slope, in order to lessen the quantity of earth-moving for leveling, two-steps leveling was considered.

b. Main Transformer

The capacity of the main transformer, as a result of load forecast and in consideration of standardization of unit capacities, is to be 120 MVA equipped with on-load tap changer.

The winding of the main transformer, since both the 220 kV side and the 132 kV side will be connected to the direct grounding system, was selected to be of economical auto transformer while the tertiary winding, in consideration of a 66 kV transmission line to Casma in the future, was made to be a delta connection. Also, in comparison of transformer banks of the same capacities, the case of one 3 phase unit and that of 3 single phase units were considered: the price of the 3 phase unit would be approximately 80% that of the single phase units while the weight would be lighter so that the quantity of foundation work would be less. Studied from the aspect of reliability, the newer transformers have extremely low rates of trouble, and considered together with the fact that there will be no lightning damage, there is little necessity for a stand-by transformer so that a 3 phase unit will be of more advantage.

c. Transmission Line Outgoing Facilities

The Interconnecting Transmission Line will initially be single circuit, but on the 132 kV side, from the standpoint of reliability of the power system, it is considered that the existing system will be led in by π-connection and 4 circuits outgoing facilities will be provided.

Further, as a future plan, it was considered that besides addition of one circuit of the Interconnecting Transmission Line, there would be construction of 220 kV, Northern Interconnecting Transmission Line, 2 circuits, a 132 kV transmission line to Cañon del Pato Power Station, 1 circuit, and a transmission line to Trujillo Substation, 2 circuits.

d. Main Bus System

As New Chimbote Substation would be a vital substation for the power system after interconnection between Lima and Chimbote, a double bus system which is advantageous in inspection of equipment, convenience of system operation and prevention of complete stoppage during fault of bus was adopted. But since the transmission line will be single circuit for the moment, the 220kV side bus was considered for single bus connection which can change to double bus easily, the 132 kV side bus was similarly made a double-bus type with a bus tie circuit breaker installed for convenience of operation.

e. Insulation Design and Salt Pollution Design

It was considered that the insulation design of the substation main bus would conform to that of the transmission line. Insulation level of substation facilities was specified to satisfy insulation level No. 170 (BIL 900 kV) assuming 220 kV direct grounding with any abnormal voltage of the system is to be protected by lightning arrestors and line entrance protection gap.

Regarding the salt-pollution design of equipment, unlike the case of the transmission line, there is an economical limit to over-insulation of equipment, while on the other hand, in the case of a substation, maintenance administration is relatively more easy than in the case of a transmission line, it was considered that periodical washing would be carried out with a hot line washer as a measure against salt pollution.

f. Main Substation Building

In order to accomodate the control circuit of the substation switches, control board, protective equipment for main transformer and transmission line, a main substation building will be built.

(2) New Paramonga Substation

a. Land Required for Substation

The ultimate scale of the substation is considered to be as follows, and the area of land necessary for this scale is to be secured.

220 kV transmission line	2 circuits
Main transformer	1 bank
132 kV transmission	1 circuit

b. Main Transformer

From the results of load forecast, the capacity was decided to be 50 MVA with on load tap changer. The structure of the transformer was taken to be that of a 3 phase unit with auto transformer as in the case of New Chimbote Substation.

c. Others

The main bus system was decided to be one in which switching could be made from either circuit by T-branch when the second circuit is additionally strung in the future. Insulation design and salt pollution design were donsidered to be of the same designs as for New Chimbote Substation.

(3) San Juan Substation and Paramonga Substation

For the San Juan Substation 220 kV transmission line outgoing facility and the Paramonga Substation 132 kV transmission line outgoing facility, the design conditions of the beforementioned New Chimbote Substation were followed, besides which, since each has existing facilities, such matters as arrangement of main equipment were considered to follow the arrangements of existing equipment.

5.3 Preliminary Design of Telecommunications Facilities

5.3.1 The outline of telecommunication facilities to be installed in this Project are as indicated below.

Equipment	Spec.	San Juan SS	New Paramonga SS	Paramonga SS	New Chimbote SS	Chimbote SS
Power line carrier equipment	3ch.35dBm	1	2		1	
Power line carrier equipment	1ch.27dBm		1	1	1	1
Blocking equipment		1			1	
Carrier protective relay equipment	40dBm	1	3	1	3	2
Fault locator equipment	C-Type	1			1	
Fixed station VHF	10 W	2	1		2	
Base station VHF	10 V	1	1		1	
Vehicle-mounted VHF	5 W	3				
Portable VHF	0.5 W	4				

Further, it is necessary to provide blocking equipment at San Juan Substation and New Chimbote Substation in order to avoid frequency interference with existing power line carrier channels. Since this interconnecting transmission line is of a very long-distance, New Paramonga Substation will have an extremely important station as a repeating point for the composition of telecommunication channels. Therefore, in case that New Paramonga Substation is not provided, (it is necessary to built a repeater station at this site for the purpose of comprising carrier protective relay circuit and power line carrier telephone channels.)

5.3.2 Circuit Composition

The telecommunication channels required for load dispatching as well as security and maintenance of the Interconnecting Transmission Line are to be provided as described below.

(1) Load Dispatching Telephone Channels

Load dispatching commands to New Chimbote Substation and New Paramonga Substation are considered to be issued from San Juan Substation, and load dispatching telephone channel are to be provided for each section by the power line carrier equipment.

Further, since the existing 2 circuit 132 kV transmission line between Chimbote Substation and Cañon del Pato Power Station will be taken into New Chimbote Substation as a π-branch, a existing power line carrier telephone equipment at Chimbote Substation is to be removed to New Chimbote Substation to establish telephone channels between New Chimbote Substation and Cañon del Pato Power Station, while between Chimbote Substation and New Chimbote Substation, new power line carrier telephone channel will be provided.

The power line carrier telephone equipment to be installed in the Project is as follows.

San Juan Substation - New Chimbote Substation
3 ch. 35 dBm, 1 system

New Paramonga Substation - New Chimbote Substation
2 ch. 35 dBm, 1 system

New Paramonga Substation - Paramonga Substation
1 ch. 27 dBm, 1 system

New Chimbote Substation - Chimbote Substation
1 ch. 27 dBm, 1 system

(2) Power Line Carrier Protective Relay

Power line carrier protective relay is to be installed at the sections of San Juan Substation - New Paramonga Subsation - New Chimbote Substation, New Paramonga Substation - Paramonga Substation and New Chimbote Substation - Chimbote Substation. Further, for San Juan Substation - New Paramonga Substation - New Chimbote Substation, a 3 terminal relay will be provided, but since San Juan Substation - New Chimbote Substation is a long-distance sector, carrier protective relay circuit between both two substations will be composed by re-transmitting the signal for carrier relay at New Paramonga Substation.

The existing carrier relay equipment to Cañon del Pato Power Station at Chimbote Substation will be relocated in New Chimbote Substation.

(3) Line Maintenance VHF Channels

In order to make possible to call a maintenance personnel along the Interconnecting Transmission Line from San Juan Substation and New Chimbote Substation, VHF base stations are to be provided at three places, and between these VHF base station and San Juan Substation, New Paramonga Substation and New Chimbote Substation, fixed VHF channels will be provided respectively.

Further, calling from San Juan Substation will be made possible by interconnecting to the VHF base station near New Paramonga Substation through the power line carrier telephone channel.

(4) Fault Locator

For the sake of speedy restoration of transmission line faults, fault locator equipment are to be installed at San Juan Substation and New Chimbote Substation.

Fig.5-1 Transmission Line Route Map

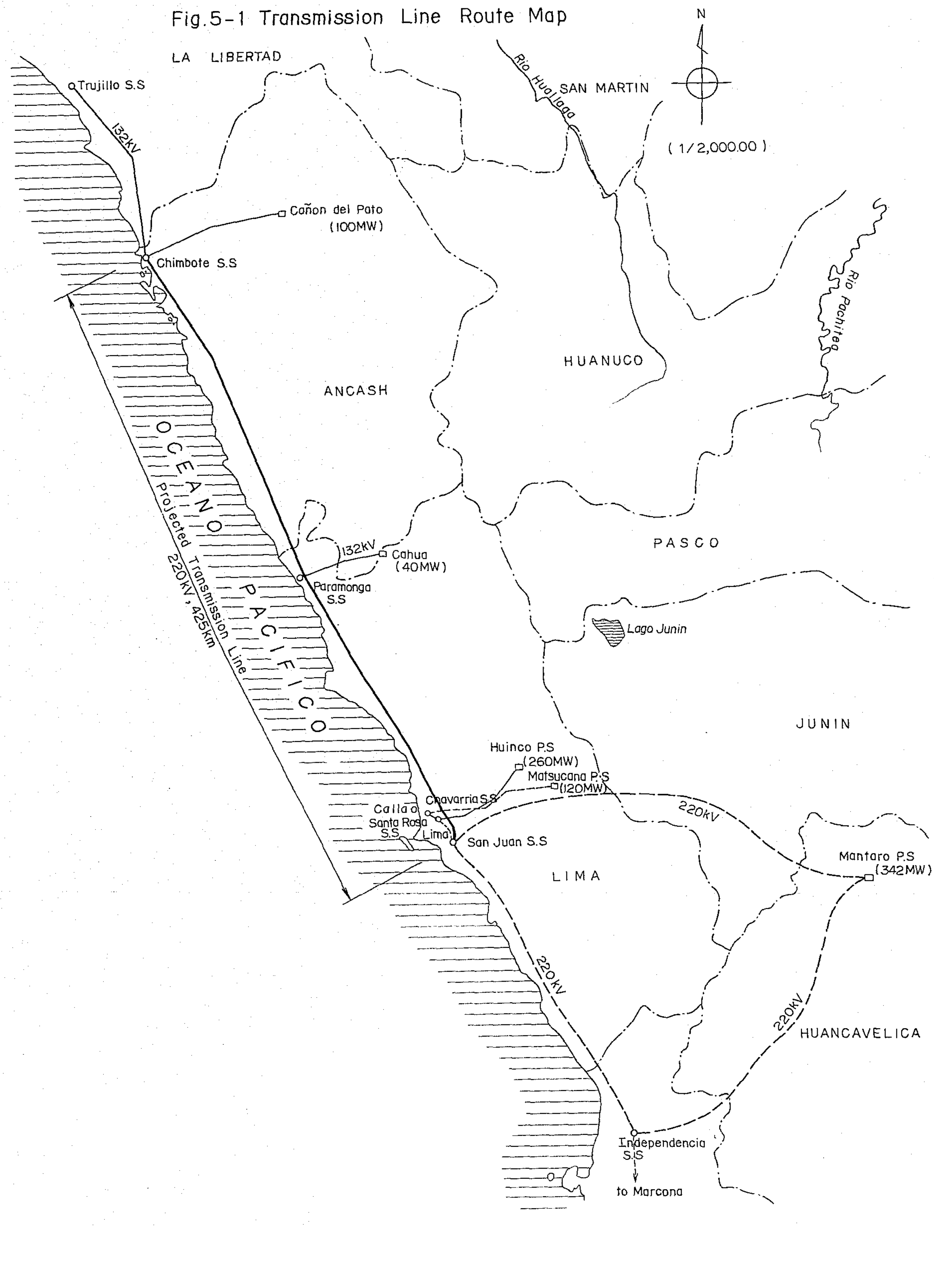


Fig. 5-2 SAN JUAN s/s

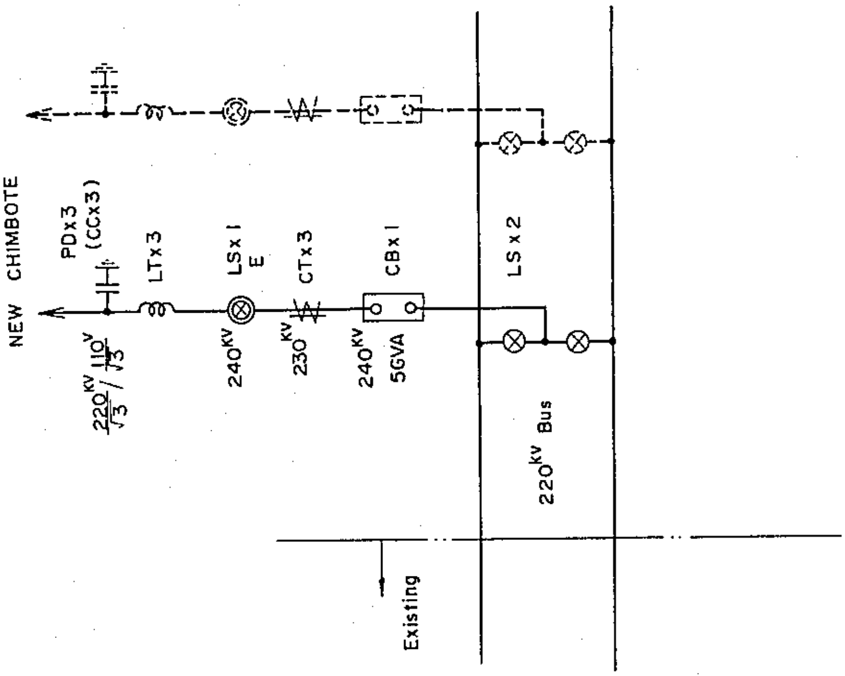


Fig. 5-3 NEW CHIMBOTE S/S

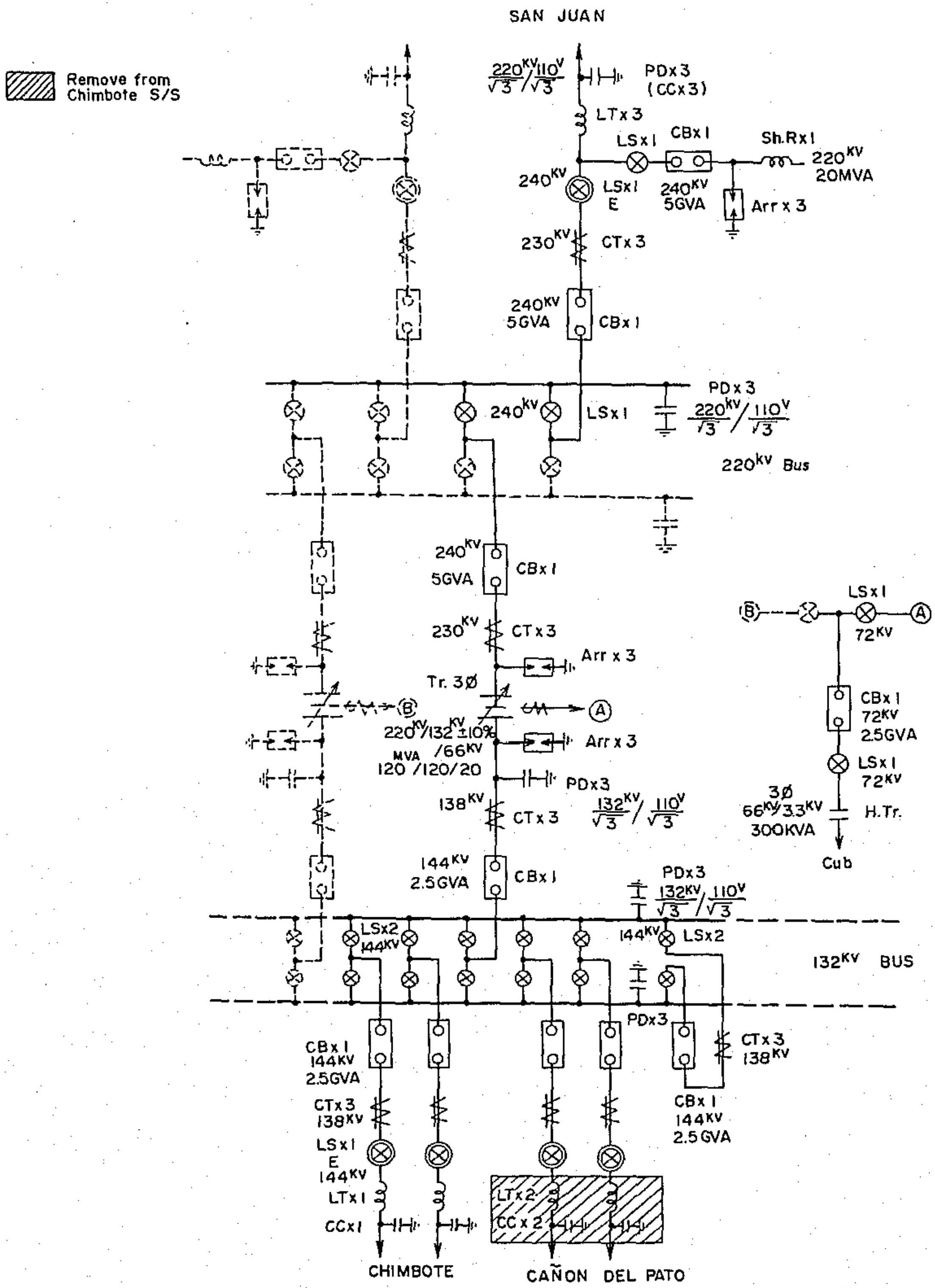


Fig. 5-4 One Line Diagram

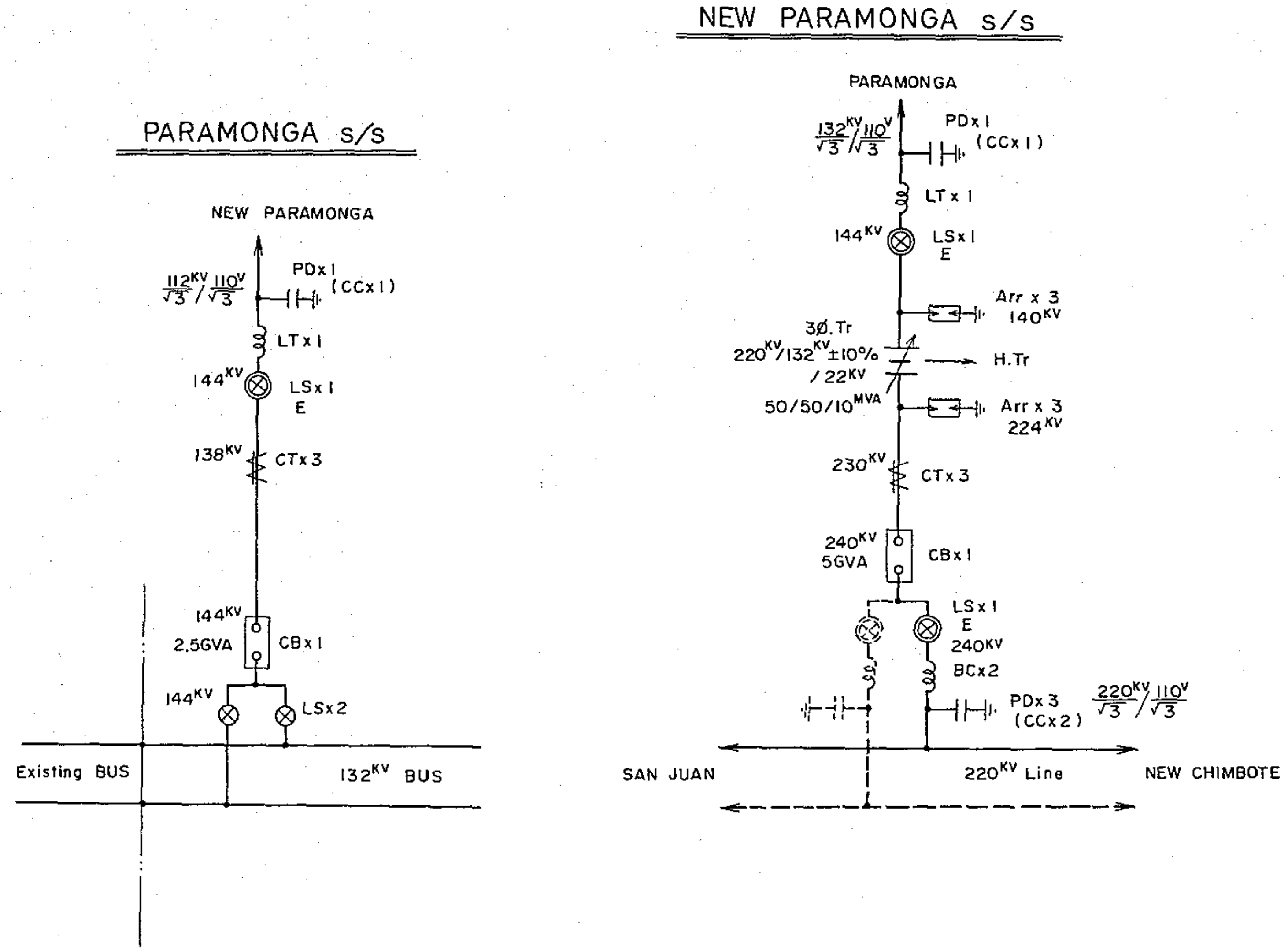


Fig. 5-5 SAN JUAN s/s (1/500)

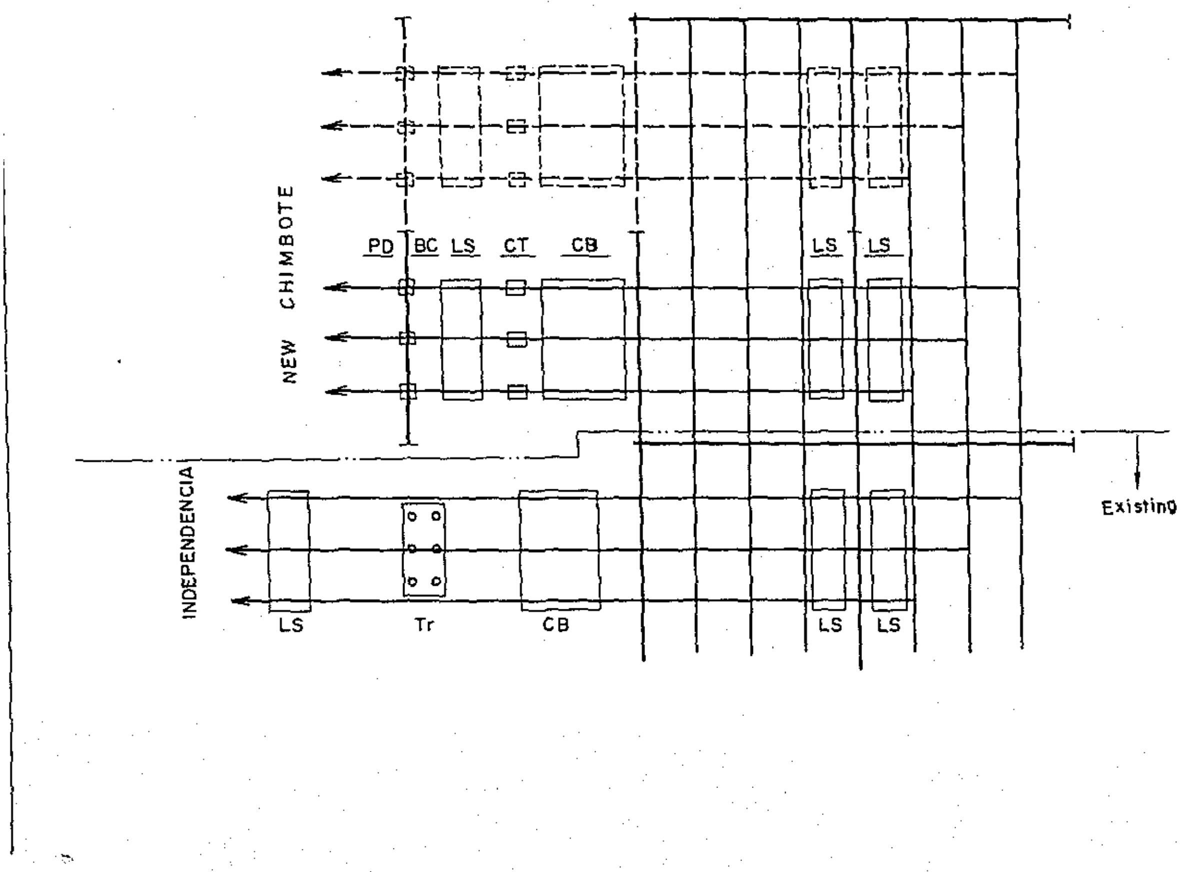


Fig.5-6 NEW CHIMBOTE s/s (1/1000)

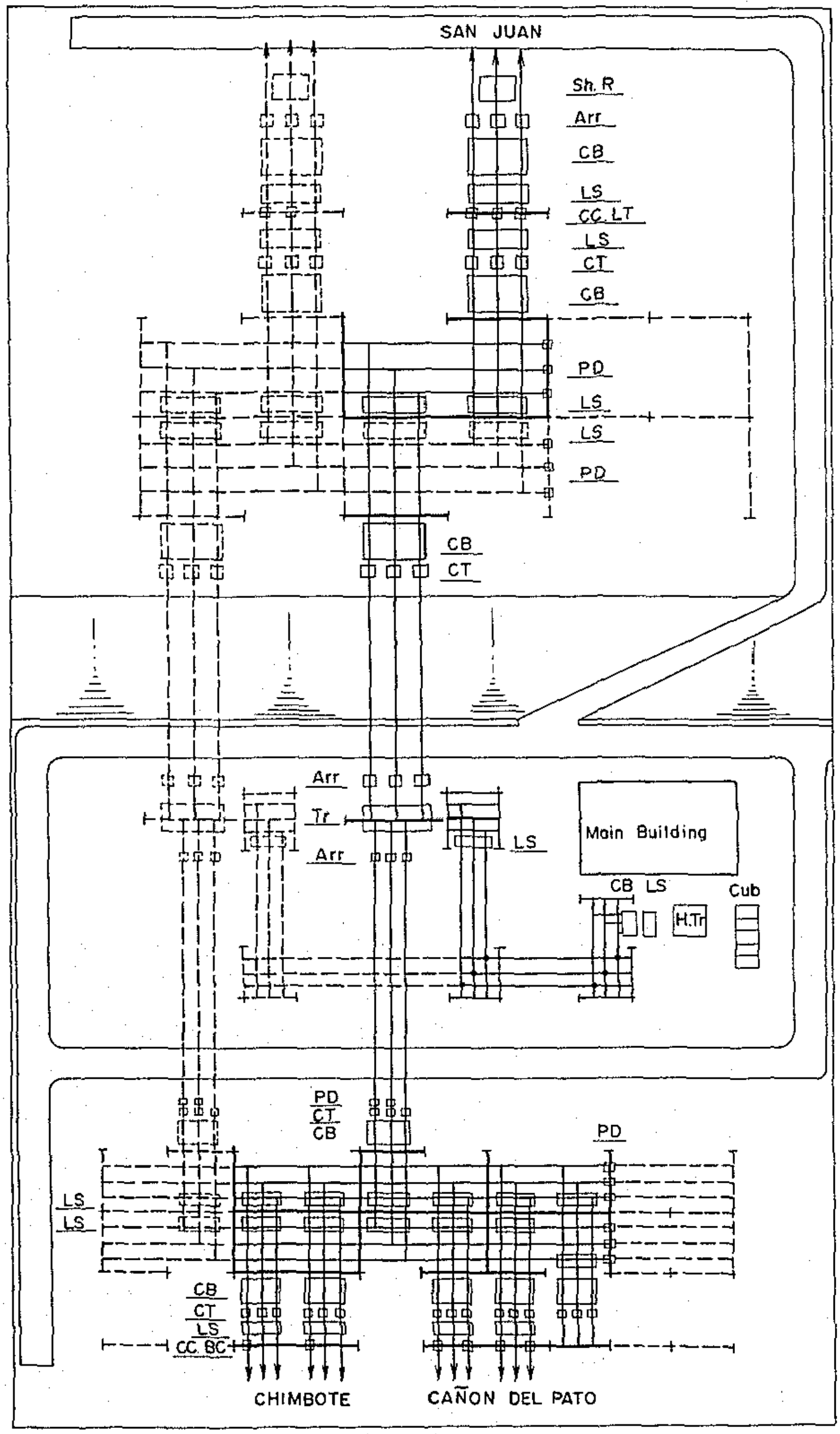


Fig. 5-7 NEW PARAMONGA s/s (1/1000)

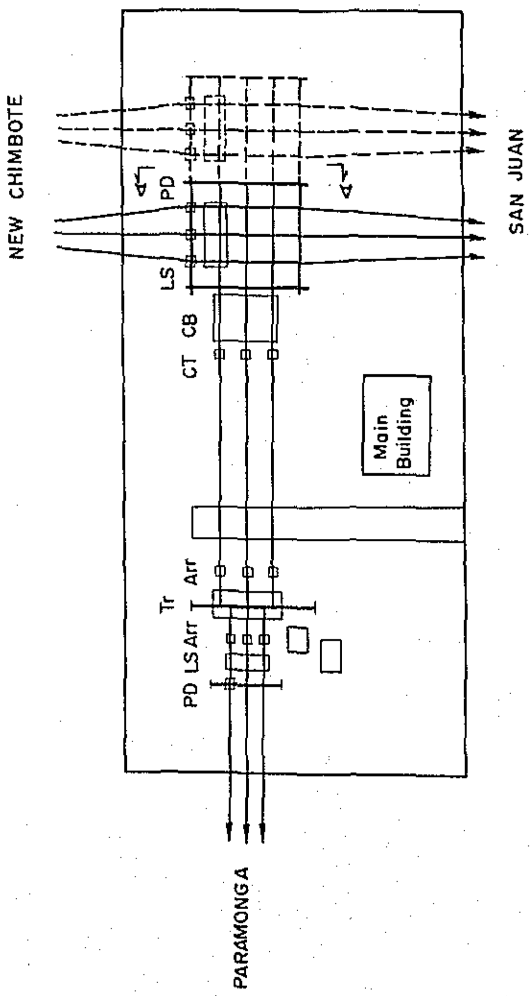


Fig. 5-8 Power Line Carrier Protective Relaying System Diagram

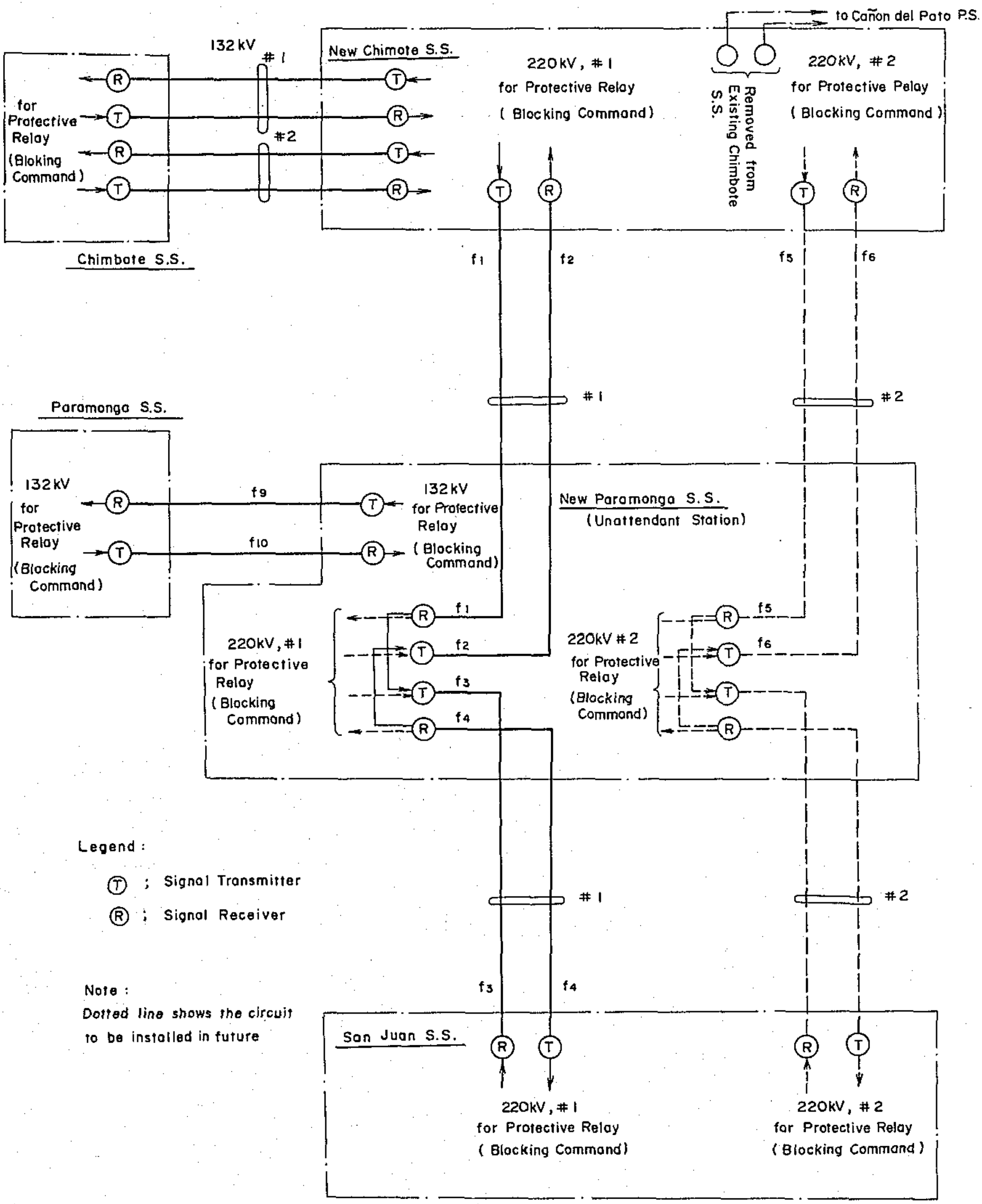


Fig. 5-9 Telecommunication Circuit Diagram

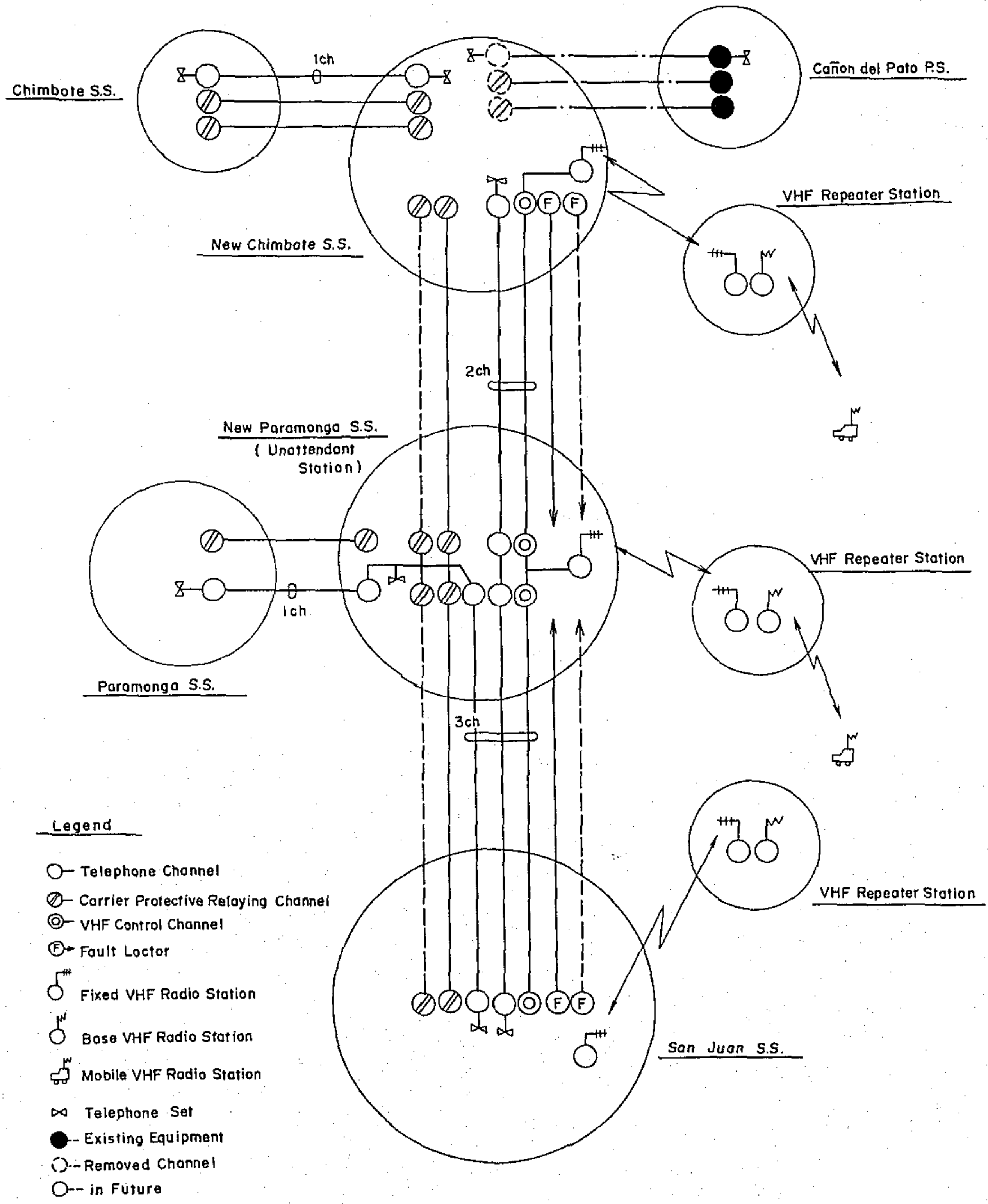
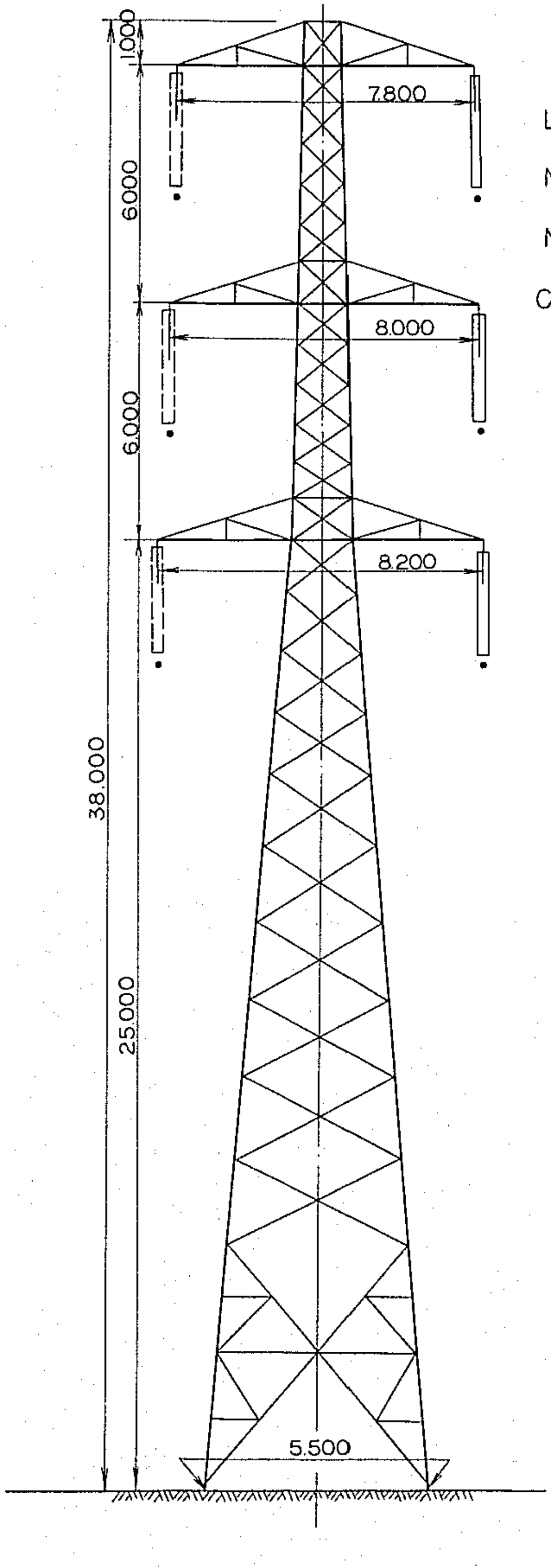


Fig. 5-10 220kV Standard Suspension Tower

S = 1/150



Line Voltage 220kV

No. of Circuits 2

Normal Span 400m

Conductor 330° A.C.S.R.

CHAPTER 6.

CONSTRUCTION SCHEDULE AND CONSTRUCTION COST

CHAPTER 6. CONSTRUCTION SCHEDULE AND CONSTRUCTION COST

6.1 Construction Schedule

This Project, because of its urgent nature, should be expedited according to the construction schedule of Fig. 6-1 with start of operation at the end of 1974.

For this purpose, besides commencing field survey work in November 1971, it is necessary to complete the definite design and technical specifications in June 1972. Further, bidding procedures, contracting for the work and other procedures should be carried out smoothly.

The construction period for the transmission line will require 24 months including construction of access roads and final tests.

6.2 Construction Cost

Based on the results of preliminary design, calculating work quantities and considering the conditions in the field, the construction cost was calculated according to the annexed table.

(1) The conditions for calculation are as indicated below:

Transmission line

Lima-Chimbote Transmission Line

Paramonga and Chimbote areas secondary side interconnecting transmission lines

Substation

San Juan Substation outgoing facilities

New Paramonga Substation

New Chimbote Substation

Paramonga Substation outgoing facilities

Chimbote Substation phase modifying facilities

Telecommunication Facility

Telecommunications facilities for the Project

(2) Land acquisition costs, indemnification costs, accessory facilities costs of company housing for operation and maintenance personnel and appurtenant works costs are not included in calculations.

(3) The main materials and equipment (steel towers, conductors, insulators, transforming equipment such as main transformers and circuit breakers, and telecommunication facilities) are all considered to be imported.

(4) It was considered that cement, reinforcing steel bar and other construction materials used would be domestic materials produced in Peru.

(5) It was considered that the installation work of the interconnecting transmission line and the transforming equipment would be carried out by Peruvian contractors with all construction tool, equipment and materials to be at the expense of the contractors.

(6) Import duties on equipment and materials to be imported, taxes on engineering fees and income tax for foreign engineer were assumed to be exempted and not included in the calculations.

(7) Estimate of the construction cost was made based on the market prices as of 1971.

(8) It was assumed that both foreign and domestic currency requirements would be financed by Yen credit. Therefore, the rate of interest during construction was assumed to be 3.5% for both foreign and domestic currencies.

(9) Engineering service and Supervision for civil works and architectural works are not including in the calculations.

Fig. 6-1 CONSTRUCTION SCHEDULE

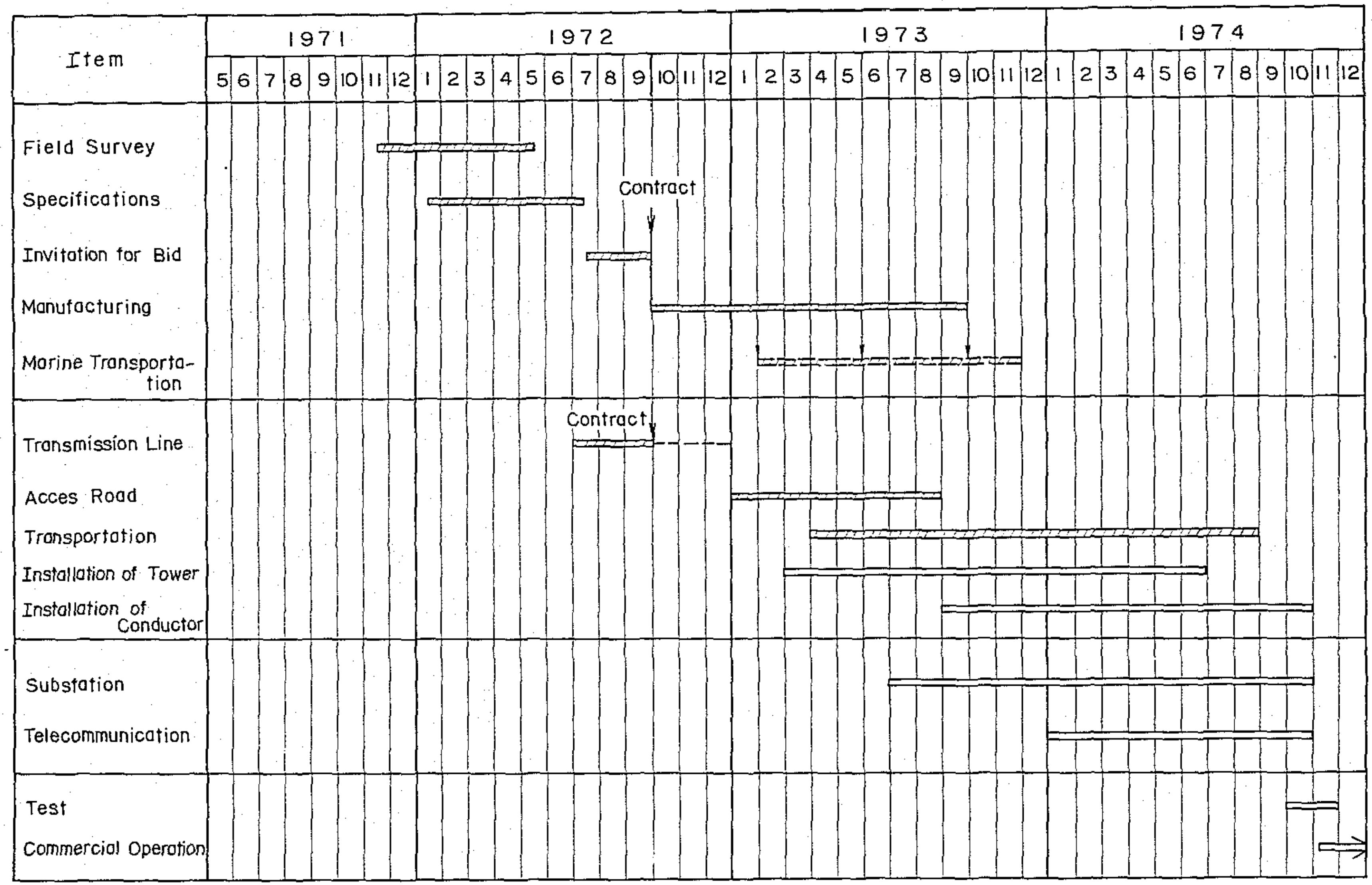


Table 6-1

Unit : 10^3 US$

		Foreign Currency	Domestic Currency	Total	Remarks
a)	Transmission line	4,870	4,516	7,740	
	220 kV	(4,750)	(2,790)	(7,540)	
	132 kV	(120)	(80)	(200)	Tie line with existing 132 kV in Lima
b)	Substations	2,379	691	3,070	Including cost of Paramonga Substation
c)	Communication facilities	566	26	592	
	Sub-total	7,815	3,587	11,402	
d)	Engineering, adminis-tration and other costs	1,280	348	1,628	
e)	Contingency	586	269	855	
	Sub-total	1,866	617	2,483	
f)	Construction Cost (a to e)	9,681	4,204	13,885	
g)	Interest during construction	497	216	713	at 3.5% p.a.
	Total	10,178	4,420	14,598	

Table 6-2 Fund Requirement

Unit : x 1,000 US$

Item	Construction Cost			Annual Fund Requirement			
	F.C.	D.C.	Total	1971	1972	1973	1974
Transmission Line							
Materials							
Steel Tower	2,300		2,300				
Insulator	633		633				
Conductor	1,287		1,287				
Insurance and Freight	530		530				
Transportation in Land		450	450				
Installation Cost		2,340	2,340				
132 kV Transmission Line	120	80	200		530	5,740	1,470
Sub Total	4,870	2,870	7,740		530	5,740	1,470
Substation							
San Juan Substation	216	64	280				
New Chimbote Substation	1,427	453	1,880				
New Paramonga Substation	483	127	610				
Chimbote Substation	166	24	190				
Paramonga Substation	87	23	110				
Sub Total	2,379	691	3,070		768	1,896	406
Telecommunication Facilities							
San Juan Substation	169	8	177				
New Chimbote Substation	199	10	209				
New Paramonga Substation	134	6	140				
Chimbote Substation	35	1	36				
Paramonga Substation	29	1	30				
Sub Total	566	26	592		40	406	146
Total of Direct Cost	7,815	3,587	11,402		1,338	8,042	2,022
Engineering Fee							
Definite Study	200	120	320				
Supervision	600		600				
Sub Total	800	120	920	320	280	160	160
Administration Expenses		228	228		76	76	76
Contingency	586	269	855		102	599	154
Maintenance Equipment	480		480				480
Total of Indirect Cost	1,866	617	2,483	320	458	835	870
Construction Cost	9,681	4,204	13,885	320	1,796	8,877	2,892
Interest during the Construction	497	216	713	6	43	229	435
Grand Total	10,178	4,420	14,598	326	1,839	9,106	3,327

CHAPTER 7.
ECONOMIC EVALUATION

CHAPTER 7. ECONOMIC EVALUATION

7.1 Economic Evaluation of the Interconnecting Transmission Line

This Project consists of a transmission line interconnecting the Central Power System centered around Lima, the Santa Power System centered around the Chimbote area, and the Paramonga Power System located between the two.

The economic benefit of such an interconnected transmission line, generally speaking, can be evaluated in great part by the amount of savings in generating facilities which can be achieved through construction of the interconnecting transmission line.

Further, the benefit which can be attributed only to this Interconnecting Transmission Line is the consumption of the surplus power of Mantaro Power Station.

The following economic benefits can be considered by the construction of this Interconnecting Transmission Line.

(1) *Saving of Addition of Generating Capacity*

The existing development plans of the Santa, Paramonga and Central power systems up to 1985 were studied, and the difference in generating facilities necessary with and without the interconnecting transmission line was calculated. The savings in capacity of generating facilities is an average of 97,500 kW from 1975 of 1985.

When the standard construction cost of a thermal power station in Peru of \$160/kW is applied, the result will be \$15,600 x 10^3.

(2) Utilization of Surplus Energy

Mantaro Power Station beginning operation in 1973 will have an installed capacity of 342 MW in its first stage and 342 MW in its second stage for a total of 684 MW, and up to 1980 surplus energy will be produced, and the salable electric energy to the Santa and Paramonga power systems utilizing this surplus energy was calculated as shown in Table 3-12. As the wholesale electricity rates at Chimbote Substation on Canon del Pato Power Station is at present U.S. 10 mill/kWh, it was considered that the surplus energy of Mantaro Power Station would be salable to both the Santa and Paramonga power systems at the same electricity rates.

As a result, the present worth of Mantaro surplus energy at the end of 1974, for the period of 1975 to 1985, will be 5,438 x 10^3 dollars.

(3) Others

The effects of this interconnection line are the availability of power source in the event of emergency and the possibility of rotating capacity addition between the interconnected power systems which would in turn produce the benefit of the adoption of large size capacity units and contribute to the reduction in the cost of power produced.

If there is surplus power in one of the interconnected power systems, it is possible to send the surplus power to the other power system, and thereby economize on the operation of thermal plant or stop operation of reservoir controlled hydro station in its power system to conserve and store water. In other words, an interconnecting line will enable the coordinated operation of power system in the interconnection.

When the system capacity becomes big, the tie line will serve to improve system reliability and stability, reduce voltage and frequency fluctuation to enable the supply of good quality electricity whcih is an improvement of service to the consumers.

CHAPTER 8.

FINANCING PROGRAM

CHAPTER 8. FINANCING PROGRAM

8-1 Fund Requirement and Financing

As stated in Chapted 6, the total construction cost is estimated to be US$14,598,000 (US$10,178,000 in foreign currency and US$4,420,000 in domestic currency), in which installation cost of the second circuit is not included. The annual fund requirement and redemption program are shown in tables 8-1, 8-2 and 8-3.

All the funds are assumed to be raised by yen credit for both foreign and domestic currency portions, and the annual interest rate to be 3.5%. The repayment is to be made in 18 years in equal installments in principal after 7 years of grace period.

8-2 Power Sales Revenue

(1) The power rate in Chimbote and Paramonga was assumed to be 10 mils for the period when the surplus energy of Mantaro Power Station is obtainable. Such surplus energy will amount to 677.4 x 10^6 kWh at consumer end resuslting in a revenue of US$6,774,000.

(2) The purchase price of energy to be produced at a thermal power station in the Central System was assumed to be 5.7 mils at Lima consisting of the incremental fuel cost of 4.7 mils and the benefit of 1.0 mils. The said energy, amounting to 482.2 x 10^6 kWh at consumer end, will be sold at 10 mils, producing a benefit of US$1,866,000.

8-3 Annual Cost and Cost Depreciation

The operation and maintenance cost and overhead cost were respsectively assumed as 2% and 0.5% of the total construction cost. The depreciation cost was computed on the fixed amount basis with no residual value. The productive years of facilities are as follows.

transmitting facility	50 years
transforming facility	30 years
communication equipment	30 years

8-4 Repayment Program

The funds to redeem the loan will comprise the clear profit in the ordinary profit and loss and the fund appropriated for depreciation. If the repayment is to be made according to the loan conditions stated in 8-1, the cash balance will be as shown in tables 8-1 and 8-2. As noted from the cash balance, deficits will be accumulated if the revenues are limited to those from sales of energy transmitted by the transmission line. This is due to the fact that the greater part of the merit of this interconnecting line, as described in the economic evaluation of the preceding chapter, is the "merit due to savings in generating facilities". In other words, the deficits appearing in the cash balance should be supplemented by the benefit which the Republic of Peru as a whole enjoys from the project. It is, therefore, believed that such deficits should be covered by the Government of Peru in addition to the Mantaro Corporation and Santa Corporation who will benefit by sales of power to be generated at Mantaro Power Station and Cauca de Pato Power Satation or by the Government alone if the financial status of the two corporations is not adequate.

By the sales of energy to be transmitted by the interconnecting transmission line alone, it will be impossible to sink the fund for the capital investment, and the deficits will be accumulated as stated in the foregoing. This is a tributable to the rale of the interconnecting transmission line which will in greater part transmit peak energy as compared with a transmission line connecting a power station directly with load center to supply base load.

Generally, energy produced at a peaking power station is more expensive when compared with that produced at the power station which takes base load. An interconnecting transmission line has a similar trait to that of a peaking power station in their load factors. This gives the ground to justify a high price of energy which is to be transmitted through an interconnecting transmission line. While, the power rate in Chimbote has been established on a political basis by the Power Rate Committee belonging to the Government of Peru, and it is far from the costing.

Therefore, the present power rate should not be supplied in the interconnecting transmission line project which is required to contain an essential to primarily transmit peak power. In other words, the deficits to be caused by the project should be reviewed in relation to the cost of peak power. Conclusion is that, as stated in the foregoing the deficits should be covered by the Government of Peru together with the power sales revenues of Mantaro Corporation and Santa Corporation or by subsidiary of the government alone.

Table - 8-1 Income Statement

Unit: x 1000 US$

			1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
(A)	Gross Revenue						922	1,722	2,176	394	633	927	774	1,208	665	1,025	1,150
	Energy Sales	(MWh)					92,200	172,200	217,600	39,400	63,300	92,700	77,400	120,800	66,500	102,500	115,000
	Unit Sales Price	(U.S. mill/kWh)					10	10	10	10	10	10	10	10	10	10	10
(B)	Total Operation Cost						734	734	734	734	734	734	1,208	1,475	1,142	1,678	1,755
	1. Operation and Maintenance						298	298	298	298	298	298	298	298	298	424	424
	2. Administration Cost						75	75	75	75	75	75	75	75	75	107	107
	3. Depreciation						361	361	361	361	361	361	361	361	361	519	591
	4. Purchased Energy												474	741	408	628	705
	Annual Parchased Energy (MWh)												83,200	130,000	71,500	110,200	123,700
	Unit Price	(U.S. mill/kWh)											5.7	5.7	5.7	5.7	5.7
(C)	Operating Income	(A) - (B)					188	988	1,442	-340	-101	193	-434	-267	-477	-653	-605
(D)	Financial Expenditure (Interest)		6	43	229	435	486	486	486	479	452	425	398	371	344	790	749
	1. Japanese Loan		6	43	229	435	486	486	486	479	452	425	398	371	344	317	290
	2. Other Loan															473	459
(E)	Net Income	(C) - (D)	-6	-43	-229	-435	-298	502	956	-819	-553	-232	-832	-638	-821	-1,443	-1,354

Table - 8-2 Cash Flow Statement

Unit: x 1000 US$

		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
(A) Cash Receipt		320	1,818	8,823	2,924	549	1,349	1,803	21	260	554	-73	1,354	4,924	-134	-86
1. Operating Income Before Interest						188	988	1,442	-340	-101	193	-434	-267	-477	-653	-605
2. Depreciation						361	361	361	361	361	361	361	361	361	519	519
3. Exterior Borrowing		320	1,818	8,823	2,924								1,260	5,040		
(B) Cash Disbursment		326	1,861	9,052	3,359	486	486	486	1,251	1,224	1,197	1,170	2,403	6,156	1,738	1,711
1. Construction Expenditure		320	1,818	8,823	2,924								1,260	5,040		
2. Interest		6	43	229	435	486	486	486	479	452	425	398	371	344	790	749
3. *Amortization of Debit (Capital)*									772	772	772	772	772	772	948	962
(C) Cash Balance	(A) - (B)	-6	-43	-229	-435	63	863	1,317	-1,230	-964	-643	-1,243	-1,049	-1,232	-1,872	-1,797
(D) Accumulated Total		-6	-49	-278	-713	-650	213	1,530	300	-664	-1,307	-2,550	-3,599	-4,831	-6,703	-8,500
(E) Subsidy		6	43	229	435	0	0	0	0	0	594	1,243	1,049	1,232	1,872	1,797
(F) Accumulated	(C) + (E)	0	0	0	0	63	926	2,243	1,013	49	0	0	0	0	0	0

Table - 8-3 Amortization Schedule

Unit: x 1000 US$

	Borrowing				Redemption			Outstanding Balance	Interest during the Grace Period	Remarks
	Transmission Line	Substation Facilities	Communication System	Total	Principal	Interest	Total			
1971	320			320				320	6	
1972	710	1,051	57	1,818				2,138	43	
1973	6,340	2,083	400	8,823				10,961	229	
1974	2,250	466	208	2,924				13,885	435	
1975								13,885	486	
1976								13,885	486	
1977								13,885	486	
1978					772	479	1,251	13,113		
1979					772	452	1,224	12,341		
1980					772	425	1,197	11,569		
1981					772	398	1,170	10,797		
1982					772	371	1,143	10,025		
1983					772	344	1,116	9,253		
1984					772	317	1,089	8,481		
1985					772	290	1,062	7,709		
1986					772	263	1,035	6,937		
1987					772	236	1,008	6,165		
1988					772	209	981	5,393		
1989					772	182	954	4,621		
1990					772	157	929	3,849		
1991					772	128	900	3,077		
1992					772	101	873	2,305		
1993					772	74	846	1,533		
1994					772	47	819	761		
1995					761	20	781	0		
1982	860	360	40	1,260						
1983	3,450	1,500	90	5,040				6,300		
1984					176	473	649	6,124		
1985					190	459	649	5,934		
1986					204	445	649	5,730		
1987					219	430	649	5,511		
¦					¦	¦	¦	¦		
2001							649	0		

APPENDIX

Lima, 1º de Junio de 1971

Señor : Shigepaka Ishihaea - 2 do. Secretario Embajada dei Japón.

Asunto : Información del Ministerio de Industrias y Comercio

Tengo el agrado de remitir a Ud. la información que hemos recibido del Ministerio de Industria y Comercio con relación al Cuestionario que tuviera a bien remitirnos.

Aprovechamos la oportunidad para solicitar por su intermedio que la Misión de Ayuda Técnica Japonesa que está preparando el Proyecto de la Línea de Transmisión Lima-Chimbote de respuesta a las sibuientes preguntas:

1) Cuál es el peso estimado de todo el material de fierro a utilizar en las torres metálicas de la Línea de Transmisión Lima-Chimbote (en TM) con excepción de la tornillería.

2) Del peso total estimado en el punto 1, cuál es el peso total que corresponde a perfiles hasta 3" de ancho.

3) Del peso total estimado en el punto 1, cuál es el peso total de perfiles de más de 3" de ancho.

4) Cuál es el peso total estimado de la tornillería.

Aprovecho la oportunidad para expresar a Ud. los sentimientos de mi mayor consideración.

Atentamente,

MANUEL MORLA VARGAS
DIRECTOR-GENERAL DE ELECTRICIDAD

ENT/mads.

Lima, 28 de Mayo de 1971

Señor Ingeniero
Manuel Moria Vargas
Director General de Electricidad
Ministerio de Energía y Minas
Ciudad. -

Con el presente acuso recibo de su Oficio N° 474-71-EM/DGE juntamente con las copias del cuestionario entregado a Uds. por los funcionarios de la Embajada del Japón.

Habiendo sido informado que el cuestionario arriba mencionado tiene su origen en la condición planteada a la misión japonesa de considerar, en el proyecto de factibilidad que están preparando para la línea Lima-Chimbote, la utilización de insumos de fabricación nacional, este despacho considera oportuno informar lo siguiente :

Torres de Acero

No existe en el país fabricantes de torres de acero para líneas de transmisión eléctrica de alta tensión que hayan registrado dicho producto en el Registro Nacional de Manufacturas.
Por consiguiente, el proyecto de factibilidad que eatá preparando la misión japonesa puede prepararse en base a la utilización de torres importadas.

Conductores

Se adjunta la respuesta obtenida del fabricante de conductores eléctricos con la información que han podido suministrar.

En general, los industriales nos han manifestado que los precios están sujetos a diferentes variables y que sólo será posible calcularlos cuando se sepa las cantidades exactas y las especificaciones de los materiales; asimismo, en general los industriales sostienen que los productos que ofrecen en las licitaciones se ajustan a normas nacionales y/o internacionales reconocidas.

Atentamente,

Ing. Bernardo Bálvez Brandon
Director General de Industrias

BGB/gfm.

APPENDIX 1. VOLTAGE REGULATION

1. Method of Voltage Regulation

Voltage regulation is accomplished by the balance achieved between the reactive power produced at or supplied to the system and the reactive power consumed by the system, and by the selection of power station and substation transformer taps to maintain suitable operating voltage of the system and secondary side voltage of the substation.

In this case, as the range of fluctuation in voltage allowable, the voltage on the load end (low voltage side of substa tion) was taken to be 100% ± 5%, while the generator terminal voltage was taken to be 100% ± 5% (provided that this would be within rated power factor).

1.1 Features of Voltage Regulation

Since this interconnecting transmission line will cover a long distance of 425 km, at the initial stage of normal load when there is little current, particularly in the middle of the night, a large amount of reactive power will be produced due to the earth capacitance of the transmission line.

However, on the Lima side, since the short circuiting capacity is comparatively large, the voltage rise due to reactive power produced in the transmission line is not prominent.

On the Chimbote side, as the power factor of the electric furnace being operated night and day is low (80% in the initial year), consumpti on of reactive power is high and prominent voltage rise cannot be recognized.

Therefore, shunt reactors for voltage regulation are not necessary. However, as explained later, shunt reactors for preventing voltage rise due to Ferranti effect at initial charging will be necessary.

Also, although the load power factor of the electric furnace is extremely low, it is considered that this would gradually be improved, so that calculations have been made with power factors of all loads to be 90% from 1975.

Further, the ratio between peak load and midnight load (PN ratio) in 1974 and the load power factor (at substation lower voltage side) are shown in Table 1.

Table 1

Location	P/N	PF (%)
Trujillo	3	85
Viru, Casma	3	85
Chimbote	2	80
Hualanca, Cañon del Pato	3	85
Paramonga	2	85
EE.EE.AA.	3	85
Cerro de Pasco Corp.	2	85
Marcona Mining Co.	2	85
CSE Power System	3	85

To comment on the voltage regulation at peak hours of the 132 kV Northern Power System north of Chimbote, as a result of study, phase modifying equipment will clearly lack capacity with only the synchronous phase modifier (15 MVar) installed at Chimbote Substation, and it is difficult to maintain 100% voltage adding the reactive power produced at Cañon del Pato Power Station.

The reason for this is that the absolute amount of Var consumption of the electric furnace will be high at 66.3 MVar even in 1974, and therefore, installation of a power capacitor will become necessary at Chimbote Substation.

The voltage at New Chimbote Substation fluctuates between peak hours and midnight hours so that the 220 kV/132 kV transformer is to be equipped with on load tap changer. Also, for New Paramonga Substation, although there will not be as much voltage fluctuation as at New Chimbote Substation, it was decided transformer with on load tap changer should be provided.

As the load at Paramonga Substation is not as high in Var consumption as the load at Chimbote Substation, there will be no need for reactive power supply equipment.

1.2 Distribution of Reactive Power

Taking the current at peak hours in 1974 as an example (see Appendix Fig. A-2), the distribution of reactive power north of Lima will be as described below.

Reactive Power Produced due to Transmission Line

Interconnecting transmission line	j 28.7 MVar
Paramonga transmission line	j 1.7 MVar
Cañon del Pato transmission line	j 0.4 MVar
Chimbote ~ Trujillo transmission line	j 5.7 MVar

Reactive Power Produced due to lagging Power Factor Operation of Generator

Cañon del Pato	j 30.8 MVar (power factor 92.5%)
Cahua	j 34.0 MVar (power factor 76.0%)

Reactive Power Produced due to Phase Modifying Equipment

Chimbote Shunt Capacitor	j 23.6 MVar
Chimbote Rotary Condenser	j 15.0 MVar
Total	j 139.9 MVar

Reactive Power Consumption due to Load

Chimbote	j 66.3 MVar
Paramonga	j 26.8 MVar
Cañon del Pato (Local load)	j 3.7 MVar
Trujillo	j 13.8 MVar

Reactive Power Consumption due to all Transformers

Total	j 28.0 MVar

Reactive Power Consumption due to Transmission Line

New Chimbote ~ Chimbote Transmission Line	j 0.4 MVar
Total	j 139.9 MVar

At peak hours in 1974, a capacitor of 23.6 MVar will become necessary at the low-voltage side (13.8 kV) of Chimbote Substation.

The reactive power production equipment requsired at the various substations in the north will be as shown in Table 2.

According to this, until 1982 while Lima - Chimbote Interconnecting Transmission Line will be operated with a single circuit, it will be necessary for a synchronous phase modifier to be operated on top of which a 75 MVar shunt capacitor would be required.

With a shunt capacitor, it would suffice to have the smallest capacity when it is installed at the facility of the customer consuming the reactive power, while moreover, the voltage will be low at 13.8 kV and there will be the merit that the cost of the capacitor will be low.

In regard to the shunt capacitor to be installed at Chimbote Substation, the cost of the 35 MVar thought to be necessary by 1975 is included in the construction cost. From 1975 and after, addition of more shunt capacitors will become necessary, but considering that these will be installed at SOGESA which consumes the greatest amount of reactive power, they will not be included in the construction cost of this interconnecting transmission line.

At time of outage of power source, even greater numbers of capacitors would be required (taking 1982 as an example, Chimbote Substation at normal times, 75 MVar ——→ 86.1 MVar). and since at time of disaster, it is thought there will be load outage, it will be sufficient to consider only normal loads.

Further, at time of outage of power source, the reactive power produced by gas turbines will be depended upon.

Table 2. Required Reactive Power of Northern Substations

(MVar)

Time			Chimbote Substation			Trujillo Substation		Santiago de Cao Substation		Pacasmayo Substation
			R.C.	S.C.	G.T.	S.C.	G.T.	S.C.	G.T.	S.C.
	1974	Peak	15.0	23.6	-	0	-			
	"	Midnight	-1.2	0	-	0	-			
	1977	Peak	15.0	57.6	-	15.0	-			
*1	"	"	15.0	57.0	26.1	15.0	3.7			
	1982	Peak	15.0	75.0	-	20.0	-			
*1	"	"	15.0	86.1	30.0	9.7	15.0			
	1983	Peak	15.0	24.7	-	44.6	-	23.4	-	17.2
	"	Midnight	0	0	-	0	-	0	-	-
*2	"	Peak	15.0	48.2	20.0	27.6	5.0	8.3	5.0	14.4
*3	"	"	15.0	97.7	-	49.1	-	26.2	-	20.2

Note: *1 Time of outage of Cañon del Pato Power Station.

*2 Time of outage of Chimbote Thermal Power Station.

*3 Case of the Chimbote Thermal Power Station is no constructed.

R.C. : synchronous phase modifier

S.C. : shunt capacitor

G.T. : gas turbine

1.3 On Load Tap Changer

The voltages at Chimbote and the mid-point Paramonga will vary depending upon the size of the current carried on the Interconnecting Transmission Line.

In other words, during the midnight at normal times, there is almost no flow of current so that voltage will rise, while at peak hours, there will be an increase in interchange so that the voltage at Chimbote will fall.

Since the daily fluctuations in this case will be large, transformers without non voltage tap changer are not desirable.

In the case of a transformer equipped with on load tap changer on the 220 kV side, the tap width is 94.9 ~ 102.5% (see Table 3) as a result of analyses of voltage regulation, so that with a margin of safety it should be sufficient with a width of 92.5 ~ 105%.

Further, in regard to appropriate tap value at time of power source outage, no special study has been made, but since at tap near the 100 % value, the 132 kV side voltage will be 100%, it is thought there will be no special problems.

Table 3. Appropriate Value of On Load Tap Changer

Time	New Chimbote	New Paramonga	Remarks
1974, peak	95.0	102.5	
" , midnight	95.0	97.5	
1977, peak	97.5	102.5	
" "	(96.3)	(98.2)	At outage of power source
1982, peak	97.5	100.0	
" , "	96.7	(96.0)	At outage of power source
1983, peak	97.5	97.5	
" , midnight	95.5	99.0	
" , peak	97.5	(94.9)	At outage of power source

Note: Figures in parentheses estimated

1.4 Generator Power Factor of Major Power Stations

The rated generator power factors of the major power stations are as indicated below, and since reactive power is produced at peak hours within this range, there will be no problem.

Santiago de Cao	Gas Turbine	80%
Trujillo	"	
Chimbote	"	
Chimbote	Thermal	85%
Cañon del Pato	Hydro	92%
Cahua	"	72%
EE.EE.AA. (hydro under 60 kW)		90%
EE.EE.AA. (thermal under 60 kW)		
Huinco	Hydro	81%
Matucana	"	75%
Mantaro	"	95%

It is taken to be that operation will be carried out with generator terminal voltage in the range of 95 - 105%.

Further, in the midnight at normal times, there are places at which generators are carrying out leading power factor operation.

1.5 Results of Voltage Regulation

The results are given in Appendix Figs. 2 - 12.

The voltages and transformer tap values of major points north of the areas indicated in these figures are shown in Table 4.

According to these figures, at normal times until 1982, the voltage is more or less 95 - 100% so that there will be no problem.

Entering 1983, the voltages north of Santiago de Cao will tend to be lowered, but there will be no problem if the taps (non voltage taps) of the two substations are lowered from 97.5% to 95%.

Table 4. Voltages (%) and Transformer Tap Values (%) of Northern Substations (Tap values indicated in parentheses)

TIME		New Paramonga			Para-monga		New Chimbote			Chimbote			Trujillo			Santiago de Cao			Pacasmoyo		
		220 kV	132kV	(tap)	66kV	(tap)	220kV	132kV	(tap)	132kV	13.8kV	(tap)	132kV	66kV	(tap)	132kV	66kV	(tap)	132kV	66kV	(tap)
1974	Peak	102.4	99.8	(102.5)	94.4	(100)	97.2	100.2	(95.0)	99.4	99.0	(97.5)	95.5	95.4	(95.0)						
1974	Midnight	101.2	100.7	(97.5)	98.2	(100)	96.3	98.5	(95.0)	97.8	97.0	(97.5)	97.5	101.1	(95.0)						
1977	Peak	99.2	98.1	(102.5)	97.5	(97.5)	97.0	100.6	(97.5)	100.1	100.0	(100.0)	98.1	98.1	(100.0)						
1977	Peak *1	97.2	98.2	(100.0)	97.5	(97.5)	96.3	98.8	(100.0)	98.8	100.0	(100.0)	99.3	100.0	(100.0)						
1982	Peak	98.4	97.5	(100.0)	95.4	(97.5)	96.9	99.4	(97.5)	98.5	100.8	(97.5)	93.9	98.2	(95.0)						
1982	Peak *2	93.7	96.0	(100.0)	95.0	(100)	93.0	96.7	(100.0)	96.5	100.0	(97.5)	94.7	100.0	(95.0)						
1983	Peak	102.2	101.1	(97.5)	97.6	(100)	102.0	102.6	(97.5)	102.2	100.0	(100.0)	92.6	98.0	(97.5)	92.0	95.0	(97.5)	91.1	95.0	(97.5)
1983	Midnight	101.2	100.3	(99.0)	98.6	(100)	97.2	98.8	(95.5)	97.0	96.1	(100.0)	95.7	96.7	(97.5)	95.6	97.7	(97.5)	95.3	97.4	(97.5)
1983	Peak *2	101.1	100.7	(97.5)	97.2	(100)	100.4	101.5	(97.5)	100.6	100.0	(100.0)	94.3	98.0	(97.5)	93.5	95.0	(97.5)	92.0	95.0	(97.5)

Note: *1 Time of outage of Cañon del Pato Power Station

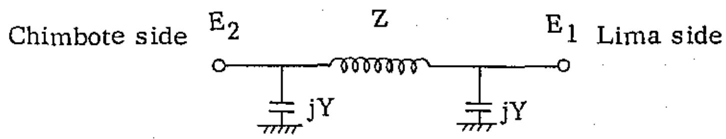
*2 Time of outage of Chimbote Thermal Power Station

2. Restriction of Voltage Rise during Line Cut off

In long distance transmission lines, voltage rise due to Ferranti effect is large. In this case the greatest voltage rise would be after addition of the second circuit; if the transmission line with no T-branch is cut off at the receiving end Chimbote side in this case, and if at this time there is no shunt reactor at the open end transmission line, a voltage rise of 20% would be produced. In order to restrict this voltage rise, a transfer tripping system should be adopted to immediately open the Lima side circuit breaker.

The voltage rise in the line with T-branch will be somewhat smaller and in this case when the Chimbote side is cut off the circuit breakers at Paramonga and Lima should be opened.

Reference Calculation of Ferranti Effect



$$\left.\begin{aligned} Z &= 42.11 + j\ 229.7 \\ Y &= j\ 6.88 \end{aligned}\right\} \quad \text{at 500 MVA Base in \%}$$

$$E_2 = \frac{1}{jY} \cdot \frac{E_1}{Z + \frac{1}{jY}} = \frac{E_1}{1 + jY \cdot Z}$$

$$= \frac{E_1}{1 + j\ 0.0688(0.4211 + j\ 2.297)}$$

$$\left| E_2 \right| = 1.191 \left| E_1 \right|$$

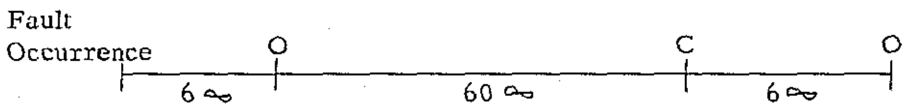
When the receiving end is open, there is voltage rise of approximately 20%. Similarly, considering the worst condition, when the sending end voltage (Lima side) is 102.5%, the capacity of the shunt reactor at the Chimbote side where the receiving end voltage will become 110% is 19.5 MVar. Rounding this out, it was determined that 20 MVar would be necessary. This would mean the same capacity as that of the 220·kV reactor scheduled to be installed in the Mantaro System.

APPENDIX 2. TRANSIENT STABILITY

(1) Transient Stability by Single Circuit, Three Phase Reclosure

An analysis was made of 3 phase reclosure due to single circuit, 3 phase line-to-ground fault at the Lima side at the time in 1983 when the line has become double circuits.

Assuming the actions of the breakers at both ends of the faulted line to be open-close-open the time was taken to be as indicated below.



The prior current would be as indicated in Appendix Fig. 11 while the swing curve as a result of analysis of the condition after occurrence of fault is stable as shown in Appendix Fig. 15. According to this, the greatest disturbance would be at Cañon del Pato, followed by El Chorro and the Rimac River system power stations of Callahuanca, Moyopampa and Huampani.

The no-voltage time of 1 sec considered as the condition for reclosing is slightly long and is on the severe side for stability, but since stability was obtained even at this value there will be no problem in the actual set value.

(2) Transient Stability at Time of Power Source Outage

There is a risk of the sound system to become unstable from shock should Cañon del Pato Power Station be tripped.

In order to study this problem, an analysis was made of power source outage at peak hours in 1982, the last year of operation as a single circuit line.

The current prior to the fault is given in Appendix Fig. 6. The result as shown in Appendix Fig. 13 was found to be stable.

The disturbance is greatest at El Chorro which is located immediately by Cañon del Pato with an amplitude of approximately 30° in the period up to 3.0 sec.

There are no special problems with other power stations.

In 1983, a 150 MW Thermal Power Plant will put into service at Chimbote district. However, since this plant is largest in northern Peru, the stability of outage time of the thermal power plant was studied.

As the result, the power flow before fault is given in Appendix Fig. 8 and as shown in Appendix Fig. 14 the result of the study was found to be stable.

APPENDIX 3. PROTECTION OF TRANSMISSION LINE

1. Protective System

The features of the Interconnecting Transmission Line is that the transmission distance is very long, 425 km, and that it will have three terminals as a T-branch will be provided at Paramonga, roughly midway along the single circuit to be provided initially.

Generally speaking, with such long distance transmission lines the current at time of fault is small, and therefore, the voltages at electric stations will not be lowered, and application of a relay system attempting high speed clearance of fault over the entire protected range from only one end is difficult. Accordingly, it is necessary to adopt a pilot relay system which judges the fault combining the conditions of the three terminals.

Further, it was considered that reclosing would not be performed during the initial single circuit operation, and the high speed reclosing will be introduced when the line is made double circuits in the future.

1.1 Main Protection

The Interconnecting Transmission Line is an important transmission line interconnecting the northern and central parts of Peru, and if quick removal of fault is delayed, the disturbance to the northern power systems will be enlarged, and there would be danger of this developing into a serious fault in the systems of the Central Region also.

Hence, for such an important transmission line, a carrier relay system should be adopted as main protection. Since the carrier relay system is a system that exchanges information with the opposite end, it has the ability to completely select faults outside the protected sector, while for faults within the protected sector it is a reliable protective relay system capable of high speed breaking of both ends.

For the carrier relay system, in the case of a long distance transmission line, both power line carrier and microwave are conceivable, and either one should be selected according to the transmitting method.

In a carrier relay system, there is direction comparison and phase comparison, but for a long distance sector (more than 200 km), application of a phase comparison system becomes difficult. This is because with increased distance there is the effect of transmission line charging current, and the delay due to time required for information exchange by the signal transmitting apparatus cannot be neglected.

Therefore, the direction comparison relay system which compares directions with relays having directional properties such as a direction distance relay should be used.

1.2 Back up Protection

The carrier relay system, in case there is some trouble with the apparatus making it unable to clear faults in its own sector, and also since it is conceivable that the main protection cannot be used due to inspection, etc. of the carrier, must always have back up protection besides the carrier relay protection to augment it.

As a back up protective relay system, the direction distance relay should be combined with a time relay.

2. High Speed Three Phase Reclosing

In consideration of the importance of the Lima-Chimbote Interconnecting Transmission Line, high speed, 3 phase reclosing should be adopted after it becomes a double circuit line.

The rate of success of reclosing according to a report by CIGRE has been said to be 70% in the case of extra high voltage systems.

In general, the main factor deciding the reclosing time of an extra high voltage transmission line is the no voltage time. In the case of 3-phase reclosure, the no voltage time is determined by the time required for recovery of insulation at the point of fault based on disappearance of residual ions produced by the fault current.

This is governed by meteorological conditions at the locastion of fault, but in general, the insulation recovery time becomes longer the higher the system voltage and the larger the fault current, and in a 220 kV transmission line a no voltage time of 15 cycles or more becomes necessary. Further, the circuit breaker must be one that has the special duty of high speed reclosing.

Three phase reclosing must confirm securance of the system interconnection by detection of power currents in parallel circuits and detection of phase differential angles at both ends of the transmission line.

It will suffice for the adjustment range of no voltage time of the apparatus to be 0.3 - 1.0 sec in 3 phase reclosing.

APPENDIX 4. SHORT CIRCUIT CAPACITY

When the Interconnecting Transmission Line has become double circuits assumed in (1983), the 3 phase short circuiting capacity of the entire system will be as shown in Appendix Fig. 16.

For generator reactance, Xd' was used, and calculations were carried out considering all generators to be put in the system.

The impedances used are shown in Appendix Fig. 1.

The short circuiting capacities in connection with the Interconnecting Transmission Line are as listed below.

San Juan	220 kV bus	3,120 MVA
New Chimbote	220 kV bus	1,163 MVA
New Paramonga	220 kV bus	708 MVA
New Chimbote	132 kV bus	1,453 MVA
New Paramonga	132 kV bus	363 MVA
Chimbote SS		1,445 MVA

Therefore, the breaking capacities of circuit breakers will have ample allowances with the following:

220 kV circuit breaker	5,000 MVA
132 kV circuit breaker	2,500 MVA

APPENDIX 5. METHOD OF ALLOCATION OF CONSTRUCTION COST OR ANNUAL OPERATION COST FOR INTERCONNECTING TRANSMISSION LINE

The following allocation of construction cost or annual operation cost is conceivable.

1. Degree of Interconnection Effect

This would be an allocation by ratio of benefit received or ratio of frequency of use and basically consists of the following thinking.

a. The effect of interconnection reaches all of the companies interconnected.

b. Therefore, the cost of realizing the interconnection should be allocated to all companies interconnected according to the degree of effect received.

Further detailed classification is given below.

1.1 Ratio of Saving in Marginal Supply Capability

There is no problem when the dependability of the two systems to be interconnected are the same.

1.2 Ratio of Expected Quantity of Utilization of Spinning Current

An agreement is made on the amount of power source outage to be assumed and the allocation is made in accordance with the ratio of the sizes of spining current.

1.3 Allocation is made by overall evaluation of scale merit, expected quantity of utilization of spinning current, and savings in marginal supply capability.

1.4 Allocation is made by overall evaluation of savings in marginal supply capability and expected quantity of utilization of spinning current.

2. System Scale Ratio

Allocation according to the scale of each system to be interconnected.

3. Uniform Rate for All Companies

Allocation is made at a uniform rate for all companies, but there would be a problem if one of the companies is especially small.

4. Others

Allocation could be made by the ratio of the size of the company (ratio of capital). Another point to be considered is whether or not adjustments should be made after start of operation based on actual performances.

Table A-5 Demand at Substation Unit : MW and MVar

Sub Station	1974		1977	1982	1983	
	PEAK	OFF PEAK	PEAK	PEAK	PEAK	OFF PEAK
Pacasmayo					23.7+j11.5	2.37+j1.15
Santiago de Cao					37.5+j18.2	3.75+j1.82
Trujillo (incl. Viru)	22.2+j13.8	7.4+j4.6	29.3+j14.2	45.9+j22.2	50.3+j24.4	16.8+j8.1
Chimbote (incl. Casma)	88.8+j66.3	44.1+j33.0	142.2+j68.9	192.2+j93.1	203.9+j98.8	101.3+j49.1
Cañon del Pato (incl. Huallanca)	5.9+j3.7	2.0+j1.2	7.2+j3.5	8.7+j4.2	9.1+j4.4	3.0+j1.5
Paramonga	43.3+j26.8	21.7+j13.4	50.0+j24.2	70.3+j34.0	74.5+j36.1	37.3+j18.1
San Juan	40.0+j24.8	13.3+j8.3	124.9+j60.5	195+j94.4	212+j102.7	70.7+j34.2
Santa Rosa	271.3+j168.1	90.4+j56.0	320+j155.0	505+j244.6	554+j268.3	184.7+j89.4
Chavaria	271.3+j168.1	90.4+j56.0	320+j155.0	505+j244.6	554+j268.3	184.7+j89.4
Cerro de Pasco	196.5+j121.8	98.3+j60.9	247.5+j119.9	365.0+j176.8	395+j191.3	197.5+j95.7
Marcona	54.0+j33.5	27.0+j16.8	68.0+j32.9	100.0+j48.4	108.0+j52.3	54.0+j26.2
Independencia	7.7+j4.8	2.6+j1.6	10.1+j4.9	15.9+j7.7	17.3+j8.4	5.8+j2.8
Ica	3.8+j2.4	1.3+j0.8	5.0+j2.4	7.9+j3.8	8.7+j4.2	2.9+1.4
Changuillo	3.8+2.4	1.3+j0.8	5.0+j2.4	7.9+j3.8	8.7+j4.2	2.9+j1.4
Total	1,008.6 +j636.5	399.8 +j253.4	1,329.2 +j643.8	2,018.8 +j977.6	2,256.7 +j1,093.1	867.7 +j420.3

Table A-6 Break Down of Supply Capability at Peak Time

Unit : MW

Station	Station Type	Installed Capacity	Out Put			
			1974	1977	1982	1983
Santiago de Cao	G	20.0	-	-	-	0
Trujillo	G	20.0	0	0	0	0
Chimbote Thermal	T	150.0	0	0	0	150.0
Chimbote	G	40.0	0	0	0	0
Cañon del Pato	H	125.0	75.0	75.0	125.0	125.0
El Chorro	H	60.0	-	-	60.0	60.0
Cahua	H	40.0	40.0	40.0	40.0	40.0
Callahuanca	H	67.8	67.8	67.8	67.8	67.8
Mayopampa	H	63.0	63.0	63.0	63.0	63.0
Huampani	H	31.4	31.4	31.4	31.4	31.4
Santa Rosa	T	450.0	0	0	450.0	450.0
Huinco	H	260.0	260.0	260.0	260.0	260.0
Matucana	H	120.0	120.0	120.0	120.0	120.0
Mantaro	H	684.0	Swing	Swing	Swing	Swing
Oroya	T	5.0	5.0	5.0	5.0	5.0
Oroya	H	9.0	9.0	9.0	9.0	9.0
Pachachaco	H	12.0	12.0	12.0	12.0	12.0
Yaupi	H	105.0	105.0	105.0	105.0	105.0
Malpaso	H	54.0	54.0	54.0	54.0	54.0
Cerro de Pasco	H	100.0	-	-	100.0	100.0

Station	Station Type	Installed Capacity	Output			
			1974	1977	1982	1983
Marcona	T	71.5	71.5	71.5	71.5	71.5
Total (Except swing Generator Capacity)		2,487.7	913.7	913.7	1,573.7	1,723.7
Generator Installed Capacity			1,360.3	1,474.3	2,297.7	2,487.7
Total Demand (Except Loss)			1,008.6	1,329.2	2,018.8	2,256.7

Note G : Gas Turbine

H : Hydro

T : Thermal

Table A-7 Break Down of Supply Capability at off Peak Time

Unit : MW

Station	Station Type	Installed Capacity	Output 1974	Output 1983
Santiago de Cao	G	20.0	-	0.0
Trujillo	G	20.0	0.0	0.0
Chimbote Thermal	T	150.0	0.0	0.0
Chimbote	G	40.0	0.0	0.0
Cañon del Pato	H	125.0	50.0	125.0
El chorro	H	60.0	-	0.0
Cahua	H	40.0	20.0	40.0
Callahuanca	H	67.8	40.0	67.8
Mayopampa	H	63.0	40.0	63.0
Huampani	H	31.4	10.0	31.4
Santa Rosa	T	450.0	0.0	0.0
Huinco	H	260.0	65.0	260.0
Matucana	H	120.0	0.0	0.0
Mantaro	H	684.0	Swing	Swing
Oroya	T	5.0	0.0	5.0
Oroya	H	9.0	5.0	9.0
Pachachaco	H	12.0	5.0	12.0
Yaupi	H	105.0	50.0	105.0
Malpaso	H	54.0	30.0	54.0
Cerro de Pasco	T	100.0	-	0.0
Marcona	T	71.5	0.0	0.0
Total (Except Swing Generator Capacity)		2,487.7	315.0	772.2
Total Demand (Except Loss)			399.8	867.7

Table A-8 Rating and Characteristics of Generator and Transformer

Station		No. of Unit	Capacity of Unit (MVA)	Output of Unit (MW)	Power Factor	Xd' Machine Base(%)	M (Sec)	Transformer Voltage (kV)	Xt Reactance of transformer Machine Base(%)	Station Capacity (MVA)
Santiago de Cao	(G)	1	25.0	20.0	0.8	30.0	5.0	13.2/132		25.0
Trujillo	(G)	1	25.0	20.0	0.8	30.0	5.0	13.2/132		25.0
Chimbote Thermal	(T)	1	177.0	150.0	0.85	15.0	5.0	13.2/132	10.0	177.0
Chimbote	(G)	2	25.0	20.0	0.8	30.0	5.0	13.2/132		50.0
Cañon del Pato	(H)	5	27.0	25.0	0.925	23.0	6.0	13.8/138	8.1	135.0
El Chorro	(H)	2	31.5	30.0	0.95	27.1	6.0	13.8/138	10.0	63.0
Cahua	(H)	2	27.5	20.0	0.72	37.0	5.4	10.0/138	10.0	55.0
Callahuanca	(H)	3	17.5	12.3	0.702	35.0	3.9	6.5/67.7	9.25	
"	(H)	1	44.0	30.9	0.702	33.0	4.36	8.0/67.5	10.3	96.5
Mayopampa	(H)	3	30.0	21.0	0.7	33.0	5.52	9.5/67.8	9.0	90.0
Huampani	(H)	2	22.4	15.7	0.7	30.0	3.22	10.0/61.5 (10.0/32.2)	8.5	44.8
Santa Rosa	(T)		92.6	64.6	0.7					92.6
"	(T)	3	177.0	150.0	0.85	15.0	5.0	13.8/60	7.5	531.0
Huinco	(H)	4	85.0	65.0	0.76	31.5	6.2	12.5/235.6 ± 1x8.2	12.0	340.0
Matucana	(H)	2	80.0	60.0	0.75	32.0	5.8	13.8/220	12.0	160.0
Mantaro	(H)	9	120.0	114.0	0.95	31.0	7.8	13.8/220 ± 2x2.5%	10.0	1,080.0
Oroya	(T)		6.25	5.0	0.8	15.0	5.0		7.0	6.25
"	(H)	3	3.75	3.0	0.8	18.0	6.46	2.3/50	7.0	11.25
Pachachaco	(H)	4	3.75	3.0	0.8	18.0	6.46	2.3/50	7.0	15.0
Yaupi	(H)	5	24.0	21.0	0.875	27.0	5.24	13.2/132	8.0	120.0
Malpaso	(H)	4	17.0	13.5	0.795	33.0	5.9	6.9/50	10.0	68.0
Cerro de Pasco	(T)	1	118.0	100.0	0.85	15.0	5.0		7.5	118.0
Marcona	(T)		84.2	71.5	0.85	15.0	5.0			84.2

Note G : Gas turbine H : Hydro T : Thermal

Table A-9 Applied Capacity of Transformers in Each Substation

Station	Capacity of Transformer (MVA)			
	1974	1977	1982	1983
Pacasmayo	-	-	-	30.0
Santiago de Cao	-	-	-	60.0
Trujillo	30.0	60.0	60.0	60.0
Chimbote	135.0	180.0	270.0	270.0
New Chimbote	120.0	120.0	120.0	240.0
Paramonga 220 kV	50.0	50.0	50.0	50.0
Paramonga 132 kV	55.0	82.5	82.5	110.0
Cavaria	470.0	470.0	620.0	770.0
Santa Rosa	470.0	470.0	620.0	770.0
San Juan	60.0	210.0	360.0	360.0
Canete	-	-	20.0	20.0
Independencia	50.0	50.0	100.0	100.0
Oroya	120.0	180.0	180.0	180.0
Huancayo	-	-	30.0	30.0
Ica	50.0	50.0	50.0	50.0
Changuillo	50.0	50.0	50.0	50.0
Marcona	100.0	100.0	150.0	150.0

APPENDIX 6. LIST OF BASIC INFORMATION

1.	Plan quinquenal de desarrollo para el periodo 71-75; Programa de inversiones en estudios:	M.E.M. (Ministerio de Energia y Minas)
2.	Plan nacional de desarrollo, 1971-1975	M.E.M.
3.	Geologia de los cuadrangulos de Puemape, Chocope, Otuzco, Trujillo, Salaverry y Santa	Servicio de Geologia y Mineria
4.	Sinopsis de la geologia del Peru	"
5.	Ley No. 12378	M.E.M.
6.	Mapa (1:2,000,000)	I.G.M. (Instituto Geografico Militar)
7.	Mapa (1:100,000)	"
8.	Informe del estudio de factibilided del suministro de energia electrica al area de Santiago de Cao desde el sistema del Santa	Corporacion Peruana del Santa
9.	Estudio de factibilidad de la Central hidroelectrico de EL Chorro (Volume II)	"
10.	Estudio de factibilidad para la electrificacion de los pueblos jovenes "EL Porvenir" "Florencia de Mora" y "Esperanza" de Trujillo	CORLIB (Corporacion de Fomento Economico y Social de la Libertad)
11.	Redes electricas de alta y baja tension para los pueblos jovenes "El Porvenir" "Florencia de Mora" y "La Esperanza" de Trujillo	CORLIB
12.	Sistemas electricos del Valle de Chicama	M.E.M.
13.	Electrification Valle Viru	CORLIB
14.	Memoria descriptiva del Parque Industrial de Trujillo	"

15.	Diagrama unifilar del sistama del Santa	Corporacion Peruana del Santa
16.	Plano de suministro en media y alta tension en la ciuded de Trujillo	M.E.M.
17.	Plano de proyecto de electrificacion y optimizacion del Departamento de Lambayeque	"
18.	Report on the feasibility of the El Chorro Hydroelectric Plant	Corporacion Peruana del Santa
19.	Posibilidades de desarrollo hidroelectrico del rio Santa	"
20.	Informe final al instituto nacional de planificacion del gobierno del Peru sobre el mercado energetico de la Corporacion Peruana del Santa y sobre los posibles desarrollos de una planta hidroelectrica en Los Pancitos ampliacion de la planta de Canon del Pato y la alternativa de una planta termica	Corporacion Peruana del Santa
21.	Plano de lineas de transmission 220/60/30 kV de EE.EE.AA.	EE.EE.AA. (Empresas Electricas Asociadas)
22.	Datos de meteorologias 1 parte	SENAMHI (Servicio nacional de meteorologia e hidrologia)
23.	Plano de sistema onda portadora sobre linea de transmision de EE. EE.AA.	EE.EE.AA.
24.	Memoria tecnico descriptiva de la instalacion linea 220 kV Callahuanca-Chavarria	"
25.	Catalogo de Industrial Canepa Tabini S.A.	Canepa Tabini S.A.
26.	El medio ambiente como factor de oerdida y perturbacion electricas	CORMAN (Corporacion de Energia Electrica del Mantaro)

27.	Estudio del comportamiento de los aisladores a emplearse en la linea Pisco - Lima	CORMAN
28.	Esquema de principio de red Mantaro I etapa	"
29.	Esquema de principio de red Mantaro II etapa	"
30.	Datos principales y funciones de Proyecto MANTARO	"
31.	Catalogo de Pirelli Peruana Industria de Conductores Electricas S.A.	Pirelli Peruana S.A.
32.	Folletos de SOGESA	SOGESA (Socieded Siderurgica de Chimbote S.A.)
33.	Folletos de proyectos de Huinco y Matucana	EE.EE.AA.
34.	Specification of tower for 220 kV Transmission Line	"
35.	Informe sobre los resultados de Estacion de Pruebas Aisladores	CORMAN
36.	Datos de meteorologias 2 parte	SENAMHI
37.	Plano de red nacional de estaciones meteorologicas e hidrologicas	SENAMHI
38.	Las tables de los precios del proyecto de Mantaro	CORMAN
39.	Tarifas y costo de energia electrica	M.E.M.
40.	Specification for the transformer of Chavarria S.S.	EE.EE.AA.
41.	Esquema de principio de substacion de Chavarria	"
42.	Sistema de telecomunicaciones de EE.EE.AA.	"

43.	Las tablas de los precios de obras civiles de subestacion de San Juan	CORMAN
44.	Codigo electrico del Peru	Asociacion electrotecnica peruana
45.	Reglamento general de tasaciones del Peru	Cuerpo tecnico de tasaciones del Peru
46.	Catalogo peruano de la construccion	Camara peruana de la construccion
47.	Experiencia del Peru en el planeamiento, construccion y puesta en servicio de sub-estaciones de tension superior	CORMAN
48.	Rio Mantaro power plant feasibility report	"
49.	Especificaciones tecnicas de sub-estaciones 1 parte	"
50.	Especificaciones tecnicas de subestaciones 2 parte	"
51.	Estudio de la red del Mantaro en el analizador de redes 1 parte	"
52.	Mantaro system and inter-connections proposal for examination on network analyzer	"
53.	Estudio de la red del Mantaro en el analizador de redes 2 parte	
54.	Especificaciones tecnico de telecomunicaciones	"
55.	Estudio para ubicar una linea en la Costa entre Lima y Pisco	"
56.	Especificaciones tecnicas de linea de transmision	"
57.	Ofertas postes de madera	M.E.M.
58.	Carta sobre el precio para los cables de aluminio	Pirelli peruana S.A.

59.	Datos de linea de 132^{kV} Chimbote-Trujillo	SEN (Servicios Electricos Nacionales)
60.	Catalogo de COSAPI	Marubeni-Iida del Peru
61.	Catalogo de SADE	"
62.	Esquema de principio de Santa Rosa	EE.EE.AA.
63.	Planta y secciones de subestacion de Chavarria	"
64.	Media de resistividad electrica del terreno a lo largo de la linea de Chimbote-Trujillo	Corporacion Peruana del Santa
65.	Inventario de costos de instalaciones de Corporacion Peruana del Santa	Corporacion Peruana del Santa
66.	Catalogo de postes de SICAC S.A.	SICAC S.A.

Fig. A-1 Impedance Map for PERU POWER SYSTEM AT 1983

220kV 500MVA Base

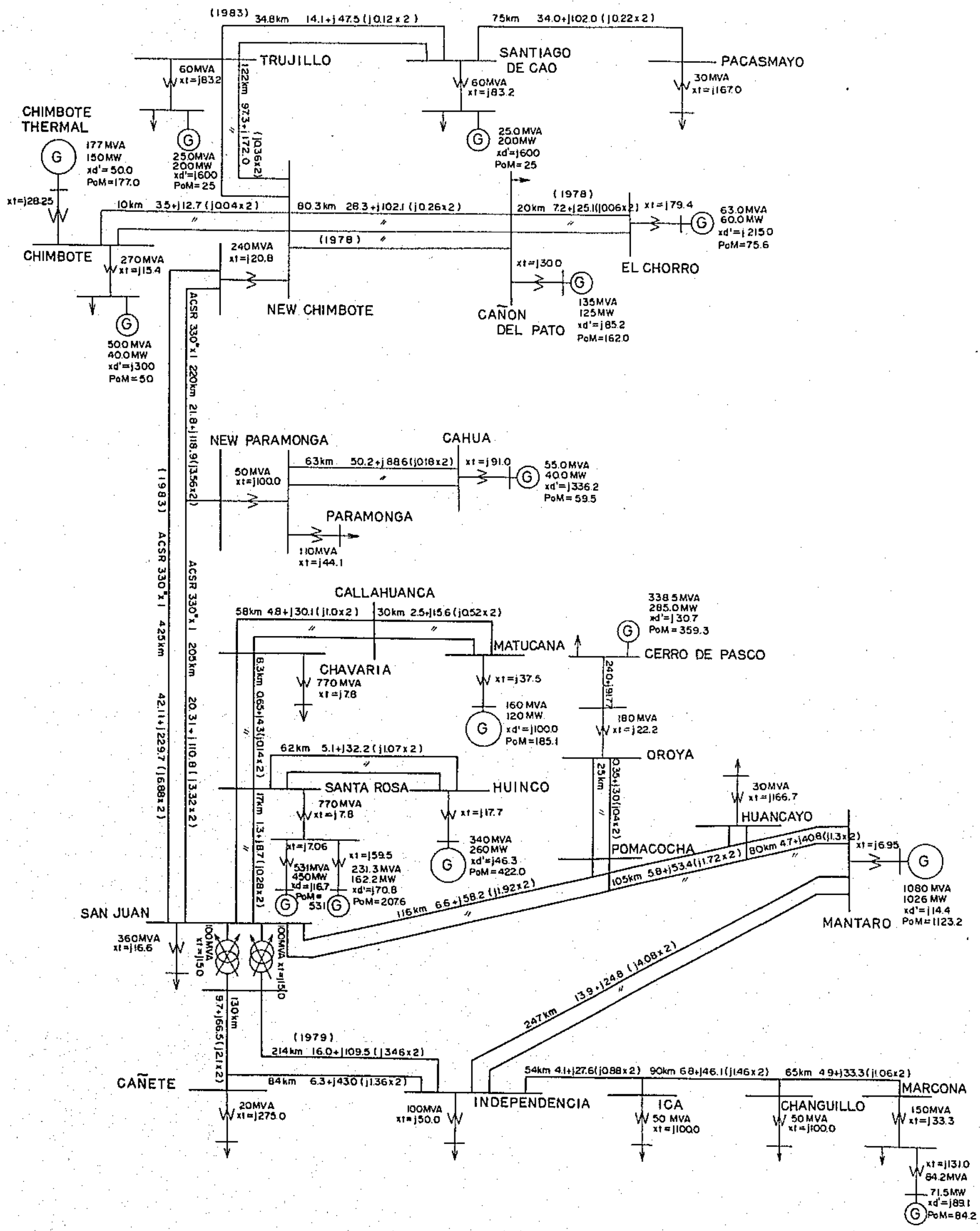


Fig. A-2 Power Flow and Voltage Regulation at Peak Time in 1974

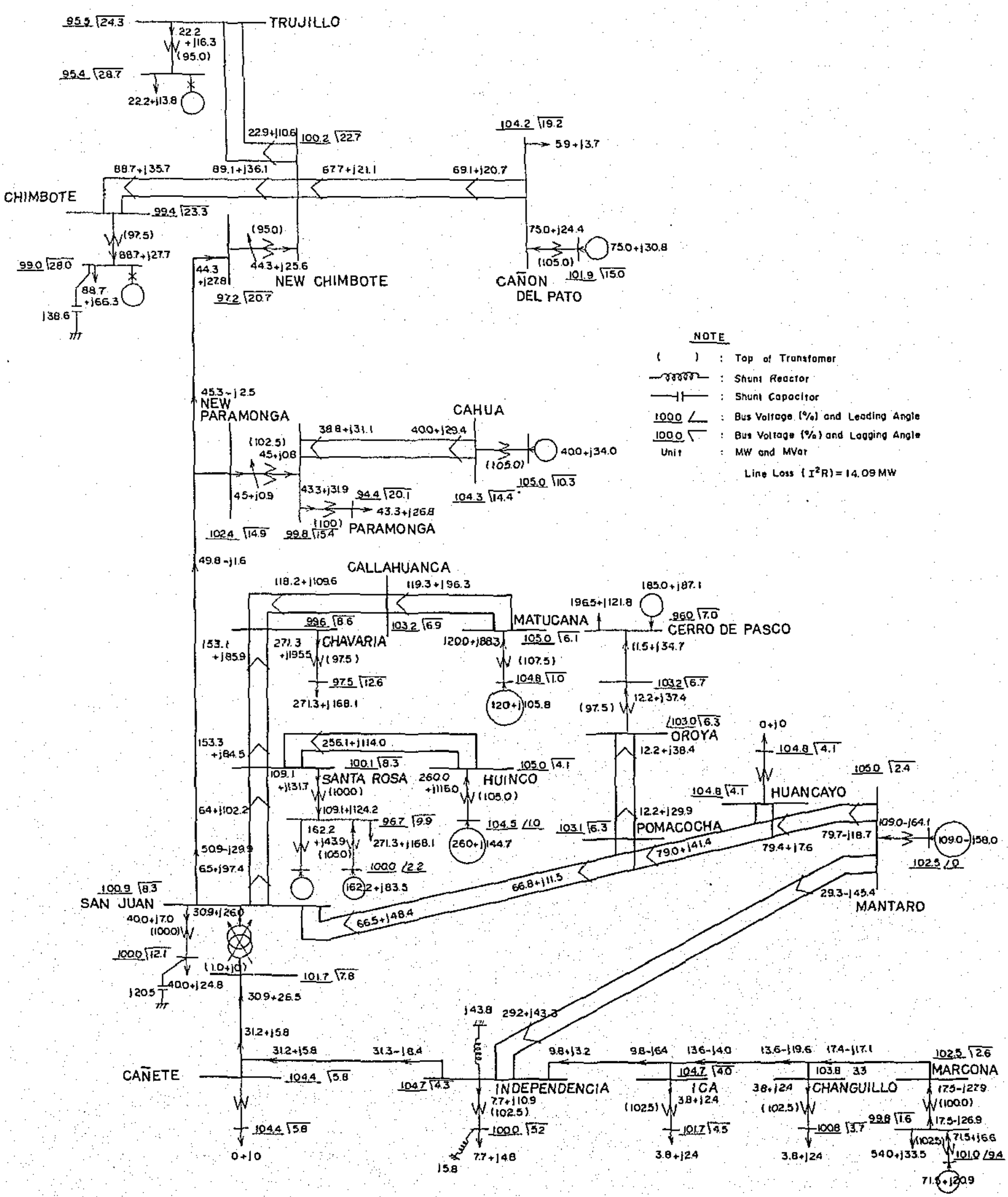


Fig. A-3 Power Flow and Voltage Regulation at Off Peak Time in 1974

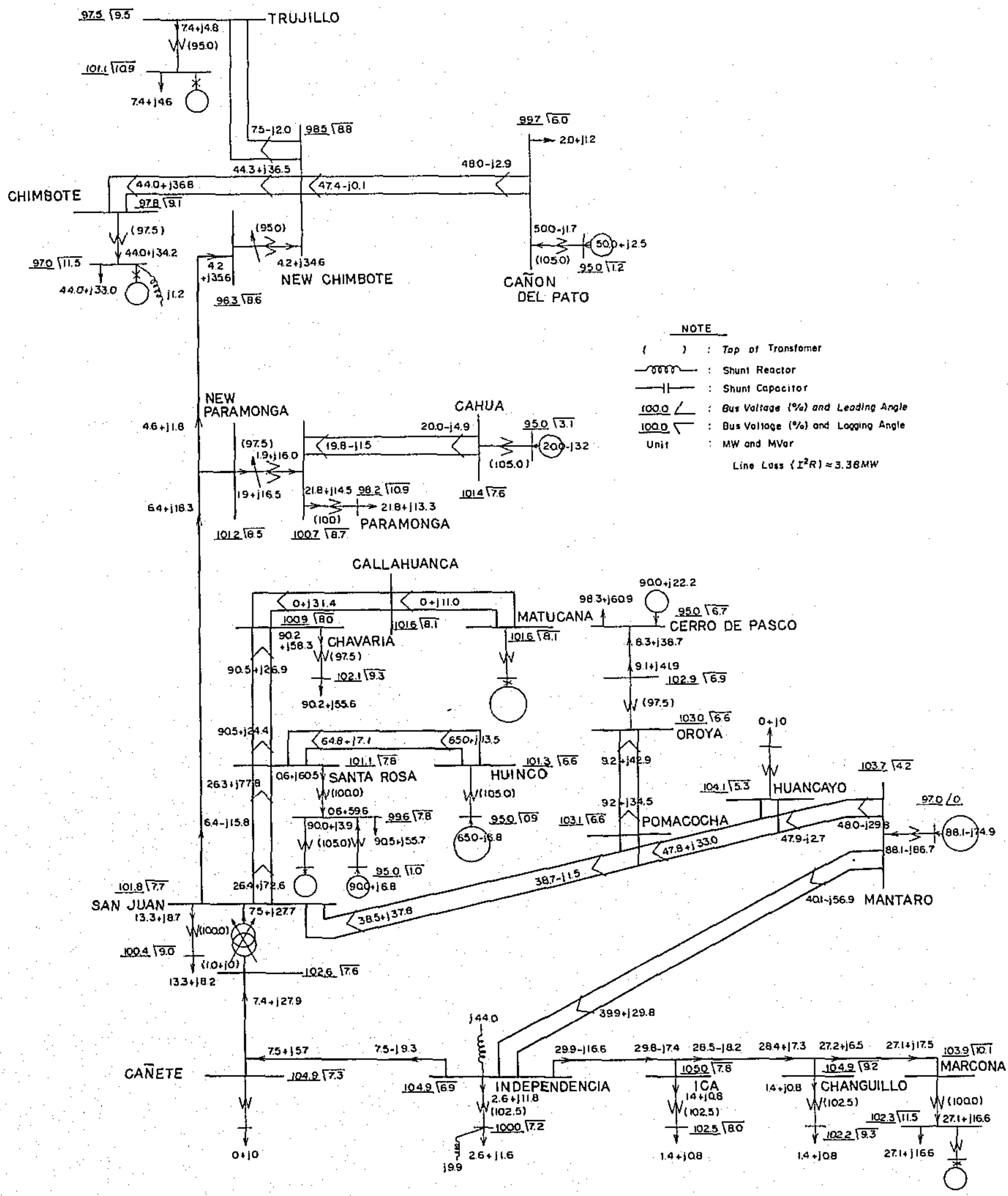


Fig.A-4 Power Flow and Voltage Regulation at Peak Time in 1977

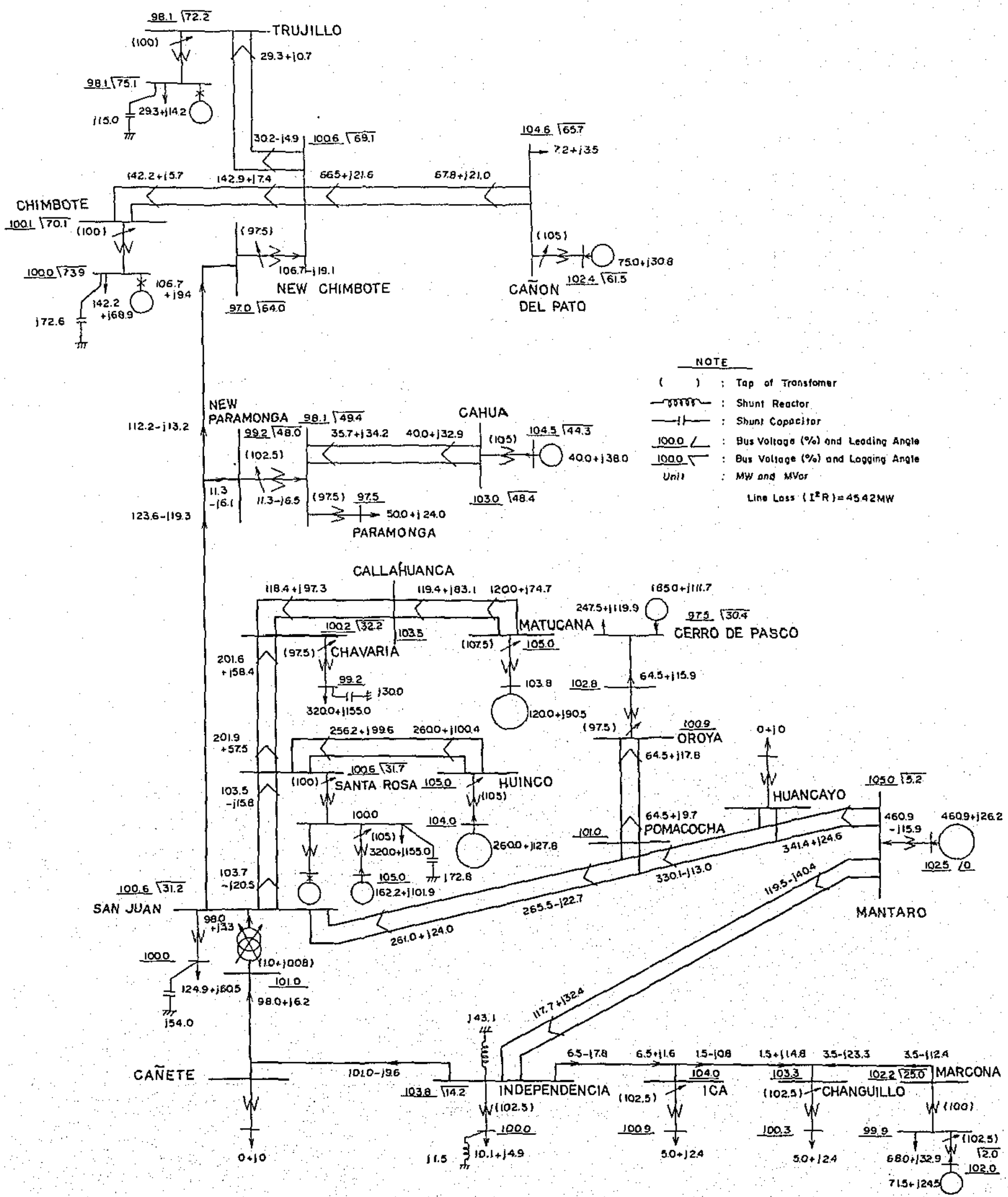


Fig. A-5 Power Flow and Voltage Regulation at Peak Time in 1977

(CAÑON DEL PATO Power Station Power Shedding)

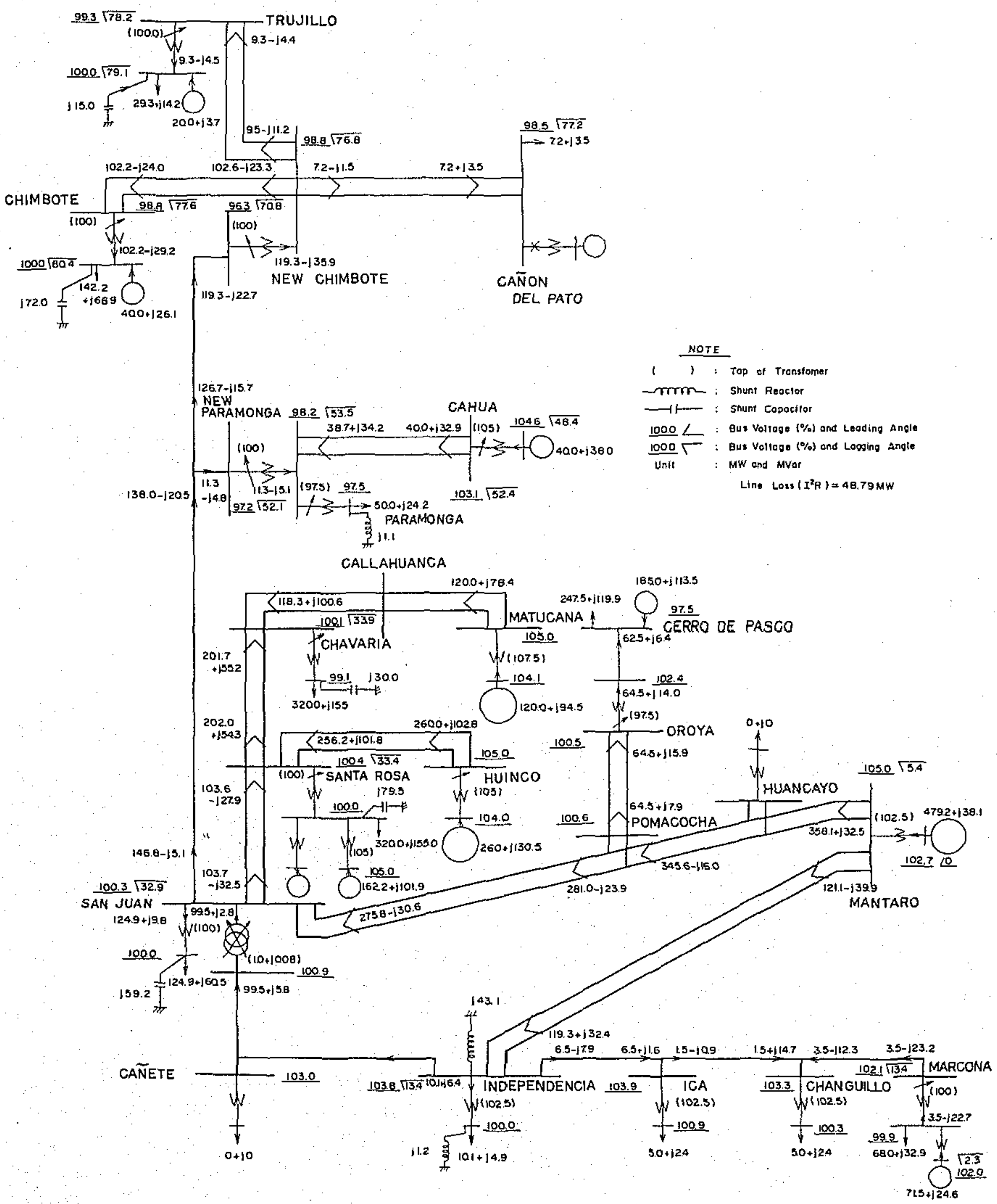


Fig. A-6 Power Flow and Voltage Regulation at Peak Time in 1982

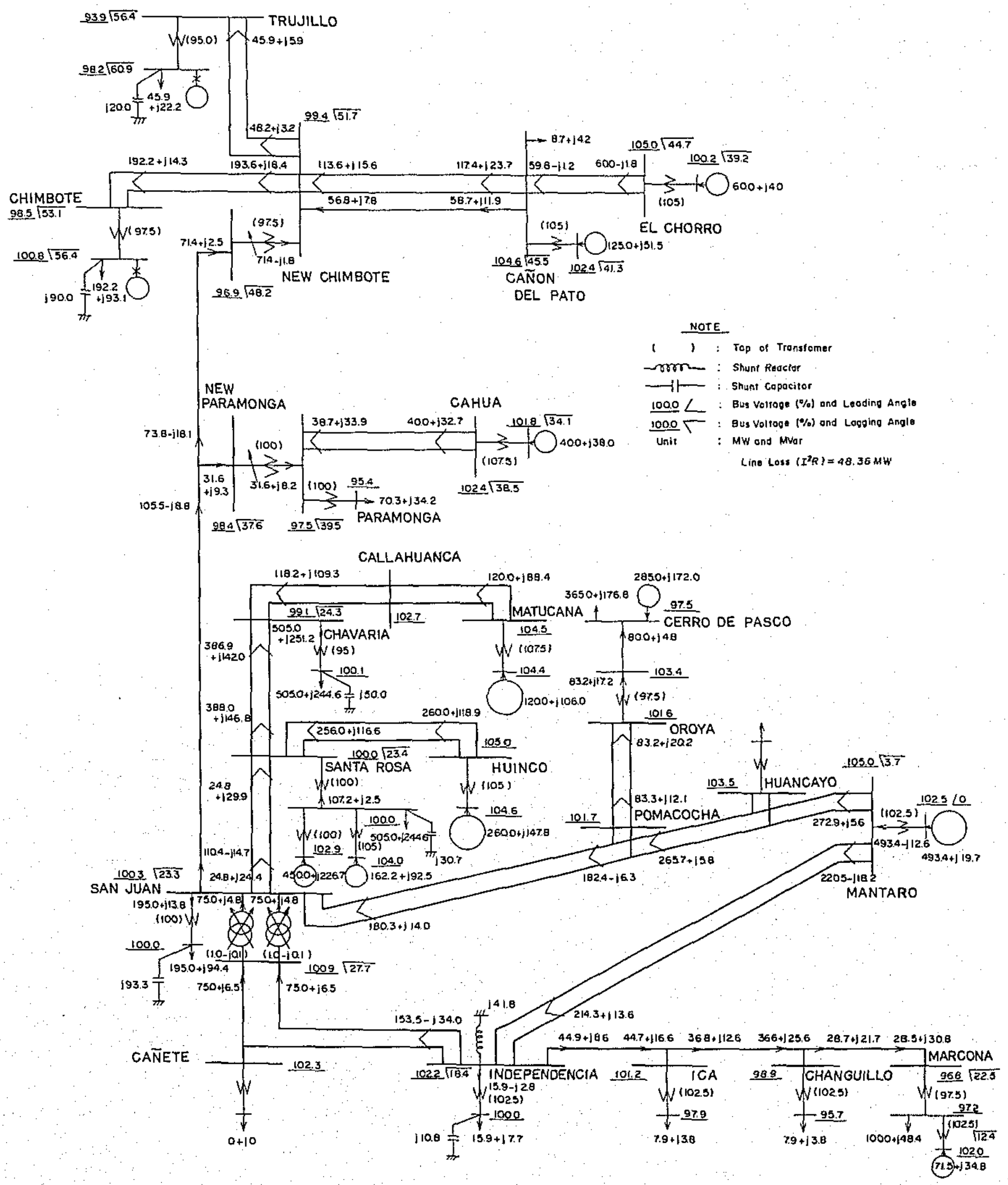


Fig.A-7 Power Flow and Voltage Regulation at Peak Time in 1982
(CAÑON DEL PATO Power Station Power Shedding)

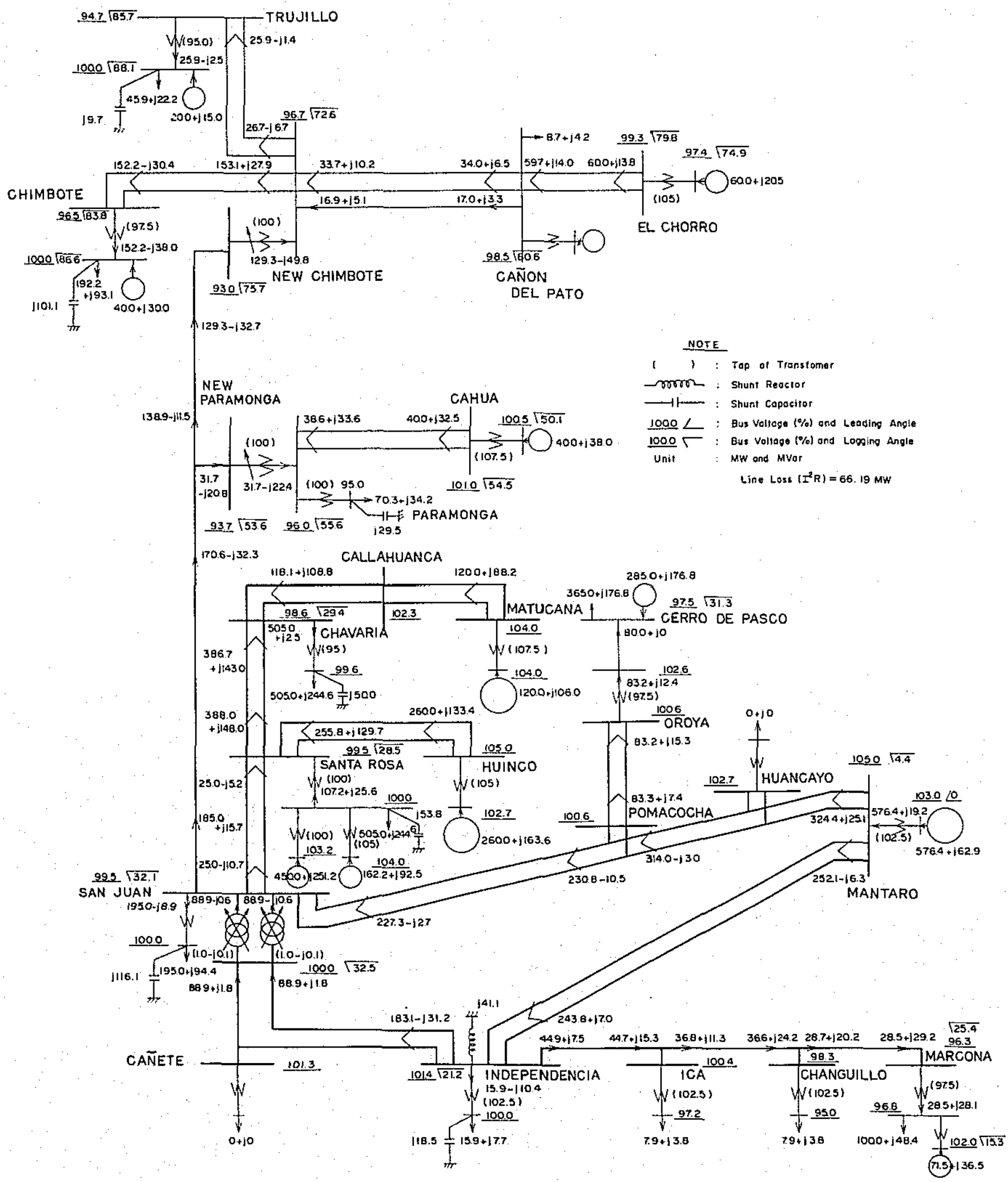


Fig. A-8 Power Flow and Voltage Regulation at Peak Time in 1983

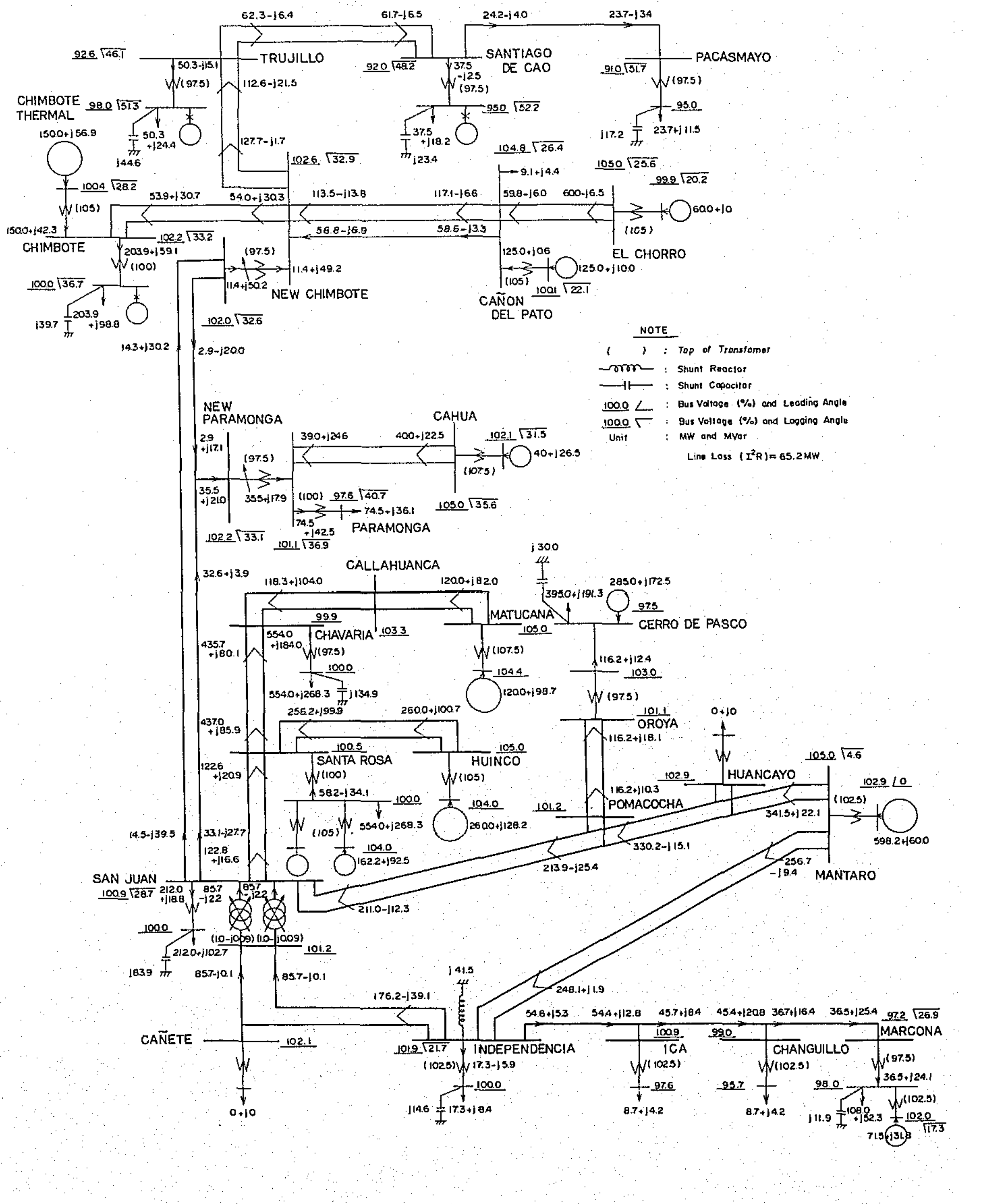


Fig. A-9 Power Flow and Voltage Regulation at Off Peak Time in 1983

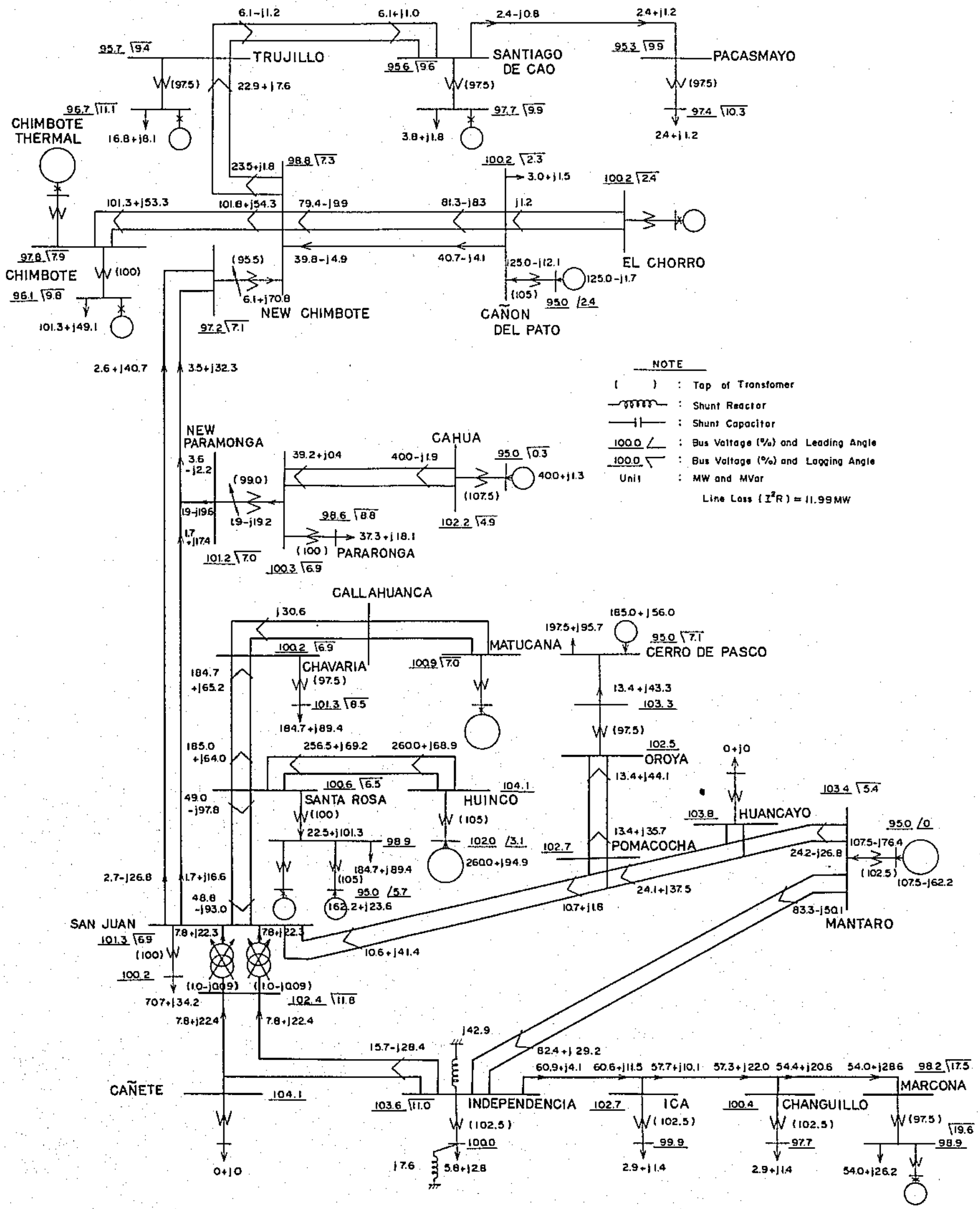


Fig. A-10 Power Flow and Voltage Regulation at Peak Time in 1983 (CHIMBOTE Power Station Power Shedding)

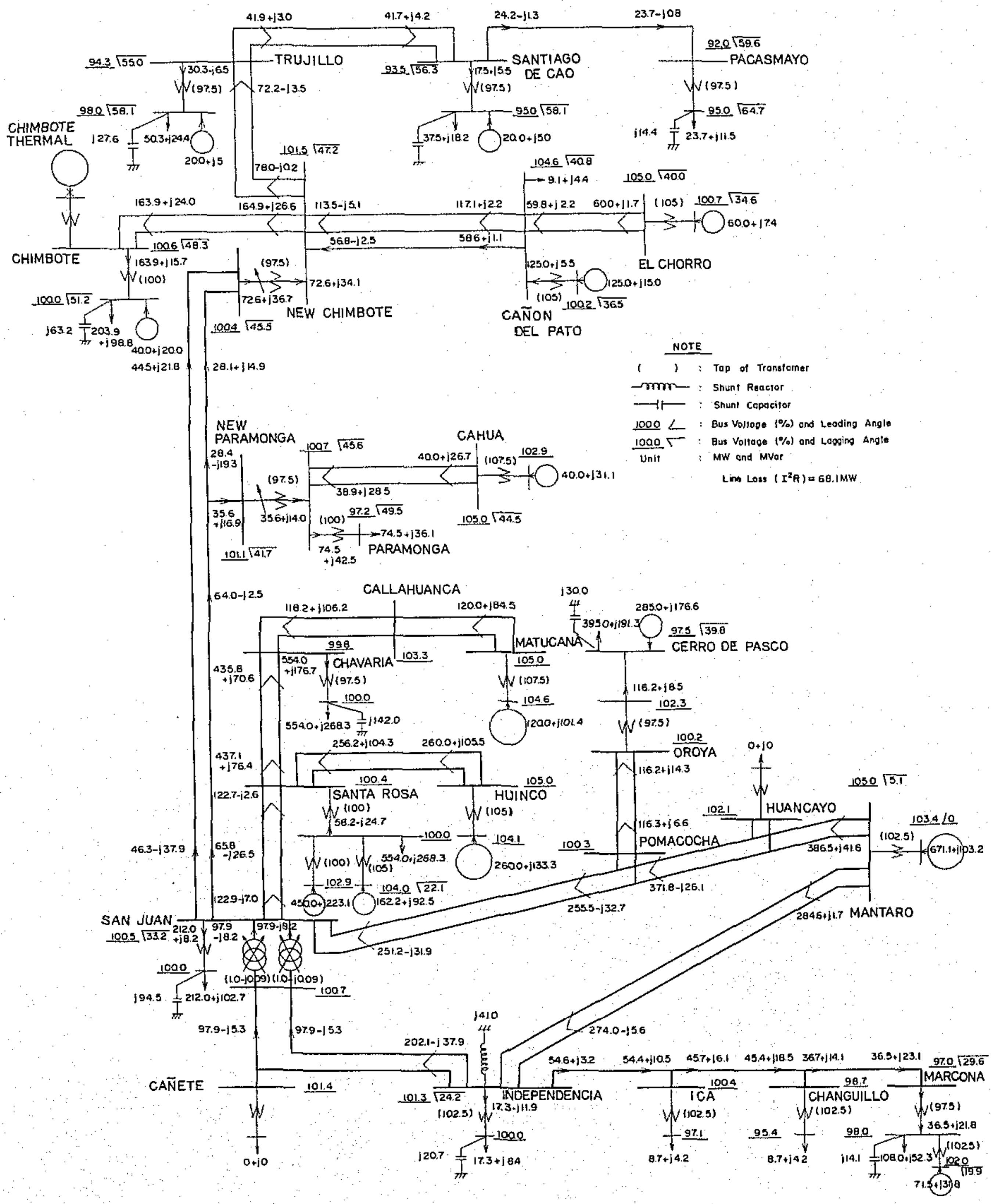


Fig. A-11 Alternative Plan
Power Flow and Voltage Regulation at Peak Time in 1983

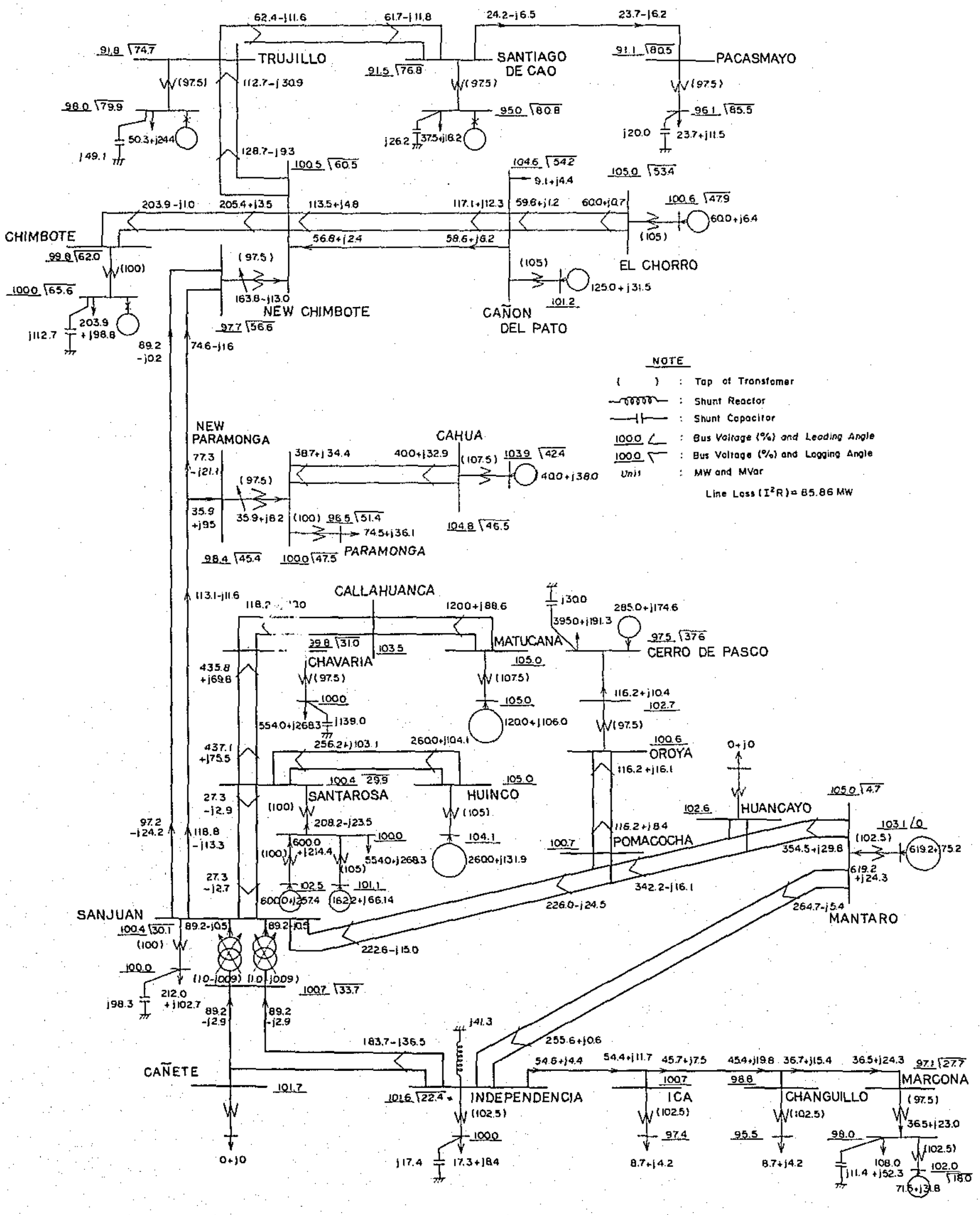


Fig. A-12 Alternative Plan
Power Flow and Voltage Regulation at Peak Time in 1983
(CAÑON DEL PATO Power Station Power Shedding)

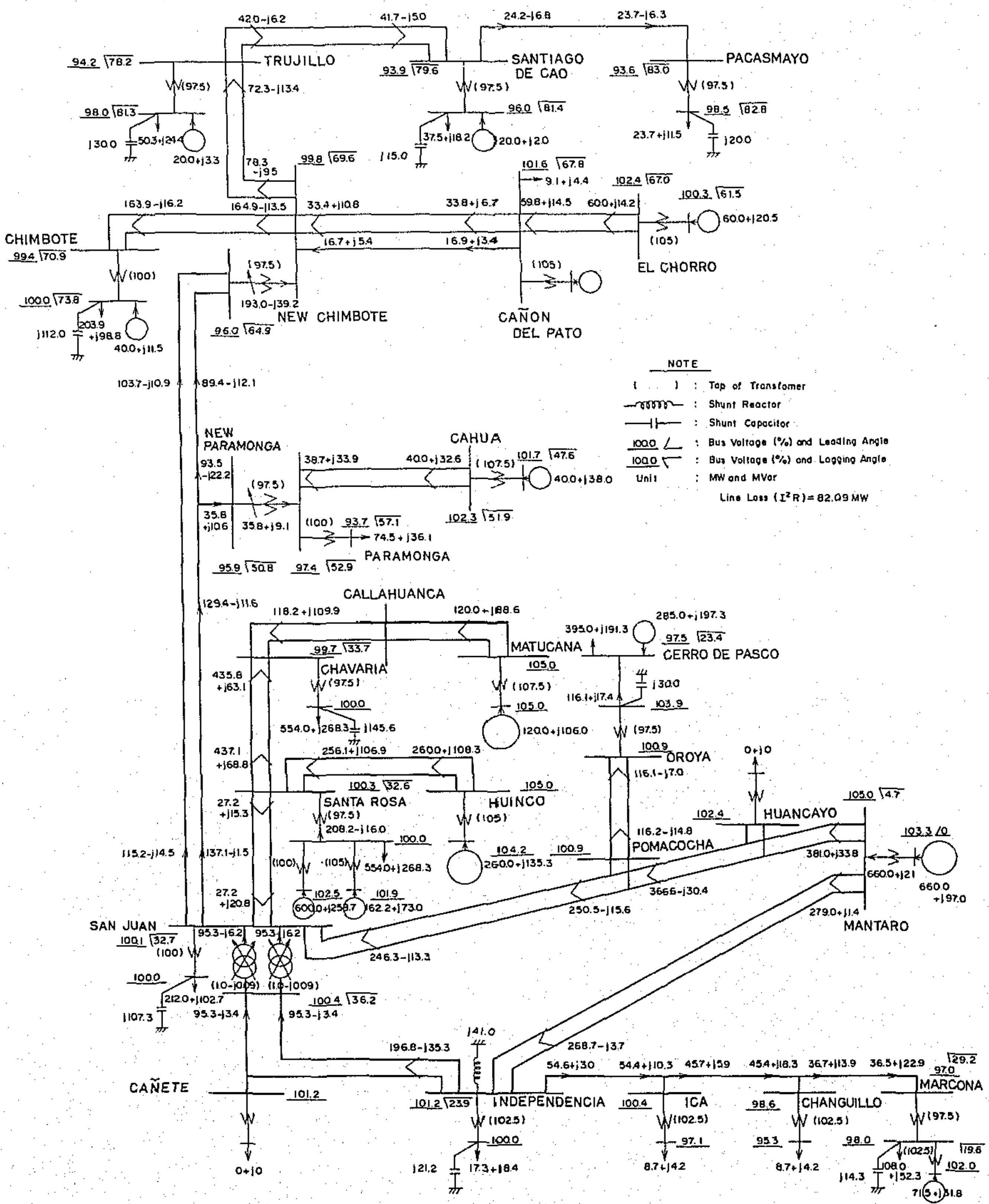


Fig.A-13 Transient Stability at Peak Time in 1982

(CAÑON DEL PATO Power Station Power Shedding)

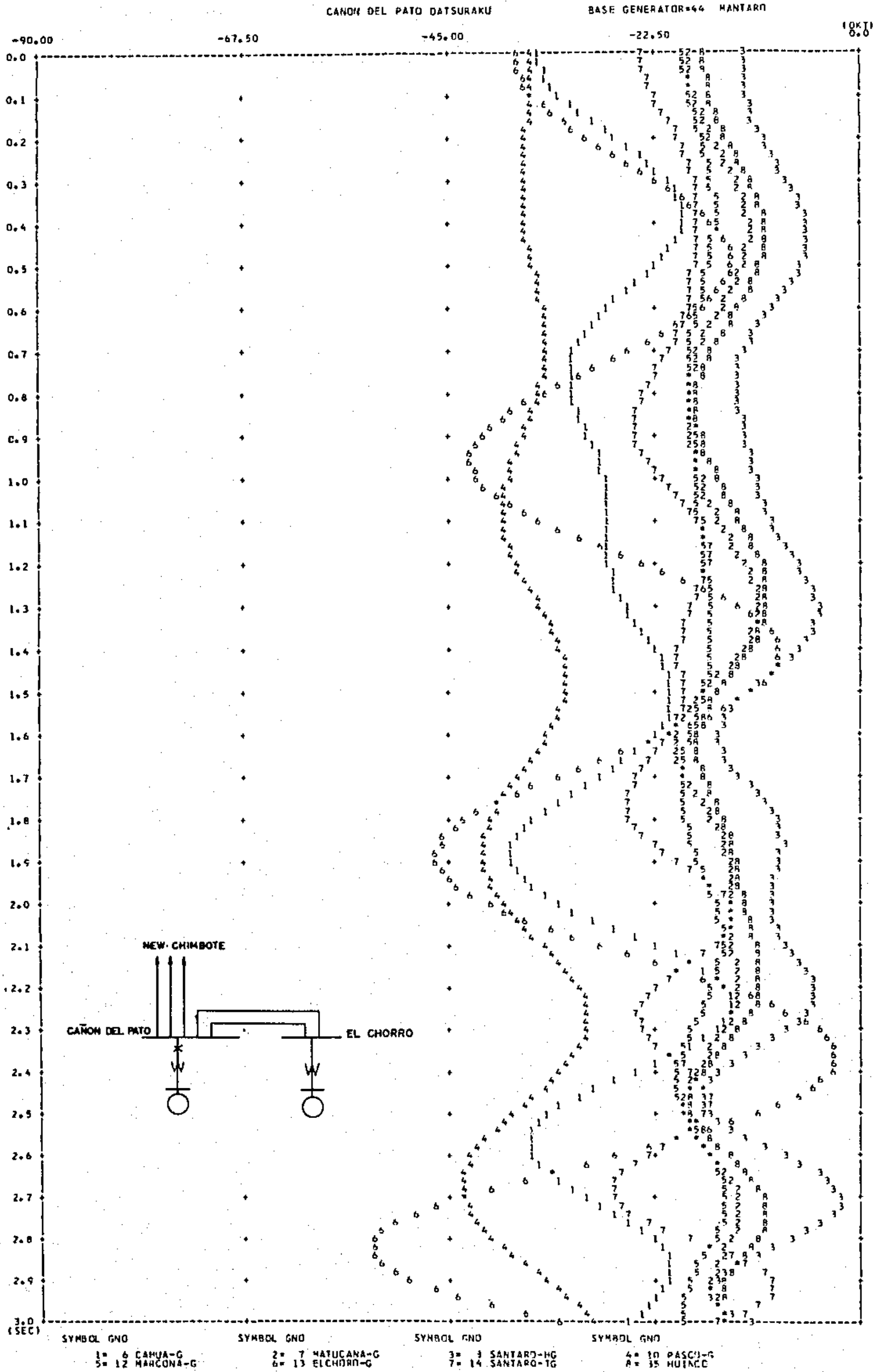


Fig. A-14 Transient Stability at Peak Time in 1983
(CHIMBOTE Power Station Power Shedding)

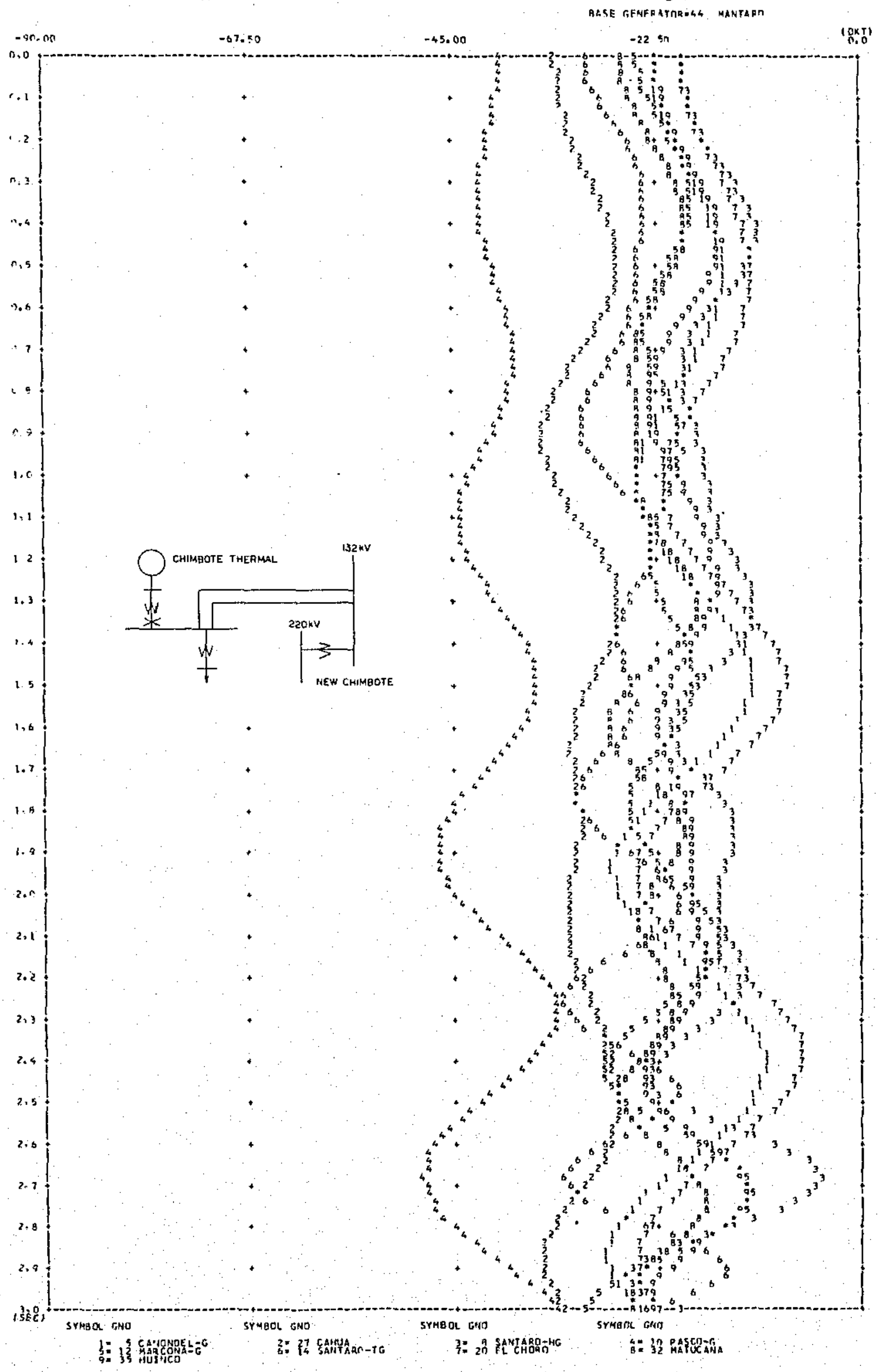


Fig. A-15 ALTERNATIVE PLAN

Transient Stability at Peak Time in 1983

1 CIRCUIT FAULT, Fault Point : SAN JUAN

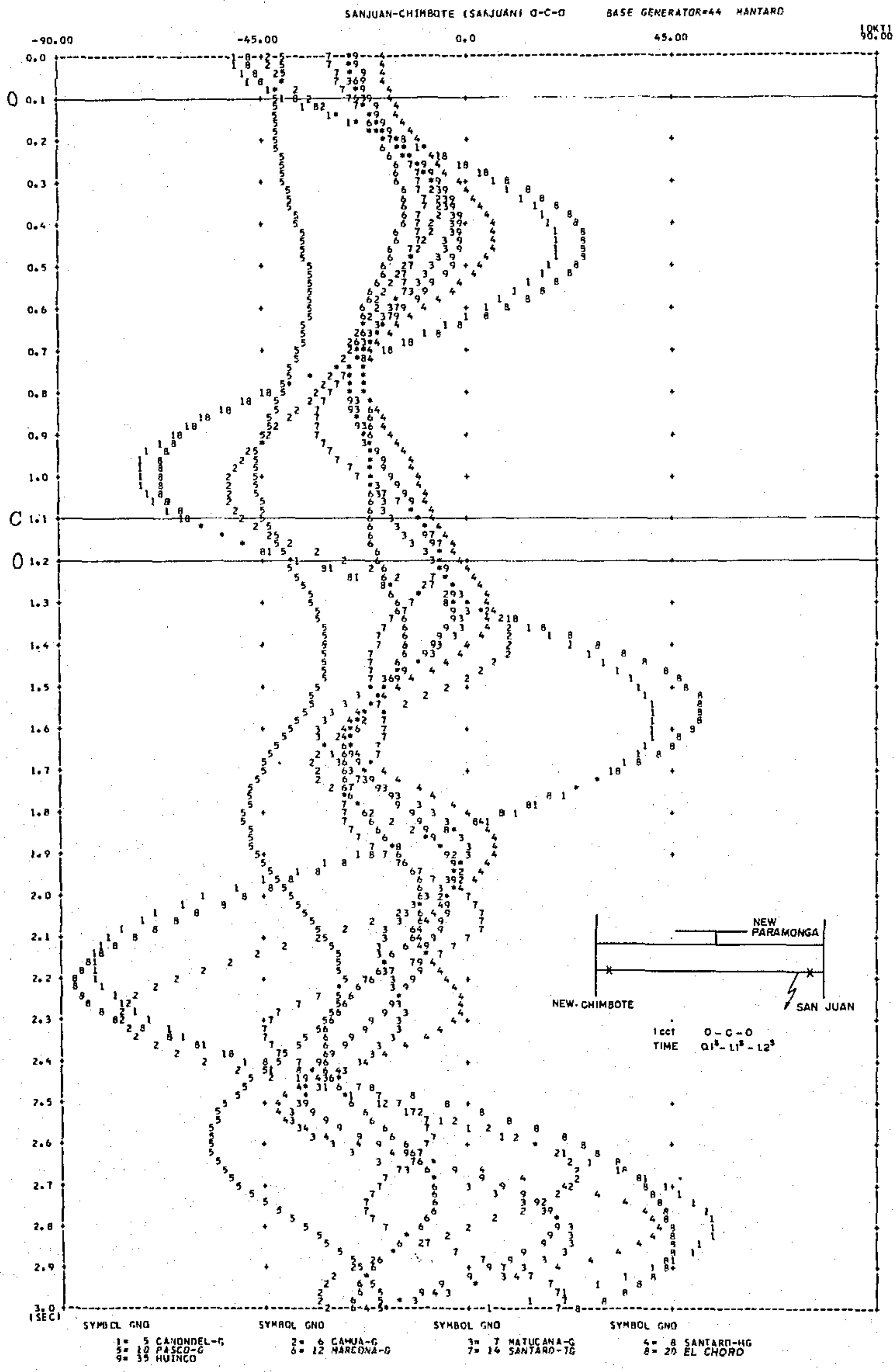


Fig. A-16 Fault Capacity in 1983

UNIT : MVA