BASIC DESIGN STUDY REPORT
ON
THE PROJECT
FOR
THE REHABILITATION
OF
TELECOMMUNICATIONS EXTERNAL LINE PLANT
IN
ACCRA
THE REPUBLIC OF GHANA

FEBRUARY 1987

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Republic of Ghana, the Government of Japan has decided to conduct a basic design study on the Project for the Rehabilitation of Telecommunications External Line Plant in Accra and entrusted the study to the Japan International Cooperation Agency (JICA).

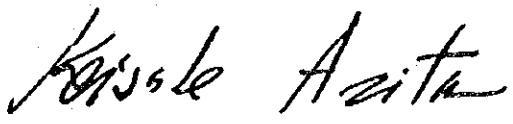
JICA sent to Ghana a study team headed by Mr. Noriyuki SHIGETA, Deputy Director, Telecommunications System Division, Ministry of Posts and Telecommunications, from October 25 to November 19, 1986.

The team had discussions on the Project with the officials concerned of the Government of Ghana and conducted a field survey in the Accra area. After the team returned to Japan, further studies were made and the present report has been prepared.

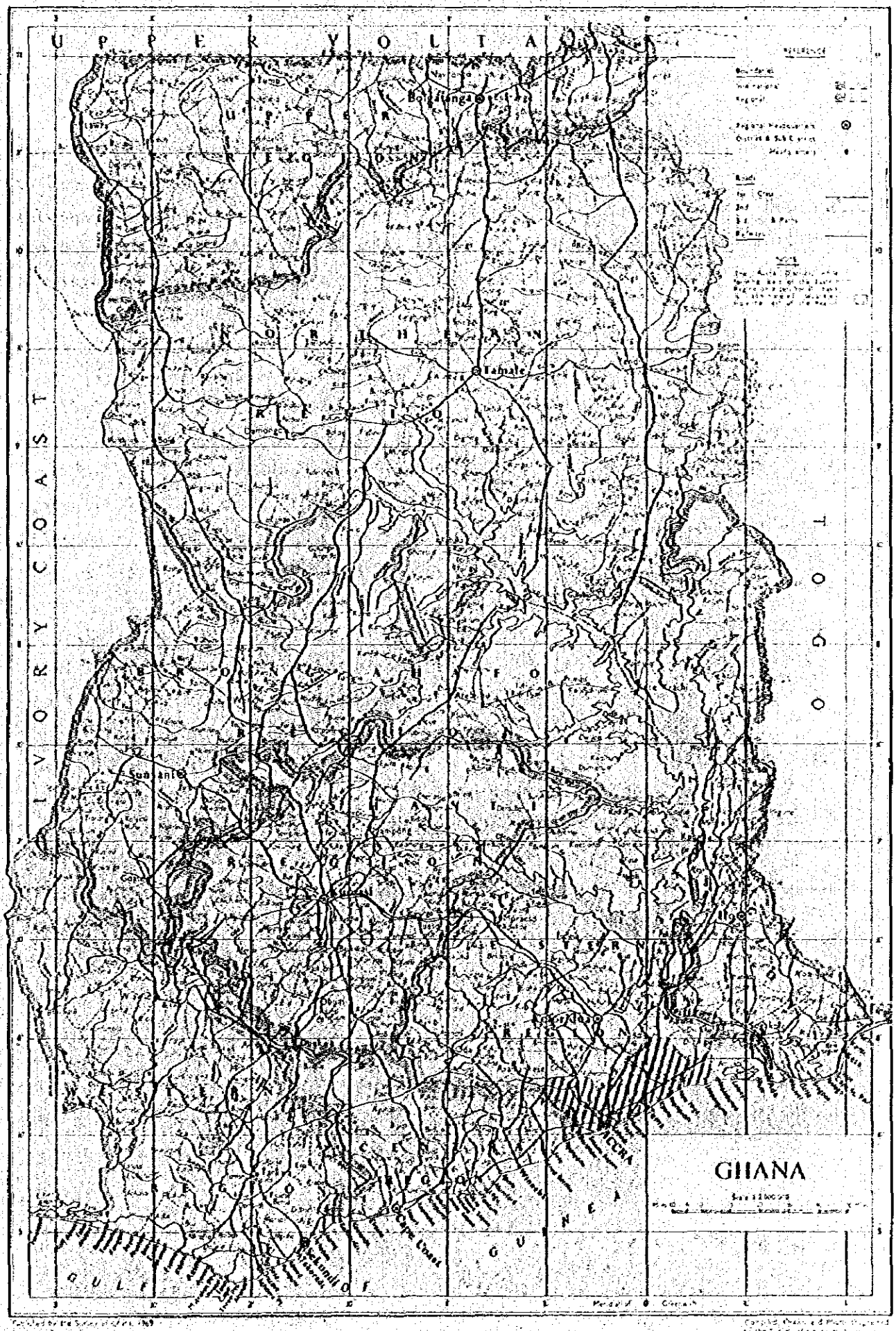
I hope that this report will serve for the development of the project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Republic of Ghana for their close cooperation extended to the team.

February, 1987



Keisuke Arita
President
Japan International Cooperation Agency


UPPER VOLTA
Bolgatanga
Tamale
Sunyani
Kumasi
Cape Coast
GHANA
IVORY COAST
TOGO
GULF OF GUINEA

SUMMARY

The Republic of Ghana, with the aim of improving and expanding telecommunications networks, has been making utmost efforts to update both international and national networks with loans from the World Bank, ADB, and the Governments of Japan and Canada. Transmission and switching facilities for international calls and trunk calls connecting major local cities have been steadily improved.

In Accra, the capital city and hence the administrative center of the country, additional 15,000 line units of up-to-date electronic switching equipment have been installed with the completion of some of these loan-financed projects. Consequently, switching equipment with a total capacity of 25,000 line units is presently being operated by the Ghana Posts and Telecommunications Corporation, or briefly P&T, which is in charge of the country's postal and telecommunications services.

In spite of such improvement in switching capacity, however, the telephone service in Accra still remains in extremely undesirable condition, mainly due to poor outside plant facilities.

Most of the existing outside plants were installed more than 20 years ago, and the number of circuits is too small to meet the present demands. In addition, many of the existing paper-insulated lead-sheathed cables have been deteriorated; they are seldom repaired nor replaced owing to insufficient maintenance and management plus parts procurement difficulty. Normally operating circuits are found only in a limited area.

With such overage outside plants, even the up-to-date electronic switching equipment cannot work efficiently. Thus the service demand from government offices, international organizations, foreign embassies, and private business offices are not fully satisfied. This naturally impedes seriously the successful progress of the country's economic recovery programme and the resultant reactivation of economic activities.

To improve such situation, the Government of the Republic of Ghana has established a rehabilitation plan for the telecommunications outside plants in Accra and, for its implementation, requested the Government of Japan to provide grant aid.

The plan consists of:

(1) Outside plant rehabilitation for eight key areas inside the service areas of three telephone exchanges in Accra, and
(2) Provision of electronic switching equipment for the training of maintenance and operation personnel.

In response to this request, the Japanese Government decided to carry out the basic design study on this project and entrusted its execution to the Japan International Cooperation Agency (JICA). JICA dispatched the basic design study team headed by Noriyuki Shigeta, Deputy Director, Telecommunications System Division, Telecommunications Bureau, Ministry of Posts and Telecommunications, Japan, to Ghana from October 25, 1986 to November 19, 1986.

The study team carried out the field survey and data and information analysis through the subsequent study in Japan, and reached the judgment that the aid for the required rehabilitation be described hereinafter:

(1) Outside plant rehabilitation for eight key areas inside the service areas of three telephone exchanges in Accra

The eight key areas comprise such areas as mentioned below where the outside plant rehabilitation is urgently needed, especially in view of the public importance of the telephone service there:

1) the area where Ghana government offices are concentrated;
2) the hospital area;
3) the central area of economic activities:

4) the area where foreign embassies are concentrated;
5) the airport residential area;
6) the east cantonments area;
7) the national broadcasting station area; and
8) the industrial area.

The scope of work includes replacement of underground cables, fitting of manhole covers and metals in manholes, replacement of underground conduit, installation of new cross-connecting cabinet and new distribution box.

Also included is the replacement of the community branch exchanges in the area where government offices are concentrated. These exchanges are more than 20 years old and cannot work well mainly due to parts procurement difficulty, and constitute the service bottleneck in the area. By replacing these facilities, effect of the outside plant rehabilitation is to be fully achieved.

(2) Introduction of training-use electronic switching equipment

P&T owns the Telecommunications Engineering School where it administers basic training to newly employed staff personnel and re-training to staff personnel several years after employment. On the training curriculum are switching, radio and outside plant technologies.

Presently, the up-to-date electronic switching equipment has already been put into commercial operation by P&T, and many more of such equipment is to be put to service in the near future. However, training of advanced system maintenance can hardly be made with the old-fashioned equipment which cannot work well.

Consequently, the training of the maintenance and operation personnel for these advanced systems is the prime requisite for satisfactory operation of the telecommunication services in Ghana.

Also with the outside plant rehabilitation, the number of telephone subscribers, as well as their calling traffic, will increase, and the work for switching equipment and test board personnel will increase, too. Therefore, the shortage of maintenance personnel is beyond doubt.

The main objective of this project is to upgrade the outside plant facilities in Accra. However, in order to ensure the satisfactory operation of the telephone network as a whole, harmonious and well balanced operation of both inside and outside plant facilities is prerequisite. Training-use electronic switching equipment is to be introduced under this project, with a view to training necessary maintenance personnel for switching system.

(3) Provision of maintenance equipment and materials

Maintenance-use tools, measuring equipment, vehicles and materials to be required after completion of the project are to be provided since the shortage of such equipment and materials constitutes another reason for unsatisfactory operation of the outside plant, besides the outage of the facilities.

(4) Provision of equipment and materials for training

For maintenance personnel training to be carried out by P&T at the Telecommunications Engineering School, necessary equipment and materials are to be provided. To be provided are equipment and materials necessary for training of about 170 personnel including the maintenance staff for completed equipment and system and those who receive three years training at the school.

The estimated cost to be borne by the Ghana side for the aforementioned outside plant rehabilitation project amounts to about 10 million Cedis. The project implementation period is considered to require 21.5 months in total after conclusion of exchange notes including 4.5 months for detailed design formulation and tender procedures.

It is expected that P&T, the implementing authority for this project, will proceed ahead with the rehabilitation and improvement of outside plants in other areas than the objective areas of this project, utilizing this plan and completed facilities as the model plant. Also expected is that this project implementation will serve for betterment of the telecommunication service management including operation and maintenance, accurate subscriber management, staff personnel training, etc.

After completion of this project, the average calling traffic which at present stands at 7 will be more than doubled to 15-17. The rate of tariff collection which is presently extremely low will also remarkably improve, contributing a great deal to improvement of P&T finance. These facts will further lead to administrative business efficiency enhancement at government offices, brisking of economic activities, alleviation of surface traffic congestion in urban areas, and so forth. It can be said that the effects of this project implementation are so extensive and versatile.

To summarize, this project assumes utmost importance in view of its contribution as the model plant to the realization of the outside plant rehabilitation in Ghana which entails much cost and money but is indispensable for materialization of the telecommunication network improvement programme now being promoted by P&T.

For Ghana busy with national economic reconstruction, telecommunications network improvement and expansion constitute the prime requisite as they are essential for upgrading the national life environment. In this sense, the grant aid cooperation by Japan for this project is considered to be a timely and significant commitment.

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CHAPTER 1 INTRODUCTION

CHAPTER 1 INTRODUCTION

The Ghana Posts and Telecommunications Corporation (P&T) is a governmental agency in charge of the postal and national/international telecommunications services in Ghana, and now implementing several telecommunications improvement projects, with the financial assistances from the World Bank, African Development Bank, and Overseas Economic Cooperation Agency, Japan.

These projects are to be completed soon. However, the telephone service in Accra, the capital and the administrative and political center of the country, is extremely poor because the outside plant facilities there have been overaged and severely deteriorated due to insufficient maintenance/operation management and parts procurement difficulty.

Under such circumstances, residents in Accra have been prevented from enjoying sufficient telephone service. Presently, 25,000 telephone line units exist in Accra, which however, is by no means enough to satisfy the demands. Moreover, only a limited number of them are operating normally. To relieve such situation, the Government of Ghana has established the outside plant rehabilitation plan for the city of Accra, and, to implement the plan, requested the grant aid cooperation from Japan.

In response to this request, the Government of Japan decided to execute the basic design study for the plan, and entrusted its execution to the Japan International Cooperation Agency (JICA).
JICA dispatched the basic design study team to Ghana for a period from October 25 to November 19, 1986. The study team was headed by Noriyuki Shigeta, Deputy Director, Telecommunications System Division, Telecommunications Bureau, Ministry of Posts and Telecommunications.

The team carried out the field survey concerning the condition of existing telecommunications facilities, degree of public utilization, maintenance and operation system, training system, and situation of infrastructure, in order to formulate the scope and scale of the project, studying the suitability of the project to the grant aid programme.

This report contains the results of analysis and studies of the data collected by the field surveys. The study team organization and study itinerary, minutes of meetings, etc. are given in ANNEX hereto.

CHAPTER 2 BACKGROUND OF PROJECT

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2-1 Overview of Republic of Ghana

The Republic of Ghana is a country situated near the center of Gulf of Guinea which is on the western coast of African Continent and in March 1957 became the first independent country in the British Settlements.

Ghana embraces the national area of about 238,500 km^2 which is equal to about 60% of the national territories of Japan. The population numbers 12,700,000 (as of 1983), whereof about 1,000,000 are in Accra, the capital city. The official language is English though the inhabitants use the local language in daily conversations. For religions, 43% are Christian, 38% believe in tribal religion and 12% are Muslims.

The climate is tropical and the annual average temperature is 21°C - 32°C. The weather is hot in March and cool in August. The rainy season covers May, June and July. Rainfalls are opulent in coastal areas but scarce in mountain areas.

The Government places emphasis on national education. Compulsory education was first enforced in 1969. Universities include University of Ghana and University of Cape Coast.

2-2 Economic Recovery Programme and Telecommunications

The Republic of Ghana is an agriculture-oriented country. As a matter of fact, agriculture constitutes the foundation of the country's national economy. However, the continued droughts in 1974 and afterward brought the economy on the brink of collapse.

The production of cocoa as staple product declined drastically. The food shortage also became aggravated.

For the reconstruction of the hard-hit Ghana economy, the creditor nation consortium approved in November 1983 the three-year economic recovery programme to the amount equivalent to US$720 million. The economic recovery guidelines at the initial stage were to transfer from the strictly controlled economic system to the more liberal economic system, as well as to stabilize the economy as a whole, and subsequently to respond to the improvement and development demands from each segment of the economy.

Such economic recovery policy has made considerable progress. Thus, the Government of Ghana has achieved its initial objective of realizing the stabilization of economy.
The main points of the economic recovery programme are:

- To carry out the elastic exchange policy.
- To provide incentives to agriculture.
- To eliminate price and distribution controls gradually.
- To reconsider the politically decided prices and adjust them quickly to the international exchange rates, and, at the same time, curtail the subsidy budget.
- To realize successive wages raises in the public service sector and keep them balanced with the wage levels in other sectors of the economy.
- To reconsider the budget policy by reducing the dependence on bank loans and increasing the utilization of national resources.
- To adopt the flexible policy about the payment of interest on loans.
- To formulate the improvement program for each infrastructure and restore its growth potential.

The year 1986 is the initial year of the Second Economic Recovery Programme of Ghana (ERP-II). The objective of ERP-II is to strengthen the foundation of economy established in the past three years.

Telecommunications constitute ultra important infrastructure as rapid information transmission media for socio-economic activities of contemporary society. Telecommunications perform vital roles for social welfare and security as well.

Despite the national transmission network and switching system in Ghana are improved through various projects, outside plants in Accra, the capital city and hence the administrative center, are superannuated. The plants more than 20 years old are poorly maintained due to difficulty in maintenance and operation as well as parts and components procurement. Telephone network as a whole fails to operate normally.

For high quality telecommunications service, indispensable is the integrated management of switching, transmission and outside plant facilities which are well balanced both qualitatively and quantitatively. In accra, however, superannuated outside plants have collapsed the balanced telephone network operation. Hence extremely low service level.

In Accra, speedy information transmission by telecommunications is practically impossible. This fact poses a serious impediment to further promotion of the national economic recovery programme which is making slow but steady progress. Thus, improvement and upgrading of telecommunications systems assume top priority as essential infrastructure in the endeavor toward successful conclusion of the programme.

2-3 Present Situation of Telecommunications in Ghana

2-3-1 Competent Authority and Common Carrier

The competent authority for telecommunications services is the Ministry of Transport and Communications. Its common carrier is Ghana Posts and Telecommunications Corporation (P&T). P&T consists of postal service division and telecommunications service division. The latter is subdivided into national and international service sectors. P&T organizational chart appears in Figure II-1.

P&T employees have decreased considerably. The worsening of national economy during the past 7-8 years kept P&T wage level low, causing not a few engineers to retire. The loss of balance in the number of employees is causing difficulties in corporate management. With a view to procuring necessary number of competent engineers to improve the above situation, P&T now gives high priority to the training of its staff.

Item	Quorum	Presently Employed
On full-time service:		
Telecommunications service	1,648	1,299
Postal service	1,892	1,582
Administration	1,647	822
Sub-total	5,187	3,703
Non-full-time employees	4,797	3,741
Total	9,984	7,444

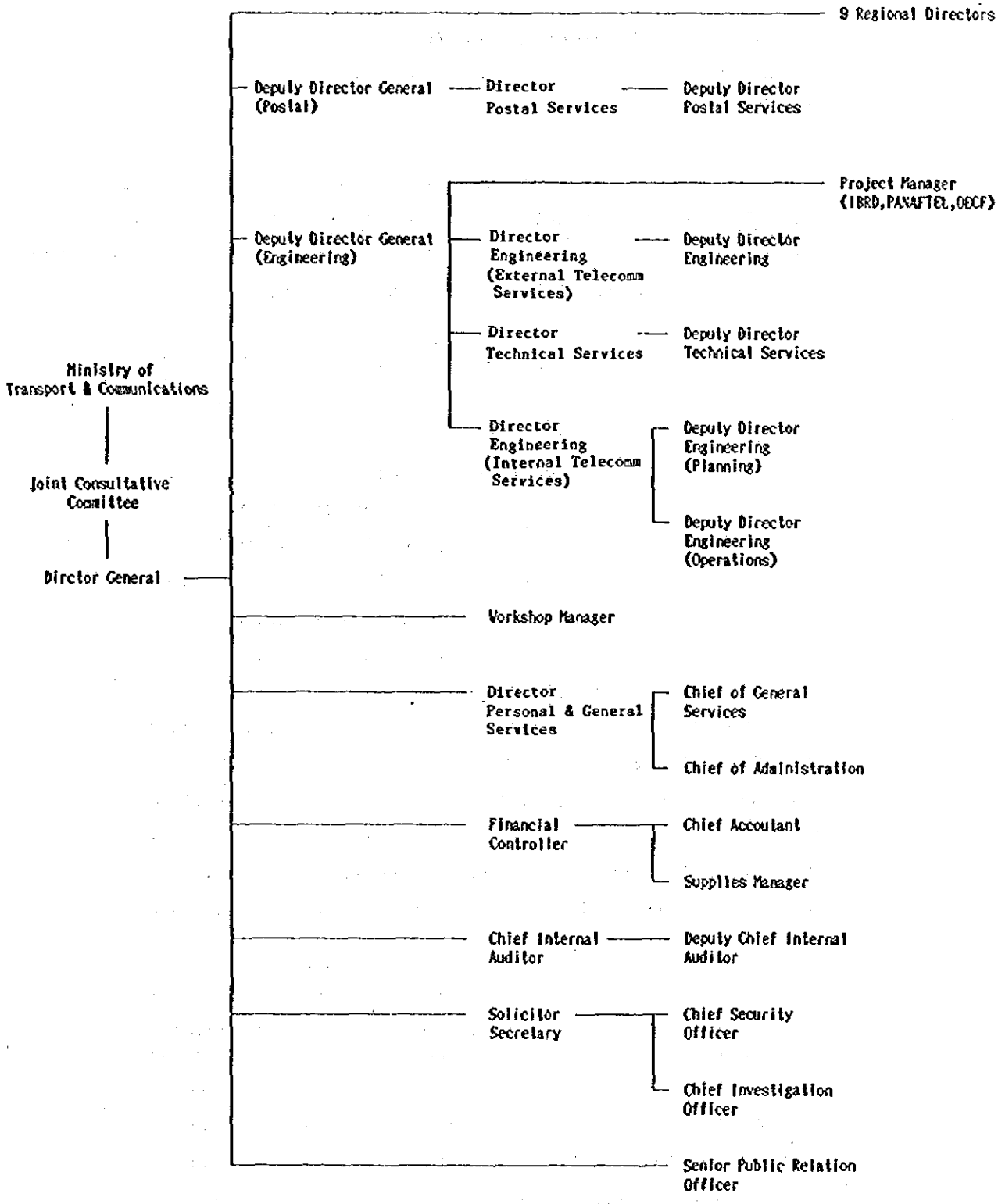


Fig. II-1 P&T Organization

2-3-2 Present Situation of Telecommunications

(1) Local Telephone

The number of local telephone exchanges, line capacity of switches, number of telephone subscribers, number of telephone sets, telephone diffusion rate (number of telephone sets per 100 inhabitants), etc., in Ghana are shown below:

1)	Number of local exchanges	(Total)	444	(1986)
	"	(Automatic)	24	
	"	(Manual)	420	
2)	Line capacity of switches	(Total)	56,000	(1986)
	"	(Automatic)	45,000	
	"	(Manual)	11,000	
3)	Number of subscribers	(Total)	38,400	(1985)
	"	(Automatic)	32,800	
	"	(Manual)	5,600	
4)	Number of telephone sets		71,000	(1983)
5)	Number of waiting applicants		30,000	(1985)
6)	Diffusion rate		0.6	(1985)
7)	Automatic service rate		80%	(1986)

Now operating automatic exchanges comprise four types. Switching units and line capacities are tabulated below.

Switch Type	No. of Switching Units	Subscriber Line Capacity
BPO 4000	4	8,400
UP49a/UD (Philips)	11	15,300
EMD F6 (Siemens)	1	3,000
HDX 10 (Hitachi)	13	18,300
Total	29	45,000

In Accra, the capital city, four (4) telephone exchanges, including Teshie/Nunga Exchange, are being operated with automatic switching equipment having 25,000 line units in total (as of year 1986) to provide telephone service to about 19,000 (as of year 1986) subscribers.

The figure in Accra represents about half of the national total. Details are shown in Table II-1.

(2) Toll Telephone and Transmission Routes

The toll telephone service as of 1985 is described below.

1) STD Service Area

STD service is available to/from the undermentioned 20 cities.

Accra, Cape Coast, Takoradi, Kumasi, Swedru, Koforidua, Ho, Sunyani, Tamale, Bolgatanga, Bawku, Manpong Ashanti, Konongo, Bekwai, Obuasi, Dunkwa, Tarkwa, Akosombo, Tema, Afloa/Denu

2) Toll Electronic Switches

Now operating toll electronic switches are of Japanese and Holland make.

3) Transmission Routes

The present nationwide transmission routes are shown in Figure II-2.

Table II-1 Existing Automatic Telephone Exchanges in Ghana

As of December 1985

No.	Exchange	Equipment Type	Year of Installation	Sub.Lines Capacity	Number of Sub.Lines	Utilization	Demand on Waiting List	Total
1	North	UR49a	1968	10,000	8,323	83.2%	6,064	14,387
2	Central*	HDX10	1986	8,000	4,729	59.1%	8,694	13,423
3	Cantonments*	HDX10	1986	6,000	3,325	55.4%	3,133	6,458
4	Teshie/Nungua	HDX10	1986	1,000	57	5.7%	32	89
5	Tema	EMD F6	1961	3,000	2,734	91.1%	3,046	5,780
6	Kumasi	BPO 4000	1957,1966	4,600	4,581	99.6%	913	5,494
7	Mampong	UD	1977	200	200	100.0%	5	205
8	Konongo	UR49a	1971	200	174	87.0%	10	184
9	Obuasi	HDX10	1986	300	159	53.0%	58	217
10	Bekwai	HDX10	1986	200	136	68.0%	8	144
11	Takoradi I	BPO 4000	1961	1,800	1,787	99.3%	417	2,204
12	Takoradi II	HDX10	1986	1,000	0	0.0%	0	0
13	Sekondi	BPO 4000	1961	1,000	688	68.8%	60	748
14	Tarkwa	HDX10	1986~	400	291	72.8%	39	330
15	Koforidua	UR49a	Dec.1968	1,000	998	99.8%	1,119	2,117
16	Akosombo	UR49a	1971	600	323	53.8%	248	571
17	Tamale	UR49a	Feb.1969	1,000	963	96.3%	260	1,223
18	Bolgatanga	UR49a	1972/1978	800	620	77.5%	25	645
19	Bawku	UD	1977	100	89	89.0%	9	98
20	Cape Coast	BPO 4000	1963	1,000	974	97.4%	662	1,636
21	Swedru	UR49a	Dec.1967	300	291	97.0%	175	466
22	Dunkwa	HDX10	1986	300	177	59.0%	118	295
23	Sunyani I	UR49a	May 1969	500	484	96.8%	1,199	1,683
24	Sunyani II	HDX10	1986	400	0	0.0%	0	0
25	Ho I	UR49a	1967	600	554	92.3%	1,264	1,818
26	Ho II	HDX10	1986	400	0	0.0%	0	0
27	Aflao/Denu	HDX10	1986	300	123	41.0%	197	320
	Total	-	-	45,000	32,780	72.8%	27,755	60,535

Note* : Two (2) switching units are installed.

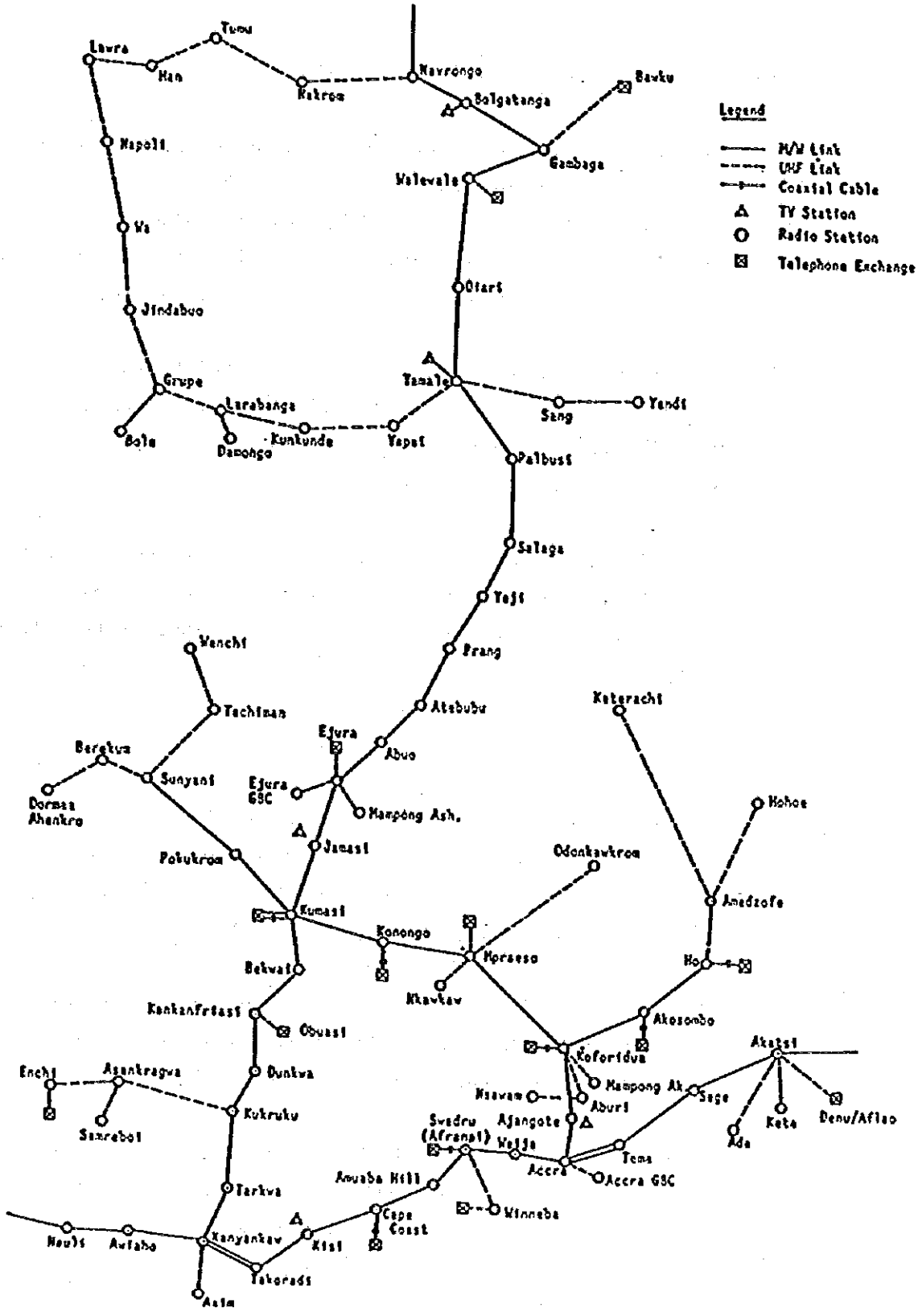


Fig. II-2 Existing Transmission Network in Ghana

4) International Calls

INTELSAT satellite system earth station exists at Nkuntunse, Ghana. It began operation in August 1981. The Nkuntunse earth station was constructed by SPAR Technology, of Canada, with Canadian loan. Capacity is for 168 circuits; however, capacity extension up to 180 circuits is possible.

By this system, direct telephone calls and telex communications to/from almost all parts of the world can be made. Relay stations are in the U.S., Britain, France, West Germany, Italy and Ivory Coast.

As of 1985, originating international calls number 126,855 and terminating international calls 151,680. Total originating call time is 793,612 minutes, and average time per call is 6.25 minutes.

5) Telex Service

International telex service, like other telecommunications services, can cover practically the whole world via satellite circuit. One automatic telex switching equipment of 784 line units in capacity is operating.

In Accra, telex subscribers can be connected by local telephone network. In rural areas, telex subscriber connection is via radio transmission route.

As of 1985, telex subscribers number 357. Service is of high quality. International telex service utilization frequencies in 1985 are as follows:

Message originations	359,136
Message terminations	372,432

2-3-3 Problem Involved in Telecommunications

In Ghana, toll transmission routes in all four directions are almost complete, as previously stated in Paragraph 2-3-2 (2). From now forward, transmission routes interconnecting medium and small sized rural cities are to be completed. With this, nationwide transmission routes will become almost complete.

Compared with backbone transmission route construction which is financed by foreign loans and other financial assistances and making steady progress, local network construction is lagging far behind.

This especially holds true in Accra which is the capital city and hence the center of administrative, economic and other national activities. Nearly one half of telephones installed in the country are concentrated in Accra. Nevertheless, the present telephone service in Accra is at an extremely low level. More than 50% of telephone circuits now used are trouble ridden and do not operate normally. Administrative and economic activities are being seriously impeded.

Such being the circumstances, people no longer depend upon telephones as public utilities. Business communications, etc., are being delivered to the other parties by messengers.

Waiting subscribers who have applied for their telephone but who cannot have their telephone installed yet a great deal of number.

Major causes of troubles with telecommunications facilities are:

(1) Facilities corrosion due to superannuation (more than 20 years after installation)
(2) Shortage of maintenance materials and spare parts
(3) Rain water incursion into time-worn cables through pinholes or at plumbing edge (splicing point)

(4) Cable damage due to other construction works (road, electricity and water works)

(5) Defective distribution boxes, drop-wires and subscriber's premise facilities

(6) Delay in trouble-shooting due to maintenance staff shortage

Judging from the foregoing, it can be safely assumed that outside plant outage with time in Accra constitutes the major bottleneck to telephone service improvement. Temporary control of cable faults is just an expedient for the present; new faults are sure to follow. Really important for the future is to replace more than 20-year-old facilities with new long-life facilities.

2-3-4 P&T Business Records

P&T's business records for the fiscal year 1984 (January 1 - December 31) are as follows:

(US$ 1 = 504 Cedis) (Unit: 1,000 Cedis)

	Revenue	Expenditure	Balance
Posts	76,230	80,984	-4,754
National telecommiunications	99,846	138,931	-39,085
International telecommunications	170,097	74,983	95,114
Central Workshop	1,196	3,806	-2,610
Others	7,248	-	7,248
Government subsidy	25,140	-	25,140
	1	-	1
Assets disposal	5,073	-	5,073
Depreciation expense	-	2,310	-2,310
		Total balance	83,817

Source: Posts and Telecommunications Corporation of Ghana Report of Auditors for the Year ended 31st December, 1984

As seen in the table above, the corporate management of P&T in the fiscal year 1984 produces a surplus balance amounting to 3,815,000 Cedis (approximately 411 million Japanese Yen when converted at the rate of exchange as of 1984 of about 245 Japanese Yen to US$ 1).

The above table, however, does not include the outstanding loan of communication projects in the past implemented by P&T, amounting to 940 million Cedis.

In individual sectors, a broad deficit in national communication sector and a significant surplus in international communication sector present a striking contrast.

For this fact, it can be pointed out that the most part of communication projects of Ghana in the past, financed by IBRD, PANAFTEL or OECF loans, were to improve/expand the satellite communication system, toll transmission networks and switching equipment. Local communication networks, especially outside plant facilities which have seldom or never been taken up in the past projects, remain superannuated. Because of their being more than 20 years old, faults are frequent, causing many subscribers to refuse payment of tariffs, while, on the other hand, maintenance cost, especially repair cost, continues to increase.

The revenue and expenditure breakdown of national and international communication services is shown below.

National Telecommunications Service

	(Unit: 1,000 Cedis)
Revenue	99,846
Telephones	
Rental fees	2,006
Installation fees	2,022
Call fees	116,081
Directories, advertisements	476
Telegrams	1,334
Broadcasting channel maintenance	295
Miscellaneous revenue	493
Reserve	(22,861)
Expenditure	138,931
Personnel expense	63,109
Supplies expense	19,974
Maintenance expense	14,530
Others	2,225
Transportation expense	6,312
General expenses	32,781
Revenue and Expenditure Balance	-39,085

International Telecommunications Service

	(Unit: 1,000 Cedis)
Revenue	170,097
International call fees	52,416
Telegram fees	84,067
Telex fees	35,987
Miscellaneous revenue	3,265
Leased circuit rental fees	(801)
Reserve	(9,837)
Expenditure	74,983
Personnel expense	5,064
Supplies expense	61,694
Maintenance expense	3,885
Others	629
Transportation expense	3,711
General expenses	32,781
Revenue and Expenditure Balance	95,114

2-3-5 Telecommunications Engineering School

Telecommunications Engineering School of P&T is located along Nusawan Road 3 km to the north of Accra North Exchange. At the school, telecommunications training is administered to P&T employees. The Organization of the school is given in Figure II-3.

Training at the school is twofold. One is for newly employed personnel. The other is for personnel several years after their employment.

Curriculum at training course for new employees comprise basic telecommunications knowledge, as well as specialized knowledge about switching, transmission, radio and outside plant facilities. Training consists of classroom lectures and on-the-job training. In the course of training, trainees are divided into several groups according to their aptitudes and specialized training is given to each group of trainees.

Training for personnel several years after their employment is to make them leaders in their respective fields of speciality. Therefore, training is mainly on on-the-job basis. Trainees are invited from all parts of Ghana so that the telecommunications technical level can be balanced and further improved all over the country.

Switching technology training is far from being satisfactory at the present stage. For, switching equipment now used for training is of old-fashioned malfunctioning step-by-step or crossbar type. Training using recently introduced digital switching equipment is not adopted at the school. Therefore, this training is limited to field training at each exchange.

For training of outside plant technology, on-the-job training is being held, using paper insulated lead-sheathed cable for trainees employed by P&T. Training is mainly about installation, splicing and

tests of all kinds. However, training is unsatisfactory because of old-fashioned measuring equipment, as well as shortage of training facilities, materials and manuals. Nor is made the training on new technology, such as installation, splicing and fault location for jelly filled cable. Training on such new technology will be introduced by this project. The outline and schedule of technical training course in the school are given in Table II-2.

2-3-6 Introduction of Switching Equipment by IBRD Project

P&T is carrying out several projects for improving national and international telecommunications networks. In 1975, P&T obtained IBRD loan to finance the Accra and rural cities telephone network improvement and expansion project.

This project is to improve and expand switching equipment in Accra, the capital city, and major rural cities, as well as radio and transmission systems interconnecting those cities. At present, most of the construction work has been completed.

As for switching equipment, up-to-date electronic switching equipment of Japanese make is introduced and operating at 11 exchanges in Accra and main rural cities (18,300 circuits). Line units of this electronic switching equipment, radio/transmission routes and other details are shown in Table II-1 and Figure II-2.

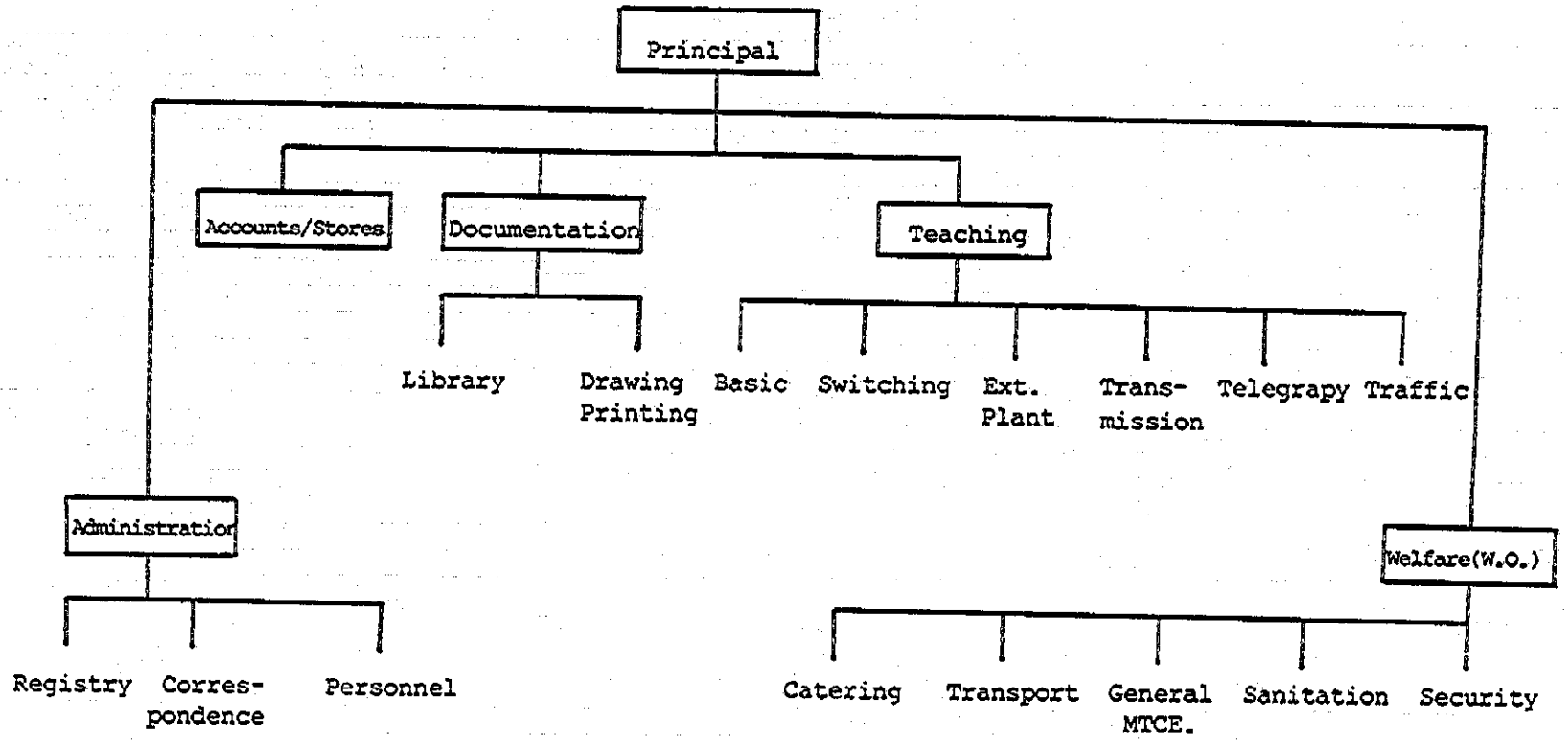


Fig. II-3 Organization Chart of Telecommunications Engineering School

Table II-2 Schedule of Training Course in Telecommunications Engineering School

COURSE TYPE	COURSE TITLE	NO. OF TRAINEES	DURATION IN WEEKS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	REMARKS
BASIC COURSES	ASSISTANT TELECOMMUNICATIONS SUPERINTENDENT- IN- TRINING	30	16													
	TECHNICIAN - IN- TRINING	24	10													
	PABX OPERATER - IN- TRINING	10	4													
	ADVANCEMENT COURSE	12	6													
REFRESHER COURSES	CABLE FAUET TESTING AND LOCATION	10	4													
EXTERNAL PLANT	GENRAL CABLE JOINTING AND PLUMBING	10	4													
	GENRAL EXTERNAL PLANT MAINTENANCE	10	4													
	TEST DESK DUTIES	10	4													
SWITCHING	NDX-10(MEDIUM SIZE EXCHANGE)	17	15													This course started from 28th october 1985
	PHILIPS UB-200 PABX	10	6													
	STD UY SIGNALING	10	10													
RADIO	NEC SERIES (OECF) MICROWAVE AND MAX EQIPMENT COURSE	20	10													This course started from 9th decesber 1985
	MICROWAVE SUPERVISARY EQIPMENT COURSE	10	4													
	MULTIPLEX AND MICROWAVE TRANSMISSION	10	4													
	SATELLITE COMMUNCAIONS	4	6													
	RIGGERS COURSE	8	8													
TRAFFIC	HITACHI SWITCHBOARD SUPERVISORS AND TELEPHONISTS	15	2													
TELEGRAPHY	BASIC AND ROUTINE MAINTENANCE COURSE (NO.4)	6	3													
	CREED TELEPRINTER NO.54	6	6													
	SIEMENS T1000	6	4													
	V.F.T	4	4													
POWER PLANT	O.E.C.F.POWER COURSE	13	4													
	AUTO EXCHANGE POWER SUPPLIES	10	4													
	ENGINE GENERATORS COURSE	10	3													
POSTAL	SNR.POSTMASTERS.etc	76	2													
GENERAL TELECOMS	DIGITAL ELECTRONIC FANDAMENTALS	10	4													
	COMPEUTER PRINCIPLES	6	4													
	TELECOMS SYSTEMS APPRECATION	10	2													
	SUPERVISORY MANAGEMENT	10	2													
INVESTIGATION BRANCH COURSE	INVESTIGATION BRANCH CORSE	27	2													
TOTAL NUMBER OF TRAINEES				37	37	50	50	50	33	20	-	16	16	16	-	27	27	-	-	31	31	31	16	71	81	66	66	30	30	82	82	82	82	78	50	50	64	84	101	121	120	100	100	64	42	202	202	4	4	-	-	

2-4 Background and Contents of Ghana's Request

For telecommunications network improvement and expansion, international and national transmission and switching systems are being steadily improved and expanded by the undermentioned projects. These projects are scheduled to be completed before long.

(1) Satellite system earth station project
(1979 - 1986; financed by Canadian loan)

(2) Telephone network expansion project in Accra and main rural cities
(1979 - 1986; financed by IBRD loan)

(3) Pan-African telecommunications network project
(1980 - 1986; financed by AfDB loan)

(4) Northern region radio transmission network expansion project
(1980 - 1986; financed by Japanese loan)

(5) P&T financial management service project
(1985 - 1988; financed by Japanese loan)

In Accra, the capital city and administrative center, switching equipment with total capacity of 25,000 line units including up-to-date electronic switchboard with capacity of 15,000 line units is installed. Maintenance and operation of this switching equipment is undertaken by P&T which is in charge of postal, as well as national and international telephone services.

However, the most part of outside plants including cables that connect the switching equipment and subscribers are worn out because they were installed more than 20 years ago. Full maintenance has not been carried out by reason of P&T's financial constraints. Many telephone circuits remain trouble-ridden for a long period. Thus, in Accra, telephone service level is extremely low.

Because of outside plant superannuation, even the up-to-date electronic switching equipment cannot operate at top efficiency. Government offices, international organizations and foreign embassies, as well as government and private business offices, cannot have their telephones operate as they should. This fact is a serious blow to the economic recovery programme and economic activities in general.

In Accra and main rural cities, up-to-date electronic switching equipment has been introduced by IBRD loan project. Maintenance staff training to keep such switching equipment in normal operation has been carried out in Ghana and Japan. However, due to Ghana's economic degradation and P&T's financial deterioration, a considerable number of trained maintenance engineers have given up their job at P&T.

In order not to cripple maintenance and operation service from now on, P&T is to establish switching equipment for training-use at the Telecommunications Engineering School to continue maintenance staff training.

In view of the foregoing situation and to put it under control, the Government of Ghana has requested the Government of Japan to provide grant aid cooperation for rehabilitating the outside plant facilities in Accra.

CHAPTER 3 OUTLINE OF PROJECT

CHAPTER 3 CONTENTS OF PROJECT

3-1 Objective

This grant aid project aims to improve and upgrade the outside plants in eight key areas inside the service areas of three telephone exchanges in Accra, and to contribute to the successful implementation of the national economic recovery programme, as well as the promotion of economic activities in general. At the same time, the project aims at the consolidation of the maintenance and operation system of overall local telephone network in Accra through the establishment of up-to-date electronic switching equipment at P&T's Telecommunications Engineering School and the continued training of maintenance staff personnel.

3-2 Study of The Request

The initial request from the Government of the Republic of Ghana consists of two main items. They are:

(1) Improvement and upgrading of outside plants in eight key areas inside three telephone exchange service areas in Accra.

(2) Establishment of switching equipment for training-use at P&T's Telecommunications Engineering School.

Attached to Item (1) above was the map showing the eight key areas. Also attached was the summary description of outside plants in the eight key areas. The order of precedence by areas for the outside plant rehabilitation work was specified. For Item (2), no in-depth comment was available.

To study the background, contents and impact of the project, as well as the project fitness for grant aid cooperation, the study team conferred with responsible officials of the Government of Ghana,

where necessary, in the course of field surveys. Through the field surveys were collected data concerning the following items:

1) Features of project coverage areas
2) Underground cable condition
3) Underground conduit condition
4) Subscriber's premise facilities
5) Inside plant condition
6) Maintenance and operation system
7) Training system
8) P&T organization and corporate management
9) Other project(s) associated
10) National Development Programme
11) Present situation of the Republic of Ghana

Data and information collected through field surveys were analyzed in Japan and, based on the findings, the contents of the Ghana Government's request were studied in depth. Judgment was then made concerning the project fitness for grant aid commitment, and the scope of work was determined as stated below.

(1) Project Coverage Areas

The eight key areas (as shown in Figure III-1) inside the three telephone exchanges service areas in Accra are areas where administrative organizations are concentrated, the hospital area, the central area of economic activities, the area where foreign embassies are concentrated, the state-managed broadcasting station area, and the industrial area. Though the order of precedence is given to these areas, all of them are important areas for administrative and economic activities of Ghana. Therefore this project covers all these 8 areas.

The general description including features of each area appears in Section 3-3-2 of this Chapter.

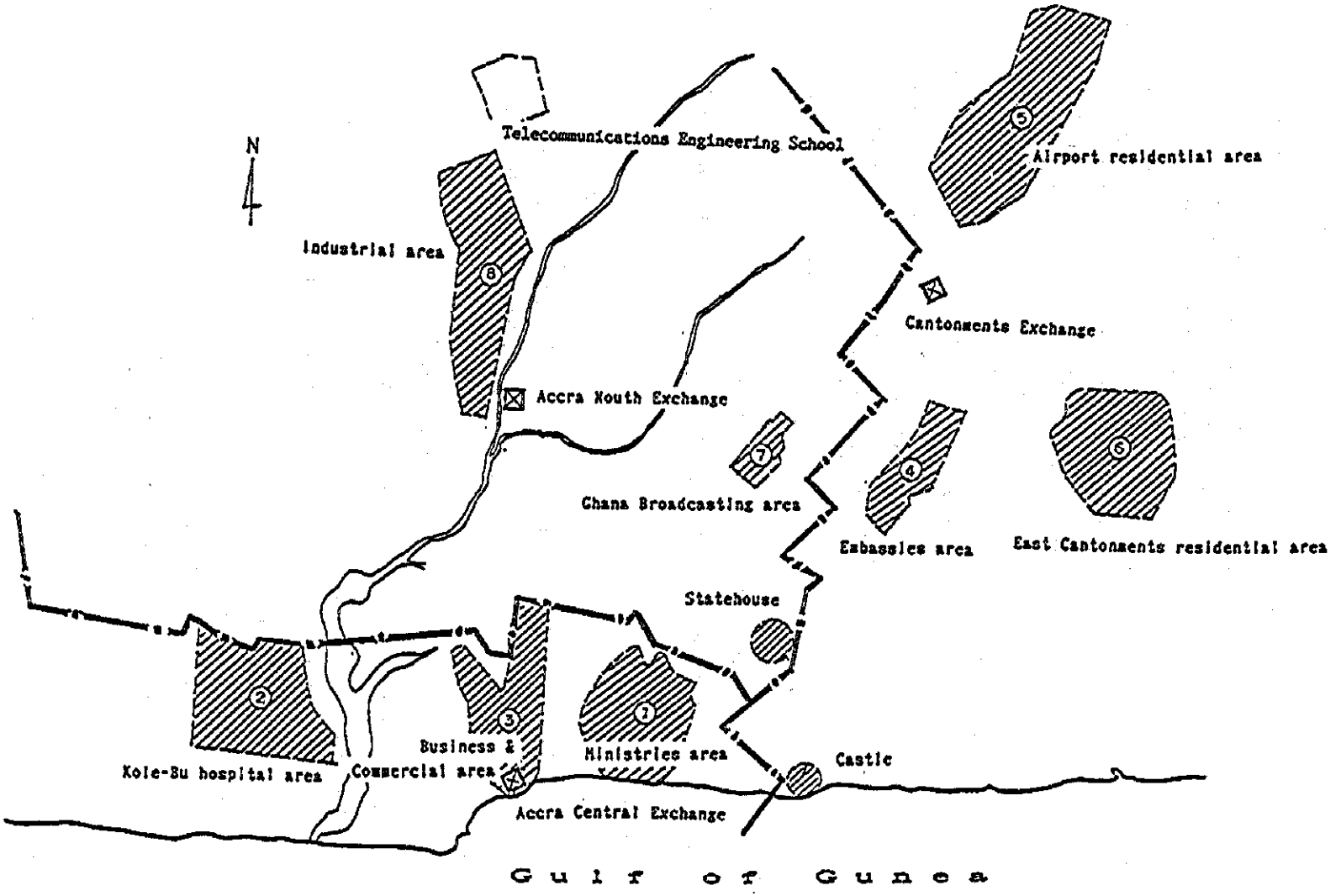


Fig. III-1 Project Coverage Areas

The number of subscribers to be rehabilitated under this project are estimated below:

Name of Exchange	Switching Capacity	Number of Existing Subscribers	Number of Subscribers to be Rehabilitated
Accra Central	8,000	5,400	2,297
Cantonments	6,000	3,600	891
Accra North	10,000	9,600	630
Ministries Area (PABX)	(1,000)	(2,265)	(2,265)
Kore-Bu Area (PABX)	(800)	(645)	(645)
Total	(1,800)	(2,910)	(2,910)
	24,000	18,600	(3,818)

In the above table, the number of existing subscribers in Ministries Area includes the figures in State House and Castle.

(2) Subscriber Cable

Most of the cables installed in the project coverage areas are more than 20 years old. Cable sheath and conductor insulation are deteriorated both physically and electrically. To use those existing cables as new cable network is, after all, to reduce the new cable network life and, furthermore, to restrict electrical characteristics also of the new cable network. Therefore, in this project, the existing cables are not to be utilized. Instead, for new cables, jelly-filled PE insulated and sheathed cables, for which no gas pressurization is required, will be adopted.

(3) Underground Conduit

In the project coverage areas, most of the manholes are supposed to have concrete-made covers. However, more than 90% of those manhole covers are either damaged or completely lost. Furthermore, in many places necessary ancillary hardwares in the manhole are missing.
Underground conduits are mostly asbestos pipes. They are likely broken or otherwise damaged due to road construction and other surface works. And they remain unrepaired.

In this project, the existing manholes will be repaired, furnished with covers and accessories. The existing underground conduits will have the damaged parts to be repaired so that as many of them as possible can be re-used in this project.

In case where no vacant conduit exists in the underground conduit route, PVC pipes will be newly installed, and where the existing manhole capacity is too small to accommodate new cables and their splice closures, manholes will be rebuilt.

(4) Subscriber's Premise Facilities

For wiring from distribution boxes to subscriber's premises, open wire and drop wire are used; however, they are time-worn and their characteristics are deteriorated. Some of indoor distribution boxes are mounted at improper places with terminals, etc., heavily corroded. Indoor cables are also time-worn. Telephone sets have the dials which do not steadily operate in many cases so that it is doubtful whether dial pulses can be normally outpulsed or not.

In this project, distribution boxes will be installed either on poles or on external or internal walls of buildings. Drop wires will be installed from distribution boxes on poles or on external walls of buildings to subscriber terminals on external

wall of buildings, which will be used for connecting with the existing internal wires and the drop wires. Replacement and improvement of defective subscriber's premise facilities will be implemented by P&T.

(5) Inside Plant

The main cable shall be terminated on the MDF through the existing cable vault in three telephone exchanges which are covered by this project. Therefore, cable bearers which are necessary for cable supporting will be newly installed, and terminal strips necessary for cable termination on MDFs will also be installed.

(6) Switching Equipment in Ministries Area

In the Ministries area which is given the highest precedence by the Government among 8 objective key areas are concentrated about 90 government office buildings. In this area, PABX telephone facilities are operating for telephone service with old-fashioned step-by-step switchboard (capacity: 1,000 line units) which was installed more than 20 years ago.

In the project, rehabilitation of the outside plant of the area will be carried out as in other coverage areas. However, unless the old-fashioned switching equipment is replaced with new one, it is difficult to enhance the effect of the telephone network improvement plan throughout this key area, where all the administrative function of Ghana is concentrated.

New switching equipment to be introduced by the project will be installed on the second floor of the existing PABX exchange building.

(7) Maintenance and Operation of Outside Plant

At three telephone exchanges to be covered by the project, maintenance-use equipment, materials, tools, measuring equipment and vehicles are in dire shortage. Therefore, outside plant maintenance personnel cannot cope with the numerous repairing works.

For maintenance and operation of outside plant facilities completed by the project, the maintenance-use equipment and materials including tools and measuring equipment, as well as vehicles must be provided for the three telephone exchanges.

(8) Maintenance and Operation of Switching Equipment

Recently, up-to-date electronic switching equipment were introduced by an IBRD loan project; however, the personnel available for maintenance and operation of those switching equipment are few. Especially during night-time, no person is assigned for system operation, supervising and trouble-shooting. The maintenance and operation system for the new equipment leaves much room to be desired.

The project is mainly concerned with improvement of outside plant including cable work. Outside plant alone cannot make the telephone network operate satisfactorily as a whole. Only when outside plant and inside plant co-work smoothly, satisfactory telephone network operation can be ensured.

Maintenance staff training to maintain newly introduced switching equipment in normal operation is of utmost importance for P&T. By this project, training-use switching equipment will be installed at telecommunication engineering school whereby to administer training so as to fill the shortage of maintenance and operation staff.

(9) Training-Use Equipment and Materials

It requires no elaboration that outside plant including cable work completed by the project must be maintained and operated satisfactorily. Because of the importance of such maintenance and operation, it is necessary to provide equipment, materials, tools and measuring equipment which is essential for the training of the outside plant maintenance staff.

3-3 Outline of Project

3-3-1 Competent Authorities and Management System

The competent telecommunications authority of Ghana is the Ministry of Transport and Communications (MOTC) and its common carrier is Ghana Posts and Telecommunications (P&T).

The project, this time, is to be administrated by P&T under the direction of MOTC. For the project implementation according to schedule, P&T will select Project Manager who will manage and promote all kinds of technical plannings and implementation work.

The Accra Area Communications Division of P&T is in charge of maintenance and operation of telephone exchanges in the project coverage area. More specifically, the Division will carry out for improvement work of subscriber's premise facilities, and withdrawl of existing equipment and facilities after the project completion.

3-3-2 Overview and Peatures of Coverage Area

(1) Ministries Area (including Castle and State House)

This area is the Accra Central Exchange service area, being located north of the sea coast about 2 km east of the exchange. In this area, about 90 government office buildings are

concentrated, constituting the administrative center and hence, the most important area in Accra.

The PABX telephone system for Ministries is served in the area, providing telephone service by the old-fashioned step-by-step switchboard (capacity: 1,000 line units) installed more than 20 years ago.

Telephone sets and related facilities in the area, including the PABX telephone system, are heavily worn out. Outside plant and subscriber's premise facilities are also time-worn. Defective equipment remains without maintaining for a long time, especially due to the shortage of replacement parts. By reason of protracted telephone system failure, government office employees in the area, who otherwise depend a great deal upon telephone service for their business efficiency, do not expect much from telephones as public utilities.

(2) Korle-Bu Hospital Area

Korle-Bu Hospital is in the Accra Central Exchange service area and is located about 2 km west of the exchange. To this hospital, the Government of Japan so far dispatched doctors and medical staff, and donated medical equipment. As the best state hospital in Ghana, this hospital contributes greatly to the social welfare of the people in Ghana.

The extensive hospital compounds are dotted with buildings including wards, doctors/nurses/medical students dormitories, surgical operations wings, medical research room wings and business office wings. Telephone services interconnecting these buildings and communications from outside of the hospital are served by PABX system.

In this area, especially in the peripheral area, open wires are used for outside plants. Manholes, cables and wires are damaged due to worn-out.

(3) Business and Commercial Area

This area is also in Accra Central Exchange service area and spreads 1.5 km to the north from the exchange (inclusive of the exchange building). In this area, many business organizations including Ghana National Bank, city banks, central market and main private business offices are concentrated, constituting the economic and commercial center of Accra.

Outside plants are more than 20 years old so that they are heavily worn out. Concrete covers of manholes on side walks are either damaged or completely lost in many cases. Cables in manholes are exposed or buried in sand dust.

(4) Foreign Embassies Area, Airport Residential Area and East Cantonments Area

In these areas, foreign embassies, residences of foreign diplomats and of high government officials are also located. All three areas constitute a very important area.

Telecommunication service in these three areas is provided by Cantonments Exchange located in Cantonments area in the eastern part of Accra.

One of the three areas, the airport-residential area located north of Kotoka International Airport is 4 - 5 km distant from the exchange. In this area, the grade of telephone service is especially low, and this is due to manhole cover damage, underground cable exposure, distribution box corrosion, and open wire dropping to subscribers' premises.

In the area where foreign embassies are concentrated, including the airport residential area and East Cantonments area, most of the outside plants are worn out. The majority of subscriber's circuits in these areas can't be operated, being precluded from telephone service for a long time due to defective outside plant and subscriber's premise facilities.

Foreign embassies, etc., in the area, which cannot use telephones, are being compelled to use cars for business contacts in the city.

(5) Ghana Broadcasting Corporation Area

Telecommunication in this area is served by Accra North Exchange. Ghana Broadcasting Corporation and IBRD office are located on the both sides of Ring Road Central about 3 km east of the exchange.

In this area also, outside plant is overage as in other areas. Telephone service is unstable because of system outage due to cable, open wire and distribution box deterioration.

(6) Industrial Area

This area is in Accra North Exchange service area and is located in the northwestern part from the exchange. The area spreads 1 - 3 km long at the crow flies from the exchange, forming the biggest industrial complex in Accra where about 70 factories, large and small, exist. This area is of great importance for the manufacturing of industrial products.

Distribution of the telephone circuits in this area is still partially served by open wires so that telephone services in this area are also unstable.

The existing outside plant such as manholes, cables, distribution boxes and drop wires are also seriously deteriorated.

3-3-3 Outside Plant Facilities

(1) Cable Distribution System

For the most part of existing cables, direct cable distributing system is adopted wherein cables are directly connected from the exchange to the distributing box.

However, P&T has newly decided in favor of cross-connecting cabinet system wherein cross-connecting cabinets are installed at several places of cable lines to make easy cable maintenance and extension works.

Therefore, in this project, cable network rehabilitation will employ cross-connecting cabinet system.

(2) Underground Cable

For new cable network, PE insulated and sheathed, jelly compound filled cables will be used. Paper insulated, lead sheathed cables, whereof the installation was more than 20 years ago and hence the physical and electrical characteristics have deteriorated, will not be re-used.

Primary cables from the exchange to the cross-connecting cabinet will be installed in underground conduits in due consideration of future cable maintenance and extension.

Secondary cables (distribution cables) extending from cross-connecting cabinets to distribution point will be installed in the existing underground conduits where such conduits are

available. Where the existing underground conduits are not available, secondary cables will be direct-buried.

Capacity of new cables to be installed by this project will be practically equal to the existing cable pairs, in principle. However, since the project covers only the limited key areas, careful consideration must be made so that the project may not conflict with the basic cable network plan prepared by Ghana side. More specifically, cable pairs to be used must be decided for individual areas and sections in consideration of technical requirements involved in work execution.

For cable splicing, the mechanical splicing of cable conductor and splice closure methods will be employed so as to ensure speedy work and uniform work quality.

(3) Distribution Boxes, Poles, etc.

Two types of the distribution boxes will be employed by this project, i.e., with stub-cable and without stub-cable, and these distribution boxes are classified to use depending on the distance between the manhole and distribution point.

Most of the existing steel poles are seriously corroded at the roots. Those existing poles will not be re-used in the project. The existing drop-wires are seldom the regular drop-wires so that they cannot be utilized in the project.

In case where a plural number of drop-wires are required in the same direction in thickly settled areas, SD wires will be used as multi-pair drop-wires.

(4) Manhole and Conduit

The existing manholes will be improved with necessary accessories, such as iron covers, cable bearers and hooks, so

that as many of them as possible can be utilized in the project. However, when the existing manholes is located in more than necessary contiguity and hence it is uneconomical to utilize them, they may be abandoned.

As for underground conduit, the existing vacant duct, if available, will be utilized. When no vacant duct exists, the necessary number of ducts and spare ducts will be installed in the project. For important underground conduit route, prior consultation with P&T will be made so that this project can be accorded with P&T's plan. Economic and technical requirements, as well as work execution method, will also be taken into full consideration.

(5) Subscriber's Premise facilities

In case of the drop wire which is in danger of contact with power line, arrestor will be installed in the subscriber's premise. In other normal case, subscriber terminal will be used for connection of drop wire and internal wire in the subscriber's premise.

(6) Inside Plant

Primary cable will be terminated to the tips of the terminal mounted on the MDF with terminating cable. The terminals to be installed on the MDF will be of separable type for switching and cable sides in the exchange office and PABX exchange also, in consideration of the maintenance work.

3-3-4 PABX in Ministries Area

In the area where Ghana's government administrative offices are concentrated, considerable telephone service improvement can be expected through the outside plant rehabilitation work. However, the bottleneck to such service improvement resides in PABX and telephone

sets. Without replacement of this PABX, the telephone network rehabilitation effect in the area will not be perfectly improved, and this is evident in field survey results.

For telephone network improvement in the area, new PABX will be installed on the second floor of the exchange building where the existing PABX is installed on the ground floor, in addition to outside plant rehabilitation work.

(1) Capacity of Switching Equipment

A lot of direct telephone lines from the Central exchange are installed in the PABX area, because of the lack of PABX switching equipment and the difficulty in connecting the extension line to the outside telephone line. High ranking government officials in the area use two telephone sets, one for extension and the other for direct circuits.

Switching equipment to be newly introduced by the project is to have initial capacity of 1,000 line units (to serve 1,000 extensions), i.e., the same as with the existing switching equipment, provided that this capacity will be extended to more than 2,000 line units and preferably 3,000 line units in the future, in accordance with the field survey result.

(2) Type of Switching Equipment

For the presently used switching equipment in the world, there are mainly four types, i.e., step-by-step type, crossbar type, analog electronic type and digital electronic type. The first three types are manufactured only for additional installation of the existing equipment. In other words, the fourth, i.e., the digital electronic type predominates. This trend does not prevail in Japan only but is the worldwide trend. Even in the country where switching equipment manufacturing plant does not exist, digital electronic switching equipment is being

introduced, and this is in consideration of the economy in telecommunications network engineering from now forward, as well as spare parts cost.

In this project also, digital electronic switching equipment which can be mutually connected with extension calls will be preferably adopted.

(3) Air-Conditioning Equipment

For commonly used switching equipment, room temperature and humidity must be kept at the level fit for equipment operation. For, should the room temperature and humidity exceed the allowable limits for switching equipment during operation, malfunction and service life reduction are unavoidable.

Therefore, in this project also, air-conditioning equipment will be installed in the switching equipment room.

(4) Power Supply Equipment

In Accra, commercial power availability is relatively stable these days. Nevertheless, day-long power supply failure is not infrequent.

For switching equipment, 24 hours/day commercial power supply is used as far as it is available. However, to prepare against power failures, backup power system consisting of batteries and generator will be installed.

(5) Others

With the establishment of new switching equipment, the installation of new MDF, cable trench and earthing equipment becomes necessary.

3-3-5 Training-Use Switching Equipment

(1) Switching Equipment Capacity

Since the objective is to train maintenance and operation staff for electronic switching equipment installed under IBRD project and now in use, the switching equipment to be introduced is of minimum capacity but fit for staff training as planned by P&T.

(2) Type of Switching Equipment

The switching equipment to be introduced is to be the same type or a similar type as the digital switching equipment presently used in Ghana. The equipment is also to operate by the same or similar software specifications as those for commonly used equipment in the country.
Such is because the personnel trained with the equipment have only to attend successfully to the digital switching equipment adopted and used by P&T.

(3) Air-Conditioning Equipment

Air-conditioning equipment will be installed in the switching equipment room of the Telecommunications Engineering School.

(4) Power Supply Equipment

Standby power system consisting of batteries with accessories will be installed in the school.

(5) Place of Installation

Training-use switching equipment will be installed in the training room adjoining the room where the old fashioned training-use switching equipment is now installed at the school.

(6) Others

With the establishment of new training-use switching equipment, the installation of new MDF, earthing equipment, etc., becomes necessary nearby switching equipment room.

3-3-6 Maintenance and Training Plan

(1) Outside Plant

For maintenance of the outside plant completed by this project, the maintenance and operation staff of the three telephone exchanges covered by the project will be responsible. Since new technology will be introduced to complete those outside plant, maintenance and operation staff of the three telephone exchanges must be duly trained to become acquainted with such new technology and perform leading roles in the future maintenance and operation system.

Maintenance staff training will be twofold. One is the necessary training for cable system construction, such as new cable installation and splicing. The other is the necessary training for system maintenance, including fault-finding by use of measuring equipment.

At the Telecommunications Engineering School, P&T conducts training for a total four months every year for about 40 outside plant maintenance personnel.

Maintenance-use equipment and materials will be provided to ensure 2-3 years maintenance of the outside plant completed by this project. Maintenance-use vehicles, measuring equipment and tools will be supplied to each of the three telephone exchanges.

For training-use equipment and materials, a stock for three years training will be supplied to P&T by this project.

Plant records containing plans and documents of the outside plant in detail will be prepared by the Contractor at the project completion and will be presented to P&T. Plant records include maintenance and operation data concerning cable network completed by cable distribution by cross-connecting cabinet system, primary cable maps, secondary cable maps, underground conduit maps, etc.

(2) PABX in Ministries Area

At the time of new switching equipment introduction, maintenance and operation field training for such new equipment will be given as on-the-job training to the maintenance staff of existing switching equipment.

Through the implementation of this project, telephone system rehabilitation will be accomplished, resulting in increased frequencies of telephone utilization and necessity to increase telephone operators. Thus, training will be held for about eight personnel, including switching equipment maintenance personnel and telephone operators. This training will be carried out by P&T for about two weeks, featuring technical guidance by the Contractor and using field equipment and instruction manuals.

Spare parts, tools and measuring equipment necessary for 2-3 years maintenance of PABX telephone switching equipment in Ministry area will be supplied.

(3) Training-Use Switching Equipment

Some of the P&T engineers have received training in Japan and hold expertise concerning maintenance and operation of switching equipment. Therefore, at the time the training-use switching equipment is introduced, the Contractor will exercise on-the-job training for about one week for those engineers, especially

maintenance and operation engineers at the Telecommunications Engineering School of P&T.

Spare parts, tools and measuring equipment necessary for 2-3 years maintenance of training-use switching equipment will be supplied.

3-4 Technical Cooperation

In conjunction with this project, Ghana desires that Japan dispatch the outside plant maintenance experts. This is because of rapid technological renovation as from step-by-step to electronic switching equipment and from lead sheathed to plastic and jelly filled cable, plus the fact that P&T, during the past several years, have let go some engineers and technician.

At present, five members of Japan Overseas Cooperation Volunteers are assigned to P&T. However, for full-scale outside plant maintenance work, the dispatch of experts who will deliver timely technical guidance is considered to be essential.

CHAPTER 4 BASIC DESIGN

CHAPTER 4 BASIC DESIGN

4-1 Guidelines of Design

4-1-1 Outside Plant

This section contains guidelines of design for cables, civil works and subscriber's premise facilities in eight target areas which are served by the three telephone exchanges in Accra.

After cutover of the existing subscriber circuits to new circuits installed by the rehabilitation works, disused poles, open wires, cables and all other accessories will be withdrawn by P&T. Therefore, the withdrawal works of those existing facilities are out of the scope of work of this rehabilitation works.

(1) Cables

1) Cable Distribution system that uses cross-connecting cabinets will be adopted for both primary and secondary cable installations. This arrangement is for economical design and for effective use of cables installed. It is also to facilitate cable system maintenance and operation, as well as expansion, by P&T in the future.
2) Jelly-filled plastic cables for both primary and secondary cables will be adopted so as to prevent water infiltration into cables and reduce cable breakdown. Existing time-worn paper-insulated, lead-sheathed cables will not be reused. Hence no need for gas pressurization on the new replacement cables.
3) For 50 pairs or less secondary cables, jelly-filled plastic cables with double PE sheathed and steel armoured will be adopted. Therefore, direct-buried system will be employed for these cables, in principle, though laying in existing vacant duct, if available, is preferred.

4) Existing overhead open wire system will be replaced by cable distribution system that ensures stable service. Hence no new open wire system is installed in the city area of Accra in future.

5) For cable conductor splicing, mechanical splicing method that requires no special skill will be applied instead of conventional manual twisting.

6) For cable sheath splicing, non-heating closure method will be applied instead of conventional plumbing with lead sleeve. The closure and compound will be re-enterable, so splicing points can be reopened, if required.

7) Cross-connecting cabinets will be used, each with capacity for 1,400 cable pairs (600 pairs for primary cables and 800 pairs for secondary cables, as the standard).

8) The demarcation for distribution area of one cross-connecting cabinet is set up being less than 720 subscriber lines.

9) Distribution boxes will be used, each with a capacity of 10 cable pairs in the case of pole type and wall type distribution boxes. For indoor type, the capacity is determined according to the required number of circuits by buildings.

10) For mounting of pole type distribution box, 8.0 m long steel poles will be used.

11) Stub cable rising to pole type and wall type distribution boxes and cable leading into buildings will be protected with U-guards or o 25-50 mm steel pipes, applying them to the vertical run of cables.

12) Water infiltration will be prevented into the cable vault and adjacent manhole of the cable vault, with stop plugs.

(2) Civil Works

1) For types of manholes/handholes, the standards currently used by P&T will be applied.

2) PVC pipes, but not asbestos pipes, will be used for underground conduits.
3) The existing manhole/handhole concrete covers will be replaced with angular iron ones.
4) If the existing manholes/handholes are without vertical iron frame and cable bearers, such hardware will be mounted in the manhole/handhole by the standard practice of P&T.
5) Underground conduit or direct-buried cable route will be selected under side walks, in principle, but not to select carriageways as far as possible.
6) PVC pipes, gravels, sands, cement and reinforcing bars locally procured will be used.

(3) Subscriber's Premise Facilities

1) For drop wire from pole type distribution box into subscriber's premise, outdoor wire or SD wire will be used. No dropping by open wire in any case.
2) In case where the contact with power line is likely with outdoor wire or SD wire dropping into subscriber's premise from pole type or wall type distribution box, subscriber's protector will be used with earthing.
3) For outdoor wire or SD wire connection with indoor wire, subscriber terminal will be used in all cases except when the subscriber's protector mentioned in 2) above is used.
4) In case where the distance from pole type distribution box to subscriber's premise is long, 7.0-8.0 m steel pole will be used as a dropping pole.
5) Repair/replacement works for deteriorated subscriber premise facilities are to be carried out by P&T in parallel with this project.

4-1-2 Inside Plant

(1) PABX Switching Equipment in Ministries Area

PABX switching equipment in ministries area consists of old-fashioned switching equipment (capacity: 1,000 Subscriber lines) and time-worn accessory equipment (batteries, rectifiers, etc.). Service upgrading by switching and accessory equipment improvement is the objective.

1) PABX Switching Equipment

a) Service Contents

- Connections with rotary dial telephone set and push-button dial telephone set are made.
- Automatic connections of office originating local and toll calls are made, and manual connections via attendant board for terminating calls from outside of PABX are made, in principle.
- Emergency calls are made to police stations, fire brigades and hospitals.
- Announcement services are made including directory announcement in service area.
- Service for abbreviated dial, automatic transfer and terminating from third party are made to a part of subscribers. These services are inherent functions of electronic switching equipment.

b) Telephone Circuit Accommodation

With existing facilities, ineffective calls including call suspensions are frequent so that reliable records for traffics could not be obtained.

The network concerned is the group telephone network which is used inside administrative organizations of Ghana. Therefore, this network is supposed to have distinction from the network in general area (where business offices and residences coexist), and such distinction is found in the fact that among administrative organizations, important subscribers with high telephone utilization frequencies are distributed in large numbers. In other words, average traffic volume per subscriber in the network mentioned is considered to be bigger than in general area. Thus, from average traffic volume per subscriber in general area which stands at 0.1579 Erlangs or thereabouts, busy hour traffic volume per subscriber in ministries area is set at 0.2 Erlangs* (originating and terminating calls), where of

In Ministries area	50%
Originating traffic to public network	25%
Terminating traffic from public network	25%

Call connections from Part of administrative organizations employees to general public network are restricted. Therefore, traffic outflow from administrative organizations to general public network is supposed to be extremely small.

From the foregoing study and Chapter 3-3-4, telephone circuit accommodation plan is diagrammed below.

c) Air-Conditioner

For generally used switching equipment, the excess of room temperature and humidity during equipment operation over allowable limits for equipment causes malfunctioning and service life degrading. Therefore,

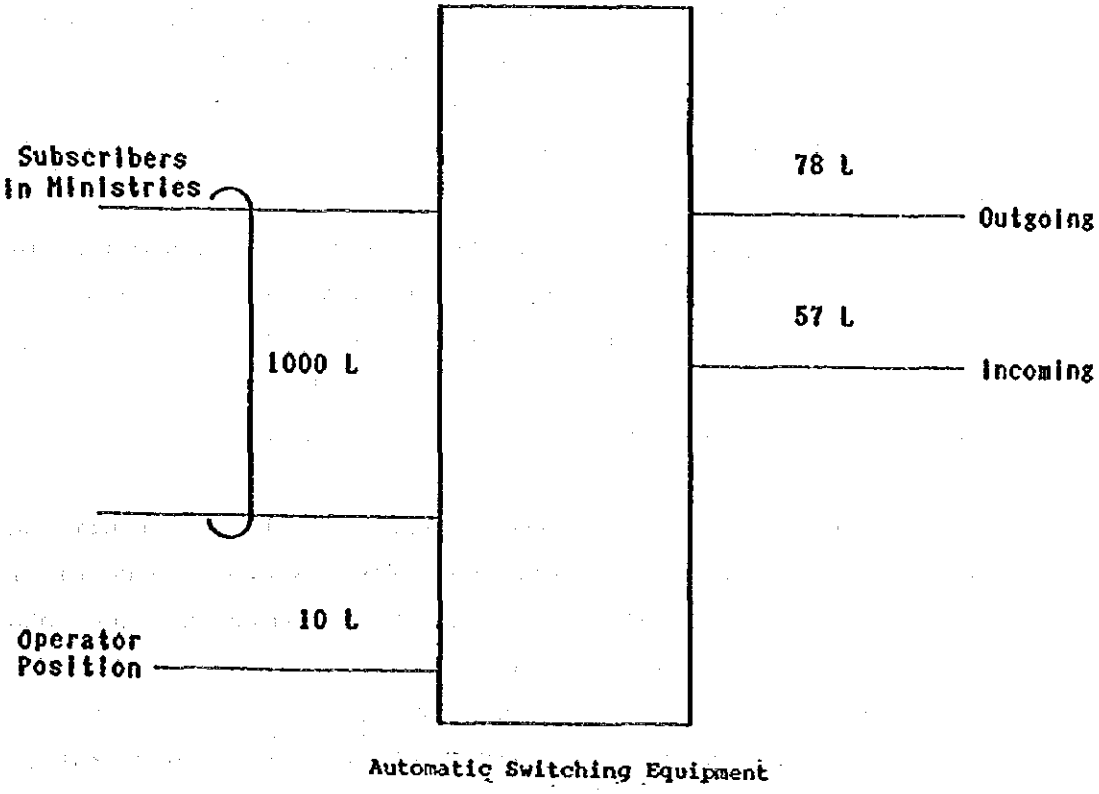
it is essential to keep room temperature and humidity at suitable levels for equipment operation. Thus, in the current project, air-conditioner will be installed in the switching equipment room.

d) Numbering Plan

Existing numbering plan will be changed to new numbering plan as the result of switching equipment replacement. The reason is that in existing numbering plan, numbering capacity is small. New numbering plan is shown below.

	Existing	New
Automatic call origination from exchange	9	9
Call origination via exchange B-board	0	0
Ministries exchange subscribers	1xx - 8xx	2xxx - 8xxx *1
Complaints		101
Telegram application (spare)		106
Police station (spare)		191 *2
Fire brigade (spare)		192
Hospital (spare)		193

Note: *1 Numberings are grouped according to departments/ sections of each administrative organization.
*2 To be conformed to numbers used in public telecommunications network in Ghana.



Note: For outgoing circuits from group switching equipment, one spare circuit per 100 subscribers is reserved at Accra Central and is used as outgoing circuit for special service (directory announcement, general announcement, etc.)

Fig. IV-1 Telephone Circuit Accommodation Diagram

e) Intra-Office Call Recording Device

Intra-office call detail recording device will be established. This is to record details of calls to office lines whereby to manage calls by extensions and department/section extension groups.

f) Attendant board

Attendant board is used for manual connections of terminating calls within PABX service area and for directory announcement, and is also used for manual connections of originating calls from outside service area.

Ten attendant board positions will be established (including superintendent's position) in consideration of the possible number of directory announcements referred to in Paragraph 4-1-2.

g) Accessory Equipment for Maintenance and Operation

- To provide maintenance and operation position where to make switching equipment supervising, control and tests.
- To provide equipment for communication between switching equipment and maintenance and operation staff (printer keyboard, etc.)
- To provide traffic measurement and fault location functions as maintenance and operation functions.

2) PABX Switching Accessory Equipment

a) Power Supply Equipment

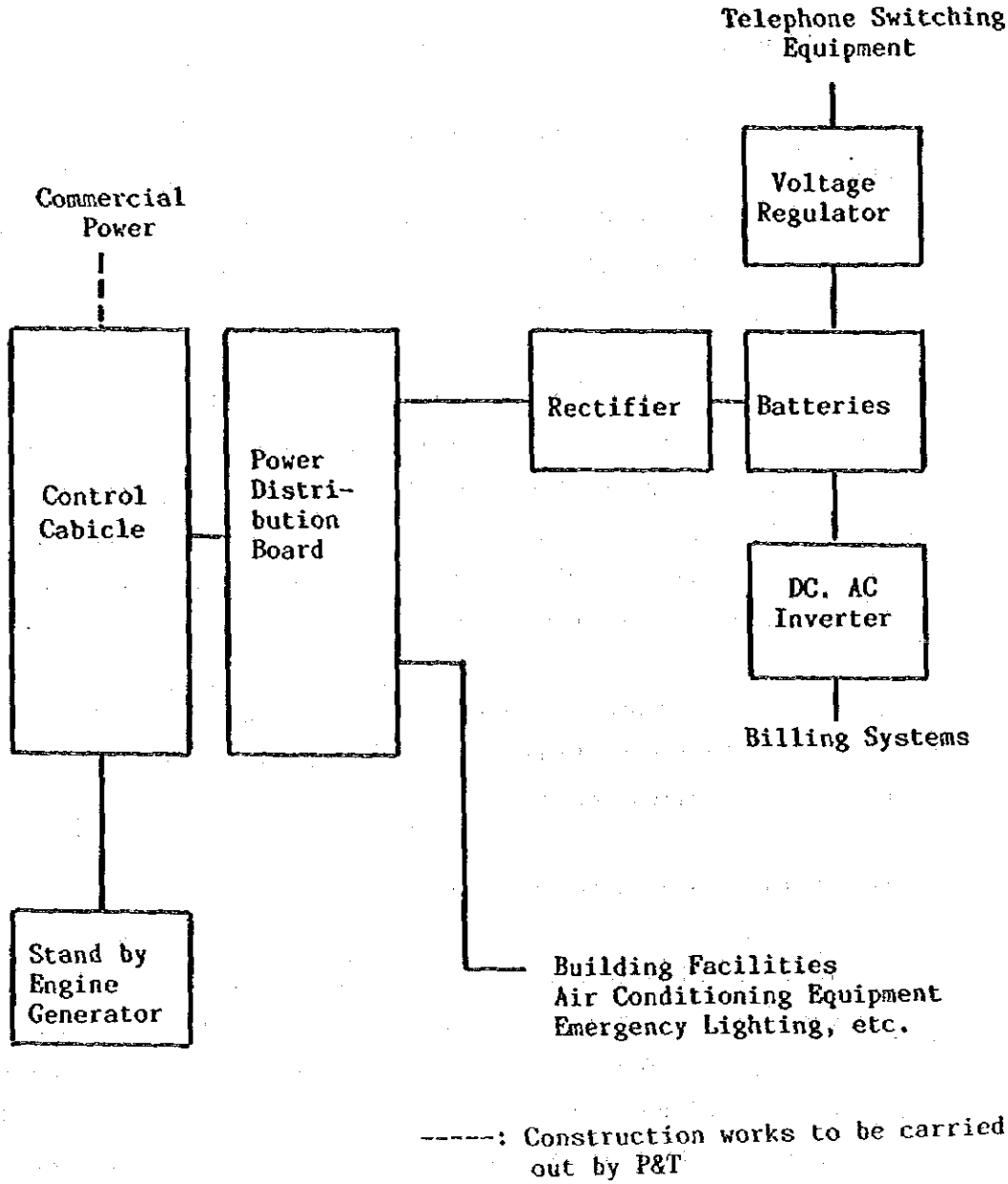
Commercial power availability in Accra is relatively stable these days though day-long power failure occurs from time to time.

For power supply to switching equipment, 24 hours/day available commercial power (voltage fluctuations: +10%/-15%) is used at all times. However, for standby system in case of commercial power failure, emergency power supply system will be established. Standby system configuration appears in next page.

This standby power system is also to supply power to air-conditioners installed in important equipment, during commercial power failure.

(2) Training-Use Switching Equipment

Telecommunications network in Ghana is in transition period from old analog switching equipment to new digital switching equipment. Therefore, to train P&T engineers and technicians for maintenance and operation of recently introduced and now-operating digital switching equipment, training-use switching equipment and its accessories will be provided.



Fig, IV-2 Configuration of power supply equipment

1) Training-Use Switching Equipment

a) Functions

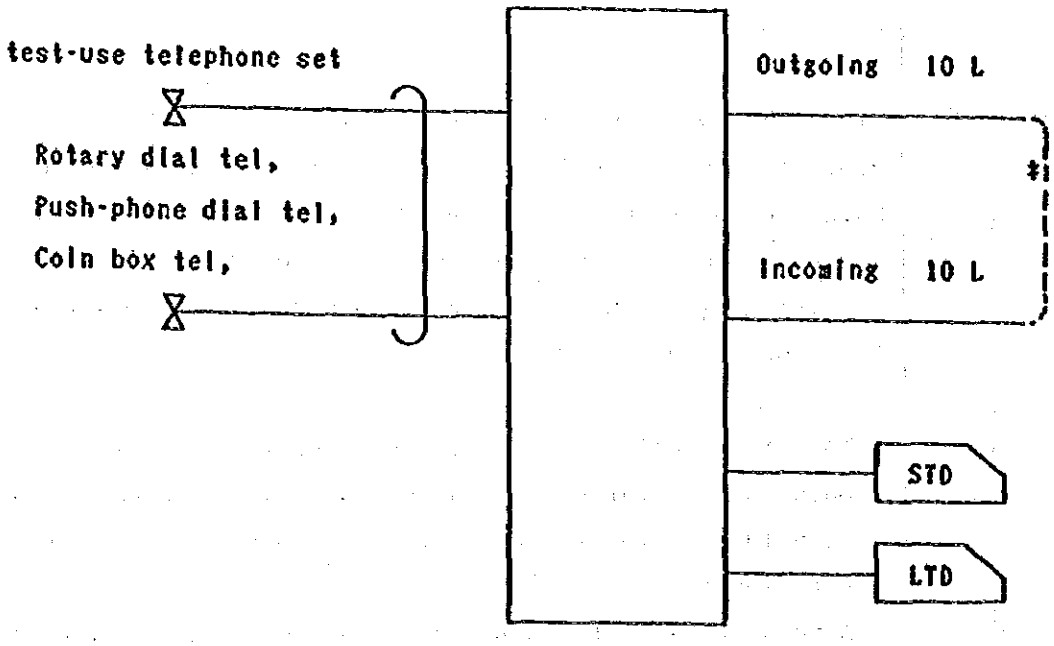
Since the objective is to train maintenance and operation staff, training-use switching equipment will have minimum requirements for maintenance and operation including local switching function. Schematic system diagram appears in Figure IV-3. Description of required functions is as follows:

- To hold function for connecting rotary dial type or push-button dial telephone set and test telephone set.
- To hold function for connections to public telephone sets and PABXs.
- Attendant board for directory announcement, etc., will not be provided because subscriber service is not scheduled.
- To be furnished with announcement service circuit for incomplete calls for the purpose of training concerning subscriber-origination control and route control.

2) Numbering Plan

Numbering plan will be conformed to that of public telecommunications network in Ghana. For telephone number of test-use telephone set, vacant numbers at Accra North Exchange will be used.

Meanwhile, existing number plan is shown in Table IV-1 and IV-2.



STD : Supervisory Test Desk

LTD : Line Test Desk

* : Outgoing line and incoming line are folded at MDF

Fig. IV-3 Schematic System Diagram

Table IV-1 Special Service Codes

Primary Area	Trunk Code	Local Exchange	Local Number	Total* Dialled Digits	Remarks (Test Number)
Accra	21	Accra North	22XXXX	8	
- do. -	21	Central LS0	662XXX-665XXX	8	
- do. -	21	Central LS1	666XXX-669XXX	8	0-21-669999
- do. -	21	Cantonments LS0	772XXX-774XXX	8	
- do. -	21	Cantonments LS1	775XXX-777XXX	8	0-21-777999
- do. -	21	Teshie/Nungua	712XXX	8	
- do. -	21	Dansoman	314XXX	8	
Tema	221	Tema	2XXX,4XXX,6XXX	7	
Akosombo	251	Akosombo	2XX-7XX	6	
Takoradi	31	Takoradi I	2XXX,30XX-37XX	6	
- do. -	31	Takoradi II	4XXX	6	0-31-4999
- do. -	31	Sekondi	6XXX	6	
Axim	(342)	Axim	(2XX,3XX)	6	
Tarkwa	362	Tarkwa	2XX-5XX	6	0-362-599
Dunkwa	372	Dunkwa	2XX-4XX	6	0-372-499
Swedru	41	Swedru	2XX-4XX	5	
Cape Coast	42	Cape Coast	20XX-25XX	6	
Kumasi	51	Kumasi	2XXX-5XXX,60XX-65XX	6	
Konongo	531	Konongo	2XX,3XX	6	
Mampong-Ashanti	561	Mampong-Ashanti	2XX,3XX	6	
Bekwai	572	Bekwai	2XX,3XX	6	0-572-399
Obuasi	582	Obuasi	2XX-4XX	6	0-582-499
Sunyani	61	Sunyani I	2XX-6XX	5	
- do. -	61	Sunyani II	73XX-76XX	6	0-61-7399
Berekum	(642)	Berekum	(YXX)	6	
Wenchi	(652)	Wenchi	(2XX)	6	
Tamale	71	Tamale	2XXX	6	
Bolgatanga	72	Bolgatanga	22XX-24XX,30XX-34XX	6	
Bawku	743	Bawku	2XX	6	
Koforidua	81	Koforidua	22XX-27XX,30XX-33XX	6	
Nkawkaw	(842)	Nkawkaw	(YXX)	6	
Ho	91	Ho I	2XX-7XX	5	
- do. -	91	Ho II	80XX-83XX	6	0-91-8399
Hohoe	(932)	Hohoe	(YXX)	6	
Denu/Aflao	962	Denu/Aflao	2XX-4XX	6	0-962-499
Keta	(966)	Keta	(YXX)	6	
Ada	(968)	Ada	(YXX)	6	

Note:

X : 0 to 9
Y : 2 to 8
( ) : Future Use

* Excluding STD Service Prefix '0'.

Table IV-2 Trunk Codes and Local Numbers in Ghana STD Network

Special Service Code	Service Type
100	Trunk Operator
101	Complaint
102	National Enquiries
103	Spare
104	Speaking Clock
105	Directory Enquiry
106	Phonograms
107	Spare
108	Spare
109	Spare
191	Police (Accra)
192	Fire (Accra)
193	Ambulance (Accra)
97	Test Robot
98	Faultsman
999	Emergency Operator

3) Maintenance and Operation Accessory Equipment

a) To provide equipment of printer and keyboard for communication between switching equipment and maintenance and operation staff.

b) To provide test desk for subscriber telephone circuits.

c) To provide malicious call tracing, traffic measurement and automatic circuit test functions as maintenance and operation functions.

(3) Training-Use Switching Equipment Accessory

1) Power Supply Equipment

For power supply to training-use switching equipment, 24 hours/day available commercial power (voltage fluctuations: +10%/-15%) will be used. Power supply system configuration as shown in Figure IV-4 ensures stable d.c. power supply to training-use switching equipment.

2) Air-Conditioner

For switching equipment, in general, the excess of room temperature and humidity during equipment operation over allowable temperature and humidity limits for the equipment causes equipment to malfunction and its service life to degrade. Therefore, it is essential to keep room temperature and humidity at suitable levels for equipment operation.

Hence, in this project, air-conditioner will be established in the training-use switching equipment room.

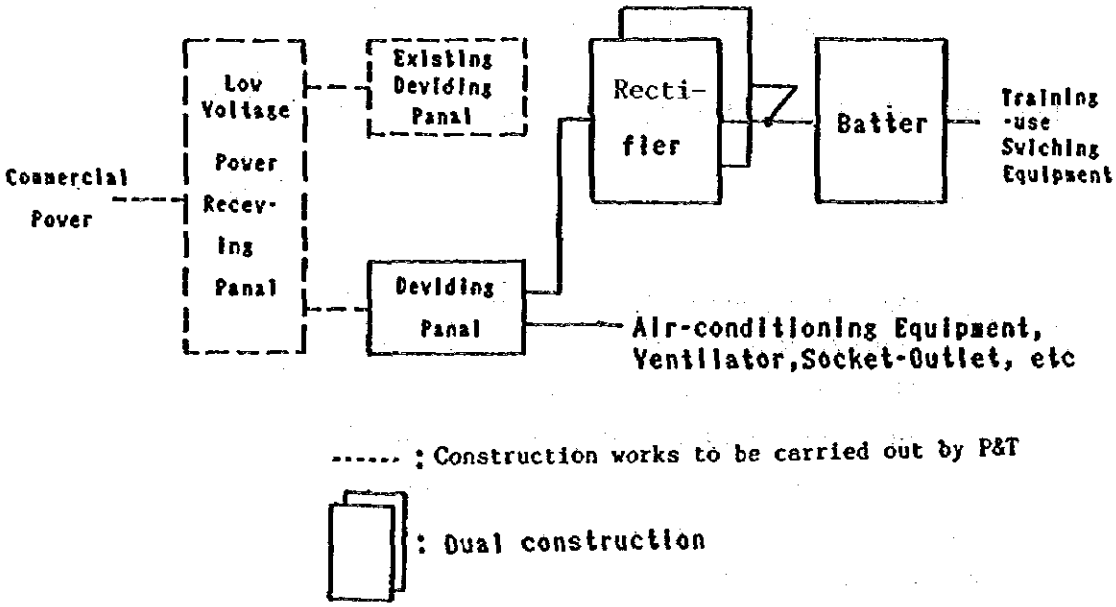


Fig. IV-4 Power Supply System Diagram

4-2 Outside Plant Design Standards

4-2-1 Cable Facilities

Cable facilities are mainly assorted with cable termination, primary cable, cross-connecting cabinet, secondary cable and distribution box. For local telephone line formation, as shown in Figure IV-5 Layout of Local Cable Network.

(1) Cable Termination

Design for cable termination onto the Main Distribution Frame (MDF) into exchange building are as follows:

1) Duct Selection
For duct selection whereby to lead primary cable and/or distribution cable into exchange building, to select the lowest duct first and then select the upper duct. Duct selection must be made in the manner not to impede future primary cable installation for extension, and without forced cable bending and crossing on the way from duct entrance to cable rising point.

2) Cable Arrangement
For cable arrangement on cable rack and cable bearer in the cable vault or trench, to use with the lowest duct at first and then proceed to the upper duct, taking the duct location into careful consideration.

3) Cable Termination
To splice primary cable led into exchange building with terminating cable and terminate it on MDF. To fill the primary cable and terminating cable splicing point with compound and make a dam for humidity-proof.

4) MDF

To terminate primary cable and office cable (from switchboard) to the terminal on MDF. To make this termination from top to bottom of MDF, beginning with the center layer conductor of primary cable and proceeding in order to the outer layer conductor.

(2) Primary and Secondary Cables

1) Planning Standard

New cable network will be totally composed of PE insulated and sheathed, jelly-filled cable. The existing paper-insulated, lead-sheathed cable, which was installed more than 20 years ago with physical characteristics deteriorated, will not be re-used. Thus, for newly installed cable, maintenance by conventional gas pressurization is not necessary.

For new cable network formation, the cross-connecting cabinet system will be employed. This is to economize primary cable installation cost and, at the same time, facilitate future maintenance and extension works.

Primary cable, as a rule, will be installed in underground conduit. Secondary cable of 100 cable pairs or more will also be installed in underground conduit.

For secondary cable of 50 pairs or less, installation is in the existing underground conduit if it is available. If the existing vacant underground conduit is not available, steel armoured cable will be direct-buried underground so as to economize installation cost.

The project is for rehabilitation, i.e., repair and replacement, of existing overage cables. New cables will be of the same capacity with the existing cables in general.

Although this project covers for rehabilitation work only limited areas out of the entire exchange service area, basic design will be formulated in careful consideration of P&T's overall plan, as well as technical characteristics of telephone cable network and civil works.

Cables to be used in the project are those that comply with international standards, such as JIS, BS, DIN and REA. Types, number of pairs, and conductor gauges of those cables are described below.

2) Types, Number of Pairs and Characteristics of Cables

a) Types

Primary Cable:
Primary cable to be used is PE insulated and sheathed, unit-twin and jelly filled.

Secondary Cable:
Secondary cable to be used is PE insulated and double sheathed, unit-twin and jelly filled, and steel armoured.

b) Number of Pairs

Primary Cable:

Conductor Gauge	Cable Pairs
0.4 mm	2400, 2100, 1800, 1500, 1200, 900, 800, 400
0.5 mm	1800, 1500, 1200, 900 600, 400

Secondary Cable:

Conductor Gauge	Cable Pairs
0.4 mm	200, 100, 50, 30, 20, 10
0.5 mm	200, 100, 50, 30, 20, 10

c) Electrical Characteristics

D.C. loop resistance and reference equivalent at 1,500 Hz, are classified by conductor gauge, as follows:

Conductor Gauge	Loop Resistance (ohm/km)	Reference Equivalent 1.5 KHz (dB/km)
0.4 mm	295	2.20
0.5 mm	187	1.75

3) Determination of Conductor Gauge

Cable conductor gauge is determined by two factors. One is the reference equivalent limitation for subscriber system. The other is d.c. resistance limitation by switching equipment. Both are determined from the viewpoint of transmission loss. Conductor gauge thus decided is economically optimum.

a) Reference equivalent limitation ..... 8 dB

b) D.C. limitation ..... 1500 ohms
(new switchboard)
1200 ohms
(old switchboard)

c) Combination of different conductor gauge
Economically optimum design is made in consideration of primary and secondary cable conductor gauge combination. However, in primary or secondary cable section, different conductor gauge combination is not practiced.

4) Primary Cable Network

Primary cable network design highlights the following points:

a) Cable units to be distributed to cross-connecting cabinet
Primary cable pairs are distributed to each cross-connecting cabinet and terminated the number of cable units (100 pairs) which can accommodate the existing number of subscribers. The existing number of subscribers is the sum total of subscribers whose telephones work normally, subscribers whose telephones do not work normally, and waiting subscriber who has applied for their telephones during the past several years but has no telephone installations yet.

b) Grouping of Cable Units
Cable units distributed to each cross-connecting cabinet along the primary cable route be grouped together by conductor gauge on the way from the side of remote cable route to the telephone exchange.

c) Cable Pairs

Cable pairs be commensurate with cable units grouped together by sections. For cable pairs decision, adjustment with P&T's overall plan must be made and effective use of conduits from the economic viewpoint must be considered.

5) Secondary Cable Network

Secondary cable network design highlights as follows:

a) Conduit and Direct-Buried Cables

Secondary cable of 100-400 pairs be installed in underground conduit while secondary cable of 50 pairs or less be direct-buried, in principle, with double PE sheathed with steel armoured. Where an vacant duct is available in the existing underground conduit, secondary cable of the latter category above be installed in the duct with steel armored.

b) Grouping of Cable Pairs

Cable pairs distributed from the side of remote cable route to distribution box along cable route in unit distributing section be grouped down to cross-connecting cabinet.

c) Cable Pairs Decision

Cable units be commensurate with cable pairs grouped by sections.

d) Depth of Direct Buried Cable

For secondary cable to be direct-buried underground, depth from ground surface to upper part of cable be as described below, based on P&T standard.

- Side walk, farmland, forest ... 75 cm or more
- Carriageway ..... 90 cm or more
- Road, across railway tracks ... 100 cm or more

e) Establishment of Distributing Section

Cross-connecting cabinet area be divided into several unit sub-areas along cable route, in consideration of existing cable line(s) and road condition.

f) Warning Tape Burying

To prevent damage on direct-buried cable and underground conduit from future ground excavation, such as power line/water pipe burying, warning tape be buried midway between direct-buried cable or conduit and ground surface.

(3) Cross-Connecting Cabinet

For the most part of existing cables, the direct distributing system is adopted wherein cables are directly connected from the telephone exchange to the distribution box. P&T intends to replace such direct distributing system with the cross-connecting cabinet system, locating those cabinets on the cable route in consideration of easy cable maintenance and expansion in future. Therefore, in this project, the cross-connecting cabinet system will be adopted.

1) Establishment of Cross-Connecting Cabinet Area

Cross-connecting cabinet area is a management distributing unit for existing subscribers, as well as subscribers on waiting list, and for demand control and system maintenance, aimed at effective use of outside plants and pertinent plant expansion. As such, each cross-connecting cabinet area will remain fixed for a long time.

P&T already holds an overall plan for cross-connecting cabinet areas. Basic design for this project is based on that overall plan as much as possible.

2) Cross-Connecting Cabinet Location

One cross-connecting cabinet will be established in each cross-connecting cabinet distribution area. The selection of the cabinet location will be the side of telephone exchange in the area. Considering primary and secondary cable installation at minimum cost, locational modification will not be necessitated in the future.

3) Cabinet Types

Cross-connecting cabinet capacity will be for 1400 cable pairs, and this is the same as the capacity presently adopted by P&T.

Terminal block capacity will be for 200 and 100 cable pairs. In case of without stub cable, cable mounting point of terminal block will be filled with compound to prevent water infiltration.

For terminal block, two types will be used, one is with stub cable with standard length, the other is without stub cable.

(4) Distribution Box

1) Types and Capacities of Distribution Box

Distribution box capacity will be for required cable pairs for accommodation of active subscribers. For pole and wall types, capacity will be for 10 cable pairs each. For indoor type, capacity will be for 10, 20, 30, 50, 100 and 200 cable pairs.

Distribution box with or without stub cable will be used according to the location of manhole, cable network and topographical conditions. For indoor use, distribution box is without stub cable so that distributing cable is mounted directly to distribution box.

Pole and wall type distribution boxes without stub cable will be the type that allows water-proofing at cable terminating portion with compound filling when distribution cable is mounted directly on terminal in the box at the working site.

2) Distribution Box Location

a) Pole Type Distribution Box

Pole whereon to mount distribution box should preferably be located on side walk where drop wire into subscriber's premise is easy and does not interfere with traffic. It is important that the distribution box location, once selected, does not need to be changed for a long time and, at that location, cable maintenance is easy.

b) Wall Type Distribution Box

Wall type distribution box is mounted on external wall of building. It is important that at the location selected, distribution of drop wire into the subscriber's premise concerned and the neighboring premise is easy, that the building concerned is strong and the distribution box mounted is least likely to be damaged by third party, and that the location selected does not need to be changed for a long time.

c) Indoor Type Distribution Box

For indoor type distribution box to be mounted inside the building, it is important that at the location selected, wiring to telephone set is easy, and that the location is easy of access for maintenance personnel and is convenient for maintenance work.

3) Protection of Pole Type Distribution Box Stub Cable

Vertical run of stub cable to pole type distribution box is to be protected with 25 mm steel pipe. For the section to be buried underground, curved pipe is to be connected.

4) Protection for Stub Cable of Wall Type and Indoor Type Distribution Box

For protection of vertical run of stub cable or distribution cable to wall type and Indoor Type Distribution Boxes, U-guard is used.

In case where the wall is of structure that makes U-guard mounting inappropriate, steel pipe to be used for pole type distribution box is used. When cable to be led in the building is of 100 pairs or more, steel pipe of 50 mm inner diameter is used.

4-2-2 Civil Facilities

Construction of civil facilities requires a big amount of financial investment. Therefore, in underground conduit design, the optimum conduit route selection and calculation of the number of ducts required, as well as the determination of type and size of manhole to be adopted, are important factors. In other words, the construction must be at minimum cost whereas the conduit constructed must ensure safety and allows easy maintenance and cable laying.

(1) Route Selection

For conduit route selection, consideration must be made concerning technical problems in construction and maintenance aspects, based on field survey results, as well as town planning and related data.

(2) Utilization of Existing Underground Facilities

In case where vacant duct, other than spare duct, is available on the existing conduit route, such vacant duct will be used. Additional duct construction will not be made.

(3) Number of Ducts

In case where vacant duct is not available on the existing conduit route, the number of ducts to be constructed consists of new cable lines plus one emergency-use spare duct (to be used for cable change in case of system failure). For final decision of the number of ducts to be constructed, P&T's fundamental plan and technical problems involved in work execution are duly taken into consideration.

(4) New Conduit Route Construction

In case where the existing underground conduit cannot be utilized due to town planning, etc., new underground conduit will be constructed, provided that the new conduit construction is more advantageous in terms of work implementation and cost required than the utilizing existing conduit route.

(5) Type of Duct

In the underground conduit to be newly constructed, ducts will be composed of PVC pipes. In case where the use of PVC pipes is inappropriate as in the case of crossing a river and/or railway, steel pipes will be used. Steel pipes will be 100 mm in inner diameter. Meanwhile, for PVC pipes, locally procured pipes of low cost will be used.

(6) Manhole Spacing

Manhole spacing will be determined in consideration of cable branching, cross-connecting cabinet locations, and topographic conditions. For manhole spacing, following are the maximum limits based on P&T standards:

Straight section : 200 m
Curved section : 150 m

(7) Conduit Location

In case where carriageway and side walk are clearly distinguishable, conduit route will be constructed under side walk. In case of no distinction between carriageway and side walk, road shoulder will be the location for conduit route construction.

(8) Type of Manhole

Manholes will be built at cable splicing points, cable branching points, and other points where manholes are necessary for cable installation and maintenance. Each manhole must have the size to contain the following:

1) Necessary number of ducts
2) Working space

3) Cable splicing closure

Manhole size must be large enough to satisfy the radius of cable curvature.

Type and dimension of manhole are shown in Table IV-3.

(9) Manhole Remodeling

When new ducts are installed in the existing manhole and if manhole capacity is too small, the manhole will be remodeled. Remodeled manhole capacity will be determined in consideration of P&T's plan.

(10) Manhole Cover Mounting

Most of the existing manholes have their concrete covers damaged or completely lost. In the project area, concrete cover of manhole will be replaced with square type of new iron covers.

(11) Accessories of Manhole

Most of the existing manholes do not have the hardware mounted. In this project, the hardware in manhole as shown in below will be newly mounted. Especially cable supporting hardware are nothing in almost all cases so that cable bearers and vertical iron frame whereon to lay cable will be mounted.

1) Vertical iron frame and anchor bolt
2) Cable bearer
3) Pulling bolt (if absolutely necessary for cable laying)
4) Iron ladder (for larger than S-3 or L-3 manhole only)
5) Step bolt (for remodeled manhole only)
6) Manhole number plate

(12) Manholes to be Abandoned

Some of existing manholes are too short in distance to/from the neighboring manhole so that those manholes will not be used in this project. Abandonment of these manholes is to be done by P&T.

(13) Underground Conduit Depth

Depth from ground surface to the upper part of underground conduit must be the following, based on P&T standards:

1) Side walk, farmland, forest ... 75 cm or more
2) Carriageway ..... 90 cm or more
3) Road, across railway tracks ... 100 cm or more

(14) Warning Tape Burying

To prevent damage on underground conduit or direct-buried cable due to ground excavation in the future for power line or water supply installation, warning tape will be buried midway between ground surface and underground conduit.

4-2-3 Subscriber's Premise Facilities

Design of subscriber's premise facilities including drop wire, SD wire and indoor cable from distribution box to telephone set highlights is shown in Figure IV-6.

Layout of Subscriber's Premise Facilities is shown in Figure IV-6.

(1) Drop Wire and SD Wire

Drop wire will be used between pole type or wall type distribution box and subscriber's premise. When the drop wire is more than two, as a rule, SD wire will be used.

(2) Subscriber's Protector and Terminal

For connecting of drop wire or SD wire and internal wire free from likelihood of contact with power line, etc., subscriber's terminal will be used. In case where drop wire or SD wire may contact with power line, etc., subscriber's protector will be mounted on external wall of building so as to protect internal facilities electrically. Subscriber's protector will be earthed.

(3) Internal Wire

For indoor wiring from subscriber's protector or subscriber's terminal to telephone set, internal wire will be used. For telephone set connection with internal wire, rosette will be used. For internal wiring, stud for concrete, wire protector, etc., will be used.

(4) Indoor Cable

For aged or faulty indoor cable in the premise of large-scale subscriber who uses indoor type distribution box, replacement will be made.

Cable pairs of indoor cable to be used are:

Conductor Gauge	Cable Pairs
0.5 mm	10, 20, 30, 50, 100

(5) Telephone Set

According to the survey on the subscriber's premise facilities conducted as part of the field survey, a considerable number of existing telephone sets is defective. Some are wrong in dial speed not complying with standard 10 pulses, some in rickety dial rotation, some in ineffective cord, and some in broken rosette.

For upgrading of telephone services, some of the faulty telephone sets in coverage area will be replaced with new one. Some telephone sets and its accessories will be granted by this project, and all the replacement works are implemented by P&T's subscriber's premise team.

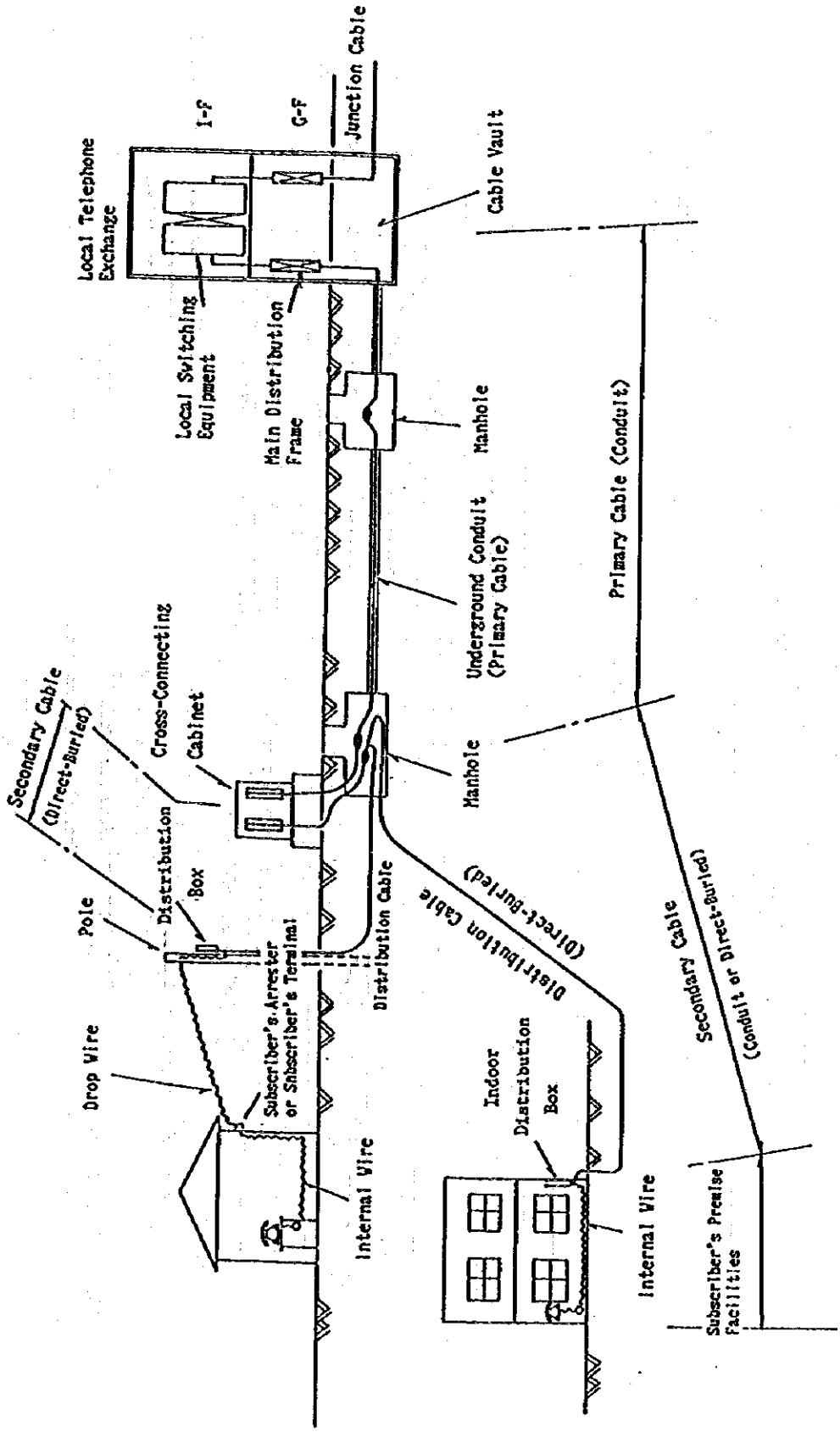


Fig. IV-5 Layout of Local Telephone Cable Network

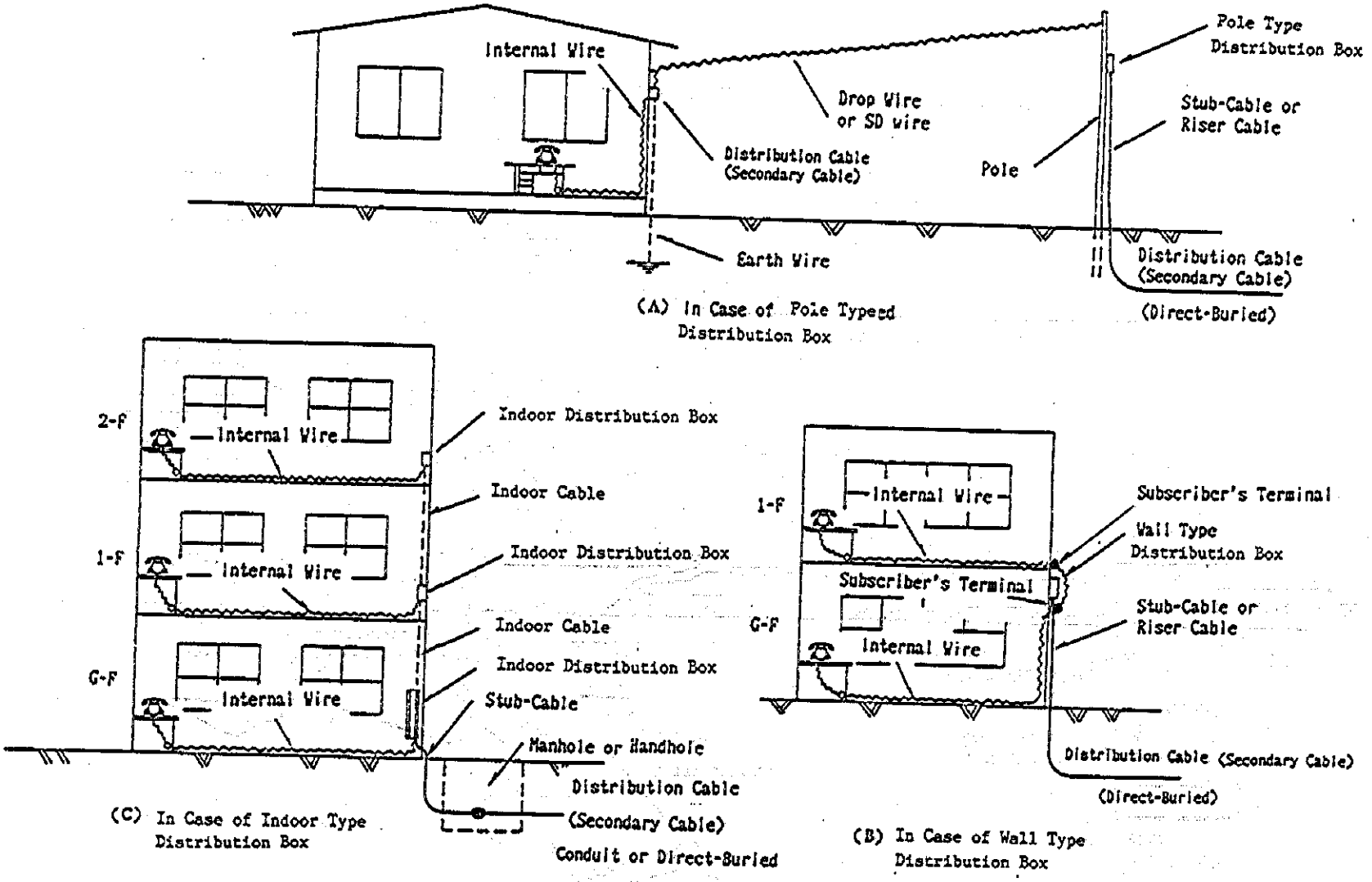


Fig. IV-6 Layout of Subscriber's Premises Facilities

Table IV-3 Type and Dimension of Manholes

TYPE	NUMBER OF DUCTS	LENGTH (M)	WIDTH (M)	DEPTH (M)	TYPE OF COVER	CABLE BRACKET
F-1	1	0.90	0.70	1.00	□	One side
F-2	2 - 4	1.50	0.80	1.20	□	"
F-3	5 - 6	2.30	0.80	1.40	□	"
S-3	7 - 9	2.30	1.30	1.50	○	Both sides
S-4	10 - 16	3.00	1.40	1.70	○	"
S-5	17 - 24	3.20	1.40	2.10	○	"
L-2	1 - 4	1.90	1.00	1.50	○	"
L-3	5 - 9	2.50	1.30	1.50	"	"
L-4	10 - 16	3.40	1.40	1.70	"	"
L-5	17 - 24	3.60	1.40	2.10	"	"
L-6	25 - 35	4.00	1.50	2.20	"	"
T-2	1 - 4	2.30	1.10	1.50	○	"
T-3	5 - 9	2.50	1.30	1.80	"	"
T-4	10 - 16	3.40	1.40	1.80	"	"
T-5	17 - 24	3.60	1.40	2.30	"	"
T-6	25 - 35	4.50	1.50	2.40	"	"
+-2	1 - 4	2.30	1.10	1.50	○	"
+-3	5 - 9	2.50	1.30	1.80	"	"
+-4	10 - 16	3.40	1.40	2.10	"	"
+-5	17 - 24	3.60	1.40	2.60	"	"
+-6	25 - 35	4.50	1.50	2.60	"	"

4-3 Inside Plant

4-3-1 PABX Switching Equipment in Ministries Area

(1) Telephone Switching Equipment

Outline of centralization equipment system (PABX) in local telephone network is as shown in Figure IV-7.
Design standards of telephone switching equipment are to be conformed with recommendations by CCITT, and also some portions will be conformed as much as possible if the current design standards being applied on P&T's public telecommunication network are capable to apply on this project.

The outline of PABX centralization extension system on th local telephone network is as shown in Figure IV-4.

1) Service quality
Grade of service (Probability that originating call can not be connected) is to be maintained at 0.01 or less for all the attempts.

2) Numbering Plan
numbering plan will be conformed with the present numbering scheme.

3) Signalling Plan
To be compatible with signalling plan on the existing system.

4) Line Loss and loop Resistance
For the line loss and loop resistance concerning the outside plant on design conditions of PABX switching equipment, the undermentioned values are to be stipulated as criteria.

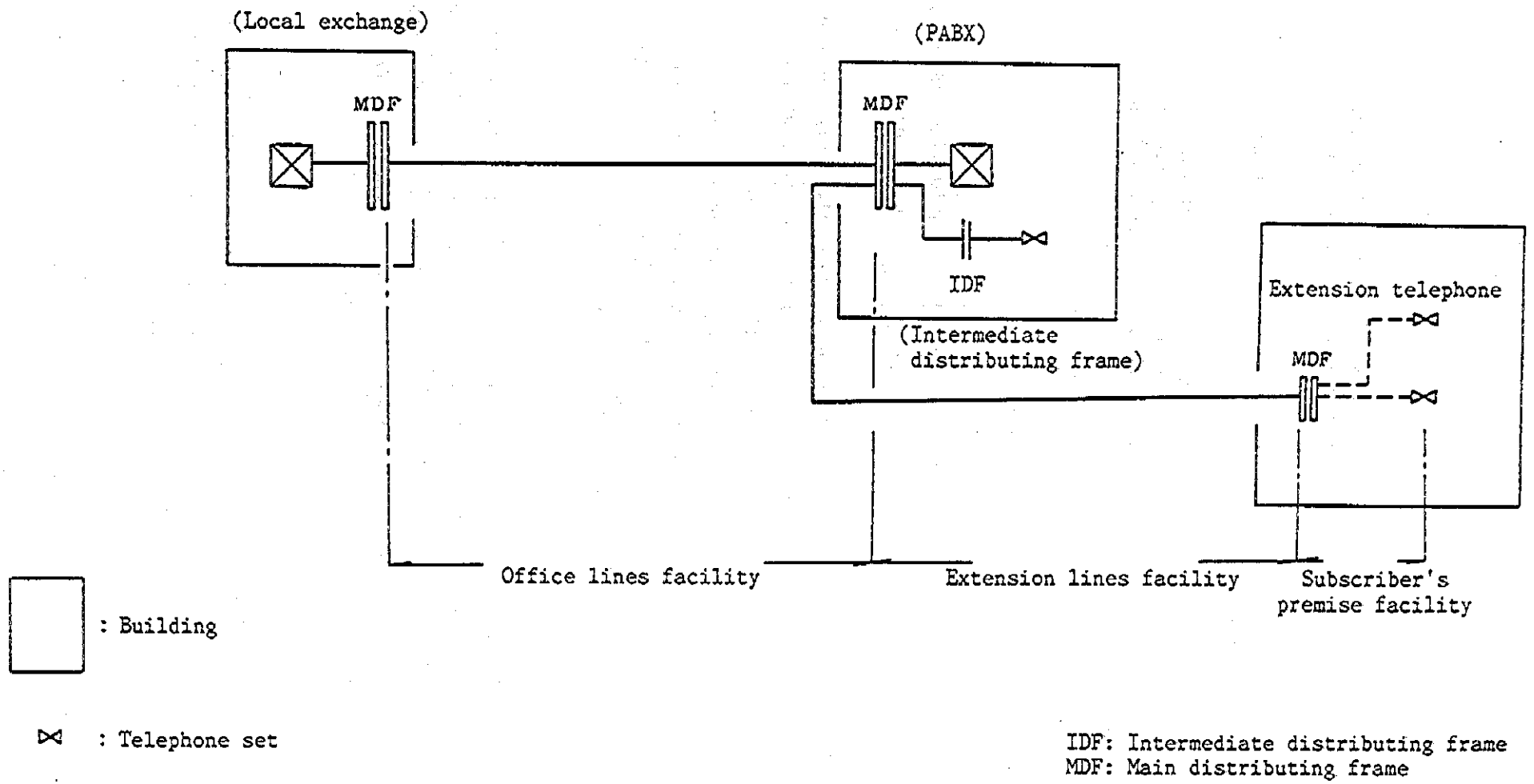


Fig. IV-7 Outline of Centralized Extension System (PABX)

	Line Loss Distribution	Loop Resistance Limit
Office Line from Central	5.0 dB	1500 ohms
Extension	3.5 dB (inclusive of office loss)	1000 ohms (inclusive of telephone set resistance)

(2) Switching Equipment Accessories

In Ghana, electrical equipment standards and guidelines whereby to make electrical equipment design are practically unavailable.

For PABX switching equipment in ministries area, equipment that requires advanced environmental condition is to be installed so that the design standards are basically to be the same as those applicable to electrical equipment or an exchange building in Japan. This time, however, optimum design will be made in consideration of local building conditions, commercial power availability, meteorological condition, and general life environment.

Especially important is to procure necessary materials locally as far as circumstances permit, to facilitate system maintenance after service-in. It has been confirmed that part of electrical equipment materials and construction materials including mortar blocks can be locally procured.

1) Battery

Battery is to have capacity for three hours power supply in case of power failure. This power supply capacity will meet with switching equipment capacity.

2) Rectifier

Rectifier output capacity is to satisfy ultimate stage switching equipment capacity. Arrangement is necessary so that the rectifier can make stable d.c. current power supply to telecommunications equipment in spite of commercial power voltage variations.

3) Generator

Generator is to have functions for automatic start at the time of commercial power failure and for automatic stop when commercial power supply is restored. Necessary fuel tank must also be provided.

4) Air-Conditioner

Switching equipment room is to be air-conditioned for 24 hours/day, in principle. Therefore, standby air-conditioner which can take over when the main air-conditioner fails must be provided.

Outdoor temperature and humidity:

Year's maximum temperature in the city of Accra ... 32.1^{o}C (variation range: ±10%)

Year's average humidity in the city of Accra ... 82.1% (variation range: ±10%)

Switching equipment room temperature and humidity:

Temperature ..... 15-30^{o}C

Humidity 30-65%

5) Power Receiving Equipment

Power receiving equipment is to satisfy capacity sum of the following items:

Rectifier input power (corresponding to switching equipment capacity)

Air-conditioner

Lighting and plug socket

6) MDF (Main Distribution Frame)

MDF for division of switching equipment side office cable and subscriber cable is to be provided.

For cutover from existing to new switching equipment, block diagram inclusive of existing MDF is as shown in Figure IV-8.

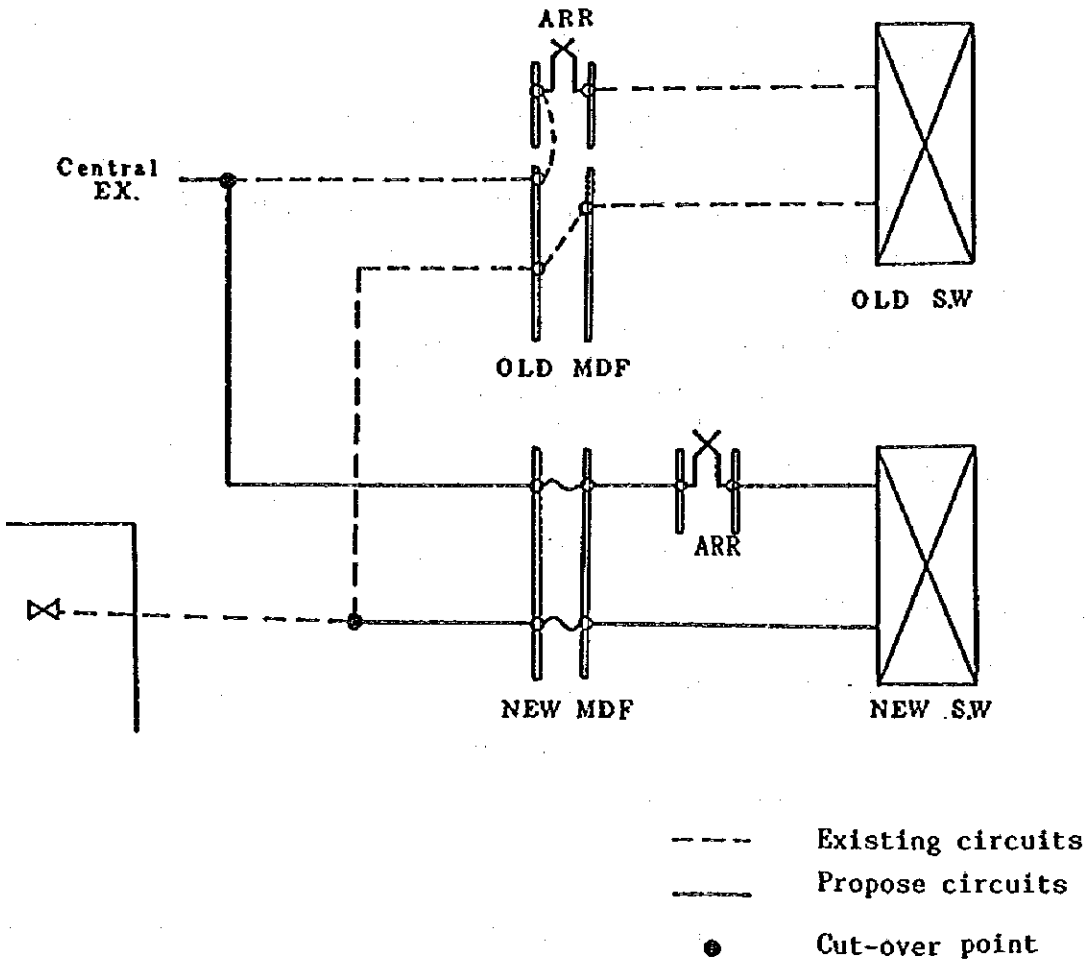


Fig. IV-8 Outline of Cut-Over

7) Earthing

Electrical facilities in the building and telecommunications equipment will be earthed as follows;

Low voltage (415/230V) ..... 100 ohms or less
Telecommunication equipment ..... 2 ohms or less
MDF ..... 10 ohms or less

4-3-2 Training-Use Switching Equipment

(1) Training-Use Switching Equipment

The objective is to train maintenance and operation engineers for recently introduced and now operating digital exchange, training-use switching equipment are to conform with recommendations by CCITT and with existing Ghana public telecommunication network facilities.

(2) Training-Use Switching Equipment Accessory

In this case also, electrical equipment standards and guidelines whereby to make electrical equipment design criteria in Ghana are practically unavailable. Therefore, in consideration of local technical condition of construction, commercial power availability and related factors, optimum design will be made.

1) Battery

Battery is to have capacity for three hours power supply in case of commercial power failure. This power supply capacity will meet with switching equipment capacity. Battery sometimes generates gas so that ventilation system must be provided in battery room.

2) Generator

No generator will be provided. This is because the objective is to train maintenance and operation staff for

switching equipment and actual subscriber service is not involved.

3) Rectifier

Rectifier output capacity is to satisfy switching equipment capacity.

4) Power Receiving Equipment

As shown in Figure IV-4 of power supply system block diagram, scope of construction for power receiving equipment ends with distribution board. Distribution board is to satisfy capacity sum of the following items:

Rectifier input power (corresponding to battery capacity)
Air-conditioner of consumption electric power
Lighting and plug socket (for connection of training-use measuring equipment and tools, and office equipment)

5) Air-Conditioner

Training-use switching equipment room is to be furnished with air-conditioner which can satisfy the following requirements at all times including training term.

	Temperature	Humidity
During training	15-30°C	30-65%
Other time	5-40°C	30-85%

6) MDF

MDF for training-use switching equipment and test-use telephone set connection and office cable connection is to be provided. MDF wiring diagram is as shown in Figure IV-9.

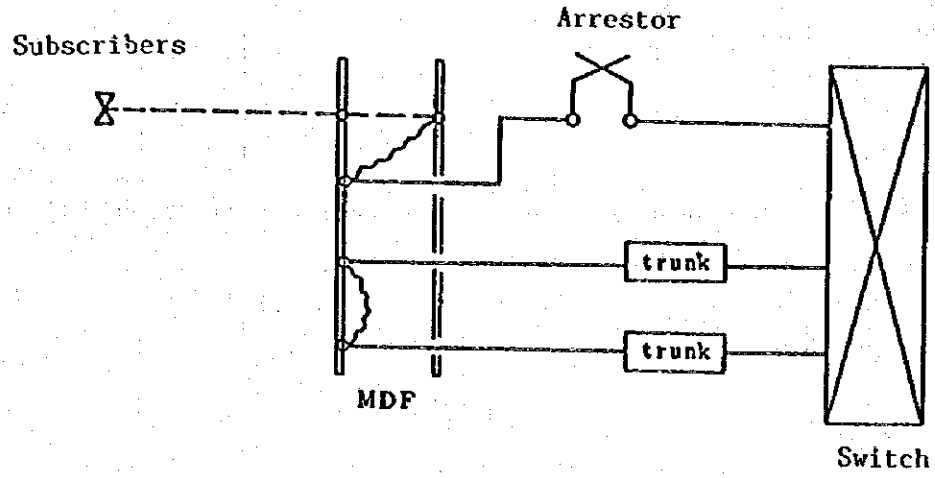


Fig. IV-9 MDF Wiring Diagram

7) Earthing

Electrical equipment for the building and telecommunication equipment will be earthed as follows:

Low voltage (415/230V) ..... 100 ohms or less
Telecommunication equipment ..... 10 ohms or less

4-4 Basic Design Result

4-4-1 Outside Plant

(1) Coverage Area

The eight areas in Accra where the rehabilitation work by this project is implemented, are as follows.
The Guide Map is given in Figure IV-10.

1) Accra Central Exchange Area

No. 1 Ministries area (Castle and State House are included.)
No. 2 Korle-Bu Hospital area
No. 3 Business and commercial area (Banks, Central Market, private business offices)

2) Cantonments Exchange Area

No. 4 Embassies area
No. 5 Airport residential area (Many residences of high government officers and foreign diplomats)
No. 6 East Cantonments residential area (Many residences of high government officers and foreign diplomats)

3) Accra North Exchange Area

No. 7 Ghana Broadcasting Corporation area
No. 8 Industrial area

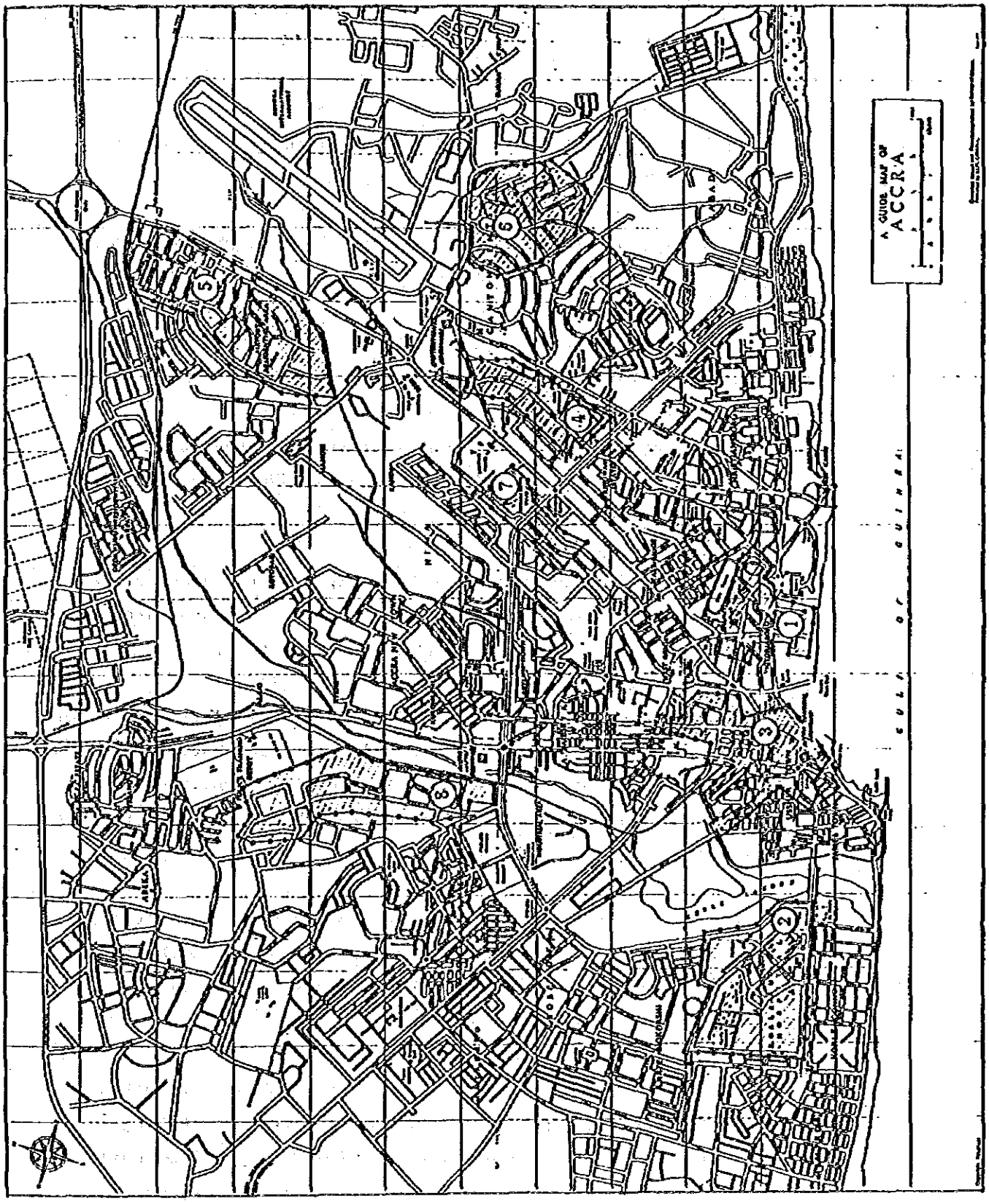


Fig. IV-10 Guide Map

(2) Basic Plan in Coverage Area

The basic plan for outside plant in eight coverage areas are described hereinafter.

The Key maps of each area to be covered by this project are as shown in Figure IV-11 - Figure IV-17.

1) No. 1: Ministries Area (Castle and State House are included)

The basic plans for outside plant in this area appears in Drawings No. 1 - No. 14. (attached in ANNEX)

- Ministries Area

Except for the area close to PABX, six cross-connecting cabinet areas will be established wherein cables are separated into primary and secondary cables.

All existing cables will be replaced. All existing indoor type distribution boxes or wall type distribution boxes as secondary cable accessories will also be replaced. Existing primary cable from Accra Central exchange to this PABX will be replaced.

Existing manhole covers, if defective or completely lost, will be replaced with iron covers. Manholes without vertical iron frame and cable bearers will be fitted with these accessories.

For primary cable termination on new MDF as a result of switchboard replacement for PABX telephone switching facilities in this area, new cable trench will be built in existing buildings whereby to terminate primary cables.

- State House

PABX area in this area is relatively small so that cross-connecting cabinet establishment is of no use. Therefore, cross-connecting cabinets will not be established. Instead, cable will be laid directly from MDF to indoor distribution box. Existing distribution boxes as cable accessories will be replaced.

Existing manhole covers, if defective or completely lost, will be replaced with iron covers. Manholes without vertical iron frame and cable bears will be fitted with these hardware.

Existing primary cable from Accra Central exchange to this PABX will be replaced, together with primary cables in Ministries area.

- Castle

Almost all inside plants in this PABX area are indoor cables and internal wires. Therefore, these are out of the scope of outside plant replacement for improvement. However, 200 pairs of existing primary cable from Accra Central exchange will be replaced, together with Ministries area and State House primary cables.

2) No. 2: Korle-Bu Hospital Area

In this area, the effect of using cross-connecting cabinets is small. Therefore, cross-connecting cabinets will not be established. Instead, the direct distribution system will be adopted.

All existing cables and distribution boxes in this area will be replaced.

Existing manhole covers, if defective or completely lost, will be replaced with iron covers. Manholes without vertical iron frame and cable bearers will be fitted with these hardware.

The basic plan for outside plant in this area appears in Drawings No. 15 through No. 18 (attached in ANNEX).

3) No. 3: Business and Commercial Area

In this area, except for part of peripheral area of Accra Central Exchange service area, nine cross-connecting cabinet distribution areas will be established, and, divided by primary and secondary cables, existing cables will be replaced and improved. All existing distribution boxes will also be replaced.

Existing manhole covers in this area, if defective or completely lost, will be replaced with iron covers. Manholes without vertical iron frame and cable bearers will be fitted with these hardware. Existing underground conduits, if usable, will be utilized.

The Basic Plan for outside plant in this area appears in Drawings No. 19 through No. 29 (attached in ANNEX).

4) No. 4: Embassies Area

In this area, one cross-connecting cabinet will be established according to P&T basic design. For embassies area and middle/high grade residential area only, cable and accessories replacement will be carried out.

Existing manhole covers, if defective or completely lost, will be replaced with iron covers. Manholes without

vertical iron frame and cable bearers will be fitted with these hardware.

The basic plan for outside plant in this area appears in Drawings No. 30 and No. 31 (attached in ANNEX).

5) No. 5: Airport Residential Area

In this area, two cross-connecting cabinet distribution areas will be established, and, divided by primary and secondary cables, all existing cables in these areas will be replaced and improved.

In this area, one cross-connecting cabinet accommodation area is distant from Cantonments Exchange so that, for primary and secondary cables, cables with conductor gauge of 0.5 mm will be used. All existing distribution boxes will be replaced.

Existing manhole covers, if defective or completely lost, will be replaced with iron covers. Manholes without vertical iron frame and cable bearers will be fitted with these hardware.

The basic plan for outside plant in this area appears in Drawings No. 32 through No. 35 (attached in ANNEX).

6) No. 6: East Cantonments Residential Area

In this area, one cross-connecting cabinet will be established, and, divided by primary and secondary cables, existing cables will be replaced and improved. All existing distribution boxes will be replaced.
Existing manhole covers, if defective or completely lost, will be replaced with iron covers. Manholes without

vertical iron frame and cable bearers will be fitted with these hardware.

The basic plan for outside plant in this area appears in Drawings No. 36 through No. 39 (attached in ANNEX).

7) No. 7: Ghana Broadcasting Corporation Area

One cross-connecting cabinet area will be established wherein to accommodate Ghana Broadcasting Corporation and IBRD Office on opposite sides of Ring Road. Divided by primary and secondary cables, existing cables will be replaced. All existing distribution boxes will be replaced. Existing manhole covers, if defective or completely lost, will be replaced with iron covers. Manholes without vertical iron frame and cable bearers will be fitted with these hardware.

The basic plan for outside plant in this area appears in Drawings No. 40 and No. 41 (attached in ANNEX).

8) No. 8: Industrial Area

In this area, one cross-connecting cabinet will be established, with P&T basic design partially changed. Divided by primary and secondary cables, existing cables will be replaced and improved. All existing distribution boxes will be replaced.
Existing manhole covers, if defective or completely lost, will be replaced with iron covers. Manholes without vertical iron frame and cable bearers will be fitted with these hardware.

The basic plan for outside plant in this area appears in Drawings No. 42 through No. 45 (attached in ANNEX).

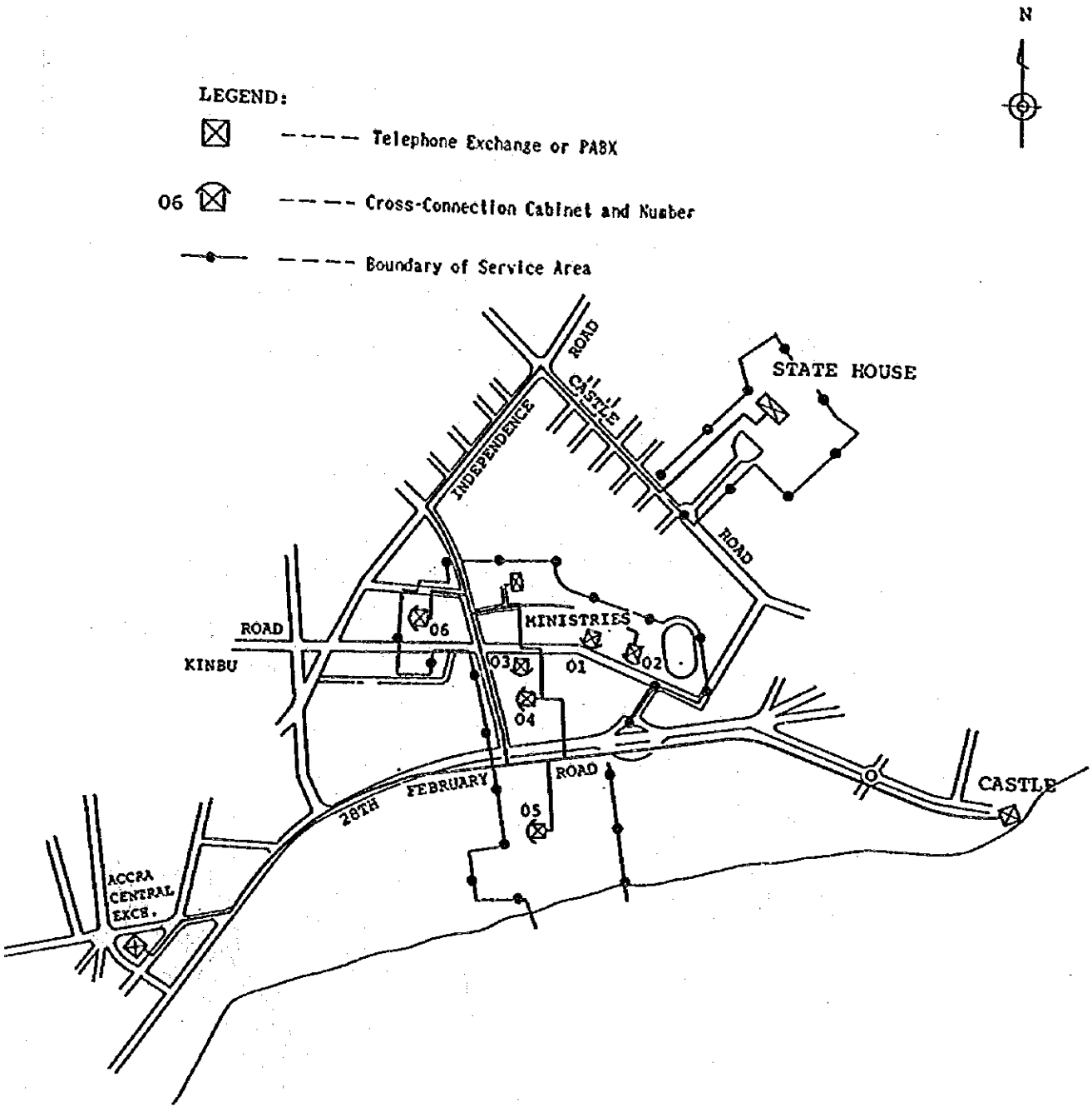


Fig. IV-11 Ministries Area

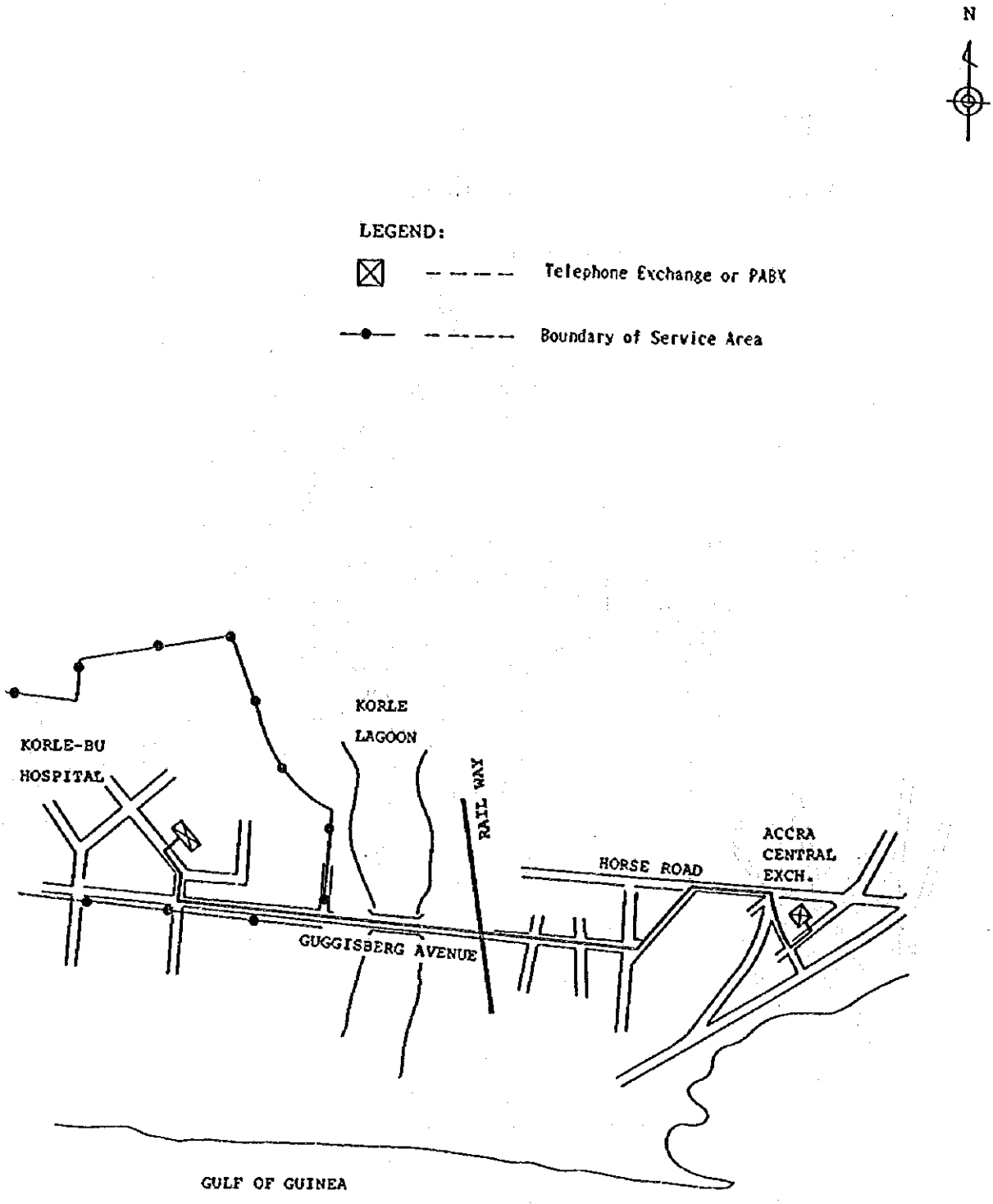


Fig. IV-12 Korle-Bu Hospital Area

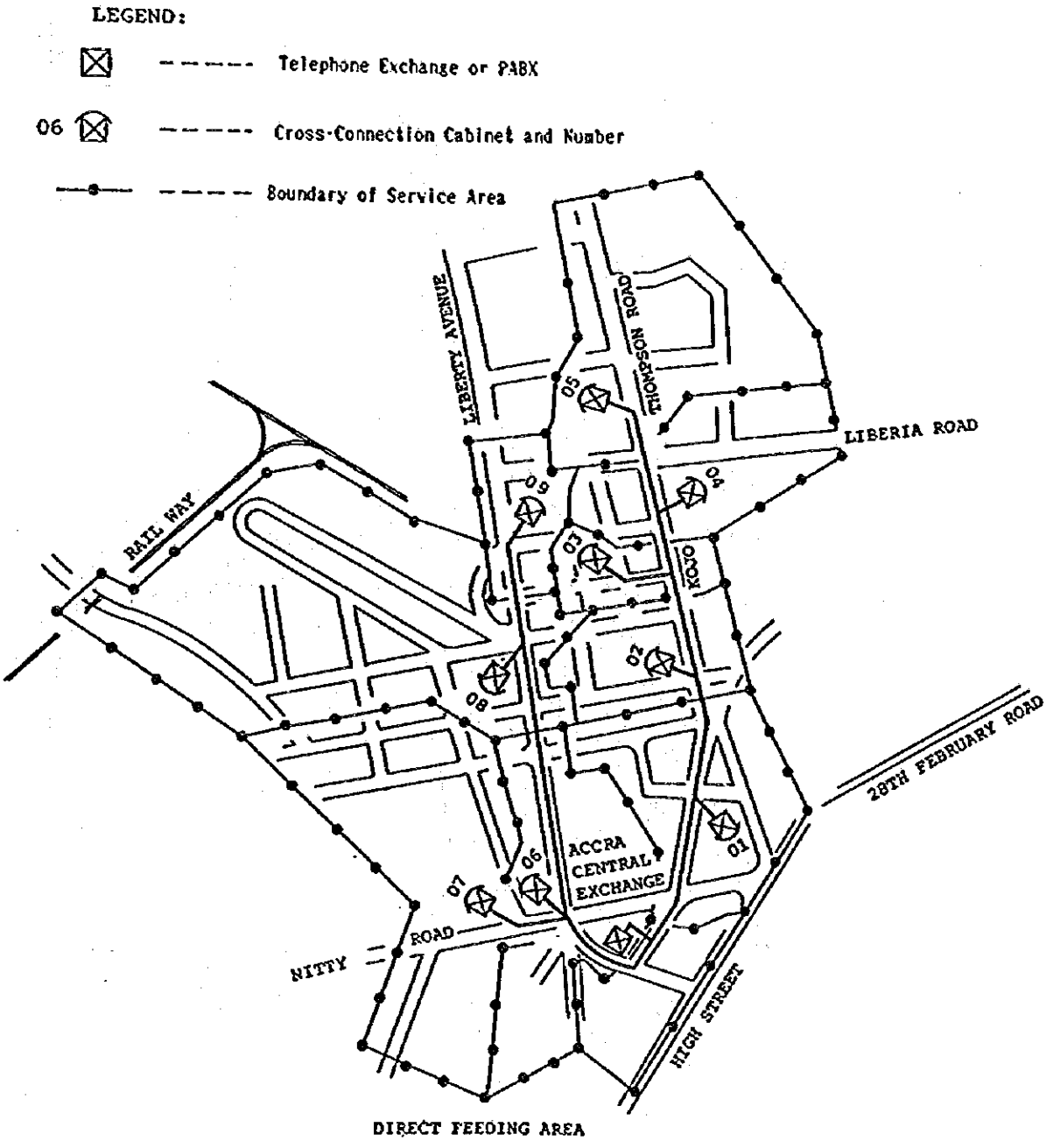


Fig. IV-13 Business & Commercial Area

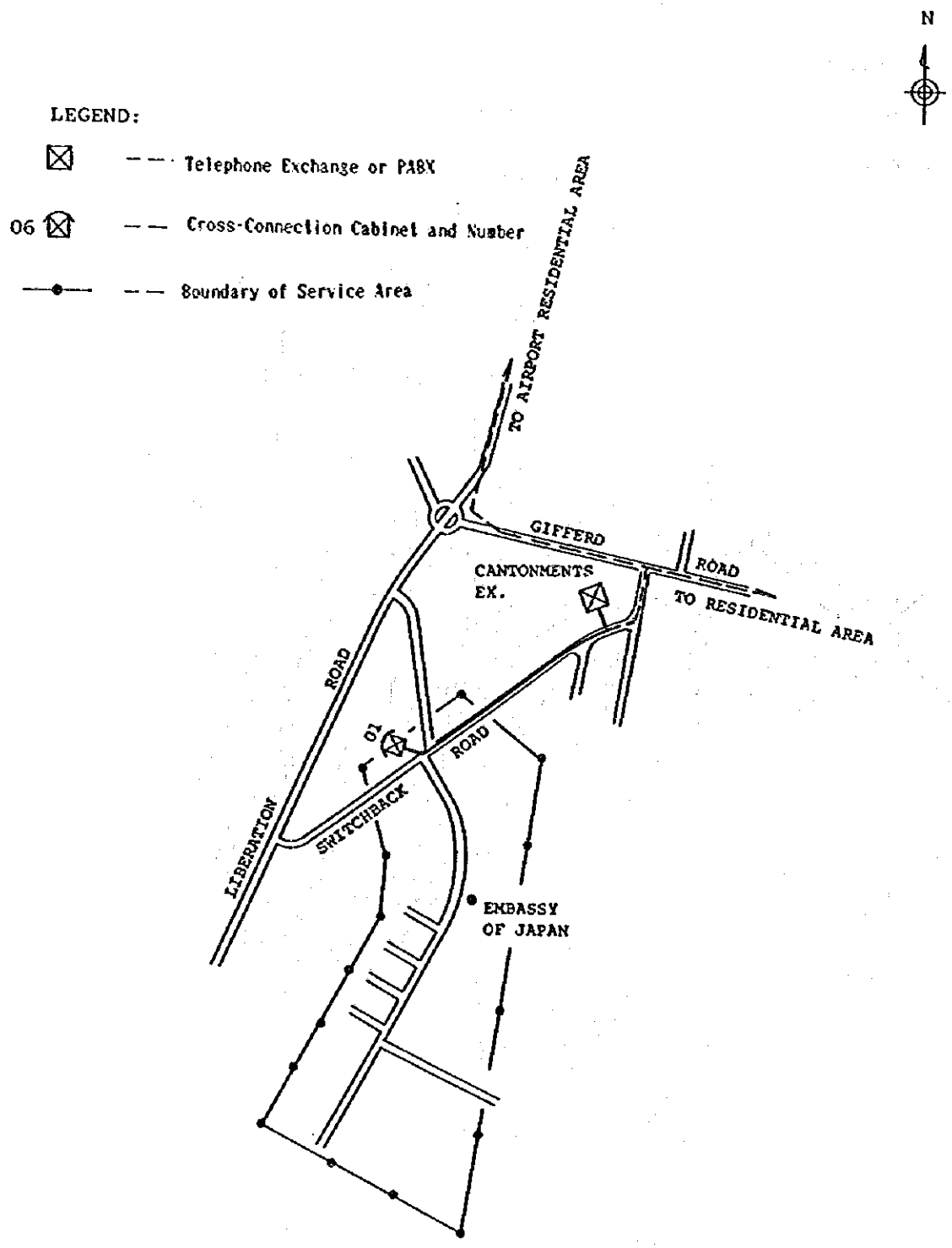


Fig. IV-14 Embassies Area

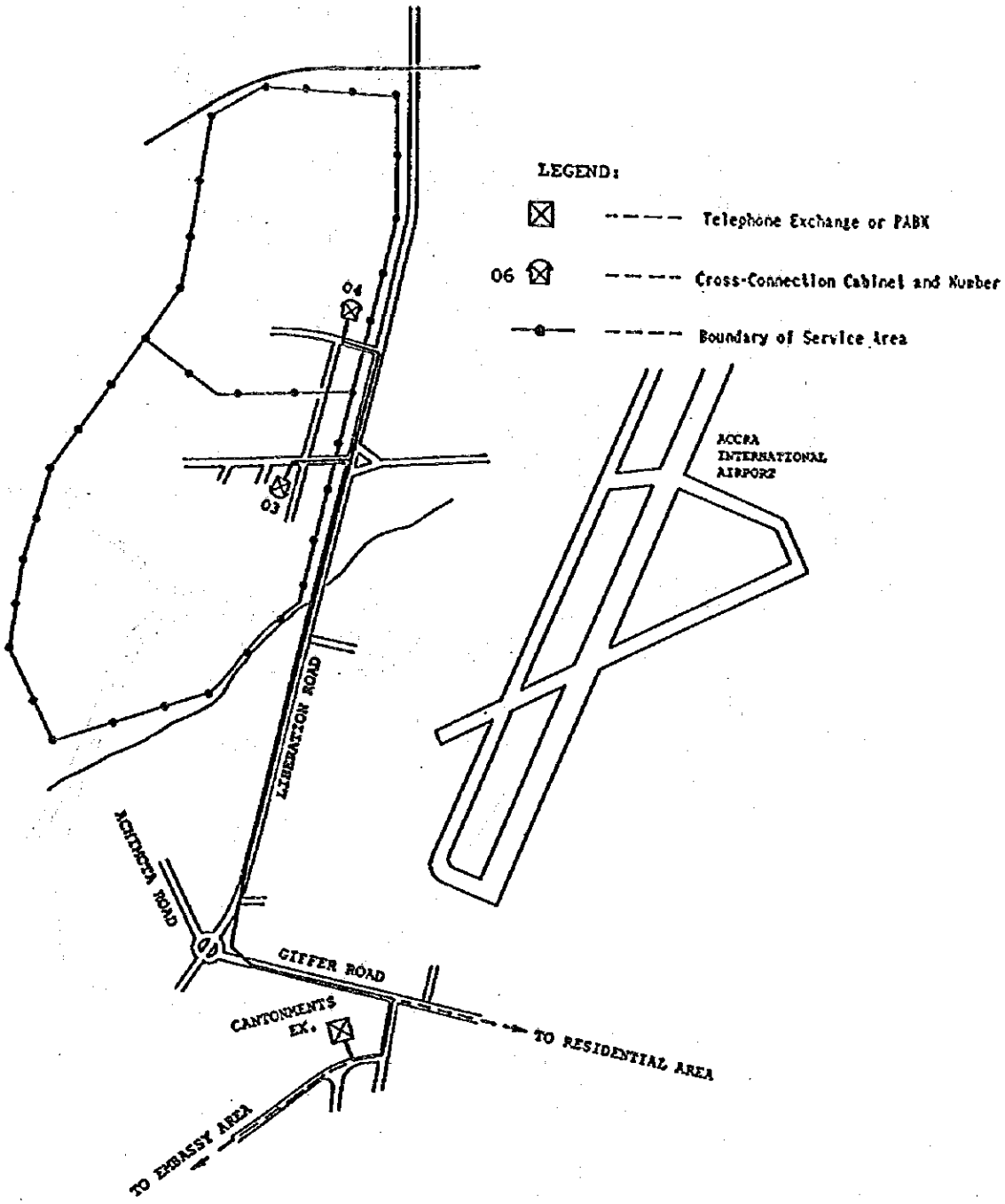


Fig. IV-15 Airport Residential Area

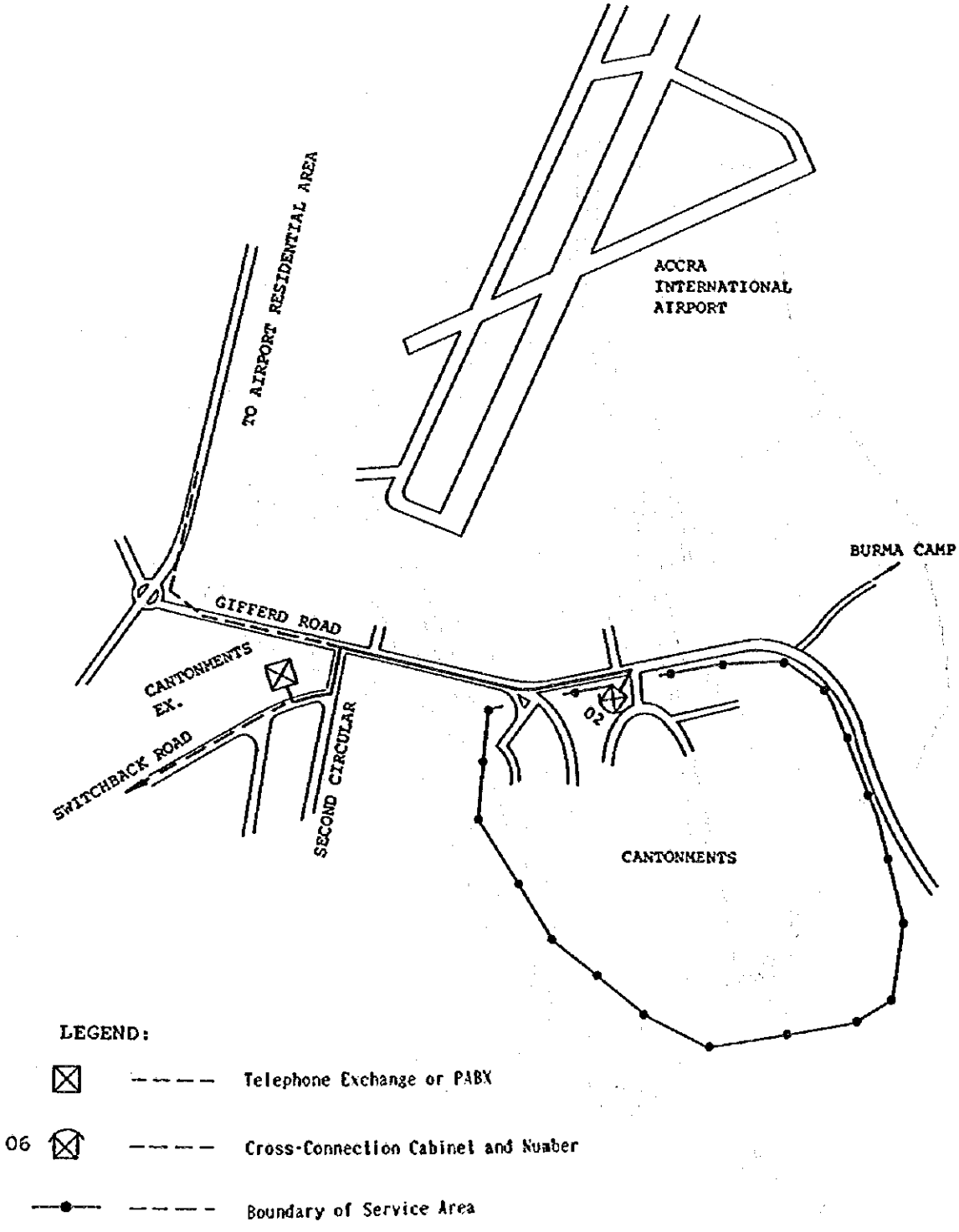


Fig. IV-16 East Cantonments Residential Area

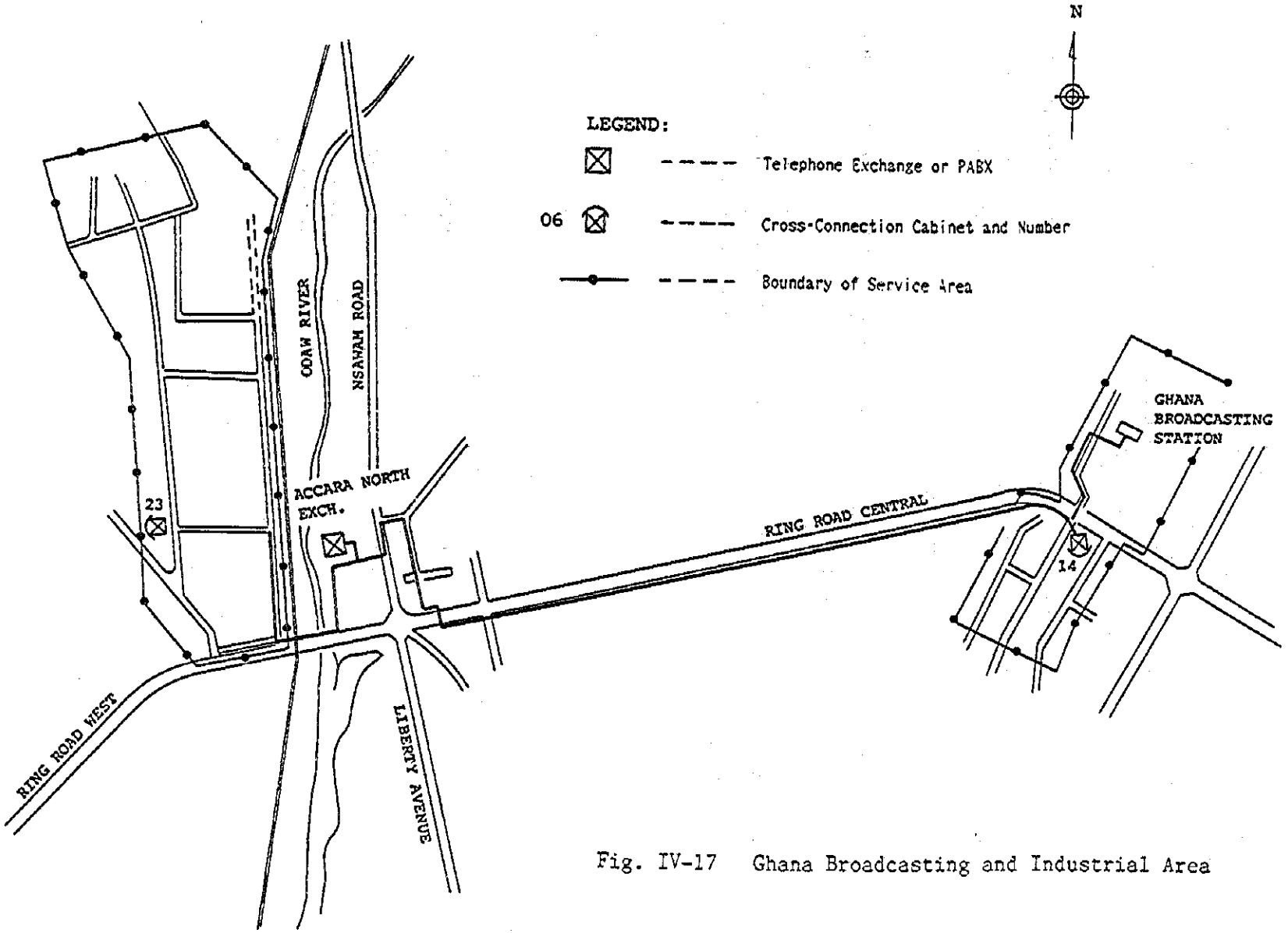


Fig. IV-17 Ghana Broadcasting and Industrial Area

(3) Subscriber's Premise Facilities

Necessary rehabilitation works for subscriber's premise facilities in the eight key areas will be implemented by P&T's subscriber's premise work group, parallel with the rehabilitation work.

The rehabilitation work by subscriber's premise facilities work group of P&T is to replace and/or improve time-worn, defective indoor cables, internal wires and indoor type distribution boxes, etc., totaling 3,500 cases.

For telephone sets, some defective telephone sets in the eight areas will be replaced by P&T.

A list of subscriber's premise equipment to be supplied to P&T for replacement is as shown in the following table.

No.	Item	
1	Telephone Set, Desk type	
2	Indoor Cable	0.5-100P
3	Indoor Cable	0.5-50P
4	Indoor Cable	0.5-30P
5	Indoor Cable	0.5-20P
6	Indoor Cable	0.5-10P
7	0.65 1 pair Internal Wire	
8	0.5 1 pair Jumper Wire	
9	Indoor Type Distribution Boxes	10P-100P

(4) Main Work Items Covered By Project

Main work items covered by this project is given in following table.

No.	Work Item
1	Construction of Manholes
2	Replacement of Manhole Covers
3	Installation of PVC Pipes
4	Construction of Cable Trench
5	Cleaning of Manholes
6	Erection of Steel Poles
7	Installation of Buried Cables
8	Installation of Duct Cables
9	Installation of Cross-Connecting Cabinets
10	Installation of Distribution Box
11	Cable Splicing
12	Cable Termination
13	Installation of Drop Wires to Premise
14	Cutover of Subscriber Lines

4-4-2 PABX Switching Equipment in Ministries Area

(1) Selection of Switching Equipment Location

PABX switching equipment in Ministries area exists in the service area of Accra Central Exchange and the service area and location of this PABX are shown in Figure IV-11.

The new PABX switching equipment in Ministries area is to be installed on the 2nd floor of the existing PABX building, after the careful study result of the below-mentioned fundamental conditions and requirement:

1) Distance and location of PABX building from Accra Central Exchange
2) Existing cable and underground duct facilities
3) Effective use of existing PABX building
4) Construction cost and period of new building
5) Cutover procedure of subscribers

(2) Design of Switching Equipment

1) Equipment Structure

Important switching equipment components will be double-structured.

2) Floor Layout

Equipment floor layout will be decided after careful consideration of the following points:

- There must be no impediment to future equipment expansion.
- Cable length must be shortest possible in consideration of cable length limits.

- There must be no trouble with equipment arrangement at installation site including installation on racks.
- There must be no adverse mutual influence between switching equipment and associated equipment (air-conditioner, lighting, etc.) to be installed in switching equipment room.
- Switching equipment location must be such that no inconvenience in installation work, as well as maintenance and operation works, will be entailed.

3) Wiring System

For indoor cable wiring, under-floor system and cable rack system are available. This time, since switching equipment is in the existing building, cable rack system will be adopted.

4) MDF

For cutover of existing circuit and interconnection of inside and outside cables, MDF will be established. MDF is to be established to satisfy the number required for termination of the undermentioned cables.

- Primary cable to Accra Central exchange
- Distribution cable to subscribers
- Switchboard cable
- Miscellaneous cable

MDF must have space for termination of other associated cables including leased circuit cable.

(3) Associated Facilities

1) Rectifier

Silicon dropper (SID) system rectifiers will be adopted, because current consumption by switching equipment is small (less than 600A). Rectifiers, while floating or charging batteries, will supply D.C. power required by switching equipment.

2) Battery

Batteries to be installed provide for the stable power supply to the switching equipment, when the commercial power supply is available, and for the power supply capacity sufficient to the switching equipment for some specified hours, when the commercial power supply is stopped.

3) Generator

Low tension diesel engine generator (output: 50 Hz, 430/230V) will be used. Fuel tank will have capacity for two days continuous generator operation. Oil barrier to prevent oil leakage will be provided.

4) Power Receiving Facilities

Existing commercial receiving facilities will be replaced. Cutover of existing facilities to new facilities will be made by Ghana side. Schematic power system diagram appears in the Figure IV-18.

5) Air-Conditioner

The temperature and humidity requirements for air-conditioner installation in switching equipment room are as follows:

Temperature: $25^{o}C \pm 5^{o}C$
Humidity : $50\% \pm 10\%$

Switching equipment room will be air-conditioned for 24 hours/day, in principle. Therefore, standby air-conditioner will be installed so that it can take over when the working system fails.

6) Earthing

For earthing, copper plate burying and metal bar parallel planting will be adopted. Seasonal variations of earthing resistance will be duly considered.

7) Interior Design

Basic requirement for exchange building is to construct it, using incombustible materials, so as to protect important equipment installed inside from damage and destruction due to untoward disaster. Openings, including windows, must be blocked, when necessary, with incombustible material. Air-tightness to improve the air-condition effectiveness must also be duly considered.

8) Fire Extinguisher

Portable type fire extinguisher will be provided in each undermentioned room. Unit type fire extinguisher is inconvenient to use, especially from a maintenance viewpoint, in exchange building.

a) Switching equipment room

HALON 1301 portable type extinguisher

b) Operator room

Portable type extinguisher using phosphate powder

c) Generator room

Both HALON extinguisher and phosphate type extinguisher

(4) Building Use Plan

Building use plan is as follows:

1) Switching Equipment Room

Vacant floor space in the present operator room will be used for installation of switching equipment, MDF and rectifiers. Consideration is necessary for the following points:

a) Wiring of communication cable and power cable.

b) Smallest possible window to improve the air-condition effectiveness.

c) Doors must be made of steel and can be locked.

d) Necessary floor space must be secured for subscriber test room and room where to keep drawings, manuals, measuring equipment, tools and subscriber cards for maintenance and operation work, as well as work space.

2) Operator Room

The present rest room will be used for operator room. The room space must be large enough for the supervisor to tour round in the room seating operators.

3) Cable Room

Cable room where to connect the primary and distribution cables and switchboard cable must be provided.

4) Generator Room

Existing toilet room for males will be remodeled for generator room. Room remodeling will be done by P&T. Ventilation system must be complete because air consumption during engine operation is in large quantity.

5) Battery Room

Existing battery room will be utilized. Ventilation facilities must be introduced to exhaust gas generated by batteries.

6) Rest Room, Office Room and Materials Storeroom

For these rooms, existing switching equipment room will be used. Withdrawal of existing switching equipment and room remodeling will be done by P&T.

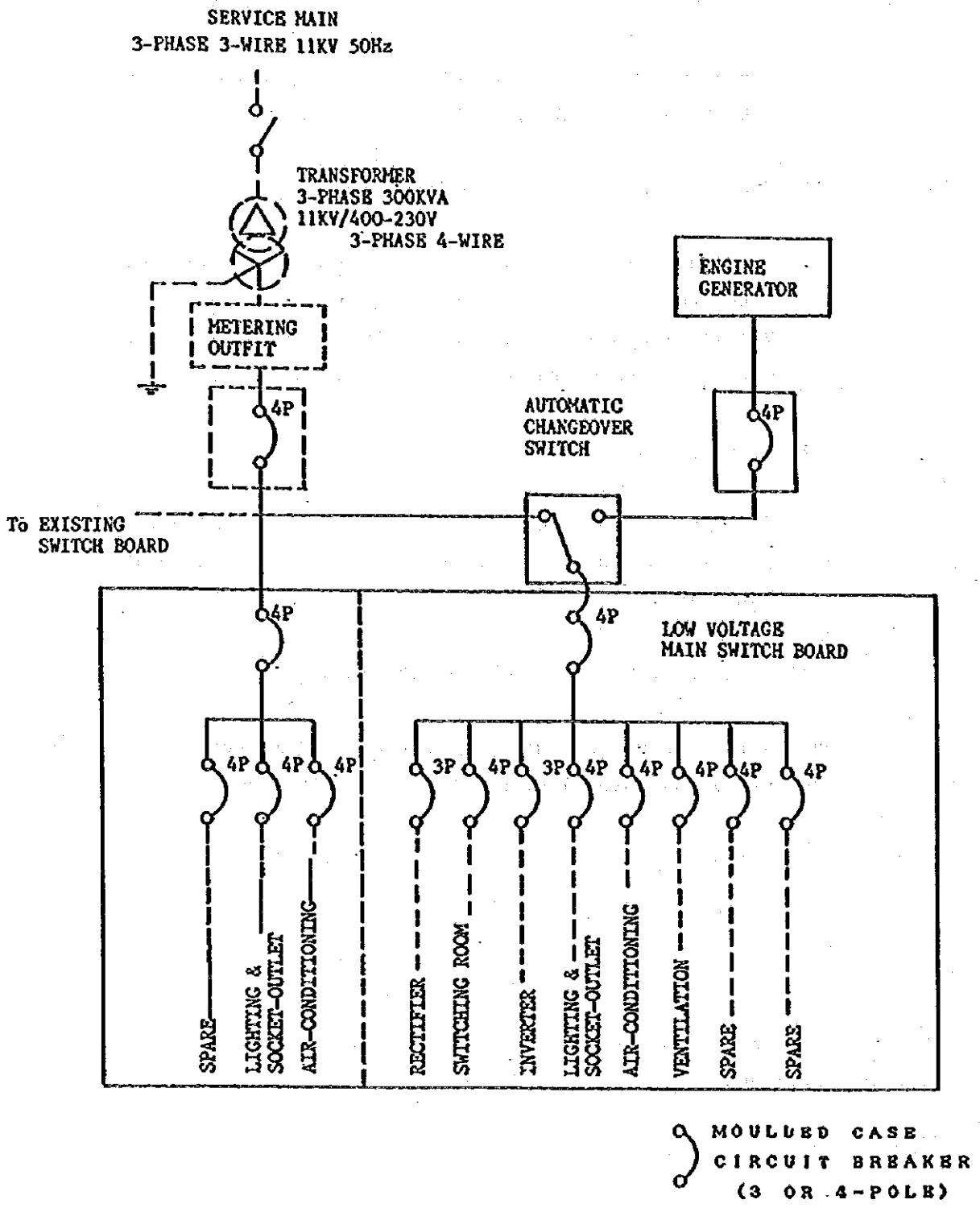


Fig. IV-18 Electrical Power Schematic Diagram