REPUBLIQUE DEMOCRATIQUE DE MADAGASCAR

REPORT OF FEASIBILITY STUDY
FOR
SOUTHERN MICROWAVE SYSTEM
IN MADAGASCAR

February, 1978

JAPAN INTERNATIONAL COOPERATION AGENCY

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Preface

In compliance with the request of the Government of the Democratic Republic of Madagascar, the Government of Japan as a part of its overseas technical cooperation decided to carry out a study on the construction of the Southern Microwave System in Madagascar.

The Japan International Cooperation Agency (JICA) sent a study team of 10 experts, headed by Mr. Susumu Sato of the Radio Regulatory Bureau of the Ministry of Posts & Telecommunications, to Madagascar for stay from July 24 to September 4, 1977, and made a feasibility study on the project.

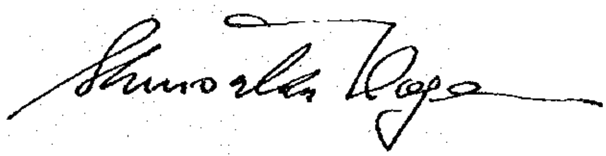
The field survey in Madagascar was carried out very smoothly with extensive cooperaration of the Government of Madagascar.

After careful review in Japan of the findings of the study this report has been finalized.

I sincerely hope that this report will contribute to the development of the telecommunication network in Madagascar, and also to the social and economic development of the country and further promote the friendly relationship between the two countries.

I should like to express my hearty gratitude to the officials concerned of the Government of Madagascar for their whole-hearted cooperation extended to the study team and to all others participated in this study.

January, 1978

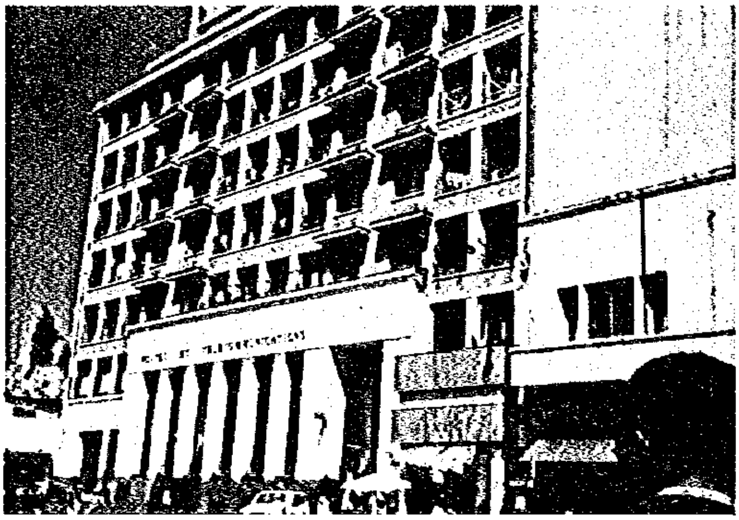


Shinsaku HOGEN
President
Japan International Cooperation
Agency

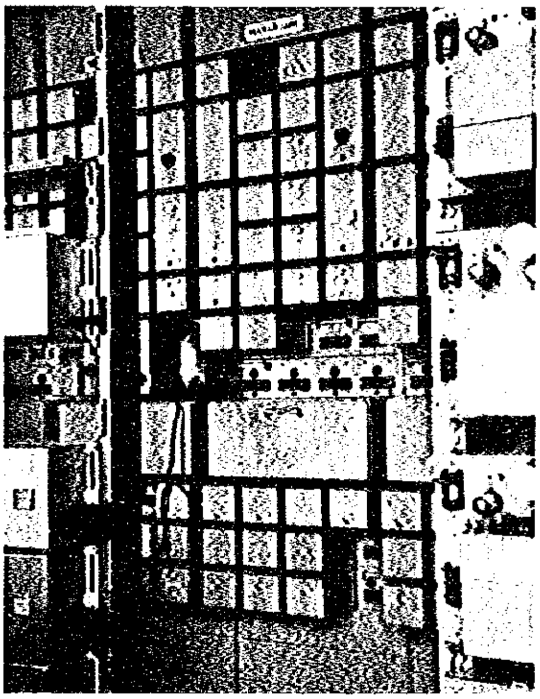
Secretary General and Director of Telecommunications, PTT, with members of the Survey Team

From right to left, Japanese Ambassador Teruhiko NAKAMURA, Secretary General RATOVONDRAHONA Pascal, Survey Team Leader S. SATO and Survey Team Member T. DEGUCHI

The Government Officials of Madagascar and Members of Survey Team upon meeting on the draft report.

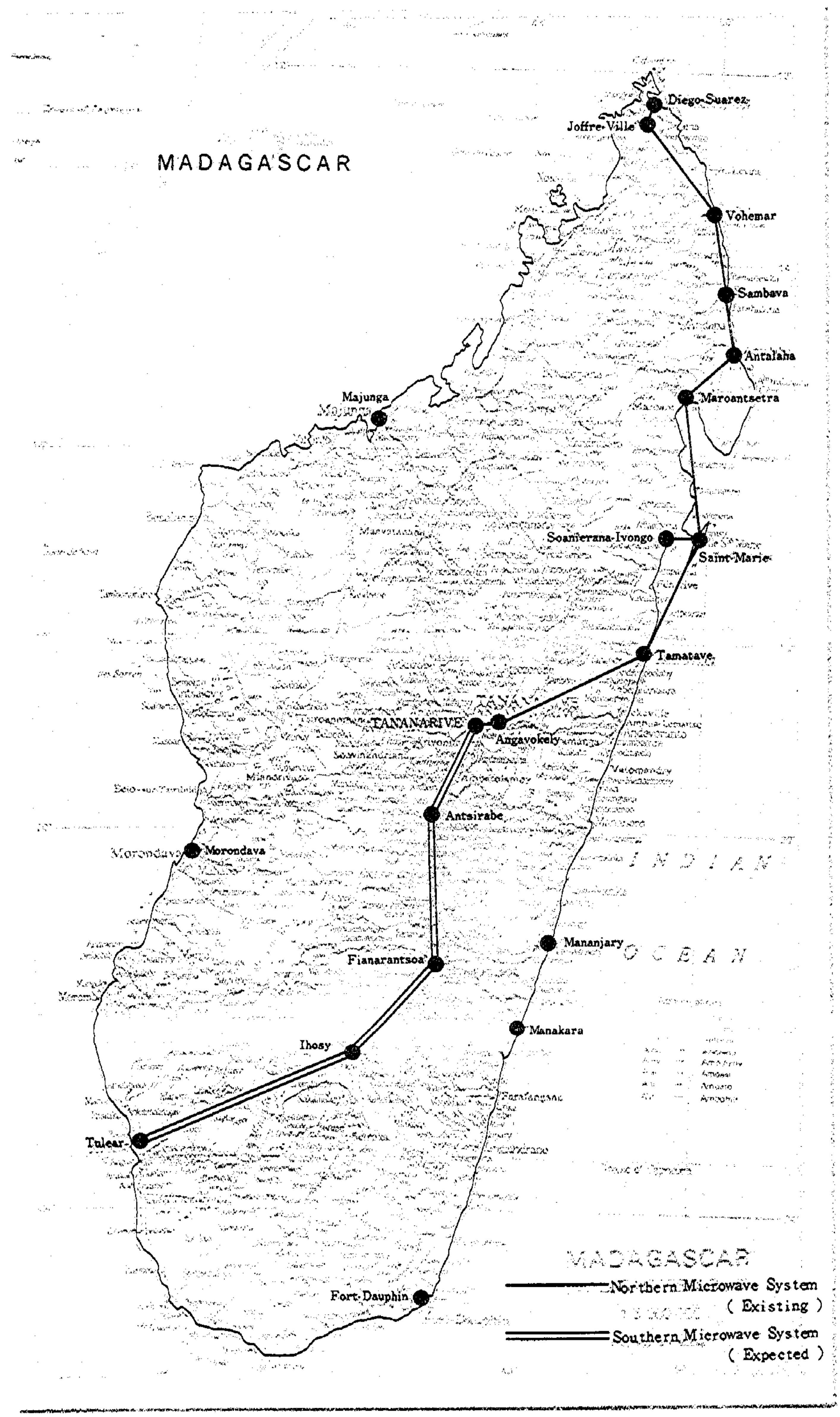


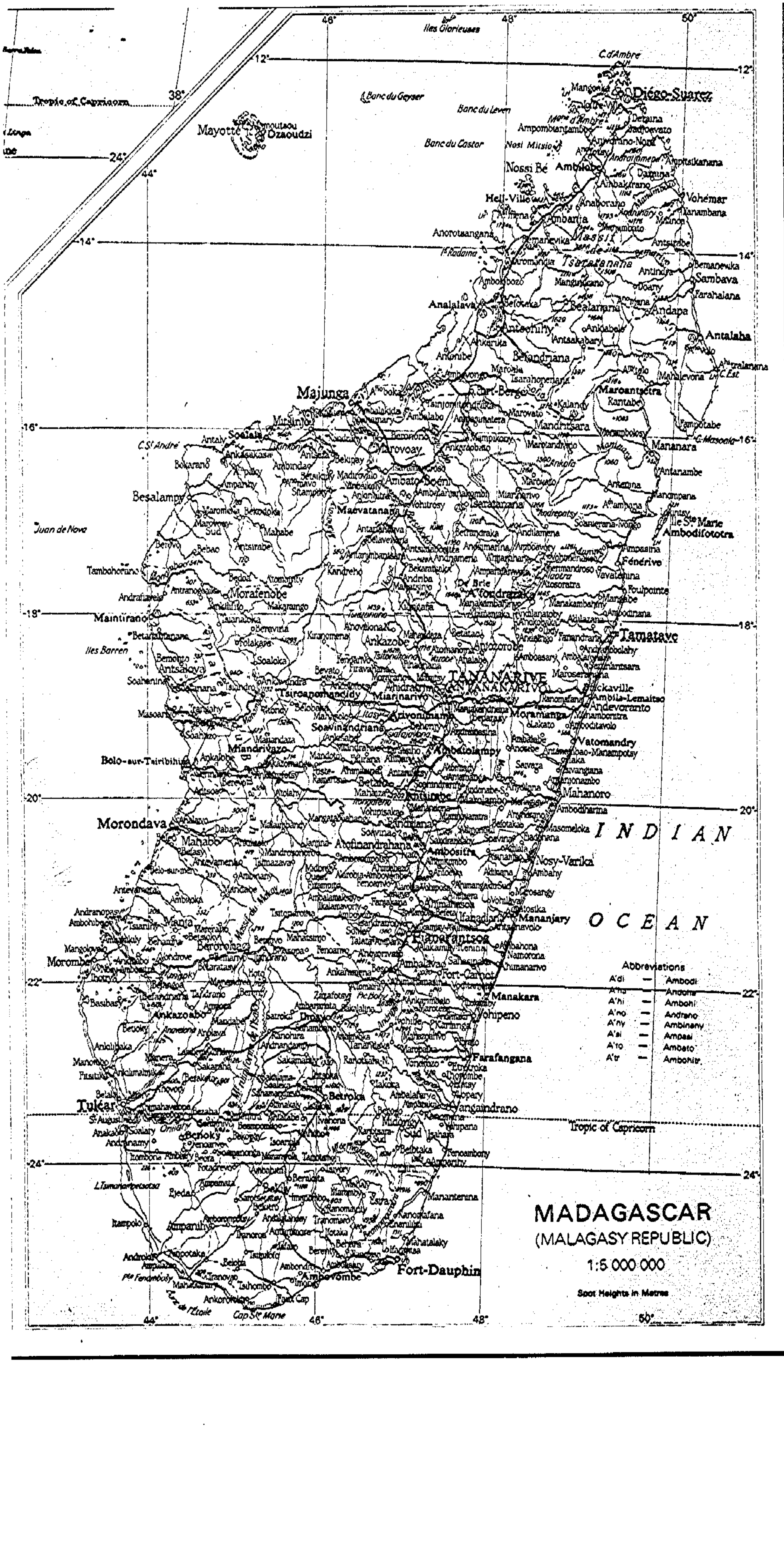
ANALAKELY Telephone Exchange Office in TANANARIVE



Open-wire carrier equipment (FIANARANTSOA Telephone Exchange Office)

Switchboard (TULEAR Telephone Exchange Office)


MADAGASCAR
Diego-Suarez
Joffre-Ville
Vohemar
Sambava
Antalaha
Maroantsetra
Majunga
Soanierana-Ivongo
Saint-Marie
Tamatave
TANANARIVE
Angavokely
Antsirabe
Morondava
INDIAN
Mananjary
OCEAN
Fianarantsoa
Manakara
Ihosy
Tulear
Fort-Dauphin
Northern Microwave System (Existing)
Southern Microwave System (Expected)


MADAGASCAR
(MALAGASY REPUBLIC)
1:5 000 000
Spot Heights in Metres
Abbreviations
A'di — Ambodi
A'hi — Ambohi
A'no — Andrano
A'ny — Ambinany
A'ai — Ampasi
A'to — Ambato
A'tr — Ambohitr
INDIAN OCEAN
Tropic of Capricorn
Diégo-Suarez
Tananarive
Tamatave
Majunga
Tuléar
Fort-Dauphin
Fianarantsoa
Morondava
Mayotte
Dzaoudzi
Iles Glorieuses
Juan de Nova

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PART I SUMMARY

PART I SUMMARY

1. General

The project for the construction of the Southern Microwave System in Madagascar is intended for the development of a telecommunication network in the Southern Area of Madagascar which somehow lags behind the Northern Area of the country in the field of telecommunication. When established, this microwave system will play an important role in telecommunication in the country together with the existing Northern Microwave System. The Government of the Democratic Republic of Madagascar requested the Japanese Government for the implementation of necessary feasibility study for the construction of the microwave system, and the Japanese Government, accepting the request, sent the "Feasibility Study Team for the Project of Constructing the Southern Microwave System in the Democratic Republic of Madagascar" for a period of 43 days from July 24 to September 4, 1977. Survey was conducted on such matters as telephone demand in the Southern Area, conditions for the selection of station sites, etc., on the basis of the microwave system route plan having been prepared by the Government of Madagascar. The analysis of the results of the survey has yielded a conclusion that the project is feasible from both technical and economical standpoints. Described hereunder are the requirements set forth by the Government of Madagascar for the project, the results of the survey, and recommendations.

2. Requirements Set out by the Government of Madagascar for the Southern Microwave System

The requirements set out by the Government of Madagascar for the Southern Microwave System are stated in the documents prepared by the Government of Madagascar and are mainly as follows.

(1) Route

Between Tananarive and Tulear via Fianarantsoa (approx. 950km)
To connect Tananarive and other nine cities on the route by telephone and to cover 15 cities along the route by television braodcasting. (See Fig. 1.)

(2) Transmission capacity

Capable of transmitting 960 telephone channels and one color television channel.

3. Results of Survey

(1) Telecommunication circuit demand

It can be estimated, by telephone demand forecast for the next 20 years after service-in on the basis of the recent tendency of the use of telephone, that the maxi-

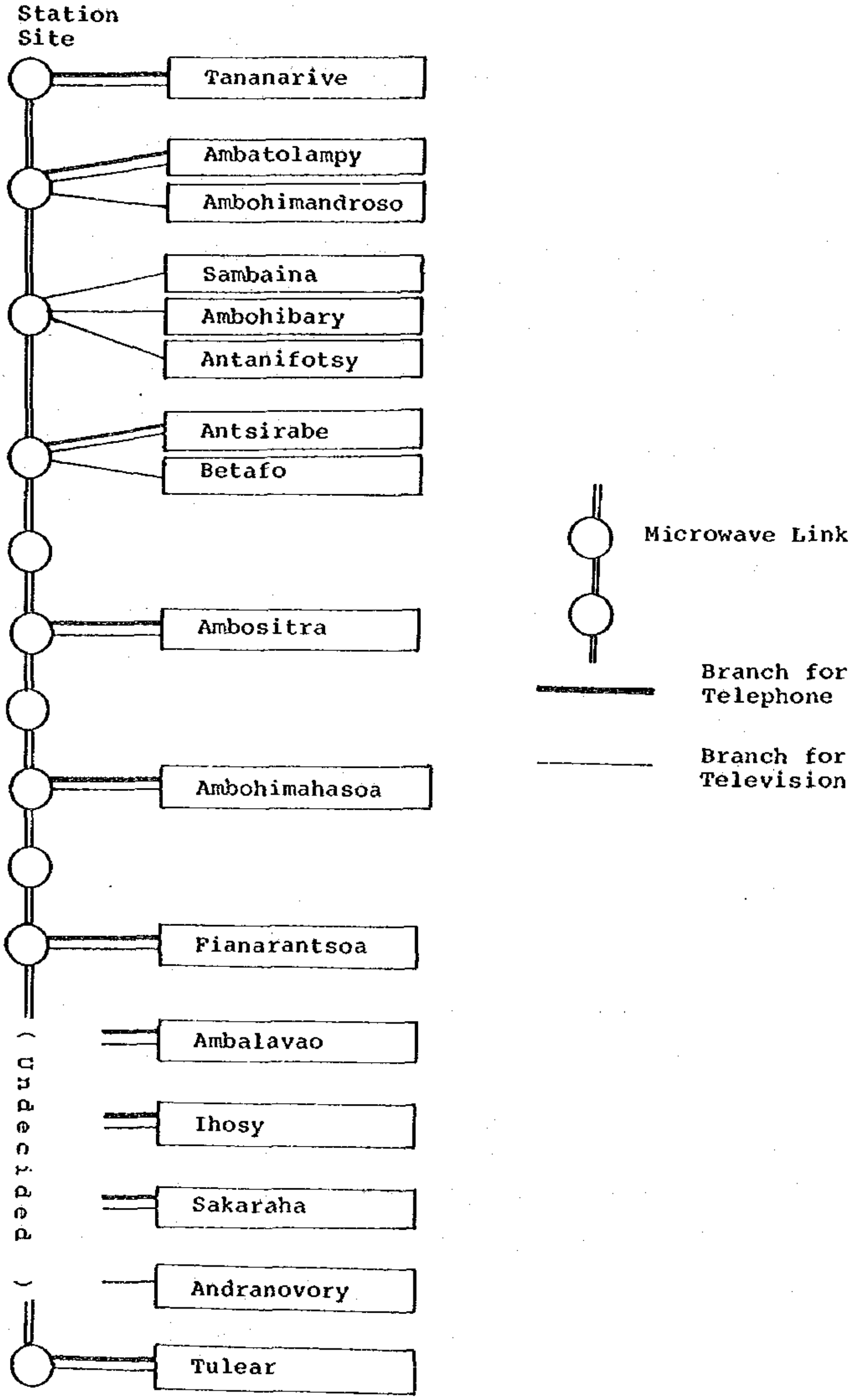


Fig. 1 Route of Southern Microwave System Planned by the Government of Madagascar

mum number of telephone channels to be required will be 500 and the above-mentioned transmission capacity will be sufficient. It will also be necessary to establish a network for sending television programs to some cities in the Southern Area in connection with the Government's plan for constructing television stations in these cities.

(2) System design

To determine the technical details of the microwave system to be constructed to meet the above-mentioned requirements, system design is required. The system design includes the selection of a suitable radio relay system and frequency band, site selection, determination of system configuration of telephone and TV transmission systems, and assessment of transmission performance, which are outlined below.

1) Radio relay system to be employed

It is understood, from the study of the geographical conditions and the distribution of population along the route of the microwave system, that these conditions of the Tananarive-Fiananarantsoa section (approx. 410km) are much different from those of the Fianarantsoa-Tulear section (approx. 540km). That is, the former section is located on heights ranging 1000 to 1400 meters in altitude, has a mild climate and includes cities having populations over ten thousands, such as Autsirabe and Ambositra, which are still surrounded by straggling villages. The latter section is mostly in thinly-populated grassy plains having savanna climate and has no particularly recognizable city but Ihosy. In consideration of these circumstances, it may be right to employ a line-of-sight microwave system, which features a short-distance relay and wideband transmission, over the Tananarive-Fianarantsoa setion. However, the following two different relay systems can be considered for the Fianarantsoa-Tulear section: line-of-sight system and over-horizon system, the latter of which is effective when the transmission capacity is comparatively small and the hop distance is considerably large. The Government of Madagascar had an idea of adopting overhorizon system in the initial stage when the demand for television transmission was not so strong. Which of the two relay methods is more suitable than the other can not be decided simply but has to be determined in consideration of the geographical conditions of the microwave route, expenses for the construction of the radio relay system, convenience of operation and maintenance, and the transmission performance of TV signal. In conclusion, these two relay systems should be employed depending on the case, as follows.

a) When only telephone transmission is required, no significant difference will be exibited between the two relay systems in the expenses for construction and in operation and maintenance. In the case of over-horizon relay system, the completion of civil work as scheduled is considered less risky.

b) When the transmission of both telephone and TV signals is intended, line-of-sight relay system is more advantageous as it provides advantages in the expenses for construction, transmission quality, and the flexibility in system expansion.

2) Frequency band

Although the 4GHz and 6GHz frequency bands may be considered in the case of line-of-sight relay system, the 4GHz band, which allows use of low-power consumption equipment, is more suitable in consideration of geographical conditions of repeater stations, etc. In the case of over-horizon relay system, the 2GHz bnad is recommended.

3) Site selection

Selection of the locations of repeater stations has been made on the basis of the route planned by the Government of Madagascar. The survey for site selection, which included the on-site survey of not only the proposed sites on the route but also many other possible locations, was conducted to examine visibility for adjacent repeater stations, availability of existing station building and commercial power, ease of construction of access roads, availability of space for the construction of station buildings and steel towers, and other conditions. The survey has allowed the selection of such station locations that can be considered most suitable. In particular, efforts were made in reducing the number of repeater stations and the length of access road upon site selection for the Fianarantsoa-Tulear section, which has allowed the selection of such a line-of-sight route that can economically cope with over-horizon relay system.

4) Number of radio systems

The number of radio systems to be incorporated in the microwave system should be determined in consideration of future telephone demand, the flow of TV programs between cities, etc. Television program transmission may be achieved by the establishment of a dedicated microwave system or the use of a stand-by microwave system and several variations can be considered in circuit configuration. It is necessary, upon determining the system configuration, to consider that (i) future transmission of TV programs to southern cities can be estimated to be made mostly from Tananarive (that is, "down" transmission will be much more frequent than "up" transmission), (ii) the probability of occurrence of troubles can be said extremely small in consideration of the present technical level of microwave communication technology, and (iii) effective investment should be made from the economical standpoint. It is considered most suitable, as the result of examination, to establish: one "up" and "down" working telephone systems; one "down" working TV system; and one "up" and "down" common-use stand-by systems. The "up" stand-by system will be used for "up" TV transmission.

5) Power supply

Commericial power is available at most proposed repeater station sites located north of Fianarantsoa but is not available at proposed sites located west of Fianarantsoa but Tulear.

a) When commercial power is available:
A battery floating charge system will be employed for the stand-by power system.

b) When commercial power is not available:
If the required power is lower than 700W, a charge-discharge system using a dual engine generator is recommended. If the required power exceeds 700W, a floating charge system of a dual engine generator is recommended.

c) For stations located west of Fianarantsoa and requiring no large power, a solar battery system is recommended, although survey on the amount of insolation will be required for determining the specifications of equipments and facilities to be employed.

(3) Operation and maintenance

In order to allow effective operation and maintenance by as small number of personnel as possible, the following should be taken into consideration.

1) In other, more general microwave systems, terminal stations are attended. However, this microwave system has so many terminal stations and they should be unattended as much as possible. Thus it is considered appropriate that unattended stations should be limited to Tananarive and four other terminal stations.

2) Maintenance and operation of the microwave system will be performed by one organization, which will handle both telephone and television.

(4) Expenses for construction and term of construction

Six different cases of system configuration can be considered depending on the method of TV program transmission. The radio relay system to be employed may be either fully line-of-sight or partially over-horizon type in each case. The expected expenses for the construction of the microwave system are given in Table 1 for the different cases. The term expected to be required for completion of the microwave system is 24 months.

Table 1 System Configurations and Construction Expenses of FULL-LOS and PARTIAL-OH Systems

(Unit: million yen)

System Configuration			Construction Expense	
			FULL-LOS System	PARTIAL-OH System
Only Telephone	1	TP → ← SB → ←	3893	3867
Telephone/ TV (down only)	2	TP → ← SB → ← (TV)	4034	4187
	3	TP → ← TV → SB → ←	4175	4288
Telephone/TV (up/down)	4	TP → ← TV → SB → ← (TV)	4268	4527
	5	TP → ← TV → ← SB → ←	4335	4641
	6	TP → ← SB_1 → ← TV → ← SB_2 → ←	4932	5048

Legend
TP: Working telephone system TV: Working TV system
SB: Stand-by system
→: "down" system ←: "up" system
(TV): TV transmission by stand-by system

(5) Economical Evaluation

The expected internal rate of return of this project is 9.6%, which is satisfactory for an infrastructure project. Although the balance at the time of starting the service will be in "red," it will turn to "black" 5 years ahead. The accumulative balance is expected to turn to "black" 9 years ahead. Thus, this project can be said fairly good on the whole.

(6) Conclusion

Technical and economical study of this project has resulted in obtaining a conclusion that this project is sufficiently feasible.

4. Recommendations

In implementing this project, the following should be taken into consideration.

(1) Radio relay system to be adopted

When it is intended to achieve the transmission of telephone signals and TV programs by a long-haul microwave system, it is desirable, from the standpoint of national economy, to construct telephone and TV transmission circuits into a single system. If such a unified system is employed, the full line-of-sight system is more advantageous on the whole.

(2) System configuration

It is most recommendable to establish one "up" and "down" working telephone systems, one "down" working television system, and one"up" and "down" common-use stand-by systems (while using the "up" stand-by system for "up" television program transmission).

(3) Frequency band and others

In consideration of the present technical circumstances, the use of the 4GHz band is recommended so as to allow the adoption of low-power consumption radio equipment. For some stations located west of Fianarantsoa, solar battery system will be used to ensure ease of maintenance and operation.

(4) Operation and maintenance

For effective operation and maintenance, as many terminal stations should be of unattended type as possible. Of the 27 stations, Tananarive and four other stations will be attended (manned). It is uneconomical to perform maintenance and operation of telephone and television systems by different organizations. An organization common to telephone and television will be much advantageous.

(5) Implementation of work

Whether the construction of this microwave system can be achieved efficiently and economically or not depends on whether civil work, such as construction of station buildings, steel towers, access roads, etc., can be advanced as scheduled or not. So, due care should be taken for supervision so that civil work should be progressed smoothly.

PART Ⅱ DETAILED DESCRIPTION

CHAPTER 1 INTRODUCTION

1-1 Purpose of Survey

In the Northern Area of the Democratic Republic of Madagascar, that is, in the area north of Capital Tananarive, two major telecommunication systems are working: the Tananarive-Tamatave-Diego Suarez microwave system constructed with the Japan's first credit in yen to the country and the Tananarive-Majunga and Tananarive-Tamatave coaxial cable lines. In the area south of Capital Tananarive, the telecommunication situation is rather poor and only two radio systems, that is, the VHF small-capacity communication system between Tananarive and Fianarantsoa (approx. 410km) and the HF-SSB single-channel communication system connecting Tananarive and several cities in the southeast coastal region, are working in addition to the open-wire carrier systems layed between major cities. These means of telecommunication provide no high performance characteristics in transmission quality, signal-to-noise ratio and system reliability and, in addition, will not be able to fill future traffic demand sufficiently. These circumstances have decelerated development in the Southern Area of the country. Meanwhile, the Government of Madagascar regarded the development of a telecommunication network in the Southern Area as one of the most important policies for establishing firm foundation for the social development of the area and planned the Southern Microwave System Construction Project between Tananarive and Tulear (approx. 540km). On the other hand, the Government of Madagascar has repeatedly requested the Japanese Government for a credit in yen since February 1975 for the completion of the project. Under these circumstances, the survey including on-site survey for about 20 days was conducted for 43 days from July 24th to September 4th 1977 for the purpose of examining the feasibility of the microwave system project.

1-2 Outline of Project

The microwave system will be layed between Tananarive and Tulear via Fianarantsoa, as set out in the "Scope of Work" prepared jointly by the PTT of Madagascar and the Japanese survey team. Route selection is the foundation of the project and the basic route will be determined in more detail by selecting station sites along the route. Site selection should be made in consideration of branching of telephone circuits to neighboring cities along the route and the adaptability of station sites to TV broadcasting stations as well if presentation of television broadcasting service to neighboring small cities along the route is desired. The transmission capacity of the microwave system will be determined by the traffic forecast of toll calls to be made by subscribers of the respective cities. The future plan of these telecommunication circuits and traffic demand forecast have been discussed by the Government of Madagascar, which are described in the following two documents submitted to the Japanese side.

(1) Proposition Technique pour le Systeme de Telecommunications par Faisceaux Hertziens Tananarive-Fianarantsoa-Tulear pour la Republique Malagache (Dec. 1975)
(Appendix 2)

(2) Renseignements generaux sur le projet de liaison Antananarivo-Fianarantsoa-Tulear (Juily 1977)
(Appendix 3)

Document (1) is prepared as of December 1975 and mainly covers the construction of telephone circuits. Document (2) is the latest document compiled through later adjustment in the Government of Madagascar and describes the requirements of RTM for television transmission in concrete form as well as those of PTT. (See Fig. 1-1).

1-3 Outline of Survey

Site selection was conducted by the survey team on the basis of the gists of the abovementioned two documents and the intended objective has been fully achieved, allowing the selection of such sites that will be most advantageous from the standpoints of both economy and operation and maintenance. Meanwhile, demand forecast for the 20 years after starting the service in the required sections has been made on the basis of the fundamental recognition of grasping the present economical activity conditions of the cities concerned as much as possible by thoroughly examining existing telephone office facilities and exchange conditions of respective cities. For the Fianarantsoa-Tulear section, line-of-sight and over-horizon relay systems are considered, which are compared with each other from both technical and economical standpoints. Although on-site survey for the expansion of the microwave system route to the southeast coastal area (Mananjary-Manakara-Fort Dauphin-Tulear) which the Government of Madagascar is particularly interested in and which is not included in the survey by the present survey team, future telephone demand that can be forecast in this area has been also considered upon estimating the future demand of the microwave system. Also, consideration has been given to the achievement of transmission through branching in the southeast coastal area as well.

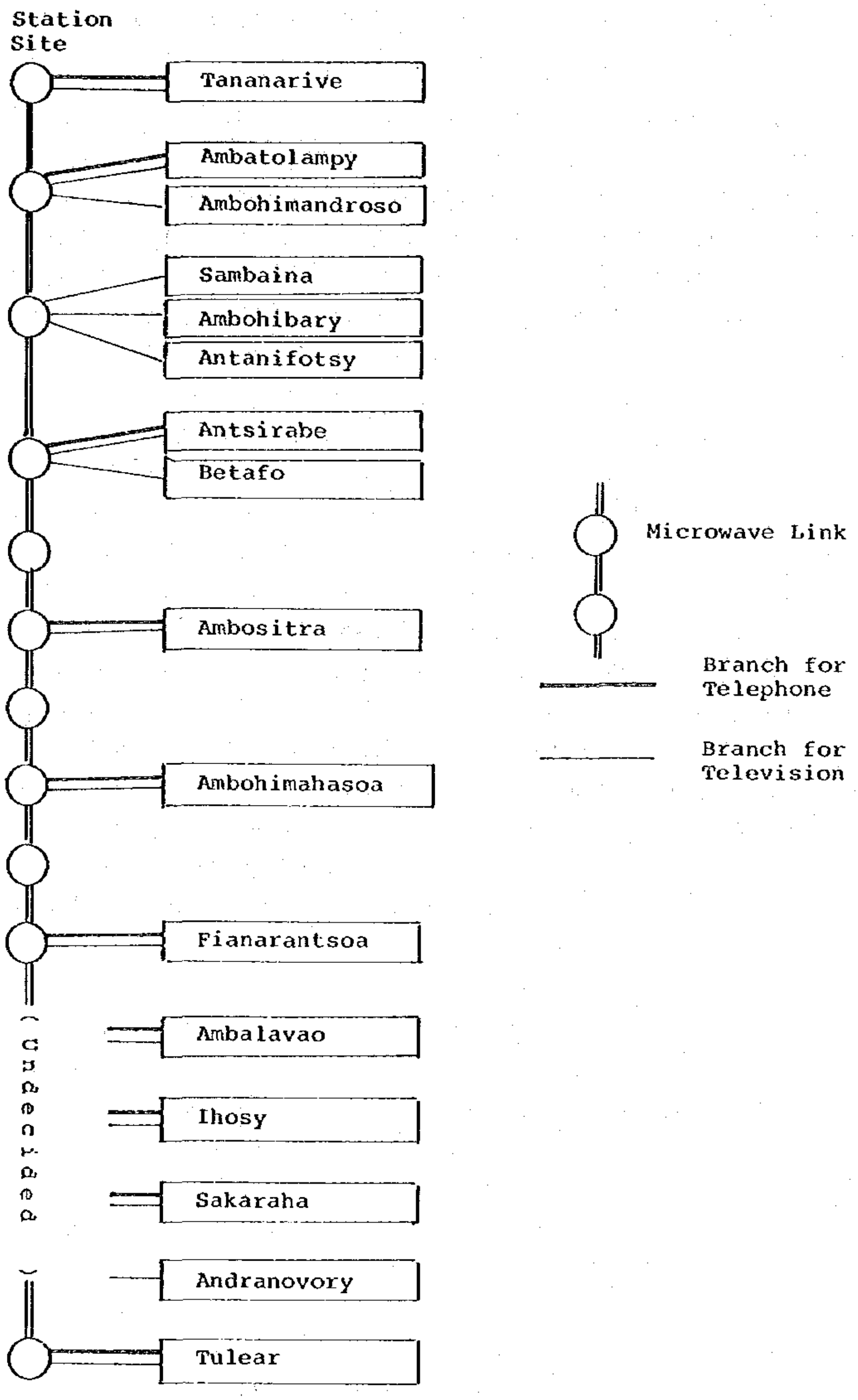


Fig. 1-1 Route of Southern Microwave System Planned by the Government of Madagascar

CHAPTER 2 NECESSITY OF THE PROJECT IN MADAGASCAR

The spread of telephone in Madagascar is 3.8 sets per 1,000 persons as of the end of 1976, which is extremely small when compared with those of developed countries such as the USA (680 sets), Japan (360 sets), France (240 sets), etc., and, moreover, smaller than those of developing African countries such as Algeria (10 sets), Morocco (10 sets), Kenya (10 sets), Kenya (10 sets), etc. Indeed, this is one of the causes which prevent Madagascar from making economical development. Accordingly, the Government of Madagascar is making efforts for the expansion of telephone networks in the country by positively introducing automatic exchanges and constructing large-capacity toll transmission lines. This project has been planned, in a series of Madagascar's telecommunication development program, to link capital Tananarive with Fianarantsoa and Tulear or major cities in southern provinces by a large-capacity microwave system. The Fianarantsoa and Tulear provinces have a population of about 3,200 thousand (which is about 38% of the national population) but toll calls between the provincial capitals and Tananarive are handled by means of small-capacity circuits of VHF, HF, and wire systems which are not satisfactory in both quality and quantity. Facilities have mostly superannuated and communication is often interrupted and cities in this area are often isolated in rainy seasons or upon encountering cyclones. At present the Government of Madagascar makes much of the development of Southern Area which rather lags the Northern Area in economical situation and it is necessary to improve the present telecommunication condition in the Southern Area. Thus, the imprementation of this project is every important. In addition, completion of this project will allow transmitting TV signal from Capital Tananarive to cities in the Southern Area, which will greatly contribute to the cultural and educational developments in the Southern Area of Madagascar.

CHAPTER 3 FORECAST OF TELECOMMUNICATION CIRCUIT DEMAND

3-1 Present Condition

The planned microwave system will be constructed to connect cities along No. 7 National Road and pass such provincial capitals as Fianarantsoa and Tulear. By this, the Fianarantsoa Province having a population of 2,000 thousand and the Tulear Province having a population of 1,200 thousand will be connected through Tananarive to the Northern Area. The Tananarive-Fianarantsoa section of No. 7 National Road is well-paved with excellent facilities of transportation and the traffic is thick. Telephone calls between Tananarive and Fianarantsoa are handled by means of over-horizon (OH) VHF systems, requiring a waiting time of a few minutes. The Fianarantsoa-Ihosy-Tulear section is also along the national road but mostly unpaved. Although this section of the national road allows transportation in all seasons of the year, the road condition is rather bad in some parts and the traffic speed in this section is lower than a half of that in the Tananarive-Fianarantsoa section. Telecommunication in this section is mostly by open-wire carrier system and partly by shortwave system, requiring a waiting time of more than 15 minutes for connection. In addition, troubles in open wire and open wire carrier system are caused frequently in this section. The present situation of the telecommunication transmission between major cities, which will be covered by the Southern Area Microwave System, is shown in Fig. 3-1. It is Fianarantsoa that has the largest population among cities along No. 7 National Road and it is Antsirabe that is well developed in town areas and has active economical activities by large business companies.

3-2 Traffic for Circuit Demand Forecast

Although telephone traffic survey is not carried out periodically, traffic estimation in the Southern Area has been made by traffic tickets (for 2 months) of 1975. In the traffic survey conducted for the September and October, the total number of calls per day was calculated with each of the two months assumed to contain 22 days and the busy hour traffic was calculated with the busy-hour concentration rate being 1/8. Traffic at each location contains all transit calls of adjacent offices. The result of the telephone traffic survey is shown in Table 3-1. The estimated traffic obtained by this calculation can be considered an average for two months and also an average for the year.

3-3 Forecast Method

Since the time sequence for traffic measurement in applicable sections was not obtained, the following forecast method was employed.

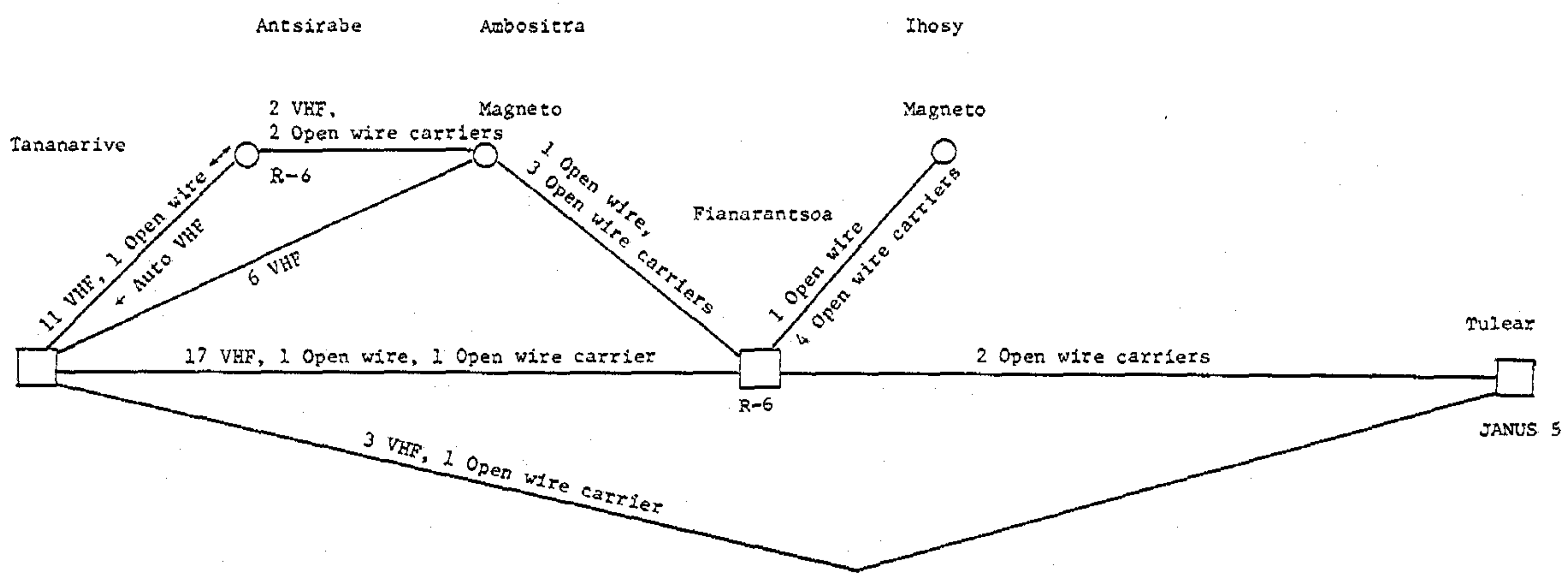


Fig. 3-1 Existing Transmission Lines Between Major Offices

Table 3-1 Telephone Traffic Grid in 1975 (erl)

To \ From	Tananarive	Antsirabe	Ambositra	Fianarantsoa	Ambaravao	Ihosy	Tulear
Tananarive		2.876	1.210	8.537	1.044	0.547	0.210
Ambatolampy	0.358	0.045		0.003			
Antsirabe	5.357		0.436	0.726	0.058	0.089	0.147
Ambositra	1.592	0.624		1.177	0.047	0.036	
Fianarantsoa	5.080	0.426	1.484		1.053	1.359	0.659
Ambaravao	0.216	0.012	0.046	0.480		0.116	
Ihosy	0.605	0.006	0.215	2.268	0.173		0.140
Tulear	1.653	0.484	0.239	1.775	0.026	0.425	

Each traffic contains transit calls.

3-3-1 Formula for Traffic Forecast

The annual traffic increase to be caused during the period between the time of measurement and the time for which forecast is to be made can be given by the following equation assuming that the calling rate will not vary in near future and traffic between two cities is proportional to the geometrical means of the rate of increase in the number of subscribers of the respective offices.

$$\alpha_t = K(\sqrt{S_1 \cdot S_2})^n$$

where

α_t: Increase in traffic between two telephone offices

K : Coefficient for compensation for factors other than the increase in the number of subscribers

S_1, S_2 : Annual increases in number of subscribers at the two telephone offices

n : Number of years for which traffic forecast is to be made

The rate of traffic increase will not remain the same but will increase with the progress in the development and economical activity in the Southern Area. The past annual traffic increases of the respective offices are shown in Fig. 3-2. In the case of Tananarive office, for example, an annual increase of more than 7% was experienced before 1971 and the expected annual increase after 1985 is supposed to be 7% for each district.

3-3-2 Annual Increase in Number of Telephone Subscribers at Respective Offices (S_1 and S_2)

By examining the time system of telephone subscribers in the respective cities in the past 10 years, the following results are obtained. (See Fig. 3-2).

Table 3-2 Annual Increase in Number of Telephone Subscribers at Respective Offices

Office	Annual Increase
Tananarive	5.1%
Antsirabe	5.8%
Fianarantsoa	3.6%
Tulear	3.2%
(Fort-Dauphin)	(2.6%)
(Mananjary)	(2.6%)
(Manakara)	(2.4%)

Remarks: Parentheses ( ) correspond to offices not covered by the present project.

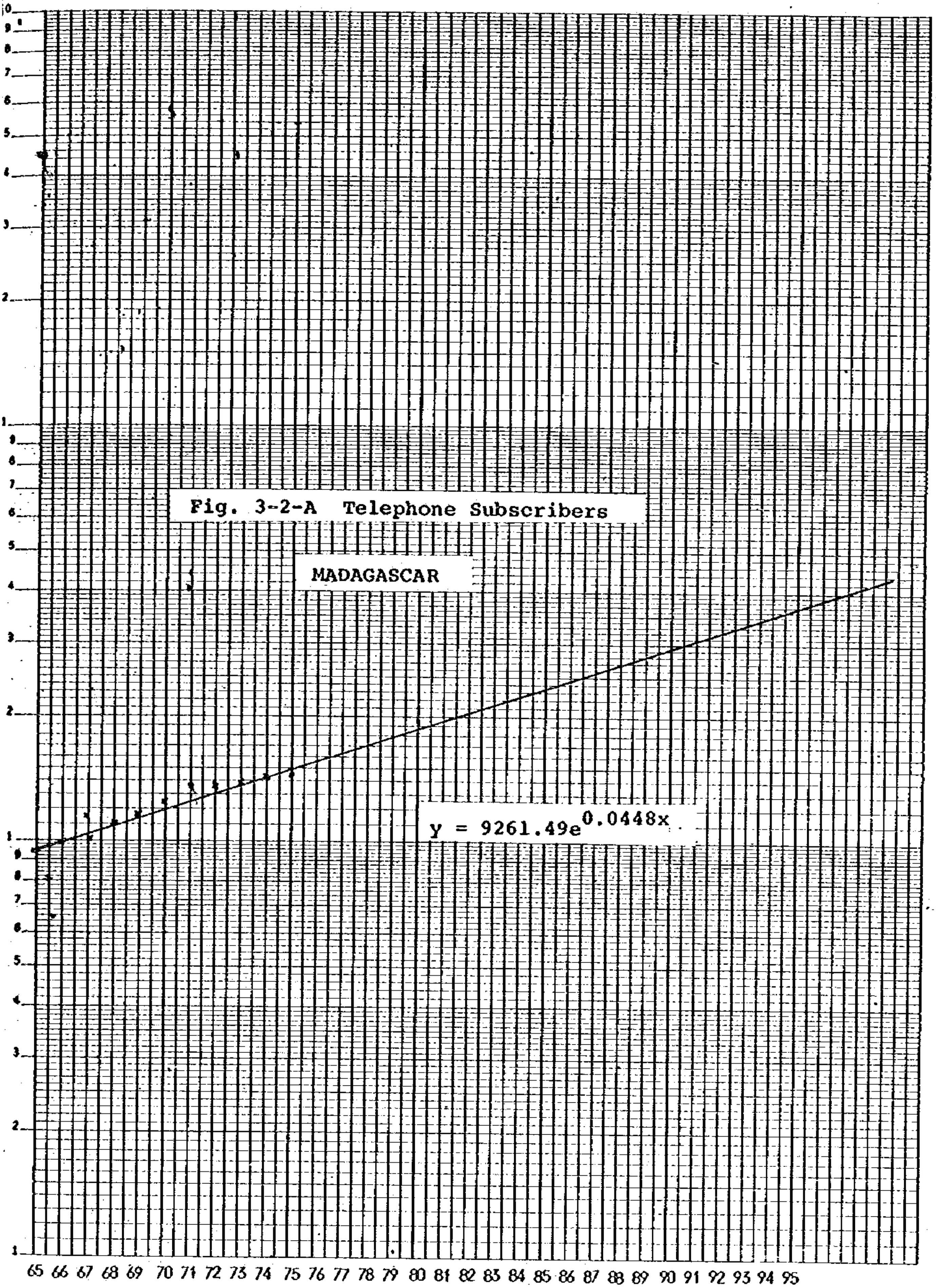


Fig. 3-2-A Telephone Subscribers
MADAGASCAR
$y = 9261.49e^{0.0448x}$
65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95

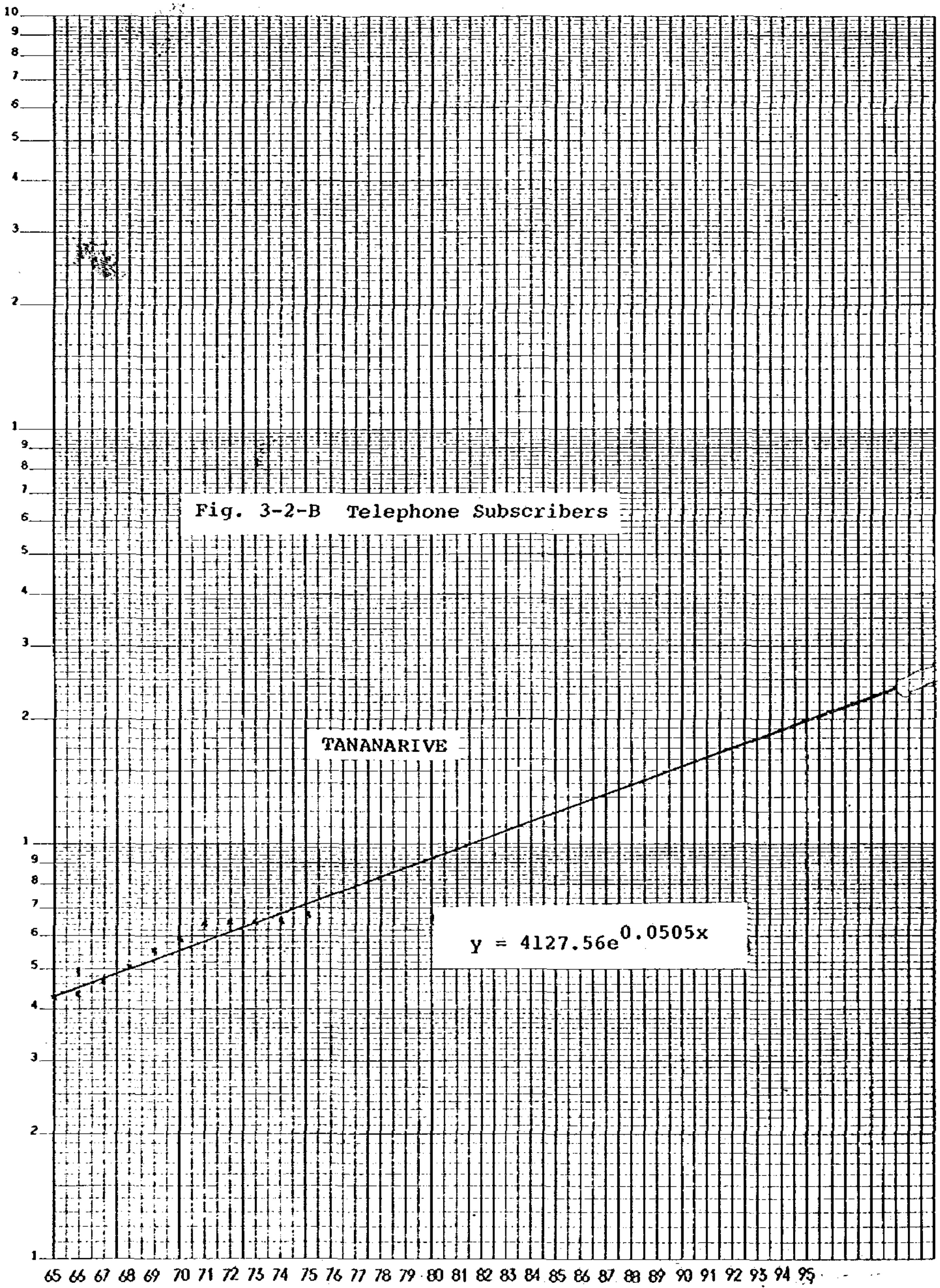


Fig. 3-2-B Telephone Subscribers
TANANARIVE
y = 4127.56e^0.0505x
10
9
8
7
6
5
4
3
2
1
65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95

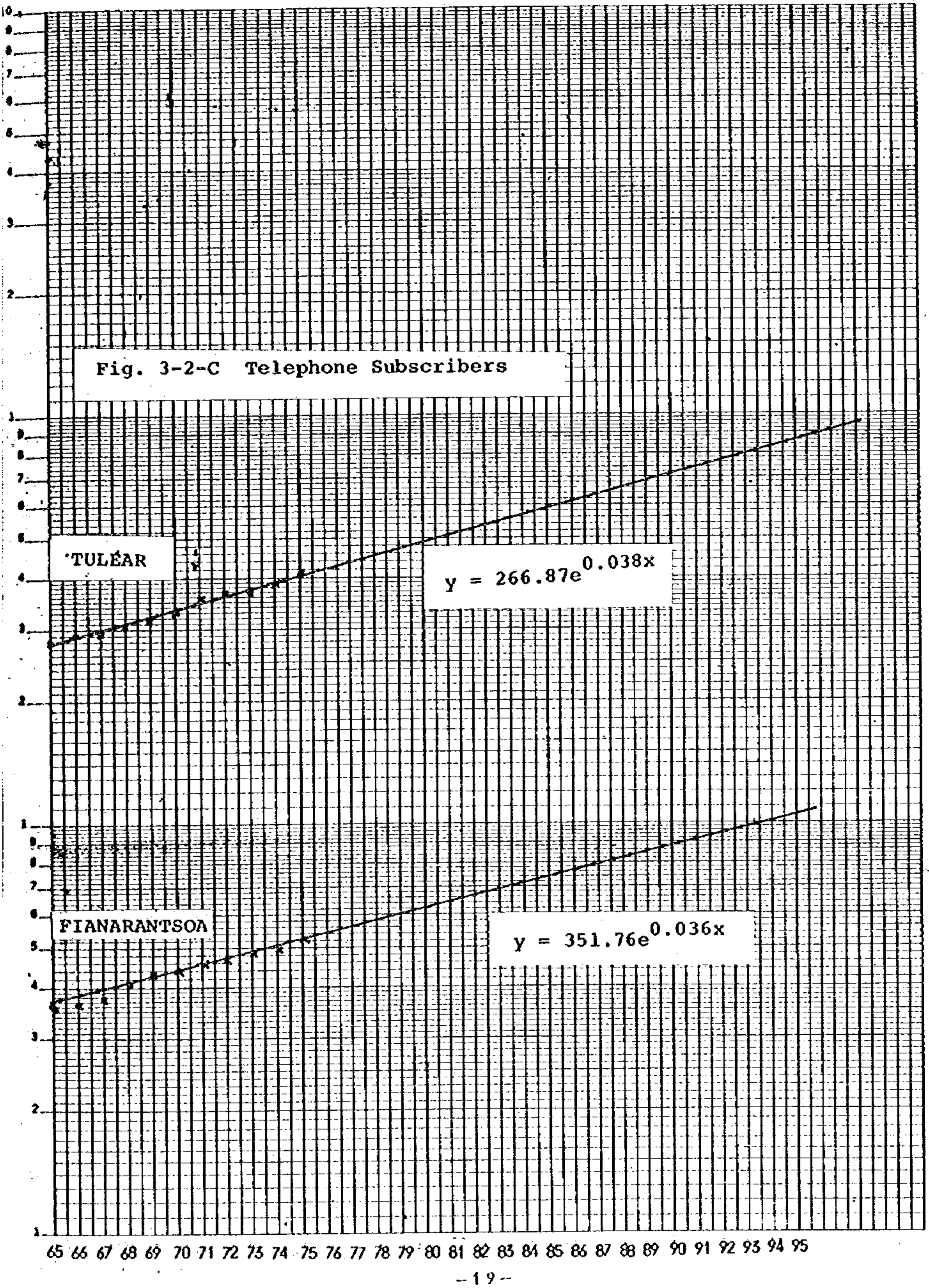


Fig. 3-2-C Telephone Subscribers
TULÉAR
y = 266.87e^0.038x
FIANARANTSOA
y = 351.76e^0.036x
65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95

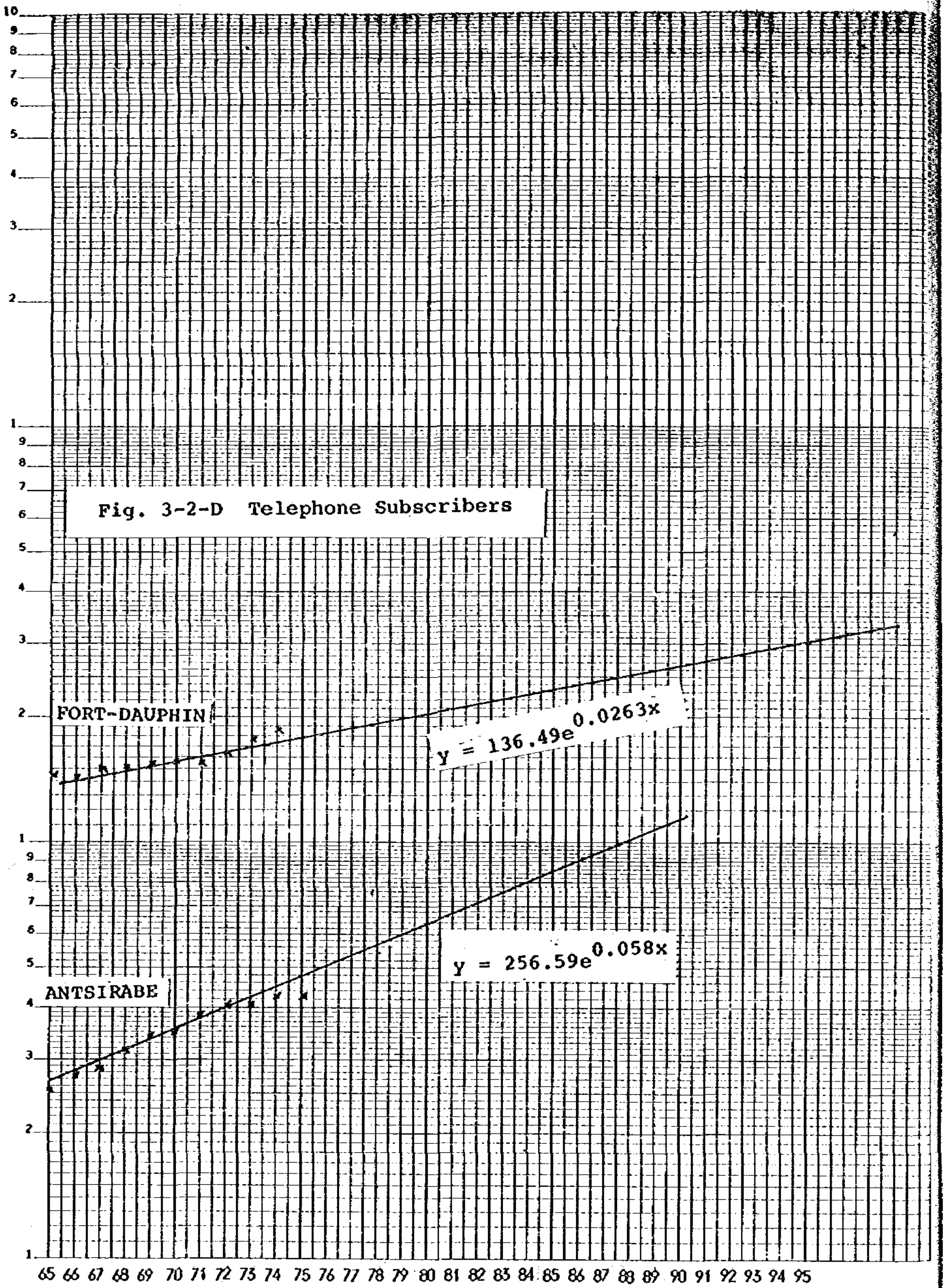


Fig. 3-2-D Telephone Subscribers
FORT-DAUPHIN
y = 136.49e^0.0263x
ANTSIRABE
y = 256.59e^0.058x
10
9
8
7
6
5
4
3
2
1
65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95

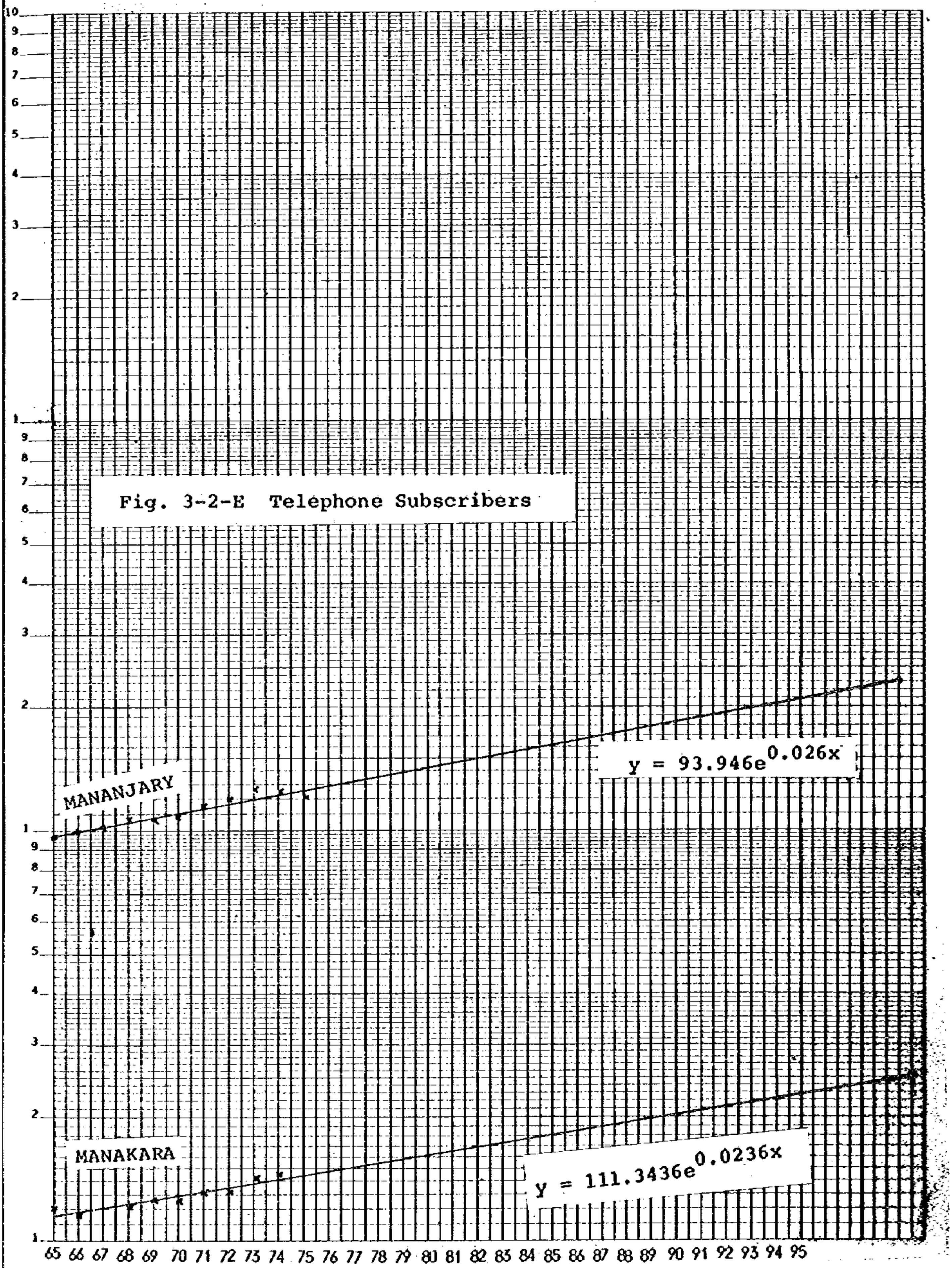


Fig. 3-2-E Telephone Subscribers
MANANJARY
y = 93.946e^0.026x
MANAKARA
y = 111.3436e^0.0236x
65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95

Tananarive district:	6%
Fianarantsoa district:	4%
(Southeast Coastal Area:	3%)

3-3-3 Coefficient K

In addition to the traffic increase by the increase in the number of subcribers, the traffic increase ascribable to the development in service quality and the coefficient of conversion from average traffic of the year to traffic for equipment and circuit calculation are considered.

1) Traffic increase ascribable to service improvement

In general, traffic increase is observed when the telephone system is changed from a delay service system with considerable distortion and noise to an STD (Subscriber Trunk Dialling) which provides high-quality service. The lower the conventional service quality is, the more the traffic will increase by adoption of a new system. The rate of traffic increase can be estimated from the past data in Japan, as follows.

Tananarive-Fianarantsoa section in which the present service condition is comparatively good.. 1.54 (times)
Fianarantsoa-Tulear section in which the present speech quality and connecting service quality are rather low .... 2,00 (times)

2) Coefficient of conversion from average traffic per year to traffic for equipment and circuit calculation.

Traffic of 1975, which is used as the base for traffic forecast, is an average traffic per year but traffic for circuit calculation must be an average value for a maximum of 30 days of a year. This coefficient of conversion is made 1.2.

From 1) and 2), we have

Tananarive-Fianarantsoa:

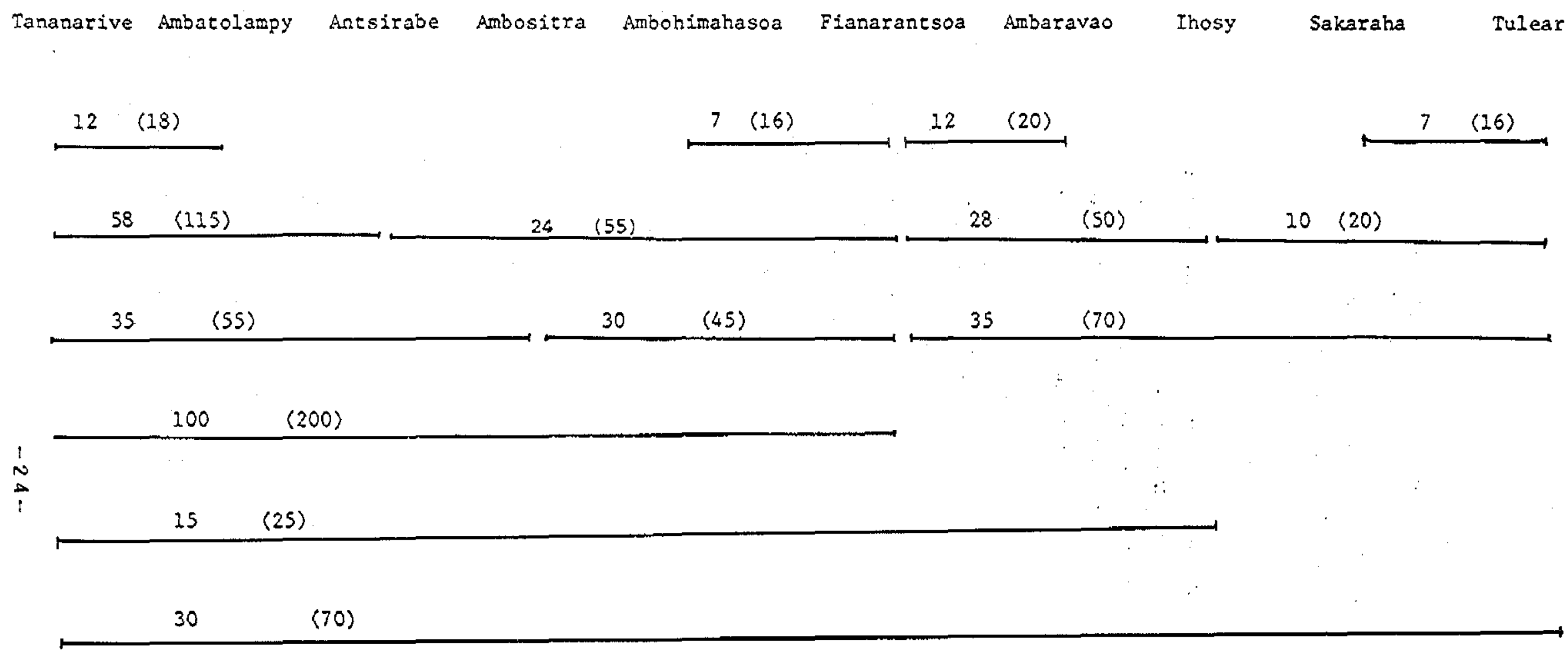
$1.54 \times 1.2 = 1.85$

Fianarantsoa-Tulear:

$2.0 \times 1.2 = 2.40$

Table 3-3 Forecast Telephone Traffic (erl)

To \ From	Year	Tananarive	Antsirabe	Ambositra	Fianarantsoa	Ambaravao	Ihosy	Tulear
Tananarive	1985		9.530	3.645	25.713	3.145	2.119	6.813
	2000		26.293	10.057	70.942	8.677	5.846	2.243
Ambatolampy	1985	1.183	0.149		0.010			
	2000	3.264	0.411		0.028			
Antsirabe	1985	17.748		1.444	2.187	0.176	0.347	0.570
	2000	48.967		3.984	6.034	0.486	0.957	1.573
Ambositra	1985	4.795	1.879		3.223	0.129	0.127	
	2000	13.229	5.184		8.892	0.356	0.350	
Fianarantsoa	1985	15.301	1.283	4.063		2.883	4.788	2.322
	2000	42.215	3.540	11.210		7.954	13.210	6.406
Ambaravao	1985	0.651	0.036	0.126	1.314		0.409	
	2000	1.796	0.099	0.348	3.625		1.128	
Ihosy	1985	2.344		0.757	8.789	0.609		0.493
	2000	6.467		2.089	24.249	1.680		1.360
Tulear	1985	6.405	1.874	0.842	6.253	0.092	1.497	
	2000	17.671	5.170	2.323	17.252	0.253	4.130	

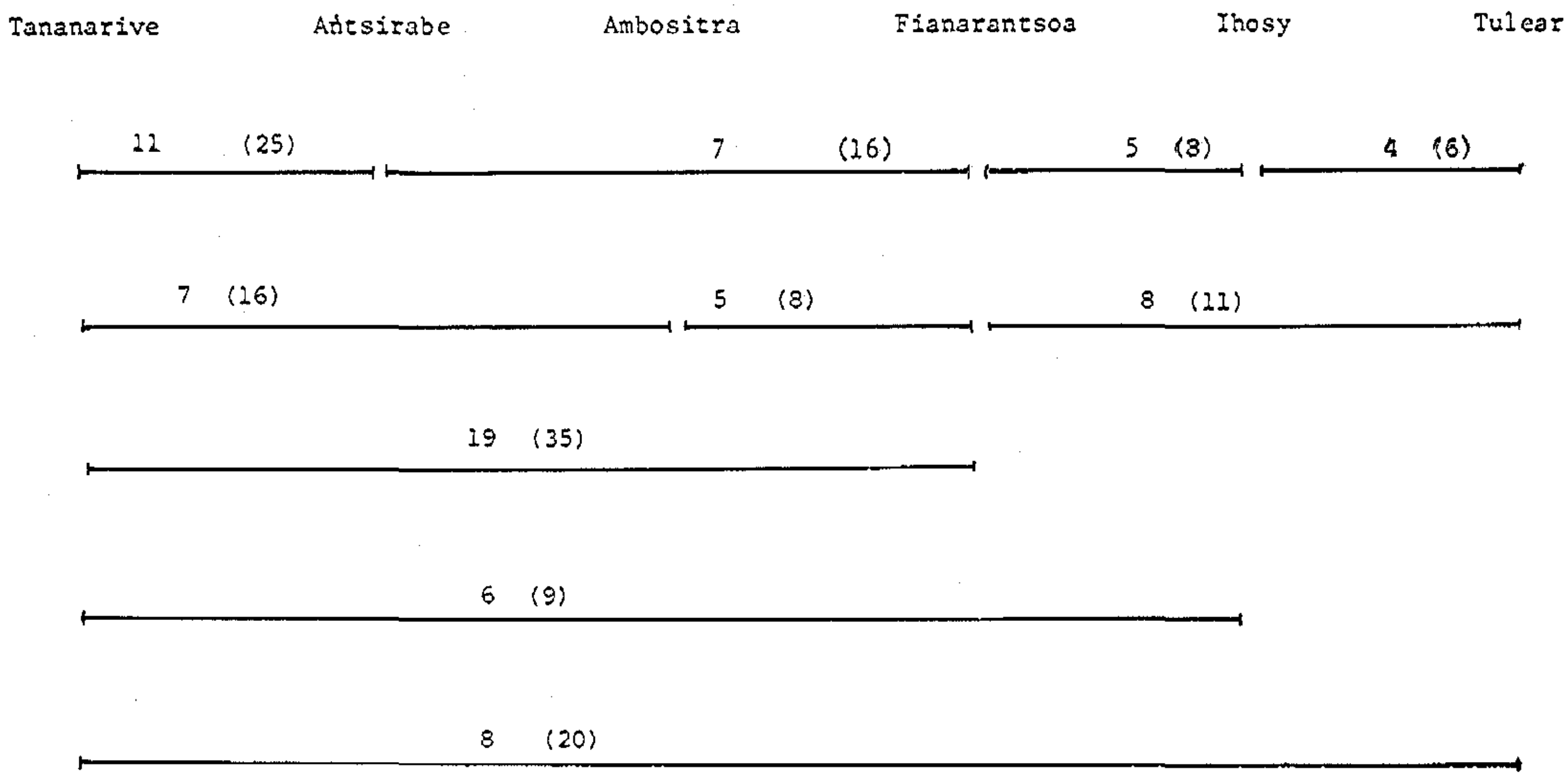


<u>Legend</u>

Figures: at initial stage (1985)

Figures in ( ): at ultimate stage (2000)

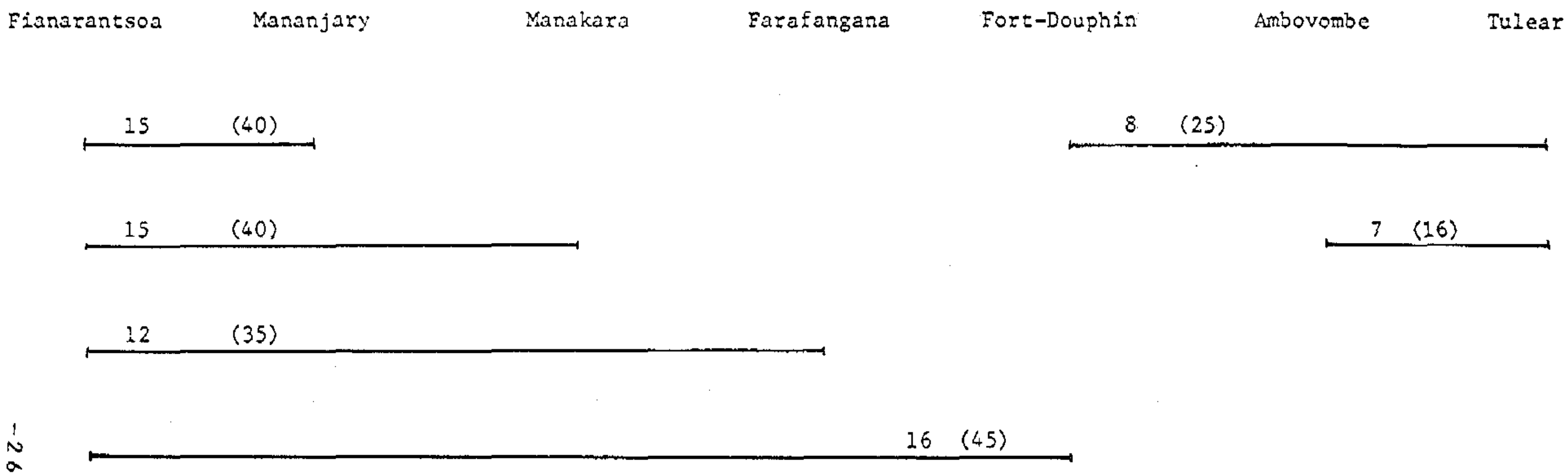
Fig. 3-3-A Telephone Circuit Demand



Legend Figures: at initial stage (1985)

Figures in ( ): at ultimate stage (2000)

Fig. 3-3-B Telegraph Circuit Demand



Legend Figures: at initial stage (1985)

Figures in ( ): at ultimate stage (2000)

- Figures given above are numbers of circuits to be considered upon connection with the Southern Microwave System.
- Fort-Dauphin ~ Tulear circuit may be via Fianarantsoa.

Fig. 3-3-C Telephone Circuit Demand for Southeast Coastal Area

3-4 Forecast Demand

Forecast traffic obtained as per Paragraph 3-3 is given in Table 3-3. The demand to be caused four years after starting the service (1985) is set as the initial demand and that to be caused in 2000 is set as the ultimate demand. Fig. 3-3 shows telephone circuit demand obtained from the erlang table (random calls) for a probability of loss of 0.01.

For telegraph circuits, circuit demand is obtained by estimating the number of telegraph subscribers in 1985 at each office. Demand forecast for the period of 1985 - 2000 is achieved by assuming an annual traffic increase of 7%. Although the Southeast Coastal Area will not be covered by this project, the number of circuits to be connected with Fianarantsoa or Tulear is given in consideration of future connection of the area to this microwave system.

3-5 Future Southern Telephone Network

Although it is supposed, in the forecast circuit demand described in Paragraph 3-4, 4-wire toll exchange, which has been already introduced at Tananarive, will be introduced also at Fianarantosoa when a microwave link will be constructed in the Southeast Coastal Area, establishment of high-usage traversal trunks at other offices is not considered. However, the desirable future southern network will be as shown in Fig. 3-4. The tertiary and secondary centers shown in Fig. 3-4 will perform switching of toll lines by 4-wire toll exchange, forming a national STD network. Traversal trunks will be established in sections of more than 5 erlang and at high usage. For the Mananjary-Fort Dauphin Southeast Coastal Area, branching will be made at Fianarantsoa and the toll exchange of Fianarantsoa will be used to send calls towards Tananarive and Tulear. Tulear will perform switching operation of offices adjacent to Tulear. When a direct transmission route is established between Morondava and Tananarive, calls to/from Morondava will be sent through the toll exchange in Tananarive. Other offices shown in Fig. 3-4 (primary centers marked o) are lowest-ranking toll exchange offices and send information on charging, routing, necessary digit, etc., to neighboring end offices.

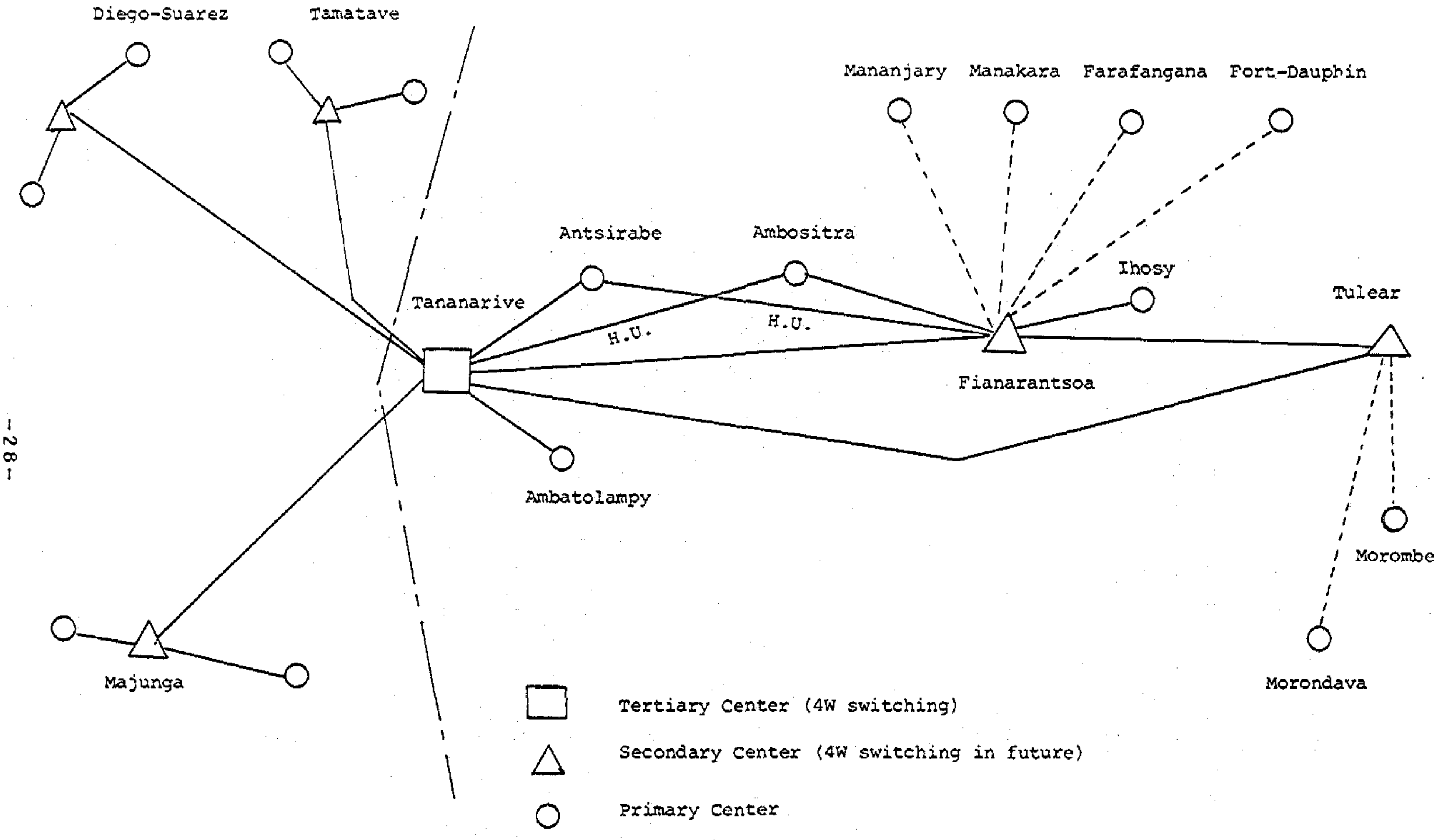


Fig. 3-4 Future Telphone Network in Southern Madagascar (STD Network)

CHAPTER 4 SYSTEM DESIGN

4-1 General

This chapter describes basic radio relay system selection, site selection based on the system selection, concrete system design to be made for the route determined, and the transmission quality of the system thus designed. For the long-haul transmission of telephone and television signals, it is most economical from the national standpoint to employ a single wide-band microwave route. System design is effected in consideration of this point.

For the radio relay system between Fianarantsoa-Tulear, line-of-sight and over-horizon systems have been selected and system design has been made for both systems by considering that comparison should be made precisely since there is no large difference in superiority between the two systems and the over-horizon system was proposed in the initial plan.

4-2 Basic System Selection

4-2-1 Selection of Radio Relay System

For the Tananarive-Fiananarive-Fianarantsoa-Tulear radio relay system, the following two plans can be considered in consideration of circuit demand, geographical conditions, locations of towns at which signals will be branched, etc.

Plan 1: Line-of-sight microwave system for the entire Tananarive-Tulear section

Plan 2: Ling-of-sight microwave system for the Tananarive-Fianarantsoa section and over-horizon system for Fianarantsoa-Tulear section

In the case of Plan 1, ease of maintenance of the power supplies at places inconveniently situated will be important. It is then necessary to minimize the power consumption of radio equipment so as to facilitate use of small-capacity power supplies which ensure ease of maintenance. Thus, a low-power consumption microwave system is recommended. For the transmission capacity, 960 channels for the Tananarive-Fianarantsoa section and 300 channels for the Fianarantsoa-Tulear section may be sufficient if only telephone transmission is required. In consideration of future color television signal transmission, however, it is recommended to provide 960 channels over the entire Tananarive-Tulear section.

In the case of Plan 2, the transmission capacity of the over-horizon system is limited, by the present technical level, to approximately 300 channels. TV transmission also limited to the monochrome TV signal. By considering these points and circuit demand, the transmission capacity to be adopted will be 300 channels. Although the quadruple diversity system using frequency and space diversity in combination has been generally used in over-horizon radio relay systems, latest design is achieving system economy by reducing the number of antennas to a half through adoption of angle diversity. Accordingly, a guadruple diversity system using frequency and angle diversity in combination is selected for the system.

4-2-2 Selection of Working Frequency Band

In general, the higher the frequency used in line-of-sight microwave relay is, the higher the probability of the occurrence of fading becomes but the smaller the equipment becomes and the more advantageous in antenna gain and transmission band. In addition, the use of a higher frequency band is advantageous for avoiding interference with satellite earth station. The proposition of a 6GHz upper band in the initial plan may be ascribable to these reasons.

However, the frequency of the low-power consumption microwave system is limited to the 2 ∿ 4GHz band for the time being because of the power efficiency of the transmitter section. In the Tananarive-Fianarantsoa section, maintenance condition will be good and commercial power will be available at most stations and it will not be required to employ particularly low-power consumption equipment. In the Fianarantsoa-Tulear section, however, it is desirable to employ low-power consumption equipment. System unification will be more advantageous for economy, ease of maintenance, and reduction in power supply capacity. Accordingly, the entire Tananarive-Tulear section will be covered by a microwave relay system of low-power consumption equipment using a single frequency band.

Which of the 2 or 4GHz band should be selected must be discussed. In the case of the 4GHz band, the antenna gain is higher and less transmitter output power and less power consumption will be required. The transmission capacity in the case of the 4GHz band is generally larger than that in the case of the 2GHz band. It has been also determined that there is no problem in interference with the satellite earth station. Thus, the 4GHz band (3.6 ∿ 4.0GHz) has been selected as the frequency band of the line-of-sight system.

In the case of the over-horizon system, it is necessary to sharpen the directivity of antenna as much as possible in order to improve propagation distortion which will increase with increased transmission capacity, and thus the 2GHz band or a comparatively higher frequency band for over-horizon system is selected.

4-2-3 Proposed Systems to be Compared

In this report, the following two plans are selected for comparison as the result of the above-mentioned examination.

Plan 1: Tananarive-Tulear section
Line-of-sight microwave system over the entire section
Frequency range: 4GHz band
Transmission capacity: 960 channels
(Plan 1 is abbreviated FULL-LOS plan.)

Plan 2: Tananarive-Fianarantsoa section
Line-of sight microwave system in this section
Frequency range: 4GHz band
Transmission capacity: 960 channels

Fianarantsoa-Tulear section
Over-horizon microwave system (using line-of-sight system in the entrance portion)
Frequency range: 2GHz band
Transmission capacity: 300 channels
Diversity: Quadruple diversity using frequency and angle diversity in combination

(Plan 2 is abbreviated PARTIAL-OH plan.)

4-3 Site Selection

4-3-1 Principles of Site Selection

Site selection is made on the following principles.

(1) To meet the transmission quality set out by the CCIR recommendations.

(2) Station sites should be located along the trunk road so as to facilitate construction and maintenance, and access roads should be as much short as possible.

(3) Number of repeater stations should be reduced for achieving economy.

(4) Branching of telephone and television signals should be facilitate as planned.

(5) Existing station facilities should be utilized as much as possible.

(6) Sufficient clearance should be acquired with a equivalent earth radius coefficient of $k = 2/3$.

4-3-2 Result of Site Selection

By carrying out site selection on the above-mentioned principles on the basis of the original plan prepared by the Government of Madagascar, the final site selection plan has been obtained as shown in the following drawings and Table.

Fig. 4-1	FULL-LOS Route Plan
Fig. 4-2	PARTIAL-OH Route Plan
Table 4-1	Outlines of Station Sites
Appendix 4-1	Topographical Drawings and Snap Photographs of Respective Photographs of Respective Sites
Appendix 4-2	Path Profiles

In particular, efforts were made in reducing the number of repeater stations and the length of access road upon site selection for the Fianarantsoa-Tulear section, which has allowed the selection of such a line-of-sight route that can economically cope with over-horizon relay system.

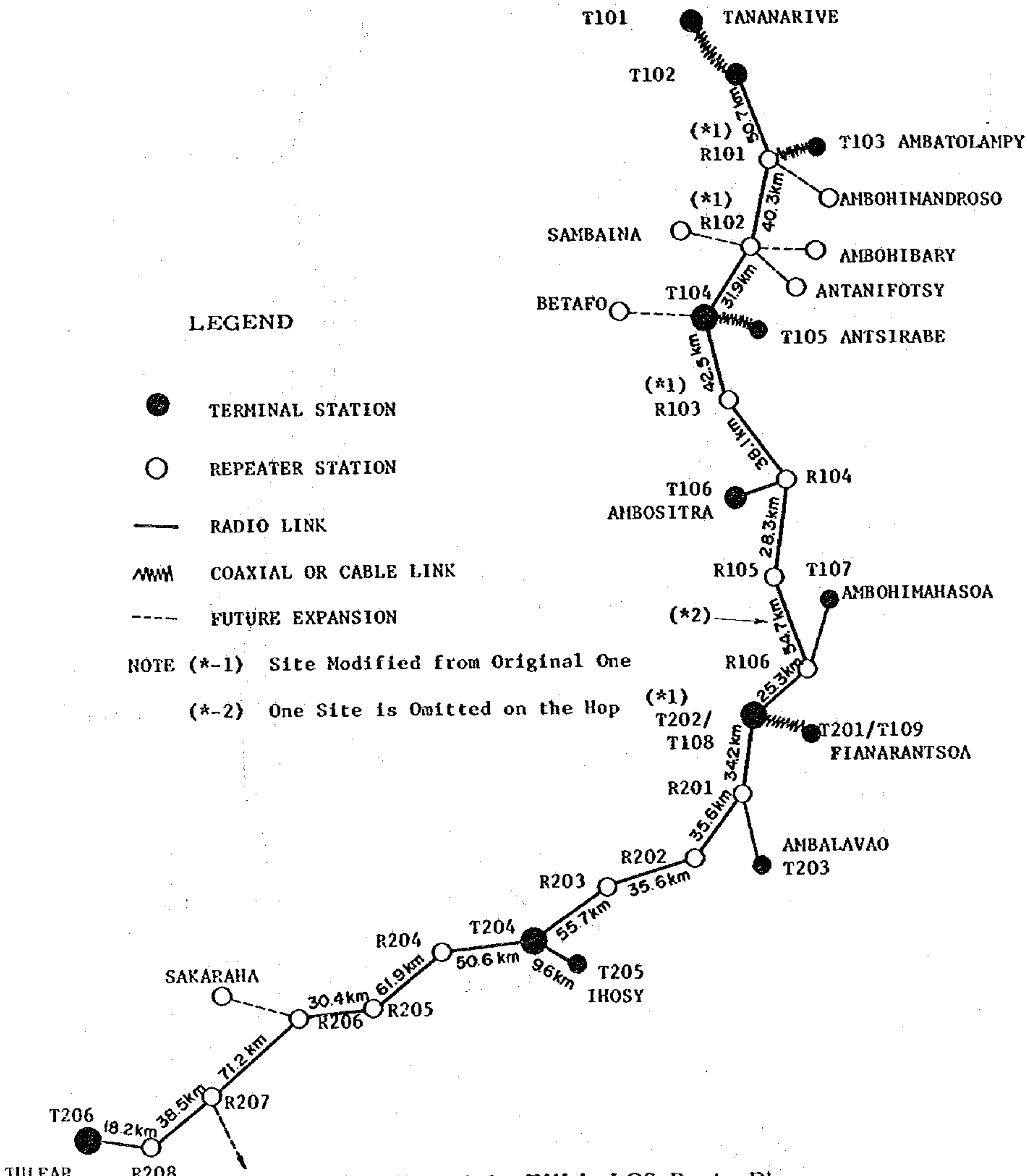


Fig. 4-1 FULL-LOS Route Plan

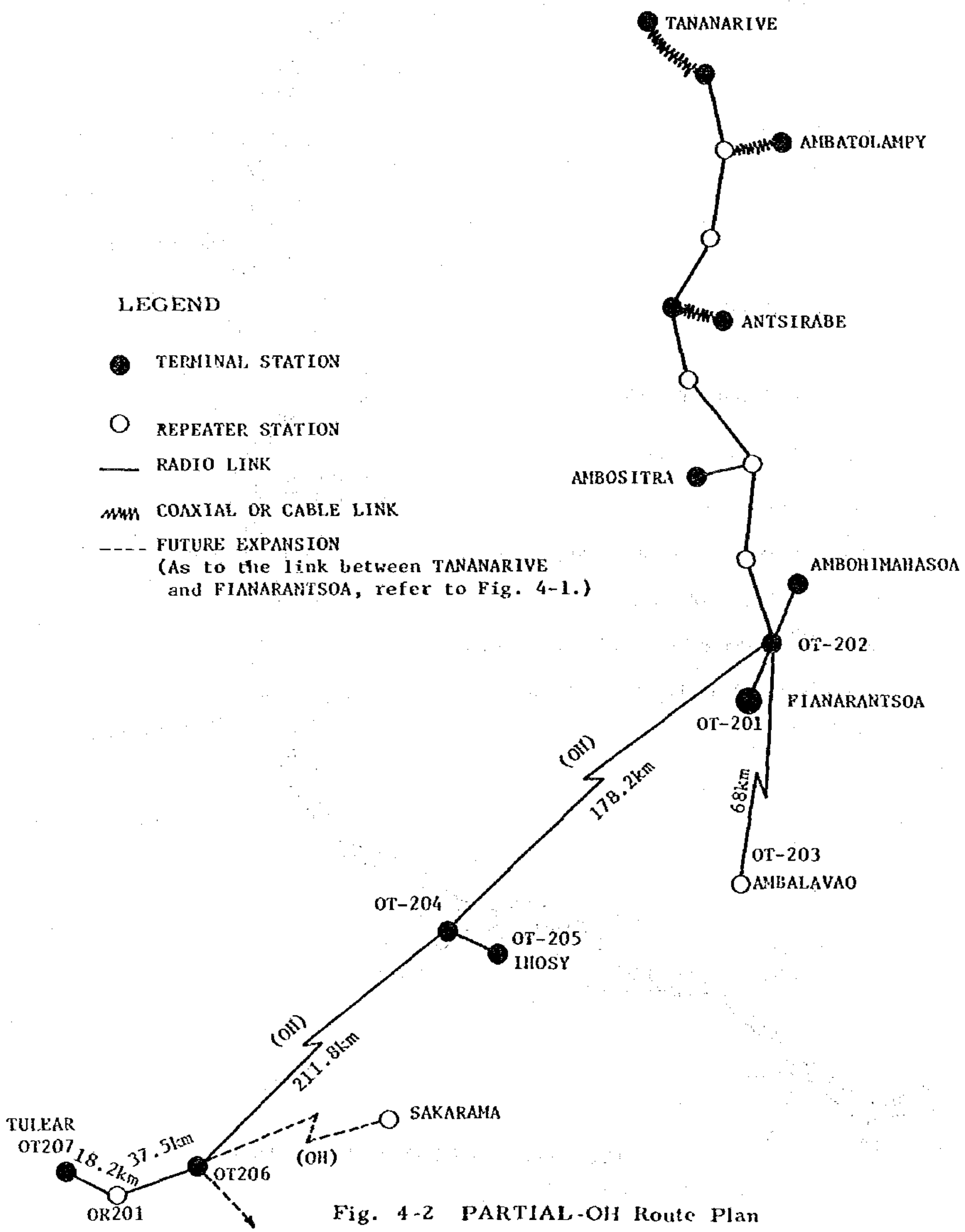


Fig. 4-2 PARTIAL-OH Route Plan

Table 4-1 Outlines of Station Sites (FULL-LOS Route Plan)

(A) FULL-LOS Plan

City	Site Code	Position		Altitude	Access Road		Tower Height	Power Supply	Building	Remarks
		Long.	Lat.		Newly const.	To be repaired				
				(m)		(km)	(m)			
TANA	T101				-	-	-	Com.	Exist.	Cox. 3km
TANA	T1o2	47°31'56"	18°55'31"	1405	-	-	20	Com.	Exist.	
	R101	47°26'52"	19°22'34"	1640	-	-	40	Com.	-	
AMBATO	T103				-	-	-	Com.	Exist.	Cable 3km
	R102	47°06'30"	19°39'16"	1950	2.5	3.0	30	Com.	-	
ANTSI	T104	47°00'30"	19°52'41"	1650	-	-	20	Com.	-	
ANTSI	T105				-	-	-	Com.	Exist.	Cox. 5km
	R103	47°05'16"	20°15'16"	1673	-	-	10	-	-	
	R104	47°16'26"	20°33'03"	1625	-	1.0	50	Com.	-	
AMBO	T106	47°14'31"	20°31'51"	1300	-	-	20	Com.	Exist.	
	R105	47°10'44"	20°47'26"	1813	1.5	-	35	-	-	
	R106	47°14'40"	21°16'51"	1422	1.0	-	20	-	-	
AMBOHI	T107				-	-	20	Com.	Exist.	
FIANA	T108	47°04'29"	21°26'43"	1387	1.0	-	20	Com.	-	
FIANA	T109				-	-	-	Com.	Exist.	Cox. 4km
FIANA	T201	Same as T109								
FIANA	T202	Same as T108								
	R201	46°57'39"	21°44'08"	1400	3.0	-	10	-	-	
AMBALAVAO	T203	46°56'00"	21°51'	1000	-	-	20	-	Exist.	
	R202	46°42'42"	21°56'21"	1350	4.0	-	20	-	-	
	R203	46°22'47"	22°01'30"	1061	2.0	-	40	-	-	
IHOSY	T204	46°02'06"	22°24'43"	1121	-	-	60	-	-	
IHOSY	T205	46°07'40"	22°24'05"	725	-	-	20	-	-	
	R204	45°33'18"	22°30'37"	950	0.5	-	60	-	-	
	R205	45°01'34"	22°46'42"	1100	0.5	-	20	-	-	
	R206	44°44'02"	22°49'24"	875	-	3.5	45	-	-	
	R207	44°07'00"	23°07'04"	491	1.5	1.0	45	-	-	
	R208	43°50'46"	23°21'33"	200	-	-	20	-	-	
TULEAR	T206	43°40'07"	23°21'26"	3	-	-	30	Com.	Exist.	

(B) PARTIAL-OH Plan

City	Site Code	Position		Altitude	Access Road		Tower Height	Power Supply	Building	Remarks
		Long.	Lat.		Newly const.	To be repaired.				
FIANA	OT201	47°05'26"	21°26'30"	1250 (m)	-	-	50 (m)	Com.	Exist.	
	OT202	47°14'40"	21°16'51"	1422	1.0	-	15	-	-	
AMBALAVAO	OT203	46°56'	21°50'	1000	-	-	20	-	-	
	OT204	46°02'51"	22°27'06"	1142	0.3	-	15	-	-	
IHOSY	OT205	46°07'40"	22°24'05"	725	-	-	20	-	-	
	OT206	44°07'18"	23°08'08"	488	1.5	1.0	15	-	-	
	OT201	43°50'46"	23°21'33"	200	-	-	20	-	-	
TULEAR	OT207	43°40'07"	23°21'26"	3	-	-	30	Com.	Exist.	

4-4 System Configuration and Equipment Performance

4-4-1 Principles of System Configuration

(1) System for telephone

1) FULL-LOS plan

Baseband switching will be performed at Tananarive, Antsirabe, Fianarantsoa, Ihosy, and Tulear (4 switching section configuration) in consideration of site locations in Tananarive-Fianarantsoa-Tulear section, number of telephone circuit drops, radio relay system switching section length, etc. A modem will be installed at these four stations to modulate and demodulate the entire baseband.

Telephone branching and insertion at other stations will be made by the leaking method since the number of circuits is rather small, thereby avoiding transmission quality degradation and reducing required expenses for construction.

Branching to Ambositra and Ihosy will be by using 4GHz bands and of 300 channels. Other branching radio systems will employ proper frequency bands other than the frequency band of the main system and have transmission capacity of 60 channels.

2) PARTIAL-OH plan

Since the three radio terminal stations in the over-horizon section are located distant from their corresponding cities, entrance radio relay systems will be required for connection. The transmission capacities of these entrance radio relay systems will equally be 300 telephone channels or one monochrome television channel in accordance with that of the over-horizon system. The frequency bands of these entrance radio relay systems will equally be the same 4GHz band as the frequency band of the Tananarive-Fianarantsoa section. Telephone branching to Ambalavao and Sakaraha will be made by small-capacity over-horizon relay systems.

(2) System for television

1) FULL-LOS plan

Television signal will usually be transmitted from Tananarive and will scarcely be inserted from other cities. Accordingly, transmission in the direction will be carried out by one microwave system dedicated for television signal and transmission in the "up" direction will be carried out by one standby system, as shown in Chapter 8.

Since it will not be necessary to perform baseband switching at the four stations as will be required in the case of telephone transmission, IF switching will be employed to achieve economy and development in transmission quality.

When the television broadcasting station and microwave repeater station are separate from each other, they will be connected by an ST link or coaxial cable.

2) PARTIAL-OH plan

Since such a stand-by system as in the line-of-sight system will not be provided in the over-horizon section, transmission of TV signal by a stand-by system will not be achievable, so that it will be necessary to expand the radio relay system dedicated for TV transmission in both "up" and "down" directions.

Also, since it will not be achievable to send both video and sound signals simultaneously as in line-of-sight relay, it will be necessary to send the sound separately by telephone system.

Since the frequency deviation in the over-horizon section should be made smaller than that of line-of-sight system to reduce waveform distortion, connection of the two systems should be made in video band and not in IF band. However, diversity combining in IF band should be adopted to transmit wideband TV signal.

Principal factors such as transmitter output power and noise figure are made equal to those for telephone.

(3) Supervisory and control system

The supervisory and control system configuration will be closely related with the radio relay system configuration and maintenance system.

In the case of the FULL-LOS plan, it is necessary to make Tananarive, Antisirabe, Fianarantsoa, and Ihosy, and Tulear stations to be attended in order to achieve efficient maintenance and Operation." However, it will not be necessary to perform supervision of the system at all attended stations and it is desirable to minimize the number of stations which will perform supervision continuously. Accordingly, Tananarive, Fianarantsoa and Tulear will be made supervisory stations and supervision of the entire system will be charged to these three stations.

In the case of the PARTIAL-OH plan, the three OH radio relay stations will be supervised respectively by Fianarantsoa, Ihosy, and Tulear terminal stations and will in principle, be designed to be unattended.

An orderwire circuit will be established between all related stations so as to allow smooth functioning of the maintenance and operation organization.

Transmission of supervisory and control signals and orderwire telephone signal will be made by using the lower baseband of the microwave system, and in case the working system fails, changeover to the stand-by system will be effected.

It will be desirable to provide a circuit for supervision and control of television broadcasting stations of which maintenance will be performed unattended so as to allow the central broadcasting station in Tananarive to supervise and control all unattended stations concentratively. Of course, the transmission path will be incorporated in the microwave system. It is rational to put the boundary of responsibility between PTT and RTM on the input terminal of the SVC and the output terminal of the SVS.

(4) Selection of power supply system

1) When commercial power is available:

When commercial power is available, the "commercial power + battery floating" system in which the battery is charged by floating while the commercial power is rectified and fed to the load will be used. One stand-by engine will back up the power system in the event of power failure. When the power facilities are to be accommodated in existing telephone office or a like, the existing power facilities will be utilized as much as possible.

2) When commercial power is not available:

As a result of recent development of solid-state radio equipment, power consumption of microwave repeater stations has been much reduced. Low-power consumption equipments will also be introduced to this microwave system as well for achieving ease of maintenance and economy of the power supply.

Various types of power supply systems have been developed for practical use to feed loads of less than several hundreds of watts in power consumption but following types will be most suitable for respective load power ranges in consideration of annual expenses required.

Power Supply System	Load Power
o Solar battery type	0~60 watts
o Thermo-generator type	60~250 watts
o "EG + battery charge/discharge" type	250~700 watts
o "EG + battery floating" type	more than 700 watts

The estimated load powers of repeater stations in line-of-sight sections where commercial power will not be available are as follows.

o Simple through-repeater stations without branch
(7 stations):

95∿140 watts

o Through-repeater stations with branch and terminal stations without carrier terminal equipment
(4 stations):

350∿600 watts

o Terminal stations with carrier terminal equipment
(3 stations):

800∿1500 watts

Accordingly, the "EG + battery charge/discharge" type and "EG + battery floating" type will be adopted in cases 2 and 3, respectively. Here, "EG + battery charge/discharge" type is a power supply system in which the operating time of the engine generator is minimized and power is fed from the battery to the load while the engine generator stops operation, thereby extending the period of maintenance of the engine generator and reducing the fuel consumption. The period of the maintenance of the engine generator is: every 6 months for periodical maintenance and every 8 years or so for overhaul.

In the case of a simple through-repeater station without branch, it can be understood that the thermo generator type is most economical in consideration of the above-mentioned applicable range. However, this type of power supply involves difficulty in procurement and transportation of required fuel when compared with types using an engine gerator. In the case of using an engine generator, only one time of fuel transportation is required a year, whereas the thermo generator type requires to transport nine (in the case of 100 watts power consumption) bombs containing 500kg fuel (approx. 1 ton in gross weight).

Accordingly, it is recommended to employ the solar battery type, which is slightly high in annual cost but requires no fuel transportation, at stations of which power consumption is less than 100 watts and which are inconveniently situated. With the recent technical progress of solar battery, the cost of solar battery is lowering and the service life of solar battery is being improved. In the sections under consideration, insolation is comparatively large and economical design will be allowed. In addition, no fuel replenishment is required and maintenance of stations can be carried out by foot patrol to the stations, possibly requiring no expense for construction and maintenance of access roads. Furthermore, when expanding the microwave system in future to areas where construction of roads is not easy, the adoption of solar battery system will be indispensable. It is very significant, therefore, to be well acquainted with solar battery system.

On the other hand, the problems to be discussed upon adopting solar battery system are as follows.

i) Since no meteorological observatory is located near proposed repeater stations, accurate insolation data necessary for design is not achievable.

ii) Estimation of annual insolation variation may sometimes be difficult.

Accordingly, it is necessary to acquire insolation data at proposed sites for about one year prior to the adoption of solar battery system, grasp the relationship between the data obtained thus and that obtained at a nearby meteorological observatory, reflect the relationship thus obtained upon design, and provide a small-capacity portable engine and a charger for a countermeasure against unexpected decrease in the solar energy or increase in load upon patrol.

As the result of the above-mentioned examination, selection of power supply systems will be made on the following principles.

i) "EG + battery floating" type

For stations of more than 700 watts in power consumption (3 stations). Although station T-204 is less than 700 watts in power consumption, it is included in the stations to employ this type of power supply, since it is supposed that the total power consumption increases by the use of television broadcast equipment.

ii) "EG + battery charge/discharge" type

For stations of less than 700 watts in power consumption (8 stations), excluding those stations of cast iii).

iii) Solar battery type

For stations of less than 100 watts in power consumption and inconveniently situated (3 stations).

However, the adoption of solar battery type will be finally determined by examining the result of insolation survey at sites.

In the following paragraphs, therefore, description is given on the assumption of including solar battery type power supply in the "EG + battery charge/discharge" type power supply for convenience's sake.

4-4-2 Concrete System Configuration and Equipment Performance

(1) System configuration and equipment performance of FULL-LOS Radio Relay System

A system configuration of the FULL-LOS radio relay system is shown in Fig. 4-3. For the reason described in Chapter 8, this radio relay system will comprise two "down" working systems, one "down" stand-by system, one "up" working system, and one "up" stand-by system. The "up" and "down" working No. 1 system will be used for telephone transmission and the "down" working No. 2 system and "up" stand-by system for television transmission. The "up" transmission of television signal will be made to Tananarive without branching at any station on the way, and branching will be conducted in the "down" system. In order to distinguish the portions to be added for TV transmission, thick lines are used in Fig. 4-3.

Table 4-2 gives the methods of branching telephone and TV signals for reference' sake. Described hereunder are performance to be set for major equipments of the FULL-LOS radio system. The transmission performance described in Paragraph 4-5 is calculated from these values.

Transmitter-receiver

1)	Frequency	4GHz band (as per CCIR Rec. 382-2)
2)	Transmission capacity	960 telephone channels or one color TV channel and 3 sound channels
3)	Repeating method	Heterodyne repeating
4)	Transmitter output	0.5 or 1.0 watts
5)	Noise factor	4.5 or 6.5dB
6)	AGC range	50dB
7)	SQL level	-75~-80dBm
8)	Amplitude response	Deviation: less than 0.4dB over ±10MHz range
9)	Group delay characteristic	Deviation: less than 3ns over ±10MHz range
10)	Input/output impedance	VSWR: less than 1.03 over ±10MHz range
11)	IF output	70MHz, +4dBm 75Ω, unbalanced
12)	Frequency stability	10^{-4}
13)	Supply voltage	-24V ±10%
14)	Ambient temperature	0 ∿ 45°C
15)	Power consumption	less than 20 watts

Modem

1)	Type of modulation	FM
2)	Baseband width	60 ∿ 4188KHz (Telephone) 0 ∿ 6MHz (Television)

3)	Frequency deviation	200 kHz/CH (Telephone) 8MHzp-p (without emphasis in the case of TV)
4)	Emphasis	as per CCIR Recommendation
5)	Baseband input/output levels	Input: -45dBr Output: -20dBr (in the case of telephone) Input/Output: 1Vp-p (in the case of TV)
6)	IF frequency and input/output level	70MHz +4dBm
7)	Modulation linearity	less than 2% over ±6MHz
8)	Demodulation linearity	less than 2% over ±6KHz
9)	Frequency stability	70MHz ±5KHz
10)	Supply voltage	-24V ±10%
11)	Ambient temperature	0~45°C

Antenna Feeder

1)	Antenna gain	4m diameter: 41.0dB 3.3m diameter: 39.5dB
2)	Input/Output impedance	VSWR: less than 1.08
3)	Feeder transmission loss	0.03dB/m
4)	Feeder impednace	VSWR: less than 1.05

(2) System configuration and equipment performance of PERTIAL-OH Radio System

Fig. 4-4 shows a system configuration of the PARTIAL-OH radio relay system. The system configuration of the Tananarive-Fianarantsoa section is the same as that of the FULL-LOS system and is omitted. (To be accurate, the R106-T108-T109 section is directly coupled with R106-T109.) The OH section comprises one "up" and "down" telephone systems and one "up" and "down" TV systems and the portions to be added for TV use are shown by thick lines in Fig. 4-4. The methods of branching telephone and TV signals are given in Table 4-3 for reference's sake.

Legend for Fig. 4-3

T:	Transmitter
R:	Receiver
M:	Modulator
D:	Demodulator
⊣-:	Switcher
MUX:	Multiplex
SVC:	Sound and Video Combiner
SVS:	Sound and Video Separator
CON:	IF combiner for space diversity
D/I:	Drop and Insertion equipment (for telephone)
SG.TR:	Supergroup Translator
SW/D:	TV branching equipment
T/R:	Transmitter/Receiver for branch use

Remarks: Thick lines show portions to be added for TV transmission use.

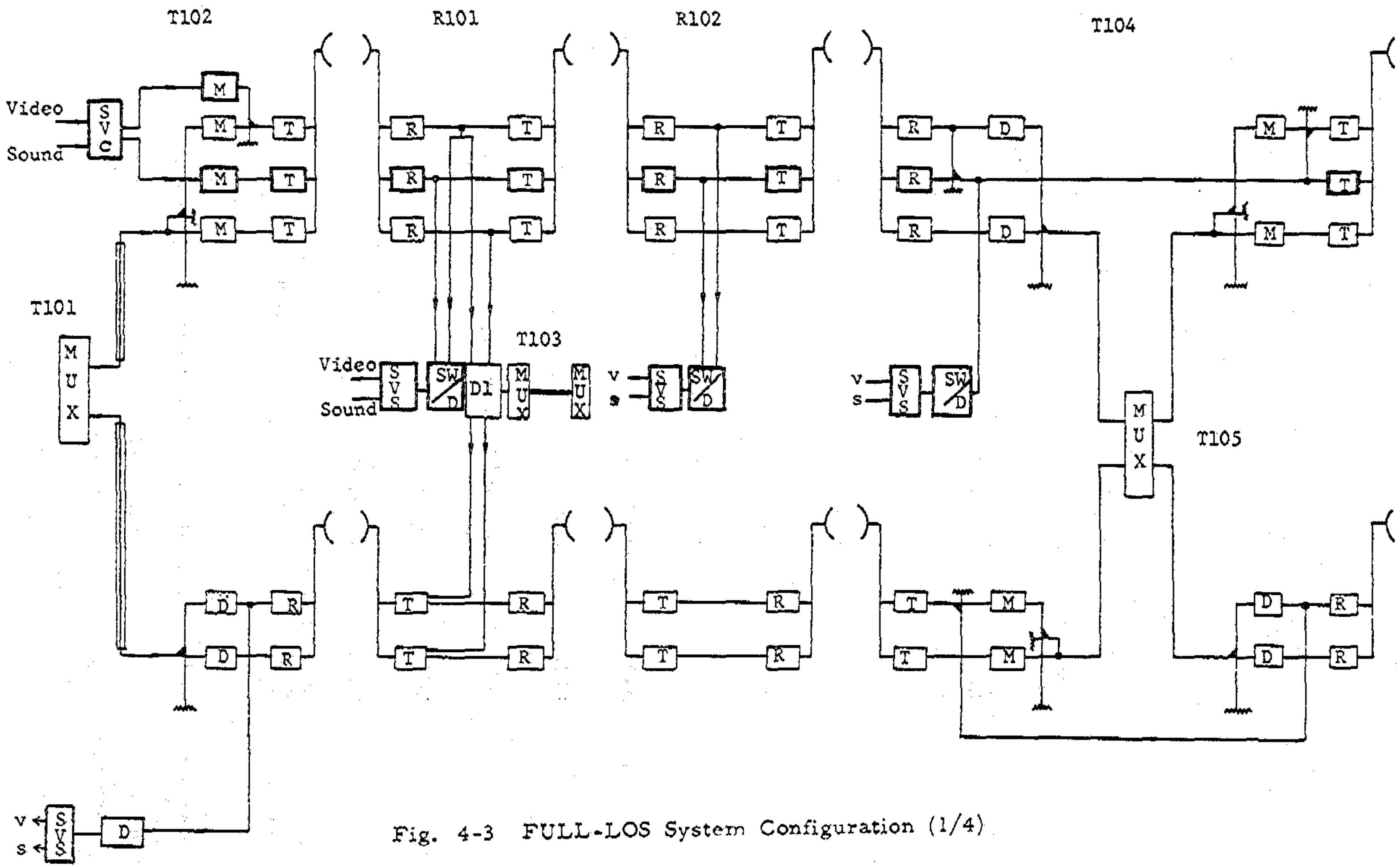


Fig. 4-3 FULL-LOS System Configuration (1/4)

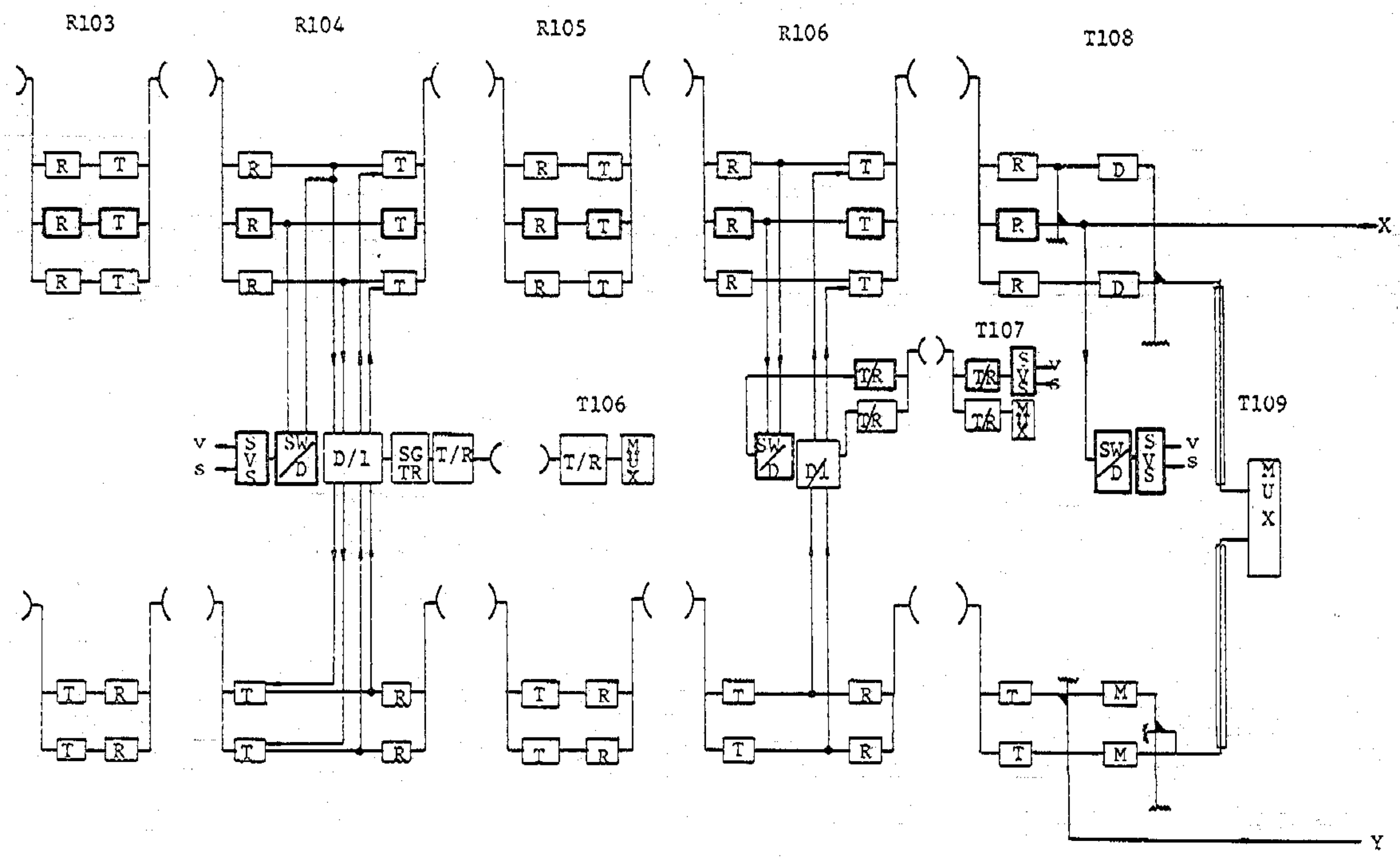


Fig. 4-3 FULL-LOS System Configuration (2/4)

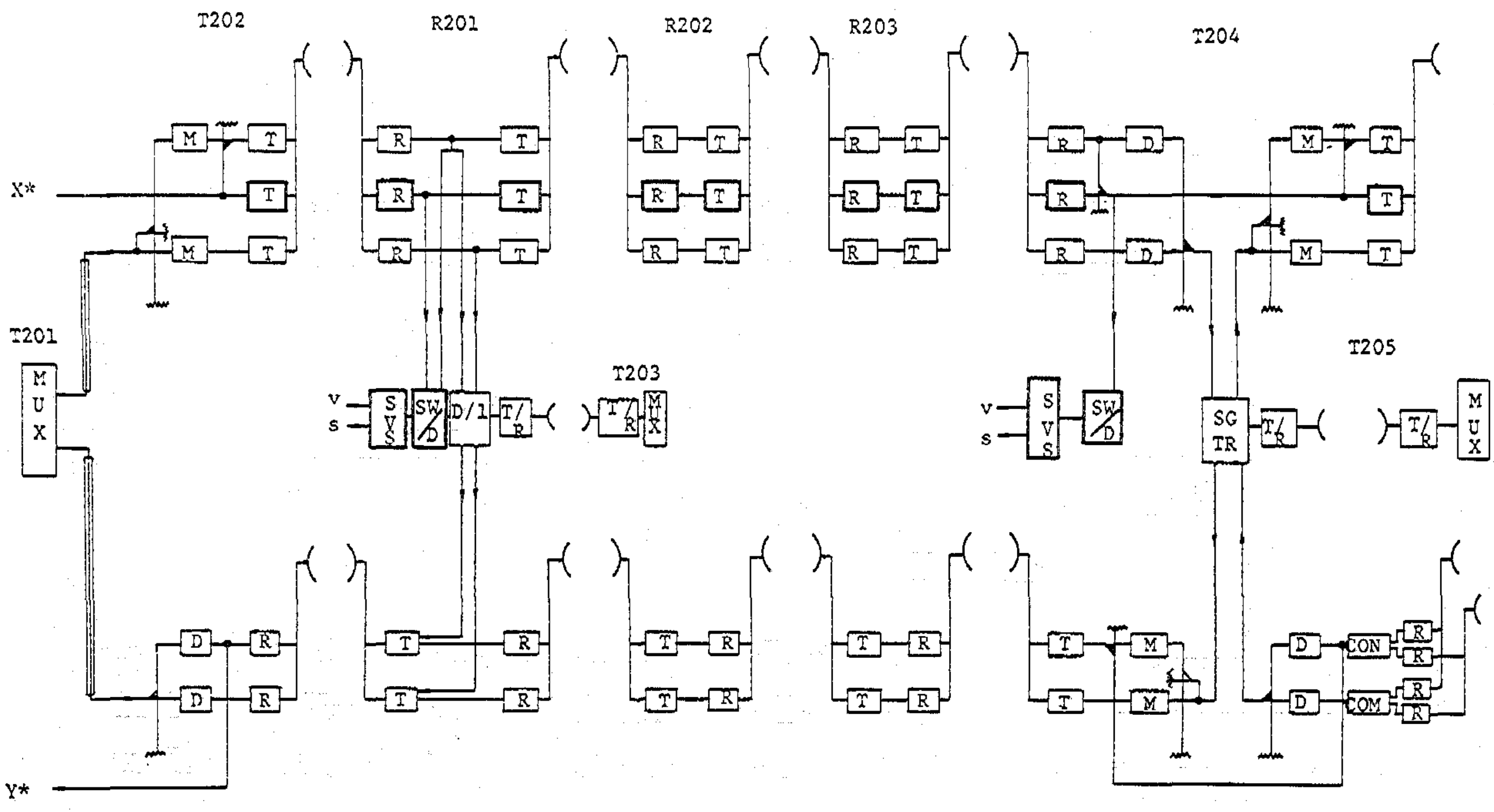


Fig. 4-3 FULL-LOS System Configuration (3/4)

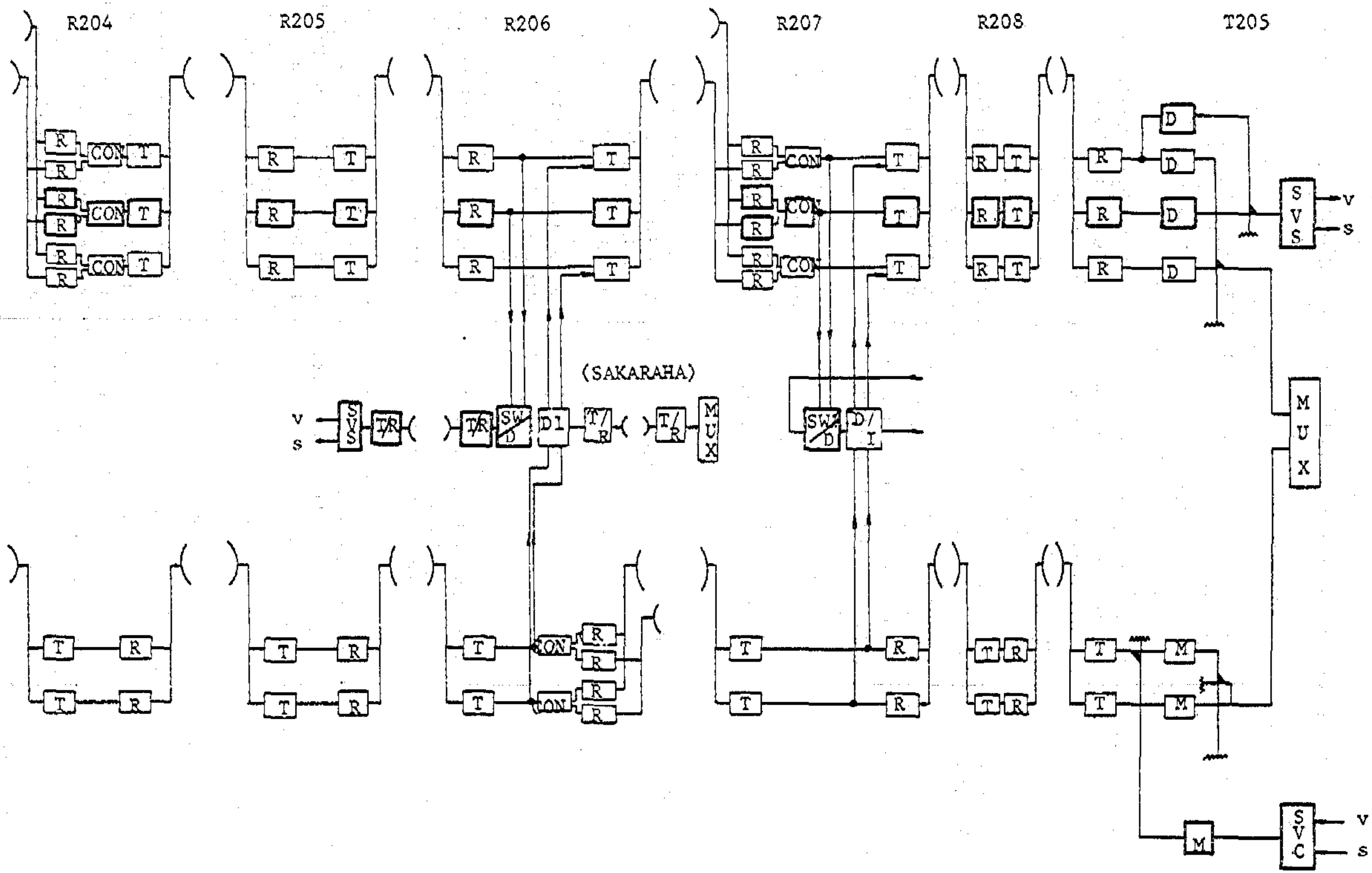


Fig. 4-3 FULL-LOS System Configuration (4/4)

Table 4-2 Methods of Branching Telephone and Television Signals (FULL-LOS plan)

Site Code	City of Branch	Branching Method	
		Telephone	Television
R101	Ambatolampy	By installing MUX in the station and dropping signal to voice channel, 200 pair cables will be led to PTT telephone office.	Coaxial cable will be used for leading into broadcasting station.
R102	Ambohibary Antanifotsy Sambaina	—	Connection with TV transmitter in the same station.
T104	Antsirabe Betafo	Coaxial cable of 6 inch (960 channels in capacity) will be used for lead-in to T105.	Connection with TV transmitter in the same station.
R104	Ambositra	Microwave system of 4GHz (300 channels in capacity) will be used for lead-in to T106.	Connection with TV transmitter in the same station.
R106	Anbatomahasoa	Radiator will be used in microwave system (60 channels in capacity) for lead-in to PTT telephone office.	Antenna and reflector for telephone branching use will be used in microwave system for lead-in to PTT telephone office and then connecting the signal to broadcasting station by coaxial cable.
T108	Fianarantsoa	6 pairs of coaxial cable (960 channels in capacity) will be used for lead-in to T109.	Coaxial cable will be used for lead-in to broadcasting station.
R201	Ambalavao	UHF system (60 channels in capacity) will be used for lead-in to PTT office.	Microwave system will be used for lead-in to local broadcasting station.
T204	Ihosy	Microwave system of 4GHz (300 channels in capacity) will be used for lead-in to T205.	Connection with TV transmitter in the same station.
R206	Sakaraha	UHF system (60 channels in capacity) will be used for lead-in to PTT office.	Microwave system will be used for lead-in to local broadcasting station.
R207	Route branching	Branching by leaking.	Branching by IF connection.

Legend for Fig. 4-4

LOS-Radio Relay System

T:	Transmitter
R:	Receiver
M:	Modulator
D:	Demodulator
⊣ :	Switcher

OH-Radio Relay System

PA:	High Power Amplifier
EX:	Exciter
LNA:	Low Noise Amplifier
CONV:	Down Converter
COMB:	IF or Baseband Combiner
MUX:	Multiplex
SVC:	Sound and Video Combiner
SVS:	Sound and Video Separator
D/I:	Drop and Insertion equipment (for telephone system)
SG.TR:	Supergroup Translator
CB:	Carrier Broadcasting Translator
T/R:	Transmitter and Receiver for branch use

Remarks: Equipments shown by thick lines are those to be added for TV transmission.

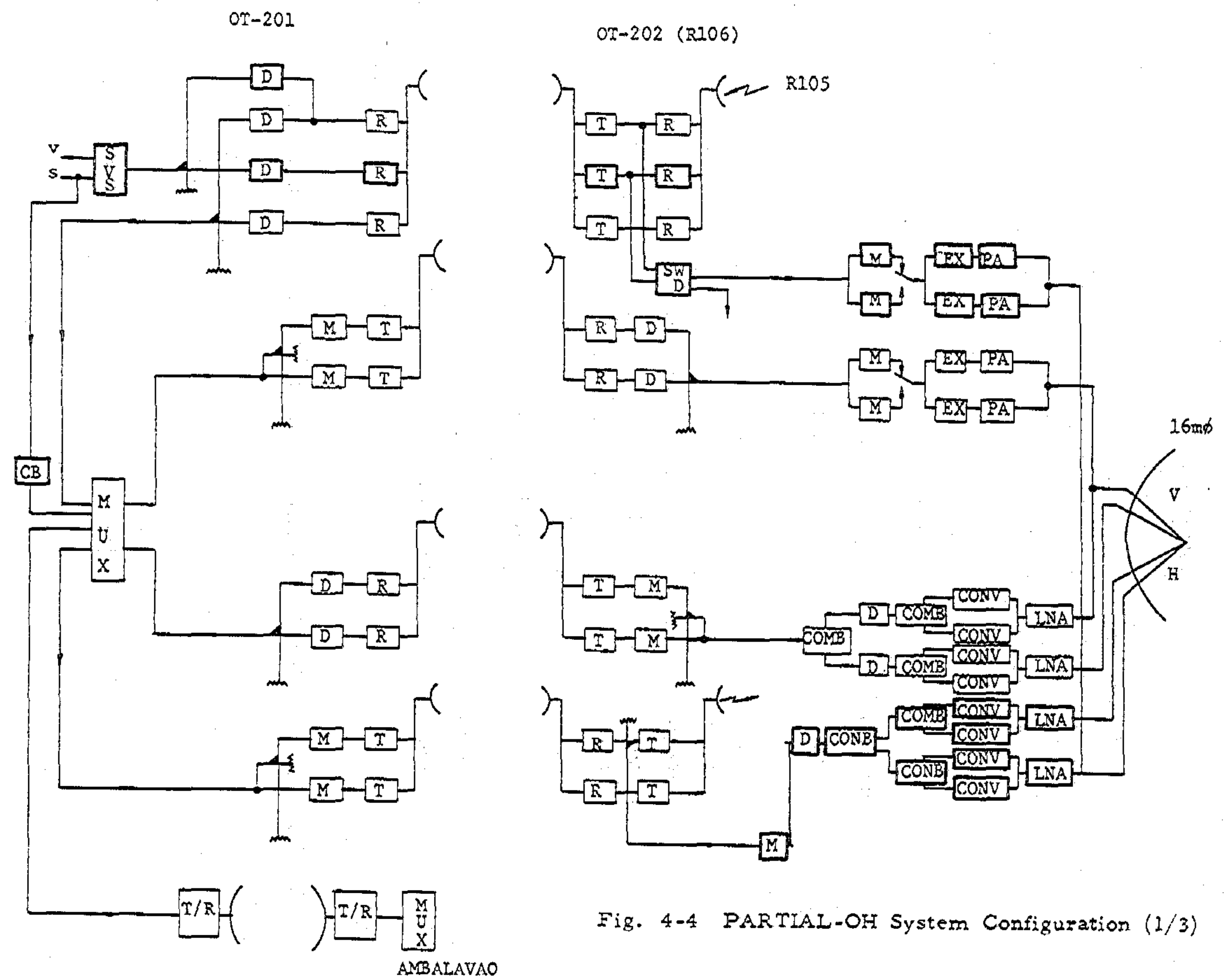


Fig. 4-4 PARTIAL-OH System Configuration (1/3)

OT 204

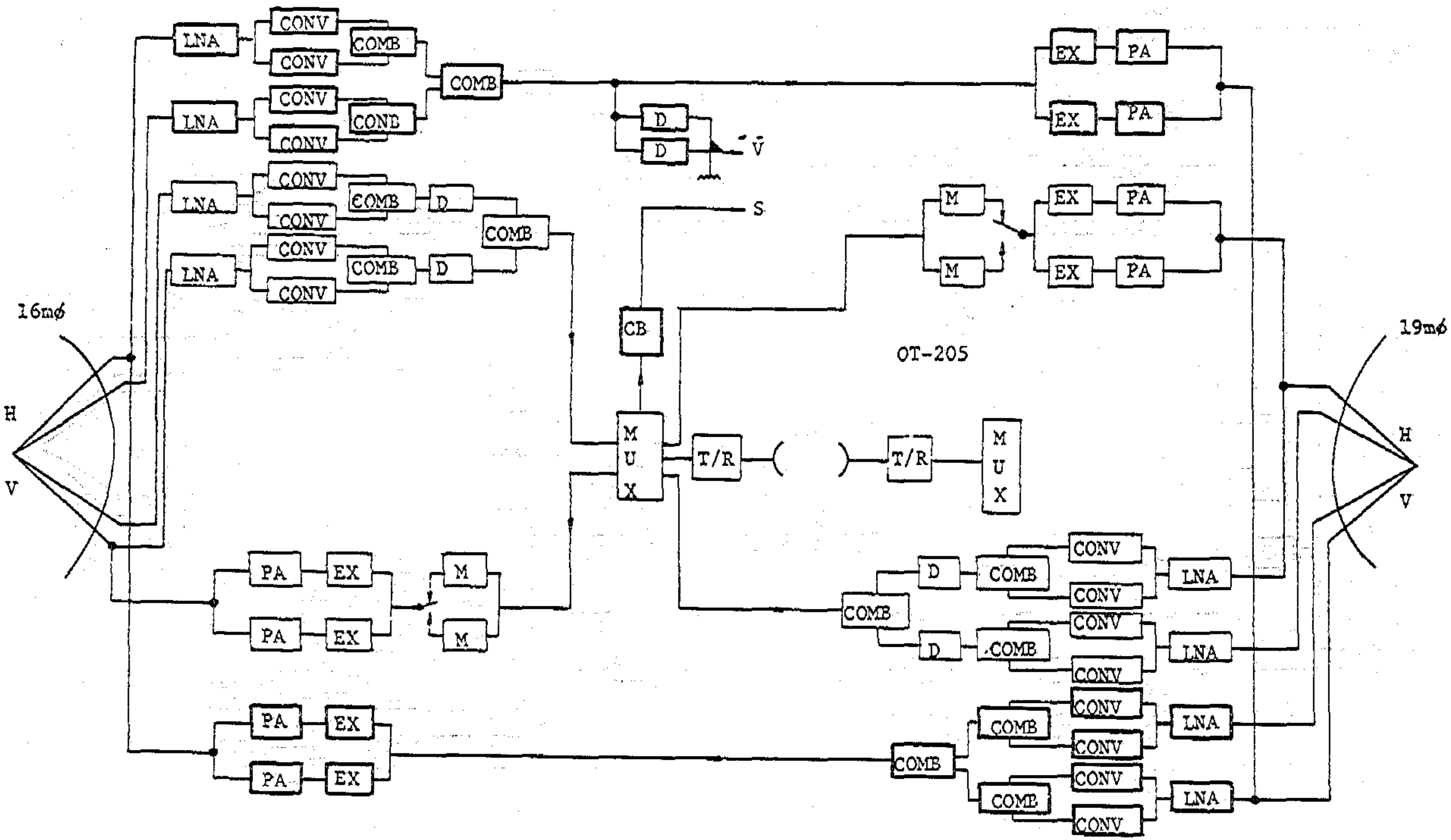


Fig. 4-4 PARTIAL-OH System Configuration.(2/3)

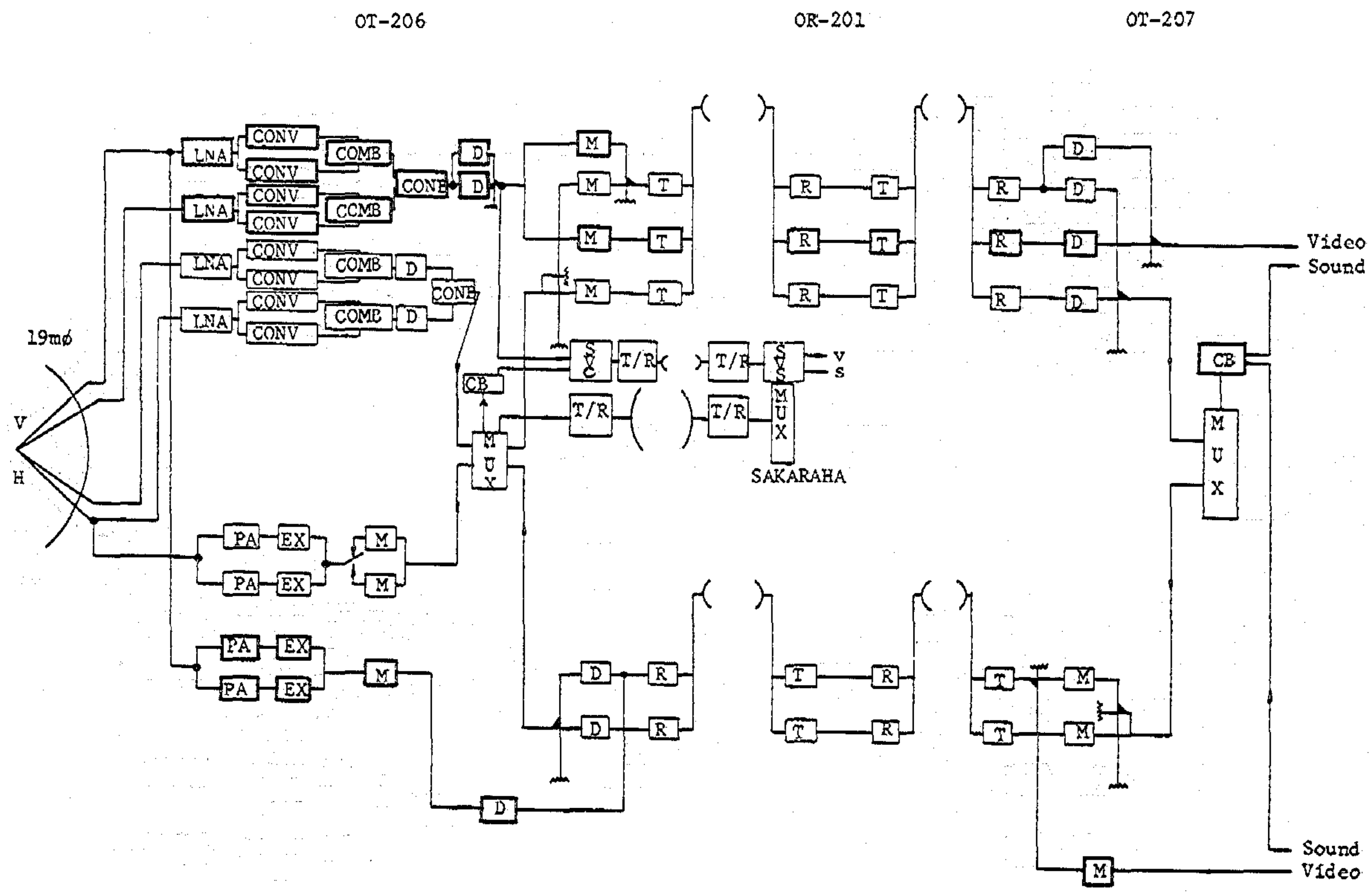


Fig. 4-4 PARTIAL-OH System Configuration (3/3)

Table 4-3 Methods of Branching Telephone and Television Signals (PARTIAL-OH plan)

Remarks: The Tananarive-Fianarantsoa section is omitted.

Site Code	City of Branch	Branching Method	
		Telephone	Television
OT-202	Ambalavao	A small-capacity OH system of 2GHz (24 channels in capacity) will be used for lead-in to PTT telephone office.	Broadcasting service will be performed by receiving program signal from Fianarantsoa Broadcasting Station and retransmitting it.
OT-203	Ihosy	A line-of-sight of 4GHz (300 channels in capacity) will be used for lead-in to OT-204.	Connection with TV transmitter in the same station.
OT-205	Sakaraha	A small-capacity OH system of 2GHz (24 channels in capacity) will be used for lead-in to PTT telephone office.	A line-of-sight microwave system will be used for lead-in to local broadcasting station.
OT-205	Route branching	Branching by leaking.	Branching by IF connection.

The performance to be set for the major equipments of the OH system in the PARTIAL-OH radio relay system are given hereunder. The transmission performance of the OH system described in Paragraph 4-5 is obtained from these values.

Transmitter Receiver

1)	Frequency	2GHz band (as per CCIR Rec. 283-2)
2)	Transmission capacity	300 telephone channel or one monochrome TV channel
3)	Diversity method	Quadruple diversity by using frequency and angle diversity in combination
4)	Transmitter output	1KW
5)	Output impedance	VSWR: less than 1.3
6)	Transmitter bandwidth	14MHz
7)	Transmitter frequency stability	10^{-5}
8)	Receiver noise factor	less than 2.5dB
9)	Receiver input impedance	VSWR: less than 1.2
10)	IF output frequency and level	70MHz +4dBm
11)	Receiver bandwidth	14MHz
12)	Receiver frequency stability	10^{-5}
13)	Supply voltage	AC 200/220V ±3%, 3 phases
14)	Ambient temperature	0∿45° C

Modem

1)	Type of modulation	PM
2)	Baseband frequency range	60~1300KHz (Telephone) 60Hz~6MHz (Television)
3)	Phase deviation	0.3 rad/channel (Telephone) 4MHzp-p (Television, without emphasis)
4)	Emphasis	as per CCIR Recommendation

5)	Baseband Input/Output levels	Input: -45dBr Output: -20dBr (Telephone) Input/Output: 1Vp-p (Television)
6)	IF frequency and input/output levels	+4dBm
7)	Modem linearity	less than 5% over ±3 MHz
8)	Frequency stability	70MHz ±5KHz
9)	Supply voltage	-24V ±10%
10)	Ambient temperature	0∿45° C

Antenna Feeder

1)	Antenna diameter and gain	16m: 47dB 19m: 49dB
2)	Type of antenna	Double-polarized type with feed horn for vertical angle diversity
3)	Feeder loss	0.02dB/m
4)	Impedance	VSWR: less than 1.2

(3) System configuration and equipment specifications of supervisory and control system

The supervisory and control system is composed of the following six circuits.

1) Supervisory circuit for radio system

2) Supervisory and control circuit for unattended television broadcast facilities

3) Switching control circuit for radio system

4) Omnibus orderwire circuit for unattended station

5) Express orderwire circuit for telephone

6) Express orderwire circuit for TV

Legend for Figs. 4-5 and 4-6

◉	Attended terminal station
◎	Unattended terminal station
⊗	Unattended through repeater station
○	Repeater station location (in general)
▯	Supervising/controlling station (Master station)
▣	Toll exchange office
■	Attended television broadcasting station
▮	Unattended television broadcasting station

Fig. 4-5 Supervisory and Control System (FULL-LOS System)

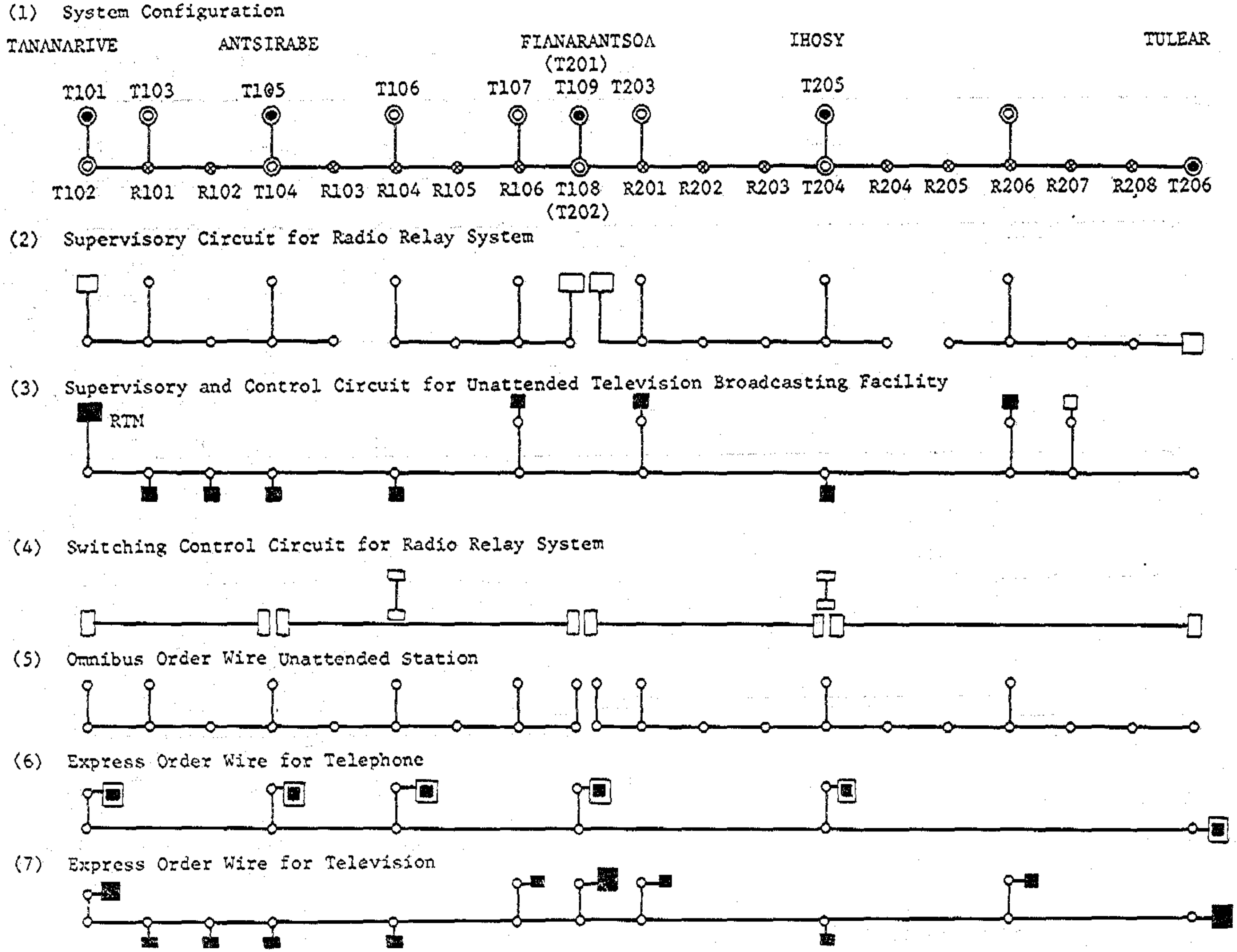
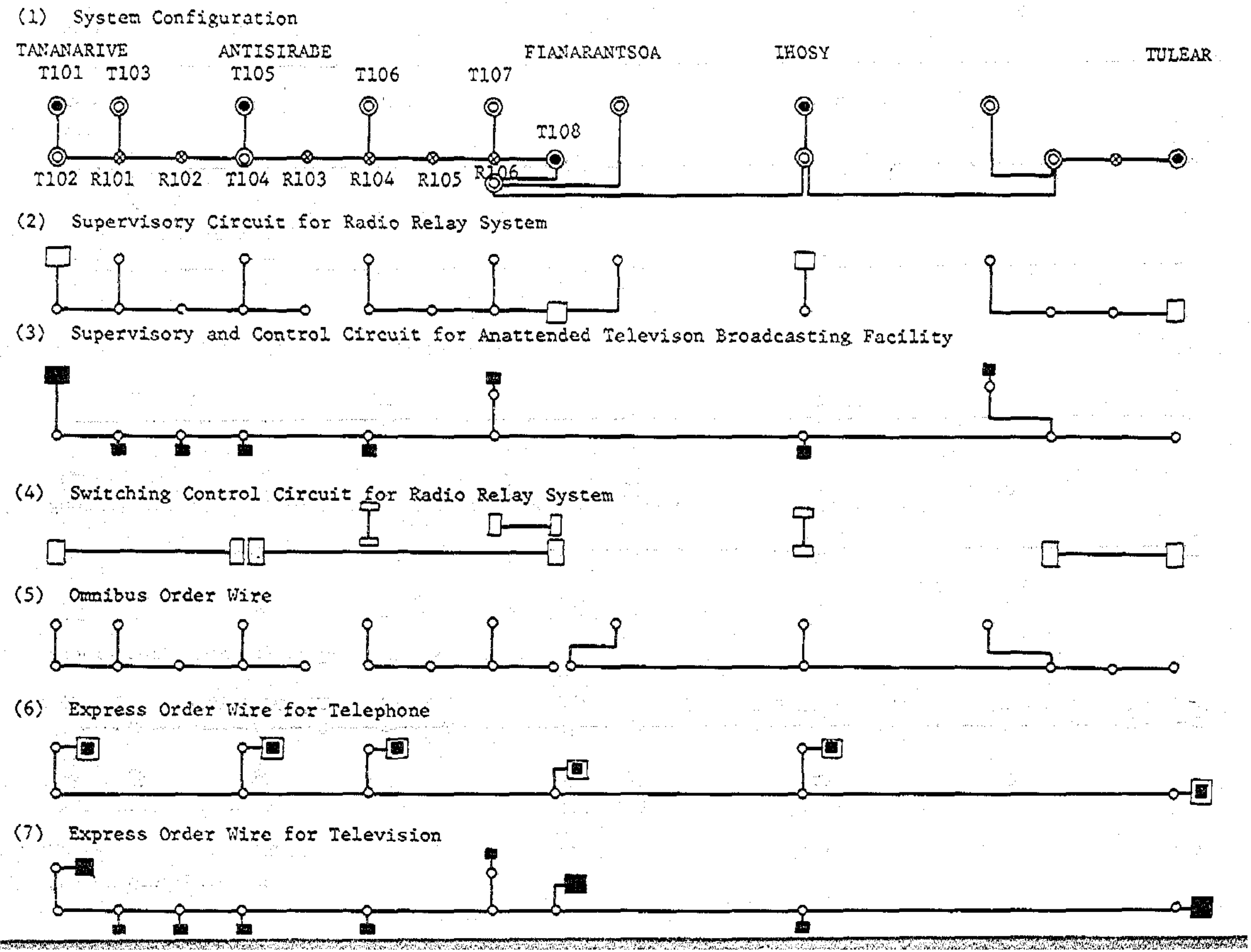


Fig. 4-6 Supervisory and Control System (PARTIAL-OH System)



The configurations of the above-mentioned circuits of the FULL-LOS and PARTIAL-OH plans are shown in Figs. 4-5 and 4-6, respectively. The major equipment performances required for the supervisory and control system are as follows.

Supervisory Circuit for Radio System

1)	Number of supervised stations:	more than 10
2)	Number of supervisory items:	more than 32items/station
3)	Signal transmission bandwidth:	4KHz
4)	Signal-to-noise ratio:	more than 30dB

Supervisory and Control Circuit for Unattended Television Broadcast Facilities

1)	Number of supervised stations:	more than 10
2)	Number of supervisory items:	more than 10
3)	Number of control items:	more than 5
4)	Signal transmission bandwidth:	4KHz
5)	Signal-to-noise ratio:	more than 30dB

Switching Control Circuit for Radio System

1)	Number of systems to be switched:	more than 3 working systems
2)	Switching control time:	less than 5ms
3)	Switching time:	less than 5μs
4)	Branch switching method:	Follow-up switching
5)	Switching method:	Pilot and noise switching
6)	Signal transmission bandwidth:	20kHz
7)	Signal-to-noise ratio:	more than 30dB

(4) Configuration and equipment performance of power supply facilities

The power supply systems of the respective repeater stations are determined on the principles specified in Paragraph 4-4-1 (4) "Selection of power supply systems," as shown in Tables 4-4 and 4-5. The power capacities of the power supply facilities of the respective stations are also given in the Tables. The configurations and outline of operation of the respective power supply systems are given in the succeeding pages.

Table 4-4 Power Supply Systems and Their Capacities (FULL-LOS System)

City	Site Code	Required Power (w)		Type of Power Supply	Capacity		
		DC	AC		EG(KVA)	RECT(A)	BATT(AH)
TANA	T101	2460	3000	COM	30	300	1800
TANA	T102	340	3000	COM	10	50	300
	R101	930	3000	COM	15	150	700
AMBATO	T103	40	-	COM	-	50	100
	R102	220	4000	COM	10	50	200
ANTSI	T104	450	4000	COM	10	100	400
ANTSI	T105	1240	3000	COM	15	150	900
	R103	95	3000	C/D	10	50	400
	R104	440	4000	COM	10	100	400
AMBO	T106	1200	3000	COM	15	150	900
	R105	95	3000	C/D	10	50	400
	R106	410	3000	C/D	15	150	1400
AMBOHI	T107	820	4000	COM	15	100	600
FIANA	T108	490	3000	COM	10	100	400
FIANA	T109	2350	3000	COM	20	300	1700
FIANA	T201	Same as T109					
FIANA	T202	Same as T108					
	R201	410	3000	C/D	15	150	1400
AMBALAVAO	T203	820	1000	FLOAT	15	100	600
	R202	95	3000	C/D *	10	50	400
	R203	95	3000	C/D *	10	50	400
IHOSY	T204	550	4000	FLOAT	10	100	400
IHOSY	T205	1350	3000	FLOAT	15	200	1000
	R204	140	3000	C/D	10	100	500
	R205	100	3000	C/D *	10	50	400
	R206	420	3000	C/D	15	200	1500
	R207	370	3000	C/D	15	150	1300
	R208	95	3000	C/D	10	50	400
TULEAR	T206	1700	3000	COM	20	200	1200

Remarks: COM: commercial power FLOAT: EG + battery floating type

C/D: EG + battery charge/discharge type

* Stations expected to introduce solar battery system

(Estimated solar battery capacity: 900 ~ 1000 watts.

Estimated battery capacity: necessary 2000 AH.)

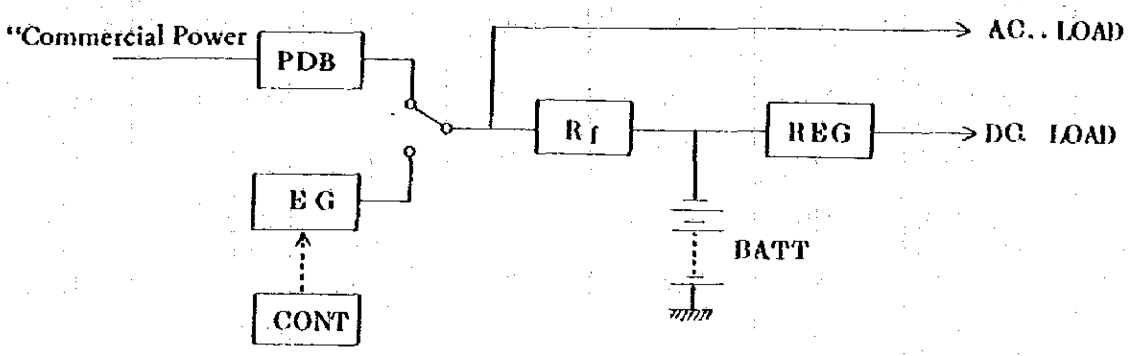
Table 4-5 Power Supply Systems and Their Capacities (PARTIAL-OH System)

City	Site Code	Required Power (w)		Type of Power Supply	Capacity		
		DC	AC		EG(KVA)	RECT(A)	BATT(AH)
TANA	T101	2460	3000	COM	30	300	1800
TANA	T102	340	3000	COM	10	50	300
	R101	930	3000	COM	15	150	700
AMBATO	T103	40	-	COM	-	50	100
	R102	220	4000	COM	10	50	200
ANTSI	T104	450	4000	COM	10	100	400
ANTSI	T105	1240	3000	COM	15	150	900
	R103	95	3000	C/D	10	50	400
	R104	440	4000	COM	10	100	400
AMBO	T106	1200	3000	COM	15	150	900
	R105	95	3000	C/D	10	50	400
	R106	1650	23000	FLOAT	40	200	1200
AMBOHI	T107	820	4000	COM	15	100	600
FIANA	T108	2530	3000	COM	30	300	1800
FIANA	OT201	Same as T108					
FIANA	OT202	Same as R106					
AMBALAVAO	OT203	1400	3000	FLOAT	15	200	1000
IHOSY	OT204	1360	43000	FLOAT	60	200	1000
IHOSY	OT205	1350	3000	FLOAT	15	200	1000
	OT206	1460	23000	FLOAT	40	200	1100
	OR201	95	3000	C/D	10	50	400
TULEAR	OT207	1700	3000	COM	20	200	1200

Remarks: COM: commercial power FLOAT: EG + battery floating type

C/D: EG + battery charge/discharge type

"Commercial Power + Battery Floating" Type



Outline of operation

1) Usually, the power rectified from the commercial power is fed to the load while the battery is floating-charged.

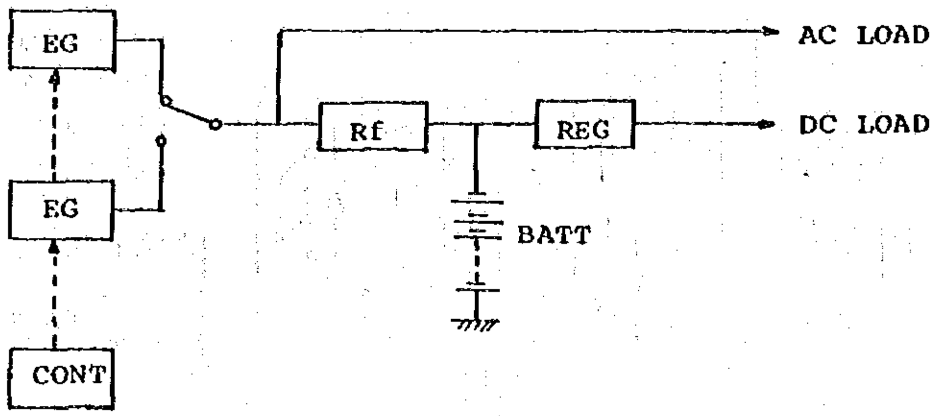
2) When the commercial power fails, the engine generator automatically starts operating and the power is fed to the load while performing floating charge of the battery.

3) When the commercial power recovers, the engine generator automatically stops operation, and the condition of 1) above is restored.

4) When the commercial power fails and the engine generator also fails, power is fed from the battery to the load. The holding time of the battery is 10 hours.

5) A circuit for periodically (every week or so) checking the engine generator for normality by compulsory start should be provided.

"EG + Battery Floating Charge" Type



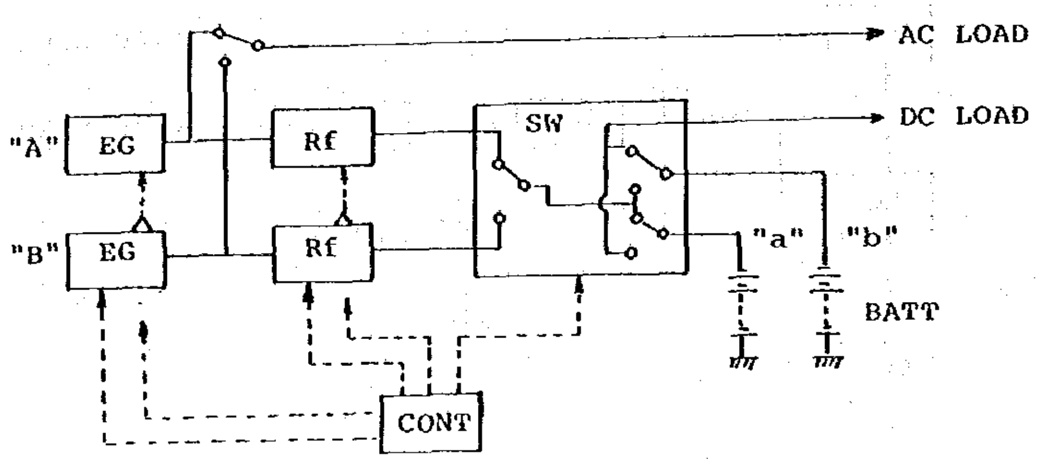
Outline of operation

1) Usually, power is fed to the load by operating two engine generators alternately (in shifts of one day) while performing floating charge of the battery.

2) When both engine generators fail, power is fed from the battery. The battery holding time is 10 hours.

3) In the case of the OH system, the capacity of the AC load is large and usually three engine generators should be provided for operation in shifts of one day.

"EG + Battery Charge/Discharge" Type



Outline of operation

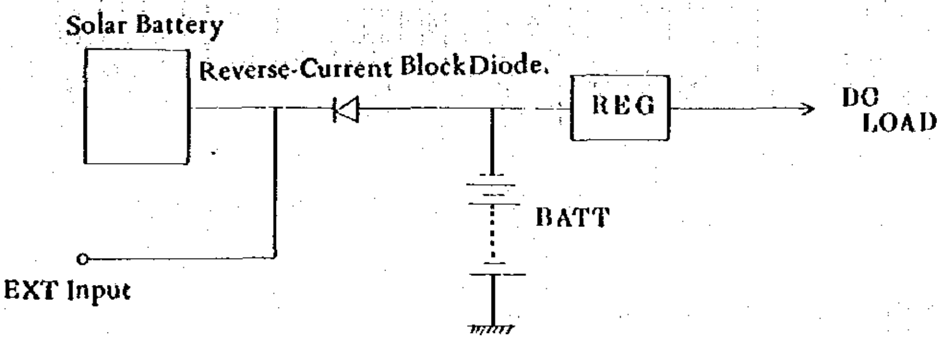
1) The engine generator "A" operates and battery "a" is charged while battery "b" supplies power to the load.

2) Battery "b" continues discharging even after completion of charging of battery "a" and, after completion of discharging, is automatically switched over to battery "a," which will then supply power to the load.

3) The engine generator "B" operates and battery"b" is charged, while battery "a" supplies power to the load.

By repeating the above steps in turn, power is fed to the load. In case the engine generator of one system fails, the engine generator of the other system is switched on to operate instead. 120% equalized charge is performed by approx. 12 hours. 100% discharge is performed by 72 hours. The program is automatically controlled by the control equipment.

"Solar Battery" Type



Outline of operation

1) While receiving the rays of the sun, power is fed to the load while the battery is charged through the reverse-current block diode.

2) During night or when sufficient insolation is not available, power is fed from the battery to the load.

3) When it is feared that the load voltage may be out of spec., it is possible to charge the battery through the EXT input terminal.

4) The required output of the solar battery is estimated to be less than 10 times the load power in the case of the insolation condition in Ihosy and the required capacity of the battery is estimated to be less than 2000AH.

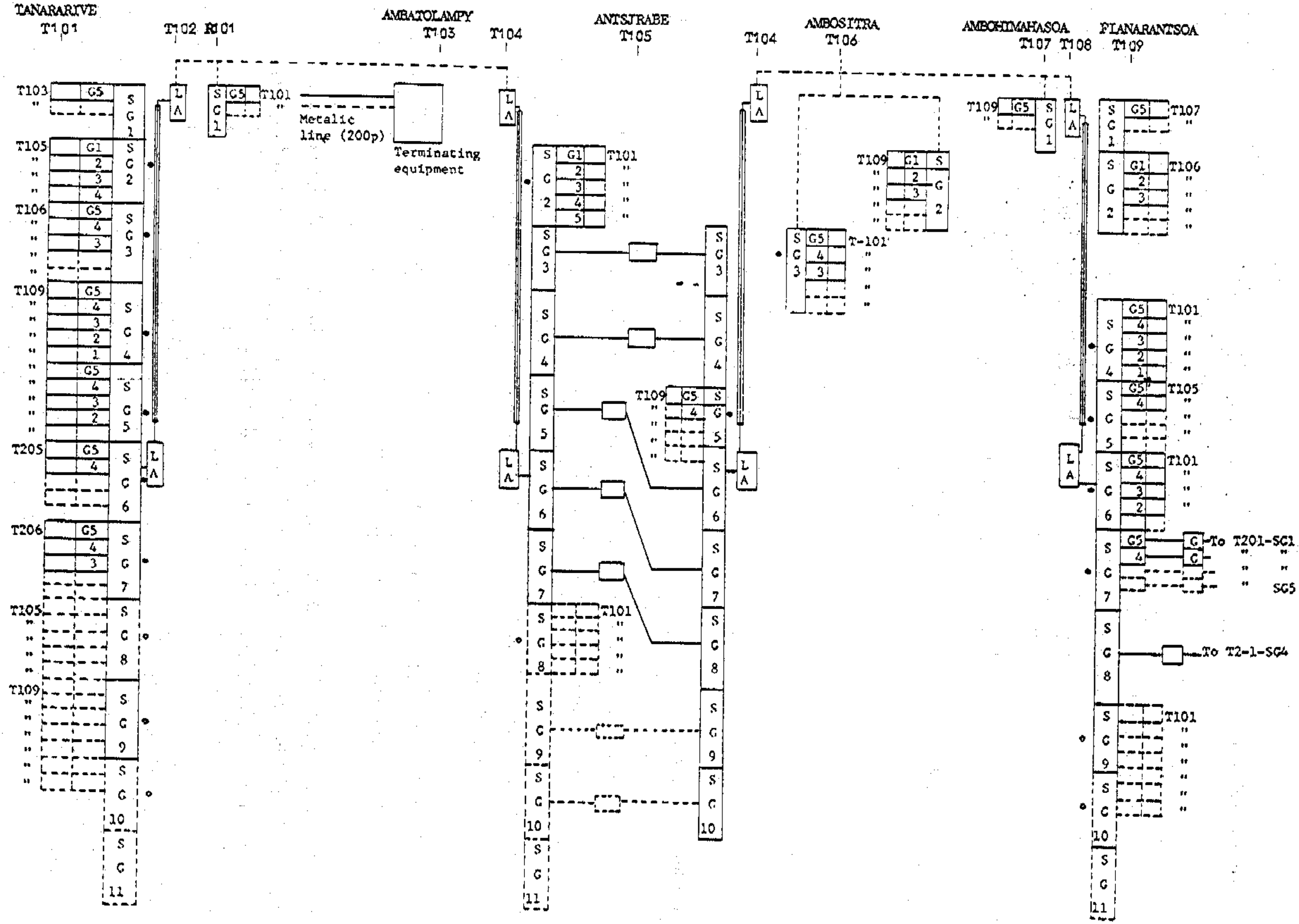


Fig. 4-7 Channel Accommodation Plan (1/2)

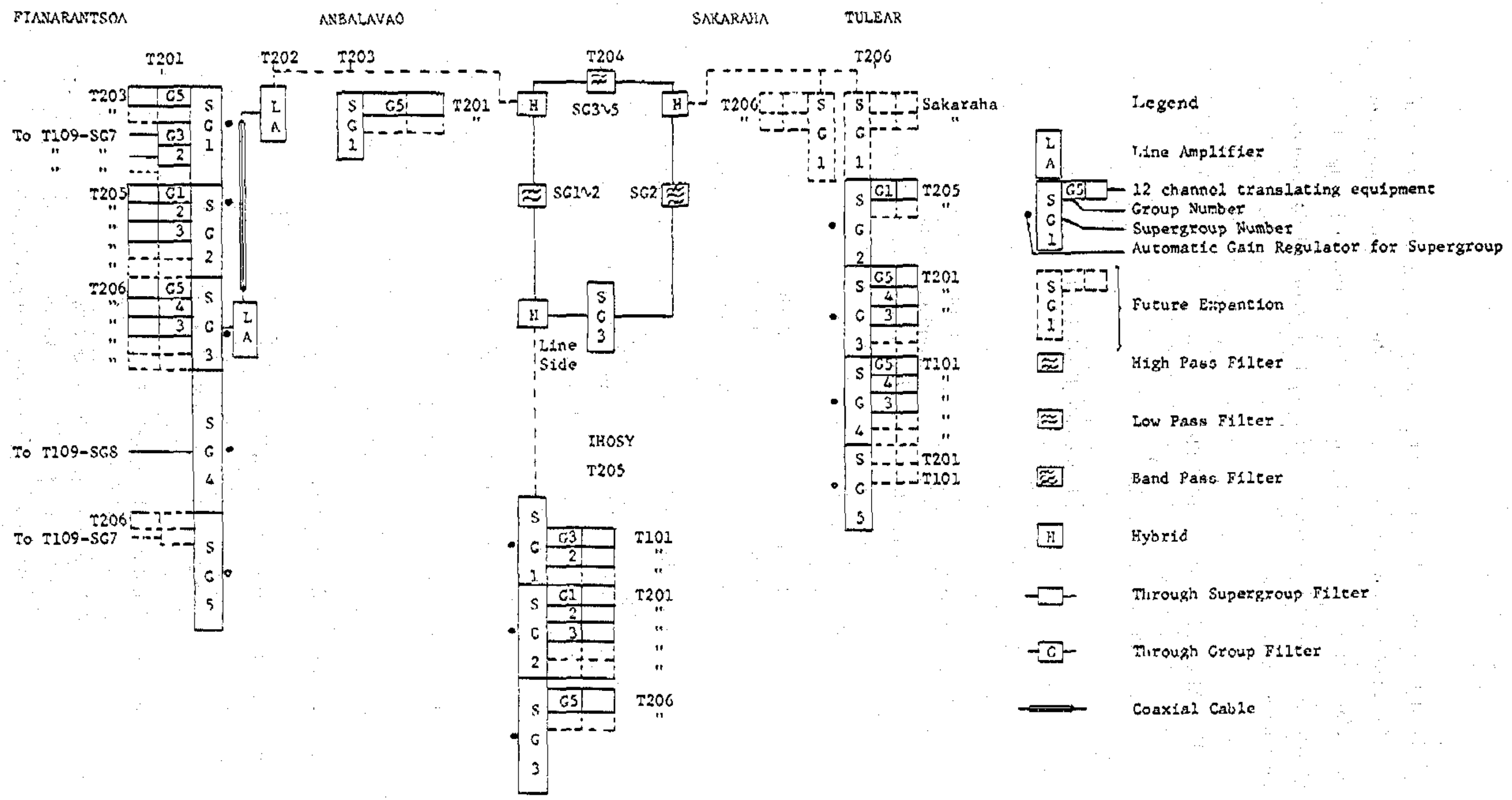


Fig. 4-7 Channel Accomodation Plan (2/2)

(5) Configuration and equipment performance of carrier terminal equipment

The configuration of the carrier telephone terminal equipment which will accommodates telephone and telegraph circuits is shown in Fig. 4-7. The major equipment performance of the carrier telephone terminal equipment to be used in the microwave system are as follows.

1) Channel translator (CH-TR)

a) Frequency allocation

as per CCITT Green Book G-211

b) Level and impedance (CH side)

4W send: −1dBr∼-16dBr
4W receive: -6dBr∼+8dBr
600Ω, balanced (both send and receive sides)

c) Level and impedance (G side)

Send out: -37dBr
Receive in: -30dBr
75Ω, balanced (both send and receive sides)

d) Attenuation distortion, carrier leak, linearity, and crosstalk

as per CCITT Green Book G-222

e) Total noise

as per CCITT Green Book G-222

f) Signalling system and frequency

3825Hz tone on idle

2) Group translator (G-TR)

a) Frequency allocation

as per CCITT Green Book G-233

b) Level and impedance (G side)

Send in: -37dBr
Receive out: -30dBr
75Ω, balanced (both send and receive sides)

c) Level and impedance (SG side)

Send out: -35dBr
Receive in: -30dBr
75Ω , unbalanced (both send and receive sides)

d) Attenuation distortion

Deviation in basic groupband is less than 0.5dB
(both send and receive sides)

Deviation in channel band is less than 0.25dB
(both send and receive sides)

e) Crosstalk

Both far- and near-end crosstalk at 84KHz are more than 70dB

f) Total noise

as per CCITT Green Book G-222

3) Supergroup translator (SG-TR)

a) Frequency allocation

as per CCITT Green Book G-423, Fig. 5.

b) Level and impedance (SG side)

Send in: -35dBr
Receive out: -30dBr
75Ω , unbalanced (both send and receive sides)

c) Attenuation distortion

less than 1.0dB in basic supergroup band

d) Crosstalk

Both far- and near-end crosstalk at 412KHz are more than 70dB

e) Total noise

as per CCITT Green Book G-222