REPORT ON THE SURVEY
FOR
THE MICROWAVE NETWORK PROJECT
IN ETHIOPIA

ADDIS ABABA-DIRE DAWA-HARRAR

ADDIS ABABA-SHASHEMANE

ADDIS ABABA-JIMMA

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OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN

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PREFACE

In compliance with the request of the Imperial Government of Ethiopia in relation to the Microwave Network Project in Ethiopia planned by the Imperial Board of Telecommunications of Ethiopia, included in the important policies under the 4th Five-Year Investment Project (1968～1973), the Government of Japan undertook to work out a microwave construction project for the three sections, namely, Addis Ababa～Dire Dawa～Harrar (No. 2 Route), Addis Ababa ～Shashemane (No. 3 Route) and Addis Ababa～Jimma (No. 4 Route) sections, following the survey for the microwave link in the Addis Ababa～Asmara section (No. 1 Route) which was conducted by a team sent previously by the Japanese Government, and entrusted the Overseas Technical Cooperation Agency with the execution of the said survey. The Overseas Technical Cooperation Agency, in view of the great significance of the Microwave Network Project in Ethiopia, decided to carry out the survey in two stages for smooth and efficient implementation.

The first survey team composed of nine members and headed by Mr. Seishi Nakamura, Technical Officer of the Radio Regulatory Bureau, Ministry of Post and Telecommunications, was sent to Ethiopia over a period of 70 days from August 18, 1970 for field survey with a primary purpose of site selection and the second team comprising ten members was sent to that country over a period of 70 days from January 19, 1971 with a primary objective of conducting a re-survey of the project area for site selection on the basis of the previous survey, carrying out propagation tests in some sections and holding discussions with the Ethiopian counterparts on technical matters relative to the design of the microwave network.

During the first and second survey periods the respective survey teams summarized findings of the survey into interim reports and submitted them to the Imperial Board of Telecommunications of Ethiopia on each occasion. After returning to Japan, the respective teams made a further study and analysis of various data obtained during both survey periods and summarized the findings in a report which also includes various information required for the preparation of technical specifications for the project. The report is now completed and ready for presentation.

It is my sincere desire that the report will prove to be helpful in early materialization of the Microwave Network Project in Ethiopia, thus helping promote social and economic growth of that country, and at the same time contribute to the promotion of friendly relations between Japan and Ethiopia.

In conclusion I would like to take this opportunity to express my gratitude to officials of the Ethiopian Government, particularly the officials of the Imperial Board of Telecommunications of Ethiopia, Staffs of the Japanese Embassy at Addis Ababa and officials of the Ministry of Post and Telecommunications and Nippon Telegraph & Telephone Public Corporation for their valuable assistance and cooperation in the execution of the survey.

July 1971

K. Tatsuke

Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency

LETTER OF TRANSMITTAL

To: Mr. Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency

It gives me great pleasure to be able to present a report of survey for the Microwave Network Project in Ethiopia on behalf of the survey mission. The Microwave Network Project planned by the Imperial Board of Telecommunications of Ethiopia envisages establishment of a microwave network, thereby providing toll telephone services and television transmission between major cities of Ethiopia with the capital city of Addis Ababa as the key point. The microwave network under plan is considered very important in that it forms part of international circuits to be linked with neighboring countries in the future.

The purpose of the survey mission is to conduct a technical survey in relation to the design of transmission circuits, composition of the network and radio station facilities for the three routes, Addis Ababa~Dire Dawa~Harrar route, Addis Ababa~Shashemane route and Addis Ababa~Jimma route, in an attempt to provide the Imperial Board of Telecommunications of Ethiopia with necessary data and information for the preparation of technical specifications for the project.

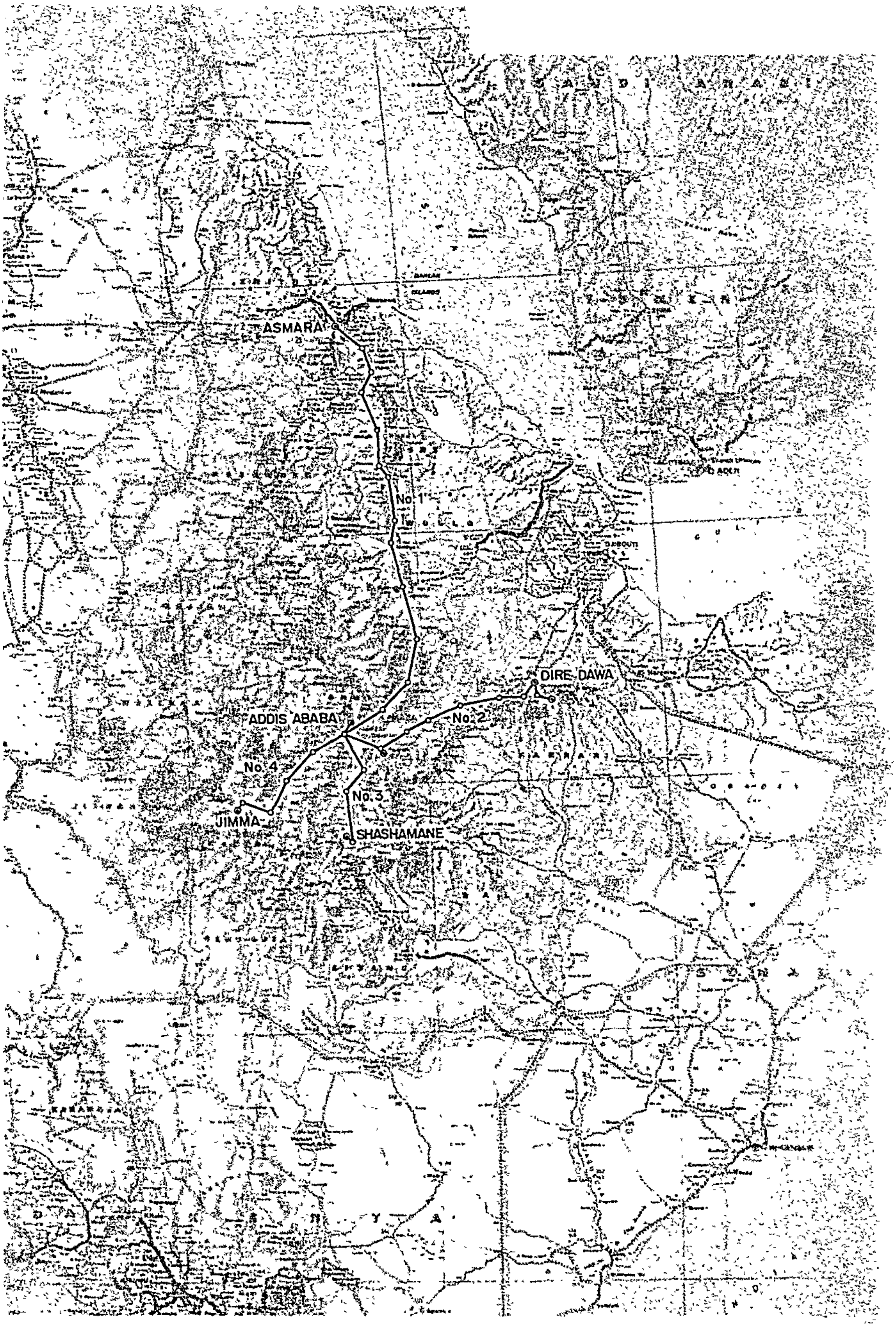
In order to ensure smooth and efficient execution of field investigation, the survey period was divided into two stages, the first and second stages. During the first stage covering a period of 70 days from August 18, 1970, a preliminary survey was conducted primarily for site selection and during the second stage, also covering a period of 70 days from January 19, 1971, a re-survey of the project area for site selection on the basis of the findings of the first survey and propagation tests were conducted, followed by the preparation of a report of survey after the return to Japan of the team. In view of the important nature of the microwave network under plan, due consideration was given to the international technical standards and the opinions of the Imperial Board of Telecommunications of Ethiopia in preparing the report.

Of the total project cost, the cost of microwave, carrier and power facilities including steel towers is estimated at about US$ 4 million and a period of about three years is expected to be required for the completion of the system.

I firmly believe that the Trunk Microwave Network Project planned by the Imperial Board of Telecommunications of Ethiopia will greatly contribute to the promotion of social, economical and cultural activities in that country upon its completion. In presenting this report I express my hearty gratitude to officials of the Imperial Board of Telecommunications of Ethiopia and staffs of the Japanese Embassy at Addis Ababa for their valuable assistance and cooperation extended to the survey mission during the survey period and to officials concerned of the Ministry of Foreign Affairs, Ministry of Post and Telecommunications, and Nippon Telegraph & Telephone Public Corporation for their efforts in facilitating the organization and assignment of the survey mission to Ethiopia.

July 1971

Seishi Nakamura
Leader of Survey Mission
for the Microwave Network Project
in Ethiopia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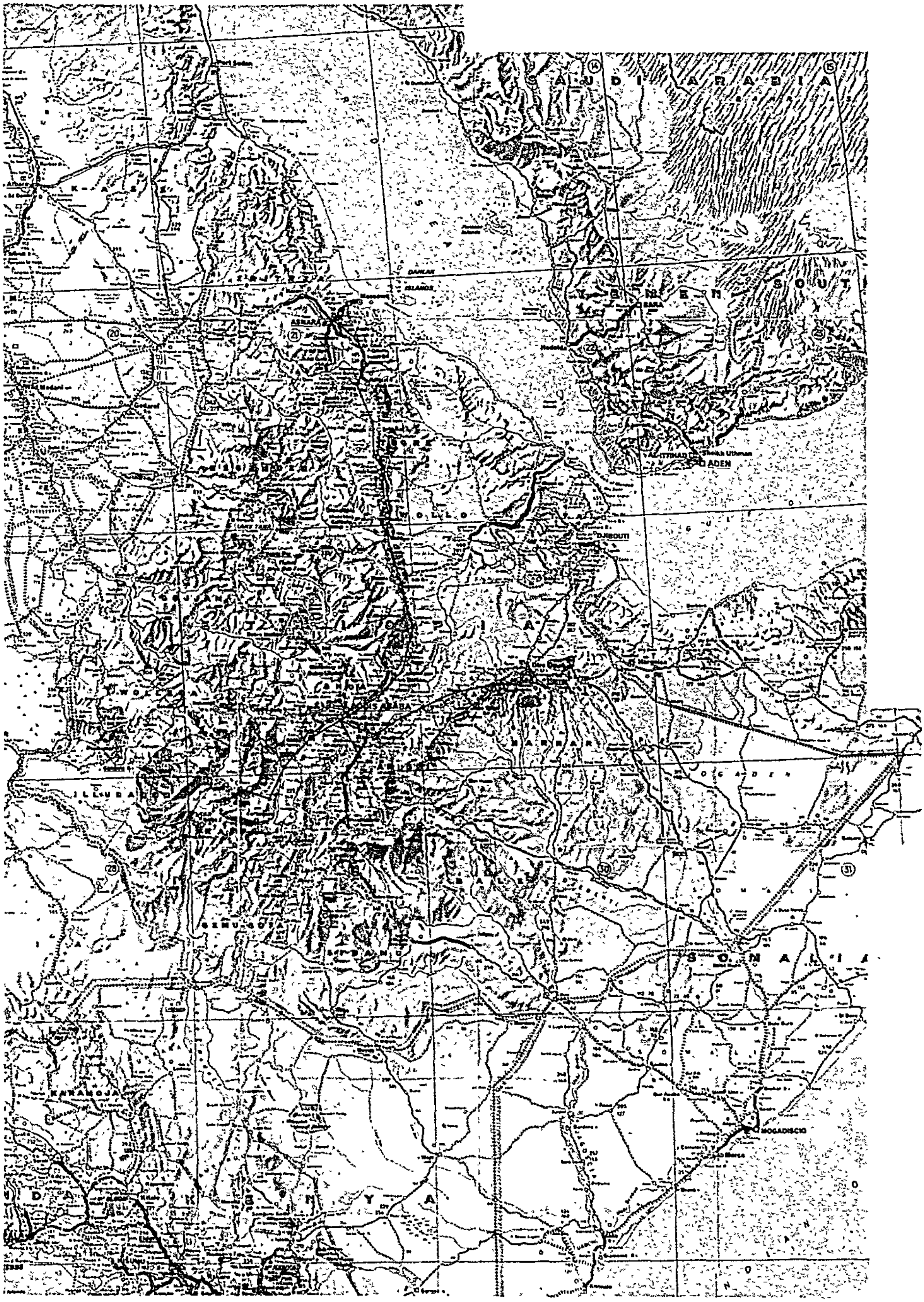

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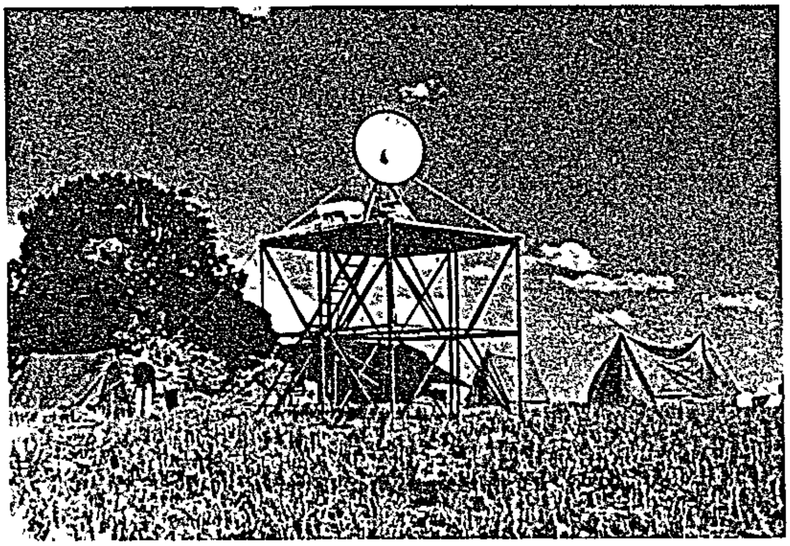
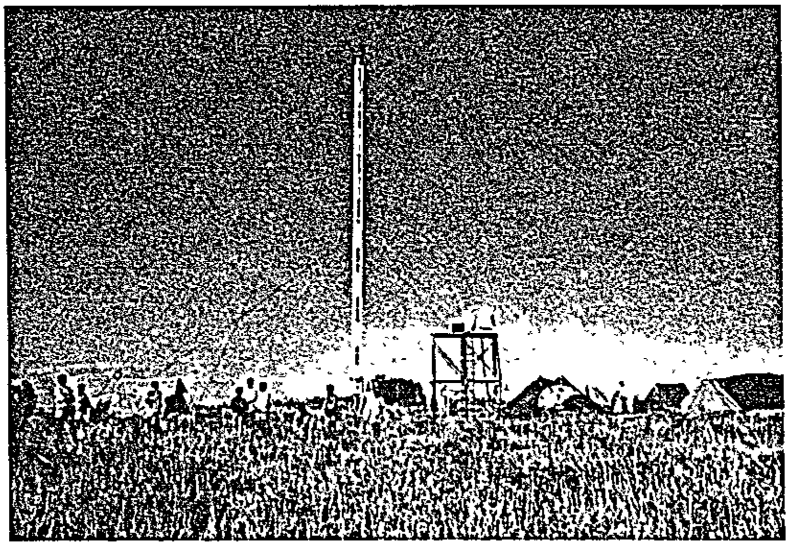
SCENES OF PROPAGATION TEST



A Scene of Radio Transmission at Mt. Furi



A Scene of Radio Receiving at Waliso

List of Abbreviations

This list enumerates abbreviations used in the report.

Abbreviation	English
I.B.T.E.	Imperial Board of Telecommunications of Ethiopia
C.C.I.R.	International Radio Consultive Committee
C.C.I.T.T.	International Telegraph and Telephone Consultive Committee
CH	Channel
pW	Pico Watt
LpW	L(distance) x pW
M.TV	Monochrome Television
SG	Super Group
OH	Over Horizon
IF	Intermediate Frequency
F-B	Front to Back
F-S	Front to Side
MDF	Master Distribution Frame
FDM-FM	Frequency Division Modulation - Frequency Modulation
SG-THF	Super Group Through Filter

CONTENTS

CHAPTER I OUTLINE OF SURVEY

I OUTLINE OF SURVEY

1. Purpose and Scope of Survey

In compliance with the request of the Imperial Government of Ethiopia, the Survey Mission has carried out a technical survey in relation to the Microwave Netwrok Project under the 4th Five-Year Investment Program formulated by the Imperial Board of Telecommunications of Ethiopia (referred to as I.B.T.E. hereinafter). Following the first survey which was conducted for the Addis Ababa ~Asmara section (referred to as No. 1 Route), the recent survey mission has conducted a field survey in the three sections covering a distance of about 1,000 km, namely, Addis Ababa~Dire Dawa~Harrar section (No. 2 Route), Addis Ababa~Shashemane section (No. 3 Route) and Addis Ababa~Jimma section (No. 4 Route) and completed the system design for the microwave link planned for these sections.

The recent survey was carried out in two stages, namely, the first and second stages. In the first stage a preliminary survey was carried out primarily for site selection.

In the second survey, a reexamination of site selection made during the previous survey was made and propagation tests were conducted in several sections where there seemed to be some problems on propagation. On the basis of the findings of this survey, the system design was completed and summarized in this report.

2. Survey Policy

The three sections covered by the recent survey form a domestic backbone route linking major cities of Ethiopia, along with No. 1 Route which was already covered by the previous survey, and will be part of the important route which is expected to be connected to an international circuit in the future.

Like in the previous case, I.B.E.E. expressed its desire for site selection that the site be located close to the all weather roads as much as possible and that the number of repeating stations be held to a minimum for reasons of convenience in maintenance and economy of the transmission line. Accordingly, the survey mission conducted a survey for site selection, propagation tests and completed the system design on the basis of the findings of the aforementioned survey and tests while paying constant attention to these facts and aiming at satisfying the requirements on transmission performance specified in C.C.I.R. and C.C.I.T.T. Recommendations.

3. Toll Trunk Plan

For the microwave link in the three sections, I.B.T.E. plans to provide a 600 CH telephone bearer and a stand-by bearer and use the stand-by bearer for transmission of monochrome television in the future.

With the completion of this project, along with the completion of the microwave link now under construction between Addis Ababa and Asmara, subscriber trunk dialing service between all major cities of Ethiopia will be materialized and as a result, the toll telephone service in Ethiopia will be improved remarkably.

As for the frequency band to be used for the microwave link it is the policy of I.B.T.E. not impose any restriction on frequency band in order to allow flexibility in design to be offered by tenders. In view of such a policy of I.B.T.E., attempts were made to make the design of all the transmission links including No. 1 Route as economical as possible.

Of various compositions of transmission line, the one which is used for connection to the telephone office includes the microwave system, coaxial cable system and loaded cable system. As each of these systems has merits and demerits, the system which was most advantageous from an economical point of view was selected for each route and the composition of transmission network as shown in Fig. I-1 and Fig. I-2 was finally determined.

4. Site Selection

Although the site selection generally requires as a precondition (1) that the standard hop distance of the section should be 50 km, (2) that there should be no ridge loss at K = 2/3, (3) that the reflected wave should be shielded and (4) that a zig-zag route should be selected as much as possible in order to minimize over-reach interference, efforts were made to expand the hop distance as much as possible and to locate the site close to the all weather roads in compliance with the request of I.B.T.E. for economic design of transmission line.

After the survey for site selection in two stages, the first survey and the second survey, two alternative plans were worked out for each route. As will be discussed in detail in Chapter 3, the most advantageous sites from an economical point of view were selected as shown in Fig. I-3, Tables I-1~I-3. Profile maps of each proposed section are shown in Figs. III-3~III-42.

Throughout the survey period, both in the first and second surveys, the survey was conducted under fine weather condition, but the mirror test for confirmation of the visibility of radio path was frequently hampered by haze or dust. Included angle between radio paths and intermediate ridge height were measured at each proposed site with the use of a transit. The results of the measurement showed a difference of 4 degrees on the average from the value obtained by plotting on a map on a scale of 1 : 500,000. The latitude, longitude and altitude of each site, path profile and hop distances were estimated from the results of these measurements and available maps. Of the sections for which the line of sight path could not be oonfirmed by mirror test because of the adverse conditions during the survey period, two sections, namely, Waliso North~Fofa North~Giren (No. 4 Route,Plan-2), were given a mirror test by I.B.T.E. and a report on the results of the test was sent to the mission recently. As a result, the system design worked out on the basis of the report was added to Chapter VI of this report.

5. Received Radio Power Recording Test

The route plan worked out during the first survey included 2 sections of a long distance with a length of 90 km and 2 sections of low propagation path where the reflected wave is not shielded, and each of the four sections is considered to involve a problem on propagation.

In the second survey, therefore, a propagation test was conducted for the following 4 sections to obtain necessary data for the system design.

(a) Gumbi South→ Waliso North (91 km): Long distance section

(b) Mt. Furi→Waliso North (74 km): Section where the reflected wave is not shielded

(c) Abaro→Zuai West (89.5 km): Long distance section where the path is over the water

(d) Adama West→Meki North (47 km): Section where the reflected wave is not shielded and the reflection point is on the water surface

The received radio power recording test was conducted in such a short period as one week for each section with the use of 6 HGz band.

The climate of Ethiopia is different from that of Japan with very little change between the four seasons and the only noticeable change in the climate throughout the year is the fluctuation of temperatures by a few degrees between the rainy season (July～ September) and the dry season. The annual precipitation is almost the same as that of Japan, but the rainfall concentrates on the rainy season. Because of the heavy rainfall accompanied by large rain drops, radio attenuation by rainfall cannot be ignored (Assuming from available data in Japan, attenuation during a heavy rainfall accompanied by large rain drops is estimated to be about 0.08 dB/km at 6 GHz band).

However, because of the fact that the survey was conducted in a short period of time and under stable weather, it is very doubtful whether the data obtained during the survey may be applied to the determination of the state of propagation for the year. During the received radio power recording test, however, the occurrence of deep fading was not observed except for the Mt. Furi ～Waliso section and Zuai～Abaro section.

As a result of system design base on the findings of the received radio power recording test, improvement of transmission quality may be expected if the frequency diversity system was used for all sections. However, in order to satisfy the transmission quality specified in C.C.I.R. Recommendations, it will be necessary to adopt the space diversity system for the aforementioned two sections where the occurrence of deep fading is observed.

6. System Design

As far as individual routes are concerned, the frequency bands which are available for this microwave link include 2 GHz band (C.C.I.R. Rec. 382-2), 4 GHz band (C.C.I.R. Rec. 382-2) and 6 GHz band (C.C.I.R.Rec. 383-1, 384-1). In adopting 4 GHz band and 6 GHz band, however, a careful study must be made so that mutual interference with communication satellite system may be prevented.

In selecting frequency band, meanwhile, it is important to make a comprehensive study of all the proposed routes, from No. 1 Route to No. 4 Route, and further take into account the transmission capacity and future plans.

In consideration of the future plan under which No. 1 Route～No. 3 Route will be linked to the system of the neighboring countries as part of international circuits and No. 4 Route will be retained as a domestic circuit, it is recommended that 4 GHz band or 6 GHz band be used for No. 2 Route and No. 3 Route and 2 GHz band or 4 GHz band be used for No. 4 Route.

7. Maintenance

As for the maintenance of the microwave route, including the cable route, six stations - Addis Ababa Radio and Carrier Terminal Station (Existing), Nazareth Radio and Carrier Terminal Station, Dire Dawa Radio and Carrier Terminal Station, Harrar Carrier Terminal Station, Shashemane Radio and Carrier Terminal Station and Jimma Radio and Carrier Terminal Station - are to be designated as maintenance centers and the rest are to be designated as unattended stations.

The maintenance center and maintenance area are shown in Table I-4 and Fig. I-4. The designation was made by taking into account the correlation with No. 1 Route under construction.

8. Recommendations

On the basis of the results of the survey and the system design, the Survey Mission recommends the followings for planning the Microwave Project.

8-1 Route and Site

The proposed routes and sites are shown in Fig. I-3 and Tables I-1, I-2 and I-3. In order to secure the probability of noise burst (exceeding 10^6 pW) specified in C.C.I.R. Recommendation, it is necessary to adopt the space diversity system for the following two sections.

(a) Zuai West ~ Abaro section (No. 3 Route)
(b) Mt. Furi ~ Waliso North (No. 4 Route)

8-2 Frequency Band to be Used

For No. 2 Route and No. 3 Route, either 4 GHz band (C.C.I.R. Rec. 382-2) or 6 GHz band (C.C.I.R. Rec. 383-1, 384-1) is to be used and for No. 4 Route, either 2 GHz band or 4 GHz band (Both covered by C.C.I.R. Rec. 382-2) is to be used.

8-3 Transmission Performance (Allowable noise power)

The allowable noise power for each route is to be in compliance with C.C.I.R. Rec. 395-1.

8-4 Transmission Capacity

The transmission capacity is to be 960 CH for No. 2 Route and 600 CH for No. 3 Route and No. 4 Route. However, the stand-by system of each route is to be able to transmit television signal (M.TV) in the future.

8-5 Composition of Transmission Network

8-5-1 System Composition

As shown in Fig. II-4, each route is to have an independent system composition respectively.

8-5-2 Telephone Branching Method to Nazareth

For branching route from Adama West to Nazareth, the loop-connection system by means of microwave system should be used as shown in Fig. II-7.

8-5-3 Connection between Radio Terminal Station and Telephone Office

The type of links (transmission line) between the radio terminal station and the telephone office should be as follows, which are illustrated in Fig. II-10 and Fig. II-12.

(1) Harrar West ~ Harrar section . . . . . Coaxial cable system

(2) Giren ~ Jimma section . . . . Microwave system

8-6 Maintenance Center and Maintenance Area

The relation between the maintenance centers and the maintenace areas are shown in Table I-4 and Fig. I-4.

9. Construction Cost

The cost of construction under this project is roughly estimated at US$ 4 million. This figure includes the cost of radio, carrier, power facilities and the tower materials, but does not include the cost of marine transportation, installation of the above equipment, and construction of radio station buildings and roads.

10. Composition of Survey Mission and Itinerary

The composition of the survey mission is as follows.

10-1 First Survey Team

Survey Period: August 18, 1970~October 26, 1970

Head	Seishi Nakamura	Engineering Officer, Radio Regulatory Bureau, Ministry of Post and Telecommunications.
Member	Yoshihiro Yokoyama	Technical Investigation Section, Radio Regulatory Bureau, Ministry of Post and Telecommunications
"	Shigeru Kunori	Land Section, Radio Communication Department, Ministry of Post and Telecommunications
"	Teruaki Sato	Staff Engineer, International Affairs Office, Nippon Telegraph & Telephone Public Corporation
"	Yoshio Nakano	Staff Engineer, International Affairs Office, Nippon Telegraph and Telephone Public Corporation
"	Shohachiro Watanabe	Staff Engineer, International Affairs Office, Nippon Telegraph & Telephone Public Corporation

Member	Shiro Kawata	Staff Engineer, International Affairs Office, Nippon Telegraph & Telephone Public Corporation
"	Makoto Tsuji	Development Survey Division, Overseas Technical Cooperation Agency
"	Shozo Hayami	Development Survey Division, Overseas Technical Cooperation Agency

10-2 Second Survey Team

Survey Period: January 19, 1971 March 29, 1971

Head	Seishi Nakamura	Engineering Officer, Radio Regulatory Bureau, Ministry of Post and Telecommunications
Member	Akira Sato	Chief, Technical Sub-Section, Technical Supervision Section, Supervision Department, Radio Regulatory Bureau, Ministry of Post and Telecommunications
Member	Hiroshi Tsukada	Land Section, Radio Communication Department, Radio Regulatory Bureau, Ministry of Post and Telecommunications
"	Teruaki Sato	Staff Engineer, International Affairs Office, Nippon Telegraph & Telephone Public Corporation
"	Yoshio Nakano	Staff Engineer, International Affairs Office, Nippon Telegraph & Telephone Public Corporation
"	Shohachiro Watanabe	Staff Engineer, International Affairs Office, Nippon Telegraph & Telephone Public Corporation
"	Shiro Kawada	Staff Engineer, International Affairs Office, Nippon Telegraph & Telephone Public Corporation
"	Shigeyuki Fujimura	Staff Engineer, International Affairs Office, Nippon Telegraph & Telephone Public Corporation
"	Yoshio Nakahira	Development Survey Division, Overseas Overseas Technical Cooperation Agency
"	Shozo Hayami	Development Survey Division, Overseas Technical Cooperation Agency

11. Conclusions

Along with the Addis Ababa～Asmara microwave radio link, all of the three microwave radio links originating in Addis Ababa, namely, the Dire Dawa, Shashemane and Jimma routes, which were covered by the recent survey, for an important backbone route and the completion of these routes will have a tremendous impact on the communication, education and industry of Ethiopia.

The Survey Mission has been in participation in this project from the very beginning and is fully aware of the significance of the project.

During the recent survey, therefore, utmost efforts were made for the selection of economic and high quality circuit to meet the requirement set forth by I. B. T. E. in the same way as the Addis Ababa～Asmara route. The Mission is confident that the findings of the survey are sufficient enough to answer the expectations of I. B. T. E.

Thanks to the whole-hearted cooperation of the General Manager and other staffs of I. B. T. E. during the entire survey period the mission was able to accomplish its assignment smoothly. To them, we extend our hearty gratitude and wish that the project will be materialized as early as possible.

Time Schedule of First Survey Team

Date		Activities
Aug.	18	Departure from Tokyo
	19	Arrival in Addis Ababa. A courtesy visit to the Japanese Embassy at Addis Ababa.
	20	A courtesy visit to I. B. T. E. and a consultation with officials of I. B. T. E.
	21	Customs clearance, receipt, unpacking and inspection of equipment and materials shipped from Japan.
	$\boxed{22}$	
	㉓	Purchase of local materials.
	24	A consultation with officials of I.B.T.E.
	25	Preliminary survey of No. 2 Route
	26	
	27	Preliminary survey of No. 3 Route
	28	
	29	
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	31	Preparation for departure for field survey of the site
Sep.	1	Survey of Adama West∼Awash section for site selection
	2	
	3	
	4	
	5	Survey of Awash∼G. Ades section for site selection
	⑥	
	7	
	8	
	9	Survey of G. Ades∼Dire Dawa section for site selection
	10	
	$\boxed{11}$	
	12	Visit to Dire Dawa Telephone Exchange, inspection of facilities and consultations.
	⑬	
	14	
	15	Survey of Dire Dawa∼G. Daleccia section for site selection
	16	
	17	
	18	
	19	
	⑳	
	21	
	22	
	23	Intra-team meeting for coordination
	24	Preliminary survey of No. 4 Route
	25	
	26	
	$\boxed{\text{㉗}}$	
	28	Preparations for departure for the survey of No. 3 Route

Sep.	29	Survey of Adama West ~ Zuai West section for site selection
	30	
Oct.	1	Survey of Zuai West~Awasa section for site selection
	2	
	3	
	④	
	5	
	6	Preparations and a trip for the survey of No. 4 Route
	7	
	8	Survey of Jimma~Mt. Furi section for site selection
	9	
	10	
	⑪	
	12	
	13	
	14	
	15	Inspection and packing of equipment and preparations for shipment. Summarization and review of gathered data. Preparation and submission of interim report. Consultations with officials of I.B.T.E.. Visits to the Japanese Embassy and I.B.T.E. to bid farewell.
	16	
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	23	
	24	
	㉕	Departure from Addis Ababa

Time Schedule of the Second Survey Team

Date		Activities
Jan.	19	Departure from Tokyo
	20	Arrival in Addis Ababa
	21	Courtesy visits to the Japanese Embassy at Addis Ababa and I.B.T.E.
	22	Customs clearance, receipt, unpacking and inspection of equipment shipped from Japan. Purchase of local supplies Consultations withe officials of I.B.T.E. Preparations for departure for field survey of site.
	23	
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	25	
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	27	
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Feb.	1	
	2	
	3	
	4	
	5	Preparations for camping for propagation test in Gumbi South ~ Waliso North section
	6	
	⑦	

Feb.	8		Propagation test in Gumbi South~Waliso North section	Re-survey of Jimma~Waliso North section for site selection
	9	Felling of trees at Mt. Abaro for propagation test		
	10			
	11			
	12			
	13			
	⑭		A trip from Gumbi South to Mt. Furi and preparations for camping	
	15			Re-survey of Addis Ababa~Mt. Zuquala~Zuai West for site selection
	16			
	17		Propagation test in Mt. Furi~Waliso North section	Re-survey of Mt. Furi~Shashemane section for site selection
	18			
	$\boxed{19}$			
	20			
	㉑			
	22		Trips from Mt. Furi and Waliso North to Addis Ababa	
	23			
	24	Intra-team meeting for co-coordination		
	25		Camping and preparations for propagation test in Abaro~Zuai West section	
	26			
	27		Propagation test in Abaro~Zuai West section	Re-survey of Abaro~Zuai West section for site selection
	㉘			
Mar.	1			Trip to Dire Dawa
	$\boxed{2}$			
	3			
	4			Survey of Dire Dawa~Harrar section for site selection
	5		Trips to Adama West and Meki North. Camping and preparations	
	6			Summarization and review of data.
	⑦		Propagation test in Adama West~Meki North section	
	8	Preparations of papers for customs clearance of equipment to be shipped out		
	9			
	10			Re-survey of Dire Dawa~Mt. Cubi section for site selection
	11			
	12		Withdrawal of equipment from Adama West and Meki North section	
	13			

Mar.	⑭		
	15		Re-survey of Jimma~Waliso North section for site selection
	16		
	17		
	18	Inspection and packing of equipment, customs procedures and preparations for shipment.	
	19		
	20		
	㉑	Summarization and review of data.	
	22	Preparations and submission of an interim report.	
	23		
	24	Consultations with officials of I.B.T.E.	
	25		
	26	Visits to the Japanese Embassy and I.B.T.E. to report on the survey and to bid farewell.	
	27	Preparations for depatrure.	
	㉘	Departure from Addis Ababa.	

Notes: Sunday

National holiday of Ethiopia

Aug. 22nd:	Ascension Day
Sep. 11th:	New Year's Day, Return of Eritrea, Feast of St. John the Baptist.
Sep. 27th:	Feast of the Finding of the True Cross (Maskal)
Jan. 19th:	Feast of the Epiphany (Timkat)
Jan. 20th:	Feast of the St. Michael (Michaelmas)
Feb. 19th:	Martyrs Commemoration Day.
Mar, 2nd:	Commemoration of the Battle of Adua.

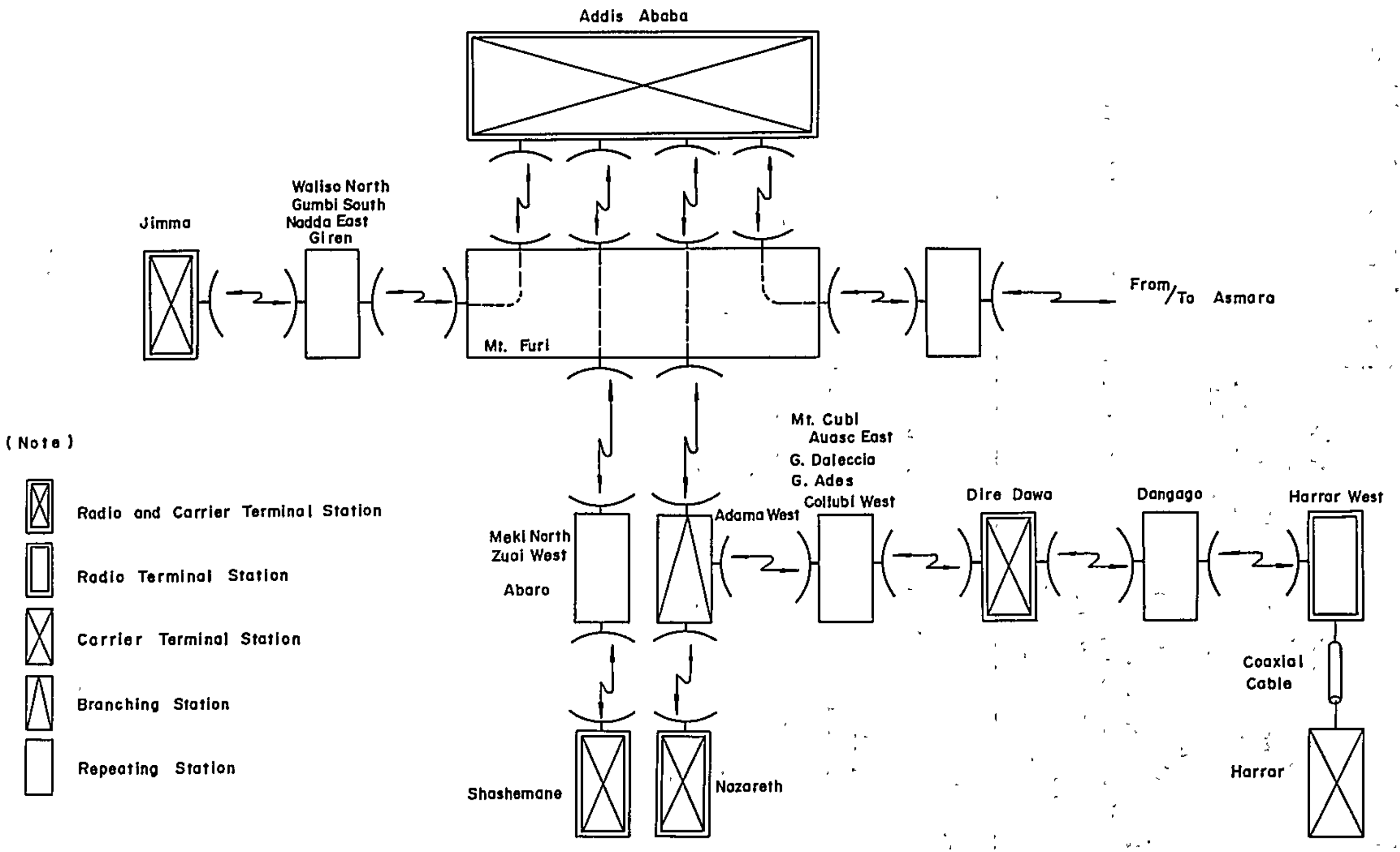
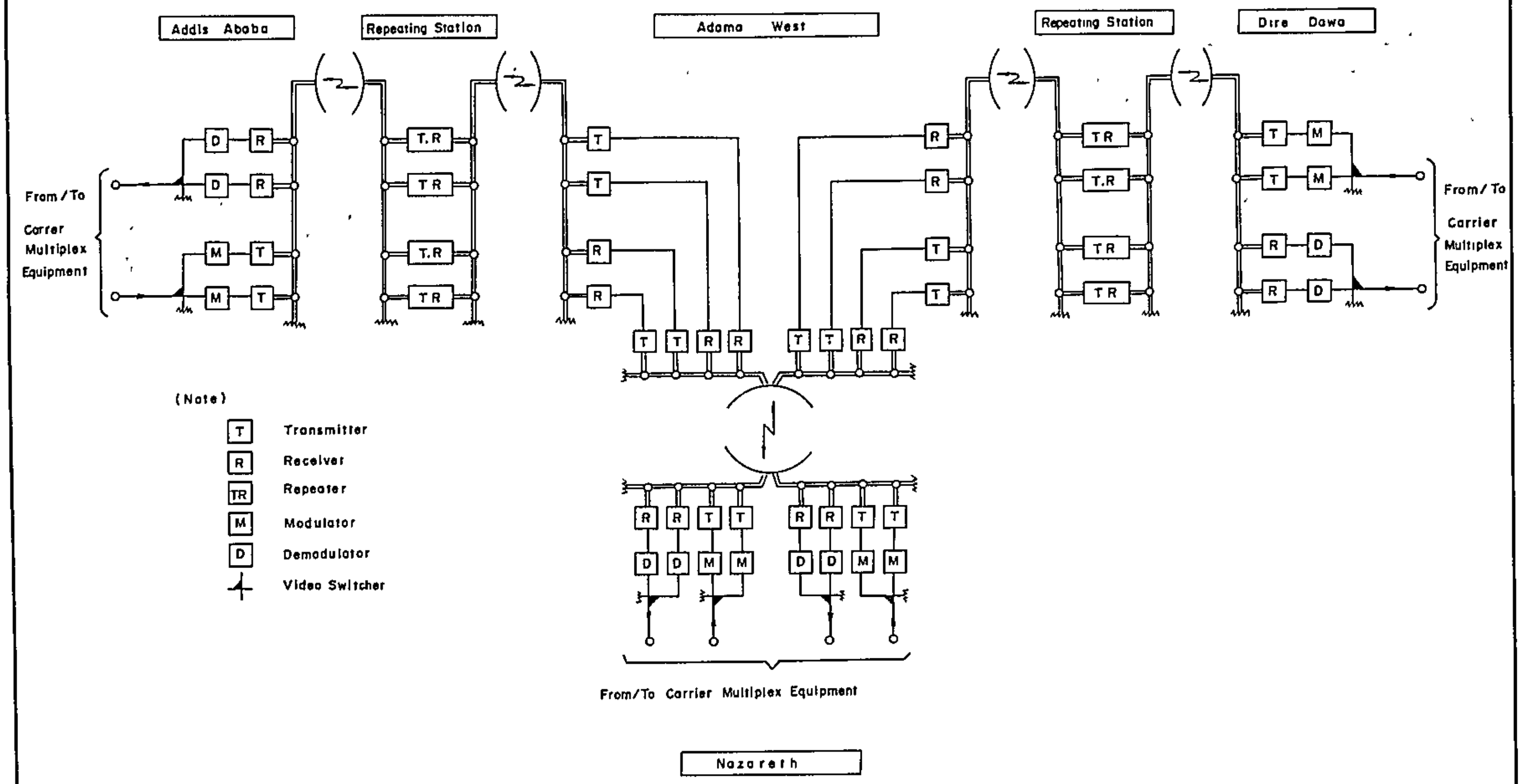


Diagram of Transmission Network

Fig. I - 1



Typical Block Diagram of System Configuration and Switching System for No. 2 Route

Fig. I - 2

Fig. I - 3 Map of the microwave route between
ADDIS ABABA and DIRE DAWA and HARRAR (No. 2 Route)
ADDIS ABABA and SHASHEMANE (No. 3 Route)
ADDIS ABABA and JIMMA (No. 4 Route)

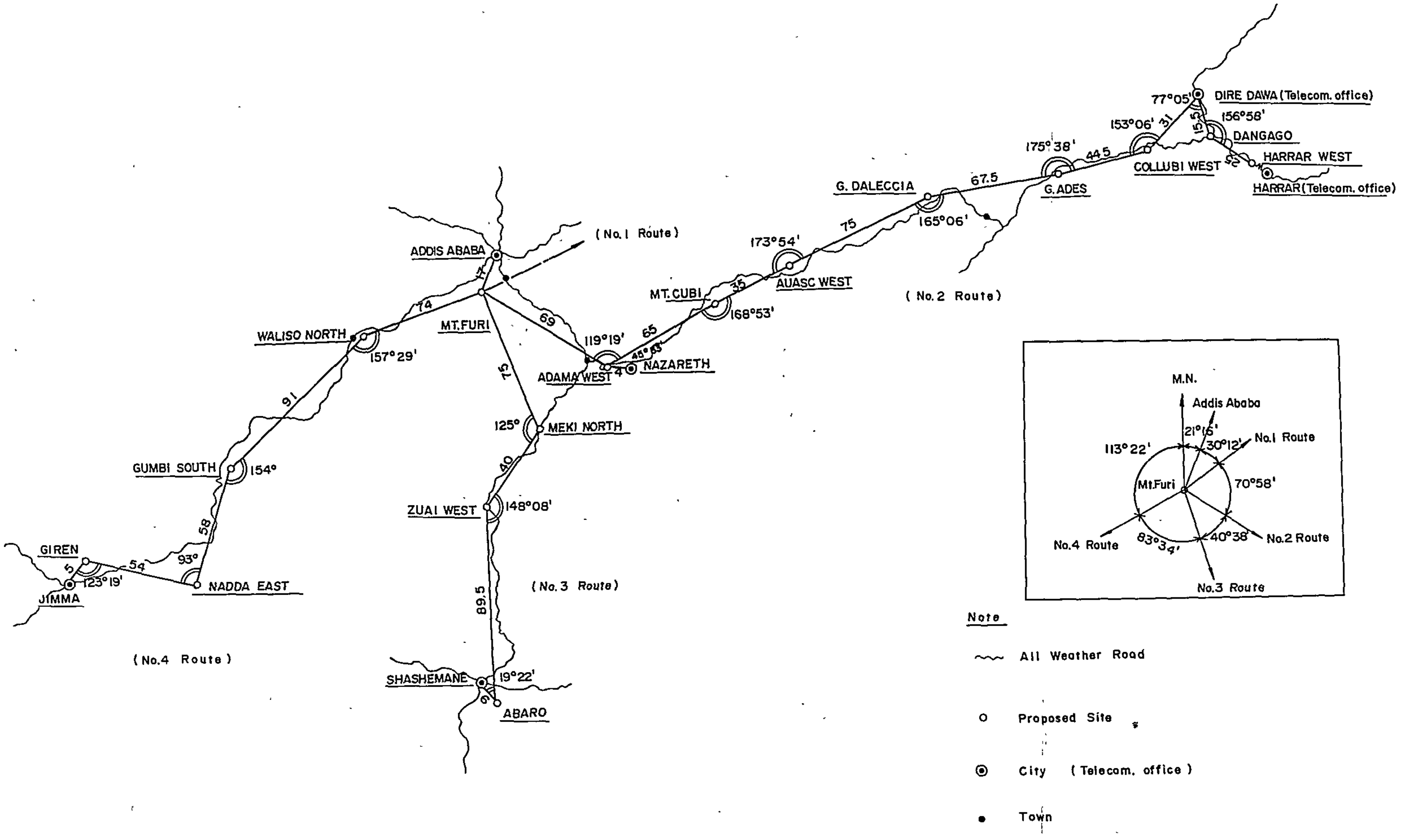


Table I-1 *Location of the Site*

Route No.	Site	North Latitude	East Longitude	Altitude (m)	Antenna Height (m)	Direction (M.N.)	Access Road (km)	
							New	Repair
2	Mt. Furi	8°52'30"	38°42'10"	2,800			*	
					20	122°26'		
	Adama West	8°32'26"	39°13'54"	1,840	20	298°29'	3.5	0
					10	103°21'		
	Nazareth (Telecom. Office)	8°32'00"	39°15'34"	1,650	20	283°00'	0	0
					-	-		
	Adama West	-	-	-	-	-	-	-
					10	57°48'		
	Mt. Cubi	8°49'52"	39°44'35"	1,500	10	245°05'	2.5	0
					10	75°12'		
	Auasc West	8°55'49"	40°01'29"	1,100	10	251°25'	0	0
					10	65°19'		
	G. Daleccia	9°12'30"	40°38'48"	1,770	10	245°55'	4.0	3.0
					20	80°49'		
	G. Ades	9°19'35"	41°15'16"	2,570	35	264°20'	0.5	0
					35	79°58'		
	Collubi West	9°24'19"	41°39'19"	2,800	10	256°29'	3.0	1.5
					10	49°35'		
	Dire Dawa	9°35'08"	41°52'14"	1,207	30	230°00'	0	0
					75	152°55'		
	Dangago	9°27'28"	41°56'24"	2,280	10	333°34'	2.5	0
					10	130°32'		
	Harrar West	9°18'20"	42°07'47"	2,053	10	310°15'	0	0
					-	-		

Note: Figures for latitude, longitude and altitude were presumed from the maps on a scale of 1 to 500,000.

* Related with No. 1 Route

Table I-2 Location of the Site

Route No.	Site	North Latitude	East Longitude	Altitude (m)	Antenna Height (m)	Direction (M.N.)	Access Road (m)	
							New	Repair
3	Mt. Furi	8°52'30"	38°42'10"	2,800			*	
					10	162°29'		
	Meki North	8°16'00"	38°54'31"	1,720	10	342°30'	0	0
					10	217°30'		
	Zuai West	7°56'37"	38°40'03"	1,750	10	36°00'	1.0	0
					10	184°08'		
	Abaro	7°07'52"	38°36'46"	2,280	10	0°53'	1.0	3.0
					10	340°31'		
	Shashemane	7°13'11"	38°35'49"	1,960	20	161°00'	0	0
					-	-		

* Related with No. 1 Route

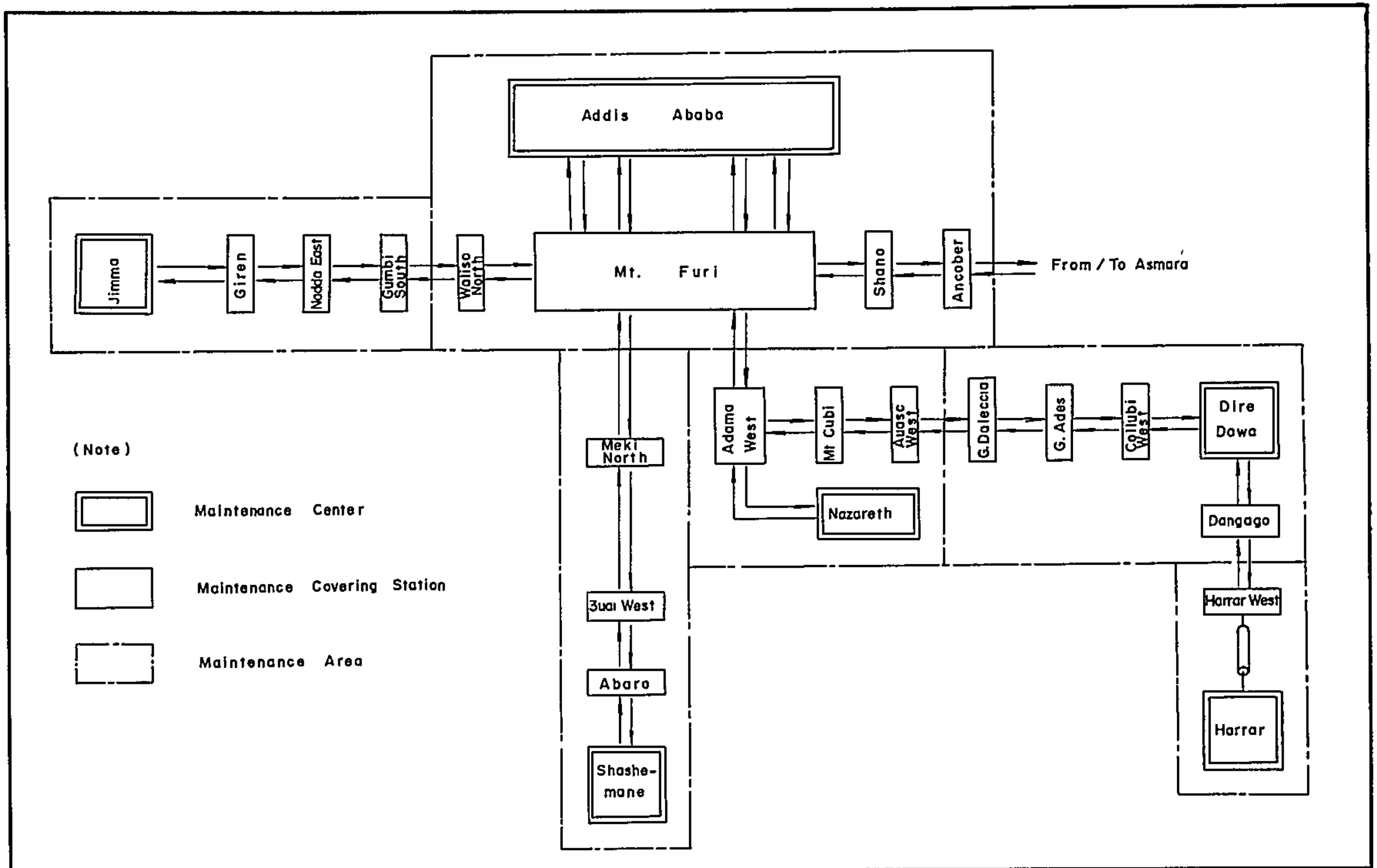
Table I-3 Location of the Site

Route No.	Site	North Latitude	East Longitude	Altitude (m)	Antenna Height (m)	Direction (M.N.)	Access Road (m)	
							New	Repair
4	Mt. Furi	8°52'30"	38°42'10"	2,800			*	
					10	246°03'		
	Waliso North	8°38'55"	38°04'44"	2,400	10	68°28'	1.0	0
					10	225°57'		
	Gumbi South	8°04'47"	37°28'55"	2,230	10	48°00'	4.0	0
					10	202°00'		
	Nadda East	7°35'13"	37°19'00"	2,240	10	14°29'	0.2	10
					10	281°29'		
	Giren	7°42'27"	36°50'45"	1,960	10	115°04'	0	3.0
					10	238°23'		
	Jimma	7°39'52"	36°49'11"	1,680	20	57°14'	0	0
					-	-		

* Related with No. 1 Route

Table I-4 Supervise Station and Maintenance Covering Station List

Maintenance Center (Supervise Station)	Maintenance Covering Station	Classification	Attended or Unattended	Remarks
Addis Ababa		Radio and Carrier Terminal Station	Attended	No. 1~No. 4 Route
	Mt. Furi	Repeating Station	Unattended	
	Waliso North			No. 4 Route
Nazareth		Radio and Carrier Terminal Station	Attended	No. 2 Route
	Adama West	Branching Station	Unattended	
	Mt. Cubi	Repeating Station		
	Auasc West			
Dire Dawa		Radio and Carrier Terminal Station	Attended	No. 2 Route
	G. Daleccia	Repeating Station	Unattended	
	G. Ades			
	Collubi West			
	Dangago			Harrar Route
Shashemane		Radio and Carrier Terminal Station	Attended	No. 3 Route
	Meki North	Repeating Station	Unattended	
	Zuai West			
	Abaro			
Jimma		Radio and Carrier Terminal Station	Attended	No. 4 Route
	Gumbi South	Repeating Station	Unattended	
	Nadda East			
	Giren			
Harrar		Carrier Terminal Station	Attended	Harrar Route
	Harrar West	Radio Terminal Station	Unattended	



Maintenance Center and Maintenance Area

Fig. I - 4

CHAPTER II TOLL CIRCUIT PLAN

II. TOLL CIRCUIT PLAN

1. Toll Telephone Service Plan

This plan envisages installation of automatic toll switches at telephone offices in Dire Dawa, Harrar, Nazareth, Shashemane and Jimma to realize subscriber trunk dialing services between these areas and the cities of Addis Ababa, Dessie, Mekele and Asmara, where installation of automatic toll switches is in progress.

The implementation of this plan will complete the toll telephone automatic dialing network covering major cities of Ethiopia and will greatly improve toll telephone services of the country.

1-1 Number of Toll Circuits

The estimated number of toll circuits required at the time of inauguration of services (1974) and 10 years after (1984) are given in Fig. II-1 - Fig. II-3 respectively. The figures include the number of leased lines for telegraph, telex, program, telephone and order wires between terminal stations in addition to that public service lines.

The figures for each section also include the number of toll circuits for connection with other cities by manual services.

The three-channel order wire circuits provided between terminal stations are for connecting every control room to provide speech services between radio rooms, carrier multiplex rooms and telephone exchange rooms.

1-2 Establishment of Transmission Lines

In order to implement the aforementioned subscriber trunk dialing service, toll telephone transmission lines by means of microwave communication system must be planned for the following routes.

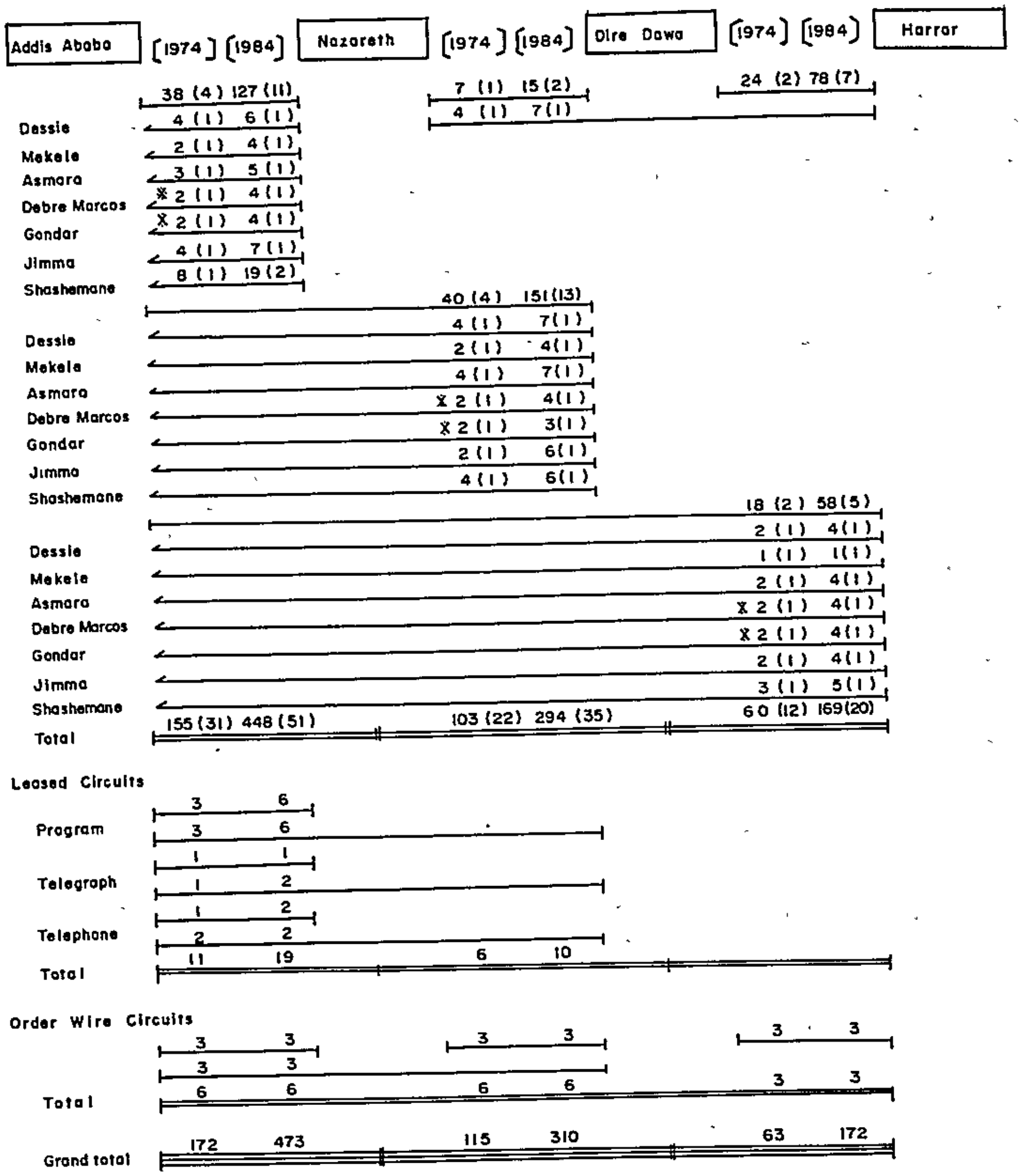
(1) Addis Ababa ~ Dire Dawa ~ Harrar (Nazareth branching included)
(2) Addis Ababa ~ Shashemane
(3) Addis Ababa ~ Jimma

2. Transmission Network Plan

In working out a transmission network plan, the principal objective should be "To establish a transmission network which will assure stable transmission quality, being easy to maintain and most economical".

Therefore, due consideration must be given to,

(1) selection of transmission system to ensure the required transmission quality,
(2) establishment of a reasonable system composition to improve system reliability,
(3) selection of frequency by taking into account the mutual interference of radio waves between routes in the case of radio system,
(4) designation of maintenance areas in order to ensure efficient and prompt correction measures against faults in the system.



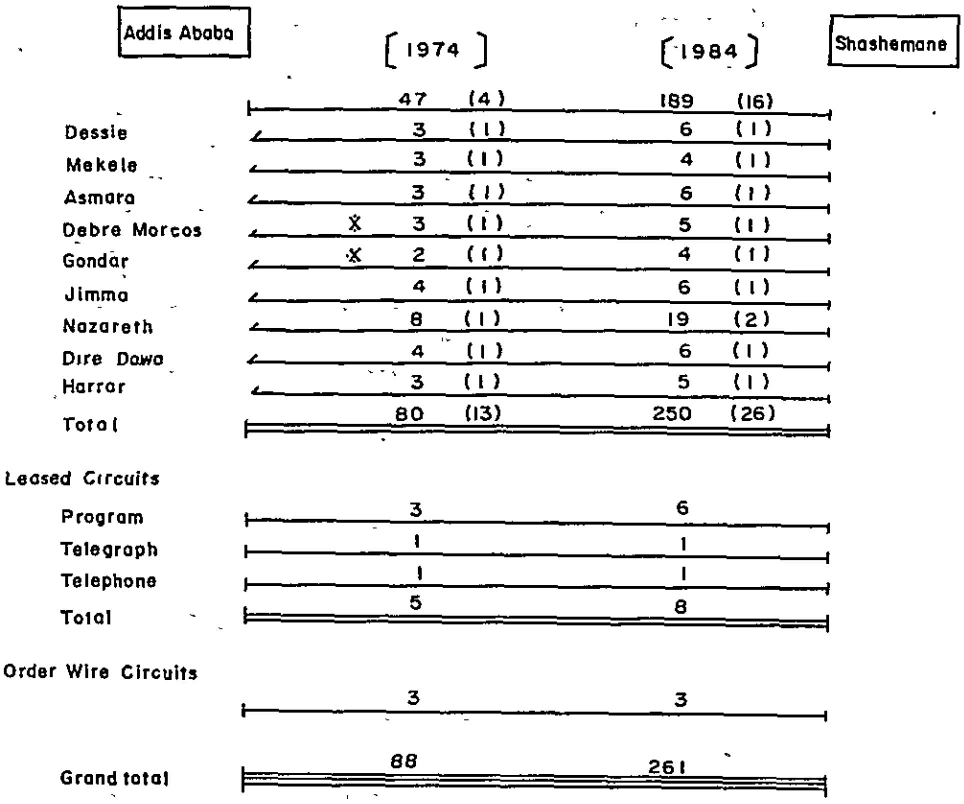
(Note) 1 X : Circuits by Manual Service

2 Program and Telegraph Circuits is Converted to Telephone Circuits

3 Showing in Parentheses Group Numbers

Number of Toll Telephone Circuits to be Required in 1974 and 1984. (Including Leased Circuits and Order-Wire Circuits)

Fig. II - 1



		1974		1984	
		47	(4)	189	(16)
Dessie		3	(1)	6	(1)
Mekele		3	(1)	4	(1)
Asmara		3	(1)	6	(1)
Debre Morcos	X	3	(1)	5	(1)
Gondar	X	2	(1)	4	(1)
Jimma		4	(1)	6	(1)
Nazareth		8	(1)	19	(2)
Dire Dawa		4	(1)	6	(1)
Harrar		3	(1)	5	(1)
Total		80	(13)	250	(26)
Leased Circuits					
Program		3		6	
Telegraph		1		1	
Telephone		1		1	
Total		5		8	
Order Wire Circuits		3		3	
Grand total		88		261	

(Note) 1. X : Circuits by Manual Service

2. Program and Telegraph Circuits is Converted to Telephone Circuits

3 Showing in Parentheses Group Numbers

Number of Toll Telephone Circuits to be Required in 1974 and 1984. (Including Leased Circuits and Order Wire Circuits)

Fig. II - 2

Addis Ababa		[1974]		[1984]		Jimma
		41	(4)	146	(13)	
Dessie		4	(1)	6	(1)	
Mekele		2	(1)	4	(1)	
Asmara		4	(1)	6	(1)	
Debre Marcos	X	2	(1)	4	(1)	
Gondar	X	2	(1)	4	(1)	
Shashemane		4	(1)	6	(1)	
Nazareth		4	(1)	7	(1)	
Dire Dawa		2	(1)	6	(1)	
Harrar		2	(1)	4	(1)	
Total		67	(13)	193	(22)	
Leased Circuits						
Program		3		6		
Telegraph		1		1		
Telephone		1		1		
Total		5		8		
Order Wire Circuits		3		3		
Grand total		75		204		

(Note) 1 X Circuits by Manual Service

2 Program and Telegraph Circuits is Converted to Telephone Circuits

3 Showing in Parentheses Group Numbers

Number of Toll Telephone Circuits to be Required in 1974 and 1984. (Including Leased Circuits and Order Wire Circuits)	Fig. II - 3

Particularly for the project under which four different routes including No. 1 Route are planned via a single repeating station (Mt. Furi), it is essential to give due consideration to the prevention of interference between each route and make a careful study so that a drastic change in the design of No. 1 Route may be avoided.

From the maintenance point of view, the planning must be made after a comprehensive study of various requirements to ensure easy identification of system and local faults by the supervising stations.

2-1 Request of I.B.T.E. on Transmission Network Plan

For the implementation of this plan, I.B.T.E. requests the fulfillment of the following conditions.

2-1-1 Transmission Performance (Allowable noise power)

(1)	Addis Ababa~Dire Dawa~Harrar route	3 LpW
(2)	Addis Ababa~Shashemane route	3 LpW
(3)	Addis Ababa~Jimma route	3 LpW + 200 pW

2-1-2 Transmission Capacity

(1) The transmission capacity of each route is to be 600 CH.

(2) The number of systems for each route is to be one normal system and one stand-by system at the final stage.
However, the stand-by system is to be able to transmit MTV in the future.

2-1-3 Others

(1) No restriction is to be imposed specifically on the selection of frequency band to be used for each route.

(2) Telephone branching from No. 2 Route to Nazareth is to be planned at the same time.

(3) No. 2 Route is to be extended to Somalia and No. 3 Route to Kenya to provide international circuits as a future plan.

2-2 Results of a Study Made on the Request of I.B.T.E.

2-2-1 Transmission Performance (Allowable noise power)

The allowable noise power in the radio link should be determined by taking into account the following condition to conform to C.C.I.R. recommendations.

When the entrance is connected by means of the coaxial cable system, the requirements for allowable noise power in the transmission line including this portion should be satisfied.

On the matters not specified in this report, refer to the report on Addis Ababa~Asmara section (Technical specifications included) which was previously presented.

That is, the allowable noise power for No. 2, 3 and 4 Routes is to conform to C.C.I.R.Rec. 395-1.

2-2-2 Transmission Capacity

The transmission capacity of Addis Ababa Dire Dawa section is to be 960 CH. If the telephone branching to Nazareth are to be planned by the very same system used for the Addis Ababa～Dire Dawa～Harrar route, 10 SG (equivalent to 600 CH) or more will be required for circuit arrangement.for which refer to IV 4-3.

2-2-3 Radio Frequency Band to be Used

For the transmission of telephone and television signals over a long distance, 4 GHz, 6 GHz and 2 GHz bands are generally used.

4 GHz and 6 GHz systems are considered advantageous in that they are in wide use with good results, less expensive and highly reliabile while the use of 2 GHz system is often restricted to OH and local microwave systems.

For this plan under which transmission lines are planned in various directions via single repeating station (Mt. Furi) with Addis Ababa as starting-point, 6 GHz band and 6 GHz upper band with more radio frequency channels are more advantageous than 4 GHz and 2 GHz bands for standardization of radio frequency and simplification of maintenance for each route.

For the radio frequency plan, detailed explanation will be made in Chapter IV. 3.

2-3 Factors to be taken into Consideration in a Transmission Network Planning

In planning transmission lines for No. 2 Route - No. 4 Route, the following factors must be taken into consideration.

(1) As the Addis Ababa～Asmara route (No. 1 Route) will be completed first, the system configuration of No. 2 Route - No. 4 Route under this plan should be such that will not result in a drastic change in the system composition of No. 1 Route. In other words, it is desirable that the system configuration of No. 2 Route - No. 4 Route under this plan should be separated from the system composition of No. 1 Route.

(2) It is desirable that the system configuration of No. 2 Route and No. 3 Route, which will be connected to international circuits in the future should be independent of that of No. 4 Route which will accommodate only domestic circuits, from the standpoint of transmission performance and maintenance and operation of microwave link.

(3) In order to simplify maintenance and improve system reliability, the branching and switching at unattended station should be avoided as much as possible.

(4) In selecting frequency band to be used, due consideration should be given to the correlation with the future planning.

(5) Efforts should be made to standardize frequency band and the system for each route to the extent possible so that the maintenance may be simplified.

2-4 Results of a Comprehensive Study of Transmission Network Plan

Three alternative transmission network plans worked out after a careful study of the request of I. B. T. E. described in the previous section 2-1 and the factors given in the previous section 2-3 are shown in Fig. II.- 4 - Fig. II-6. Each of these alternative plans adopts system configuration independent of that of No. 1 Route.

2-4-1 Transmission Network Plan - Plan 1.

This plan envisages independent system configuration for each route to ensure simplicity of maintenance and operation.

2-4-2 Transmission Network Plan - Plan 2.

Under this plan, each of the three routes is to have a composite system configuration and is to be switched over to the stand-by system at Mt. Furi. Consequently, the system configuration becomes very complicated.

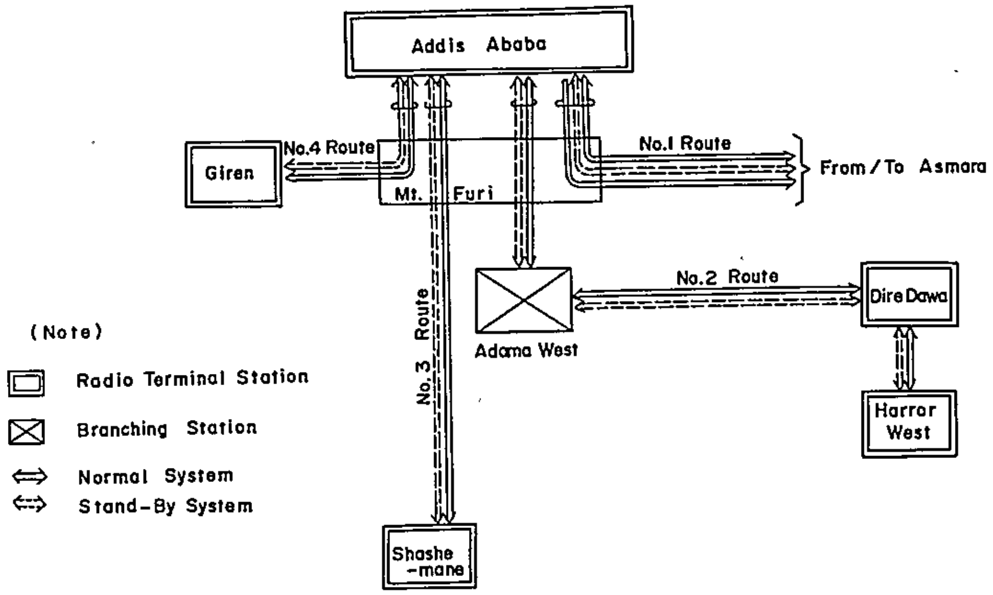
2-4-3 Transmission Network Plan - Plan 3.

Under this plan, No. 2 Route and No. 3 Route, which will be connected to international circuits in the future, are to have system configurations independent of that of No. 4 Route and Nazareth section.

Each of the three alternative plans has merits and demerits under different conditions and the judgement on their superiority is very difficult. However, on the basis of an overall evaluation shown in the table below, Plan 1 seems to be more advantageous than other two. The cost comparison shown in the table below is only for the radio facilities for the microwave section and does not include the entrance portion and other facilities. For the comparison of costs of the branching section and entrance portion, refer to Chapter II 2-5 and Chapter II 2-6.

Items compared / Plan		Plan 1	Plan 2	Plan 3
System reliability		A	C	B
Convenience for maintenance		A	C	B
Others		B	C	A
Economy	Construction cost	B	A	C
	Maintenance cost	A	C	B

Note: A, B and C in the table represent the sequence of superiority in that order.



1. System Configuration and System Reliability

(a) Each route has a system configuration completely independent of those of other routes and the system switching for each route is to be made only between its own radio terminal stations.

(b) The system configuration is the simpliest and the system reliability is higher than under other plans.

(c) No branching or switching at the intermediate repeating station is required.

2. Maintenance

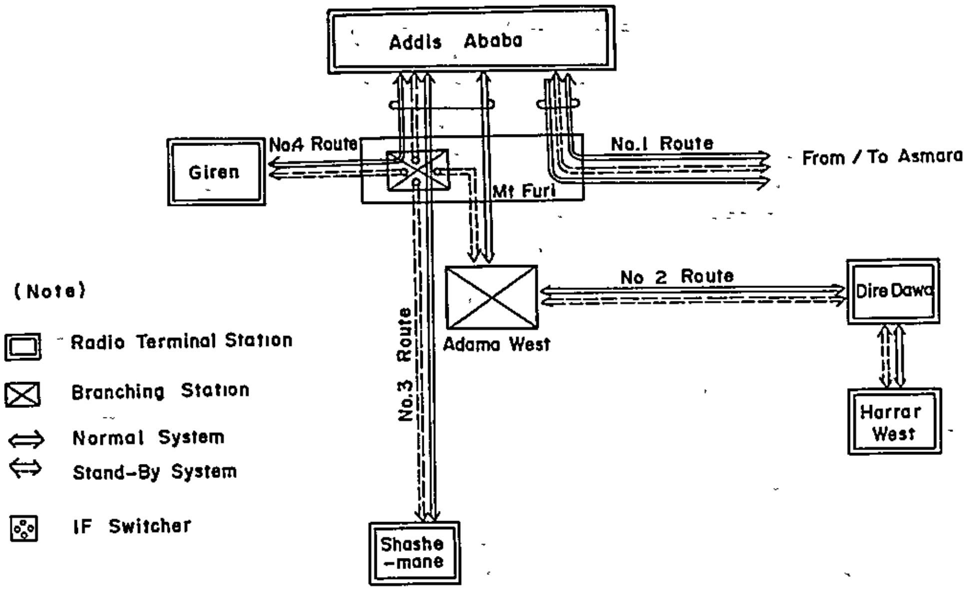
As there is no branching or switching at unattended stations, easy operation and maintenance are ensured.

3. Construction Cost

The construction cost calculated on the basis of the system configuration under Plan 1 (Fig. II-4) is to be used as reference value (1.00).

Transmission Network Plan

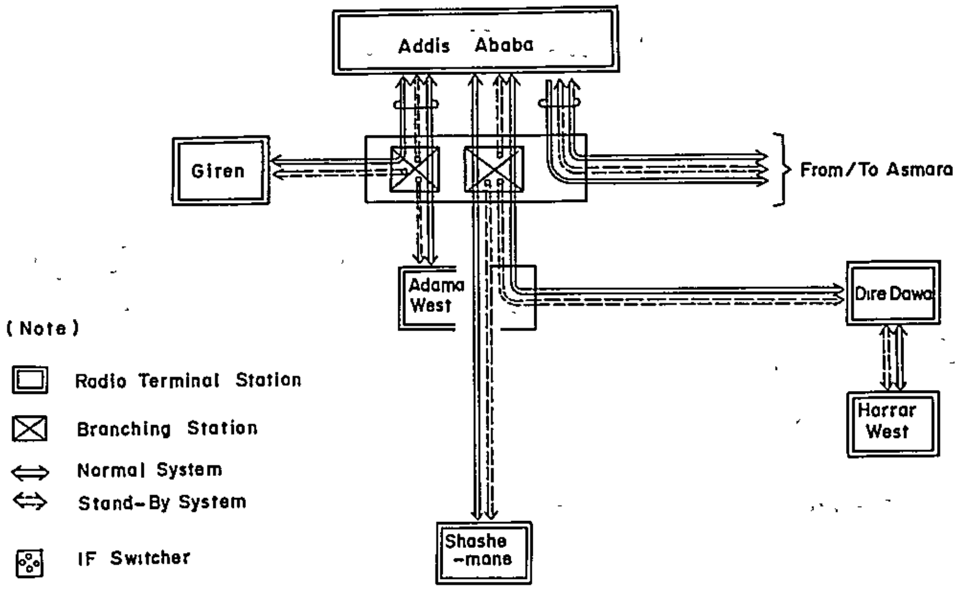
Fig. II - 4



1. System Configuration and System Reliability
   - (a) No. 2 Route - No. 4 Route have composite system configurations.
   - (b) Switching to the stand-by system for each of the three routes is made at Mt. Furi in the IF band.
   - (c) As a result, the system switching method becomes very complicated and the system reliability deteriorates considerably.
2. Maintenance
   - (a) Because of the complicated switching method, operation and maintenance at the control station are very difficult.
   - (b) The three routes are liable to be affected by the faults in the control system, thus causing a confusion.
3. Construction Cost

   The rate is 0.96 against 1.00 under Plan-1.

Transmission Network Plan (plan-2)	Fig. II - 5



1. System Configuration and System Reliability

   (a) The system configurations of No. 2 and No. 3 Routes, which will be connected to international circuits in the future, are independent of those of No. 4 Route and Nazareth section.

   (b) System switching to two different system configurations is made at Mt. Furi in the IF bands of each system configuration.

   (c) Adama West acts both as intermediate repeating station for No. 2 Route and as video terminal station (unattended) for the Nazareth section.

   (d) System reliability is higher than under Plan-2.

2. Maintenance

   Although the maintenance may become somewhat complicated, it is possible under this plan to take corrective measures against system faults in the order of priority.

3. Others

   (a) There is no requirement for branching and switching at Adama West.

   (b) Change in the circuit arrangements for the sections from Nazareth to Dire Dawa and from Nazareth to Harrar.

4. Construction cost

   The rate is 1.12 against 1.00 under Plan-1.

Transmission Network Plan (plan-3) Fig. II - 6

2-5 Telephone Branching to Nazareth

For telephone branching from No. 2 Route to Nazareth, two methods are conceivable. One is to branch off from Adama West to the Nazareth Telephone Office by means of microwave system and the other is to use cable system for entrance cable.

Though the distance of this section is approximately 4 km on the straight line, it will be approximately 9 km if the cable system is used as the cable has to detour along the road. When the hop distance is short, the cable system is generally said to be more advantageous economically. In this case, however, the difference is very small.

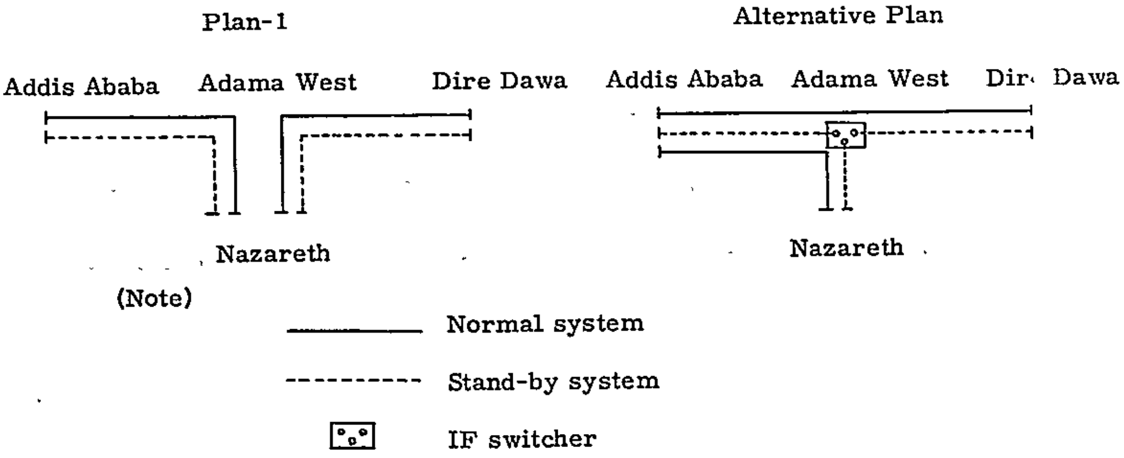
For branching method, three different methods are shown in Fig. II-7 - Fig. II-9 respectively. Fig. II-7 and Fig. II-8 show representative methods which use microwave system and coaxial system in most economical way respectively and Fig. II-9 shows a method which uses loaded cable system.

2-5-1 Method Using Microwave System (Plan-1)

With this method, branching route from Adama West in the Addis Ababa Dire Dawa section to Nazareth is provided by the loop connection system by means of microwave system. Consequently Adama West becomes a mere unattended repeating station. Under the alternative plan, a direct microwave system is to be established in the Addis Ababa~Dire Dawa section and at the same time an additional system is to be established in the Addis Ababa~Nazareth section and their stand-by systems are to be switched at Adama West, respectively.

The construction cost under alternative plan is slightly higher than that under Plan-1, and because of the switching at an unattended station, maintenance becomes more complicated.

For this reason, the alternative plan is not recommended.



2-5-2 Method Using Coaxial Cable System (Plan-2)

With this method, part of carrier terminal equipment will have to be provided at Adama West in order to divide the system into a direct circuit and a drop circuit. Branching is to be made by coaxial cable system in video band. Although this method is effective for minimizing the number of tubes in coaxial cable,the toll circuits from Nazareth to Dire Dawa and from Nazareth to Harrar will have to be established via Addis Ababa.

The detouring circuit like this one is often established when the number of circuits is small.

2-5-3 Method Using Loaded Cable System (Plan-3)

With this method, the loaded cable system is used in place of the coaxial cable system. Therefore, all the carrier multiplex equipments must be provided at Adama West which must be converted to an attended station. The results of a detailed study of the three alternative plans are given in Fig. II-7 - Fig. II-9. Although each plan has merits and demerits, Plan-1 is considered most advantageous from the results of an overall evaluation shown in the following table.

In making final decisions, however, due consideration must be given to the space of station building, power situation and other factors in Nazareth in addition to the aforementioned factors.

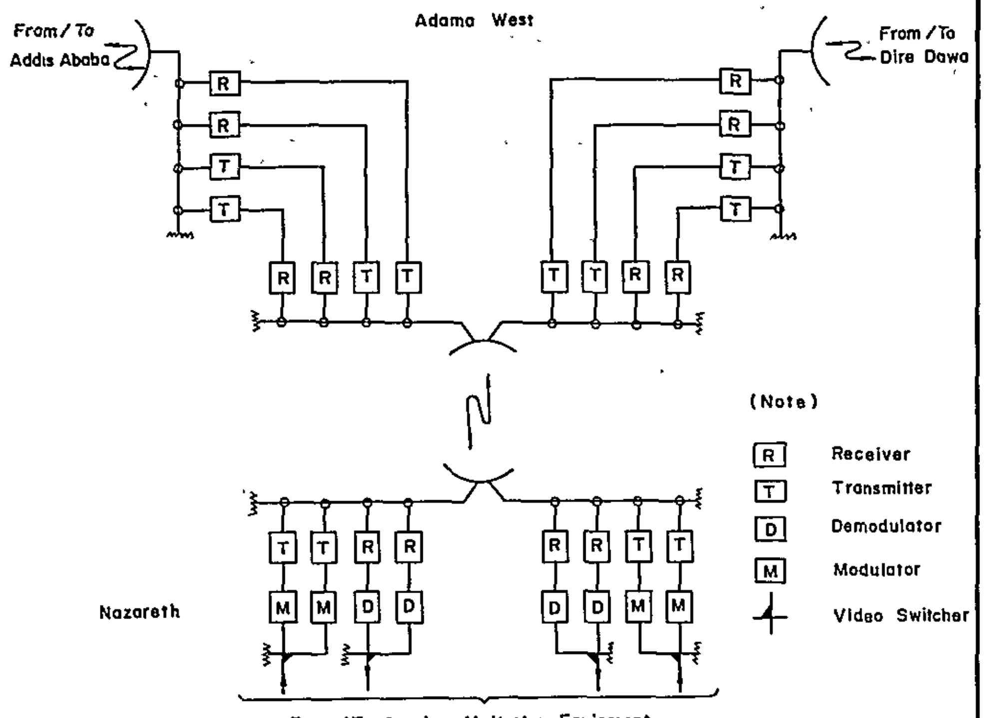
Items compared / Plan		Plan-1	Plan-2	Plan-3
System reliability		A	C	B
Maintenance condition		A	C	B
Others		C	A	B
Economy	Construction cost	B	C	A
	Maintenance cost	A	B	C

(Notes) 1. A, B and C in the table represent the sequence of superiority in that order.

2. Comparison of construction costs was made on the basis of the following conditions.

   (1) The coaxial cable is to be laid underground and 50% of the total length of the toll cable is to be the over-head cable.

   (2) 150 pr cable is to be used for toll cable and phantom circuit is to be used.



1. Branching and switching method (Plan-1)

(a) The frequency band and the system of transmission line are of microwave system the same as those for the main route and the Adama West station becomes an intermediate repeating station.

(b) Switching section of the system is provided between Addis Ababa ~ Nazareth and Nazareth~Dire Dawa, and the switching is made independently at each terminal station.

(c) System reliability is higher than under other plans.

2. Circuit route

The circuits between Addis Ababa~Dire Dawa, and Addis Ababa~Harrar will be established via Nazareth.

3. Maintenance

As the Adama West station will become a mere intermediate repeating station, its operation and maintenance are easily accomplished.

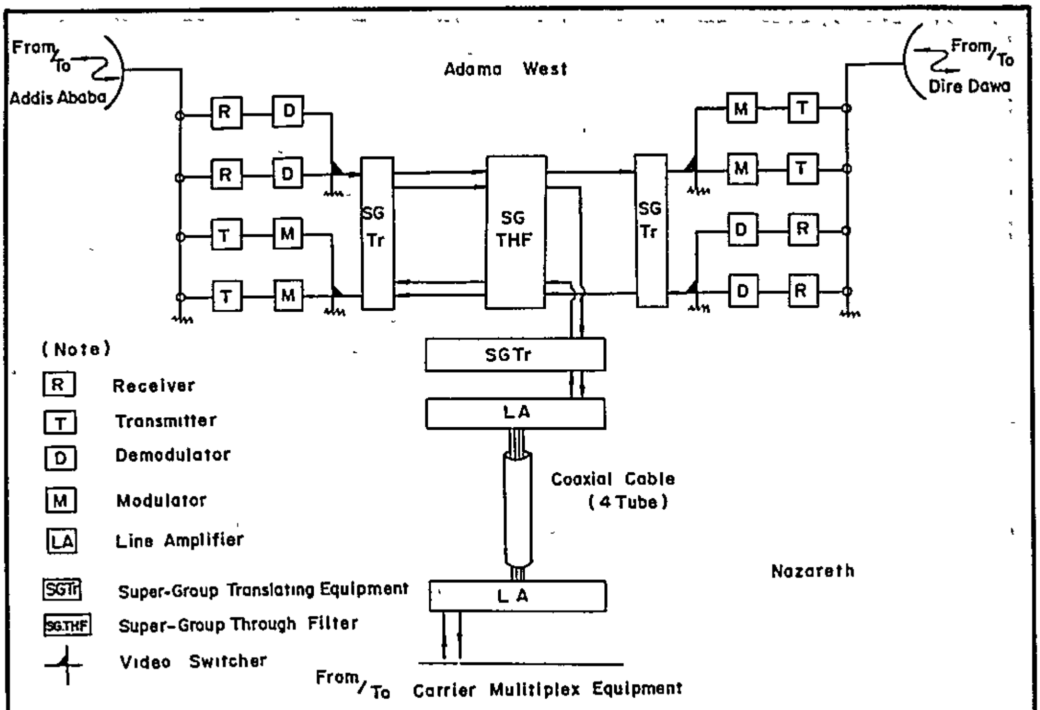
4. Others

As the circuit route will be such as described in the previous paragraph 2, the through circuit between Addis Ababa and Dire Dawa, Harrar will be affected in the event of a local fault at Nazareth.

5. Construction cost

The construction cost calculated for the branching method under Plan-1 (Fig. II-7) is to be used as the reference value (1.00).

Branching System Plan	(plan-1)	Fig. II - 7



1. Branching and switching methods (Plan-2)
   - (a) The microwave system and the branching system are separated each other from the standpoint of system composition and the Adma West Station becomes an unattended video terminal station for the microwave system.
   - (b) The entrance cable is provided by means of coaxial cable system.
   - (c) Part of the carrier multiplex equipments is provided at Adama West and the through circuit and the drop circuit are separated each other at Adama West.
   - (d) System reliability is lower than under Plan-1.

2. Circuit route

The circuit from Nazareth to Dire Dawa and Harrar has to be established via Addis Ababa.

3. Maintenance

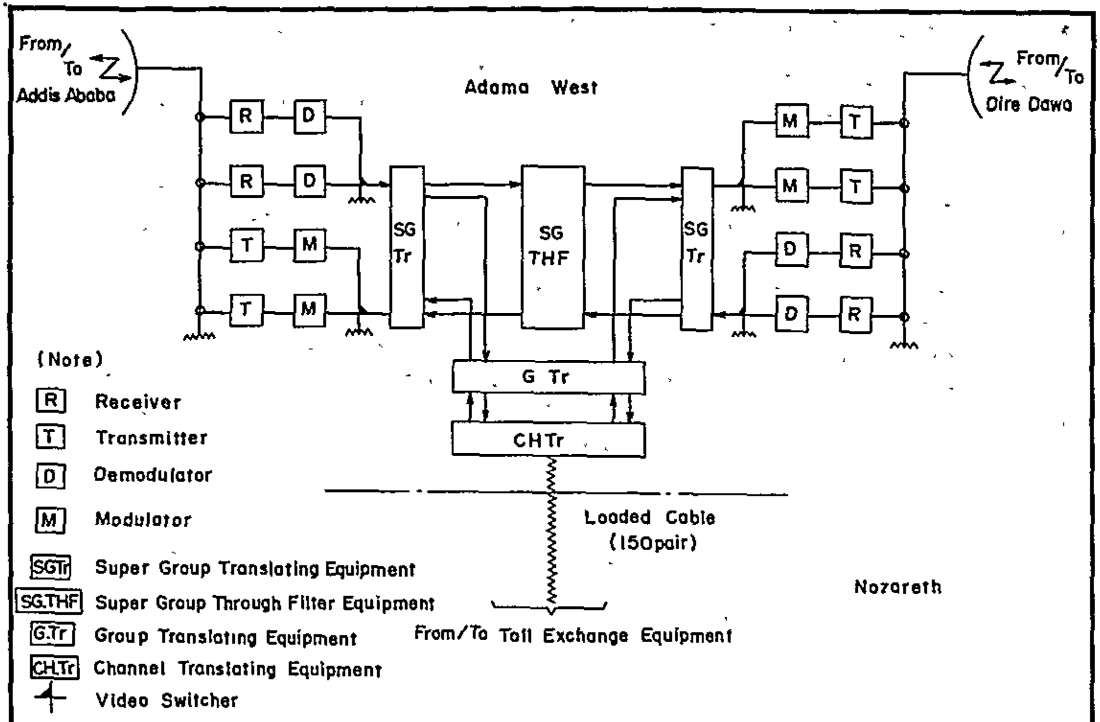
As the Adama West station is an unattended terminal station with part of carrier multiplex equipments, maintenance is somehow complicated. Also due to the detouring circuit, complexity is expected in expanding facilities.

4. Others
   - (a) The through circuit is not affected by local faults at Nazareth.
   - (b) Because of the detouring circuit, some extra facilities may be required for Addis Ababa terminal station.

5. Construction cost

The rate is 1.04 against 1.00 under Plan-1.

Branching System Plan (plan-2)	Fig. II - 8



1. Branching and switching method (Plan-3)

   (a) All carrier multiplex equipments are provided at Adama West and the entrance cable to the Nazareth Telephone Office is provided by means of loaded cable system after translation to channel part.

   (b) The switching method of the microwave system is the same as that under Plan-2.

   (c) The system reliability is the same as that under Plan-2 for the microwave system, but for the entrance portion, for which the loaded cable system is used, the system reliability is deteriorated slightly.

2. Circuit route

   An independent circuit route is established for each individual section.

3. Maintenance

   As the Adama West station becomes an attended station, no specific problems are expected.

4. Construction cost

   The rate is 0.98 against 1.00 under Plan-1.

Branching System Plan (plan-3) Fig. II - 9

2-6 Connection to Radio Terminal Station

For the connection when the radio terminal station and the carrier terminal station are located separately, the following two alternative plan are conceivable.

One is to connect from the radio terminal station by means of carrier multiplex system, and the other is to connect by the loaded cable system.

When the number of circuits is small and the hop distance is short, the loaded cable system is generally considered more advantageous. However, the radio terminal stations located at the top of mountains must be made into attended stations. This method also involves various pboblems such as deterioration of service in the event of a cable fault. For this reason, it is important to make a comprehensive study on these various factors.

2-6-1 Sections to be covered

Though the sections to be provided under this project are the following two sections, it is necessary to make a study for each section separately in accordance with the number of circuits and the distance in each section.

(1)	Harrar West~Harrar section	Approx. 4 km,172 CH (1984)
(2)	Giren~Jimma section	Approx. 7 km,204 CH (1984)

2-6-2 Connecting Method of Terminal Facilities

The connecting methods of terminal facilities are shown in Fig. II-10 - Fig. II-12.

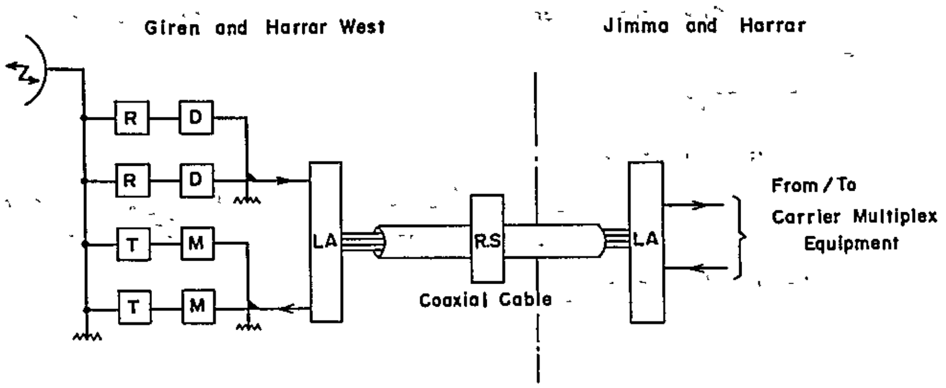
The following three plans may be pointed out as typical methods.

(1) Plan to be provided by means of coaxial cable system
(2) Plan to be provided by means of loaded cable system
(3) Plan to use microwave system instead of entrance cable

Though each of the above three alternative plans has merits and demerits under different conditions, the following systems are considered most advantageous from the results of a comprehensive study made on various factors.

(1)	Harrar West~Harrar section . . .	Coaxial cable carrier system
(2)	Giren~Jimma section	Microwave system

In making final decisions, however, due consideration must be given to the state of building and power condition at each terminal station and telephone office.



(Note)

R	Receiver
T	Transmitter
D	Demodulator
M	Modulator
LA	Line Amplifier
RS	Repeating Station

1. Method of coaxial cable system

Entrance cables are provided from the radio terminal station (unattended) in the form of base-band by means of coaxial cable system (4 tube) and all carrier multiplex equipments are provided at the telephone office.

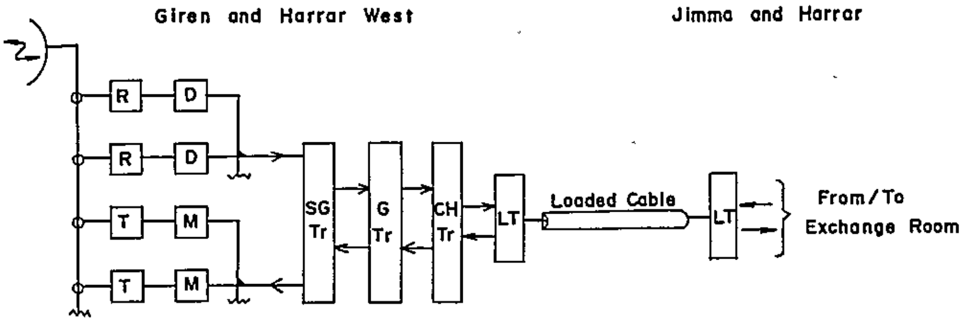
2. Others

There is a need to provide an intermediate repeating station depending on the distance of the cable.

3. Construction cost

The construction cost calculated for the method (Harrar West~Harra section and Giren~Jimma section) under Plan-1 (Fig. II-10) is to be used as the reference value (1.00).

Entrance System Plan (plan-1) Fig. II - 10



(Note)

R	Receiver
D	Demodulator
T	Transmitter
M	Modulator
SGTr	Super Group Translating Equipment
GTr	Group Translating Equipment
CHTr	Channel Translating Equipment
LT	Line Terminal Equipment

1. Method of loaded cable system

The entrance cable to the telephone office is installed by means of loaded cable system after all carrier multiplex equipments have been provided and translated to the channel part at the radio terminal station.

2. Others

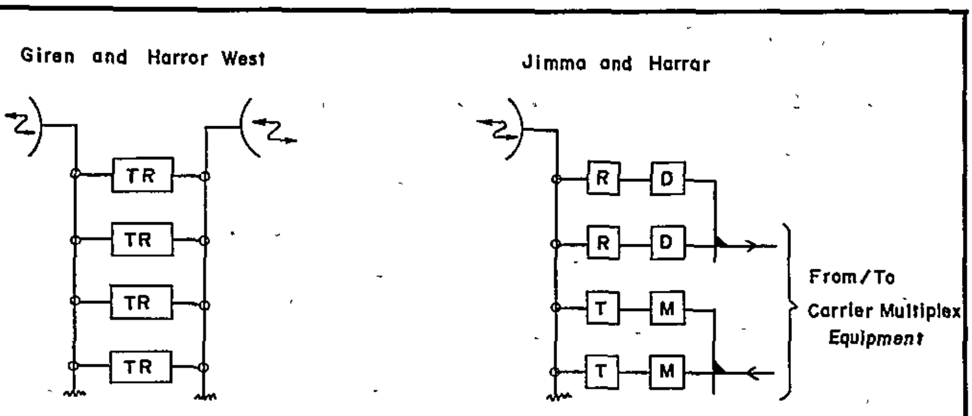
In this case, the radio terminal station should be made into an attended station.

3. Construction cost

(1) The rate for the Harrar West~Harrar section is 0.98 against 1.00 under Plan-1.

(2) The rate for the Giren~Jimma section is 0.96 against 1.00 under Plan-1.

Entrance System Plan (plan-2) Fig. II - 11



(Note)

TR	Repeater
R	Receiver
T	Transmitter
D	Demodulator
M	Modulator

1. Method of microwave system

Instead of entrance cable this method is to use the microwave system after converting the radio terminal station to an intermediate repeating station.

The radio terminal equipments and carrier multiplex equipments are provide at the telephone office.

2. Maintenance

The entrance portion is also unified into the main system and the operation and maintenance of the system may be standardized.

3. Construction cost

(1) The rate for the Harrar West~Harrar section is 1.01 against 1.00 under Plan-1.

(2) The rate for the Giren~Jimma section is 0.85 against 1.00 under Plan-1.

Entrance System Plan (plan-3) Fig. II - 12

3. Relation with Future Plans

3-1 Relation with Domestic Microwave Links

I.B.T.E. has a long-range plan of establishing a microwave link for the Addis Ababa～Gondar～Asmara route as shown in Fig. II-13.

As the microwave link under the long-range plan is scheduled to be established with Addis Ababa as its starting-point, it is necessary to give due consideration to the correlation with the future plans in designing No. 2 - No. 4 Routes under the current project.

3-2 *Relation with Earth Station for Communication Satellite System*

I.B.T.E. is planning to construct an earth station for communication satellite system at the site (Sululta) about 12 km northwest of Addis Ababa in the future.

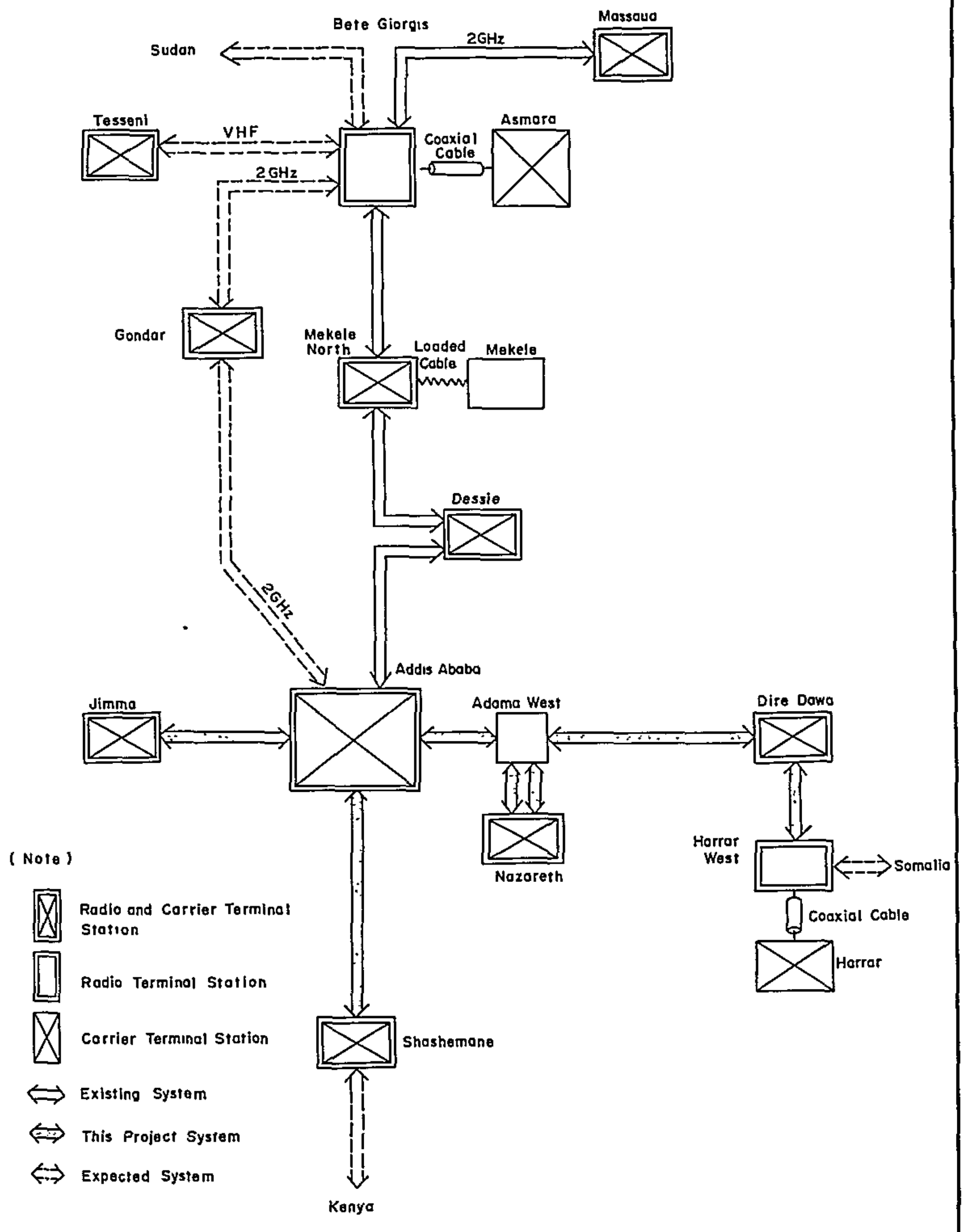
A study on the mutual interference between the earth station and each route of the project revealed that such interference would pose problems explained in III 1-4.

It will be necessary, therefore, to consider relocation of the earth station depending on the circumstances.

3-3- *Interconnection with International Circuits*

As No. 2 Route and No. 3 Route of the project are planned to be extended and interconnected with international circuits linked to Somalia and Kenya respectively, it is necessary to design these routes so as to equip them with transmission performance which will conform to C.C.I.R. and C.C.I.T.T. Recommendations.

It is also important that a careful study is made on the route composition and connection method at the connecting terminal stations.



Future Transmission Network Plan

Fig. II - 13

CHAPTER III RESULTS OF SITE SELECTION AND CONTINUOUS RECORDING TEST OF RECEIVED RADIO POWER

III RESULTS OF SITE SELECTION AND CONTINUOUS RECORDING TEST OF RECEIVED RADIO POWER

Following the first survey which was conducted in the August~October period of the previous year, the Survey Mission carried out a re-survey of the proposed site location and propagation tests over a period of about 40 days from February 5th to March 17th, 1971 with the cooperation of I.B.T.E. engineers.

For propagation test, a continuous recording test of received radio power including the measurement of height pattern was conducted in four sections including those with a long hop distance and/or low path propagation sections where the reflected wave was not shielded. Because of the delay in arrival of the test equipment sent from Japan by air and the work required for the installation of equipment and the erection of towers on the tops of mountains, the duration of actual recording test of received radio power had to be limited to 5 6 days for each section.

1. Results of Site Selection

1-1 Outline

Throughout the survey period the site was under continuous sunny weather and because of this, dust often obscured the visibility in horizontal direction and the confirmation of the line-of-sight by mirror test was frequently hampered at each proposed site. However, the Mission was able to review the findings of the previous survey as a whole by conducting measurement of the location of proposed site including intermediate ridges with a transit and a survey of alternative routes. As a result, the following sites were selected.

Of these proposed plans, Plan-1 is considered to be most advantageous in that the transmission performance which conforms with C.C.I.R. Recommendation economically may be expected under this plan.

Plan-2, a substitute for Plan-1, involves some problems such as the occurrence of fading and poor condition of access road while it is possible to reduce the number of repeating stations by one. This Plan includes part of the sections where the line-of-sight was not confirmed by mirror test because of the unfavorable weather condition during the survey period. For this reason, detailed information including various factors of propagation path is omitted in this report.

The sections which are likely to present specific problems in relation to propagation characteristics are the Zuai West~Abaro section (No. 3 Route) and the Mt. Furi~Waliso North section (No. 4 Route). This may also be said of the Waliso North Fofa North section (No. 4 Route) under Plan-2. In order to attain the transmission performance specified in C.C.I.R. Recommendations, therefore, it will be necessary to adopt the space diversity system for these sections.

As the included angles between radio paths at Mt. Furi, Dire Dawa, Abaro and Adama West (Branching route) are rather small to suppress the radio interference due to F-B or F-S coupling, a careful study must be made of frequency allotment plan.

1-1-1 Addis Ababa~Dire Dawa~Harrar route (No. 2 Route)

This route under Plan-1 consists of three base band sections- Addis Ababa~Nazareth, Nazareth~Dire Dawa and Dire Dawa~Harrar - as shown in the following map and has a total hop distance of about 470 km.

The radio and carrier terminal station in Addis Ababa is situated at the same place as that of No. 1 Route, now under construction at the site of old headquarter.

As the Nazareth Telephone Office has a limited space both in ground area and building, expansion and modification of building will be necessary for accommodation of radio and carrier multiplex equipment.

For the Dire Dawa Telephone Office, there is a limited space for the accommodation of radio and carrier multiplex equipment and the expansion and modification of building will be necessary.

The tower (15 m above ground) installed on the roof of the Dire Dawa Telephone Office provides a good visibility toward Collubi West (In the direction of Addis Ababa) but fails to provide a visibility toward Dangago (In the direction of Harrar). In order to secure a ridge clearance in the direction of Harrar, it will be necessary to construct a steel tower of 75 m or more in height above ground.

In order to use the antenna at Dire Dawa at an effective height of 30 m above ground, the following methods are conceivable:

1) 2-reflector (30 m^2 x 2) system will be provided on the mountain in the outskirts of Dire Dawa which constitutes a ridge.

2) If a new radio terminal station is to be built for Dire Dawa instead of providing it in the present Talephone Office, the station will be located at a sight in the city area of Dire Dawa where a good line-of-sight can be secured towards Collubi West and Dangago as well.

For the G. Daleccia~G. Ades section under Plan-1, there is a ridge on the propagation path. In order to secure 1st Fresnel zone at K = 2/3, therefore, the antenna height at each station must be respectively over 20 m and 35 m above ground.

Also for the Mt. Furi~Adama West Section, the antenna height at both stations must be more than 20 m above ground in order to secure a ridge clearance.

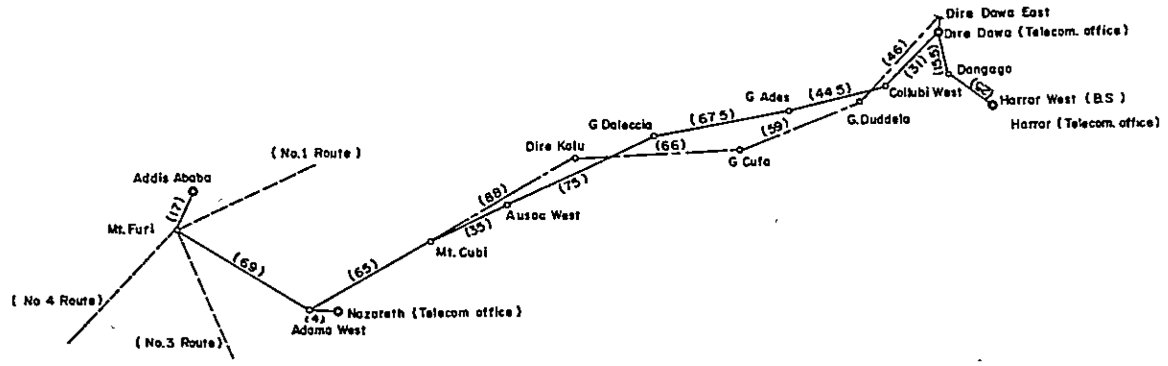
For the Adama West~G. Daleccia section, a study with the use of a map on a scale of 1 : 500,000 revealed that there will be over-reach interference which cannot be ignored when the 2 frequency reception method is used. Therefore, a careful study must also be made for frequency allocation.

As for Plan-2, the number of repeating stations may be reduced by one, but the hop distance increases on the other hand and there is also a possibility of fading occurrence. As the line-of-sight cannot be secured for the G. Duddela~Dire Dawa section, it will also be necessary to take such measures as the installation of a reflector at Dire Dawa East. The site in G. Cufa is located considerably far from the all weather road and construction of an access road having a total length of about 7 km will be necessary. For the Mt. Cubi~Dire Kalu~G. Cufa section, the line-of-sight was not confirmed by mirror test because of unfavorable weather condition.

The Dire Dawa~Harrar section has one repeating station (Dangago) and its total hop distance is about 40 km. The Harrar Telephone Office is an automatic telephone exchange located almost in the center of the city and has sufficient space to accommodate carrier multiplex equipment.

As Harrar is situated in a basin surrounded by mountains on three sides, no visibility between Dangago and Harrar could be secured. For this reason, Harrar West (where a broadcast station is located) has been selected as a proposed site. As the distance between Harrar West and the Harrar Telephone Office is less than 4 km along the road, the entrance by means of coaxial cable will be more advantageous than connection by microwave system.

Map of microwave route between ADDIS ABABA and DIRE DAWA and HARRAR (No. 2 Route)



A.A - DIRE DAWA Route

Nazareth
(Plan-1) A.A. — Mt. Furi — Adama West — Mt. Cubi — Auasc West — G. Daleccia — G. Ades — Collubi West —
Dire Dawa (Telecom. office)

Nazareth
(Plan-2) A.A. — Mt. Furi — Adama West — Mt. Cubi — Dire Kalu — G. Cufa — G. Duddela — Dire Dawa East —
Dire Dawa (Telecom. office)

DIRE DAWA - HARRAR Route

Dire Dawa (Telecom. office) — Dangago — Harrar West (B.S.) —ww— Harrar (Telecom. office)
(cox)

1-1-2 Addis Ababa~ Shashemane route (No. 3 Route)

Under Plan-1 this route consists of 5 sections as shown in the map below and has a total hop distance of about 230 km.

The existing building of the Shashemane Telephone Office has no extra space to accommodate radio and carrier multiplex equipment. Therefore, it will be necessary to construct a new building in the city area to house such equipment.

In the first survey a route originating from Mt. Furi, passing through Adama West and reaching Meki North was considered. As a result of the second survey, however, a direct route linking Mt. Furi with Meki North was adopted for the following reasons.

(1) In the Adama West~ Meki North section there is no intermediate ridge which shields the reflected wave and because of the fact that the reflection point is on the water surface in the lake, strong reflected wave is expected.

(2) The line-of-sight between Mt. Furi and Meki North has been confirmed.

(3) The number of repeating stations may be reduced by one.

Although the Zuai West~Abaro section has a long propagation path (89.5 km) on which the reflected wave is not shielded, a propagation test showed relatively good results. However, as a considerably deep fading is anticipated during the rainy season, adoption of the space diversity system will be required as a countermeasure.

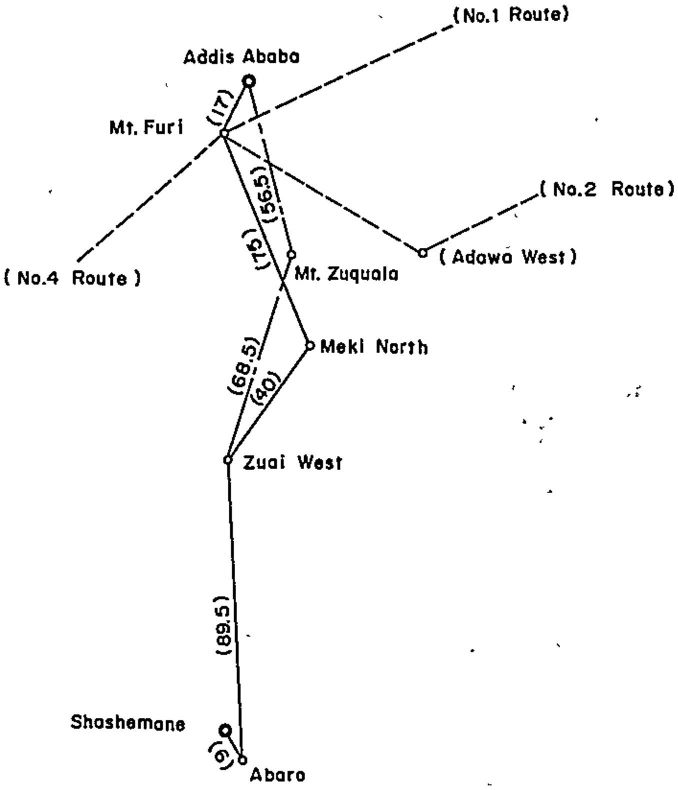
For Shashemane, difficulties were encountered in selecting a site for terminal station which can command a direct view of the city area because of a hill in the northern part of the city.

Selection of Abaro which is situated in the south-east section of Shashemane as a site of repeating station will be advantageous for interconnection with an international circuit linked to Kenya in the future.

Under Plan-2, while the number of repeating stations may be reduced by one, there are some problems on road condition. The proposed site at Mt. Zuquala is about 35 km from the all weather road and involves considerable difficulties in the repair of the existing road and construction of a new access road. In the Mt. Zuquala ~Zuai West section, the line-of-sight was not confirmed by mirror test because of unfavorable weather condition.

Map of microwave route between ADDIS ABABA and SHASHEMANE

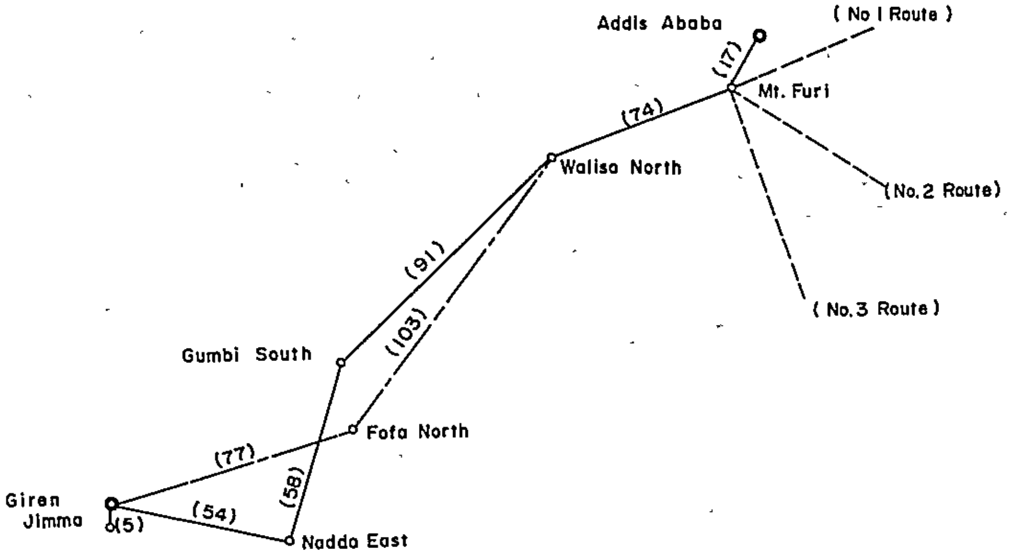
(No. 3 Route)



(Plan-1) A.A. — Mt. Furi — Meki North — Zuai West — Abaro — Shashemane

(Plan-2) A.A. — Mt. Zuquala — Zuai West — Abaro — Shashemane

Map of microwave route between ADDISABABA and JIMMA (No. 4 Route)



(Plan-1) A. A. — Mt. Furi — Waliso North — Gumbi South — Nadda East — Giren — Jimma (Telecom. office)

(Plan-2) A. A. — Mt. Furi — Waliso North — Fofa North — Giren — Jimma (Telecom office)

1-2 Proposed Site and Profiles

Approximate values of latitude, longitude, altitude and hop distance of each proposed site are given in Table I-1 ~ Table I-3. Profile maps (K = 4/3, K = 2/3) are shown in Fig. III-3 ~ Fig. III-42. For guide maps, topographic sketches of the sites and vicinities and that photographs refer to Fig. III-43 ~ Fig. III-132.

1-3 Calculation of Various Factors for Each Propagation Path

The profile maps shown in Fig. III-3 ~ Fig. III-42 were prepared on the basis of the maps on a scale of 1 : 500,000 and the data obtained during the field survey. Various factors for each propagation path given in Table III-1 ~ Table III-9 were calculated from the data obtained from these profile maps. The conditions for the calculation of these factors are the same as those given in the previous report on No. 1 Route (March, 1970). For frequency band, however, assumption was made that 4 GHz band was used for No. 2 and No. 3 Routes and that 2 GHz band was used for No. 4 Route.

1-4 Mutual Interference between Communication Satellite System and Terrestrial Microwave Communication System

1-4-1 Outline

The site of the earth station for communication satellite system in Addis Ababa has been selected in Sululta approximately 12 km northwest of the city of Addis Ababa. Also in the previous survey for No. 1 Route a study was made on the mutual interference to/from this site. The study on the mutual interference was based on the following criteria.

(1) The minimum allowable transmission loss from the terrestrial microwave station to the earth station, Lb (4 GHz band), is to be obtained from the following formula:

$$Lb(20\%) + Fs + D_{\theta t} + D_{\theta r} \geq 274 \text{ (dB)}$$

(All factors used are the same as those given in the Report on No. 1 Route)

(2) The minimum allowable transmission loss from the earth station to the terrestrial microwave station, Lb (6 HGz band), is to be obtained from the following formula:

$$Lb(20\%) + Fs + D_{\theta t} + D_{\theta r} \geq 264.4 \text{ (dB)}$$

(3) Concerning the interference of the terrestrial microwave station with the orbit of stationary communication satellite, it is necessary that the main beam of any antenna of terrestrial microwave station will not direct less than 2° away from the stationary orbit.

1-4-2 Results of Study

(1) Interference of terrestrial microwave station with satellite earth station

The line-of-sight between the earth station and the terrestrial microwave station is obstructed by mountains around the earth station. However, a greater ridge loss cannot be expected from these mountains because they are so close to the earth station. The ridge loss in 4 GHz band was calculated by the theoretical method for the knife edge on the basis of the results of a measurement with a transit and the declination obtained from the map.

The differences between the required ridge loss and that obtained from the map for particularly small sections are as follows:

Although the study on No. 4 Route should have been made with 2 GHz band, calculations for this report were made with 4 GHz band.

Interfering stations		Stations being interfered	Required ridge loss (dB)	Calculated ridge loss (dB)
Terrestrial microwave station				
Transmission	Receiving	Earth Station		
Mt. Furi	Addis Ababa	Sululta	31*	33
Adama West	Mt. Furi		32	41
G. Ades	G. Daleccia		29.5	40+
Abaro	Shashemane		30	40+
Meki North	Mt. Furi		38.5	40+
Abaro	Zuai West		50.5	40
Waliso North	Mt. Furi		31	38
Gumbi South	Waliso North		36.5	40+

(Note) * : 9 dB equalization of transmission loss is considered.

The above table shows that in one interfering route (Abaro→Sululta) the ridge loss does not satisfies the required ridge loss. As the values of calculated ridge loss were assumed from a map on a scale of 1 : 500,000, a further study on the interfering route including other interfering routes will be necessary.

(2) Interference of satellite earth station with terrestrial microwave station

This interference takes a course quite opposite to that of the interference of terrestrial microwave station with satellite earth station discussed in the previous paragraph a) and the results of the study may be used as they are. In this case, however, the minimum allowable transmission loss is less than that in the case of 4 GHz band, discussed in the previous paragraph (1), by about 10 dB.

(3) Interference of terrestrial microwave station with orbit of stationary communication satellite

Under Plan-1 none of the proposed routes has any site which radiates within the range of ±2° of the orbit of stationary communication satellite.

The above are the results of a map study for Sululta, a proposed site of the satellite earth station. Though this site, being situated close to the capital city of Addis Ababa, is favorably located for construction of control line, attention must be paid to the mutual interference following the establishment of a terrestrial microwave station in the future. It will be necessary to consider relocation of the satellite earth station from Sululta to another appropriate location depending on the circumstances.

2. Results of Continuous Recording Test of Received Radio Power

2-1 Outline

Continuous recording tests of received radio power were conducted for the 4 sections where the hopdistances are relatively long and/or the reflected waves are not shielded, out of the proposed routes selected during the preliminary survey.

At the transmission side, a collapsible tower of 3 m high was erected, on which an antenna (1.2 m ϕ parabolic antenna) and a transmitter were installed. At the receiving side, a collapsible tower of 3 m high was erected, on which an antenna (electromagnetic horn) and a field intensity meter were installed and the received radio power was recorded continuously with a recorder. On the other hand, measurement of height pattern was made several times a day with the use of a simple propagation test pole (15 m high with an elevator).

100 V AC power was supplied by a gasoline engine generator and a rectifier was used to provide the transmitter with DC 24 V power.

The equipments used for the test are as follows:

Two 6 GHz test transmitters: Transmitting power of more than 26 dBm

Two 6 GHz field intensity meters: Power range of -40~-95 dBm

Antenna: One 1.2 m ϕ parabolic antenna (for transmission)
One 0.5 m ϕ parabolic antenna (for measurement of height pattern)
One electromagnetic horn (for receiving)

Two recorders

Gasoline engine generator: Three 1 KvA generators
One 600 VA generator

Other accessory equipment: One complete set

2-2 Test Results

The test sections, hop distances and a summary of the results of the continuous recording test of received radio power are shown in the table below.

Item / Section	Hop distance (km)	Transmitting power (dBm)	Antenna	Feeder loss (dB)	Receiving power (dBm)		Fading range (dB)	
					Cacl value	50% value	Depth (1-50%)	Rise (50-99%)
Gumbi South~Waliso North	91	26	1.2 m ϕ - Horn	4	-66.7	-73.5	2.6	2.5
Mt Furi~Waliso North	74	26	1.2 m ϕ - Horn	4	-64.9	-62.3	6.3	3.7
Abaro~Zuai West	89.5	26	1.2 m ϕ - Horn	4	-66.5	-72.5	5.0	3.3
Adama West ~Meki North	47.5	26	1.2 m ϕ - Horn	4	-61	-57	3.3	2.7

Note: Antenna Gain 1.2 m ϕ, 33.5 dB
Horn, 25 dB

2-2-1 Gumbi ~ Waliso North

This is a long section with a hop distance of 91 km. As a part of the reflected wave is shielded by a ridge on the propagation path and the reflection point is on the waste land, the effective reflection coefficient is such a small value as around 0. 3. However, because of the decrease in the ridge loss of the reflected wave by the increase of K and due to the fact that the area around the reflection point is expected to turn a muddy land temporarily during the rainy season (July ~ September), there is the possibility of a greater reflection coefficient..

The test results show a stable fading depth of 2. 6 dB (1% hourly rate) and fading range of 5. 1 dB (1% ~ 99%), with no duct type fading recognized in spite of the long hop distance. This is attributable to the fact that there was no temperature nor humidity inversion because of strong wind and dry air throughout the survey period. There are only scintillation fading which fluctuates within a very small range such as 2 ~ 3 dB and the range of height pattern was only about a few dB.

The chief reason for obtaining such stable values, with small variations in the level for both daytime and nighttime as described above, is considered to be that the continuous recording test of received radio power was conducted under stable weather condition.

2-2-2 Mt. Furi ~ Waliso North

Besides being a long section with a hop distance of 74 km, this section has no ridge to shield the reflected wave. The area around the reflection point is a grassland dominated by weeds and the effective reflection coefficient is 0. 4 ~ 0. 5

The difference of temperature between the day and night is around 25°C and the humidity, while being as low as less than 40% during the daytime, sometimes exceeds 80% at night. There were occassions when the fog was observed during early morning hours. The propagation test conducted at a highland and under peculiar weather condition as mentioned above showed a comparatively large variation of field intensity and the fading exceeding 30 dB was observed. The occurrence of fading is considered to have been caused by a duct which was formed by temperature or humidity inversion as a result of the sudden coolness at night.

According to the test results, the fading depth was 6. 3d dB (1% hourly rate), the fading range (1% ~ 99%) was 10 dB and the range of height pattern was 9 dB on the average.

From the results of the continuous recording test of received radio power, the occurrence probability of K type and duct type fading is estimated at about 15% by hourly rate. The duct type fading occurs mainly at night and in early morning and fading exceeding 20 dB was observed on several occasions. The probability of decrease in the field intensity exceeding 30 dB was about 0. 01% by hourly rate.

2-2-3 Abaro ~ Zuai West

Besides being a long section with a hop distance of 89.5 km, this section has a part which forms a propagation path over the water surface and has no ridge to shield the reflected wave. The area around the reflection points, on the other hand, is a field with scattered shrubs and the effective reflection coefficient is about 0.4. Because of the fact that a part of the propagation path is over the lake and that the section has a long hop distance, frequent occurrence of duct type fading was anticipated. According to the test results, the occurrences were less than anticipated. This is attributable to the fact that the wind was so strong and the air was so dry during the entire test period that it prevented the occurrence of fading.

The test results show a fading depth (1% hourly rate) of 5 dB, a fading range (1%~ 90%) of 8.3 dB and the range of height pattern of about 8 dB on the average.

From the record the occurrence probability of K type and duct type fading is estimated at about 10% by hourly rate and the fading is considered to be mostly of the K type. Although the fading was observed to exceed 20 dB, it never exceeded 30 dB.

2-2-4 Adama West ~ Meki North

This section is a standard section with a hop distance of 47.5 km, but it has no ridge to shield the reflected wave. Furthermore, this section has its reflection point on the lake water. Accordingly, the effective reflection coefficient is such a large value as about 0.8.

According to the test results, the fading depth (1% hourly rate) was 3.3 dB and the fading range (1%~ 99%) was 6 dB, which were comparatively stable. The results of height pattern measurement showed a considerable influence of the nearby reflected wave, but there was less fading through variation of K than anticipated.

During the test period, the fading which is considered to be of the duct type occurred once and the fading exceeding 20 dB was observed. However, the occurrence of fading was for a comparatively short period of time. As the line-of-sight between Mt. Furi and Meki North were confirmed during the second survey, it was decided to select the Mt. Furi - Meki North section instead of this section.

2-3 Conclusions

The continuous recording tests of received radio power were conducted in 4 sections over a period of 40 days. As the test period for one section was very short, being 5 to 6 days, it is rather difficult to conclude the propagation characteristics of each section. As a result of a field intensity test, however, the following data were obtained.

(1) In the section where the reflected wave is not completely shielded, the occurrence of K type fading is expected. From the pitch of height pattern, K is estimated at about 5/3, which is slightly greater than the average value of 4/3 for the region of mid latitudes. The variation of K during the test period was 1.0~ 3.0 (Refer to Fig. III-1).

(2) The reflection coefficient of the reflection surface (field and plain) without water content is 0.4 ~ 0.5. When the reflection surface has a high water content at the time of rainfall, the coefficient of 0.7 ~ 0.8 should be expected. (Refer to Fig. III-2). For this reason, the section where the reflected wave is not shielded should be excluded from site selection as much as possible. If such a section must be used as a route for unavailable reasons, it will be necessary to take some measures concerning the reflected wave.

(3) The occurrence of Rayleigh fading was seldom observed during the entire test period. Although the occurrence probability of Rayleigh fading for the Mt. Furi ~ Waliso North section was 0.03 according to the results of calculation with the use of a formula for 6 GHz band, the measured value is considerably smaller than this. Therefore, it is presumed that even under the worst propagation condition the occurrence probability of Rayleigh fading will not be greater than the calculated value.

Fig. III-1 K Distribution Table

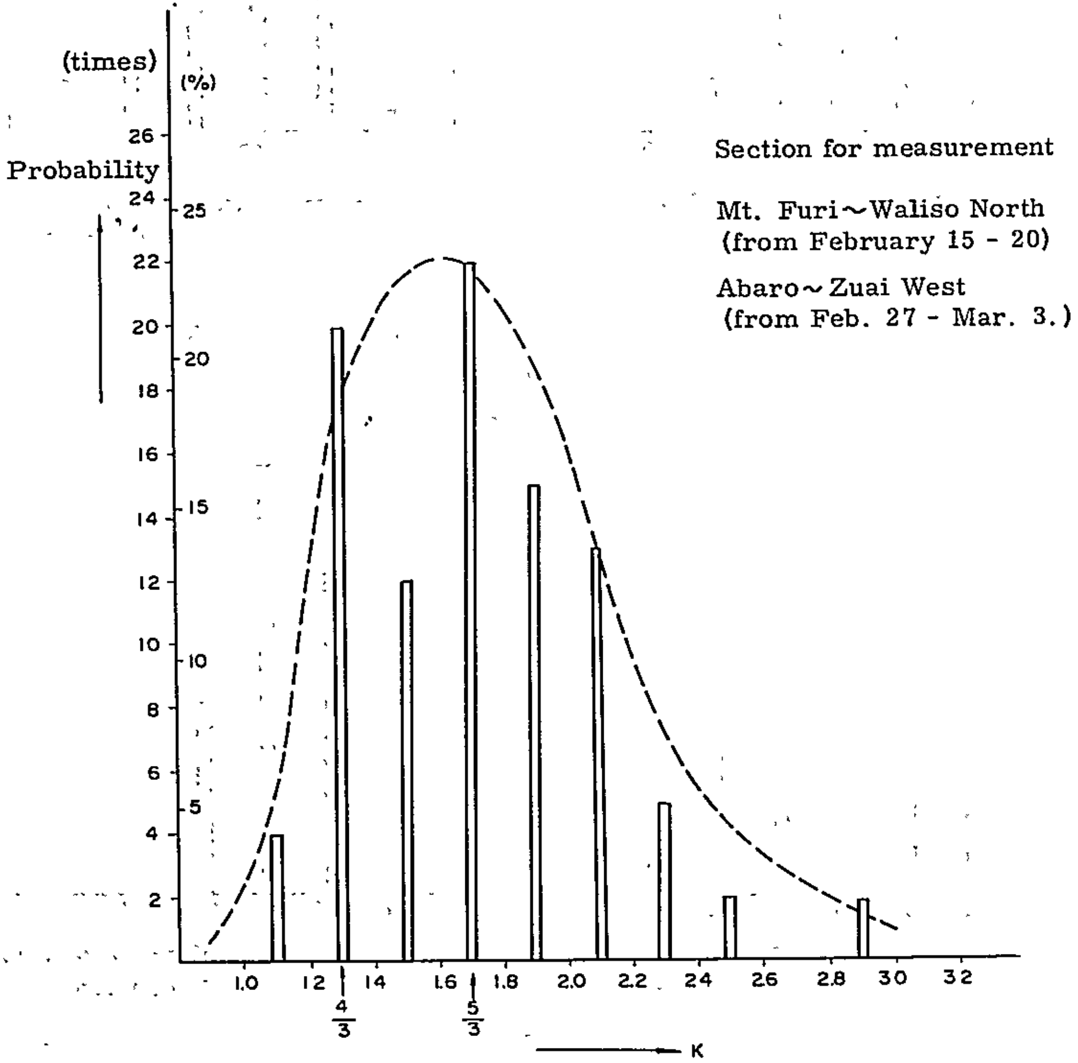
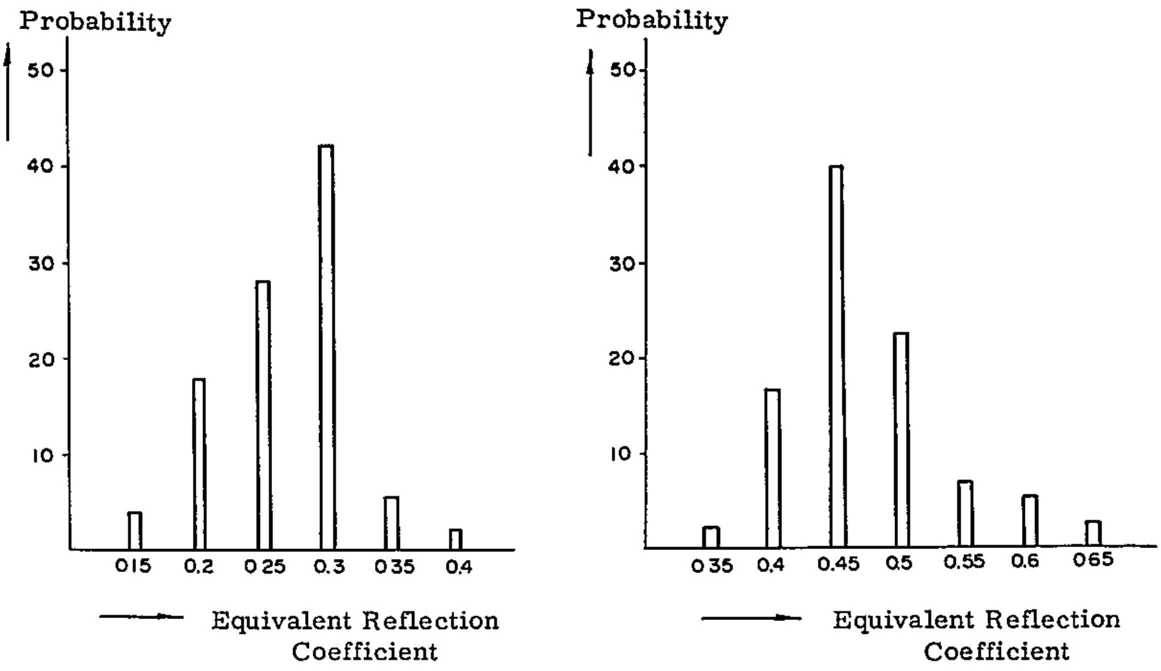
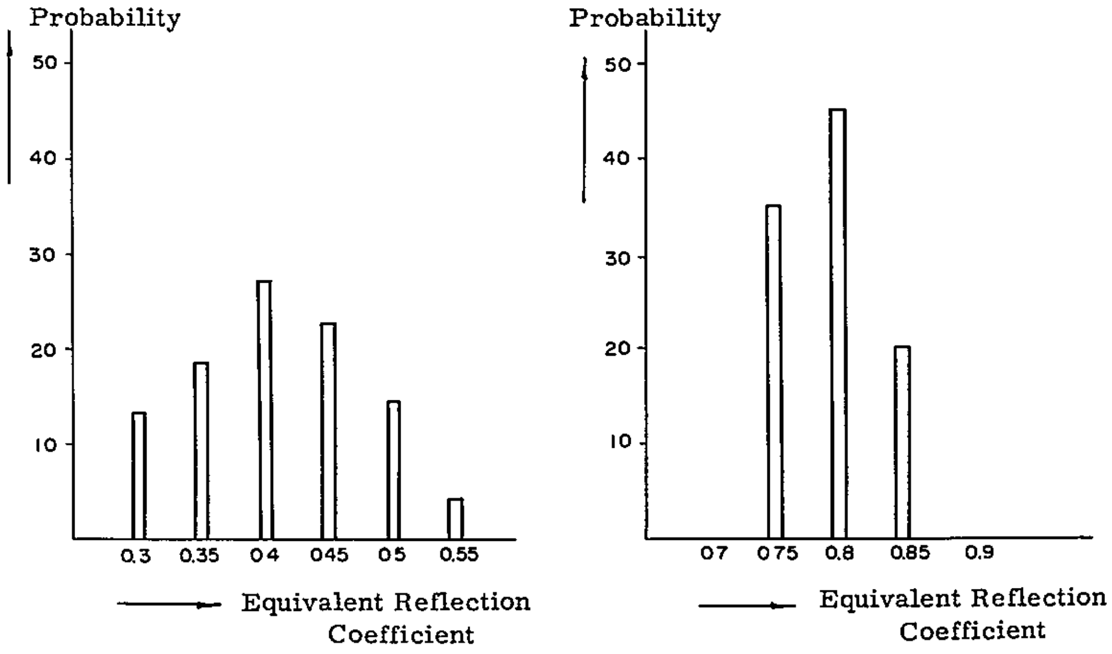


Fig. III-2 Equivalent Reflection Coefficient Table


1. Gambi South — Waliso North

2. Mt. Furi — Waliso North


3. Abaro — Zuai West

4. Adama West — Meki North

CHAPTER IV SYSTEM DESIGN

IV SYSTEM DESIGN

1. Configuration of Transmission Network

The configuration of transmission network is shown in Fig. I-1.

2. Design Condition of Radio Link

Both No. 2 and No. 3 Routes, like No. 1 Route, are important trunk routes which are expected to be interconnected to international links in the future. Moreover, the mutual interference with a satellite earth station scheduled to be constructed in Sululta cannot be ignored.

In designing the link due consideration was given to attain the transmission performance compatible with that of an international link and the utmost efforts were made to work out an economical design with construction cost reduced as much as possible. However, it is almost impossible to satisfy all the requirements simultaneously. For example, as the measures to reduce the cost, due consideration should be given to the reduction in the number of repeating stations and the construction of access roads of footpath standard to solve the problem of increase in the length of access roads resulting from the decreased number of repeating stations.

For allowable noise power in the radio link, efforts were made to design the link so as to meet the requirements specified in C.C.I.R. Recommendations as in the case of No. 1 Route.

No. 2 Route was divided into the following three modulator— demodulator sections.

Addis Ababa ~ Nazareth (90 km)

Nazareth ~ Dire Dawa (322 km)

Dire Dawa ~ Harrar West (40.5 km)

No. 3 Route comprises

Addis Ababa ~ Shashemane section (230.5 km);

and No. 4 Route comprises

Addis Ababa ~ Jimma section (299 km)

The designs of the above routes are to be in compliance with the design conditions contained in the Report for No. 1 Route (March,1970) unless otherwise specified.

3. Quality of Radio Link, Radio Frequency Band and Applied Radio System

3-1 Radio Frequency Band and Radio Frequency Channel Arrangement

For radio frequency channel arrangement, 4 GHz band is used for No. 2 and No. 3 Routes as in the case of No. 1 Route and 2 GHz band is used for No. 4 Route.

Tables IV-1 ~ IV-3 show the examples of radio frequency channel arrangements and polarization for each route.

For radio frequency channel arrangement and polarization, normal frequency of V-polarization is used in principle. However, for the following sections where the desired system quality cannot be obtained because of F-B and over-reach interferences, the interleaved frequency and H-polarization is used.

The interleaved frequency is used for the Addis Ababa ~ Mt. Furi section in No. 2 and No. 3 Routes because of the small included angle between the Mt. Furi ~ Sendafa East section and Mt. Furi ~ Addis Ababa section, which was confirmed at the time of designing No. 1 Route.

(1) No. 2 Route

As the angle of the propagation path of Nazareth ~ Adama West to that of Adama West ~ Mt. Cubi is 45.5° and the angle between the path of Collubi West ~ Dire Dawa and that of Dire Dawa ~ Dangago is 77°, both of which are considered comparatively small, there is considerable F-S interference. For this reason, the interleaved frequency is used for the Nazareth ~ Adama West section and the Dire Dawa ~ Dangago ~ Harrar section.

As the interference by over-reach propagation occurs more considerably in the Adama West ~ G. Daleccia section, the interleaved frequency is used for the Adama West ~ Mt. Cubi section.

(2) No. 3 Route

The radio frequency channel arrangement and polarization for this route have been determined in such a manner as to reduce interference noise by taking into account the branching angles of Mt. Furi to each route. An example of this design is shown in Table IV-2. The branching angles of Mt. Furi to each route are shown in Fig. I-2.

As the angle of the path of the Zuai West ~ Abaro section to that of the Abaro-Shashemane section is as small as 19.3°, F-B interference of high intensity is observed.

In order to reduce interference noise, therefore, it is necessary to arrange the radio frequency for the Abaro ~ Shashemane section so as to separate it from that for the Zuai West ~ Abaro section by more than 29 MHz.

(3) No. 4 Route

For the design of this route, the use of 2 GHz band has been contemplated. Therefore, there is no problem of interference with other routes. However, F-B interference is considerable in each section. To solve this problem, the four frequency reception method shown in Table IV-3 has been adopted.

3-2 Applied System and Equipment

In designing the radio system, the following conditions were taken into consideration.

(1) Radio frequency band

No. 2 Route & No. 3 Route: FDM-FM system operating in the 4 GHz band
No. 4 Route: FDM-FM system operating in the 2 GHz band

(2) Transmission capacity

No. 2 Route & No. 3 Route: 960 CH or TV (M. TV) per system
No. 4 Route: 600 CH or TV (M. TV) per system

(3) Transmission power

4 GHz band: 29.5 dBm
2 GHz band: 34.0 dBm

(4) Antenna

4 m ϕ parabolic antenna is used in principle. When there is less interference noise, a parabolic antenna of either 3.0 m ϕ or 2.0 m ϕ is used. The same antenna is to be used for transmission and receiving.

(5) Characteristics of equipment

The characteristics of the equipment mentioned in this report are shown in Table IV-4.

3-3 Quality of Radio Link

The results of calculation of the quality of radio link made with the use of the characteristics of the equipment shown in Table IV-4 are given below.

3-3-1 Addis Ababa ~ Dire Dawa route (No. 2 Route)

Summaries of the results of study are shown in Table IV-5 and IV-8. However, the study was made on the assumption that it may be possible to take the following measures.

(1) Addis Ababa ~ Mt. Furi section

The interleaved frequency is to be used and the transmission power is to be decreased by 9 dB as in the case of No. 1 Route.

(2) Adama West ~ Mt. Cubi section

The interleaved frequency is to be used to reduce over-reach interference in the Adama West ~ G. Daleccia section.

(3) Adama West ~ Nazareth section

As the interleaved frequency has been used for the Adama West ~ Mt. Cubi section (preceding paragraph b) and the angle of path of the Nazareth ~ Adama West section to that of the Adama West ~ Mt. Cubi section is 45.5°, thus causing considerable F-B interference, normal frequency has been used for the Nazareth ~ Adama West section in order to reduce interference. Also, in order to reduce F-S interference and receiver distortion, the transmission power from Adama West to Nazareth and from Nazareth to Adama West is to be reduced by 15 dB with attenuator.

(4) Dire Dawa ~ Dangago ~ Harrar West section

As the included angle of path between the Collubi West ~ Dire Dawa section and the Dire Dawa ~ Dangago section is 77°, thus causing considerable F-B interference, the interleaved frequency is used for the Dire Dawa ~ Dangago ~ Harrar West section in order to reduce the interference. As the included angle of path between the Dire Dawa ~ Dangago section and the Dangago ~ Harrar section is 157°, the use of a 3.0 m ϕ parabolic antenna will increase F-B interference. In order to reduce interference resulting from this situation, a 4.0 m ϕ parabolic antenna is to be used for transmission from Dangago to Harrar.

3-3-2 Addis Ababa ~ Shashemane route (No. 3 Route)

The results of study are shown in Table IV-9. However, the following improvement measures were taken into consideration.

(1) Mt. Furi ~ Meki North section

For this section, the interleaved frequency which causes less interference is considered most appropriate in view of the angle of path between Mt. Furi and each route.

(2) Abaro ~ Shashemane section

The included angle of path between the Zuai West ~ Abaro section and the Abaro ~ Shashemane section is 19.3°, thus causing considerable F-S interference. In order to reduce the interference, therefore, it is necessary to separate the frequency for the Abaro ~ Shashemane section from that for the Zuai West ~ Abaro section by more than 29 MHz. As this section has such a short hop distance as 9 km, a 3.0 m ϕ parabolic antenna is to be used in consideration of F-B interference and receiver distortion. It is also necessary to reduce transmission power at both stations by 9 dB with attenuators.

3-3-3 Addis Ababa ~ Jimma route (No. 4 Route)

For this route, the four frequency reception method is used in order to reduce F-B interference.

The results of study are shown in Table IV-10. For the study, the following improvement measures were taken into consideration.

(1) Addis Ababa ~ Mt. Furi section

Because of such a short hop distance as 17 km, a 3.0 m ϕ parabolic antenna is used.

(2) Giren ~ Jimma section

Because of the extreme short hop distance such as 5 km, a 2.0 m ϕ parabolic antenna is used. Also, in order to reduce receiver distortion, it is necessary to reduce transmission power at both stations by 6 dB with attenuators.

3-4 A Study on Noise Burst Probability

The results of study on the probability of noise burst exceeding 1,000,000 pW for No. 2 and No. 3 Routes (4 GHz band) and for No. 4 Route (2 GHz band) are shown in Table IV-11 ~ Table IV-15. Similar to the Report for No. 1 Route, the study for this report was made on the assumption that the method of estimation which is based on the extensive data obtained in Japan may also be applied to the system in Ethiopia. As a result, the system design, which satisfies the requirements specified in C.C.I.R. Recommendations, as shown in Table IV-11 ~ Table IV-13, was obtained.

The Zuai West ~ Abaro section of No. 3 Route shown in Table IV-14 has such a long hop distance as 89.5 km. This section has a large effective reflection coefficient with lake water being on both sides of its propagation path and, moreover, it is a low path propagation section. Such being the case, frequent occurrence of fading is expected. In order to meet the requirements specified in C.C.I.R. Recommendations, it is necessary to adopt the space diversity system so as to reduce the noise burst probability exceeding 10^6 pW.

No. 4 Route is not in conformity with the requirements specified in C.C.I.R. Recommendation as shown in Table IV-15. Particularly the Mt. Furi ~ Waliso North section, with a long hop distance of 74 km, has a large effective reflection coefficient and it turns to a swamp during the rainy season. For this reason, frequent occurrence of fading is expected in this section. Therefore, the use of the space diversity system must be considered. In order to ensure effectiveness of improvement work through the use of the frequency diversity system, it is desirable to provide a large separation between the frequencies to be used.

3-5 Overall Performance

Table IV-5 (No. 2 Route), Table IV-9 (No. 3 Route) and Table IV-10 (No. 4 Route) show overall performance, a summarization of the previous paragraphs 3-3-1 ~ 3-3-3. Table IV-5 is a summarization of Table IV-6 ~ Table IV-8. The allowable noise power in the radio link as a whole meets the requirements specified in C.C.I.R. Recommendations although the margin is very little. In the two modulation ~ demodulation sections, namely the Addis Ababa ~ Nazareth section and the Dire Dawa ~ Harrar West section, in particular, 3 LpW is not satisfied because of the short hop distance of these sections. For overall performance of the system, however, the requirements are all satisfied.

In the event of changes in the factors required for the design of the above-mentioned routes, a review must be made in each case.

The above are the results of study on 4 GHz band (No. 2 Route and No. 3 Route) and 2 GHz band (No. 4 Route).

For the application of 6 GHz band and 6 GHz upper band to No. 2 and No. 3 Routes and 4 GHz band to No. 4 Route, the followings must be satisfied.

(1) 6GHz band and 6 GHz upper band (No. 2 and No. 3 Route)

(a) As for thermal noise, the receiving power should be equivalent to that for 4 GHz band. Because the antenna gain is larger than that of 4 GHz band, however, the feeder loss and free space loss will increase.

Table IV - 1. Radio-Channel Frequency Arrangement & Polarization (4GHz band C. C. I. R. Rec. 382)
(No. 2 Route)

Frequency	Channel No.	Addis Ababa
3810	1.1	SP
3824.5	1	
3839	1.2	No.2
3853.5	2	
3868	1.3	No.1 TV
3882.5	3	
3897	1.4	No 3.
3911.5	4	
3926	1.5	No.1 TP
3940.5	5	
3955	1.6	
3969.5	6	
4023	1.1'	SP
4037.5	1'	
4052	1.2'	No.2
4066.5	2'	
4081	1.3'	No.1 TV
4095.5	3'	
4110	1.4'	No.3
4124.5	4'	
4139	1.5'	No.1 TP
4153.5	5'	
4168	1.6'	
4182.5	6'	

Polarization

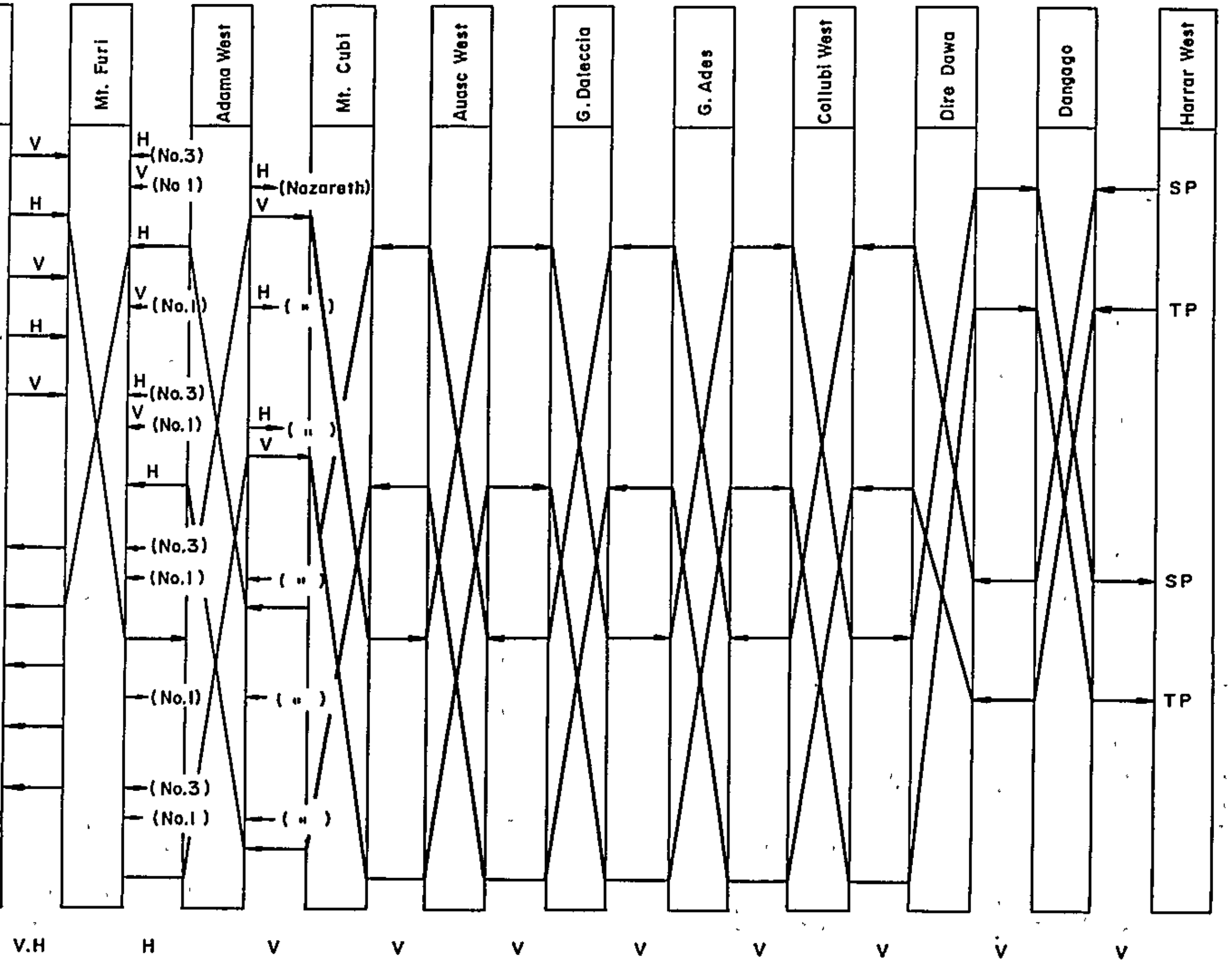
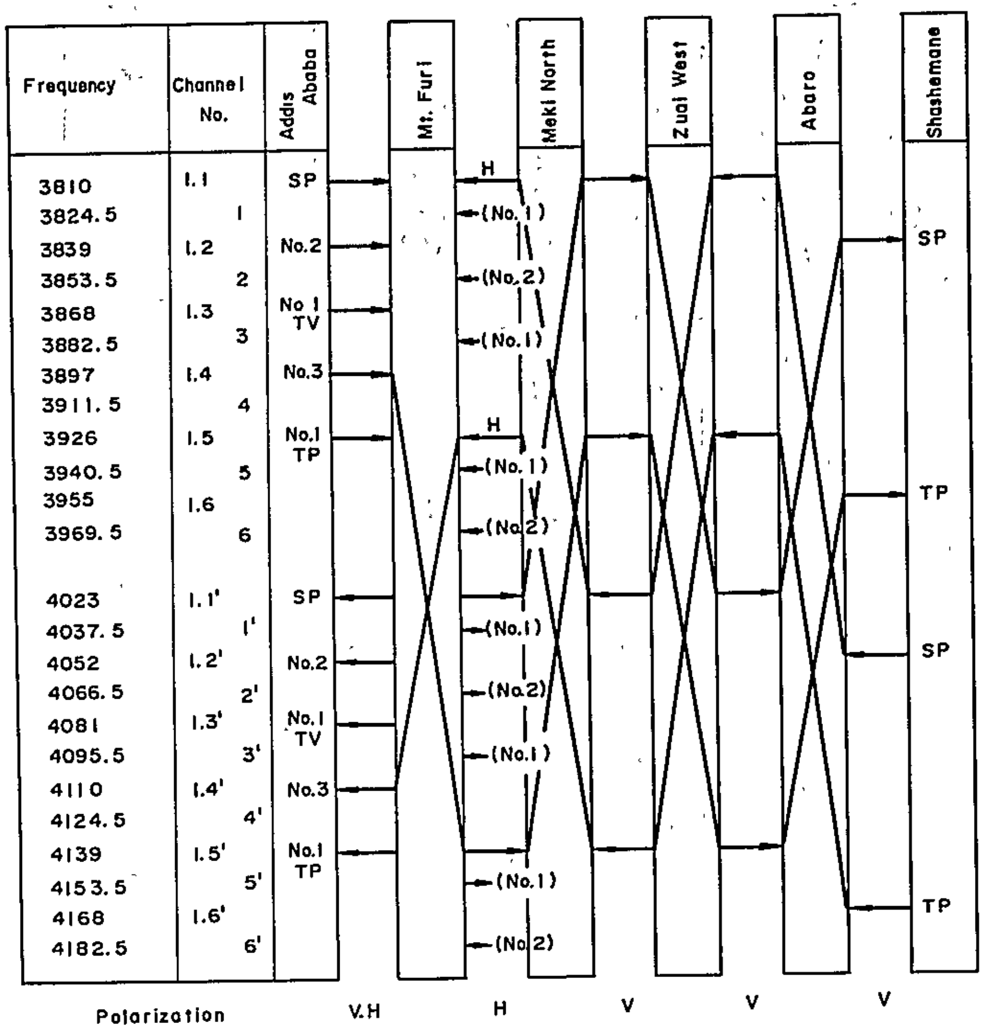


Table IV - 2. Radio-Channel Frequency Arrangement & Polarization (4GHz band C. C. I. R. Rec. 382) (No. 3 Route)



Frequency	Channel No.		Addis Ababa
3810	1.1		SP
3824.5		1	
3839	1.2		No.2
3853.5		2	
3868	1.3		No 1 TV
3882.5		3	
3897	1.4		No.3
3911.5		4	
3926	1.5		No.1 TP
3940.5		5	
3955	1.6		
3969.5		6	
4023	1.1'		SP
4037.5		1'	
4052	1.2'		No.2
4066.5		2'	
4081	1.3'		No.1 TV
4095.5		3'	
4110	1.4'		No.3
4124.5		4'	
4139	1.5'		No.1 TP
4153.5		5'	
4168	1.6'		
4182.5		6'	

Table IV - 3. Radio-Channel Frequency Arrangement & Polarization (2GHz C. C.I.R. Rec. 382-1)
(No. 4 Route)

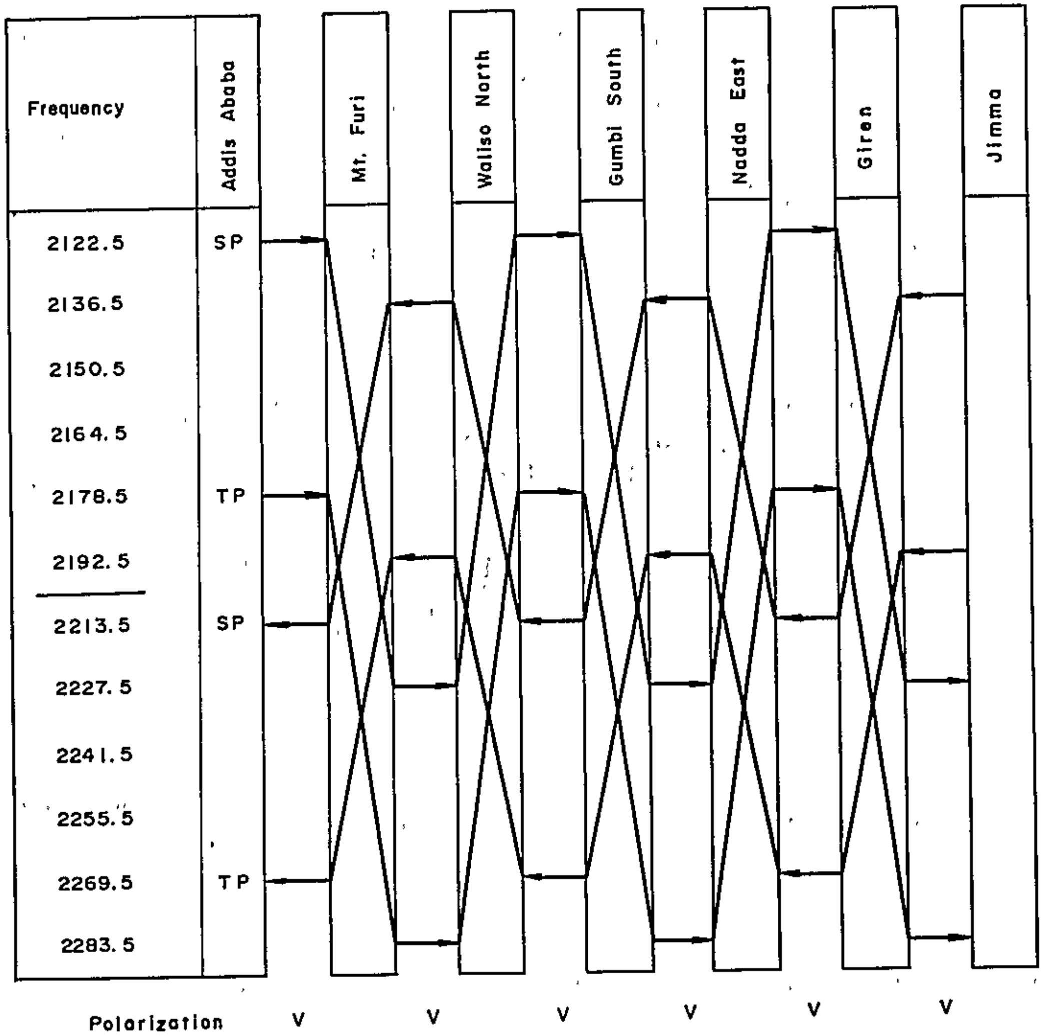


Table IV-4 Applied Characteristics of Equipment

Radio Frequency (GHz)	2	4
Transmission capaicity	600 CH or TV	960 CH or TV
Transmission output power (dBm)	34	29.5
Noise figure (dB)	7	6.7
SQL (operation) point (dBm)	-79	-76 ~ -80
Modulator & demodulator Thermal noise pW/EP	30	30
Auxiliary equipment: Thermal noise pW/EP	45	45
Antènna: (Parabolic Antenna)		
4 mϕ gain/Front-to-Back Coupling	35.6/50	42/63
3 mϕ "	33/47	39.5/60
2 mϕ "	31.4/43	36/56
Feeder:		
Attenuation dB/m	0.06	0.035
V.S.W.R.	under 1.08	under 1.05
Branching filter:		
Attenuation dB/trans. receiv.	5	4.6

Table IV-5 Over-all Circuit Performance for the Addis Ababa ~ Dire Dawa ~ Harrar section

(4 GHz 960 CH)

Section / Item		Addis Ababa ~ Nazareth	Nazareth ~ Dire Dawa	Dire Dawa ~ Harrar West	Total
Distance of Video section (km)		90	322	40.5	452.5
Number of hops		3	7	2	12
Noise power in the radio section (unweighted)	Thermal noise (pW)	201.5	350.9	109.6	662
	Distortion noise (pW)	296	578	238	1112
	Interference noise (pW)	36.3 32.3	271.4 282.9	35.3 67	343 382.2
	Total (pW)	533.8 529.8	1,200.3 1,211.8	382.9 414.6	2,117 2,156.2
	C.C.I.R. Recommendation (pW)	481	1,719.5	216	2,416.5

Note: $\frac{\text{Down ward}}{\text{Up ward}}$

Table IV-6 Addis Ababa ~ Nazareth Section

(4 GHz 960 CH)

Section	Thermal noise		Intermodulation noise	Interference noise					
	Repeater	Others	2nd 3rd	Feeder echo	Propagation distortion	F/B	Over-reach	F/S	Others
	pW	pW	pW	pW	pW	pW	pW	pW	pW
Addis Ababa									
	32.4	75	296	9.2	0.4	$\frac{0.3}{1.6}$	$\frac{-}{0}$		
Mt. Furi									
	67.7			10	0	$\frac{0.7}{1.5}$	$\frac{-}{0}$	$\frac{1.2}{0}$	
Adama West									
	26.4			9.5	0			$\frac{5}{0.1}$	
Nazareth									
Sub-total	126.5	75	296	28.7	0.4	$\frac{1.0}{3.1}$	$\frac{-}{0}$	$\frac{6.2}{0.1}$	
Total	201.5		296	$\frac{36.3}{32.3}$					
Total for section	$\frac{533.8}{529.8}$								
C.C.I.R. Recommendation	3L = 481 pW								

Note: $\frac{\text{Down ward}}{\text{Up ward}}$

Table IV-7 Nazareth~ Dire Dawa Section

(4 GHz 960 CH)

Section	Thermal noise		Intermodulation noise	Interference noise					
	Repeater	Others	2nd 3rd	Feeder echo	Propagation distortion	F/B	Over-reach	F/S	Others
	pW	pW	pW	pW	pW	pW	pW	pW	pW
Nazareth									
	26.4	75	578	9.5	0			$\frac{0.3}{20}$	
Adama West									
	51.3			9.8	4.5	$\frac{1.1}{0.6}$	$\frac{0}{45}$	$\frac{0}{4}$	
Mt. Cubi									
	14.8			9.8	20.9	$\frac{3.5}{5.0}$	$\frac{0}{1}$		
Auasc West									
	67.7			9.8	0.2	$\frac{25}{77.5}$	$\frac{60}{0}$		
G. Daleccia									
	72.6			10	0	$\frac{41.3}{17.6}$	$\frac{4.6}{0}$		
G. Ades									
	29.6			9.9	0.2	$\frac{36.6}{10.2}$	$\frac{0}{0}$		
Collubi West									
	13.5			9.2	0.2	$\frac{5}{8}$	$\frac{0}{0}$		
Dire Dawa									
Sub-total	275.9	75	578	68	26	$\frac{112.5}{118.9}$	$\frac{64.6}{46}$	$\frac{0.3}{24}$	
Total	350.9		578	$\frac{271.4}{282.9}$					
Total for section	$\frac{1200.3}{1211.8}$								
C.C.I.R. Recommendation	3L = 1719.5 pW								

Note: $\frac{\text{Down ward}}{\text{Up ward}}$

Table IV-8 Dire Dawa~Harrar Section

(4 GHz 960 CH)

Section	Thermal noise		Intermodulation noise	Interference noise					
	Repeater	Others	2nd 3rd	Feeder echo	Propagation distortion	F/B	Over-reach	F/S	Others
	pW	pW	pW	pW	pW	pW	pW	pW	pW
Dire Dawa									
	19.2	75	238	7.2	0	$\frac{13.3}{10}$	$\underline{0}$		
Dangago									
	15.4			9.8	0	$\frac{5}{40}$	0		
Harrar									
Sub-total	34.6	75	238	17	0	$\frac{18.3}{50}$	$\underline{0}$	0	
Total	109.6		238	$\frac{35.3}{67}$					
Total for section	$\frac{382.9}{414.6}$								
C.C.I.R. Recommendation	3L = 216 pW								

Table IV-9 Noise Power in the Addis Ababa~Shashemane Section

(4 GHz 960 CH)

Section	Thermal noise		Intermodulation noise	Interference noise					
	Repeater	Others	2nd 3rd	Feeder echo	Propagation distortion	F/B	Over-reach	F/S	Others
	pW	pW	pW	pW	pW	pW	pW	pW	pW
Addis Ababa									
	32.4	75	427	9.2	0.4	$\frac{6.5}{40}$	$\frac{}{0}$		
Mt. Furi									
	67.7			9.8	0	$\frac{56.9}{44}$	12		
Meki North									
	19.1			9.8	0	$\frac{8}{9.5}$	$\frac{0}{0}$		
Zuai West									
	95.5			9.8	0.4	$\frac{5}{79.5}$	$\underline{17.4}$		
Abaro									
	33.9			9.9	0	$\frac{0}{0}$	$\underline{0}$		
Shashemane									
Sub-total	248.6	75	427	48.5	0.8	$\frac{76.4}{173}$	$\frac{17.4}{12}$		
Total	323.6		427	$\frac{143.1}{234.3}$					
Total for section	$\frac{893.7}{984.9}$								
C.C.I.R. Recommendation	3L = 1231 pW								

Table IV-10 Noise Power in the Addis Ababa～Jimma Section

(2 GHz 600 CH)

Section	Thermal noise		Intermodulation noise	Interference noise					
	Repeater	Others	2nd 3rd	Feeder echo	Propagation distortion	F/B	Over-reach	F/S	Others
	pW	pW	pW	pW	pW	pW	pW	pW	pW
Addis Ababa	18.2	75	500	30	3.9	0/0	/0		
Mt. Furi	79.5			32.4	118	0/0.2	/0		
Waliso North	120.1			32.4	4.5	0/0	0/0		
Gumbi South	49.1			32.4	1.7/0	0.3/0.2	0/0		
Nadda East	41.7			32.4	64.6	2.0/0.2	0/		
Giren	11.5			33.6	0.2	0.5/0	0/		
Jimma									
Sub-total	320.1	75	500	193.2	192.9/191.2	2.8/0.6	0	0	0
Total	395.1		500	388.9/385					
Total for section	1284/1280.1								
C.C.I.R. Recommendation	3L = 1596.7 pW								

Note: Down ward / Up ward

Table IV-11 No. 2 Route

Frequency 4 GHz

Item		Addis Ababa～ Nazareth			
Switching Section / Station		Addis Ababa	Mt. Furi	Adama West	Nazareth
Propagation path condition		Field	Mountain	Field	
Propagation path-height (in case over-sea)	m				
Hop distance	Km	17	69	4	
Distance of switching section (L)	Km	90			
Thermal noise (No.)	pW	32.4	67.7	26.4	
Occurrence probability of Rayleigh fading (P)	10^{-4}	1.03	56.08	0.007	
Ditto (Pe) (in case of reflection coefficient more than about 0.3)	10^{-2}	-	-	-	
Probability of noise burst exceeding 1,000,000 pW (Pi)	10^{-8}	1.0	113.9	0	
Total of Pi in one section	10^{-8}	114.9			
Ditto (including the noise-switching effect)	10^{-8}	(Improvement factor 1/5) 22.98			
C.C.I.R. Recommendation (0.01%)	10^{-8}	4L : 360			

Table IV-12 No. 2 Route

Frequency 4 GHz

Switching Section / Station / Item		Nazareth ~ Dire Dawa						
		Naza-reth Adama West	Mt. Cubi	Auasi West	G. Daleccia	G. Ades	Collubi West	Dire Dawa
Propagation path condition		Field	Field .	Field	Field	Mountain	Mountain	Mountain
Propagation path-height (in case over-sea)	m							
Hop distance	Km	4	65	35	75	67.5	44.5	31
Distance of switching section (L)	Km	322						
Thermal noise (No.)	pW	26.4	51.3	14.8	67.7	72.6	29.6	13.5
Occurrence probability of Rayleigh fading (P)	10^{-4}	0.007	113.58	13.01	187.43	51.92	12.08	3.41
Ditto (Pe) (in case of reflection co-efficient more than about 0.3)	10^{-2}	-	-	-	(0.43) 22	-	-	-
Probability of noise burst exceeding 1,000,000 pW (Pi)	10^{-8}	0	174.8	5.8	2978.8	113.1	10.7	1.4
Total of Pi in one section	10^{-8}	3284.6						
Ditto (including the noise-switching effect)	10^{-8}	(Improvement factor 1/5) 657						
C.C.I.R. Recom-mendation (0.01%)	10^{-8}	4L : 1288						

Table IV-13 No. 2 Route

Frequency 4 GHz

Switching section / Station / Item		Dire Dawa ~ Harrar			
		Dire Dawa	Dangago	Harrar West	
Propagation path condition			Mountain	Field	
Propagation path-height (in case over-sea)	m				
Hop distance	Km		15.5	25	
Distance of switching section (L)	Km	40.5			
Thermal noise (No.)	pW		19.2	15.4	
Occurrence probability of Rayleigh fading (P)	10^{-4}		0.3	3.99	
Ditto (Pe) (in case of reflection coefficient more than about 0.3)	10^{-2}		-	(0.36) 1	
Probability of noise burst exceeding 1,000,000 pW (Pi)	10^{-8}		0.2	30.8	
Total of Pi in one section	10^{-8}	31			
Ditto (including the noise-switching effect)	10^{-8}	(improvement factor 1/5) 6.2			
C.C.I.R. Recom-mendation (0.01%)	10^{-8}	4L : 162			

Table IV-14 No. 3 Route

Frequency 4 GHz

Item \ Switching Section / Station		Addis Ababa ～ Shashemane					
		Addis Ababa	Mt. Furi	Meki North	Zuai West	Aboso	Shashe-mane
Propagation path condition		Plain	Plain	Overseas	Overseas	Plain	
Propagation path-height (in case over-sea)	m			26	205		
Hop distance	Km	17	75	40	89.5	9	
Distance of switching section (L)	Km	230.5					
Thermal noise (No.)	pW	32.4	67.7	19.1	95.5	33.9	
Occurrence probability of Rayleigh fading (P)	10^{-4}	1.03	187.43	301.9	1795	0.11	
Ditto (Pe) (in case of reflection coefficient more than about 0.3)	10^{-2}	-	-	-	(0.44) 36	-	
Probability of noise burst exceeding 1,000,000 pW (Pi)	10^{-8}	1.0	380.7	173	6876	0.1	
Total of Pi in one section	10^{-8}	7430.8					
Ditto (including the noise-switching effect)	10^{-8}	(improvement factors 1/5) 1486.2					
C.C.I.R. Recom-mendation (0.01%)	10^{-8}	4L : 922					

Table IV-15 No. 4 Route

Frequency 2 GHz

Item \ Switching Section / Station		Addis Ababa ～ Jimma						
		Addis Ababa	Mt. Furi	Waliso North	Gumbi South	Nadda East	Giren	Jimma
Propagation path condition		Field	Field	Field	Montain	Field	Field	
Propagation path-height (in case over-sea)	m							
Hop distance	Km	17	74	91	58	54	5	
Distance of switching section (L)	Km	299						
Thermal noise (No.)	pW	18.2	79.5	120.1	49.1	41.7	11.5	
Occurrence probability of Rayleigh fading (P)	10^{-4}	0.45	77.4	158.5	13.6	25.6	0.006	
Ditto (Pe) (in case of reflection coefficient more than about 0.3)	10^{-2}	-	(0.72) 49	-	-	(0.34) 2.3	-	
Probability of noise burst exceeding 1,000,000 pW (Pi)	10^{-8}	0.2	7791	571.1	20	191.8	0	
Total of Pi in one section	10^{-8}	8574.1						
Ditto (including the noise-switching effect)	10^{-8}	(improvement factor 1/5) 1714.8						
C.C.I.R. Recom-mendation (0.01%)	10^{-8}	4L : 1196						

(b) As for interference noise power, the antenna directivity in 6 GHz band is slightly better than that in 4 GHz band. However, in the case of greater F-B, F-S and over-reach interferences, there must be some improvement measures as in the case of 4 GHz band.

(c) As the interference from the satellite earth station makes the minimum allowable transmission loss which is more advantageous than in 4 GHz band, the transmission loss satisfied by 4 GHz band will be sufficient.

(d) As for the noise burst probability, the occurrence probability of Rayleigh fading will increase as the radio frequency becomes higher. As a countermeasure, it is necessary to adopt the space diversity system for the Zuai West∼Abaro section as in the case of the above-mentioned 4 GHz band.

(2) 4 GHz band (No. 4 Route)

The application of 4 GHz band to No. 4 Route using the characteristics of equipment shown in Table IV-4 gives almost the same results as for 2 GHz band. For radio frequency channel arrangement, 2 frequency method instead of 4 frequency method is satisfactory.

As for noise burst probability, the occurrence probability of Rayleigh fading will increase as radio frequency becomes higher.

For this reason, it is necessary to adopt the space diversity system for the Mt. Furi∼Waliso North section as in the case of 2 GHz band.

It may be concluded, therefore, that the use of any of 4 GHz and 6 GHz bands and 6 GHz upper band for No. 2 and No. 3 Routes and any of 2 GHz and 4 GHz bands for No. 4 Route will result in only small differences as long as the design conditions discussed so far are satisfied.

4. Toll Circuit Design

For toll circuit design, refer to the Report for No. 1 Route (March 1970) which was previously submitted.

For the preparation of design and technical specifications for toll circuit for each route, it is important to give due consideration to the following conditions.

4-1 Design Condition for Basic Equipment

It is advisable that the carrier terminal station for each route is equipped with the following basic equipment in order to meet the traffic demand for 10 years hence.

(1)	Addis Ababa~Dire Dawa section	960 CH
(2)	Addis Ababa~Shashemane section	480 CH
(3)	Addis Ababa~Jimma section	300 CH
(4)	Dire Dawa~Harrar section	480 CH

As the basic equipment of carrier multiplex system at the Addis Ababa will be provided under the project for No. 1 Route, it is advisable to utilize this equipment to the extent possible.

4-2 Equipment Design

As the circuit demands are small at each route the design of equipment should adopt the composite frame type for the economy sake.

4-3 Circuit Arrangement Plan in Terminal Station

The circuit arrangements in 1974 and 1984 are shown in Fig. IV-1~IV-3.

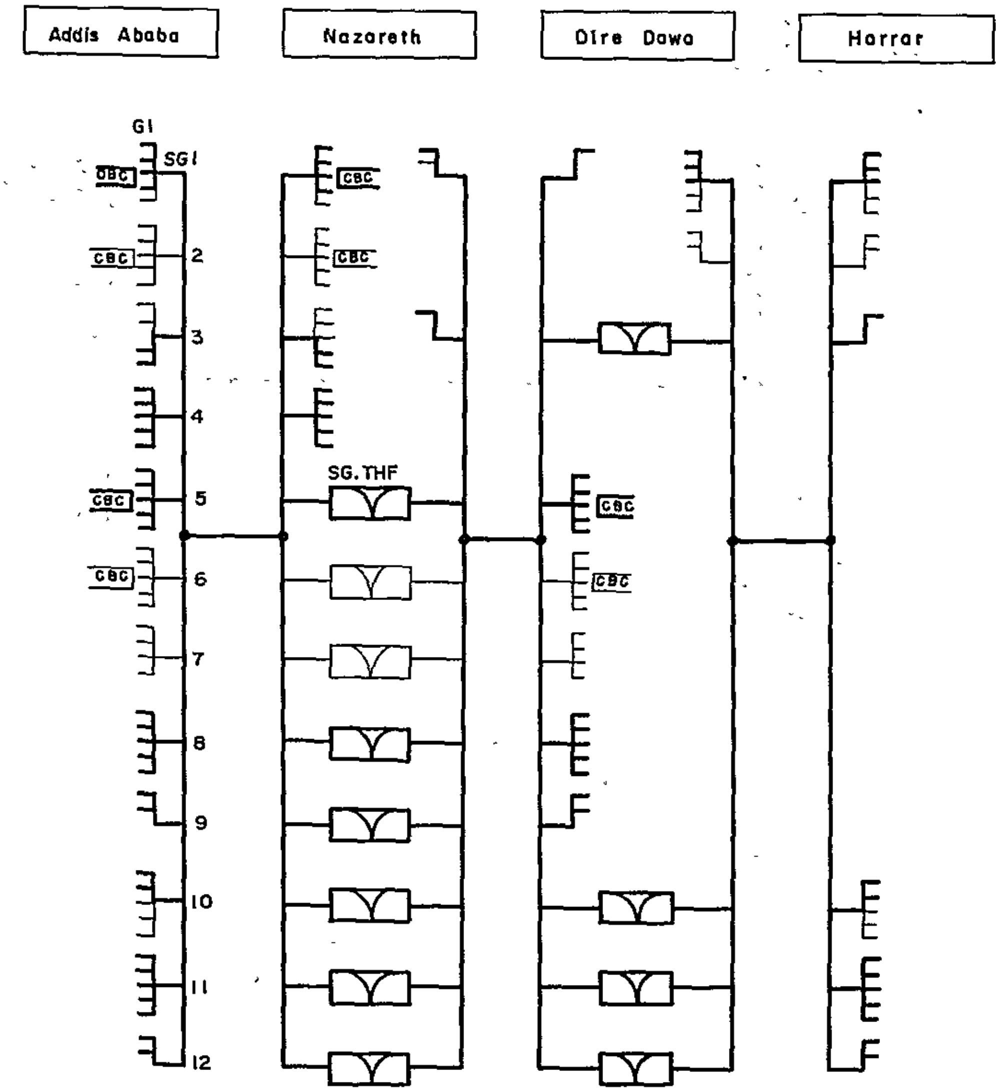
For the circuit arrangement plan, all channels, regardless of their number, are bundled in groups by circuit sections, as described in the Report (March, 1970) for No. 1 Route which was previously submitted, and these groups are bundled in super-groups by carrier terminal stations. At the transit carrier terminal stations, therefore, all connections are made with the Super-Group Through Filter.

In Addis Ababa where distribution and consolidation of groups are made for each individual route separately, group connection is used more frequently.

Under current plan, the arrangement in channel stage described above is considered appropriate because of the small number of channels. This method, however, entails back-to-back connection of channels at each terminal station, thus resulting in the increase of the cost.

It also requires changes in arrangement at every installation of an additional channel, making the work more complicated and the maintenance more difficult.

From the standpoint of transmission performance, this method is not recommended as there will be an increase in the number of channel connecting portions.



(Note) 1. Thick line means circuits in 1974. Thin line means circuits in 1984.

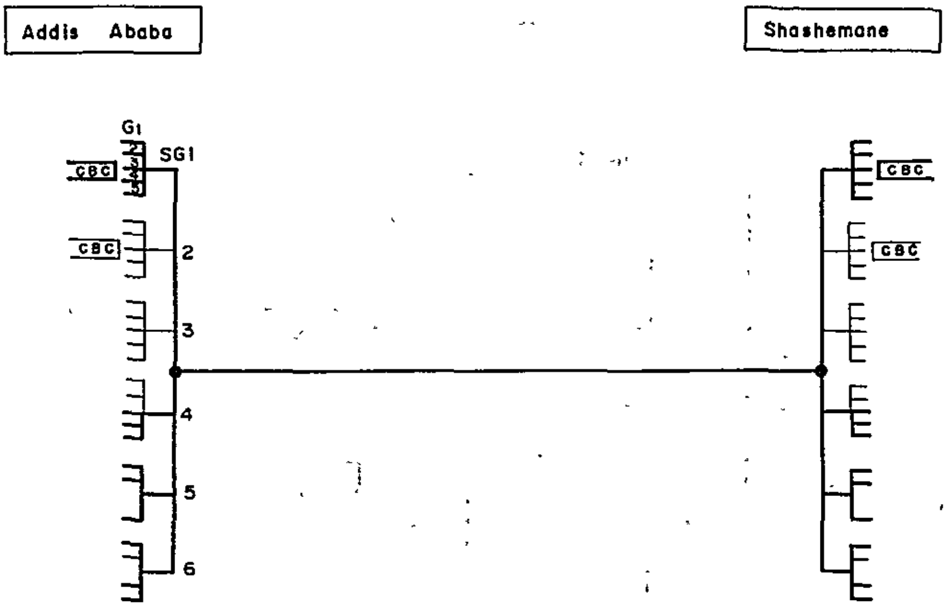
2. CBC Accommodates one program transmission circuit and nine telephone channels.

3. G : Group Translating Equipment.

SG : Super-Group Translating Equipment.

SG. THF : Super-Group Through Filter Equipment.

Diagram of Accommodated Circuits to be Required in 1974 and 1984 (No. 2 Route)	Fig. IV - 1



(Note) 1. Thick line means circuits in 1974. Thin line means circuits in 1984.

2. CBC Accommodates one program transmission circuit and nine telephone channels.

3. G : Group Translating Equipment.

SG : Super-Group Translating Equipment.

Diagram of Accommodated Circuits to be Required in 1974 and 1984. (No. 3 Route)

Fig. IV - 2

(Note) 1. Thick line means circuits in 1974. Thin line means circuits in 1984.

2. CBC Accommodates one program transmission circuit and nine telephone channels.

3. G : Group Translating Equipment.

SG : Super-Group Translating Equipment.

Diagram of Accommodated Circuits to be Required in 1974 and 1984. (No. 4 Route)

Fig. IV - 3

5. Cable System Design

Under current project, the coaxial cable system is required for the Harrar West ~ Harrar section.

For the design of coaxial cable system, reference is made to the Report for No. 1 Route (March, 1970) which was previously submitted. In designing it, the following conditions must be taken into consideration.

(1) Of the two types of coaxial cable, 9.5 mm and 4.4 mm, the use of 4.4 mm cable is advisable in view of technical requirements and economy of the cable.

(2) The coaxial cable system to be installed must be capable to transmit 600 CH or 960 CH multichannel telephone signal and, in the future, television signal (M. TV).

(3) Although the required number of tubes in the coaxial cable varies with the system composition and other factors, the use of 4 tube (2 tube for normal and 2 tube for stand-by) is considered appropriate.

However, as the number of tubes for this section is expected to vary with the route configuration, system composition, circuit connection method and the location of radio terminal station when the route is extended for connection to the Somalia route in the future, a careful study must be made in planning a new cable system. In other words;

1) If the connection to the Somalia route is made at the Harrar Telephone Office, an extra 2 tubes will be necessary.

2) If a separate microwave link is provided for the Dire Dawa ~ Somalia section, there will be no requirement for facilities for the Harrar West ~ Harrar section.

3) If the microwave link to Somalia is to be branched and inserted at Harrar West, installation of a Super-Group Translating equipment and a Super-Group Through Filter will be necessary.

4) As the number of interstitial quad and outlayer pairs, which will be required following the installation of a new coaxial cable, varies with the type of supervise and control system, final decision should be made by I. B. T. E.

5) Specifications for 4.4 mm coaxial cable and 4.4 mm coaxial cable system must conform with C.C.I.T.T.Rec. G 342 and Rec. G 343.

6. Power System Design

For the design of power system refer to the Report for No. 1 Route (March, 1970) which was previously submitted.

For the toll telephone office, the design and construction of power facilities should be provided by I.B.T.E.

Emergency power vehicles should be provided at the following 4 stations in consideration of the supervise station and the maintenance area described in the previous section I. 7.

Nazareth Radio and Carrier Terminal Station
Dire Dawa " "
Shashemane " "
Jimma. " "

7. Design of Building, Tower, Earthing and Underground Fuel Storage Tank

For the design outline and design conditions, refer to the Report for No. 1 Route (March, 1970) which was previously submitted.

7-1 Outline of Station Building and Tower

7-1-1 Addis Ababa

The building of the Addis Ababa Radio and Carrier Terminal Station is to accommodate all equipment for all routes under current project.

7-1-2 Nazareth

(1) The existing Nazareth Telephone Office is to accommodate radio and carrier multiplex equipment plus power facilities.

(2) It is necessary to provide a control room and a maintenance center in this terminal station for remote control of unattended repeating stations.

(3) It is necessary to provide office rooms and others for maintenance personnel.

(4) It is necessary to erect a tower 20 m in height above ground in the terminal station.

It is advisable that the tower is located as close to the radio equipment room as possible.

(Note) As the space of the existing Nazareth Telephone Office is so limited that the accommodation of all toll telephone equipment will not be possible. For this reason, construction of a new building will be necessary.

7-1-3 Dire Dawa

(1) The existing Dire Dawa Telephone Office is to accommodate radio and carrier multiplex equipment plus power facilities.

(2) It is necessary to provide a control room and a maintenance center in this terminal station for remote control of unattended repeating stations.

(3) It is necessary to provide office rooms and others for maintenance personnel.

(4) It is necessary to erect a tower about 75 m in height above ground in the terminal station.

It is advisable that the location of the tower is as close to the radio equipment room as possible.

(Note) 1) Though a space of about 25 m^2 has been secured in the existing telephone office for accommodating carrier multiplex equipment, it is too small for a radio and carrier terminal station. For this reason, it is necessary to secure an additional space of about 90 m^2 for such facilities including control room.

2) Although a space of about 28 m^2 has been secured for a power room, it is necessary to review the floor plan of toll telephone office.

7-1-4 Harrar

(1) Radio equipment is to be accommodated by the Harrar West Station (Present Harrar Broadcasting Station). As a result, construction of power facilities and a tower will be necessary.

(2) This radio terminal station is to be designed as an unattended station and the Harrar Telephone Office is to be designated as supervise station.

(3) Carrier multiplex equipment is to be accommodated by the existing Harrar Telephone Office.

(4) It is necessary to provide a control room and a maintenance center in this carrier terminal station for remote control of unattended stations.

(5) It is necessary to provide office rooms and others for maintenance personnel.

(Notes) 1) Since a space of about 87 m^2 has been secured in the existing Harrar Telephone Office for Radio and Carrier Room and M.D.F. Room, efficient use of this space will provide sufficient rooms for carrier multiplex equipment and control.

2) A space of 66 m^2 (35 + 31) has been secured for use as a room for housing Generator, Rectifier, and Battery. Since this space, though sufficient in size, is separated from the main room, it is desirable to integrate these facilities in the main room from a maintenance point of view.

7-1-5 Shashemane

(1) As the existing Shashemane Telephone Office is extremely limited in space, it is necessary to construct a new toll telephone office under current project.

(2) The new Shashemane Toll Telephone Office is to secure a radio and carrier multiplex equipment room and a power room to accommodate respective terminal equipment.

(3) It is necessary to provide a control room and a maintenance center in this radio and carrier terminal station for remote control of unattended stations.

(4) It is necessary to provide office rooms and others for maintenance personnel.

(5) It is necessary to erect a tower about 20 m in height above ground.

7-1-6 Jimma

(1) The existing Jimma Telephone Office is to accommodate radio and carrier multiplex equipment plus power facilities.

(2) It is necessary to provide a control room and a maintenance center in this radio and carrier terminal station for remote control of unattended stations.

(3) It is necessary to provide office rooms and others for maintenance personnel.

(4) It is necessary to erect a tower about 20 m in height above ground in the premises.

It is advisable that the tower is located as close to the radio equipment room as possible.

(Notes) 1) A space of about 80 m^2 has been secured in the existing Jimma Telephone Office for use as a radio and carrier room and a M.D.F. room. Modification of part of these rooms will be sufficient for the purpose.

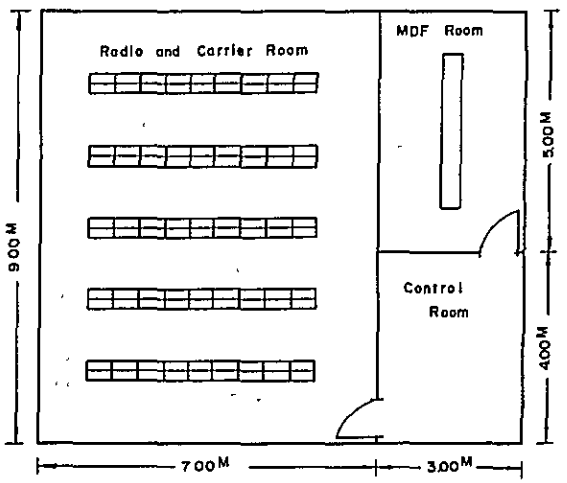
2) Although a space of 26 m^2 has been secured for use as a power room, it is considered too small for toll telephone office. It is necessary, therefore, to provide a power room separately.

7-1-7 Intermediate Repeating Stations and Branching Stations

For each of the intermediate repeating stations and branching station (Adama West) other than those mentioned above, a radio station building (Radio equipment room, power room and tower) is to be constructed.

7-2 Building Plans

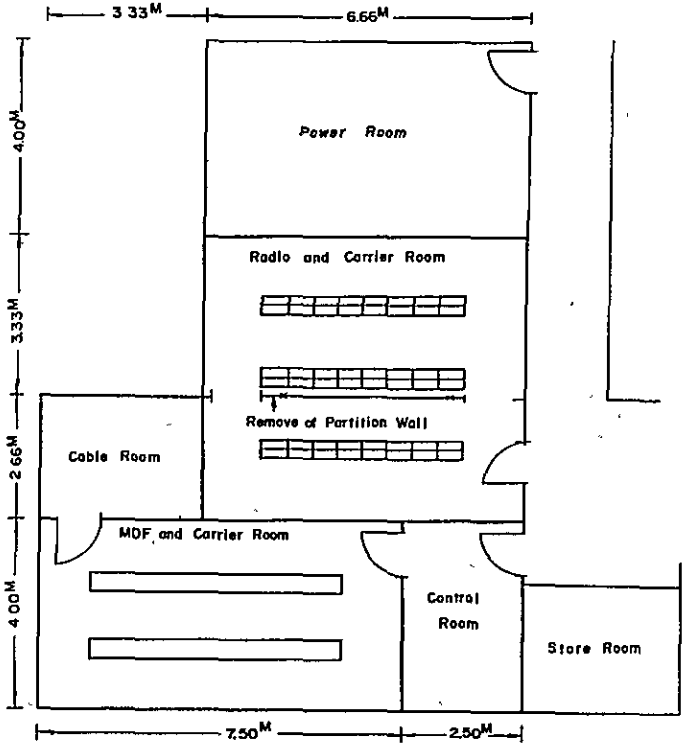
Floor layout plans for each station are shown in Fig. IV-4 - IV-8.



Floor Layout Plan

Dire Dawa, Shashemane
Nazareth

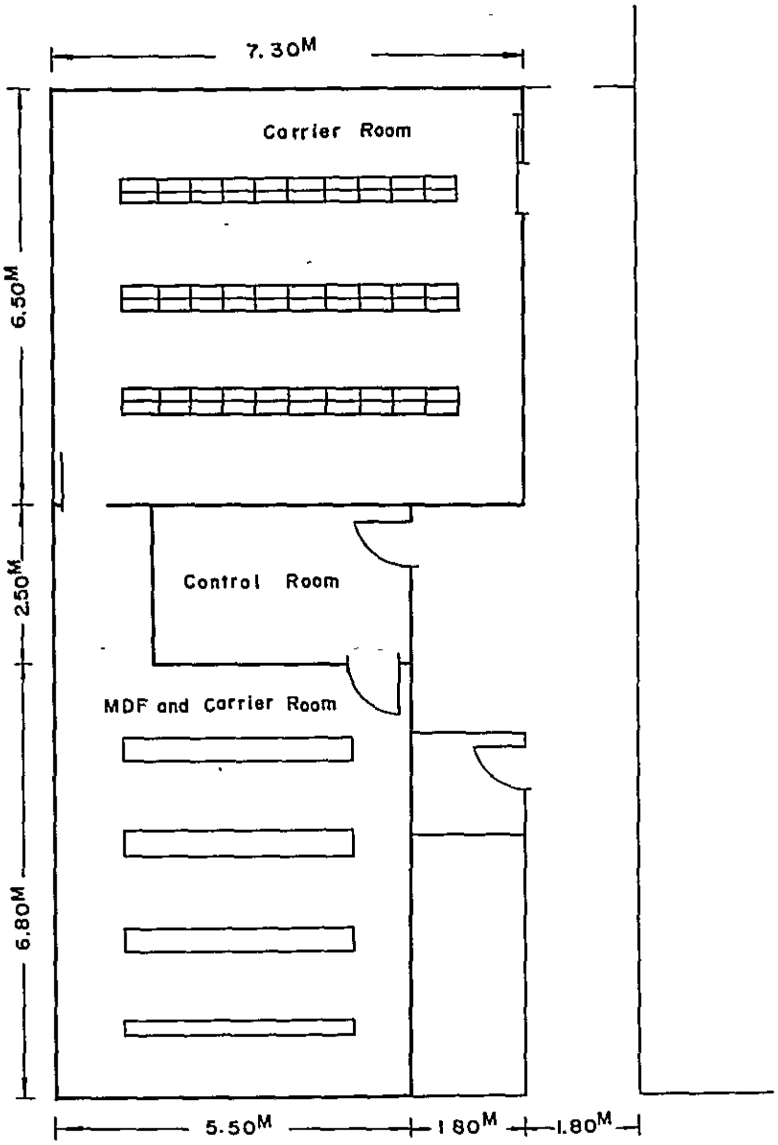
Fig. IV - 4



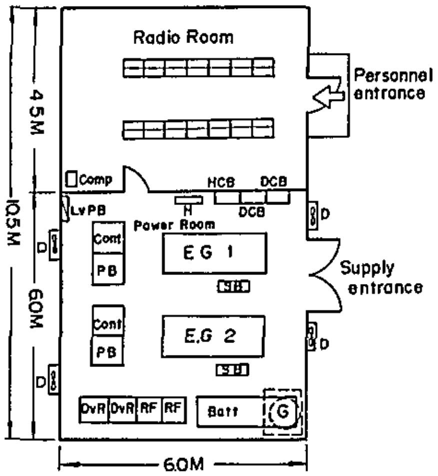
Floor Layout Plan

Jimma

Fig. IV - 5



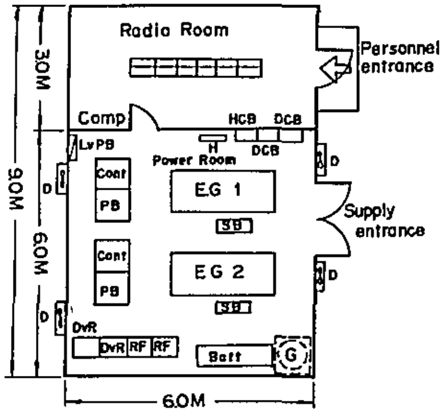
Floor Layout Plan	Harrar
	Fig. IV - 6



Floor Layout Plan

Adama West

Fig. IV - 7



Floor Layout Plan

Unattended Repeating Station

Fig. IV - 8

CHAPTER V APPENDIXES

V APPENDIXES

1. Calculated Figures of Various Fundamental Factors for Each Section
2. Profile Maps (K = 4/3, K = 2/3)
3. Guide Maps of the Proposed Sites and Topographic Sketch of the Sites and Vicinity
4. Photographs of the Proposed Sites

1. Calculated Figures of Various Fundamental Factors for Each Section

Table III-1 Calculated Figures of Various Fundamental Factors on Each Section (No. 2 Route; Plan-1)

K = 4/3

		Item / Name of Site	Addis Ababa	Mt. Furi		Adama West		Mt. Cubi
		Altitude (m)	2,400	2,800		1,840		1,500
		Antenna Height above Ground (m)	30	10	20	20	10	10
		Effective Antenna Height (m)	54.8	421.8	709.2	-11.5	287.1	-94.9
Effective Reflection Coefficient		Included Angle between Directed and Reflected Waves (°)	2.81	0.37	0.03	1.8	0.3	0.4
		Attenuation of Reflected Wave due to Antenna Directivity (dB)	20	0.5	0	15	0.5	1
		Shielding Ridge Loss of Reflected Wave (dB)			24.5		12.5	
	Reflection Point	Distance from Site (km)	2	15	66.7	2.3	46.4	18.6
		Classification of Condition	City		Field		Field	
		Reflection Loss (dB)	14		6		6	
		Altitude (m)	2,375		1,810		1,310	
		Total Loss of Refrected Wave (dB)	34.5		45.5		20	
Pass Difference		Pass Difference between Direct and Reflected Waves (m)	2.7		1.36		2.3	
		Distortion $(S/I)_{CH}$ (dB)	94.5		100<		83.5	
		Propagation Pass Length (km)	17		69		65	
		Propagation Loss in Free Space (dB)	129.1		141.3		140.8	
		Profile Map	Fig. III-3 Fig. III-4		Fig. III-5 Fig. III-6		Fig. III-7 Fig. III-8	
		Clearance	no problem		hc/ho = 1.8(K=2/3)		no problem	
		Remarks						

Table III-2 Calculated Figures of Various Fundamental Factors on Each Section (No. 2 Route; Plan-1)

K = 4/3

Item \ Name of Site			Mt. Cubi	Auasc West		G. Daleccia		G. Ades
Altitude (m)			1,500	1,100		1,770		2,570
Antenna Height above Ground (m)			10	10	10	10	20	35
Effective Antenna Height (m)			506.5	146.4	47	448.9		
Effective Reflection Coefficient	Included Angle between Directed and Reflected Waves (°)		0.48	1.66	0.68	0.07		
	Attenuation of Reflected Wave due to Antenna Directivity (dB)		1.3	14	2.6	0		
	Shielding Ridge Loss of Reflected Wave (dB)							
	Reflection Point	Distance from Site (km)	27.2	7.8	7.1	67.8		
		Classification of Condition	Field		Field			
		Reflection Loss (dB)	6		6			
		Altitude (m)	960		1,060			
	Total Loss of Reflected Wave (dB)		21.3		7.3			
Pass Difference	Pass Difference between Direct and Reflected Waves (m)		4.2		0.56			
	Distortion $(S/I)_{CH}$ (dB)		76.8		96.3		100<	
Propagation Pass Length (km)			35		75		67.5	
Propagation Loss in Free Space (dB)			135.4		147		141.1	
Profile Map			Fig. III-9 Fig. III-10		Fig. III-11 Fig. III-12		Fig. III-13 Fig. III-14	
Clearance			no problem		hc/ho=2(K=2/3)		hc/ho=1.2(K=2/3)	
Remarks								

Table III-3 Calculated Figures of Various Fundamental Factors on Each Section (No. 2 Route; Plan-1)

K = 4/3

Item \ Name of Site			G. Ades	Collubi West		Dire Dawa		Dangago
Altitude (m)			2,570	2,800		1,207		2,280
Antenna Height above Ground (m)			35	10	10	30	75	10
Effective Antenna Height (m)			-36.5	156.7	1,545.3	27	–133.3	864.7
Effective Reflection Coefficient	Included Angle between Directed and Reflected Waves (°)		2.5	0.1	0.1	5.9	11.4	0
	Attenuation of Reflected Wave due to Antenna Directivity (dB)		23	0	0	23	22	0
	Shielding Ridge Loss of Reflected Wave (dB)		38.7				35.7	
	Reflection Point	Distance from Site (km)	9.9	34.6	30.5	0.5	0.6	14.9
		Classification of Condition	Field		City		City	
		Reflection Loss (dB)	6		14		14	
		Altitude (m)	2,200		1,210		1,207	
	Total Loss of Reflected Wave (dB)		67.7		37		71.7	
Pass Difference	Pass Difference between Direct and Reflected Waves (m)		16.6		2.7		13.9	
	Distortion $(S/I)_{CH}$ (dB)		97.7		97		100<	
Propagation Pass Length (km)			44.5		31		15.5	
Propagation Loss in Free Space (dB)			137.5		134.3		128.3	
Profile Map			Fig. III-15 Fig. III-16		Fig. III-17 Fig. III-18		Fig. III-19 Fig. III-20	
Clearance			hc/ho=1(K=2/3)		hc/ho=1.8(K=2/3)		hc/ho=1(K=4/3)	
Remarks								

Table III-4 Calculated Figures of Various Fundamental Factors on Each Section (No. 2 Route; Plan-1)

K = 4/3

		Item \ Name of Site	Dangago	Harrar West
Altitude (m)			2,280	2,053
Antenna Height above Ground (m)			10	10
Effective Antenna Height (m)			207.5	12.9
Effective Reflection Coefficient		Included Angle between Direct and Reflected Waves (°)	0.06	0.94
		Attenuation of Reflected Wave due to Antenna Directivity (dB)	0	3
		Shielding Ridge Loss of Reflected Wave (dB)		
	Reflection Point	Distance from Site (km)	23.5	1.5
		Classification of Condition	Field	
		Reflection Loss (dB)	6	
		Altitude (m)	2,050	
		Total Loss of Reflected Wave (dB)	9	
Pass Difference		Pass Difference between Direct and Reflected Waves (m)	0.2	
		Distortion $(S/I)_{CH}$ (dB)	100 <	
Propagation Pass Length (km)			25	
Propagation Loss in Free Space (dB)			132.5	
Profile Map			Fig. III-21 Fig. III-22	
Clearance			no problem	
Remarks				

Table III-5 Calculated Figures of Various Fundamental Factors on Each Section (No. 2 Route; Plan-1)

K = 4/3

<table>
<tr><th colspan="3">Name of Site
Item</th><th>Adama West</th><th>Nazareth</th></tr>
<tr><td colspan="3">Altitude (m)</td><td>1,840</td><td>1,650</td></tr>
<tr><td colspan="3">Antenna Height above Ground (m)</td><td>10</td><td>20</td></tr>
<tr><td colspan="3">Effective Antenna Height (m)</td><td>199.2</td><td>20</td></tr>
<tr><td rowspan="8">Effective Reflection Coefficient</td><td colspan="2">Included Angle between Directed and Reflected Waves (°)</td><td>0.6</td><td>5.43</td></tr>
<tr><td colspan="2">Attenuation of Reflected Wave due to Antenna Directivity (dB)</td><td>1</td><td>20</td></tr>
<tr><td colspan="2">Shielding Ridge Loss of Reflected Wave (dB)</td><td colspan="2"></td></tr>
<tr><td rowspan="4">Reflection Point</td><td>Distance from Site (km)</td><td>3.6</td><td>0.4</td></tr>
<tr><td>Classification of Condition</td><td colspan="2">City</td></tr>
<tr><td>Reflection Loss (dB)</td><td colspan="2">14</td></tr>
<tr><td>Altitude (m)</td><td colspan="2">1,650</td></tr>
<tr><td colspan="2">Total Loss of Reflected Wave (dB)</td><td colspan="2">35</td></tr>
<tr><td rowspan="2">Pass Difference</td><td colspan="2">Pass Difference between Direct and Reflected Waves (m)</td><td colspan="2">2</td></tr>
<tr><td colspan="2">Distortion $(S/I)_{CH}$ (dB)</td><td colspan="2">100<</td></tr>
<tr><td colspan="3">Propagation Pass Length (km)</td><td colspan="2">4</td></tr>
<tr><td colspan="3">Propagation Loss in Free Space (dB)</td><td colspan="2">116.5</td></tr>
<tr><td colspan="3">Profile Map</td><td colspan="2">Fig. III-23
Fig. III-24</td></tr>
<tr><td colspan="3">Clearance</td><td colspan="2">no problem</td></tr>
<tr><td colspan="3">Remarks</td><td colspan="2"></td></tr>
</table>

Table III-6 Calculated Figures of Various Fundamental Factors on Each Section (No. 3 Route; Plan-1)

K = 4/3

Item		Name of Site	Addis Ababa	Mt. Furi		Meki North		Zuai West
Altitude (m)			2,400	2,800		1,720		1,750
Antenna Height above Ground (m)			30	10	10	10	10	10
Effective Antenna Height (m)			54.8	421.8	784.1	19.8	34.1	17.1
Effective Reflection Coefficient		Included Angle between Directed and Reflected Waves (°)	2.81	0.37	0.03	1.25	0.18	0.26
		Attenuation of Reflected Wave due to Antenna Directivity (dB)	20	0.5	0	9	0	0.3
		Shielding Ridge Loss of Reflected Wave (dB)					15.5	
	Reflection Point	Distance from Site (km)	2	15	73.3	1.7	20.1	19.9
		Classification of Condition	City		Field		Water Surface	
		Reflection Loss (dB)	14		6		0	
		Altitude (m)	2,375		1,710		1,630	
		Total Loss of Reflected Wave (dB)	34.5		15		15.8	
Pass Difference		Pass Difference between Direct and Reflected Waves (m)	2.72		0.4		0.1	
		Distortion $(S/I)_{CH}$ (dB)	94.5		100<		100<	
Propagation Pass Length (km)			17		75		40	
Propagation Loss in Free Space (dB)			129.1		142		136.5	
Profile Map			Fig. III-3 Fig. III-4		Fig. III-25 Fig. III-26		Fig. III-27 Fig. III-28	
Clearance			no problem		hc/ho=1.7(K=2/3)		no problem	
Remarks								

Table III-7 Calculated Figures of Various Fundamental Factors on Each Section (No. 3 Route; Plan-1)

K = 4/3

Item			Zuai West	Abaro		Shashemane
Altitude (m)			1,750	2,280		1,960
Antenna Height above Ground (m)			10	10	10	20
Effective Antenna Height (m)			81.2	328.6	325.8	20
Effective Reflection Coefficient	Included Angle between Directed and Reflected Waves (°)		0.42	0.1	0.25	4.2
	Attenuation of Reflected Wave due to Antenna Directivity (dB)		1	0	0.1	20
	Shielding Ridge Loss of Reflected Wave (dB)					
	Reflection Point	Distance from Site (km)	17.9	71.6	8.5	0.5
		Classification of Condition	Field		City	
		Reflection Loss (dB)	6		14	
		Altitude (m)	1,660		1,960	
	Total Loss of Reflected Wave (dB)		7		34.1	
Pass Difference	Pass Difference between Direct and Reflected Waves (m)		0.6		1.45	
	Distortion $(S/I)_{CH}$ (dB)		94		100<	
Propagation Pass Length (km)			89.5		9	
Propagation Loss in Free Space (dB)			143.5		123.6	
Profile Map			Fig. III-29 Fig. III-30		Fig. III-31 Fig. III-32	
Clearance			no problem			
Remarks						

Table III-8 Calculated Figures of Various Fundamental Factors on Each Section (No. 4 Route; Plan-1)

K = 4/3

Item \ Name of Site			Addid Ababa	Mt. Furi		Waliso North		Gumbi South
Altitude (m)			2,400	2,800		2,400		2,230
Antenna Height above Ground (m)			30	10	10	10	10	10
Effective Antenna Height (m)			54.8	421.8	483.4	210.5	335.1	84.8
Effective Reflection Coefficient	Included Angle between Directed and Reflected Waves (°)		2.81	0.37	0.33	0.75	0.35	0.63
	Attenuation of Reflected Wave due to Antenna Directivity (dB)		7.5	0.1	0.1	0.7	0.2	0.3
	Shielding Ridge Loss of Reflected Wave (dB)						17.5	
	Reflection Point	Distance from Site (km)	2	15	51.6	22.4	55.1	35.9
		Classification of Condition	City		Swamp		Field	
		Reflection Loss (dB)	10		2		4	
		Altitude (m)	2,375		2,170		1,800	
	Total Loss of Reflected Wave (dB)		17.6		2.8		22	
Pass Difference	Pass Difference between Direct and Reflected Waves (m)		2.72		2.75		3.58	
	Distortion $(S/I)_{CH}$ (dB)		84.1		69.3		83.5	
Propagation Pass Length (km)			17		74		91	
Propagation Loss in Free Space (dB)			123.9		136.7		138.5	
Profile Map			Fig. III-3 Fig. III-4		Fig. III-33 Fig. III-34		Fig. III-35 Fig. III-36	
Clearance			no problem		no problem		no problem	
Remarks								

Table III-9 Calculated Figures of Various Fundamental Factors on Each Section (No. 4 Route; Plan-1)

K = 4/3

Item \ Name of Site			Gumbi South	Nadda East		Giren		Jimma
Altitude (m)			2,230	2,240		1,960		1,680
Antenna Height above Ground (m)			10	10	10	10	10	20
Effective Antenna Height (m)			93.2	76	432.5	211.6	288.7	20
Effective Reflection Coefficient	Included Angle between Directed and Reflected Waves (°)		1.4/0.2	0.14/0.57	0.45	0.92	0.44	6.9
	Attenuation of Reflected Wave due to Antenna Directivity (dB)		2.5/0	0/0.4	0.3	1.1	0	18
	Shielding Ridge Loss of Reflected Wave (dB)		34.1/24'		6			
	Reflection Point	Distance from Site (km)	14.9/36.1	43.1/21.9	36.3	17.7	4.7	0.3
		Classification of Condition	Field		Swamp		City	
		Reflection Loss (dB)	4		2		10	
		Altitude (m)	1,840/1,980		1,740		1,680	
	Total Loss of Reflected Wave (dB)		40.6/28.4		9.4		28	
Pass Difference	Pass Difference between Direct and Reflected Waves (m)		8.3/2.1		3.4		2.3	
	Distortion $(S/I)_{CH}$ (dB)		87.6/99.4		71.9		97	
Propagation Pass Length (km)			58		54		5	
Propagation Loss in Free Space (dB)			134.6		133.9		113.3	
Profile Map			Fig. III-37 Fig. III-38		Fig. III-39 Fig. III-40		Fig. III-41 Fig. III-42	
Clearance			hc/ho=1.3(K=2/3)		no problem		no problem	
Remarks			(Down ward/Up ward)					

2. Profile Maps (K = 4/3, K = 2/3)

Fig. Ⅲ-3 PROFILE MAP

(K = 4/3)

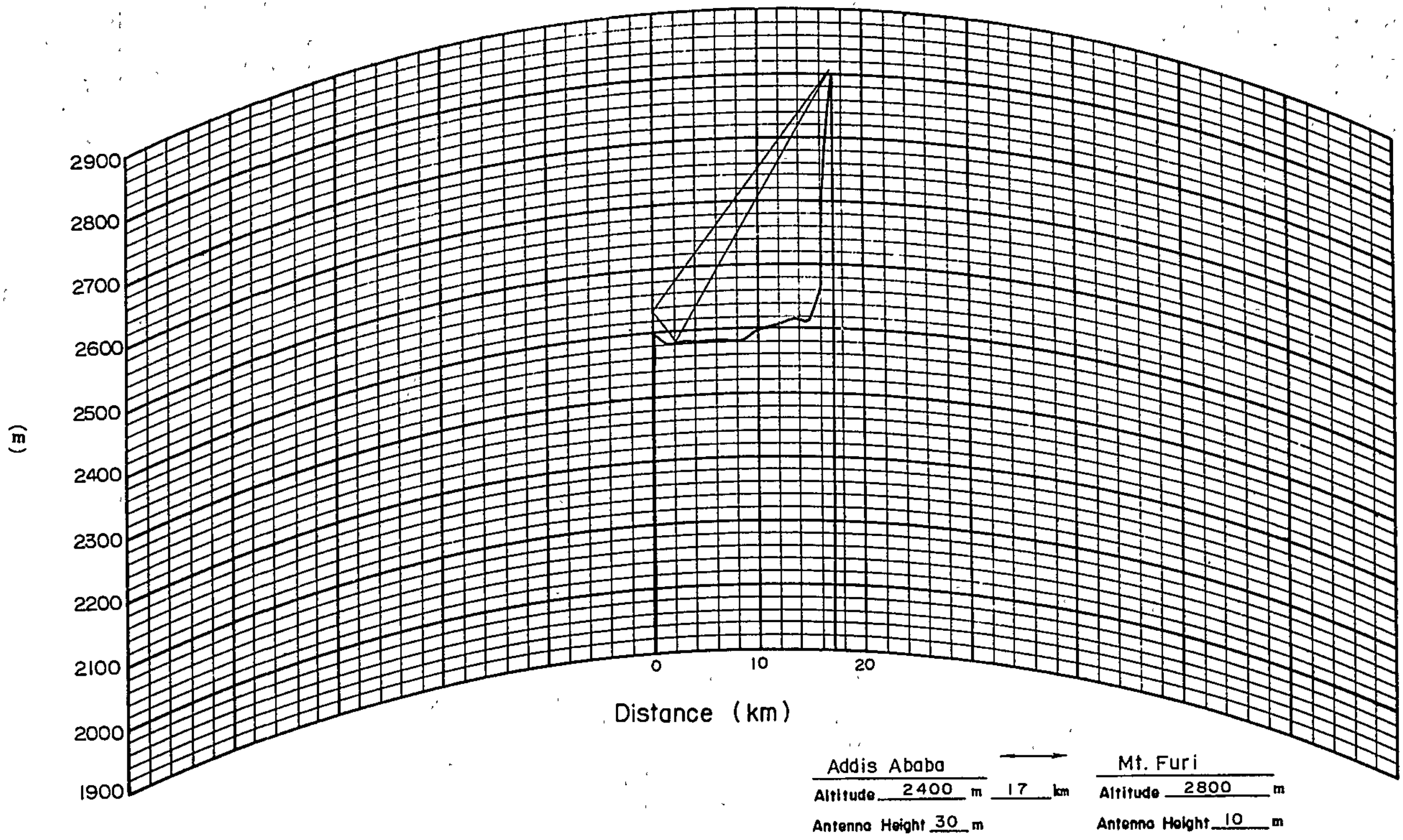


Fig.Ⅲ- 4 PROFILE MAP

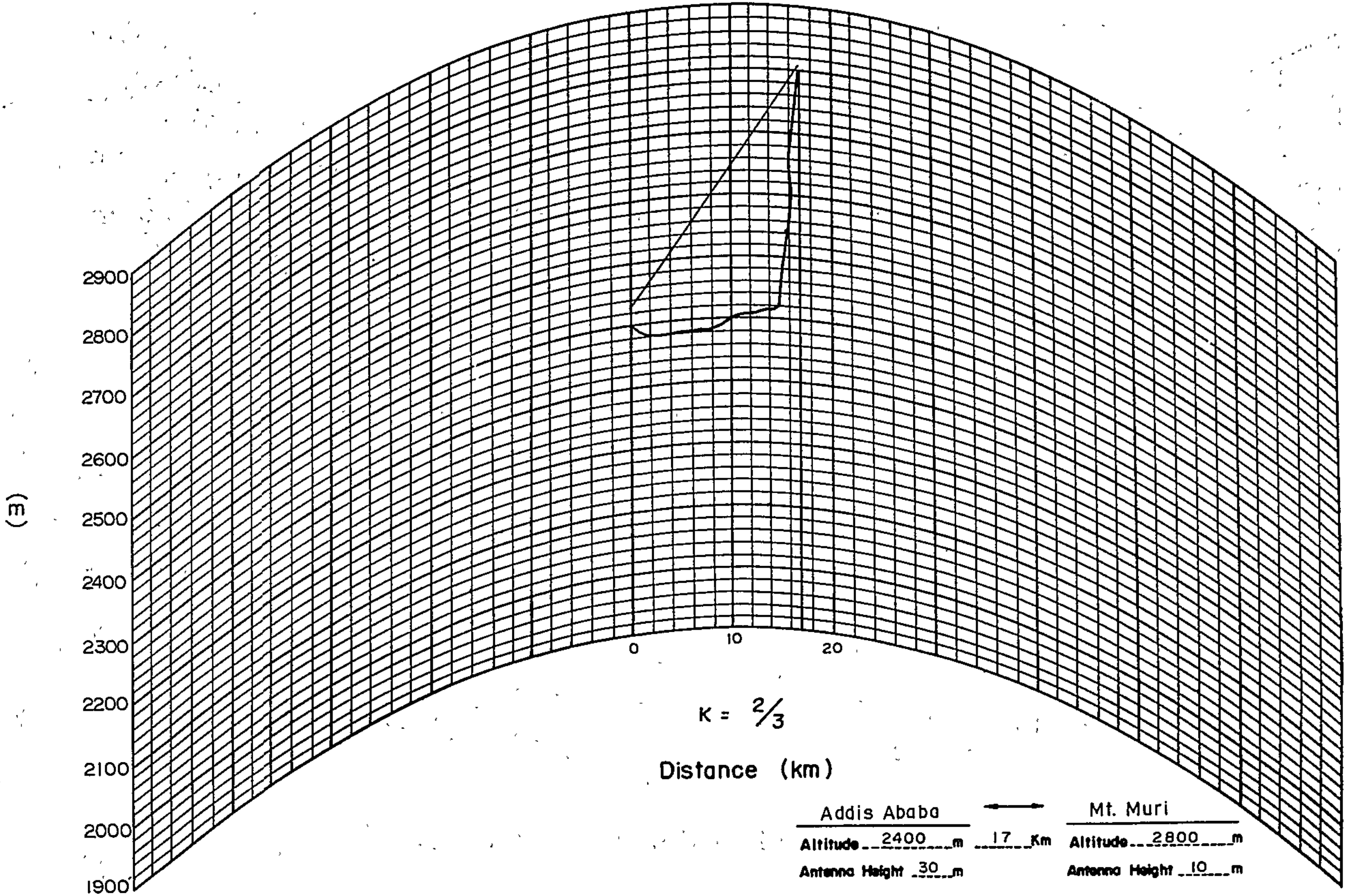


Fig.III-5 PROFILE MAP

(K = $^4/_3$)

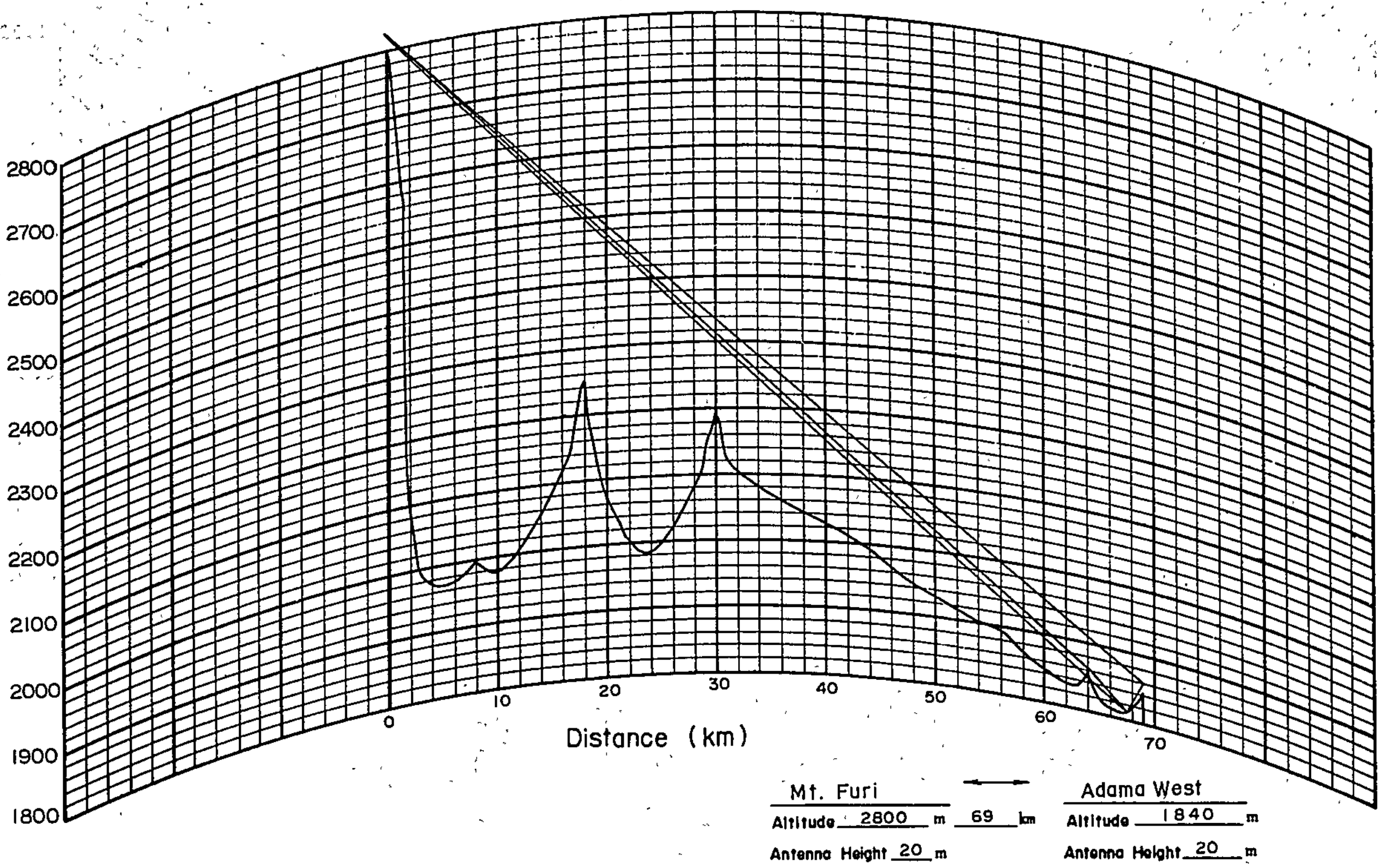


Fig.Ⅲ-6 PROFILE MAP

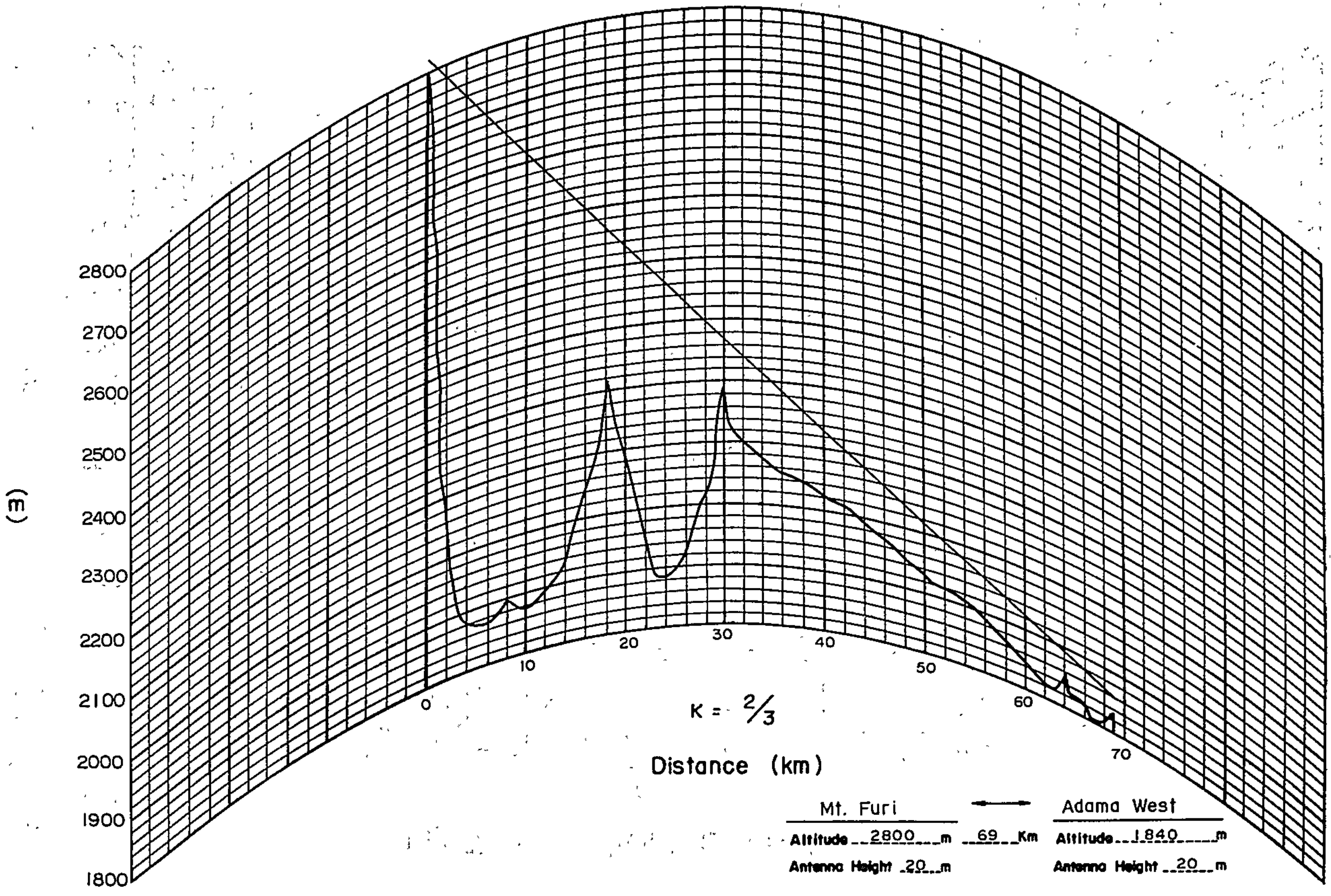


Fig. Ⅲ-7 PROFILE MAP

(K = $^4/_3$)

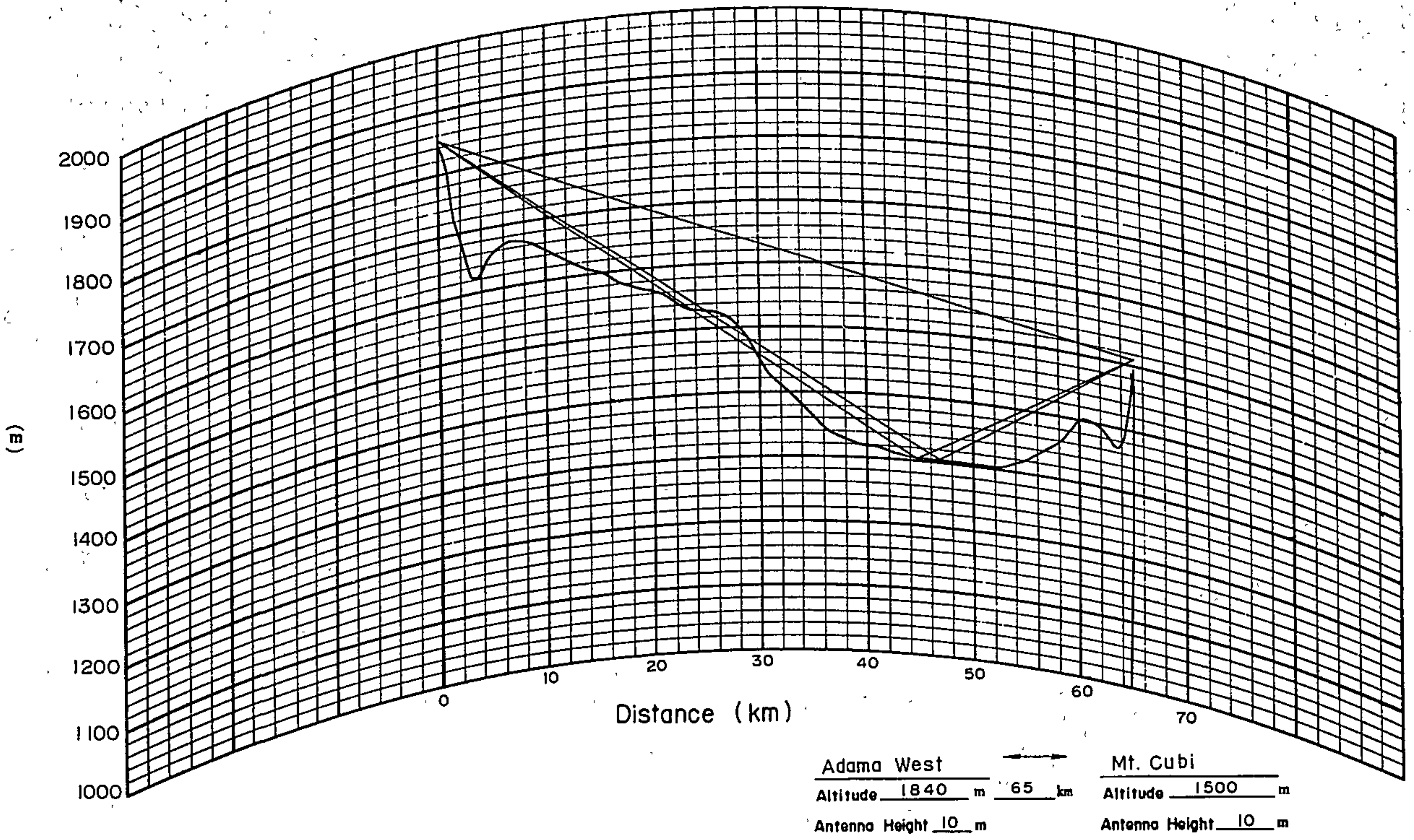
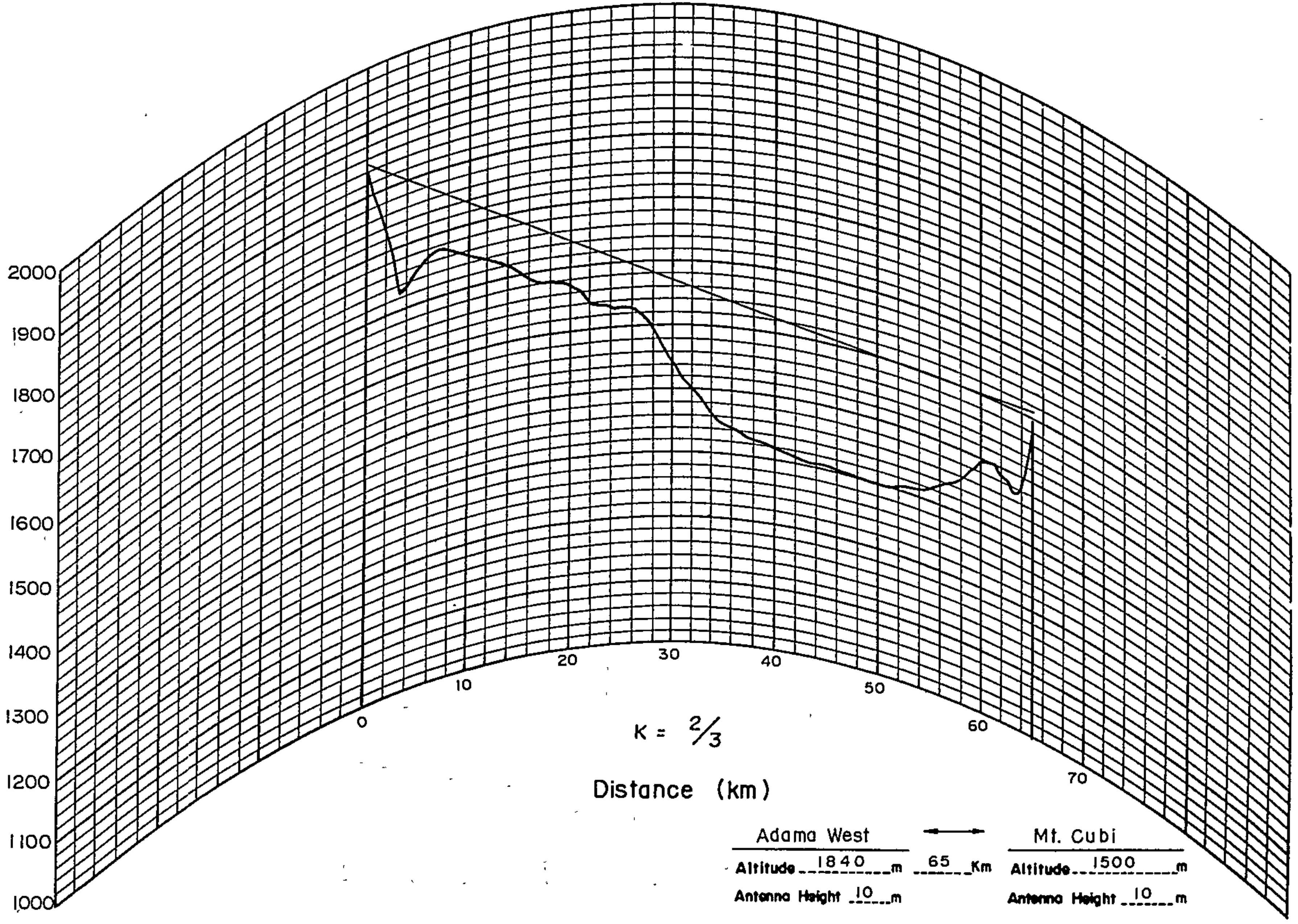


Fig. III-8 PROFILE MAP



(3)

Fig. III-9 PROFILE MAP

(K = 4/3)

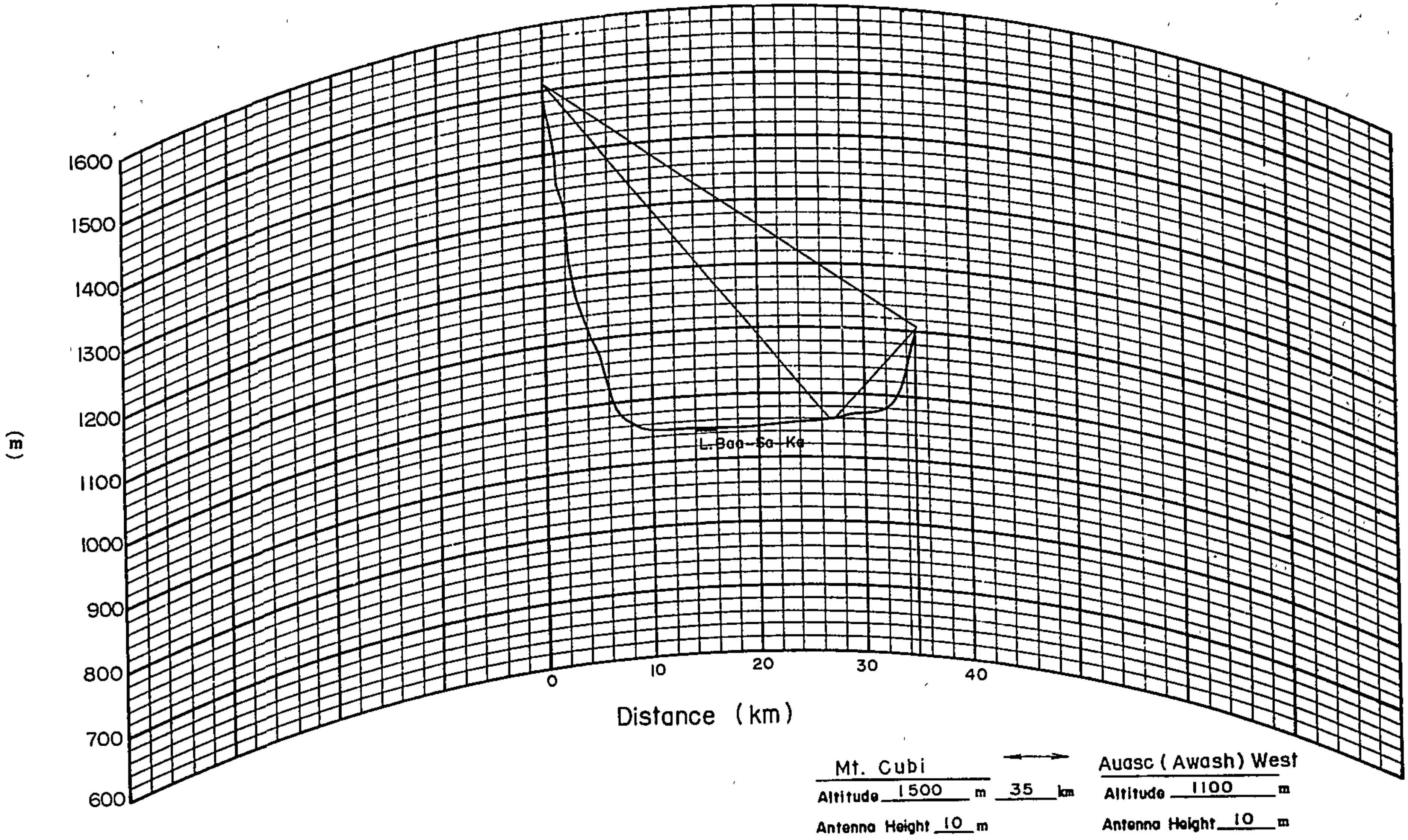


Fig. Ⅲ-10 PROFILE MAP

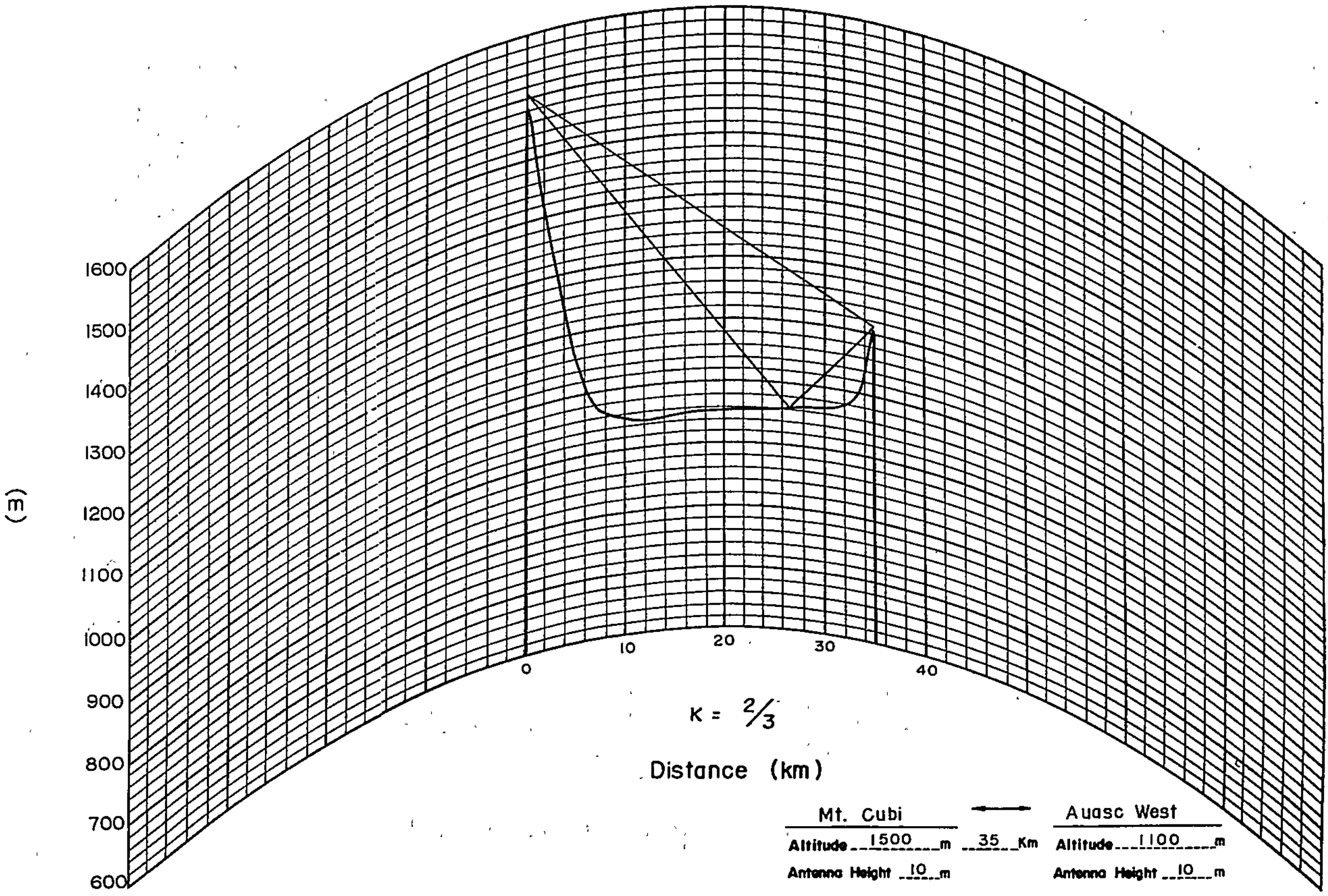


Fig.Ⅲ-11 PROFILE MAP

(K = $^4/_3$)

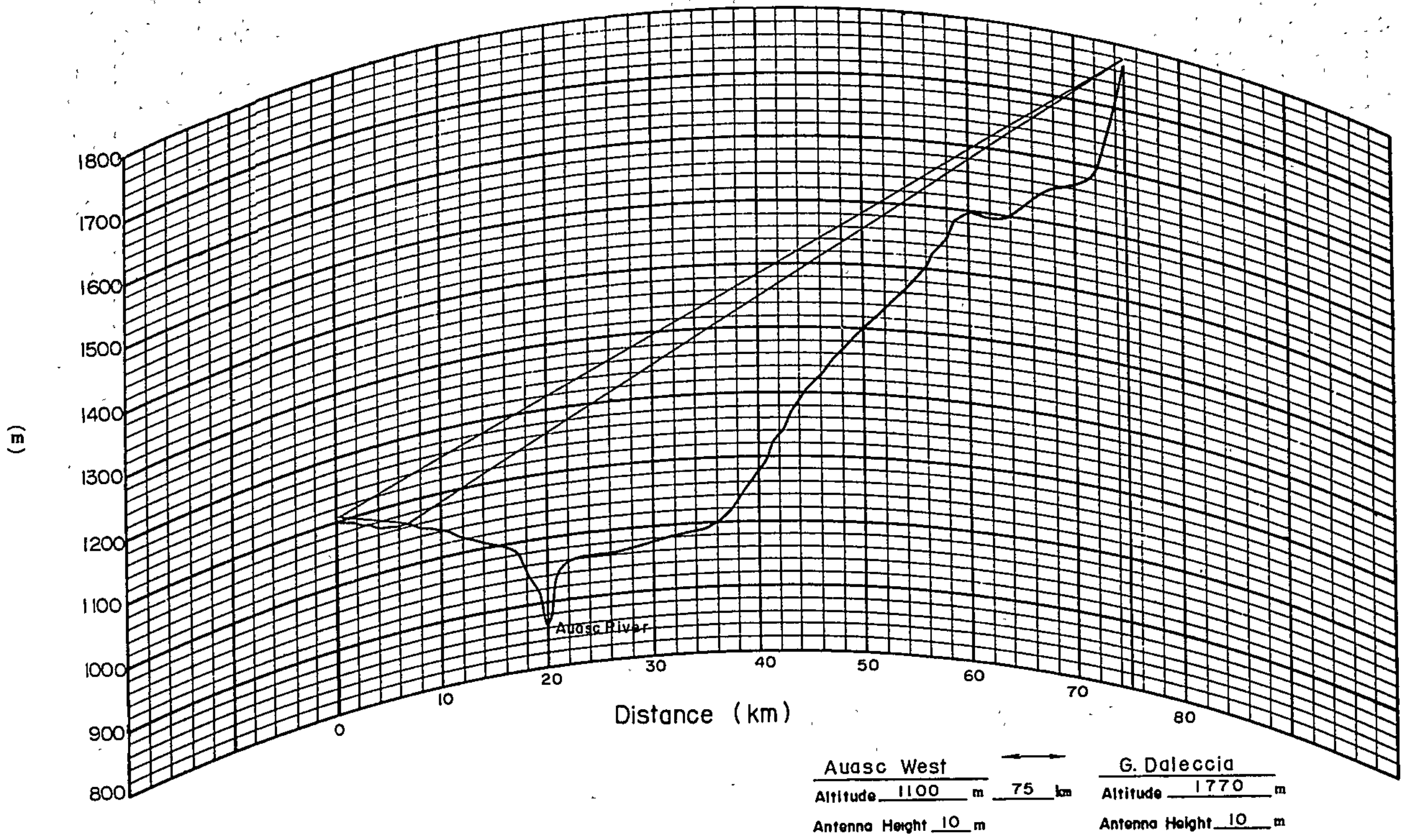


Fig.Ⅲ-12 PROFILE MAP

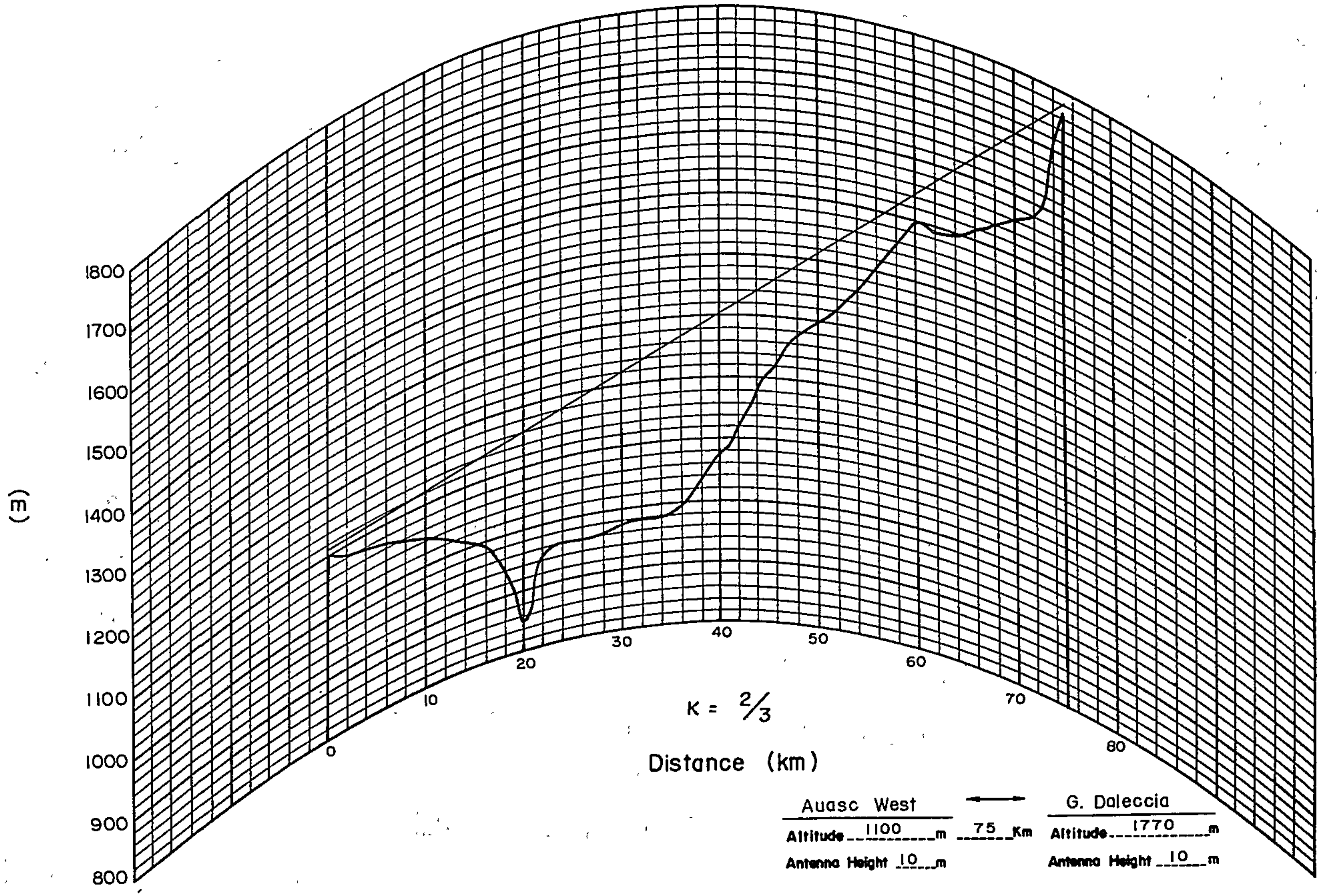


Fig. III-13 PROFILE MAP

(K = 4/3)

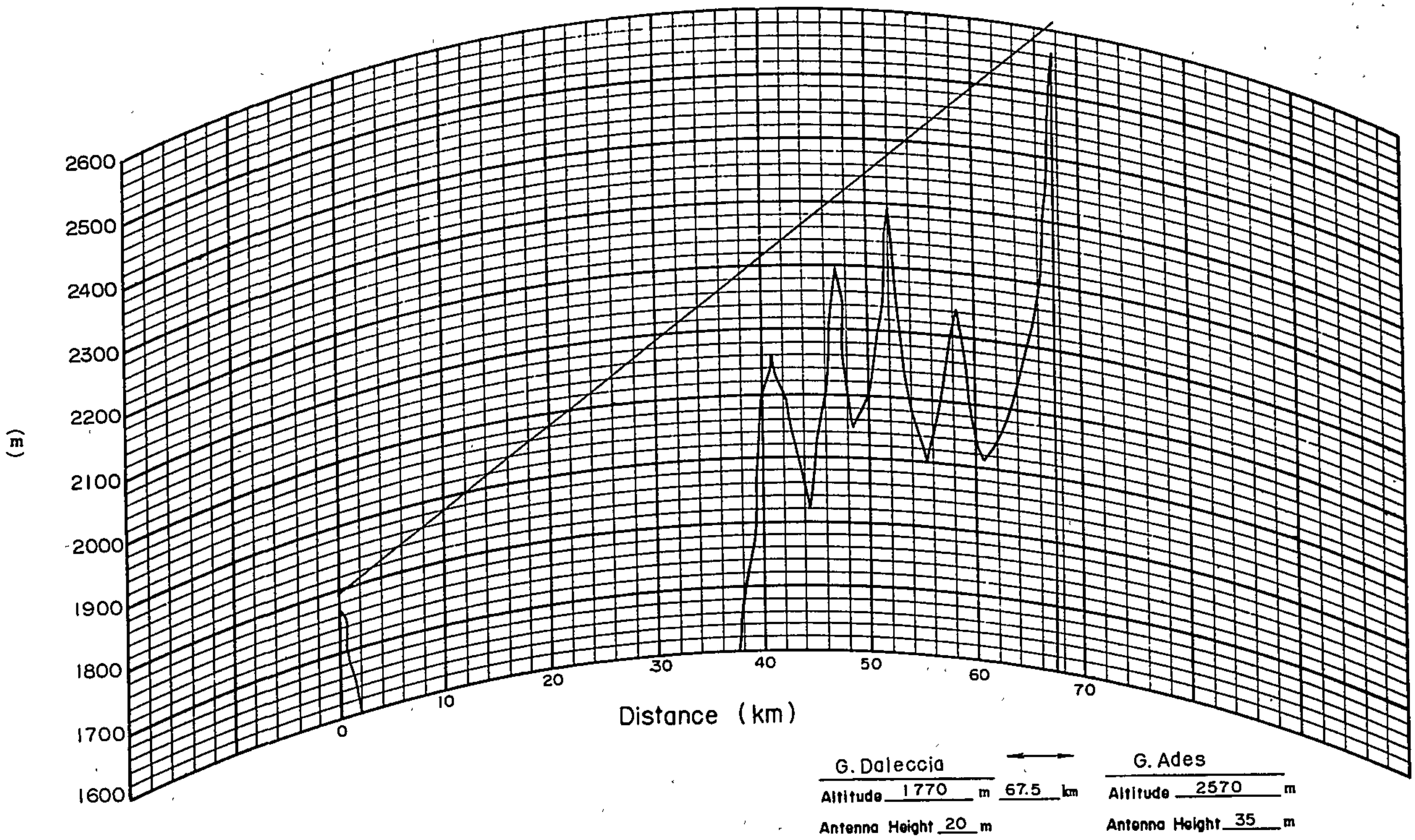


Fig. III-14 PROFILE MAP

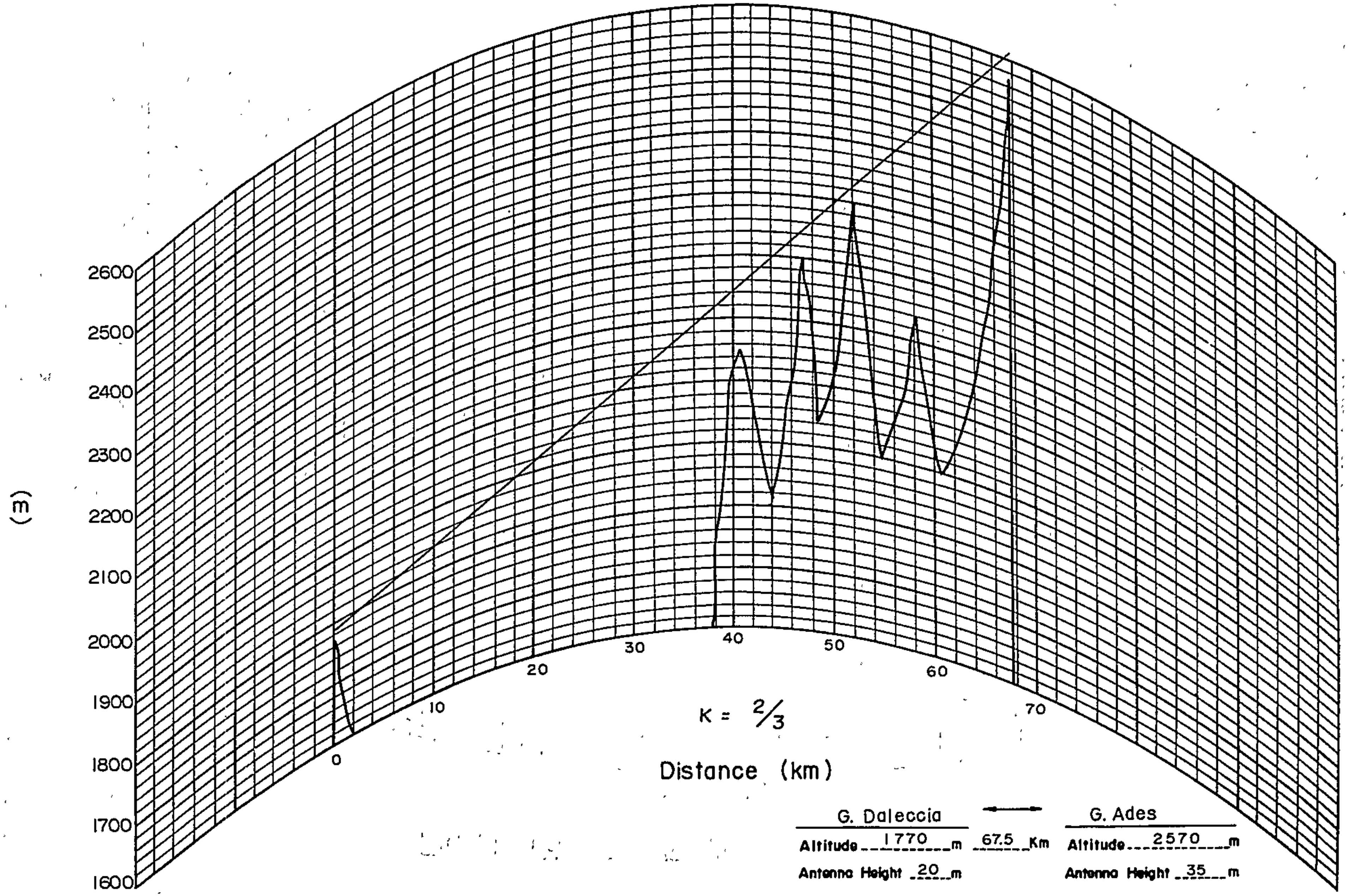


Fig.III-15 PROFILE MAP

(K = 4/3)

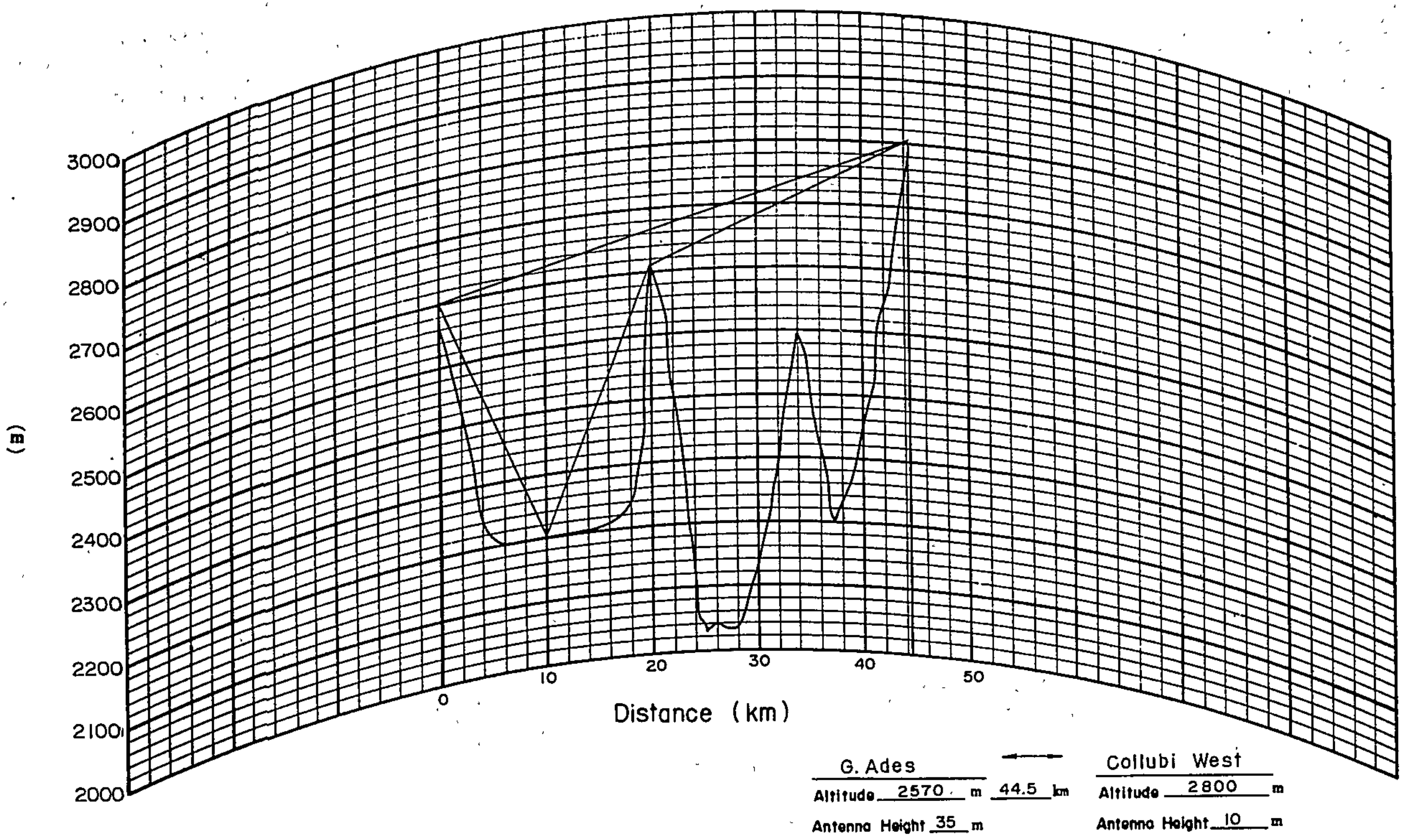


Fig.III-16 PROFILE MAP

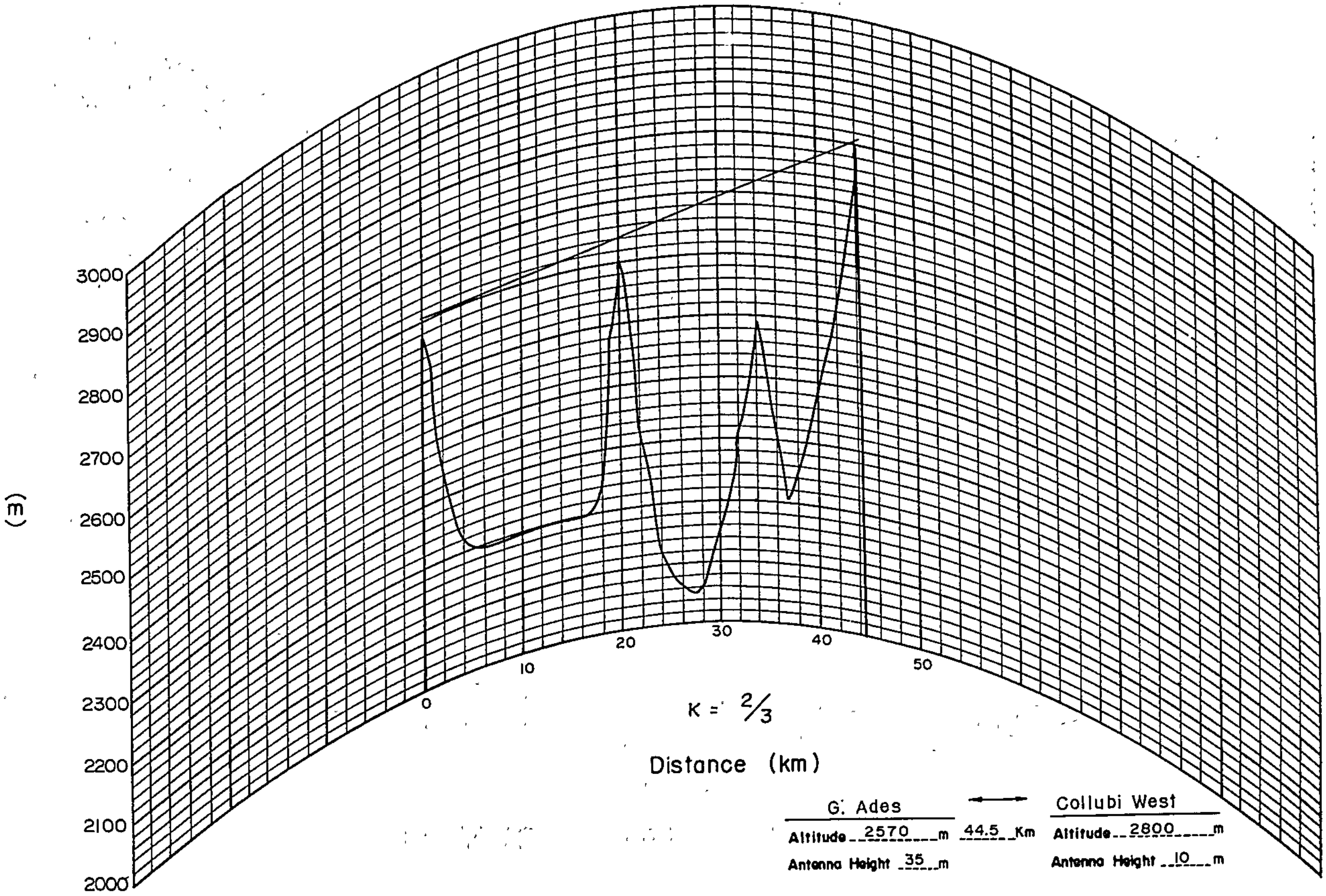


Fig. Ⅲ-17 PROFILE MAP

(K = 4/3)

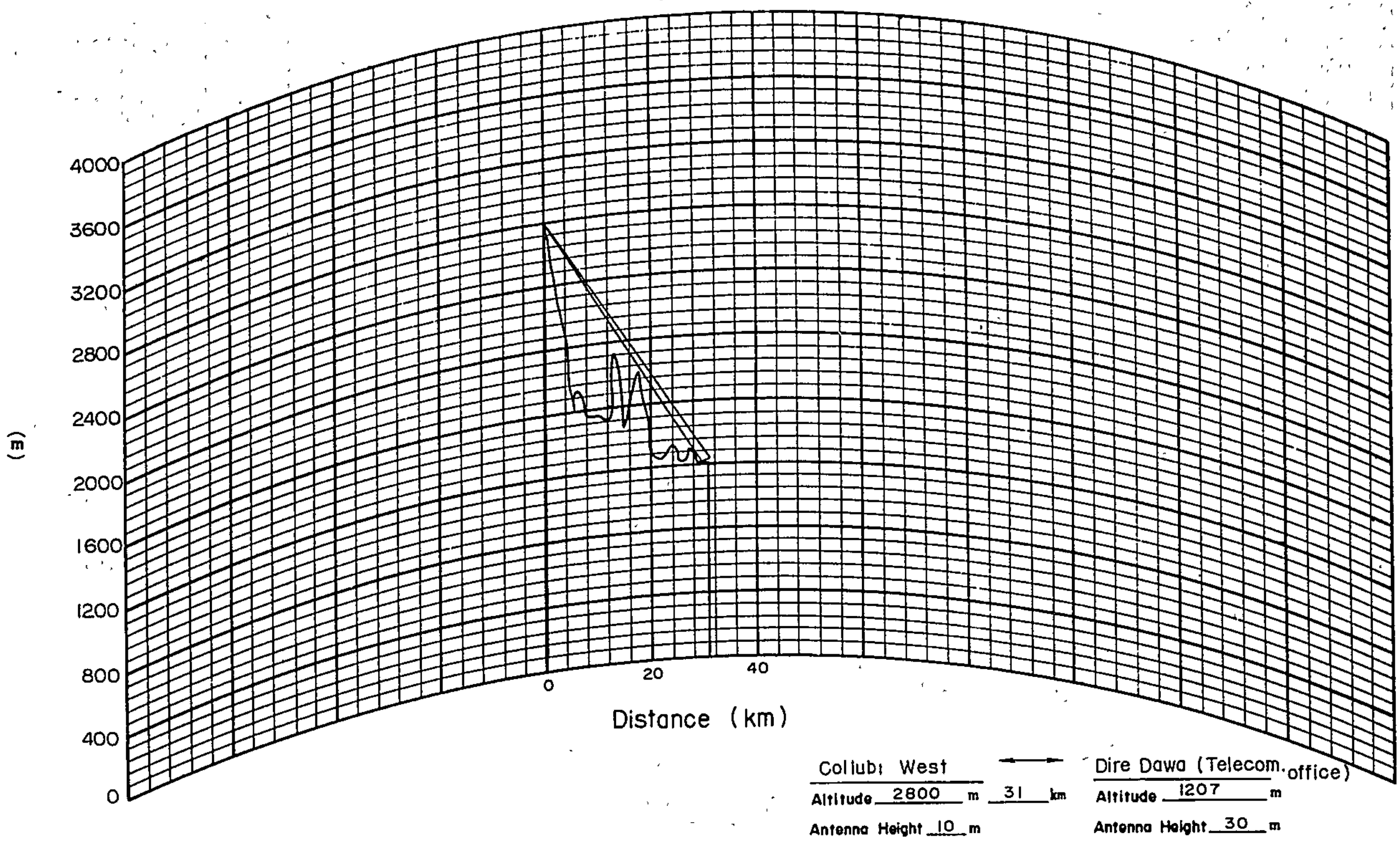


Fig.III-18 PROFILE MAP

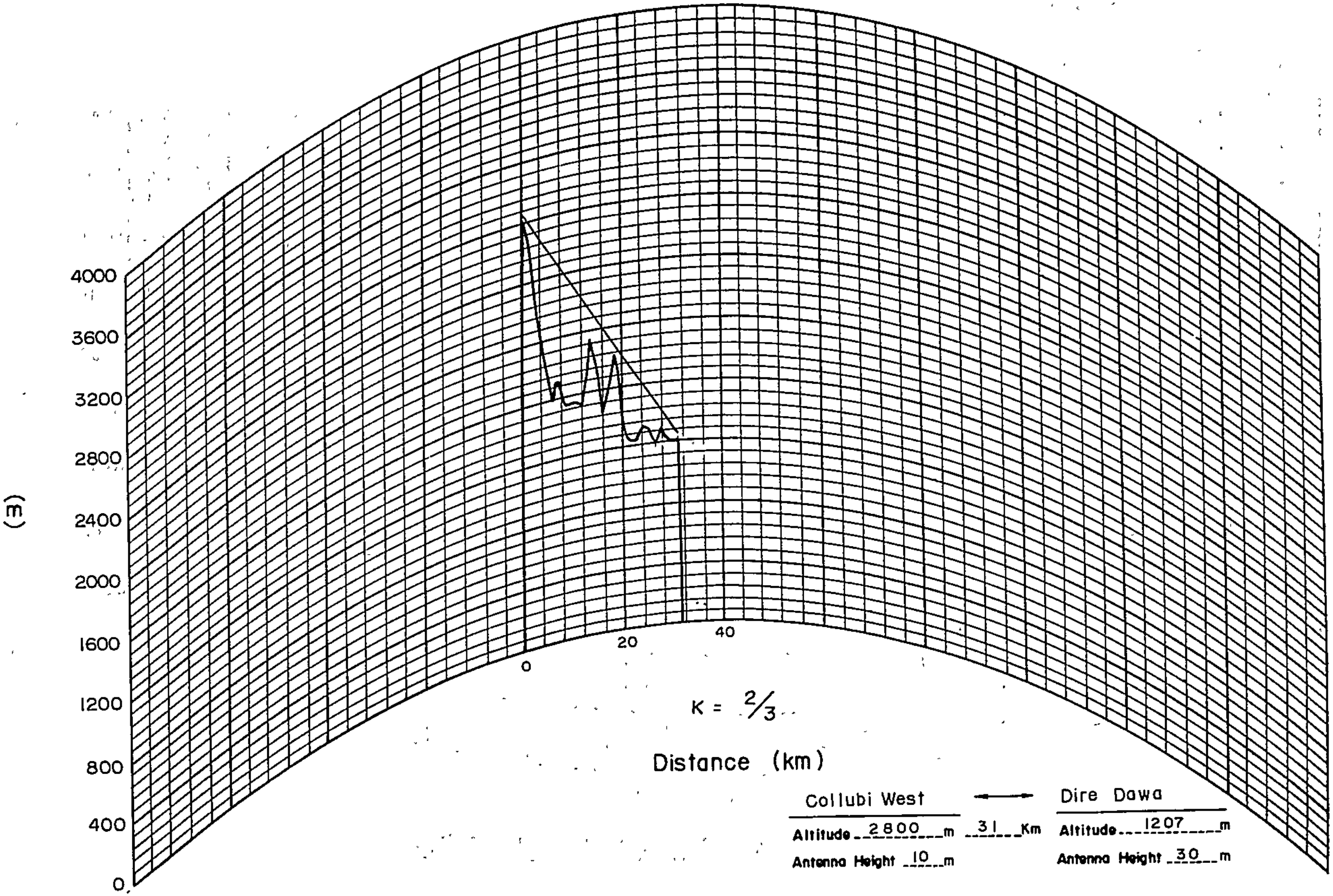
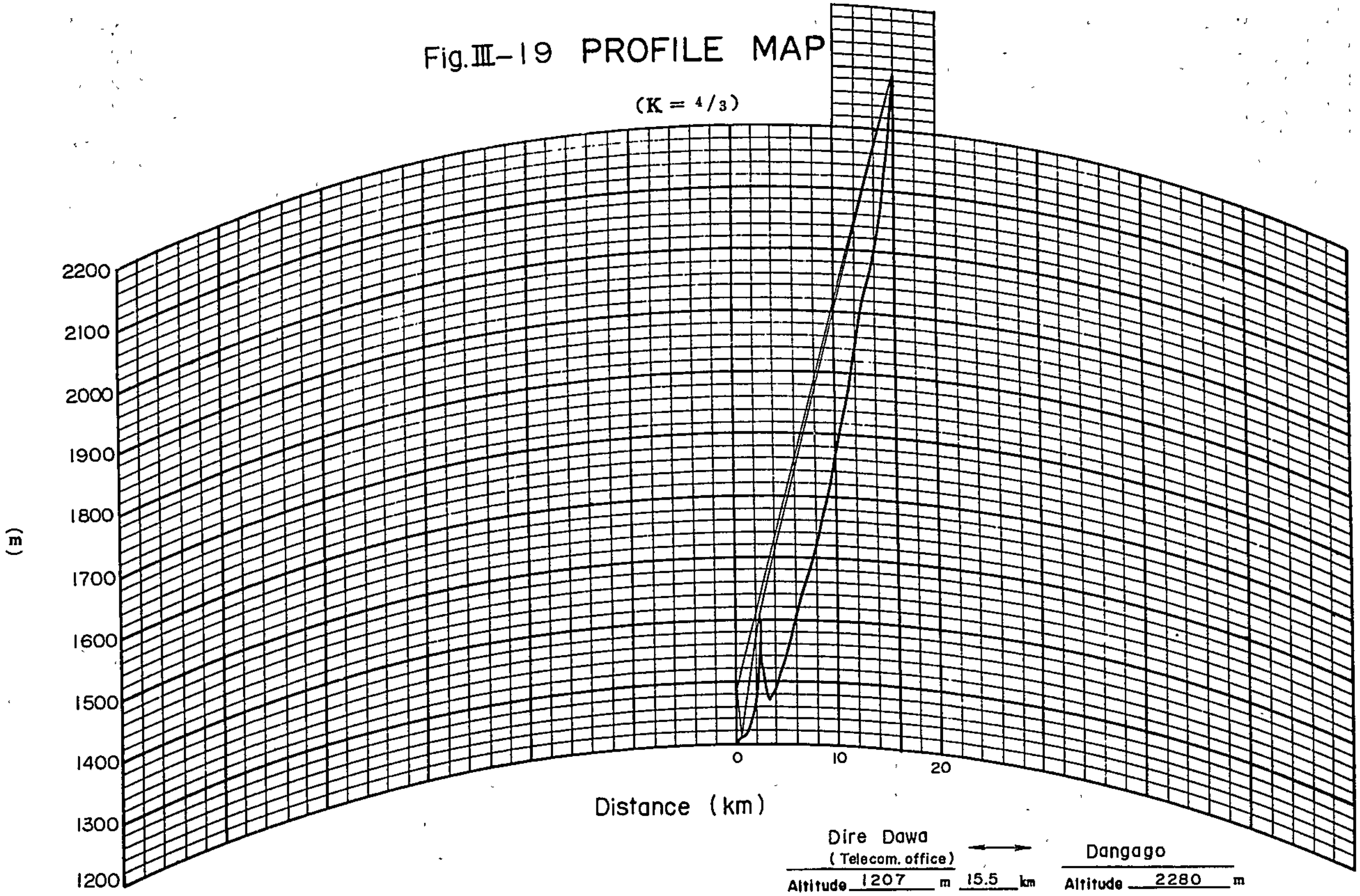


Fig.III-19 PROFILE MAP

(K = 4/3)



Dire Dawa (Telecom. office) ⟷ Dangago

Altitude 1207 m   15.5 km   Altitude 2280 m

Antenna Height 75 m   Antenna Height 10 m

Fig.Ⅲ-20 PROFILE MAP

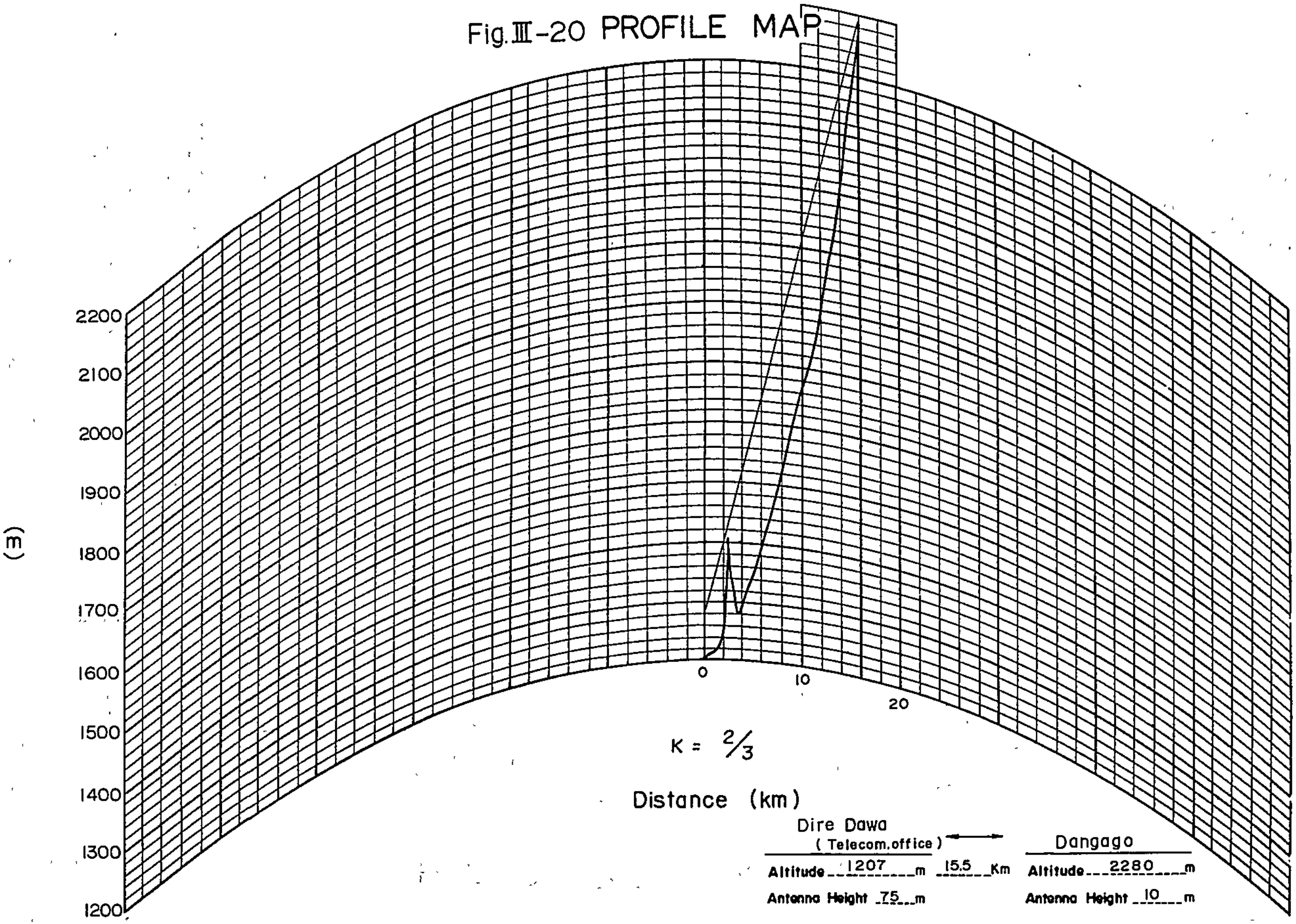


Fig. III-21 PROFILE MAP

(K = 4/3)

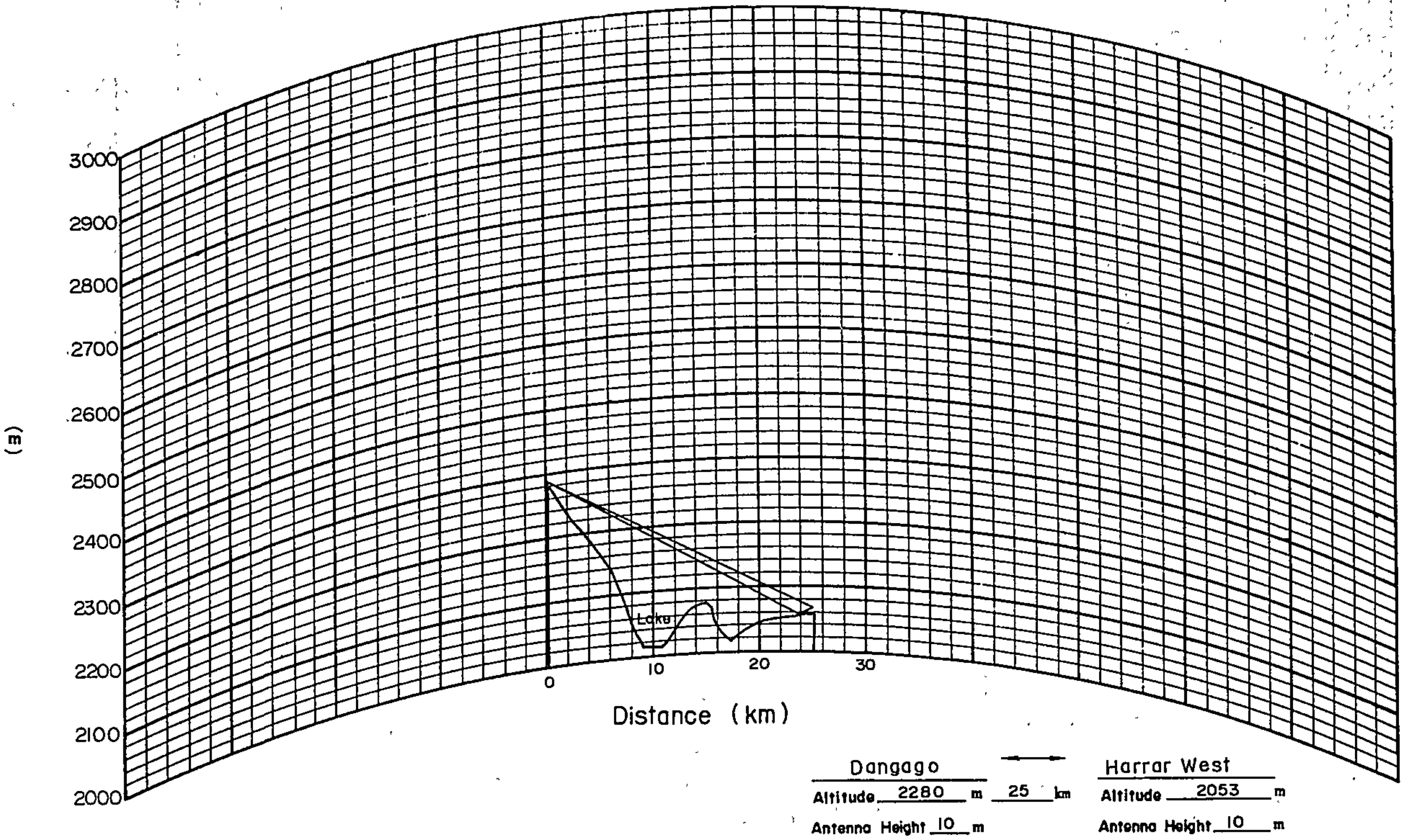


Fig.Ⅲ-22 PROFILE MAP

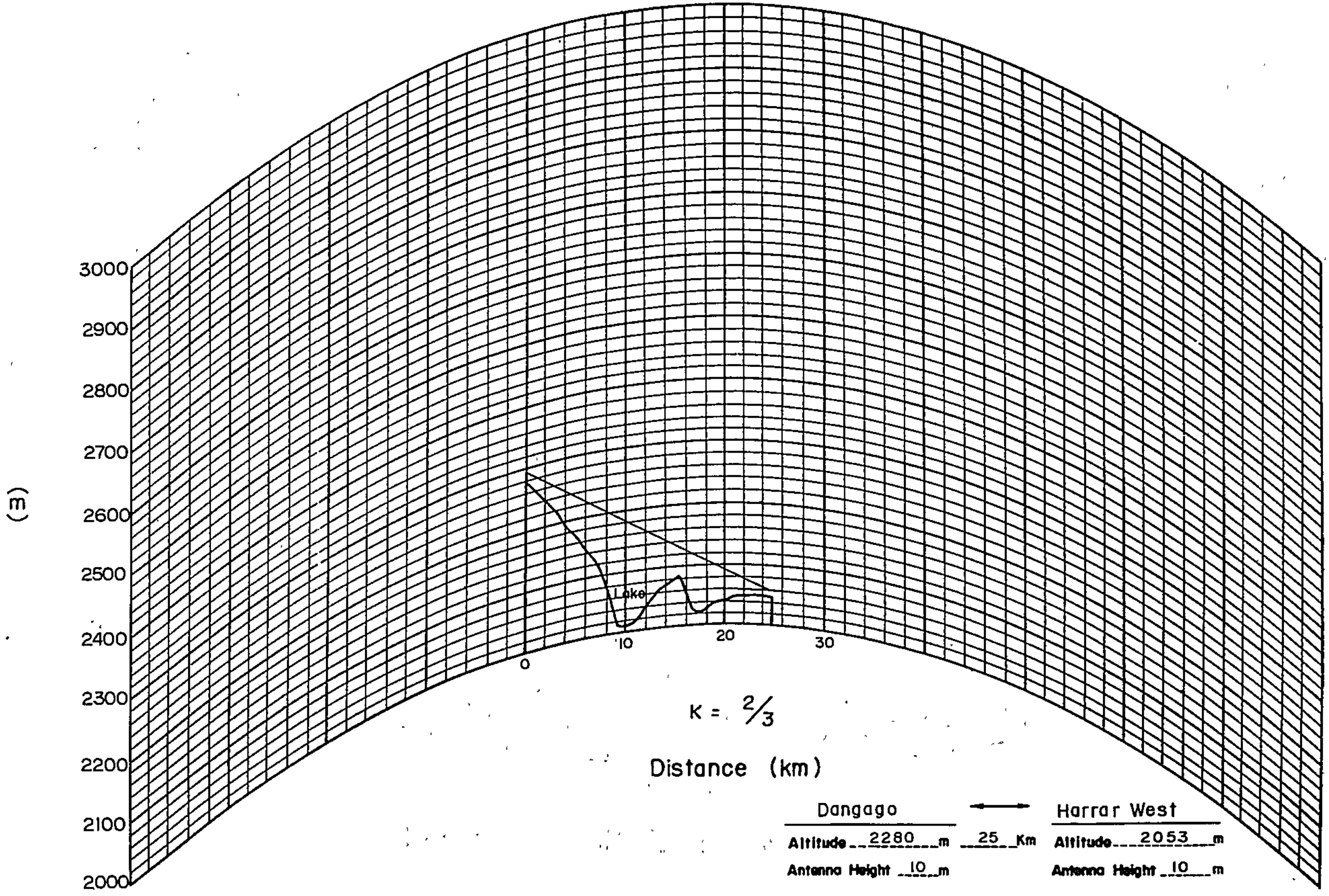


Fig.Ⅲ-23 PROFILE MAP

(K = 4/3)

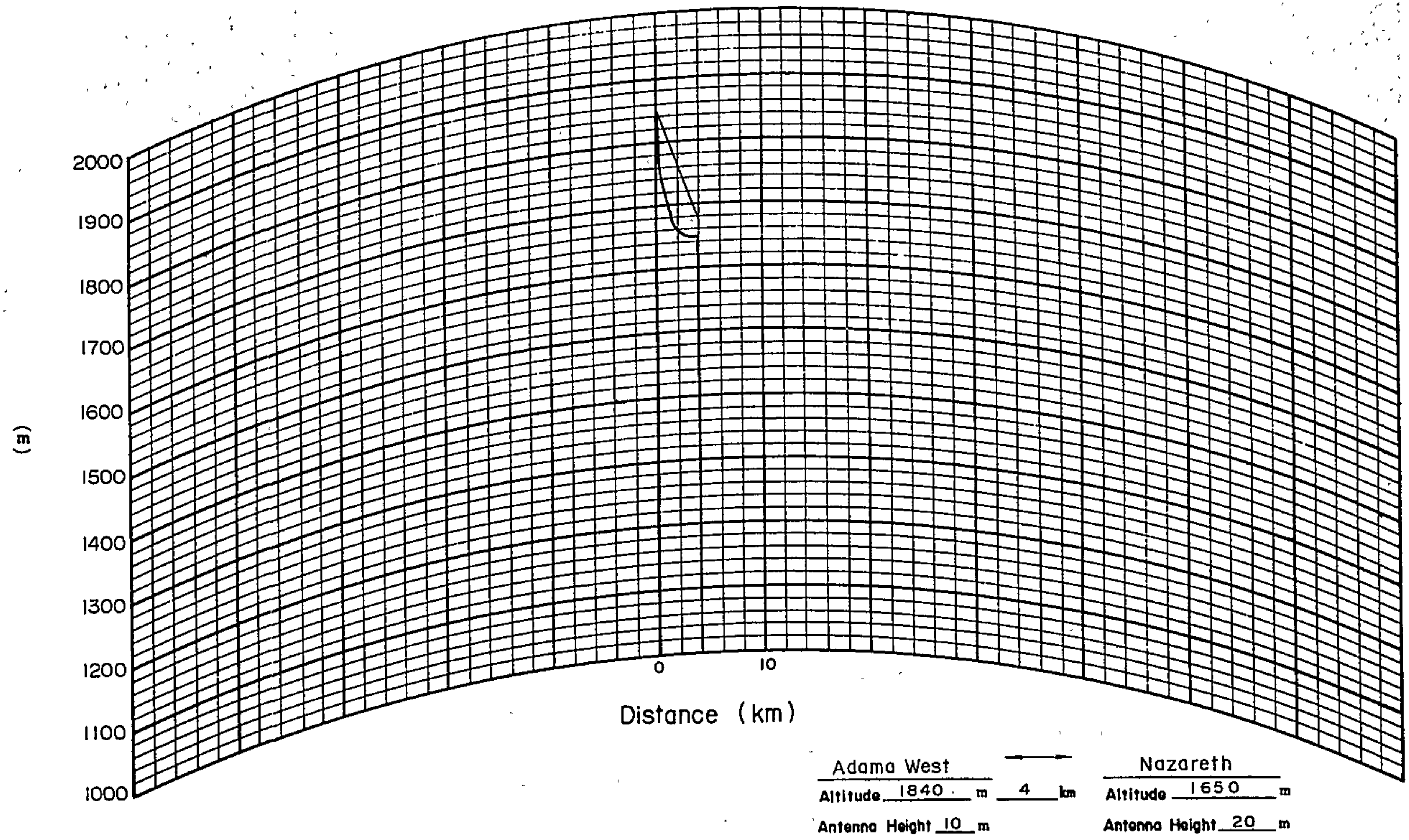


Fig.III-24 PROFILE MAP

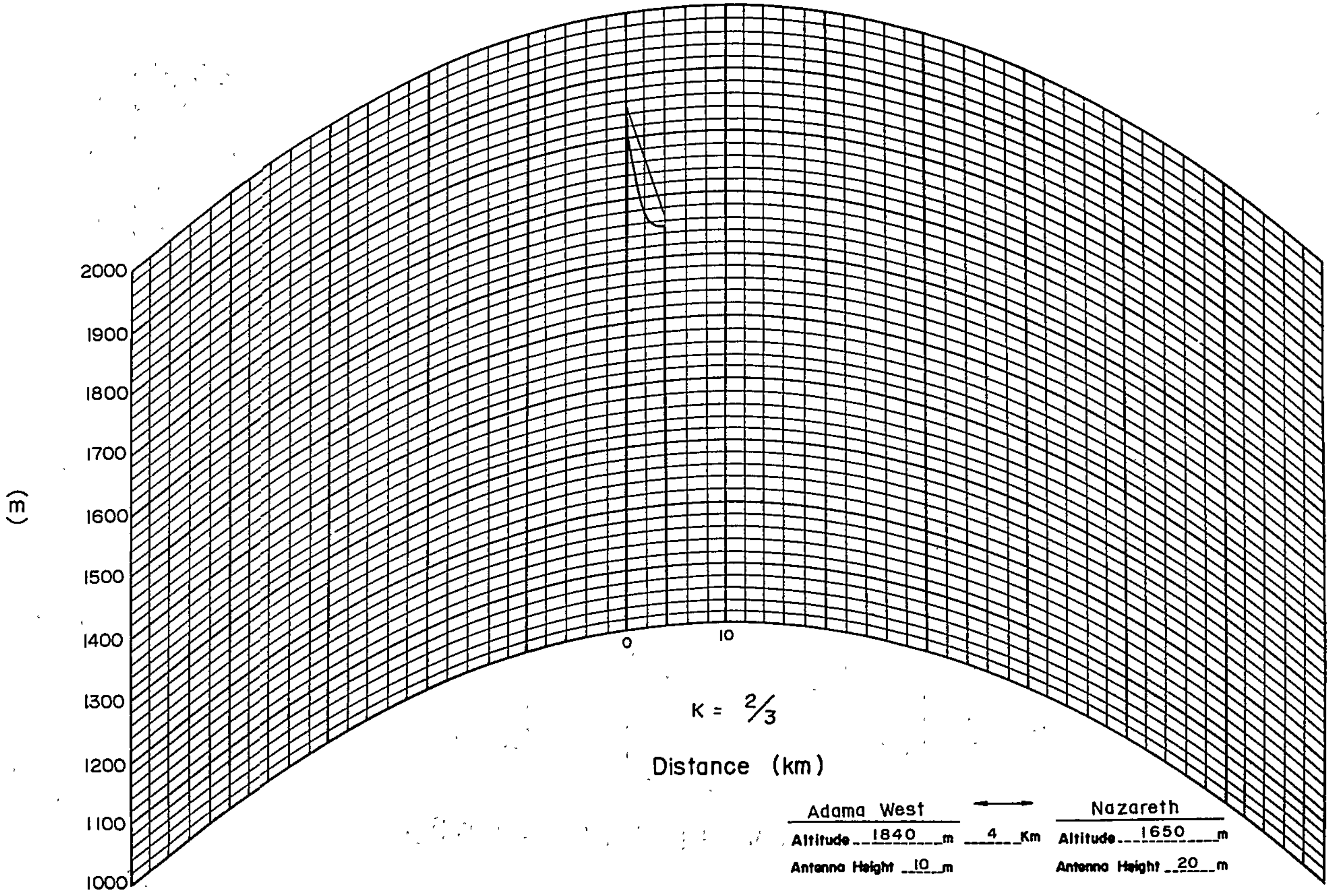


Fig. Ⅲ-25 PROFILE MAP

(K = 4/3)

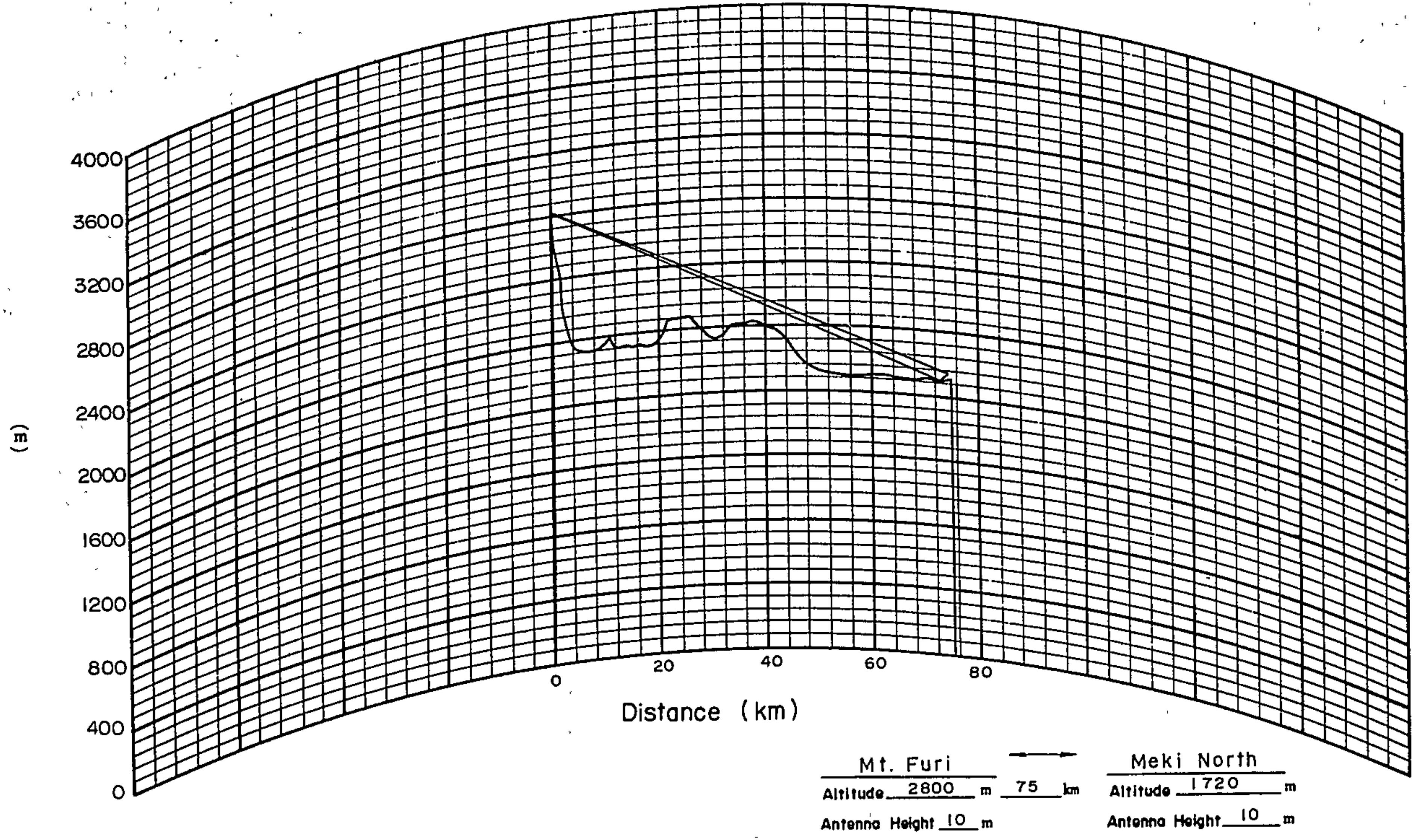


Fig. III-26 PROFILE MAP

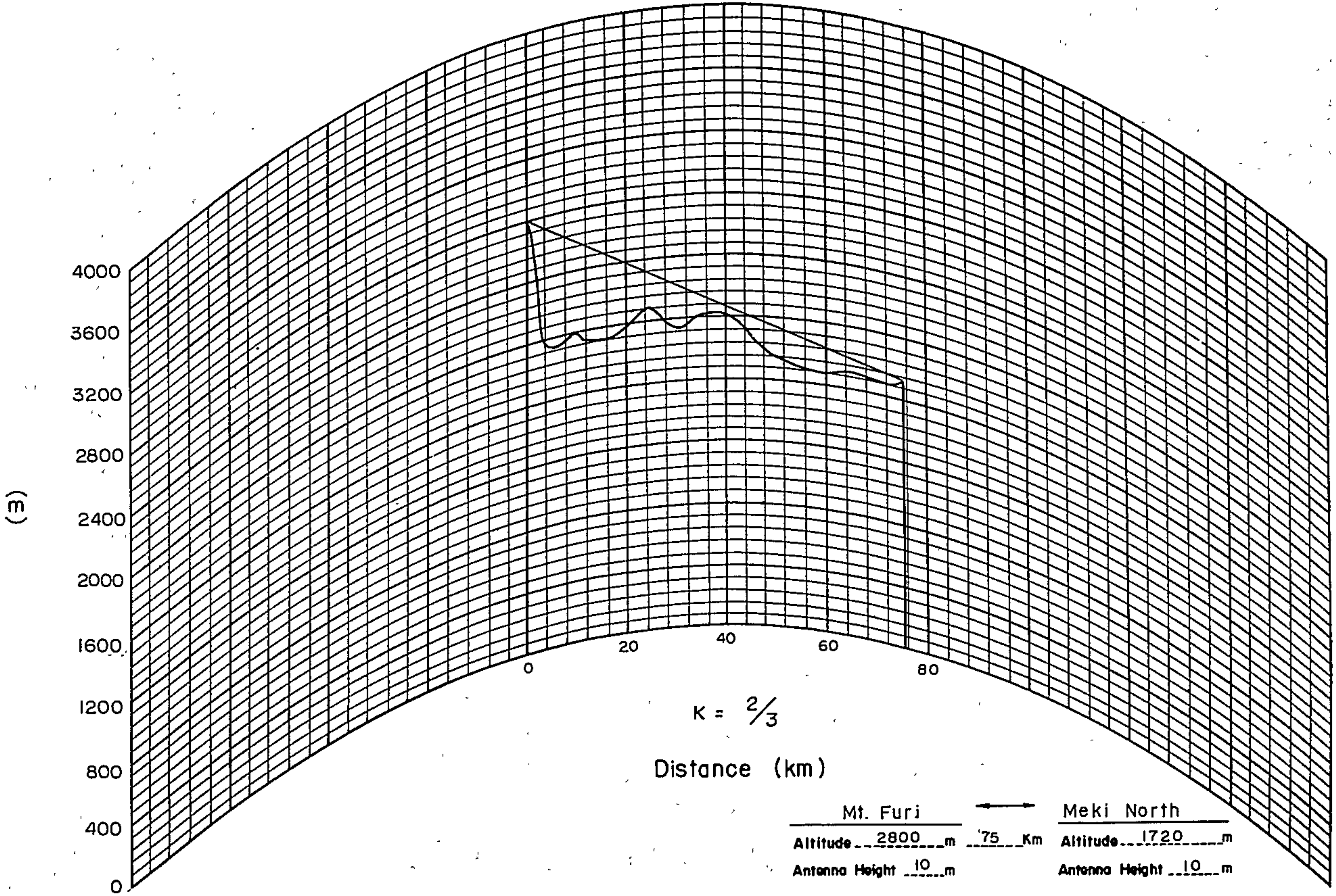


Fig. Ⅲ-27 PROFILE MAP

(K = 4/3)

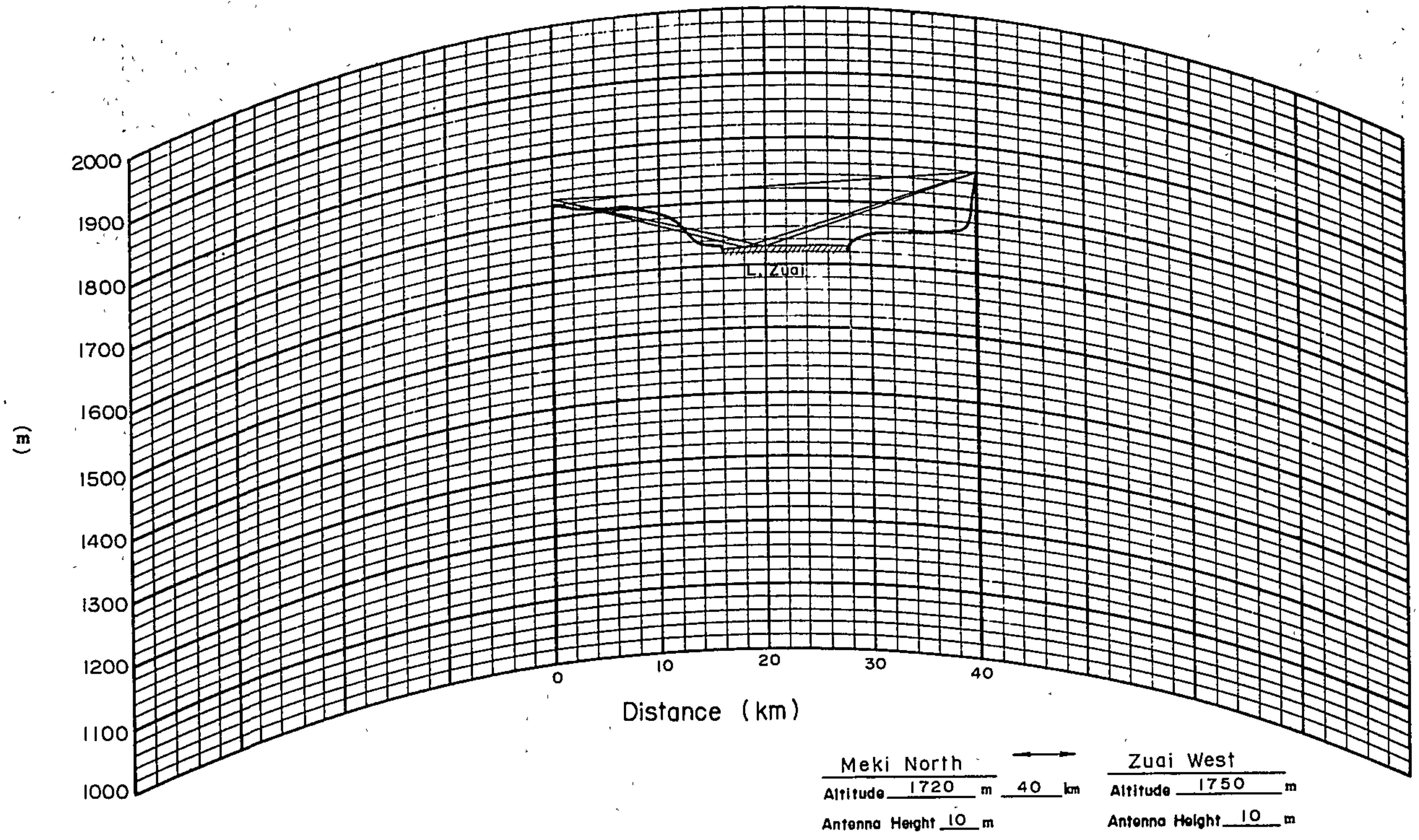


Fig.Ⅲ-28 PROFILE MAP

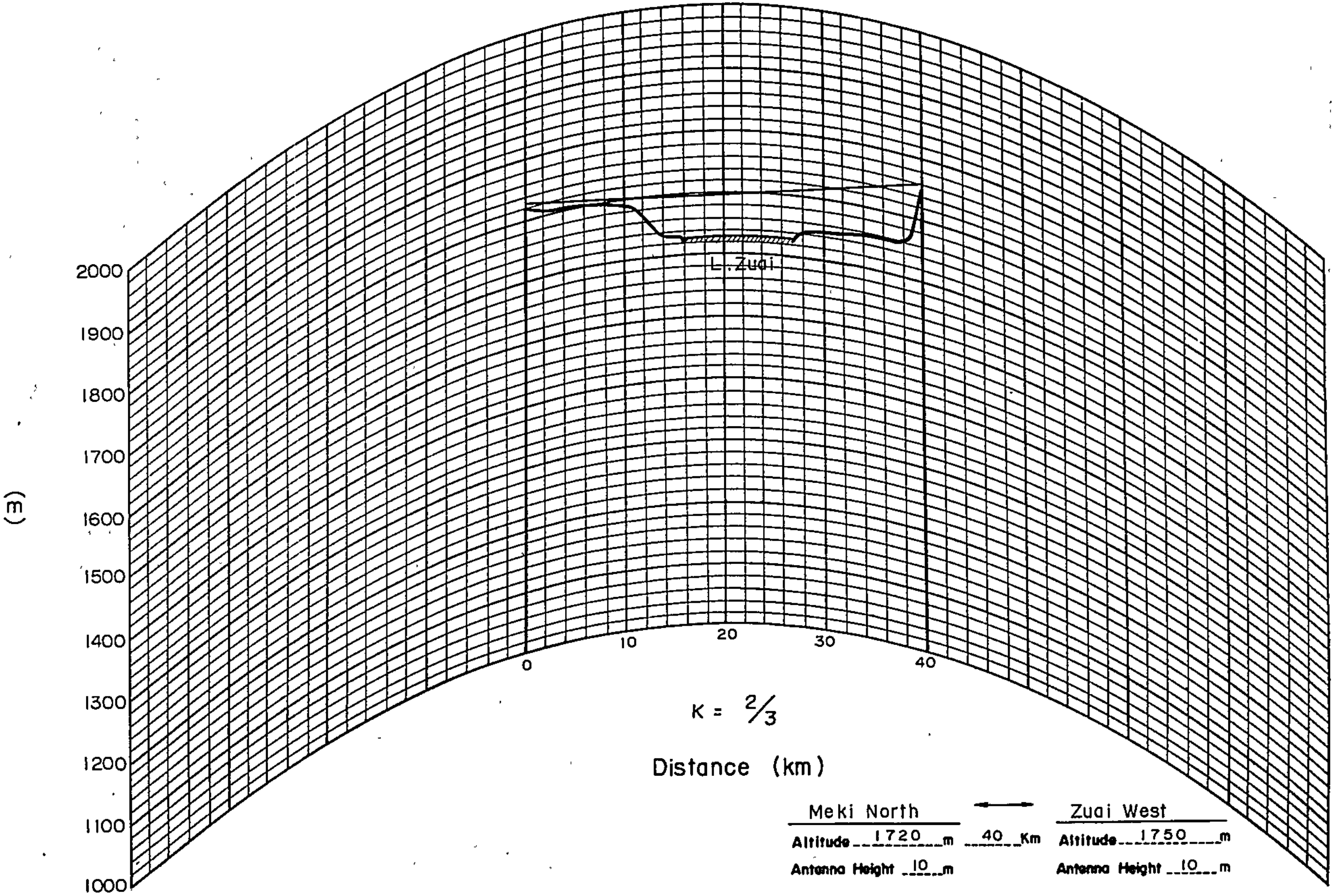


Fig.III-29 PROFILE MAP

(K = 4/3)

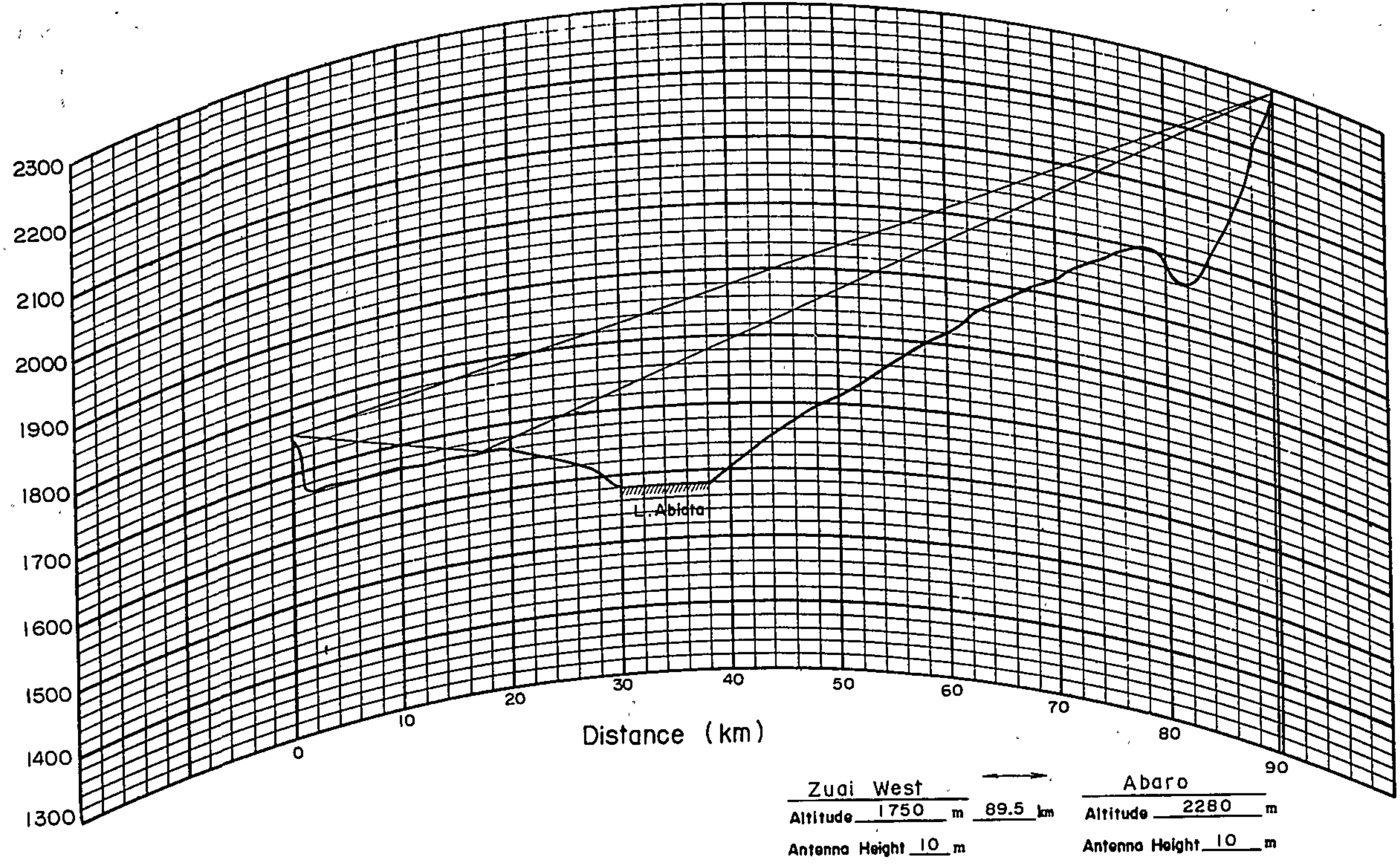


Fig.Ⅲ-30 PROFILE MAP

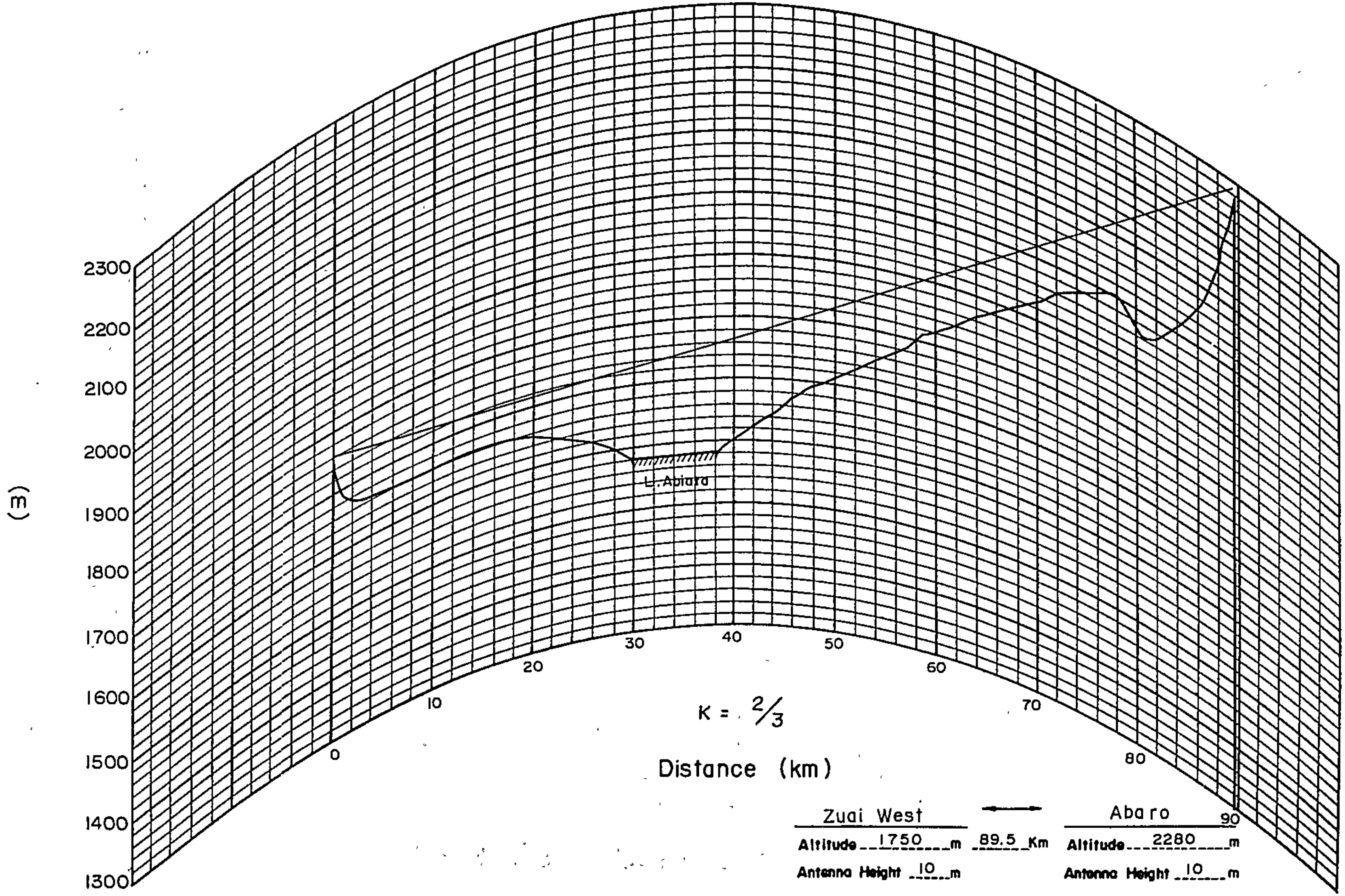


Fig.Ⅲ-31 PROFILE MAP

(K = 4/3)

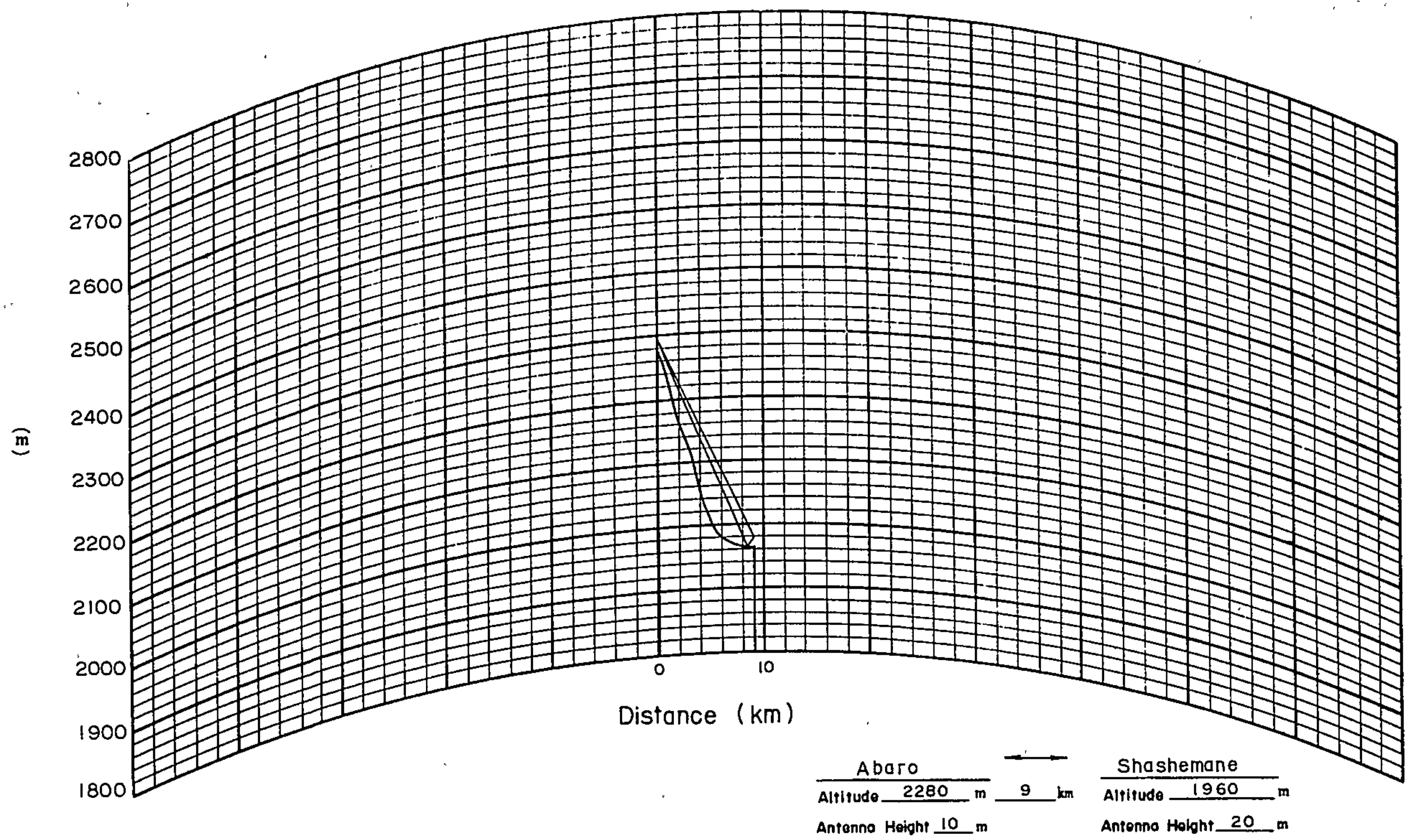
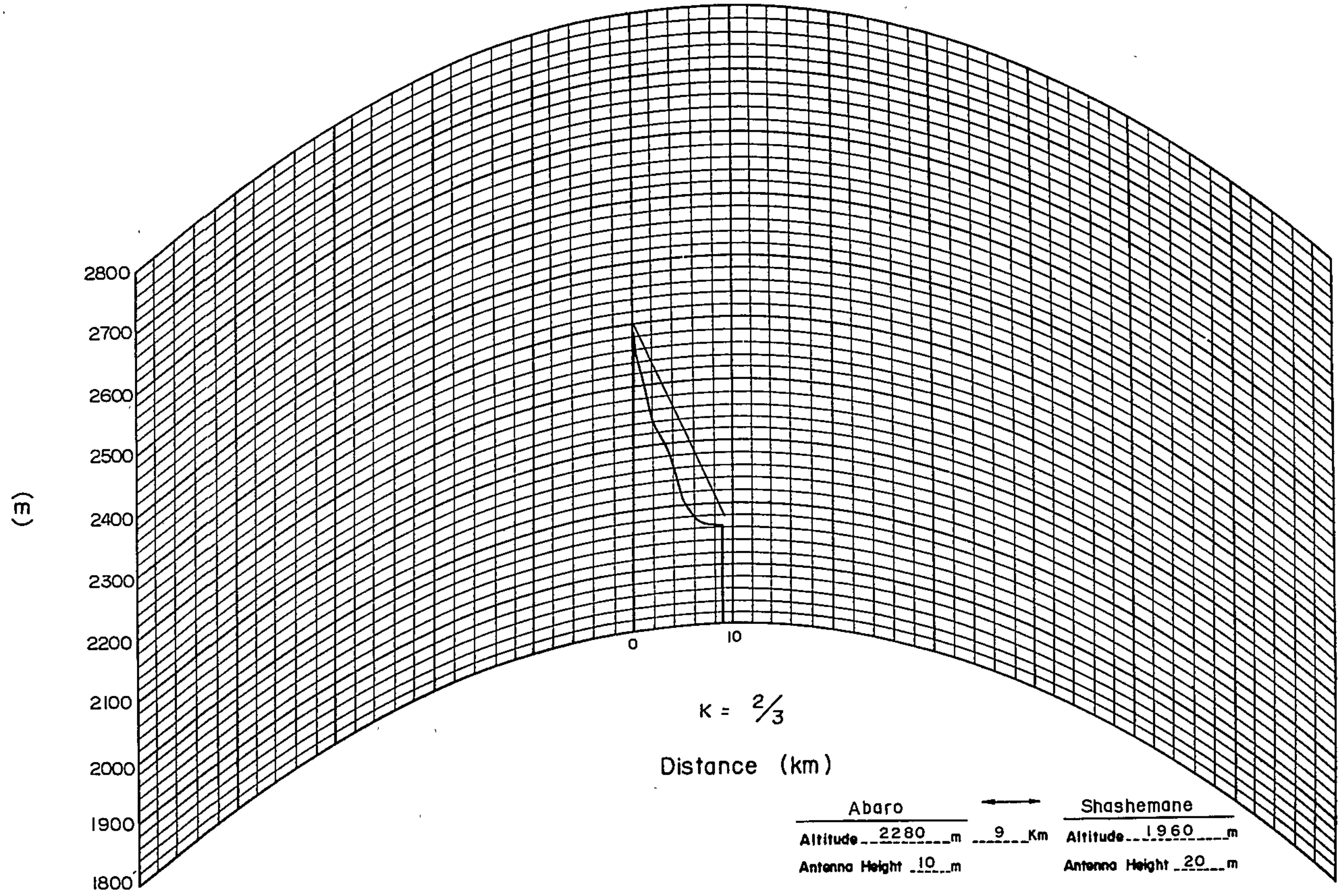


Fig.Ⅲ-32 PROFILE MAP



Abaro
Altitude 2280 m
Antenna Height 10 m

9 Km

Shashemane
Altitude 1960 m
Antenna Height 20 m

Fig. III-33 PROFILE MAP

(K = 4/3)

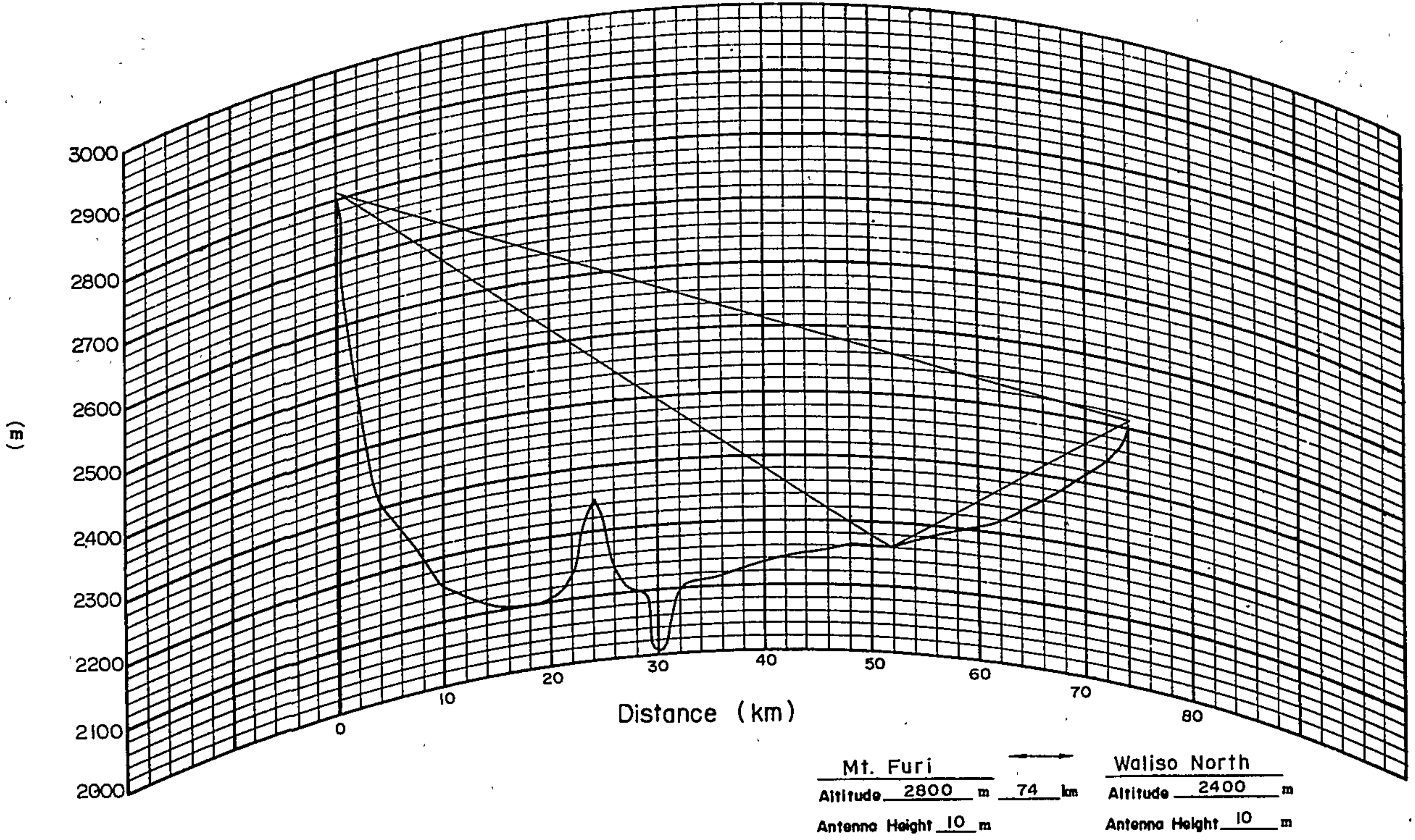


Fig.Ⅲ-34 PROFILE MAP

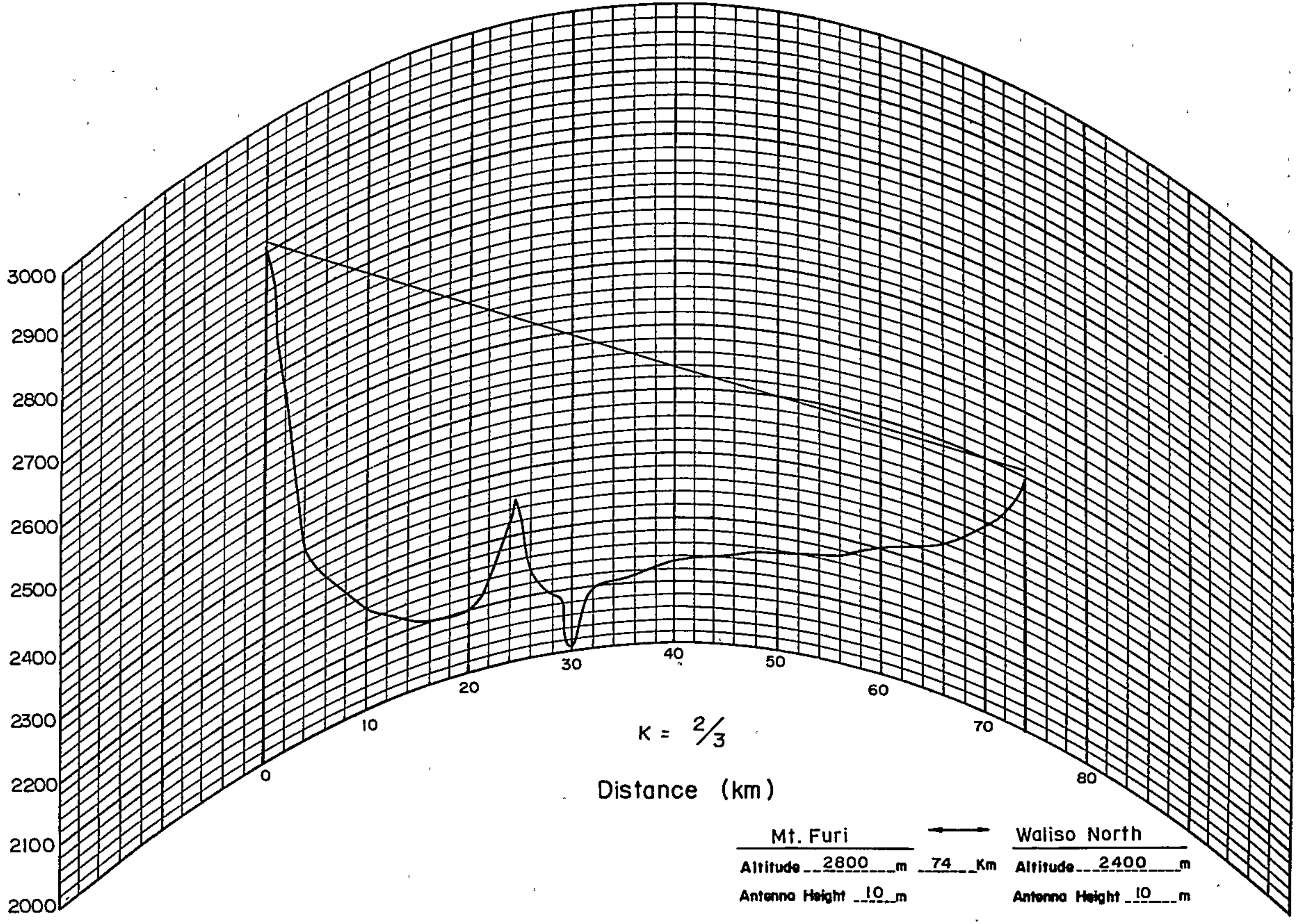


Fig.Ⅲ-35 PROFILE MAP

(K = 4/3)

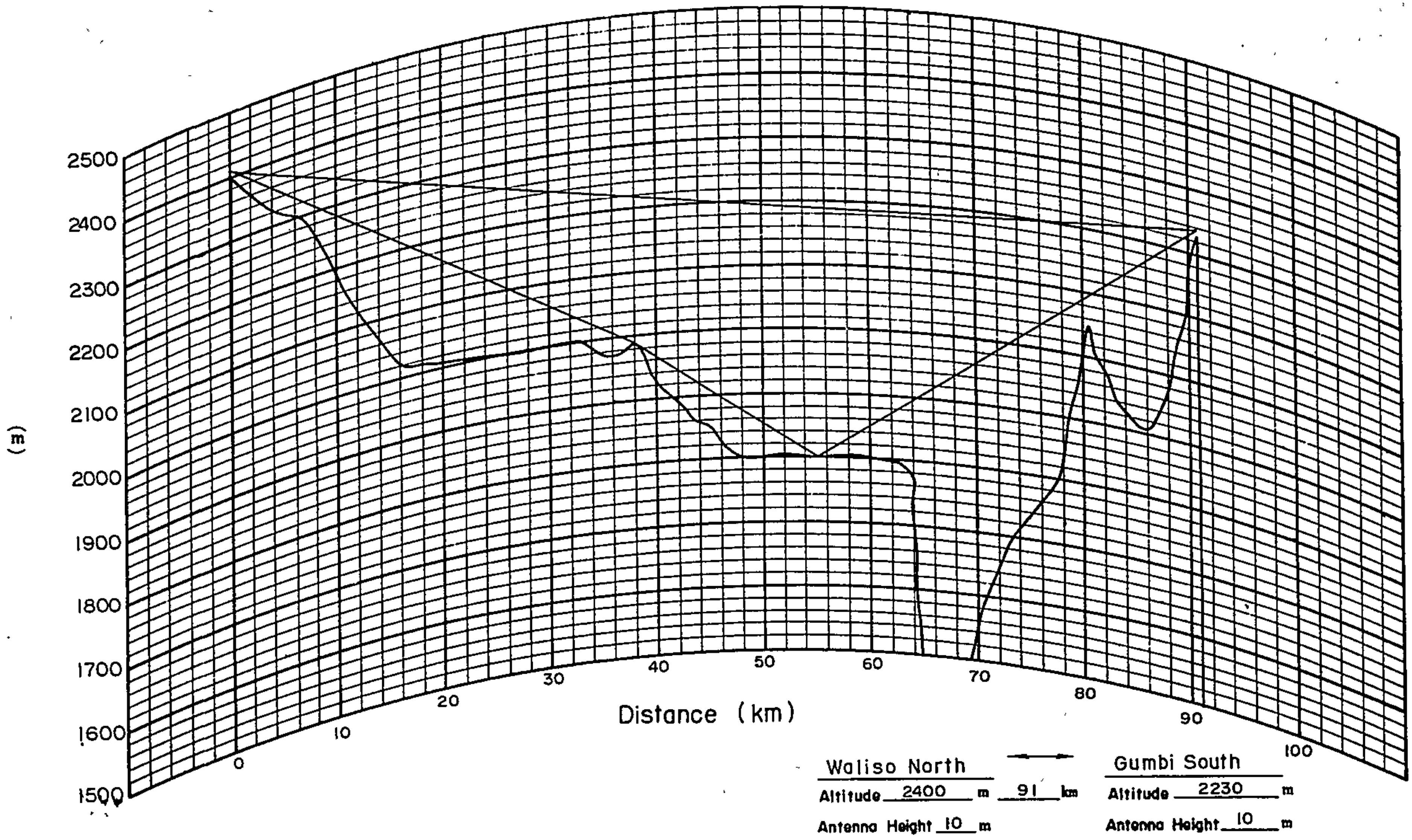


Fig.Ⅲ-36 PROFILE MAP

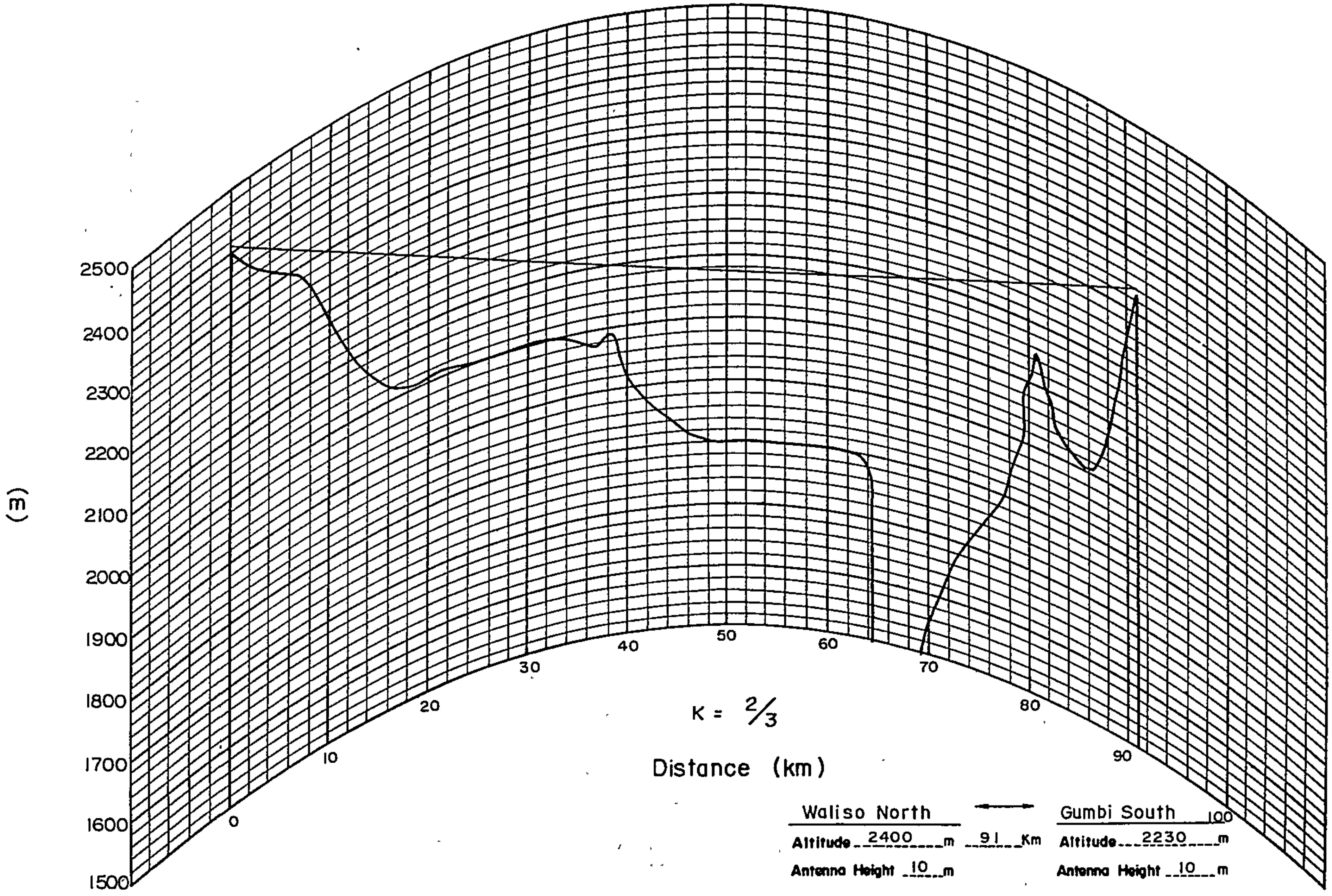


Fig.III-37 PROFILE MAP

(K = 4/3)

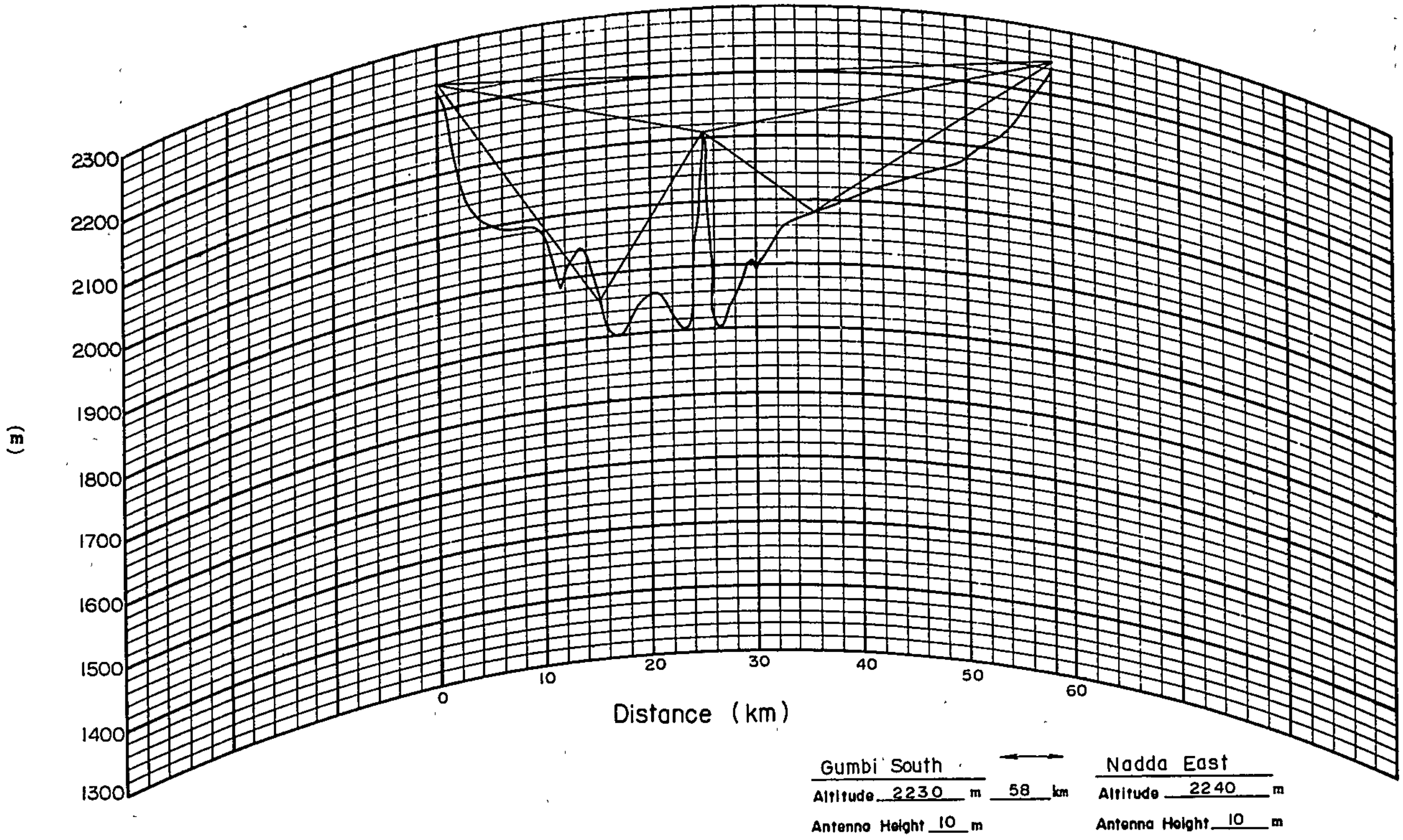


Fig.III-38 PROFILE MAP

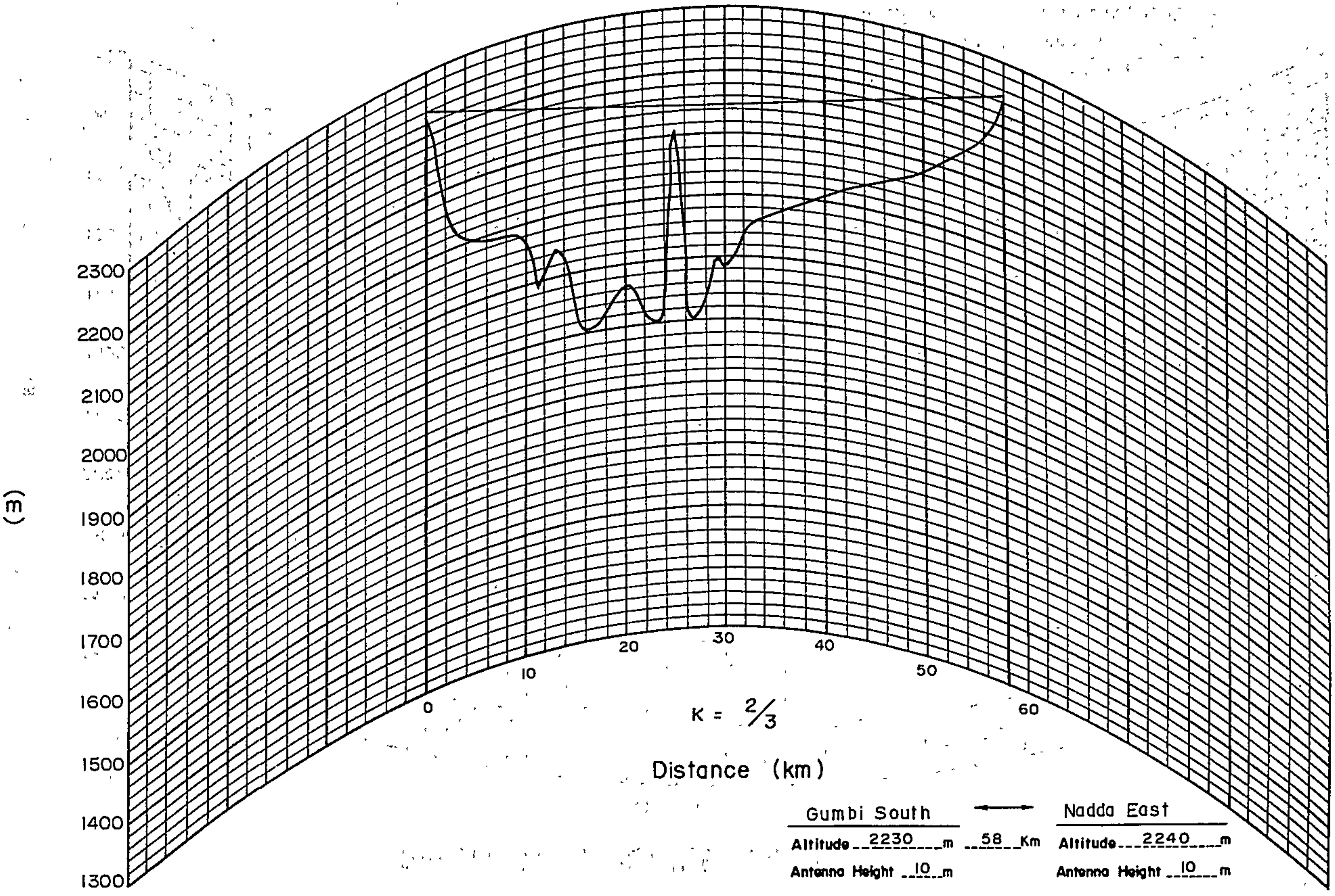


Fig.III - 39 PROFILE MAP

(K = 4/3)

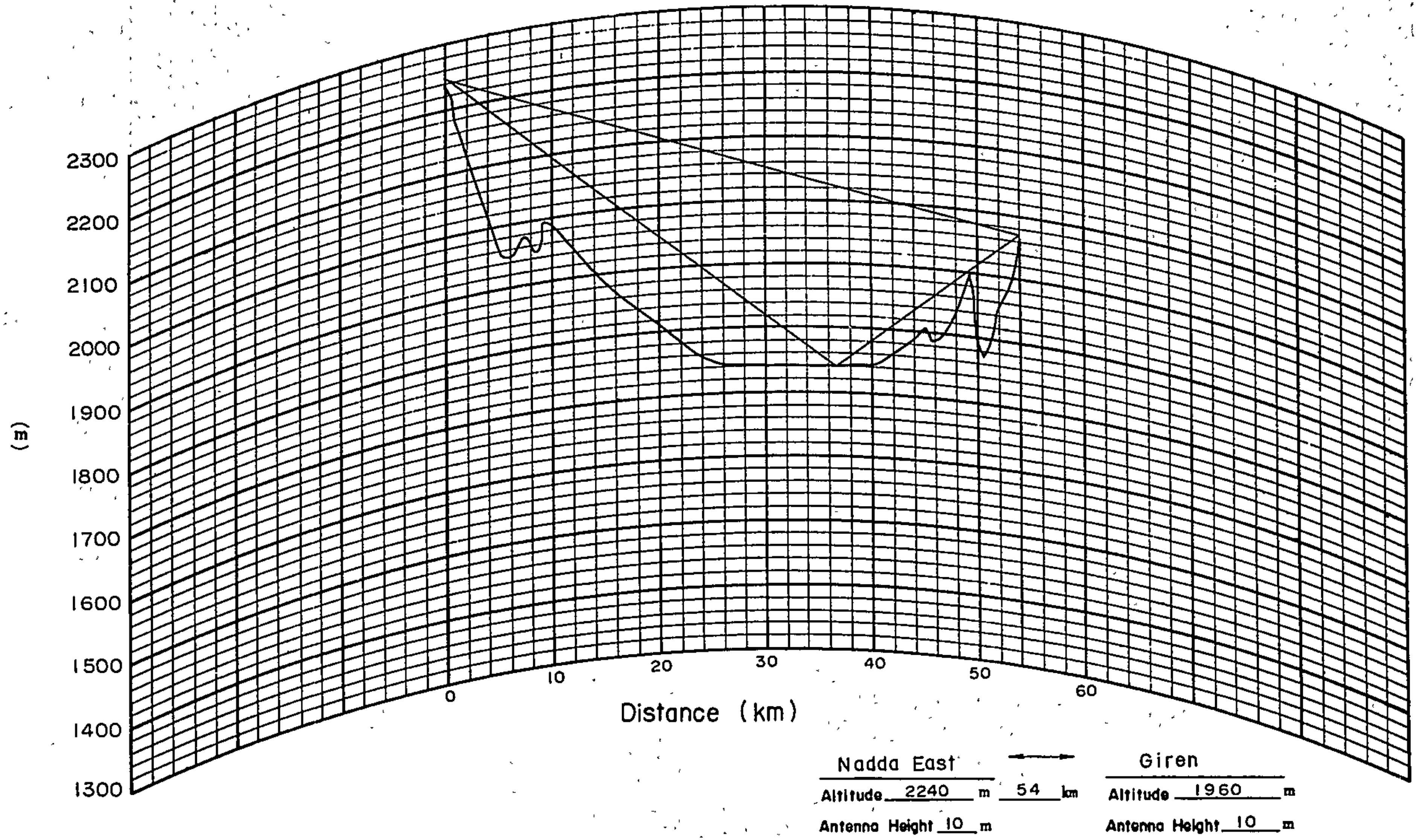


Fig.III-40 PROFILE MAP

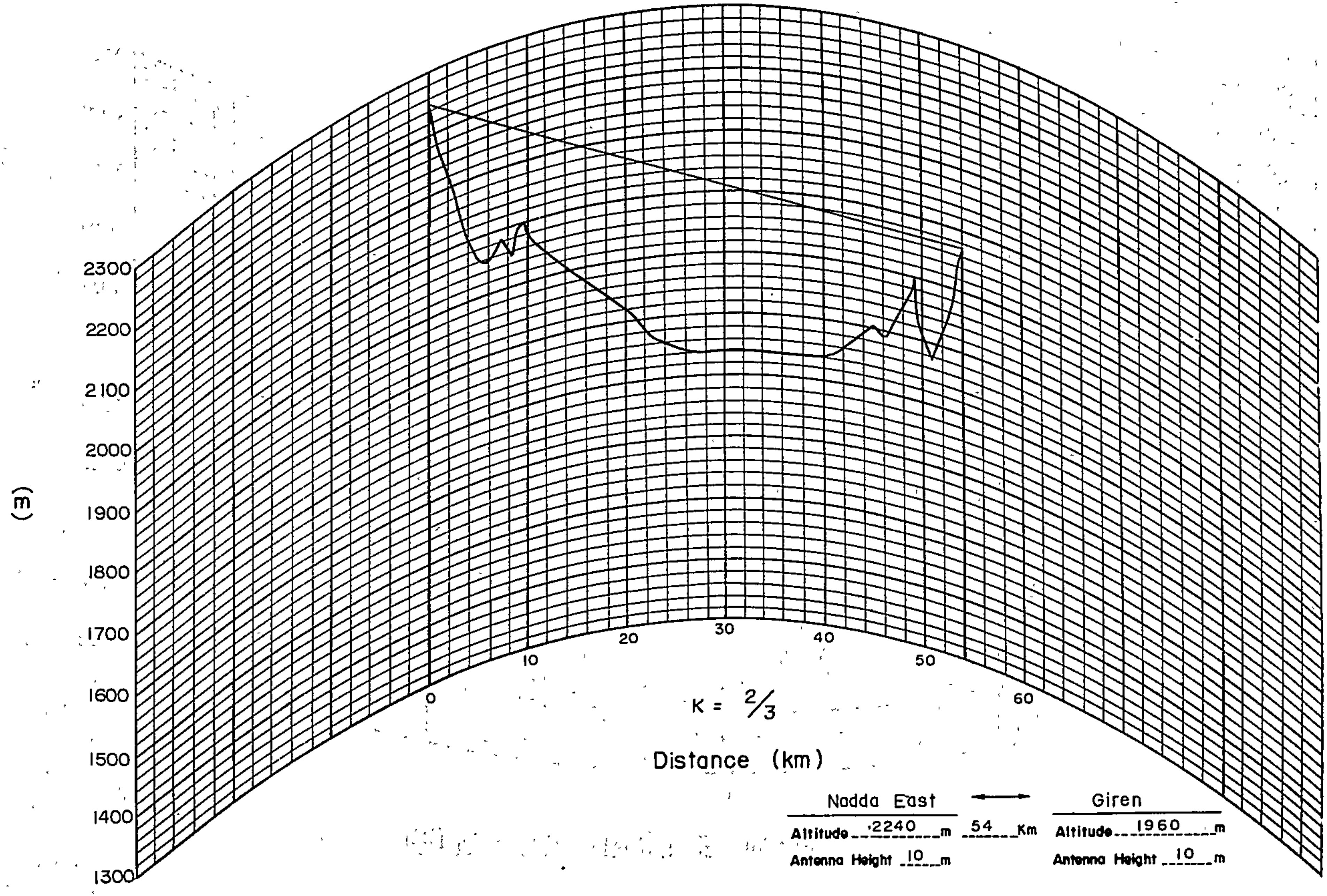


Fig.III-41 PROFILE MAP

(K = 4/3)

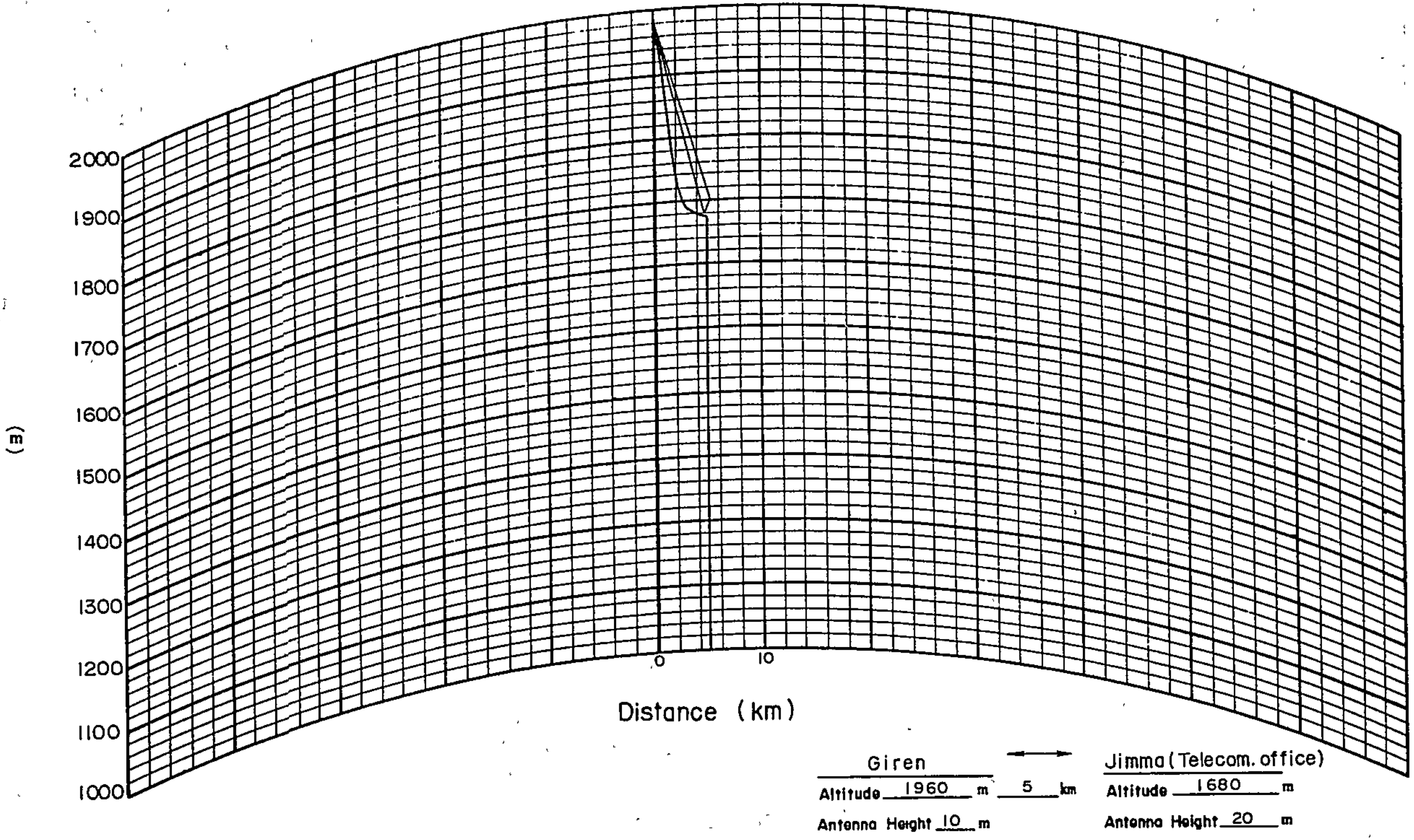
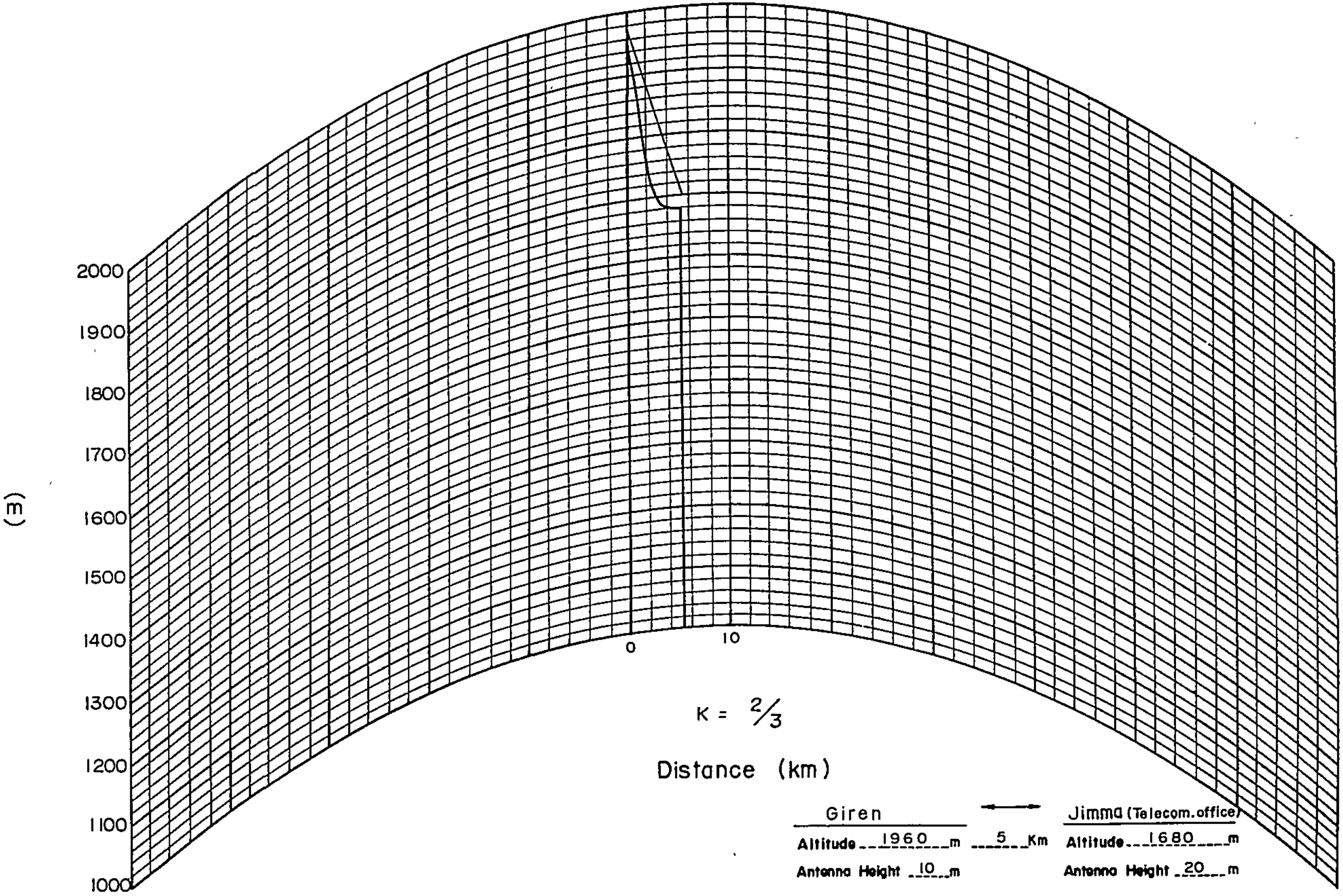
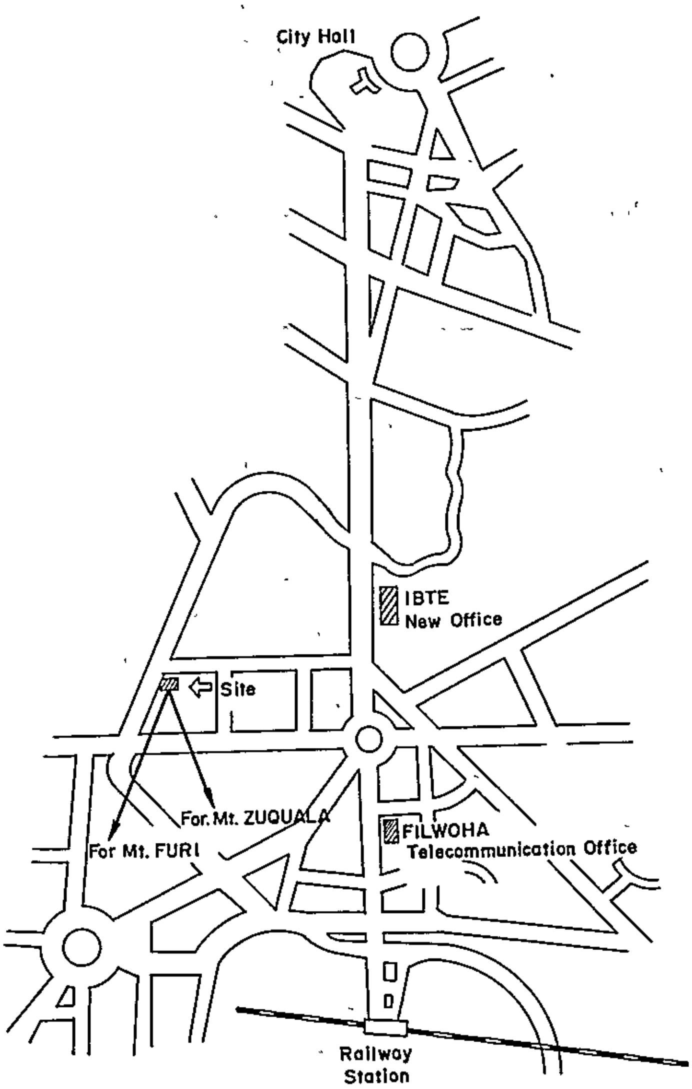


Fig.III-42 PROFILE MAP



3. Guide Maps of the Proposed Sites and Topographic Sketch of the Sites and Vicinity

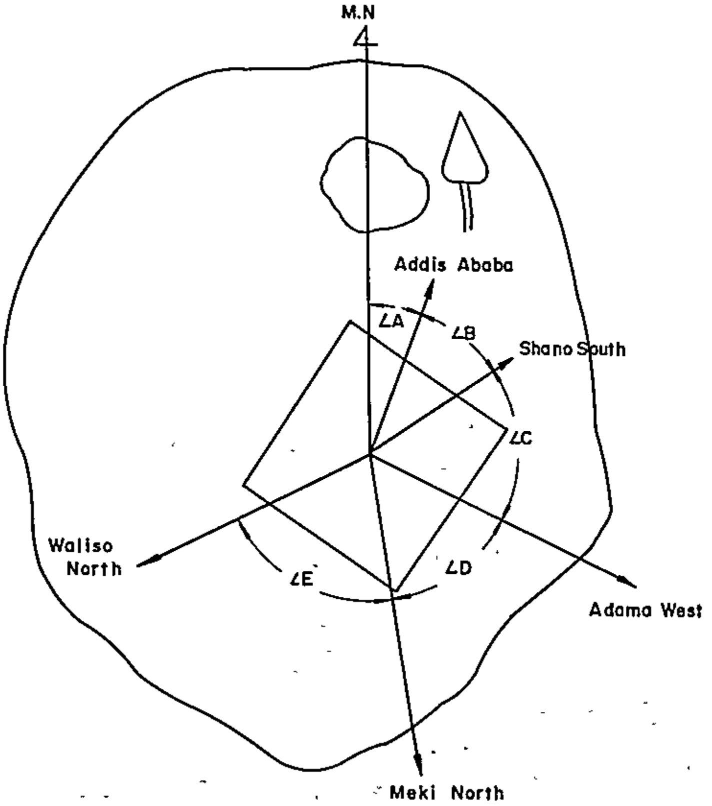


Note; An antenna-tower for this station shall be erected to be more than 30m height in order to clear tall buildings expected to be built around the site in the future.

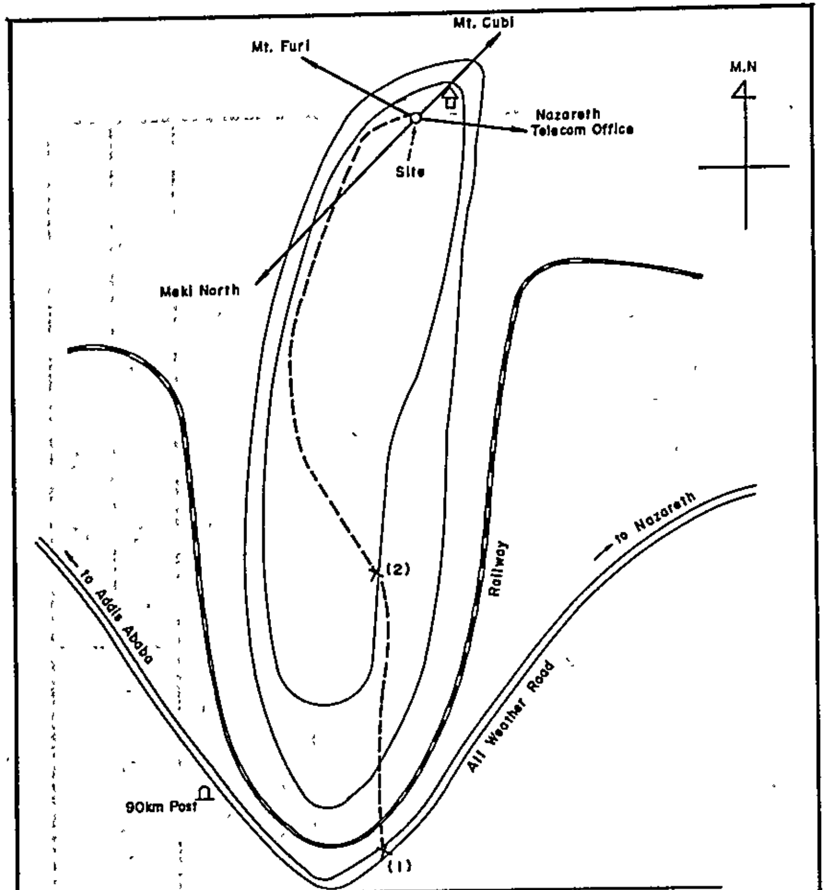
Guide Map of the Site	ADDIS ABABA ("IBTE" HEAD QUARTER)
	Fig. III - 43

ITEM	REMARK
A	21° 16'
B	30° 12'
C	70° 58'
D	40° 38'
E	83° 34'

Note; The site is prepared in the lot of the No. 1 Route



Topographic Sketch of the Site and Neighbourhood	Mt. Furi
	Fig. III - 44

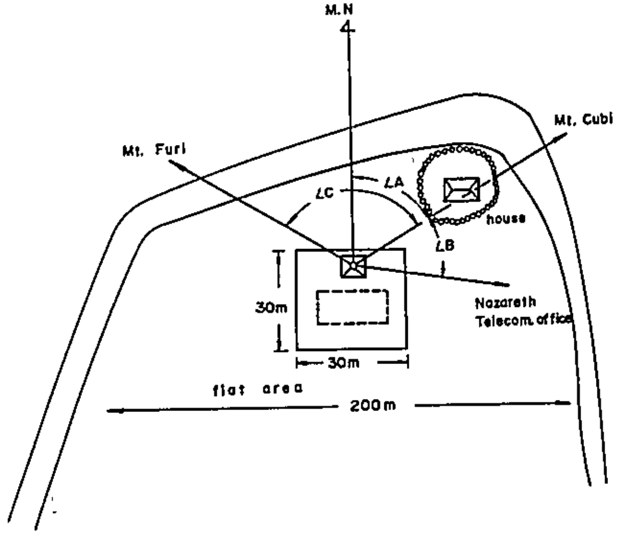


ITEM	REMARK
(1) — Site	a new access road would be required. (about 3.5 Km)
(2) — Site	a flat field.
(1) — (2)	a steep slope. difference in altotude ; about 140 m.
(1) — Nazareth Telecom. office	about 5 Km.

Guide Map of the Site

Adama West

Fig. III - 45

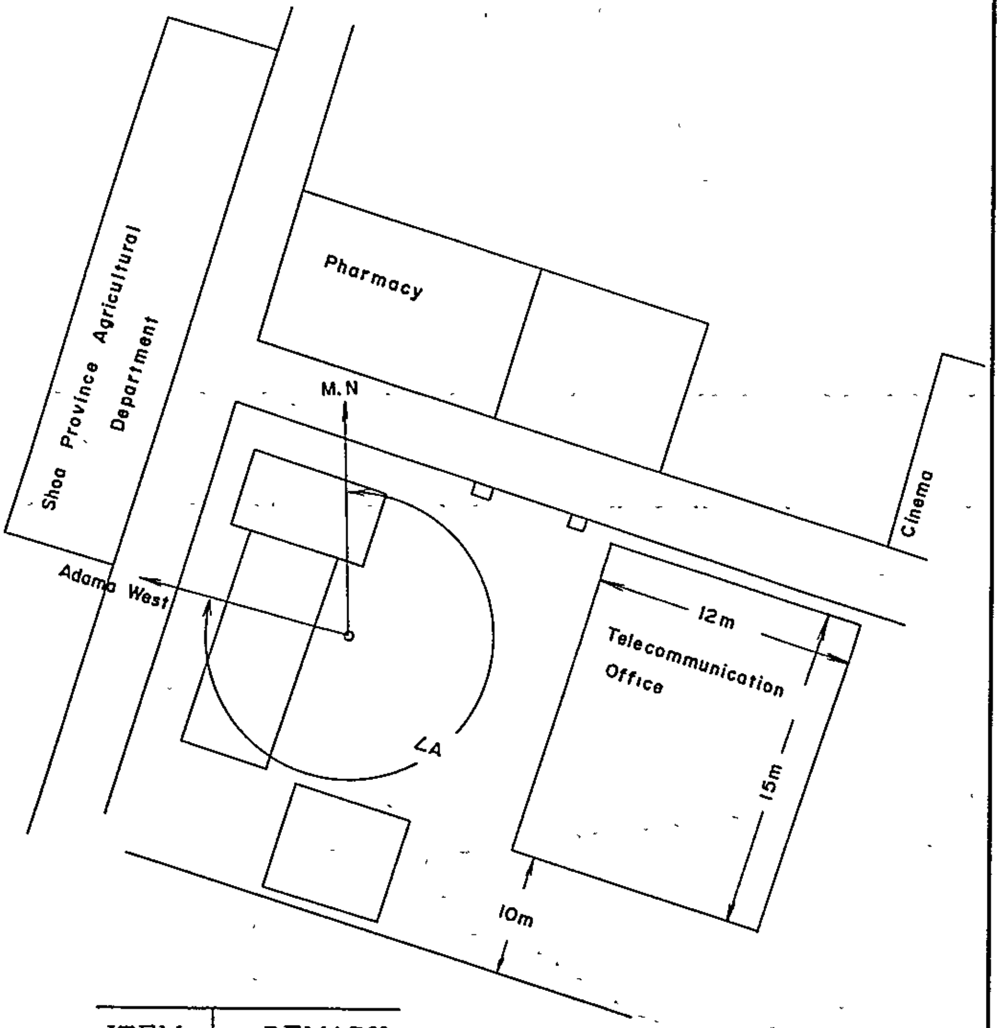


ITEM	REMARK
A	57° 48'
B	45° 33'
C	119° 19'
Site	a flat field. visibility in both directions; sufficiently provided.

Topographic Sketch of the Site and Neighbourhood

Adama West

Fig. III - 46

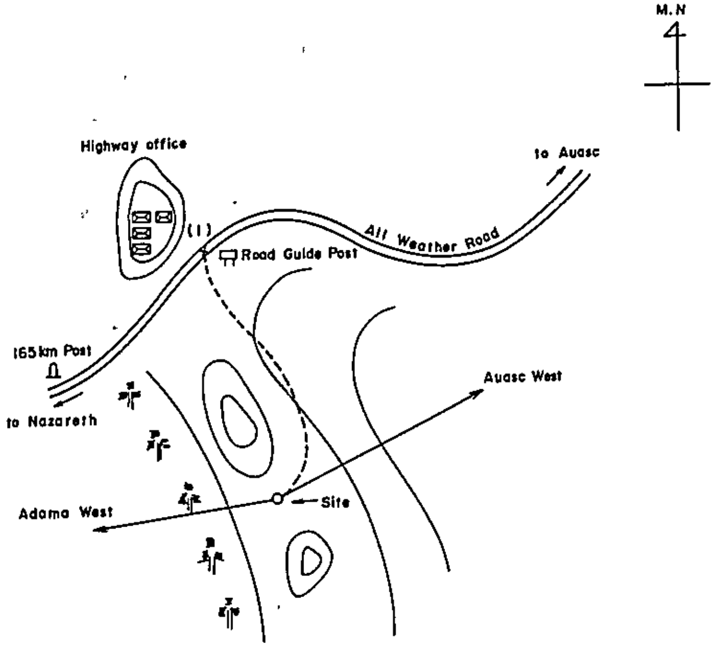


ITEM	REMARK
A	283° 00'

Topographic Sketch of the Site and Neighbourhood

Nazareth (Telecom. office)

Fig. III - 47

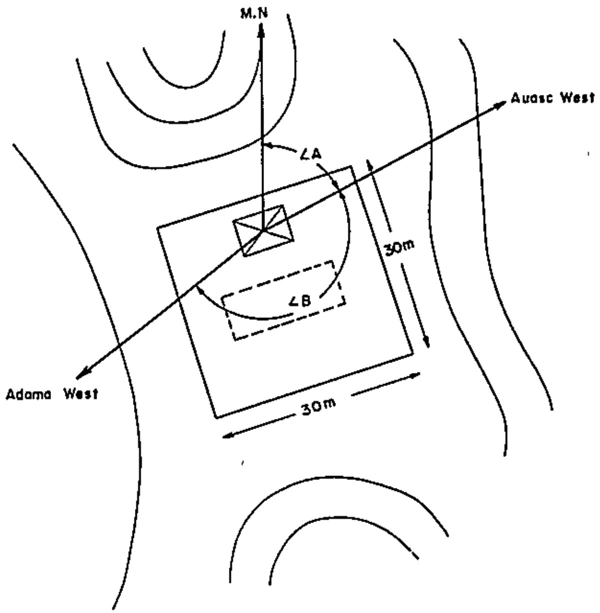


ITEM	REMARK
(1) — Site	a new access road would be required. (about 2.5 Km) difference in altitude ; about 100 m.
(1) — 165 Km Post	about 2 Km.

Guide Map of the Site

Mt. Cubi

Fig. III - 48

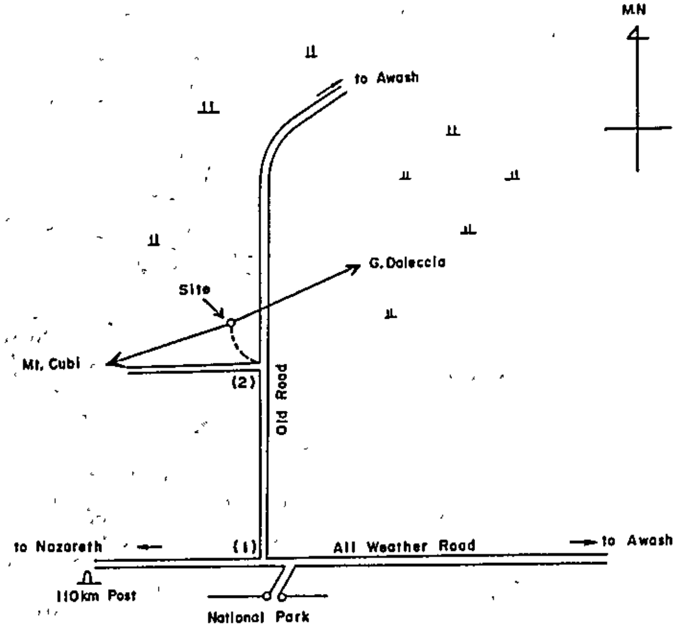


ITEM	REMARK
A	75° 12'
B	168° 53'
Site	a flat and rocky field.

Topographic Sketch of the Site and Neighbourhood

Mt. Cubi

Fig. III - 49

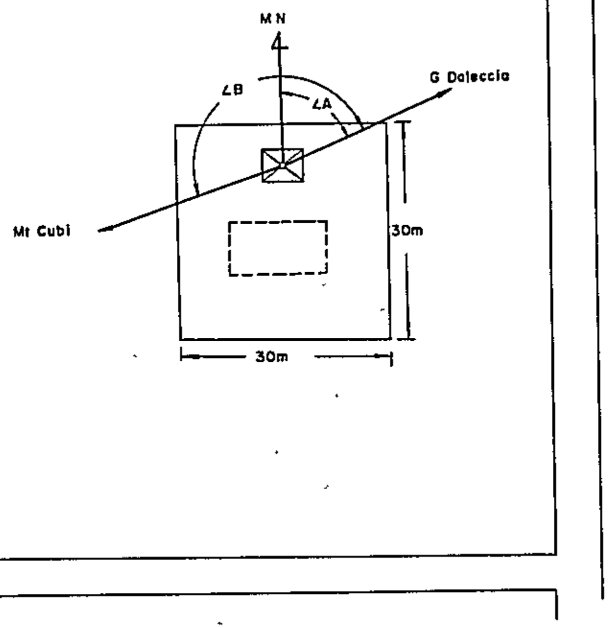


ITEM	REMARK
(1) — (2)	about 2.1 Km. good road.
(2) — Site	about 50 m.
Site	adjacent to the Old Road.
(1) — 110 Km Post	about 1 Km.

Guide Map of the Site

Auasc West

Fig. III - 50

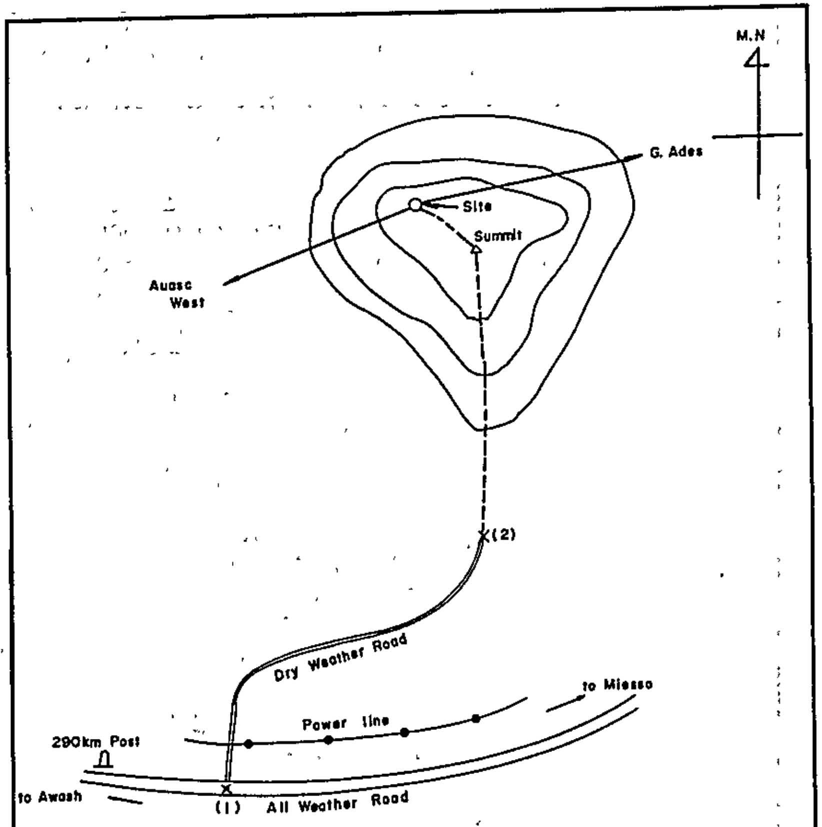


ITEM	REMARK
A	$65^{\circ} 19'$
B	$173^{\circ} 54'$
Site	flat and entirely covered with weeds. visibility in both directions; sufficiently provided.

Topographic Sketch of the Site and Neighbourhood

Auasc West

Fig. III - 51

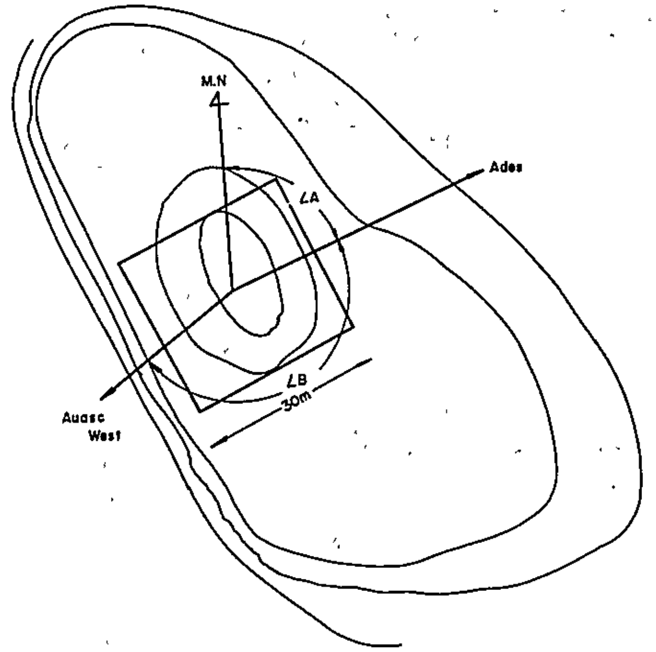


ITEM	REMARK
(1) – (2)	about 3 Km. accessible by jeep in the dry season. some repair work may be required.
(2) – Site	a new access road would be required. (about 4 Km)
(1) – Site	difference in altitude; about 250 m.
(1) – 290 Km Post	about 1 Km.
(1) – Miesso	about 11 Km.

Guide Map of the Site

Daleccia

Fig. III - 52

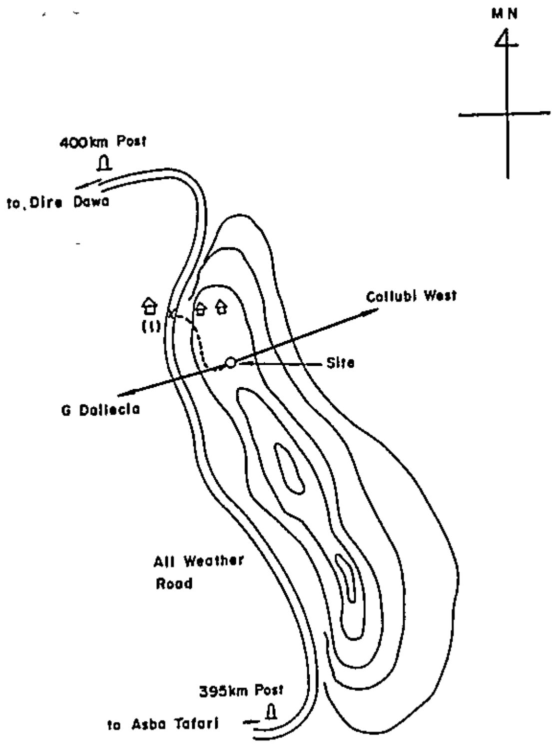


ITEM	REMARK
A	80° 49'
B	165° 06'
Site	undulated and stony field with shrubs. west side; a steep slope. sufficient area to construct a repeating station is available with difficulty. (about one meter ground leveling will be required.)

Topographic Sketch of the Site and Neighbourhood

Daleccia

Fig. III - 53

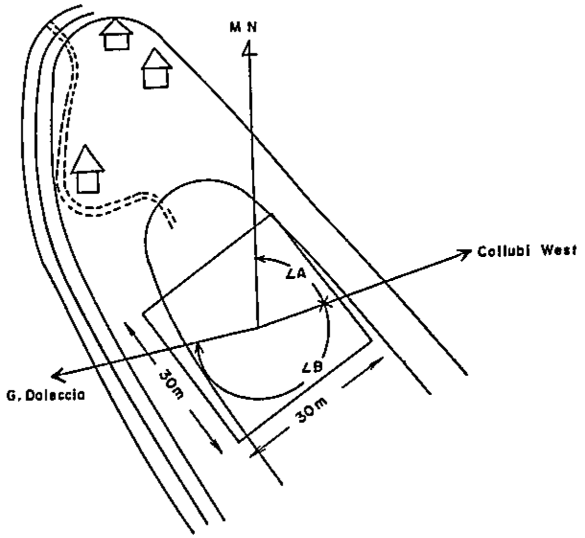


ITEM	REMARK
(1) – Site	a new access road would be required. (about 0.5 Km)
(1) – 400 Km Post	about 1 Km.

Guide Map of the Site

G. Ades

Fig. III - 54

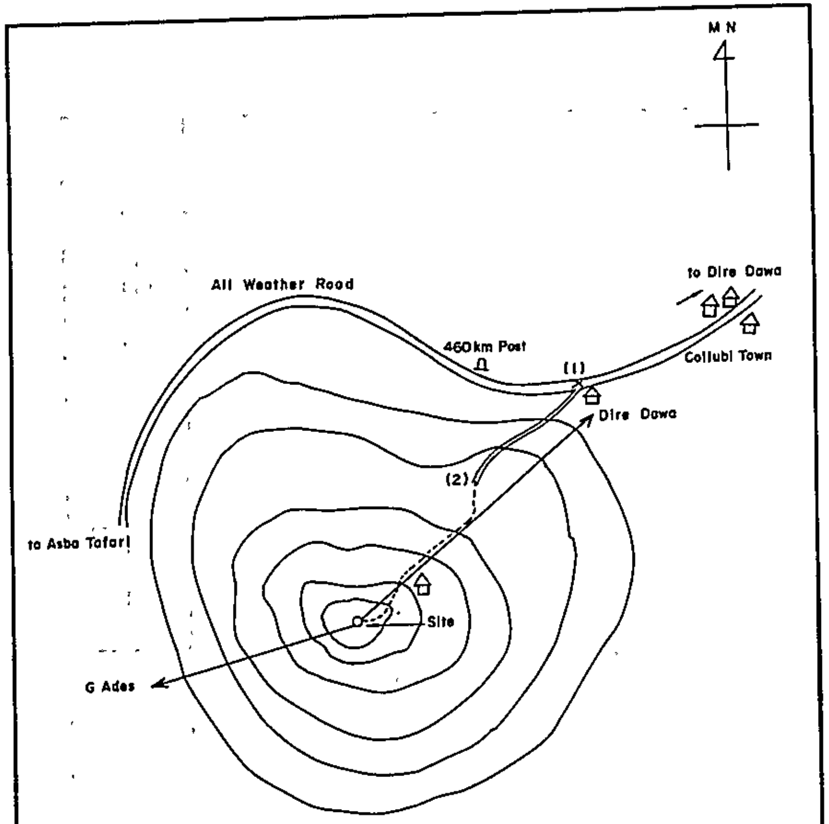


ITEM	REMARK
A	79° 58'
B	184° 22'
Site	located on the sloping side of the mountain with a cliff near the All Weather Road. about 3 meter ground leveling will be required for the construction of a repeating station. antenna height would be required more than 35 m due to ridges in both directions.

Topographic Sketch of the Site and Neighbourhood

G. Ades

Fig. III - 55

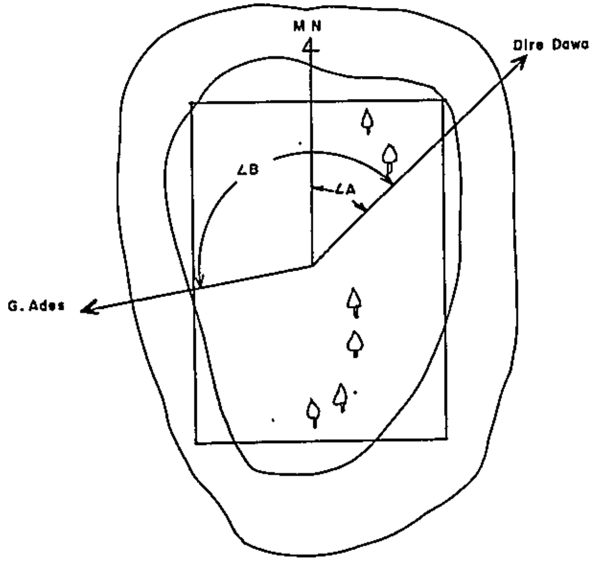


ITEM	REMARK
(1) – (2)	about 1.5 Km. accessible by jeep in the dry season. some repair work may be required.
(2) – Site	a new access road would be required. (about 3.0 Km)
(1) – Site	difference in altitude ; about 260 m.
(1) – 460 Km Post	about 1 Km.

Guide Map of the Site

Collubi West

Fig. III - 56



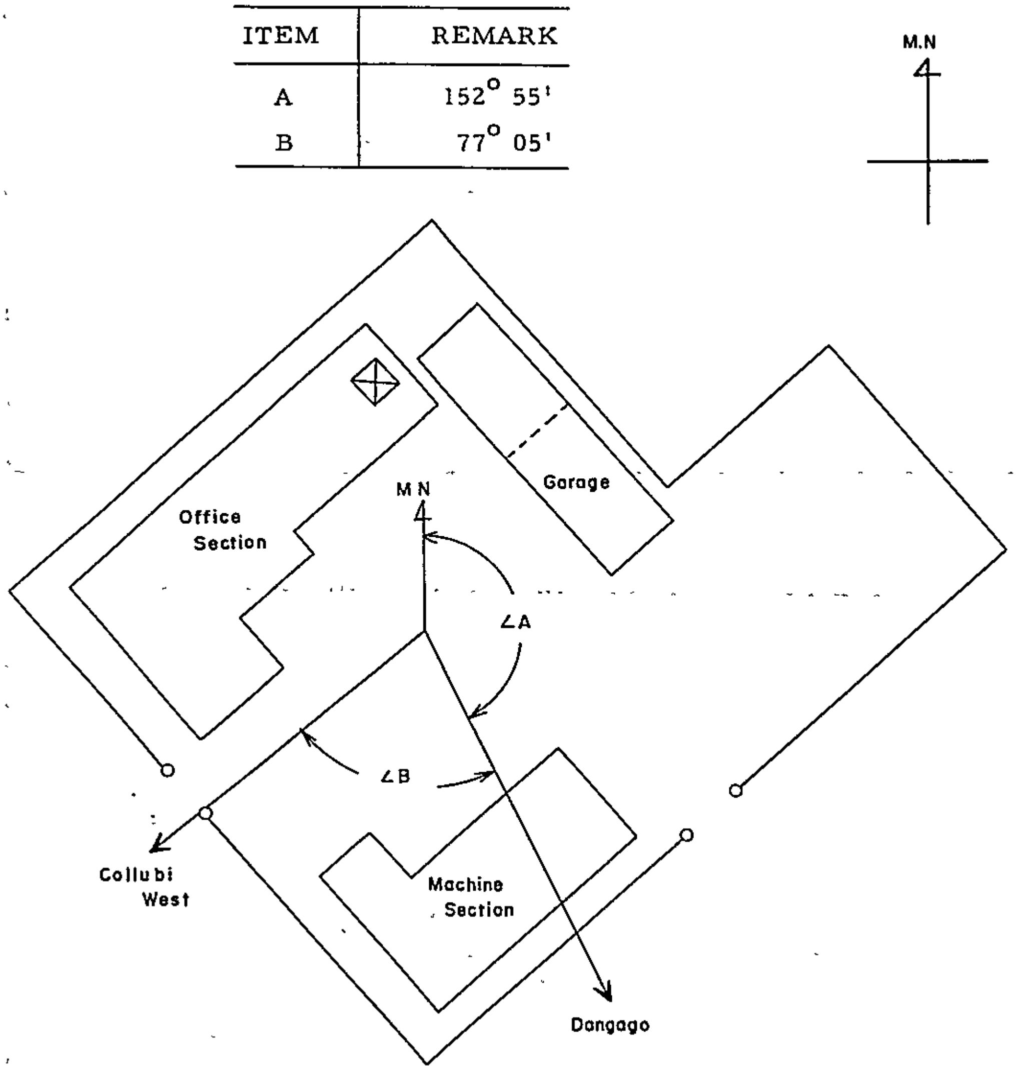
ITEM	REMARK
A	49° 35'
B	153° 06'
Site	visibility in both directions ; sufficiently provided.

Topographic Sketch of the Site and Neighbourhood

Collubi West

Fig. III - 57

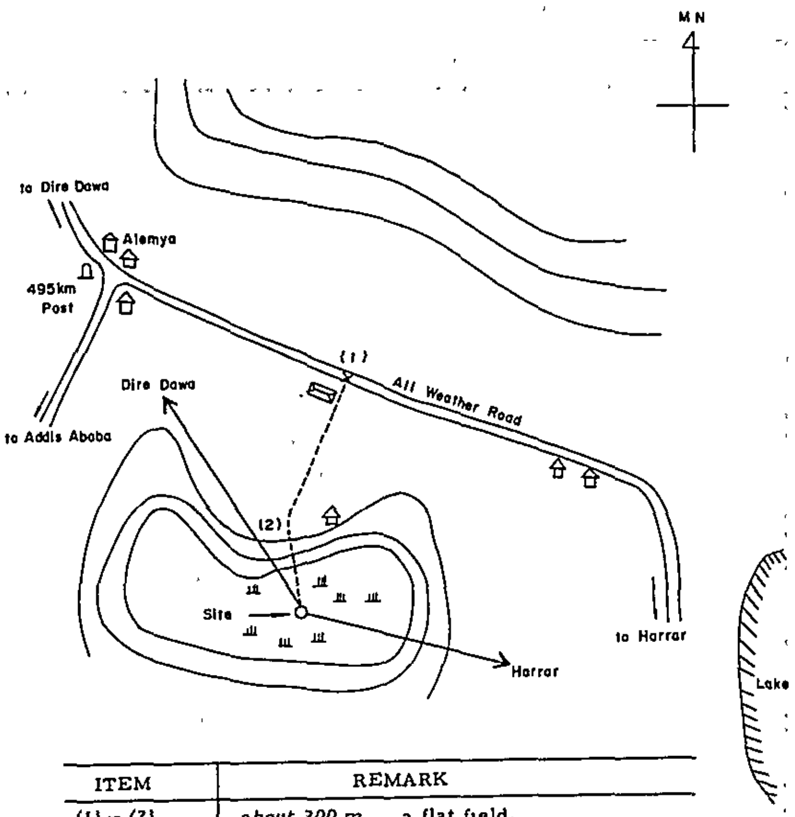
ITEM	REMARK
A	152° 55'
B	77° 05'



Topographic Sketch of the Site and Neighbourhood

Dire Dawa (Telecom. Office)

Fig. III - 58

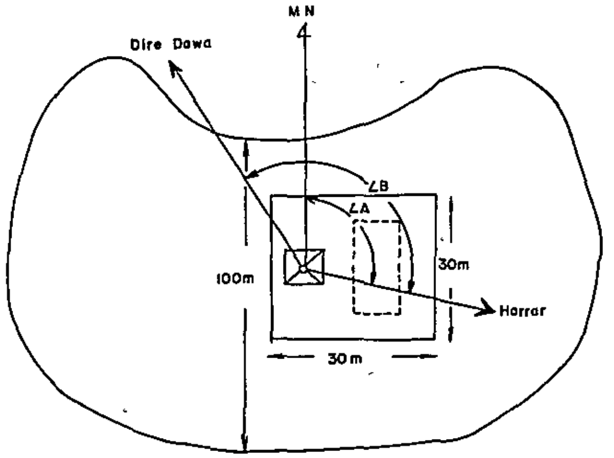


ITEM	REMARK
(1) – (2)	about *300 m.* *a flat field.*
(1) – Site	a new access road would be required. (about 2.5 Km) difference in altitude ; about *200 m.*
(2) —*Site*	about 2 Km. stony and fairly steep slope. an access road construction seems to be not easy.
(1) – 495 Km Post	about *1* Km.

Guide Map of the Site

Dangago

Fig. III - 59

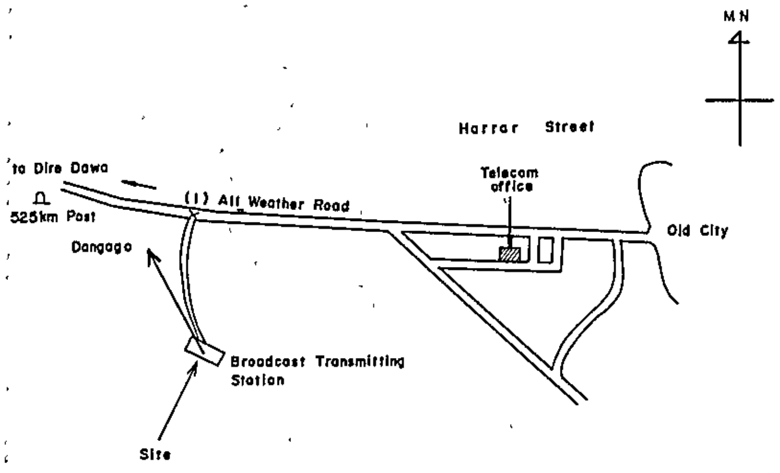


ITEM	REMARK
A	130° 32'
B	156° 58'
Site	located at the summit of the mountain with a flat field. visibility in both directions ; sufficiently provided.

Topographic Sketch of the Site and Neighbourhood

Dangago

Fig. III - 60

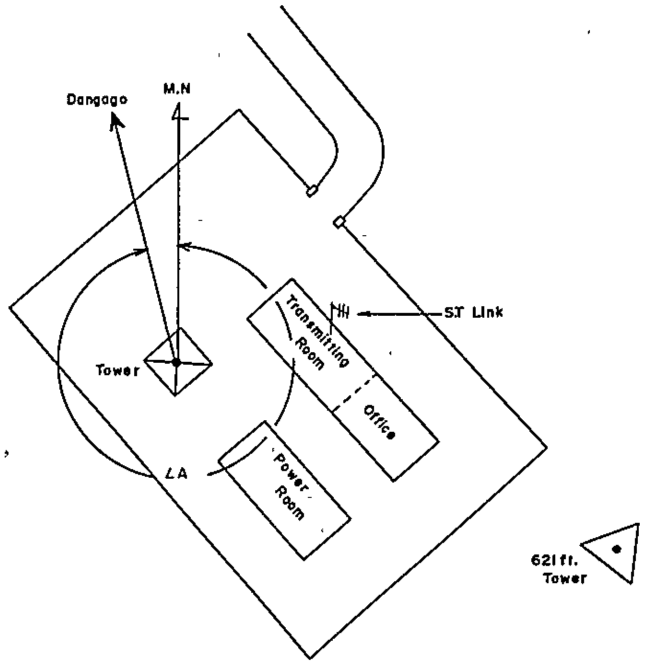


ITEM	REMARK
(1) – Site	about 800 m.
(1) – Telecom. office	about 2.5 Km.
(1) – 525 Km Post	about 600 m.

Guide Map of the Site

Harrar West

Fig. III - 61

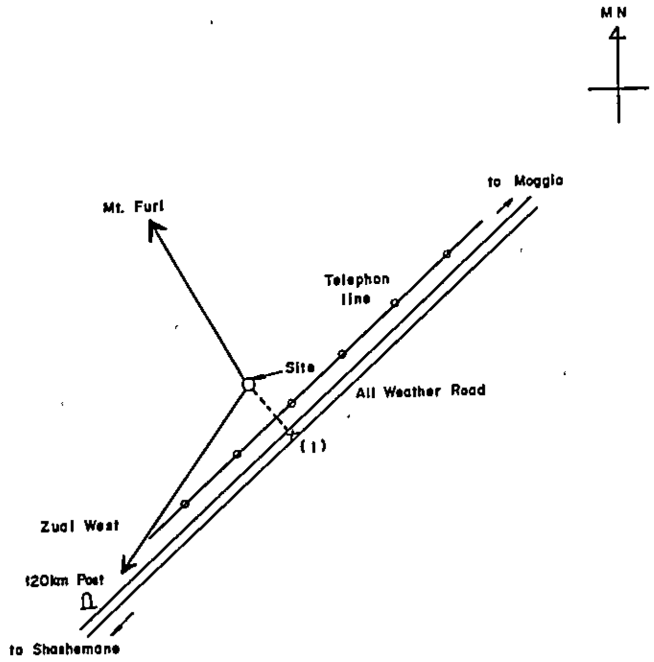


ITEM	REMARK
A	310° 15'

Topographic Sketch of the Site and Neighbourhood

Harrar West

Fig. III - 62

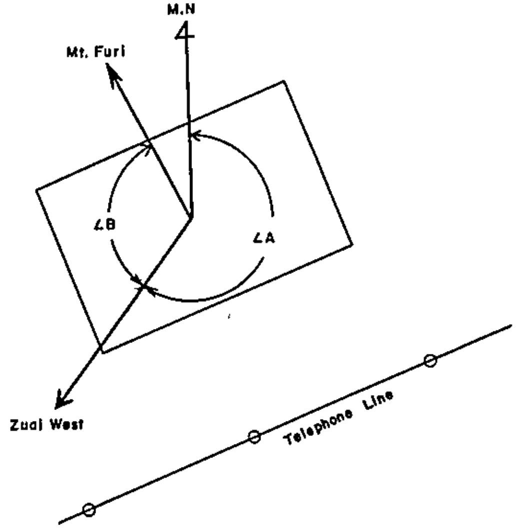


ITEM	REMARK
(1) – Site	about 50 m.
Site	road construction seems to be not necessary. adjacent to the All Weather Road.
(1) – 120 Km Post	about 1 Km.

Guide Map of the Site

Meki North

Fig. III - 63

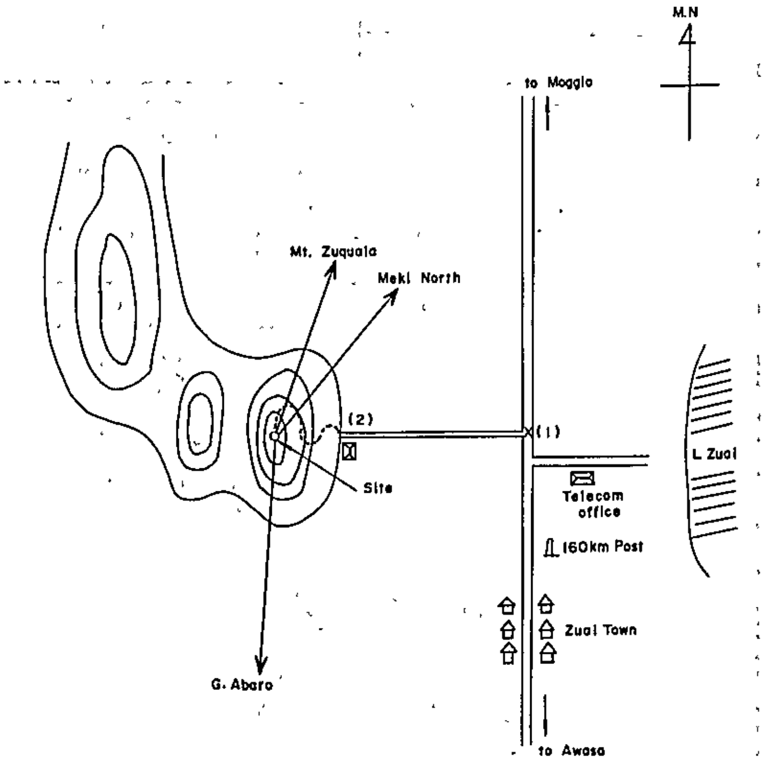


ITEM	REMARK
A	217° 30'
B	125°
Site	flat and entirely covered with weeds. necessary to cut down some trees. visibility in both directions ; sufficiently provided.

Topographic Sketch of the Site and Neighbourhood

Meki North

Fig. III - 64

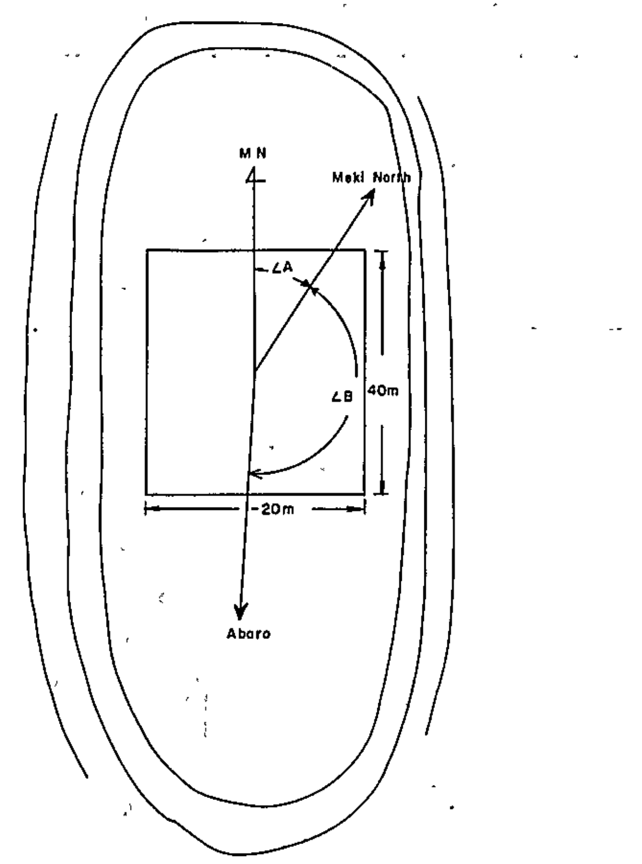


ITEM	REMARK
(1) – (2)	about 5 Km. the condition of the road surface is not satisfactory. (2) ; a quarry.
(2) – Site	gently sloping field with shrubs. a new access road would be required. (about 1.0 Km) difference in altitude: about 90 m.
(1) – 160 Km Post	about 1 Km.
(1) – Zuai town	about 2 Km.

Guide Map of the Site

Zuai West

Fig. III - 65

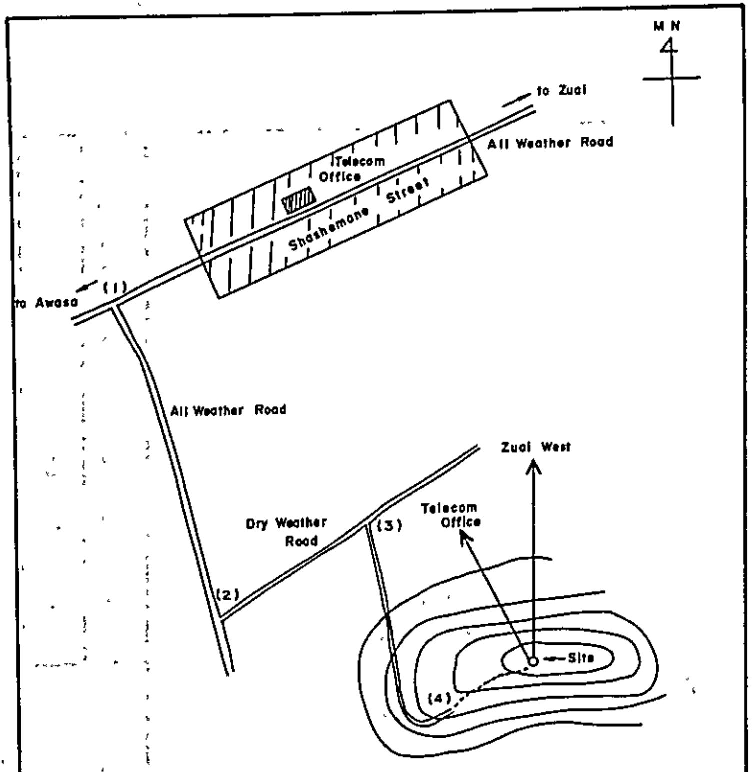


ITEM	REMARK
A	36°
B	148° 08'
Site	located at the summit of the mountain with some shrubs. ground leveling will be required. visibility in both directions ; sufficiently provided.

Topographic Sketch of the Site and Neighbourhood

Zuai West

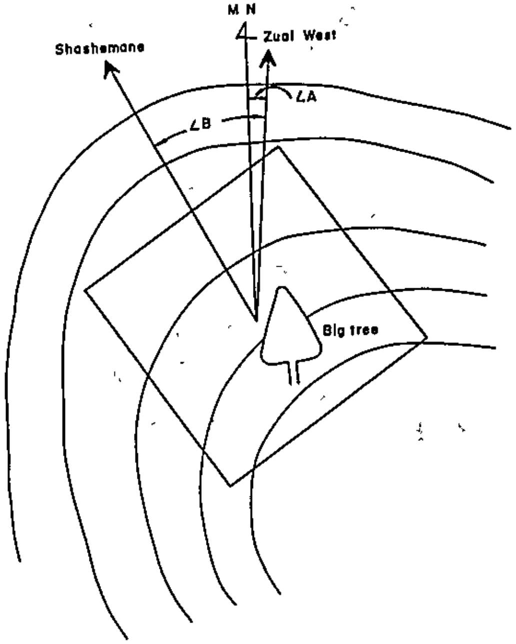
Fig. III - 66



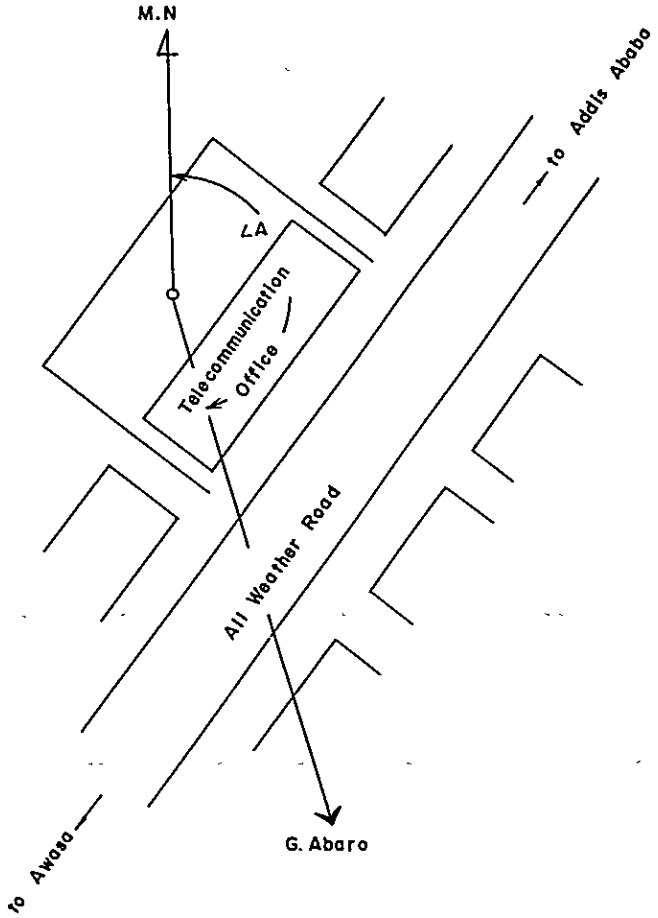
ITEM	REMARK
(1) – (2)	about 6 Km.
(2) – (3)	about 3 Km.
(3) – (4)	about 3 Km. accessible by jeep in the dry season. the condition of the road surface is not satisfactory and some repair work may be required.
(4) – Site	a new access road would be required. (about 1.0 Km)
(1) – Telecom. office	about 1 Km.
(3) – Site	difference in altitude, about 120 m.

Guide Map of the Site	Abaro
	Fig. III - 67

ITEM	REMARK
A	0° 53'
B	19° 22'
Site	necessary to cut down some large trees. about one meter ground leveling will be required for the construction of a repeating station. visibility in both directions; sufficiently provided.

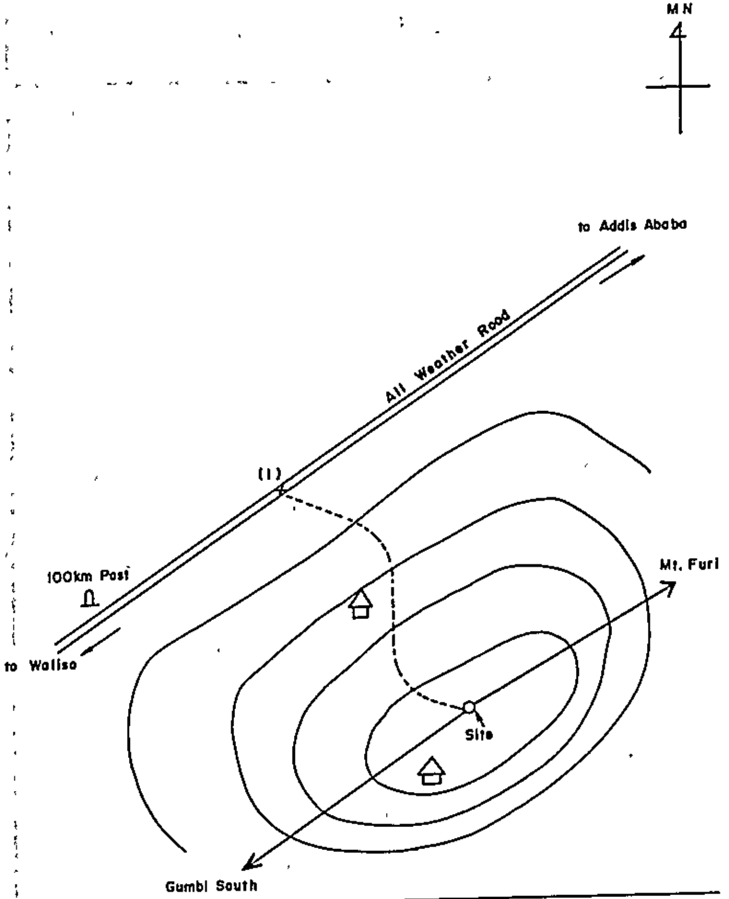


Topographic Sketch of the Site and Neighbourhood	Abaro
	Fig. III - 68



ITEM	REMARK
A	160° 38"

Topographic Sketch of the Site and Neighbourhood	Shashemane (Telecom. Office)
	Fig. III - 69



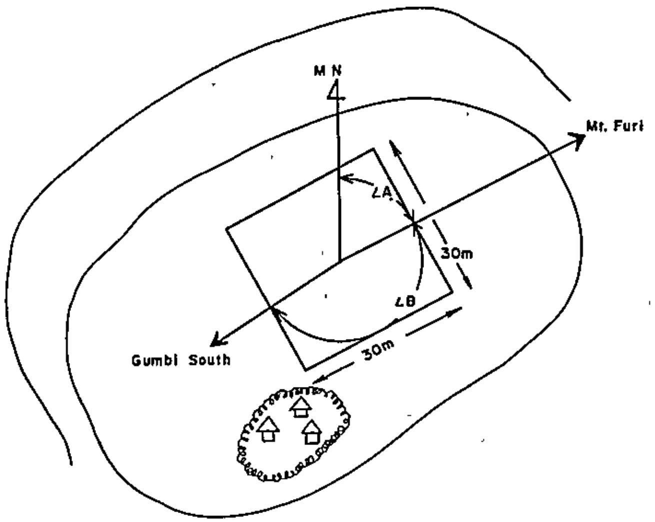
ITEM	REMARK
(1) – Site	a gently sloping field. a new access road would be required. (about 1 Km)
(1) – 100 Km Post	about 200 m.
(1) – Addis Ababa	about 99 Km.

Guide Map of the Site

Waliso North

Fig. III - 70

ITEM	REMARK
A	68° 28'
B	157° 29'
Site	located at the summit of the mountain and enough land area to construct a repeater station is available. visibility in both directions; sufficiently provided.

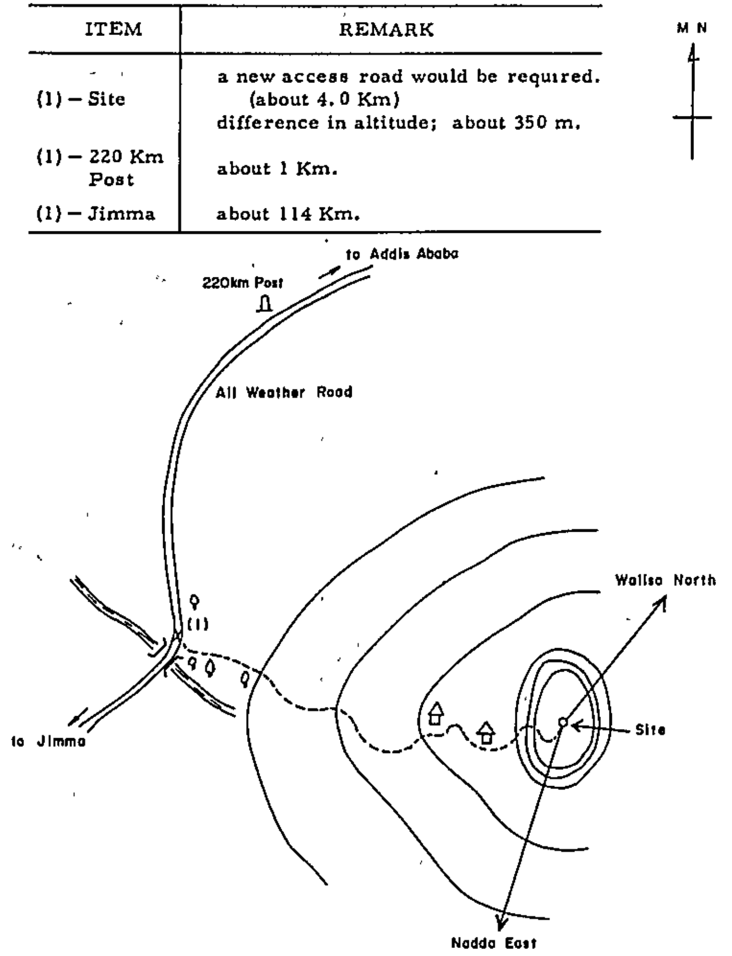


Topographic Sketch of the Site and Neighbourhood

Waliso North

Fig. III - 71

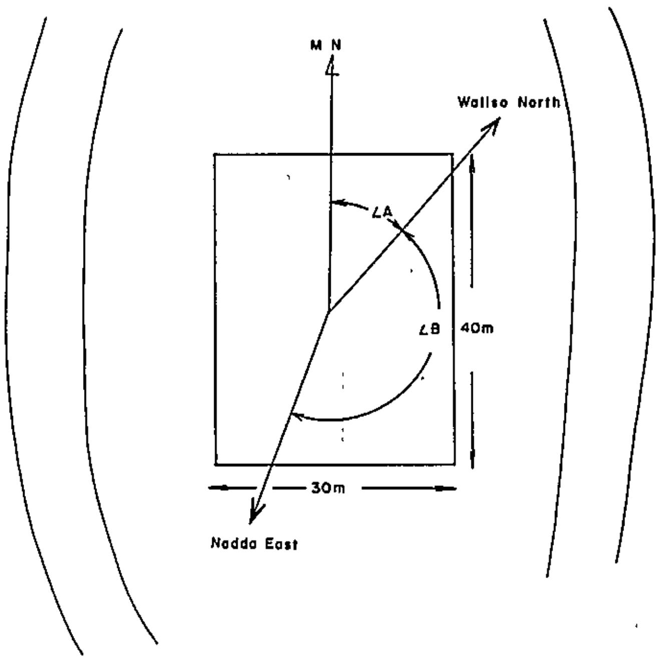
ITEM	REMARK
(1) – Site	a new access road would be required. (about 4.0 Km) difference in altitude; about 350 m.
(1) – 220 Km Post	about 1 Km.
(1) – Jimma	about 114 Km.



Guide Map of the Site

Gumbi South

Fig. III - 72

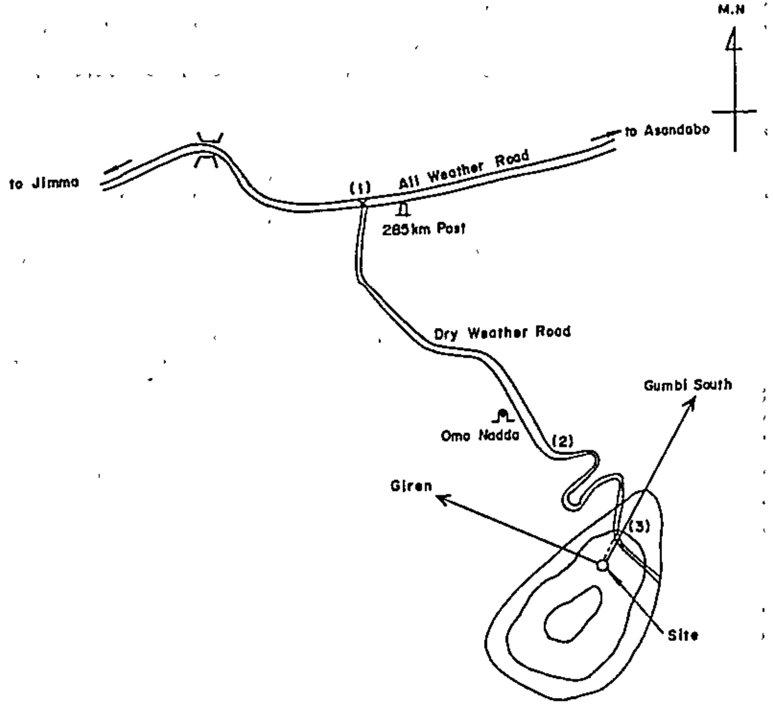


ITEM	REMARK
A	48°
B	154°
Site	located at the summit of the mountain and enough land area to construct a repeating station is available. visibility in both directions; sufficiently provided.

Topographic Sketch of the Site and Neighbourhood

Gumbi South

Fig. III - 73

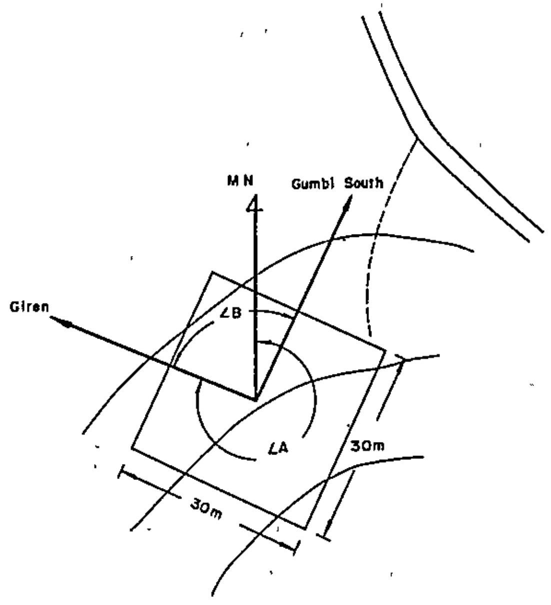


ITEM	REMARK
(1) – (2)	about 20 Km.
(2) – (3)	about 5 Km.
(3) – Site	a new access road would be required (about 0.2 Km)
(1) – (3)	accessible by jeep in the dry season. (Dry Weather Road) some repair work may be required for All Weather Road. (about 10 Km)
(1) – 285 Km Post	about 100 m.
(1) – Jimma	about 50 Km.

Guide Map of the Site

Nadda East

Fig. III - 74

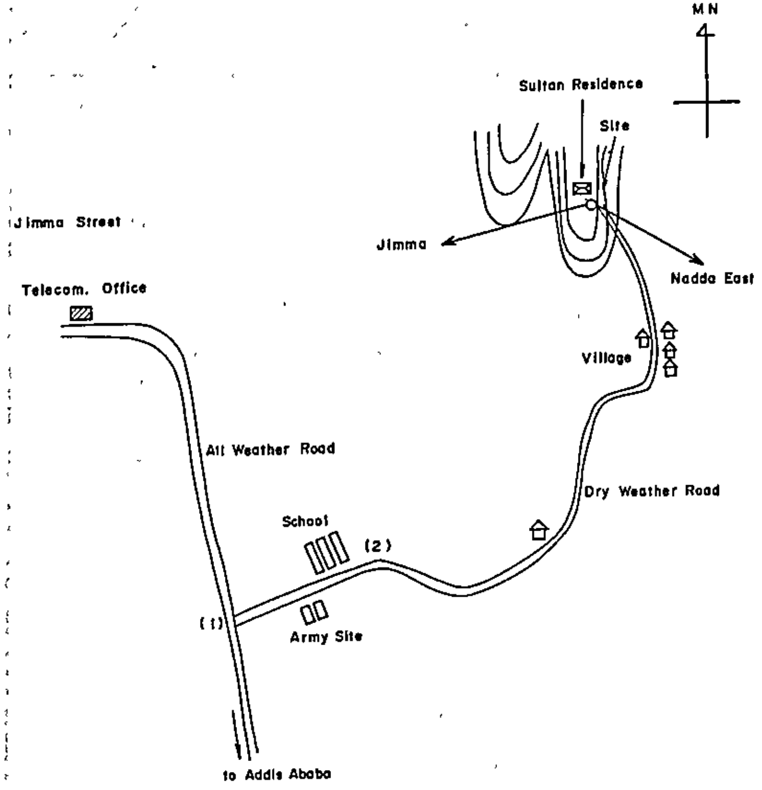


ITEM	REMARK
A	281° 29'
B	93°
Site	a sloping field with shrubs. about 2 meter ground leveling will be required for the construction of a repeating station.

Topographic Sketch of the Site and Neighbourhood

Nadda East

Fig. III - 75

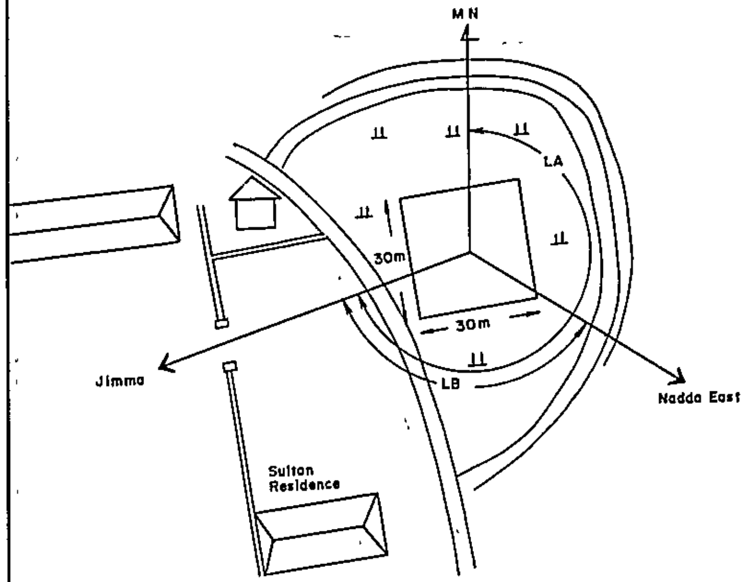


ITEM	REMARK
(1) – (2)	about 1.6 Km. a paved road.
(2) – Site	about 3 Km. accessible by jeep in the dry season. some repair work may be required.
(1) – Telecom. office	about 2.6 Km.
Site – Telecom. office	difference in altitude; about 130 m.

Guide Map of the Site

Giren

Fig. III - 76

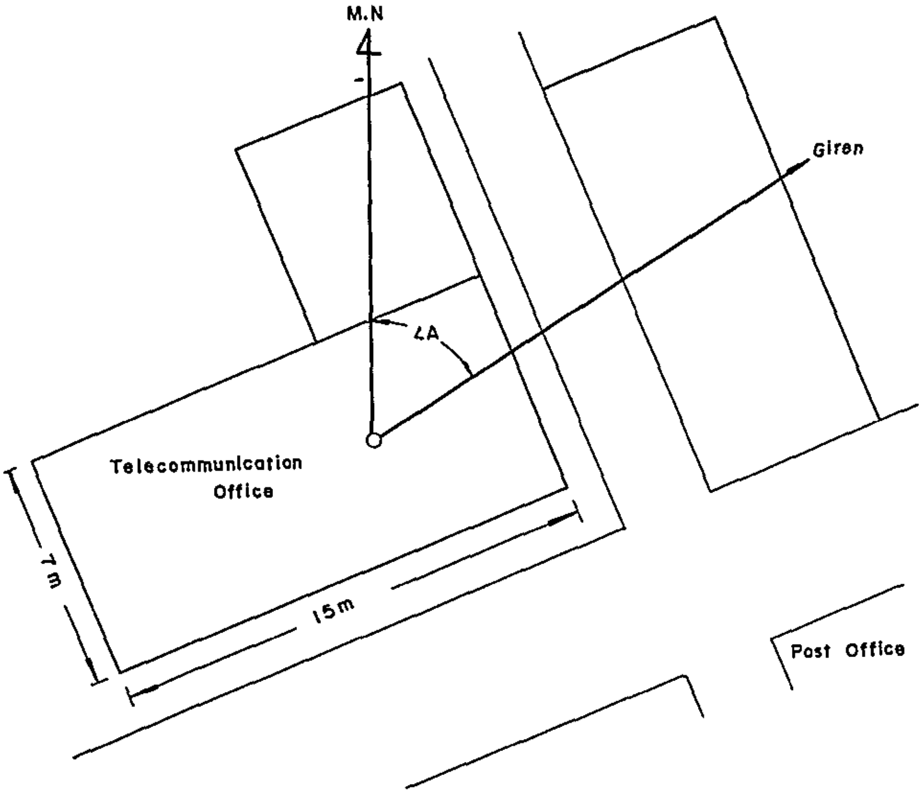


ITEM	REMARK
A	238° 23'
C	123° 19'
Site	suitable for construction of a repeating station in front of the Sultan Residence. visibility; sufficiently provided to Nadda East and Jimma.

Topographic Sketch of the Site and Neighbourhood

Giren

Fig. III - 77



ITEM	REMARK
A	57° 14'

Topographic Sketch of the Site and Neighbourhood	Jimma
	Fig. III - 78

4. Photographs of the Proposed Sites

No. 2 Route 1st plan

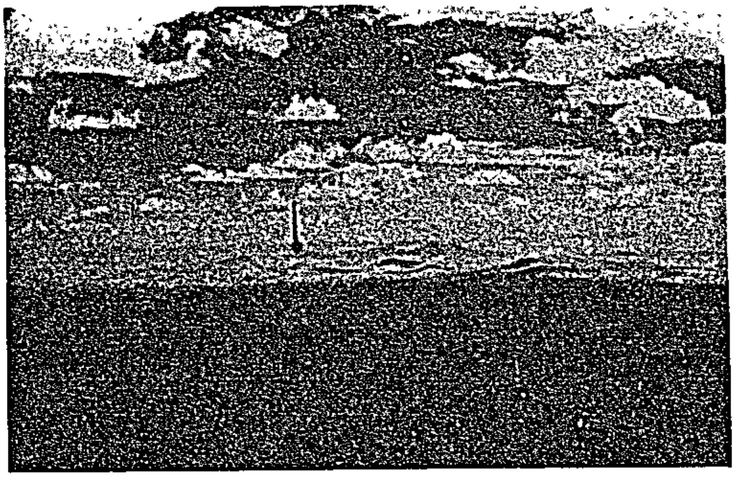


Fig. III-79 A Distant View of ADAMA WEST from the Site

Fig. III-80 A Panoramic View of the Site

Fig. III-81 A Distant View of MT. FURI from the Site

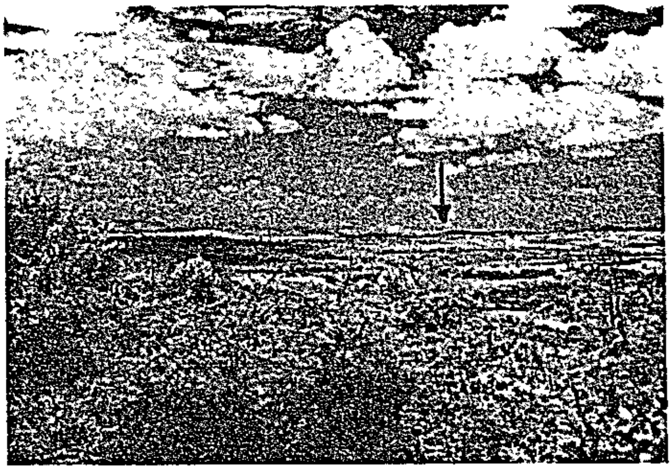


Fig. III-82 A Distant View of MT. CUBI from the Site

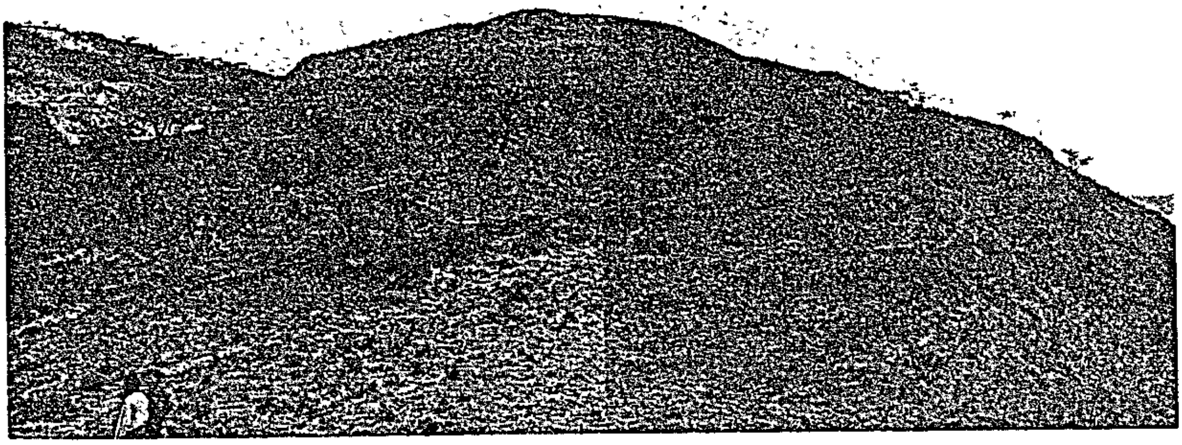


Fig. III-83 A Panoramic View of the Site

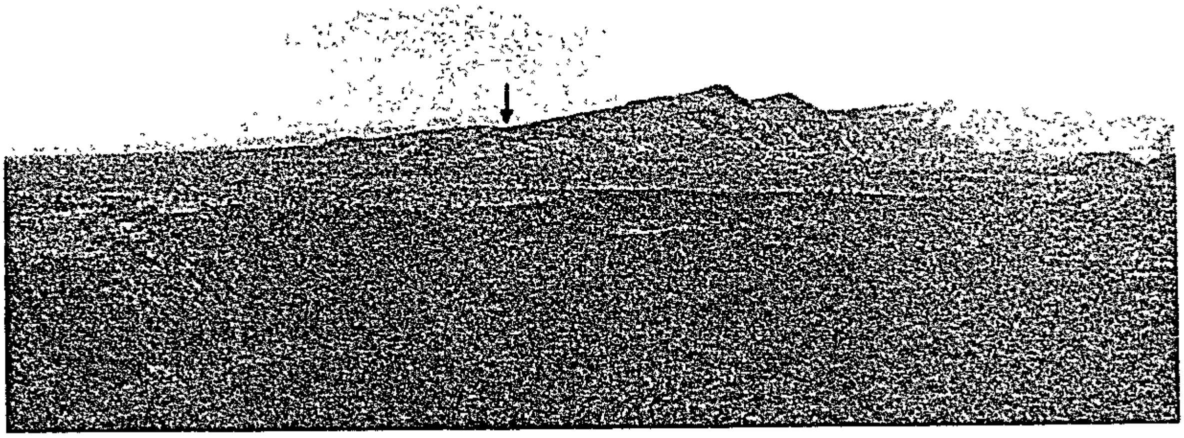


Fig. III-84 A Distant View of ADAMA WEST from the Site

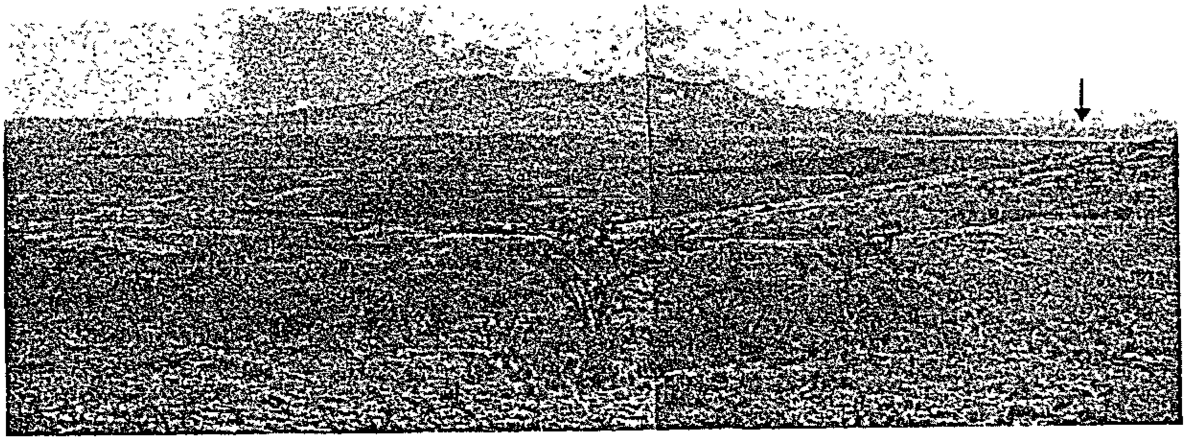


Fig. III-85 A Distant View of AWASH WEST from the Site

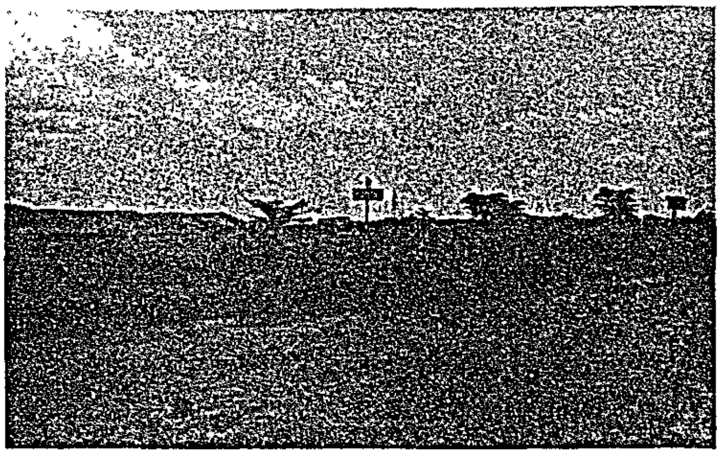


Fig. III-86 A Panoramic View of the Site

Fig. III-87 A Distant View of MT. CUBI from the Site

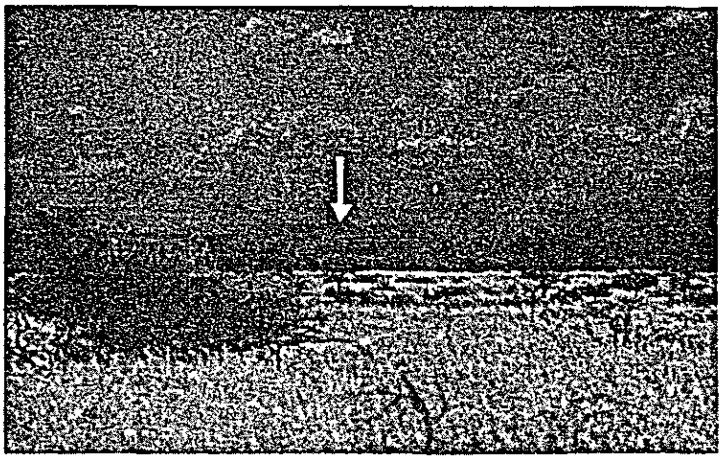


Fig. III-88 A Distant View of G. DALECCIA from the Site

G. DALECCIA

Fig. III-89 A Scene of the Site

Fig. III-90 A Distant View of AWASH WEST from the Site

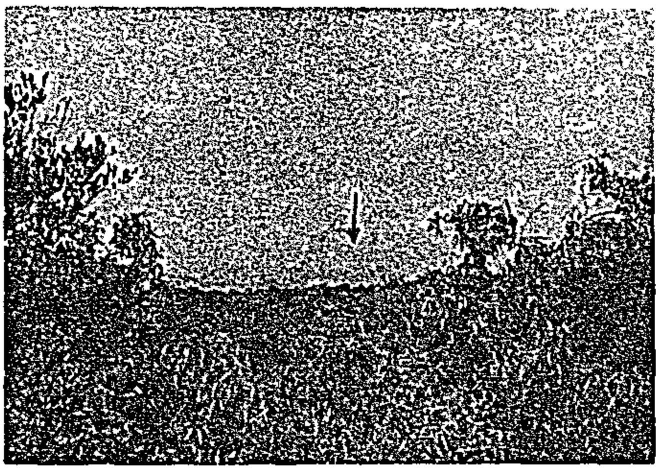


Fig. III-91 A Distant View of G. ADES from the Site

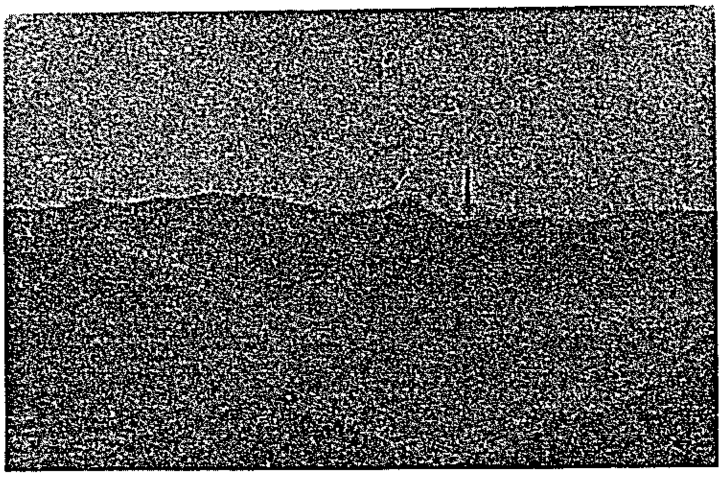


Fig. III-92 A Distant View of G. DALECCIA from the Site

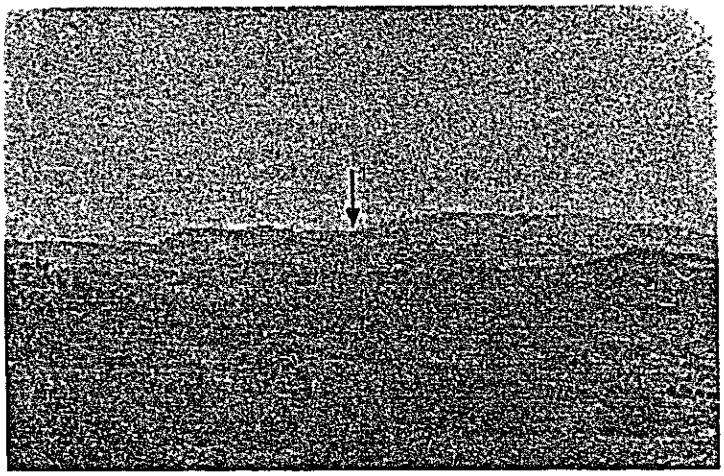


Fig. III-93 A Distant View of COLLUBI WEST from the Site

Fig. III-94 A Scene of the Site

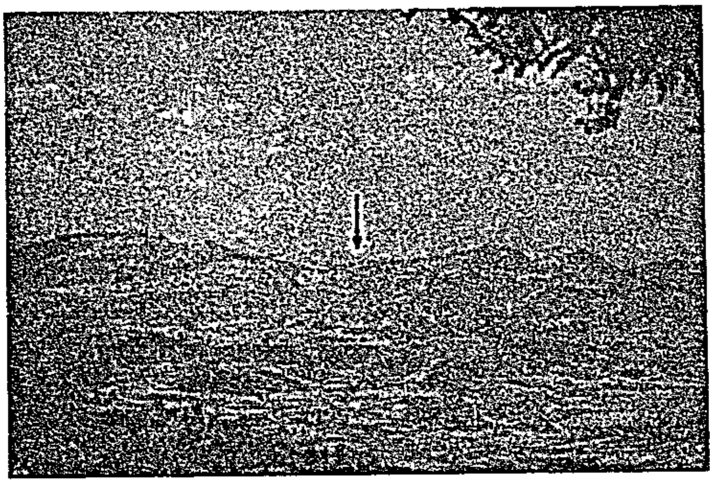


Fig. III-95 A Distant View of G. ADES from the Site

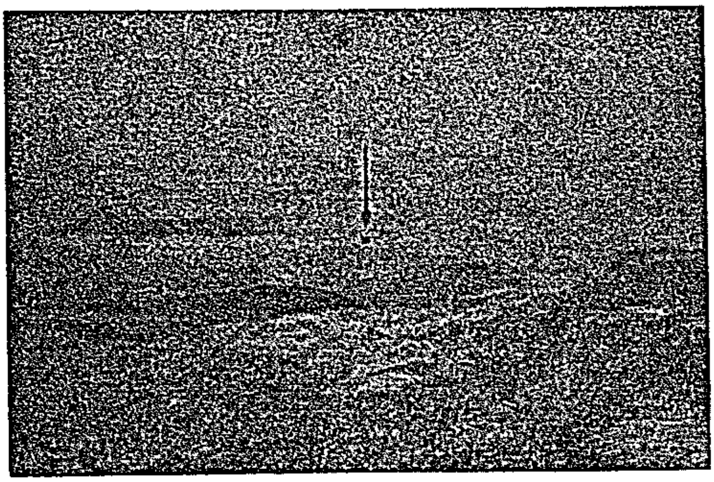


Fig. III-96 A Distant View of DIRE DAWA from the Site

Fig. III-97 A Scene of the Site

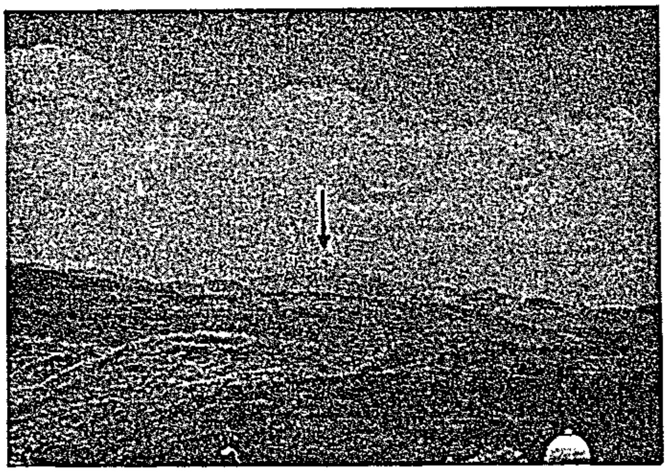


Fig. III-98 A Distant View of COLLUBI WEST from the Site

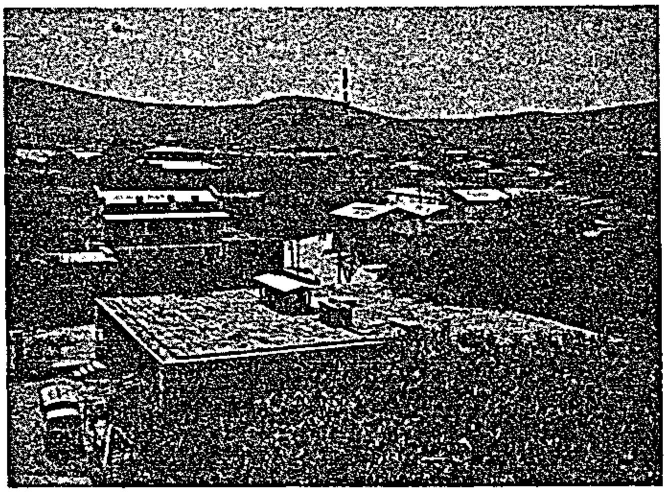


Fig. III-99 A Distant View of DANGAGO from the Site

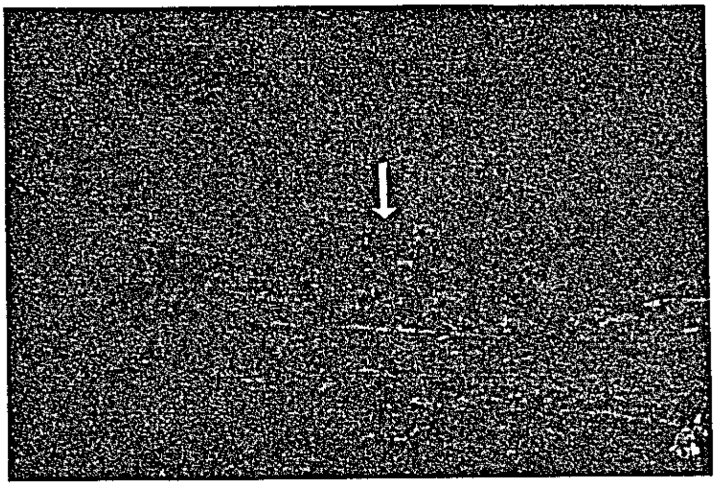


Fig. III-100 A Distant View of DIRE DAWA from the Site

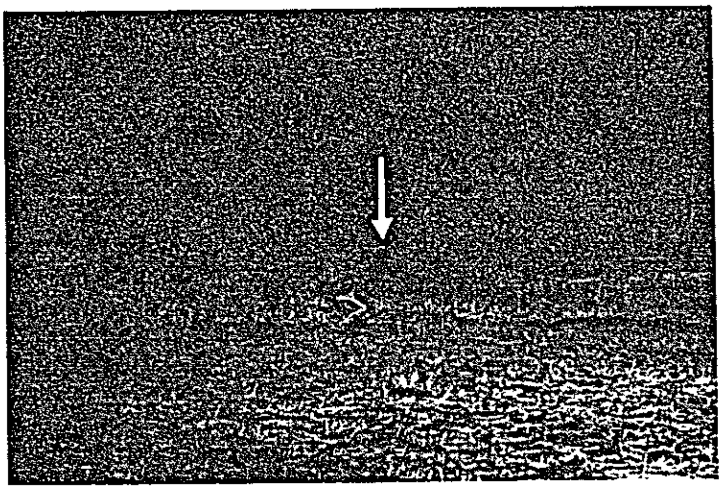


Fig. III-101 A Distant View of HARRAR from the Site

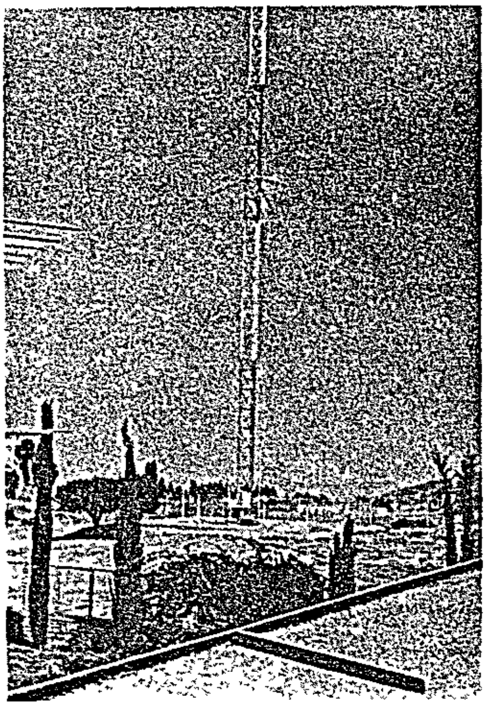


Fig. III-102 A Scene of the Site

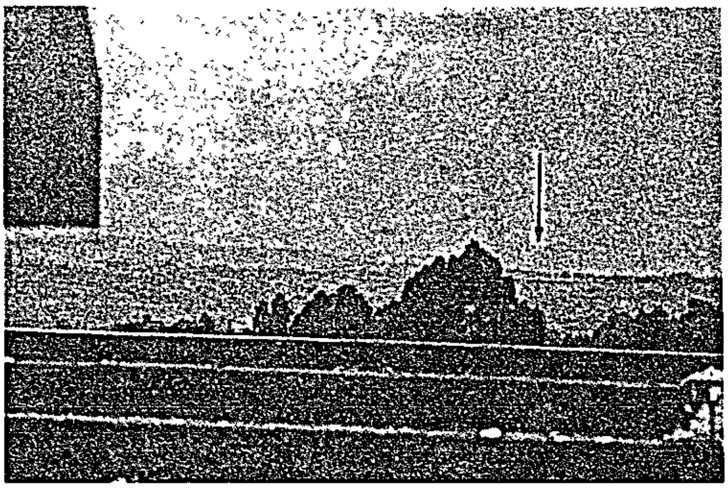


Fig. III-103 A Distant View of DANGAGO from the Site

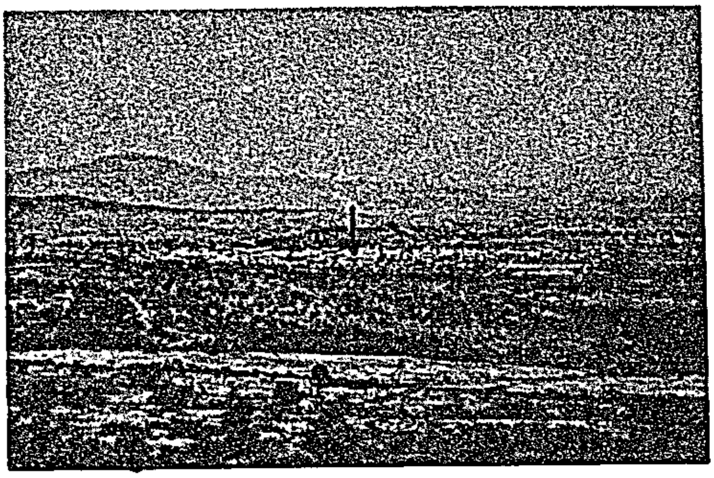


Fig. III-104 A Distant View of NAZARETH TELCOM. from the Site

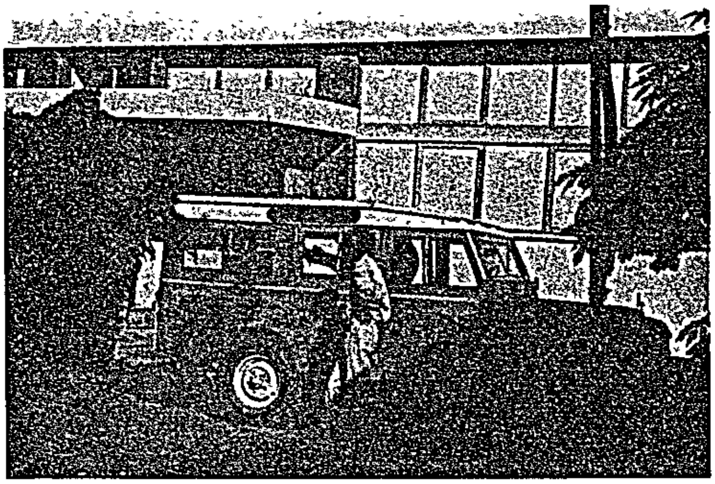


Fig. III-105 A Scene of the Site

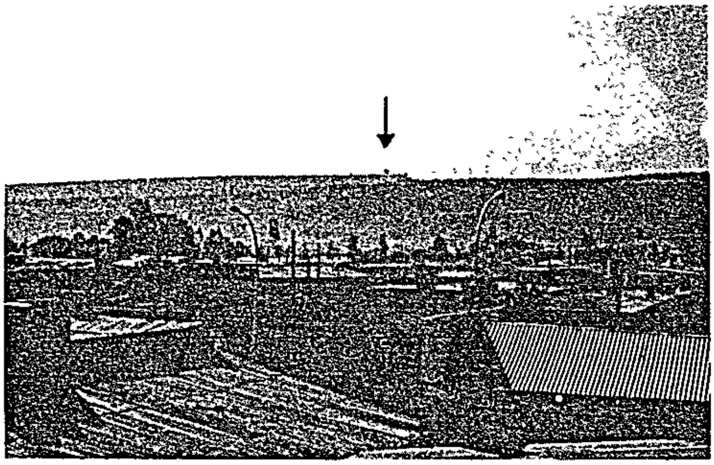


Fig. III-106 A Distant View of ADAMA WEST from the Site

Fig. III-107 A Distant View of MEKI NORTH from the Site

MEKI NORTH

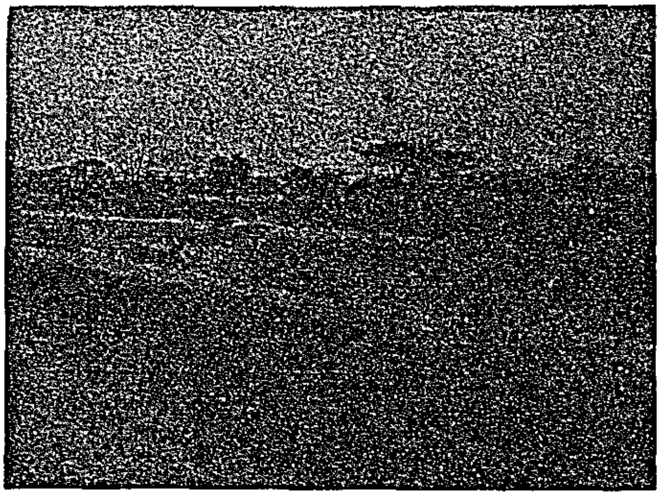


Fig. III-108 A Scene of the Site

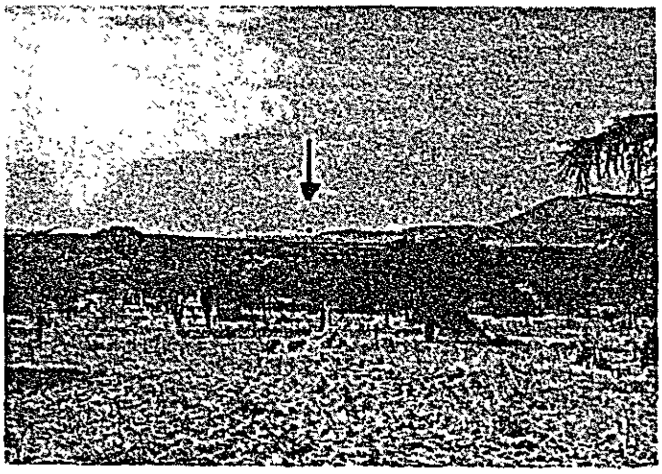


Fig. III-109 A Distant View of MT. FURI from the Site

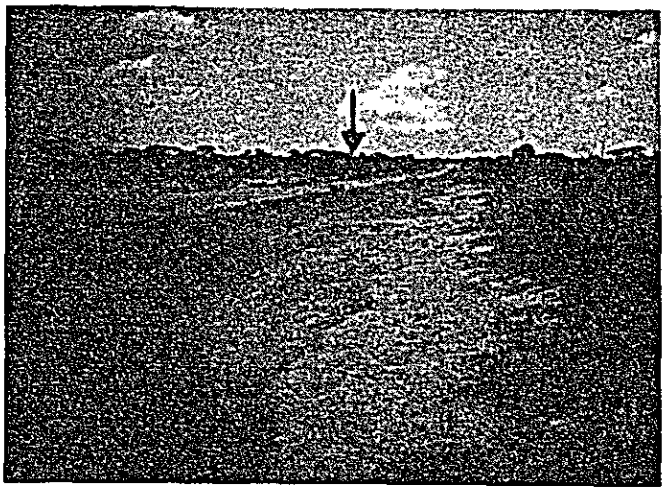


Fig. III-110 A Distant View of ZUAI WEST from the Site

Fig. III-111 A Scene of the Site

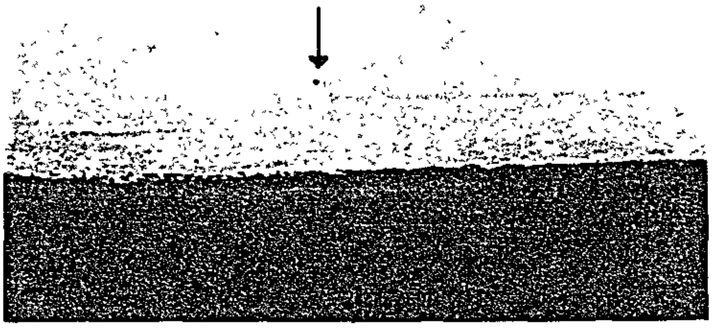


Fig. III-112 A Distant View of MEKI NORTH from the Site

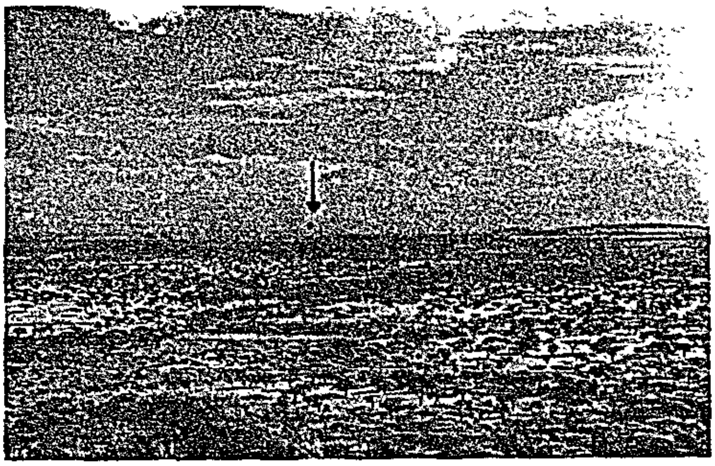


Fig. III-113 A Distant View of G. ABARO from the Site

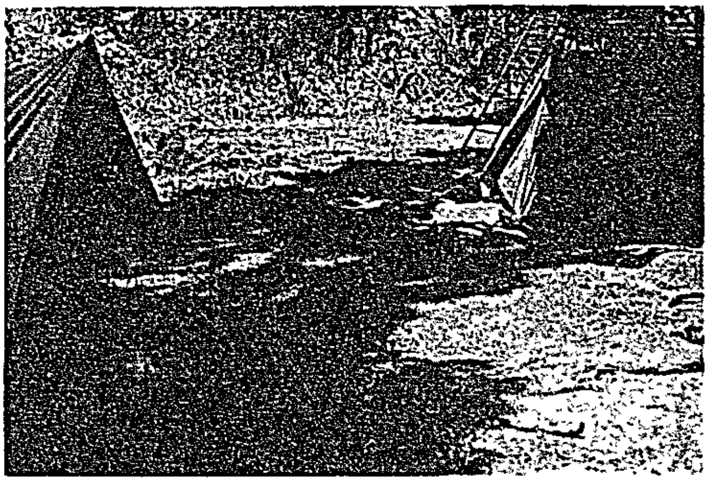


Fig. III-114 A Scene of the Site

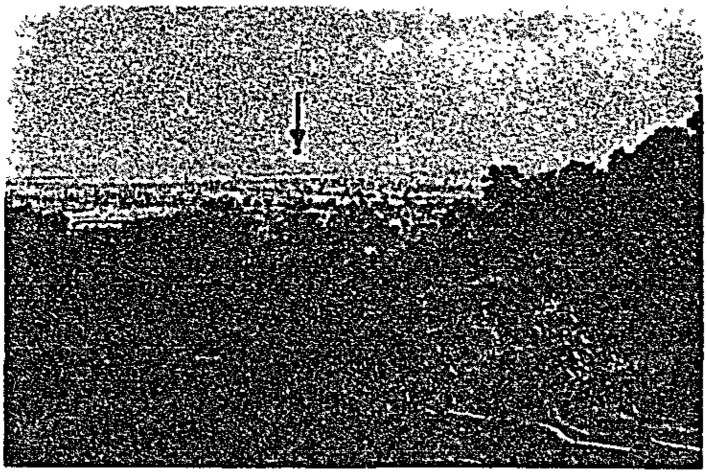


Fig. III-115 A Distant View of ZUAI WEST from the Site

Fig. III-116 A Distant View of SHASHEMANE from the Site

Fig. III-117 A Distant View of G. ABARO from the Site

Fig. III-118 A Distant View of WALISO NORTH from the Site

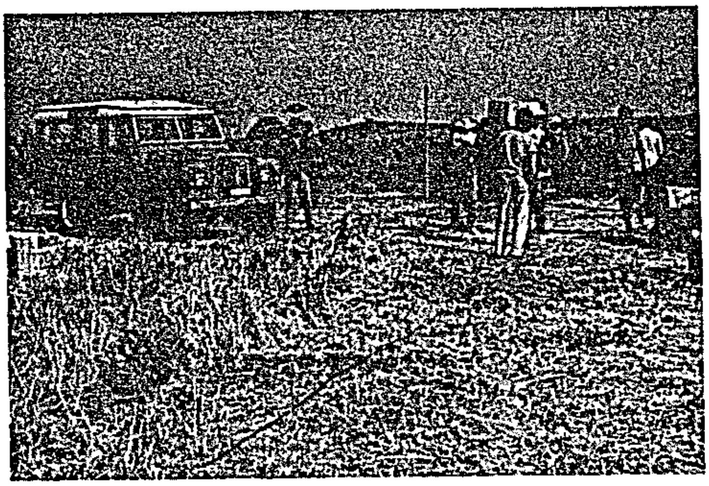


Fig. III-119 A Scene of the Site

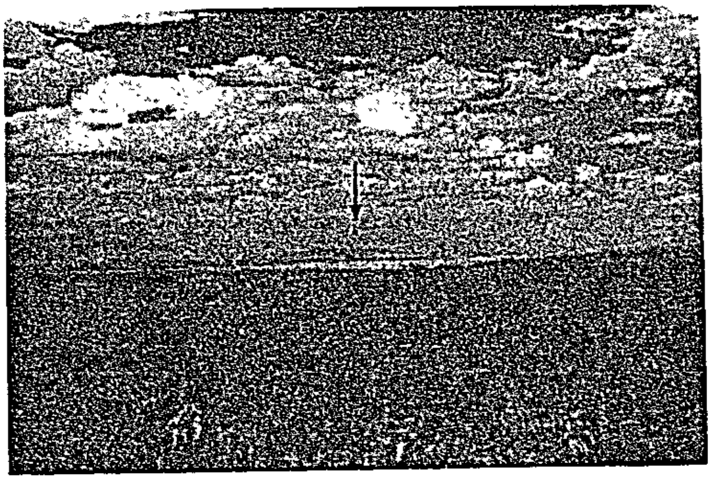


Fig. III-120 A Distant View of MT. FURI from the Site

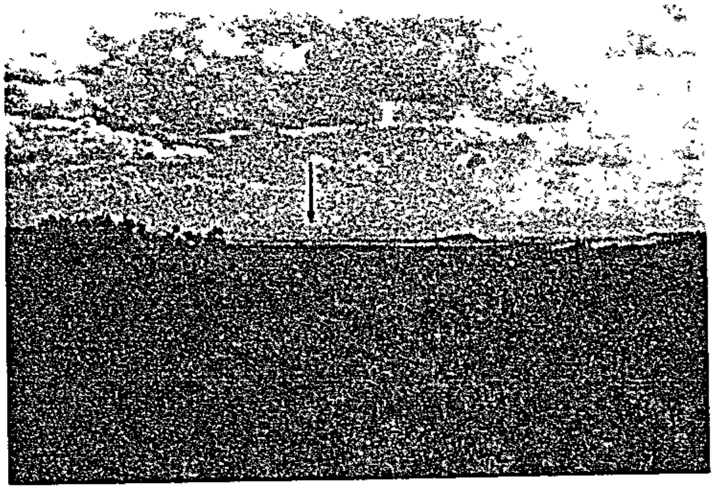


Fig. III-121 A Distant View of GUMBI SOUTH from the Site

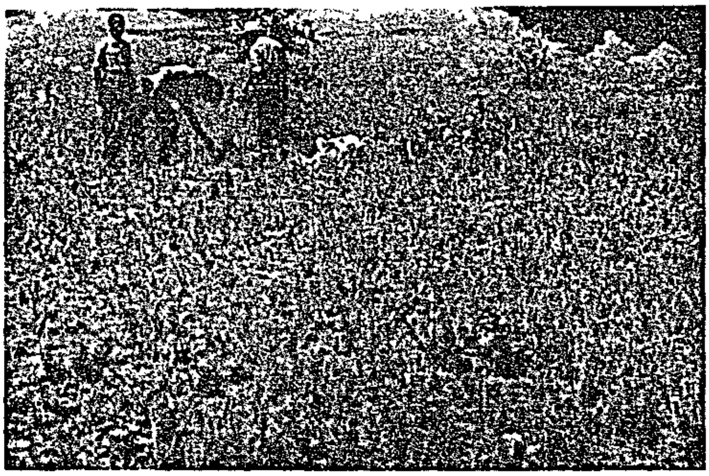


Fig. III-122 A Scene of the Site

Fig. III-123 A Distant View of WALISO NORTH from the Site

Fig. III-124 A Distant View of NADDA EAST from the Site

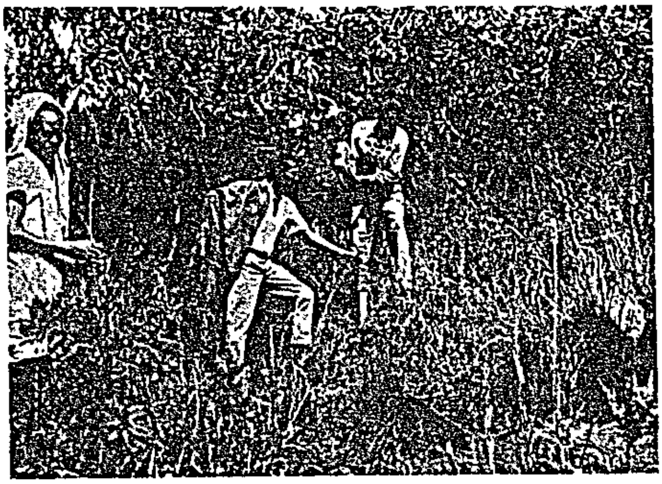


Fig. III-125 A Scene of the Site

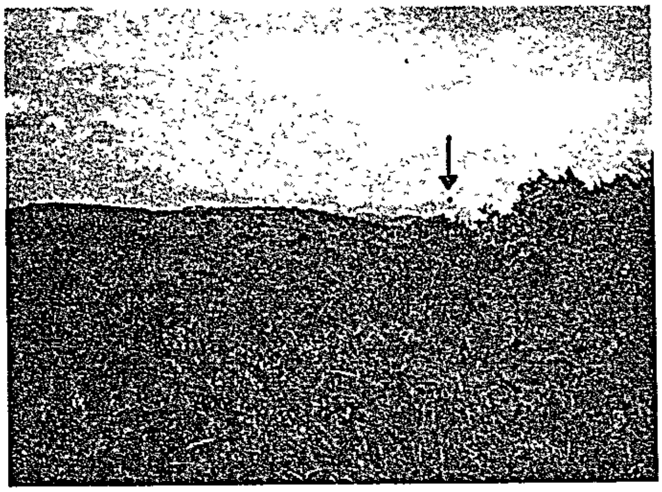


Fig. III-126 A Distant View of GUMBI SOUTH from the Site

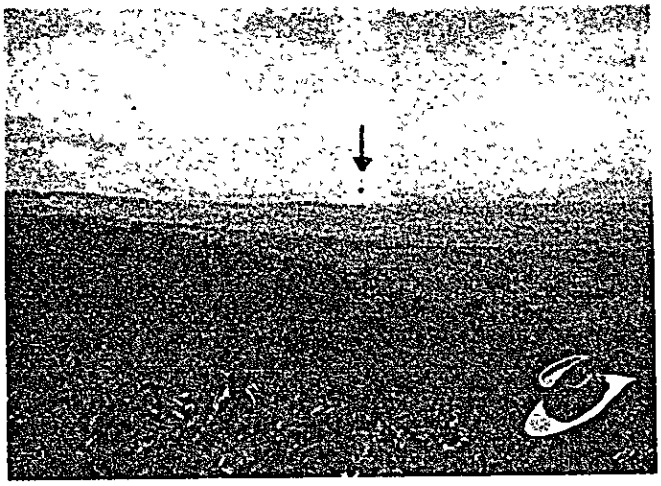


Fig. III-127 A Distant View of GIREN from the Site

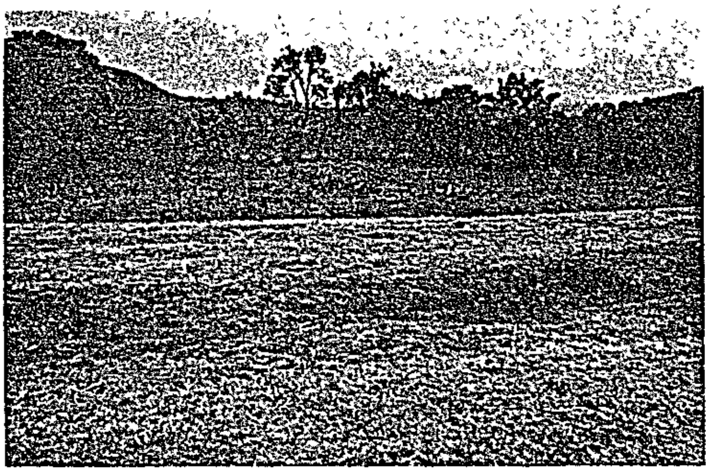


Fig. III-128 A Scene of the Site

Fig. III-129 A Distant View of NADDA EAST from the Site

Fig. III-130 A Distant View of GIMMA from the Site

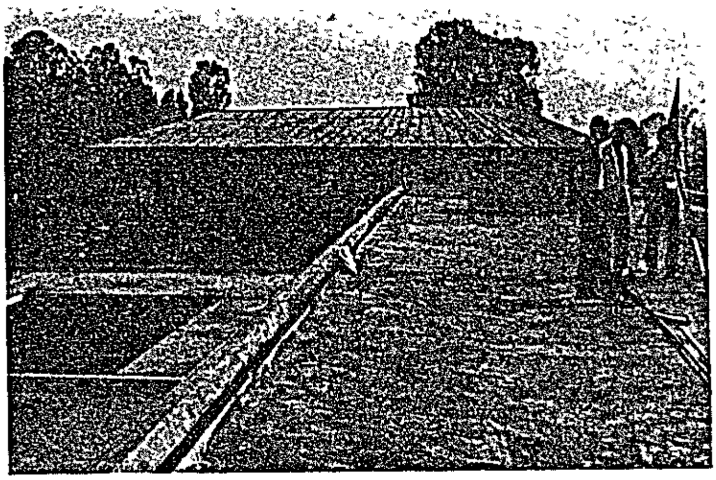


Fig. III-131 A Scene of the Site

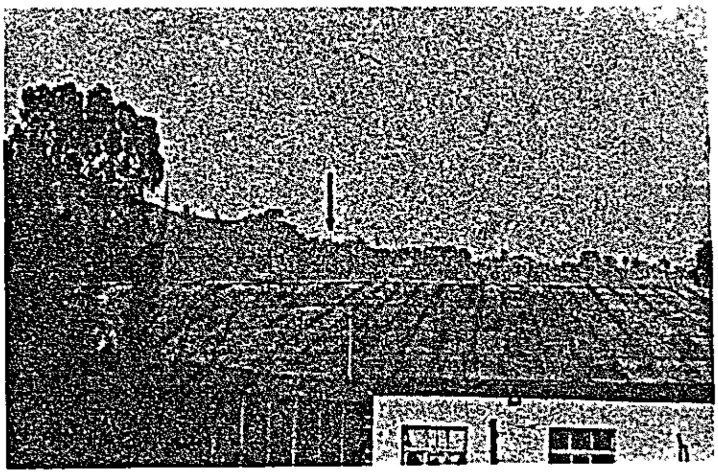


Fig. III-132 A Distant View of GIREN from the Site

CHAPTER VI DESIGN OF RADIO LINK FOR ADDIS ABABA JIMMA ROUTE (NO. 4 ROUTE, PLAN 2)

VI DESIGN OF RADIO LINK FOR ADDIS ABABA ~ JIMMA ROUTE (NO. 4 ROUTE, PLAN 2)

1. Conditions to be Considered for System Design

For the design of radio link, the radio system and the specifications for equipment described in Chapter IV were fully utilized. The data on the line-of sight confirmed by a mirror test, which was sent by I.B.T.E., was also used. With regard to Fofa North-1, however, the clearance in the direction of Giren was not available and therefore this site was excluded from this study.

2. Design and Quality of the Radio Link

The frequency used for the design of radio link is 2 GHz band. To reduce F-B interference, the use of the four-frequency methods was also decided.

The results of study and computation on the basis of the specifications for equipment shown in Table IV-4 are summarized in Table VI-1. The study was made on the assumption that the improvement is also possible in this case like the one mentioned in Chapter IV.

3. Probability of Noise Burst

The results of study on noise burst probability are shown in Table VI-2. The results shown are almost the same as those under Plan-1. However, it is considered necessary to adopt the space diversity system for the Mt. Furi ~ Waliso North section where the noise burst probability is high for the same reason as under Plan-1.

4. Overall Circuit Performance

The overall circuit performance barely meets the performance specified in the C.C.I.R. Recommendations. In order to secure clearance for the Fofa North ~ Giren site, however, the antenna height of more than 20 m above ground must be secured at both sites. Further, when changing the frequency to 4 GHz band, it is important to give due consideration to the following.

(a) The frequency plan may adopt the two-frequency method.

(b) In relation to the noise burst probability, the probability of occurrence of Rayleigh Fading in 4 GHz band is more than twice that in 2 GHz band. Assuming that the same value of receiving power is available for both 2 GHz and 4 GHz, it is considered inevitable to adopt the space diversity system also for the Mt. Furi ~ Waliso North section.

(c) As for the clearance of 4 GHz band for the Fofa North ~ Giren section, the antenna height of more than 10 m above ground is sufficient for both sites.

If the above requirement is satisfied by taking into consideration these factors, the difference in the quality of radio link between 2 GHz band and 4 GHz band will be very small. The difference in the quality of radio link for this route between Plan-1 and Plan-2 is also very small. The remaining question, therefore, is the economic comparison of the plans. The differences in the economic aspect will be:

Plan-1 (1) The length of new access roads in Gumbi South .... 4 km.
(2) There is the portion where construction of a road is impractical in Gumbi South.

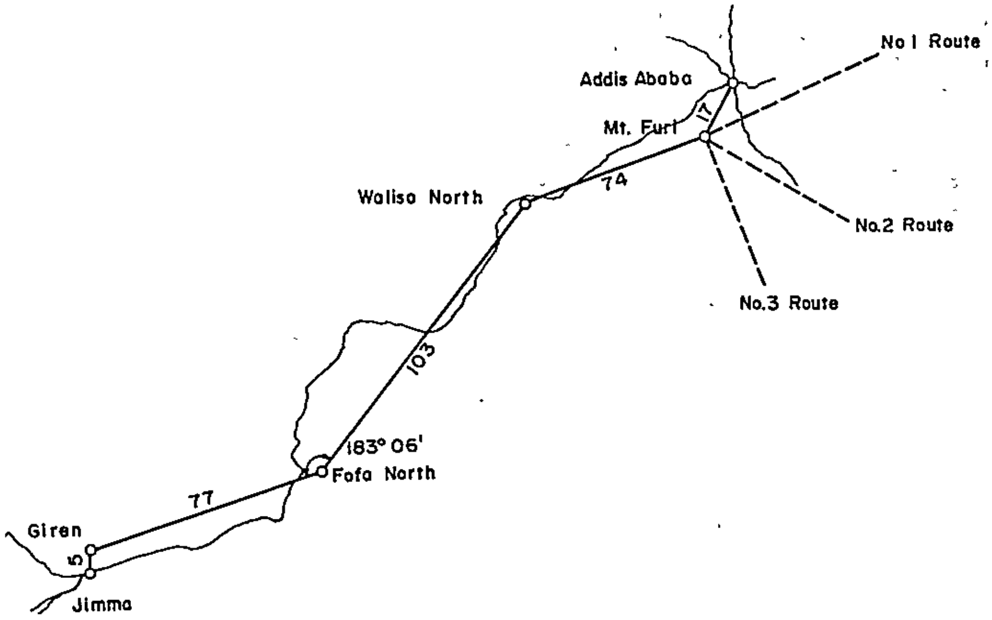
Plan-2 (1) The length of road to be repaired in Nadda East ....10 km.
(2) The number of intermediate repeating stations is to be reduced by one.
(3) The length of road to be repaired in Fofa North ....22 km.

From the above, Plan-2 is considered more advantageous than Plan-1.

5. Amendments

Entries concerning the Addis Ababa～Jimma section (No. 4 Route) shown in Fig. 1-3, paragraph 8-1 (Route and Proposed Site), I, 8 (Recommendations) are to be changed as shown in Fig. VI-1.

Fig. VI - 1 Map of Microwave route between ADDIS ABABA - JIMMA (No. 4)



	Latitude	Longitude	Altitude
Fofa North	7°54'27"	37°30'45"	2630 m

Table VI-1 Noise Power in the Addis Ababa～Jimma Section (No. 4 Route-2)

2GHz 600 CH)

Section	Thermal noise		Inter-modulation noise	Interference noise					
	Repeater	Others	2nd 3rd	Feeder echo	Propa-gation distortion	F/B	Over reach	F/S	Others
	pW	pW	pW	pW	pW	pW	pW	pW	pW
Addis Ababa									
	18.2	75	427	30	3.9	$\frac{0}{0}$	$\frac{\ }{0}$		
Mt. Furi									
	79.5			32.4	118	$\frac{0}{0.2}$	$\frac{\ }{0}$		
Waliso North									
	155			32.4	7.1	$\frac{0}{0}$	$\frac{0}{0}$		
Fofa North									
	85			22.4	0.6	$\frac{0.6}{0}$	$\frac{0}{\ }$		
Giren									
	11.5			33.6	0.2	$\frac{0}{0}$	$\frac{0}{\ }$		
Jimma									
Sub-total	349.2	75	427	150.8	129.8	$\frac{0.6}{0.2}$	$\frac{0}{0}$	0	0
Total	424.2		427	$\frac{281.2}{280.8}$					
Total of all sections	$\frac{1132.4}{1132}$								
C.C.I.R. Recommendation	3L = 1473.8 pW								

Table VI-2 No. 4 Route - Plan 2 Frequency 2 GHz

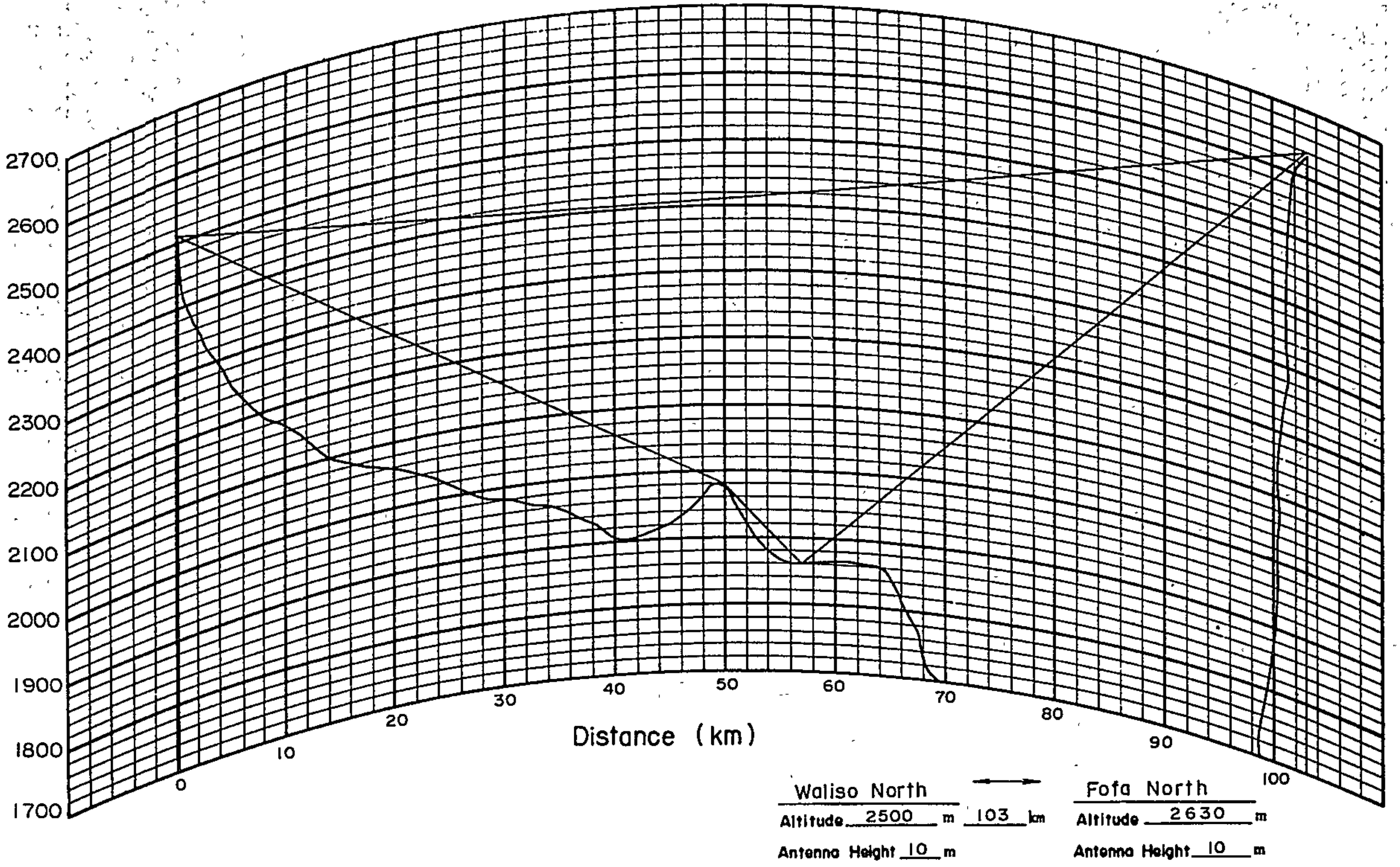
<table>
<tr><td colspan="2" rowspan="2">Name of switchover section
Name of station
Item</td><td colspan="12">Addis Ababa ~ Jimma</td></tr>
<tr><td colspan="2">Addis Ababa</td><td colspan="2">Mt. Furi</td><td colspan="2">Waliso North</td><td colspan="2">Fofa North</td><td colspan="2">Giren</td><td colspan="2">Jimma</td></tr>
<tr><td>Propagation path condition</td><td></td><td></td><td colspan="2">Field</td><td colspan="2">Field</td><td colspan="2">Field</td><td colspan="2">Field</td><td colspan="2">Field</td><td></td></tr>
<tr><td>Propagation path height (in case of over-sea)</td><td>m</td><td></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td></td></tr>
<tr><td>Hop Distance</td><td>km</td><td></td><td colspan="2">17</td><td colspan="2">74</td><td colspan="2">103</td><td colspan="2">77</td><td colspan="2">5</td><td></td></tr>
<tr><td>Distance of Switching section (L)</td><td>km</td><td colspan="12">276</td></tr>
<tr><td>Thermal Noise (No)</td><td>pW</td><td></td><td colspan="2">18.2</td><td colspan="2">79.5</td><td colspan="2">155</td><td colspan="2">85</td><td colspan="2">11.5</td><td></td></tr>
<tr><td>Occurrence probability of Rayleigh Fading (P)</td><td>10^{-4}</td><td></td><td colspan="2">0.45</td><td colspan="2">77.4</td><td colspan="2">260</td><td colspan="2">94</td><td colspan="2">0.006</td><td></td></tr>
<tr><td>Occurrence probability of Rayleigh Fading (Pe) (in case of reflection coefficient more than about 0.3)</td><td>10^{-2}</td><td></td><td colspan="2">-</td><td colspan="2">(0.72)
49</td><td colspan="2"></td><td colspan="2"></td><td colspan="2">-</td><td></td></tr>
<tr><td>Probability of Noise Burst exceeding 1,000,000 pW (Pi)</td><td>10^{-8}</td><td></td><td colspan="2">0.2</td><td colspan="2">7791</td><td colspan="2">1209</td><td colspan="2">239.7</td><td colspan="2">0</td><td></td></tr>
<tr><td>Total of Pi in one section</td><td>10^{-8}</td><td colspan="12">9240</td></tr>
<tr><td>Ditto (including the noise-switching effect)</td><td>10^{-8}</td><td colspan="12">(Improvement factor 1/5)
1848</td></tr>
<tr><td>C.C.I.R. Re Recommendation (0.01%)</td><td></td><td colspan="12">4L : 1104</td></tr>
</table>

Calculated Figures of Various Fundamental Factors on Each Section

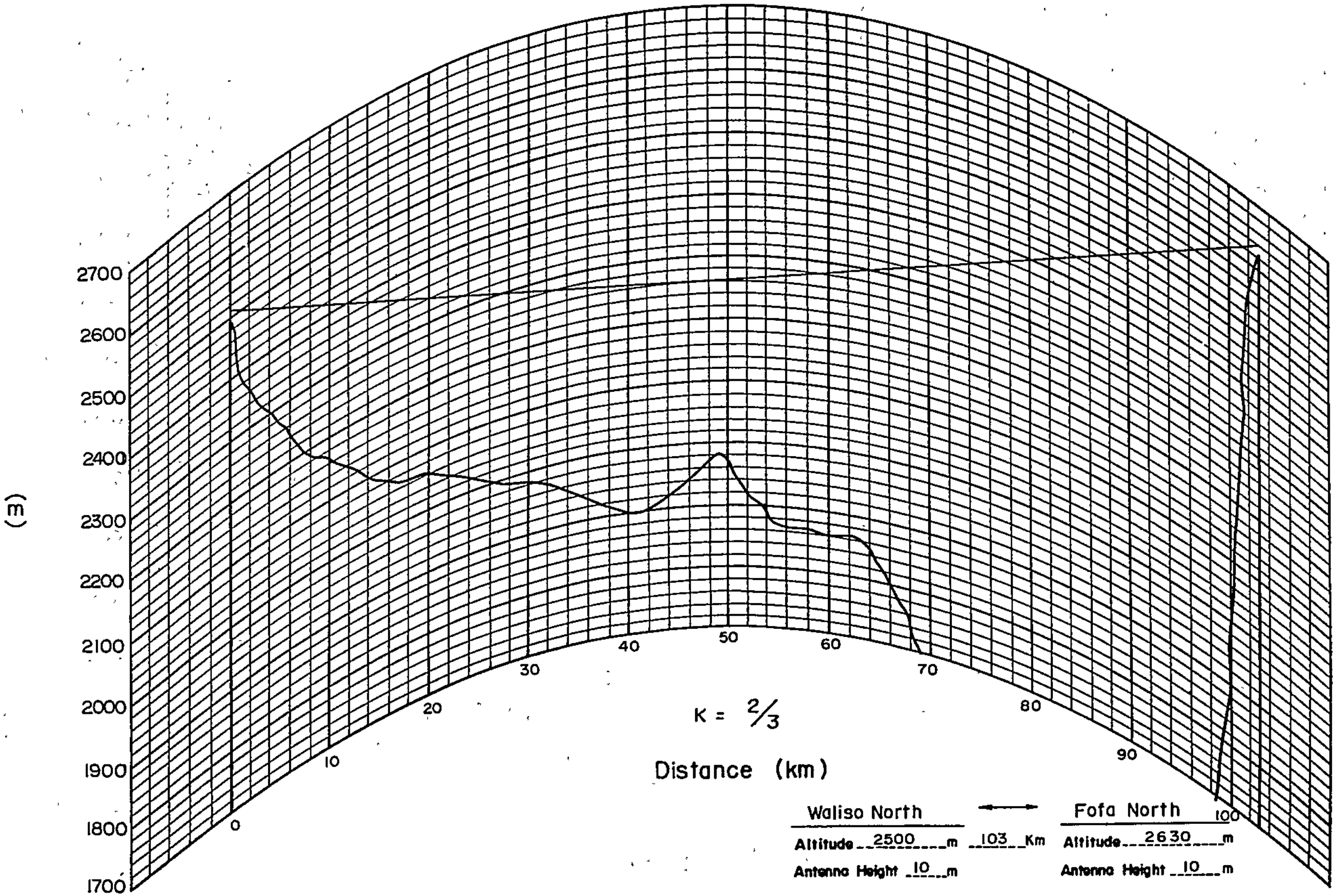
Item \ Name of site				Waliso North	Fofa North		Giren
Altitude				2,500	2,630		2080
Antenna height above ground				10	10	20	20
Effective Antenna Height				388.8	488.5	406.2	-94
Effective Reflection Coefficient		Included Angle between Direct and Reflected Waves	°	0.51	0.7	0.16	0.8
		Attenuation of Reflected Waves due to Antenna Directivity	dB	0.3	0.7	0	0.8
		Shielding Ridge Loss of Reflected Wave	dB	26		15	
	Reflected Point	Distance from Site	Km	57.2	45.8	61.8	15.2
		Classification of Condition		Field		Field	
		Reflection Loss	dB	4		4	
		Altitude	m	1860		1940	
		Total Loss of Reflected Wave	dB	31		19.8	
Path Difference		Path Difference between Direct and Reflected Waves	m	6.5		1.9	
		S/I	dB	81.5		92.3	
Propagation path length			km	103		77	
Propagation Loss in Free Space			dB	139.6		137	
Profile Map				Fig. VI-1 Fig. VI-2		Fig. VI-3 Fig. VI-4	
Clearance				No problem		hc/no = 1 (K=2/3)	
Remarks							

PROFILE MAP

(K = 4/3)

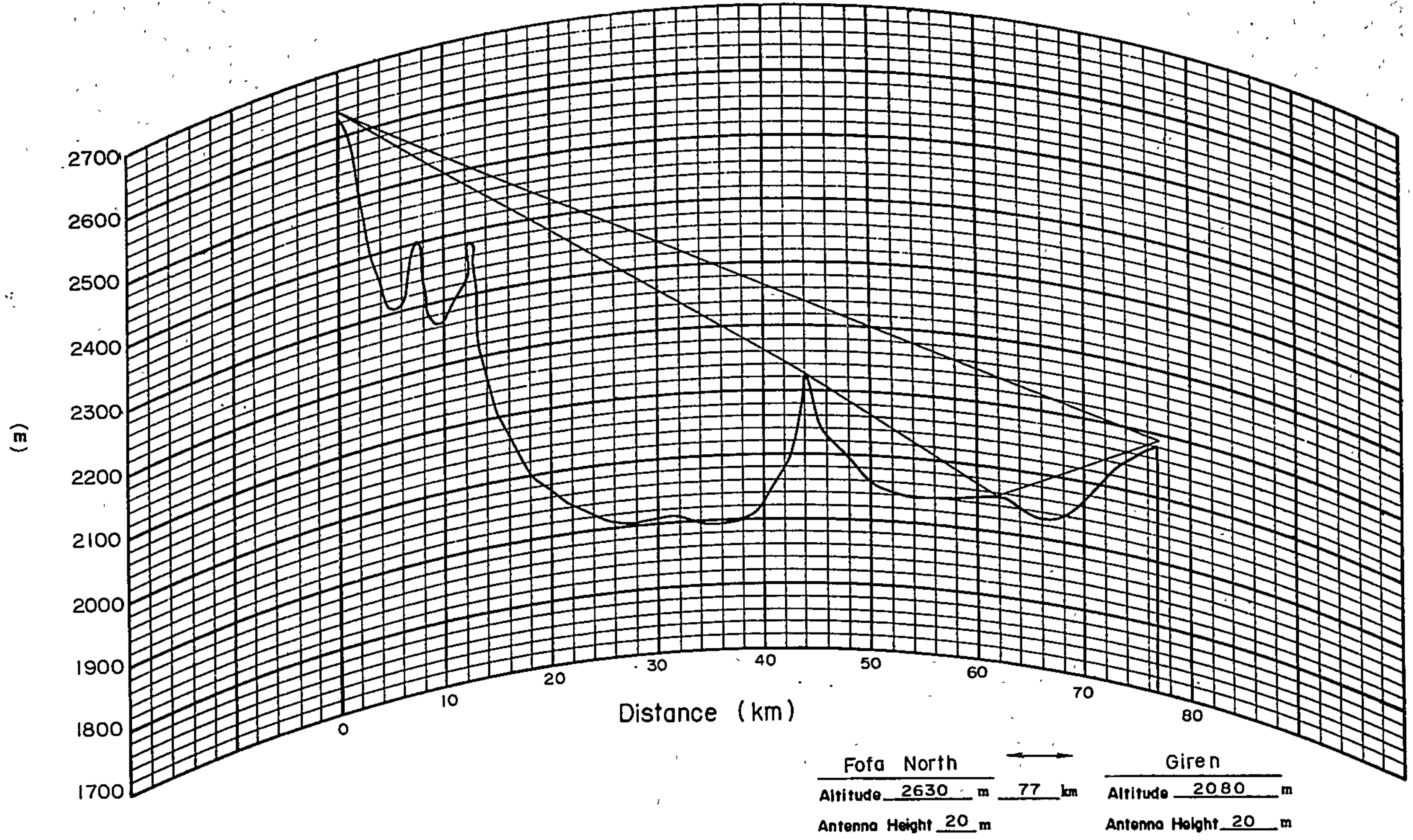


PROFILE MAP


(m)
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
0
10
20
30
40
50
60
70
80
90
100
K = 2/3
Distance (km)
Waliso North
Altitude 2500 m
Antenna Height 10 m
103 Km
Fofa North
Altitude 2630 m
Antenna Height 10 m

PROFILE MAP

(K = 4/3)



Fofa North ⟷ Giren

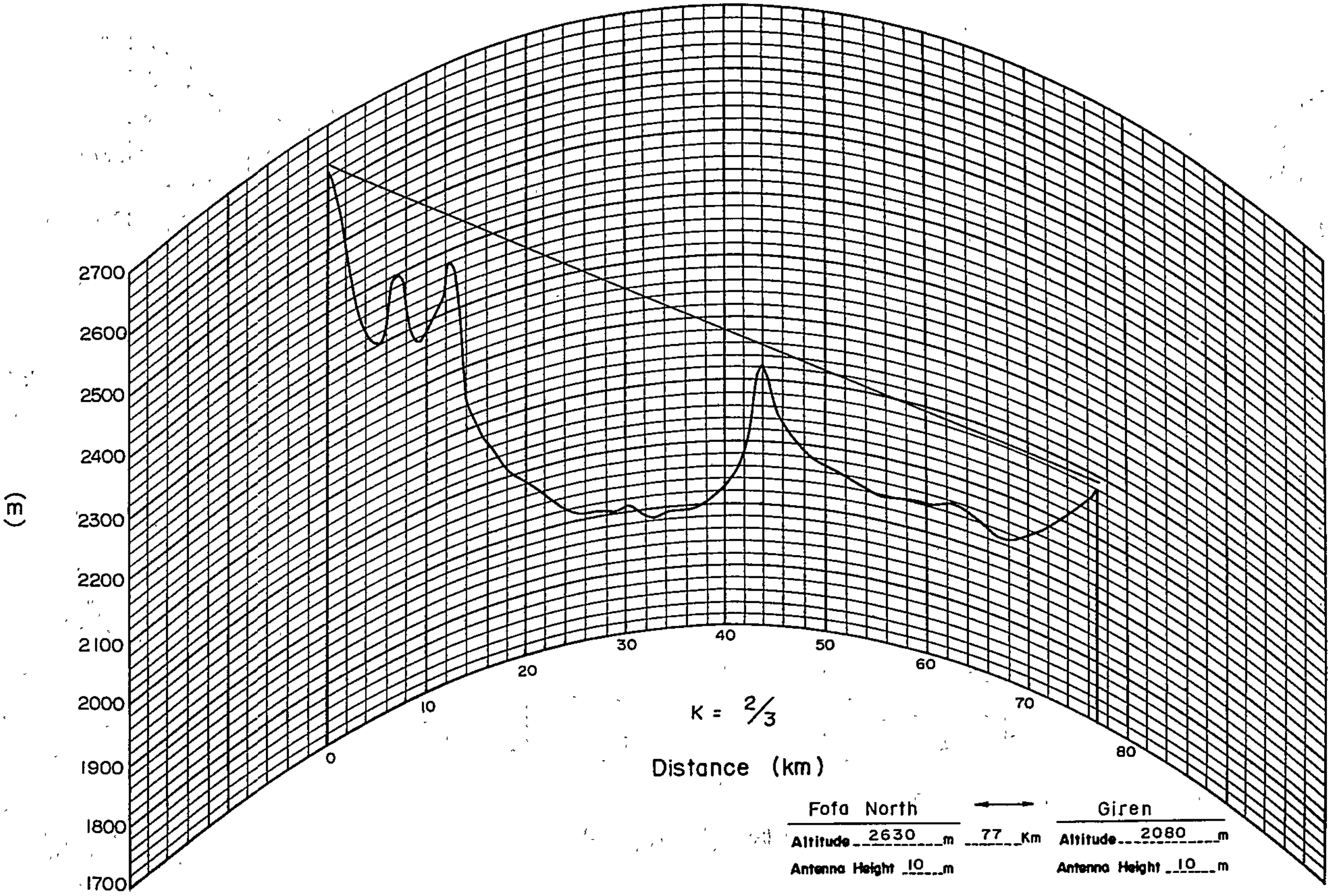
Altitude 2630 m 77 km

Antenna Height 20 m

Altitude 2080 m

Antenna Height 20 m

PROFILE MAP


(m)
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
0
10
20
30
40
50
60
70
80
K = 2/3
Distance (km)
Fofa North
Altitude 2630 m
Antenna Height 10 m
77 Km
Giren
Altitude 2080 m
Antenna Height 10 m