REPORT ON THE SECOND SURVEY
FOR
THE MICROWAVE NETWORK PROJECT IN ETHIOPIA

⟨ ADDIS ABABA — ASMARA ROUTE ⟩

TECHNICAL SPECIFICATION FOR SUPPLY AND
INSTALLATION OF COMMUNICATION EQUIPMENT
(DRAFT)

MARCH 1970

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

PREFACE

The Overseas Technical Cooperation Agency previously undertook a preliminary survey for Microwave Network Construction Project in Ethiopia during a periodof forty-five days from February 15 to March 31, 1969. The report of the above survey was already presented by the Agency in June 1969.

At the request of the Imperial Government of Ethiopia, the Government of Japan decided to execute the second survey for this important project which is included in the 4th 5 year Investment Program.

The Agency immediately organized a secondary survey team, and despatched it to Ethiopia for a period of about four months from August 5, 1969. The survey team consisting of 8 experts headed by Mr. Seishi Nakamura, Technical Officer of the Ministry of Post and Telecommunications, undertook the propagation test and ultimately decided the site locations on the microwave route between Addis Ababa and Asmara.

The report hereby presented is based on the outcome of the secondary survey carried out for the propagation test and site selection, and included the tender specifications of the microwave network construction on the above route.

Nothing would be more gratifying for the Agency if this survey report proves to be of any help to promote the 4th 5 year Investment Program and to develop the telecommunication in Ethiopia, and at the same time contribute to the betterment of the mutual friendship and economic intercourse between our two countries.

I take this opportunity to express my hearty thanks to the Imperial Government of Ethiopia, particularly to the officials of the Imperial Board of Telecommunications of Ethiopia, for their valuable assistance and support extended to the team.

March 1970

Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency
Japan

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CHAPTER I INTRODUCTION

CHAPTER 1 INTRODUCTION

1 Purpose and Scope of the Survey

At the request of the Imperial Board of Telecommunications of Ethiopia (hereinafter referred to as IBTE) for technical cooperation in establishing the 830 km long microwave radio link between Addis Ababa and Asmara, which is to be included in the 4th 5 year investment program, the preliminary survey team was organized and dispatched to Ethiopia by the Government of Japan. The survey team carried out a route survey for 45 days from February 15, 1969.

The purpose of delegating the 2nd Survey Team was to develop the site re-survey for the microwave route based on the preliminary survey report and to prepare the tender specifications.

The period required was 112 days from August 5 to November 24, 1969.

2 Organization of the Second Survey Team

The 2nd Survey Team consists of the following eight deputed engineers.

Head	Seishi Nakamura	Chief, International Cooperation Affairs, Radio Regulatory Bureau, Ministry of Post and Telecommunications of Japan
Member	Muneshige Kobayashi	Staff Member, Administrative Directorate of Telecommunications, Ministry of Post and Telecommunications of Japan
"	Makoto Hattori	Staff Engineer, Land Section, Radio Regulatory Bureau, Ministry of Post and Telecommunications of Japan.
"	Teruaki Sato	Chief Engineer, International Affairs Office, Nippon Telegraph and Telephone Public Corporation
"	Kichiro Kimura	Staff Engineer, International Affairs Office, Nippon Telegraph and Telephone Public Corporation
"	Shohachiro Watanabe	Staff Engineer, International Affairs Office, Nippon Telegraph and Telephone Public Corporation
"	Shiro Kawata	Staff Engineer, International Affairs Office, Nippon Telegraph and Telephone Public Corporation
"	Makoto Tsuji	Technical Adviser, Development Survey Division, Overseas Technical Cooperation Agency of Japan

3 Outline of the Survey

3.1 Survey Policy

The microwave link between Addis Ababa and Asmara is a domestic backbone route running through Ethiopia from south to north. It is also an important link which is expected, in the future, to form a part of some international network. Besides the above, IBTE is planning 3 other microwave routes from Addis Ababa towards Dire Daua, Shashamene and Gimma, respectively.

Realization of such huge projects, however, will inevitably necessitate a heavy expenditure. Hence, it is quite reasonable to resort to special means wherein the initial investment is minimized to the utmost and then allow additional expansion or consolidation installation is allowed to be scheduled as occasion required.

Since this had been previously presented to the Survey Team as IBTE's policy, the Survey Team exerted incessant effort to comply with the established policy in its entirety. Nevertheless, because of the impossibility of making future alternation of the site locations with ease, special caution was taken so that the radio link would finally be able to cater to the recommended performances by C.C.I.R. and C.C.I.T.T.

Incidentally, due to shortage of statistical data about radio wave propagation and meteorology, prediction of long term radio wave propagation characteristics is rather difficult. Accordingly, in order to obtain practical link design and method, continuous recordings of received radio field intensity were accumulated along with some radio paths where hop distance was long or influence of the ground-reflected signal was forecast.

Considering maintenance convenience, IBTE requested that the radio relay station sites should be selected near the All Weather Roads which are assured of passage even during the rainy season and that the number of stations must be restricted to the minimum possible. Keeping this IBTE instruction in mind, the Survey Team set out on their route survey.

3.2 Toll Trunk Route Plan

The Addis Ababa - Asmara microwave link includes: a 960 channels telephone bearer and a stand-by bearer capable of transmitting a 625 line monochrome television and its associated program signals.

The stand-by bearer is to be capable of transmitting a PAL color television signal in the future. Besides, the easy additional installation of one more bearer which is exclusively used for TV transmission is under consideration.

Meanwhile, a long range plan for TV broadcasting service is not settled upon as yet by the Ministry of Information, Ethiopia. Accordingly, construction plans for TV station or stations in individual cities have scarcely been decided upon, with the exception of a very few cases, and almost no definite inauguration plan in these cities is made clear, either.

In order to cope with the aforementioned present situation and still reserve future flexibility against a composition of TV program transmission network on the microwave system, the present project tentatively might embarace such terminal equipment as sound-vision combiners and separators in radio terminal stations. Entrance links to the respective broadcasting stations are inevitably left to another project.

The microwave link between Addis Ababa and Asmara accommodates radio program transmission channels, voice frequency telegraph circuits and telex circuits. A high speed data transmission channel (1000 Bauds) is, however, not included at this moment, but its introduction is expected in the sections between Addis Ababa and Asmara, and between Addis Ababa and Dire Daua, in 10 or 15 years. The foregoing toll trunk route plan was decided by the IBTE, based on the traffic estimation which was calculated by the Survey Team by refering to the statistical data at the end of 1968. In this project, it is assumed that a 960 channel telephone bearer will afford twelve years' traffic demands until 1984 after inauguration of this microwave link in 1972.

Nevertheless, this project may be still subject to earlier modification because of unexpected traffic increase caused by revelation of latent demands due to service improvement, like automatic exchange system and/or introduction of new telecommunication services due to rapid progress in this technical field.

Apart from such excessive anxiety, the completion of the microwave link and inauguration of the automatic toll telephone exchange facilities in Addis Ababa, Dessie, Macalle and Asmara Exchanges will cater to subscriber toll dialing (STD) service between each two of these cities mentioned above and today's traffic congestion of delay toll service will be marvelously improved. Macalle Telephone Exchange will, however, remain a manual exchange service for some time due to postponement of the building construction schedule. Therefore, STD service will be introduced therein 5 to 10 years behind the other exchanges.

The microwave radio link under this project is to be joined with entrance cable links at Macalle and Asmara, respectively. The whole aspect of the network plan is shown in Drawing I-1.

3.3 Site Selection

Owing to cloudy weather conditions, unfortunately the primary route plan selected in the preliminary survey included two radio hops where mirror test for the visibility of radio path could not be comfirmed and other two hops where mensuration for the height of obstacle ridge along with the radio path was left. The Second Survey Team exerted efforts not only to remove these suspended matters, but to select new or alternative sites to ensure higher link performances. In consequence, three new sites were found and, on a whole, hop distances were largely equalized with each other. Further along, the section between Mai Ceu North and Amba Alagi, though initially designed to include a passive reflector at Near Adi Shahu, could be revised into an alternative route of literally complete line-of-sight path excluding the passive reflector. Shown in Drawing I-2 is the final microwave route plan. In Ethiopia, the Survey Team could only get big-reduced maps with a scale of 1 : 500,000 which were not necessarily suitable for the present purpose, and no triangulation point was available for the field survey. Hence, the Survey was inevitably restricted merely to measuring the angle between adjoining two radio paths and making a rough estimate of the

Altitude of the ridge along the propagation paths. Five degrees difference was found on an average between the angle thus actually investigated and the value obtained from the said reduced maps with a scale of 1 : 500,000. Latitude, longitude and altitude of each site, path profile and distance of each hop were estimated with both the maps and the results of the survey.

3.4 Propagation Test

The preliminary survey team selected 8 long distance hops of more than 60 km which included one hop without shielding ridge for reflected wave, on which radiowave was to propagate in the lower atmospheric layer and another hop which had not its line-of-sight path confirmed yet. The weather variation of the four seasons is seldom found in Ethiopia, which differs from that in Japan.

Though the temperature difference between day and night is rather marked, daily average variation of temperature is hardly discernible. The humidity varies comparatively little, Viz. between 40 and 60 percent in general.

The estimation procedure for fading occurance probability, which can be applied for the microwave link design, is still under study.

At the site selection, it is necessary that the estimation of the fading occurence probability is made based on analysis of the meteorological and propagation test data in the area concerned. The estimation procedure for the matter mentioned above has been established in Japan based on plenty of experience and the data concerning meteorological conditions and actual propagation data for real links. Sufficient test data for producing an experimental formula which is used for assumption of the fading occurence probability were not necessarily obtained with the propagation test performed by the Survey Team this time. The propagation test data, however, showed that few deep fadings occured on the paths where the test were carried out.

Propagation tests were performed on the 7 hops during a period of from 4 to 14 days for each hop, using the 6 GHz frequency band. According to data from the above mentioned tests, comparatively large variation of receiving power was recorded on the hops of Mt. Furi - Shano South and Karrakorre - Korke, but stable receiving power was recorded on the other 5 hops.

A presumption was made that the fadings which occured during the test period were to be of K type or of Duct type, by considering the recording data and the path conditions. In accordance with the facts mentioned above, the propagation features in Ethiopia seemed to be very similar to those in Japan, so that estimation procedures of the fading occurence probability currently used in Japan was adopted by the Survey Team.

The microwave link between Addis Ababa and Asmara will satisfy the quality specified in C.C.I.R. Recommendations by adopting the radio frequency diversity means throughout whole the link and, at the same time, the facilities having the performance used at the link design by the Survey Team, which are being, at present, used in Japan.

As the above conclusion was made judging from the propagation test data carried out during a rather short period and an economical point of view which was requested by IBTE, it is required that, after the completion of the link, continuous and long-term recording of the receiving power be performed in order to obtain the fading occurence data. With reference to the data thus obtained, adoption of the space diversity would be necessary, if demanded the link quality improvement.

3.5 Designing of the Microwave Radio Link

Frequency band to be used for the microwave link between Addis Ababa and Asmara is, as described in III-4.4 of this Report, alloted for 4 GHz band specified by C.C.I.R. Recommendation 382-1 as well as 6 GHz band specified by C.C.I.R. Recommendation 384-1. In case the 4 GHz band mentioned above were used, consideration shall be given for adopting the radio facilities which have adequate performances to avoid mutual radio interference between the microwave link and the earth station. Mutual interferences are to be avoided even if 4 GHz band were used, which is assumed in the design by the Survey Team. 4 GHz band will not, however, be capable of being used if the conditions differed from those presumed during the design. For instance, if a higher power transmitter is used, the mutual interference cannot be ignored.

In this case, the 6 GHz band specified in C.C.I.R. Recommendation 384-1 must be used. Selection of the frequency band used in this link, shall be made under consideration of the long term prospects for frequency allotment plan, channel capacity to be included, merits or demerits of the link design and technical innovation. A 4 GHz band applied to the link design by the Survey Team is suitable for transmitting 960 telephone channels, which satisfies the final capacity scheduled by the IBTE, and color television video and program signals. It is to be anticipated that a 4 GHz band is preferable to a 6 GHz one in the propagation characteristics and that the high reliability of the link is secured by using the all-solid-state equipment due to technical progress. In accordance with the facts mentioned above, the selection of the frequency to be used should fully be taken into consideration for the mutual interference between the earth stations of Sululta and Asmara, and this microwave link. In this regard, the tender specifications specify that the 4 GHz band shall preferable be used, but that the 6 GHz band prescribed in C.C.I.R. Recommendation 384-1 is also acceptable.

From the maintenance point of view, radio relay stations composing the link were designed as unattended bases, as far as possible. Accordingly, all the radio relay stations are unattended ones, except for 4 stations, i.e., Addis Ababa radio and carrier multiplex terminal station, Dessie Telephone Office, Macalle North radio and carrier multiplex terminal station and Asmara Telephone Office, which are planned to be attended stations for control and supervisory purposes.

The toll trunk route plan by IBTE explains that the Addis Ababa - Asmara microwave link should include a telephone bearer and a stand-by bearer at the initial stage. Therefore, even if consideration were given to the front-to-side radio interference caused by the narrow angles of adjoining paths of Addis Ababa - Mt. Furi - Sendafa East and Dessie - Korke - Karrakorre, it will be possible to compose the link with the 6 both way radio channels which use 4 GHz "Normal" frequency. In spite of the matter described above, 4 GHz "Interleaved" frequency should be schemed for to increase radio channels such as of a television whose installation has been planned and some bearers which are out of the present project. The New Macalle North radio terminal station is to be constructed and the carrier multiplex equipment, in addition to the radio terminal equipment, is to be installed in this station because the present Macalle Telephone Office building has insufficient space for installation of new equipment and construction project of the new building is delayed, 0.65 mm 54 pair loaded cable is to be laid between the radio terminal station and the present telephone office because of the low traffic demand in this area. The 54 pair loaded cable can carry the traffic for a period from 5 to 10 years until when the new Macalle Telephone Office building will be completed and the toll exchange facilities will also be installed in the building. When the new Macalle Telephone Office building is completed, short haul carrier multiplex systems will be used instead of the loading cable. The Bete Giorgis radio terminal station situated at one end of the link is designed as unattended station, and coaxial cable which can transmit a 960 channel telephone signal and color television video and program signals, is laid between the Bete Giorgis station and Asmara Telephone Office. The number of tubes included in the coaxial cable is set at 8, as decided under consideration of future increment of microwave routes.

3.6 Tender Specification

General conditions which are a part of the tender specifications were to be made by IBTE. On the other hand, production of the technical specifications was the responsibility of the Survey Team. Major technical problems were discussed between IBTE and the Survey Team, and the technical specifications were produced according to the matters discussed, and submitted with this Report. The technical specifications include all the items necessary for completion of the microwave link other than the installation of the roads, the buildings, the tower foundations and power facilities at the present telephone offices, which work is to be made by the IBTE.

The technical specifications specify necessary prescriptions for securing the link quality required, and conditions for carrying out economically and readily the maintenance work for all the facilities through the link.

The specifications allow that the tenderer may offer his own system and facilities on condition that the requirements regarding the economy, quality and reliability of the link shall be fulfilled.

3.7 Investment Plan and Rough Estimation of the Installation Cost

The General Manager of IBTE published the investment plan in the newspapers on October 16th 1969. The total cost for 4th 5 year Investment Program is 63 million Ethiopia Dollars (E$). This include the installation cost of 12 million E$ for all the microwave links. For the microwave link between Addis Ababa and Asmara, the cost of 6 million E$ was counted out.

The cost for the Addis Ababa - Asmara link is estimated as 10 million E$ by the Survey Team, this cost, however, does not include the fees for transportation on board, installation work and civil works (access roads, buildings and tower fundations etc.)

This contract is not on a Turnkey Basis, but on a Supervisor Basis, hence the cost for dispatching the Supervisor to Ethiopia is included.

3.8 Time Schedule for Survey

Date	Work Progress		
8/5	Departure from Tokyo		
6	Arrival at Addis Ababa. Visit for greeting to Japan Embassy & IBTE		
7			
8	Custom procedure, reception & opening of equipment transported		
9	Check & repair work for the equipment		
10	Purchase of necessary materials		
11	Preparation for starting the survey		
12			
13	Conference with IBTE		
14			
15			
16			
17			
18			
19			
20	Starting the survey		
21			
22	Preparation for propagation test between Mt. Furi & Shano South	Preparation for propagation test between Shano South & Ancober North	
23			
24			
25			
26			
27			
28			
29			
30	Propagation test between Mt. Furi & Shano South	Propagation test between Shano South & Ancober North	Site survey for the sites between Addis Ababa & Korke
31			
9/1			
2			
3			
4			
5			
6			

Date	Work Progress		
9/6			
(7)			
8			
9	Removal from Mt. Furi to Karrakorre & installation	Removal from Shano South to Korke & installation	
10			
(11)			
12			
13			
(14)	Propagation test between Ancober North & Karrakorre		
15			
16			
17	Removal from Ancober North to Ualdia & installation		
18			
19			
20			Resurvey of the sites between Korke & Mai Ceu North
(21)	Propagation test between Ualdia & Korke		
22			
23		Propagation test between Karrakorre & Korke	
24			Resurvey of the sites between Korke & Shano South
25			
26			
(27)			
(28)			
29			
30			Resurvey of the sites between Addis Ababa & Korke
10/1			
2	Over-reach propagation test between Mai Ceu North & Korke		
3			
4			
(5)	Removal from Mai Ceu North to Adigrat West & installation		
6			
7		Removal from Karrakorre to Amba Alagi & installation	
8			Resurvey of the sites between Korke & Macalle
9			
10			

Date	Work Progress		
10/10	Propagation test between MacalleNorth & Adigrat West		
11			
(12)			
13		Propagation test between Amba Alagi & Macalle North	Measurement of ridge between Macalle & Asmara
14			
15	Removal & transport of test equipment		
16			
17		Removal & transport of test equipment	Survey for mutual interference toward the recent US Army's radio station in Asmara region
18			
(19)			
20			
21			
22	Interim conference		
23	Removal from Asmara to Addis Ababa		
24			
25			
(26)			
27			
28	Checking & packing of equipment, preparation of dispatch		Mutual interference test toward Sululta earth station site
29			
30	Data analizing		
31			
11/1			
(2)			Site survey for Addis Ababa radio terminal station
3			
4			
5			
6	Submission of interim report		
7			
8	Conference regarding the technical specifications		
(9)			
10			
11			
12			
13			

Date	Work Progress
11/14	
15	
(16)	
17	
18	
19	
20	
21	
22	Visit for greeting to IBTE & Japan Embassy
(23)	Departure from Addis Ababa

Legend:

○ Sunday

⬭ National holiday of Ethiopia

2/22 Ascension Day

9/11 Rexersion of Eritoria and St. Johanes Festival

9/27 Mascal Festival

11/2 Emperor Coronation Day

4 Conclusion

Expansion of telecommunications, traffic and education is the most important theme for the development of Ethiopia. Hence, great significance is given for the completion of the Addis Ababa - Asmara microwave radio link.

The Survey Team is pleased and takes pride in participating in the realization of this important project, and sincerely desire that this microwave link will be successfully completed at the earliest opportunity and will contribute as a motive power to the development of the country.

The Survey Team, through the preliminary and the second surveys, made efforts in answer to the requests by the IBTE. In consequence, the Survey Team is convinced that the microwave link fully complies with the C.C.I.R. Recommendations which specify the link quality, and, at the same time, economical measure is to be applied in the design for the link.

The technical specifications are made based on the conditions that high reliability is guaranteed for a long time and hence good telecommunication services can be offered by employing the most up-to-date facilities, and that economical means is considered as far as possible.

Throughout the survey period, full cooperation and assistance were extended to the Team by the IBTE staff personnel, including the General Manager, and, with their favour, the survey was able to be accomplished smoothly.

Furthermore, earnest discussions regarding the technical problems were held within a short period.

The Team hereby presents this Report and the Technical Specifications together with its hearty gratitude to the staff personnel concerned.

Fig. I-1 Network Plan

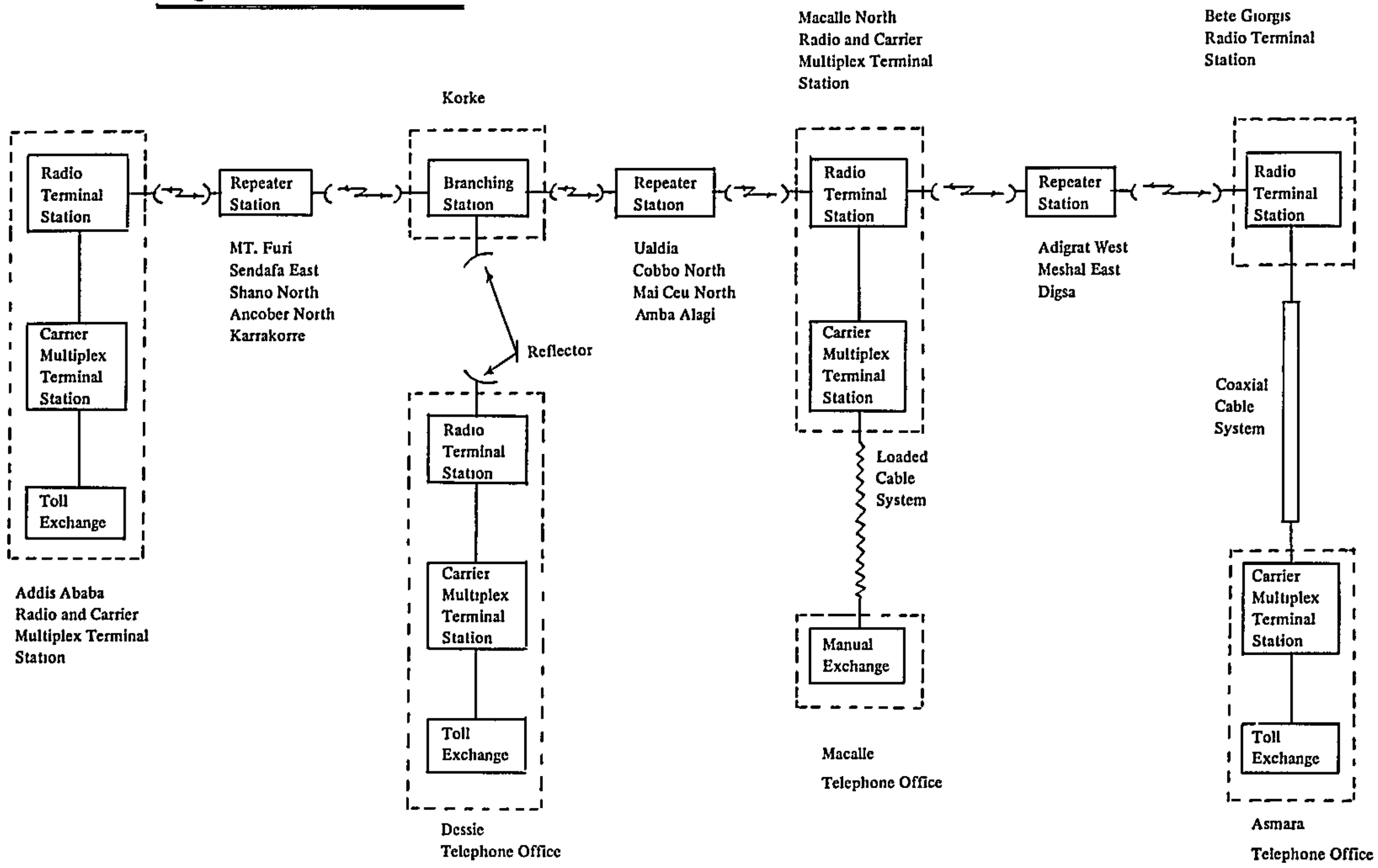


Fig. I-2 Map of Microwave Route between ADDIS ABABA and ASMARA

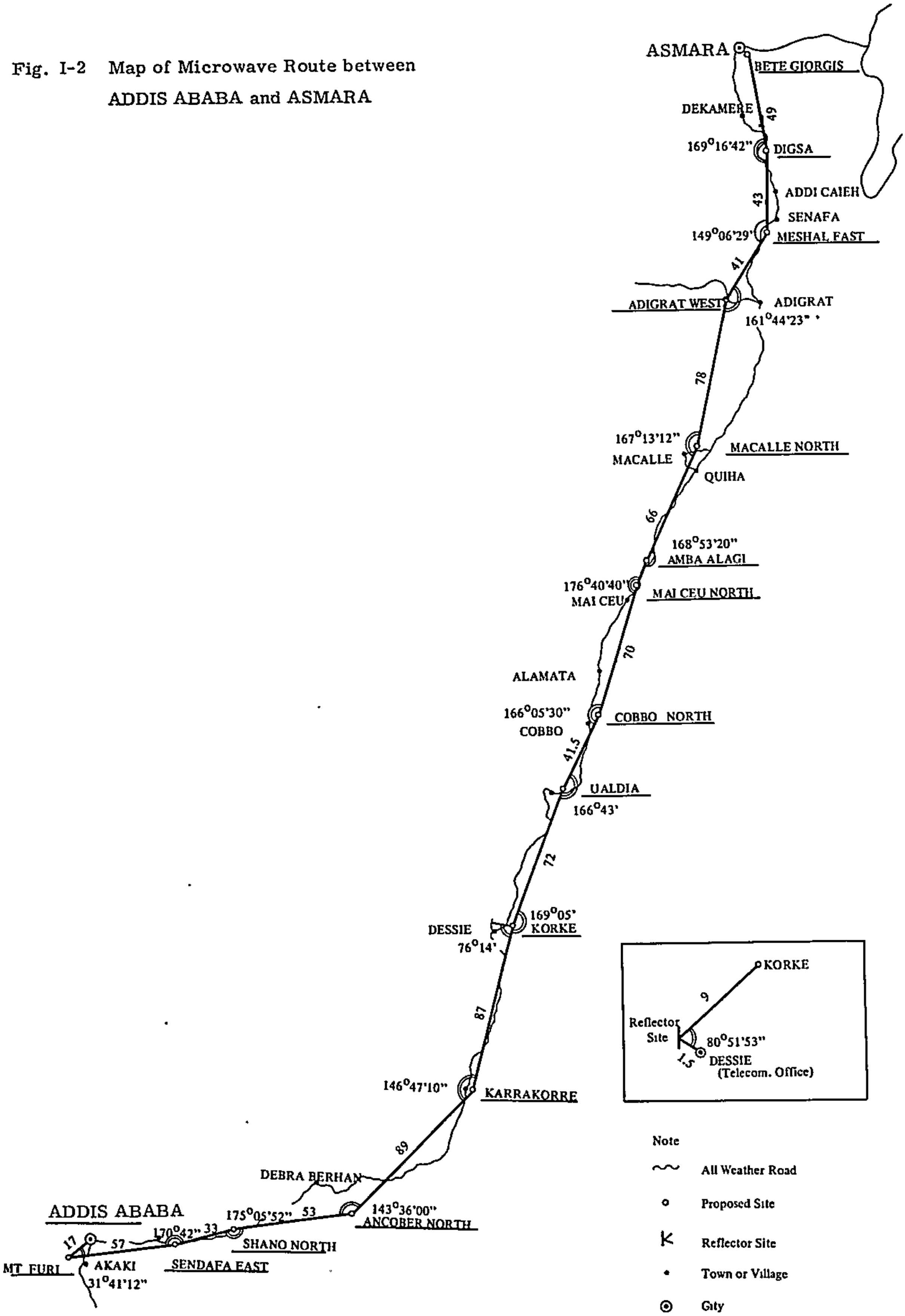


Table I-1 Location and Altitude of the Site and Hop Distance

Site	Latitude (° ' ")	Longitude (° ' ")	Altitude (m)	Hop Distance (km)
ADDIS ABABA * (Head Quarter)	9.01.38 N	38.45.25 E	2400	17
MT. FURI	8.52.30 N	38.42.10 E	2800	57
SENDAFA EAST*	9.10.08 N	39.08.09 E	2950	33
SHANO NORTH*	9.22.02 N	39.21.29 E	3050	53
ANCOBER NORTH	9.40.30 N	39.44.30 E	3600	89
KARRAKORRE*	10.26.50 N	39.57.30 E	1910	87
KORKE	11.11.20 N	39.42.00 E	2600	72
UALDIA	11.50.30 N	39.36.40 E	2430	41.5
COBBO NORTH*	12.13.00 N	39.39.38 E	1510	70
MAI CEU NORTH*	12.50.33 N	39.34.10 E	3260	14.5
AMBA ALAGI	12.58.10 N	39.32.40 E	3120	66
MACALLE NORTH	13.34.30 N	39.32.20 E	2360	78
ADIGRAT WEST	14.15.10 N	39.20.00 E	2830	41
MESHAL EAST	14.37.10 N	39.24.30 E	2540	43
DIGSA	14.58.10 N	39.14.10 E	2210	49
BETE GIORGIS	15.20.30 N	38.58.10 E	2460	
KORKE	11.11.20 N	39.42.00 E	2600	9
DESSIE (Reflector Site)	11.07. N	39.37 E	2700	1.5
DESSIE (Telecom. Office)	11.07.30 N	39.37.10 E	2528	

Note 1: Figures of latitude, longitude and hop distance were presumed by the maps on scale 1 to 500,000

Note 2: * New Site

CHAPTER II OUTLINE OF TOLL CIRCUIT PLAN

CHAPTER II OUTLINE OF TOLL CIRCUIT PLAN

1 Toll Telephone Service Plan

This plan describes the non-delay toll service between 4 cities in the Addis Ababa - Asmara section. It includes construction of automatic toll switches at 4 cities -- Addis Ababa, Dessie, Macalle and Asmara -- and operation of the subscriber trunk dialing between those cities. However, as a new telephone office at Macalle is not to be built in the first stage, manual switching by operater dialing is planned and, after 5 or 10 years, a change will be made to subscriber trunk dialing. After achieving this plan, toll service of this section will be greatly improved.

1.1 Number of Toll Circuits

In 1974 and 1984, the required number of toll circuit in this section is estimated to reach the number shown in Fig. II-1.

In addition to public service lines, this figure includes leased lines for telegraph, telex, broadcast program, telephone and order wire among terminal stations. It also contains toll circuits which connect between other cities in other links. The above-mentioned order wire circuits, three channels, are for connecting every control room to provide speech services between radio rooms, carrier multiplex rooms and exchange rooms. The order wire circuit for the exchange to be provided at Macalle should be extended to Macalle telephone office.

1.2 Transmission Circuit Network Plan

The transmission circuit network plan means consideration as to how to connect subscribers at random (Toll zone system), and how to effectively utilize the installed circuits. (Network composition).

That is, the toll zone system is made by dividing the country into small areas, all with an exchange office, concentrating some of them into one zone center, and again concentrating some of zone centers into one district center by a systematic transmission circuit network. To compose this network, all the exchange offices must be classified by rank, and mutual relations among these offices must be determined. The toll zone system must be based upon due consideration to the size of the nation, population distribution, relation of each city, charging area, possibility of economical transmission lines, etc.

Network composition is the configuration of the circuit connection among these offices based upon the above-mentioned toll zone system.

Generally, the star-type network is suitable in a country which has only one big city, while a combination of star-type network and mesh-type network is suitable in a country which has many cities with direct trunks between them.

All toll telephone calls on the star-type network are connected via only one transit office, and trunking is arranged between toll telephone offices according to office rank. This network has the merit that it is capable of simplifying the network, improving trunk efficiency, allowing reasonable distribution of speech quality, etc., when the traffic volume is small.

On the other hand, the mesh-type network is arranged for a high usage route, if necessary, and the toll telephone call on the mesh-type network can be connected by direct trunk, not via transit office. This network has the merit that it is capable of providing a low quality and low cost circuit composition when the traffic volume is large. Each city in Ethiopia is radiatedly distributed in all directions from Addis Ababa, and the total length of transmission lines will reach about 2,000 km. Therefore, it is advisable to adopt the star-type network, but also to consider the mesh-type network to handle increases of traffic volume. Furthermore, it is desirable to introduce a four-wire switch to insure satisfactory transmission performance at district centers.

1.3 Office Rank

Office rank is defined as the status of an exchange office which plays the role of an area center based on the "Toll zone system".

In Ethiopia, rank is as shown in Table II-1.

Table II-1 Office Rank

Office Rank	Telephone Office	Rank in NTT
National Center	Addis Ababa	Regional Center
District Center	Asmara, Dire Daua, Shashamene	District Center
Zone Center	Dessie, Macalle, Gimma, Nazareth, Harrar	Toll Center
Terminal Exchange		End Office

2 Television Signal Relay Plan

2.1 Television Relay Line

A television relay service is to be inaugurated at the same time this microwave link is put into service. However, at first, the television signal is to be transmitted through a stand-by radio channel from Addis Ababa to Asmara. In the future, television transmission lines will be constructed.

Therefore, it is necessary to install the television transmission equipment in each radio terminal station. In the television relay system, the C.C.I.R. Recommendation Group G, B and 625 scanning line system is adopted.

IBTE has already decided to use the PAL system for color television service in the future. The construction plan for television transmitting station and television studio is not yet decided, therefore, the equipment required to connect them and the radio terminal station is not included in this plan. Simultaneous transmission of one channel television sound program in the same radio channel is adopted.

2.2 Television Broadcasting Service

In Ethiopia, a television broadcasting service is presently operated only in Addis Ababa. It is operated about 3 hours a day. In Asmara, the United States Army has a television broadcasting service for its own use.

An Ethiopian use television broadcasting station will be constructed by about 1970 and will feature their own programs at that time. In other districts, service in Nazareth will be started in 1973 or 1974, using a re-broadcasting system. It is planned that the Addis Ababa - Dire Daua microwave link will, in the future, be used as a television relay link furnishing TV service to Dire Daua. As mentioned above, the plan for television broadcasting service has not yet been decided, but may be clarified in connection with the future microwave network plan.

3 Other Service Plans

Besides the services previously mentioned, telex service and radio broadcasting service are planned to start at the same time as the inauguration of this microwave link. About 10 years later, high speed data transmission (about 1,000 bauds) is planned to be put in service at the Addis Ababa - Asmara section and the Addis Ababa - Dire Daua section.

4 Relation between the Microwave Link Plan and Future Expansion Plan

4.1 Relation to No.2-No.4 Microwave Link

IBTE plans, as a portion of the 4th - 5 year investment program succeeding this microwave link plan, to construct microwave links at Addis Ababa - Dire Daua, Addis Ababa - Shashamene and Addis Ababa - Gimma sections.

Since these links must have their terminal station in Addis Ababa, it is necessary to pay close attention to frequency usage and composition of transmission line.

4.2 Relation to the Earth Station in Communication Satellite System

In the future, it is planned to construct an earth station (Sululta) 12 km to the northwest of Addis Ababa microwave station. It was determined that the earth station and some stations of this microwave link might mutually interfere somehow. At Asmara, it was determined that the earth station of the US armed forces and the microwave link connecting their bases might interfere with this Addis Ababa - Asmara microwave link. Therefore, the frequency band to be used and the system configuration must be carefully discussed.

The same consideration must be paid to No. 2 - No. 4 microwave links.

4.3 Interconnection with International Circuit

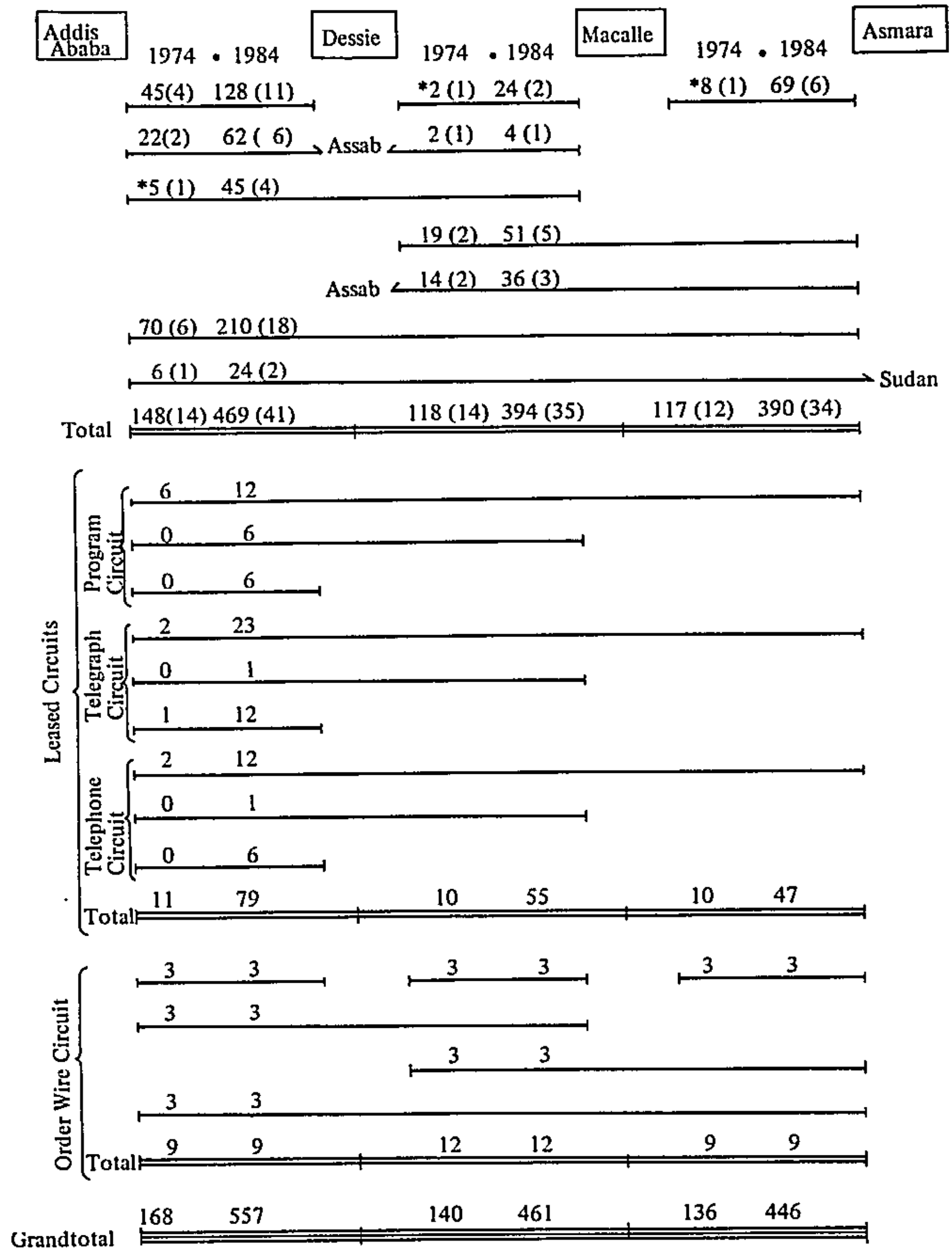
The Addis Ababa - Asmara microwave link and the Addis Ababa - Shashamene microwave link are planned to be interconnected with the international circuits of Sudan and Kenya, respectively. Therefore, it is necessary to base them on C.C.I.R. and C.C.I.T.T. Recommendations, especially with respect to transmission quality.

4.4 Further Study on Future Plan

Toll trunk dialing service, which starts from the completion of this microwave link, must contribute greatly to the development in the field of economy, community, culture and education in Ethiopia, and also must lead to the so-called"Third telecommunication". Then, together with great and rapid progress in communication technique, the sort of communication will be changed, that is, communication capabilities must be able to handle not only telephone and telegraph services, but also different kinds of communication, for example, data transmission.

These innovations will increase the demand for communication capacity.

Therefore, network plan should have sufficient flexibility to handle changes in sort and capacity of planned communication, and also must take into consideration improvement of communication network reliability.



(Note) (1) * : Number of Circuits by Operator Dial at Macalle in 1974.
(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 Circuit and Order Wire Circuit)	Fig. II - 1

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

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

A field survey including a continuous recording test of received radio power and a detailed site selection in the area between Addis Ababa and Asmara was carried out with the cooperation of engineers of IBTE, during the period of about 2 months from August 20th to November 3rd. It should be noted that Mr. Betru Admassie (General Manager) and Mr. Beyene Desta (Manager of Radio Division) joined the field survey for the Karrakorre - Korke section and the Macalle - Adigrat West section, respectively, to investigate the continuous recording test of received radio power and the site selection.

In the survey, the recording test was performed at the seven special hops, that is, long hop, or low layer propagation hop where a reflected wave is not shielded. On that occasion, it was very difficult to transport the test equipments, to install the tower, equipments and the other needs required for the test, because of adverse rainy season conditions. Therefore, an actual recording test was continued for only a period of from 4 to 14 days for one section.

The survey team had to endure the bad accommodation condition in a tent on a mountain in the rainy season. But the all-out cooperation and the perfect arrangement in security, by IBTE, allowed the survey team to carry on the survey without any trouble.

1 Remaining Problem at the Preliminary Survey

The preliminary survey was performed principally by means of the mirror test to confirm the line-of-sight between the adjacent proposed sites and the measurement of angle of adjoining paths with a transit located at the proposed sites. However, the line-of-sight of the Shano South - Ancober North section and the Ancober North - Karrakorre section had not been confirmed due to the mist hanging around Ancober North at an altitude of 3,600 meters.

In addition, the selection of the propagation path with a shielding ridge for a reflected wave from the swamp in the Karrakorre - Korke section, the affirmation of the clearance between Macalle North and Adigrat West, the confirmation of an altitude of the ridge between Digsa and Bete Giorgis, as well as the review of the site selection, have been tasks left to the second survey. Meanwhile, the data on microwave propagation characteristics and meteorological conditions in a low latitude and a high altitude area like Ethiopia is unavailable. Therefore, a fundamental problem was how to estimate the occurence probability of the Rayleigh fading in the long distance hops exceeding standard 50 km, which were selected at the preliminary survey.

2 Results of Continuous Received Radio Power Recording Test

2.1 Outline

The seven sections in the route plan proposed at the preliminary survey, which was anticipated to have some difficulty in microwave propagation because of its long distance, were selected for continuous recording tests of received radio power. At the site, a collapsible tower 3 or 4 meters high was installed, and on it, an antenna and a test transmitter or a receiving part of a field intensity meter was set up.

100V AC power was supplied from a gasoline engine generator, and a rectifier was provided to obtain DC -24V power. The received radio power was recorded by the recorder continuously. When it was remarkably changed, a high speed recorder was operated simultaneously. Following equipments were provided for the test.

(1) 6 GHz test transmitter ; 3 sets, transmitting power .. more than 26 dBm
(2) Type WI - 3 field intensity meter ; 3 sets, power range .. -40~-90 dBm
(3) Antenna ; 5 sets total, parabolic antenna (1.8 m and 1.0 m in diameter), electromagnetic horn.
(4) Recorder ; 1 set of 2 pen recorder
2 sets of 1 pen recorder
(5) Gasoline engine generator ; 2 sets of 2 KVA output 3 sets of 1 KVA output
2 sets of 600 VA output
(6) Other needs ; 1 complete set

2.2 Test Result

A summary of the test results, the test section and its hop distance is shown in following table.

Table

Item / Section	Hop Distance (km)	Trans-mitting power (dBm)	Antenna (mϕ)	Feeder loss (dB)	Receiving Power (dBm)		Fading Range	
					Calc. Value	50% Value	Depth (1-50%)	Rise (50-99%)
Mt. Furi Shano South	74	26.1	1.8-1.0	3	-51.3	-60	8.5	8.5
Ancober Nor. Shano South	72	27.7	1.8-1.0	3	-44.5	-47.8	4.7	4.8
Ancober Nor. Karrakorre	89	27.7	1.8-1.0	3	-46.3	-50.5	5.0	3.2
Karrakorre Korke	87	26.1	1.8-1.0	3	-47.7	-53.8	5.2	5.8
Ualdia Korke	73	27.7	1.8-1.0	3	-49.5	-60.5	5.5	7.5
Amba Alagi Macalle Nor.	66	26.1	1.8-1.0	3	-50.3	-51	2.5	4.0
Adigrat Wes. Macalle Nor.	78	27.7	1.8-1.0	3	-45.1	-51	4.0	4.3

Antenna Gain 1.8mϕ ; 38 dB
1.0mϕ ; 33 dB

2.2.1 Mt. Furi --- Shano South

The hop is very long, 74 kilometers, and, in the propagation path, there is no ridge to shield a reflected wave.

The neighborhood of the reflection point is waste land. It is presumed that the reflection point will be on the water surface and its reflection coefficient will be larger at the time of a heavy rain in the rainy season.

The test was carried on for about two weeks, selecting the rainy season which is anticipated to be a bad propagation condition time. The difference between the theoretical value and the recorded value was 24 dB, maximum.

However, the difference of 24 dB was recorded only one time and for a short period. In all the other periods, small level variation within a few dB was recorded. Through the test period, no peculiar fading was recorded. In spite of the long hop distance, even duct type fading did not occur. However, the period when the received radio power fell in the range of 10 - 24 dB coincided with the period of heavy rainfall on the propagation path. Therefore, this fading is presumed to be caused on the variation of K and the affection of the reflected wave.

As mentioned above, the test results showed, generally, a small variation in the continuous recording test. Therefore, it should be further investigated whether the test period was by chance coincided with the stable period of the fading on this section has normally deep fading.

As the result of the present survey, a new site was proposed, that is Sendafa East and Shano North. Therefore, the Mt. Furi - Shano South section is not adopted.

2.2.2 Ancober North -- Shano South

This hop is 72 kilometers long. Since the line-of-sight between the 2 sites normally confirmed by means of the mirror test had not been confirmed in the preliminary survey, the received radio power recording test for this section was carried out in this survey, simultaneously with the recording at the Mt. Furi -- Shano South section. No correlation between the two recorded results was found. The K type fading, which was recorded at the test of the Mt. Furi - Shano South section during heavy rainfall, was not observed in this section. Neither was the duct type fading observed. Stable received power level was recorded.

2.2.3 Ancober North - Karrakorre

The section is 89 kilometers long. Line-of-sight by means of the mirror test had not been confirmed in the preliminary survey.

The received radio power continuous recording test was carried out to confirm the clearance of the ridge at the Karrakorre site.

The recording was carried on for four days, and stable received power was recorded. The following factors are considerable as reasons.

(1) In the test period, the propagation condition was most stable.
(2) The propagation path is the ideal high-low path.

2.2.4 Karrakorre - Korke

The hop is 87 kilometers long.

Almost all of the transmission path, including the reflection point, is on a swamp. It was considered necessary to investigate the ridge altitude shielding a reflected wave. The measurement of the clearance clarified that the ridge near Kemssie village can shield the reflected wave sufficiently. Also, in the received radio power continuous recording test, fading, which was regarded as K type, was observed for only 20 minutes. In the fading, four comparatively deep level dips were observed, and only two of them reached 30 dB down from the normal level. In a part of the swamp near the reflection point, a hot spring is located, over which a mist frequently hangs. Therefore, duct type fading was anticipated, but was not recorded in the test.

2.2.5 Ualdia - Korke

The transmission path is on the mountains and the reflected wave is shielded well. In the recording test, 50% of the received power fell 11 dB below the theoretical value. Cause was presumed to be unsufficient height of the test tower at Ualdia. No large level dip was observed.

2.2.6 Amba Alagi - Macalle North

The path is a typical standard high - low type one, and the most stable result among the all test section was observed.

2.2.7 Adigrat West - Macalle North

The hop is 78 kilometers long, and it had been feared that sufficient clearance was not available, because of the ridge located at the middle of the path. Measuring the clearance by means of a transit, it was confirmed to be sufficient. Also, a stable received power was recorded.

2.2.8 Mai Ceu North - Korke

When the study was made with a 1 : 500,000 scale map, a problem of over-reach interference arose along with the two frequency system.

Therefore, an attempt to measure the ridge loss to the over-reach wave was made, but could not be accomplished. Theoretical received power intensity is -60 dBm without ridge loss and applied measuring equipment can measure up to the level of -90 dBm. Then, even if 5 dB measuring error were taken into account, about 25 dB ridge loss can be expected.

2.3 Conclusion

The survey team carried out continuous received radio power recording tests during about two months at seven sections. The test period for one section was very short, two weeks at the longest, therefore, it is not clear whether the recorded data corresponds to the worst period data or the best period data in the present sections. Strictly speaking, the data must be dealt with as a reference. However, if it is assumed that the test was performed at the worst period in Ethiopia, the estimation method in Japan, concerning occurence probability of fading, will be applied to the microwave system design in Ethiopia.

3 Site Selection Result

3.1 General

In the survey, line-of-sight was confirmed by means of a mirror. Ridge altitude was measured with a transit at a few sections where it could not be confirmed at the preliminary survey. Also, new sites were selected and investigated. Generally, a site selection is carried on at the field after desk study with a 1 ; 50,000 scale map, and provision of several route plans. But the only maps available in Ethiopia are on a scale of 1 : 500,000, therefore map study accomplishment was difficult. The altitude of the ridge on the propagation path is usually measured with a triangulation point where a altitude, latitude and longitude are known. In the area where the field survey was made, however, there was no such triangulation point, therefore the altitude of the ridge was presumed based on the measurement of an angle of elevation and depression, and eye measurement of the distance.

In the route plan selected at the preliminary survey, passive reflectors were applied to two sections. The reflector to branch off the main route to Dessie city is inevitable because of the mountains around Dessie city.

However, for the Mai Ceu North - Amba Alagi section, a new Mai Ceu North site was proposed and the reflector was removed from the system design.

The Mt. Furi - Korke route is composed of 4 sections and each hop distance exceeds 70 km. In addition, the route includes a section where reflected wave is not shielded. Therefore, two new sites were proposed and the route was changed. Details are as follows:

3.1.1 Addis Ababa - Dessie

This section is composed of seven sections, including the reflector relay section between Korke and Dessie, with a total distance of approximately 347 km.

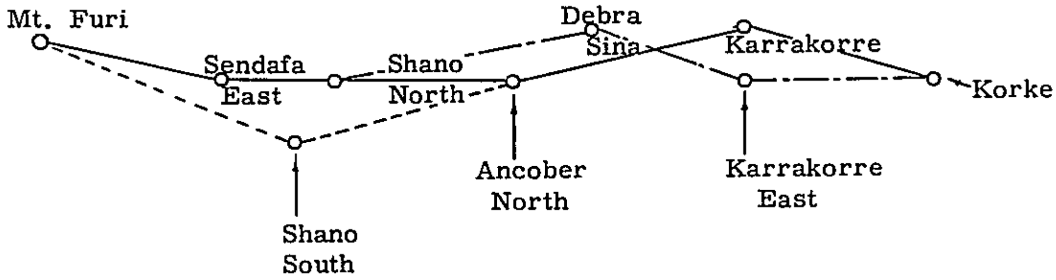
The radio and carrier multiplex terminal station in Addis Ababa will be constructed on the site of the previous Head quarters and will contain toll telephone exchange equipment plus radio and carrier terminal equipment.

In Dessie, the radio and carrier multiplex terminal station will be constructed on the site of the existing Dessie telephone office, because there is no room for the equipment.

In the preliminary survey route, the Mt. Furi - Korke link is composed of four sections which contain long spans such as 74 km, 72 km, 89 km, and 87 km. Moreover, two of the spans Karrakorre - Korke, and Mt. Furi - Shano South, did not screen the reflected wave. The Karrakorre - Korke section has a shielding ridge confirmed during the second-survey. The Mt. Furi - Shano South section contains no shielding ridge. The receiving power record in this section indicates that fluctuations are not so large, except for a single peak of -24 dB.

It is keenly felt, however, that a section having a shielding ridge for the reflected wave or a section having less distance would be more desirable.

The three routes designed by the survey team are as follows.



Route 1: (Mt. Furi)--(Sendafa East)--(Shano North)--(Ancober North)--(Karrakorre)--(Korke)

Route 2: (")--(")--(")--(Debra Sina)--(Karrakorre East)--(")

Route 3: (")--(Shano South)--(Ancober North)--(Karrakorre)--(Korke)

Route 3:

This route was proposed at the preliminary survey. However, at Shano South, a 4 km access road would be required from the All Weather Road. It would be very difficult to construct because most of the road becomes a swamp in the rainy season.

Route 1:

In place of the Shano South site with its access road construction problem, two sites are proposed, Sendafa East, and Shano North. In spite of increasing number of repeater stations, these access roads are shorter compared Shano South. The distance for Sendafa East is 2 km, and Shano North has no access road problem. In the Ancober North - Karrakorre - Korke sections, the path leads through a range of mountains with altitudes 3,600 m to 2,000 m. Note that it is difficult to determine the propagation path proposed in vicinity of Karrakorre. Even though the Ancober North - Karrakorre span is the longest in this route, 89 km, the propagation condition are favorable on the range of mountains and in the high-low pattern. Note that it was confirmed at the second survey that the site proposed at the preliminary survey shall be moved approximately 200 m to the east and that a 35 m antenna shall be erected on the new site, in order to secure line of sight over the ridge approximately 10 km from Karrakorre, i.e. to maintain 2/3 of the 1st Fresnel zone at K = 2/3. Though sufficient data for the fading occurance was not obtained, it is expected that selecting an alternative site would be quite difficult both technically and economically, since it was definitely determined that the reflected wave at the swamp between Karrakorre and Korke is shielded due to an intermediate ridge.

Route 2:

Instead of Ancober North, Debra Sina, which is located on the mountain to the west of Debra Sina town, has been selected. A 200 m higher mountain to the east of Korrakorre has been also selected, since line-of-sight cannot be obtained between Debra Sina and the present Karrakorre site.

In this case, the distance between Shano North and Debra Sina is 70 km, and the Karrakorre East access road is 2 km longer than the Karrakorre distance.

3.1.2 Dessie - Macalle

This route is composed of six sections, including the reflector relay section, covering a total distance of approximately 275 km, according to the preliminary survey.

The existing Macalle telephone office building cannot accept the radio and carrier multiplex equipment because it would cause delay in the construction planning. Therefore, the radio and carrier multiplex terminal station will be constructed in Macalle North 13 km northeast from Macalle city, and connection between Macalle telephone office and Macalle North radio and carrier multiplex terminal station will employ toll cable.

In the vicinity of the section between Mai Ceu North and Amba Alagi, which is situated at about the center of this route, there are several steep mountains with a height of approximately 3,000 m on both sides of the road. Because of this geographical condition, it was inevitable to divide this section into two hops with an extremely short distance of 8 km and 7 km, during the preliminary survey.

During the second survey, an appropriate new site was selected on the mountain located 4 km west from the former site, where line-of-sight to Amba Alagi is directly obtained without the use of a reflector.

The length of access road for the new proposed site is approximately 3.5 km, a little longer than that for the former site, but it enables having a communications route with better transmission quality.

The new site, Cobbo North located 6 km northefrom Cobbo East, was selected in consideration of a balanced distance for the Mai Ceu North-Cobbo North-Ualdia sections. Ridge shieleding of the reflected wave between Cobbo North and Mai Ceu North was not found, but this dows not represent a problem because of the high-low propagation path utilization.

3.1.3 Macalle - Asmara

This route is composed of four sections with a total distance of approximately 210 km.

The selected Bete Giorgis site is the same place as the terminal station of the existing 2 GHz band microwave route, extending from Bete Giorgis to Massaua. As neither the building or antenna tower have room in reserve to accommodate the new microwave route facilities, it will be necessary to build a new station at this site similar to the other four sites.

Cable system is expected to be used for the section between Bete Giorgis and Asmara telephone office.

At the second survey, it was confirmed that 10 m of antenna height is enough to clear 2/3 of the 1st Fresnel zone at K=2/3, in the Macalle North - Adigrat West section.

Not all the sites are always close to the All Weather Road, running between Addis Ababa and Asmara. However, as the existing roads are useful as an access road, the length of access road to be newly constructed at each site shall not exceed 1 km.

The path length of each section is almost equal to the standard of 50 km without reflected wave.

3.2 Proposed Site

Approximate latitude and longitude as well as altitude of each site and hop distance are shown in Table I-1. In addition, guide maps for the sites and topographic sketches around the sites are shown in Fig. III-33 to Fig. III-66.

3.2.1 Addis Ababa - Dessie

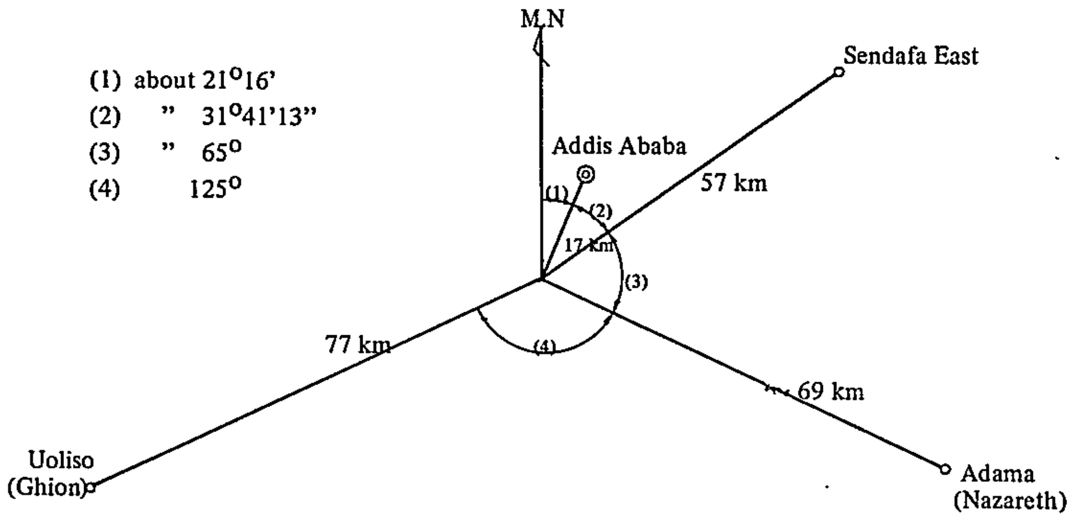
(a) Addis Ababa (Site for radio and carrier multiplex terminal station) station

This site is located in the site of the old IBTE Headquarters in Addis Ababa city. An antenna tower for this station should be erected to a more than 30 m height to clear tall buildings expected to be built around the site in the future.

(b) Mt. Furi

This site is proposed to be located at the summit of Mt. Furi with an altitude of about 2,800 m, about 17 km south-west of Addis Ababa city. This site provides an unobstructed visibility in the direction of Dire Daua, Shashamene and Gimma, where a microwave route is scheduled to be located in the future.

The availability of a microwave route via this site becomes clear by this rough survey for the next stations of each route. That is, the route establishment is possible, using the mountain near Adama (Nazareth) town as the common site for the Dire Daua and Shashamene route, and then, using the mountain near Uoliso (Ghion) town as the site for the Gimma route. The relation between the Addis Ababa - Asmara route and these sites is shown in this figure. There seems to be no problems even when using the same frequency (4 or 6 GHz).



(c) Sendafa East

This site is proposed to be located at the summit of the mountain about 1 km west of the All Weather Road between Addis Ababa and Asmara. As the summit of the mountain is stony and desolate, enough land area to construct a new repeater station is available. Further, access road construction seems to be easy. Visibility in both directions is sufficiently provided.

(d) Shano North

This site is located at the foot of a hill about 100 m east from the All Weather Road between Addis Ababa and Asmara, about 5 km north of Shano town.

Near the site is a field, and the place near the road appears to have been used as a road-repair work shop, so it does not seem to be necessary to construct a access road. Visibility in both directions is sufficiently provided.

(e) Ancober North

This site is located at the summit of a mountain with an altitude of about 3,600 m, north-east of Debra Berhan town and north of Ancober town.

A road leading from Debra Berhan town to Ancober town passes by the south side of the mountain base. The difference in altitude between the road and the site is about 200 m. The access road to this site may be constructed by making use of the gently sloping side of the mountain. The mountain summit with huge exposed rocks is so narrow that sufficient area for constructing a repeater station is not available. But, on the wide grass land about 15 m below the mountain summit, there is sufficient area to construct a repeater station. However, as the back of Mt. Ancober shields the Shano North direction, a 30 m antenna is necessary, and, as there is no shielding object in the direction of Karrakorre, a 10 m antenna is sufficient. Because of its high altitude of 3,600 m, this mountain is always covered by mist, and the average temperature in the night-time is between 2 and 5°C.

(f) Karrakorre

This proposed site location is halfway up a mountain standing east of the All Weather Road between Addis Ababa and Asmara. From the north end of Karrakorre town, a narrow foot way leads to the site. It takes about 45 minutes on foot. A new access road could be constructed more easily by making use of the north slant. The site is entirely covered with weeds, and Site Mark "NO 2" is painted in red on the rock almost at the center of the site.

In the direction of Ancober North, due to a ridge about 10 km from this point, a 35 m antenna is necessary, but the visibility in the Korke direction is sufficient.

(g) Korke

This site location has been proposed at the summit of a mountain in a line due north east of Dessie city and east of the point situated about 13 km distant from the city on the All Weather Road leading to Asmara city. The site is within about a 45 minute walk from the road. The mountain summit is a field with many exposed small rocks and provides a space large enough for the construction of a repeater station. This site is proposed not only for a repeater station of Addis Ababa - Asmara route, but also as an unattended branching station to branch off the main route to Dessie city. The branching angle (the angle between the path of the main route and that of a branching one) is about 76 degrees. This branching angle is not so large, considering the antenna interference characteristics, therefore the frequency allocation plan must be thoroughly and satisfactorily considered.

Visibility in three directions is sufficiently provided.

(h) Dessie (Reffector Site)

This proposed site location is halfway up a mountain east of Dessie city, and sufficient area to construct a reflector is available.

(i) Dessie (Telephone offfice)

This site is proposed in the compound of the existing telephone office in the center of Dessie city. As there is no space for the radio and carrier multiplex equipments room in this present building and since the structure of this building is not suitable for the construction of an antenna tower on it's roof, there is no alternative other than constructing a new building in the back yard of this telephone office.

IBTE would provide the radio and carrier multiplex equipment room in the new building and construct an antenna tower on it's roof, and the increase of buildings for the increase of toll exchange equipments should be considered for the future.

3.2.2 Dessie - Macalle

(a) Dessie, Korke

These sites are proposed to be located at the same places as those for the Addis Ababa - Dessie route.

(b) Ualdia

This proposed site location is near the summit of a mountain situated north-east of Ualdia town. On the mountain summit stands the St. Gabriel Church. The site is proposed to be located in a wide and gently sloping grass land on the east of the mountain. The difference in altitude between the site and the All Weather Road is about 500 m, and the access road to be constructed will be about 6 km long. Visibility in both directions is sufficiently provided.

(c) Cobbo North

This proposed site location is on a small hill about 7 km north of Cobbo village. The site chosen at the preliminary survey was located near Cobbo village, but, because of the unbalance between the hop distances, that is 38 km to Ualdia and 77 km to Mai Ceu North from this site, the site has been changed to a place near Mai Ceu North. Access road to be constructed is about 3.5 km long. It seems a little long, but, as a broad field stretches from the All Weather Road to the site, access road construction will be very easy.

There are many small rocks and the area is not so broad as the other sites, but necessary area to construct a repeater station is provided.

The location of an antenna tower should be decided so as not to be shielded by the northern higher part of the hill in the Mai Ceu North direction.

Visibility in the Ualdia direction is sufficiently provided.

(d) Mai Ceu North

This proposed site location is at the summit of a mountain about 10 km north of Mai Ceu town, and located about 4 km southwest of the site chosen at the preliminary survey. The site is located on the gently sloping side of the mountain with a cliff near the All Weather Road, and the land space is large enough for the construction of a repeater station. The land is marked with red paint. The difference in altitude between the site and the All Weather Road is about 370 m, and the access road to be constructed will be about 3.5 km long. There may be one place near the cliff in the access road, but the other places can be constructed easily, utilizing the slope of the mountain.

Visibility in both directions is sufficiently provided.

(e) Amba Alagi

This proposed site location is half way up Mt. Amba Alagi, which stands southeast of Amba Alagi village, and is a grass field with little swells.

About a one meter ground leveling will provide a land space enough for the construction of a repeater station. The newly constructed road about 1 km long connects the All Weather Road to the site and is accessible by jeep. However, repair work on the U turn location and on the road surface will be required for driving a truck into the land to construct a repeater station. Visibility in both directions is sufficiently provided.

(f) Macalle North (Radio terminal station site)

This proposed site location is on the table land which lies northeast of Macalle city and stretches from east to west. The new All Weather Road between Addis Ababa and Asmara runs close to the east side of the site, which is about 13 km from the telephone office in the central part of Macalle city.

This extensive tableland consists of farmland and a wasteland with many small rocks and pebbles. The vicinity of the site slants slightly southward.

Then, at the request of IBTE, the radio and carrier multiplex terminal station will be constructed as a maintenance station for the maintenance of radio and carrier multiplex equipment, including a loaded cable between this site and the telephone office. Visibility in both directions is sufficiently provided.

(g) Macalle (Telephone office)

This site is the existing telephone office. Loaded cable connects this site to Macalle North radio terminal station, so equipment necessary for pull-in of the loaded cable is to be arranged in the exchange room.

3.2.3 Macalle - Asmara

(a) Macalle, Macalle North

These proposed sites are to be located at the same place as those for Dessie - Macalle.

(b) Adigrat West

This proposed site is to be located about 20 km west of Adigrat town.

The road, branched off from All Weather Road at Adigrat town and extended in the direction of Axum, runs by the north side of the site.

The difference in altitude between the site and this road is about 70 m.

An access road about 1 km long will have to be constructed between the All Weather Road and the site. The portion of the proposed route for access road is covered by base rocks, but it does not seem to create any problem in the road construction. In and around the site are many rocks of various sizes, and east of the site is farmland. Land space sufficiently large to construct a repeater station is available. The location of the antenna tower should be determined so as to provide sufficient clearance by considering the height of the ridge between this site and Macalle North. Visibility in both directions is sufficiently provided.

(c) Meshal East

This proposed site is to be located on the table land which lies about 10 km southeast of Senafe town and extends toward the east from the All Weather Road.

A comparatively new road about 2 km long runs from the All Weather Road to St. Gabriel Church near the site and is accessible by jeep.

The site is about 30 m from the church, passing the north side of it.

The site is broad and flat desolate and rocky. Visibility in the Adigrat West direction is sufficiently provided. However, as a large rocky mountain lies near the site in the Digsa direction, the location of an antenna tower should be determined considering this problem.

(d) Digsa

This site is located at a point about 15 km southeast of Saganeiti town and is at the entrance of Digsa village, which is about 2 km eastward from the All Weather Road. The existing road from the All Weather Road to Digsa village is accessible by jeep, but the condition of the road surface is not satisfactory and some repair work may be required. The proposed site is to be located on the hill top and is within a 10 minute walk from the road. The difference in altitude between the existing road and the site is about 50 m and the construction of an access road seems to be easy. The top of the hill is a little narrower than other sites, but necessary area for constructing a repeater station is available. Visibility in both directions is sufficiently provided.

(e) Bete Giorgis

This proposed site is to be located at the same site as the existing repeater station for the 2 GHz microwave route between Bete Giorgis and Massaua.

There is a church at the proposed site, but, since both the existing building and antenna tower have no room to accommodate the new microwave route, a new station is to be constructed in the vacant lot in the south part of the site.

The existing road can be used to the site. IBTE will make the building and antenna tower, including the future route to Gondar and Tessenei direction, but our survey team did not investigate these routes.

(f) Asmara (Telephone office)

This telephone office is the existing telephone office in Asmara city, and is to be connected to Bete Giorgis with a coaxial cable system.

The room being prepared for the exchange room in the telephone office will be used for the carrier multiplex equipment and control of the microwave system.

3.3 Calculation of the Various Factors on Each Propagation Path

The profile maps shown in Figs. III -1 to Fig. III - 32 were prepared on the basis of the data obtained during the preliminary and second survey.

Various factors on each propagation path shown in Table III - 1 to Table III - 6 were calculated from the data given by these profile maps. These data are calculated under the following conditions.

(a) The profile maps were prepared on estimation based on the altitude of the sites and of the All Weather Road measured by Aneroid Altimeter. Map scale was 1 : 500,000 and the elevation and depression angles were measured from each site.

(b) The various factors on each propagation path were calculated on the basis of the data given by these profile maps.

(c) Assumption was made that an antenna to be used at each station would be 4.0 mϕ in diameter. The polar curve of the near axis calculated theoretically and the broad polar curve with more than 63 dB concerning the Front to Back ratio was adopted.

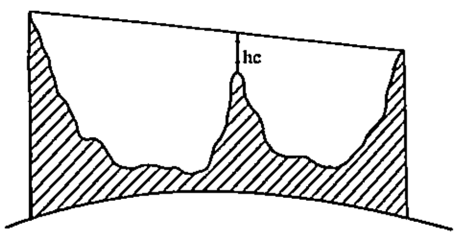
(d) The determined antenna height at each station is considered most appropriate judging from the profile maps and the features of the site vicinity.

But the antenna height adopted here does not include the additional height, which may be required to adopt the space diversity reception system, etc., in order to improve the propagation performance which may further be required according to the number of antennas put on the tower.

(e) The various factors on each propagation path were calculated on the assumption that the 4 GHz band be used for this route.

(f) All profile maps correspond to the condition with the coefficient of equivalent earth's radious of k = 2/3 and k = 4/3, however the various factors were calculated assuming the latter condition.

For a section where the clearance factor is smaller than 3 under the condition that k = 2/3, the value of clearance factor is shown. Here, the clearance factor is defined as the ratio of the path clearance, hc, to the radius of the 1st Fresnnel Zone at the same point, ho.



hc/ho · Clearance Factor

(g) The calculation of the ratio of signal to distortion noise, S/I (the value of unweighted noise per CH), is based on the theoretical formula by R.G. Medhurst.

(h) Regarding the reflection coefficient of various kinds of reflection point, the following values have been adopted in accordance with empirical data obtained in Japan. The factors are to be used for 4 GHz frequency band.

Water Surface	:	1 (0 dB)
Swamp	:	0.8 (2 dB)
Farmland, Dryfield	:	0.5 (6 dB)
Mountain, Forest	:	0.2 (14 dB)

3.4 Interference from the Satellite Communication System and existing Microwave Link

3.4.1 Summary

a) Addis Ababa earth station for satellite communication system

IBTE has a project whereby a satellite system will be used for international telecommunication among foreign countries after the fourth five-year investment program.

Sululta, located about 12 km to the northwest of Addis Ababa city, is selected as a site of the earth station for satellite communication system. The site proposed is prepared in the lot of IBTE's radio receiving station. It locates in a valley open in the direction of the stationary satellite over the Atlantic and the other directions are blocked by mountains. The site is in a favorable situation for the installation of entrance link and etc. as it is located near the Addis Ababa Capital. But great concern for the mutual interference is required to install the microwave circuit, because the microwave circuits will expand centering around the capital in the future.

b) Interference between the earth station for U.S. Armed Forces and the microwave circuit for a connecting line

A satellite communication system for U.S. Armed Forces in Asmara district is being operated now. Some U.S. Armed Forces communication bases around Asmara city and a U.S. Armed Forces earth station in the suburbs of Decamere town located 30 km to the southeast of Asmara city, are connected by microwave circuit. The microwave circuit between Addis Ababa and Asmara will be assigned very severe conditions about mutual interferences, because it is installed east of the U.S. Armed Forces satellite communication systems and near these systems.

3.4.2 Limited Values of Interference between the Satellite Communication System and the Terrestrial Microwave System

A satellite communication system and a terrestrial microwave system should be installed after the interferences were sufficiently studied because both systems will sometimes be operated in the same frequency band. Therefore, in case a new earth station is installed or a terrestrial microwave station is installed close by an existing earth station, it is necessary to suppress the interference. Limited interference values are provided as follows. (refer to C.C.I.R. Report No. 382)

a) Minimum allowable transmission loss for 6 GHz from an earth station to terrestrial microwave station is given by the following formula.

$$L_b = (P_t + G_t - D_{\theta t}) - Fs + 192.6 - 10 \log T - (Ic - Nc) + G_r - D_{\theta r} \text{ (dB)}$$

L_b	:	Minimum allowable transmission loss	(dB)
P_t	:	Transmitting power of earth station	(7 dBW/ 4kHz)
G_t	:	Antenna gain of earth station	(61 dB)
$D_{\theta t}$	:	Antenna directivity attenuation of earth station	(dB)
Fs	:	Earth station site-shielding factor	(dB)
T	:	Noise temperature of receiving equipment in terrestrial station	(1200°K)
Ic	:	Allowable interference noise power in a telephone channel Ic (0.01%) -49 dBm0p Ic (20%) -66 dBm0p	(dBm0p)
Nc	:	Allowable thermal noise power in a telephone channel	(-76.4 dBm0p)
G_r	:	Antenna gain of terrestrial station	(45 dB)
$D_{\theta r}$	:	Antenna directivity attenuation of terrestrial station	(dB)

The following discrimination is given by applying the estimation values of survey team to the above mentioned formula.

$$L_b\ (0.01\%) + Fs + D_{\theta t} + D_{\theta r} \geq 247.4 \text{ (dB)}$$
$$L_b\ (20\%) + Fs + D_{\theta t} + D_{\theta r} \geq 264.4 \text{ (dB)}$$

b) Minimum allowable transmission loss (for 4 GHz) from a terrestrial microwave station to an earth station is given by the following formula.

$$L_b = (P_t + G_t - D_{\theta t}) - Fs - B - Ic - P_{want} + G_r - D_{\theta r} \text{ (dB)}$$

L_b	:	Minimum allowable transmission loss	(dB)
P_t	:	Transmitting power of terrestrial station	(1 dBW)
G_t	:	Antenna gain of terrestrial station	(42 dB)
$D_{\theta t}$	:	Antenna directivity attenuation of terrestrial station	(dB)
Fs	:	Earth station site-shielding factor	(dB)
B	:	Interference reduction transfer factor	(dB)
P_{want}	:	Desired signal input power at earth station $B + P_{want}$ = -106 dBW	(dBm)
Ic	:	Allowable interference noise power in a telephone channel Ic (0.01%) - 47 dBm0p Ic (20%) - 66 dBm0p	(dBm0p)
G_r	:	Antenna gain of earth station	(59 dB)
$D_{\theta r}$	:	Antenna directivity attenuation of earth station	(dB)

The following discrimination is given by applying the estimation value of survey team to the above mentioned formula.

$$L_b\ (0.01\%) + F_s + D_{\theta t} + D_{\theta r} \geq 261\ dB$$
$$L_b\ (20\%) + F_s + D_{\theta t} + D_{\theta r} \geq 280\ dB$$

3.4.3 Investigation Result

a) Interference with Satellite Earth Station at Addis Ababa

Line-of-sight between satellite earth station and each terrestrial microwave station is obstructed by the mountains near the satellite earth station. It is difficult to expect a large ridge loss, since those mountains are found near the satellite earth station. The following table shows the ridge loss at the 4 GHz frequency band obtained from the theoretical calculating method by knife-edge based upon the measurement result by transit and the azimuth angle on the map.

Item / Station	Ridge Loss Required	Calculated Ridge Loss
Mt. Furi	31 dB *	33 dB
Sendafa East	31 dB	39 dB
Ancober North	30 dB	34 dB

* 9dB equalization of transmission loss is considered.

Also, it shows the calculated result of ridge loss required for prevention of interference, based upon the dimensions of the system desige designed by the survey team.

The differences between the two values are quite small. Since it is a result obtained presuming the azimuth angle on a 1 : 500,000 map, more detailed study shall be done.

In case of adopting 6 GHz frequency band, the interference of satellite earth station to terrestrial microwave stations shall be studied carefully, but it seems to be more favorable than in the 4 GHz band. As mentioned above, system performance which does not interfere with satellite earth station shall be decided, in case of adopting 4 GHz frequency band for the construction of microwave circuit Addis Ababa - Asmara.

b) Interference with Satellite Earth Station for U.S. Armed Force

Line-of-sight between satellite earth station and terrestrial microwave station is obstructed by the surrounding mountains since satellite earth station is located in a basin.

However, ridge loss is not always enough and it is quite vital to examine the system performance after due consideration of interference with satellite earth station in case of adopting 4 GHz frequency band at the

Bete Giorgis, Digsa, Meshal East stations.

(In case the 4 GHz frequency band, in accordance with C.C.I.R. Recommendation 382-1, is adopted for satellite earth station.)

The 6 GHz frequency band for satellite earth station for U.S. Armed Forces would not be the cause of interference at all, since it is different from the 6 GHz frequency band of C.C.I.R. Recommendation 383-1 and 384-1.

c) Interference with the microwave link for communication use of U.S. Armed Forces

A microwave link for communication use, adopting 6 GHz frequency band of C.C.I.R. Recommendation 383-1 is actually under service between satellite earth station for U.S. Armed Forces and a communication base near Asmara.

This link adopts the over-the horizon mountain diffraction system over the mountains near the satellite earth station. Besides, it would be difficult to use this frequency band since transmitting output is 500 watts and obviously it could cause great interference to the Addis Ababa - Asmara microwave circuit.

d) After due consideration of interference with the two satellite earth stations at Addis Ababa and Asmara and the microwave link for communication use, the 4 GHz frequency band could be used if only the system performance could be decided so as not to cause interference with the satellite earth station. The 6 GHz frequency band of C.C.I.R. Recommendation 383-1 can not be used because of interference with the microwave communication link used by U.S. Armed Forces in the region of Asmara, but it is quite possible to adopt the 6 GHz frequency band in accordance with C.C.I.R. Recommendation 384-1.

Table III-1 Calculated Figures of Various Fundamental Factors on Each Section

K = 4/3

Item \ Name of Site		Unit	ADDIS ABABA		MT. FURI		SENDAFA EAST		SHANO NORTH
Altitude		(m)	2400		2800		2950		3050
Antenna Height above Ground		(m)	30		10		10		10
Effective Antenna Height		(m)		54.8	421.8	325.6	455.4	42.9	110.6
Effective Reflection Coefficient	Included Angle between Direct and Reflected Waves	°		2.81	0.37	0 94	0.69	0.36	0.14
	Attenuation of Reflected Wave due to Antenna Directivity	dB		20	0.5	(11) 5	(7) 2.5	0.5	0
	Shielding Ridge Loss of Reflected Wave	dB		0		0		0	
	Reflection point: Distance from Site	Km		2.0	15.0	24.1	32.9	8.8	24.2
	Reflection point: Classification of Condition			City		Swamp		Farm	
	Reflection point: Reflection Loss	dB		14		2		6	
	Reflection point: Altitude	m		2375		2450		2915	
	Total Loss of Reflected Wave	dB		34.5		(20.0) 9.5		6.5	
Path Difference	Path Difference between Direct and Reflected Waves	m		2.7		5.2		0.3	
	Distortion $(S/I)_{CH}$	dB		94.5		(69.0) 58.5		100 <	
Propagation path Length		Km		17		57		33	
Propagation Loss in Free Space		dB		129.1		139.6		134.9	
Profile Map				Fig. III-1 Fig. III-2		Fig. III-3 Fig. III-4		Fig. III-5 Fig. III-6	
Clearance				no problem		no problem		hc/ho=2.6(K=2/3)	
Remarks						( ) Antenna is orientated +0.5° in the vertical plane			

Table III-2 Calculated Figures of Various Fundamental Factors on Each Section

K = 4/3

Item \ Name of Site		Unit							
			SHANO NORTH	ANCOBER NORTH		KARRAKORRE		KORKE	
Altitude (m)			3050	3600		1910		2600	
Antenna Height above Ground (m)			10	30	10	35	10	10	
Effective Antenna Height (m)			58.2	497.3	1243.0	-60.9	189.8	762.1	
Effective Reflection Coefficient	Included Angle between Direct and Reflected Waves	°	1.08	0.13	0.73	0.46	1.46 0.72	0.53 0.94	
Effective Reflection Coefficient	Attenuation of Reflected Wave due to Antenna Directivity	dB	5.5	0	3	1	13 3	1 5	
Effective Reflection Coefficient	Shielding Ridge Loss of Reflected Wave	dB	0		38.3		20.1 35.7		
Effective Reflection Coefficient — Reflection point	Distance from Site	Km	5.5	47.5	63.2	25.8	21.2 41.9	65.8 45.1	
Effective Reflection Coefficient — Reflection point	Classification of Condition		Farm		Farm		Water Surface		
Effective Reflection Coefficient — Reflection point	Reflection Loss	dB	6		6		0		
Effective Reflection Coefficient — Reflection point	Altitude	m	3000		1520		1425 1440		
Effective Reflection Coefficient	Total Loss of Reflected Wave	dB	11.5		48.3		34.1 43.7		
Path Difference	Path Difference between Direct and Reflected Waves	m	1.1		22.2		10.9 13.2		
Path Difference	Distortion (S/I) cH	dB	88		74.8		70.6 77.2		
Propagation path Length		Km	53		89		87		
Propagation Loss in Free Space		dB	139.0		143.5		143.3		
Profile Map			Fig. III-7 Fig. III-8		Fig. III-9 Fig. III-10		Fig. III-11 Fig. III-12		
Clearance			no problem		hc/ho = 1.0(K=2/3)		no problem		
Remarks									

Table III-3 Calculated Figures of Various Fundamental Factors on Each Section

K=4/3

Item \ Name of Site				KORKE		UALDIA		COBBO NORTH		MAI CEU NORTH	
Altitude			(m)	2600		2430		1510		3260	
Antenna Height above Ground			(m)	10		10		10		10	
Effective Antenna Height			(m)				830.1	-5.7	79.3	1569.2	
Effective Reflection Coefficient	Included Angle between Direct and Reflected Waves		°				0.22 0.10	1.06 3.83	2.56	0.13	
	Attenuation of Reflected Wave due to Antenna Directivity		dB				0 0	5.5 20	20	0	
	Shielding Ridge Loss of Reflected Wave		dB				30.4 30.3		0		
	Reflection point	Distance from Site	Km				36.4 39.8	5.1 1.7	3.4	66.6	
		Classification of Condition					Farm		Farm		
		Reflection Loss	dB				6		6		
		Altitude	m				1485 1440		1440		
	Total Loss of Reflected Wave		dB				41.9 56.3		26		
Path Difference	Path Difference between Direct and Reflected Waves		m				2.7 4.5		3.6		
	Distortion (S/I) cH		dB				101.9 107.3		81.5		
Propagation Path Length			Km	72			41.5		70		
Propagation Loss in Free Space			dB	141.7			136.9		141.4		
Profile Map				Fig. III-13 Fig. III-14			Fig. III-15 Fig. III-16		Fig. III-17 Fig. III-18		
Clearance				no problem			hc/ho =1.4(K=2/3)		no problem		
Remarks											

Table III-4 Calculated Figures of Various Fundamental Factors on Each Section

K=4/3

Item \ Name of Site			MAI CEU NORTH	AMBA ALAGI	MACALLE NORTH	ADIGRAT WEST
Altitude		(m)	3260	3120	2360	2830
Antenna Height above Ground		(m)	10	10	10	10
Effective Antenna Height		(m)				
Effective Reflection Coefficient	Included Angle between Direct and Reflected Waves	°				
Effective Reflection Coefficient	Attenuation of Reflected Wave due to Antenna Directivity	dB				
Effective Reflection Coefficient	Shielding Ridge Loss of Reflected Wave	dB				
Effective Reflection Coefficient	Reflection point: Distance from Site	Km				
Effective Reflection Coefficient	Reflection point: Classification of Condition					
Effective Reflection Coefficient	Reflection point: Reflection Loss	dB				
Effective Reflection Coefficient	Reflection point: Altitude	m				
Effective Reflection Coefficient	Total Loss of Reflected Wave	dB				
Path Difference	Path Difference between Direct and Reflected Waves	m				
Path Difference	Distortion (S/I) ch	dB	100 <	100 <	100 <	
Propagation path Length		Km	14.5	66	78	
Propagation Loss in Free Space		dB	127.7	140.9	142.3	
Profile Map			Fig. III-19 Fig. III-20	Fig. III-21 Fig. III-22	Fig. III-23 Fig. III-24	
Clearance			no problem	no problem	hc/ho =1(K=2/3)	
Remarks						

Table III-5 Calculated Figures of Various Fundamental Factors on Each Section

K=4/3

Item			Unit	ADIGRAT WEST	MESHAL EAST	DIGAS WEST	BETE GIORGIS
Altitude (m)				2830	2540	2210	2460
Antenna Height above Ground (m)				10	10	10	10
Effective Antenna Height (m)				33.9	273.0		
Effective Reflection Coefficient		Included Angle between Direct and Reflected Waves	°	0.49	1.36		
		Attenuation of Reflected Wave due to Antenna Directivity	dB	1.5	10.5		
		Shielding Ridge Loss of Reflected Wave	dB	16.2			
	Reflection point	Distance from Site	Km	29	12		
		Classification of Condition		Farm			
		Reflection Loss	dB	6			
		Altitude	m	2330			
Path Difference		Total Loss of Reflected Wave	dB	34.2			
		Path Difference between Direct and Reflected Waves	m	5.3			
		Distortion (S/I)ch	dB	82.7	100 <	100 <	
Propagation Path Length			Km	41	43	49	
Propagation Loss in Free Space			dB	136.8	137.2	138.3	
Profile Map				Fig. III-25 Fig. III-26	Fig. III-27 Fig. III-28	Fig. III-29 Fig. III-30	
Clearance				no problem	hc/ho =1.5(K=2/3)	hc/ho =1(K=2/3)	
Remarks							

Table III-6 Calculated Figures of Various Fundamental Factors on Each Section

K=4/3

Item \ Name of Site			Unit	KORKE		DESSIE (Reflector)		DESSIE			
Altitude (m)				2600		2700		2528			
Antenna Height above Ground (m)				10		3		15			
Effective Antenna Height (m)							174.9	15.0			
Effective Reflection Coefficient		Included Angle between Direct and Reflected Waves	°				0.86	12.03			
Effective Reflection Coefficient		Attenuation of Reflected Wave due to Antenna Directivity	dB				4	28			
Effective Reflection Coefficient		*Shielding Ridge Loss of* Reflected Wave	dB								
Effective Reflection Coefficient	Reflection point	Distance from Site	Km				1.4	0.1			
Effective Reflection Coefficient	Reflection point	Classification of Condition					City				
Effective Reflection Coefficient	Reflection point	Reflection Loss	dB				14				
Effective Reflection Coefficient	Reflection point	Altitude	m				2528				
Effective Reflection Coefficient		Total Loss of Reflected Wave	dB				46				
Path Difference		Path Difference between Direct and Reflected Waves	m				3.5				
Path Difference		Distortion (S/I)ch	dB		100 <		108.5				
Propagation Path Length			Km		9		1.5				
Propagation Loss in Free Space			dB		123.6		108.0				
Profile Map					Fig. III-31 Fig. III-32		"				
Clearance					no problem		no problem				
Remarks											

Fig. III - 1 PROFILE MAP
(K =4/3)

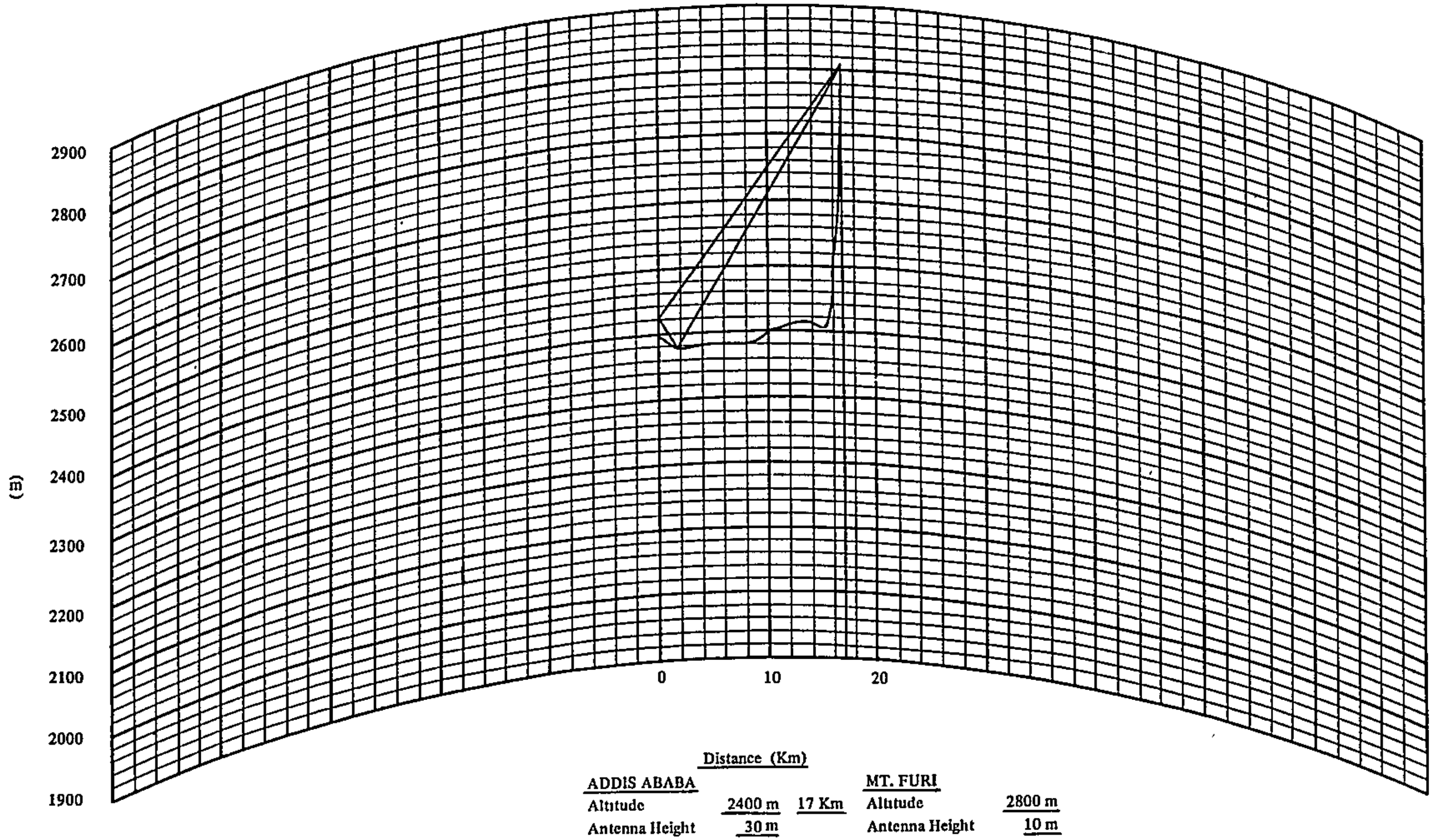
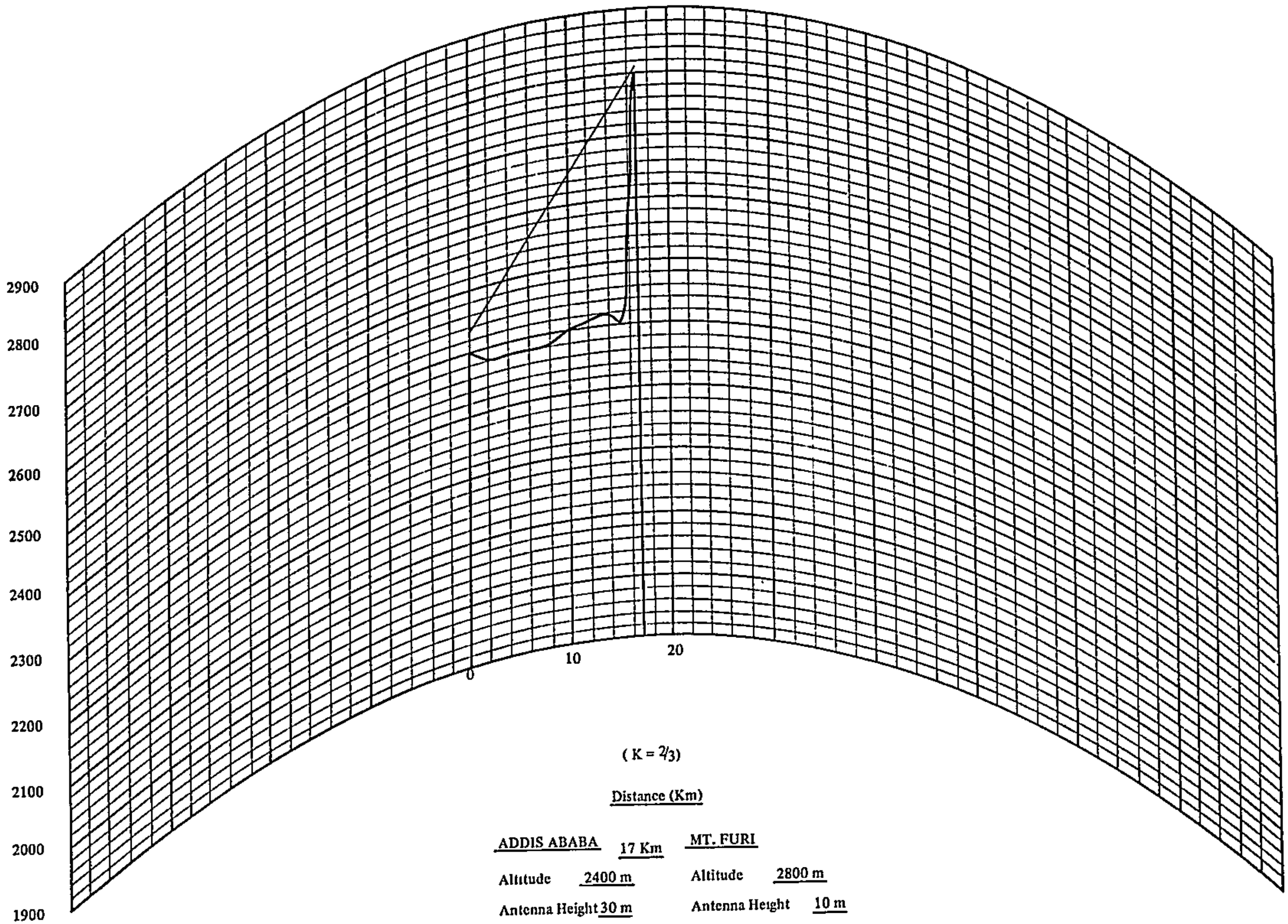


Fig. III - 2 PROFILE MAP



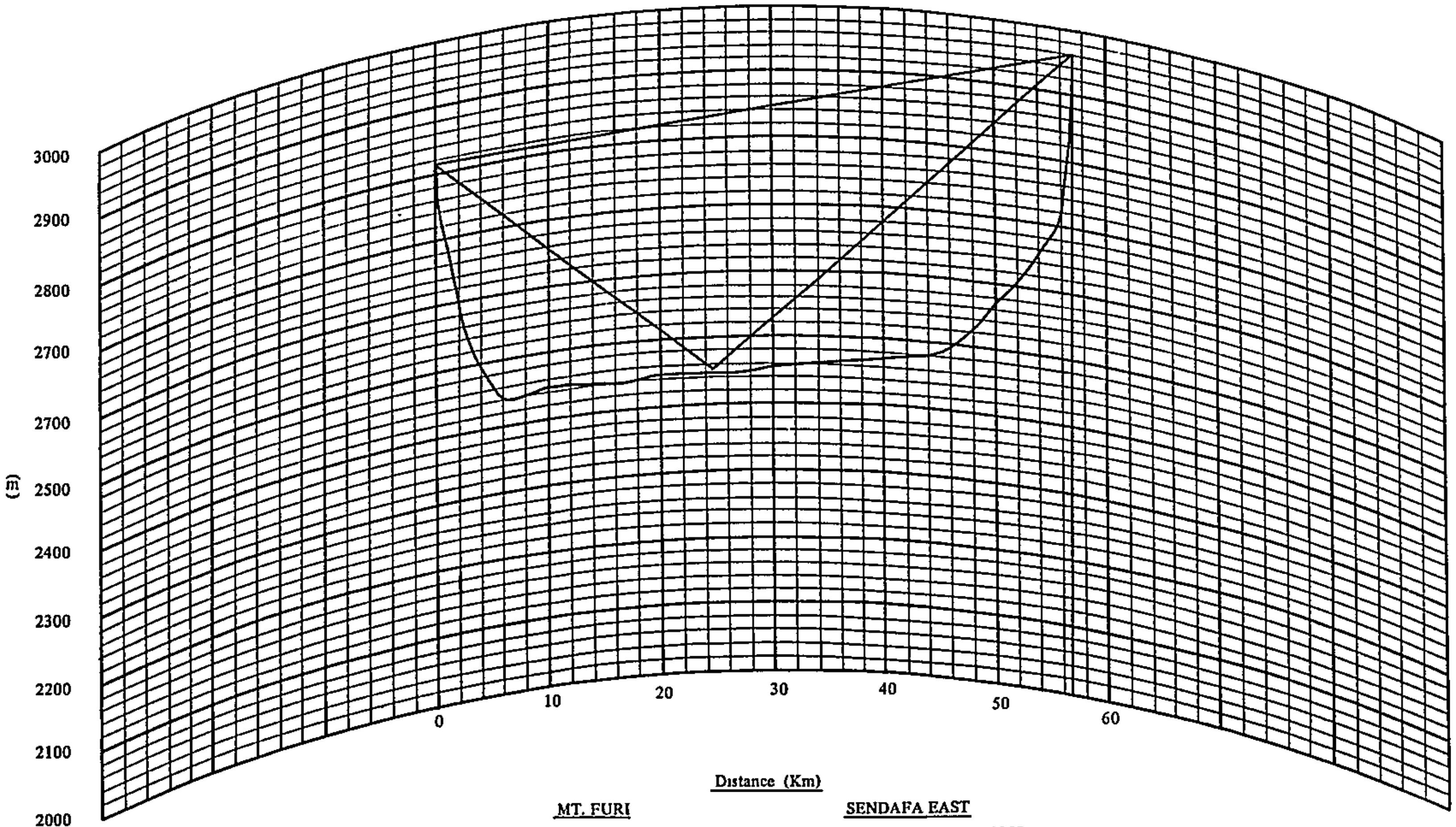
(K = 2/3)

Distance (Km)

ADDIS ABABA	17 Km	MT. FURI	
Altitude	2400 m	Altitude	2800 m
Antenna Height	30 m	Antenna Height	10 m

Fig. III - 3 PROFILE MAP

(K = 4/3)



Distance (Km)

MT. FURI			SENDAFA EAST	
Altitude	2800 m	57 Km	Altitude	2950 m
Antenna Height	10 m		Antenna Height	10 m

Fig. III - 4 PROFILE MAP

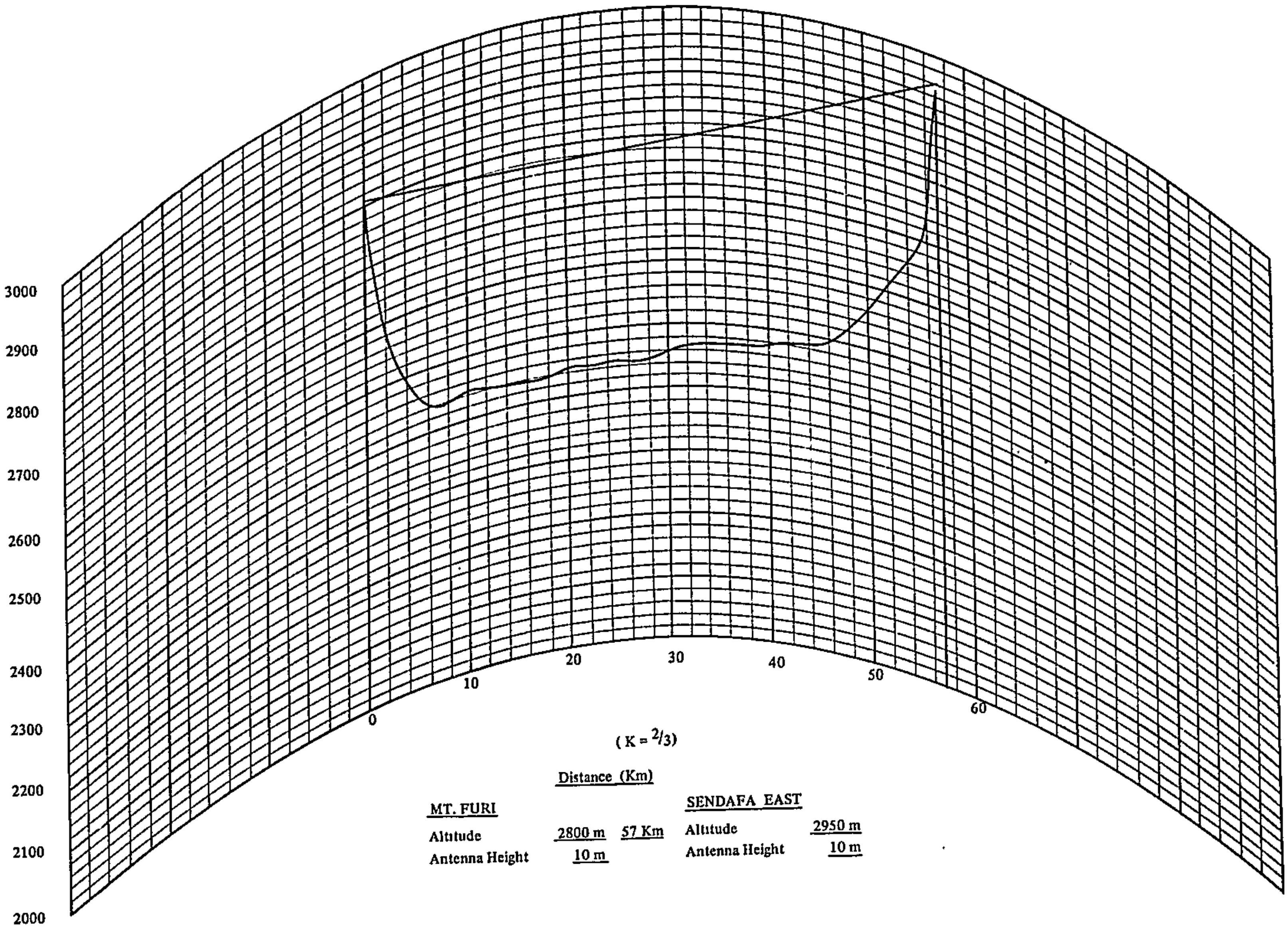


Fig. III - 5 PROFILE MAP
(K =4/3)

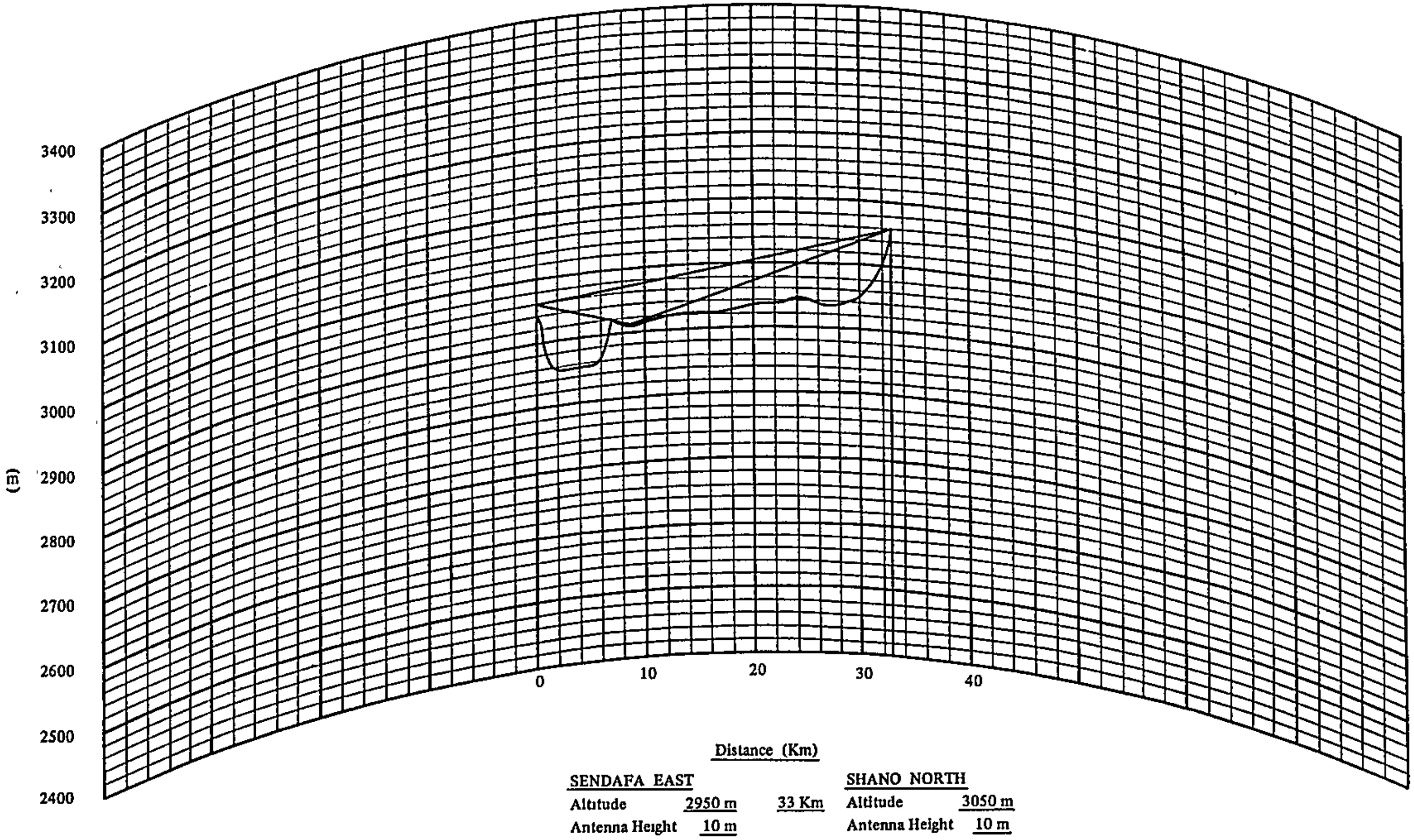


Fig. III - 6 PROFILE MAP

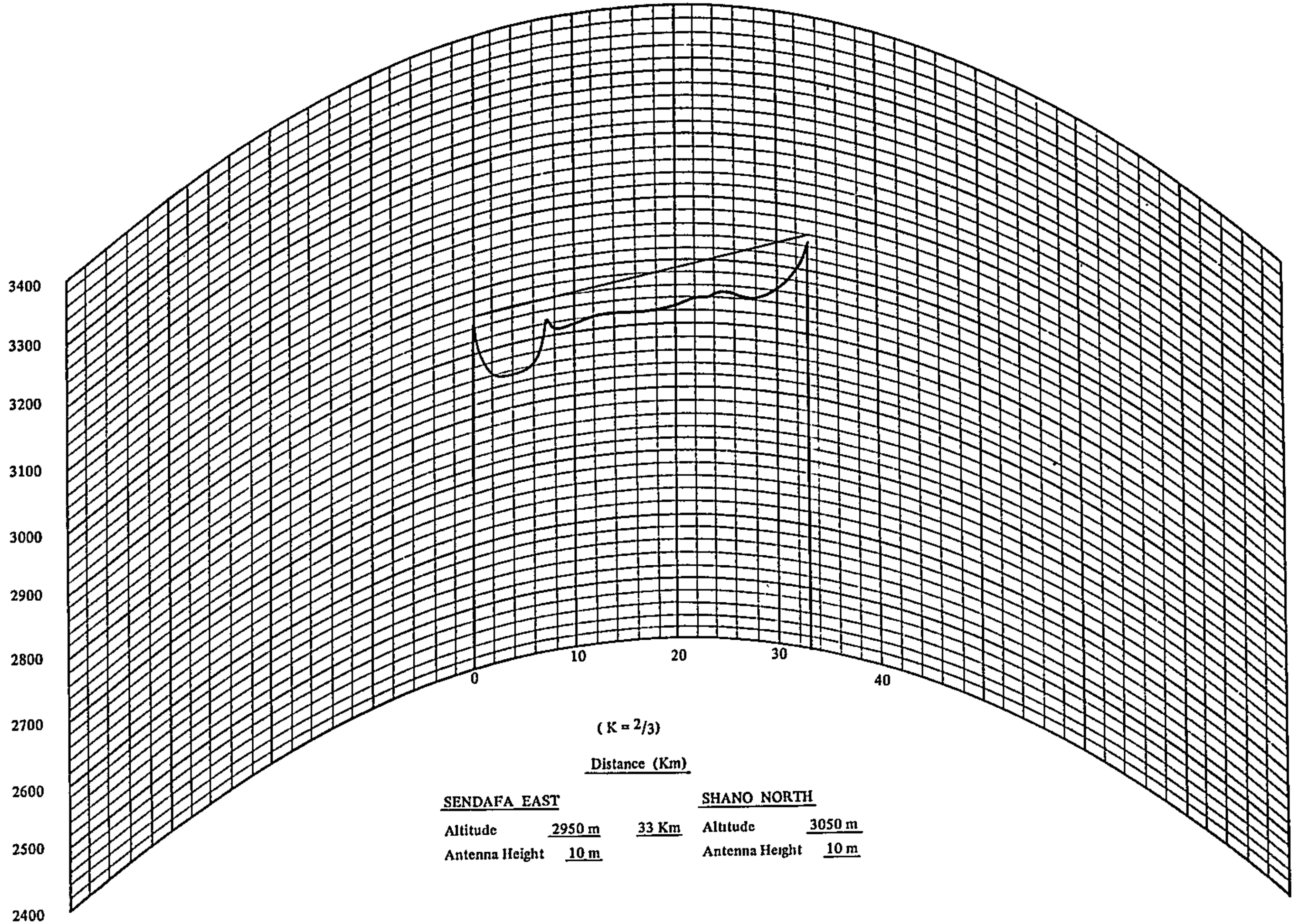


Fig. III - 7 PROFILE MAP

(K =4/3)

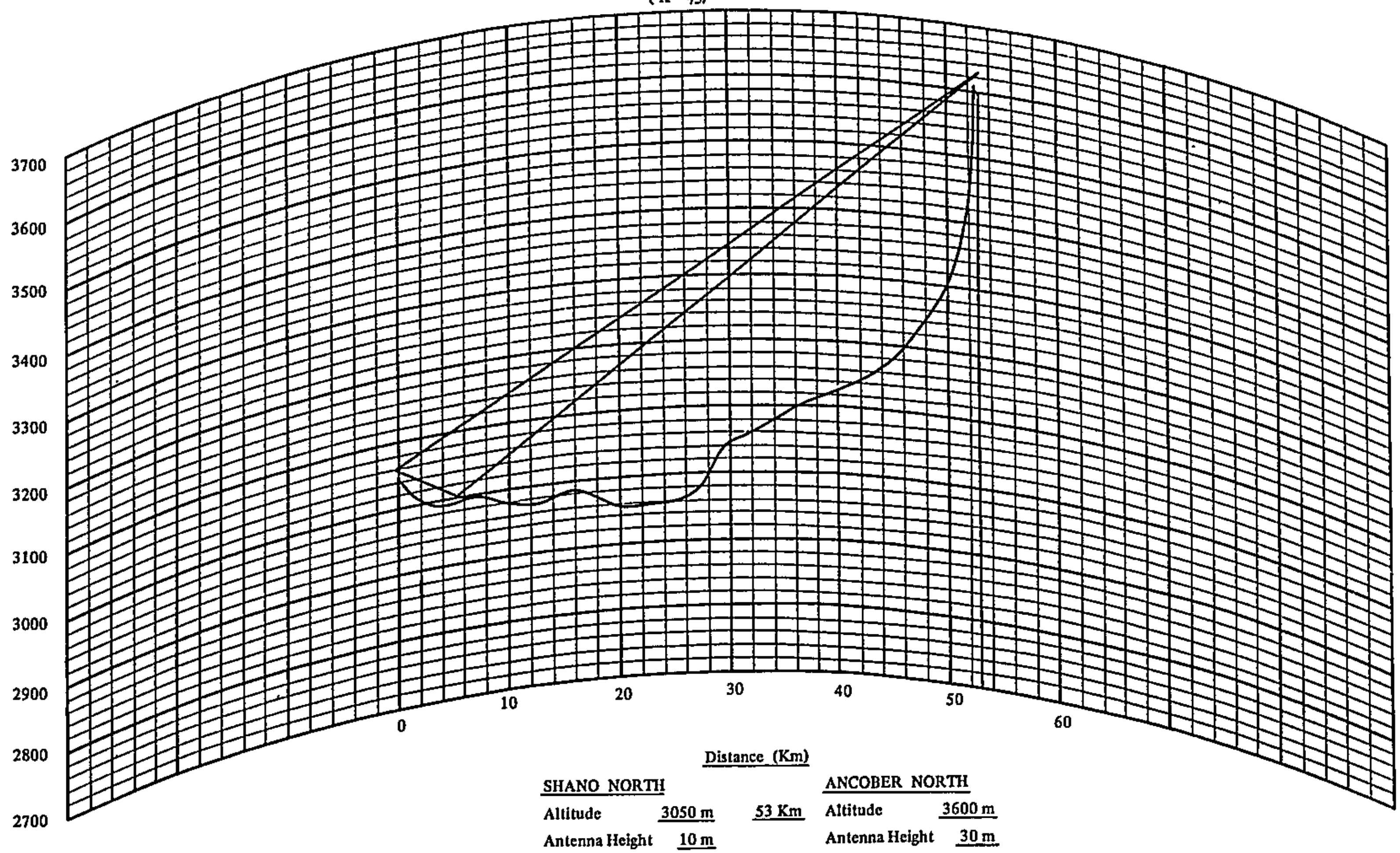


Fig. III - 8 PROFILE MAP

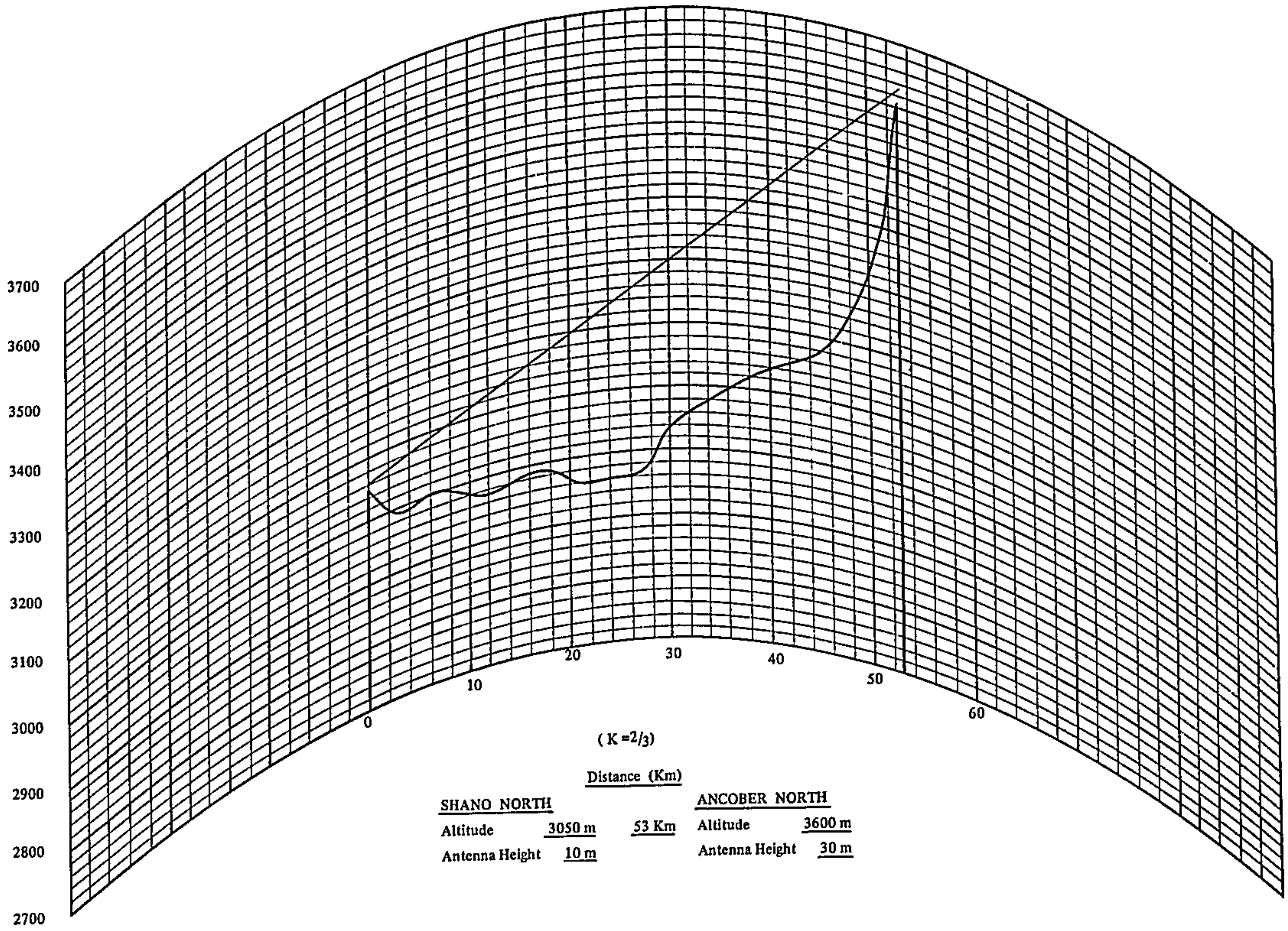


Fig. III - 9 PROFILE MAP

(K =4/3)

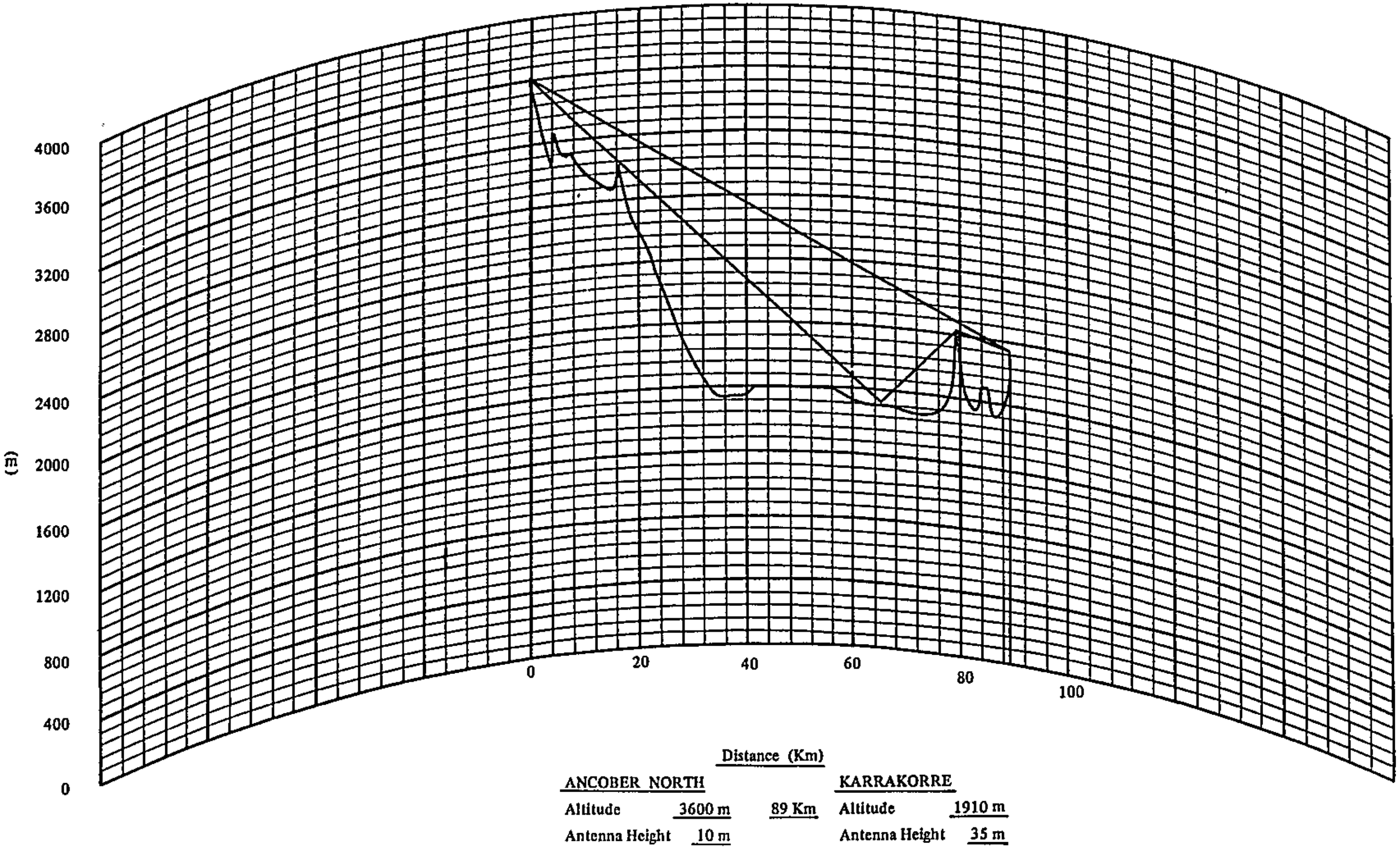


Fig. III -10 PROFILE MAP

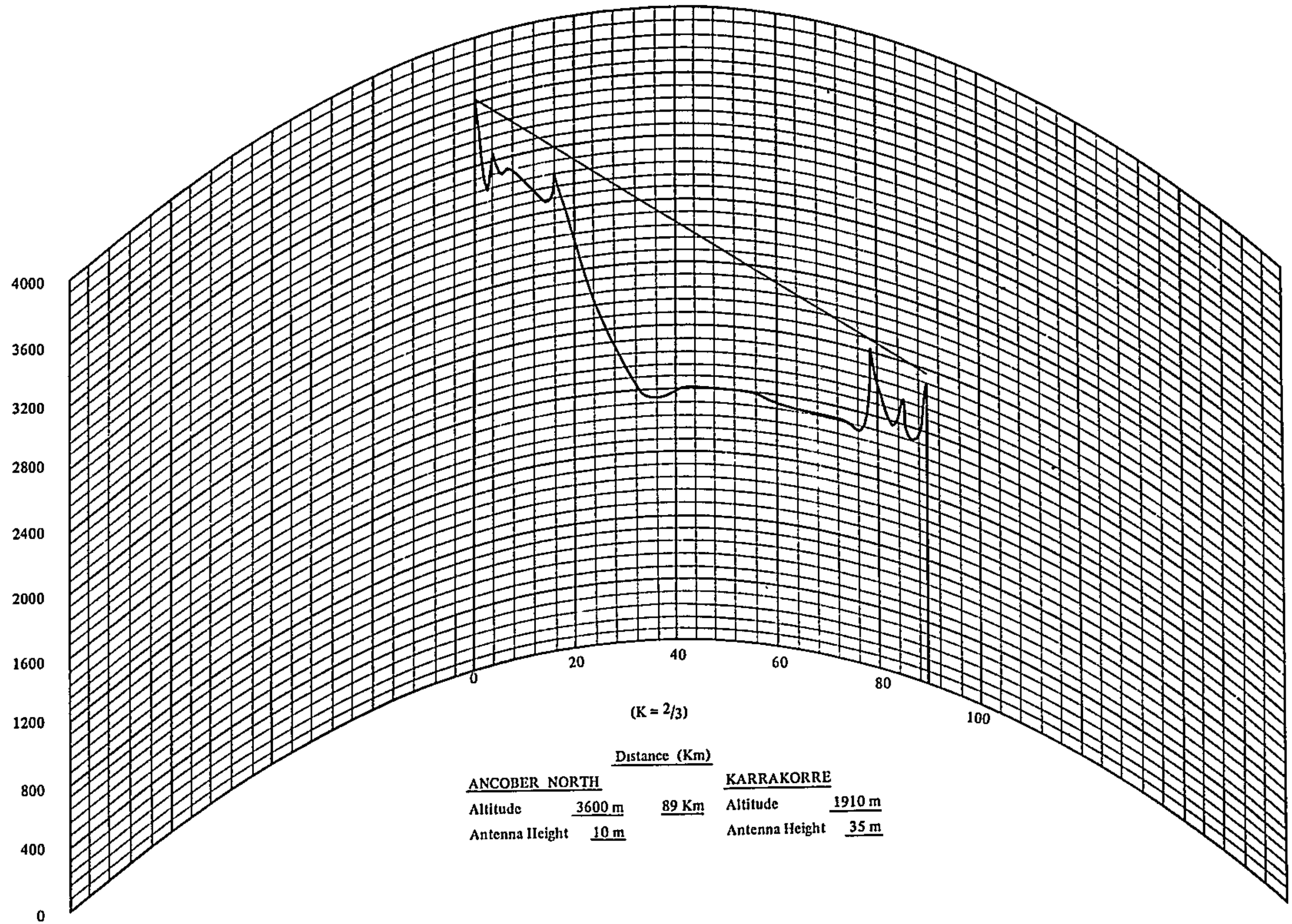


Fig. III - 11 PROFILE MAP

(K = 4/3)

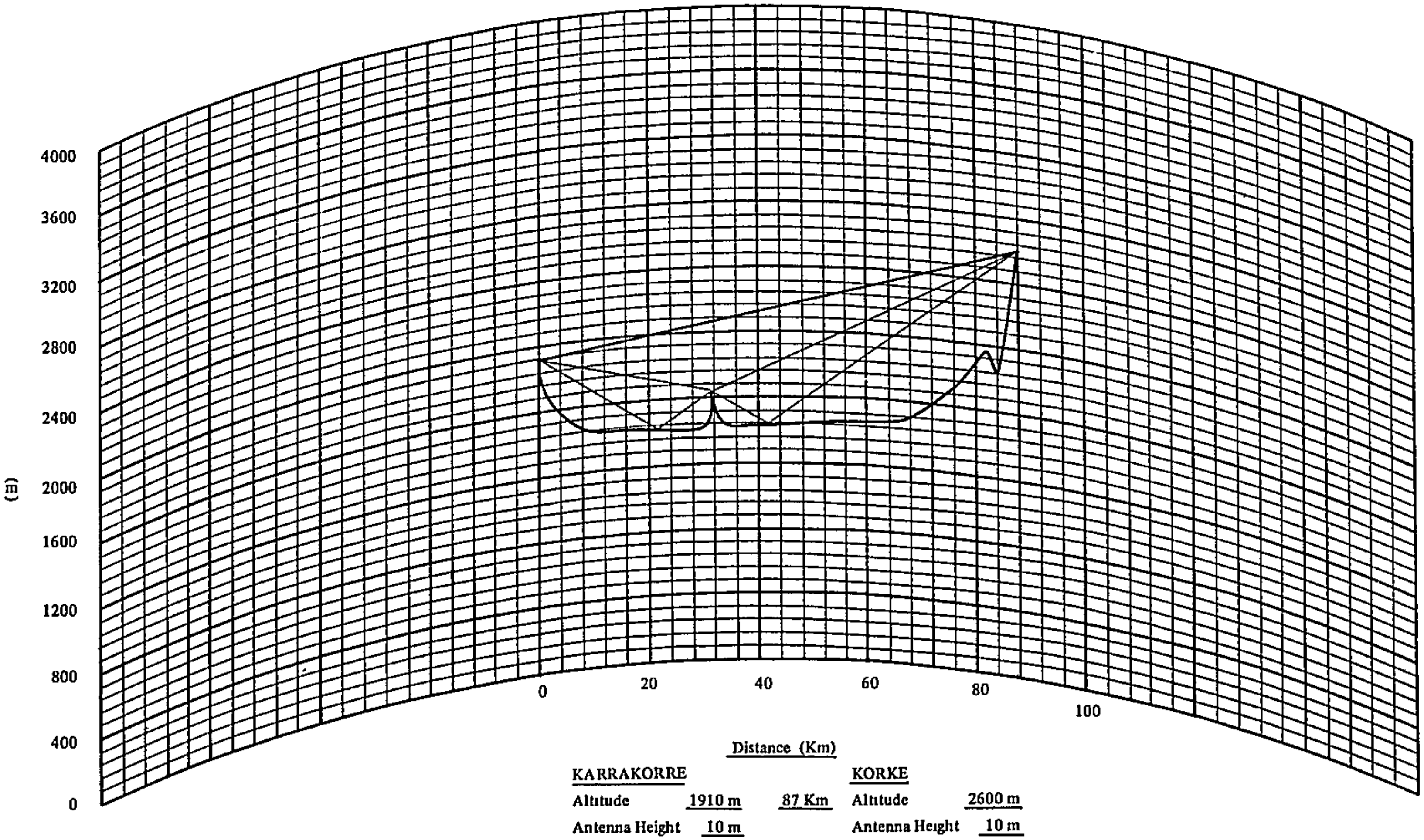


Fig. III - 12 PROFILE MAP

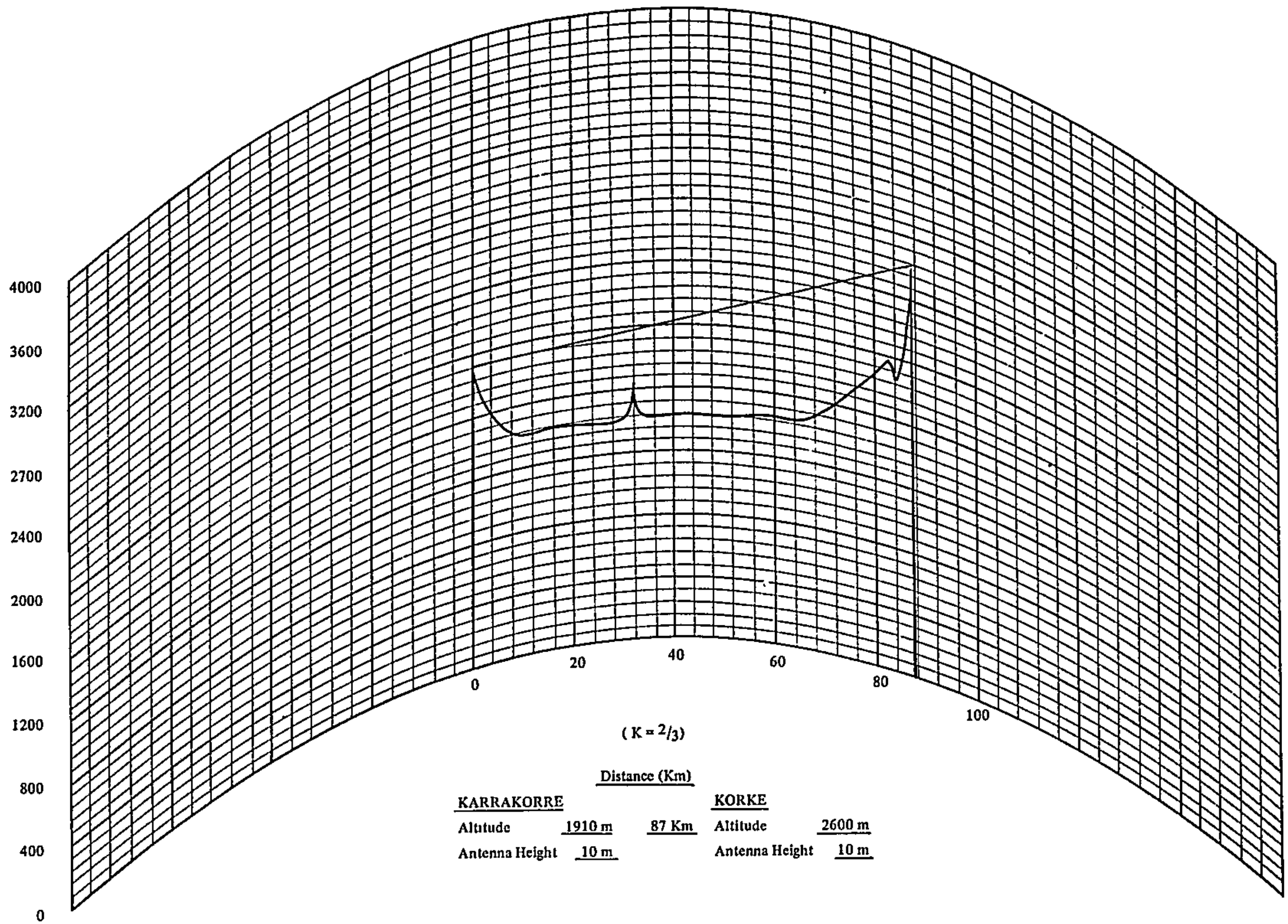


Fig. III - 13 PROFILE MAP
(K =4/3)

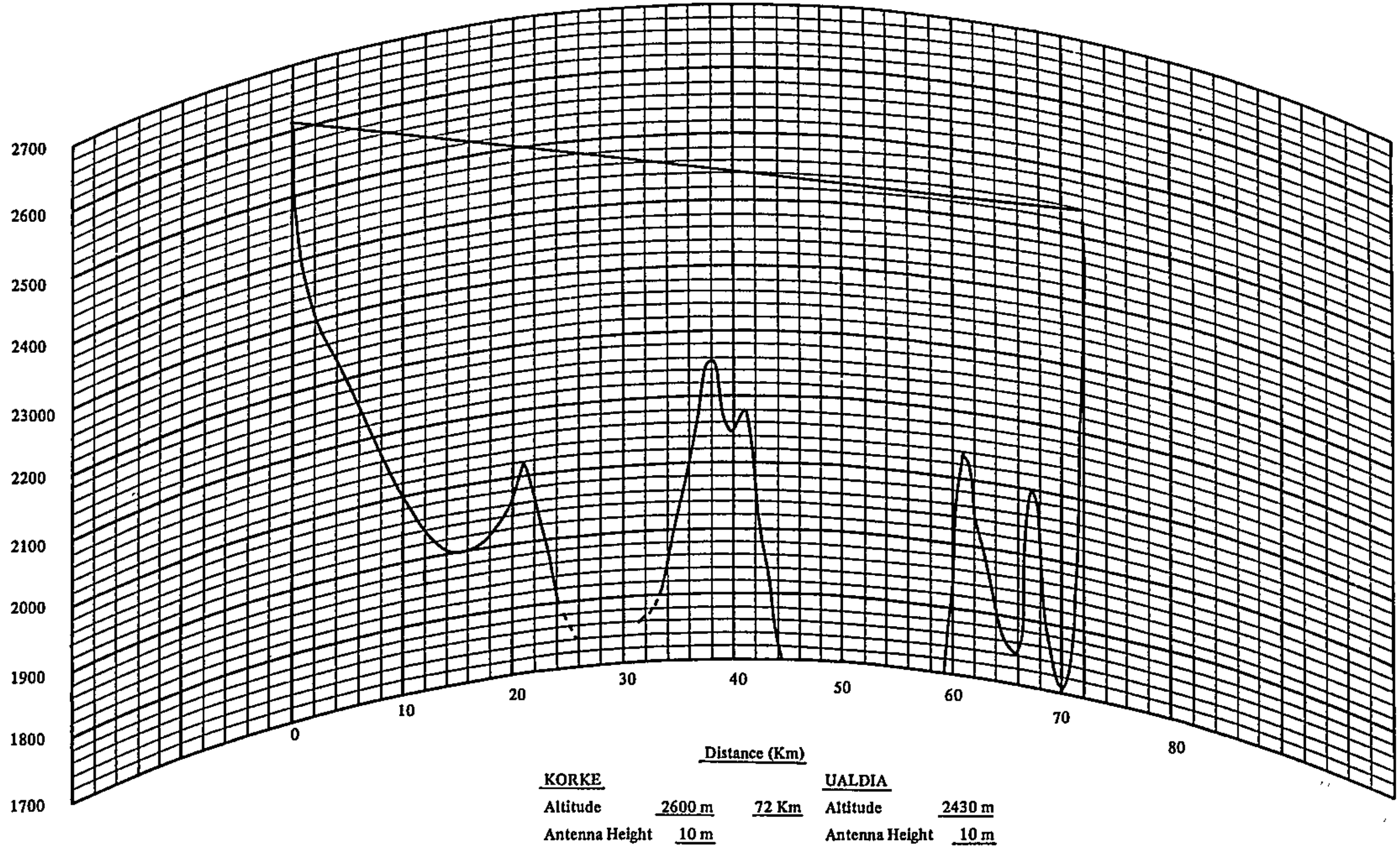


Fig. III - 14 PROFILE MAP

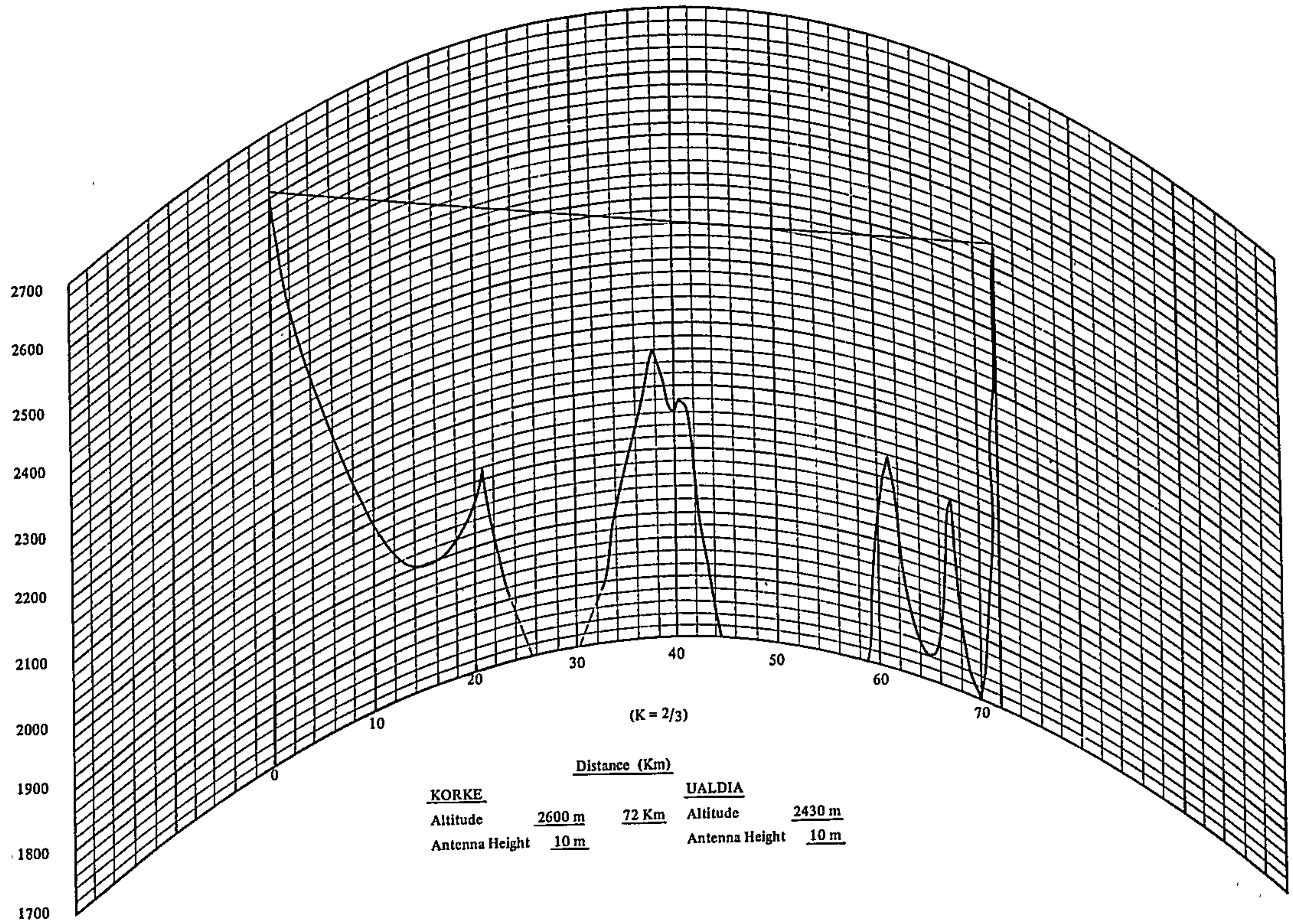


Fig. III - 15 PROFILE MAP

(K = 4/3)

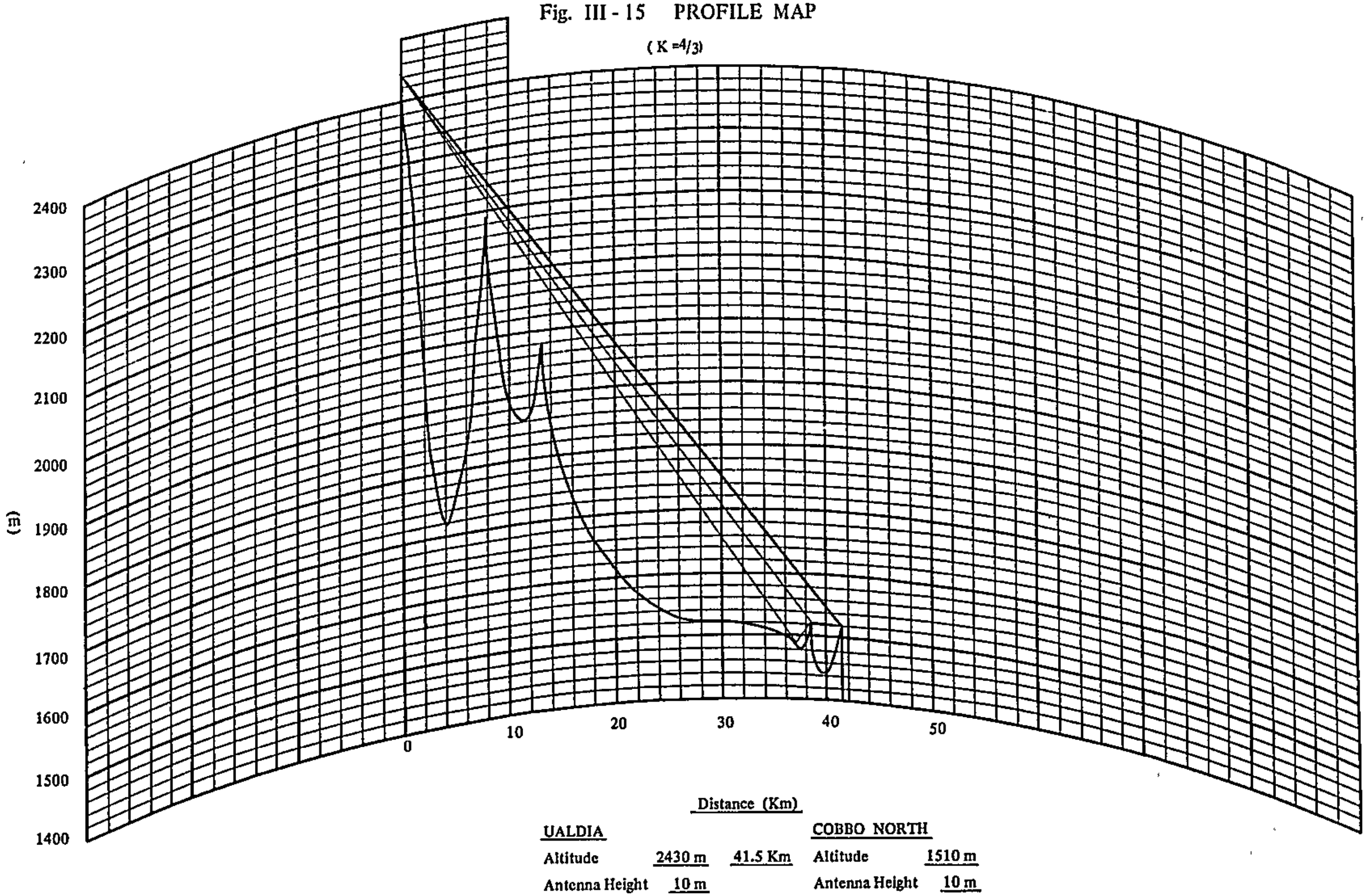


Fig. III - 16 PROFILE MAP

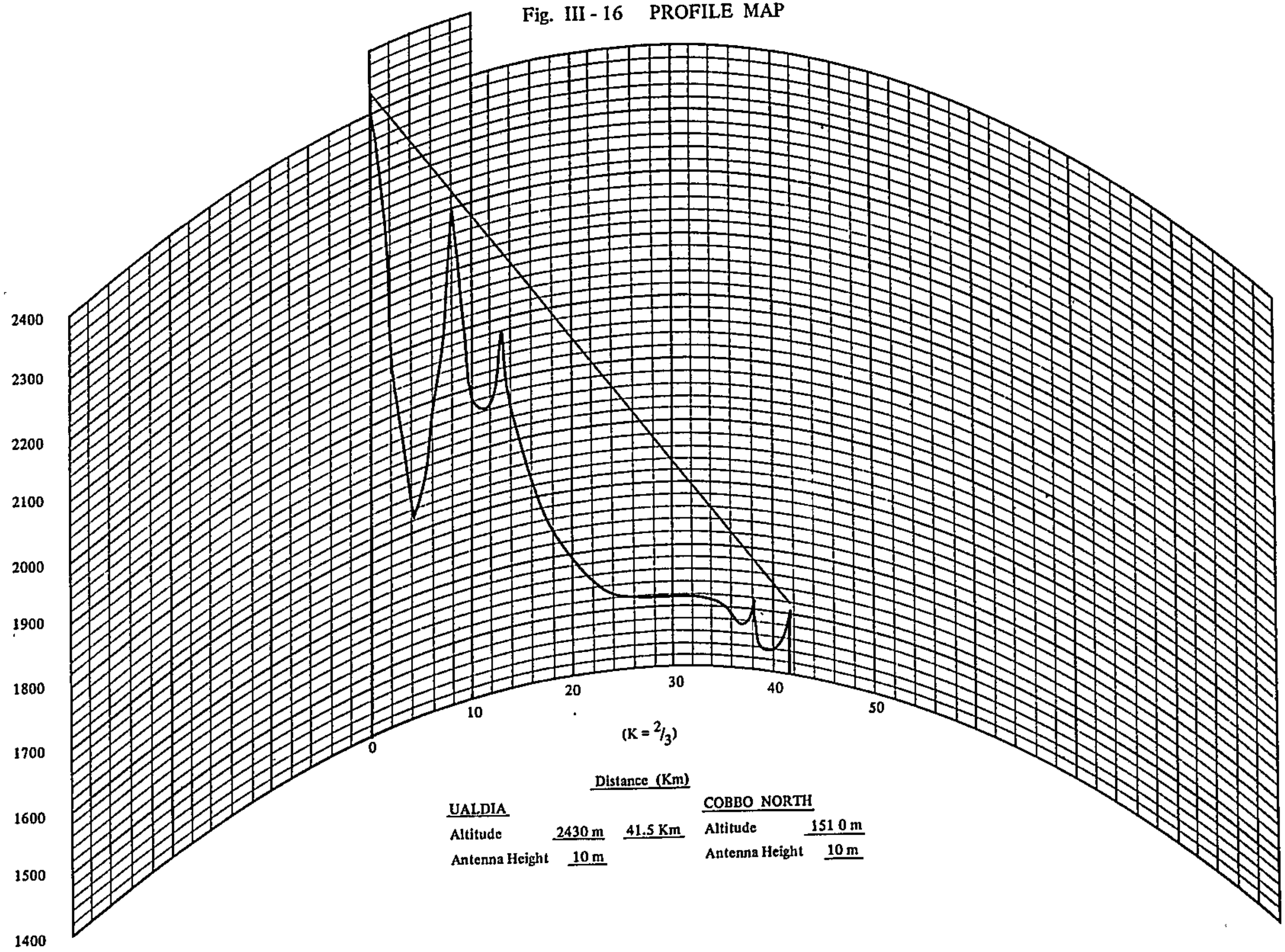


Fig. III - 17 PROFILE MAP

(K = 4/3)

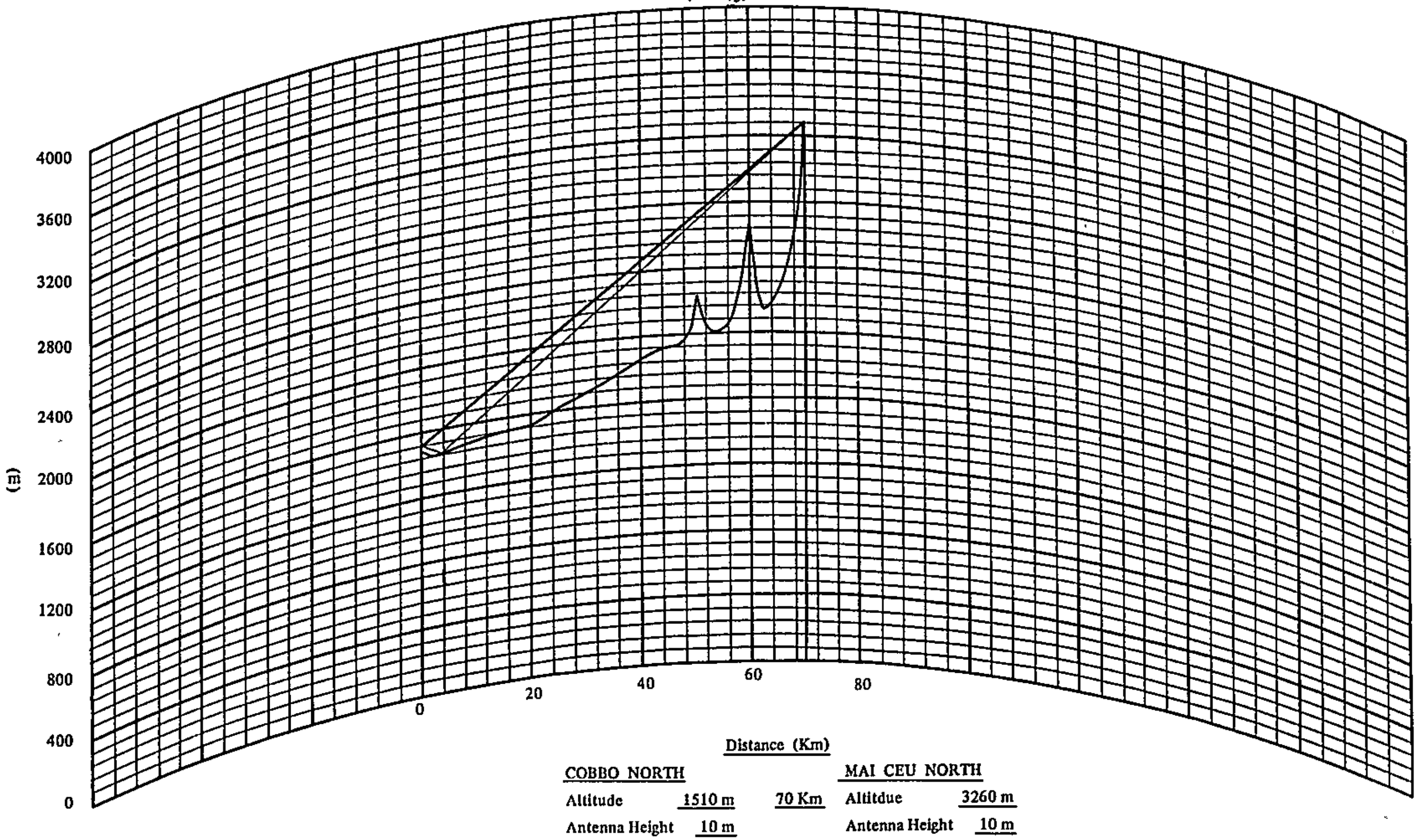


Fig. III - 18 PROFILE MAP

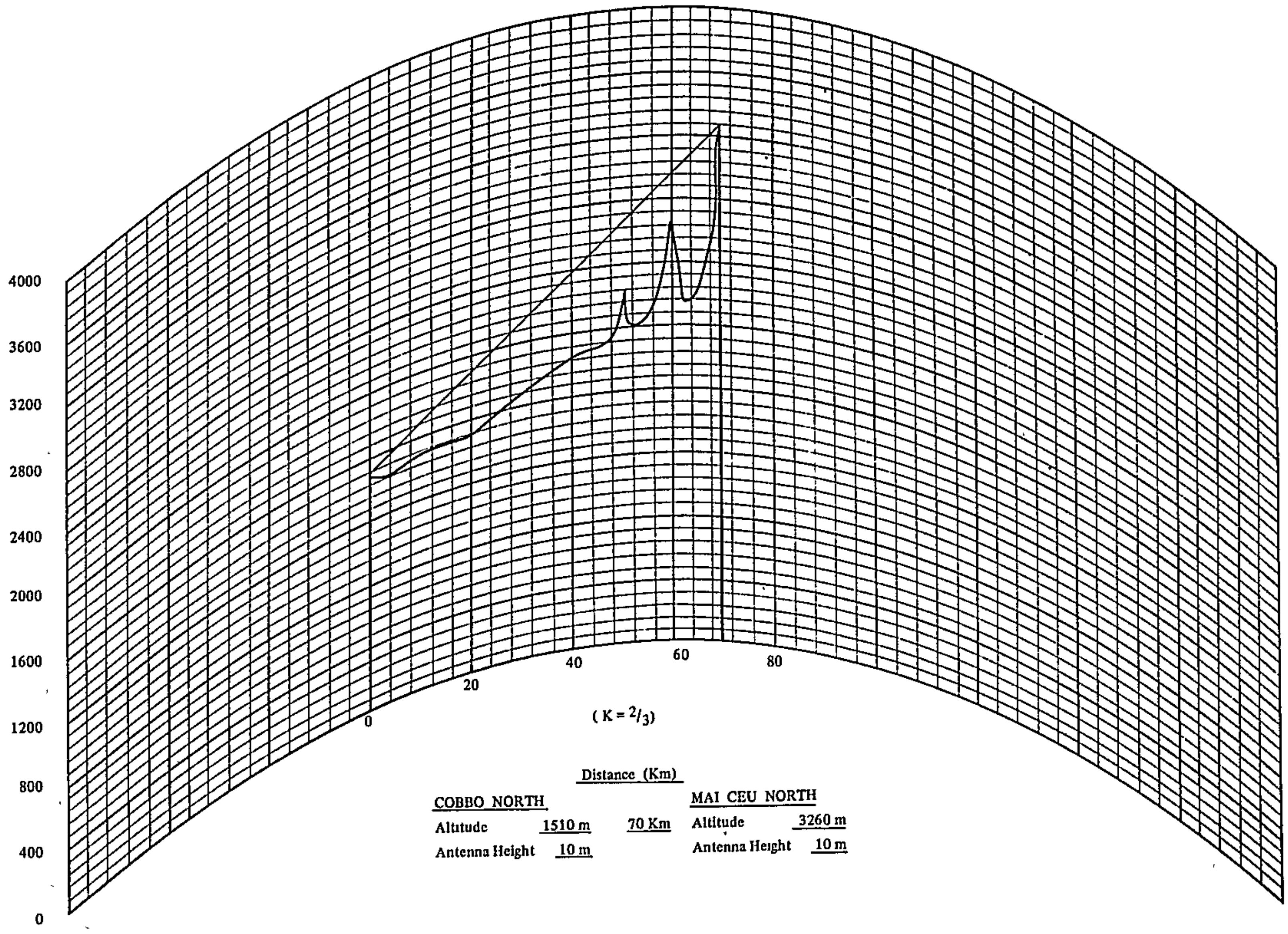


Fig. III - 19 PROFILE MAP

(K = 4/3)

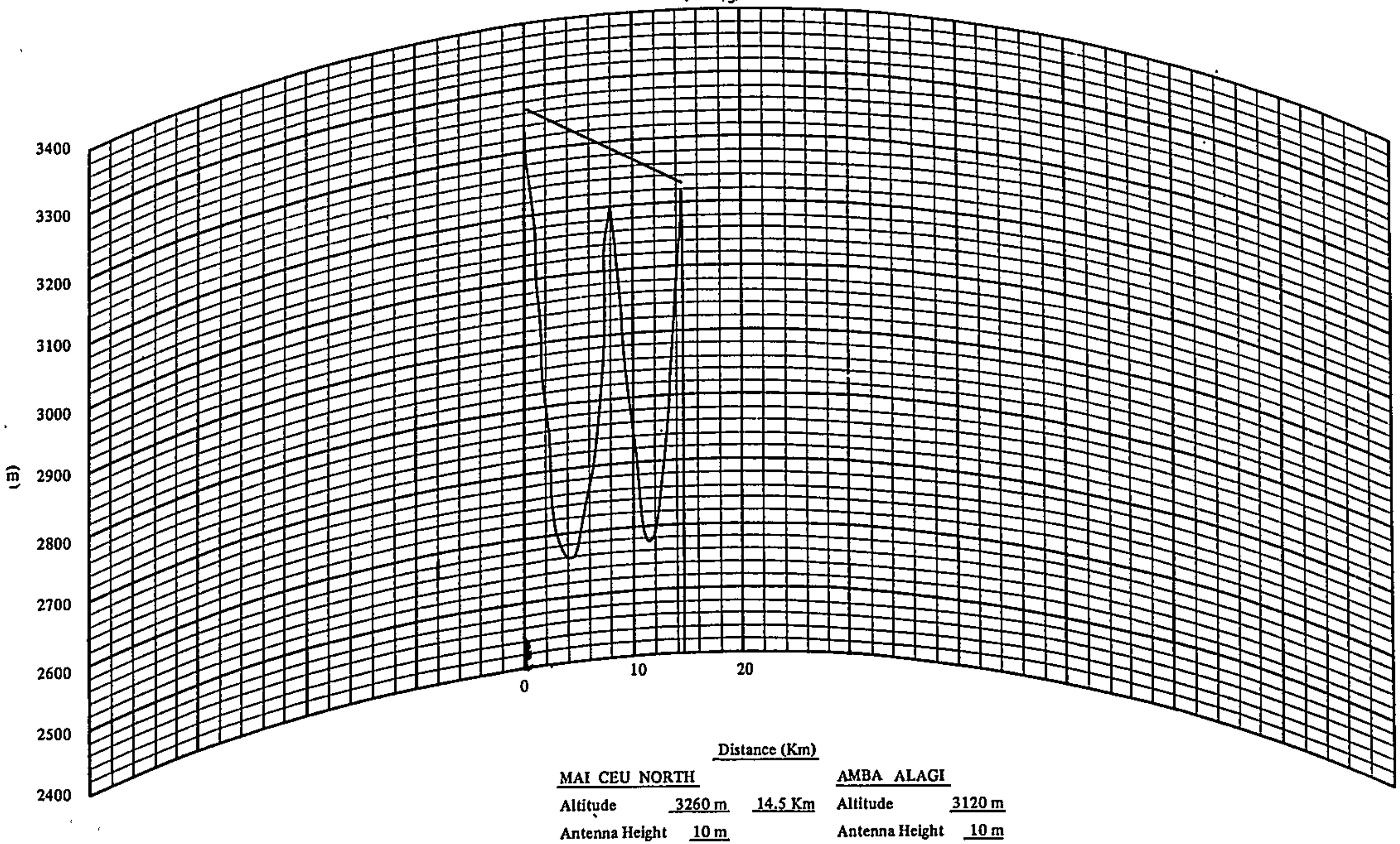


Fig. III - 20 PROFILE MAP

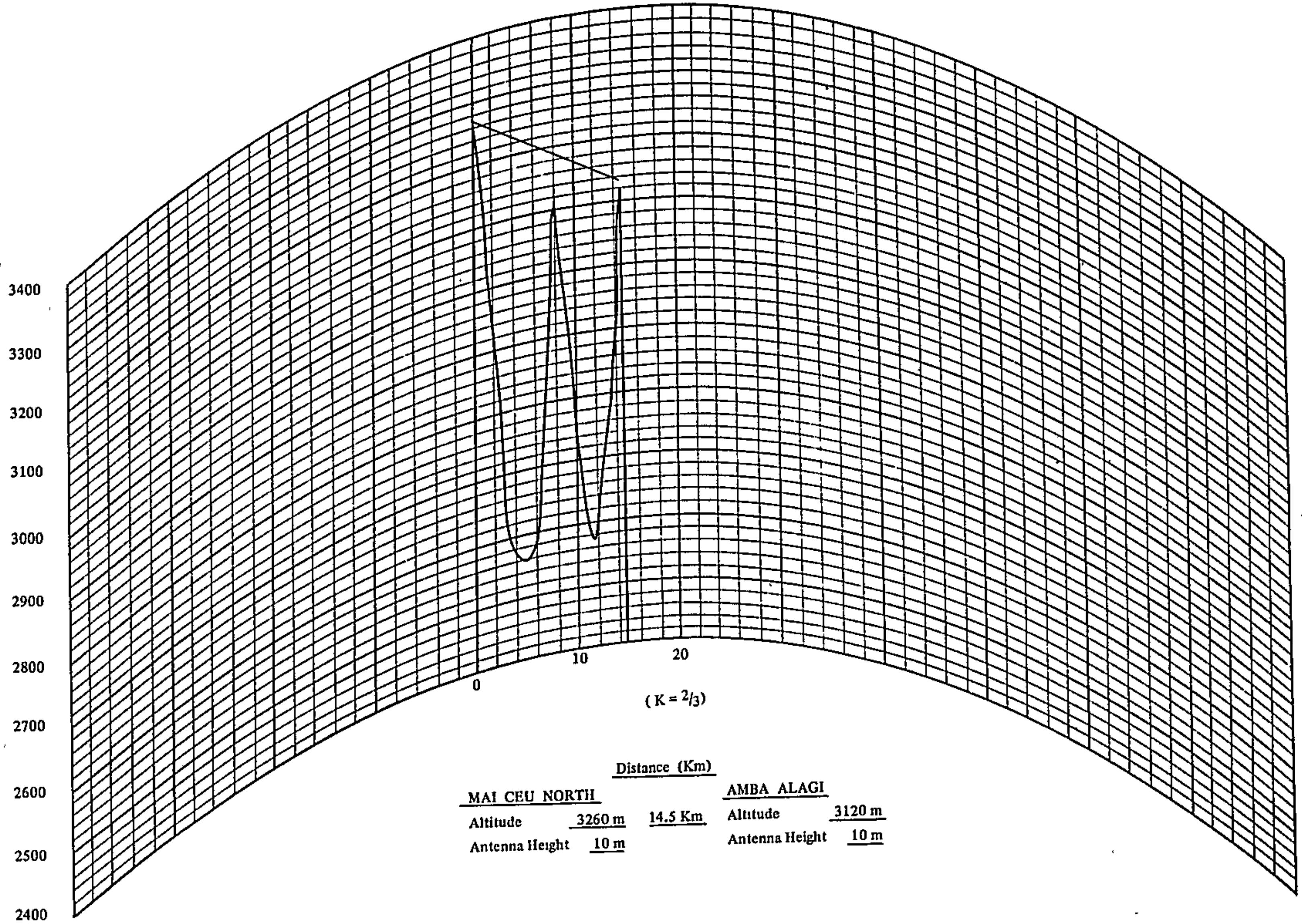
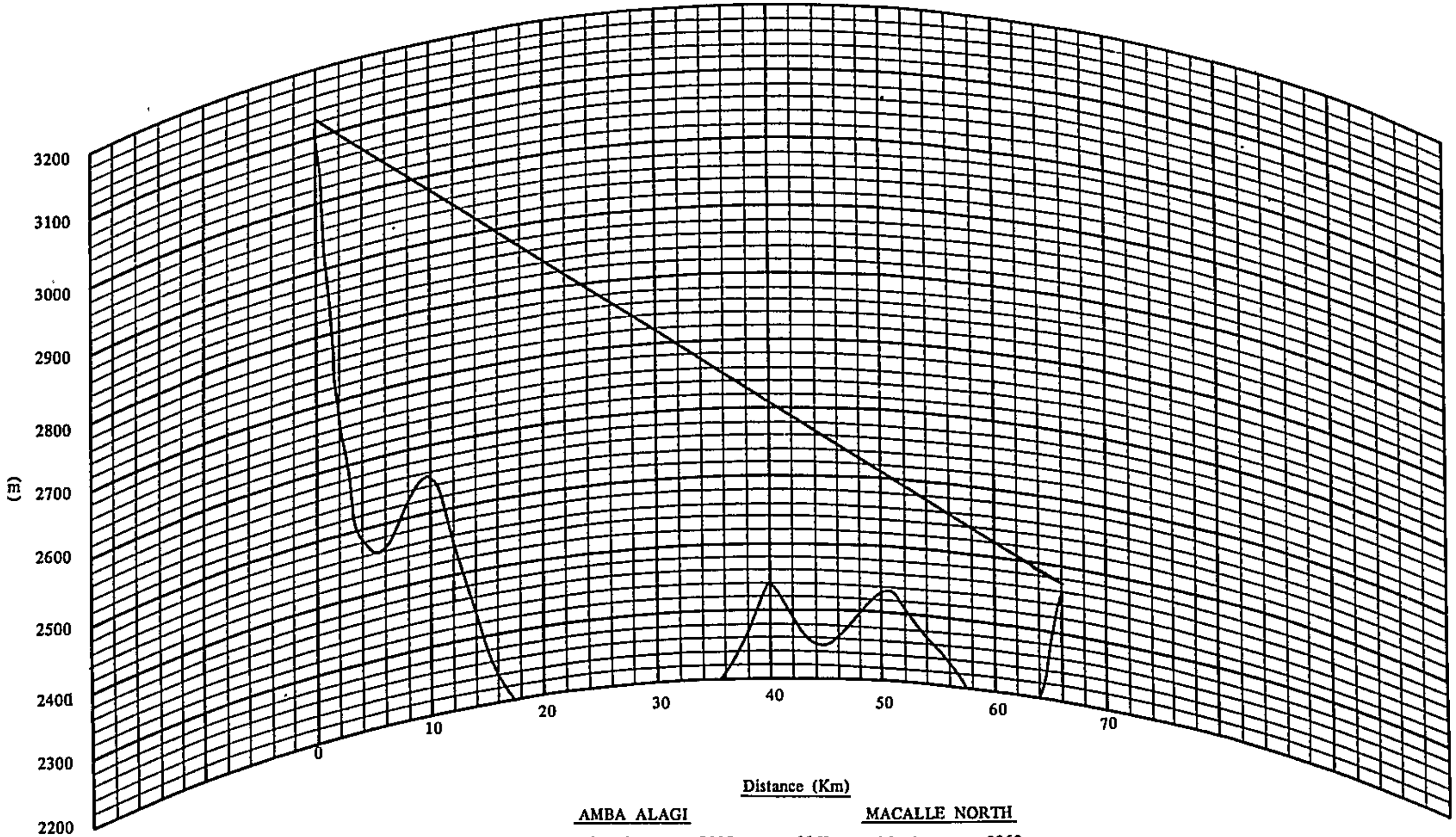


Fig. III - 21 PROFILE MAP

(K = 4/3)



AMBA ALAGI			MACALLE NORTH	
Altitude	3120 m	66 Km	Altitude	2360 m
Antenna Height	10 m		Antenna Height	10 m

Fig. III - 22 PROFILE MAP

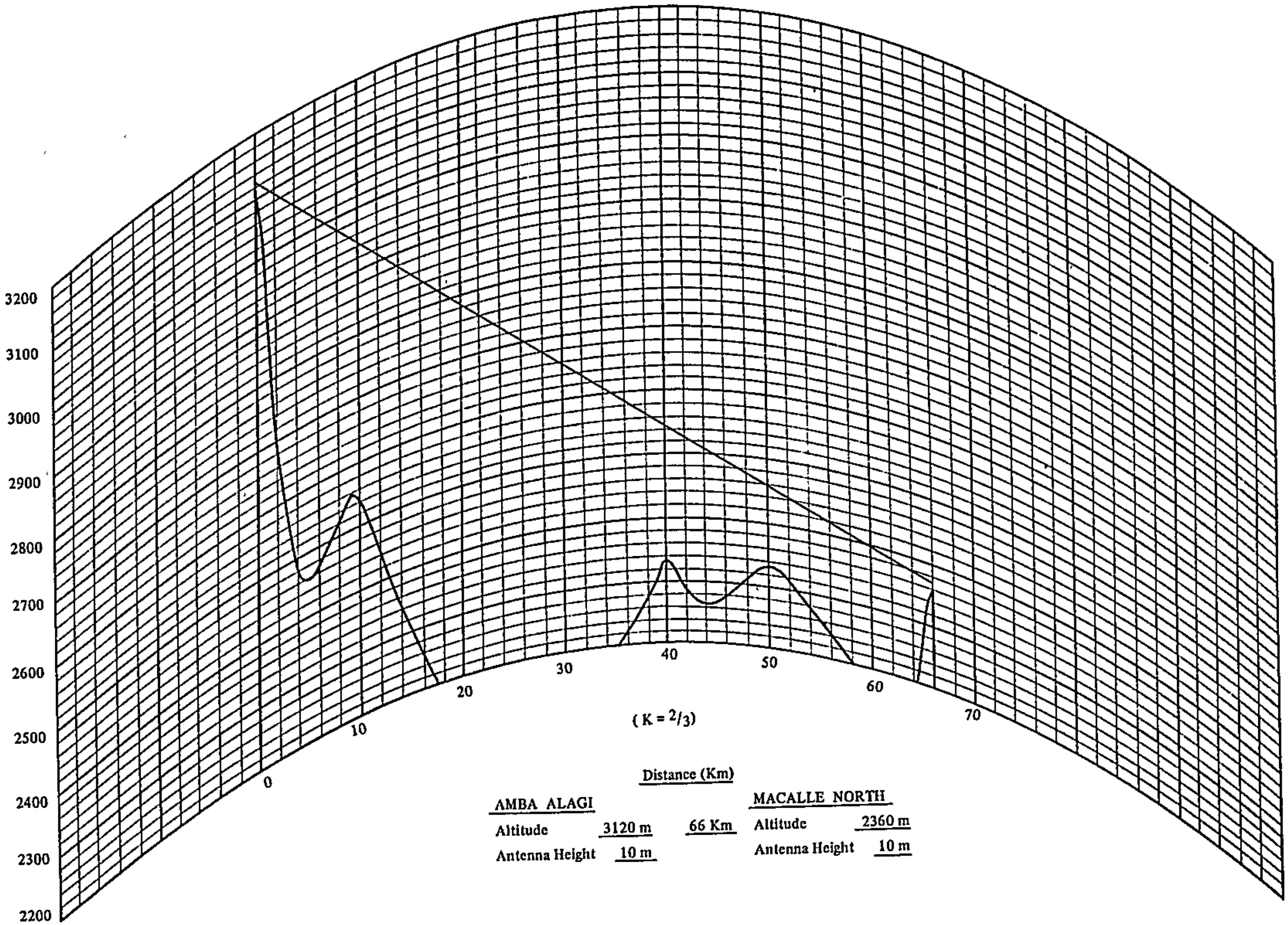
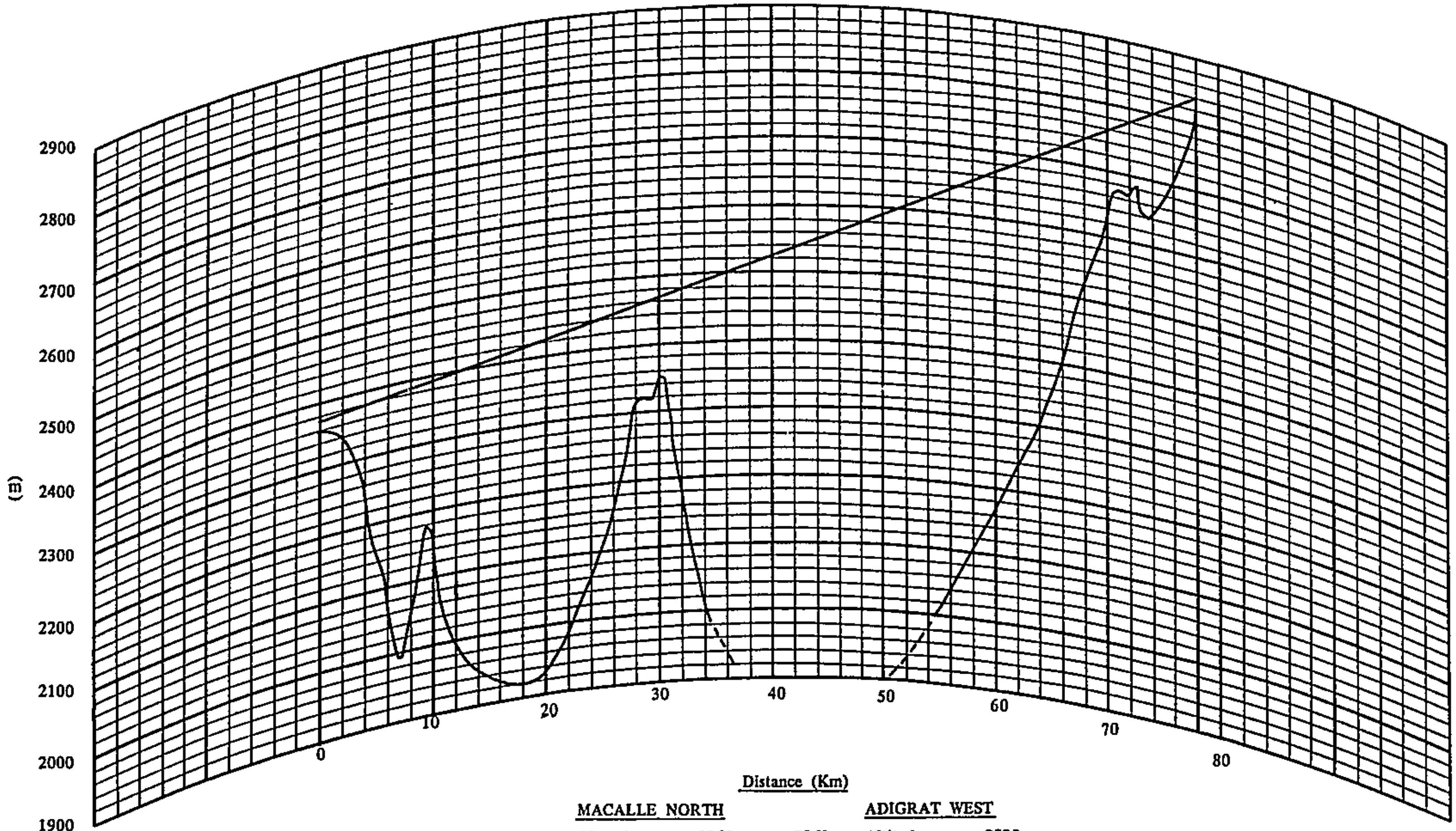


Fig. III - 23 PROFILE MAP
(K = 4/3)



MACALLE NORTH
Altitude 2360 m
Antenna Height 10 m

78 Km

ADIGRAT WEST
Altitude 2830 m
Antenna Height 10 m

Fig. III -24 PROFILE MAP

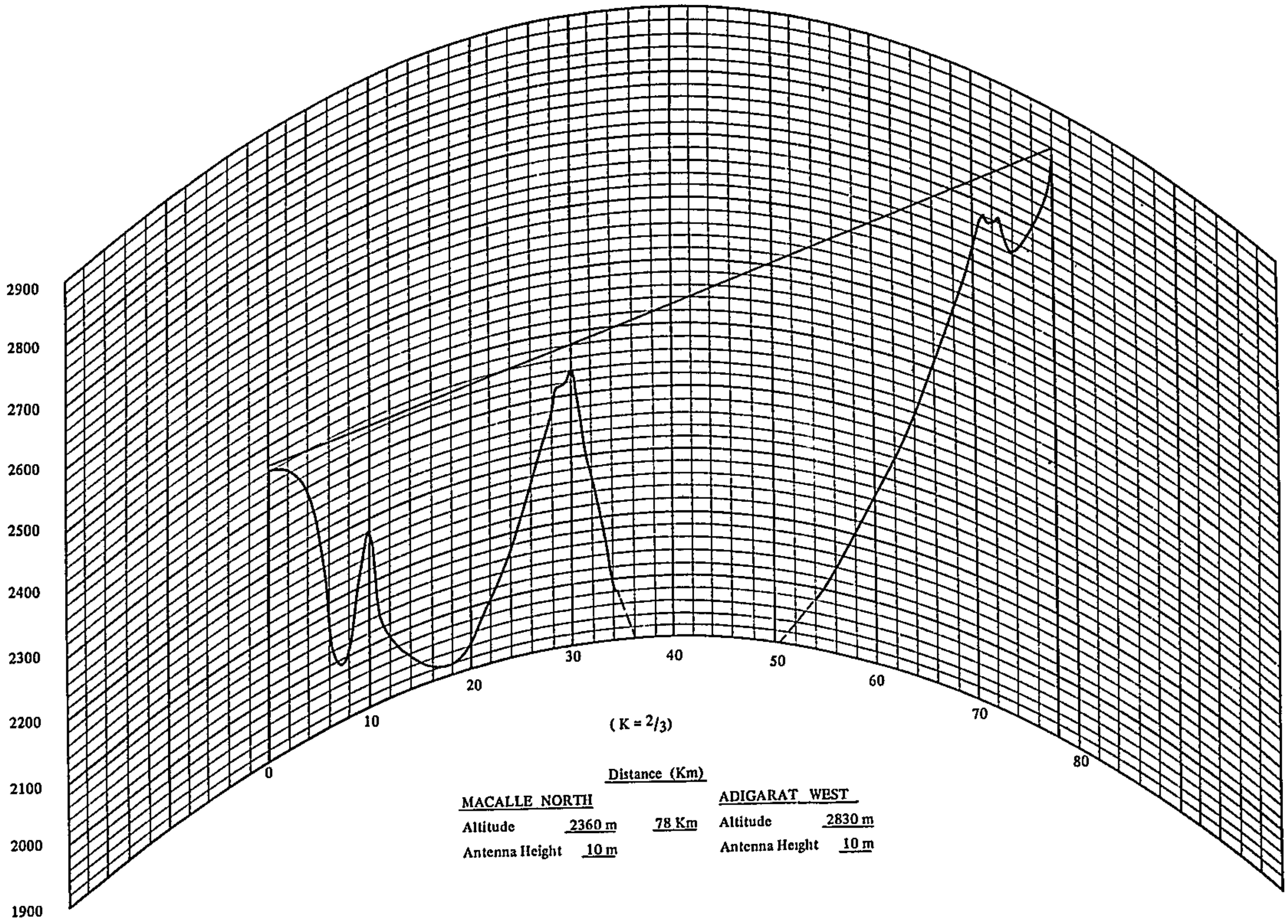


Fig. III - 25 PROFILE MAP

(K = 4/3)

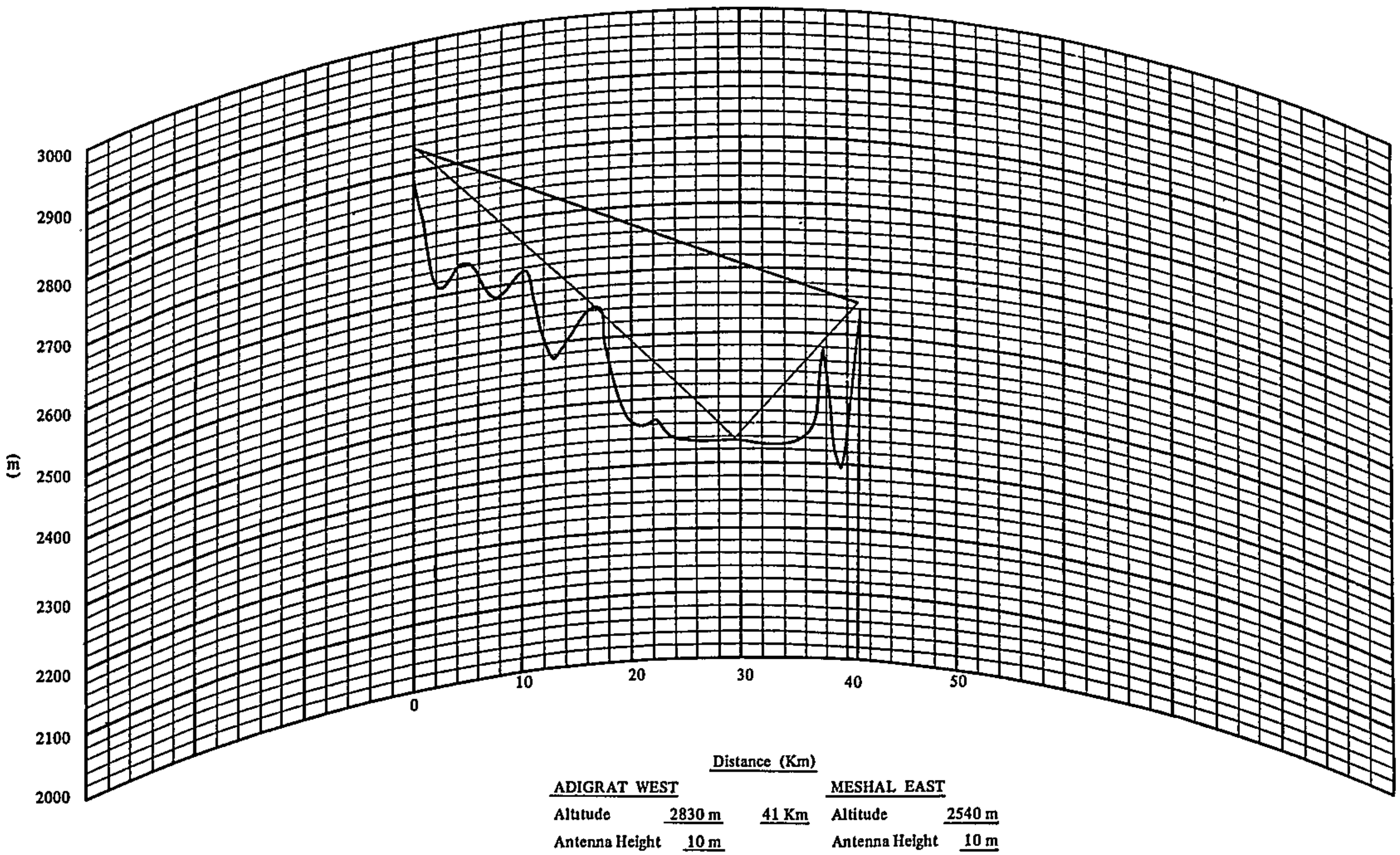


Fig. III –26 PROFILE MAP

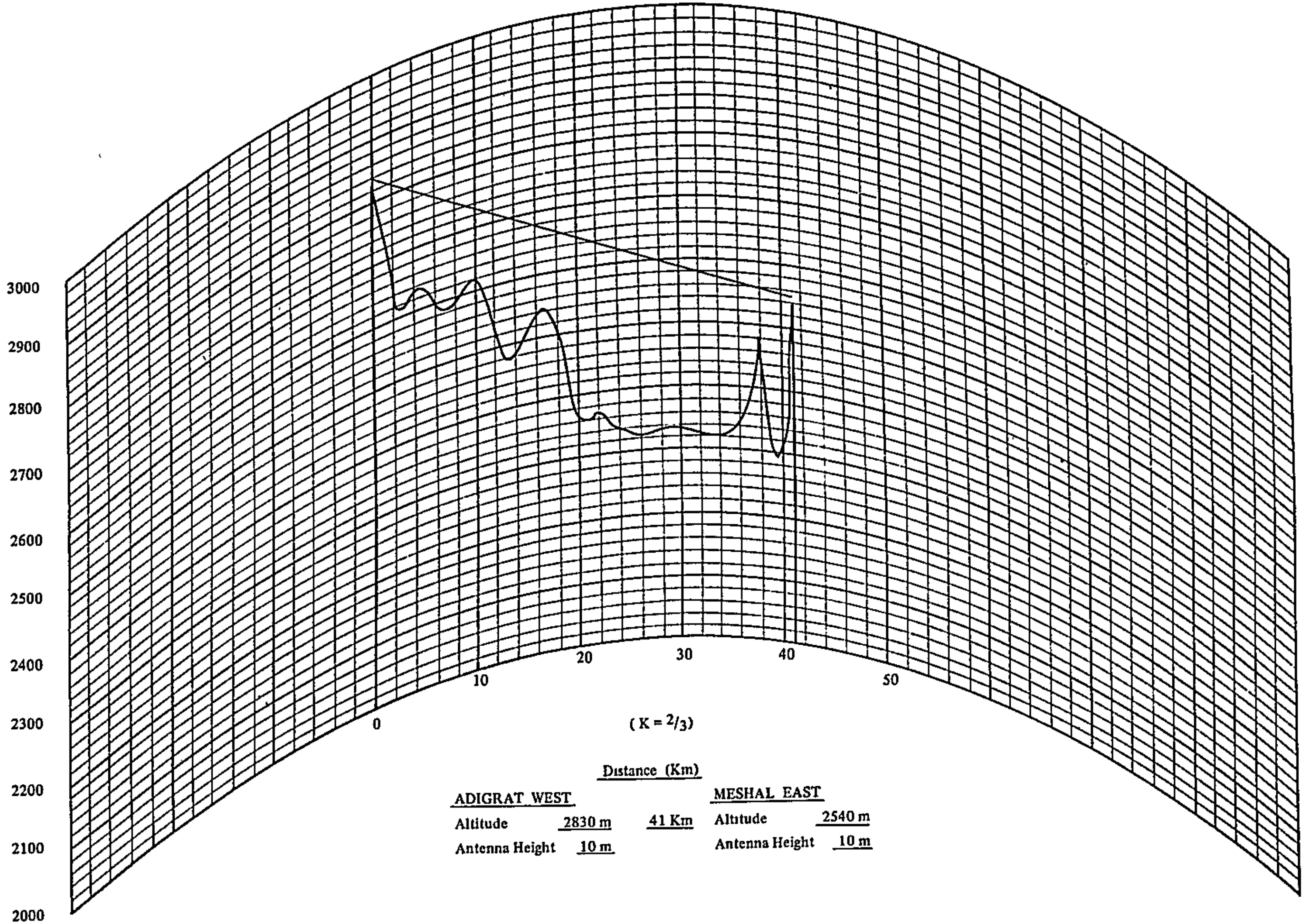


Fig. III - 27 PROFILE MAP

(K = 4/3)

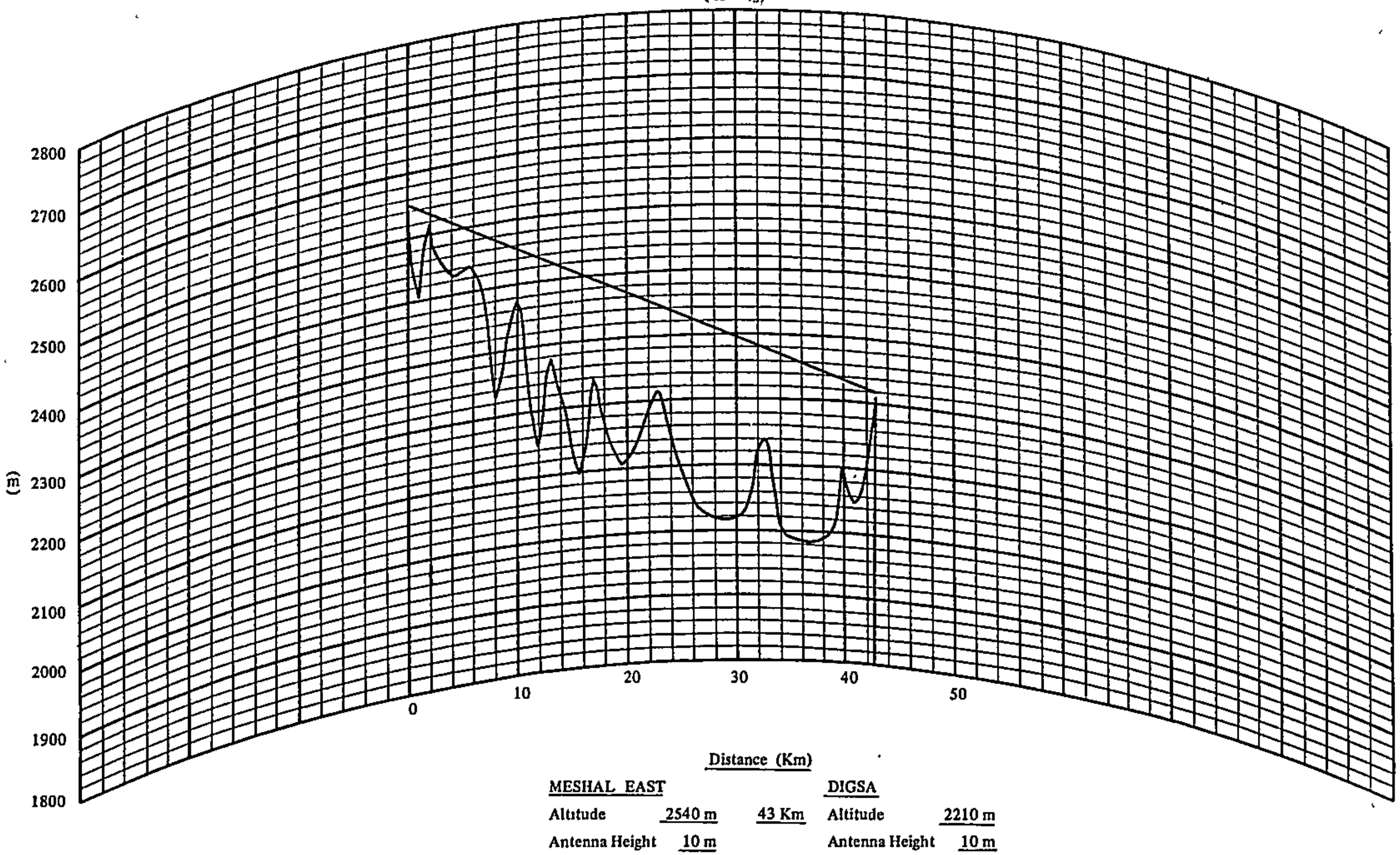


Fig. III – 28 PROFILE MAP

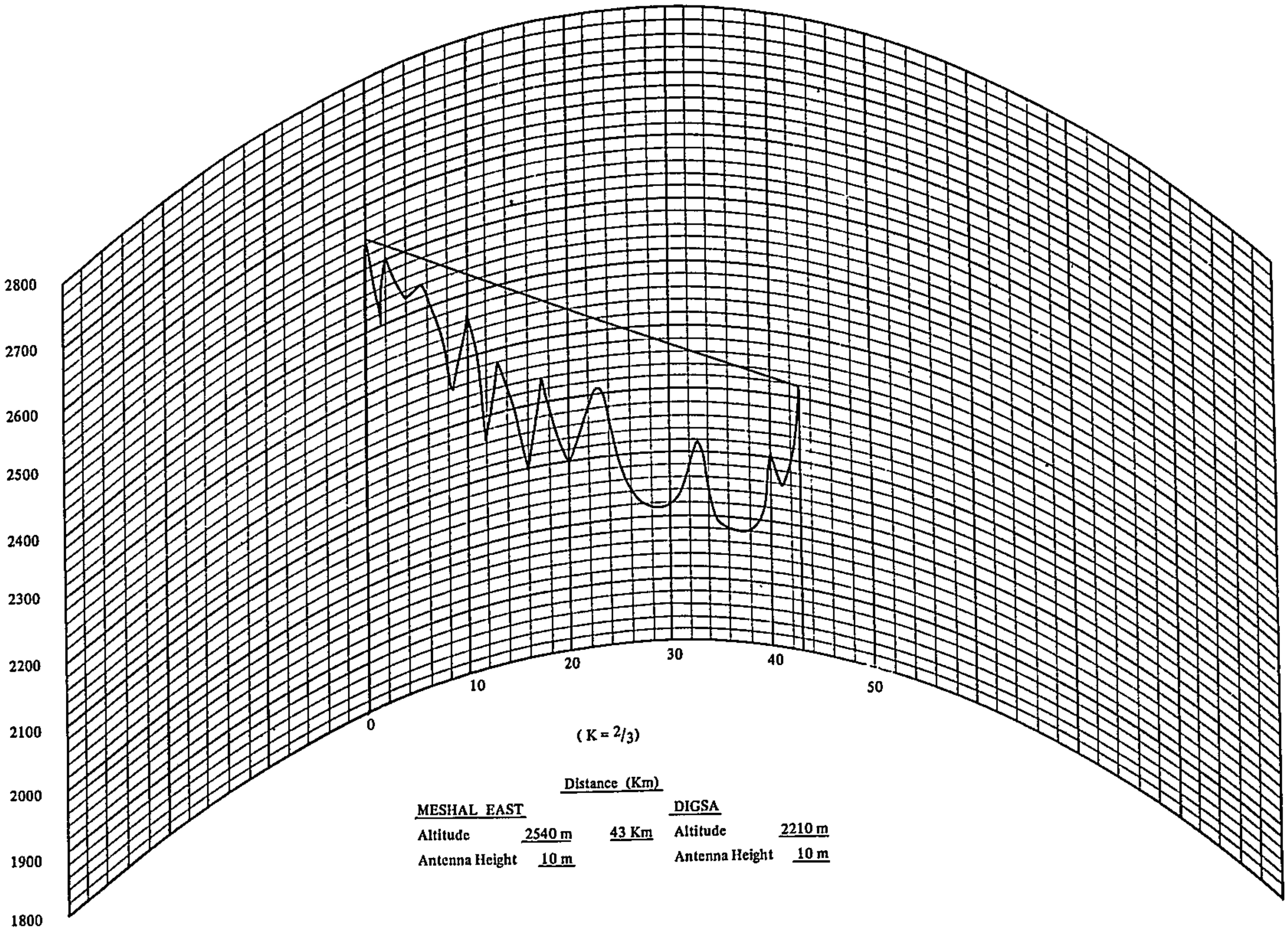


Fig. III - 29 PROFILE MAP

(K = 4/3)

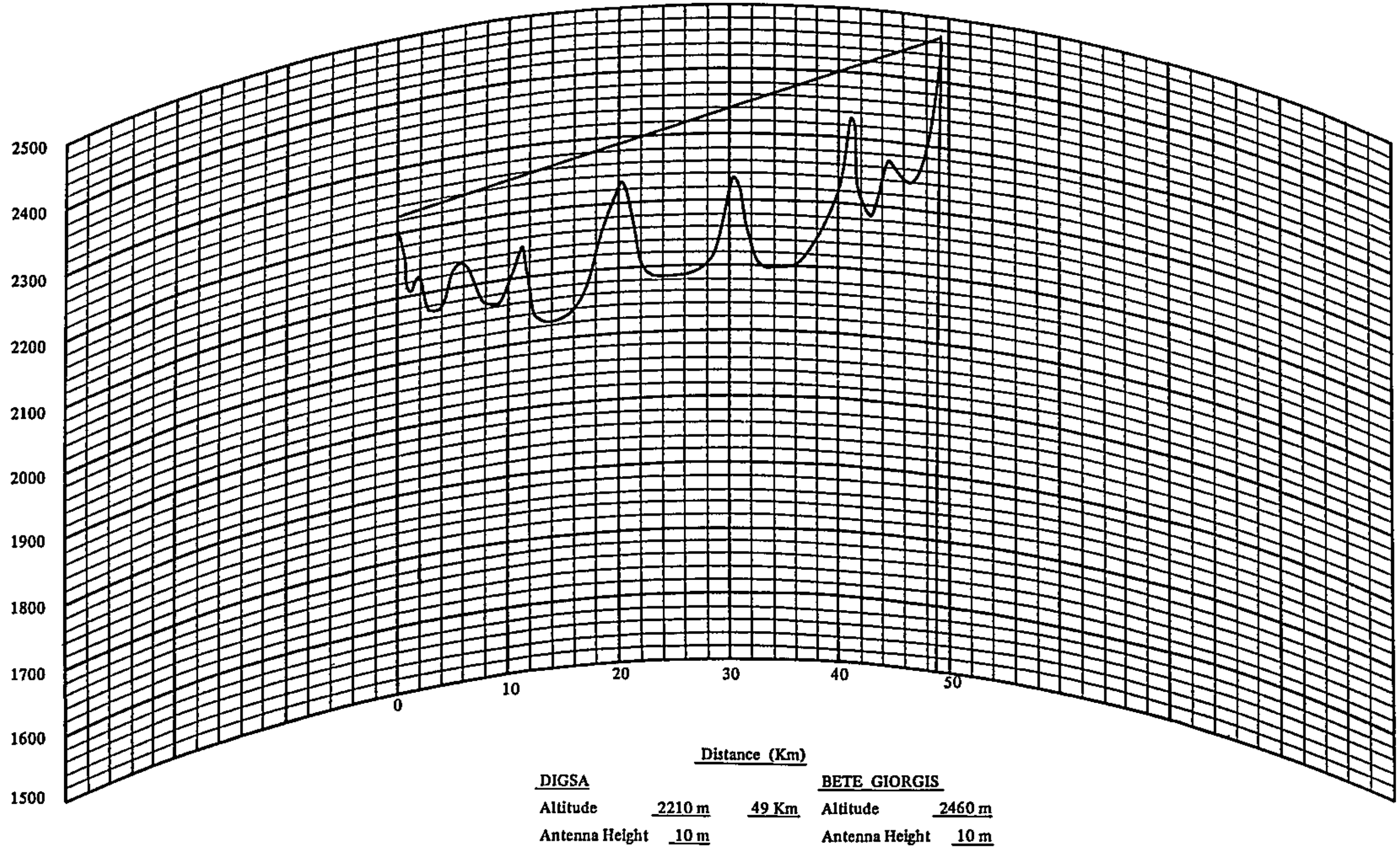


Fig. III - 30 PROFILE MAP

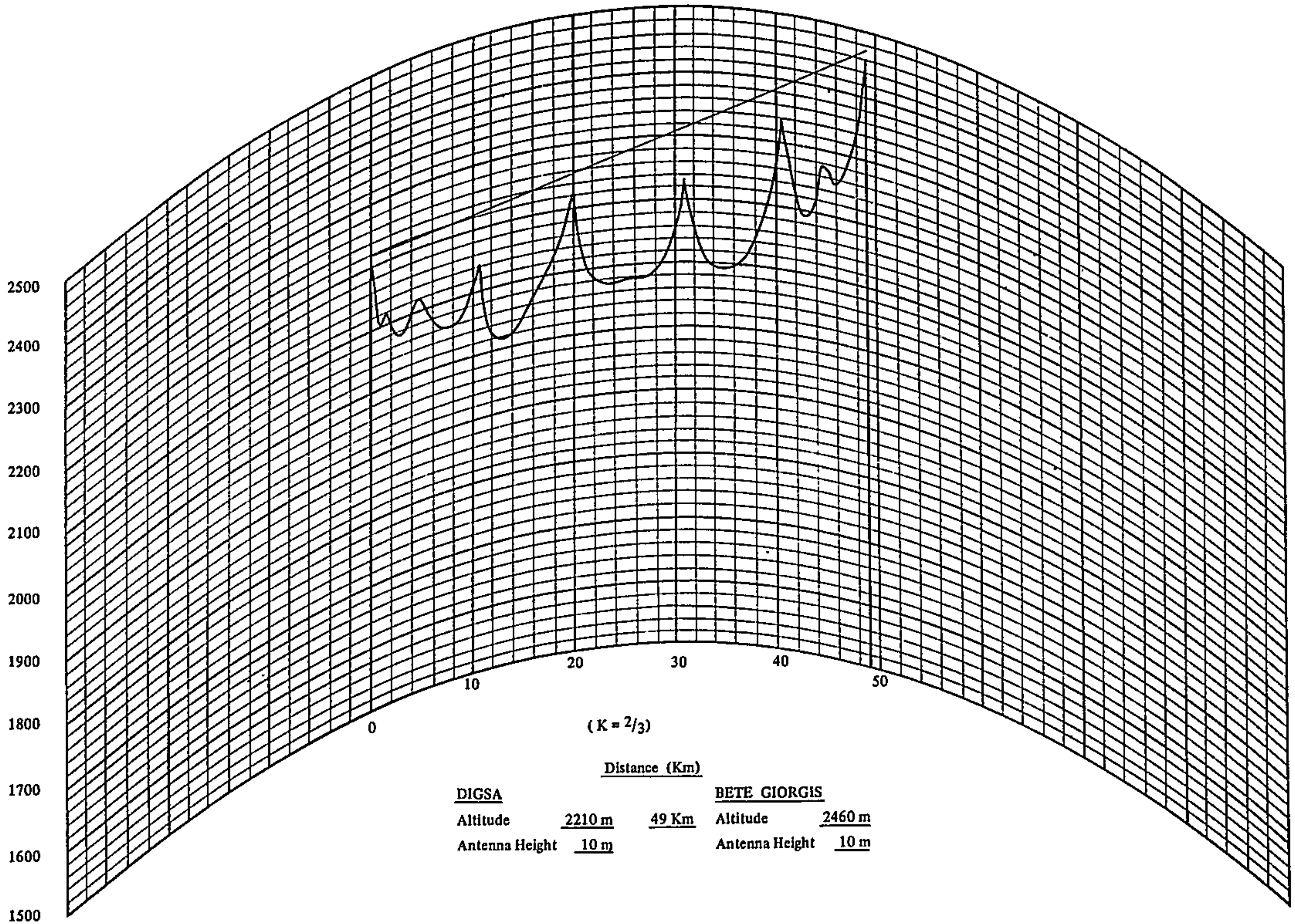
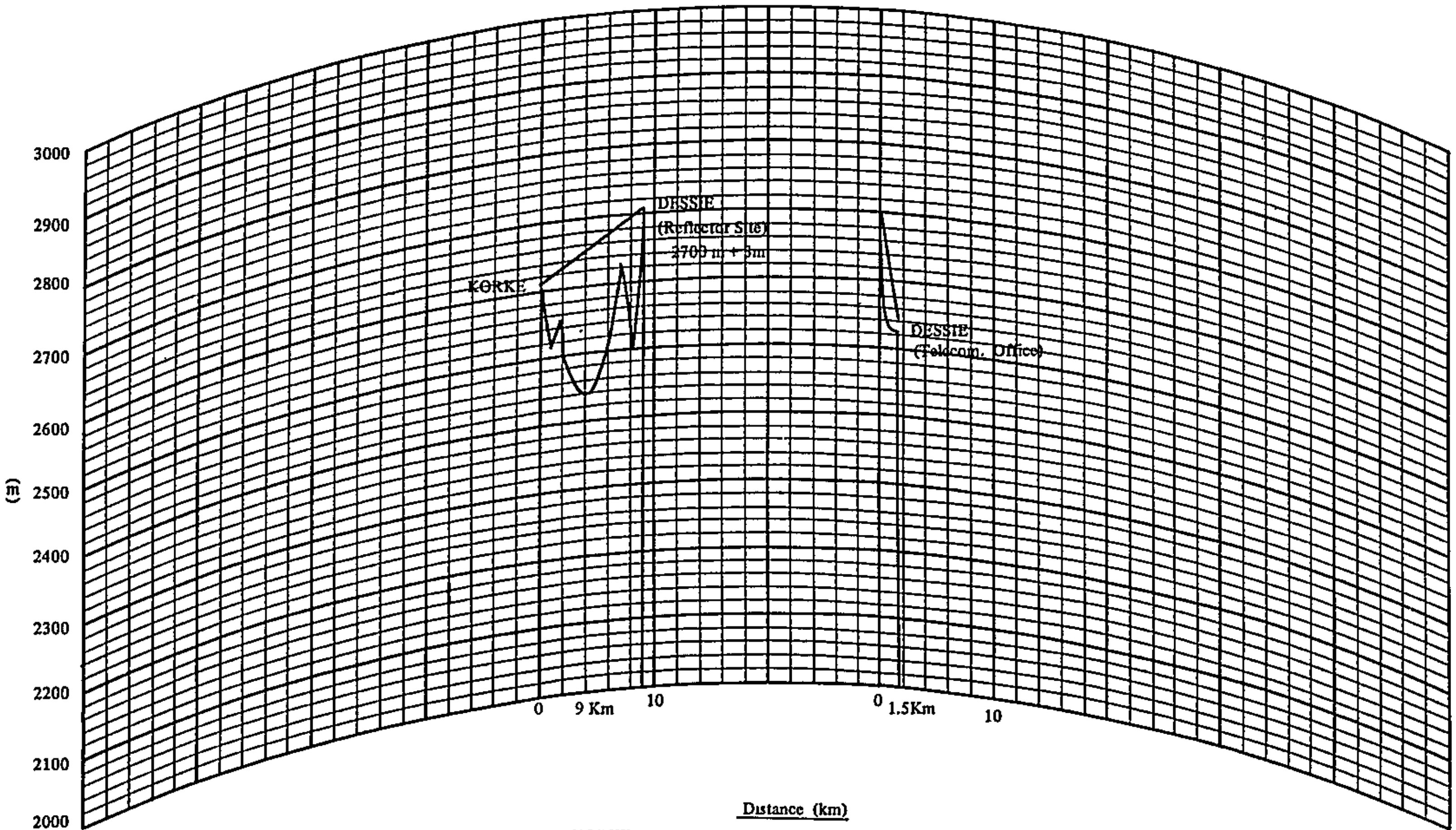


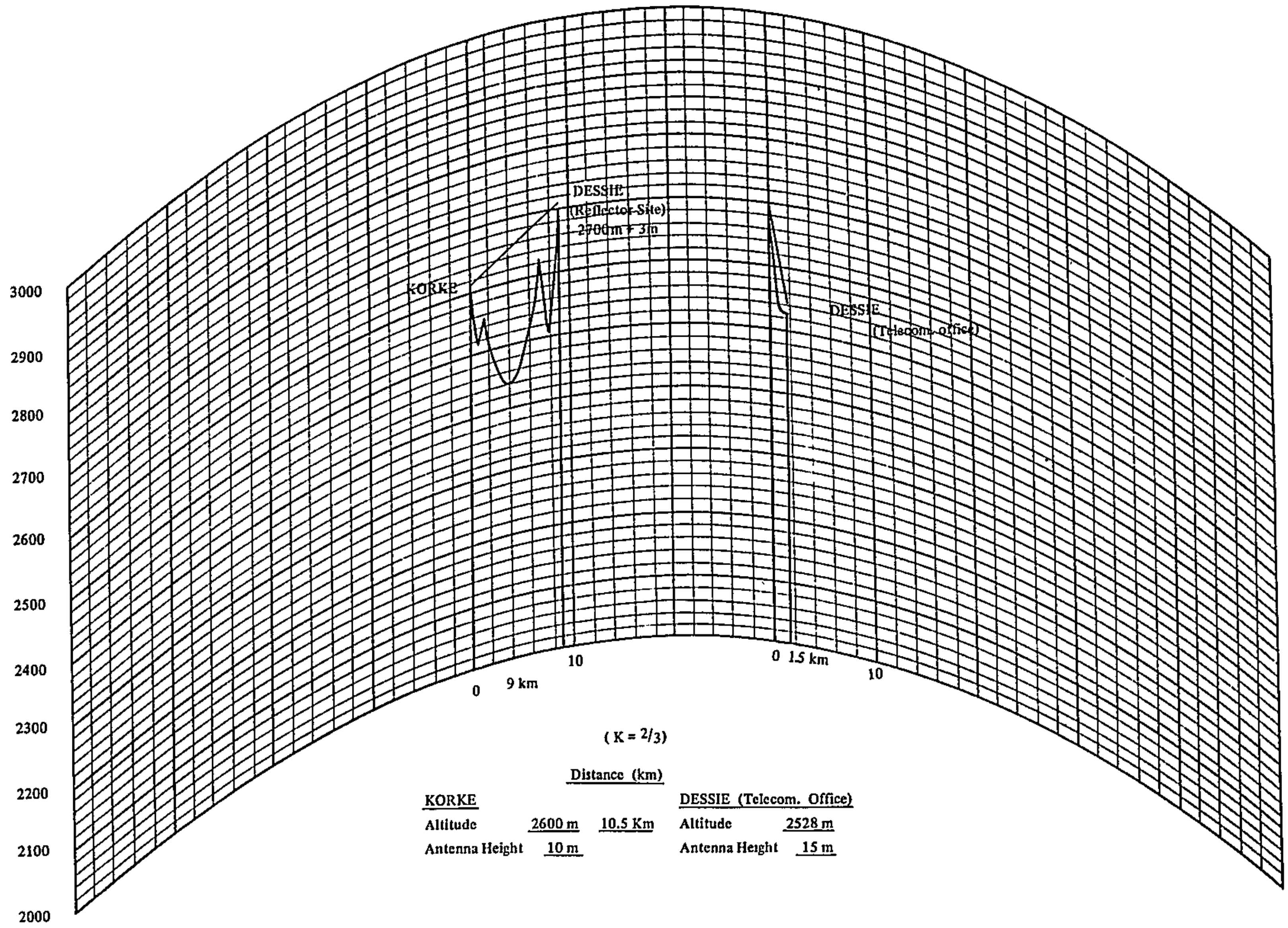
Fig. III - 31 PROFILE MAP
(K = 4/3)

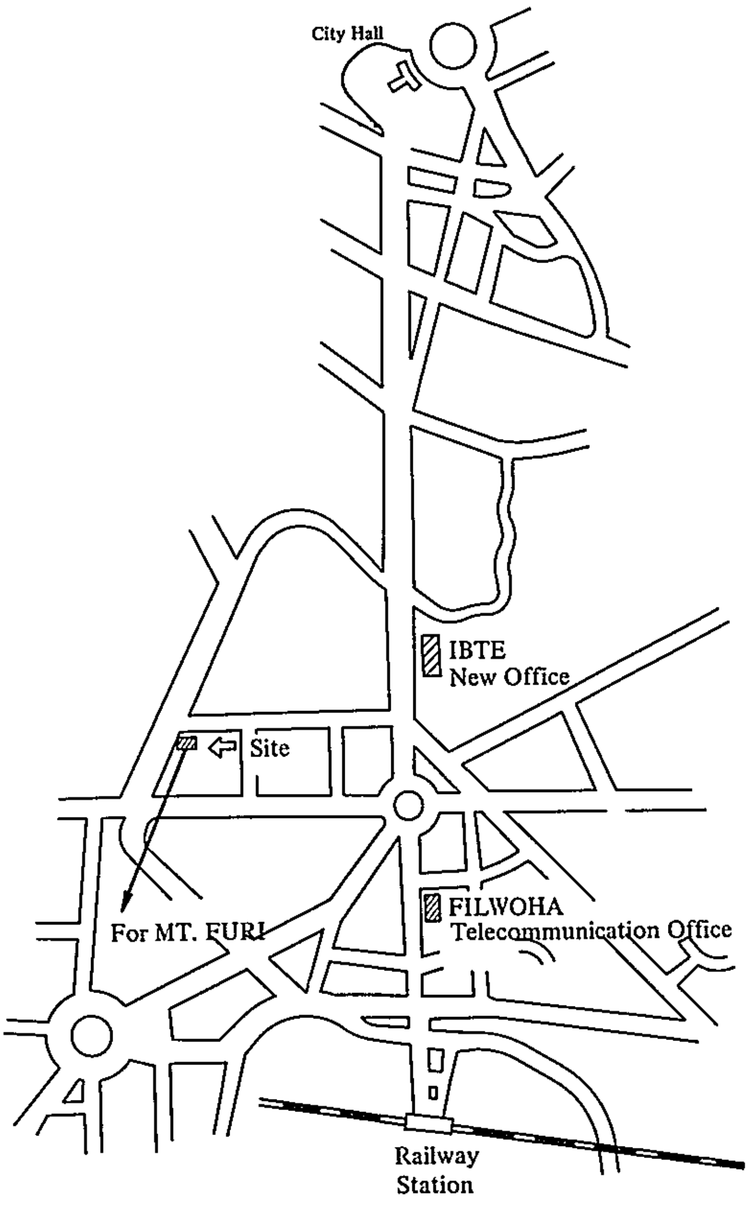


Distance (km)

KORKE			DESSIE (Telecom. Office)	
Altitude	2600 m	10.5 Km	Altitude	2528 m
Antenna Height	10 m		Antenna Height	15 m

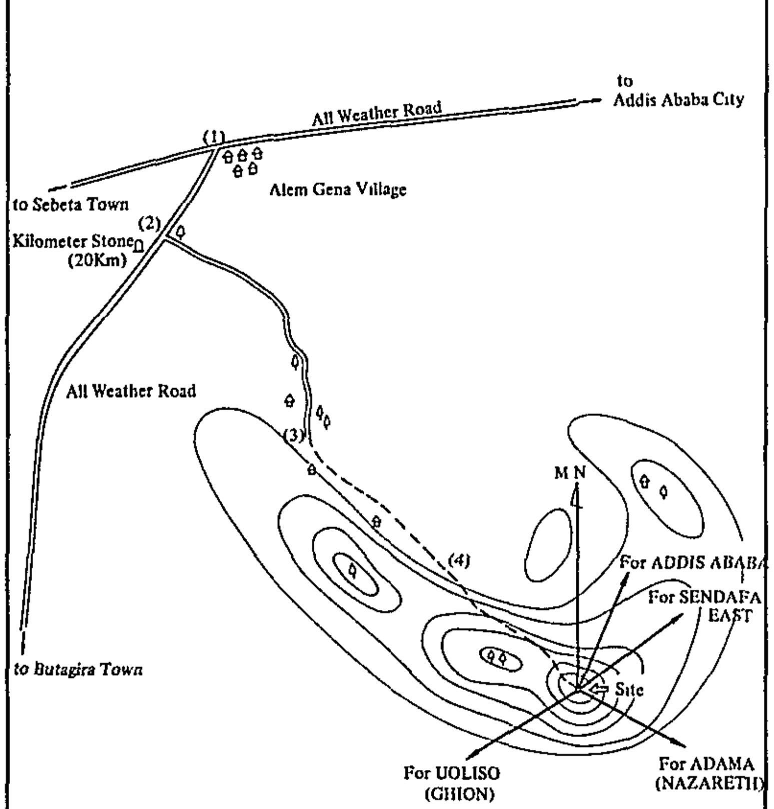
Fig. III - 32 PROFILE MAP



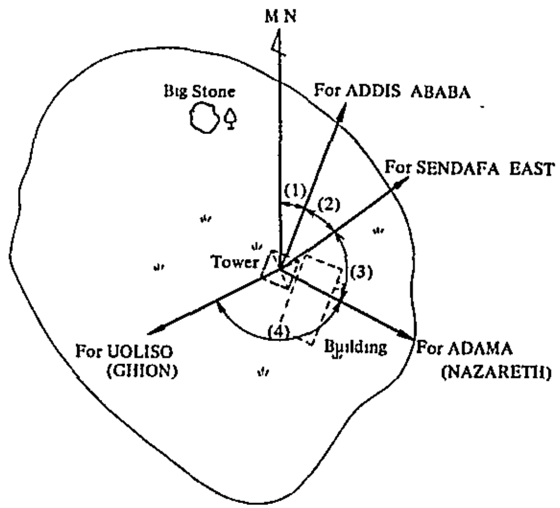


Guide Map of the Site	ADDIS ABABA ("IBTE" HEAD QUARTER)
	Fig. III - 33

(1) – *Addis Ababa City*, *about 20 Km*, *All Weather Road.*
(1) – (2) : about 0 8 Km. All Weather Road.
(2) – (3) : about 3 Km Open to jeep
(3) – (4) : about 1 Km flat grossland.
(4) – *Site* : *about 2.5 Km* about 1 hr. on foot



Guide Map of the Site	MT. FURI
	Fig. III - 34



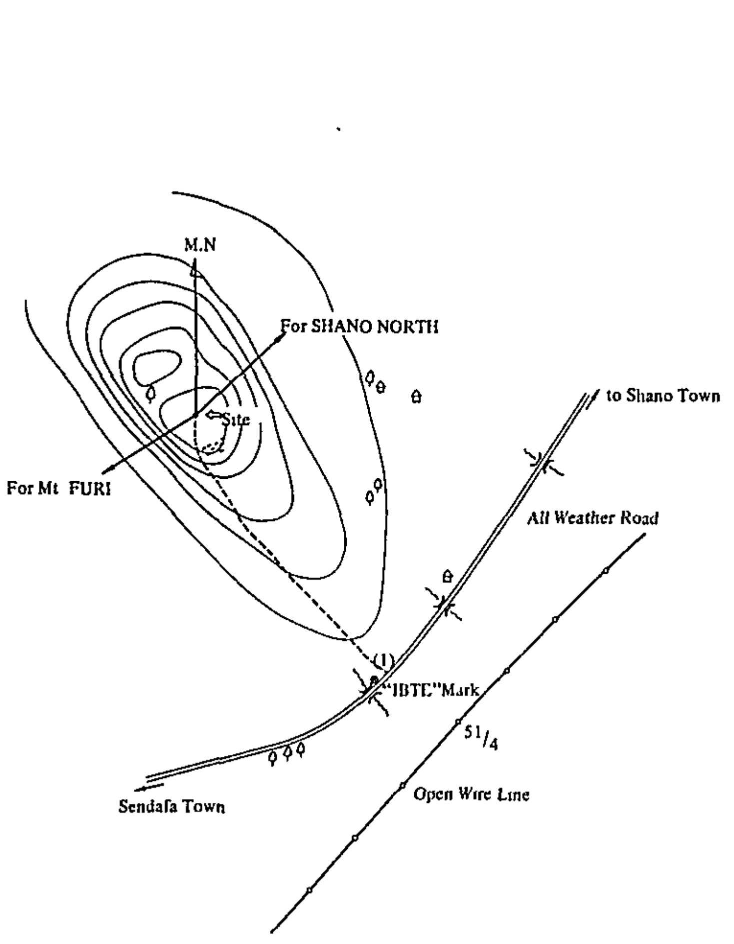
(1) *about 21°16'*
(2) 31°41'12"
(3) about 65°
(4) about 125°

Topographic Sketch of the Site and Neighbourhood	Mt FURI
	Fig. III - 35

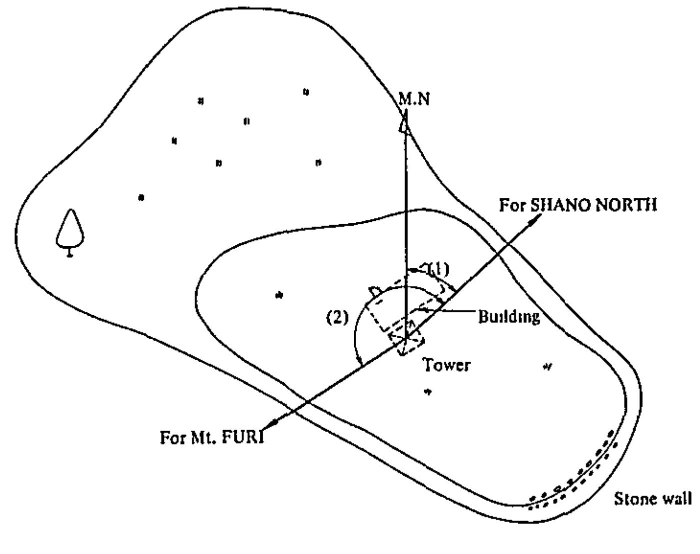
(1)- Addis Ababa City : about 53Km All Weather Road

(1)- Sendafa Town : about 15Km All Weather Road.

(1)- Site : about 1.5Km, about 30 min of foot.



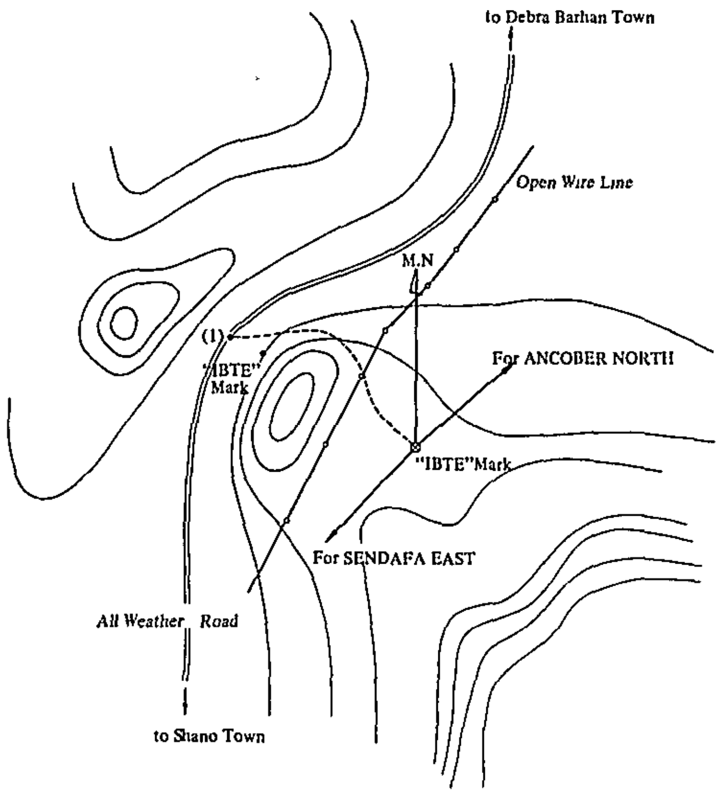
Guide Map of the Site	SENDAFA EAST	
	Fig. III-36	



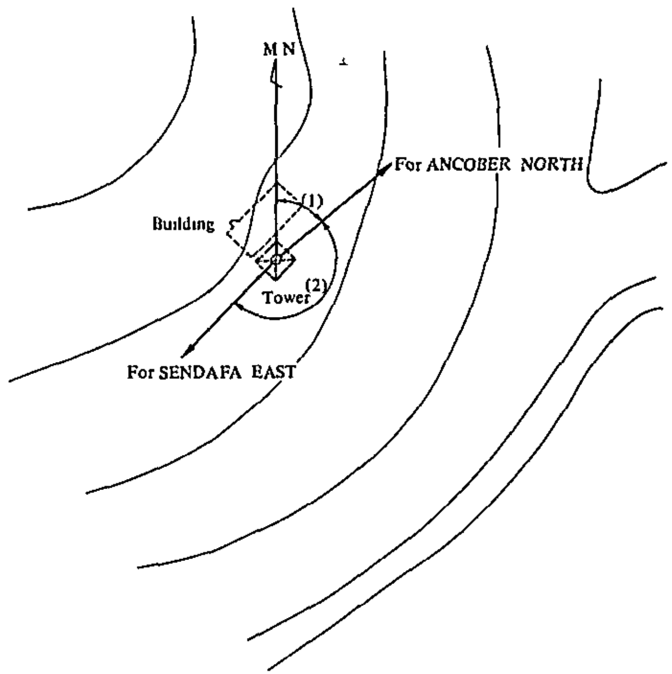
(1) . about 47°48'
(2) . 189°18'

Topographic Sketch of the Site and Neighbourhood	SENDAFA EAST	
	Fig III - 37	

(1) – Shano Town : about 5 Km. *All Weather Road.*
(1) – Debra Barhan Town : about 47 Km. All Weather Road
(1) – Site : about 0.1 Km. open to jeep

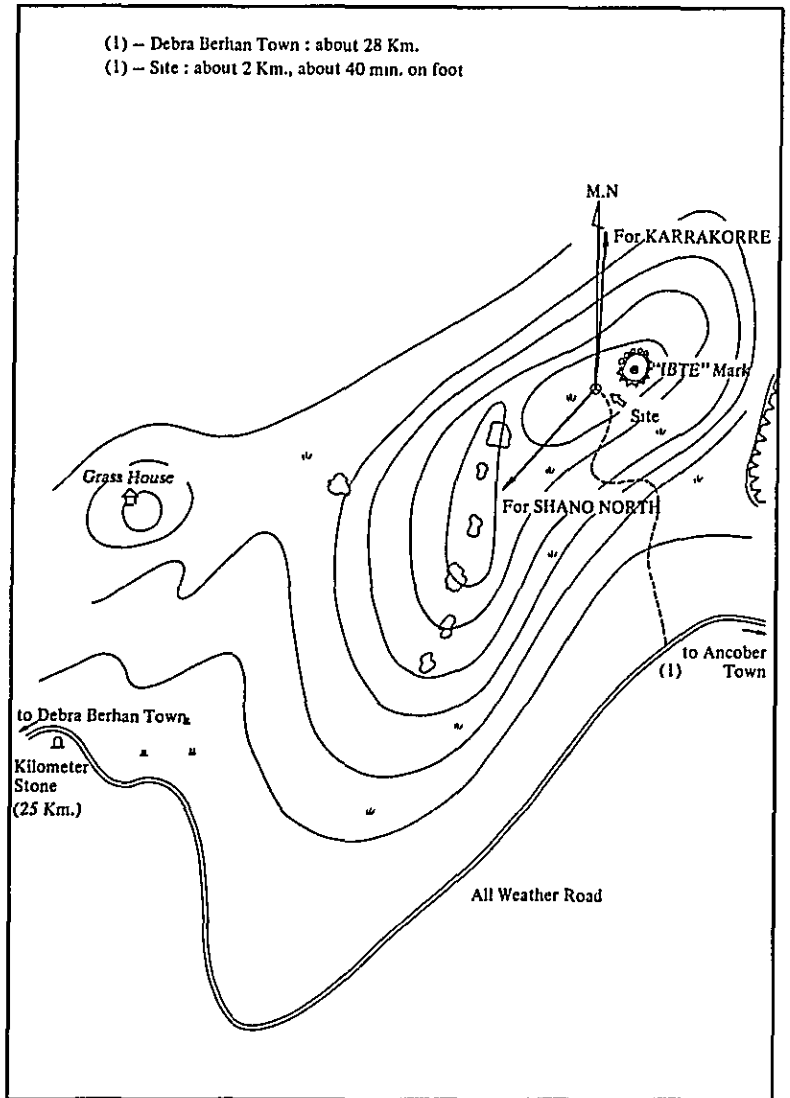


Guide Map of the Site	SHANO NORTH
	Fig. III - 38

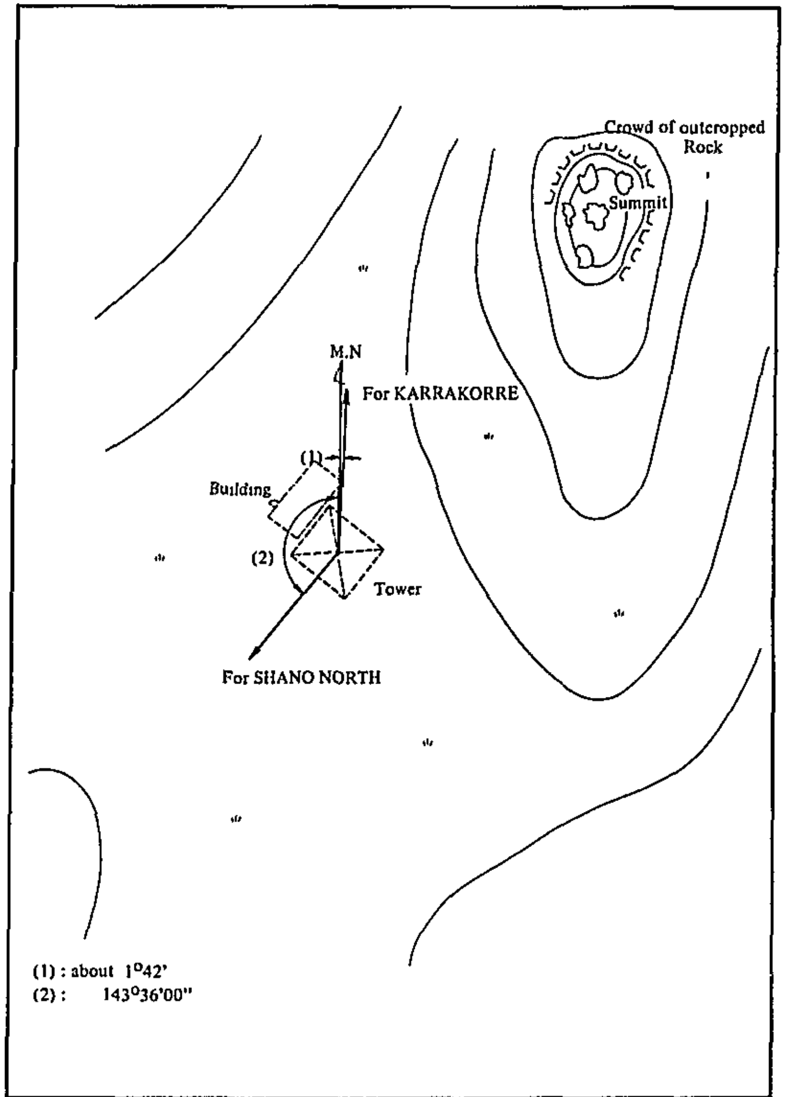


(1) : about 49°57'
(2) 175°06'03"

Topographic Sketch of the Site and Neighbourhood	SHANO NORTH
	Fig. III - 39

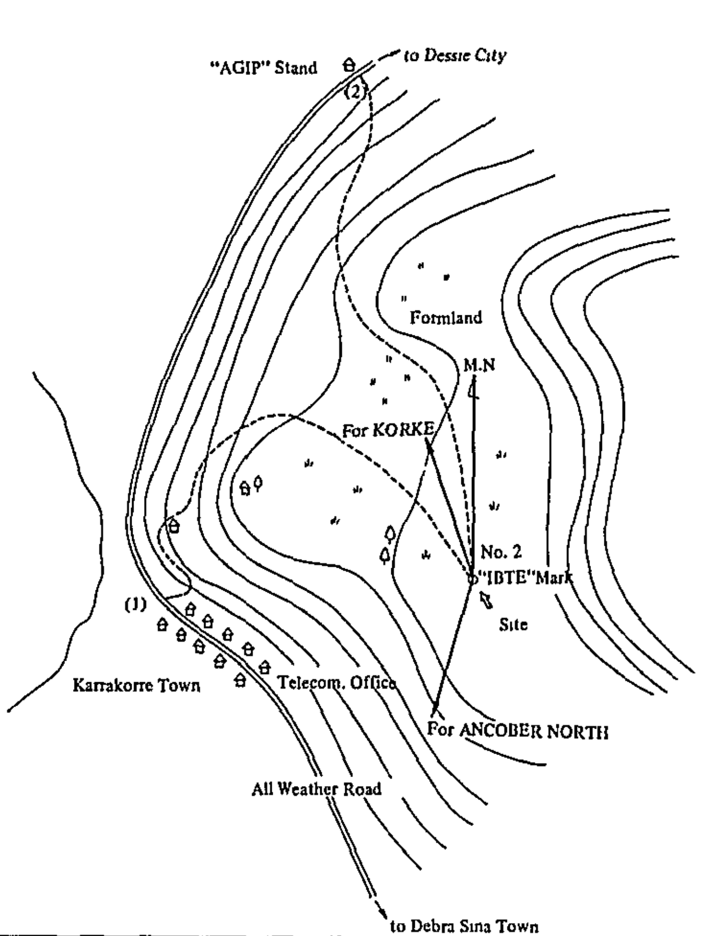


Guide Map of the Site	ANCOBER NORTHE
	Fig. III - 40

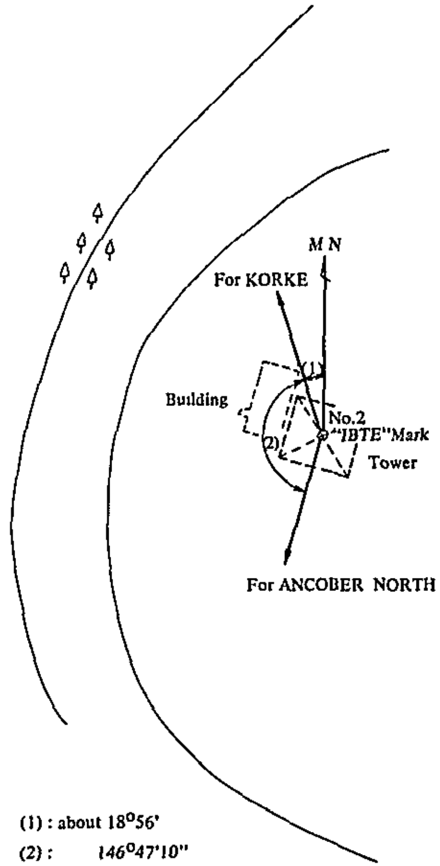


Topographic Sketch of the Site and Neighbourhood	ANOCOBER NORTH
	Fig III - 41

(1) – Dessie City : about 115 Km. All Weather Road
(1) – Debra Sina Town : about 100 Km. All Weather Road.
(1) – Site : about 1.5 Km., about 30 min. on foot.
(2) – Site : about 2 Km , about 45 min. on foot



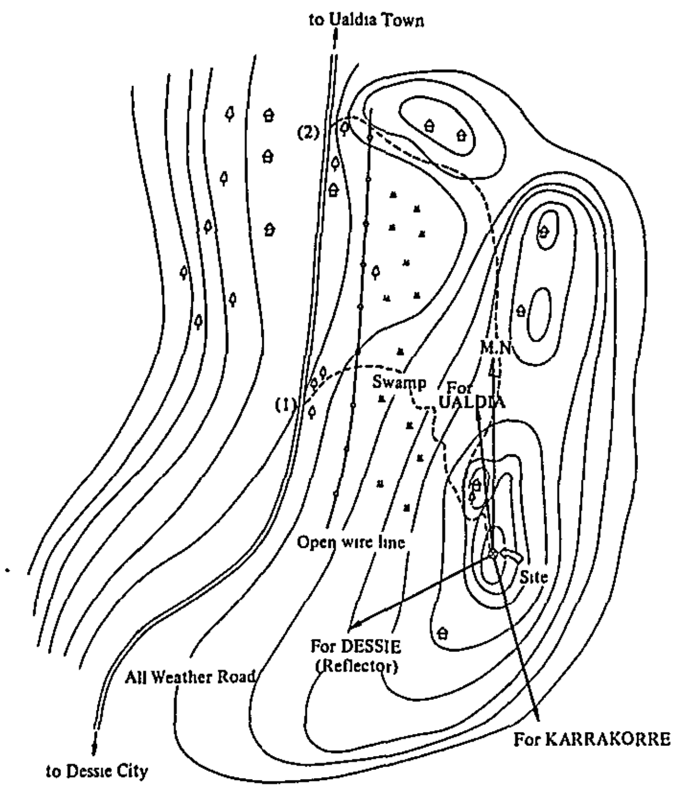
Guide Map of the Site	KARRAKORRE	Fig. III - 42



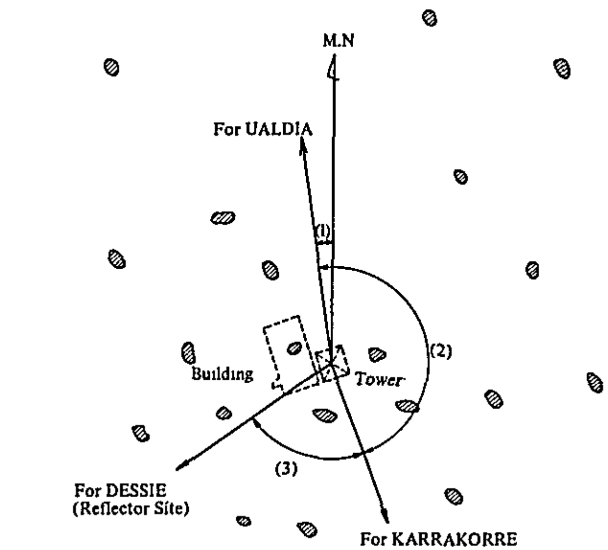
(1) : about 18°56'
(2) : 146°47'10"

Topographic Sketch of the Site and *Neighbourhood*	KARRAKORRE	Fig. III - 43

(1) – Ualdia Town : about 110 Km.
(1) – Dessie City (Telecommunication Office) . about 13 Km.
(1) – Site . about 2.5 Km., about 45 min. on foot.
(2) – Site : about 3.5 Km



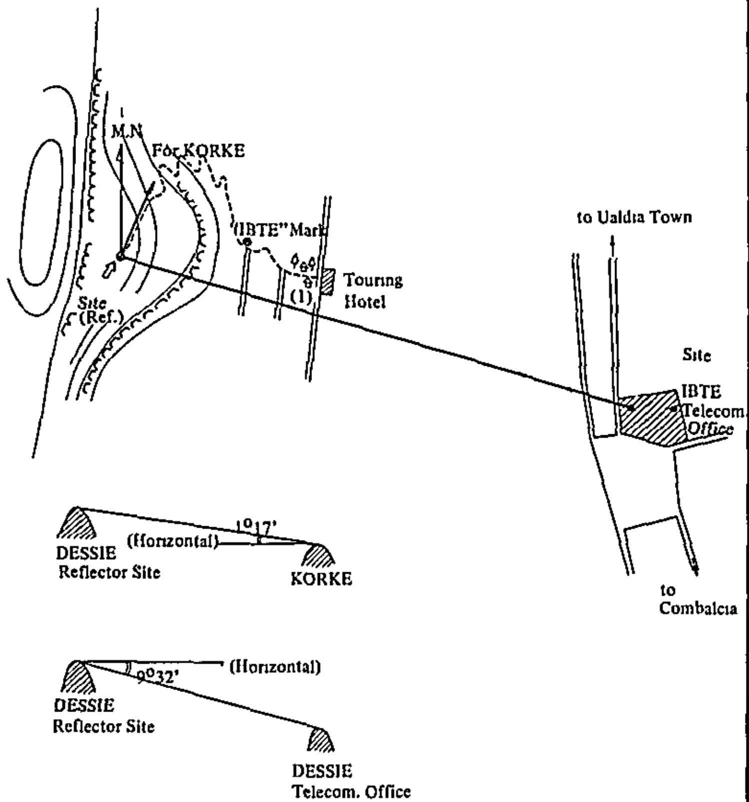
Guide Map of the Site	KORKE
	Fig. III - 44



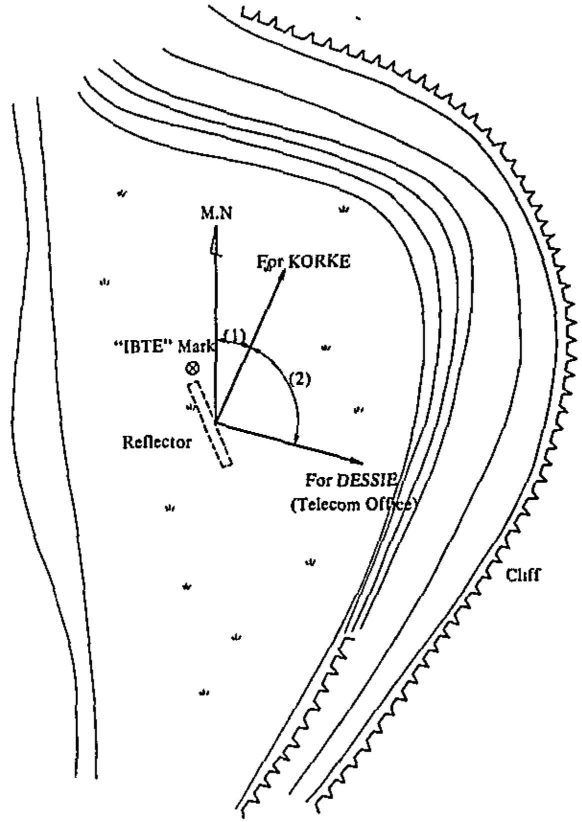
(1) . about 7°55'
(2) · 169°05'
(3) · 76°14'

Topographic Sketch of the Site and Neighbourhood	KORKE
	Fig III - 45

(1) – Telecommunication Office : about 1 Km.
(1) – Site . about 1 Km., about 30 min. on foot.

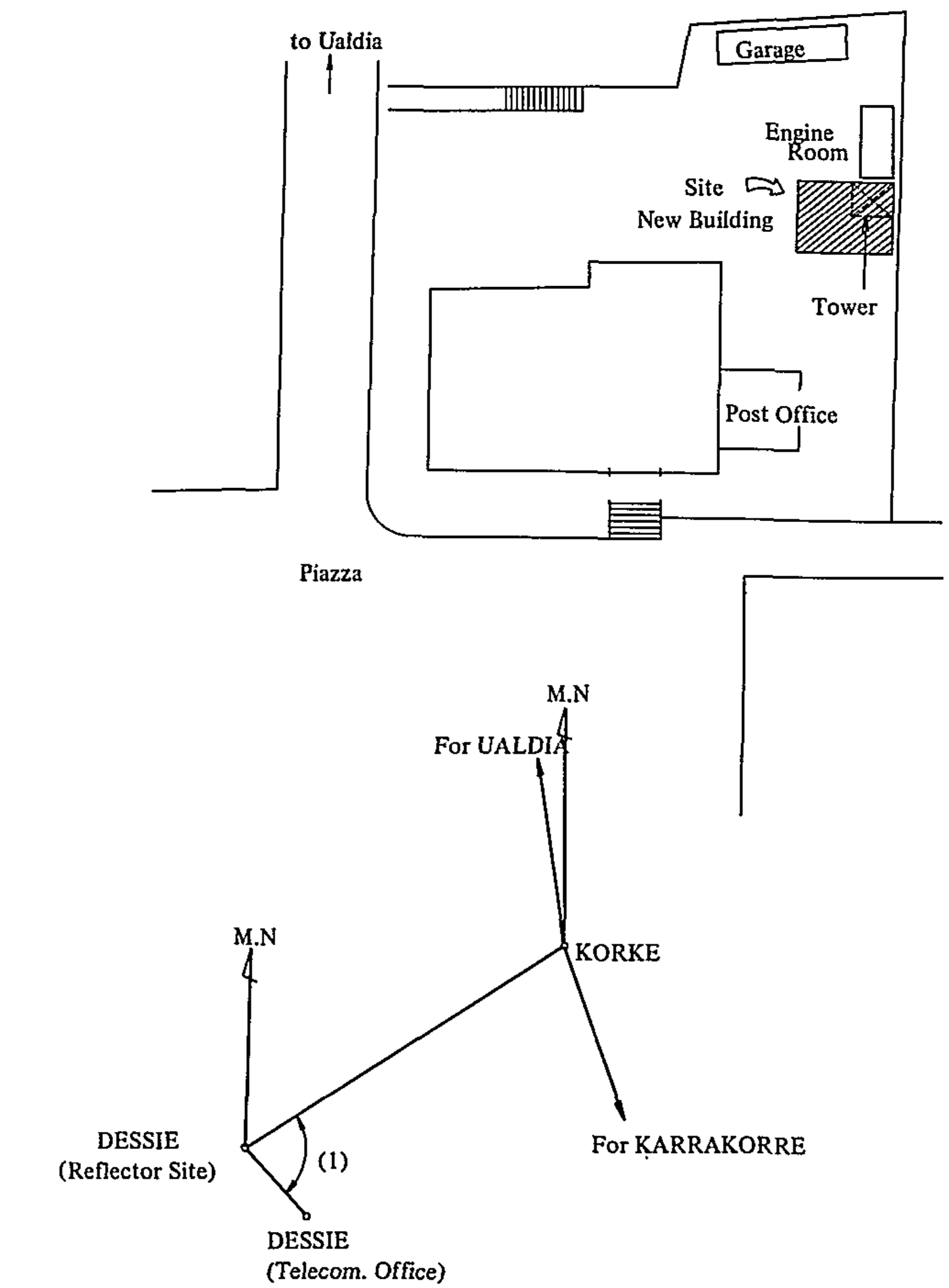


Guide Map of the Site	DESSIE
	Fig. III - 46



(1) : about 23°33'
(2) : 80°51'53"

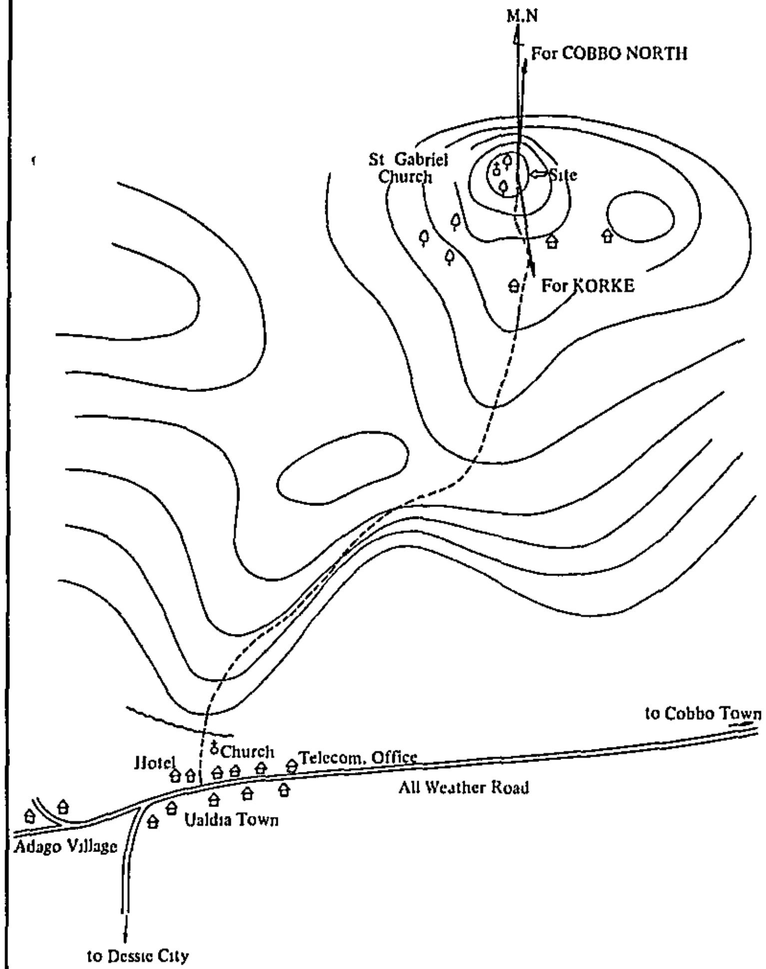
Topographic Sketch of the Site and Neighbourhood	DESSIE (Reflector Site)
	Fig. III - 47



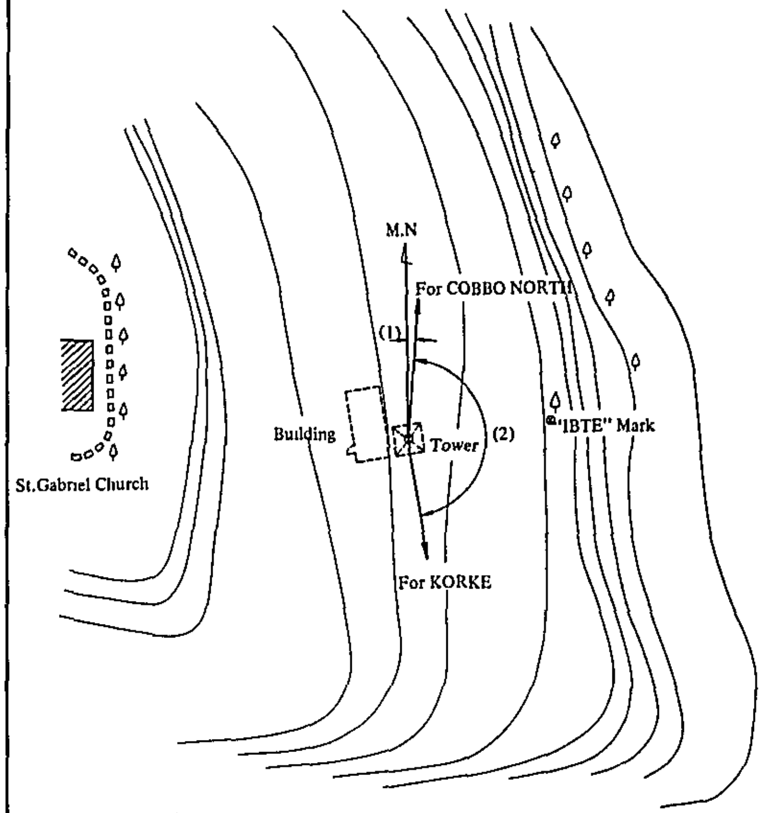
(1) : 80°51'53"

Topographic Sketch of the Site and Neighbourhood	DESSIE
	Fig. III - 48

(1) – Cobbo Town : about 50 Km. All Weather Road.
(1) – Dessie City : about 125 Km. All Weather Road.
(1) – Site : about 5 Km. about 1.5 Hr on foot.



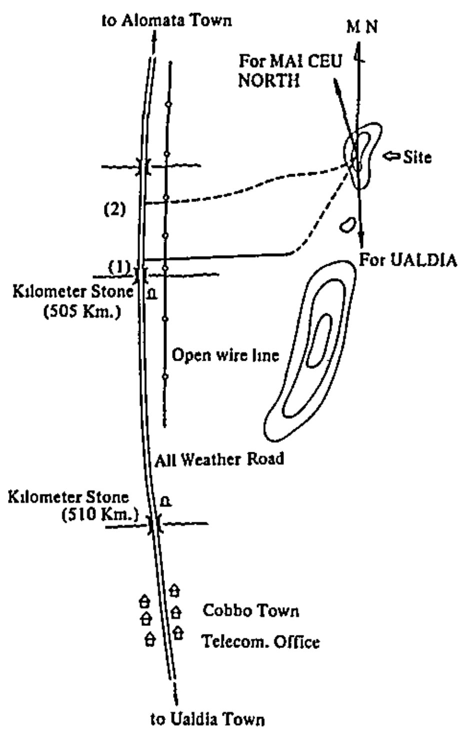
Guide Map of the Site	UALDIA
	Fig III - 49



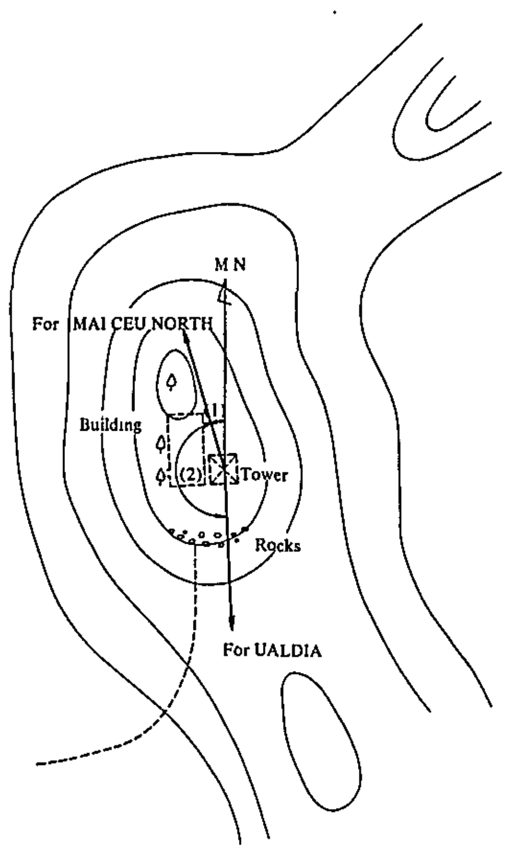
(1) . about 4°33'
(2) : 166°43'

Topographic Sketch of the Site and Neighbourhood	UALDIA
	Fig III - 50

(1) – (2) : about 0.7 Km. All Weather Road.
(2) – Cobbo Town : about 7.2 Km All Weather Road.
(2) – Alomata Town : about 24 Km All Weather Road.
(2) – Site : about 3.5 Km. about 50 min. on foot



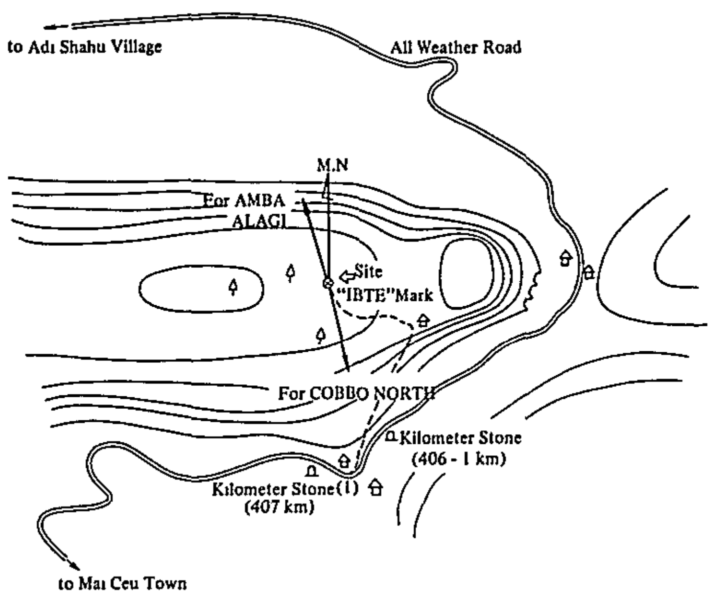
Guide Map of the Site	COBBO NORTH
	Fig III-51



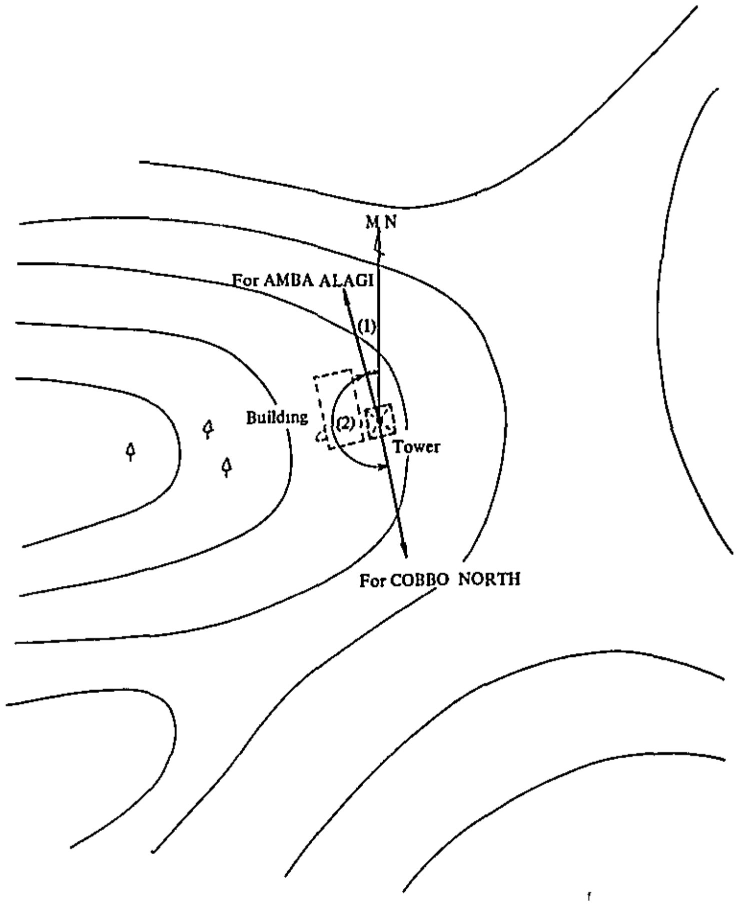
(1) : about 15°56'
(2) : 166°03'30"

Topographic Sketch of the Site and Neighbourhood	COBBO NORTH
	Fig III-52

(1) - Mai Ceu Town : about 11 Km. All Weather Road.
(1) - Adi Shahu Village : about 19 Km All Weather Road.
(1) - Site : about 3.5 Km, about 1.5 hr. on foot.



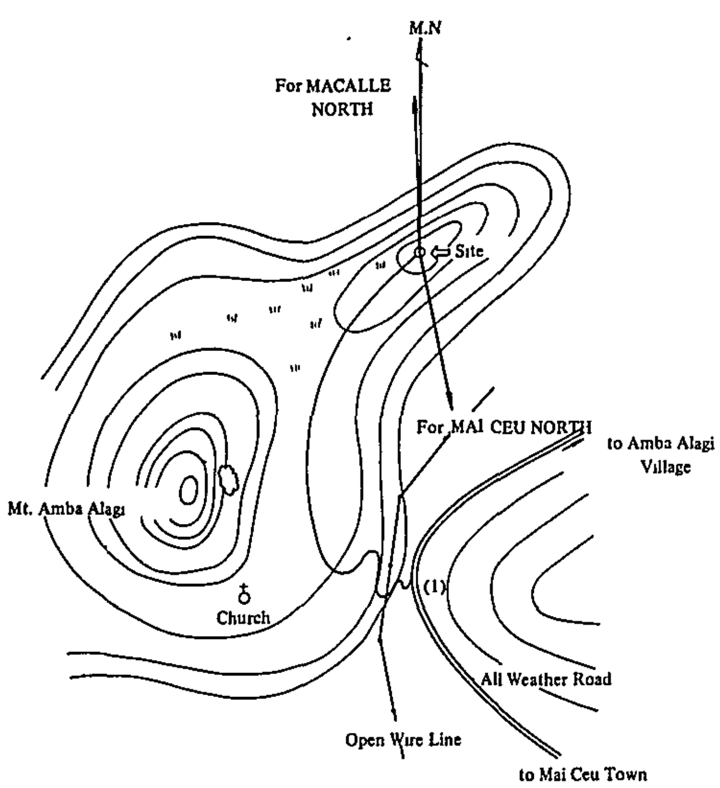
Guide Map of the Site	MAI CEU NORTH Fig. III - 53



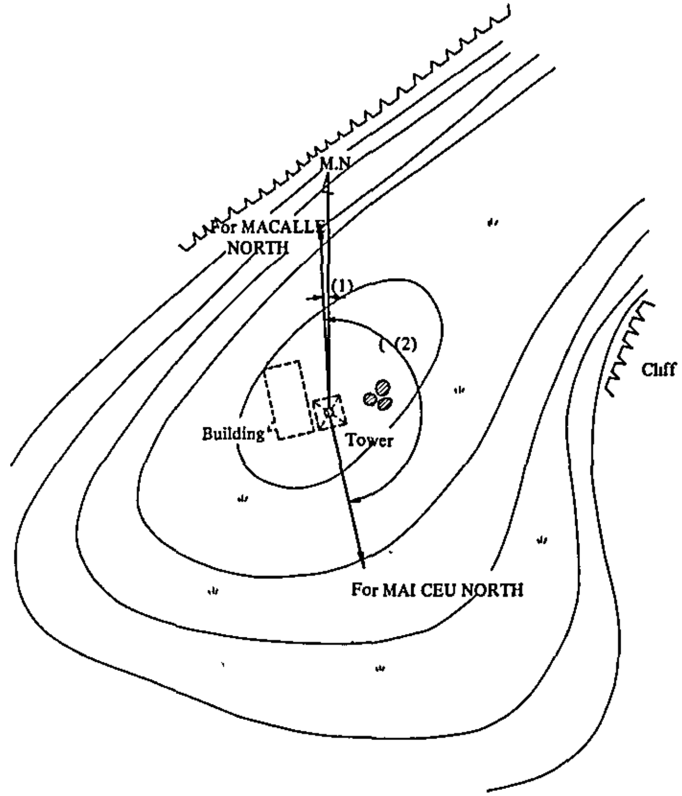
(1) : about 15°04'
(2) : 176°40'40"

Topographic Sketch of the Site and Neighbourhood	MAI CEU NORTH Fig III - 54

(1) - Mai Ceu Town : about 44 Km.
(1) - Amba Alagi Village : about 6 Km.
(1) - Site : about 1 Km., open to jeep



Guide Map of the Site	AMBA ALAGI
	Fig. III - 55

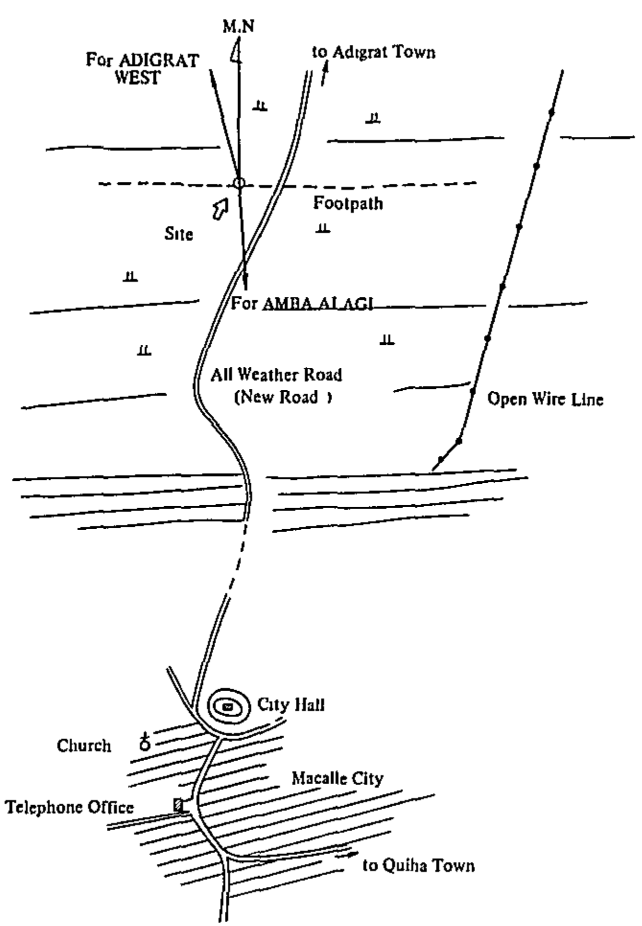


(1) : about 51'
(2) : 168°53'20"

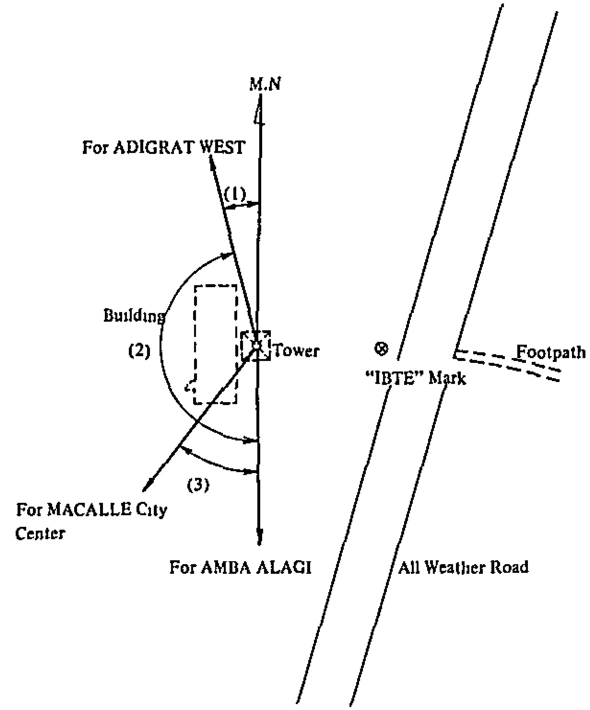
Topographic Sketch of the Site and Neighbourhood	AMBA ALAGI
	Fig III - 56

Site – Adigrat Town : about 105 Km.

Site – Macalle City (Telephone Office) : about 13 Km.



Guide Map of the Site	MACALLE NORTH AND MACALLE (Telephone Office)
	Fig III - 57



(1) : about 15°31'

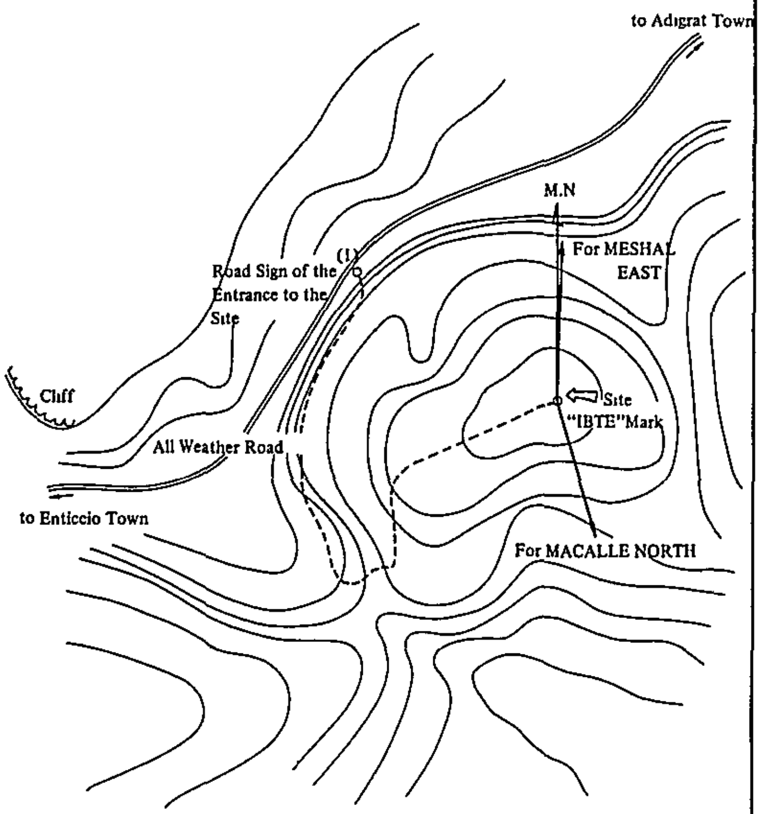
(2) . 167°13'12"

(3) · about 38°35'

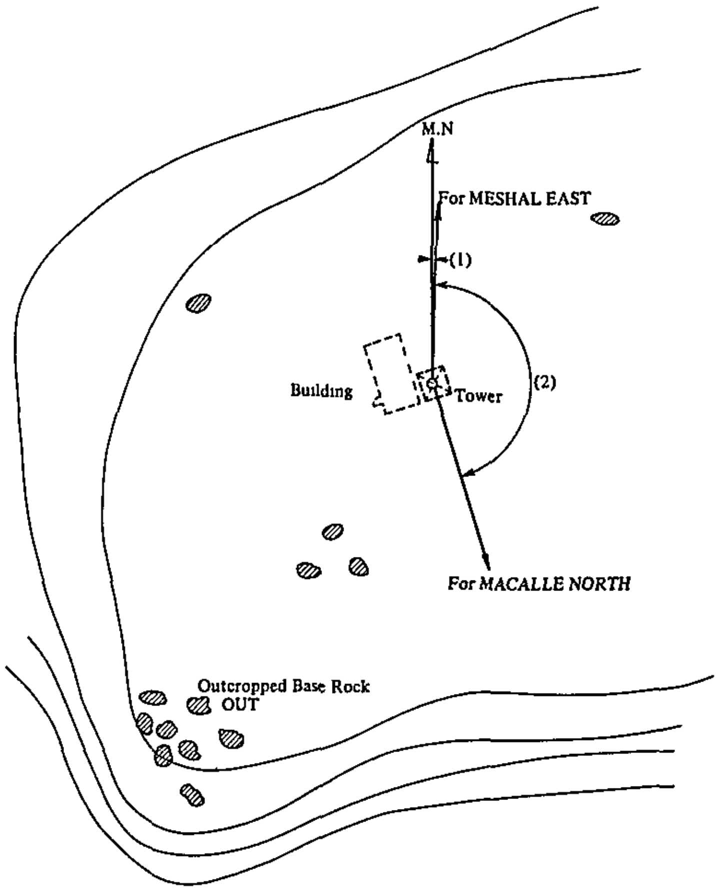
Topographic Sketch of the Site and Neighbourhood	MACALLE NORTH
	Fig. III - 58

(1) - Adigrat Town · about 20 Km

(1) - Site : about 1 Km about 20 min on foot.

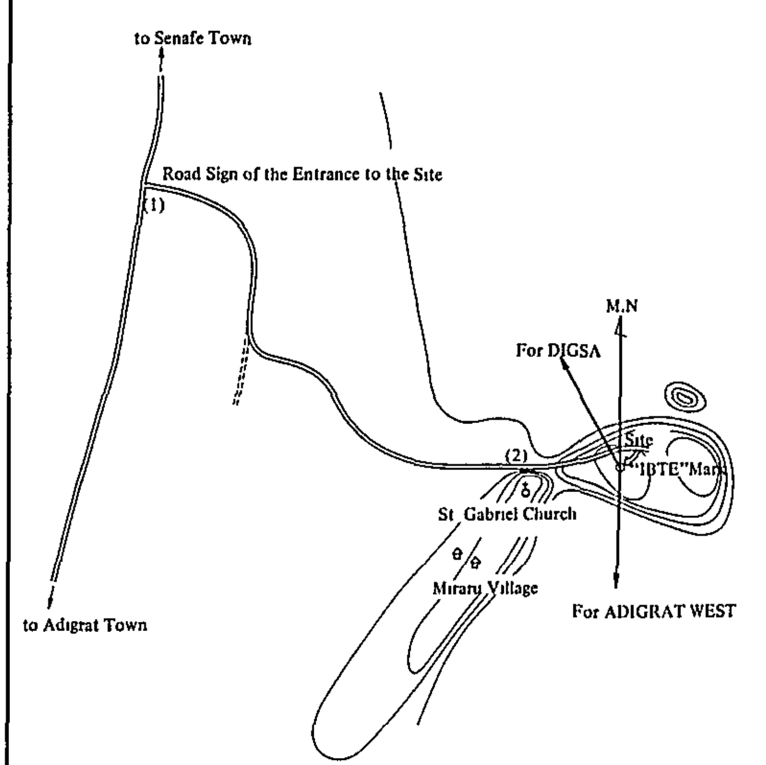


Guide Map of the Site	ADIGRAT WEST	Fig. III - 59

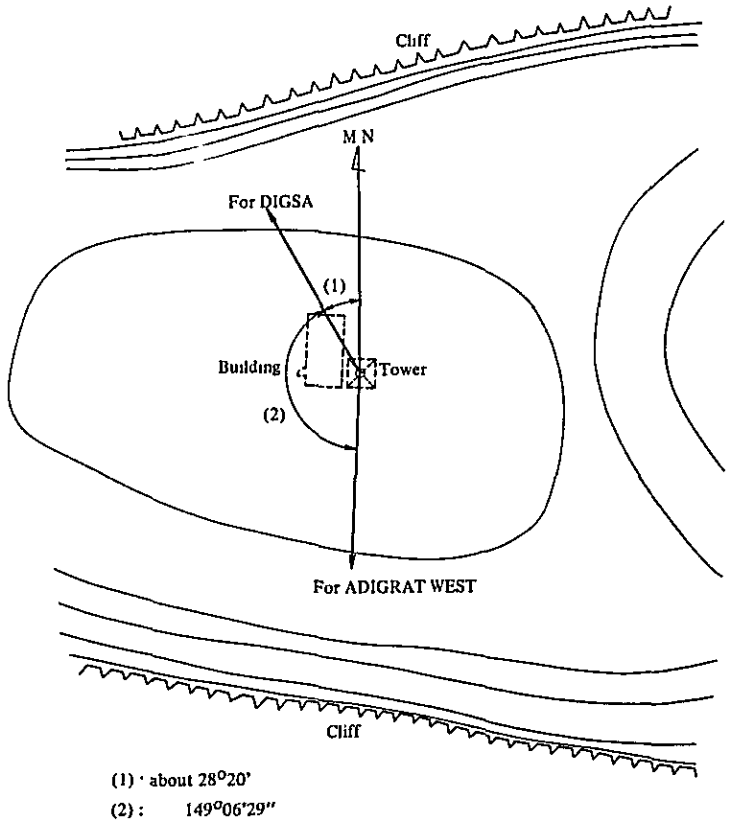


(1) : about 54'
(2) . 161°44'23"

Topographic Sketch of the Site *and Neighbourhood*	ADIGRAT WEST	Fig. III - 60

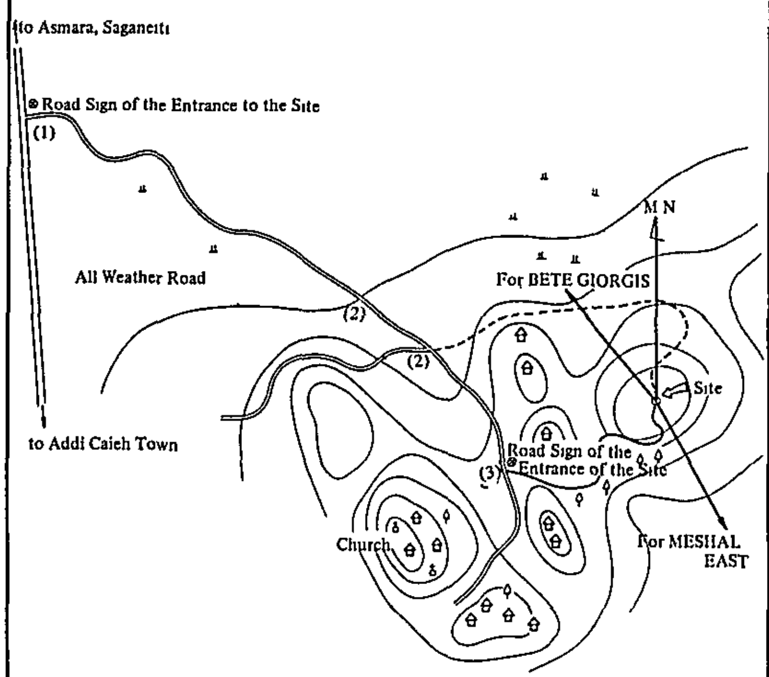


Guide Map of the Site	MESHAL EAST
	Fig III - 61

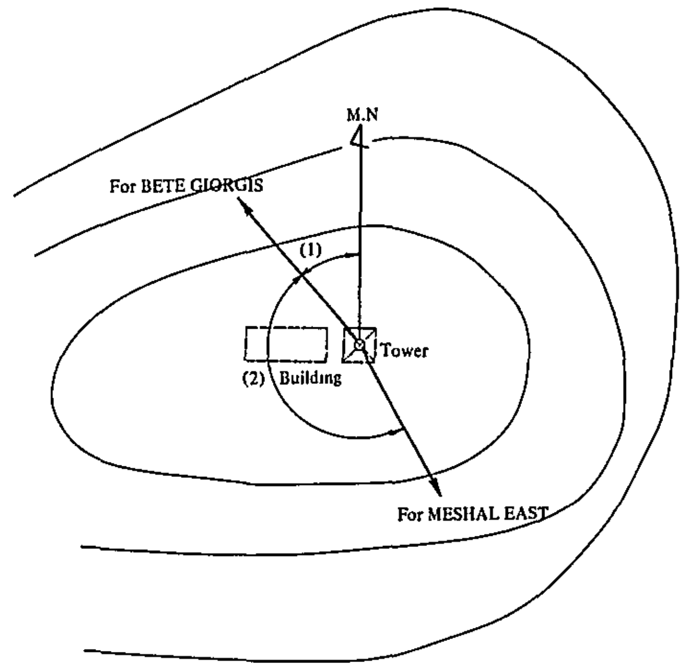


Topographic Sketch of the Site and Neighbourhood	MESHAL EAST
	Fig. III - 62

(1) - Addi caieh Town . about 42 Km.
(1) - Asmara City about 70 Km
(1) - (2) · about 2 Km., open to jeep
(2) - (3) : about 0 3 Km, open to Jeep
(2) - Site : about 1 Km.
(3) - Site . about 0.3 Km, about 10 min. on foot.



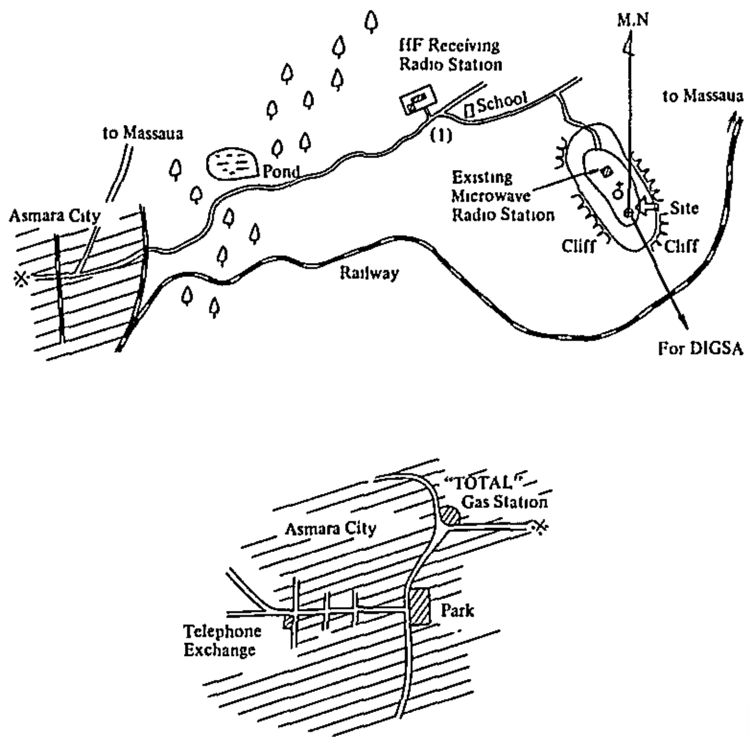
Guide Map of the Site	DIGSA
	Fig III - 63



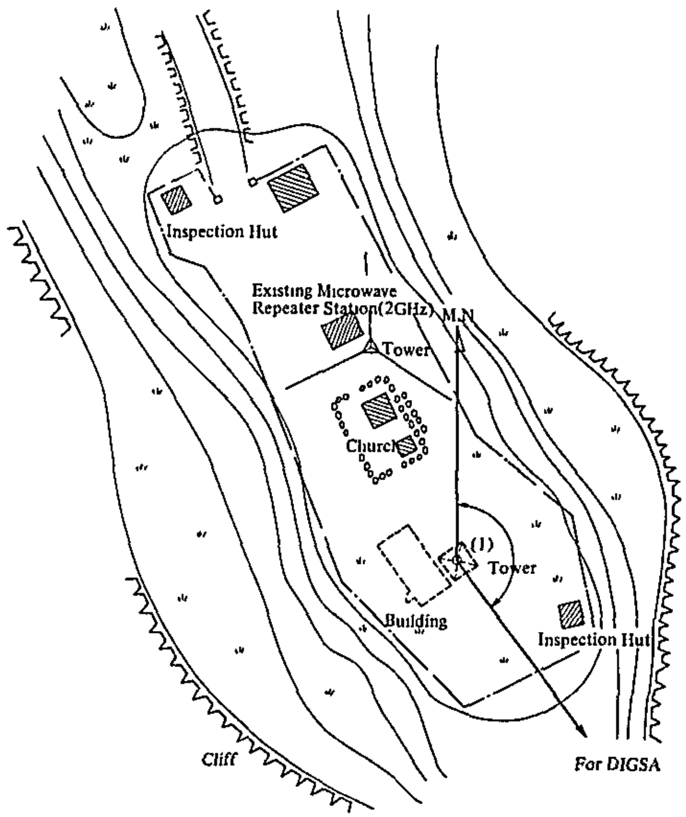
(1) · about 39°58'
(2) : 169°16'42"

Topographic Sketch of the Site and Neighbourhood	DIGSA
	Fig. III - 64

(1) – Asmara City (Telephone Exchange) : about 4 5 Km
(1) – Site : about 0 5 Km, open to jeep



Guide Map of the Site	BETE GIORGIS and ASMARA (Telephone Exchange)
	Fig III - 65



(1) : about 144°15'

Topographic Sketch of the Site and Neighbourhood	BETE GIORGIS
	Fig III - 66

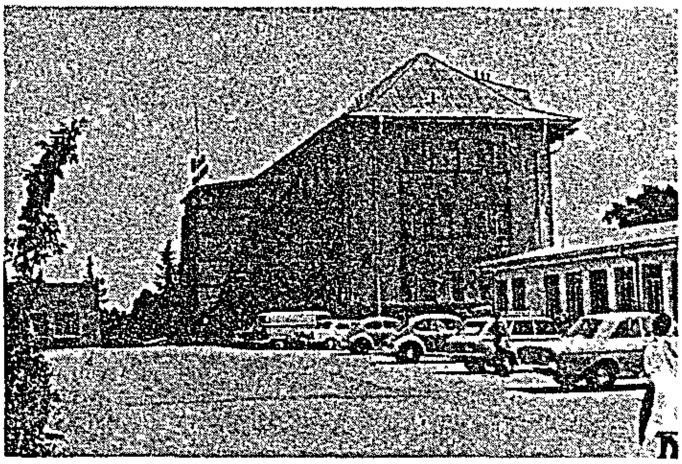


Fig. 67 View of the Site (I.B.T. E. Head Quarters)

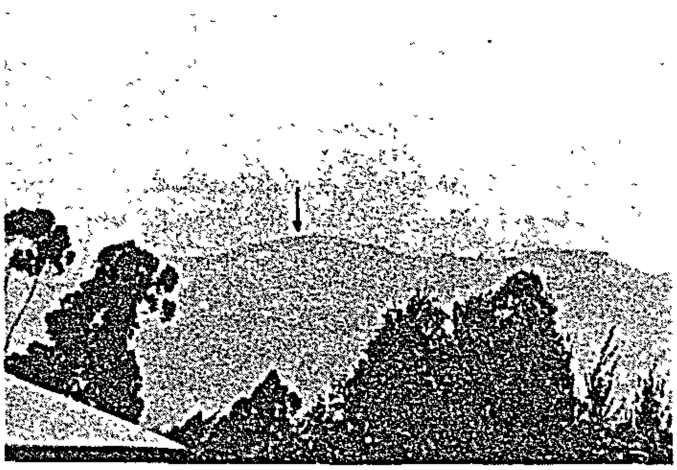


Fig. 68 Distant View of MT. FURI from the Site

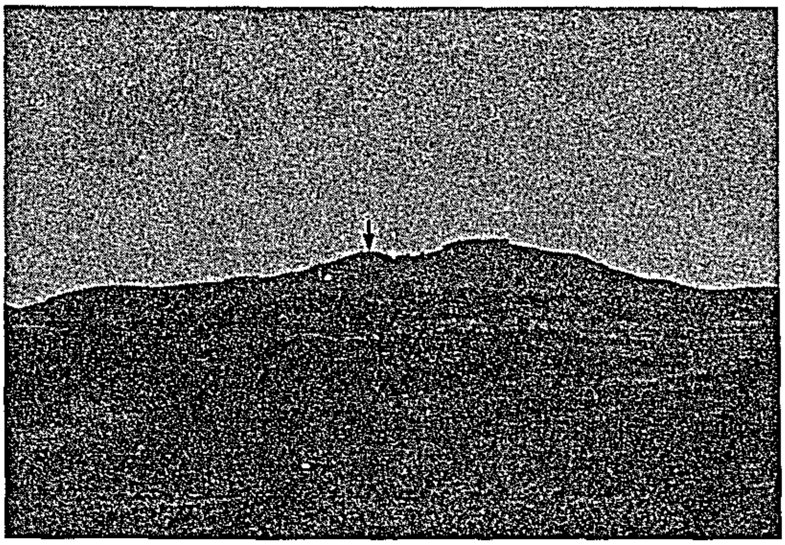


Fig. 69 Distant View of MT. FURI from All Weather Road

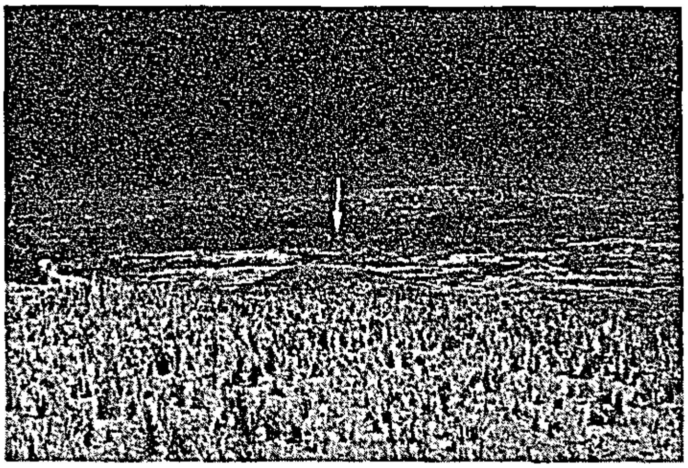


Fig. 70 Distant View of ADDIS ABABA from the Site

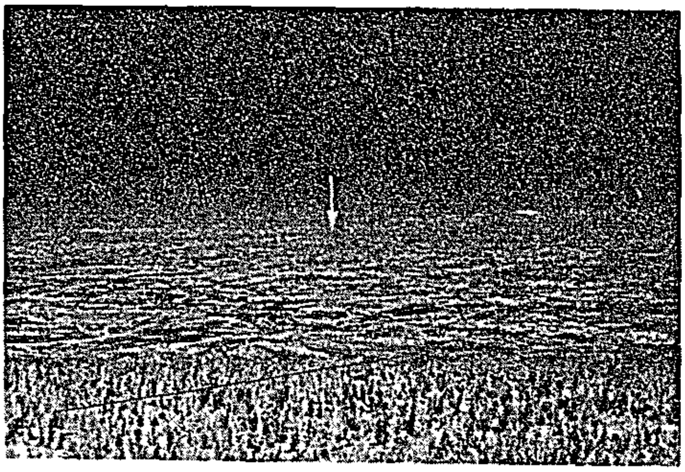


Fig. 71 Distatnt View of SENDAFA EAST from the Site

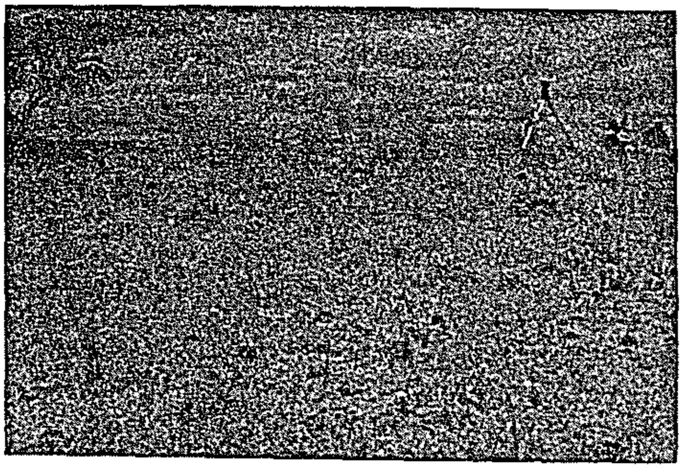


Fig. 72 View of the Site

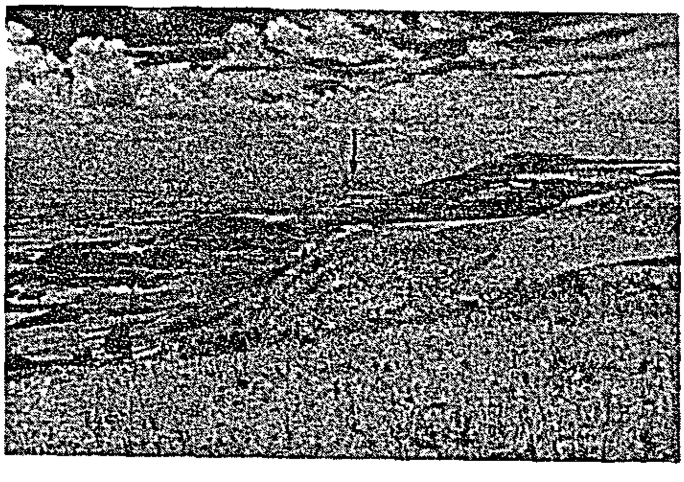


Fig. 73 Distatnt View of MT. FURI from the Site

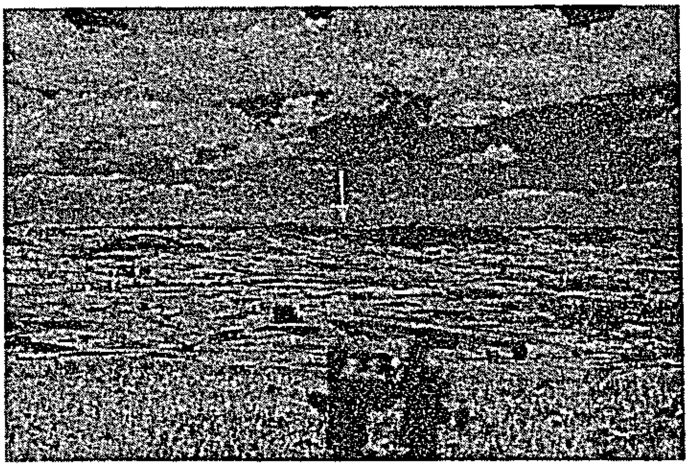


Fig. 74 Distant View of SHANO NORTH from the Site

Fig. 75 View of the Site

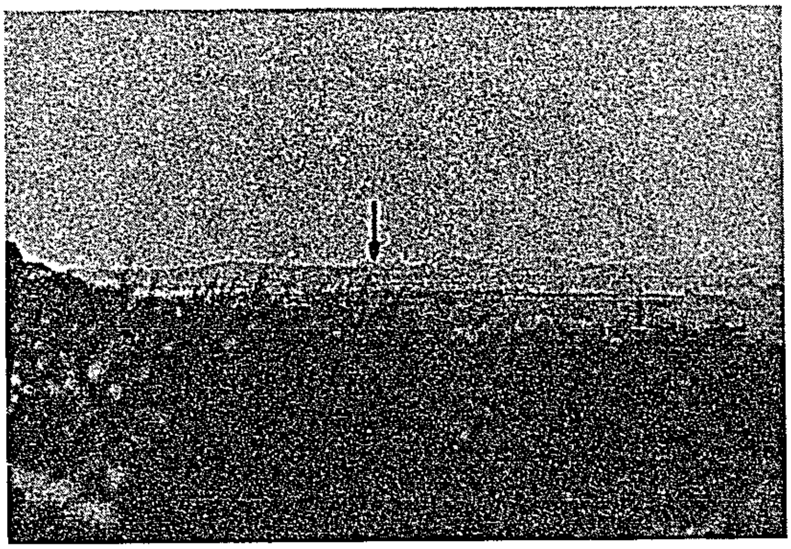


Fig. 76 Distant View of SENDAFA EAST from the Site

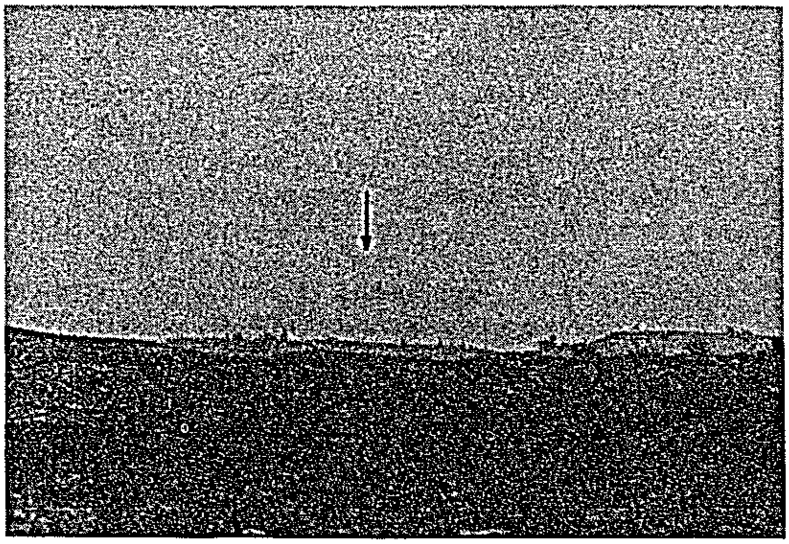


Fig. 77 Distant View of ANCOBER NORTH from the Site

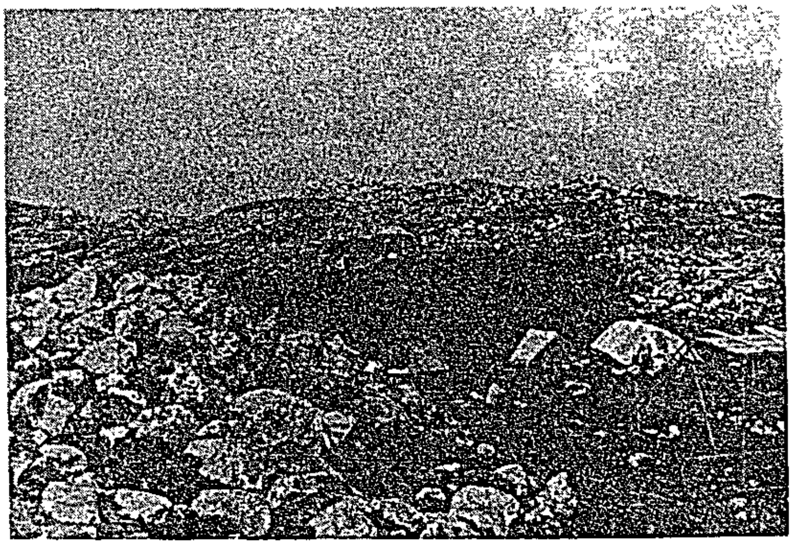


Fig 78 View of the Site

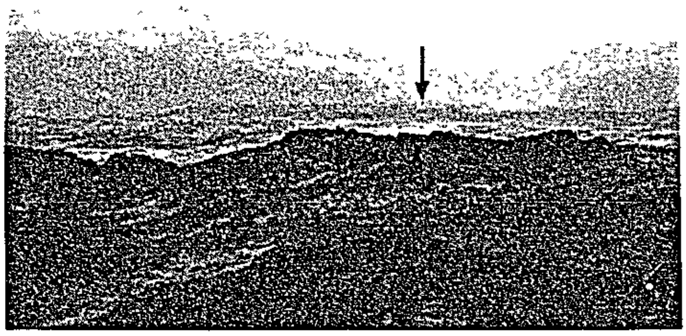


Fig. 79 Distant View of SHANO NORTH from the Site

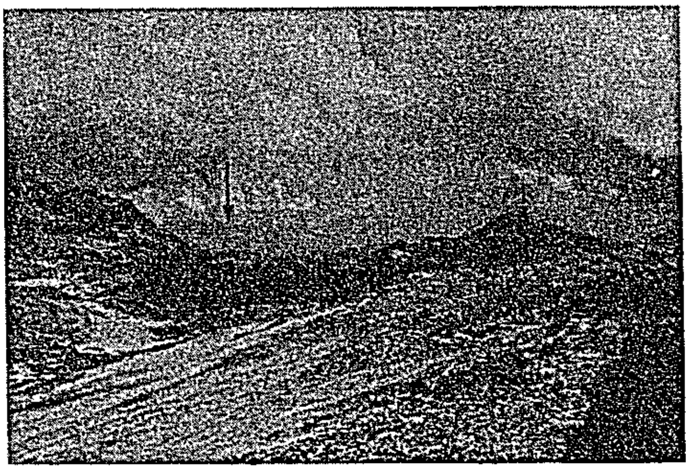


Fig. 80 Distant View of KARRAKORRE from the Site

Fig. 81 View of the Site

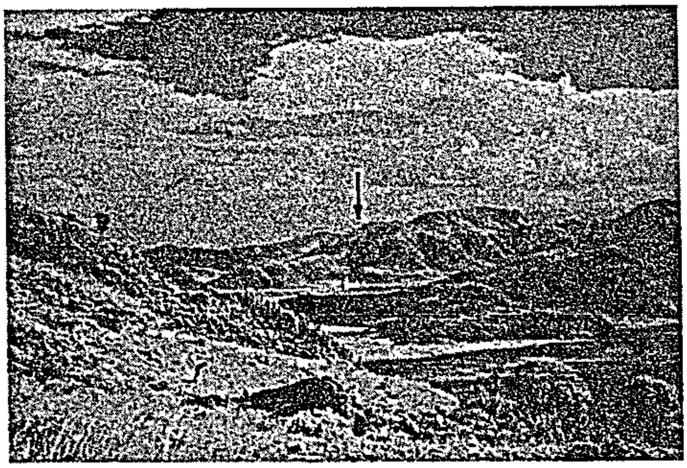


Fig. 82 Distant View of ANCOBER NORTH from the Site

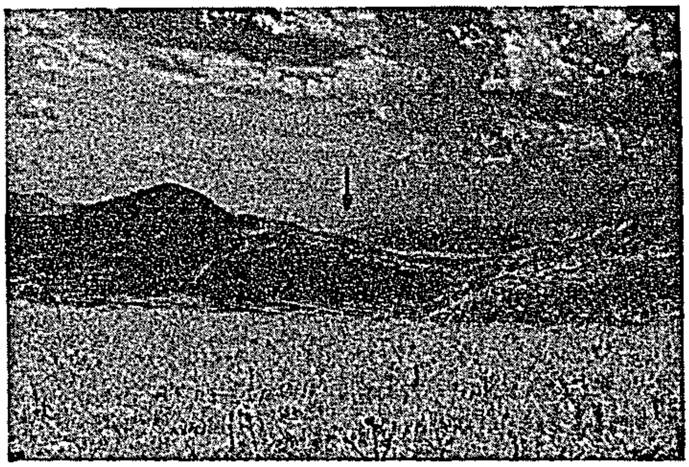


Fig. 83 Distant View of KORKE from the Site

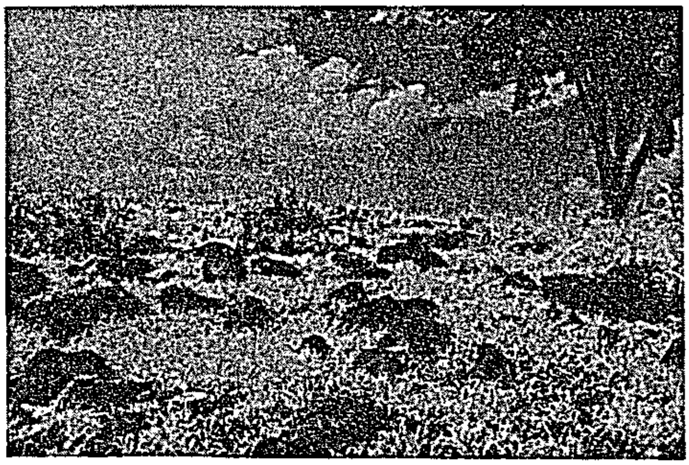


Fig. 84 View of the Site

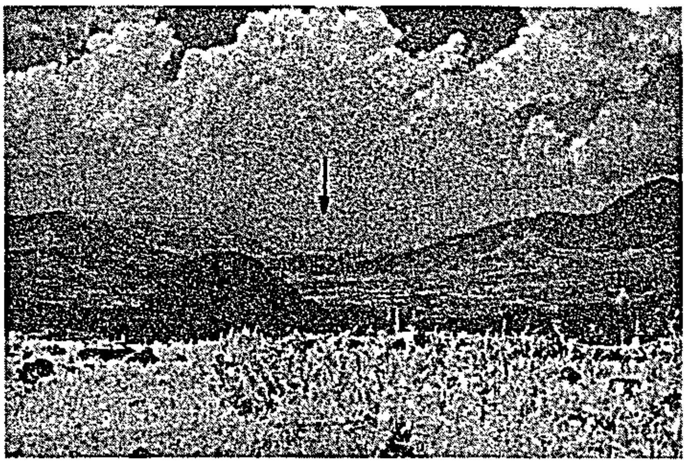


Fig. 85 Distant View of KARRAKORRE from the Site

KORKE

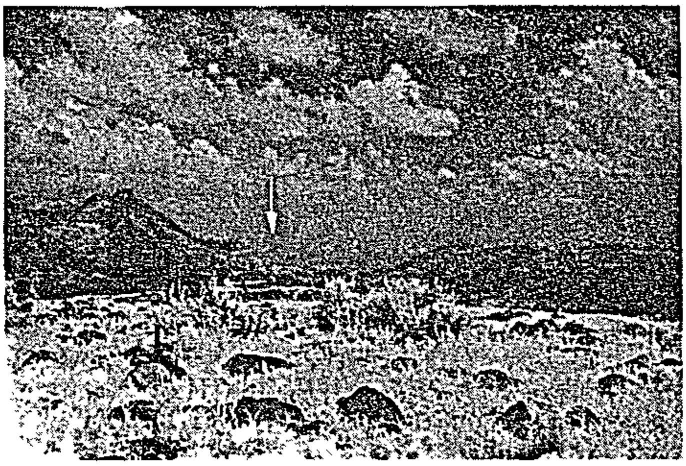


Fig 86 Distant View of UALDIA from the Site

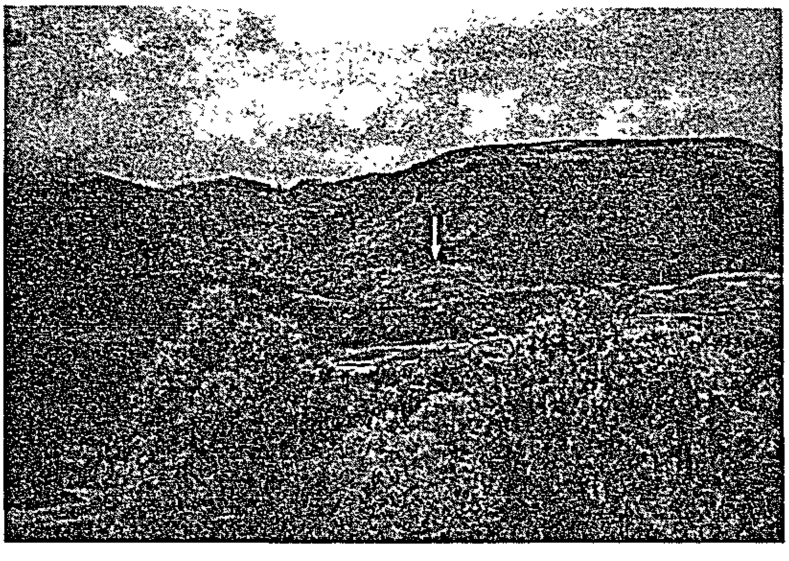


Fig. 87 Distant View of DESSIE Reflector Site from the Site

DESSIE (Reflector Site)

Fig 88 Distant View of KORKE from the Site

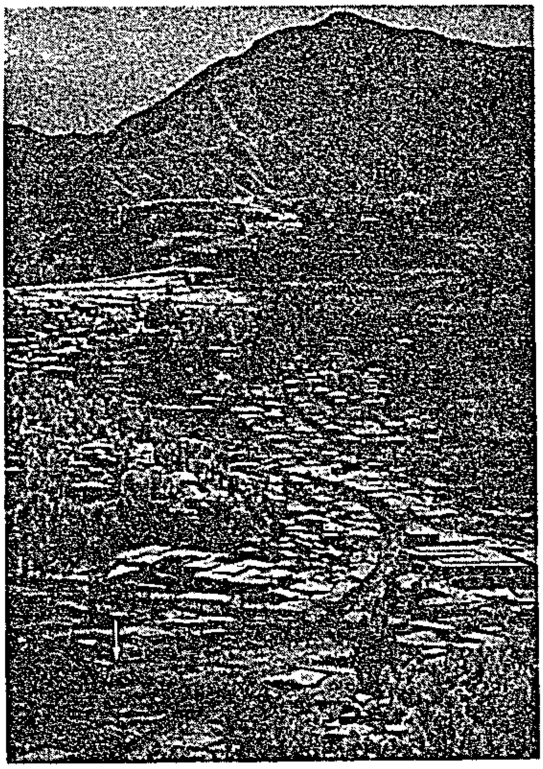


Fig 89 Distant View of DESSIE (Tele Cffice) from the Site

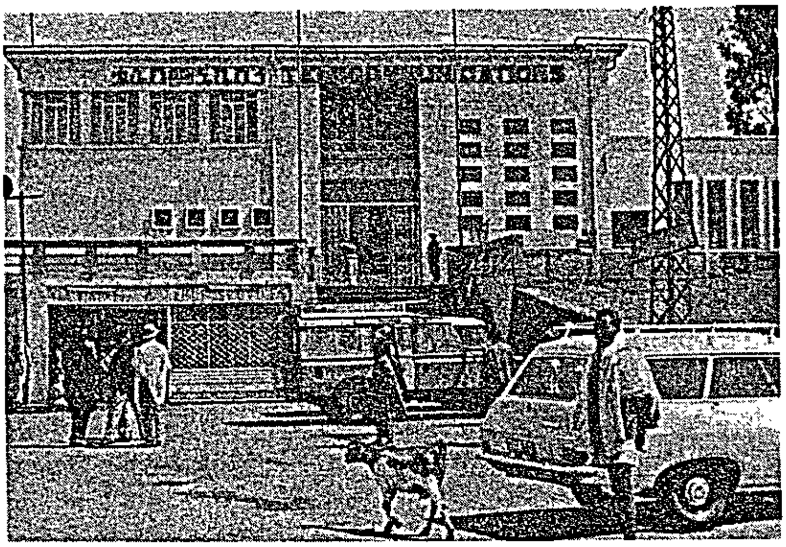


Fig 90 View of DESSIE Telephone Office

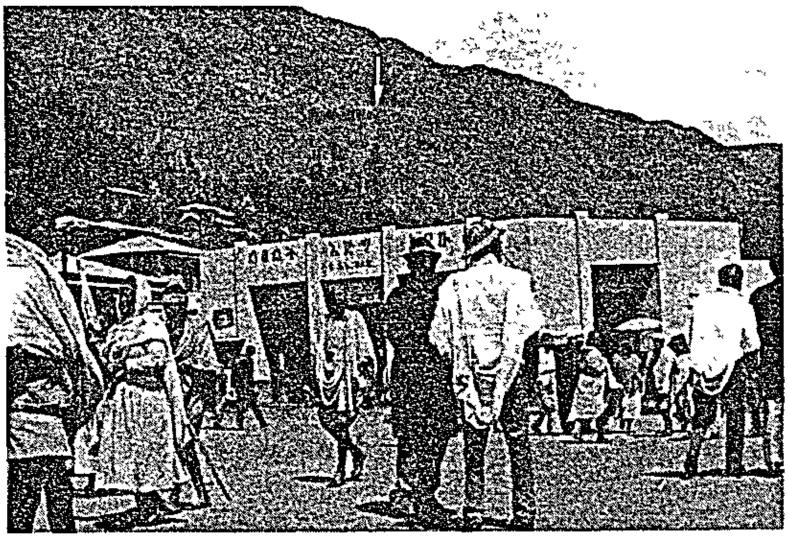


Fig. 91 Distant View of DESSIE Reflector Site from Piazza in front of Telephone Office

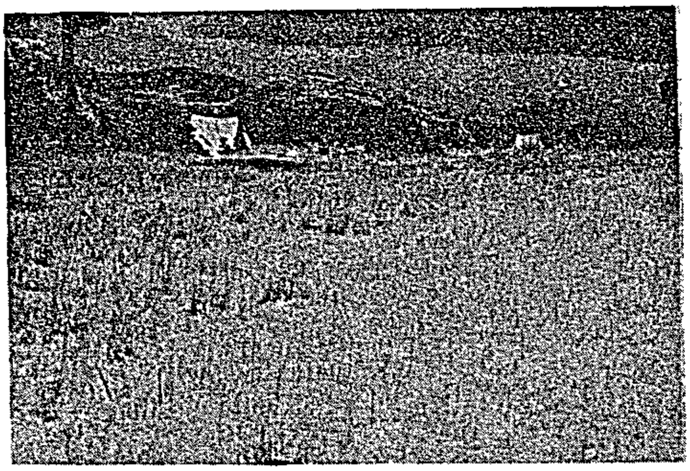


Fig. 92 View of the Site

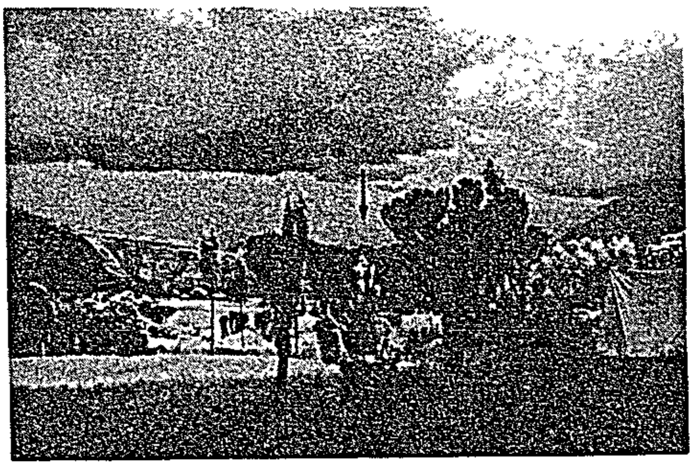


Fig 93 Distant View of KORKE from the Site

Fig. 94 Distant View of COBBO NORTH from the Site

Fig 95 View of the Site

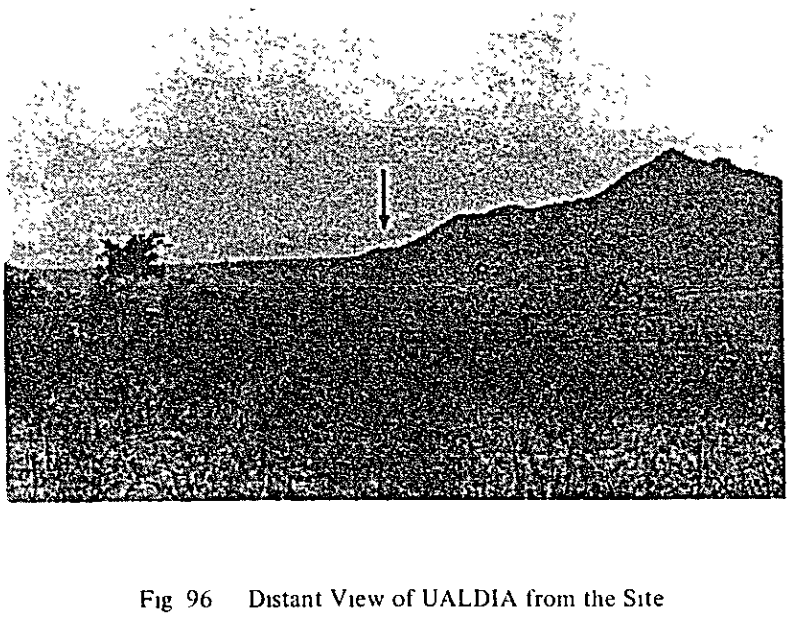


Fig 96 Distant View of UALDIA from the Site

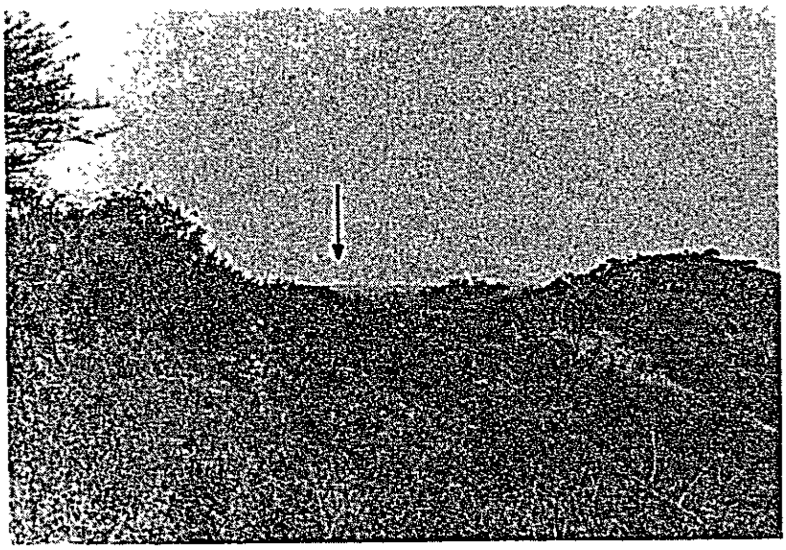


Fig 97 Distant View of MAI CEU NORTH from the Site

Fig 98 View of the Site

Fig. 99 Distant View of COBBO NORTH from the Site

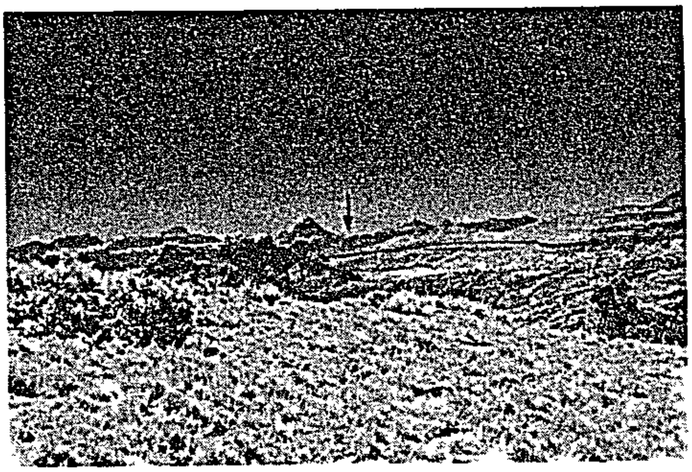


Fig. 100 Distant View of AMBA ALAGI from the Site

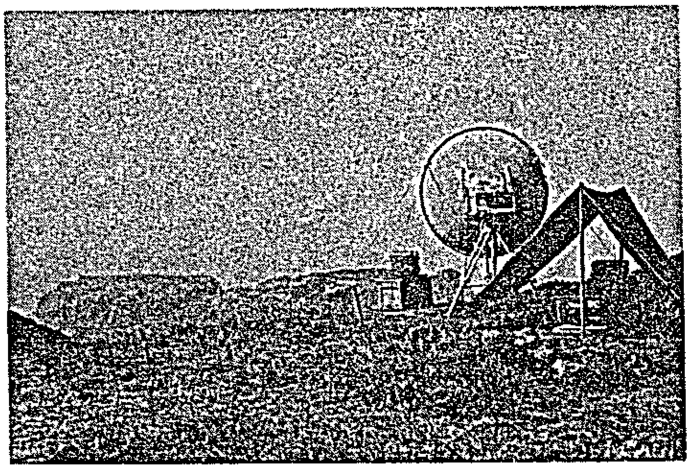


Fig. 101 View of the Site

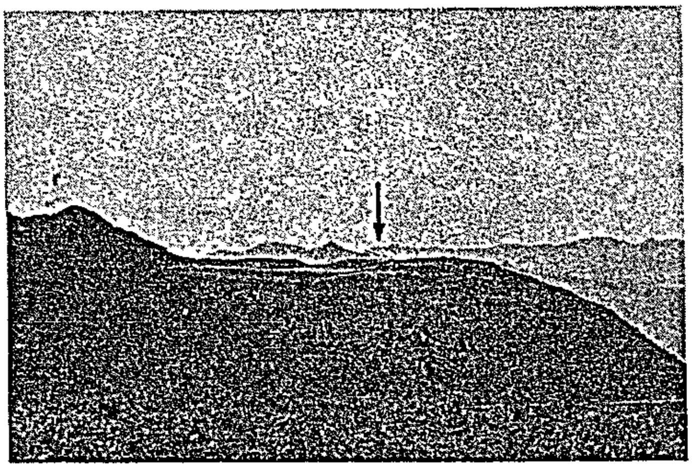


Fig. 102 Distant View of MAI CEU NORTH from the Site

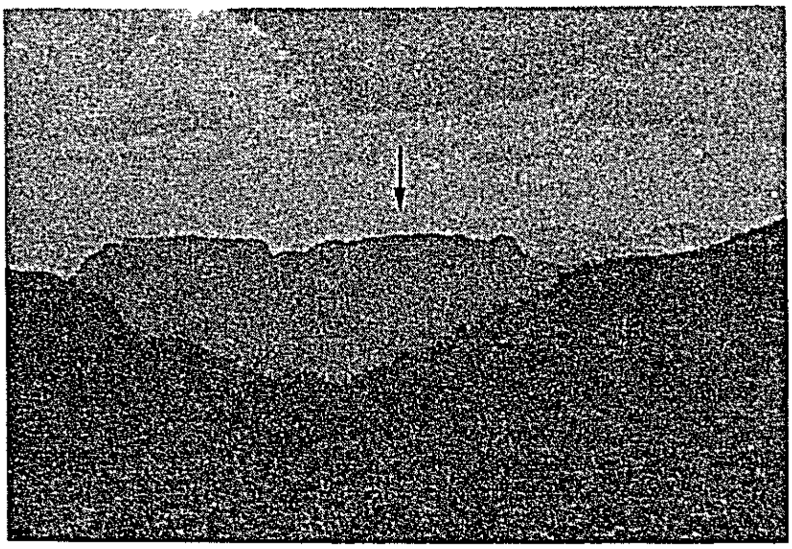


Fig 103 Distant View of MACALLE NORTH from the Site

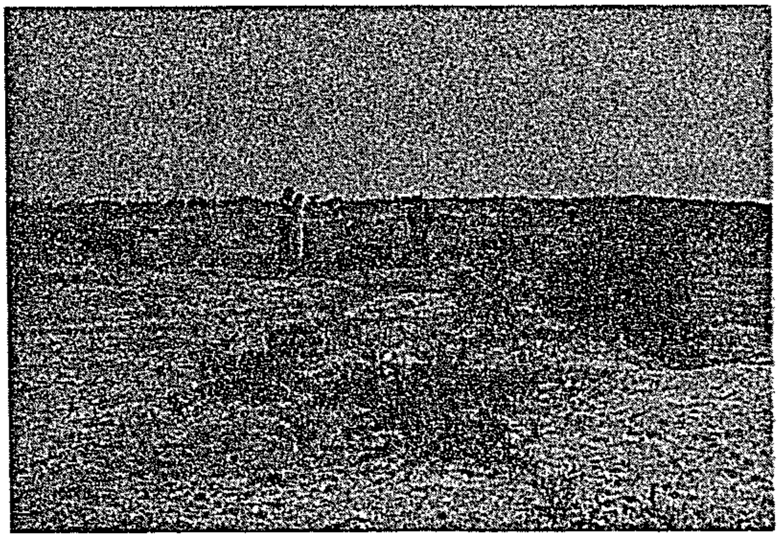


Fig 104 View of the Site

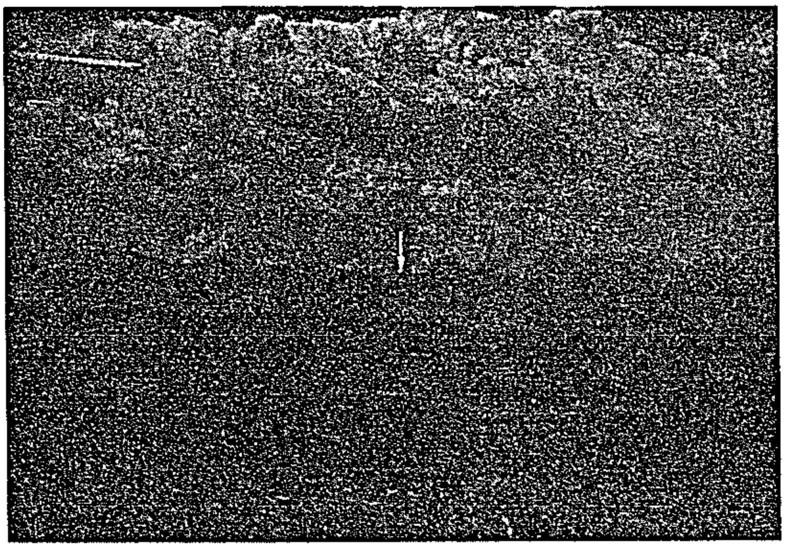


Fig. 105 Distant View of AMBA ALAGI from the Site

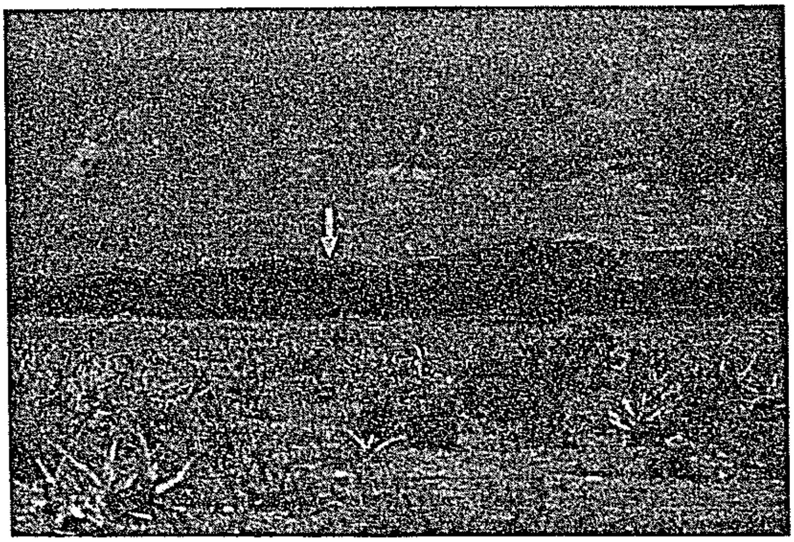


Fig 106 Distant View of ADIGRAT WEST from the Site

Fig 107 View of the Site

Fig. 108 Distant View of MACALLE NORTH from the Site

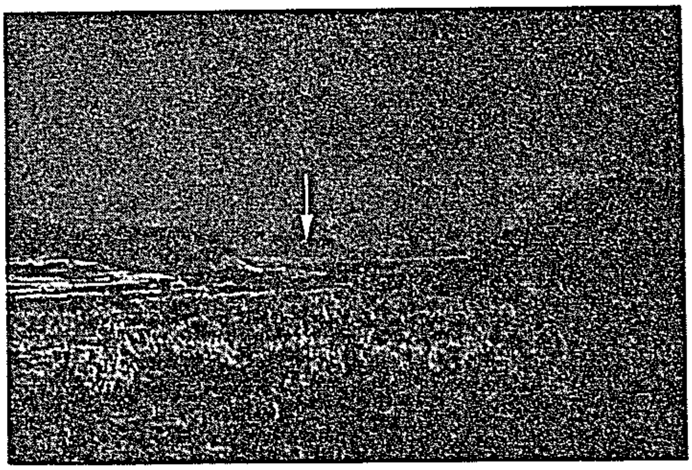


Fig. 109 Distant View of MESHAL EAST from the Site

Fig. 110 View of the Site

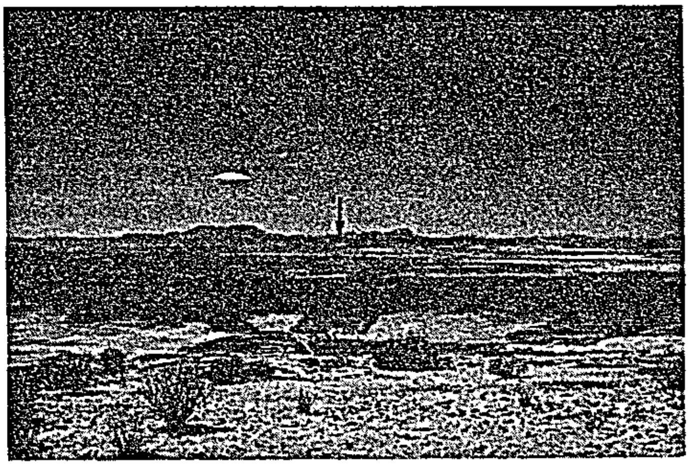


Fig. 111 Distant View of ADIGRAT WEST from the Site

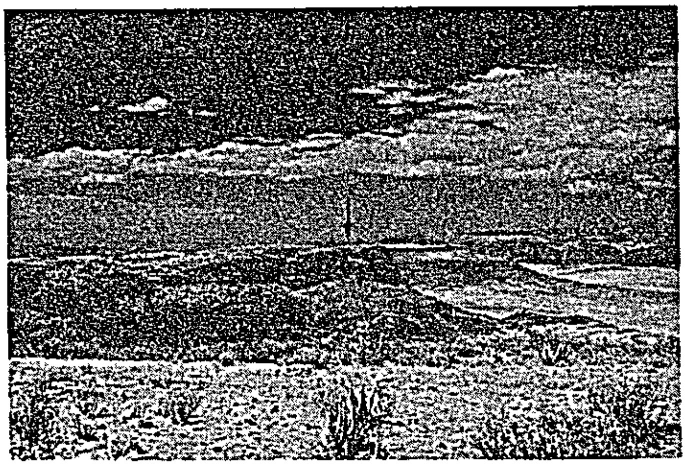


Fig 112 Distant View of DIGSA from the Site

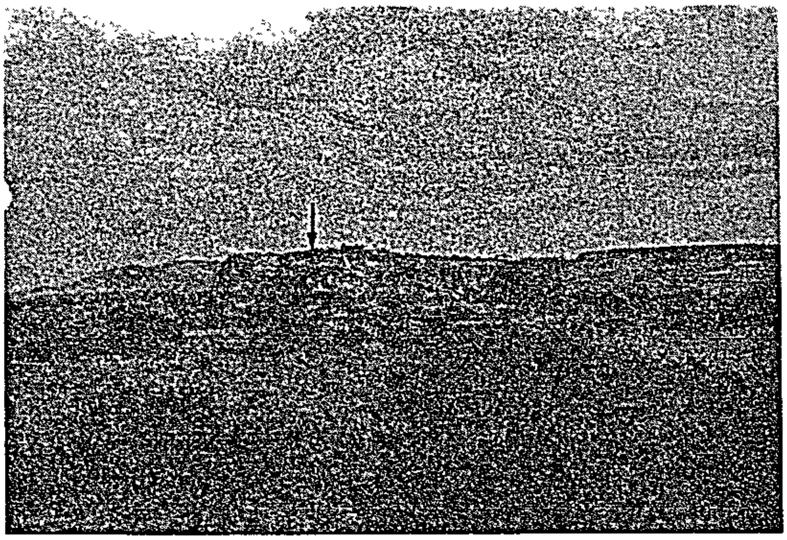


Fig. 113 View of the Site from All Weather Road

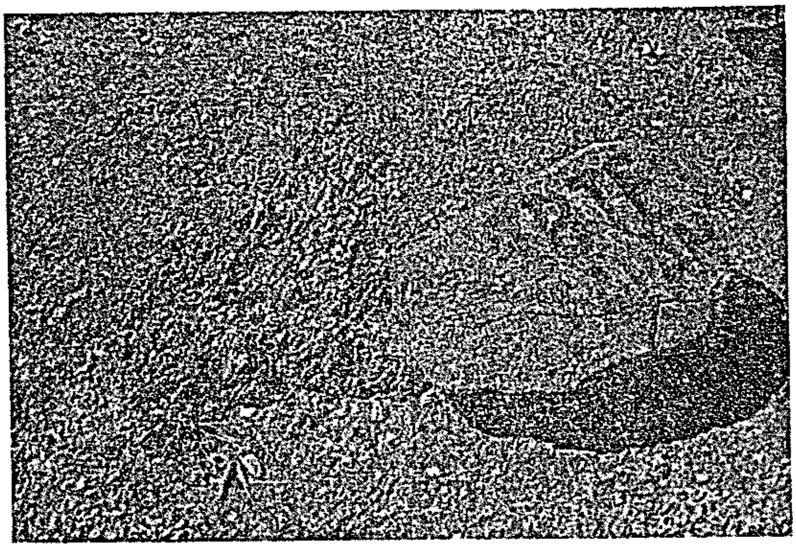


Fig 114 View of the Site

Fig 115 Distant View of MESHAL EAST from the Site

Fig. 116 Distant View of BETE GIORGIS from the Site

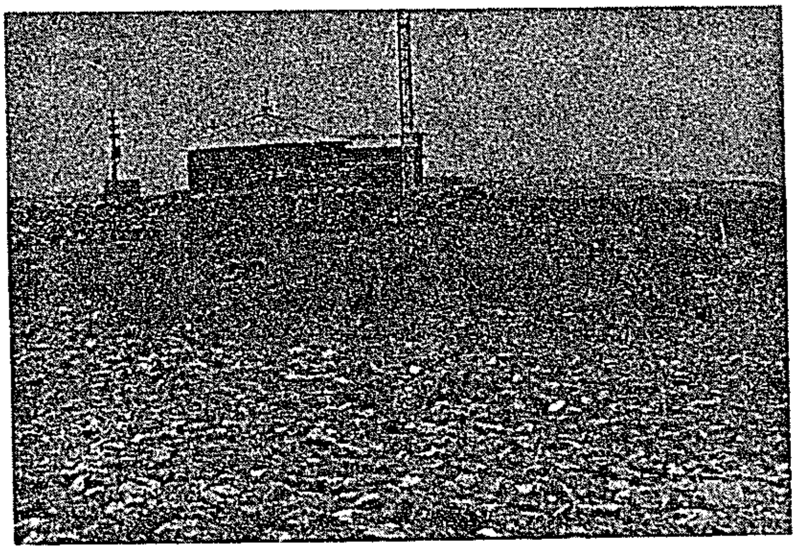


Fig. 117 View of the Site

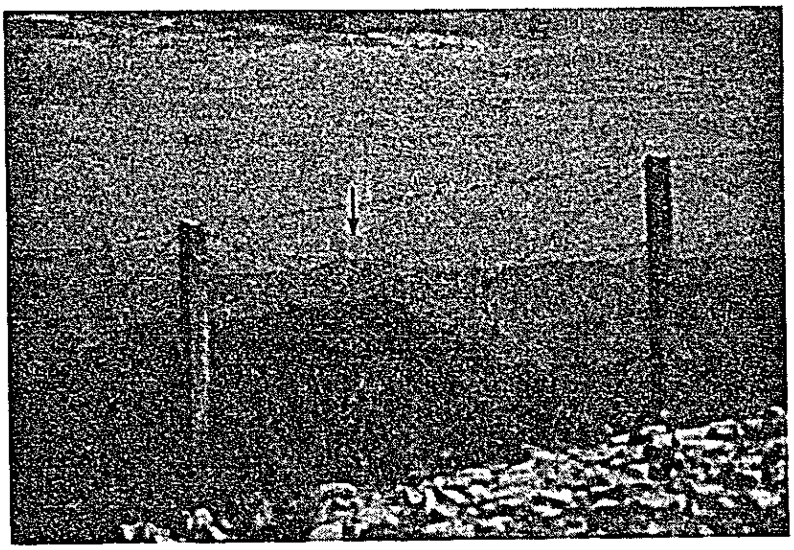


Fig 118 Distant View of DIGSA from the Site

CHAPTER IV SYSTEM DESIGN

CHAPTER IV SYSTEM DESIGN

1 System Composition

The composition of telecommunication system is shown in Fig. I. 1.

2 Conditions to be Considered for System Design

The microwave link between Addis Ababa and Asmara is the most important link that will be connected with international circuit in the future.

It should be considered that the present radio link might interfere with the satellite earth station to be constructed at Sululta in the future, the U.S. Armed Forces' earth station in Asmara, the microwave link to connect this earth station with bases and three other microwave links to be extended from Addis Ababa. IBTE requests that the present link should meet C.C.I.R. Recommendation with respect to transmission quality, but also wishes to have a more economical plan for the financial reason, if it is possible to make a remarkable reduction of the cost by constructing a system whose design objective is just below C.C.I.R. Recommendation. Accordingly, the survey team took economic design into account as much as possible.

2. 1 Allowable Noise Power in the Radio link

C.C.I.R. recommended, at the IXth Plenary Assembly, that the noise power at a point of zero relative level in any telephone channel on a 2, 500 km hypothetical reference circuit (C.C.I.R. Rec, 362) consisting of nine sets of radio modulators and demodulators, as shown in Fig. IV-1. should not exceed the provisional values given below which have been chosen to take account of fading: (C.C.I.R. Rec. 393).

(a) 7, 500 pW psophometrically weighted mean power in any hour
(b) 7, 500 pW psophometrically weighted one-minute mean power for more than 20% of any month
(c) 47, 500 pW psophometrically weighted one-minute mean power for more than 0. 1% of any month
(d) 1, 000, 000 pW unweighted (with an integrating time of 5 ms) for more than 0. 01% of any month

According to this recommendation, the design was made on three divided modulator - demodulator sections, namely, Addis Ababa - Dessie (364. 6 km), Dessie - Macalle North (274. 5 km), and Macalle North - Asmara (211 km) whose distances resemble the hypothetical reference circuit.

2. 2 Noise Distribution

The 1/9th of the total noise is distributed to each radio modulator and demodulator section, assuming that the nine radio modulator and demodulator sections that compose the hypothetical refernce circuit are entirely homogeneous. Namely, it is distributed to a radio modulator and demodulator section of about 280 km as shown in Table IV-1.

It is necessary to distribute the unweighted noise power of 58.2dB, which is distributed to one base band section, equally into thermal, intermodulation and interference noise as a design object, although some unbalance is unavoidable when considering the manufacturing technique of equipment, difficulty of site selection and economy.

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

3.1 Radio Frequency Band and Radio Frequency Channel Arrangement

Table IV-2 shows an example of a radio frequency channel arrangement and polarization in the 4 GHz band employing a two-frequency plan.

Normal frequency of V polarization is used, in principle. However, the interleaved frequency and H polarization are used at the following sections to satisfy the system quality:

The path of Addis Ababa-MT. Furi and the path of MT. Furi-Sendafa East make angle of 31°, and the path of Karrakorre-Korke and the path of Korke-Dessie make an angle of 76°. These angles are rather small, and so interference caused by front to back antenna coupling is big. In order to reduce this interference, and considering the future expansion of the microwave system and the future plan for the new microwave routes, interleaved frequency is used at the two sections, Addis Ababa-MT. Furi and Korke-Dessie.

Calculation was conducted assuming that the receiver has a selectivity of more than 18 dB between desired wave and an undesired wave which has a frequency difference of 14.5 MHz.

Interferences caused by over-reach propagation at the three sections between MT. Furi and Ancober, between Korke and Mai Ceu North, and between Mai Ceu North and Adigrat West are big. Therefore, H polarization is used at the sections of Shano North-Ancober North, Cobbo North-Mai Ceu North, and Mai Ceu North-Amba Alagi in order to reduce the interference.

3.2 Applied System

The following items have been applied in designing:

a) FDM-FM system operating in the 4 GHz band.
b) Transmission capacity of 960 telephone channels or monochrome TV (color TV in the future) for each radio channel.
c) Transmitter output power of 29.5 dBm.
d) Parabolic antenna with a 4 m diameter is used at all stations.
e) Common transmit-receive antenna is used.
f) Receiver has selectivity of 18 dB between desired wave and undesired wave, which has a frequency difference of 14.5 MHz, in order to avoid interference and false operation of squelching function.
g) The equipment characteristics used in this report are shown in Table IV-3.

3.3 Quality of the Radio Link

The results of calculation using characteristics listed in Table IV-3 are mentioned below:

3.3.1 Addis Ababa - Dessie

The Results are listed in Table IV-4.

a) Addis Ababa - MT. Furi

The interleaved frequencies are used in this section in order to avoid the interference caused by front-to-back antenna coupling because the paths for Addis Ababa-MT.Furi and MT. Furi-Sendafa East make small angle, and also considering the future expansion of the link and the future plan for new microwave routes.

At MT.Furi, transmitting power for Addis Ababa and received power from Addis Ababa are decreased by 9 dB attenuator, in order to reduce the interference caused by the front-to-back antenna coupling, intermodulation noise of microwave receiver and the interference with the Sululta earth station.

b) MT.Furi - Sendafa East

There is no ridge to shield the reflected wave. Therefore, propagation distortion occurs in this section.

In order to reduce the propagation distortion, the antenna at MT.Furi for Sendafa East and antenna at Sendafa East for MT. Furi are orientated for directions different from the direction for the adjoining station by 0.5° up vertically. Accordingly, the direct waves are decreased by 1 dB, ' respectively, but D/U ratio between direct wave and reflected wave is improved enormously by this method.

c) Sendafa East - Shano North

At Shano North, transmitting power to Sendafa East and received power from Sendafa East are decreased by 3 dB attenuator, respectively, in order to reduce the interference caused by front-to-back antenna coupling, and to suppress the received power to within the allowable maximum received power.

d) Shano North - Ancober North

In order to avoid over-reach interference between MT. Furi and Ancober North, H polarization is used in this section.

e) Korke - Dessie

Interleaved frequency is used in this section in order to reduce the large interference caused by front-to-back antenna coupling caused by the paths of Korke-Dessie and Korke-Karrakorre making an angle of 76°, and also for the reason of future expansion of the microwave system.

Line-of-sight is not obtained between Korke and Dessie. Therefore, the reflector relay system is adopted at the Korke-Dessie section. The passive reflector site is located in the suburbs of Dessie city.

It needs 30 m^2 effective area for the reflector as a result of such calculation that the transmission loss of this section including a reflector may be equalized the transmission loss of standard hop distance, but assuming the efficiency of the reflector is 85%.

3.3.2 Dessie - Macalle North

The results incorporating the improvements as mentioned below are listed in Table IV-5.

a) Dessie - Korke

Same as Item 3.3.1 e).

b) Cobbo North - Mai Ceu North

Cross polarization is adopted in this section, because the result of continuous received power recording tests, which were made to confirm the over-reach interference between Korke and Mai Ceu North, is different from the estimated value based upon the map study.

c) Mai Ceu North - Amba Alagi

At Mai Ceu North, transmitting power to Amba Alagi and received power from Amba Alagi are reduced by 12 dB attenuator, in order to reduce interferences caused by the front-to-back antenna coupling and over-reach, and to suppress the received power within the allowable maximum received power.

Moreover, cross polarization is used between Mai Ceu North and Amba Alagi, in order to reduce the over-reach interference between Mai Ceu North and Adigrat West.

3.3.3 Macalle North - Bete Giorgis

The results are listed in Table IV-6. There is no particular problem in each section.

3.3.4 Over-all Circuit Performance

Table IV-7 shows the over-all circuit performance, which is the summary of section 3.3.1-3.3.3. Therein the noise power in the radio link meets the C.C.I.T. Recommendation with a 1 dB margin. It is necessary to take into account the 4 dB thermal noise deterioration which is due to a fading. In the present design, thermal noise improvement owing to the emphasis network (meet to the C.C.I.R. Rec. 405) is applied to cancel the deterioration mentioned above. The larger the transmitting power is, for improvement of thermal noise, the bigger the interference to an earth station in the satellite communication system is. In this case, detailed investigation should be carried out. As to an antenna, it is possible to apply a 3.3 mϕ antenna, if the F-B, F-S and over-reach interference are satisfied. These factors and data are the result of the investigation on the 4 GHz band. Same consideration is applied to the design of 6 GHz (C.C.I.R. Rec. 383-1 and 384-1) systems. The following essential condition is derived from the consideration.

a) 6 GHz band (C.C.I.R. Rec. 383-1)

In view point of a thermal noise comparing 6 GHz with 4 GHz radio system, the antenna gain and noise figure of a receiver are superior. On the contrary, antenna feeder loss and free space loss characteristics are inferior, thus it is necessary to increase transmitting power to compensate for the loss. Also, comparing with the 4 GHz radio system, a 6 GHz system has an advantage in a minimum allowable transmission loss. Then, in case the 4 GHz system has no interference noise problem with the earth station in satellite communication system, the 6 GHz system also has no problem. The directivity of 6 GHz antenna is sharper than that of the 4 GHz one, but, at Asmara, the transmitting power, radiated from the U.S. Armed Forces microwave link, is considerably large. Thus the interference noise to the Addis Ababa-Asmara link is over the specified value. As a conclusion, it is difficult to apply the 6 GHz band.

b) 6 GHz upper band (C.C.I.R. Rec. 384-1)

It is necessary to increase the transmitting power, as well as 6 GHz band, from the view point of thermal noise. For mutual interference from/to the satellite communication system, no trouble will occur because of the other frequency band usage.

Other aspects are the same as the Item a). Considering a) and b) above, the following conclusion obtains.

1) For interference to the satellite communication system, ,even if the minimum allowable transmission loss is satisfied, the 4 GHz band, stable in circuit performance, is most preferable.

2) 6 GHz upper band follows 4 GHz band.

In spite of a large transmitting power, this band has no mutual interference with the satellite communication system.

3.4 Noise Burst Exceeding 1,000,000 pW

In the C.C.I.R. Recommendation, it is recommended that the 2500 Km reference circuit noise power should not exceed 1,000,000 pW unweighted (with an integrating time of 5 mS) for more than 0.01% of any month.

In the C.C.I.T.T. Recommendation, 0.001% is recommended instead of 0.01%. Fading, where the noise power exceeds 1,000,000 pW, occurs in the Rayleigh fading. The occurence probablity is due to the radio frequency, hop distance, transmission path condition and seasonal conditions. In the system design in Ethiopia, the estimation method which was based on a large volume of the experimental data obtained in Japan, was applied since propagation problems in Japan and Ethiopia are much the same. The occurence probability of the Rayleigh fading (Pr) in the worst month is able to be obtained from Figure IV-3. The probability of the noise burst exceeding 1,000,000 pW Pi is calculated by following formula.

P_i: $3\,Pr \cdot N/N_o$
N : thermal noise power
N_o: 1,000,000 pW

Over-all probability of noise burst in modulator-demodulator section (ΣPi) is calculated by adding the probability in each hop algebraically. In case that the noise switching system is applied, over-all probability is reduced to 1/5. The probability of noise burst calculated in each modulator-demodulator section is shown in Table IV-8, 9, 10 and meets the C.C.I.R. Recommendation.

4 Toll Circuit Design

The toll circuit to be constructed between Addis Ababa and Asmara, which provides toll telephone circuit, carrier telegraph circuit and program transmission circuit, is composed of the microwave system mentioned in chapter IV. 2., and carrier system in this chapter. The technical specification on all carrier multiplex terminal equipment is based on C.C.I.T.T. Recommendations.

Although no specification is provided for the rack assembly, it is specified that the Tenderer should propose the system which requires small initial investment but allows easy future expansion. This toll circuit is a main trunk network in Eghiopia, and is expected to be connected with many other cities in the future. Therefore, system design of this circuit is particularly important.

4.1 Design Outline

The final carrier multiplex terminal equipment capacity must meet the demands for traffic after 10 years. As the microwave system between Addis Ababa and Asmara has the capacity of 960 telephone channels, the system design of the carrier multiplex equipment has been based also upon transmission of 960 channels.

However, future expansion at each carrier multiplex station is not necessarily big, no particular specification is provided on the rack assembly and so force to allow for a proposal of small initial investment.

Nevertheless, it is desirable that the carrier supply equipment and the super-group translating equipment can be easily expanded simply by inserting additional panels and/or parts. The initial capacity of terminal equipment is based upon traffic demands in 1974, two years after commencement of service, and, therefore, it is sufficient for a little fluctuations of demand, if any, or for providing spare panels. The VDF, GDF, and SGDF are designed to meet final capacity in order to fulfil the extensions very easily.

The interconnecting point between carrier multiplex terminal equipment side and exchange side is placed at the VDF.

4.2 Toll Telephone Circuit

The Addis Ababa —Asmara toll telephone circuit is capable of providing 960 telephone channels by connection of the microwave system and the cable system as after-mentioned. The noise value of this over-all transmission circuit, including the coaxial cable section, is specified to satisfy the weighted value of 3 LpW in the technical specification. The carrier multiplex equipment is specified to meet related C.C.I.T.T. Recommendation.

The distance of the actual route is approximately one third of hypothetical reference circuit whose distance is 2,500 km, and, therefore, the over-all signal to noise ratio can be maintained at 57.5 dB (weighted).

The typical block diagram of a carrier terminal station is illustrated in Fig. IV-3.

4.3 Program Transmission Circuit

The program transmission circuit is capable of transmitting a broadcasting program of the bandwidth of 50 - 10,000 Hz with use of a carrier transmission circuit in accordance with C.C.I.T.T. Recommendation J-22.

This circuit is accommodated in the frequency band of 84 - 96 KHz, corresponding to three telephone channels, within the same basic group in the carrier transmission circuit, and can be transmitted simultaneously with other nine telephone channels. The technical specification draft specifies the transmission characteristics in accordance with C.C.I.T.T. Recommendation J-21, and interconnection conditions in accordance with same Recommendation J-13. The input/output ends of the equipment should be extended up to GDF installed in the carrier multiplex equipment room, and, because of uncertainty of the line characteristics at the broadcasting station side, no particular consideration is paid to level adjustment between equipment and cable section.

4.4 Voice Frequency Carrier Telegraph Circuit (VFT)

This circuit, which is able to transmit 24 telegraph channels by means of frequency shift system, occupies from 300 Hz to 3,400 Hz of the 4-wire telephone circuit.

The frequency interval between telegraph channels is maintained at 120 Hz, and the characteristics are specified in the technical specification draft in accordance with relevant C.C.I.T.T. Recommendations. IBTE has agreed that the fundamental equipment such as VDF shall have final capacity of 1984 from the biginning, but it is specified in the draft that the jack board shall have the capacity of 200 % of the initial installations. Since only the required VFT system number is indicated in the traffic data given by IBTE and no actually required VFT channels are indicated, it is assumed in the specification draft that all the VFT systems may have fully-mounted 24 channels.

Therefore, when the number of actually required telegraph channels are clarified, they should be indicated in the network plan.

4.5 Circuit Arrangement in Terminal Stations

The channel allocation in 1974, and 1984 is illustrated in Fig. IV-4.

Regardless of the number of channels, all channels are bundled in one group separately for each opposite station, and all groups are bundled in one super-group separately for each opposite carrier terminal station.

Therefore, at the pass-through carrier terminal stations, all connections are made at SG through filter. This arrangement is different from the conclusion of the meeting with IBTE that SG-connection is used in stations for more than 30 channels and G-connection for less than 30 channels at the stage of 1974. At Dessie and Macalle stations between Addis Ababa - Asmara circuit, SG-connections are used. This is because re-investigation has showed that, although SG connection at each terminal station can be saved on account of small channel numbers toward opposite station, the G-translating equipment and group through-filter are required additionally at pass-through carrier terminal stations which results in more equipment and bad economy.

Furthermore, future expansion of the system requires some troublesome changes in the arrangement, being followed by troublesome maintenance, and the transmission quality cannot be maintained satisfactory.

5 Cable Systems Design

The cable systems in this section are used as a part of the toll circuit between Addis Ababa and Asmara comprising microwave system and carrier multiplex system. That is, the coaxial cables are laid between the radio terminal station and the carrier terminal station, and the toll cables are laid between the carrier terminal station and the telephone office, as entrance facilities.

The requisite ducts and manholes for cable systems are to be furnished by IBTE.

5.1 Design Outline

5.1.1 Asmara

In Asmara, an 8 tube, 9.5 mm coaxial cable is laid between the radio terminal station constructed in Bete Giorgis, and the carrier terminal station which is settled in Asmara telephone office. This cable handles the Addis Ababa - Asmara telephone circuit, television links, and future planning circuits for Asmara-Gondar, Asmara-Tessenei, and others.

The cable route map is illustrated in Fig. IV-5.

The existing 4-tube small diameter coaxial cable is in this section at present. Two tubes are used for the 2 GHz system toll circuit between Asmara and Massaua.

The remaining two tubes are provided for spare route when new cable fails. Therefore, the maintenance work required of these tubes is that the characteristics be satisfactory to transmit 960 telephone channels which is new cable system construction work.

Particularly, note that the cable distance is 4.67 km, in general, which exceeds the standard distance of 3 or 4 km.

Therefore, it is necessary to provide a terminal repeater designed to meet the purpose, or to insert an intermediate repeater.

The new cable route is quite different from that of the existing cable, and, when new cable failures occur, existing cable is used for spare cable immediately by manual switching.

5.1.2 Macalle

In Macalle, 0.65 mm/54 pr toll cable is laid between the radio and carrier multiplex terminal station which is to be constructed in Macalle North, and the Macalle telephone office. This cable carries toll circuits between the route of Addis Ababa-Asmara and Macalle. It will, at first, be used as the voice cable system. It will later be changed into the short-haul carrier system.

The installation of new cable is so arranged that it will be buried under-ground up to a distance of 140 m from the telephone office. In other sections, it will be supported on existing poles used for existing cables for the open-wire system. IBTE has investigated the strength of these poles to determine whether the additional stress of supporting the new cable can be withstood.

The cable route map is illustrated in Fig. IV-6.

The new cable is used as loaded cable which is connected with terminal equipment in Macalle North radio and carrier multiplex terminal station through the conversion of 2-wires into 4-wires. It is composed of phantom and side circuits, so that the 54 pr capacity is sufficient to satisfy traffic demands until automatic exchange equipment is installed in the Macalle telephone office.

All cable end pairs are connected to the VDF in both terminal station and telephone office.

5.2 Coaxial Cable System

The coaxial cable systems to be constructed between Bete Giorgis radio terminal station and Asmara telephone office will be used as entrance cable for the Addis Ababa - Asmara microwave links.

The coaxial cable systems combined with microwave link and carrier multiplex equipments shall be capable of transmitting both 960 multichannel and a color television signal in the future. Therefore, it's characteristics shall comply with C.C.I.T.T. Recommendations and C.C.I.R. Recommendations as mentioned in the technical specifications draft.

(a) The coaxial cable systems involve both 9.5 mm and 4.4 mm coaxial cables. The standard distance in C.C.I.T.T. Recommendations is 9 km using 9.5 mm oaxial cable, and 4 or 3 km using 4.4 mm coaxial cable.

The distance between Bete Giorgis radio terminal station and Asmara telephone office is approximately 5.7 km. Therefore if 4.4 mm coaxial cable is used, the distance is exceeded, making it necessary to provide an intermediate repeater for transmitting color television signal. In this connection, 9.5 mm coaxial cable shall be installed after due consideration of maintenance and transmission performance requirements.

(b) It is necessary that the new cables be capable of transmitting 960 telephone channels and a color television signal (PAL system). To transmit a color television signal, the factory length and the characteristics of the repeater section are prescribed in technical specifications draft because the terminal equipment for color television signal is not installed, so it is impossible to confirm transmitting characteristics of television signal.

The weighted noise value shall not exceed 3 LpW for the total distance of the microwave link and the coaxial cable sections. The value shall not be divided separately per each coaxial cable section.

(c) In arranging the coaxial cable route, from structures of cable, it is necessary to prevent deterioration of characteristics due to any tension, shock or vibration, to consider expansion and contraction due to temperature variation, as well as displacement of cables. Especially, in consideration of buried cables when they are laid, it is desirable that all cable be installed along or in ducts or conduits to protect them from the forces of bending and tension.

(d) The 960 channels transmission by existing 4.4 mm small coaxial cable shall be possible when a special terminal equipment compensating for a large section is provided, and when the intermediate repeater is not expected. In this case, noise will inevitably increase.

(e) The total interstitial quad related to the construction of coaxial cable shall be decided in consideration of the supervising and control signals necessary for the supervised station of microwave link, and the alarm signals necessary for maintenance of coaxial cable system, in accordance with the microwave system designed by the survey teams.

There are a total of 19 interstitial coaxial cable pairs. However, the number of pairs shall be decided by each tenderer, since they are dependent upon the composition of supervising signals, the cable structure etc.

5.3 Voice Cable System

The voice cable system is used as entrance cable between Macalle North radio and carrier multiplex terminal station and Macalle telephone office. This system uses a loaded cable system whose coil spacing is 1 km. At a future period, in order to obtain high transmission qualities, this section is intended to be changed into a short-haul carrier system or other identical system.

(a) In Ethiopia, the toll zone system, network planning and transmission engineering standards are presently being prepared. It is desirable that the transmission loss of basic trunk between (Asmara) District Center and (Macalle) Zone Center not exceed the limit of 5 dB in the constitution illustrated in Fig. IV-7. At present, the installation of a loaded cable system between Macalle North radio and carrier multiplex terminal station and Macalle telephone office, cannot be avoided because of planning uncertainty concerning the Macalle telephone office building. When the new telephone office building is constructed and the automatic telephone exchange equipment is provided in this new building, and when this system is changed into a carrier system, the transmission loss will be greatly improved. 0.65 mm toll cable and repeater will maintain the transmission loss performance between Macalle radio and carrier multiplex terminal station and Macalle telephone office.

(b) In the Macalle area, the first telephone service will use operator's dial. After five or ten years, service will be changed into non-delay service. The change of loaded system into carrier system will be performed at this time. Therefore, the loaded cable capacity is 54 pairs, taking into account the side and phantom circuits, which satisfies demands for approximately 70 circuits, forcast after about ten years from the time service opens.

Polyethylene insulated cable is employed to allow changing carrier system.

(c) In Macalle radio and carrier multiplex terminal station, the amplifiers are required to compensate for attenuation due to 2-wire into 4-wire conversion, and cable loss.

(d) In Macalle radio and carrier multiplex terminal station and Macalle telephone office, signalling equipment are required for side and phantom circuit constitution.

6 Power System Design

The present section deals with the design of a power supply system and of various kinds of equipments which supply continuous power to the radio equipment, carrier multiplex equipment, etc. of the terminal and repeater stations.

6.1 Basic Condition

(a) The design deals with all the other stations except the Addis Ababa, Dessie and Asmara stations.

(b) Fully solid state equipments are applied to the radio and carrier multiplex stations, therefore the required final (1984) power capacity is not much different from the initial (1974) one.

Therefore, the design is based on the final capacity.

(c) In practice, the capacity of the power supply system should be sufficient to supply the power for the load, that is, 120% of the final capacity of the communication load and 100% of the non-essential needs. In addition, an AC power supply system (220 V, 2 KVA) should be furnished, which is required for lighting in a station building, measuring equipment and heating etc. for a patrol team. An AC power supply system in terminal station should be designed in compliance with the situation of the station.

(d) The power system in the Addis Ababa, Dessie and Asmara stations is to be designed and constructed by IBTE, including the wiring of power cables between a power equipment room and radio or a carrier multiplex equipment room, and also including the wiring of an earth line.

(e) The wiring of commercial power cables as far as an integrating watt meter and an oil circuit breaker (OCB), required at Bete Giorgis only, should be performed by IBTE.

(f) A "duct" is applied to the wiring in the power equipment room and a "Rack" is applied to the wiring in the radio and carrier multiplex equipment room.

6.2 Design Condition

6.2.1 Power Source and Allowable Voltage Limit

The following two kinds of power source are required by the equipment, and the allowable voltage limit at the input end of the equipment is shown in Table IV-11.

Table IV-11 Power Source and Allowable Voltage Limit

Power Source	Allowable Voltage Limit
DC -24V	within 24V ± 10%
AC 220V	within 220V ± 5%

6.2.2 Power Consumption

The quantity of power consumption should be estimated based on the network plan and the circuit demand in 1984, in accordance with the situation of the station and the sort of power source. In this estimation, power is consumed by the radio equipment, the carrier multiplex equipment, terminal equipment for cable and by the other facilities.

It is necessary to provide some excess power to meet any change of the power consumption plan.

6.3 System Design

Two types of power supply system are designed, as shown in Table IV-12, one is for stations where commercial power is available, and the other is for stations where commercial power is unavailable.

Table IV-12 Power Supply System

Commercial Power	Power Supply
Available	EG(1) + RF + Batt.
Unavailable	EG(2) + RF + Batt.

Note:

EG ; Engine generator
RF ; Rectifier
Batt ; Battery
( ) ; Number of engine generators

6.3.1 EG(1) + RF + Batt. System

This power system is applied to the station with available commercial power.

As shown in Fig. IV-8, it consists of one diesel engine generator with automatic switchover function, rectifiers, batteries. Under normal conditions, commercial power is supplied to a rectifier and converted to DC power. The output is supplied to the communication load and also to the batteries to float in constant-voltage. In case the commercial power fails, the AC power source is switched to and is supplied from the engine generator.

When both the engine and commercial power fail to operate in sequence, the batteries supply the DC power directly to the load. To deal with the above mentioned emergency, a mobile power supply system, described in 6. 5, should be prepared.

6. 3. 2 EG(2) + RF + Batt. System

This power system is applied to the station where commercial power is unavailable. As shown in Fig. IV-9, one more engine generator is set up as a substitute for the commercial power. These two engine generators are operated to supply the AC power alternately for certain periods of time.

The system organization, except for the engine generators, is quite the same as that of the EG(1) + RF + Batt. system.

6. 4 Equipment Design

6. 4. 1 Engine Generator

The present equipment is operated to supply AC power to the communication load. It consists of a diesel engine generator with starting cell-motor, control and automatic switch-over function.

In the station with available commercial power, when commercial power fails, the diesel engine generator starts automatically and supplies power to the load in place of the commercial power. When the commercial power is restored, the engine generator is stopped and is substituted for with commercial power automatically. The switch-over is also able to be operated manually.

In the station where commercial power is unavilable, the AC power is supplied by only two engine generators. Therefore these should have high reliability.

(a) Engine generator capacity

To specify engine generator capacity, in addition to the communication power load prescribed in 6. 2. 2, it is necessary to take into account the following loads.

(1) Rectifier
(2) Automatic ventilator in the power equipment room
(3) Fuel feeding equipment
(4) Rectifier for battery charge
(5) Dehydrator
(6) Power for measuring equipment
(7) Lighting of the station
(8) Other needs ..... in an unattended station, the power for heating and cooking for patrol personnel has to be provided.

Also, it is necessary to take into account the effects of temperature and altitude condition of the station, and to compensate for them when furnishing the power capacity.

6.4.2 Rectifier

Terminal voltage of batteries in a full-floating system, which consists of a rectifier and batteries, is greatly changed according to the battery's situation, that is, charging, floating and discharging. Therefore, it is necessary to provide some device to control the output voltage of batteries, between batteries and a load. This rectifier is designed to be applied in a full-floating, constant voltage system using commercial power of three phase, 220/380 V, 50 cycle per second, and provides AC-DC conversion. Output DC power is supplied to the batteries to float or charge. Simultaneously, it is supplied to the load in DC - 24V through a load voltage compensation circuit. Therefore, load voltage is maintained at DC - 24V by regulating the change of input voltage and output voltage. A rectifier should provide capacity enough for the total load current in the final year (1984).

In the power system, two rectifiers are set up. Each of them should have sufficient capacity to float and charge batteries by itself.

6.4.3 Battery

The role of batteries in a full floating system, combination of batteries and a rectifier, is very important. The batteries also function as an emergency power source. It means that, when neither commercial power nor engine generator is operated, power for a load is supplied directly from batteries. In normal conditions, batteries are connected to the load in parallel and kept in floating condition.

(a) Voltage holding time

In discharging, the terminal voltage of the batteries goes down to a specified voltage (discharge final voltage) after a certain period of time. This time is called "voltage holding time".

In the selection of the voltage holding time, it is necessary to take into account the time to go to the station, to repair faults and to adjust characteristics. Frequency of equipment faults and a possible disaster should be taken into consideration. In the present design, the voltage holding time is specified as follows, as request by IBTE.

(1)	Unattended station	10 hours
(2)	Attended station	3 hours

(b) Battery capacity

Battery capacity is based on the following formula.

$$\text{Required battery capacity (AH)} = \frac{t}{PN\theta}\ I$$

where :

t: voltage holding time

p: deduction coefficient of capacity

Nominal capacity of the battery is, generally speaking, the capacity taken out of the battery

when it is discharged at a ten-hour -rate current.
The "deduction co-efficient of capacity" is the capacity when it is discharged at a N-hour-rate current against the nominal capacity. Namely, as N becomes smaller than ten, the capacity taken out of the battery becomes smaller.

N: deduction coefficient of capacity due to age

Battery capacity deteriorates through the years. Therefore, it is necessary to take the deterioration into account. In a full floating system, N is equal to one under the assumption of no deterioration.

θ: deduction coefficent of capacity due to temperature

As battery capacity is affected by temperature, it is necessary to compensate the capacity. The value of in 25 degree centigrade is defined as one.

I: load current (designed battery current)

6.4.4 Auxiliary Equipments

(a) Automatic Ventilator

The upper limit of temperature is specified for power equipments operating at a specified current or specified capacity. To operate the equipment in higher temperature than the specified one results in reduction of life time.

Operation over the specified temperature for hours causes deterioration, overheating, breakdown and so on. Therefore, it is necessary to set up a ventilator to keep the room temperature below the specified value which is decided based on the heat radiated by the equipments.

(b) Fuel feeding equipment

The fuel feeding equipment transfers oil from an underground fuel storage tank system to the engine. It consists of a fuel pump and a fuel service tank.

A fuel pump transfers fuel from the underground fuel storage tank system to the fuel service tank, and should be operated automatically and manually.

A fuel service tank feeds fuel to the engine using gravity. Therefore it is set up at a higher position than the engine.

(c) Underground fuel storage tank

A underground fuel storage tank is set up under the ground

in which to store the engine fuel. Storage capacity of the tank is decided according to the engine capacity and the location of the station. In the unattended station where commercial power is unavailable, a patrol team is dispatched there every 90 days. Therefore it is reasonable to choose a storage capacity which insures operation for 120 days continuously.

6.5 Emergency Power Vehicle

An emergency power vehicle is dispatched to the unattended station and acts as an emergency power source in case of engine emergency or engine overhaul.

It is loaded on a gasoline engine or diesel engine vehicle. Generator capacity should be specified to be capable to furnish the maximum capacity of the maintenance area in question. In the present plan, four emergency power vehicles are to be provided and arranged in each maintenance station.

6.6 Earthing

To prevent an accident involving lightning strikes and fire due to power system emergency, it is necessary to install an earth circuit for lightning protection and security of equipment. Also it is necessary to install an earth for the communication circuit. Here, a part of the communication circuit is earthed for use as a return circuit. An earth resistance is specified based on Table IV-13.

Table IV-13 Earth Resistance

Usage	Earth Resistance (Ω)
For Power	Less than 100
For Protection Lightning	Less than 10
For Communication Circuit	Less than 10

6.7 Report to be Presented

At the time of tender, IBTE will require the Tenderer to submit the design condition and the foundation of calculation on the following items, and will judge their suitability.

(a) Estimation of power consumption in 1974 and 1984
(b) Outline of maintenance and operation, periodic maintenance program
(c) Capacity and foundation of capacity calculation engine generator, battery, rectifier, underground fuel storage tank
(d) Countermeasures to extend a maintenance period in a high altitude station

7 Building, Tower, Earthing, and Fuel Storage Tank Design

7.1 Design Outline

IBTE shall perform to ensure the site and access road, and to design and to install the station building, and install the tower foundation. Also, for the unification for civil-engineering works, it is preferable that IBTE shall carry out earthing and fuel storage tank installing below ground-level. The Contractor, therefore, shall submit these requirements to IBTE within two months as specified in the technical specification.

7.2 Design Conditions

7.2.1 Site

(a) The site area for unattended repeater station is determined by relative locations between the station building, tower and fuel storage tank. That is, experimentally, it is desirable that the site area be approximately 1,500 m^2, and that its shape be square or rectangular.

(b) The site, if necessary, shall be flattened.

(c) In a prevailing strong wind area, the station building location shall take into considerations that the ventilation for the power supply room and equipment room shall not be affected by wind, and that the rain or moisture shall not penetrate into the power supply and equipment rooms through the ventilation ducts.

(d) The relative location between building and tower is important, in order to reduce to a minimum length the waveguides which shall connect the antenna and the transmitting-receiving equipment. This waveguide must be as short and straight as possible.

If the site mentioned in (a) above can not be obtained due to geographical condition restriction, the relative locations between any objects shall be decided by items (c) and (d) on a restricted site.

7.2.2 Station Building

(a) The equipment room and business room areas shall satisfy future demands after ten years.

(b) When the power supply room and the equipment room are on the same level, some protections shall be provided to isolate vibration while operating the engine.

(c) Partitions between the equipment room and other rooms shall be provided which will completely shield the equipment room from any kind of dust.

(d) The average value of floor load on the equipment room shall be 1 t/m^2, on the condition that the equipment are installed back-to-back.

(e) For wave-guide arrangement, wiring and cable support and maintenance, the height of equipment room and power supply room shall be more than 3.5 m from girder to floor.

7.2.3 Tower

(a) The total amount of antennas as a load on the tower shall be determined to satisfy future demand after fifteen years.

(b) The tower and the tower foundation shall be designed to withstand instantaneous wind velocity of 55 m/sec.

(c) The soil bearing force in the site shall be investigated by IBTE, and this data shall be given to the Contractor for use in the tower foundation design.

7.2.4 Earthing

The standard earthing resistance shall not exceed the limits in Table IV-13 specified in Section 6. However, if it is impossible in practice to obtain the preceding values, the common earthing with both protective and functional earth connected together may be used for a particular station.

7.3 Outline of each Station involving Planning Route

7.3.1 Addis Ababa

(a) A new toll telephone office, consisting of radio and carrier multiplex room, toll exchange room, power room and tower, is constructed at the old Head Quarter premise, and radio and carrier multiplex equipment, toll telephone exchanges and power plant are accommodated in this office.

In this radio and carrier multiplex terminal station are provided a control room to remote supervise and control unattended repeater stations, a maintenance center and an office.

(b) The power plant required for this office shall be designed and installed by IBTE under a separate contract.

(c) Equipment, including future planning, installed in the radio and carrier multiplex terminal station, are as follows:

(1)	Addis Ababa - Asmara	960 ch, TV 1 way
(2)	Addis Ababa - Gimma	600 ch
(3)	Addis Ababa - Dire Daua	600 ch
(4)	Addis Ababa - Shashamene	600 ch
(5)	Addis Ababa - Gondar	2 GHz, 1 system
(6)	Other additional equipment or devices	

(d) The tower shall be to be so designed that one antenna, exclusive of the planning route mentioned in (c) above, shall be taken into account as spare.

7.3.2 Dessie

(a) The new building for both radio and carrier terminal station, which contains rooms for radio equipment, carrier multiplex equipment, and control room for supervision of some unattended stations, and maintenance center, shall be constructed on the existing telephone office site.

(b) The business room and others shall be obtained from the existing telephone office building.

(c) The anchor bolts for a 5 m high tower, which shall be constructed on the new building, shall be installed by IBTE.

(d) The design and installation of power supply equipment which shall be installed in the power supply room of the existing telephone office building, shall be otherwise performed by IBTE.

7.3.3 Macalle

(a) The new building for the radio and carrier multiplex terminal station contains room for radio and carrier multiplex equipment and business, and control room for supervision of unattended stations and maintenance center, and the new tower, shall be constructed in Macalle North. The terminal equipment for cables connected with the Macalle telephone office shall be installed in the new building.

(b) The terminal equipment for cables connected with that station above, shall be installed in the telephone exchange room of the existing telephone office building.

7.3.4 Asmara

(a) The new building for the radio terminal station contains room for radio equipment and power supply equipment, and the new tower, shall be constructed in the site of the existing Bete Giorgis radio station. This radio station shall be designed as an unattended station. The maintenance station shall be provided in Asmara telephone office.

(b) The existing building of the Asmara telephone office shall be used as the carrier multiplex terminal station. Carrier multiplex equipment room, control room for supervision of some unattended stations, maintenance center, and business room shall be obtained here.

(c) Equipment, both present and future, installed in the radio terminal station and the carrier multiplex terminal station are as follows:

(1)	Asmara - Addis Ababa	960 ch, TV 1 way
(2)	Asmara - Massawa	120 ch 2 GHz, 1 system
(3)	Asmara - Tessenei	VHF-24, 2 system
(4)	Other additional equipment or devices	

(d) The design and the installation of power supply equipment for the carrier multiplex terminal station, and for work to bring in commercial power supply for the radio terminal station, shall be otherwise performed by IBTE.

(e) The tower shall be designed in accordance with (c) above.

(f) Existing equipment of Asmara - Massaua route, 2 GHz system will be moved to the new building in the future.

7.3.5 Relay Station and Branching Station

Two branching stations, Mt. Furi and Korke, and other repeater stations shall have new buildings constructed containing radio equipment room and power supply room, as well as a new tower.

7.4 Site Drawing

The location of station building, tower, and other objects on the site of any station is illustrated in Fig. III-35 to Fig. III-66.

7.5 Equipment Layout

The location of equipment in rooms of any station is illustrated in Fig. IV-10 to Fig. IV-16.

7.6 Documents offer from Bidder at Tender

IBTE shall require documents including designing conditions and designing drawings, as follows, and check compliance:

(a) IBTE requires equipment installation drawings for all stations, and shall check these arrangement as required.

(b) IBTE require documents including tower design drawing and tower strength calculations for any particular station indicated by IBTE, and shall check these documents as required.

Fig. IV-1 Hypothetical Reference Circuit

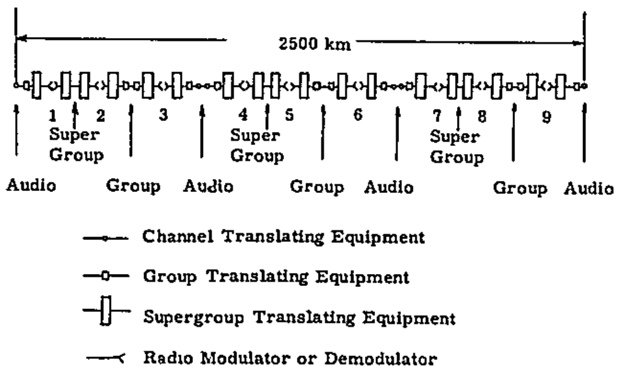


Table IV-1 Noise Distribution

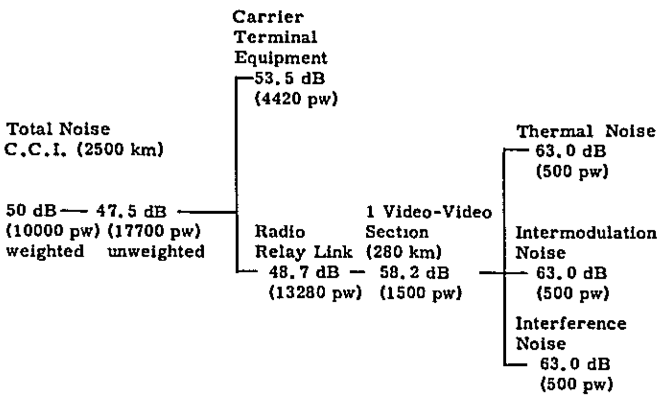
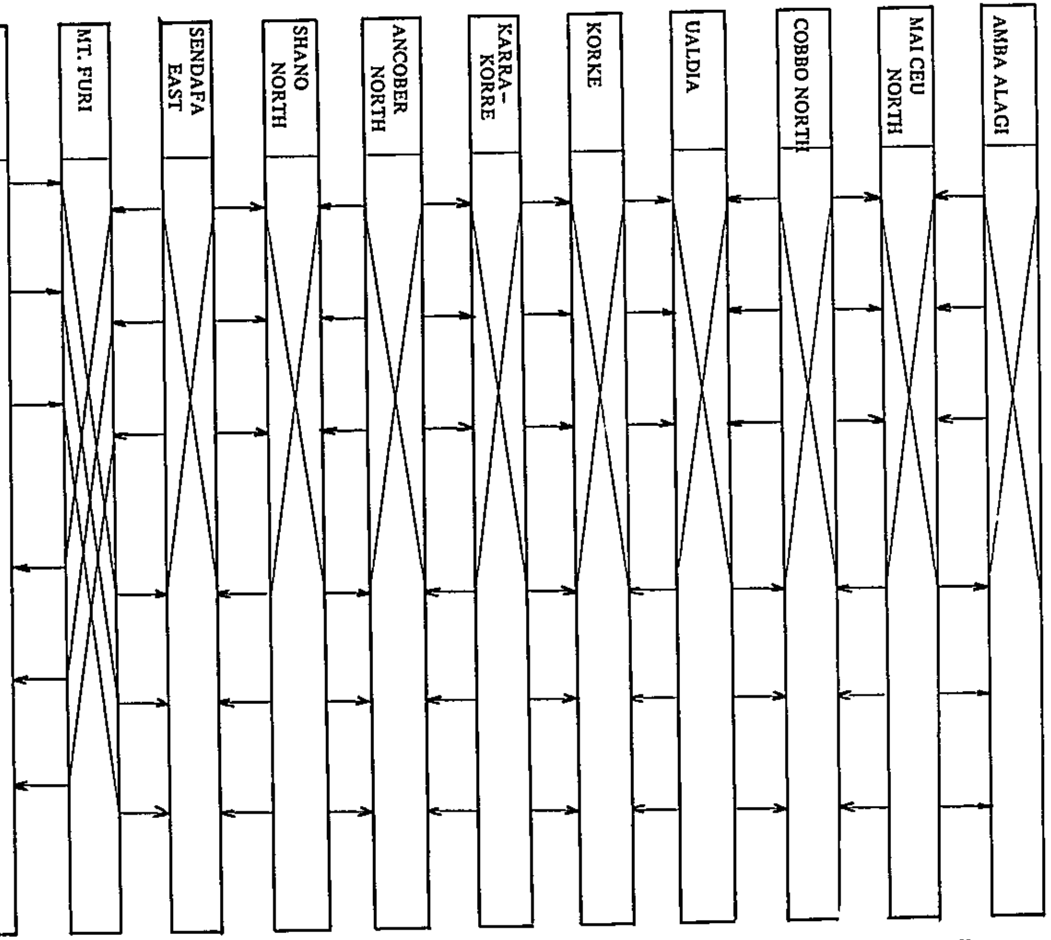


Table IV-2 Radio-Channel Frequency Arrangement & Polarization (4GHz band C.C.I.R.Rec. 382)

Frequency	Channel No.		ADDIS ABABA
3810	1.1		SP
3824.5		1	
3839	1.2		
3853.5		2	TV
3868	1.3		
3882.5		3	
3897	1.4		
3911 5		4	
3926	1.5		TP-1
3940.5		5	
3955	1 6		
3969.5		6	
4023	1.1'		SP
4037.5		1'	
4052	1.2'		
4066.5		2'	
4081	1.3'		TV
4095.5		3'	
4110	1.4		
4124.5		4'	
4139	1.5'		TP-1
4153.5		5'	
4168	1.6'		
4182.5		6'	



Polarization: V V V H V V V V H H

Table IV-2 Radio-Channel Frequency Arrangement & Polarization (4GHz band C.C.I.R. Rec. 382)

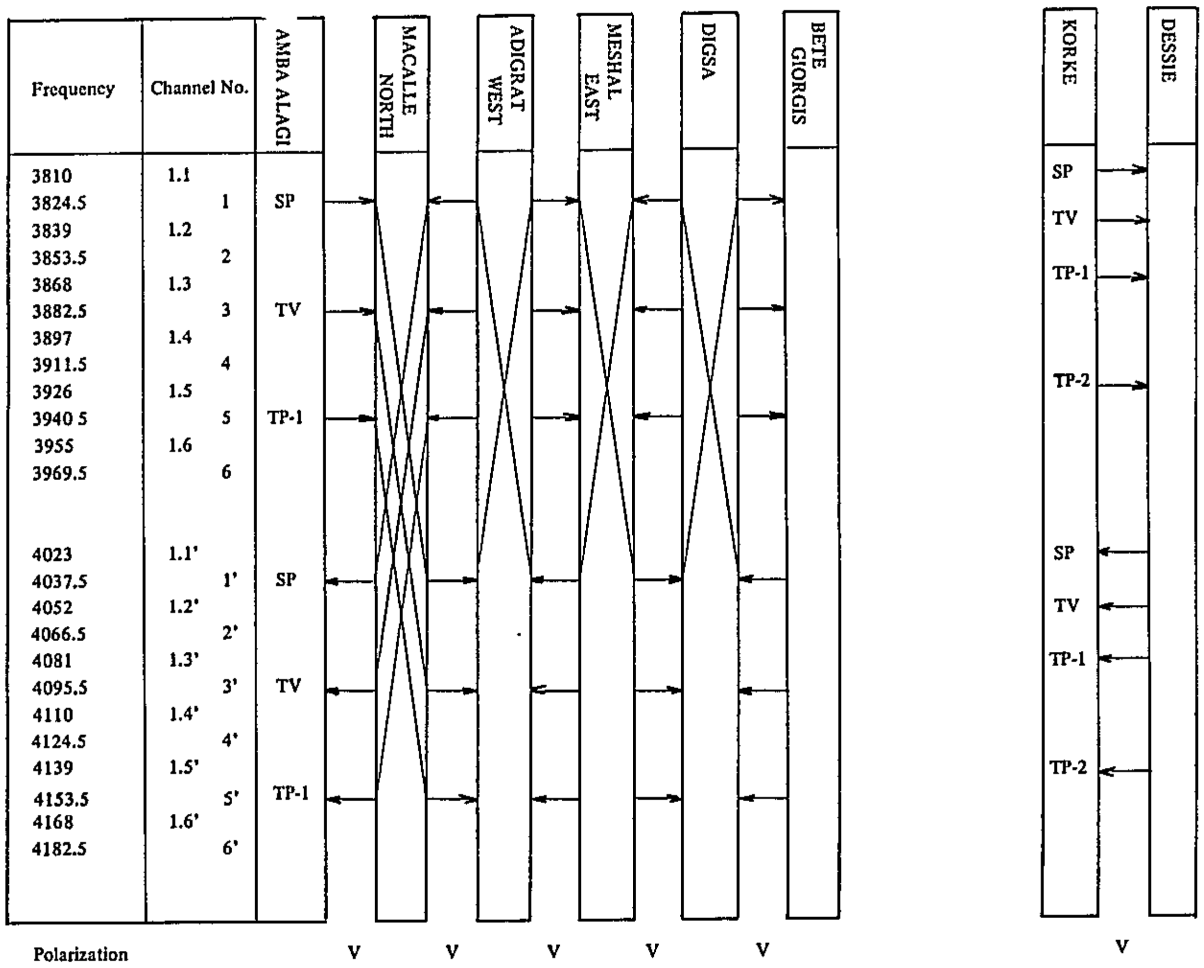


Table IV-3 Applied Characteristics

4 GHz band Transmitter-Receiver	
Transmission capacity	960 telephone channel or 1 TV.
Transmitter output power	29.5 dBm
Noise figure	6.7 dB
Nominal input level	-34.8 dBm
SQL operation point	-76~-80 dBm
Allowable maximum received power	-30 dBm
Modulator & Demodulator	
Thermal noise	30 pw / Modulater-Demodulator
Auxiliary equipment	
Thermal noise	45 pw / 1 video section
Antenna (Parabolic Antenna)	
Antenna gain (4 mø)	42 dB
Front-to-back coupling	More than 63 dB
Feeder (Elliptical Wave Guide)	
Loss per unit length	0.035 dB / m
V.S.W.R.	Less than 1.1
Branching filter	
Branching band loss	0.7 dB
Pass band loss	0.5 dB
Pass loss of Isolator	0.4 dB
Pass loss of Circulator	0.2 dB

Table IV-4 Addis Ababa - Dessie (346.5 km) (4 GHz 960 CH)

Section	Thermal Noise		Inter-modulation Noise	Interference Noise					
	Repeater	Other	2 nd 3 rd	Feeder Echo	Propagation Distortion	F/B	Over Reach	F/S	Other
	pw	pw	pw	pw	pw	pw	pw	pw	pw
ADDIS ABABA – MT.FURI	32.4	N=1 75	n=7 578	9.9	0.4	28.2/100	0/0	0/0	
MT.FURI – SENDAFA EAST	61.7			11.0	126	31.5/77.1	0/1.3	0/0	
SENDAFA EAST – SHANO NORTH	26.3			6.9	0	10.3/18.5	0/0	0/0	
SHANO NORTH – ANCOBER NORTH	39.8			9.9	1.6	7.3/53.9	0.6/0	0/0	
ANCOBER NORTH – KARRA-KORRE	117.5			9.6	33.1	21.5/50.6	0/0	0/0	
KARRA-KORRE – KORKE	91.2			11.0	106.0	27.2/22.5	0/0	112/12.6	
KORKE – DESSIE	38.0			11.0	0	0/0	0/0	12.6/14.1	
Sub Total (pw)	406.9	75	578	69.3	267.1	126.0/322.6	0.6/1.3	124.6/26.7	
Total (pw)	481.9		578	588.6/687.0					
Section Total(pw)	1,648.5/1,746.9								

Note-1: C.C.I.R. Recommendation (unweighted) 3L pw; 1848.5 pw

2: Down ward / Up ward

Table IV-5 Dessie - Macalle North (274.5 km) (4 GHz 960 CH)

Section	Thermal Noise		Inter-modulation Noise	Interference Noise					
	Repeater	Other	2nd 3rd	Feeder Echo	Propagation Distortion	F/B	Over Reach	F/S	Other
	pw	pw	pw	pw	pw	pw	pw	pw	pw
DESSIE – KORKE	38.0			11.0	0	0/0	0/0	0.8/0.4	
KORKE – UALDIA	63.1			11.0	0	53.0/16.0	0/1.6	0.4/2.4	
UALDIA – COBBO NORTH	20.9	N=1 75	n=6 500	11.0	0	10.6/10.3	0/0	0/0	
COBBO NORTH – MAI CEU NORTH	58.9			11.0	7.1	5.7/45.0	3.1/0	0/0	
MAI CEU NORTH – AMBA ALAGI	39.8			5.5	0	91.5/5.7	0/0.7	0/0	
AMBA ALAGI – MACALLE NORTH	52.5			11.0	0	17.0/5.0	0/0	0/0	
Sub Total(pw)	273.2	75	500	60.5	7.1	127.8/82.0	3.1/2.3	1.2/2.8	
Total (pw)	348.2		500		249.7/154.7				
Section Total(pw)	1,097.9/1,002.9								

Note-1: C.C.I.R. Recommendation (unweighted) 3L pw; 1464.4 pw

2 Down ward / Up ward

Table IV-6 Macalle North - Bete Giorgis (211.0 km) (4 GHz 960 CH)

Section	Thermal Noise		Inter-modulation Noise	Interference Noise					
	Repeater	Other	2nd 3rd	Feeder Echo	Propagation Distortion	F/B	Over Reach	F/S	Other
	pw	pw	pw	pw	pw	pw	pw	pw	pw
MACALLE NORTH – ADIGRAT WEST	72.4			11.0	0	62.5/27.4	34.0/0	0/0	
ADIGRAT WEST – MESHAL EAST	20.4	N=1 75	n=4 359	11.0	5.4	19.5/9.4	0/0.2	0/0	
MESHAL EAST – DIGSA	22.4			11.0	0	17.3/22.4	0/0	0/0	
DIGSA – BETE GIORGIS	28.4			11.0	0	5.0/20.4	0.3/0	0/0	
Sub Total(pw)	143.6	75	359	44.0	5.4	104.3/79.6	34.3/0.2	0/0	
Total(pw)	218.6		359	188.0/129.2					
Section Total(pw)	765.6/706.8								

Note-1: C.C.I.R. Recommendation (unweighted) 3L pw; 1125.7 pw

2: Down ward / Up ward

Table IV-7 Over-All Circuit Performance

Item \ Section		Addis Ababa-Dessie	Dessie-Macalle North	Macalle North-Bete Giorgis	Total
Distance of Video Section (km)		346.5	274.5	211.0	832.0
Nomber of Hops		7	6	4	16
Noise Power in Radio Section (Unweighted)	Thermal Noise (pW)	481.9	348.2	218.6	1,048.7
	Distortion Noise (pW)	578.0	500.0	359.0	1,437.0
	Interference Noise (pW)	588.6 / 687.0	249.7 / 154.7	188.0 / 129.2	1,026.3 / 970.9
	Total (pW)	1,648.5 / 1,746.9	1,097.9 / 1,002.9	765.6 / 706.8	3,512.0 / 3,456.6
	Specified Value (pW)	1,848.6	1,464.4	1,125.7	4,438.6

Note. $\frac{\text{Upward Circuit}}{\text{Down ward Circuit}}$

Fig. IV-2 Occurrence Probability of Rayleigh Fading

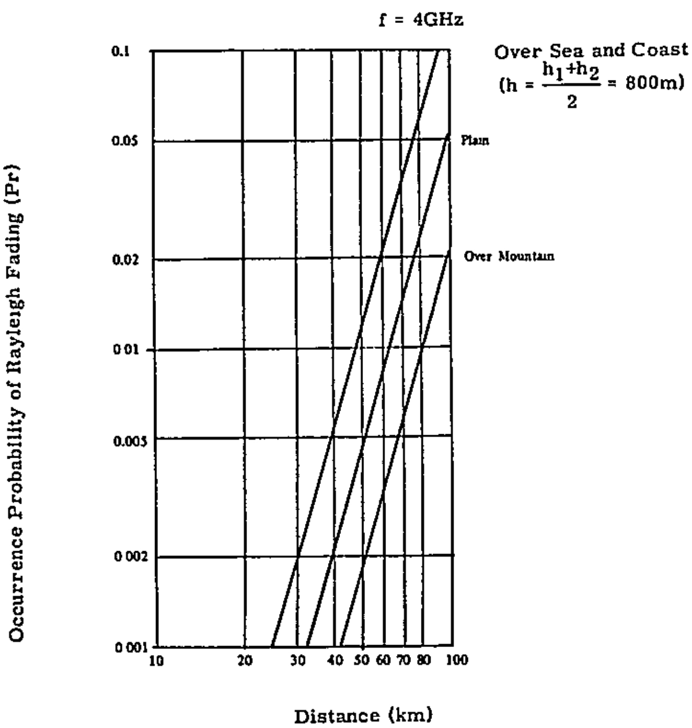


Table IV-8 Addis Ababa - Dessie Section (346.5 km)

(Frequency. 4 GHz)

Station / Item	Addis Ababa	Mt. Furi	Sendafa East	Shano North	Ancober North	Karrakorre	Korke	Dessie
Propagation Path	Plain	Plain	Plain	Plain	Over Mountain	Over Sea	Over Mountain	
Propagation path-height (m) (in case of over-sea)						845		
Hop Distance (km)	17	57	33	53	89	87	10.5	
Thermal Noise (pw)	32.4	61.7	26.3	39.8	117.5	91.2	38.0	
Occurrence probability of rayleigh fading (Pr)	1.03×10^{-4}	7.14×10^{-3}	1.05×10^{-3}	5.53×10^{-2}	1.36×10^{-2}	7.77×10^{-2}	7.66×10^{-6}	
Probability of Noise Burst Exceeding 1,000,000 pw (Pi)	1.0×10^{-8}	1.3×10^{-6}	8.3×10^{-8}	6.6×10^{-7}	4.8×10^{-6}	2.12×10^{-5}	8.73×10^{-10}	
Total of Pi in One Section	2.81×10^{-5}							
Ditto (including the noise switching effect)	(Improvement factor 1/5) 5.62×10^{-6}							
C.C.I.R. Recommendation (0.01%)	$4L \times 10^{-8}$: 1.39×10^{-5}							

Table IV-9 Dessie - Macalle North Section (274.5 km)

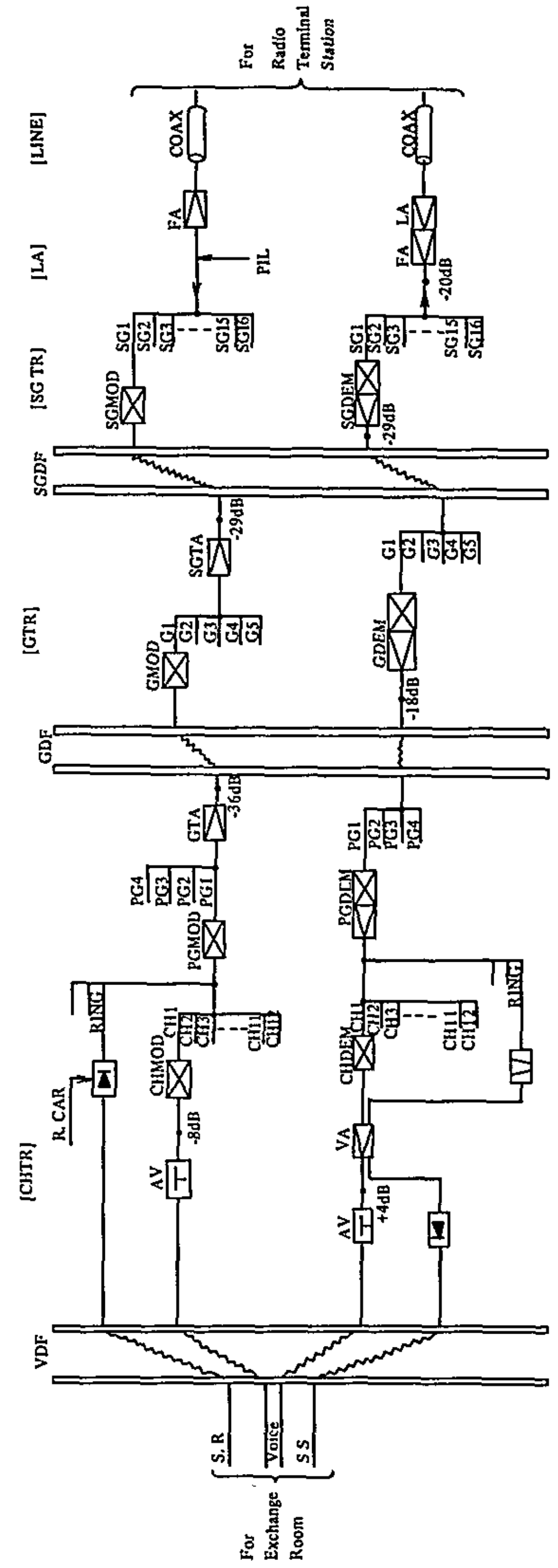
(Frequency: 4 GHz)

Station / Item	Dessie	Korke	Ualdia	Cobbo North	Mai Ceu North	Amba Alagi	Macalle North
Propagation path	Over Mountain	Over Mountain	Over Mountain	Over Mountain	Over Mountain	Over Mountain	
Propagation path-height (m) (in case of over sea)							
Hop Distance (km)	10.5	72	41.5	70	14.5	66	
Thermal Noise (pw)	38.0	63.1	20.9	58.9	39.8	52.5	
Occurrence probability, of Rayleigh Fading (Pr)	7.66×10^{-6}	6.5×10^{-3}	9.4×10^{-4}	5.9×10^{-3}	2.4×10^{-5}	4.8×10^{-3}	
Probability of Noise Burst Exceeding 1,000,000 pw (Pi)	8.73×10^{-10}	1.23×10^{-6}	5.9×10^{-8}	1.04×10^{-6}	2.87×10^{-9}	7.56×10^{-7}	
Total of Pi in One Section	3.09×10^{-6}						
Ditto (including the noise-switching effect)	(improvement factor) 1/5 6.18×10^{-7}						
C.C.I.R. Recommendation (0.01%)	$4L \times 10^{-8}$: 1.1×10^{-5}						

Table IV-10 Macalle North - Bete Giorgis Section (211.0 km)

(Frequency. 4 GHz)

Item \ Station	Macalle North	Adigrat West	Meshal East	Digsa	Bete Giorgis
Propagation Path	Over Mountain	Over Mountain		Over Mountain	Over Mountain
Propagation Path-heighs (in case of over-sea) (m)					
Hop Distance (km)	78	41		43	49
Thermal Noise (pw)	72.4	20.4		22.4	28.4
Occurrence Probability of Rayleigh Fading (pr)	8.6×10^{-6}	9×10^{-4}		1.1×10^{-3}	1.7×10^{-3}
Probability of Noise Burst Exceeding 1,000,000 pW (Pi)	1.87×10^{-6}	5.51×10^{-8}		7.39×10^{-8}	1.45×10^{-7}
Total of Pi in one Section	2.14×10^{-6}				
Ditto (including the noise switching effect)	(improvement factor 1/5) 4.3×10^{-7}				
C.C.I.R. Recommendation (0.01%)	$4L \times 10^{-8}$: 8.45×10^{-6}				



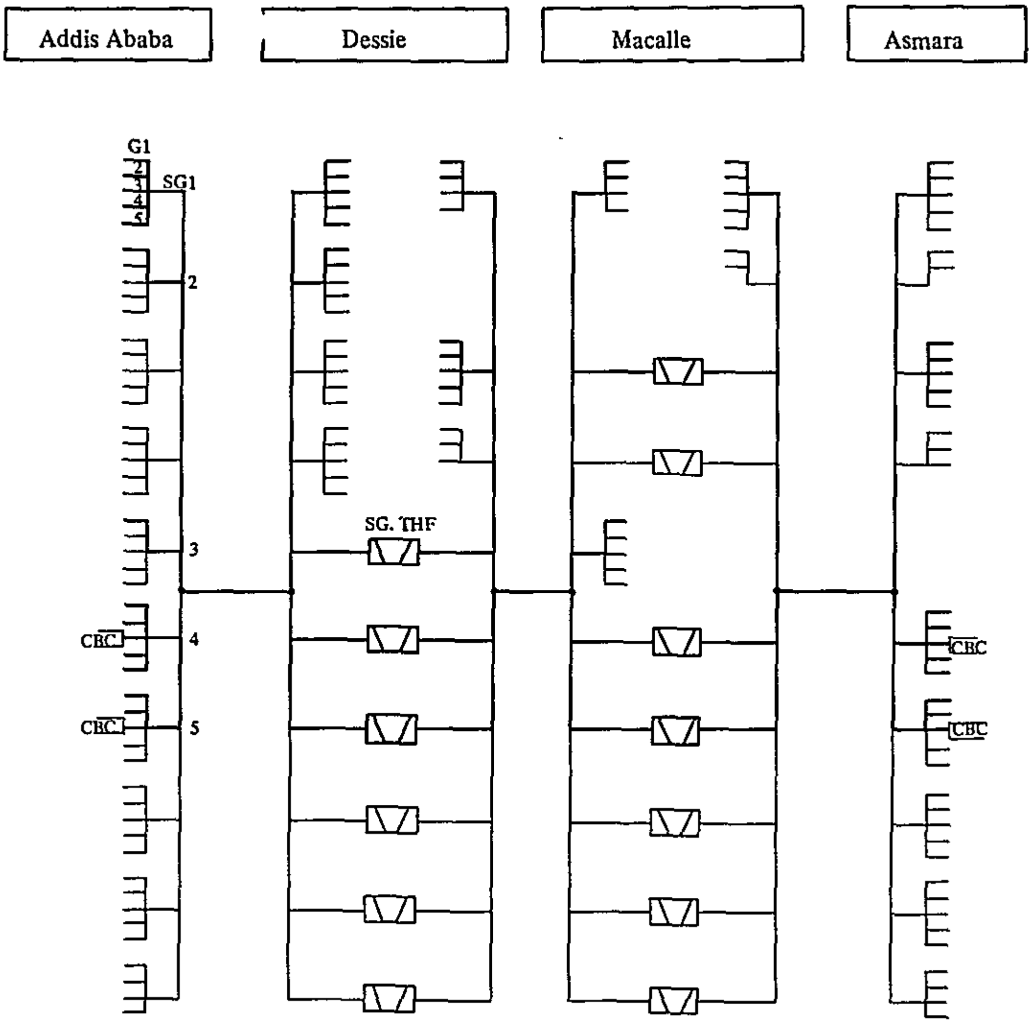
(Note)

VDF : Voice Distribution Flame
AV : Level Regulater
VA : Voice Amplifier

CH.MOD : Channel Modulator
CH.DEM : Channel Demodulator
PG.MOD : Pre-Group Modulator
G.TA : Group Transmission Amplifier
G.MOD : Group Modulator
G.DEM : Group Demodulator
G.DF : Group Distribution Flame
SG.TA : Super-Group Transmission Amplifier
SG.DF : Super-Group Distribution Flame

SGMOD: Super-Group Modulator
SGDEM : Super-Group Demodulator
FA : Flat Amplifier
LA : Line Amplifier
PIL : Pilot Signal

The Typical Block Diagram of Inside Connection	Fig. IV - 3



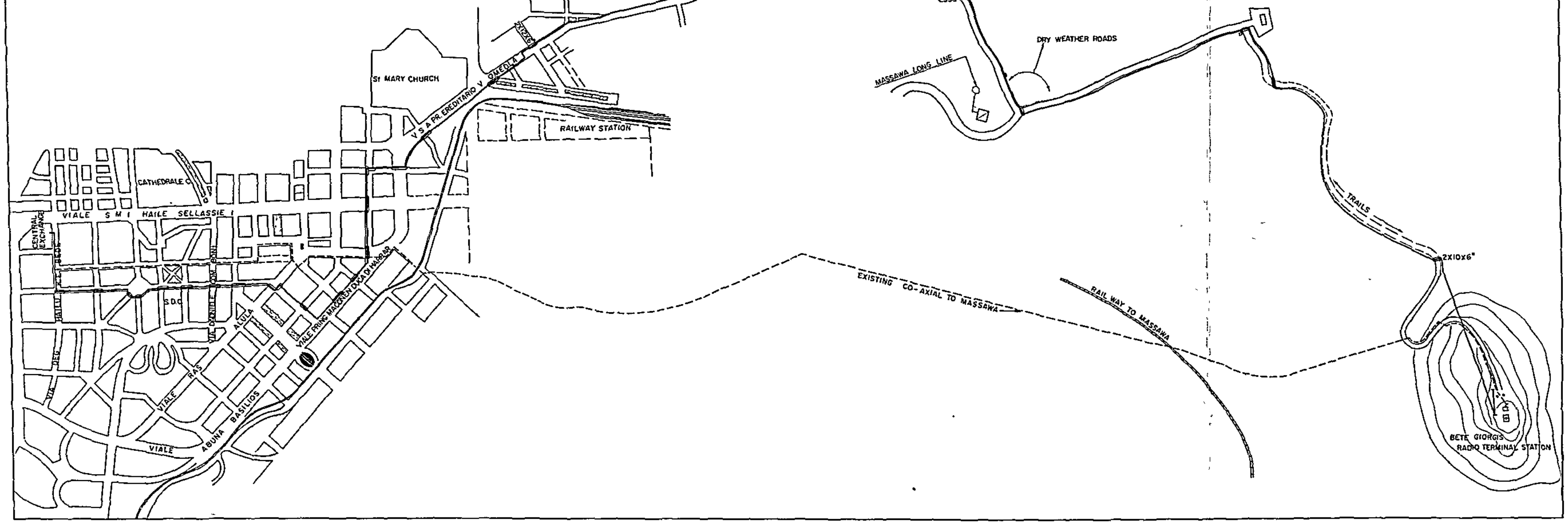
(Note)(1) Thick line means circuits in 1974. Thin line means circuit in 1984.

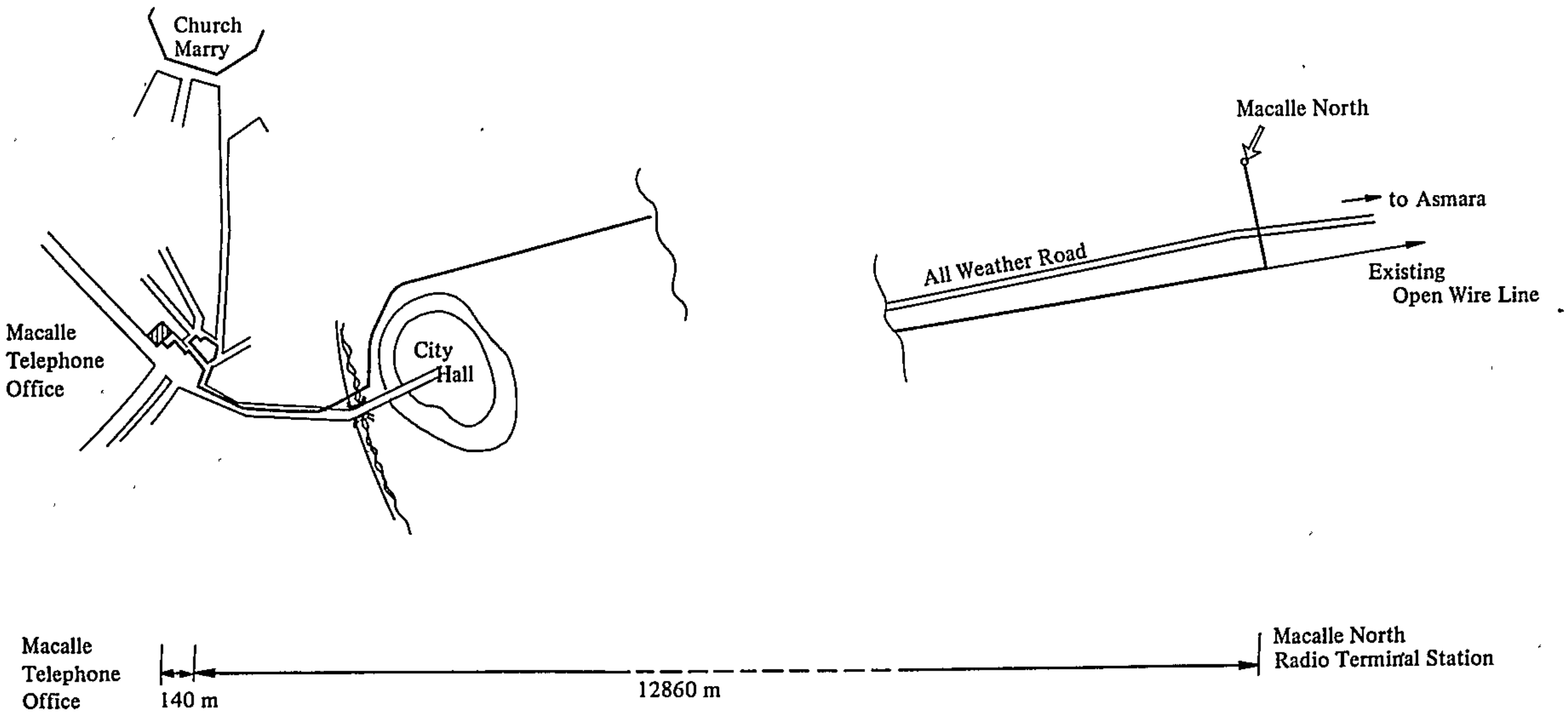
(2) CBC Accommodates one program transmission circuit and 9 telephone channels.

(3) G : Group Translating Equipment
SG : Super-Group Translating Equipment
SGTHF : Super-Group Through Filter Equipment

Diagram of Circuit to be Required in 1974 and 1984	Fig. IV - 4

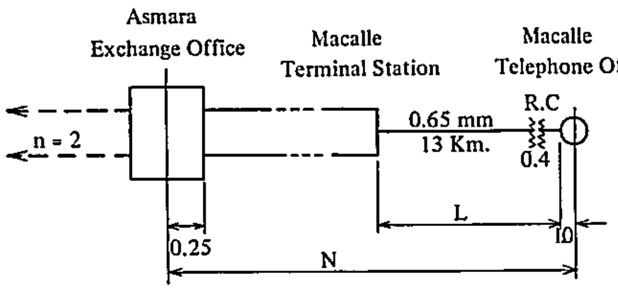
Fig. IV-5 ROUTE MAP OF COAXIAL CABLE SYSTEM





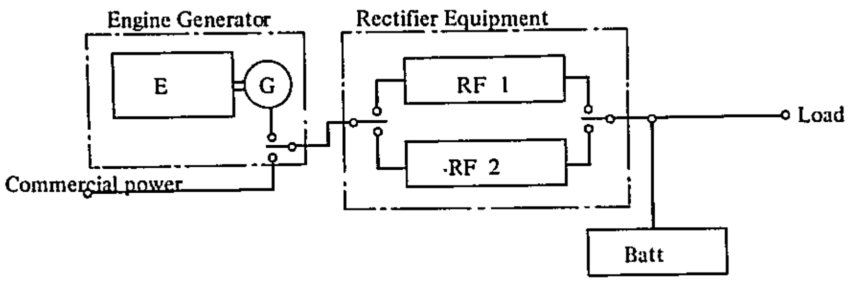
Note 140 m : Length of the underground part
12860 m : Length of the overhead part

Fig. IV - 6 Route Map of the Loaded Cable System



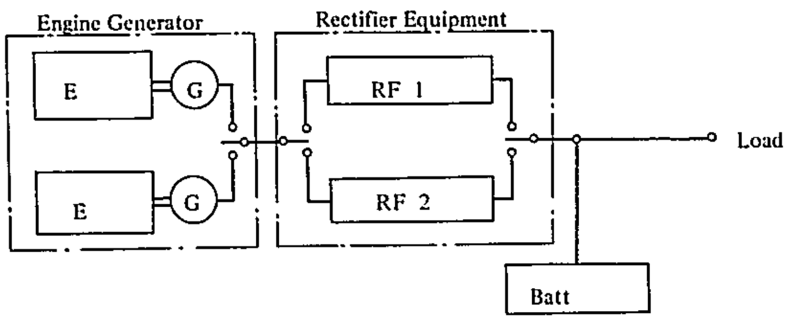
(Note) n : Number of 4 wire circuit sections
L : Entrance cable loss (Line loss and repeating coil loss)
N: Minimum transmission loss

Fig. IV - 7 Transmission Line Loss Breakdown



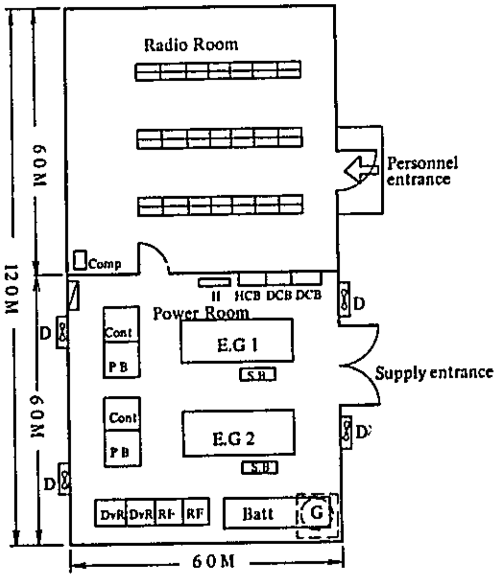
(Note) A voltage adjusting device shall be comprised in each rectifier.

Fig. IV - 8 Single Generator Power System Block Diagram

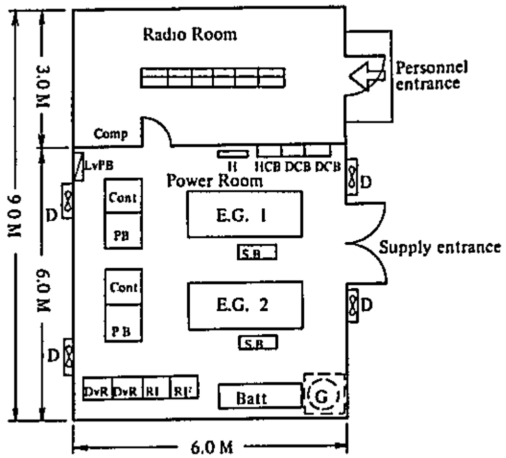


(Note) A voltage adjusting device shall be comprised in each rectifier

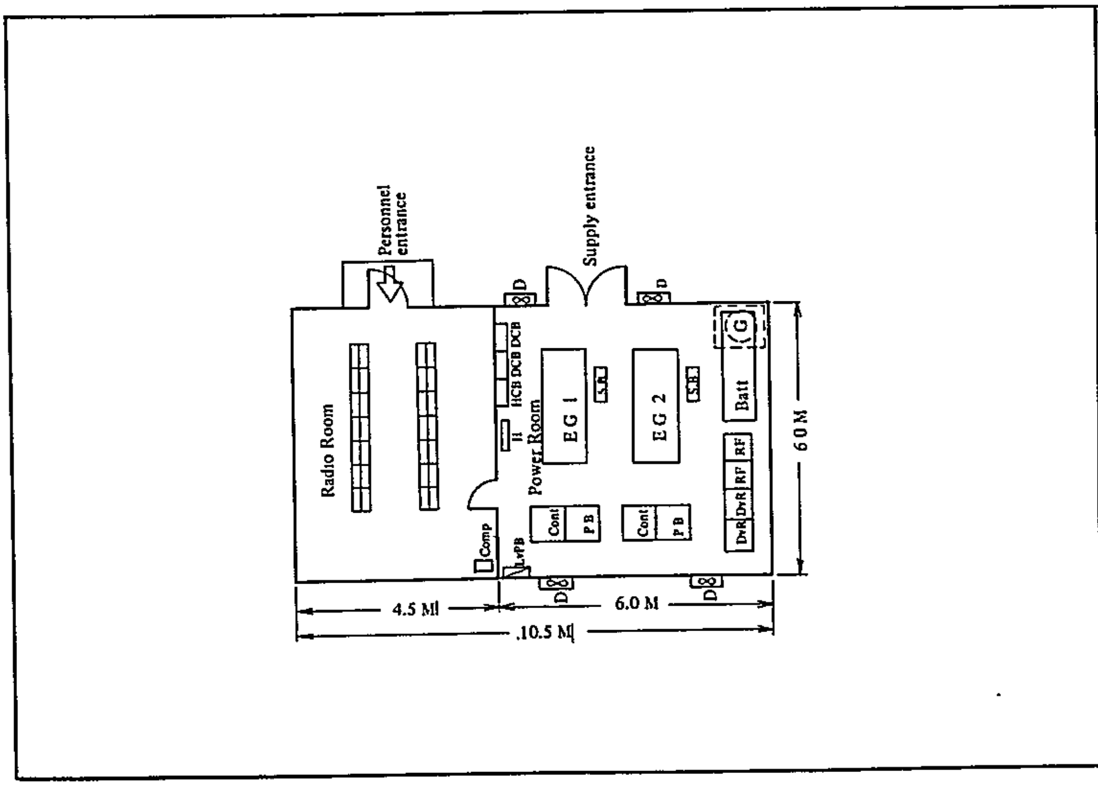
Fig. IV - 9 Double Generator Power Systme Block Diagram



Floor Layout Plan | Mt. Furi | Fig IV - 10



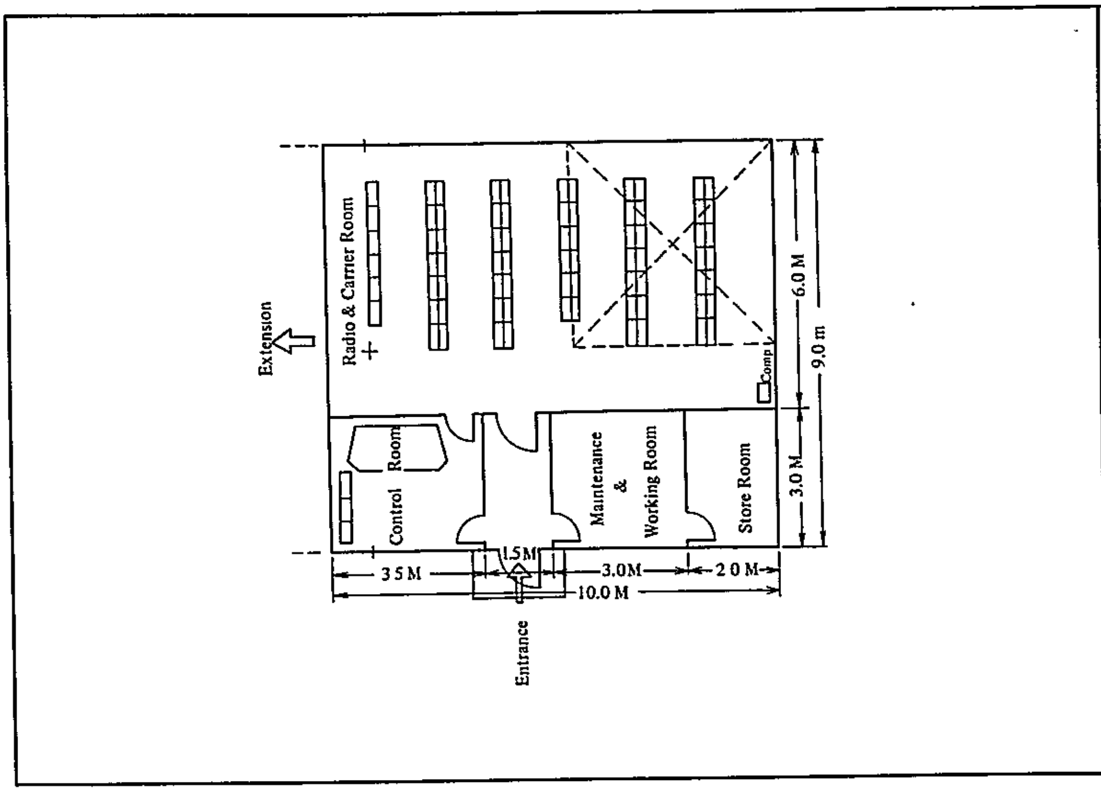
Floor Layout Plan | Unattended Repeater Station | Fig. IV - 11



Floor Layout Plan

Korke

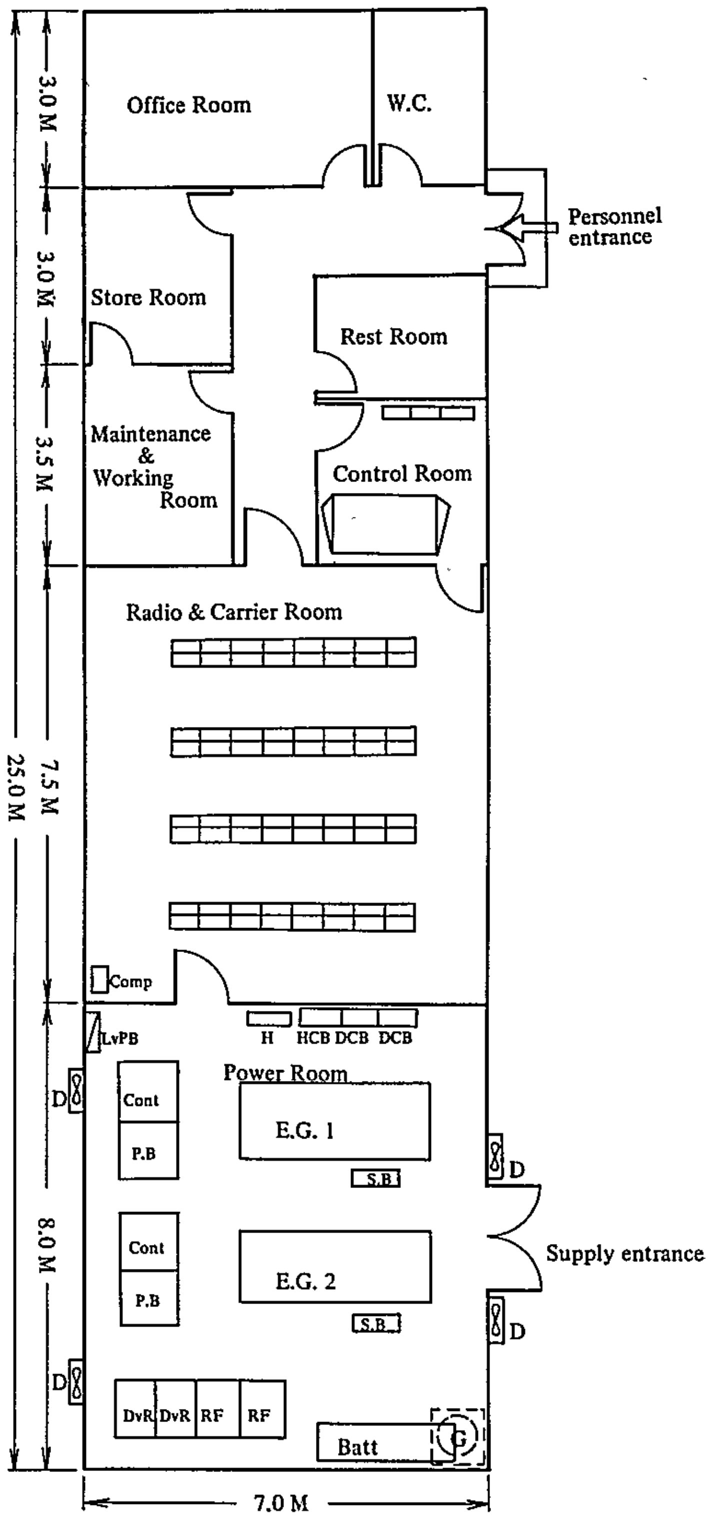
Fig. IV - 12



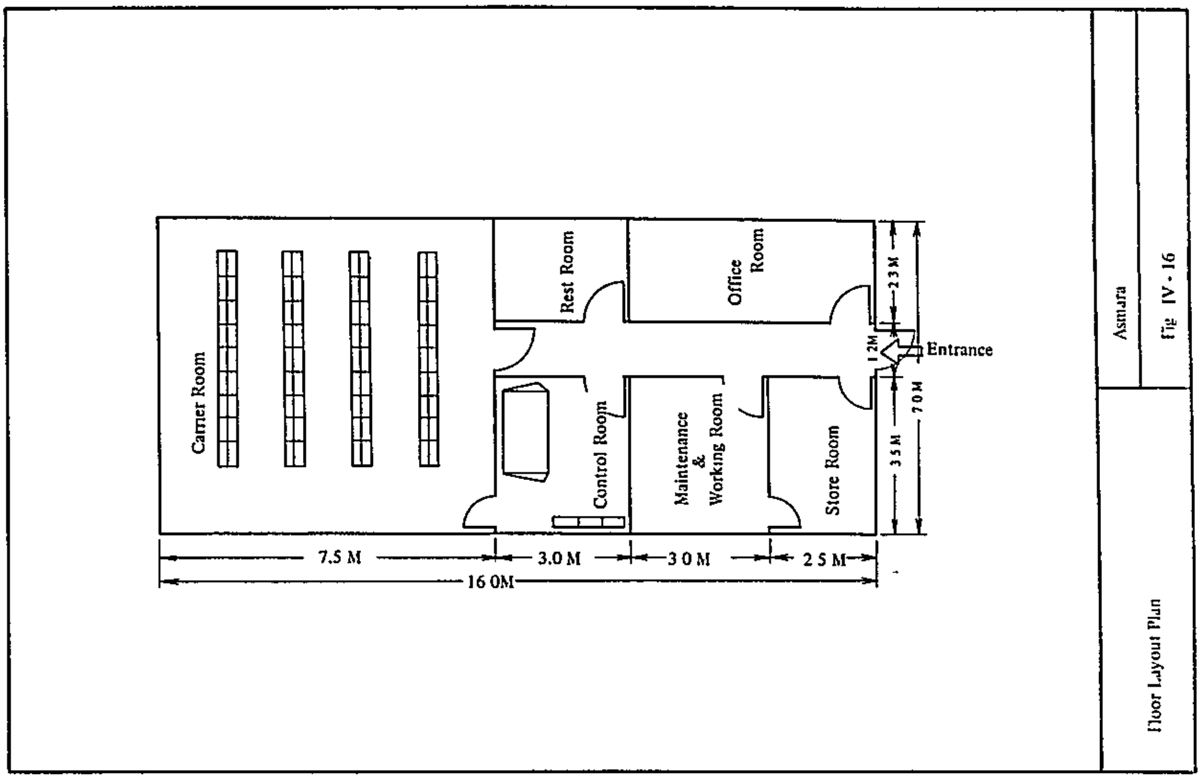
Floor Layout Plan

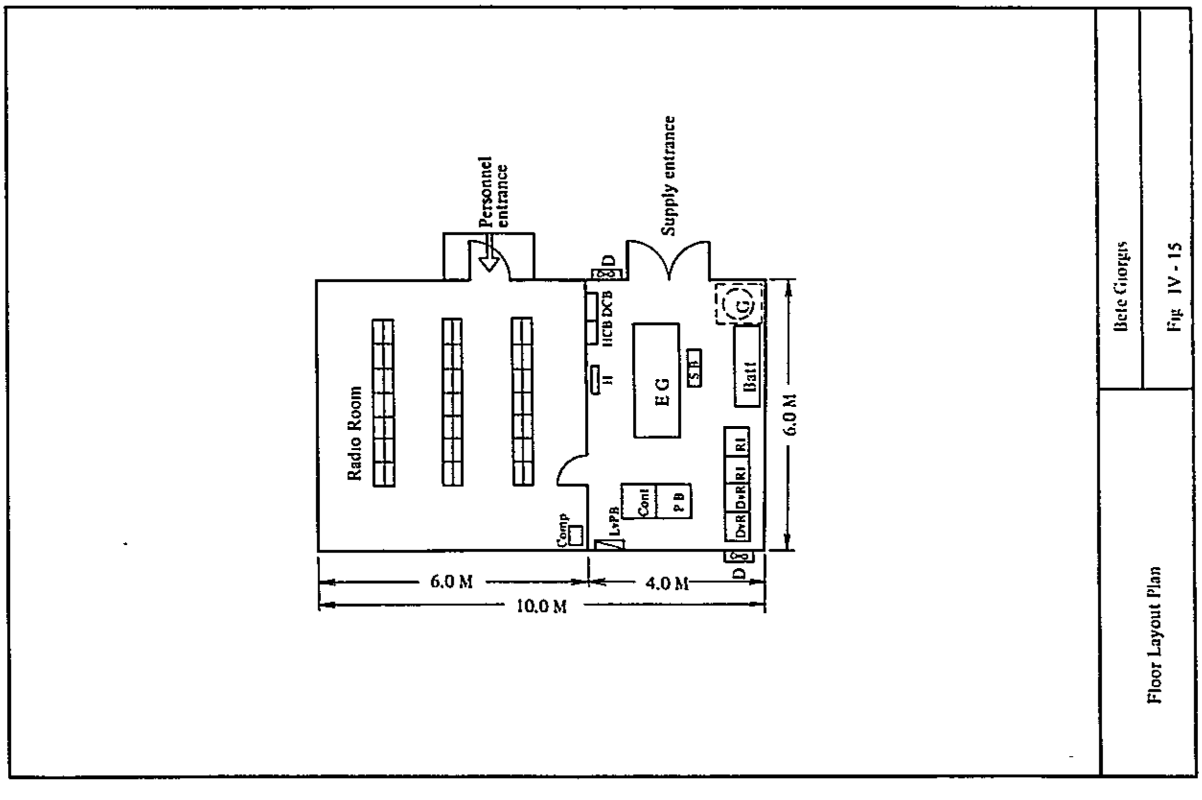
Dessie

Fig. IV - 13



Floor Layout Plan	Macalle North	
	Fig. IV - 14	


Carrier Room
Rest Room
Office Room
Control Room
Maintenance & Working Room
Store Room
Entrance
2.3 M
1.2 M
3.5 M
7.0 M
7.5 M
3.0 M
3.0 M
2.5 M
16.0 M
Asmara
Fig IV-16
Floor Layout Plan


Personnel entrance
Supply entrance
Radio Room
E G
Batt
Cont
P B
Comp
6.0 M
4.0 M
10.0 M
Bete Giorgis
Fig IV-15
Floor Layout Plan

CHAPTER V MAINTENANCE

CHAPTER V MAINTENANCE

The survey team recommends the following proposal about the maintenance system, considering IBTE's organization and the characteristics of the state.

1. Maintenance Area and Maintenance Center

Stations along the microwave route, including the cable route, from the Addis Ababa Radio and carrier terminal station to Asmara telephone office through Dessie telephone office and Macalle telephone office, and their maintenance centers, will be shown in Fig. V-1. The maintenance area and the covering stations for each maintenance center will be also shown in Fig. V-1. Classifications as to whether attended station, un-attended station, supervisory station and alarm station are shown in Table V-1. A maintenance center is originally established in a telephone office where the IBTE regional center locates.

However, a maintenance center is especially established in Macalle terminal station in addition to Asmara telephone office because long access time is required to go to the covering un-attended station and because the room space at Macalle telephone office is too limited.

Each maintenance center performs the following assigned work.

(a) Monitor alarms from the covering un-attended stations and the responsible circuits.
(b) Trouble shoot the fault in case of circuit trouble.
(c) Select spare panels and measuring equipments which match the trouble details.
(d) Dispatch a repair team to the un-attended station for fault correction.
(e) Arrange and perform regular maintenance work according to guidance and regulation from the general control office.

2 Maintenance Organization, Required Personnel and Maintenance Method

2.1 Purpose of maintenance

The purpose of maintenance is to keep the transmission circuit operating normally, so that it will constantly meet the electric or mechanical performance requirements of various facilities, which make up the circuit, maintaining them at the required maintenance limited value.

2.2 Definition

2.2.1 Telephony Circuit and Television Circuit

"Telephony circuit" means a transmission channel between an output terminal of the toll exchange and input terminal of the toll exchange in the opposite terminal station. "Television circuit" means a transmission channel between an input terminal of TV sound combiner and an output terminal of TV sound separater in the opposite terminal station.

2.2.2 RF Link

RF link means a radio transmission channel between an input terminal of the FM modulator and an output terminal of the FM demodulator.

2.2.3 Carrier Section

Carrier section means the part of the transmission channel, except for the radio link which is separated from the telephony circuit. Telephony circuit, radio link and carrier section are shown in Fig. V-2.

2.3 Maintenance Organization and Allotment of the Work

A desirable maintenance organization and required personnel are shown in Table V-2. A maintenance organization should have a radio division and multiplex division. It is best to divide each division into two sections, a control section and a maintenance section.

Accordingly, the survey team recommends the proposed plan as shown in Table V-2, considering that a personnel increase, caused by dividing an organization, is undesirble for the real situation of IBTE. General control office and respective section will allot affairs as shown hereafter.

2.3.1 General Control Office

(1) Remains aware of the real situation of all system and guides the maintenance centers.

(2) Regulates the test schedule effectively.

(3) Gives instructions on the plan for new installations or future expansion and supervises the construction.

(4) Arranges a repair plan, a purchase plan and a distribution plan for spare panel and measuring facilities.

(5) Plans and implements a complement of existing facilities.

(6) Accounts for the required maintenance personnel.

(7) Awards technical guidance.

(8) Performs other activities as required.

2.3.2 Control Section

(1) Supervises the situation of covering RF link, effectively arranges, operations and repairs the RF link trouble.

(2) Performs supervision of circuit situation and arrangement of circuit operation affairs for telephony circuits and repairs insertion, drop and through telephony circuit troubles.

2.3.3 Maintenance Section

(1) Performs the RF link test. Handles ability tests on, and fault corrections for, RF equipments in the maintenance center.

(2) Performs circuit tests on telephony circuits, and take responsibility for ability tests and fault corrections on carrier multiplex equipments in the maintenance center.

(3) Performs ability tests and fault corrections on coaxial cable and loaded cable.

(4) Performs ability tests and fault corrections on power plant.

2.3.4 Patrol Section

(1) Performs ability tests and fault corrections on covering un-attended stations.

(2) Maintains a power supplying vehicle and a patrol vehicle.

2.4 Maintenance Activities

All maintenance activities should be performed in such a manner as to operate transmission circuit economically and to maintain high level transmission qualities. On the other hand, no matter how small a trouble is, interruption is not approved for telecommunication service based on public service and importance. Such a social requirement will become more and more severe, in accordance with popularization of telecommunication.

Therefore, a maintenance organization which consists chiefly of preventive maintenance is preferable than a corrective maintenance type of activity.

Therefore, it is necessary to plan the periodic maintenance work with the optimum period according to various equipments and test item, taking sufficiently into account the operating situation of respective facilities.

Table V-1 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		Carrier terminal station Radio supervise station Radio terminal station	Attended	
	Mt. Furi	Repeater station	Unattended	
	Sendafa East	Ditto	Ditto	
	Shano North	Ditto	Ditto	
	Ancober North	Ditto	Ditto	
	Karrakorre	Repeater station	Unattended	
	Korke	Repeater station	Ditto	
Dessie Telephone Office		Carrier terminal station Radio supervise station Radio terminal station	Attended	
	Ualdia	Repeater station	Unattended	
	Cobbo North	Ditto	Ditto	
	Mai Ceu North	Repeater station	Unattended	
	Amba Alagi	Ditto	Ditto	
Macalle North		Carrier terminal station Radio supervise station Radio terminal station	Attended	
	Macalle Telephone Office	Telephone office	Unattended	Exchange; attendant station cable maintenance; Macalle North
	Adigrat West	Repeater station	Unattended	
	Meshal East	Repeater station	Unattended	
	Digsa	Ditto	Ditto	
	Bete Giorgis	Radio terminal station	Ditto	
Asmara Telephone Office		Carrier terminal station Radio supervise station	Attended	

Note: Radio terminal station means the switching station setting the microwave terminal equipment.

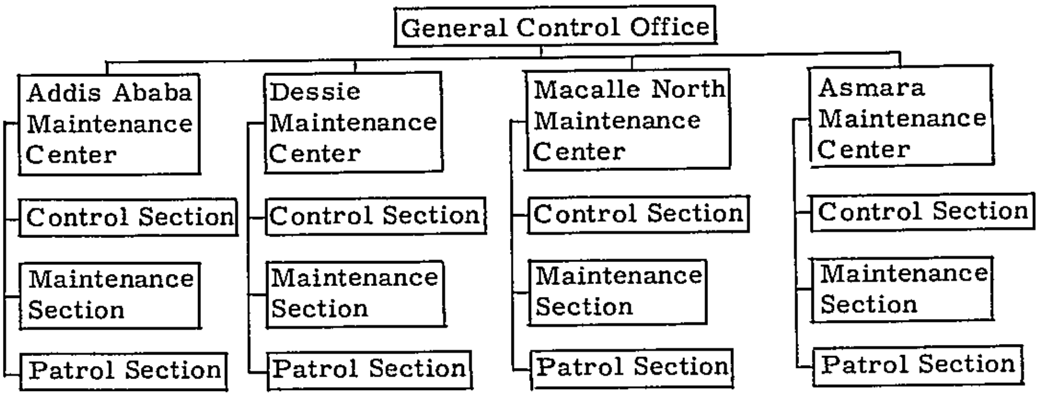
Carrier terminal station means the station setting the carrier terminal equipment.

Radio supervise station means the station supervising system and the maintenance covering station.

Telephone office means the station setting the exchange equipment.

Repeater station means the station setting the repeater equipment.

Table V-2 Maintenance Organization, Affair and Personnel



Organization / Affair	Maintenance Center			General Control Office
	Control Section	Maintenance Section	Patrol Section	
Supervise	○			
Fault Transaction	○			
Fault Correction		○	○	
Test and Check		○	○	
General Management				○
Remark	Work whole day (3 times substitution in a day	Work during day time	Work during day time (work during night time very often)	Work during day time
Personnel / Head Officer	1			
Technician	6	2	1	2
Total	10			

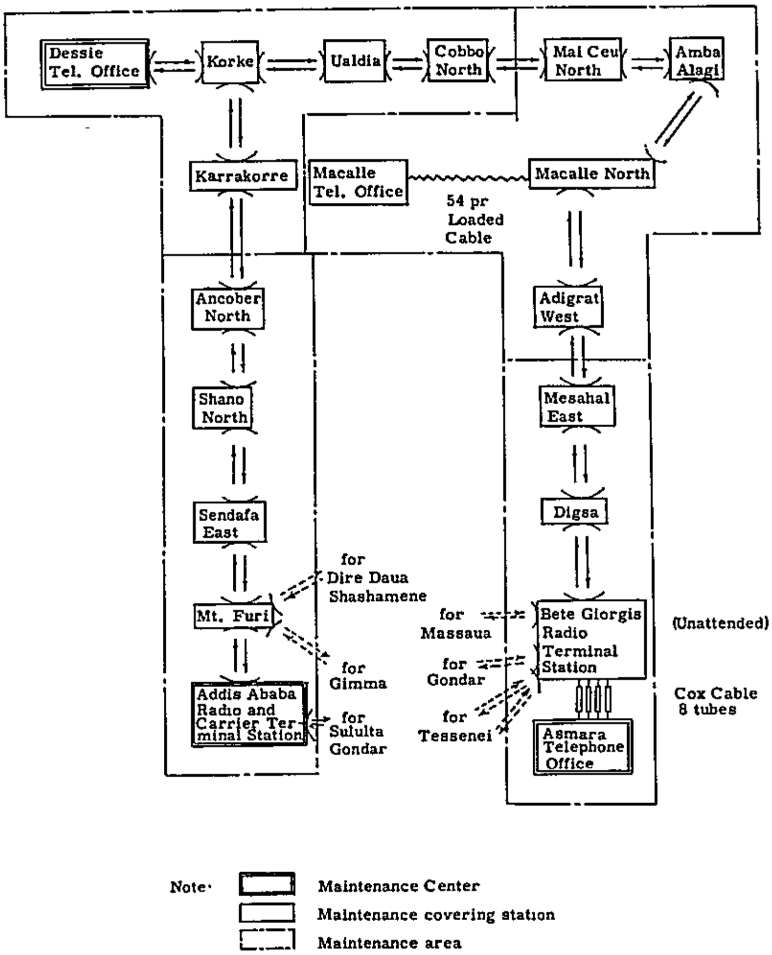


Fig. V-1 Maintenance Area and Maintenance Center

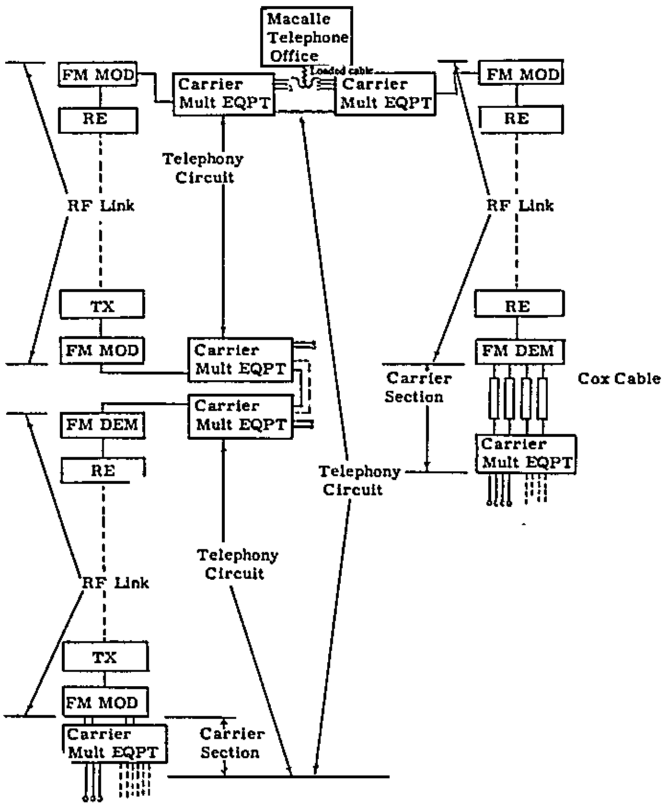


Fig. V-2 System Blockdiagram

CHAPTER VI PROJECT SCHEDULE

CHAPTER VI PROJECT SCHEDULE

The project schedule since the Survey Team proposed the draft of the technical specification to IBTE is shown in Table VI-1. The final tender specification will be announced publicly, after IBTE investigates the draft of technical specification and supplemented general conditions to the draft.

Before that, IBTE will prepare the tender specification for the construction of road, building and tower foundation, and will announce it publicly. Moreover, the concrete condition of building and tower foundation, which is required for facilities construction, will be proposed by Contractors within 2 months after the signing of contract. It is necessary to arrange carefully the complete period of civil and construction work about building and tower foundation, because progress of this work has an important effect upon the construction planning schedule.

The supervisor system will be applied for the facility work and a supervisor dispatched from the Contractor will engage to install and test until finishing of the continuous recording test. After finishing the installation test, expected at the end of July, 1972, the automatic service will be commenced through the proper circuit among Addis Ababa, Dessie and Asmara.

Semi-automatic services are furnished by the operator in Macalle through the circuit between Macalle and the above mentioned cities.

Table VI-1 Project Schedule

1970/JAN	Drafting of report and tender			Completion of tender specification
FEB	Technical specification by the Japanese Survey Team			Concerning road and building by IBTE
MAR				
APR	Final completion of tender specification (Including general conditions) by IBTE			Announcement of tender
MAY				
JUN	Announcement of tender			
JUL				Closing of tender
AUG				
SEP				Evaluation
OCT	Closing of tender			Award
NOV	Evaluation of tender			
DEC				
1971/JAN				Construction
FEB	Award			
MAR	Design			Road completed
APR			Manufacture	
MAY	Manufacture			
JUN	(Tower)	(Power plant)	(Radio and carrier equipment)	
JUL				
AUG	Transport			
SEP				Building completed
OCT				
NOV	Erection			
DEC			Transport	
1972/JAN				
FEB		Antenna erection	Equipment installation	
MAR				
APR				
MAY				
JUN			Testing	
JUL				
AUG		Service in		
SEP			Continuous Recording	
OCT				
NOV				
DEC				