REPORT ON THE SURVEY
FOR
CHILE MICROWAVE NETWORK PROJECT

MAY 1962

OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

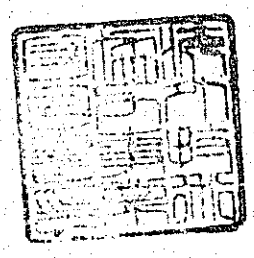
保存用
持出禁止
調査統計課

JICA LIBRARY
1026038[8]

REPORT ON THE SURVEY
FOR
CHILE MICROWAVE NETWORK PROJECT

MAY 1965

OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN



国際協力事業団
受入
月日 '84. 4. -3
登録No. 02409
704
647
KE

FOREWORD

The Government of Japan, at the request of the Government of the Republic of Chile, has decided to execute the basic survey for the construction of microwave network in Chile and to entrust its practical work with the Overseas Technical Cooperation Agency, the government's execution organization.

In the light of great importance of the development of tele-communication in Chile, the Agency organized and despatched to Chile a Survey Team consisting of 5 experts under the leadership of Mr. Hideo Katsuta of the Nippon Telegraph and Telephone Public Corporation.

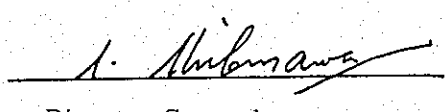
Fortunately, the survey works there have been completed smoothly thanks to the special support and cooperation accorded by the officers concerned of the Chile government. Upon returning home all the members of the Team this survey report has been made ready for presentation.

It would be a greatest joy to me if this survey report should be of use to help promote the development of tele-communications and to serve the betterment of the mutual friendship and economic intercourse between Chile and Japan.

In conculsion, I have to express our sincere gratitude, in behalf of the Agency, for the facility and assistance extended to the mission by the authorities of the Chile Government, particulary by the CORFO and Airforces.

May, 1965

Shinichi Shibusawa



Director General
Overseas Technical Cooperation
Agency of Japan

CONTENTS

I. SUMMARY OF REPORT 1

II. SELECTION OF RELAY STATIONS 3

1. The Object of the Survey 3

2. Period of our Survey 3

3. Member of Team of the Field Survey 3

4. Method of Survey 3

5. Basic Policy for the Location of the Station Sites 4

6. The Results of the Location of the Station Sites 5

III. CIRCUIT AND SYSTEM DESIGNS 66

1. Circuit Specification 66

2. Construction of Circuit 67

3. Designing of Steel Tower of Antennas 73

4. Space Diversity System 73

5. System of Power Sources 74

6. Supplementary Remarks (Features of Radio Wave Propagation in relation to the topographical and meteorological conditions in Chile) 75

I. SUMMARY OF REPORT

I. SUMMARY OF REPORT

1. This Report is the summary of survey results made available by the Japan Telecommunications Survey Team for Chile which was sent out by the Japanese government, to work out for the selection of the sites of repeater stations necessary for the construction plannings of the microwave networks ranging from Santiago to Arica and from Santiago to Concepcion, as well as for determining the system design to be applied between Santiago and Arica.

2. Names of the members and their respective employment in the survey

Leader :	Mr. Hideo Katsuta
Microwave technique :	Mr. Isamu Takasu
System Design of microwave circuit :	Mr. Kinjiro Nakagawa
Telephone traffic and exchange technics :	Mr. Hiyoshi Hiraoka
Carrier transmission technique :	Mr. Isao Iimura

3. Basic Policy of Our Survey

We have arrived at a conclusion through our survey that it would be most desirable for the present conditions and the future planning of the Telecommunication networks that these networks would be composed of the systems of 2000 MC and 4000 MC bands, and also stand-by circuits, so that the quality of circuits may satisfy CCI's recommendations with due consideration of the fact that these networks should serve the main routes of tele-communication and simultaneously a part of the global network in future.

The outline of our suggestion for the circuit structure of each zone as follows;

(1) Number of repeater stations

Zone 1	10	(including the section of Tololo - La Serena)
Zone 3	8	
Zone 2	9	

(2) Switchover stations

Zone 1	Santiago, Tololo, La Serena and Bramador
Zone 3	Bramador and Los Morros
Zone 2	Los Morros, M° Tarapaca and M° Gordo

(3) Telephone branch offices of main circuits

Zone 1	Santiago, Tololo, La Serena and Bramador (Copiapo)

Zone 3 Bramador (Copiapo) and Los Morros (Antofagasta)

Zone 2 Los Morros (Antofagasta), M° Trapaca (Iquique) and M° Gordo (Arica)

(4) Telephone branch offices of auxiliary circuits

Zone 1 Co Del Roble (San Felipe, Los Andes)
Llampangui (Illapel)
Co Del Fraile (Ovalle)
Algarobo (El Algarobo, Vallenar)

Zone 3 C° Trondoro Bramador (Chanaral)
Placeres (Taltal)

Zone 2 Mejillones (Mejillones)
C°1170 (Tocopilla)
Colorado (Pisagua)

Note : The name of the towns to be branched is shown in ( ).

(5) Switch over stations and terminal stations must be attended.

(6) For the transmission of the television signals, use of a stand-by channel of main circuit would be economical.

(7) Space diversity system should be applied for the sections of long repeater spacing and over sea propagation, at least for 5 sections at the outset.

(8) All transisterized equipment and apparatus shall be used.

(9) The system of the power source shall be the floating system through storage batteries.

Ⅱ. SELECTION OF RELAY STATIONS

II. SELECTION OF RELAY STATIONS

1. The Object of the Survey

The object of the survey of our team was the selection of repeater stations and the system design of main routes of microwave circuits for the transmission of the telephone and television signals in Chile, and that main routes extend over a distance of about 2300 Km consisting of sections between Santiago and Copiapo (Zone 1), Copiapo and Antofagasta (Zone 3), Antofagasta and Arica (Zone 2), and an additional section between Santiago and Concepcion.

2. Period of our Survey

From December 19th 1964 to March 13th, 1965

3. Member of team of the Field Survey

Japanese engineers	5 persons
CORFO engineers	5 persons
Total	10 persons

The vanguard three members of our Japanese team investigated the whole sections, and the other two joined to the survey for the section between Antofagasta and Arica. The CORFO engineers worked under the leadership of Mr. Robert Cofré Remedi, four persons taking in charge of the investigation work concerning the following sections as chief engineers respectively.

Santiago - Conception	Mr. Eduardo Carmi M.
Santiago - La Serena - Copiapo	Hernan Campos C.
Copiapo - Antofagasta	Rene Muñoz H.
Antofagssta - Arica	Patricio Dias Berr

4. Method of Survey

In the first place the conditions of routes and stations sites was studied on the map. The plan of microwave routes taken from this study and the plan of routes made available by CORFO's engineers have been brought into careful study and discussion including the characteristics of this country. From this study on the map we decided our best plan and an alternative as well, and put together the problems of survey which were to be taken up subsequently.

In the field survey regarding each site derived from the map study, we investigated

various problems in connection with the microwave propagation and the conditions of the sites. The period of our survey was rather short as compared with the number of stations to be investigated, and we used helicopters, jeeps and automobiles. Helicopters were for the sake of the field survey and the cars for the delivery of persons, instruments, materials and gasoline, etc. required for this survey.

As regards the points of survey, the following items were mainly investigated.

(1) Conditions of the radio wave path from the viewpoint of propagation characteristics.

(2) Conditions of the proposed area from the viewpoint of construction and maintenance, including the conditions of sites, roads and power lines.

From the aforementioned field survey the final plan of the microwave route has been reached, with due consideration of economy and satisfaction of electric conditions, after the discussions with the engineers of CORFO. This survey is to be the nucleus of our designing, and therefore, before starting the construction work it is necessary to clear the various information in order to fix the more detailed points.

5. Basic Policy for the Location of the Station Sites.

Judging from the present condition prevailing in Chile it is necessary to construct microwave circuits in a short time and to expand tele-communications network, which, however, requires great expenses. Therefore, it may be desirable to cut down as much as possible the cost of initial investment and to execute the practice of supplementary works of construction or adjust the facilities if occasion requires. The selection of the sites must be decided carefully, for any future change of location would be difficult and necessitate much money.

At the time of the selection of the microwave routes of circuit it is necessary to have an eye upon satisfying the conditions of the radio wave propagation and upon the circumstances under which the sites of stations are to be economical. Our survey was executed under the basic policies as follows;

(1) The quality of circuits shall meet the CCI's recommendations with the consideration that this microwave circuit may be the main circuit for the transmission of the telephone and television signal in Chile and will be connected with international networks as a part of global betworks in future.

(2) As regards frequency, 4 GC shall be used.

(3) Transmission signal shall be used for telephone and television. The number of channel accomodation for the telephone circuits per one radio channel shall be 960 telephone channels between Santiago and Concepcion, and 300 channels between Santiago-Copiapo-Antofagasta-Arica.

(4) The branching circuits to each town shall be easy and simple.

(5) The number of repeater stations shall be reduced as much as possible in order to make economical designing available. The fading which occurs in the radio wave propagation especially where the repeater spacing is rather long shall be relieved by means of the diversity reception.

(6) The clearance on radio wave propagation path shall be standardized to have the width of 2/3 of the first fresnel zone when the factor K of effective radius of earth is equal to 2/3.

(7) The repeater stations shall have easy access to present road and be convenient for construction and maintenance.

(8) The repeater stations shall have easy access to existing commercial power and be convenient for construction and maintenance.

6. The Results of the Location of the Station Sites.

6.1 The Section of Santiago-La Serena-Copiapo (Zone 1)

6.1.1 Progress of the Site Locations

This is the Section of about 700 Km spreads from Santiago, the capital, to Copiapo. In this section there are towns along the coast such as La Serena, Coquimbo, and in inland area there are Los Andes, Sanfelipe, Illapel and Ovalle, etc. The branching circuit between La Serena and Copiapo is only to Vallnar. In the southern part of this section there are many mountains covered with trees and the towns are well developed, but the northern district is partly the desert where we have an astronomical observatory and the mines.

Taking these circumstances into consideration an original plan had already been composed for the section Santiago - La Serena and the selection work undertaken on the part of the Chilean sides. The plan included the proposed sites convenient for construction and maintenance, utilizing existing stations, roads and power lines, etc. The plan also included the long distance sections between CoDel Roble and Colorado and between Llampangui and

Tololo. The former has clear prospective and no intermediary station is needed but the space diversity system is to be adopted against the duct type fading, while in the latter the generation of large K type fading is anticipated owing to the ridges on the mountaineous district of propagation routes, and this phenomenon can not be relieved by the diversity system and an repeater station may be advisable between them . The final plan was acquired as shown in Fig. 1.

As regards the section from La Serena to Copiapo, plans of various routes and many proposed sites are selected according to the map study. This region is the desert, and each proposed site is situated in the area where utmost difficulty is expected for construction and maintenance, and long repeater spacings are selected owing to the aforementioned bad conditions of location. In connection with the period of survey complete investigation could not be executed, but the final plan of routes as shown in Fig. 1 is taken as a route of the field investigation. There are many problems in question as shown hereunder.

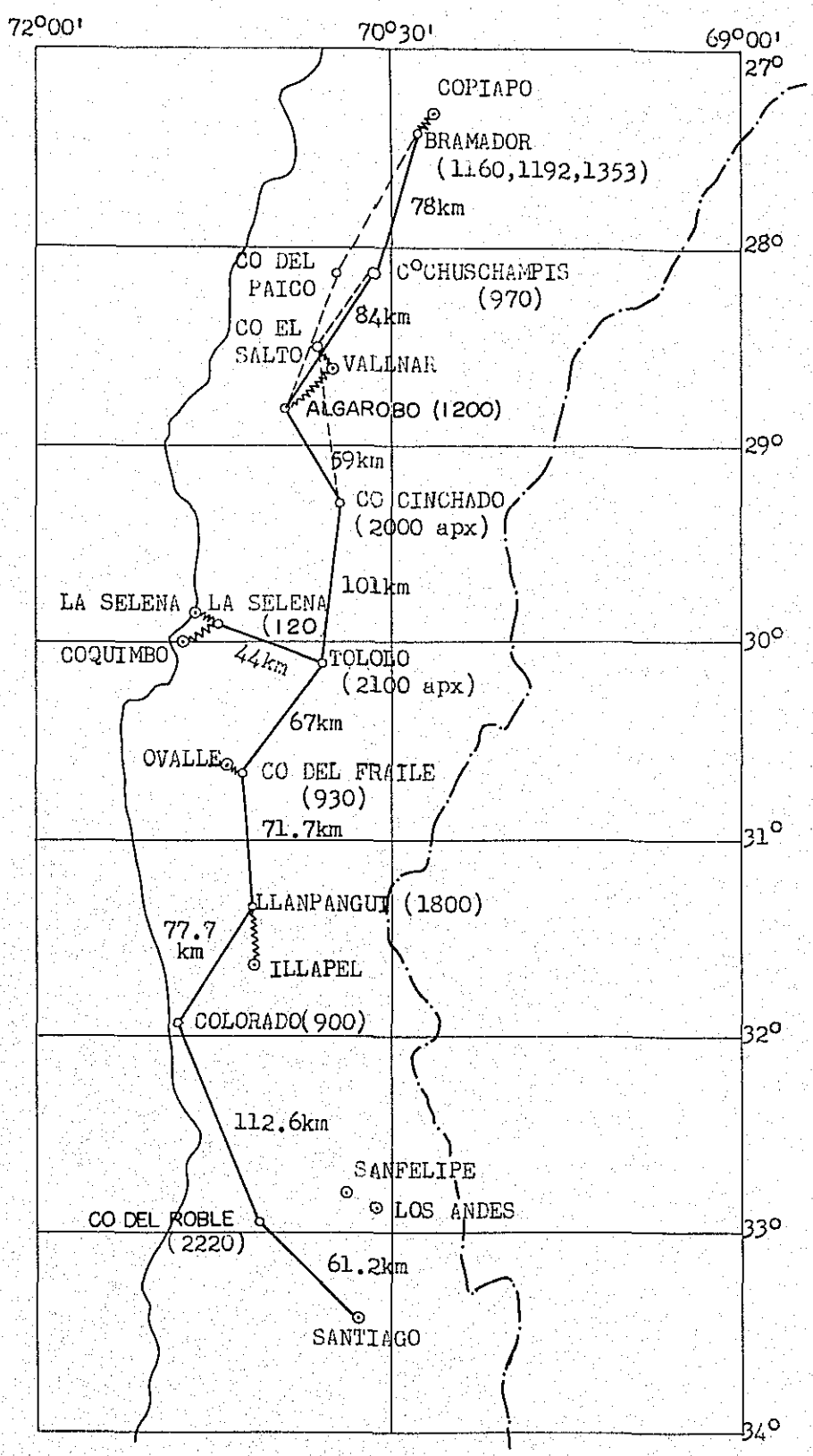
(1) Optical sight and the measurement of clearance between Tololo and Cinchado, and the selection of an alternative plan if this section is impossible.

(2) Selection of Algarrobo or Co Del Salto.

(3) Selection of C° Chuschampis or Co Del Paico.

Re-investigation must be executed in regards to these points and an economical route must be dicided collectively including the problems of branch to Vallnar and the cost of construction.

Fig. 1 SANTIAGO - LA SERENA - COPIAPO (Zone - 1)



6.1.2 The Matters that Demand Special Attention to the Proposed Station Sites.

(1) Santiago

There is no trouble in regard to the prospect between Co Del Roble and Santiago, but the height of antenna above ground must be necessarily decided with due considerations of the heights of buildings in Santiago city, present and future.

(2) Co Del Roble

There is no trouble in regard to access roads and power lines, etc., because the existing stations of VHF are used. The repeater spacing between Co Del Roble and Cororado is long and it is necessary to relieve the duct type fading by the application of the space diversity system in this section. This point must be considered in designing the steel tower of antennas. The intervals between main and auxiliary antennas are to be about 15 meters each. There are many big rocks near the building and the ground is narrow, and the tableland of the west is thought most suitable. In designing the building the grasp of future planning is necessary for the mobile service and the concurrent use of building with other radio apparatus may be practised.

The branch lines to Los Andes and Sanfelipe pose many difficulties of direct prospective to these towns. It would be advisable that the site of repeating terminal station is selected in the neighbourhood of this towns and the route is branched by means of radio and cable systems. In this case it is desirable to select the repeating terminal station with due consideration of future possibilities of the role which the station should play in the event of international connection to Argentina.

(3) Corolado

As regards the propagation route to Co Del Roble, the Conditions are already mentioned previously. The prospect to Llampangui is not necessarily perfect. It is necessary to measure strictly the height of Espuela ridge and to decide the height of antenna above ground.

(4) Llampangui

Near the VHF station under operation some locations are proposed, but from the view point of prospect and economy the neighbourhood of VHF station is thought most advisable. In the vicinity of the building there is a piece of comparatively broad ground. From the two points of view concerning the prospect to the direction of Corolado

and the vicinity of Co Del Fraile, it is desirable to decide the place best fit and the height of antenna in order to minimize its height above ground, ten odd meters of which would be to the purpose. Direct prospect to Illapel is impossible and therefore the branching circuit by VHF band or cables would be the most advisable.

(5) Co Del Fraile

The plan of the direct connection between Llampangui and Tololo had previously been made out. However, this plan was discarded on account of the facts that there are many ridges on the propagation route which constitutes a long way and there is a possiblity of large-scaled occurance of the K type fading, and also in consideration of future convenience of the branching to Ovalle, and thereupon Co Del Fraile has been substituded in our survey. It cannot be found a suitable site near Ovalle and Co Del Fraile is selected in spite of its long distance from Ovalle. There are many rocks on this site and the construction of the road is thought difficult. The prospect from this site to Llampangui and Tololo are excellent. Direct prospect to Ovalle is also possible.

(6) Tololo

On the top of the mountain an astronomical observatory is now under construction and the ground is already levelled to produce a spacious premises, which, however, should make the construction on the building for microwave repeating station impossible. The site of building for microwave circuit has therefore been decided on the tableland to the west and about 50 meters below from the summit. The access road is already completed and the condition of site is satisfactory, but the clearance of the propagation route toward Co Chinchado is unsatisfactory. The height of the antenna should be decided after strict measurement of clearance. If the results of strict measurement should necessitate any such lofty steel towers as cannot be constructed, changing of route may be suggested. As regards the branch from Tolol to La Serena, a radio terminal station is to be constructed in the suburbs of the city, and this station is connected to the city with the cable, because the direct prospect between La Serena and Tololo is not possible.

(7) La Serena

The direct prosect from La Serena to Tololo cannot be expected. Therefore, radio terminal station is to be constructed in the suburbs. In this case the most suitable locality necessarily be decided in consideration of the heights of antenna and the length of

cable, etc., The possibility of the construction of station in the suburbs has been confirmed by field investigation. The connection from La Serena to Coquimbo is to be installed by the cable.

(8) Co Chinchado

This is the predetermined site for construction of the astronomical observatory. There are many rocks on the summit which should necessitate a certain smoothing work of ground. The designing of the building should be considered with the construction program of the astronomical observatory. The slope of mountain are gentle and the road construction may be comparatively easy. The prospect to Tololo is as mentioned above in (6). There is not any trouble as to the prospect to Algarobo.

(9) Algarobo (Co Del Salto)

Algarobo is the biggest iron mine in Chile and power lines and roads are already installed and the site provides itself much space. It is necessary to decided the location in consideration of the planning of mining of iron ores. The prospect to C° Chuschampis is is very good. It is situated far from Vallnar city, and cannot have direct prospect thereto.

As an alternative plan for the site, Co Del Salto may be suggested, which is situated near Vallnar and can be seen through. Co Del Salto is superior to Algarobo in this respect but on the other hand it is compared unfavourable as to the condition of road and power cable.

After due comparison of economy either Algarobo or Co Del Salto should be selected.

(10) C° Chuschampis (Co Del Paico)

C° Chuschampis is situated in the desert and the condition of location is not good. Alternatively, Co Del Paico is selected. The condition of its location is thought almost alike and the selection between the two should be made upon re-investigation and comparison of economy involved. Prospect from C° Chuschampis to Algarobo is good.
As regards the prospect to Barmador, reference is made to the following.

(11) Bramador

Bramador is an iron mine and the access roads and power lines are in the neighbourhood of this area. There are three proposed sites for the construction. The comparison of the condition of roads and electric power lines is shown in the following table.

Sites	Roads (Altitude difference from the existing road)	Power sources
Site 1, Bramador (1353)	about 300 m	Power line is comparatively near.
Site 2, Bramador (1192)	about 150 m	Power line is comparatively distant.
Site 3, Bramador (1160)	about 100 m	Power line is comparatively distant

As regards the prospect from each site to C° Chuschampis and Morro De Copiapo, the site 1 is good, but the sites 2 and 3 are insufficient which should require the construction of steel towers of antennas. Thus, the electrical and location conditions are in opposite with each other as shown in the above table and the most economical and final site may necessarily be decided upon all-round examination and comparison from different angles of such factors as roads, electric power lines, costs of construction of the steel tower and its maintenance.

(12) Copiapo

It is advisable to decide the height of antenna by the heights of buildings within the city and the prospect to the direction of Bramador.

6.1.3 Profiles of Each Propagation Path.

The profiles of each propagation path of Santiago - La Serena - Copiapo are shown as follows. (Fig. 2)

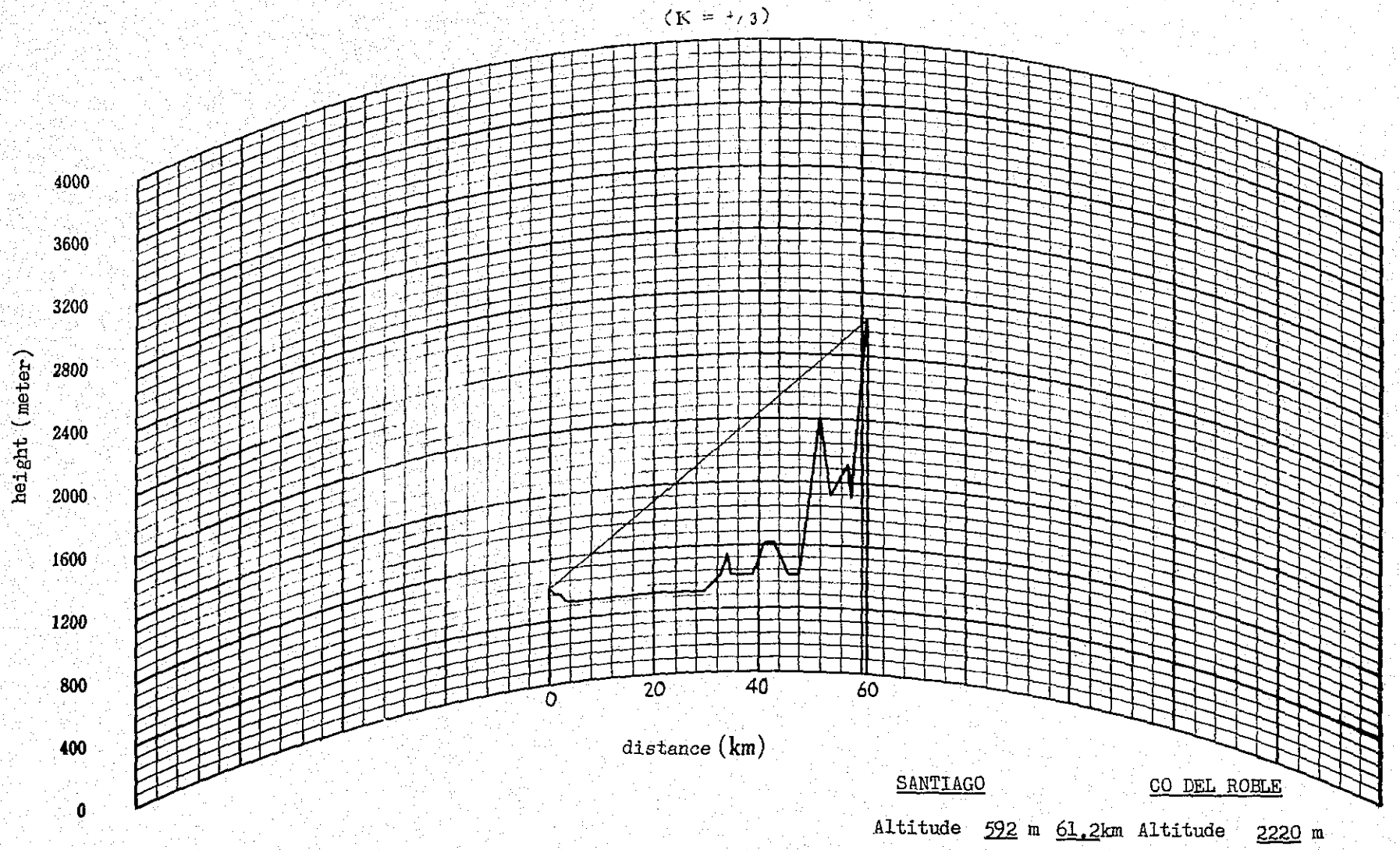


Fig. 2 Profile (Santiago ~ Copiapo) (1)

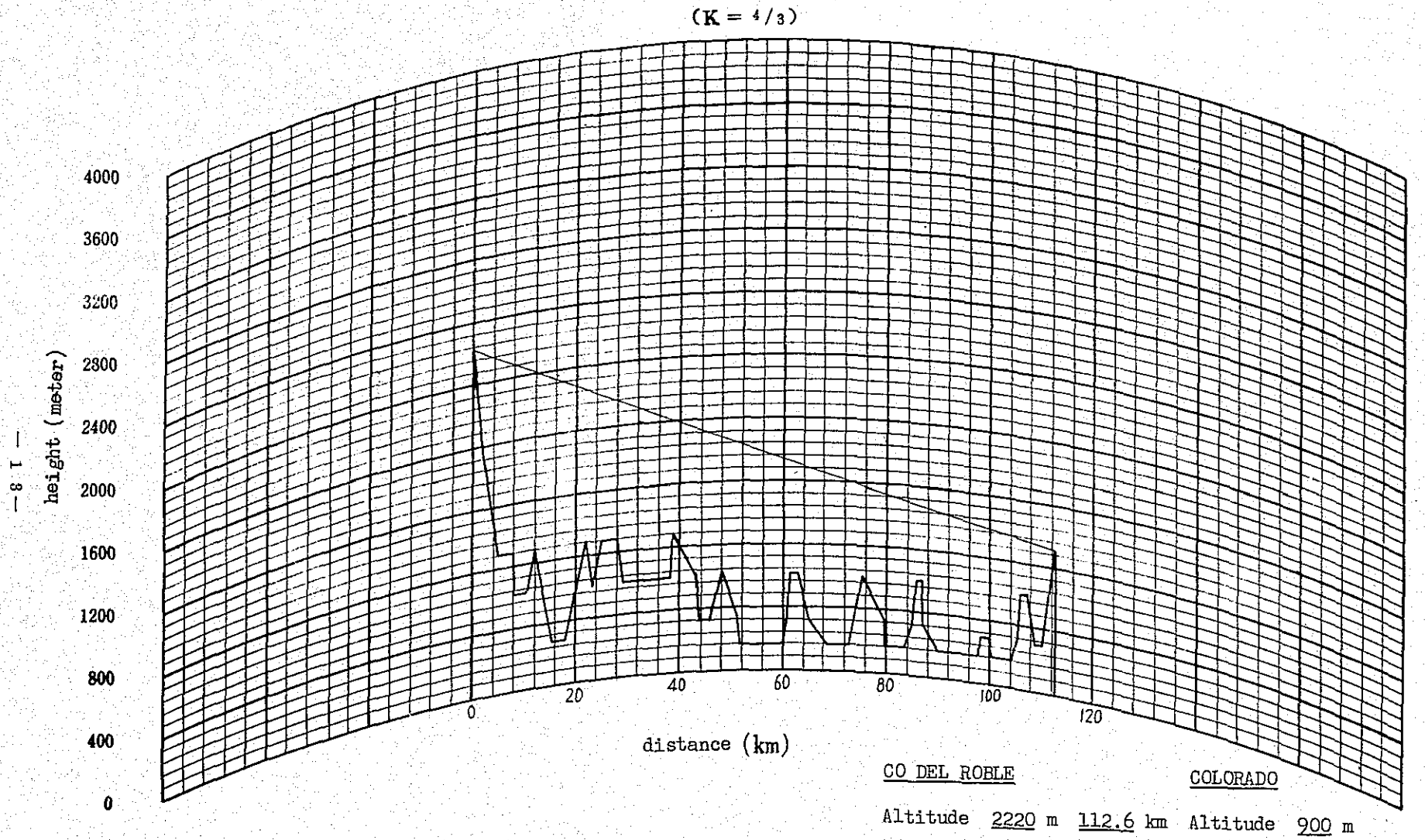


Fig. 2 Profile (Santiago～ Copiapo) (2)

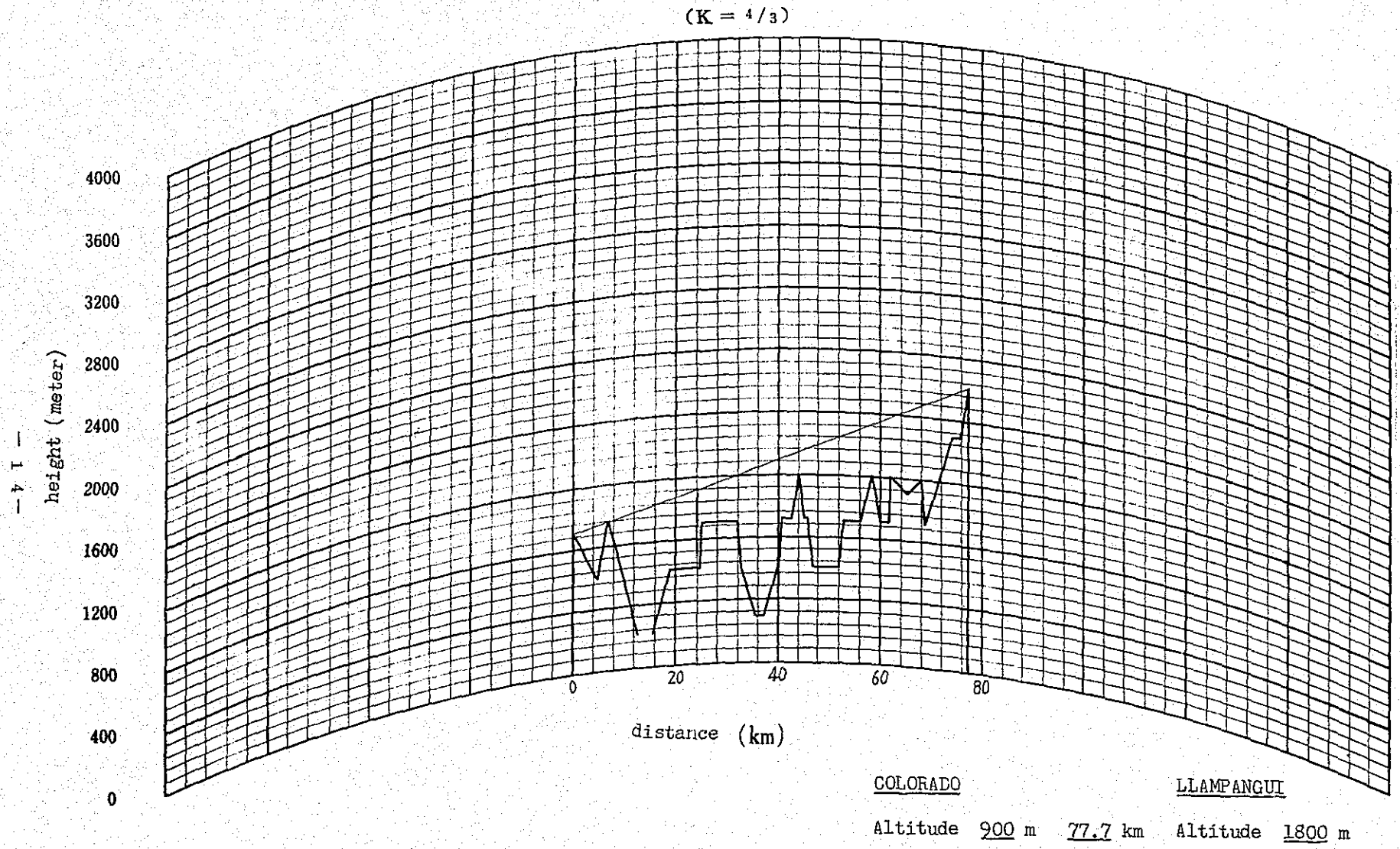


Fig. 2 Profile (Santiago ~ Copiapo) (3)

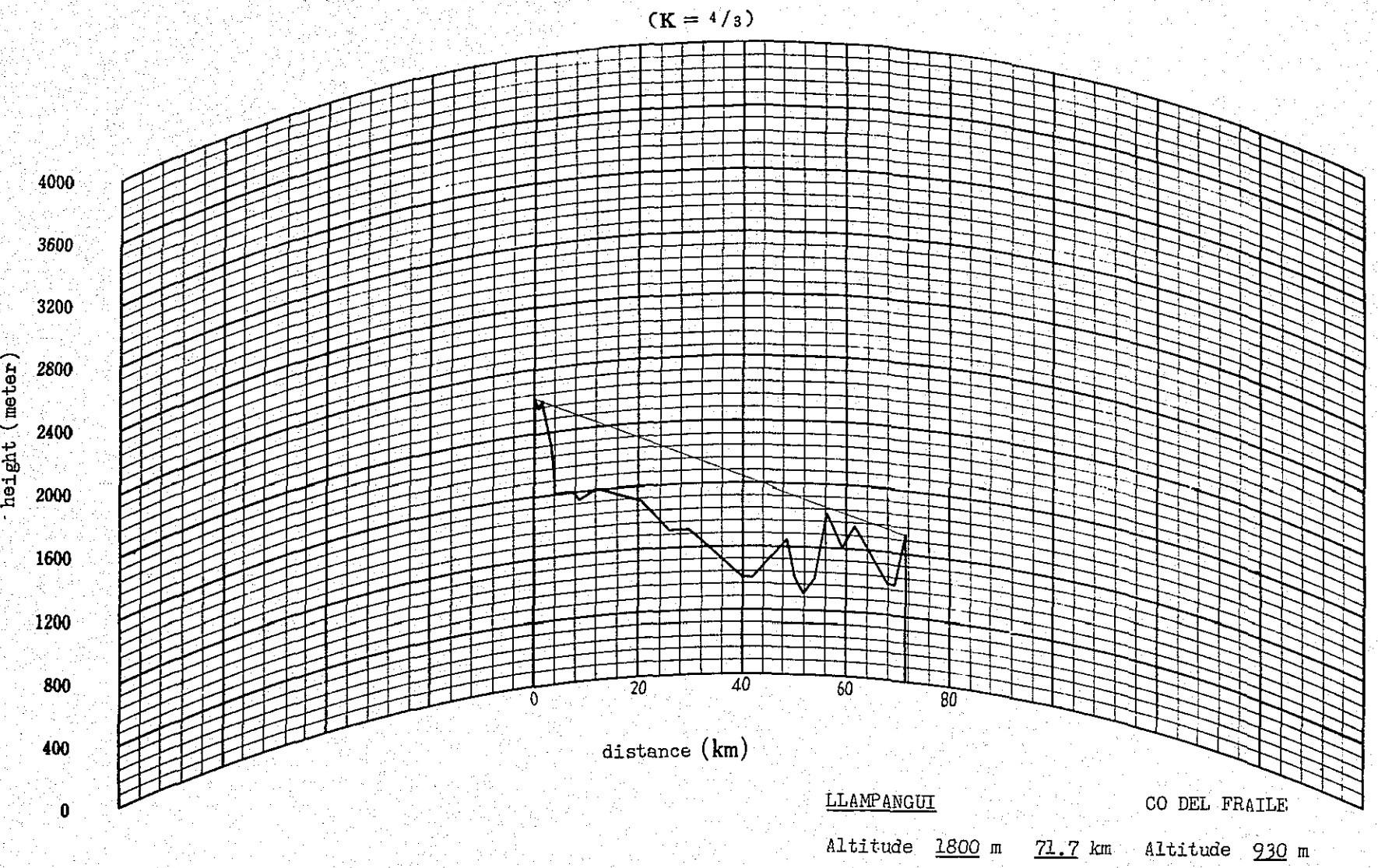


Fig. 2 Profile (Santiago～ Copiapo) (4)

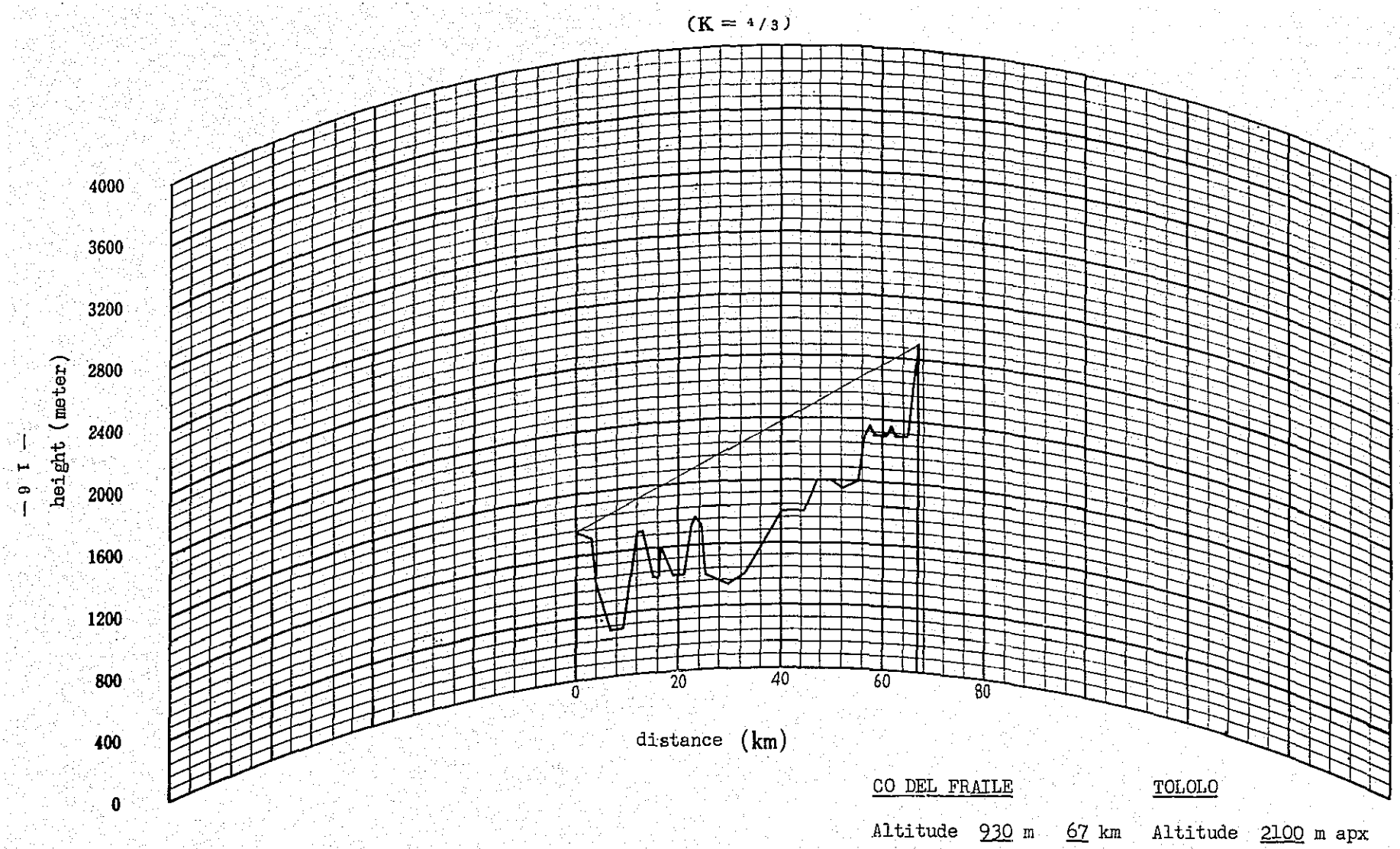


Fig. 2 Profile (Santiago ~ Copiapo) (5)

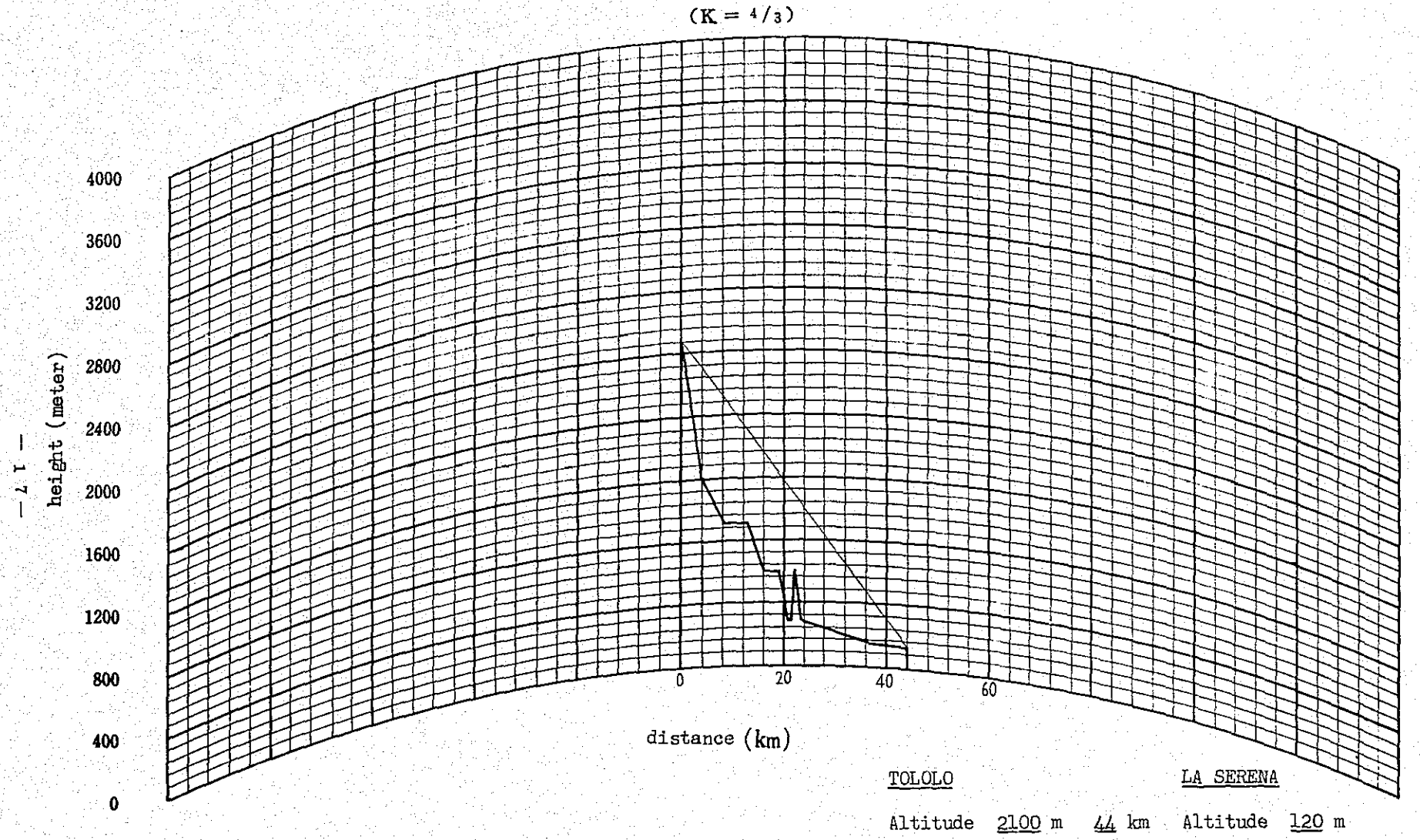


Fig. 2 Profile (Santiago～ Copiapo) (6)

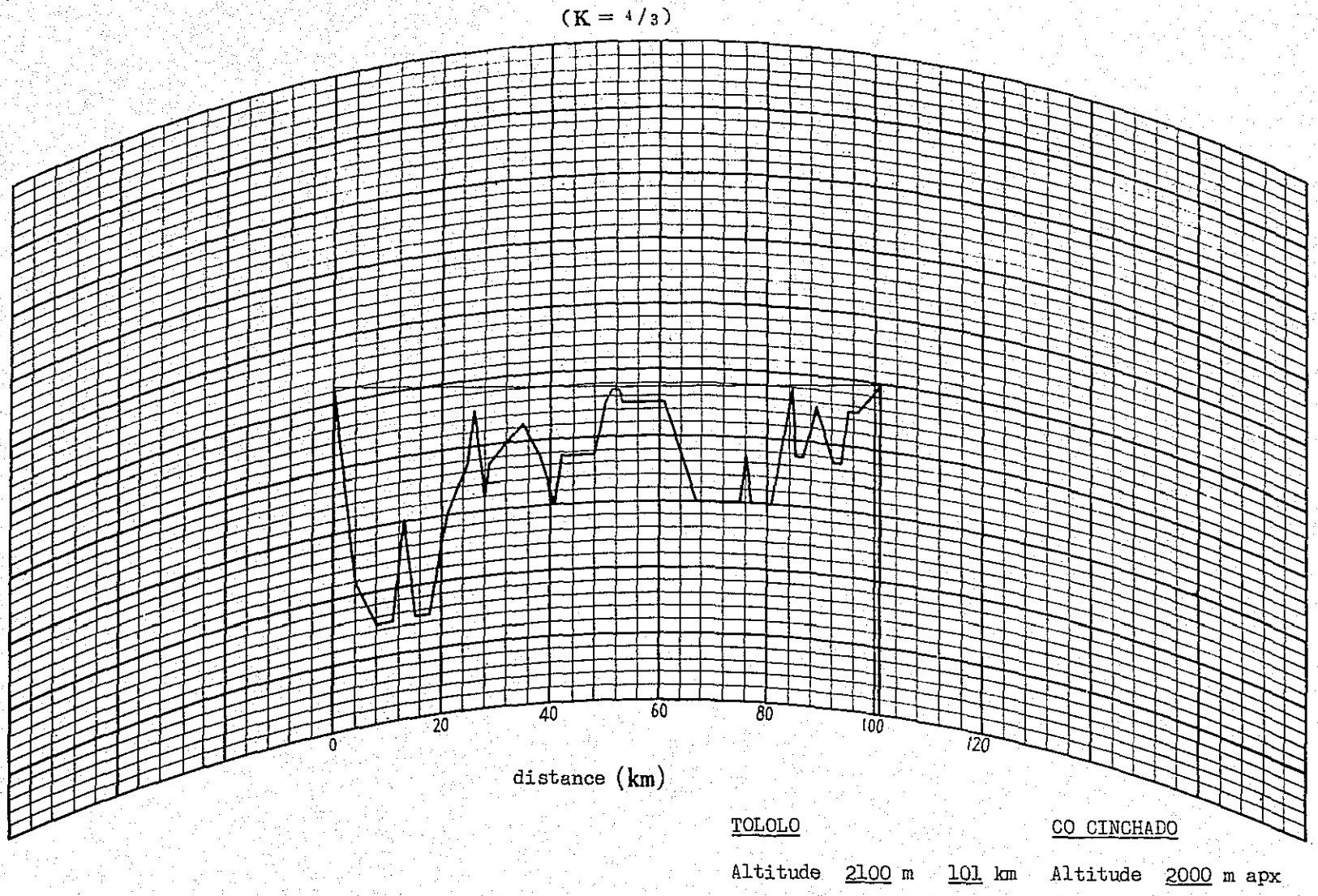


Fig. 2 Profile (Santiago ~ Copiapo) (7)

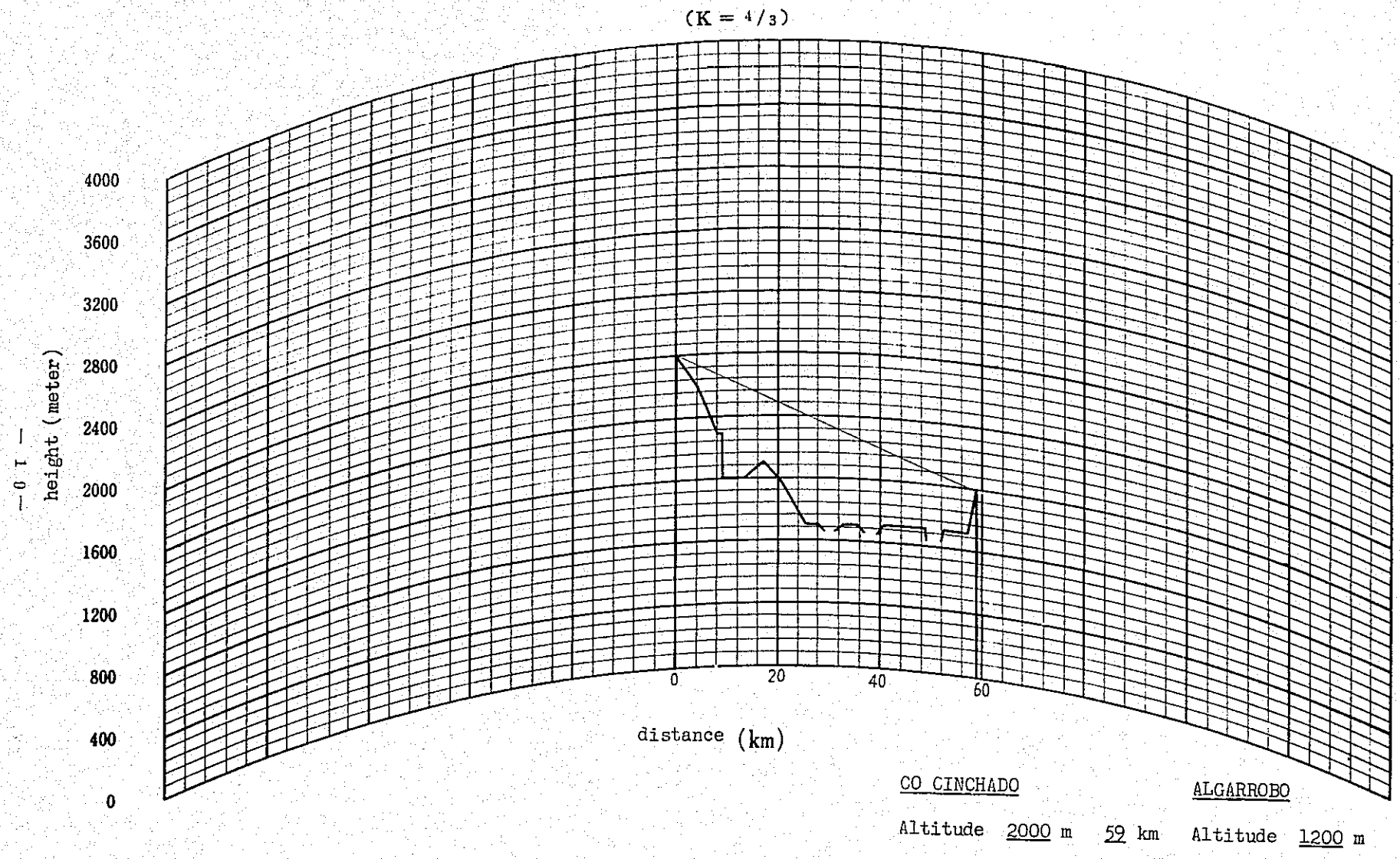


Fig. 2 Profile (Santiago ~ Copiapo) (8)

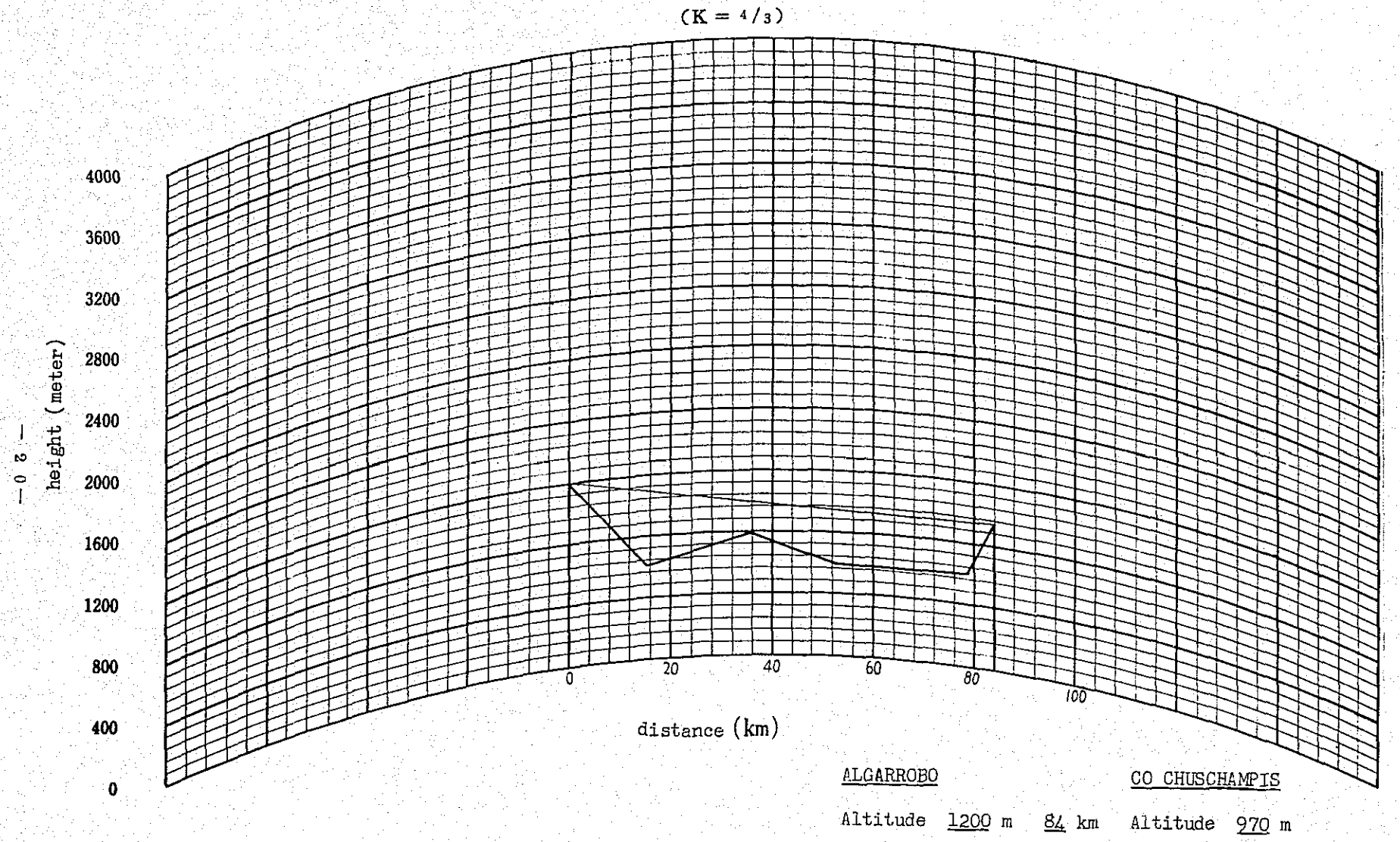


Fig. 2 Profile (Santiago ~ Copiapo) (9)

6.2 Copiapo - Antofagasta (Zone 3)

6.2.1 Progress of the Site Locations

The district ranging from Copiapo to Antofagasta is the desert and most under-developed zone with small population in the north part of Chile. The only towns are Chanaral, Taltal and Potrerillos and there are no big cities in this Section. Most economical designing in due consideration of construction and maintenance is therefore required for this Section more badly than others.

As regards the plan of microwave circuits, 3 routes are suggested as below:

(1) Route which is operated by means of long distance repeater spacings of over sea propagation

(2) Route which is operated by means of combination work of over sea and inland propagation in which repeating stations are to be constructed along the Pan American Road.

(3) Inland route through which repeating stations are to be constructed partly along the old roads and partly along the Pan American Road.

Among these, the first one was eliminated from the application routes, because it required high power transmitter and large diameter antenna with high gain, its prospect through Morro Del Copiapo - Antofagasta was poor, it required other circuits for communication with the cities such as Chanaral and Taltal, and, as the connection route to Zone 1 and Zone 2, it revealed characteristic disproportion in the quality of circuit and in the degree of channel multiplexity. Plan (2) and (3) are the line of sight propagation, each route is convenient for circuit branching and has good proportion with the microwave circuits of Zone 1 and Zone 2. Our field investigation, therefore, was executed into these two routes to decide the final route to be adopted. As a result, route (2), the transmission route along the Pan American Road, was determined superior to route (3) as to the conditions such as the roads and power sources, etc. and was also advantageous with respect of circuit branching, and thus, route (2) was adopted as the final route.

The final route is shown in Fig. 3.

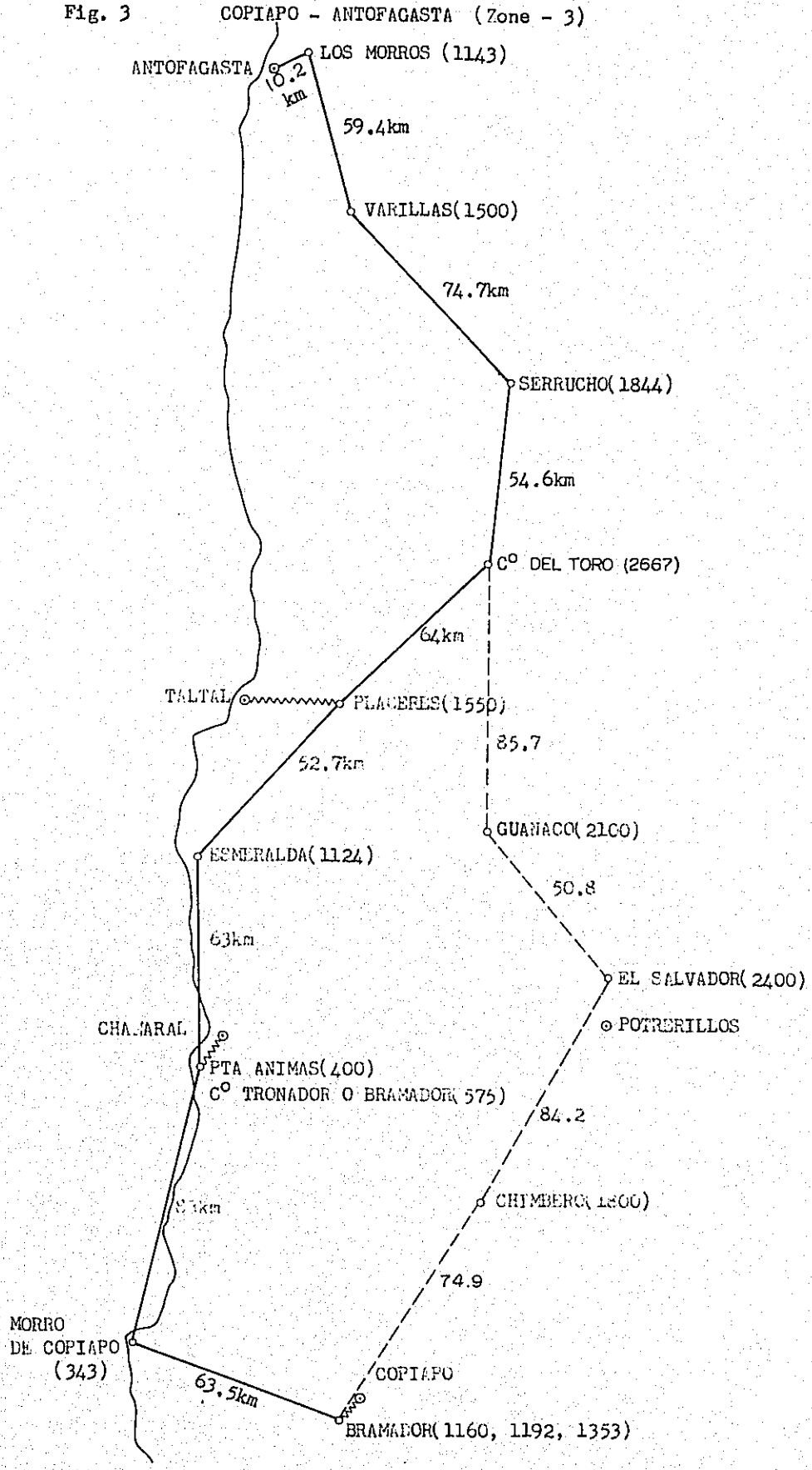
The special points of question are as follows;

(1) Decision of the most adequate station site as to C° Tronador 0 Bramador should be made.

(2) The necessary height of antenna of C° Del Toro is comparatively high.

However, the results of our field investigation guarantee the possibility of realization of these points.

Fig. 3 COPIAPO - ANTOFAGASTA (Zone - 3)



6.2.2 The Matters that Demand Special Attention to the Proposed Station Sites.

(1) Copiapo

Same as mentioned in the above paragraph.

(2) Bramadador

Same as mentioned in the above paragraph.

(3) Morro Del Copiapo

This is the place near the seaside and the site is very spacious and even. There is no access road at present, Mountains and hills are of mild slopes and sandy in some cases, but jeeps can go through. The distance to the existing electric power lines is about 11 kms. The optical sight to Bramador and Pta Animas is good. However, the section from Morro Del Coipapo to Pta Animas requires over sea propagation which is subject to receive reflected wave and the generations of large and quick change fading. Distortion noise is also to be feared. Therefore, it would be necessary as mentioned herebelow to shift the site of the station of ~~Morro Del Copiapo~~ Pta Animas a littel to inland-ward to suppress oversea reflected wave. As a matter of course the problem of optical sight must again be considered in doing this.

(4) C° Tronador O Bramador Pta Animas had been taken as the repeating station site from the map study, but the propagation path from this site to Morro Del Copiapo runs over sea, moreover there is no shielding ridge among this path to attenuate the reflected wave. Our survey team has discovered a new site which is situated in the neighbourhood of C°Tronador O Bramador and a little nearer to inland than the first proposed site. The reflected point viewing Morro Del Copiapo from the new site is to be on land with a fair optical sight being expected toward Esmeralda. This site may be compared a little unfavourably against Pta Animas as regards the conditions of construction, but the characters of radio wave propagation are to be given priority and therefore this site should be decided.

Both of the above sites, however, cannot have direct sight to Chanaral, and must be connected to Chanaral by cable.

(5) Esmeralda

At Esmeralda, the ground consists of comparatively easy slope ways and the area is quite spacious, and though there are numerous pebbles and stones no big rocks are seen. A road runs climbing up near to the summit which indicates to be an old truck way, but it needs a little repair. The difference of altitude between the site and the existing road

is about 150 m and the construction of new road is thought comparatively easy. The site is situated near the Pan American Road but not equipped with the power lines. The prospect to Pta Animas and Placeres are good.

(6) Placeres

The site needs a little work of smoothing. About 6 Km of access road from the Pan American Road is necessary to be constructed, of which some 4 Km may allow jeeps to pass. The prospect to both directions are generally good.

The direct prospect to Taltal is impossible and Taltal is connected to Placeres using both radio and cable systems.

(7) Co Del Toro

The area is spacious but needs some work of smoothing. A new road of about 10 Km is needed from the Pan American Road.

In the direction of Placeres optical sight is generally good but the prospect to Serrucho is not good. The height of antenna above ground may be about 50 meters, but actualy, it must be decided upon the more detailed investigation.

(8) Serrucho

Serrucho is a mountain rising up above pampas at the distance of 11 Kms from the Pan American Road, and the slope is gentle to the top, but some smoothing work of ground is necessary. There is no road, but jeeps can go through. Towards the both directions of Toro, and Varillas the prospect must be re-examined with attention.

(9) Varillas

The mountain slope is mild and jeeps are passable though no road facilities. Present power line is constructed along the Pan American Road. The difference of altitude between the site and the Pan American Road is about 500 meters. Over the ground there are numerous small rocks and some works of smoothing may be required. In the direction of Los Morros the ridge draws near the site and good optical sight can be taken. Therefore, the height of antenna may be decided by the sight in the direction of Serrucho.

(10) Los Morros

Field investigation has been omitted, but this is a mine in itself and is well equipped with roads and power lines and the condition of location is good.

The sight in the direction of Antofagasta is good.

(11) Antofagasta

The height of antenna must be decided in consideration of the heights of buildings, at present and in future.

6.2.3 Profiles of Each Propagation Path.

The profiles of each propagation path between Copiapo and Antofagasta are shown in Fig. 4.

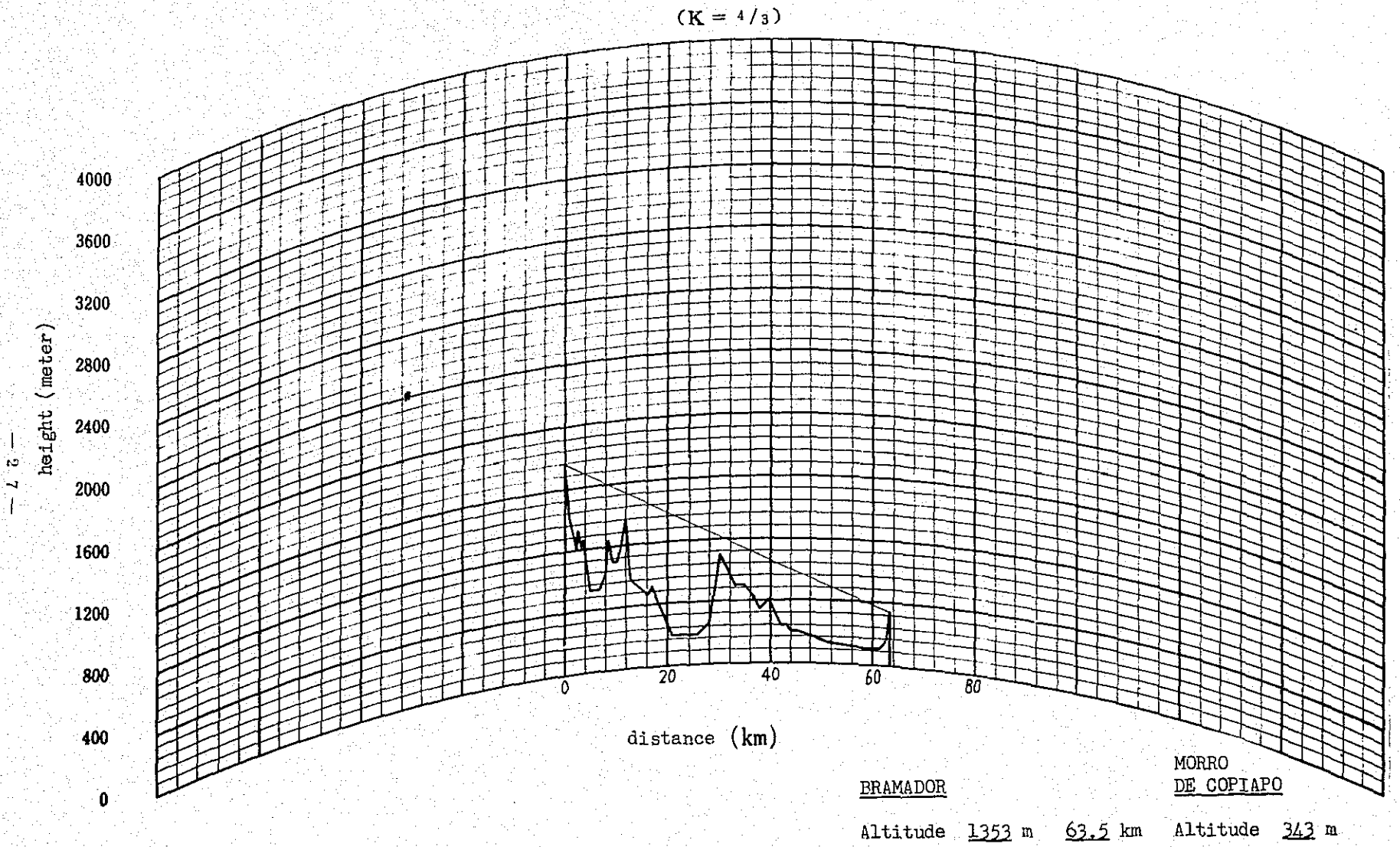


Fig. 4 Profile (Copiapo ~ Antofagasta) (1)

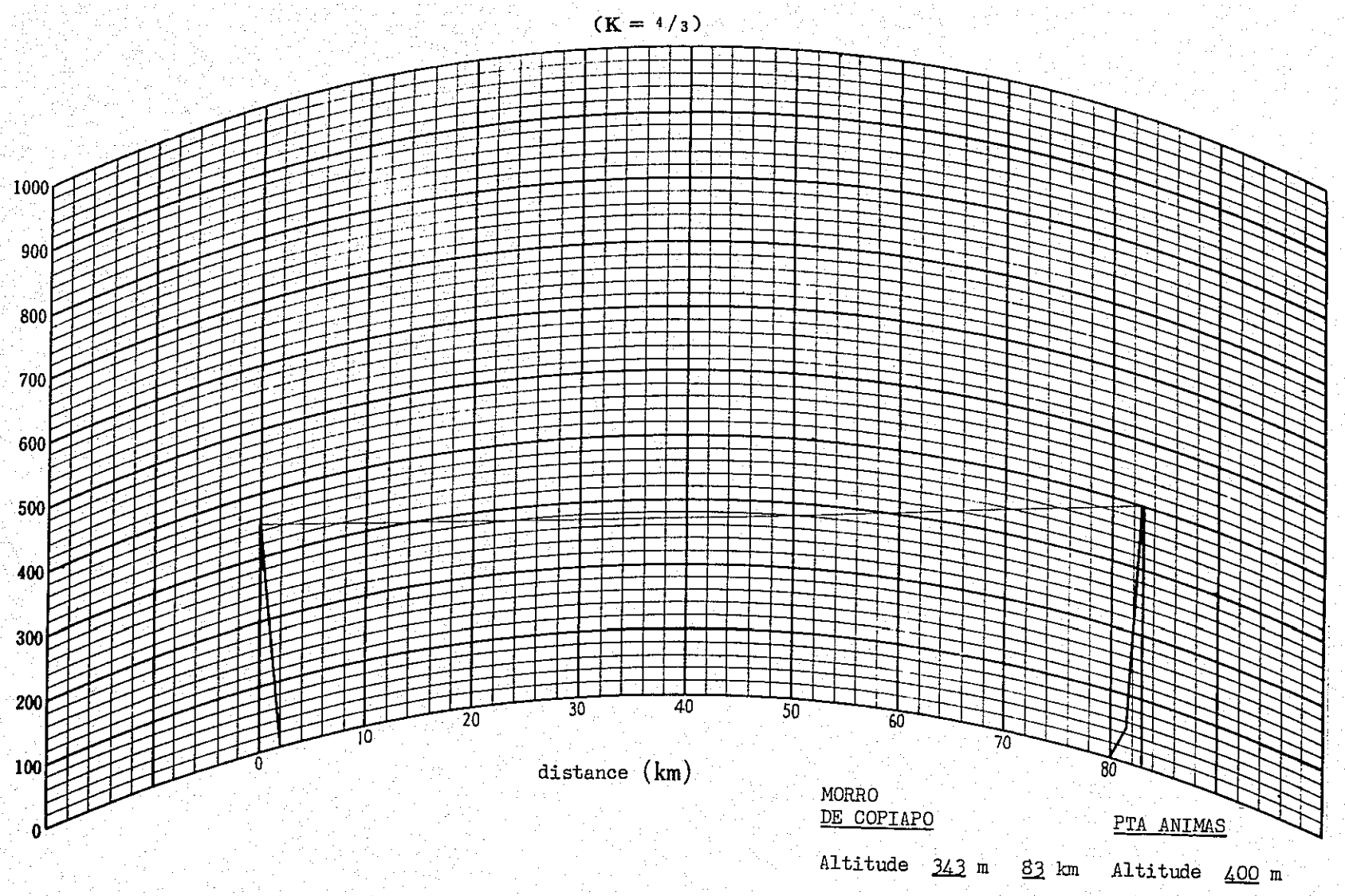


Fig. 4 Profile (Copiapo ~ Antofagasta) (2)

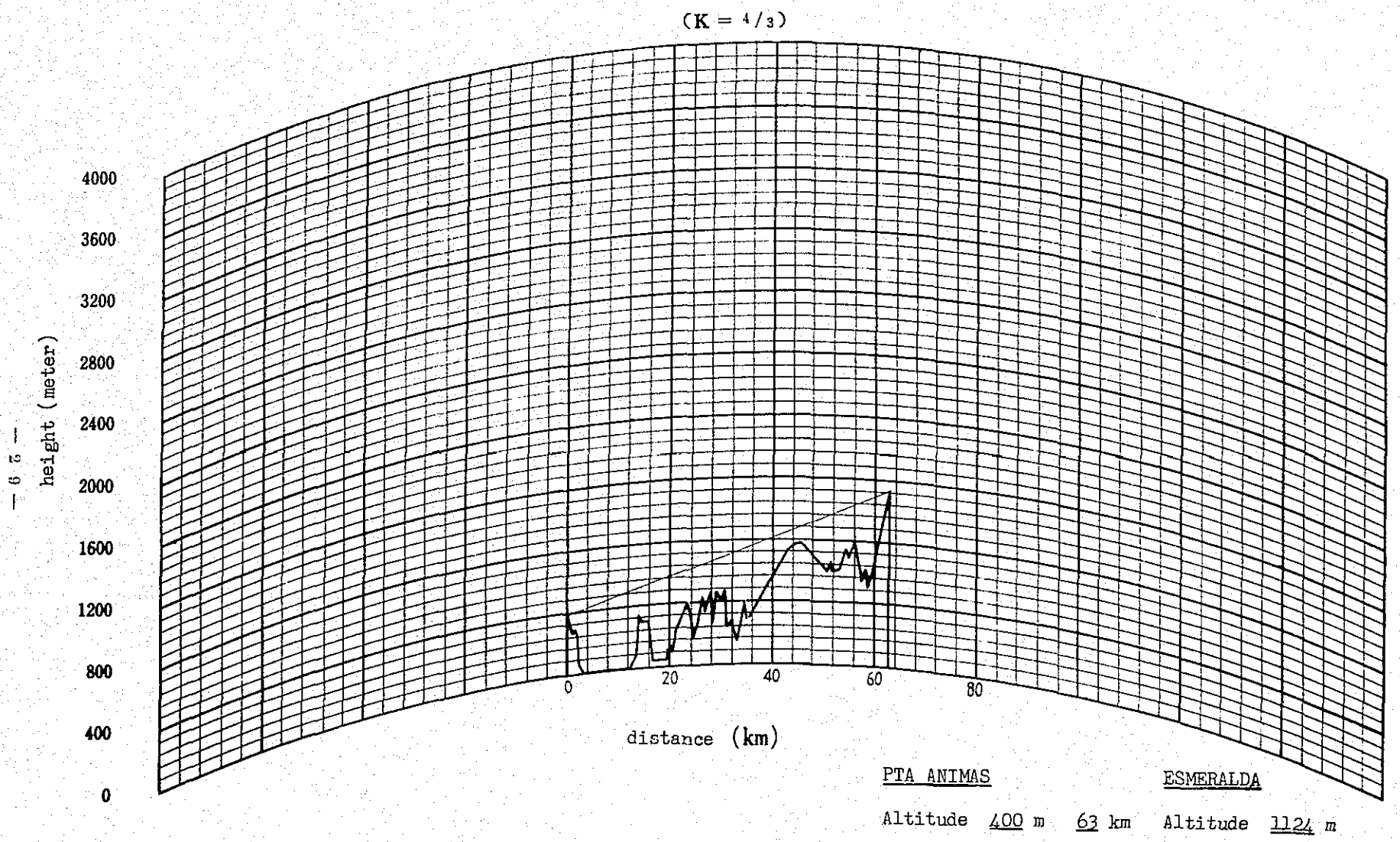


Fig. 4 Profile (Copiapo ~ Antofagasta) (3)

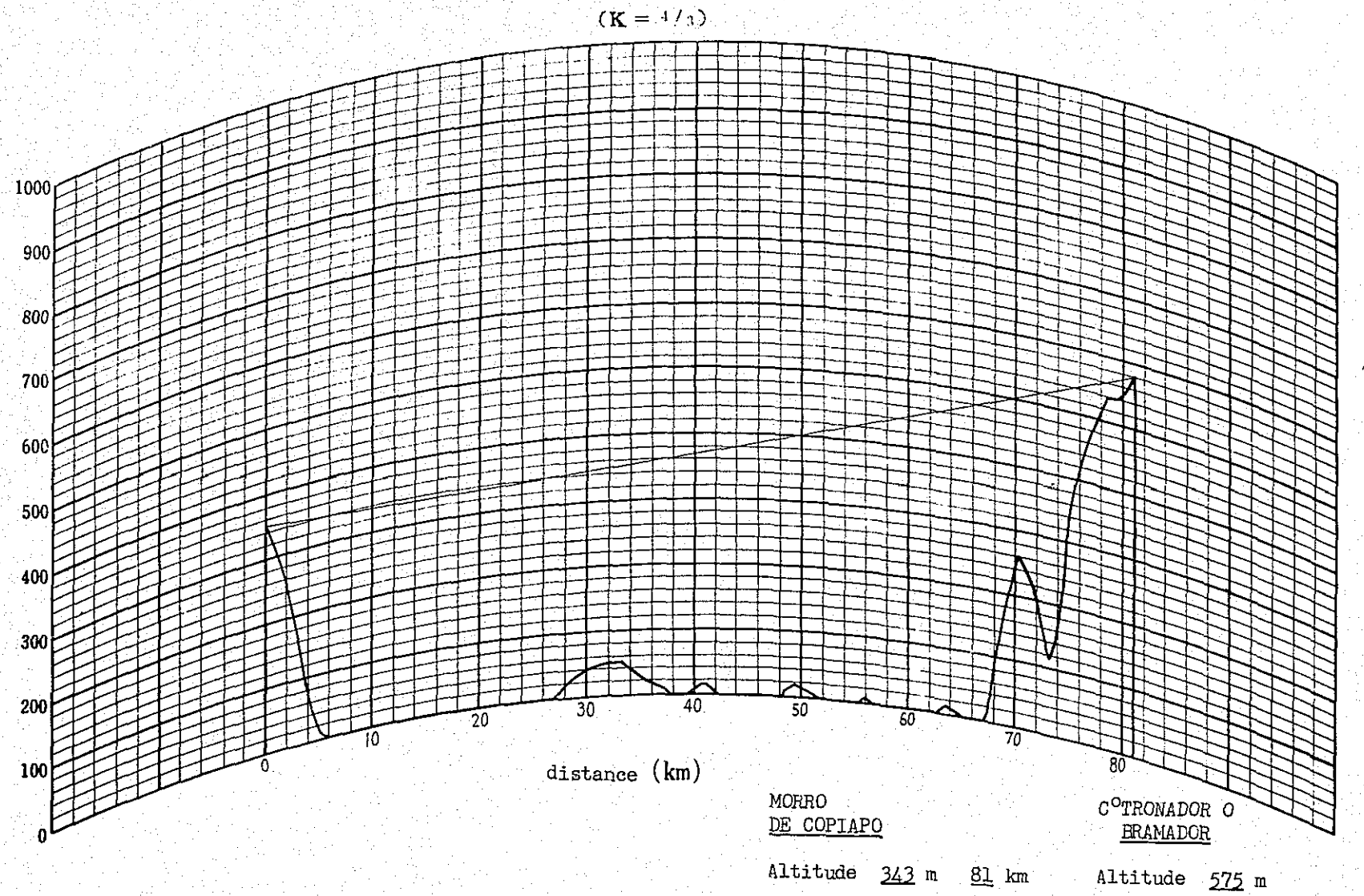


Fig. 4 Profile (Copiapo~ Antofagasta) (4)

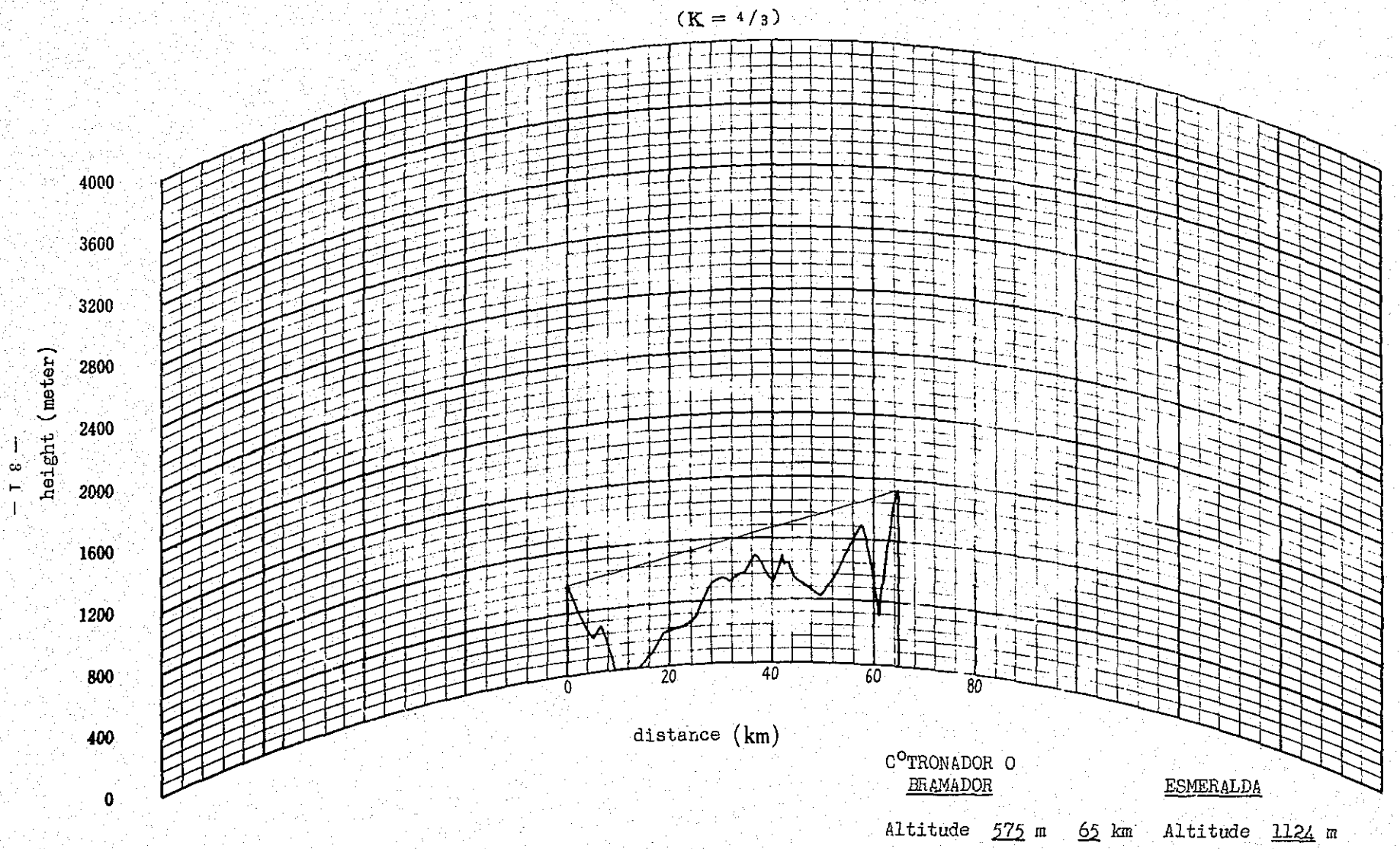


Fig. 4 Profile (Copiapo～ Antofagasta) (5)

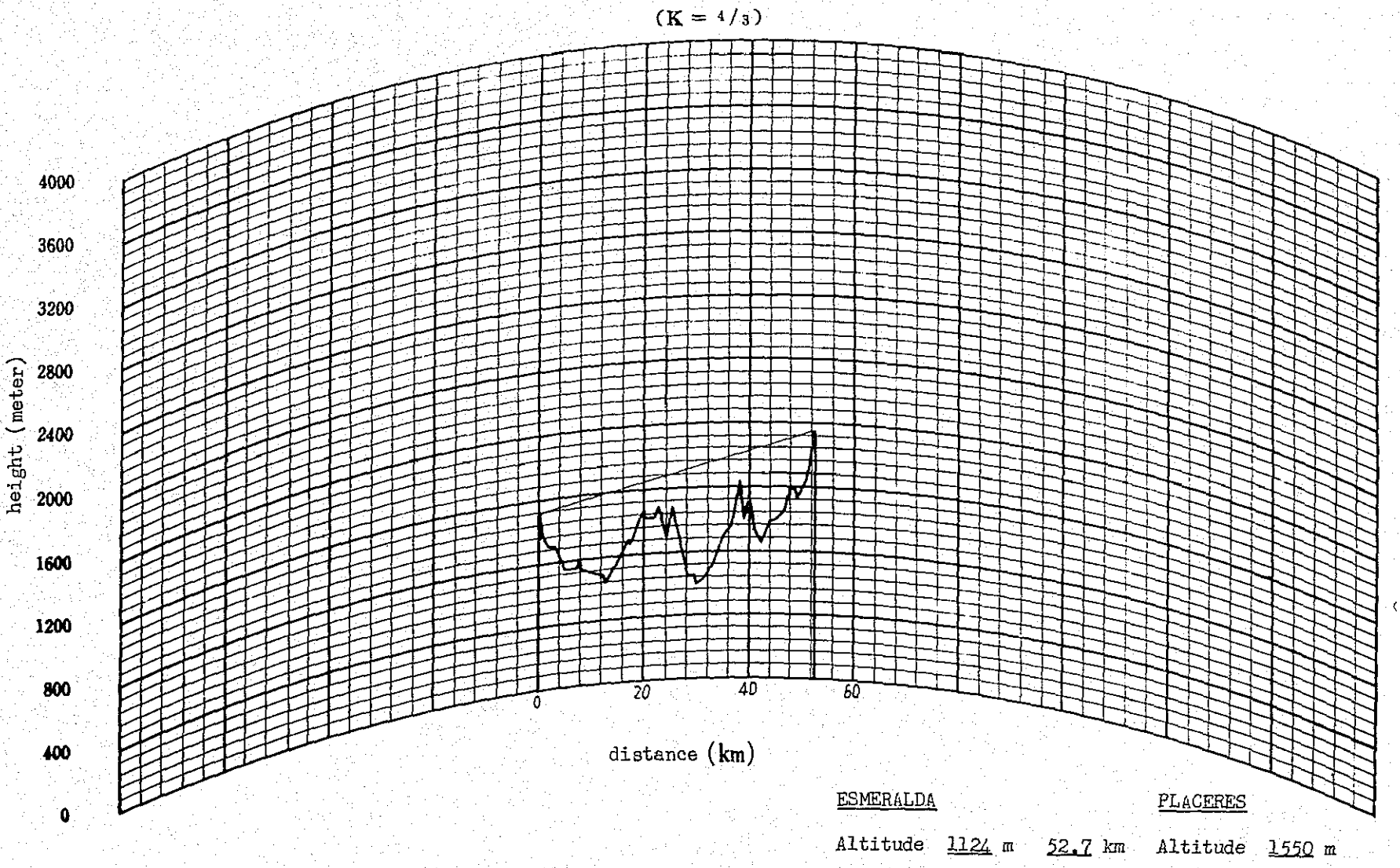


Fig. 4 Profile (Copiapo ~ Antofagasta) (6)

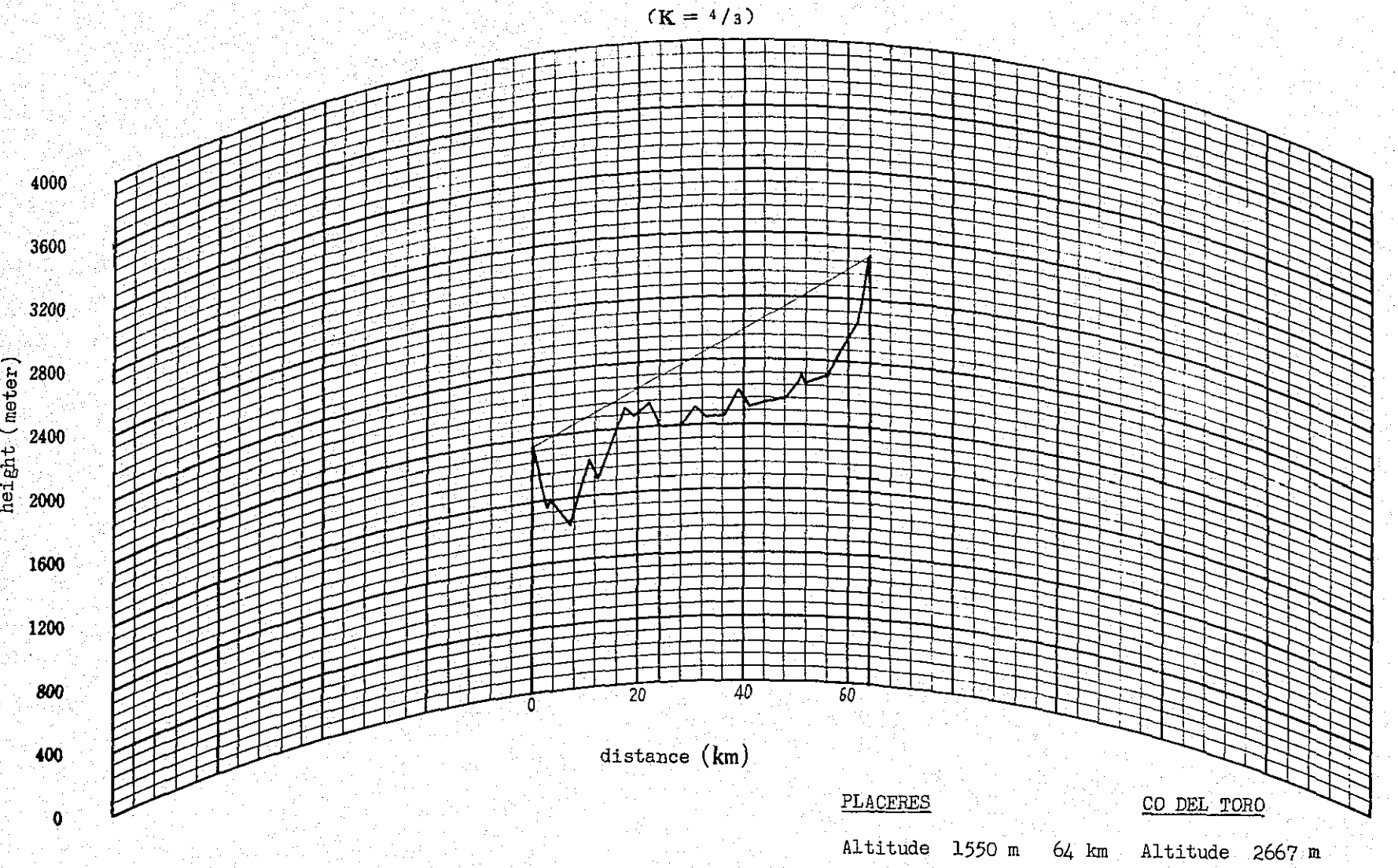


Fig. 4 Profile (Copiapo ~ Antofagasta) (7)

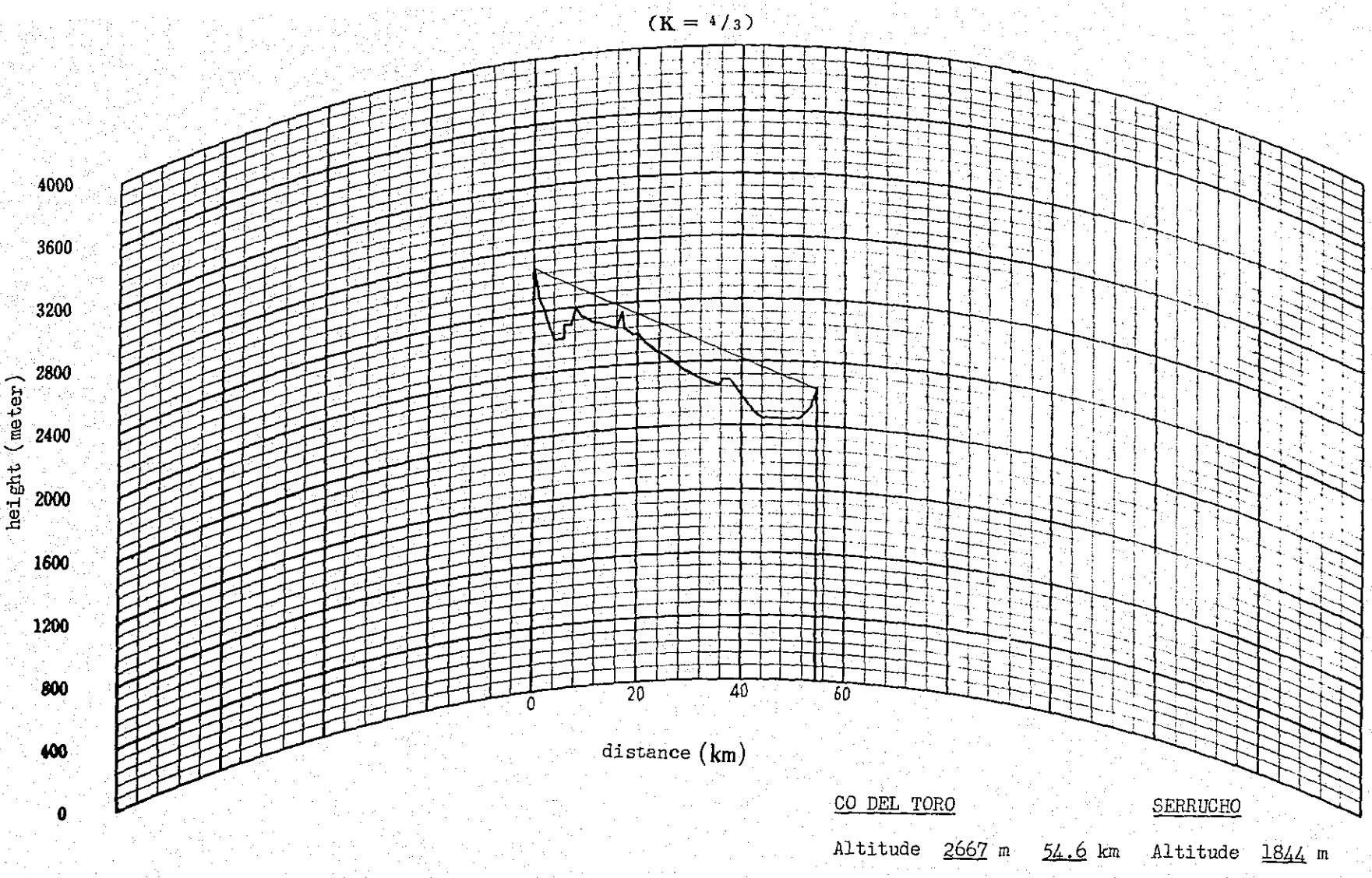


Fig. 4 Profile (Copiapo~ Antofagasta) (8)

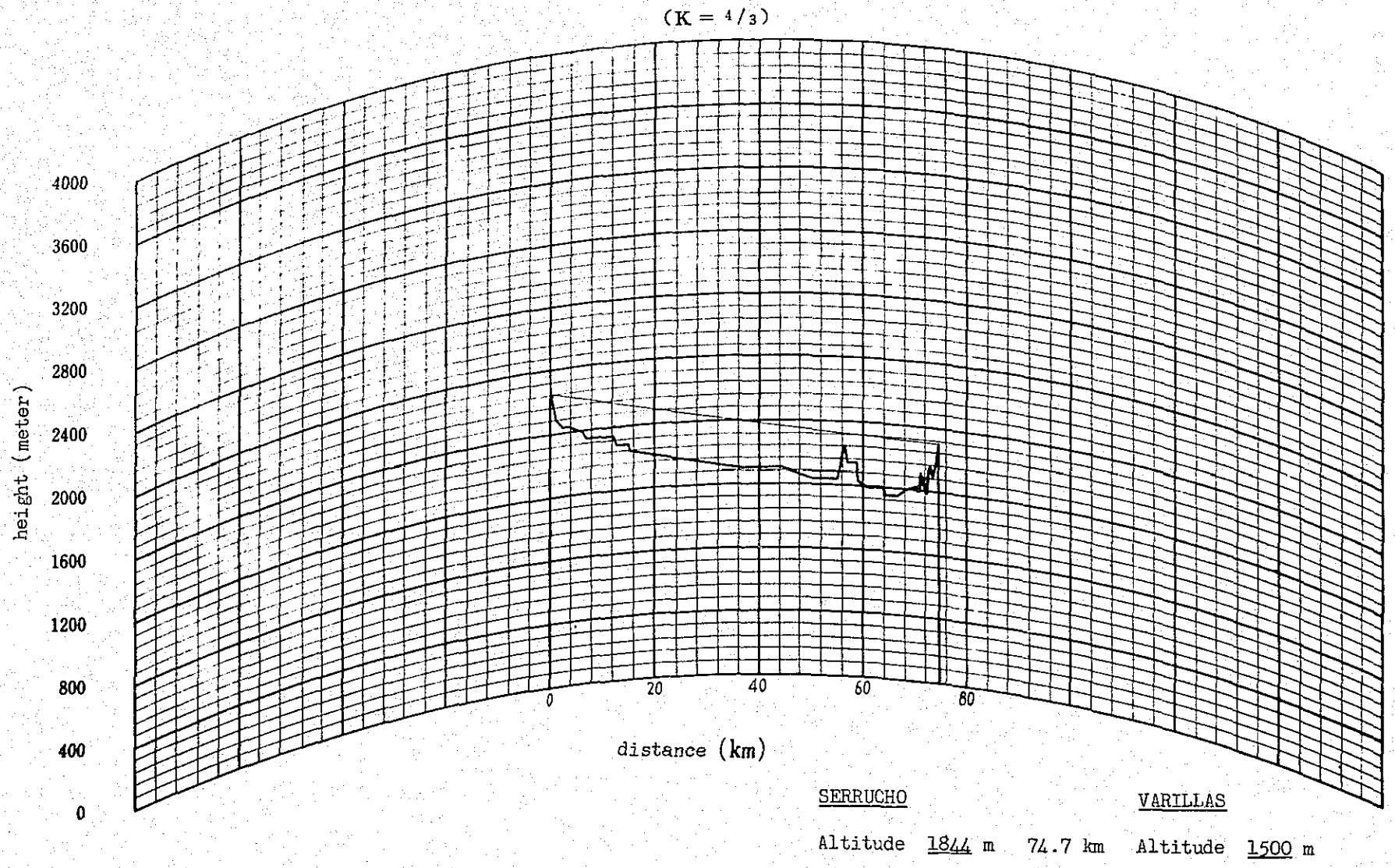


Fig. 4 Profile (Copiapo ~ Antofagasta) (9)

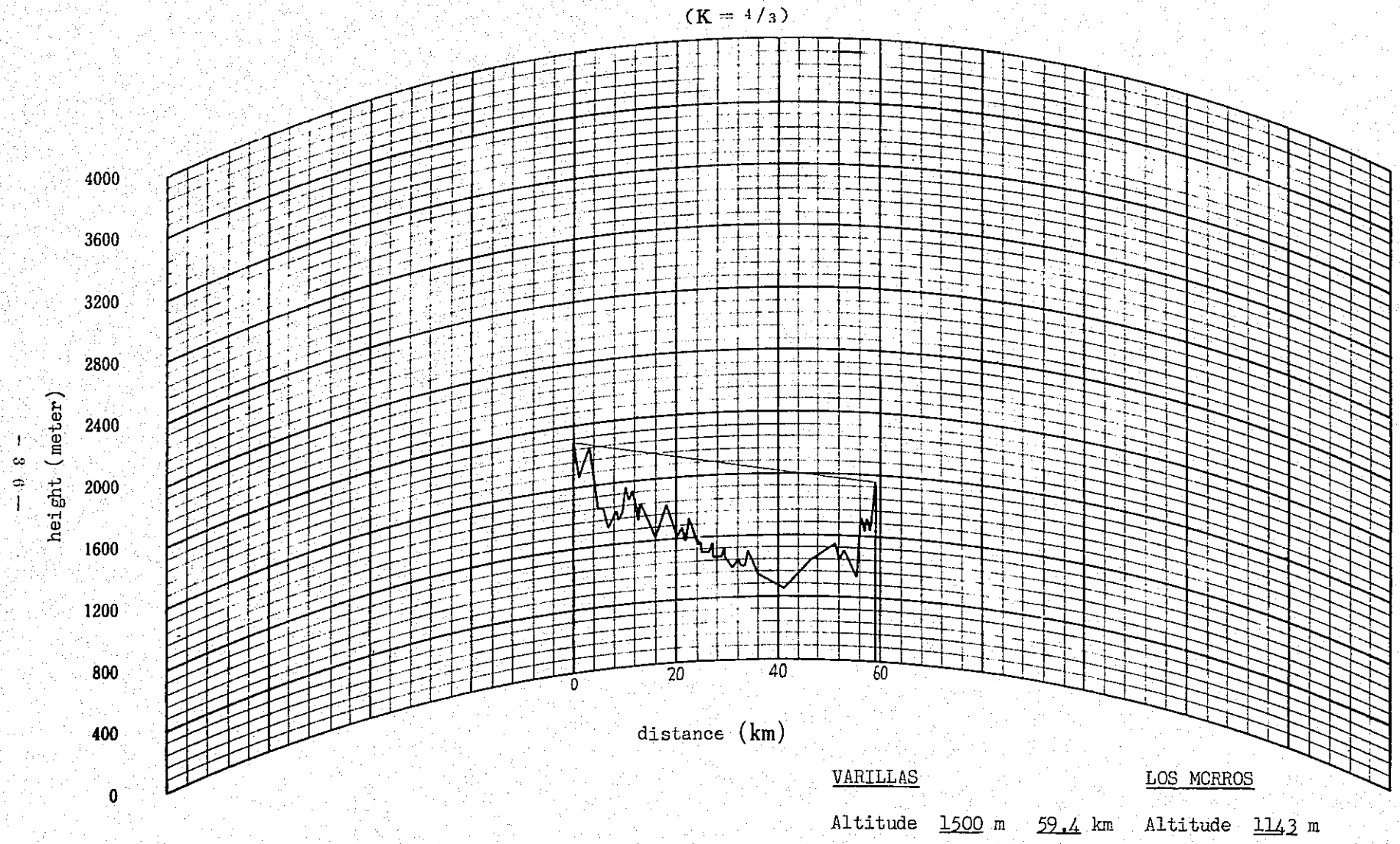


Fig. 4 Profile (Copiapo ~ Antofagasta) (10)

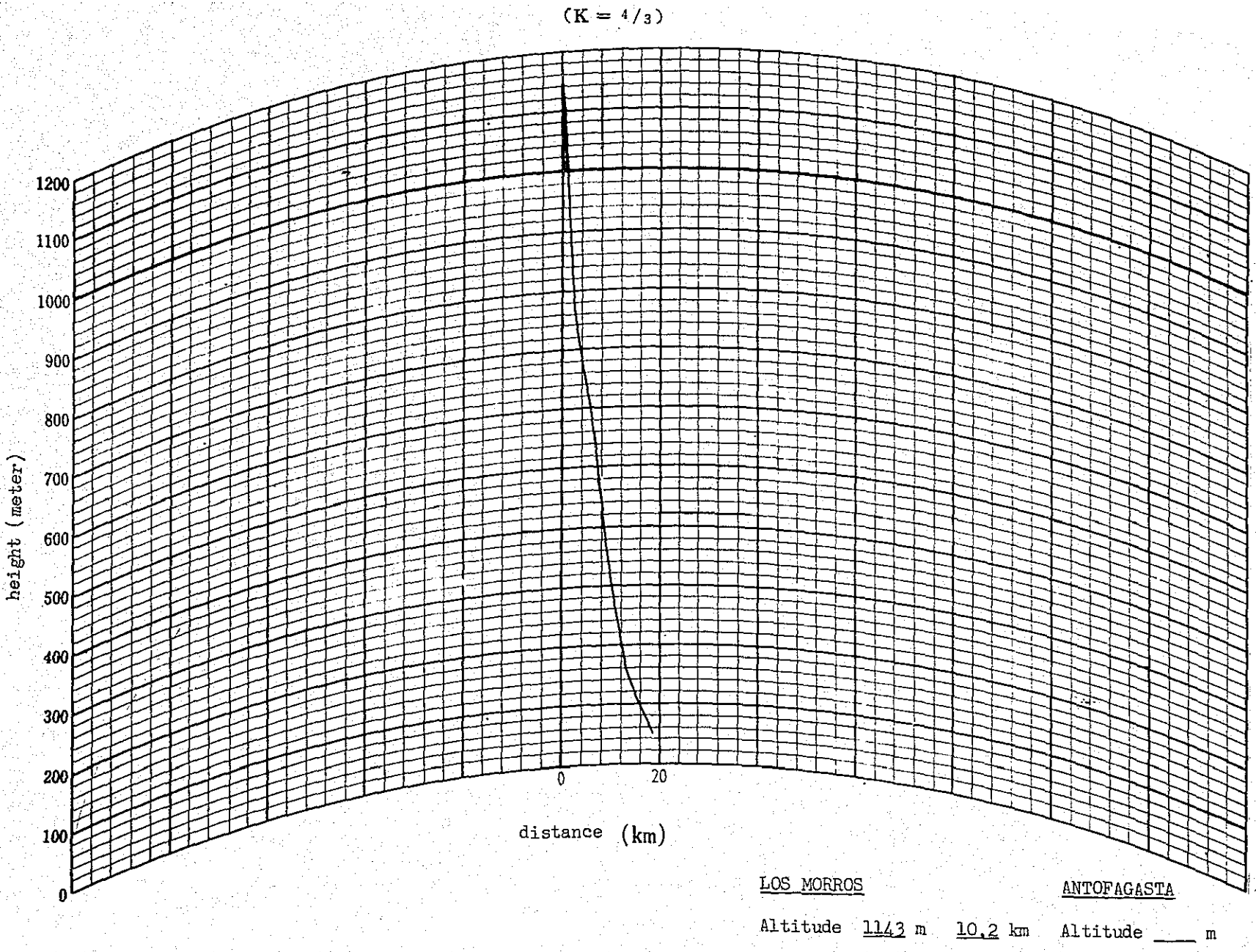


Fig. 4 Profile (Copiapo ~ Antofagasta) (11)

6.3 Antofagasta - Arica (Zone 2)

6.3.1 *Progress of the Site Locations*

The section between Antofagasta and Arica which is the northernmost city in Chile extends about 800 Kms and the land borders on Bolivia and Argentina over the Andes mountains in the east. There lie small mountains over the plateau, or pamps, of about 1000 ~ 1500 meters high which stretch over the west coast. Along the coast lines a chain of steep mountains rise from the north to the south which vanish into the east plateau and prairie of the inland district.

A long the coast, there are some towns and cities such as Antofagasta, Mejillones, Tocopilla, Iquique, Pisagua and Arica, etc., all of which need the branch circuits of telephones.

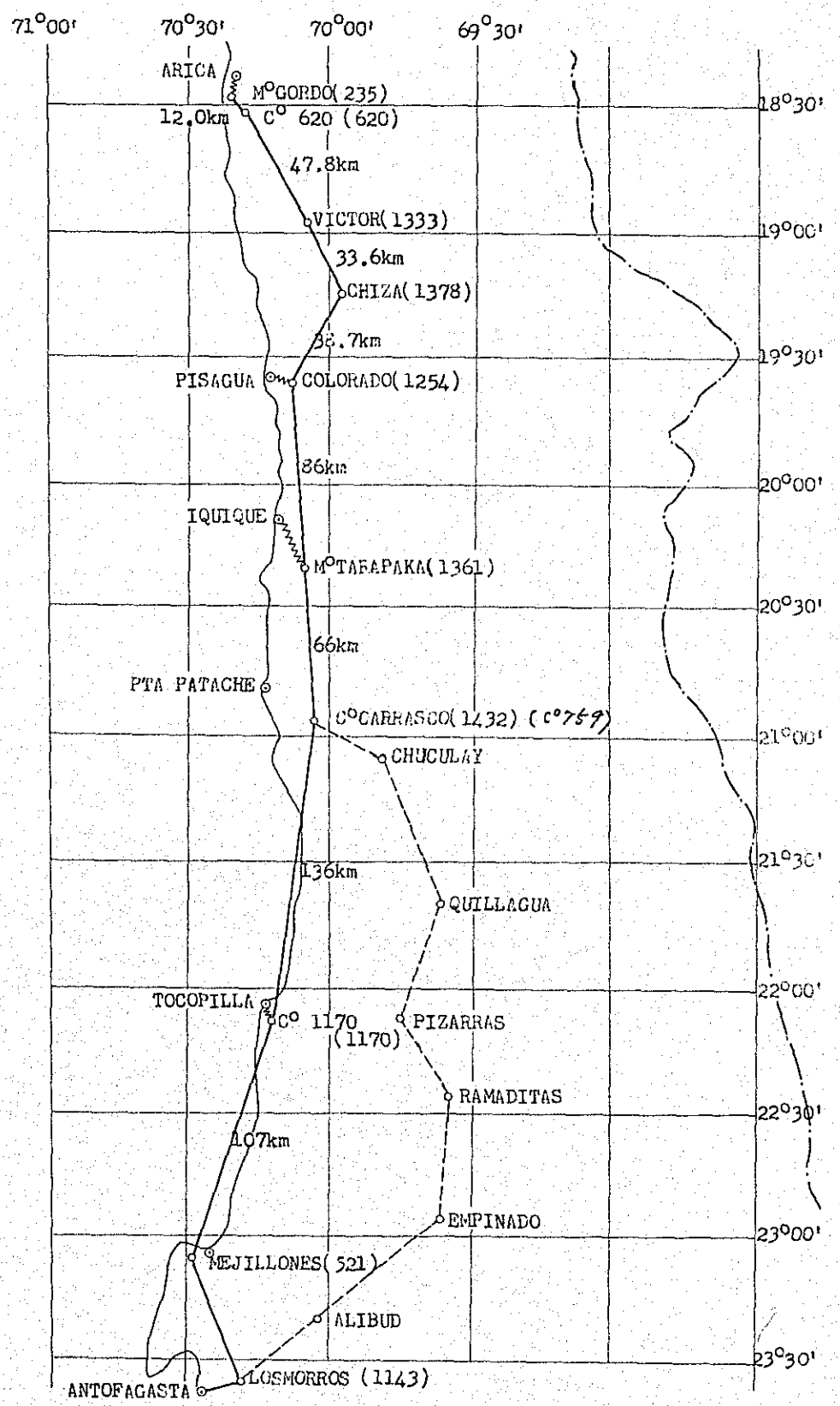
As regards the microwave route which is to be constructed in this section with such characteristics of land as aforementioned, there are two plans, one is the inland plan and the other is the route along the coast.

Of the two, the inland route is comparatively advantageous and it is easy to construct stations there at proper intervals mainly along the Pan American Road and is possible to select better propagation path as compared with the coast route. However, the route has some economical disadvantages, for it necessitates the construction of many repeater stations and has difficulties as to construction of branch circuits to the towns or cities along the coast.

On the other hand, as regards the coast route, mountains crosses the propagation path and makes worse the conditions of line of sight. The route also involves many difficulties in the construction of repeater stations at adequate intervals.

As a result of our field investigations, mainly from economical reasons the final plan such as shown in the Fig. 5 has been decided, which consists of the coast route between Antofagasta and Iquique including the two sections of propagation over sea and constitutes the inland route between Iquique and Arica.

Fig. 5 ANTOFAGASTA - ARICA (Zone - 2)



It is noted that two sections, namely from Mejillones to C°1170 and from C°1170 to C°759, were not fit to construct good repeater stations on account of the topographical features of these districts, and long repeater spacings of propagation over sea more than 100 Kms had to be selected respectively.

The matters taken into special consideration at the selection of the sites were the following;

(1) Application of high altitude propagation path in order to prevent the characters of circuits from becoming ineffective due to the occurence of the duct type fading;

(2) Acquisition of the shielding ridges to alleviate the effects of reflected wave on the sea. The final decision of the sites of C°1170 and C°759 should be arrived at in accordance with the results of the re-investigations

In other words, these sections involve much difficulties in selecting the sites as compared with other sections and the decision of the final site especially of the location of repeater station and the height of antenna must be considered, the following conditions;

(1) The actual measurement of the accurate heights of the sites and shielding ridges must be executed. Forms of shielding ridges may also be considered.

(2) In this case the conditions are as follows;

Under effective earth's radius factor K = 1, the clearance against the first fresnel zone must be acquired.

Under effective earth's radius factor K = ∞, necessary attenuation of reflected wave must be acquired by shielding ridge.

(3) The location of antennas for the diversity system must be considered. The antenna for the diversity system must be installed on the lower side than the main antenna's. In this case, the main antenna's beam must have satisfactorily good clearance and diversity antenna's beam must have not always good clearance except the clearance by the obstacles near the diversity antenna.

Even if the sites are selected in consideration of the factors aforementioned, the problem that the frequent occurence of the radio duct may be presumed owing to the meteorological conditions of the area. In order to clarify the special characters of propagation, the long range propagation test is necessary.

For this purpose high gain antenna and high efficiency space diversity system

must be applied, which should bring forth the necessary specifications.

At the selection of the sites in zone 2 it was considered the repeater stations of microwave circuits may be used concurrently for the maritime mobile radio telephone service. This had been desired by the chilean government.

Among the sites selected, M°Gordo, Colorado, M°Tarapaca, C°1170 and Los Morros may be most suitable for this service.

6.3.2 The Matters that Demend Special Attention to the Proposed Station sites.

(1) Los Morros

The station of site is connected with Zone 3 (Copiapo - Antofagasta). Situated near a mine, conditions of this site are execellent.

In future it can also be used as a base station for maritime service and the branch circuit to Antofagasta by means of the radio system may be possible.

(2) Mejillones

Situated near the town of Mejillones, there are facilities of a lift for mining use, power lines and access roads in its vicinity. The ground, however, is narrow and not very spacious.

In the direction to C°1170 station, reflected wave by the surface of sea presents an impediment and the final decision of the site and the height of antennas must be carefully made. The arrangement of antennas for space diversity use must also be considered.

(3) C°1170

This is situated about 8.5 Kms South of Tocopilla and near Punta Blanca. Branching circuit to Tocopilla by means of the radio system is possible, by the installation of reflection board on the side of the mountain which is 470 meters high and is situated about 2 Kms north east of the town. This site is at a distance of 107 Kms to Mejillons and 149 Kms to C°759 respectively. The propagation path is over the sea, and this is most difficult in the technical conditions as to the selection of stations.

In the direction of Mejillones there exist ridges near the site against reflected wave, but the conditions of clearance to direct wave and the attenuation given to reflected wave are opposite each other, which should require careful consideration upon deciding the final station and height of antenna. This site may be used concurrently for the maritime mobile service.

(4) C° Carrasco (C°759)

In our field survey C°759 was investigated as the site scheduled for construction, but the results of subsequent examinations reveal the fact that the over reachs betweens C°1170 - C°759 and M° Tarapaka - Colorado are measured below the specifications of circuits and the scheduled site of C°759 was changed to C° Carrasco (1432). C° Rojo was also examined, but this is unsuitable for the site, for the shielding ridge against reflected wave by the

sea surface in the direction of C°1170 cannot be guaranteed. C° Carrasco has been picked up through the map and most suitable site should be decided from the points of sight, conditions of location and economy by the actual survey.

(5) M° Tarapaka

This is situated about 15 Kms south of Iquique and has good sight into the city. The conditions for a base station of maritime service is thought good. As far as optical sight is possible, the final site of station may be decided at a point below the summit, but it is furthur desirable to decide it in relation to the possible use for a maritime service station.

(6) Colorado

Colorado is situated about 8 Km east of Pisagua. Because the prospect to the direction of Pisagna is impossible, branching circuit is inevitably to be executed by cable, and the use as the base station for maritime service may be possible too. The summit is a narrow tableland which spreads from east to west and the final station must be decided in due consideration of road conditions, etc.

(7) Chiza

The site research of this place by our survey team was omitted but the prospect to both directions may be attained comparatively with ease.

(8) Victor

Victor is a broad plateau in the desert district, and the station should be decided in due consideration of the conditions of road and maintenance, as similar configurations surround the site.

Propagation route to both directions is to be of a low altitude over pampas, and the height of the steel tower of antennas may be decided antenna tower in accordance with clearance and the conditions of the neighbourhood ground.

(9) C°620

The Condition of the site is very good and there is not any troubles.

(10) M° Gordo

This is the tableland adjoining the south of the city of Arica, and is suitable for the base station for maritime service. It is also suitable for junction station in case of international circuit route is connected with the Peruvian routes. The distance to Arica

City is about 2 Kms and the connection with cables is advantageous. Otherwise the installation of the reflection board may be possible when a radio terminal station is constructed in the city.

(11) Arica

When a radio terminal station is installed Arica city, the height of antenna above ground must be decided in due consideration of the height of buildings at present and to be constructed in future.

6.3.3 Profiles of Each Propagation Path

The profiles of each propagation path between Antofagasta to Arica are shown in Fig. 6.

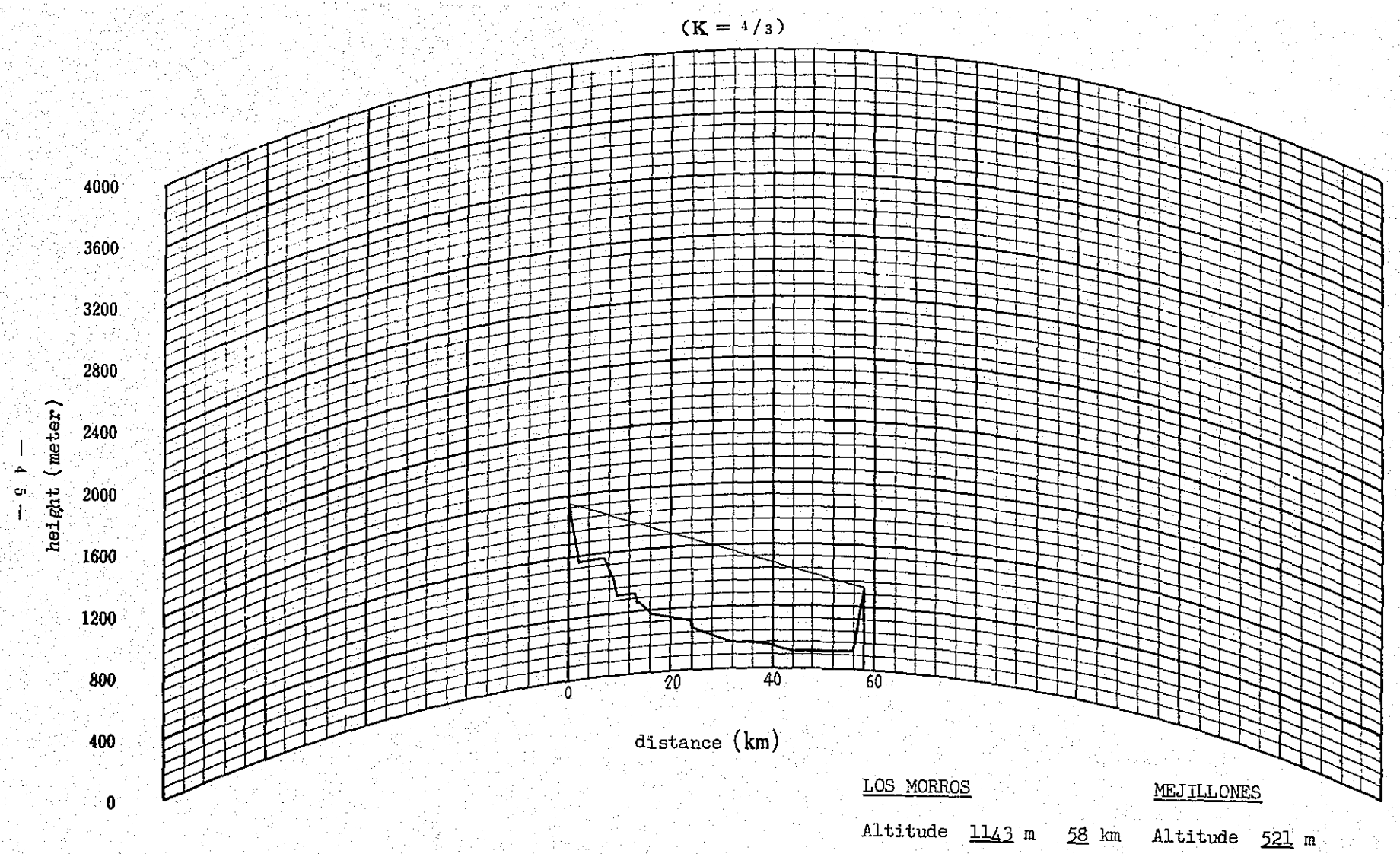


Fig. 6 Profile (Antofagasta ~ Arica) (1)

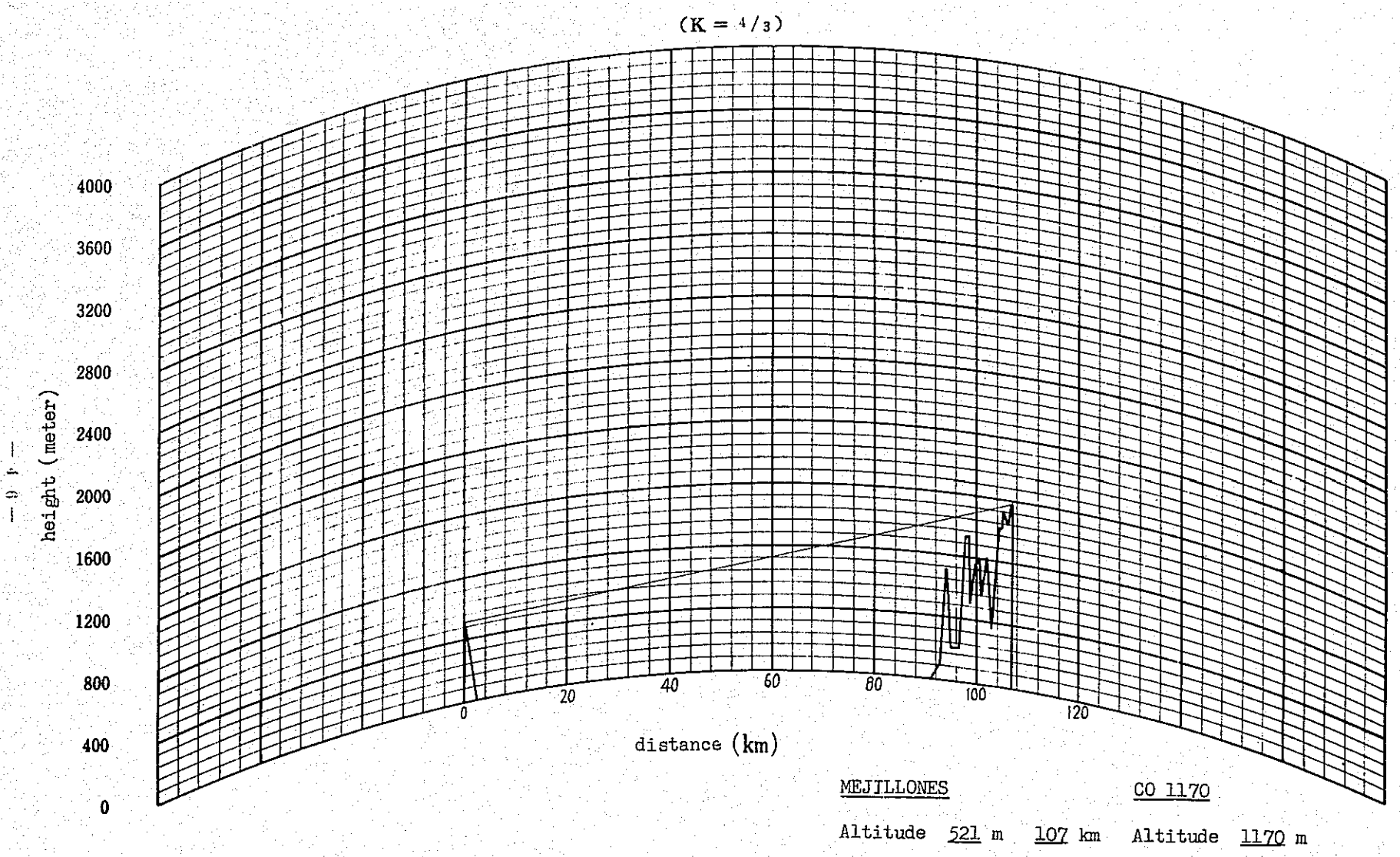


Fig. 6 Profile (Antofagasta ~ Arica) (2)

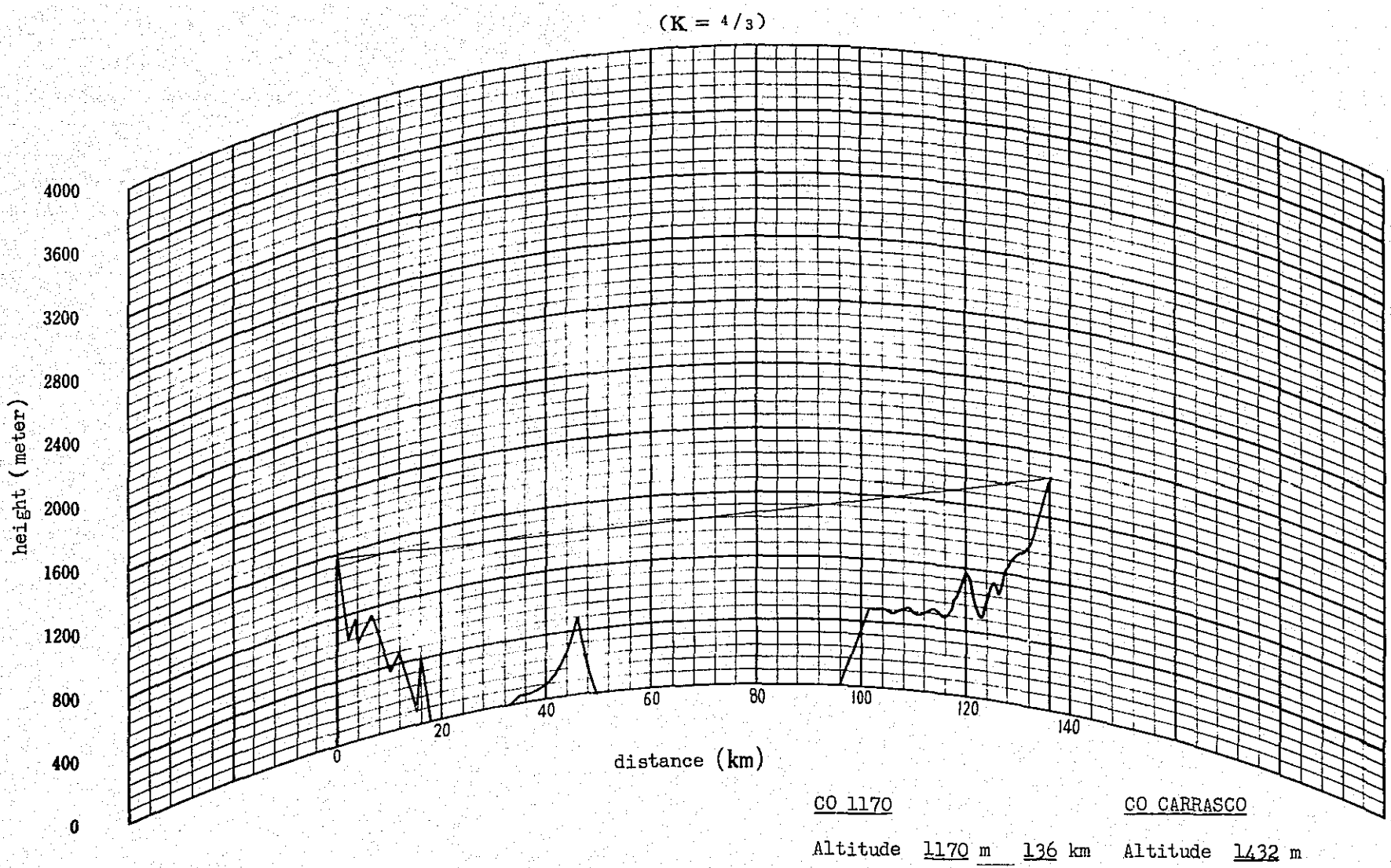


Fig. 6 Profile (Antofagasta ~ Arica) (3)

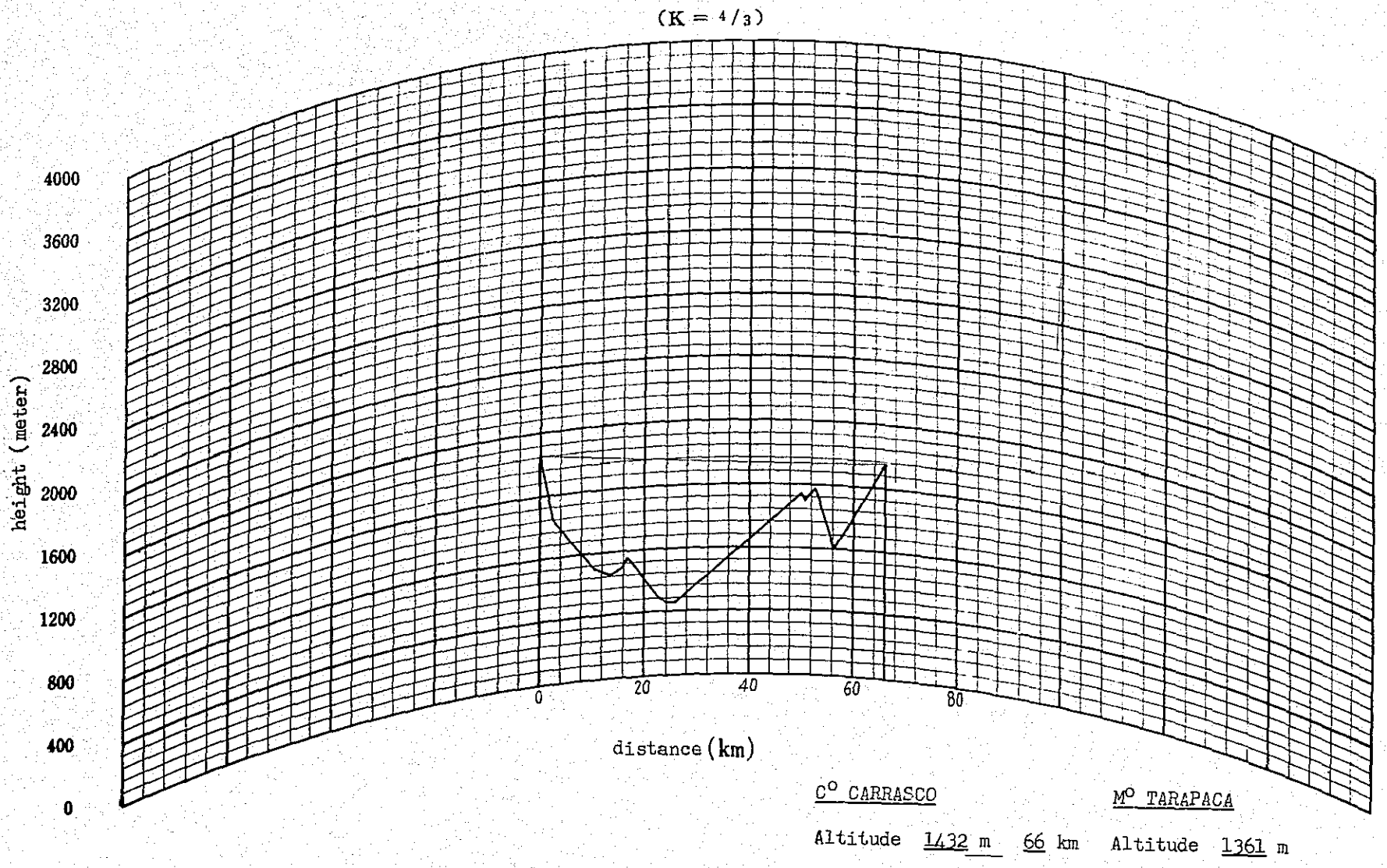


Fig. 6 Profile (Antofagasta ~ Arica) (4)

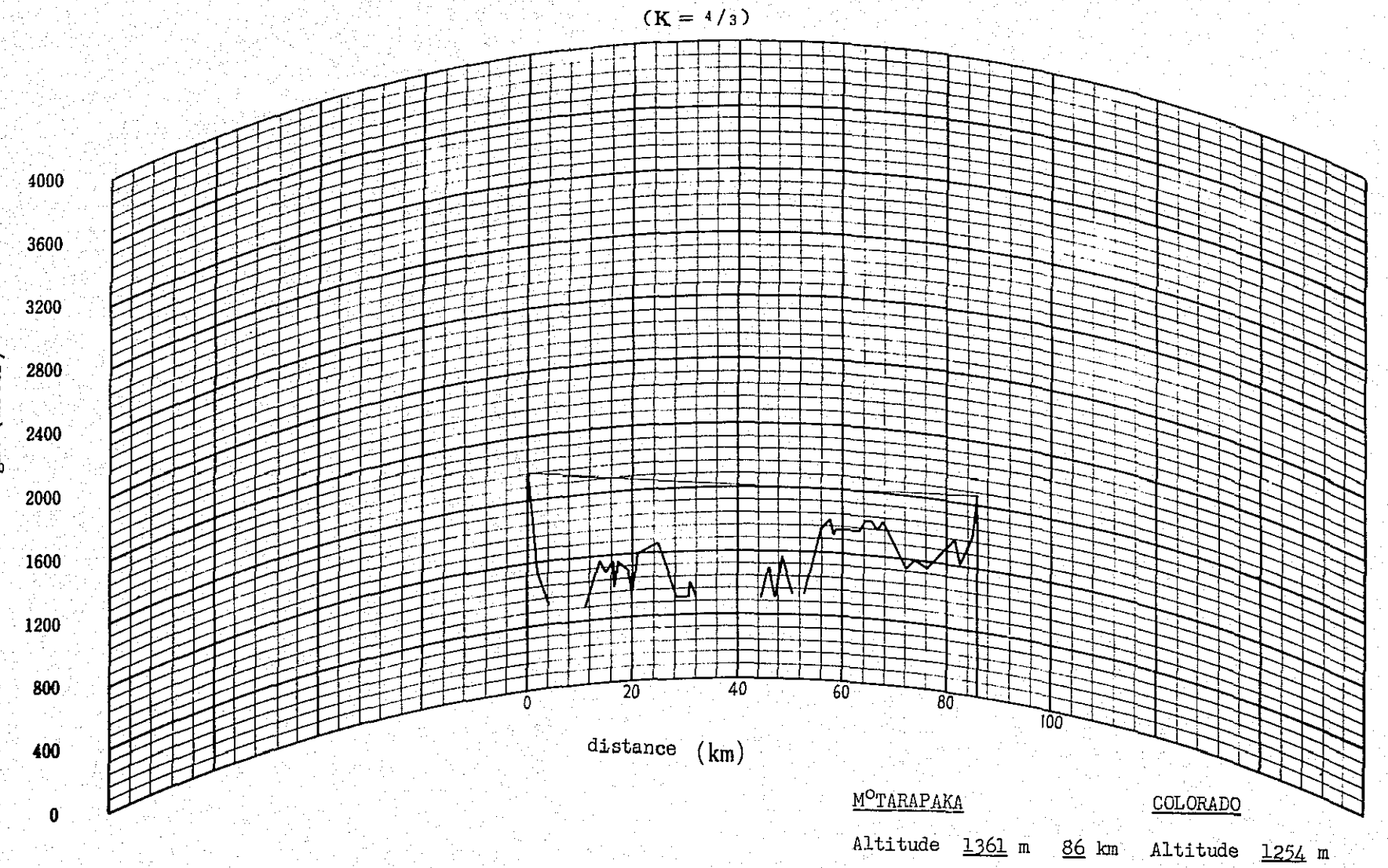


Fig. 6 Profile (Antofagasta ~ Arica) (5)

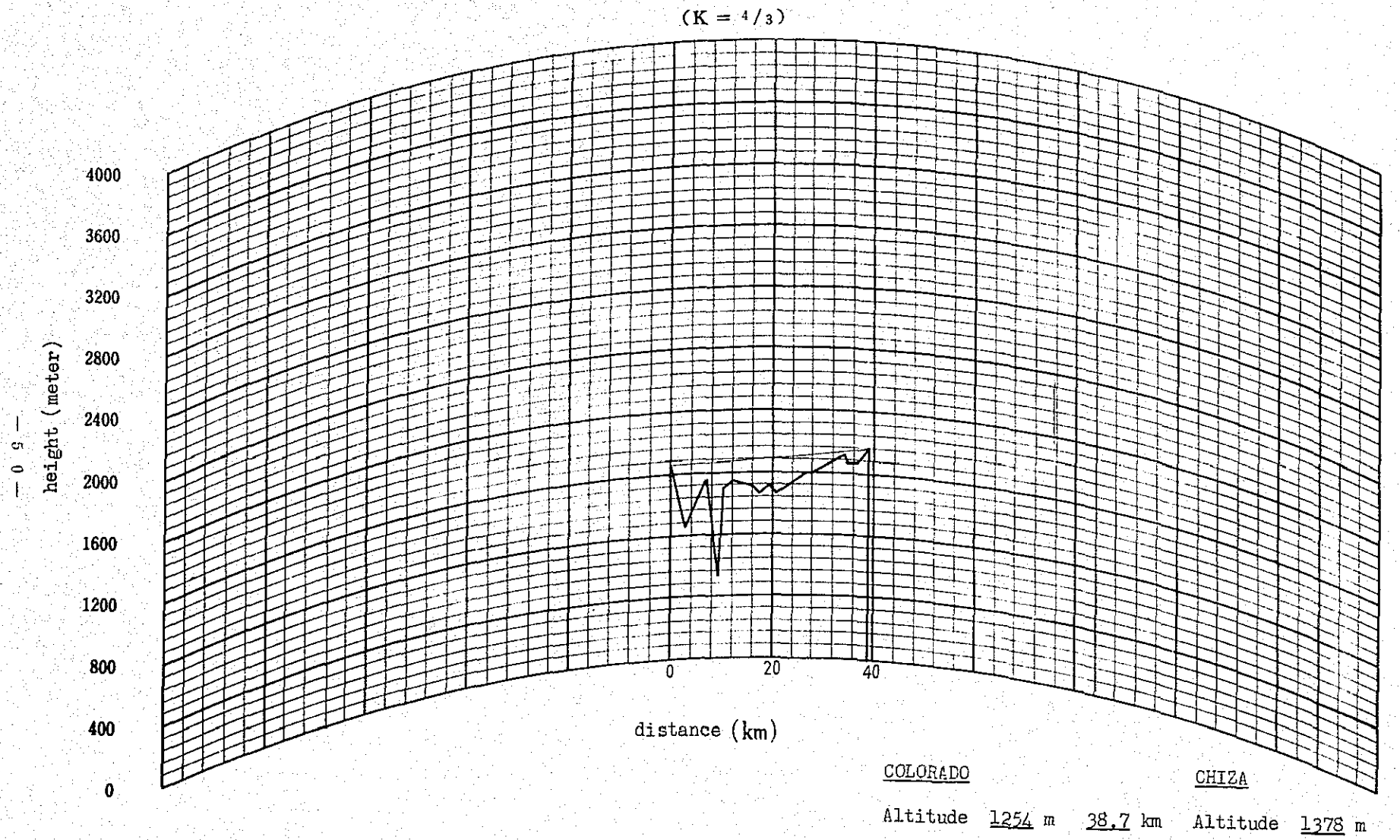


Fig. 6 Profile (Antofagasta ~ Arica) (6)

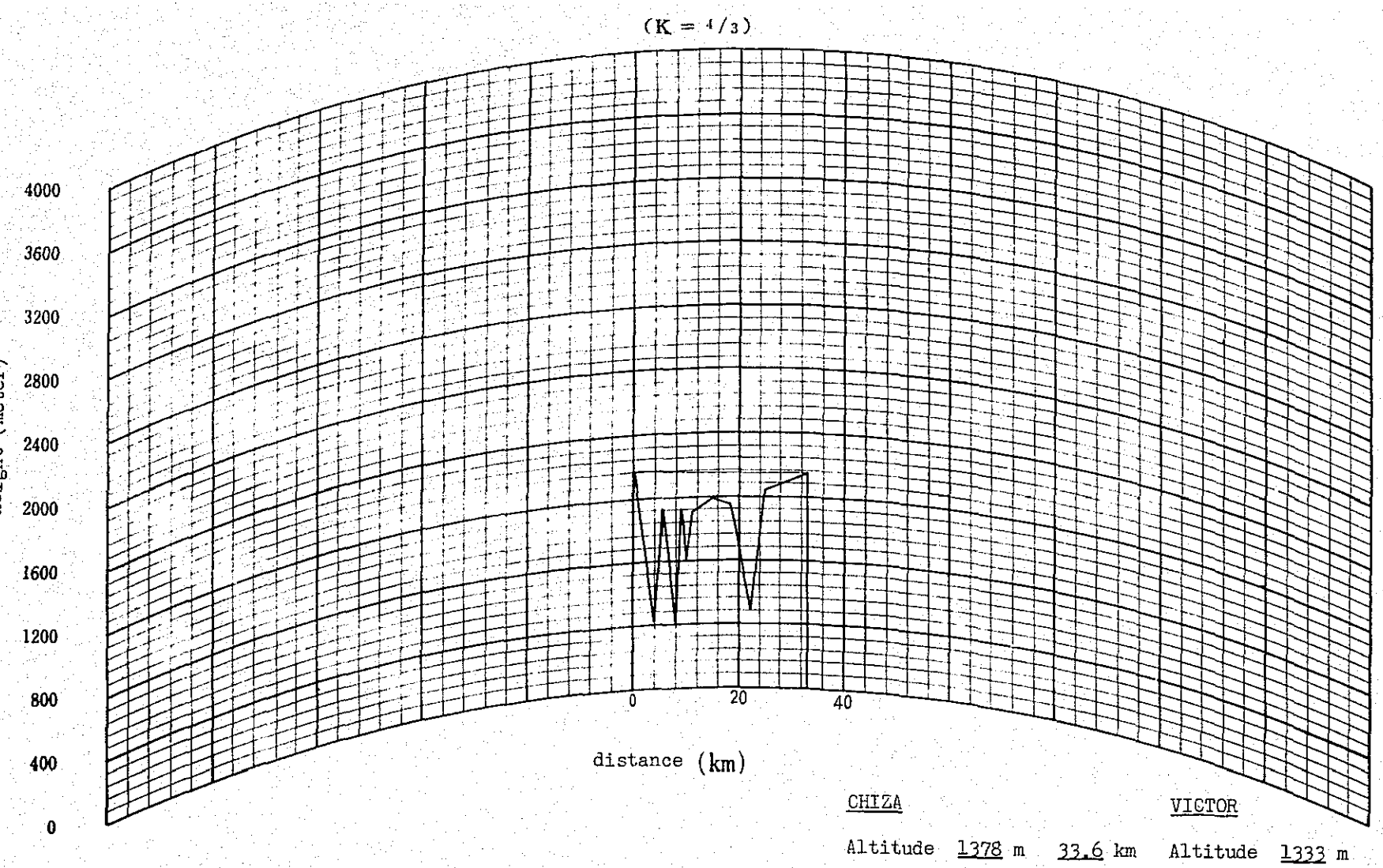


Fig. 6 Profile (Antofagasta ~ Arica) (7)

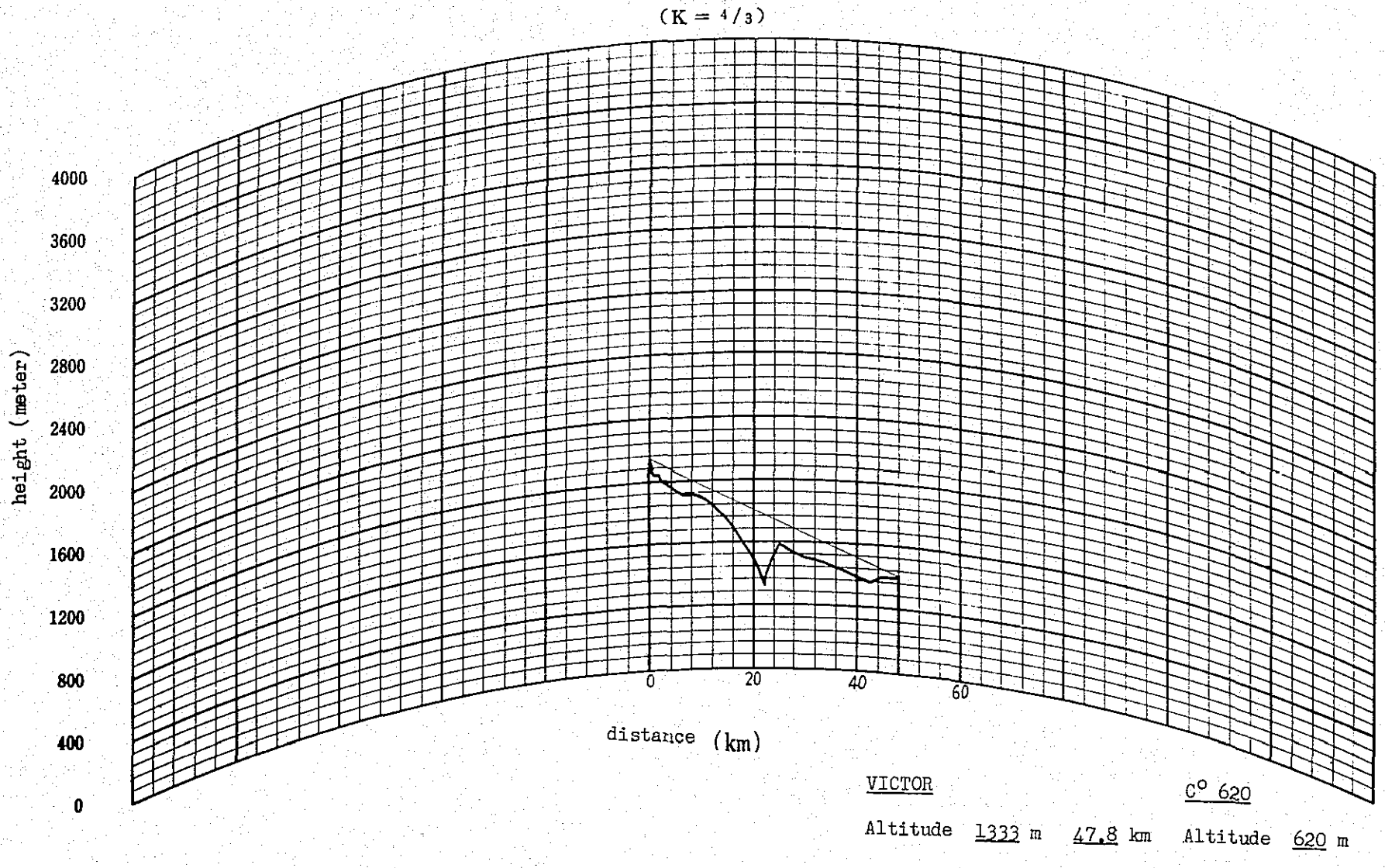


Fig. 6 Profile (Antofagasta ~ Arica) (8)

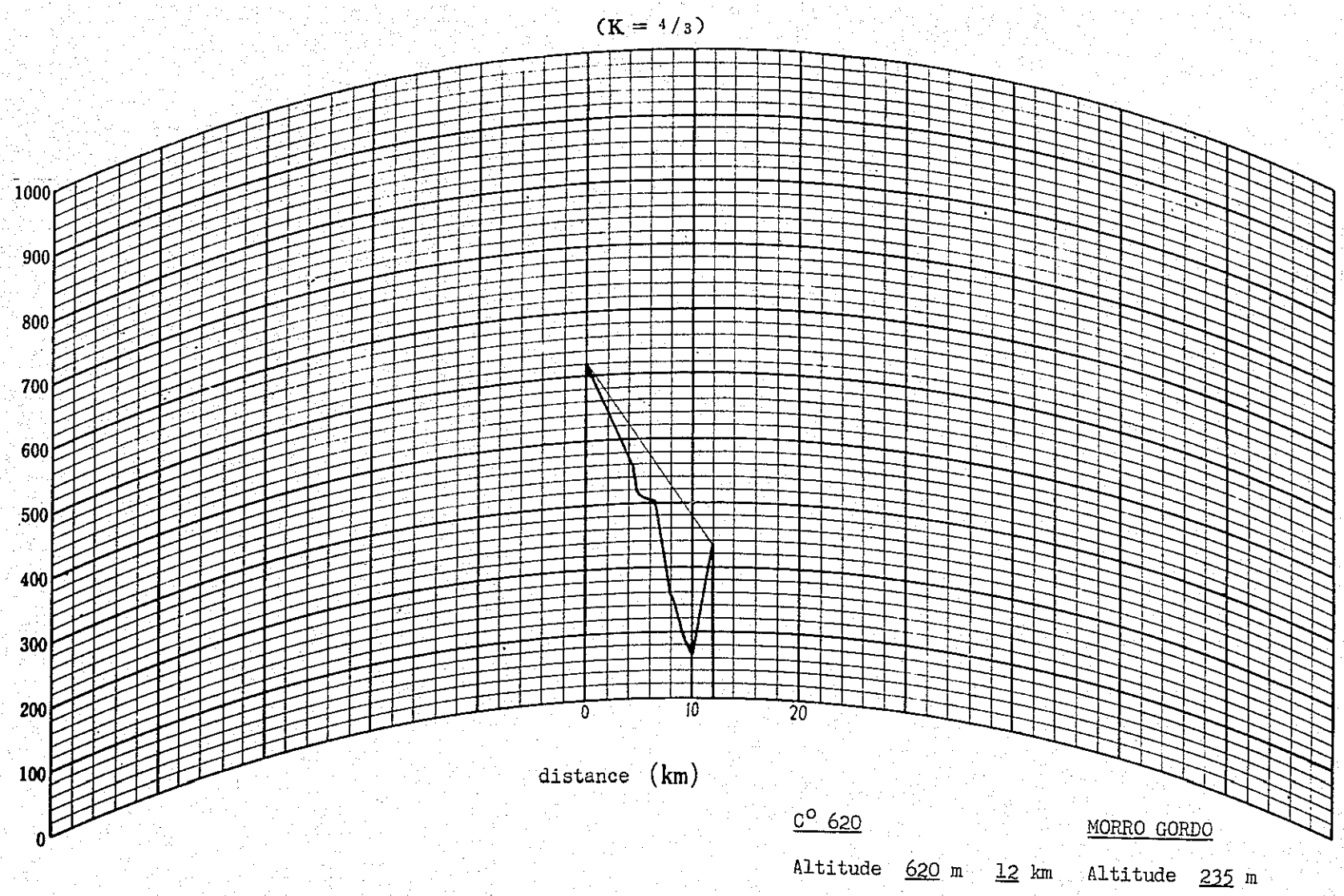


Fig. 6 Profile (Antofagasta ~ Arica) (9)

6.4 Santiago - Concepcion

6.4.1 Progress of the Site Locations

As regards the location of stations between Santiago and Concepcion the plan of junction by 11 hops was already completed according to the survey by CTC. This design is to select and construct a station with utmost safety for the convenience of the propagation and the work of construction and maintenance, in consideration of the transmission of 960 telephone channels and the televison signals. However, this design is not necessarily be economical in connection with the construction and maintenance of circuits and working expenses as well.

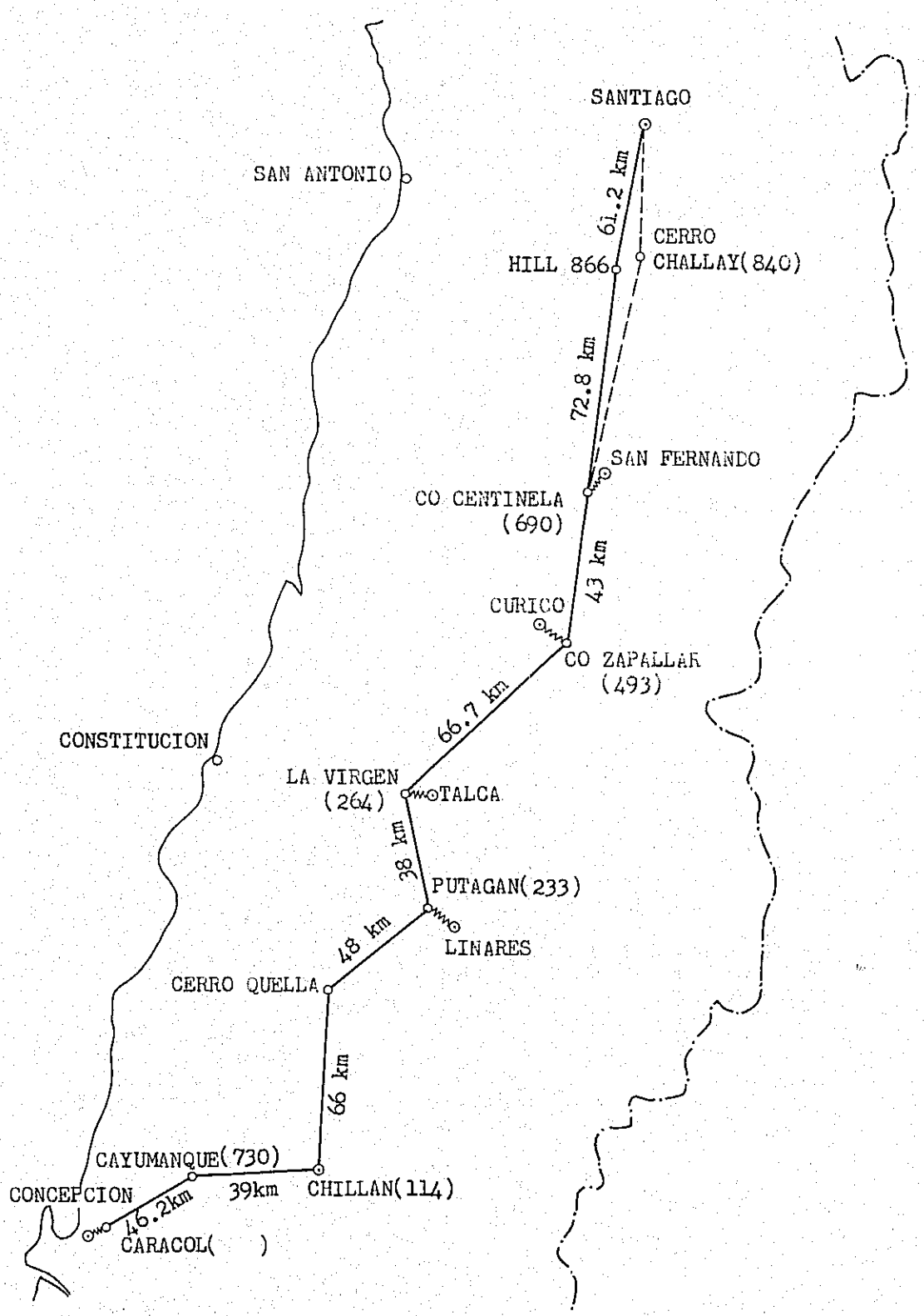
As our map survey suggestedthe possibility of economical construction, the final plan has been prepared upon our field inspection accordingly which consists of 9 hops with the possibility of transmission of signals as aforementioned. This was also in accordance with the request of CORFO.

Different from the dried zone of north Chile this district is comparatively wet and plain with rice field extending here and other. Our attention was paid to the condition of the points of reflection during the field investigation. Having comparatively many branch circuits, the district required our careful attention so that the main circuits may pass through branching stations or the repeater stations may be situated as near to the branching stations as possible, and the designing all in all may be executed as economically as possible. As to the section between Santiago and Chillan, we made re-designing with a view to arranging the plan most economically so that the station may be situated as near as possible along the Pan American Road or on the sites of existing VHF's stations in order to reduce the distance of the required road and the length of the electrical power lines.

For a station between Chillan and Concepcion, the present VHF station of Cayumanque, was nominated for the use and Caracol in the suburbs of Concepcion was selected for the connection with Concepcion.

The final plan prepared in accordance with the results of the field survey is as shown in Fig. 7 and the main circuit consists of 9 hops, each repeater spacing is almost alike. The designing of circuit which may satisfy the circuit specifications recommended by CCIR or CCITT is thought possible through utilization of usual apparatus of microwave system now under development.

Fig. 7 SANTIAGO - CONCEPCION



6.4.2 The Matters that Demand Special Attention to the Proposed Station Sites.

(1) Santiago

As regards the sights to Hill 866 or Cerro Challey, the clearance is good enough and no special problem of the reflected wave is seen. In case the station is situated at the center of Santiago, the height of antenna above ground must be so decided as to allow sufficient clearance and to avoid the interference of reflected wave from the metropolitan buildings, which may be heightened and become more massive in future.

(2) Hill 866

There is no special problem as to the prospects to Santiago and Co Centinela. The height of antenna, therefore, need not be made higher. Through a little work of smoothing of the ground the site necessary for the construction of building and steel tower of antenna should be secured. As an alternative, Cerro Challay may be considered for the site, and upon due examination of roads, power lines and other geographical conditions either one or the other may necessarily be selected.

(3) Co Centinela

Near the summit of this hilly section there is the repeater station of the Army. The location condition is good as the site is spacious and provided with acces road and electric power lines.

The optical sights to Hill 866 and Co Zopallar are satisfactory, but the sight to San Fernando cannot be attained from near the summit. We recommend that re-investigation should be carried out and locate the site.

(4) Co Zapallar

The ground has a broad area and is easy of road construction. Due attention must be paid to the selection of site to be proposed, as Curico, the branching town, can be seen from here if its location is set right.

(5) La Virgen

There is no problem of prospects to both directions. Concurrent use for the transmitting station of television and private radio station is also thought advisable and all-round designing is necessary. The point under CTC's plan would be most suitable. The prospects to Talca is good.

(6) Putagan

As an alternative plan, Quilipin Hill was investigated, but from the point of view of the conditions of location Putagan was selected. However, the prospect in the direction of Cerro Quella is not particularly satisfactory. After strict measurement of clearance the height of antenna above ground should be decided.

(7) Cerro Quella

As aforementioned, the clearance of the section to Putagan is thought unsatisfactory. In this case, in order to relieve, to any extent if possible, the low altitude propagation path between Cerro Quella and Chillan, the height of antenna above ground may advisably be made higher.

(8) Chillan

In consideration of the heights of the city buildings, present and future, the height of antenna above ground must be decided. As the section to Cerro Quella consists of low altitude propagation path, the height of antenna may advisably made higher.

(9) Cayumanque

This is the existing station of VHF band. The prospect to Chillan is good but the prospect to Caracol is thought unsatisfactory.

(10) Caracol (Concepcion)

Upon strict measurement of clearance the necessary height of antenna above ground should be decided, as the accurate standard of the sight to Cayumanque cannot be attained throuh the map - survey. If enough clearance is established, a plan may be thought about which calls for using and applying reflection board to Concepcion, but the tall trees cover the wide area and it may be difficult to cutting them down. Therefore, it is suggested to establish here a radio terminal station to connect with Concepcion by cable.

6.4.3 Profiles of Each Propagation Path

The profiles of each propagation path are shown in Fig. 8.

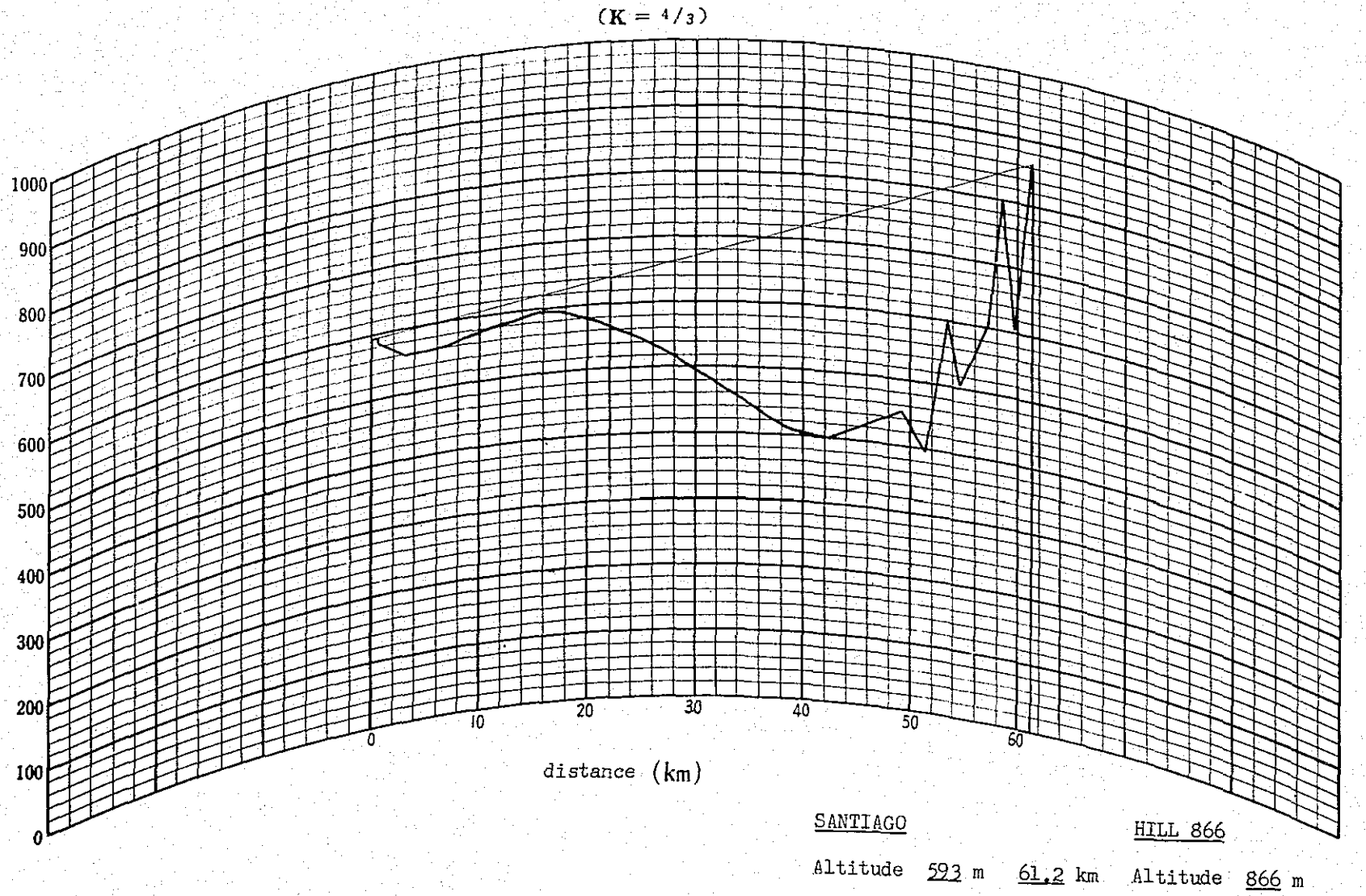


Fig. 8 Profile (Santiago ~ Concepcion) (1)

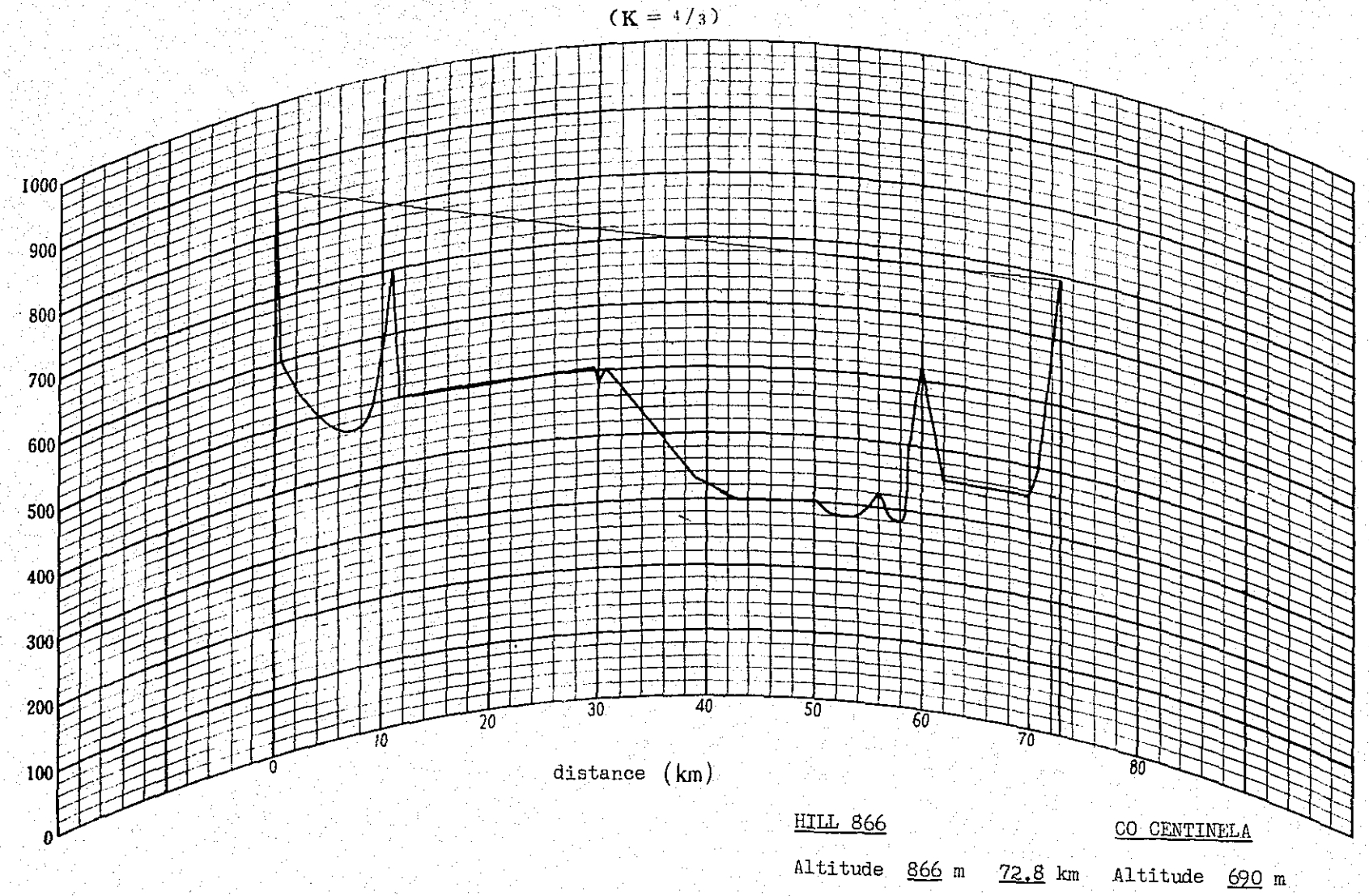


Fig. 8 Profile (Santiago～ Concepcion) (2)

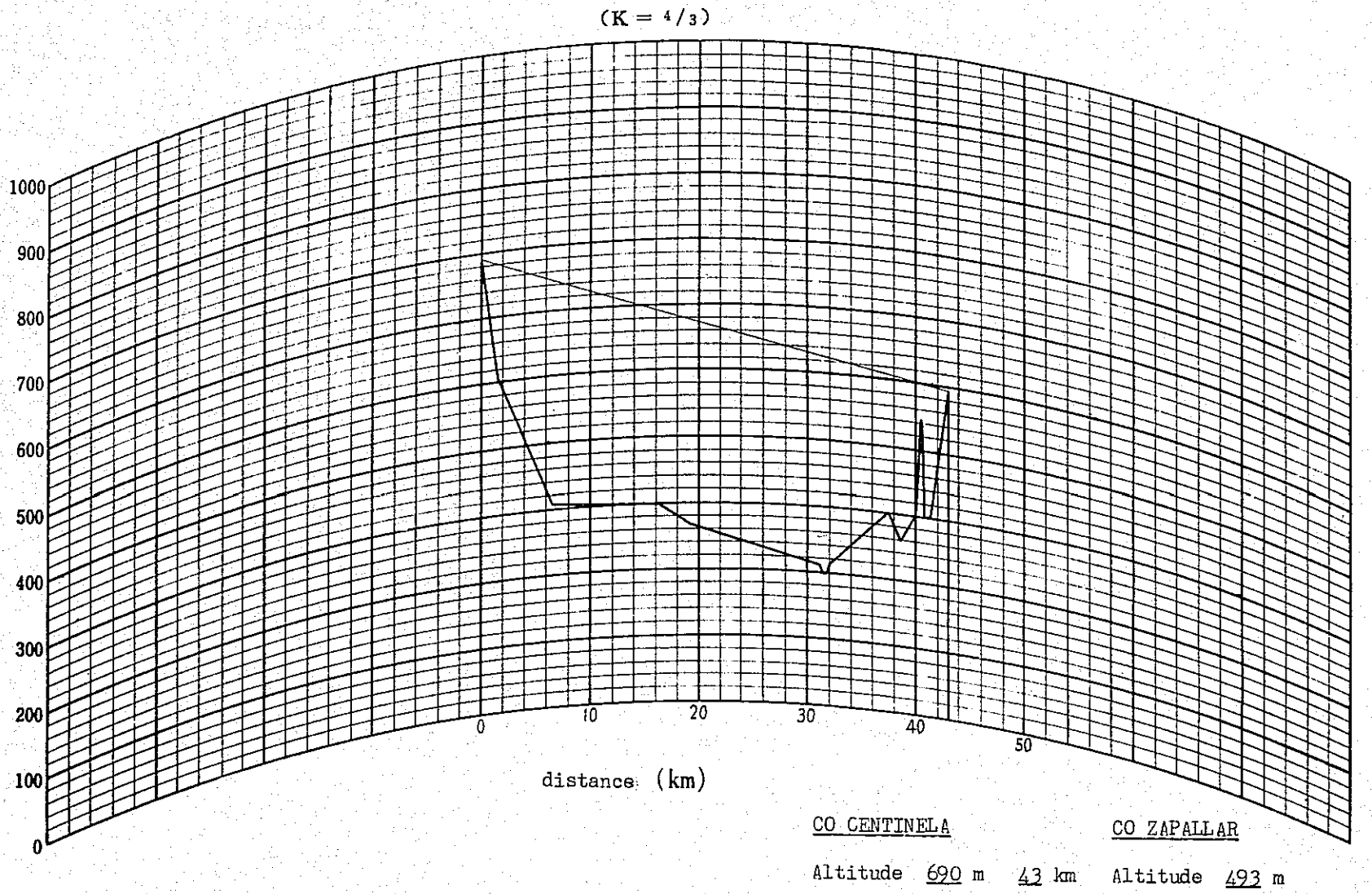


Fig. 8 Profile (Santiago～ Concepcion) (3)

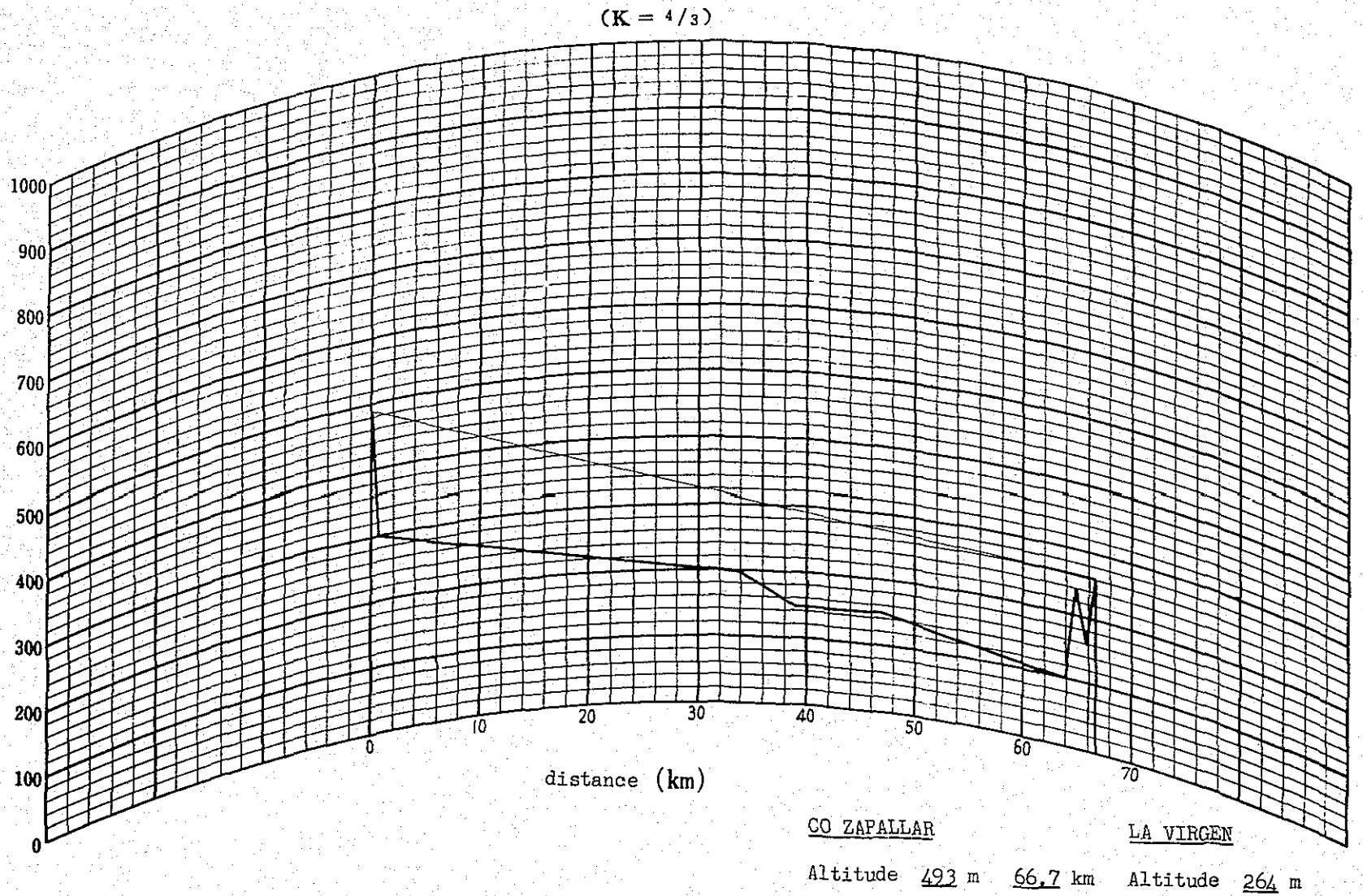


Fig. 8 Profile (Santiago～ Concepcion) (4)

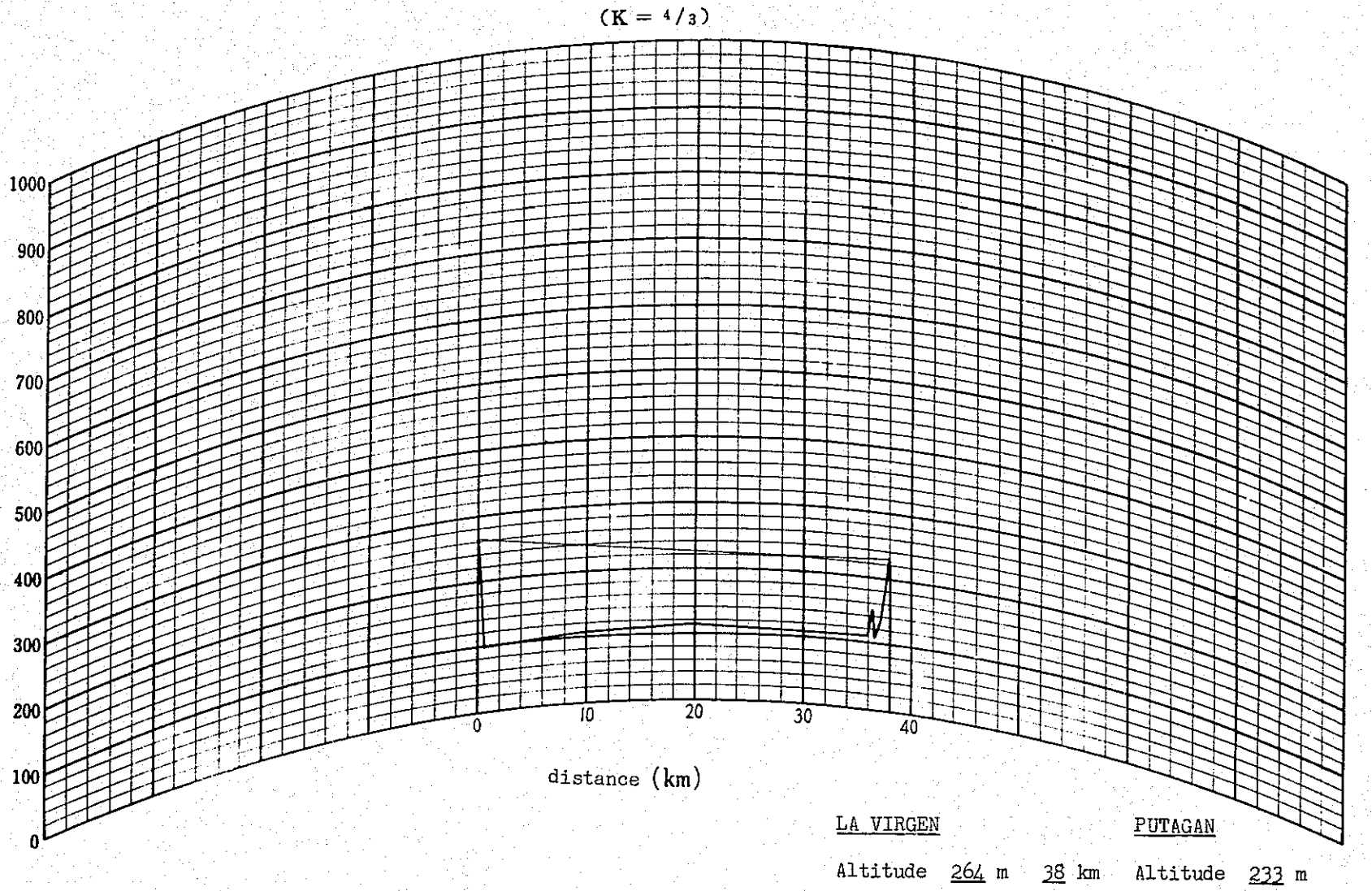


Fig. 8 Profile (Santiago ~ Concepcion) (5)

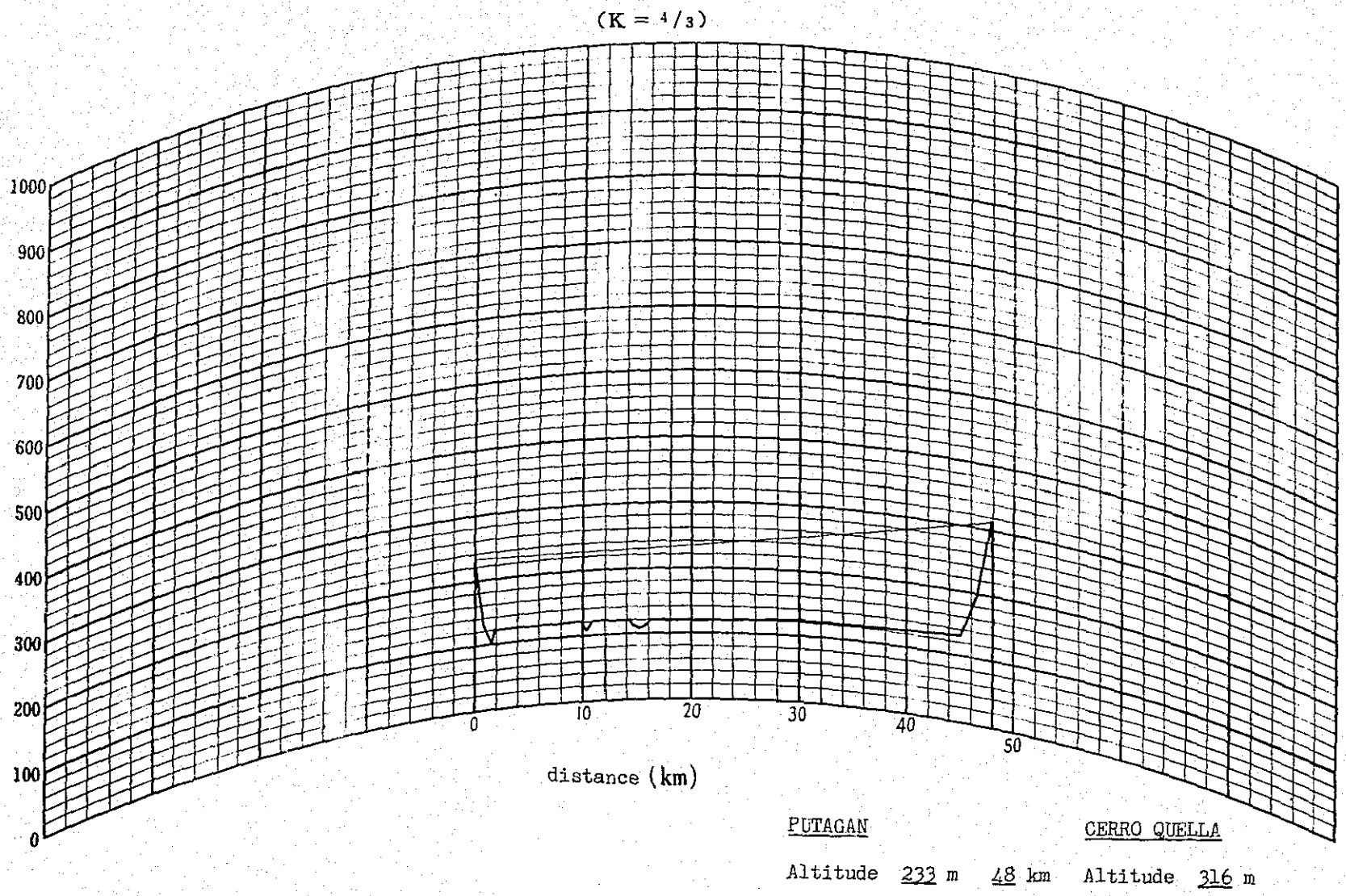


Fig. 8 Profile (Santiago ~ Concepcion) (6)

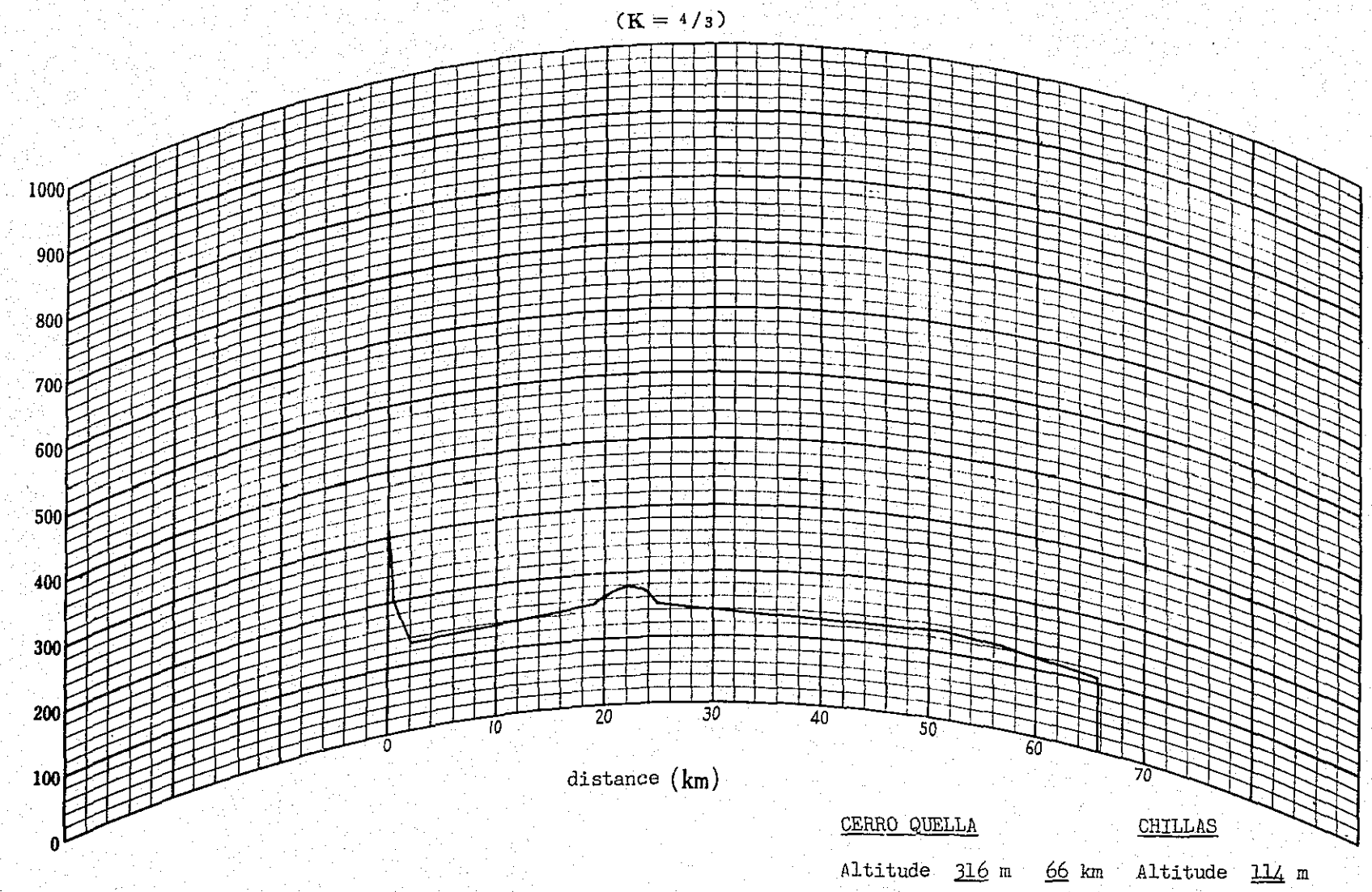


Fig. 8 Profile (Santiago～ Concepcion) (7)

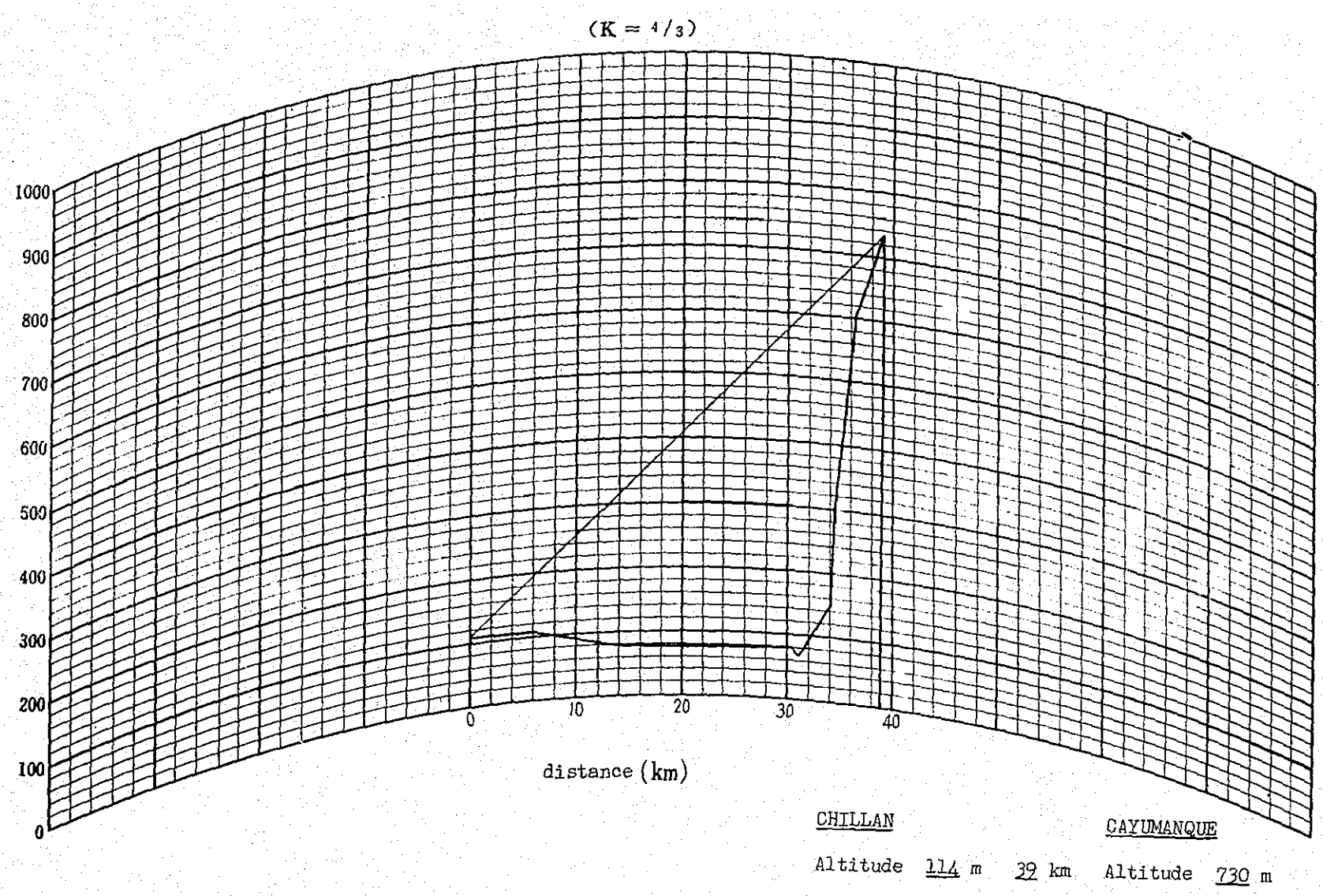


Fig. 8 Profile (Santiago～ Concepcion) (8)

Ⅲ. CIRCUIT AND SYSTEM DESIGNS

III. CIRCUIT AND SYSTEM DESIGNS

1. Circuit Specification

Noise power of main telephone circuit shall satisfy the CCIR's Recommendation. The allowable noise power in radio relay system is shown in CCIR's Recommendation No. 393 and No. 395 (Geneva 1963)

There Recommendations state that the allowable noise power in hypothetical reference circuit shall satisfy the following provisional value:

"The noise power at a point of zero relative level in any telephone channel on a 2,500 km hypothetical reference circuit for frequency division multiplex radio-relay system should not exceed the provisional value given below, which have been chosen to take account of fading.

(1) 7,500 pW psophometrically weighted mean power in any hour.

(2) 7,500 pW psophometrically weighted one-minute mean power for more than 20 % of any month

(3) 47,500 pW psophometrically weighted one-minute mean power from more than 0.1 % of any month.

(4) 1,000,000 pW unweighted (with an integrating time of 5 ms) for more than 0.01 % of any month.

Note; Noise in the frequency division multiplex equipments if excluded from above.
On a 2,500 km hypothetical reference Circuit the CCITT allows 2,500 pW mean value for the noise is any hour."

Noise power under radio relay system is roughly classified into three classes, thermal noise. intermodulation noise and interference noise.

Such noise power may be determined either by the use of circuits apparatus or by the location of repeater stations.

The designing of circuit shall be executed so that the noise power which integrates these two elements may satisfy CCIR's recommendation.

At the selection of the sites of repeater stations thermal noise and interference noise may satisfactorily be examined.

It has been already known that the integrated noise power in radio relay system may vary in accordance with the fluctuation of loading level and the occurance of fading, and

indicate the distribution of some probability density.

According to the experiences through quite a number of radio relay system operated in our country, it is known that, if the sites of stations and the radio equipment meeting the conditions described in the item (1) of CCIR's Recommendation could be acquired, specifications as to other items may also meet the conditions with enough margine.

As the selection of the sites of the stations of radio relay system, therefore, estimate of the quality of circuit is generally considered sufficient provided that it is executed only as to the first item of Recommendation No. 393. However, item No. 393 of this Recommendation is related to the ratio of noise burst or monentary interruption of radio relay system which is greatly influenced by the conditions of the propagation path and it is necessary to examine also this very item in the event that the system especially should include long repeater spacings or propagation path upon the sea.

2. Construction of Circuit

The construction of circuit must be executed in due consideration of the specifications of circuit and the ways of its utilization. Within adequate limits of these matters circuit must be constructed economically and maintained without difficulty.

Among various circuit structures the following are the representatives formed under the hypothesis described hereinafter.

(1) The circuit line connecting through Santiago-Tololo (La Serena)-Copiapo-Antofagasta-Iquique-Arica is to be used as the main circuit running through Chile, which may from a part of international circuits in future.

For this purpose the circuit specifications need to meet the CCIR's specifications.

(2) As regards the circuits connecting these main cities and other provincial towns along this microwave route, as well as such provincial towns themselves, circuit specifications must be prescribed and produced which should fit to the circumstances and free from any actual troubles, in other words, the distribution ratio as per the unit distance according to the CCIR's specifications must not be satisfied.

(Note) Figures prescribed in Chile

At the ratio of 50 % ..... 55 db

At the ratio of 99.9 % ..... 30 db

(3) Transmission of television signals must be possible.

(4) As regards the construction of circuits the future project must be considered. For the initial stage of construction, structures as much simple and economical as possible must be applied. The consideration must be paid enough for the addition of transmission routes for the telephone and the television in accordance with the increaseof demand in future.

(5) Maintenance must be easy.

In consideration of the conditions aforementioned, the construction as described in this report is thought most suitable for the route of microwave system selected in our survey.

2.1 *Repeating System*

The construction of circuits shall be formed by main and auxiliary circuits.

(1) As regards main circuit,application of the heterodyne repeater system by 4000 MC band is suitable, in the fact that the sites of stations are selected including many long repeater spacings and the transmission of television must be considered. The radio frequency arrangement of 4000 MC is shown in Fig 9. and inside structures of station are shown in Fig. 11 - 13.

(2) As the circuits connecting the provincial towns among themselves, an auxiliary circuit must be constructed. This circuit is to be applied the detection repeating system of 2000 MC and 400 MC frequency bands. The radio frequency arrangement of 2000 MC is shown in Fig. 10.

The main reasons calling for the application of this system are as follows;

a. The numbers of necessary telephone channels for branching circuit to provincial towns is limitted and it is quite enough if their specifications satisfy the value shown in Item 2-(1) Note.

b. The branching repeater stations are many.

c. The circuits for supervision and control of unattended stations and order lines can be easily installed.

2.2 Methods of Switchover

The following methods of switchover are thought suitable.

(1) Main circuit consists of the transmission channel under operation and its protection circuit, and it may be changeable by a unit of six sections, namely, Santiago-Tololo,

Tololo - La Serena, Tololo - Bramador, Bramador - Los Morros, Los Morros - M° Tarapaca and M° Tarapaca - M° Gordo respectively.

The switchover is done by the automatic switching system operated in base band as shown in Fig. 14.

(2) Auxiliary circuits are to be operated under the system of automatic switching of base band at a every hop.

(3) Control line of automatic switching for the main circuit and the order line are installed in auxiliary circuits.

2.3 Supervision and Control of Unattended Stations

(1) Repeater stations are advisable to be designed as much as possible as unattended stations, but the stations for switching over such as Santiago, Tololo, La Serena, Bramador, Los Morros, M° Tarapaca, M° Gordo are desired to be made attended type from the initial stage of construction, so as to take charge of the maintenance including supervision and control of unattended stations among these stations.

The relations between attended stations (stations to supervise and control) and unattended stations (stations to be supervised and controlled) are decided mainly in accordance with each other's geographical conditions. An example may be given as the following;

Stations for Supervision and Control	Stations to be Supervised and Controlled
Santiago	Santiago
	Co. Del Roble
	Colorado
Tololo	Llampangui
	Co del Fraile
	Tololo
	Co Chinchado
La Serena	La Serena
Bramador	Algarrobo
	C° Chucham pas
	Bramador
	Copiapo
	Morro Del Copiapo
	C° Tronador O Bramador
	Esmeralda
Los Morros	Placeres
	C° Del Tolo
	Serrucho
	Varillas
	Los Morros

	Antofagasta Mejillones C° 1170
M° Tarapaka	C° Carrasco M° Tarapaka Iquique Colorado
M° Gordo	Chiza Victor C° 620 M° Gordo

(2) If, however, the branching to provincial towns is considered, such stations to be branched would become more effective and adequate, for the sake of alleviating fault time of circuits. The branched stations should be made the attended stations to be in charge of supervision and control of repeater station.

The relation between the stations of supervision and control and the stations to be supervised and controled is thought as follows, taking an example of Antofagasta and Arica.

To change the intermediate repeater station into branching station is possible, the switchover terminal station may be equipped with the apparatus for supervision and control.

Stations for Supervision and Control	Stations to be supervised and Controlled
Los Morros	Antofagasta Los Morros Mejillones
Tocopilla	Tocopilla C° 1170
M° Tarapaca	C° Carrasco M° Tarapaca
Pisagua	Pisagua Chiza
M° Gordo	Victor C° 620 M° Gordo

(3) Among the duties required for the supervision and control of an unattended station, the most important is the precise judgement as to the urgency for help sent for from such attended stations and the quality of a person to be sent when an accident happens.

Therefore, as the item of supervision and control, if the distinction between urgency and unurgency should be indicated for radio equipment and the power facilities, there

would be no trouble, but, generally, the supervision and the control may be considered to require the following items :

a) Items of Control

Starting and stop of engines, and switch over of load

Branch and control of the television transmission channels. (Only for the branching station of the television signals)

b) Items of Supervision

Fire

Opening of doors

Faults of radio equipment under operation

Faults in stand-by rradio equipment

Existence or non-existence of commercial power

Start of engine

Shortage of fuel for engine

(4) The line of supervision and control of unattended stations and also the lines of order among the attended stations can be installed in auxiliary circuits.

2.4 Construction of Telephone Circuit

The construction of branch circuits of the telephone must be decided in overall consideration of these matters such as the initial and future telephone traffic, the conditions of telephone offices and the site conditions of microwave circuits.

2.4.1 Branching Circuits to Main Cities

The branching circuits to the main cities such as Santiago, La Serena, Copiapo, Antofagasta, Iquique and Arica are to be constructed as follows ;

(1) Between Tololo and La Serena branching circuit must be constructed as the part of main circuit, but at Tololo station the main and auxiliary circuits are connected in basic super groups or basic groups .

(2) The determination of the system of junction between Bramador and Copiapo, that whether the section is to be connected through the radio or cables, depends on how good prospect this section could avail itself of, and if the radio system is applied, the connection in basic super groups and basic groups shall be performed through the system of detection repeating system of 2000 MC band at Bramador station alike Tololo station.

(3) The distances from Los Morros to Antofagasta and from M° Tarapaca to Iquique shall be connected in similar manner as Bramador and Copiapo are connected through radio system.

2.4.2 Branching to Provincial Towns

Branching circuits to the provincial towns are diverged from the auxiliary circuits composed of detection repeating system.

Branching is done either by the radio system or the cables, and if under the radio system, the detection repeating system using 2000 MC or 400 MC band is suitable.

Since time was insufficient for our team to survey branching system, it is suggested that a decision may be reached after careful re-investigation as to which system is most suitable. Selection of method must be executed in due consideration of the following conditions.

a) Repeater spacing

b) Necessary telephone channels

c) Difficulties for the construction of cables and the propagation conditions of radio system

d) Economy, stability and maintenance

2.5 Transmission of the Television signal

2.5.1 In order to get the necessary specifications for the transmission of the television signals, application of heterodyne repeating system, same as for the main telephone circuits, may be desirable.

2.5.2 With the future spread of television relaying network the construction of exclusive transmission route may become necessary, but in the initial stage it may be more proper to serve the concurrent use of protection channel of main telephone circuits.

2.5.3 In case of branching the television signals from the main circuit, it is useful that the connection at intermediate frequency band may be applied, the studio or transmitting station for telecasting may be connected with the main circuit through the television link of microwave system and the I.F. television signals are changed to the video frequency signals.

However, if the transmitting station to be connected is situated very near to the branching station, say within about 7 kms, it is more useful to convert it into the video frequency band at the branching station through demodulator and to connect it by coaxial cable

systems.

3. Designing of Steel Tower of Antennas

Upon designing steel tower of Antennas the following items must be considered;

(1) The number, method and form of antenna to be loaded on steel tower and the direction and the location of its installation

(2) Necessary height of antenna to be calculated out from the propagation conditions.

(3) Conditions to cope with the wind or the earthquake

As to the first item above, decisions shall be made including the future project. As regards the second item decisions shall be made in consideration of long-range weather conditions and the character of soil, etc..

Necessary height of antenna which is most important at the selection of the sites of station and to regulate the height of steel tower may as well be decided in accordance with the following conditions;

(1) Generally the height is calculated through the profile. In this case, however, the height should be such as to ensure the clearance to 2/3 of the first fresnel zone of direct wave, subject to the effective earth's radius factor being K=2/3. In case of long repeater spacing and existing of reflective wave, the height should be such as to ensure the clearance, subject to K=1.

(2) The hight of antenna is to be decided in the range free from the effect by reflection or hindrance in the neighbourhood of repeater station.

4. Space Diversity System

Generally speaking, distance of repeater spacing under microwave system, in case of 4000 MC band, should be decided from the number of telephone circuit to be transmitted, and from the necessary specifications and conditions for radio wave propagation of the section concerned. The standard distance is about 50 - 60 kms.

However, at the actual selection of sites, long hop over the above standard may sometimes be applied, in due consideration of 1) topographical conditions along the propagation path, 2) necessary number of telephone channels to be transmitted, 3) its economy and difficulties of construction and maintenance.

Through the selection of long hop, the inferiority may appear in the forms such as

the increases of propagation loss and the Frequency of occurrence of fading. The increase of propagation loss may easily be made good through the introduction of high gain antenna. Besides, in order to correct the inferiority of circuit characteristics originating from the increase of the occurence of fading, application of the space diversity system (Fig. 21) is most effective.

The necessity of the space diversity system as to the selected sections is decided according to the ratio of the occurrence of fading inferrable from the topographical and meteorological conditions of each section. As to the section with the space of repeater station over about 70 - 80 kms. introduction thereto of the space diversity system may be desirable.

Judging from the results of the selection of the sites of stations from Santiago to Arica, five sections, namely, Co Del Robble - Colorado, Tololo - Co Chinchado, Morro De Copiapo - C° Tranador O Bramador, Mejillones - C° 1170 and C° 1170 - C° Carrasco should adopt the space diversity system from the initial stage of construction.

Concerning three sections, namely, from Argarrobo to C° Chuschampis, from C° Chuschampis to Bramador and from M° Tarapica to Colorado, the application of the space diversity system is thought unnecessary in the initial stage of construction, however, it would be advantageous from the economical point of view if due considerations as to the steel tower, of antennas building and the arrangement of equipment are taken in at the outset, in order that these equipment should be increased as occasion demands in future.

The above suggestion implies the reasons to avoid over-estimate of the frequency of occurrence of fading, over-investment into unnecessary equipment in the initial stage of construction, and provides the possibility of adding the space diversity systems, and solution of problems through the system, when there happens the occurrence of deep fading that could not be estimated at the beginning, or when improvement of circuit quality, as economically as possible and without any addition of the systems, should become necessary against increase of telephone circuits.

5. Systems of Power Sources

As the power sources for the transisterized microwave repeating equipment, the following systems are generally used.

(1) System to be used for the stations available of commercial power

This system is called "Battery floating system," composed of storage battery,

battery charger and stand-by engine-generator. The load of battery is always supplied through the storage battery, and the battery charger is supplied with A. C. power from the commercial sources to charge the storage battery and to be floated.

In case of interruption of commercial power service, each apparatus can be supplied with power from the storage battery without any momentary suspension, and stand-by engine generator will start to switch the battery charger and the floating is made by engine generator.

As soon as the commercial power recovers and service interruption ceases, stand-by engine generator will stop automatically and the floating is resumed through commercial power.

(2) System to be operated in the station unavailable of commercial power

This system is composed of storage battery, battery charger and 2 sets of engine generator.

Under this system, the functions of the battery charger and the storage battery and supplementing of load are exactly same as in the case of item (1), but as the commercial power cannot be used, 2 sets of engine generator are to be operated alternately and the floating is operated through the battery charger.

The representative systems are shown in Fig. 23 and Fig. 24. We further add that the capacity each electric apparatus is to be decided by the load capacity and the conditions of the stations concerned, however, the capacity of storage battery should be such that covers about 3 hours' use in case of the attended stations against about 6 hours' use in case of the unattended stations.

6. Supplementary Remarks

Features of Radio Wave Propagation in relation to the topographical and meteorological conditions in Chile

The land of Chile extends very long from south to north with the Andes mountains soaring to the east and the Pacific waves washing the west coasts for whole length, which makes her topography and the characteristics of radio wave propagation resemble comparatively same as Japan. However, in the northern part of Chile there happens frequent occurrence of radio duct for radio wave propagation, where deepest attention is required in relation

to the selection of the site of microwave stations. The opinions as to the features of radio wave propagation, from the points of topographical and meteorological conditions, are as follows:

(1) The east-to-west cross section figure of topography of this district is shown as Fig. 22. In the pampas' district the difference of temperature between the daytime and night is drastic as to rise up to as high as about 36° C for the maximum in summer day and fall down to as low as about 6°C in the night, it is reported. Thus, the conditions which witness such difference of temperature according to daytime and night will bring forth the temperature inversion layer through night cooling and the frequent occurrence of very big constant radio duct is anticipated.

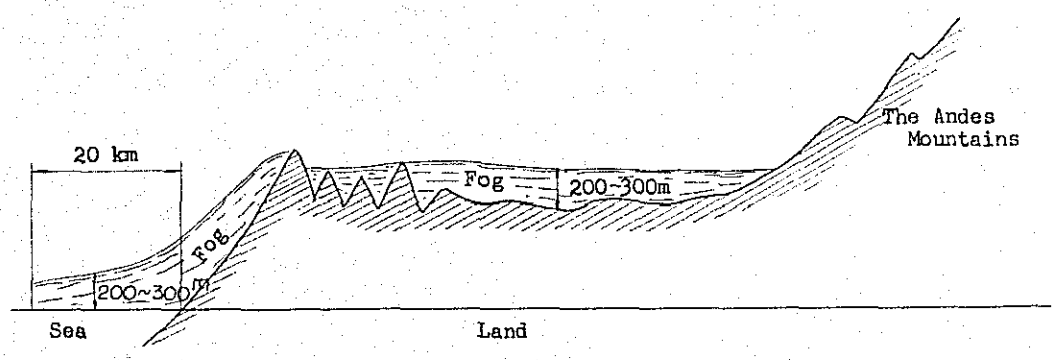


Fig. 22 Cross section of Chile

(2) The year round dense fog will set in from night to early morning as shown in Fig. 22. It generally sets in from 17.00 to 10.00 and its frequency per week is about 4 times in summer and about once in winter. This meteorological phenomenon indicates the generation of meteorological duct owing to the temperature inversion layer through night colling, and it is common that this has deep relation with the occurrence of radio duct for radio wave propagation.

(3) On the sea or along the coast, wind generally blows from the sea to the Andes mountains, from the west to the east, but in inland district its direction is not constant. Wind blows comparatively strong almost every day from 10.00 to 17.00 but outside of these hours it is mild and almost windless at night. In the inland pampas district numerous sand

pillars of small scale can be seen in the daytime.

Our overall inference upon the features of radio wave propagation from the points aforementioned will thus be introduced :— In the daytime the generation of radio duct is comparatively insignificant on account of wind, and the constant features of radio wave propagation is possible, but at night or early in the morning very strong radio duct will be brought forth through night cooling due to the windless condition, and deep fading in relation to the features of radio wave propagation will generate with utmost frequency. This fading is thought much stronger than in Japan.

The above mentioned view is the qualitative assumption as to the features of radio wave propagation from the points of topographical and meteorological conditions. The quantitative characteristics may be worked out from the upper region meteorological data, such as the " radiosonde" apparent every time, every day and every season, extending over a long period, and also from the test data of radio wave propagation.

The occurence frequency of Rayleigh distribution fading in Japan is obtained from the following experimental formula in accordance with the data of numerous propagation tests.

$$P = \left(\frac{f}{4}\right)^{1.2} Q\, d^{3.5}$$

P : Probability of Rayleigh distribution fading at the worst time

f : Radio wave frequency GC

Q : Factor of propagation path. When the propagation path is in the mountaneous area $Q = 2.055 \times 10^{-9}$

When the propagation path is on the plain earth

$$Q = 5.13 \times 10^{-9}$$

When the propagation path is over sea

$$Q = 1.875 \times 10^{-8} \times \frac{\sqrt{\frac{1}{h}}}{0.0508}$$

$$h = \frac{h_1 + h_2}{2}$$

h_1 and h_2 represent the heights of antennas above ground for transmitting and receiving.

d : Distance of propagation path(repeater spacing)

The classification of propagation paths such as those of mountain, plain and

sea is shown in the following table:

Classification	Conditions of the propagation paths
Mountain	Most of the path is mountaneous.
Plain	(1) Most of the path is even. (2) Most of the path is mountaneous but includes bay, inlet, coast and sea.
Sea	(1) The path is on the sea. (2) The path is along the coast and the land is even.

This formula indicates the mean and statistical figures, and is applied to the designing of circuit under the hypothesis that 2 P should represent the probability of Rayleigh distribution of each path.

Quantitative assumption of fading applicable to designing derived from the data as to the meteorological conditions is very difficult. This problem is treated as the research themes of many scholars in the world. Before the selection of the sites of stations, and the decision as to the adoption of space diversity reception and its forms, the standard of analysis must be made in accordance with due analysis of sufficient data of meteorological conditions and testing data of propagation, and in accordance with the quantitative assumption of fading. However, under present condition of Chile where quick construction of circuits is required any undesirable routes must be avoided as much as possible from the selection of sites, for instance, those routes that pass through the sections shown in the above table or the low altitude propagation paths on the sea or along the coast, and if inevitable, the adoption of high efficient diversity system must be considered for these sections. It is further suggested that an addition of diversity reception to the sections is possible, where the characteristics of propagation is unsatisfactory, to improve the characteristics of circuits, if occasion arises, after construction of the circuits.

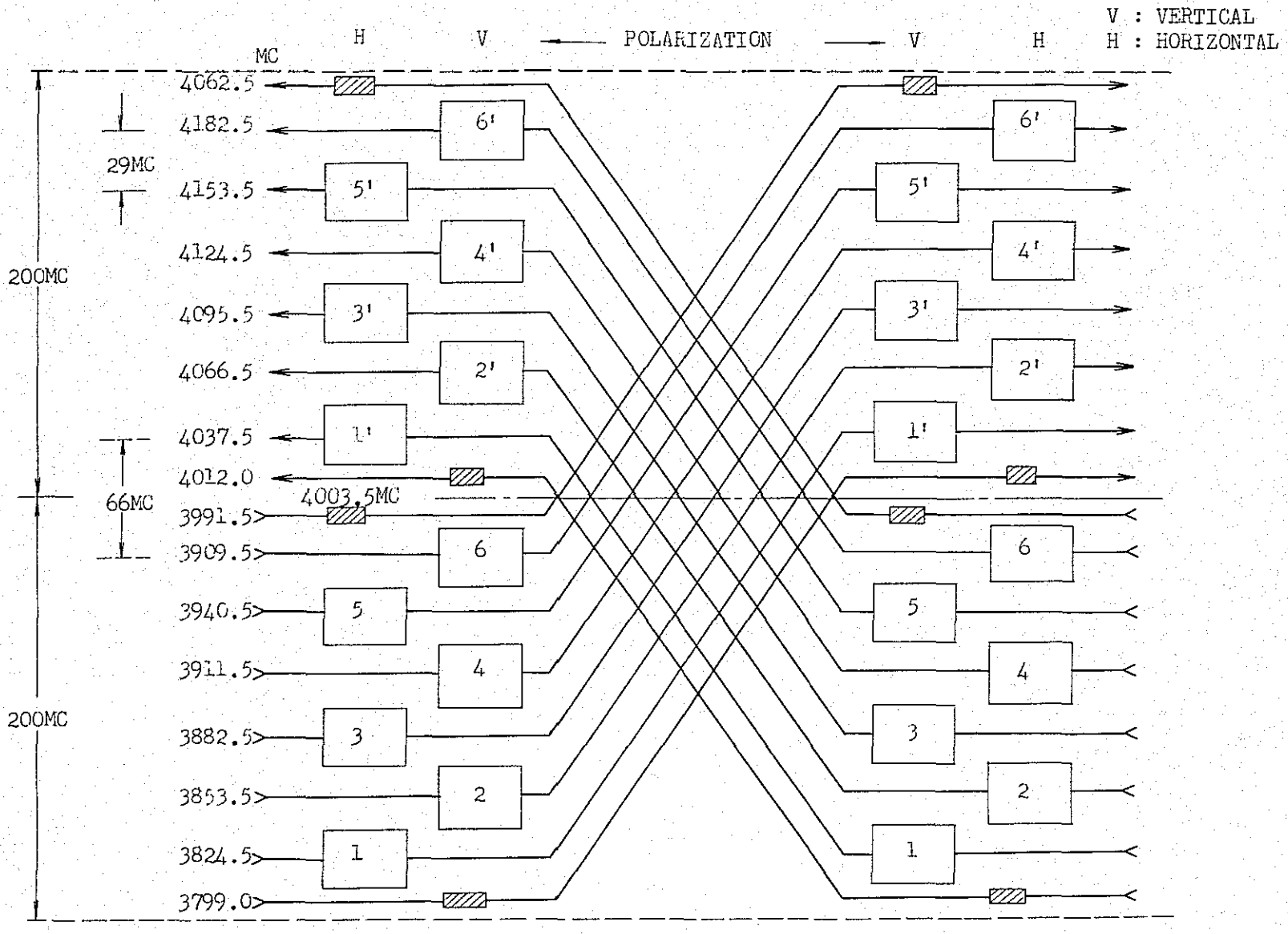


Fig. 9 4000MC Radio Frequency Allocation

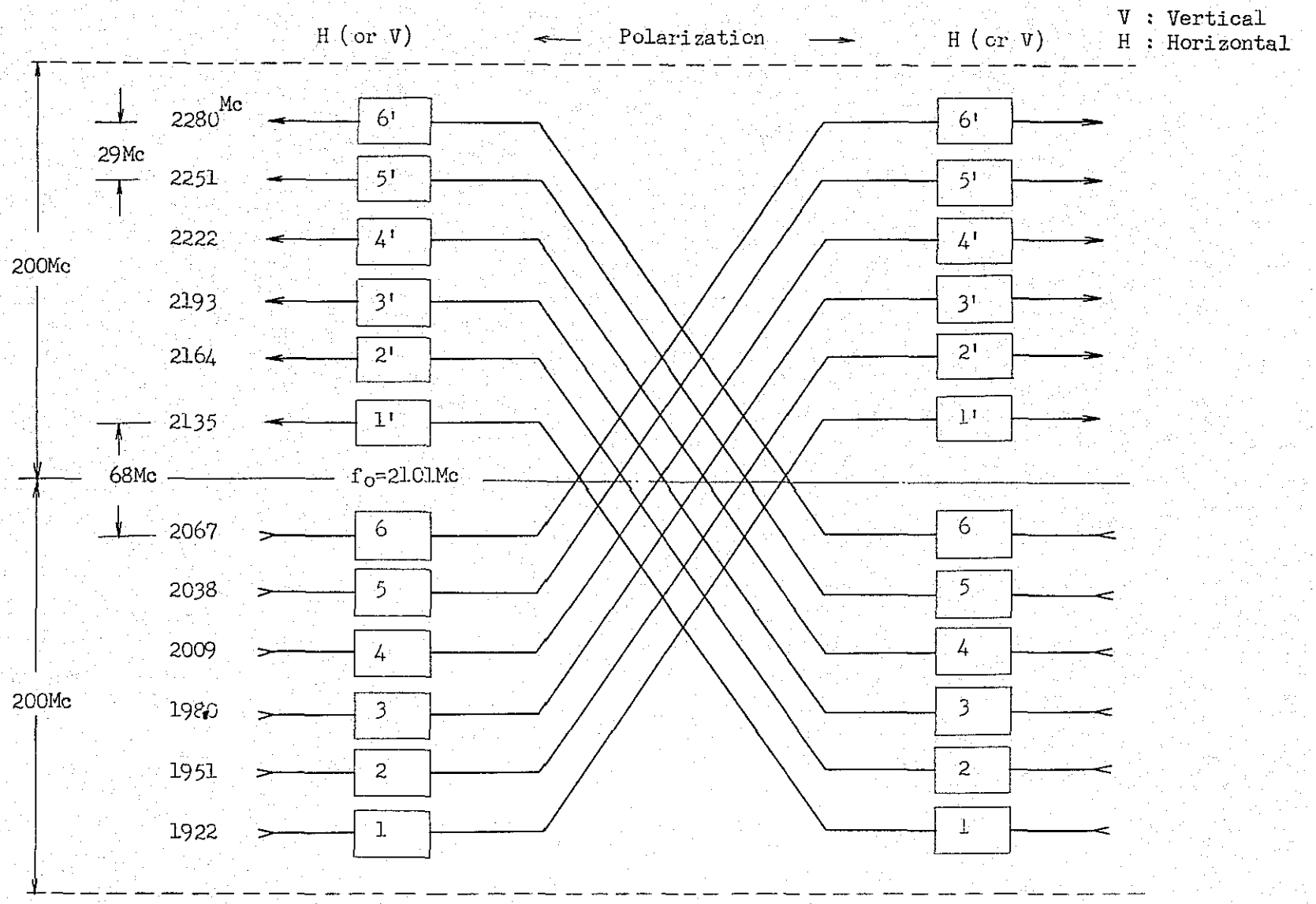


Fig. 10 2000Mc Radio Frequency Allocation

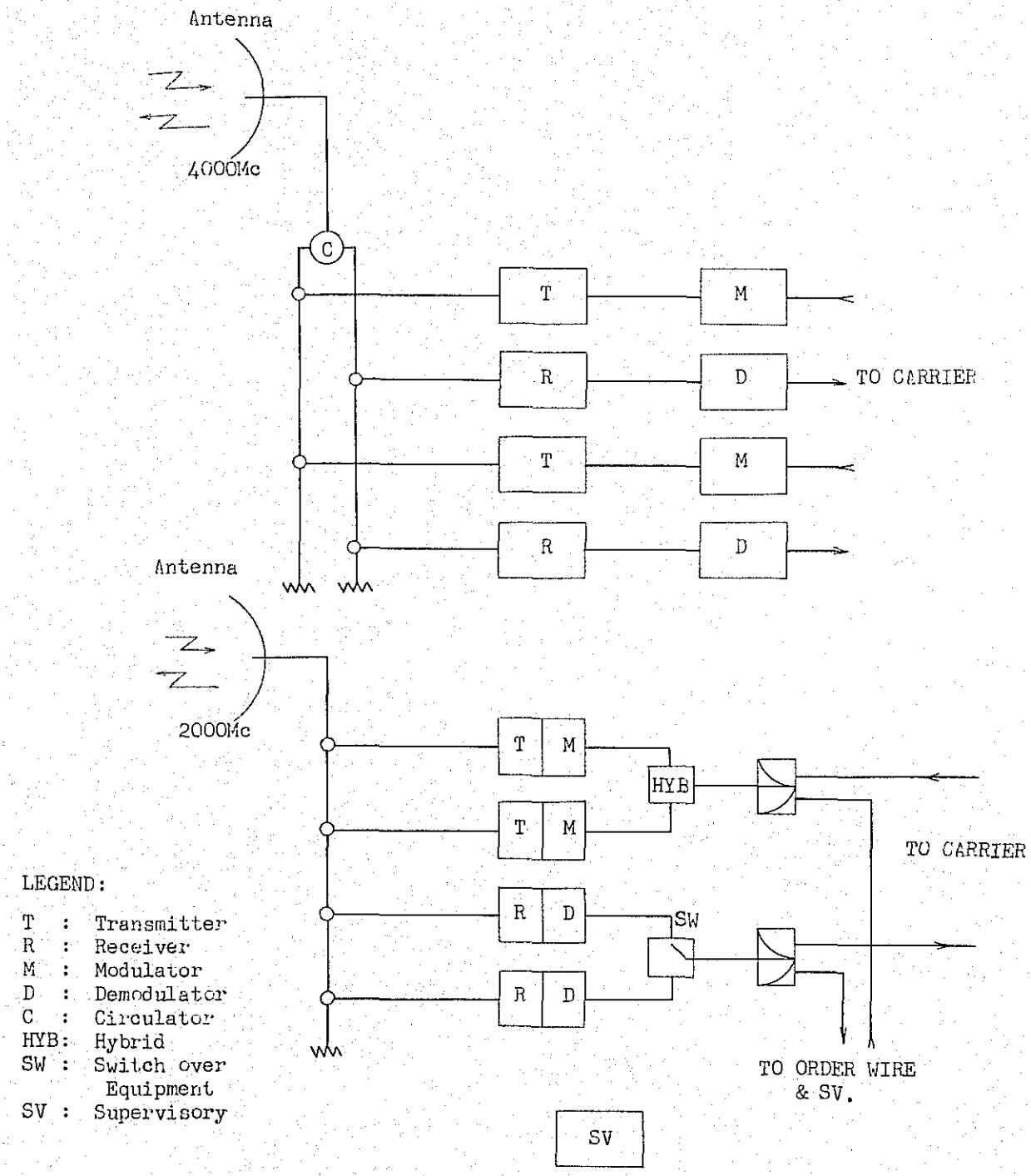


Fig. 11 System Block Diagram of Radio Terminal Station for Original Plan.

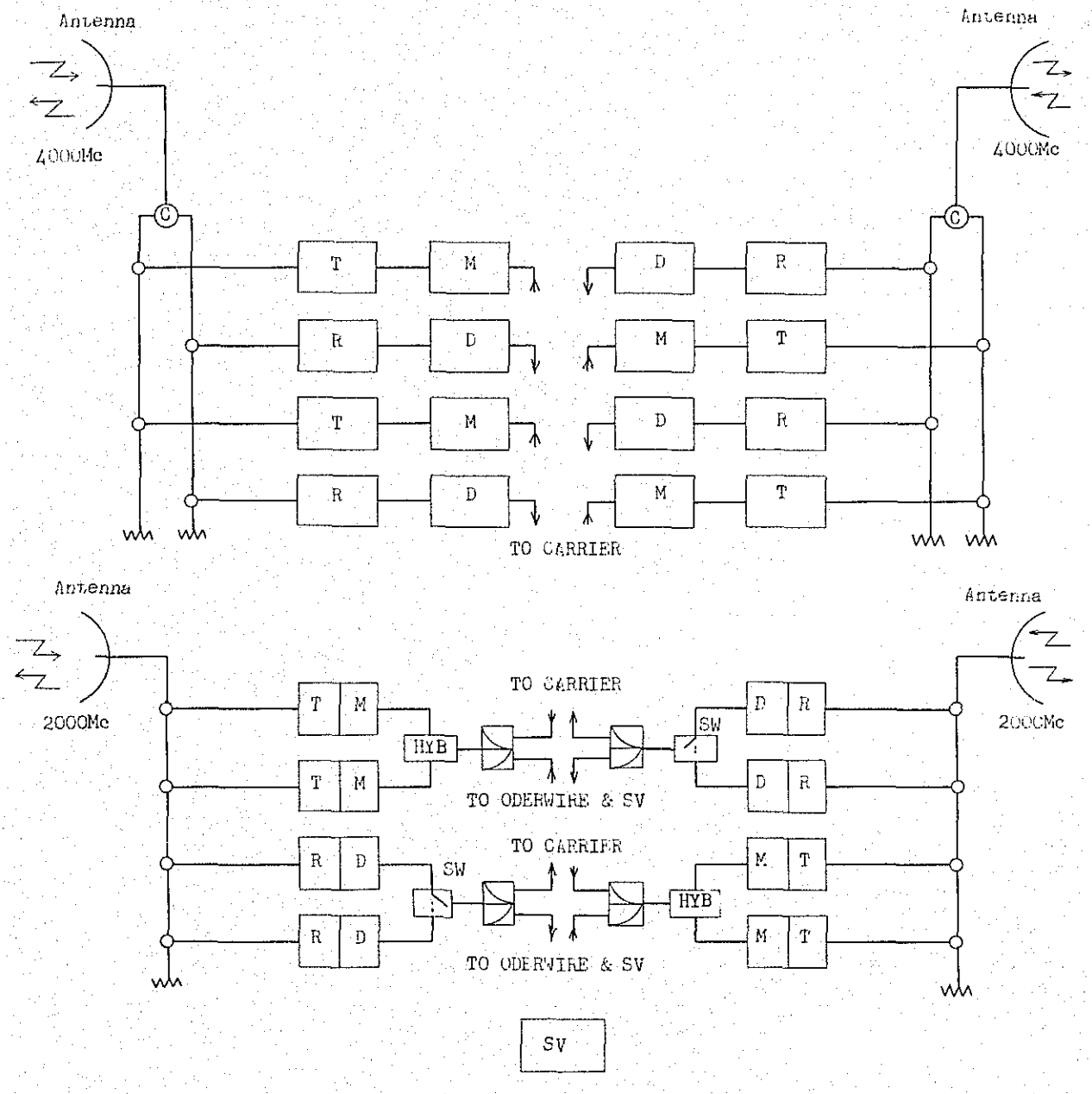


Fig. 12 System Block Diagram of Radio Terminal Repeater Station for Original Plan

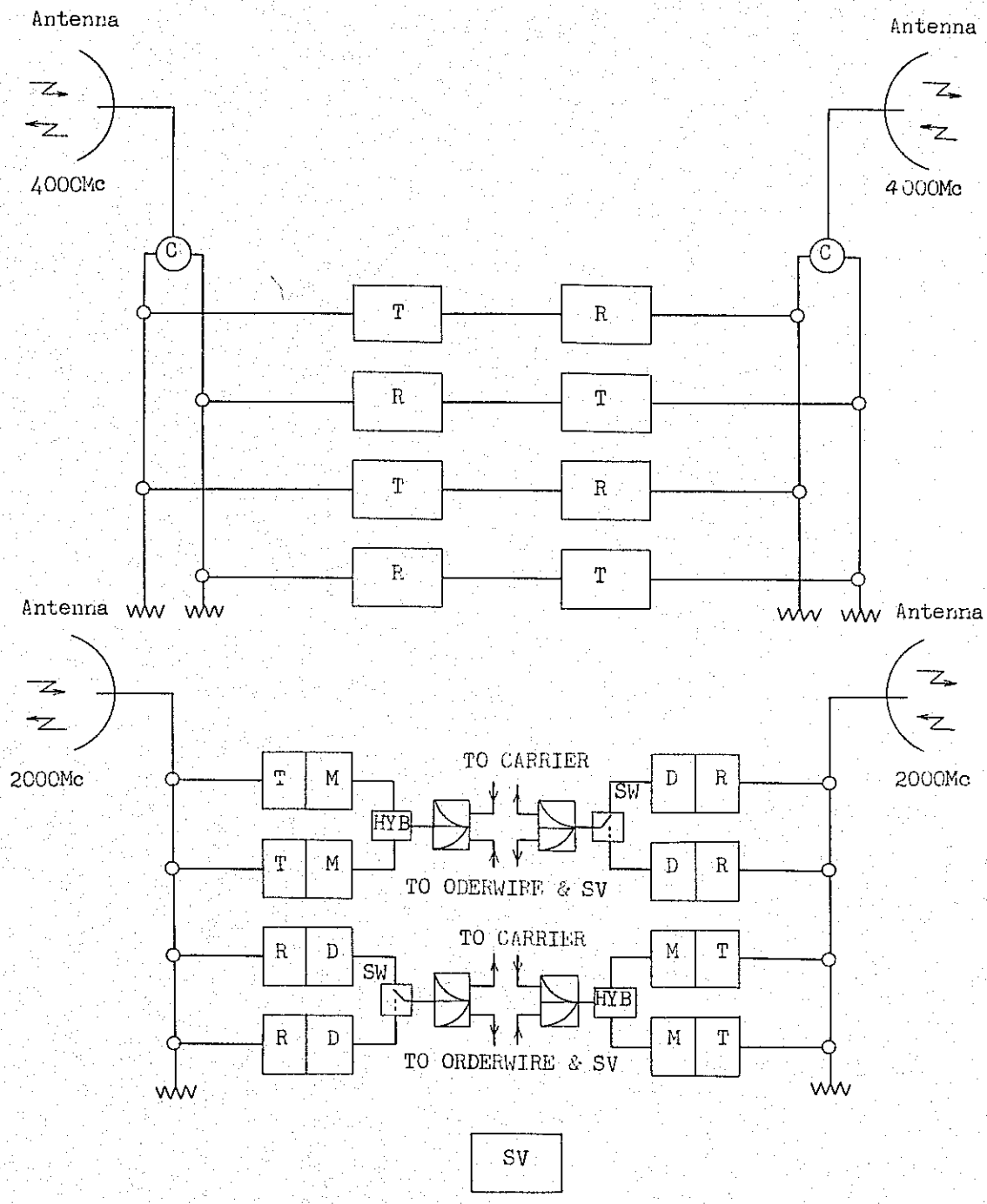


Fig. 13 System Block Diagram of Radic Repeater Station for Original Plan

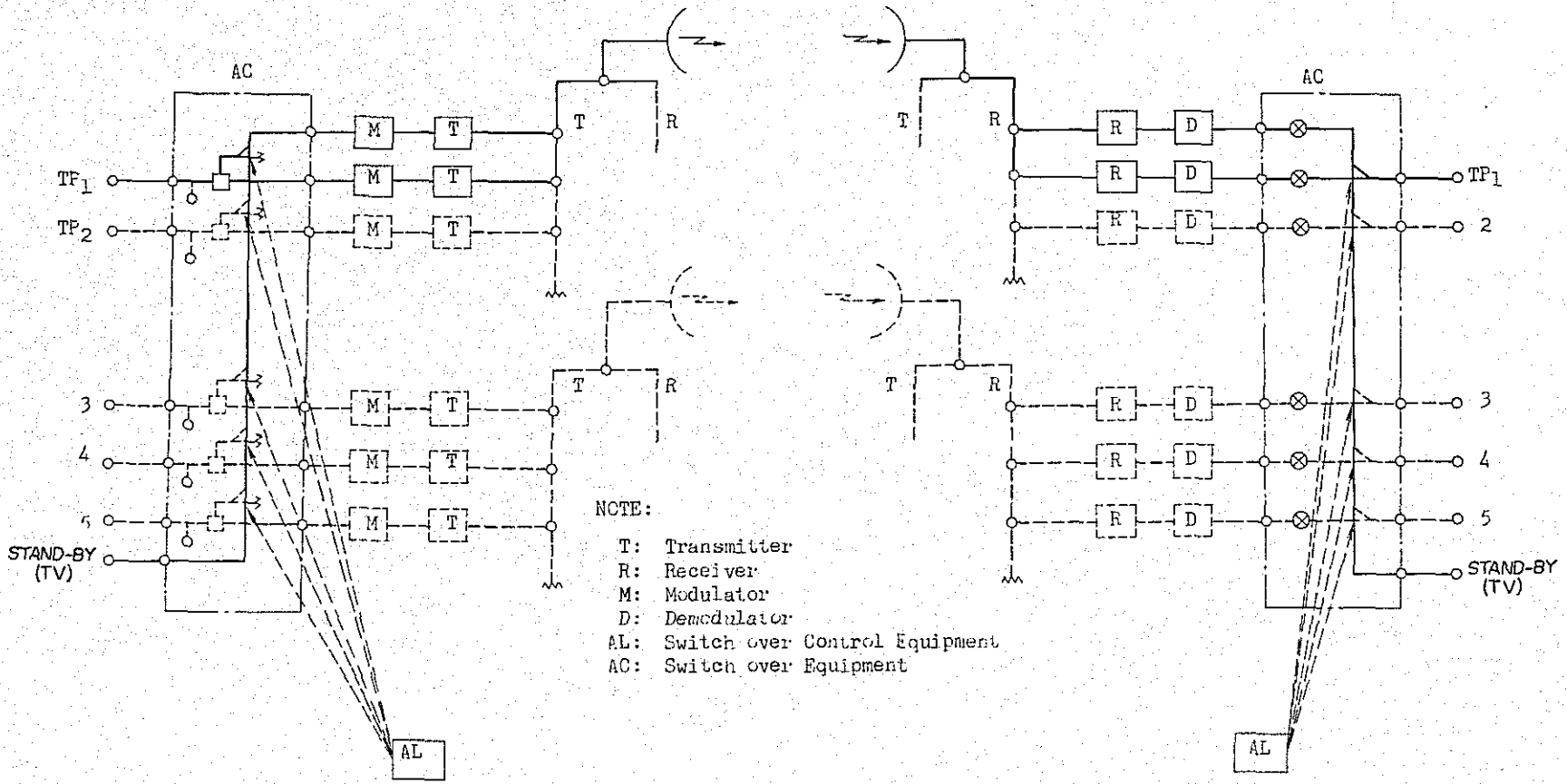


Fig. 14 Block Diagram of Switchover Control System of Baseband

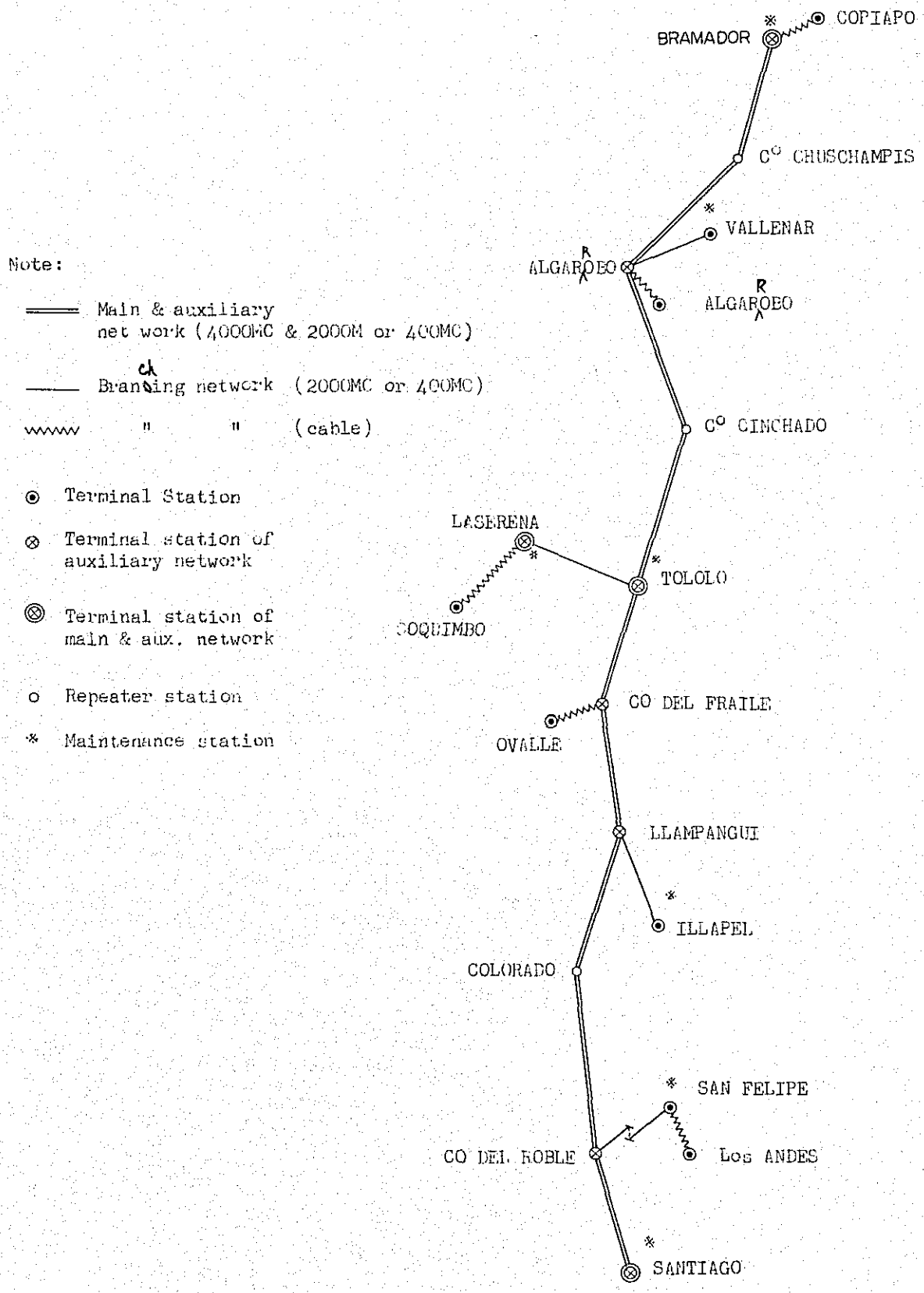


Fig. 15 Circuit Structure of Zone-1

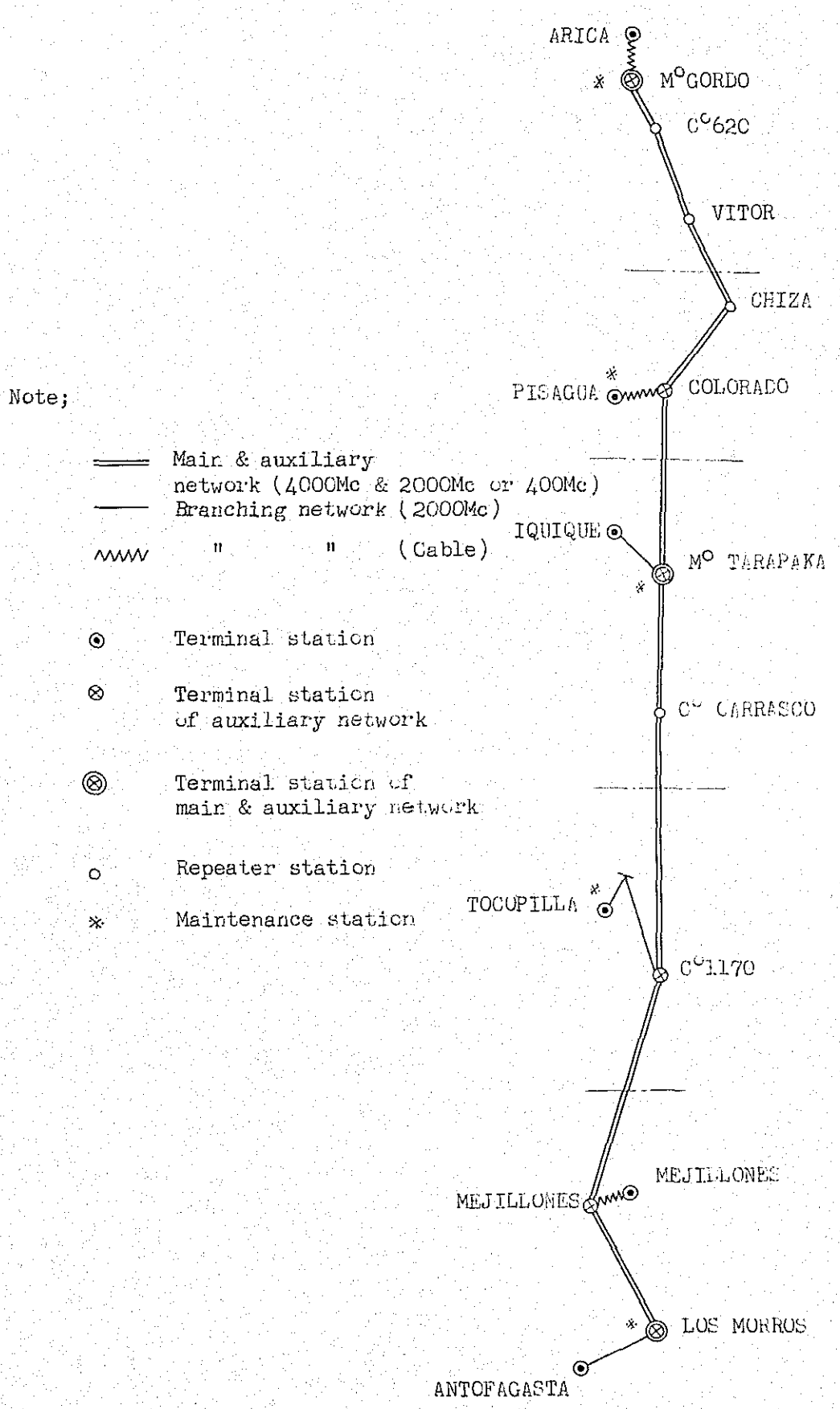


Fig. 16 Circuit Structure of Zone-2

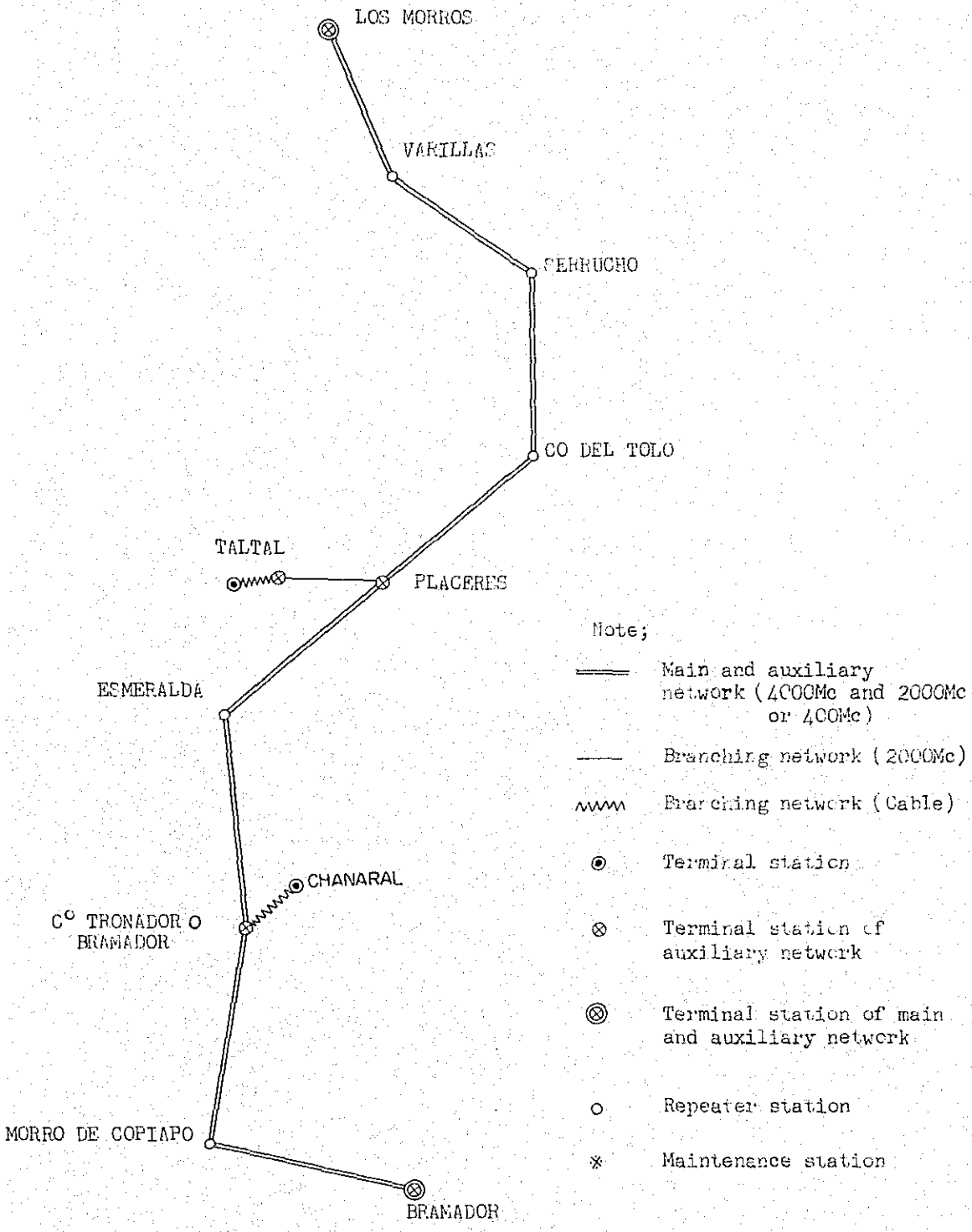
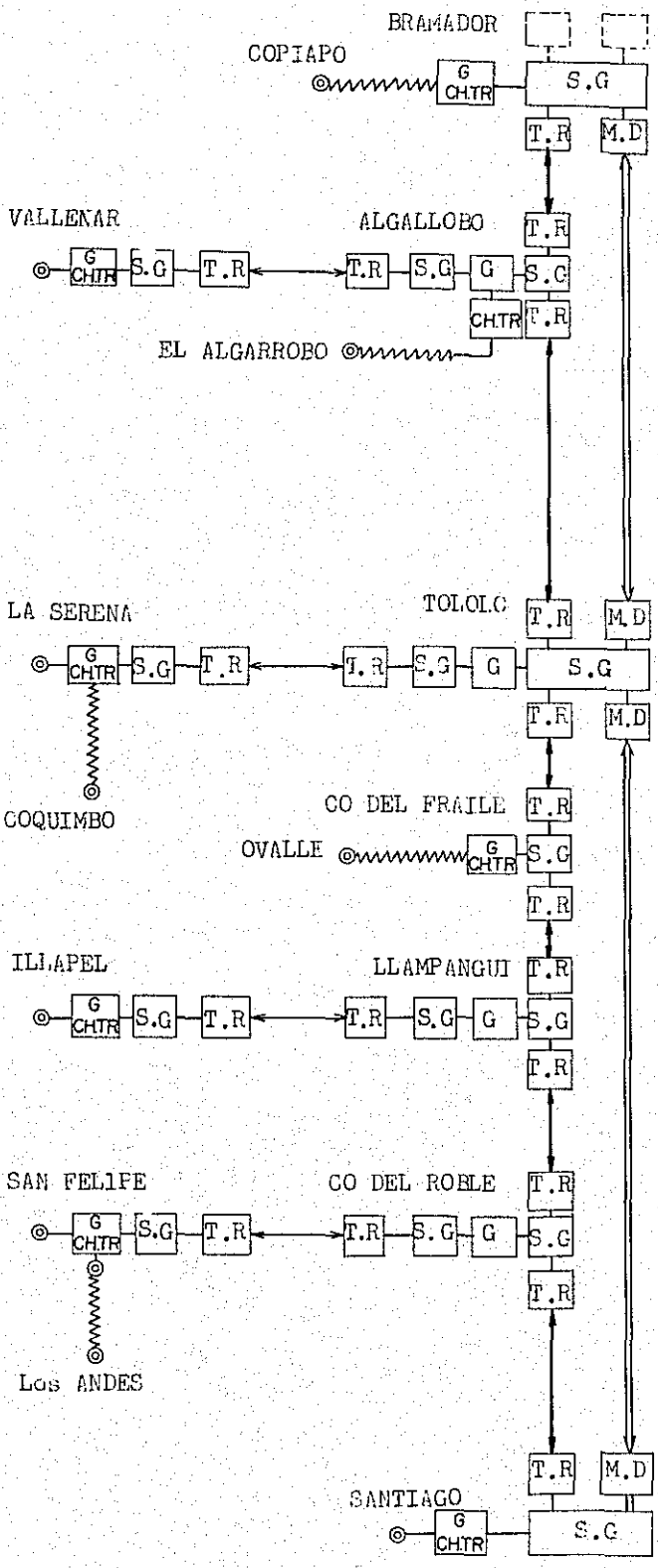


Fig. 17 Circuit Structure of Zone-3



Note;

main

auxiliary

branching

cable

M.D Mod & demodulator of main network

T.R transmitter & receiver of aux. network

S.G supergroup translating equipment

G group & channel
CHTR translating equipment

This figure shows the system of 2000Mc band used in the auxiliary circuit. When the system of 400Mc band is used, Transmitter and Receiver equipment is directly connected with basic group translating equipment and basic super group translating equipment becomes unnecessary.

Fig. 18 System Block Diagram of Zone-1

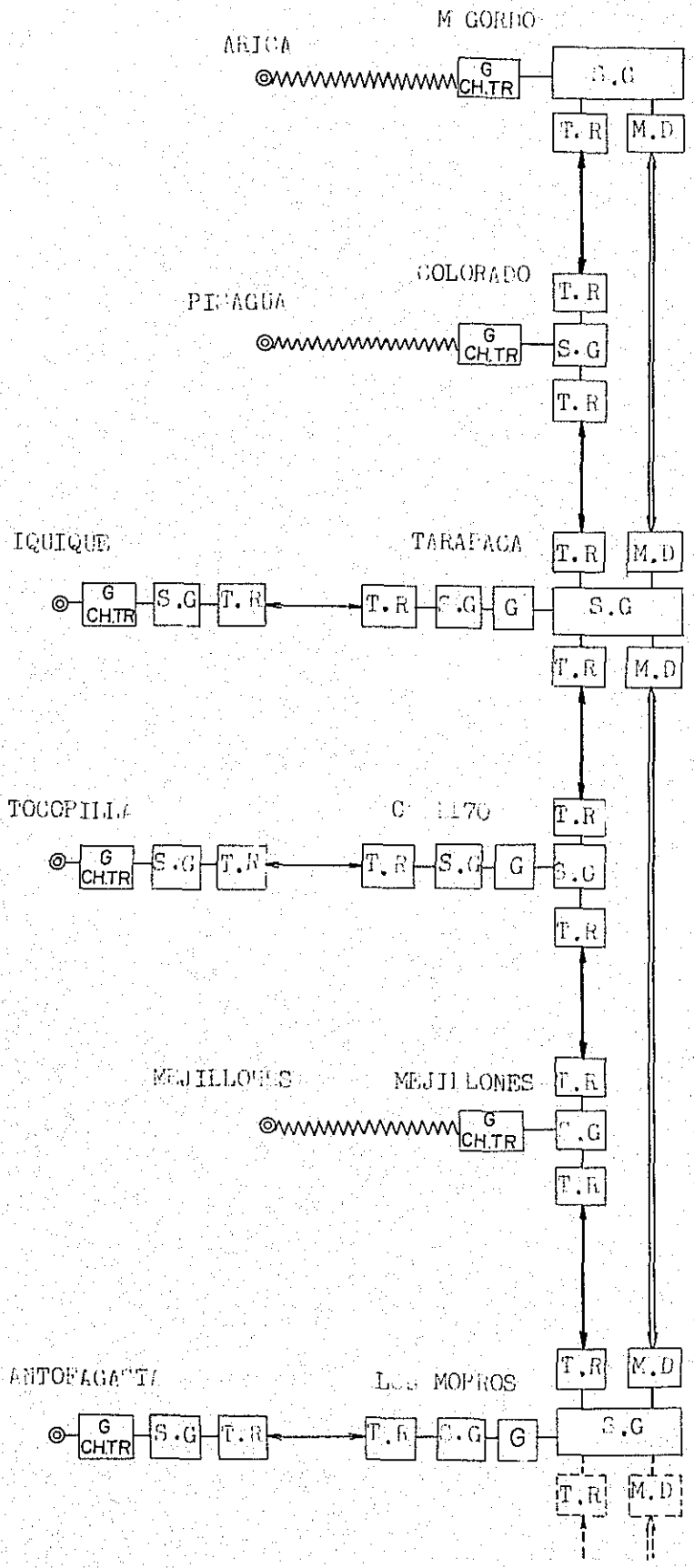


Fig. 19 System Block Diagram of Zone-2

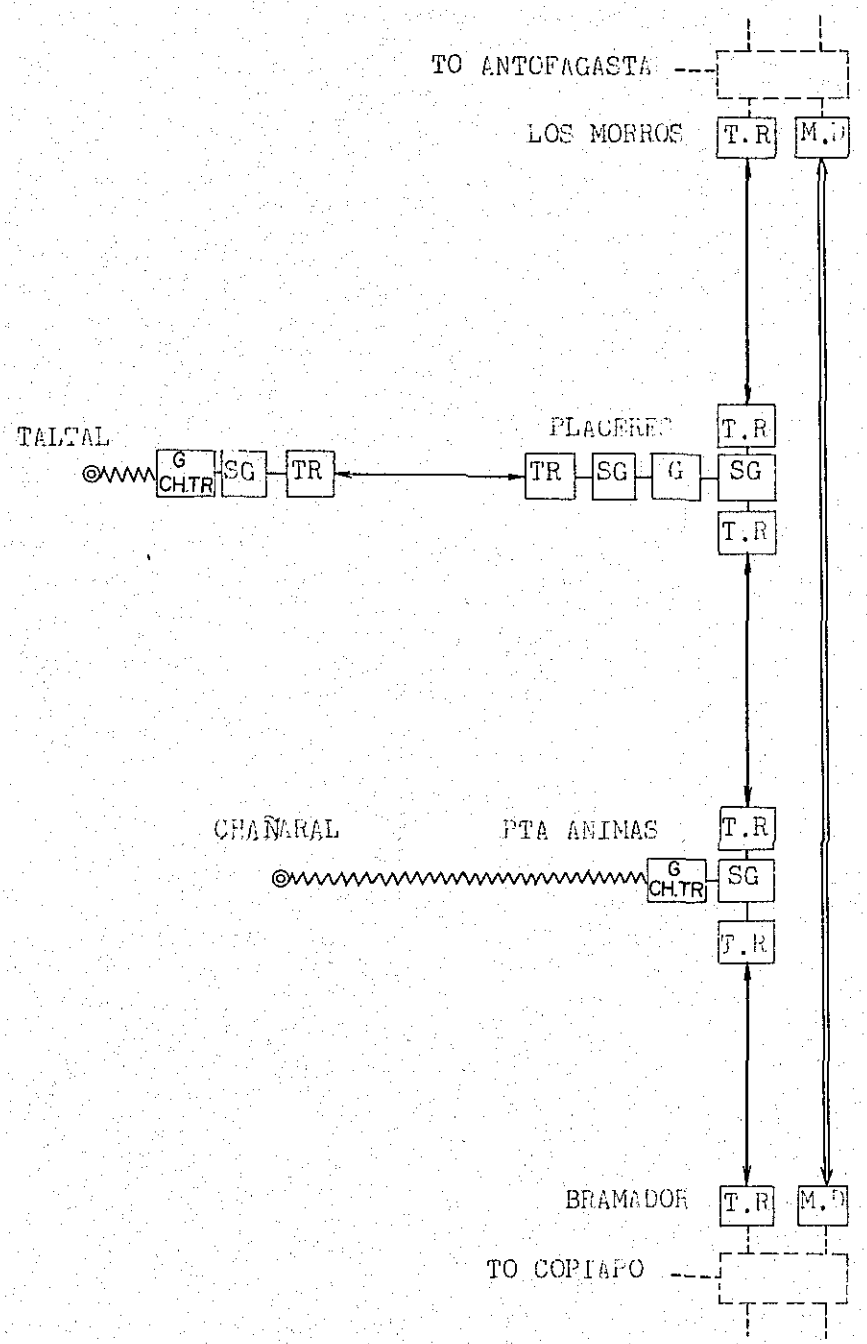


Fig. 20 System Block Diagram of Zone - 3.

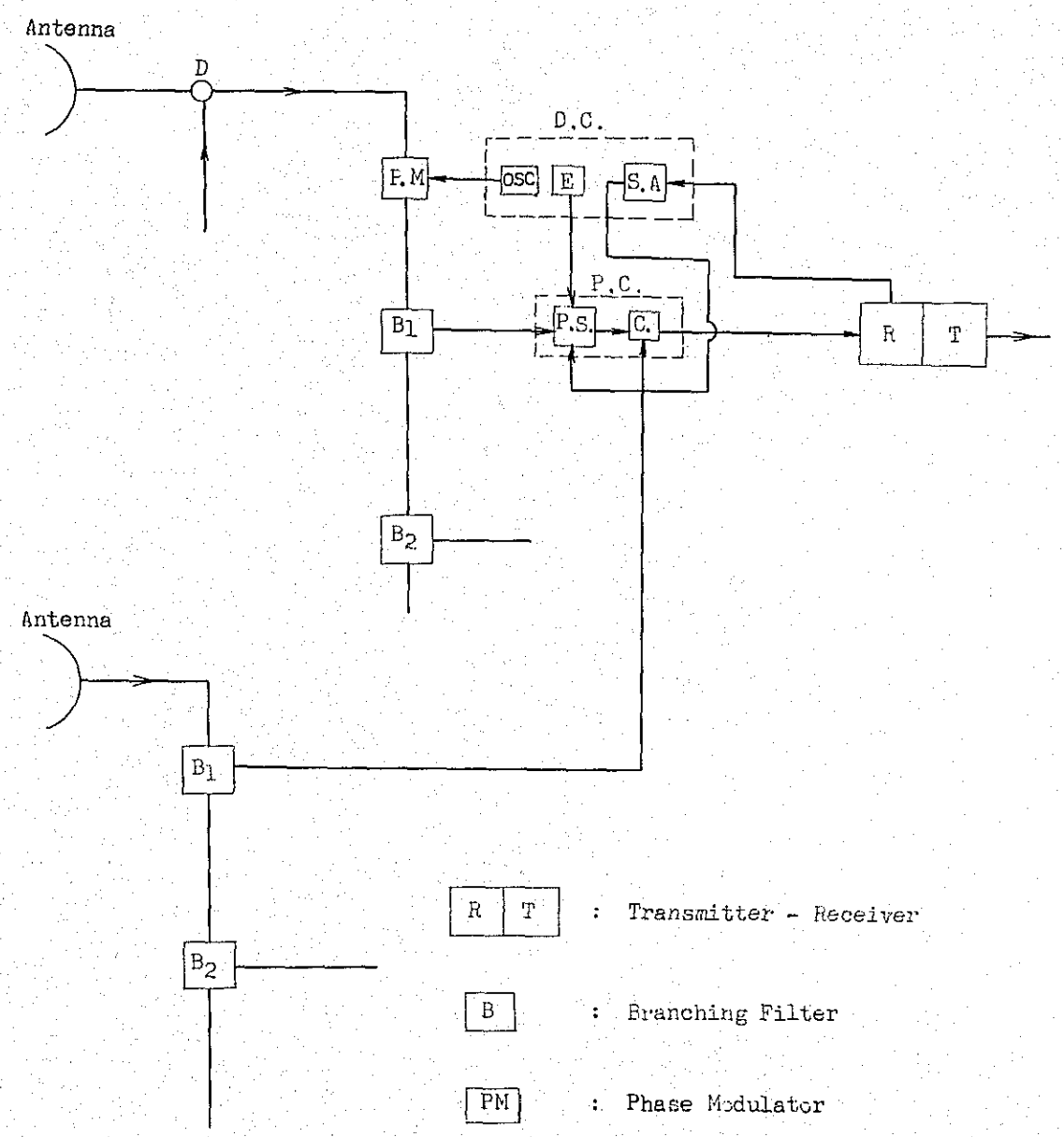
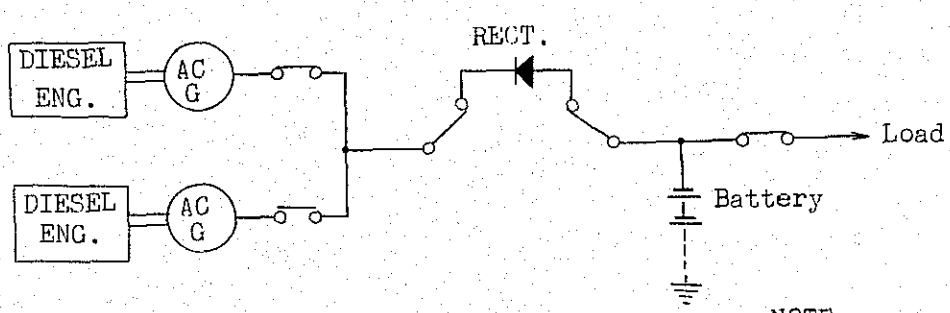


Fig. 21 Block Diagram of Space Diversity System



NOTE:

AC.G : Generator (Alternative Current)

RECT.: Rectifier

Fig. 23 Power system without the Facilities of Commercial Power.

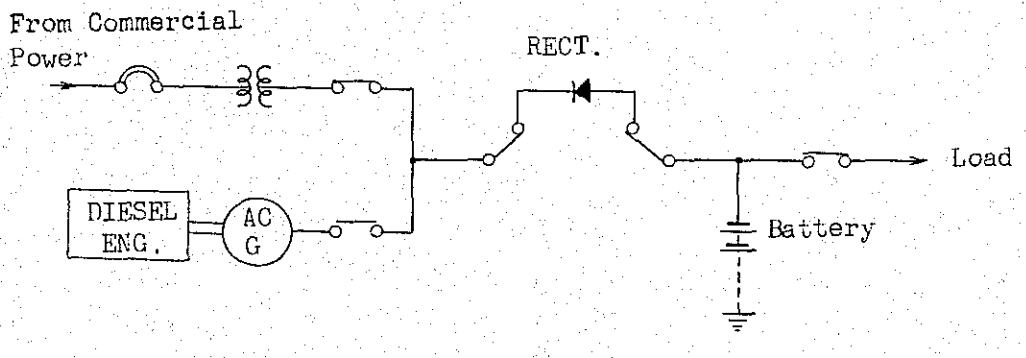


Fig. 24 Power System available of Stable Commercial Power.