REPORT ON THE SURVEY
FOR
WEST PAKISTAN
MICROWAVE NETWORK PROJECT

APRIL 1965

OVERSEAS TECHNICAL COOPERATION AGENCY

JAPAN

REPORT ON THE SURVEY
FOR
WEST PAKISTAN
MICROWAVE NETWORK PROJECT

APRIL 1965

OVERSEAS TECHNICAL COOPERATION AGENCY

JAPAN

FOREWORD

The Government of Japan, at the request of the Government of the Republic of Pakistan, has decided to execute the basic survey for the construction of micro-wave network in West Pakistan 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 Pakistan, the Agency organized and despatched to Pakistan a Survey Team consisting of 6 experts under the leadership of Mr. Nobuo Saji 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 Pakistan government. Upon returning home of 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 Pakistan and Japan.

In conclusion, 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 Pakistan Government, particulary by the Telegraph and Telephone Department.

April, 1965

Shinichi Shibusawa

Director General
Overseas Technical Cooperation
Agency of Japan

CONTENTS

1. PREFACE

1. Preface

The Pakistan government has carried out the first and second Five Year Plans to the achievement of great improvement of the condition of tele-communication — Above all, the government has taken up the planning of the extension of communication network as one of its most important policies, with the aim of attaining the level where the people may enjoy nationwide subscriber's trunk Dialing service through microwave and co-axial cable systems.

The construction of microwave network that may connect the main cities in southern and northern parts of West Pakistan has indeed a great significance not only for the establishment of the main communication routes of this country, but also for the attainment of prompter communication between East and West Pakistan, which should further be extended to be the bridge between Asia, Middle and Near East and Europe.

1.1 Characters of this Survey

This survey is to execute, at the request of the Pakistan government, the basic research of the Planning of Construction of Microwave system, one of the important development policies of this country, which may connect Karachi, Sukkur, Rawalpindi and Peshawar in West Pakistan.

The basic research adverted to means synthetic and fundamental research. Therefore, this survey means the basic investigation of the construction of the microwave routes, including, to be precise, trunk traffic research, the planning of the network of communication circuit, planning and research of the position of microwave station, research of the microwave equipment, the electric power system, relations with the present communication network and the rough estimate of construction expenses. As this survey bears such characteristics the team has actually executed research of many possible routes, but on the other hand it has engaged in research as detailed and practical as possible of the routes of high priority.

1.2 Member of Survey Team

The chief and members of the team and their respective assignment were as follows:

Nobuo Saji	Chief of the survey team
Koichi Asako	Microwave system engineering
Isao Ebihara	Microwave system design
Iwao Ueda	Estimate of traffic demand and carrier telephone engineering.
Nobuo Suzuki	Exchange engineering
Hiroei Fujioka	Planning of the microwave system

1.3 Period of Survey

70 days (November 25th 1964 - February 2nd 1965)

1.4 Summary of the Results of Survey

The super multi-channel transmission system now in use in West Pakistan, including the facilities under construction, may be divided into two forms, one b-ing the co-axial cable system with the capacity of 960 telephone channels which is being operated in Karachi-Hyderabad, Sargodha - Rawalpindi and Sargodha - Lahore, the other being CENTO micro-wave system with the capacity of 600 telehone channels which extends from Karachi to Ankara, Turkey, via Lakhi (Sukkur) and Mastung (Quetta). It has been revealed by this survey that the capacity of these systems should become insufficient in 1969. Moreover, we think it will become necessary toward the end of 1969 at the latest to construct new transmission systems for comprehensive areas connecting the cities in northern part of West Pakistan, e.g., Rawalpindi, Lahore, Peshawar, etc. with Karachi, taking into consideration the television signal transmission expected in the near future between Karachi, Rawalpindi and Lahore. The Survey Team examined this new systems taking into consideration various kinds of technical problems as regards the trunk telephone traffic, economy, measures for the prevention of disasters, future planning of the network of communication circuits, the construction and maintenance of facilities etc. Consequently a conclusion has been reached following terms.

This new system should warrant reinforcement of the already existing coaxial cable system and furtherance of the stability of trunk lines in West Pakistan, and help promote the enforcement of telephone communications and television signal transmission and execution of effectual maintenance and perfect nation-wide subscriber's trunk dialing system.

Essential Points of Recommendation

1. The Routes designed to be constructed

Between Karachi - Sukkur - D.G. Khan - D.I. Khan - Sargodha - Rawalpindi and Peshawar. (Total number of stations are 35 including through repeater stations.)

2. Frequency bands to be used.

4,000 MC bands of the Frequency Arrangement by CCIR's Recommendation.

3. Transmission Capacity

As to the circuit at the initial period of construction, one system with the capacity of 960 channels of telephone use of CCIR specification and one system of stand-by would be sufficient. However, television signal transmission, this stand-by circuit may be diverted, or one more system for the transmission of television signal should necessarily be constructed. This circuit should be designed with the capacity of increasing 5 systems of circuit under operation and one system of stand-by use at the maximum.

4. Method of switching with the circuit of stand-by use and the terminal station

Switching with stand-by circuit is to be automatically operated by means of noise detection. Standard section distance of switching should be arranged to cover approximately the distance of 5 repeating stations. Karachi, Kotri (Hyderabad), Sukkur, D.G. Khan, Rojhan, D.I. Khan, Sargodha, Rawalpindi and Peshawar are assigned to be the terminal stations for switching and to be attended by persons for maintenance.

5. Standard repeater spacing

The standard of distance is to be 50 KM. In plain ground, the repeater spacing must be reexamined after propagation test in summer. In this report, however, designs are made on the standard value of 50 km less 10 - 20 % for level ground.

6. Auxiliary Circuit

For this purpose the auxiliary circuits of exclusive use of V.H.F. band is to be used and one part of this circuit is designed to be assigned to the circuits of telephone in small towns.

7. Period of construction 2 - 3 years

8. Time of completion End of 1969

9. Total construction cost (except the cost for the channel translating equipments)

270 - 296 lac of Rupees (In the case of one system of telephone circuit and one system of stand-by use)

320 - 350 lac of Rupees (In the case of one system of telephone circuit, one system of transmitting and one system of receiving for television signal transmission, and one system of stand-by use)

2. FORECAST OF THE TRUNK TELEPHONE TRAFFIC

2. Forecast of the Trunk Telephone Traffic

2.1 Objective of Forecast

Long-term traffic forecast is necessary anywhere when planning construction of the basic tele-communication facilities. The objective of the survey is to investigate the planning of the construction of micro-wave in West Pakistan, but more rational and practical is to make its planning in consideration of the future traffic forecast as well as of the establishment of network of communication circuits based on such traffic forecast.

2.2 Forecast of the Number of Subscriber

As regards the forecasting of the number of subscriber, the Team has decided, out of different methods, to calculate out the average national pervasion rate based on gross national income and to take into account the national population in order to seek for the estimated number of subscribers. The relation between national income per capita and the pervasion rate of telephone proves as is shown in Fig. 2-2-1, and this function may be used for calculation of the rate by the following equation.

$$y = Ax^K$$

y = pervasion rate of telephone in the year of forecast

A = pervation rate of telephone in the base year

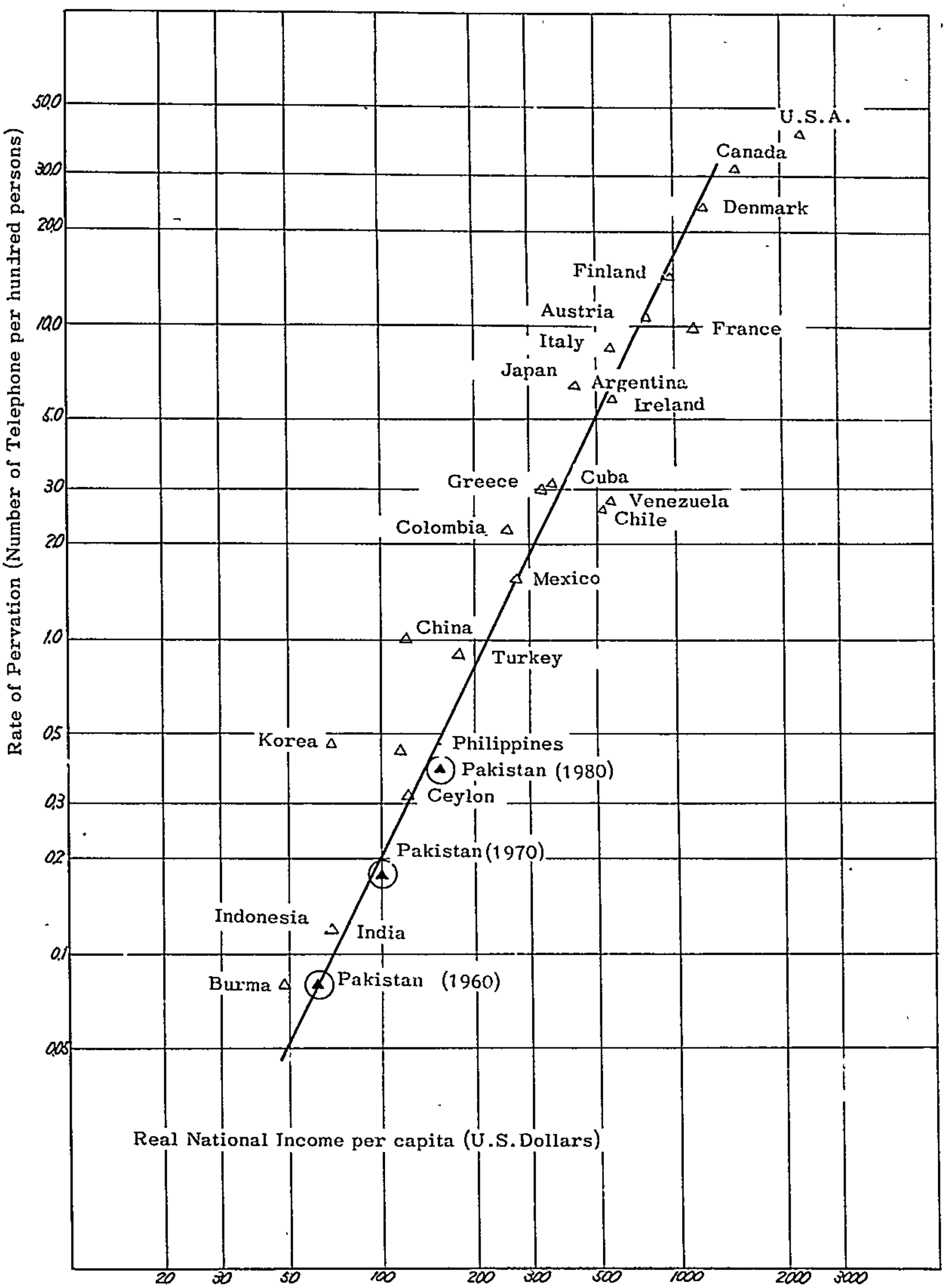
x = ratio of G.N.P. per capita for the base year against the year of forecasting.

k = Value of increase of percentage of telephone pervasion to one-per-cent increase of G.N.P. per capita. The value, called elasticity, may be put at 2 from the straight-line - relation of Fig. 2-2-1.

The national income per capita has been decided in accordance with the government report on the third 5 year program coupled with the actual figures in the past.

As regards the future economic growth, all figures should be based on presumption that the program of the Pakistan government can be accomplished as scheduled.

Fig. 2.2.1 National Income and the Telephone Pervasion Ratio (1961)



2.2.2 Forecasting the Number of Nationwide Subscribers

According to the methods aforementioned the number of nationwide subscribers may be forecast. From the source materials and the government report of the third 5 year's plan the figures of the Gross National Product of the years 1960, 1970 and 1980 are shown in Table 2.2.1., the sums of which being Rs 31,440 million, Rs 57,000 million and Rs 104,500 million, and these sums are respectively shown as the indexes of 181 and 332 on the basis of 100 in 1960. These figures correspond to 6.1% and 6.37%, or the average growth rate per year in 10 years respectively.

With regards to the rate of increase and total figures of population the Team has set the figure of about 2% for increase and 120 million in 1970 and 146.3 million respectively for total population. From these figures we may obtain per capita G.N.P. These sums will be $66.7 in 1960, $100 in 1970 and $150 in 1980. From these figures referring to Fig. 2.2.1, we calculate on the aforementioned formula and, estimate the number of sets per one hundred person and obtain the figures 0.18 of 1970, 0.4 of 1980, and the total number of telephones to be set in the country will amount to 216 thousand in 1970 and 585 thousand in 1980 respectively. This figure, 216 thousand in 1970, nearly equals to the number of increase during the third five year planning of Telegraph and Telephone Department (T & T) of the Pakistan government.

Table 2.2.1 Actual Results and the Future Program of the Increase of G.N.P.

	G.N.F. (million Rs)	Population (million)	Index		G.N.P. per head		Index	Average increase rate per annum(%)		
			G.N.P.	Population	(Rs)	($)	Per capita G.N.P.	G.N.P.	Population	Per capita G.N.P.
1960	31,440	99	100	100	317.5	66.9	100			
1970	57,000	120	181	122	475	100	150	6.1	2.0	4.1
1980	104,500	146.3	332	147	714	150	225	6.3	2.0	4.1

Table 2.2.2 Estimate - Figure of the Number of Telephone Sets

	Population (Million)	Pervation-rate of telephone sets (per hundred persons)	Total number of telephone sets,	Index	
				Rate	Number of sets
1960	99	0.18	79,000	100	100
1970	120	0.18	216,000	225	273
1980	146.3	0.4	585,000	500	740

2.2.3 Forecast of the Number of Subscribers in Main Cities of West Pakistan

As regards the forecast of the number of subscribers in the main cities of West Pakistan, it is most reasonably considered that the figures shown in the planning of the third 5 year program of the T & T Department, may be used as bases, on the ground that the total number of telephone sets in the whole country of Pakistan in 1970 is almost equal to the summing up of the capacity of each telephone exchange, in the last year of the third 5 year program of the T & T Department of Pakistan.

The estimate of the number of subscribers of main cities in 1980 may not be sufficiently explained as any highly accurate results for the year so far ahead is infeasible, however, we estimate the figures as shown in Table 2.2.3.

While these figures show the capacity of the telephone exchange but do not represent the number of real subscribers, we can utilize these figures of base and estimate years in order to forecast the traffic of trunk calls.

Table 2.2.3 State of the Increase of the Subscription Capacity of Main Telephone Exchanges

	Capacity		
	1963	1970	1980
Karachi	34,600	93,000	232,500
Hyderabad	2,000	8,000	20,000
Sukkur	1,000	3,000	7,500
Multan	2,000	4,000	10,000
Mirpurkhas	400	1,000	2,500
Quetta	600	3,000	7,500
Lyallpur	3,000	7,000	17,500
Sargodha	600	2,000	5,000
Rawalpindi	4,000	20,000	50,000
Lahore	12,000	32,000	80,000
Peshawar	1,200	4,000	10,000
D.I. Khan	200	300	750
D.G. Khan	150	300	750
Montgomery	400	1,000	2,500
Jhelum	200	600	1,500
Gujranwala	1,000	3,000	7,500
Mianwali	100	300	750
Bannu	200	400	1,000
Larkana	200	400	1,000

2.3 Forecast of the Traffic of Trunk Telephone Calls.

2.3.1 Methods of Forecasting

As to the methods of forecasting, now we adopt two ways, one is to estimate the future increase of number from the past actual condition of trunk calls and the other is to estimate the figures from the future number of telephone sets and subscribers in main cities. Then we assume the following as the factors common to both methods.

(i) Concentrating rates

From the number of telephone calls per day to calculate the necessary circuit of trunk call we must obtain the information of concentrating rate of total telephone calls per day on the assumption that telephone calls must be linked and completed at a fixed rate of exchange even in the most busy hours. In Pakistan, there are still few sections performing Subscriber's Trunk Dialing (S.T.D.) service and only the section between Karachi and Hyderabad has that service for more than one year. We determine such concentrating rate to be 15% on the basis of actual results between Karachi and Hyderabad as well as of the experiences in our country.

(ii) Average holding time

In order to obtain the traffic from the number of trunk calls we must ascertain the average holding time for one call that may occupy a trunk line. In Pakistan the call duration in the section of delayed service is recorded every three minutes and is limited below six. Our experiences tell us that the calls of delayed service and S.T.D. service tend to change the occupied time. Therefore according to the actual data made available through the service between Karachi and Hyderabad together with our experiences in Japan we determined to use the following figure as average holding time.

Short distance call (For distance less than 100 miles) .... 120 seconds
Middle distance call (For distance between 100 - 200 miles) ... 300 seconds
Long distance call (For distance more than 200 miles) .... 360 seconds

(iii) Rate of Increase of the number of calls resulted from the S.T.D. service

Usually the number of telephone calls increases rapidly when the delayed service in switched to S.T.D. We note the great increase of percentage amounting to 400% in the section between Karachi and Hyderabad, however, as this may be rather abnormal we revised it to read 200% through an inference admissible in our country. The reason is attributed to the known fact that the ratio of the number of ordinary calls to that of urgent calls actually operated tend to change, according to the relation between the demand of subscribers for trunks service (the Number of callings) and the number of trunk circuits (the capacity of the transmission of trunk traffic) in the section of the delayed service.

If the number of the trunk circuits should fail to satisfy the demand for trunk calls, time requires from looking of a call to connection tends to become longer, and the subscribers desirous of shortening such waiting time are inclined to apply for urgent calls in spite of the high charge. Therefore, the ratio of urgent calls to ordinary calls associates closely with the length of the trunk circuit in the section of the delayed service, or with the condition of the increased number of calls under sufficiently expanded number of circuits. The actual ratios between the cities in Pakistan were unavailable, but we decide the ratio R shown as 1.55 in the following equation and the ratio of increase of the number of call as 1.45 under the improvement from the delayed service to the operator dial service.

The equation referred to is as follows.

$$R = \frac{n_1 + 2n_2}{n_1 + n_2}$$

R = ratio of urgent calls to ordinary calls

n = number of ordinary calls

n = number of urgent calls

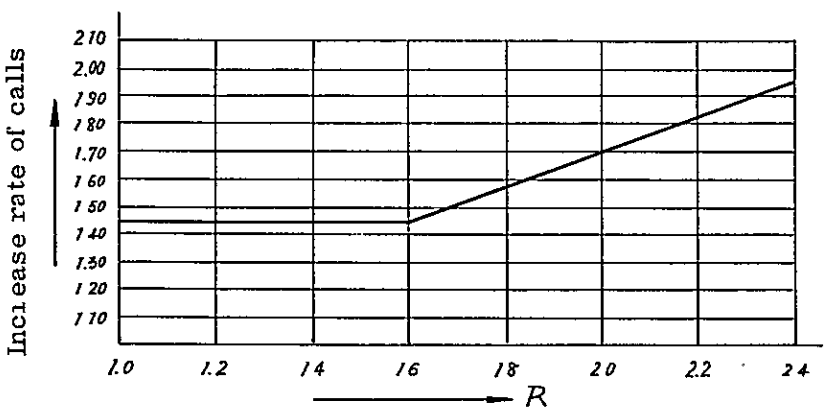


Fig. 2.3.1 Increase rate of calling accompanied by the betterment of service (delayed service → operator dial service)

We decide the rate of increase of the number of calls to be 1.4 as the Japanese standard in the case of change from the operator dial service to S.T.D. service. The overall increase of the rate of calls when the telephone service is shifted from delayed service to S.T.D. may be obtainable from the product of the two rates mentioned. The calculation formula is as follows:

$$1.45 \times 1.4 \fallingdotseq 2$$

(iv) Lost Calls Ratio

The Lost Calls Ratio is decided to be one-hundredth.

(v) Methods of estimate of the number of channel.

We multiply the estimated number of calls per day by concentration rate and average holding time, and we can get the traffic load by the unit of H.C.S. (Hundred Call Seconds) In order to get the necessary number of channel from the traffic load obtained we used the following tables.

a) Molina's figure table as to the traffic load below 357 H.C.S.

b) Figure table of double selection as to the traffic load above 357 H.C.S.

In these tables, the required number of circuits against the traffic load tends to be calculated out to a little greater figure.

(vi) Time of execution of the service of S.T.D.

As regards to the execution time of S.T.D. service we have decided that the scheduled sections slated before 1970 are to be completed according to Pakistan T & T Department and that the sections which were left out of the S.T.D. service up to the end of 1970 are also to be completed by 1980.

(vii) As regards the network of circuit

The national numbering plan is now at the stage of discussion. We also could not get the final zone system in Pakistan. In addition, as we are short of any information about trunk exchange system, the planning of circuit network is yet obscure and we estimate the number of channel in terms of following suppositions.

a. The section for the establishment of circuit network is to remain unchanged as it is now.

b. Increase of efficiency by means of alternative trunking is not to be taken into account.

c. The traffic load is not to be divided according to origination and termination of calls in order to estimate the number of channel.

d. Shunt loss due to the establishment of plural trunk exchange in a single town is not to be considered.

e. Difference of efficiency between the kinds of circuit is to be disregarded.

f. The S.T. D. service and the delayed service are not to be operated concurrently.

(viii) Year forecast

In the case of the planning of the construction of new transmission line it is necessary to examine the plan in relation to the traffic of at least 15 years to come, and therefore we decided to estimate the traffic in 1980. However, so far as this estimate bears much indefinite factors we cannot expect any more than a temporary aim out of the estimate. Moreover in order to determine the time of construction of new transmission line, it is necessary to take into the estimate of time when the present route facilities should come beyond their capacities and we estimated the traffic volume in 1970 as the temporary aim above adverted to.

(ix) Standard traffic load

As regards the standard traffic we use as the basis the number of calls taken from the statistics of P.T. & T. (The date of statistics; 1st December, 1964)

2.3.1-1 Method by Time Series

In order to estimate figures by time series in addition to the methods by the common matters mentioned, it is necessary to obtain the actual trend of the increase of trunk calls at least several years back, in the past, and then to decide the rate of future increase per year. We investigated into the past actual condition, ranging from five to ten years back, of the telephone offices of main cities in Pakistan and estimated each rate of increase of number of calls.

There are many kinds of figures taken, but it is rather desirable to divide figures for the sake of our estimate, and we have summarized such yearly rates of increase into four groups such as 10%, 15%, 20% and 25% according to the actual figures.

Moreover, as regards Rawalpindi, as Islamabad, the new capital, is now under construction and the government facilities are soon to be removed and planted there, we cannot presume each yearly increase up to 1970 of number of trunk calls only from the actual condition prevailed in the past, and therefore we applied special rates of increases for several years until 1970. Besides, as to the sections lacking actual data we applied the figure drawn from the opinions of the planning engineers of the T. & T. Department and also from the figures of similar sections.

2.3.1-2 Method of Estimate from the number of Telephone Sets and Subscribers

We estimated the number of telephone sets of each central telephone exchange and, based on this, the number of subscribers. As regards the relation between the numbers of telephone sets and subscribers, we have decided the ratio of 15% of the number of extension sets to the total number of sets in the larger exchange (office, the number of telephone sets exceed 5,000) and also the similar ratio of 10% in the smaller exchange (Office, the number of telephone sets is below 5,000) on the grounds of the ratio of the number of subscribers to the number of total telephone sets in the Lahore and Multan exchanges.

Table 2.3.1 Ratio of the Number of Subscribers to the Total Number of Telephone Sets

Year / Cities	1960	1961	1962	1963	1964	Average
Lahore	15.7	14.9	15.2	17.8	14.5	15.6
Multan	14.2	13.1	10.9	9.7	8.0	11.0

In order to estimate the number of trunk calls from the number of subscribers thus taken we use the following expression.

$$\frac{c}{c_0} = \left(1 - \alpha + \frac{sI_1}{sI_0} \cdot \alpha\right)\left(1 - \alpha + \frac{sII_1}{sII_0} \cdot \alpha\right)$$

sI_0 .... Number of subscribers at the standard time of I exchange office

sII .... Ditto of II exchange office.

sI_t .... Number of subscribers at the estimated time of I exchange office

sII_t ....Ditto of II exchange office.

Co. ....Number of calls at the standard time between I and II exchanges

C .... Ditto ...... at the estimated time ..... Ditto .....

α ,.........Ratio of call rate of new subscribers to old subscribers

(We decide it 0.7)

2.3.2 Results of Estimate

The results of estimate according to the methods above-mentioned are shown as in the table 2.3.2 and 2.3.3.

In the table 2.3.2 we show the results made available by the methods both of time series and of the number of subscribers. In the table 2.3.3 we show the results by the method of the number of subscribers. As can be noted therein, the results by the method of the number of subscribers are generally more than the results by the method of time series. However, considering the fact that the call rate of new subscribers to that of old ones is about 0.7 ..... It may be reasonably presumed that the ratio is rather bigger than this figure in the countries of lower pervasion ratio of telephone.

We may be able to obtain the results rather near to actual condition by the method of the number of subscribers. Besides, as regards the necessary capacity of transmission lines for estimated traffic, we used to adopt the one corresponding to big traffic between these two methods.

Table 2.3.2. Estimate Table for Trunk Traffic of 1970 and 1980

Section	Number of trunk calls of 1st December, 1964	Rate of increase per annum		Rate of increase by S.T.D.	Number of estimated trunk calls (1970)		Number of estimated trunk calls, H.C.S. (1970)		Number of necessary channels (1970)		Necessary transmission circuits (1970)		Number of necessary channels (1980)		Necessary Transmission circuits (1980)
		Number by the method of time series	Number by the method of the increase of subscribers		Number by the method of time series	Number by the method of the increase of subscribers	Number by the method of time series	Number by the method of the increase of subscribers	Number by the method of time series	Number by the method of the increase of subscribers	Number by the method of time series	Number by the method of the increase of subscribers	Number by the method of time series	Number by the method of the increase of subscribers	
Karachi-Hyderabad	9440 129 69	25	25	2	35,870 980 159	35,870 980 159	6,633	6,637	236 4	236 4	20G	20G	2,159	970	180G
Karachi-Sukkur	391	15	26	2	1,800	3,128	810	1,408	38	60	4G	5G	126	206	18G
-Multan	264	15	20	2	1,212	1,584	655	856	32	40	3G	4G	105	135	12G
-Sargodha	66	20	28	2	396	580	(214)	313	13	17	2G	2G	57	56	5G
-Lyallpur	309	20	24.4	2	1,854	2,286	1,002	1,135	45	50	4G	5G	286	186	24G
-Lahore	1,775	20	30	2	10,700	15,266	5,778	8,244	208	287	18G	24G	1,229	1,160	103G
-Rawalpindi	685	25(30)	33.8	2	6,580	7,810	3,554	4,218	134	157	12G	14G	1,114	600	93G
-Peshawar	161	25	26.6	2	1,224	1,320	661	713	38	34	4G	3G	222	89	19G
-Quetta	252	25	29.4	2	1,916	2,370	1,035	1,280	47	56	4G	4G	334	192	18G
-Mirpurkhas	160	20	23.8	2	960	1,152	432	519	24	27	2G	3G	105		10G
Hyderabad-Sukkur	307 78	20	32.6	2	14,230 1	3,316 421	934	1,492	43	63	4G	6G	228	239	20G
-Lyallpur	42	15	30.4	2	194	412	105	223	8	14	1G	2G	23	40	4G
-Lahore	217	15		2	1 (1,000)	2,474	540	1,336	28	58	3G	5G	87	199	17G
-Rawalpindi	21	30	40	2	202	320	109	173	9	12	1G	1G	17	32	3G
-Quetta	34	15	35.7	2	156	422	134	228	10	14	1G	2G	18	40	4G
-Mirpurkhas	406	20	29.8	2	1,480	2,362	267	425	15	23	2G	2G	69	74	7G
-Nawabsha	249	15	26.4	2	1,830	3,058	512	826	29	46	3G	4G	121	112	11G
Sukkur-Multan	72	10	25.4	2	260	562	141	304	10	17	1G	2G	20	58	5G
-Lyallpur	39	10	29	2	140	360	76	195	7	12	1G	1G	13	40	4G
-Lahore	123	15		2	566	1,328	306	717	17	35	2G	3G	50	110	10G
-Quetta	130	15	34.3	2	600	1,534	324	828	18	39	2G	4G	58	126	11G
Multan-Sargodha	62	10	23.2	2	240	434	108	195	9	12	1G	1G	15	35	3G
-Lyallpur	246	10	19.5	2	1,428	643	400	643	22	32	2G	3G	46	101	9G
-Lahore	394 56	10		2 -	1,802	2,680 191	811	1,206 -	38	57	4G	5G	143	196	17G
-Rawalpindi	101	30	29	2	970	930	524	502	27	26	3G	3G	125	79	7G
-Peshawar	46	25	22	2	350	284	189	153	12	11	1G	1G	74	32	3G
-Quetta	40	25	24.3	2	300	296	162	160	11	11	1G	1G	38	32	3G
- Montgomery	161	10	19.5	2	580	934	105	168	8	11	1G	1G	15	34	3G
-Mianwali	40	10	22	-	72	132	-	-	2	3			11	14	2G

Section	Number of trunk calls of 1st December, 1964	Rate of increase per annum		Rate of increase by S.T.D.	Number of estimated trunk calls (1970)		Number of estimated trunk calls, H.C.S. (1970)		Number of necessary channels (1970)		Necessary transmission circuits (1970)		Number of necessary channels (1980)		Necessary transmission circuits (1980)
		Number by the method of time series	Number by the method of the increase of subscribers		Number by the method of time series	Number by the method of the increase of subscribers	Number by the method of time series	Number by the method of the increase of subscribers	Number by the method of time series	Number by the method of the increase of subscribers	Number by the method of time series	Number by the method of the increase of subscribers	Number by the method of time series	Number by the method of the increase of subscribers	
Multan-D.G.Khan	77	10	16.5	-	139	193	-	-	3	4			10		2G
Sargodha-Lyallpur	1,147	10	27.5	-	2,064	4,932	372	888	21	41	2G	4G	43	142	12G
-Lahore	1,406	10		-	1,530	7,030	456	1,266	25	55	3G	5G	51	190	16G
-Rawalpindi	180	30	37	2	1,730	2,376	312	428	17	23	2G	2G	55	73	7G
-Peshawar	61	25	30	2	476	586	215	264	13	15	2G	2G	80	48	4G
-Mianwali	98	10	30	-	177	375	-	-	4	8			11	10	1G
Lyallpur-Lahore	4,300 169	10	26	- 2	8,042	17,200	1,448	3,096	62	119	6G	10G	144	440	37G
-Rawalpindi	226	15	33	2	2,170	2,486	977	1,119	44	50	4G	5G	149	169	15G
-Peshawar	79	25	26	2	614	632	332	341	18	18	2G	2G	116	56	10G
-Montgomery	80	10	23	2	288	560	56	101	6	8	1G	1G	9	23	2G
Lahore-Rawalpindi	2,046	30	37	2	19,700	26,600	8,865	11,970	308	416	26G	35G	1,898	1,700	159G
-Peshawar	530	25	29	2	4,120	4,982	2,235	2,690	89	103	8G	9G	701	313	59G
-Quetta	144	25	32	2	1,094	1,526	591	824	30	39	3G	4G	200	124	17G
-Montgomery	355 129	10	26.6	2 -	1,280	2,890 529	230	520 -	14	38	2G	3G	36	99	9G
Lahore-Mianwali	2,046	30	29	-	254	649	-	-	6	13			30		4G
-Gujranwala	1,028 254	10	28	2	3,700	9,252 1,143	666	1,665	33	91	3G	8G	85	236	2G
-Jhelum	119	10	29	-	215	548	-	-	5	11			13	22	2G
Rawalpindi-Peshawar	627	30	36.2	2	6,030	8,026	1,082	1,445	48	61	4G	6G	110	207	18G
-Quetta	35	30	38.6	2	336	498	182	269	12	15	1G	2G	25	48	4G
-D.I. Khan	60	30	25	-	288	228	-	-	6	5			33	23	3G
-Mianwali	40	30	35.5	-	192	248	-	-	4	5			24	25	3G
-Jhelum	150	30	35.5	-	719	930	-	-	15	19			33	34	3G
-Bannu	75	30	29	-	360	345	-	-	8	7			39	32	4G
Peshawar-D.I. Khan	84	10	18	-	151	227	-	-	4	5			19	23	2G
-Bannu	104	10	22	-	188	343	-	-	4	7			11	15	2G
D.I.Khan-Mianwali	41	10	18	-	74	111	-	-	2	3			7	7	1G
-Bannu	117	10	12	-	211	234	-	-	5	5			12	12	1G
Sukkur-Larkana	254	10	25	2	.914	1,606	167	564	18	36	2G	3G	29	114	10G

Table 2.3.2 Estimated Table of Trunk Traffic of 1970 and 1980 (By the number of subscribers)

Section	Number of telephone sets: Cities of the left side 1963	1970	1980	Cities of the right side 1963	1970	1980	Number of trunk calls 1st December 1964	Coefficient of the increase of traffic: Cities of the left side 1970	1980	Cities of the right side 1970	1980	Product 1970	1980	Rate of increase by the S.T.D.	Estimated number of trunk calls 1970	1980	Estimated number of trunk calls H.C.S. 1970	1980	Necessary number of channels 1970	1980	Remarks
Karachi-Hyderabad	34.6	93	232.5	2	8	20	9449	1.95	2.05	2.59	2.05	3.8	4.1	-	36,872	156,000	6,637	28,080	240	970	
							129 69								(159)						
" -Sukkur	"	"	"	1	3	7.5	391	"	"	2.07	"	4.0	"	2	3,128	12,700	1,408	5,700	60	206	
" -Multan	"	"	"	2	4	10	264	"	"	1.56	"	3.0	"	2	1,584	6,600	856	3,564	40	135	
" -Sargodha	"	"	"	0.6	2	5	66	"	"	2.26	"	4.4	"	2	580	2,400	313	1,296	17	56	
" -Lyallpur	"	"	"	3	7	17.5	309	"	"	1.88	"	3.7	"	2	2,286	9,430	1,135	5,092	50	186	
" -Lahore	"	"	"	12	32	80	1,775	"	"	2.2	"	4.3	"	2	15,266	62,730	8,244	33,874	287	1,160	
" -Rawalpindi	"	"	"	4	20	50	685	"	"	2.94	"	5.7	"	2	7,810	32,000	4,218	17,280	157	600	
" -Peshawar	"	"	"	1.2	4	10	161	"	"	2.13	"	4.1	"	2	1,320	5,230	713	2,224	34	89	
" -Quetta	"	"	"	0.6	3	7.5	252	"	"	2.4	"	4.7	"	2	2,370	9,800	1,280	5,292	56	192	
" -Mirpukhas	"	"	"	0.4	1	2.5	160	"	"	1.84	"	3.6	"	2	1,152	4,768	519	2,136	47	86	
Hyderabad-Sukkur	2	8	20	1	3	7.5	307 78	2.59	"	2.07	"	5.4	"	2	3,316 (421)	15,000	1,492	6,750	63	239	
" -Lyallpur	"	"	"	3	7	17.5	42	"	"	1.88	"	4.9	"	2	412	1,600	223	864	14	40	
" -Lahore	"	"	"	12	32	80	217	"	"	2.2	"	5.7	"	2	2,474	10,200	1,336	5,508	58	199	
" -Rawalpindi	"	"	"	4	20	50	21	"	"	2.94	"	7.6	"	2	320	1,200	173	648	12	32	
" -Quetta	"	"	"	0.6	3	7.5	34	"	"	2.4	"	6.2	"	2	422	1,600	228	864	14	40	
" -Mirpurkhas	"	"	"	0.4	1	2.5	246	"	"	1.84	"	4.8	"	2	2,362	9,884	425	1,779	23	74	
" -Nawabsha	"	"	"	0.3	0.6	1.5	249 164	"	"	1.57	"	4.1	"	2	2,042 1,018	8,366 4,174	368 458	1,506 1,378	46	112	
Sukkur-Multan	1	3	7.5	2	4	10	72	2.07	"	1.56	"	3.9	"	2	562	2,500	304	1,150	17	58	
" -Lyallpur	"	"	"	3	7	17.5	39	"	"	1.88	"	4.6	"	2	360	1,600	195	864	12	40	
" -Lahore	"	"	"	12	32	80	123	"	"	2.2	"	5.4	"	2	1,328	5,330	717	2,828	35	110	
" -Quetta	"	"	"	0.6	3	7.5	130	"	"	2.4	"	5.9	"	2	1,534	6,150	828	3,321	39	126	
Multan-Sargodha	2	4	10	0.6	2	5	62	1.56	"	2.26	"	3.5	"	2	434	1,600	195	720	12	35	
" -Lyallpur	"	"	"	3	7	17.5	246	"	"	1.88	"	2.9	"	2	1,428	5,740	643	2,583	32	101	
" -Lahore	"	"	"	12	32	80	394 56	"	"	2.2	"	3.4	"	"	2,680 (191)	12,000	1,206	5,400	57	196	
" -Rawalpindi	"	"	"	4	20	50	101	"	"	2.94	"	4.6	"	"	930	3,600	502	1,944	26	79	
" -Peshawar	"	"	"	1.2	4	10	46	"	"	2.13	"	3.3	"	"	284	1,200	153	648	11	32	
" -Quetta	"	"	"	0.6	3	7.5	40	"	"	2.4	"	3.7	"	"	296	1,200	160	648	11	32	
" -Montgomery	"	"	"	0.4	1	2.5	161	"	"	1.84	"	2.9	"	"	934	3,830	168	690	11	34	
" -Mianwali	"	"	"	0.1	0.3	0.75	40	"	"	2.1	"	3.3	"	-	(132)	541	-	244	3	14	
" -D.G.Khan	"	"	"	0.15	0.3	0.75	77	"	"	1.57	"	2.5	"	-	(193)	791	-	143	4	10	

Section	Number of telephone sets: Cities of the left side 1963	1970	1980	Cities of the right side 1963	1970	1980	Number of trunk calls 1st December 1964	Coefficient of the increase of traffic: Cities of the left side 1970	1980	Cities of the right side 1970	1980	Product 1970	1980	Rate of increase by the S.T.D.	Estimated number of trunk calls 1970	1980	Estimated number of trunk calls H.C.S. 1970	1980	Necessary number of channels 1970	1980	Remarks
Sargodha-Lyallpur	0.6	2	5	3	7	17.5	1,147	2.26	2.05	1.88	2.05	4.3	4.1	-	4,932	21,000	888	3,780	41	142	
" -Lahore	"	"	"	12	32	80	1,406	"	"	2.2	"	5.0	"	-	7,030	29,000	1,266	5,220	55	190	
" -Rawalpindi	"	"	"	4	20	50	180	"	"	2.94	"	6.6	"	2	2,376	9,840	428	1,771	23	73	
" -Peshawar	"	"	"	1.2	4	10	61	"	"	2.13	"	4.8	"	"	586	2,400	264	1,080	15	48	
Lyallpur-Lahore	3	7	17.5	12	32	80	4,300 169	1.88	"	2.2	"	4.0	"	-	17,200	70,500	3,096	12,690	119	440	
" -Rawalpindi	"	"	"	4	20	50	226	"	"	2.94	"	5.5	"	2	2,486	10,200	1,119	4,590	50	169	
" -Peshawar	"	"	"	1.2	4	10	79	"	"	2.13	"	4.0	"	"	632	2,400	341	1,296	18	56	
" -Montgomery	"	"	"	0.4	1	2 5	80	"	"	1.84	"	3.5	"	"	560	2,296	101	413	8	23	
Lahore -Rawalpindi	12	32	80	4	20	50	2,046	2.2	"	2.94	"	6.5	"	"	26,600	110,000	11,970	49,500	416	1,700	
" -Peshawar	"	"	"	1.2	4	10	530	"	"	2.13	"	4.7	"	"	4,982	20,000	2,690	9,000	103	313	
" -Quetta	"	"	"	0.6	3	7.5	144	"	"	2.4	"	5.3	"	"	1,526	6,000	824	3,240	39	124	
" -Montgomery	"	"	"	0.4	1	2.5	355 129	"	"	1.84	"	4.1	"	"	2,890 (529)	11,849 2,169	520	2,523	27 (11)	99	
" -Mianwali	"	"	"	0.1	0.3	0.75	141	"	"	2.1	"	4.6	"	-	(649)	2,661	-	1,196	13	53	
" -Gujranwala	"	"	"	1	3	7.5	1,028 254	"	"	2.07	"	4.5	"	2	9,252 (1,143)	42,620	1,665	7,672	69 (24)	260	
" -Jhelum	"	"	"	0.2	0.6	1.5	119	"	"	4.6	"	2.9	"	-	(548)	2,247	-	405	11	22	
Rawalpindi-Peshawar	4	20	50	1.2	4	10	627	2.94	"	2.13	"	6.4	"	2	8,026	32,000	1,445	5,760	61	207	
" -Quetta	"	"	"	0.6	3	7.5	35	"	"	2.4	"	7.1	"	"	498	2,000	269	1,680	15	48	
" -D.I.Khan	"	"	"	0.2	0.3	0.75	60	"	"	1.29	"	3.8	"	-	(228)	935	-	421	5	23	
" -Mianwali	"	"	"	0.1	0.3	0.75	40	"	"	2.1	"	6.2	"	-	(248)	1,017	-	458	5	25	
" -Jelum	"	"	"	0.2	0.6	1.5	150	"	"	2.1	"	"	"	-	(930)	3,813	-	686	19	34	
" -Bannu	"	"	"	0.2	0.4	1	75	"	"	1.56	"	4.6	"	-	(345)	1,415	-	637	7	32	
Peshawar-D.I.Khan	1.2	4	10	0.2	0.3	0.75	84	2.13	"	1.29	"	2.7	"	-	(227)	931	-	419	5	23	
" -Bannu	"	"	"	0.2	0.4	1	104	"	"	1.56	"	3.3	"	-	(343)	1,406	-	253	7	15	
D.I.Khan-Mianwali	1.2	0.3	0.75	0.1	0.3	0.75	41	1.29	"	2.1	"	2.7	"	-	(111)	455	-	82	3	7	
" - Bannu	"	"	"	0.2	0.4	1	117	"	"	1.56	"	2.0	"	-	(234)	960	-	178	5	12	
Sargodha-Mianwali	0.6	2	1.5	0.1	0.3	0.75	78	2.26	"	2.1	"	4.8	"	-	(375)	1,538	-	277	8	16	
Sukkur-Larkana	1	3	7.5	0.2	0.4	1	111 52 91	2.4	"	1.56	"	3.8	"	2	1,606	6,585	564	2,963	36	114	

3. PLANNING OF THE TRUNK TELEPHONE TRANSMISSION CIRCUITS

3. Planning of the Trunk Telephone Transmission Circuits

3.1 Objective of the Designing of Trunk Circuits

It is necessary, after estimating the present and future conditions of trunk telephone traffic, to examine and determine the construction of trunk telephone transmission circuits, based on as many factors as possible in order to assure the necessary transmission quality, to secure the lowest level of trunks service and to set up most economically the trunk telephone circuits.

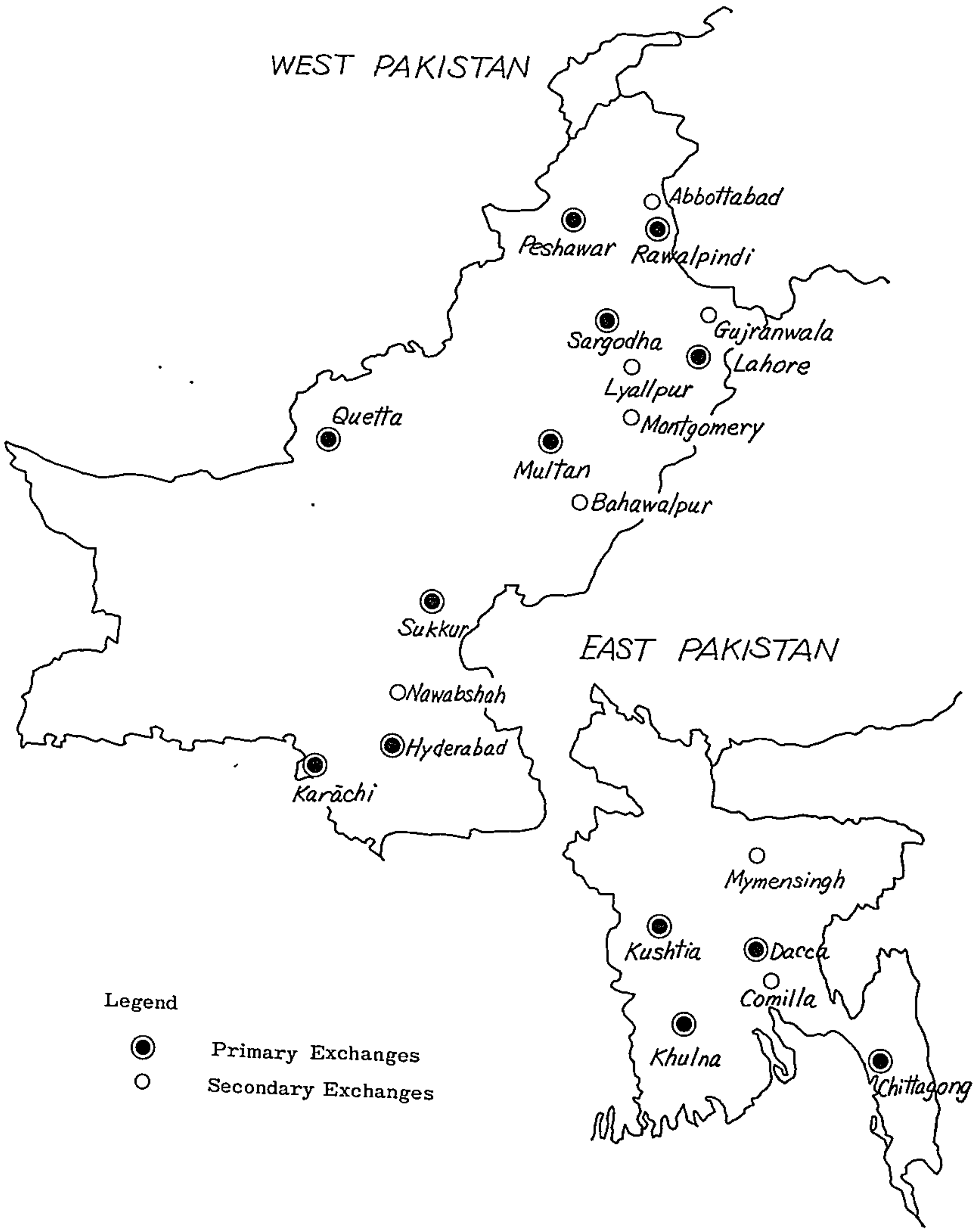
At the time of determination of the construction of trunk circuits it will also become necessary to examine all-round phases prevalent in this country from the angles of her geographic elements, culture, politics, economic policies, national defence, and general economy, etc. With this in mind, our survey team examined the designing of transmission circuits in Pakistan.

3.2 Determination of the Rank of Trunk Exchanges (Establishment of the National Numbering Plan)

In order to introduce nationwide subscriber's trunk dialing, it would be prime importance that more economical method for construction of circuit network (including the facilities for trunk circuit, switchboard of trunk exchange, station building and all other relative arrangements) should be examined and determined, in relation to the system of switchboard of trunk exchange.

For the maintenance of the transmission quality above a certain standard and for the composition of economical construction of circuit network, areas throughout the nation should reasonably be devided, and the trunk telephone traffic of intra and inter-areas should be presumed and finally the ratio of the channel construction and maintenance costs against the exchange arrangements costs should be examined. For this decision, all-round collective examination of various factors such as the nation's geographic considerations, economy, culture and also the national policies should become necessary, and in general the construction of the network of trunk telephone circuit with the mixture of star and mesh circuits should be taken as reasonable. Under the toll area system thus determined, according to the function of each trunk exchange and switchboard, the ranking of

Fig. 3.2.1 Ranking of the trunk exchanges in Pakistan



trunk exchanges should be decided. It is thought that each rank of trunk exchanges in West Pakistan should be determined in Fig. 3.2.1 according to the plan of T & T in Pakistan.

For the achievement of the plan of nationwide subscriber's trunk dialing it is necessary to give subscribers all over the country the numbers distinguishable to each other, and for this reason, the numbering plan in connection with the toll area system of trunk exchange should be established. In regards to this a plan nearly final has been already drawn on the plan of T & T of Pakistan.

3.3 Time and Steps of the Execution of S.T.D.

As to the execution of S.T.D. (Subscriber's Trunk Dial) service it is necessary to consider collectively various conditions such as culture, economy, national policies and also the prospects of needs and income of subscribers in the cities and towns and then to decide the time of execution. With regards to the system of the execution of S.T.D. service it goes without saying that the system should be decided after the full examination in relation to the plan of circuit network, numbering plan and the conditions of transmission lines in future. Under a long-range schedule lasting till 1970, S.T.D. service put in execution in the following sections.

Multan, Sargodha, Lahore, Rawalpindi (include Islamabad), Peshawar, Bahawalpur, Lyallpur, Montgomery, Gujranwala, Abbottabad, Sialkot, Muree, Mardan, Muzafarabad, Karachi, Hyderabad, Sukkur, Quetta, Nawabsha, Mirpurkhas, Larkana, and Haripur.

3.4 Design of the Trunk Circuits

As regards the design of the trunk circuits, it may be desired to take into consideration the achievement of the target explained in Chapter 3.1, and the fundamental matters are explained collectively in the following sections.

(1) The necessary number of trunk circuit in 1970 and 1980 estimated in the above chapter means the number of circuits for general public use, and it is estimated on the basis of the number of traffic of 1st December, 1964 (the day of statistics : first Tuesday of every month) and it does not contain the numbers such as those of monthly or seasonal variations, various kinds of leased circuits, carrier-

telegraphy, the order lines for maintenance and also the shunt loss for designing of the multi-channel circuit route, etc.. Therefore, when the rate of increase attains the level abovementioned bigger capacity of transmission channels ought to be necessary, but in consideration of the fact that the estimation of these figures is difficult and the number of circuit should have some surplus, any amendment accompaning these factors will not be given and the necessary capacity of transmission channels will be estimated.

(ii) When the actual number of circuit is estimated, in consideration of the plan for circuit network, high quality of transmission should be assured and the links on voice frequency band are not performed and the links on these ways of transmission must be performed above basic group, for the simplification of the construction of increased trunk telephone circuits, every year, and of maintenance operation for trunk telephone circuits and transmission channels.

As a rule the links among main primary exchanges should be the basic super group links.

(iii) Every section of extra multiplex transmission has one basic super group for testing and maintenance.

(iv) The capacity of CENTO microwave system in Pakistan expected available by 1970 may be established at 6 SG which afterwards will become zero.

(v) In order to highten the degree of safety for various factors in relation to the transmission network such as weather conditions, disasters, public peace and national defence etc. more than two circuit routes should be necessary to come into operation and each route should be situated as far as possible, and both wire and wireless should be installed. Besides, the transmission lines constructed separately should be installed in the state that each line should be able to display function synthetically backing up each other and to exchange on basic super group band between each transmission line at the terminal stations on way of transmission.

In this connection, among the necessary capacities in West Pakistan the figures held in the sections of Karachi-Lahore, Karachi-Rawalpindi (including

Peshawar) and Lahore - Rawalpindi (including Peshawar) are as shown in Fig. 3.4.2 ( ) (( )), and as regards the position of primary exchange on way of the transmission channels of coaxial cable system, new wireless transmission channels should also come under operation in a state so as to change over to split and exchange transmission.

(vi) The open-wire carrier system now in function will accomplish its mission in near future as the facilities for main prime transmission routes, and is to be used as the facilities for local transmission in short distances.

(vii) Facilities for fundamental transmission channels should be installed so that it may have surplus of capacity over the need of every year. This fact has very important meaning in relation to the work of construction and maintenance assigned to every year.

(viii) Consideration of the transmission of television signals should be taken in.

(ix) The method suitable to the plan for areal development should be considered.

(x) Eventual consideration should be taken into the transmission network between East and West Pakistan.

Table 3.4.1 The state of excess and shortness of the capacities of transmission circuits in 1970 and 1980.

	Karachi - Hyderabad	Hyderabad - Sukkur	Sukkur - Multan	Multan - Sargodha	Sargodha - Rawalpindi	Sargodha - Lyallpur	Lyallpur - Lahore	Multan - Lahore	Lahore - Rawalpindi	Sukkar - Quetta
Capacities of present transmission circuits	22^{SG}	22^{SG}	16^{SG}	16^{SG}	16^{SG}	16^{SG}	16^{SG}	0	0	6^{SG}
Needed capacities of transmission circuits in 1970	19	19	18	19	19(10)	22(10)	22(13)		(10)	5
Needed capacities of transmission circuits in 1980	102	75	70	75	81(37)	101(57)	92(48)		(45)	17
Excess and shortage of capacities in 1970	3	3	-2	-3	-3 (6)	-6(3)	-6(3)		(-10)	1
Excess and shortage of capacities in 1980	-80	-53	-54	-59	-65(-21)	-85(-41)	-76(-32)		(-45)	-11

Remarks: The values in ( ) show the figures subtracted the numbers which is able to put in new transmission circuits. (Multan-Lahore, Lahore-Rawalpindi)

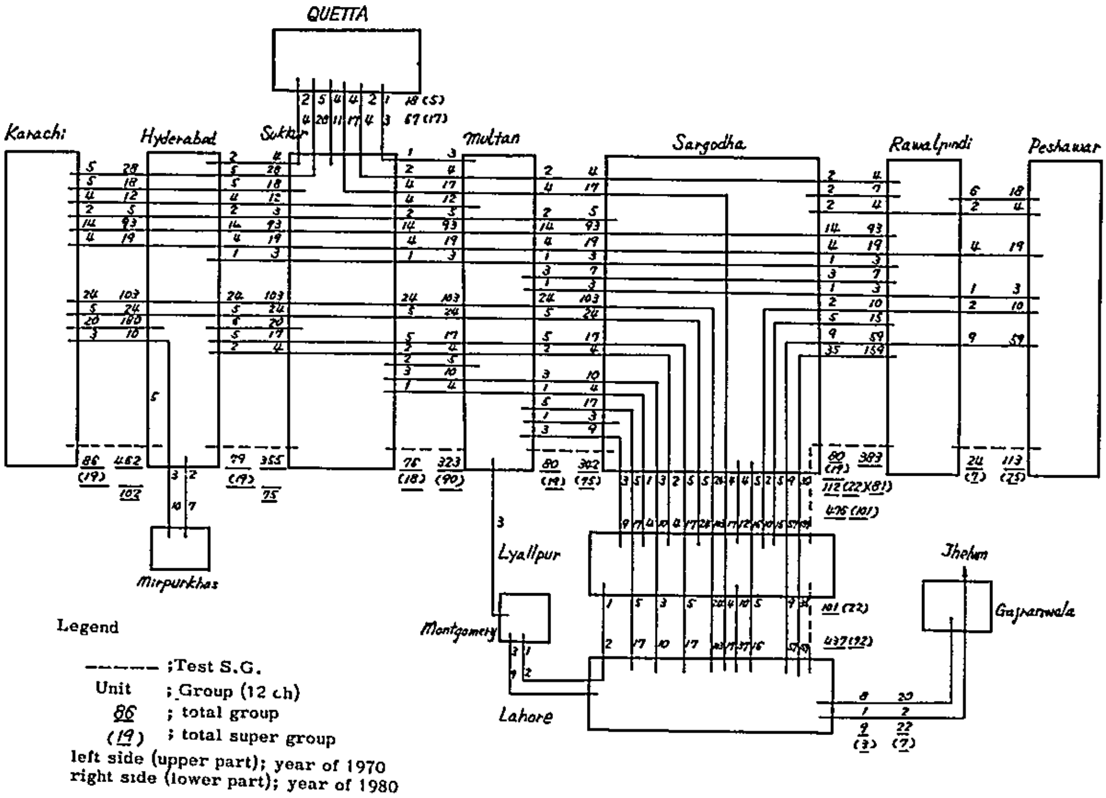


Fig. 3.4.1 Needed transmission channels for 1970 and 1980

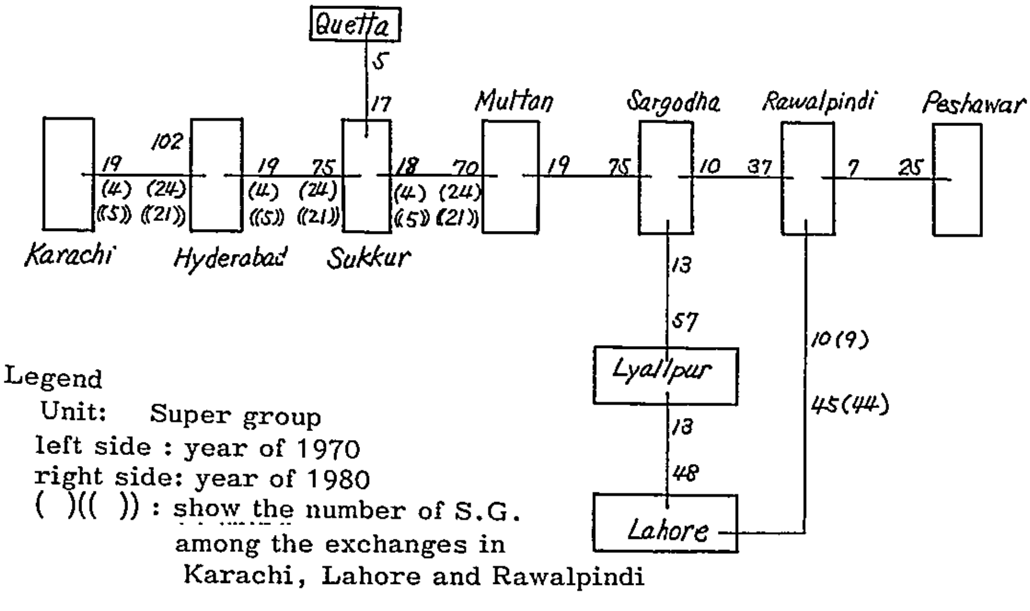


Fig. 3.4.2 Needed capacities of transmission circuits for 1970 and 1980

3.5 Planning of Main Transmission Circuits

In addition to the trunk telephone traffic estimated in the above section in this report with the consideration of fundamental conditions of the paragraph before, needed capacities of transmission channels in 1970 and 1980 should be estimated. The results are as shown in Figure 3.4.1. In these figures, capacities scheduled to be put in the circuits of present and under-construction channels are shown. Fig. 3.4.2 shows the results gathered by the units of basic super group. The examination of this results in relation to the capacities of present transmission channels makes the figures of excess and shortage available as shown in Table 3.4.1. Even in 1970, the capacities of channels between Sukkar-Multan, Multan-Sargodha, Sargodha-Rawalpindi, and Sargodha-Lyallpur-Lahore are short of 2^{SG}, 3^{SG}, 3^{SG}, and 6^{SG}, respectively. To succour and make amend the shortage in capacities new channels of transmission between Sukkur-Sargodha-Rawalpindi and also Lahore-Rawalpindi should be constructed before 1970, at latest by the end of 1969. As regards the system and routes of these new transmission circuits, in consideration of the reasons mentioned in the above paragraph and also the fact that the remodelling to 12 MG of the present coaxial cable system is difficult in connection with the operation of construction work, the installation of microwave systems through the routes shown in Figure attached at the end of this report should be judged as adequate.

For the construction of such transmission systems, some more arguments and grounds are introduced herebelow, i) and ii), in addition to the facts described above.

i) Between Rawalpindi and Lahore, present transmission channel has not sufficient capacity for the traffic and a new transmission system is thought necessary. This may be prompted by the fact that the transmission lines for television signals will become necessary in near future and also by the possibility of its use as the transmission line at the time of opening of S.T.D. service at Gujranwala on the route.

ii) In order to relieve insufficient capacity after 1970 through the line of Sargodha-

-Lyallpur-Lahore, traffics between the cities such as Karachi, Hyderabad, Sukkur, etc. and Lahore as well as Lyallpur should be annexed into the new transmission line to be constructed between Lahore and Multan. However, in order to initiate S.T.D. service into Montgomery on this route, construction before-hand of a new transmission line is recommended.

The network for transmission line and the number of circuits to be installed in each system in 1970 and 1980 under the above designs are shown as follows.

(1) Planning of the Transmission Routes and the Installation of Multiplex Channels in 1970.

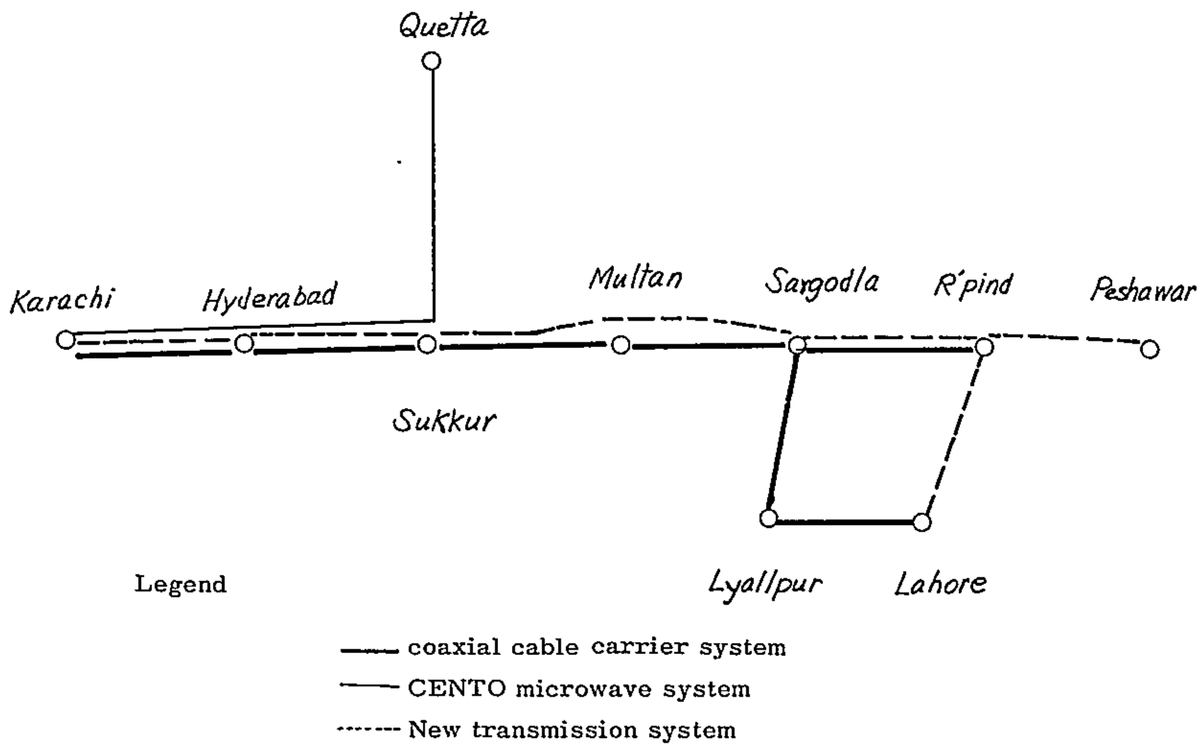


Fig. 3.5.1 Transmission System in 1970

New transmission system shown in dotted line in Fig. 3.5.1 is to be constructed by 1970. As regards the installation of circuits, those among the following exchanges and between Peshawar and other exchanges are to be equipped with in new systems, which details are shown as follows:

Karachi - Rawalpindi	7^G	2^{SG}	(7^G)
Karachi - Lahore	10	2	(14)
Karachi - Peshawar	4	1	(40)
Rawalpindi - Lahore	19	4	(16)
Rawalpindi - Peshawar	6	2	(0)
Lahore - Peshawar	4	1	(5)

Remarks: Figures in ( ) show the numbers of super group channels to be installed into new system.

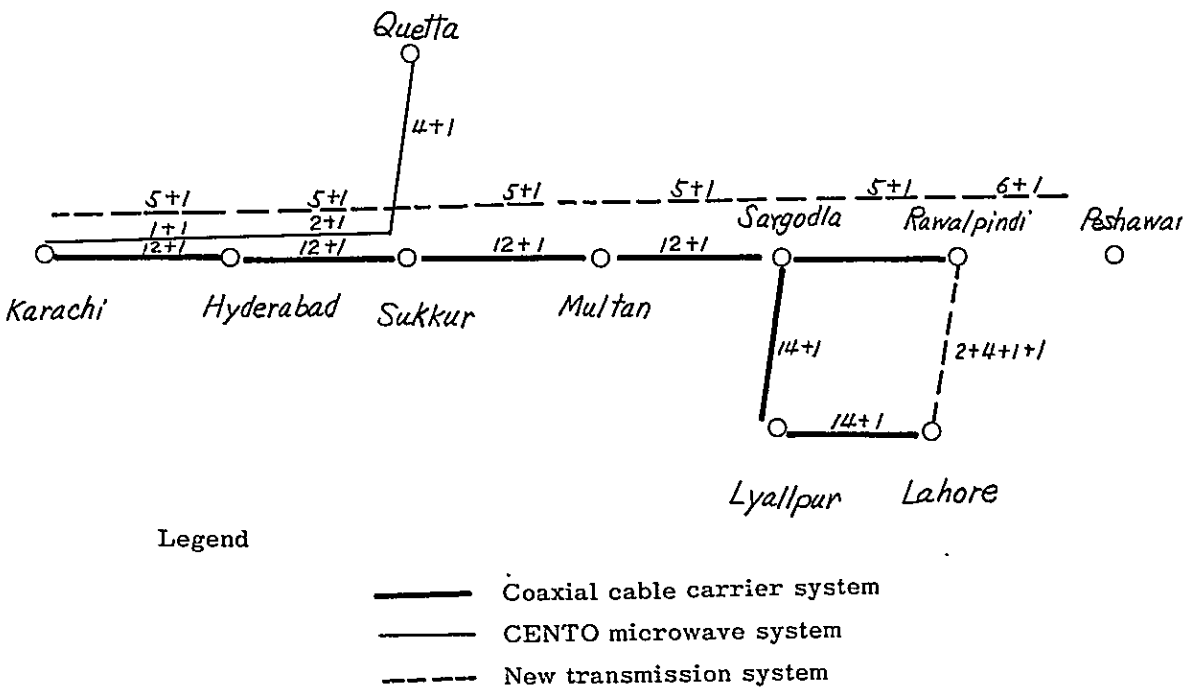


Fig. 3.5.2 Installation of multiplex channels into various kinds of transmisstion circuits in 1970 (Figures show the number of basic supergroups contained in each transmission circuits, +1 shows reserve super group for maintenance.

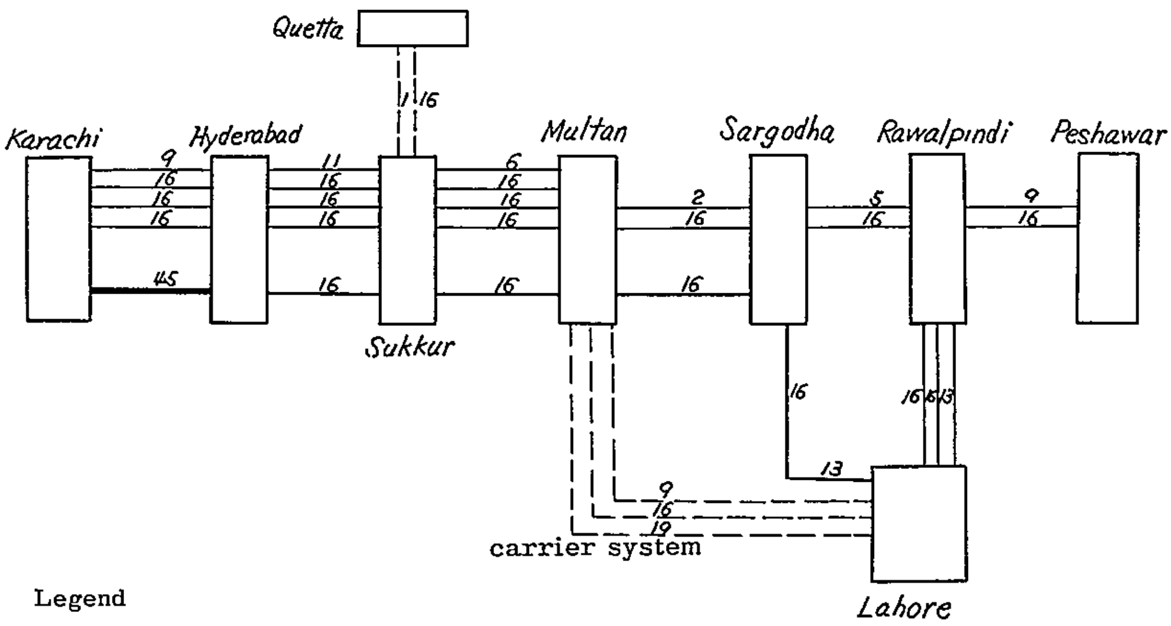
As regards the carrier equipments to be taken into the calculation of construction expenses, they should correspond with the numbers of channels installed in new system and the numbers necessary for the construction of all circuits to Peshawar.

Karachi	$7^{G} + 10^{G} + 4^{G}$	$= 21^{G}$
Rawalpindi	19 + 6 + 7	= 33
Lahore	10 + 19 + 4	= 33
Peshawar		24
Total		111

(ii) Planning of Transmission Routes and the Installation of Multiplex Channels in 1980.

As regards the transmission systems in 1980, new channels should be installed between Multan and Lahore, Sukkur and Quetta, and the remodelling of coaxial cable to 12MC of present system should be performed between Karachi and Hyderabad.

The plan of installation for such various transmission systems is as shown in Fig. 3.5.3.



Legend

12 Mc Coaxial cable carrier system

4Mc Coaxial cable carrier system

Microwave system

New transmission system

Fig. 3.5.3 Installation of multiplex channels in various kinds of transmission system in 1980.

4. DETERMINATION OF PRIORITY ROUTES

4. Decision of Priority Routes

4.1 Various Routes to be examined and Conditions for the Decision of their Order

With reference to the general plan of routes presented by the officials of the Pakistan government, summary examination of the state such as the distribution of main cities in various parts of West Pakistan and also the geographical conditions was performed in advance, and the routes imagined were to be decided as follows; (Reference to Figure attached at the end of this report.)

a. Karachi - Sakkur - D.G. Khan - D.I. Khan - Sargodha - Rawalpindi - Peshawar (–Multan)

b. Karachi - Sakkur - D.G. Khan - D.I. Khan - (Sakesar) - Sargodha - Rawalpindi - Peshawar (- Multan)

c. Karachi - Sukkur - D.G. Khan - D.I. Khan - Bannu - Peshawar - Rawalpindi (- Multan)

d. Karachi - Sukkur - D.G. Khan - Multan - Lyallpur - Sargodha - Rawalpindi - Peshawar

e. Karachi - Sukkur - Quetta - Fort Sandeman - Bannu - Peshawar - Rawalpindi

Among these (a), (b) and (c) may be considered to be of similar character, which may be summarized and tentatively named "Central Route", (d) may be called "Eastern Route" and (e) "Western Route" correspondingly.

At the time of construction of the trunk transmission networks, it is noted that generally the trunk numbering plan, various standards such as connection and transmission quality and different technical standards should first be decided, which is to be followed by the performance of the demand forecast, traffic forecast and the set up of nationwide transmission networks in relation to the future plan of areal development, as well as by the execution of allround examination of the transmission systems, upon completion of all the foregoing the systems are finally to be decided. And after further examination of various concrete conditions as to the transmission systems, the selection of routes should be executed.

With regards to the various technical and economic conditions needed for the selection of routes connecting southern and northern parts of West Pakistan, comparison of differences among the routes aforementioned are examined hereinafter.

4.2 Forecast of Trunk Telephone Traffic and the Plan of Transmission System

As mentioned in Chapter 2, the roùtes of forecast of the future trunk traffic among main cities reveal the fact that the capacity of installing circuits in coaxial cable main routes may become unsufficient in the north of Multan by 1970 and in all sections of routes by 1980, and new transmission system will become necessary. Namely, as regards the circuits north of Sukkur, connecting cities of so-called developed area of north-eastern part of West Pakistan, coaxial cable facilities completed or under construction will soon reach the limit of capacities in a few years to come. Of course, the remodelling of some part of the existing cables to extra multiplex transmission system (12 MC system) will reasonably be thought, but under present condition which lacks substitute routes, the execution of remodelling is practically very difficult, and from the standpoint of the construction of transmission line it is rather desirable to disperse the routes and to make the whole circuit network more transworthy by means of the construction of new route of transmission line.

In this case, for the conditions for the construction of route, from the viewpoint of forecasting of trunk traffic it is clearly desirable if the route shall pass through the developed areas of the eastern part, but in order to avoid duplication with the present route it is rather desirable to select the route passing through the central part, though it has rather little value in connection with trunk traffic. If this meaning, the route passing through the western part might not be expected to have much merit from any point of view.

Finally , in consideration of the construction of television signal transmission network with the initiation of television, broadcasting under planning to keep abreast with the service of subscriber's trunk dialing, the planning should be performed based on the capacity of television transmission, even if there is some time lag of its execution. There is little difference between eastern and central routes in connection with the television signal transmission network.

4.3 Conditions of Propagation

One of the most important problems as to the selection of the position of microwave station may be the nature of conditions for radio wave propagation. Considering generation of fading, progagation routes may be desired to keep some height and mountainous route be possibly selected, but in the case of level ground, as mentioned hereinafter, propagation quality can be complemented by means of shortening of the repeater spacing.

As regards the weather conditions, though we much consider the temperature of atmosphere, the windless zone in which the density of air tends to generate the duct is not desirable for radio wave propagation. The wind is preferable to be had to some extent.

The comparison of these respects of each route aforementioned tells us the fact that almost all the level part of eastern and central routes naturally become the route of extra-low altitude propagation, and in this connection the route through western mountainous areas have some advantage. On the other hand, judging from the data of weather conditions, some influence of wind may be apparent except on the zone of eastern route, and central route is always blessed with rather strong wind, and in this connection the latter may be presumed passably advantageous.

The regional distribution of temperature of earth have much effect on the condition of propagation, but each route may be presumed under same condition and the examination may as well be omitted.

4.4 Difficulties as to Construction and Maintenance

Not only for the present work of construction but also for the maintenance thereafter, difficulties are seen to be influenced by those conditions such as the progress of road communication in the areas concerned, the capacity of transportation as well as the procurement of materials and labour resources for construction.

In this connection, most part of the plain district of the east route are more favourably posted and may be supposed to have no trouble, but as to the central route, some part of the section (e.g. Kashmor - Rojhan) each road communication and besides during the flood season of summer the communications at the places would be interrupted from time to time. At our selection of the position of the station these conditions have fully been examined.

As regards the west route, road condition is comparatively good except the mountainous areas of north district and the route is free from worries of floods in rainy season, but most repeater station scheduled to be situated in mountainous areas may have the trouble of their maintenance against snow in winter especially in the highlands. The route also passes through the under-developed areas for the most part and it is presumed that there may be many difficulties in construction and maintenance.

4.5 Comparison of Economy

General comparison of necessary expenses will follow hereinafter. Commonly, the unit cost of construction varies greatly according to the conditions of the position of station. The cost and expenses incurred in the mountainous district will become heavier as a matter of fact than those in the plain district, especially in the case when the construction of approach road for exclusive use is necessary. Comparison of the number of repeater stations tells us the figures as to 23 stations on the east route (north of Sukkur), 22 stations on the central route and 18 stations on the west route (north of Quetta). In the west route the number of stations is not so many, but the cost for construction per one station is greater by scores of percent because of the cost for building the approach road of exclusive use, and therefore the total expenses of these three route have not so much difference. However the west route between Sukkur and Quetta necessitates increase of cost for CENTO circuit and it may become most expensive on the basis of yearly expenditure. There is almost no difference between east and central.

4.6 Development of the Areas Concerned

As against our examination hereinbefore, technically and economically, into the possibility of the construction of new route, our new observations from the standpoint of the development of areas affected in whole of West Pakistan, present and future, are to follow which tell us that each of the three routes has its proper meanings. As long as the construction of new main route should have an important bearing in the future development of areas affected, much consideration should be given to the central district around the Indus Basin and the mountainous district in the west. The Indus Basin, with its vast plain and numerous cannals to cultivate it, coupled with the prospect of industrial development of the area in near future, should play an important role indeed, probably next to the eastern and northern districts. As regards the western district, judging from the least possibility of development, the projected route appears to have much drawbacks as compared with other route, and taking these conditions into consideration the central route may be judged most suitable for the execution of this plan.

4.7 Conclusion

Our examination into the project from various different angles supported by the fact-finding comparisons as commented and presented hereinbefore may be led into the following conclusion:

The west route should be arranged last of all in construction of transmission line as it requires most expenses and labour both for construction and maintenance, not to speak of the most unfavourable state of alternation of trunk traffic. On the other hand, the east and center routes are to be rated nearly equal in their construction order, from technical or economical standpoints, the former barely surpassing the latter for priority. However, in view of advisability of dispersing the risks against main coaxial cable route and in connection with the early development of the west bank of the Indus Basin, construction of the center route should be given priority and considered exactly to the point.

The center route, as mentioned before, is to branch into three separate routes at the points further in the north district, and the one in the farthest west, interalia, or the one covers the mountainous section from D.I. Khan to Peshawar via Bannu has much defects alike the west route or more than that. Therefore this shall be excepted from our main study and be arranged in Appendix for only.

5. POLICY FOR DESIGNING THE MICROWAVE SYSTEM

5. Policy for Designing the Microwave System

5.1 Outline

As above examinations show us this microwave system is to become a part of the main transmission route in West Pakistan, having the possibility of forming a part of international telephone circuit which passes through from east to west of Asia, which, therefore, should make it imperative to satisfy international standards. In this chapter the recommendations of CCIR and the special features of Pakistan shall be examined and the fundamental policy of designing the system shall be explained.

5.2 Recommendations of CCIR.

Here the main items of the recommendations of C.C.I.R. as the basis of designing shall be explained.

5.2.1. Hypothetical Reference Circuit (Rec. 392)

C.C.I.R. provides the following as reference circuits for the designing of radio-relay system using frequency-division multiplex with a capacity of more than 60 telephone channels per radio-frequency channel.

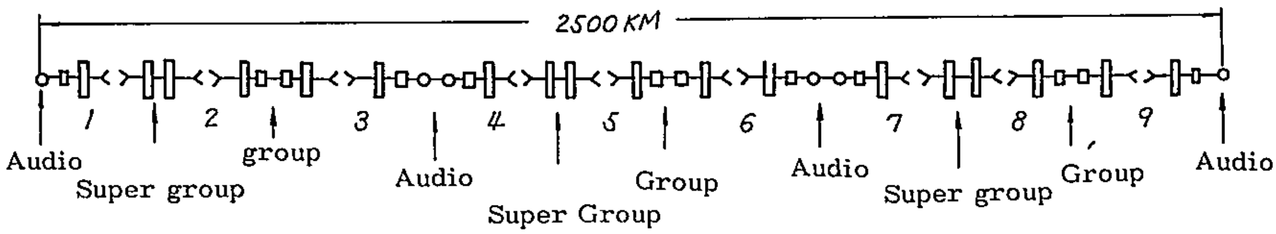


Fig. 5.2.1 Hypothetical Reference Circuit of the CCIR Recommendation

Accordingly, it contains 3 voice junctions, 6 sections of group and 9 sections of super group within the total length of 2,500 KM. As compared with this, the structure of circuits in Pakistan to be described afterwards has the length of about 1,520 KM's circuit line, and throughout this distance there are seven terminal stations, six section, including Karachi, Sukkur, D.G. Khan, D.I. Khan, Sargodha, Rawalpindi, which are scheduled to joint on the frequency band below super group. Therefore the number of junctions in a little more in proportion to the reference circuit but the structure is considered to be almost same.

5.2.2 Radio-frequency Arrangement (Rec. 382, 383)

CCIR recommends the arrangement shown in the figure for the wireless communication system transmitting 600 - 1,800 CH, and the microwave relaying system in Pakistan is adequately thought to observe this recommendation.

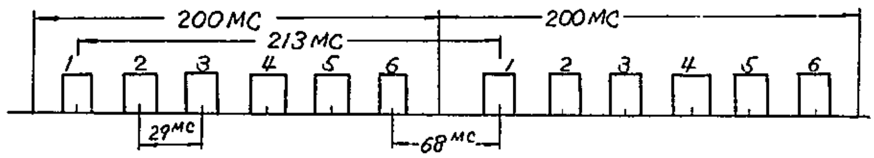


Fig. 5.2.2 CCIR Recommendation of radio frequency arrangement of the 2,000 MC and 4,000 MC band (Rec. 382. As the center frequency f_0 in case of 2,000 MC 1903 or 2101 MC are desirable, and in case of 4,000 MC, 4003.5 MC is desirable. Alternating use of the plane of polarization is desirable.)

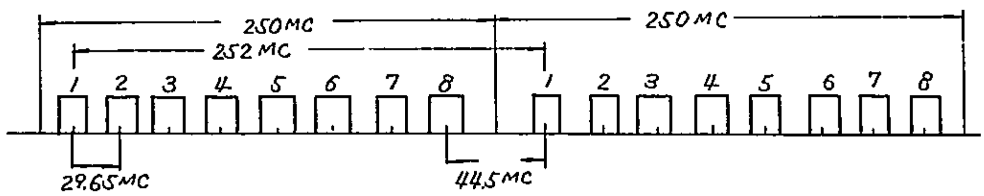


Fig. 5.2.3 CCIR Recommendation of radio-frequency arrangment of the 6,000 Mc band (Rec. 383. As the center frequency f_0 6,175.0 Mc is desirable. Alternating use of the plane of polarization is desirable.)

5.2.3 Allowable Noise Power (Rec. 393)

CCIR use the rate of time, to decide the maximum allowable noise power. 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 systems should not exceed the provisional values given below, which have been chosen to take account of fading.

i) 7,500 pw psophometrically weighted mean power in any hour.

ii) 7,500 pw psophometrically weighted one-minute mean power for more than 20% of any month.

iii) 47,500 pw psophometrically weighted one-minute mean power for more than 0.1% of any month.

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

Under this rule the item (i) is to decide the noise power in ordinary time and constitutes the basis for designing the propagation factors such as transmitting power and antenna gain, etc.. And the provision of item (iv) is to rule the rate of time of noise surge or noise burst at the time of deep fading, but in practice the value of 0.001% under CCITT's recommendation should be adopted instead. Microwave relay system if designed to satisfy these item (i) and (ii) may usually satisfy others. In order to decide the location of station in the plairie district of west Pakistan the rules in connection with item (iv) is important and the designing must be executed so as to fully put down the rate of generation of deep fading. If there is any unreasonable work at the time of designing of the location of station, frequent suspension and noise burst are apt to happen gradually during the time of frequent fading generation, if not immediately after the completion of the system, and the bit errors of telegraphy and data transmission and the disorder in subscriber's trunk dialing may also happen at times, which shall lead to a grave consequence. This presents itself a matter worthy of deep and close attention.

5.2.4. Others

CCIR recommends those other than the aforementioned, such as F.M. frequency deviation per channel, Base band frequency, Pilot frequency and also Level. These are summed up and shown in the following table.

	Limits of band occupied by telephone channels(kc/s)	Frequency limits of base band (kc/s)	R.m.s. deviation Per channel (kc/s)	Continuity pilot frequency (kc/s)	R.m.s.deviation proceed by the pilot (kc/s)
24	24-108	12-108	35	116 or 119	20
60	12-252 60-300	12-252 60-300	50,100,200	304 or 331	25,50,100
120	12-552 60-552	12-552 60-552	50,100,200	607	25,50,100
300	60-1300 60-1296	60-1364	200	1499,9000 or 8,500	100 or 140
600	60-2540 60-2660	60-2792	200	3200 or 8500	140
960	60-4028 316-4188	60-4287	200	4715 or 8500	140
1800	312-8204 316-8204	300-8248	140	9023	100
2700	312-12388 316-12388	308-12435		13627	
405 line TV				8500	140
625 line TV				8500	140

5.3 Basic Conditions of the Location of the Station

5.3.1 Conditions of the Approach Road and Commercial Power

At the time of the selection of the positions of repeater station, such places as laying close to the highways or roads available for maintenance and construction work and also having easy access to commercial electric power should be selected, failing which, however, the first cause of the road conditions should at least be maintained. This is an ideal, however, in Pakistan where these are no roads other than a main highway within an extremely wide range of area, it would be inevitable to set up those repeater station at places along the highway or the roads in its vicinity. However, where the highway keeps a straight line through several sections of station, to prevent necessary over reach angles, stations may have to be established off such spots of the highway and the access roads should be constructed.

5.3.2 Over Reach Angles

In order to decrease the interference noise generates from over-reach per one repeater section to the power of 100 PW, the D.U. ratio at the input of the receiver should be made over 54 dB. On the other hand, one example of the main lobe of antenna directivity is as shown in Fig. 5.3.1. It proves that the least limit of over-reach angle should be 3 degrees.

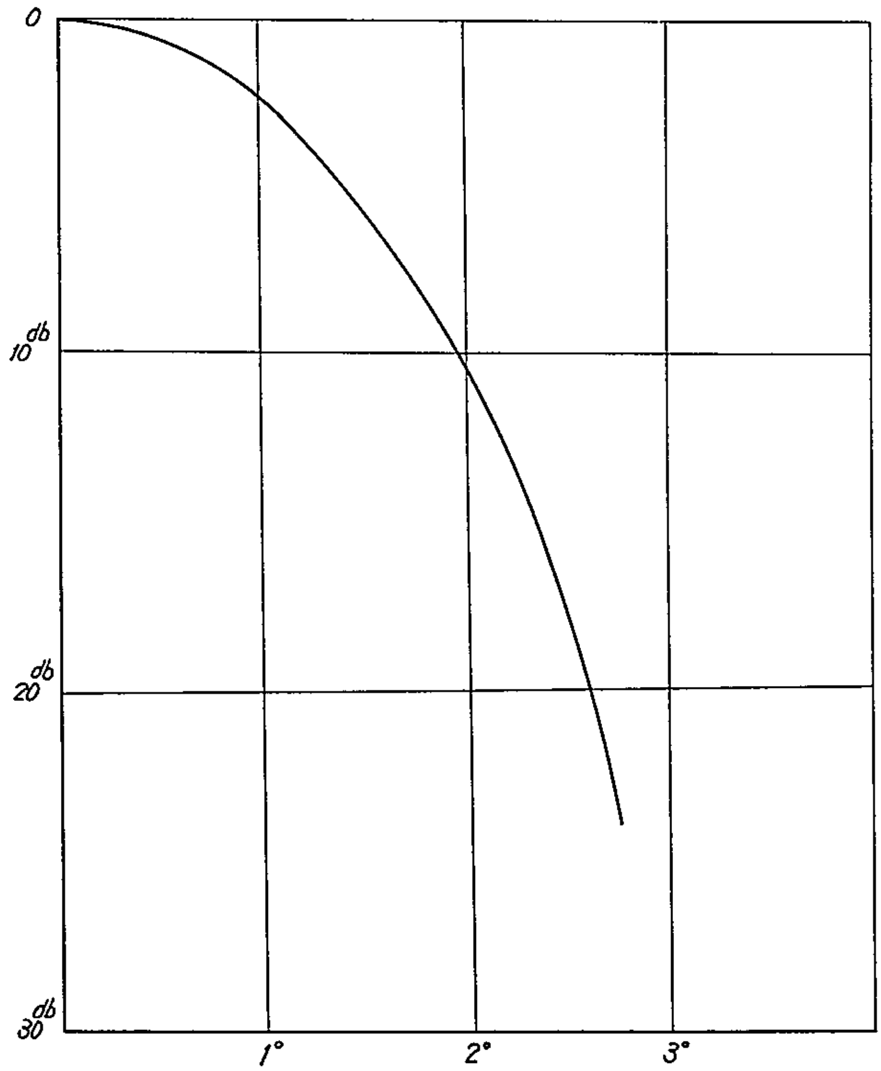


Fig. 5.3.1. The Main Lobe of Antenna Directivity (4 GC, diameter; 10 feet, aperture angle; 90°)

As a matter of fact over-reach angle may be thought safe if it marks 5 degrees, considering the errors in adjusting directions of antenna. However, if it is difficult to secure the said five degrees according to the road conditions the angle as low as 3 degrees may be permissible, but in this case, it is necessary to measure the D.U. ratio originate from over-reach at the time of regulating the direction of antenna and to avoid deviation.

5.3.3 Repeater Spacing

The standard repeater spacing of line of sight microwave system is usually 50 kM, and in the case of the vast plain area such as the Indus Basin the path of radio wave naturally passes through low altitude such as several decades of meter above ground. This provides a possibility of a big ratio of generation of deep fading. In this survey the standard distance of repeater station may reasonably be shortened by 10 - 20%. However, as the propagation test on typical path does not show so big a ratio of generation of fading, standard spacing of 50 KM may be safely adopted.

5.3.4. Problems of Maintenance

In the case of a mechanical disorder at nonattended station, time to be required for a maintenance - man to reach the distressing station may be desired to be at least below four hours. (Ref. Chapter 5.4.3 item (ii))

A terminal station (a repeater station for change over between working and protecting channels) should be manned by the attendants to supervise circuit quality.

5.3.5 Weather Condition

Judging from the weather data of various places, Pakistan may be rated as the worst of the conditions of propagation because she has many days of very high temperature and no wind in summer, and the difference of temperature between day and night is big all over the country.

5.3.6 Outline of CENTO Microwave System and the Relation with the System being Planned.

Various data for the CENTO microwave system from Karachi through

Sukkur to Lakhi are shown in Table 5.3.1. This system uses 2,000 Mc band and consists of one system with the capacity of 600 telephone channels. This system provides one protecting channel to one working channel, and the latter is not designed to be able to increase in relation to the switch-over control equipment and waveguide system. As the F/B ratio of antenna is not satisfactory, (small aperture angle (about 70 degrees) and mesh mirror) 4 frequency method has been adopted, and there is no radio frequency channel for the increase of system other than one working channel.

The radio frequency arrangement is the spacing of 29 Mc according to CCIR's recommendation as shown in the table but in order to avoid over reach in some repeating section the frequency is reasonably shifted. Average distance of repeater spacing is over 60 KM and propagation characteristic is thought not so good.

However, for the designing against the noise burst generating from fading, the switch-over between the working and protecting channels, namely frequency diversity, is judged fully effective, and the perfect non-corelating case is adopted, and the probability is squared, so a good circuit can be reasonably made from the view point of designing. When there is much reflected wave from ground, it is observed as in this circuit, frequency corelation may become rather small. So, the hypothesis is thought to have not so much error, but there may be some questions in the fact that the fading margin of equipment which is the basis of time ratio of circuit failure and time ratio of noise burst may be converted straightly to the time ratio itself; that is the fact that the reduction of fading margin at the time of the operation of equipment or the existence of attenuation fading when Rayleigh fading generates are unreasonably ignored. Taking these factors into consideration the installation of repeater stations of the new microwave system between Karachi and Sukkur should be decided before-hand to utilize as much as possible the facilities of the repeater stations of CENTO System, but as regards the section between Gopang and Larkana whose repeater spacing is especially long, some other repeater, site may be suitable. As regards other sections between Karachi and

Table 5.3.1 CENTO Microwave System

	Type of Repeater	Antenna System				Hop distance (KM)	Frequency of transmit	Power Plant				Location	
		Tower Height	Tower Type	Size of Dish	Length of feeder			Engine	Gener.	Effect. load	Fuel tank	Longitude	Altitude
KARACHI	End terminal	350'	Self supporting	10'			V 2135 / 2251 ↓	180LDC	*1 12.5 KW	9.30 KW	560 GAL	24°53'40"	67°03'40"
						48.0							
GHARO	Through	340'	Guyed	10'	330'		V 1922 / 2038 ↑	3x 180LDC	3x 7.5KW	4.97 KW	4000 "	24°46'50"	67°32'10"
				10'	250'		V 1951 / 2007 ↓						
						52.8							
HILLAYA	"	380'	"	10'	370'		V 2164 / 2280 ↑	"	3x 7.5KW	5.64 KW	4000 "	24°53'37"	68°03'08"
				10'	370'		H 2135 / 2251 ↓						
						56.0							
KOTRI	Drop	380'	"	10'	370'		H 1922 / 2038 ↑	"	3x 12.5 KW	8.09 KW	4000 "	25°21'54"	68°16'56"
				*2 10'	270'		H 1951 / 2067 ↓						
						44.0							
GOPANG	Through	380'	"	*2 10'	170'		H 2104 / 2280 ↑	"	3x 7.5KW	4.97 KW	4000 "	25°45'44"	68°17'15"
				15'	370'		V 2135 / 2251 ↓						
						75.2							
SEHWAN	"	380'	"	15'	370'		V 1922 / 2038 ↑	"	"	5.64 KW	4000 "	26°20'00"	67°52'00"
				15'	370'		V 1951 / 2067 ↓						
						78.4							
SITA ROAD	"	400'	"	15'	390'		V 2164 / 2280 ↑	"	"	4.47 KW	4000 "	27°02'43'	67°50'45"
				15'	390'		H 2135 / 2251 ↓						
						65.6							
LARKANA	"	400'	"	15'	390'		H 1922 / 2038 ↑	"	"	4.97 KW	4000 "	27°33'45"	68°12'10"
				15'	390'		V 1936.5 / 2052.5 ↓						
						59.2							
LAKHI	Terminal	400'	"	15'	390'		V 2169.5 / 2265.5 ↑	3x 190LDC	3x 18.5 KW	10.56 KW	8000 "	27°51'30"	68°42'25"

*1 All stations do not use commercial power except Karachi station

*2 This antenna are lacked on the half height of the tower.

Gopang, Larkana and Lakhi present station can be used. In this case if the solid-state equipment can be used as the new microwave system, the present station buildings and electric power facilities may be safely utilized as they are.

In order to increase the equipment of CENTO microwave system the following difficulties may be supposed:

(i) The capacity of radio frequency channel which remains in frequency band is for 600 telephone channels use or the capacity of one circuit for the television signal transmission, and no capacity remains for protecting channel. It is necessary to improve the present protecting equipment into one for common use, calling for equipping with the circuit change-over switch, switch-over control equipment, transmission lines for change-over between sending and receiving terminal stations etc.. And in this case, the effect of frequency diversity will decrease about 30%.

(ii) As the joint part between transmitter-receiver equipment and antenna is not designed to be increased, it may be necessary to improve it into the branching filter system.

5.4 Conditions of the System Design

5.4.1 Radio Frequency

4 GC band is most useful for microwave circuit in Pakistan. Generally, the frequency band has several types 2, 4, 6, 11 GC. which are used for the broad-band microwave circuit. 2GC band is already used in CENTO microwave system and cannot be used in the section between Karachi and Sukkur. 6GC band tends to be used for transmission of extra broad-band over 1,800 CH, and it may be desirable to be kept for the expansion in future. 11GC band tends to greatly attenuate the power of radio wave in rainfall, and offers difficulty to secure good quality transmission line for main route, and therefore is used exclusively for short distance transmission. The remaining 4 GC band is most commonly used for the microwave circuit, on the ground that it is considered as the most reliable transmission devices at the lowest cost.

5.4.2. Capacity of Transmission Line

960 CH is most suitable for the transmission capacity for one radio frequency channel. As the capacities recommended by CCIR there are 600 CH, 960 CH, 1,800 CH, and 2,700 CH. Among these the two, 1,800 CH and 2,700 CH are not on the stage of technical perfection yet and the devices of fully satisfactory results of use are not necessarily obtainable at the lowest cost. In comparison between 600 CH and 960 CH, the reasons by which the 960 CH is adopted are as follows:

(i) The capacity of 960 CH is necessary for changing into alternative transmission line when coaxial cable system is out of order.

(ii) Following proposition has been made by Pakistan government that the future possibility of transmitting of colour television signal should be considered and for this purpose transmission line equivalent to 960 telephone channel is thought necessary.

However, if the use of 960 CH for alternate transmission line at the time of coaxial cable being in disorder should be given up and lowered quality, to a certain extent, of pictures of colour telecasting could be taken as acceptable, 600 CH may as well be adopted. In this case, the price of the devices and the system of circuits are thought almost same, but the repeater spacing can be made a little longer and the diameter of antenna a little smaller, and the total construction cost will become a little less. In spite of this fact, in this survey the designing has been made in relation with 960 CH according to the above items (i) and (ii).

5.4.3. Protecting Channels and Switch-over System

As regards protecting channels the ratio of reserve, switch-over sections and the method of switch-over etc. must be decided.

(i) Ratio of reserve circuit

As regards system, two ways can be thought, one is the system in which a protecting channel to a working channel will be prepared, namely one to one system, and the other is the system in which one protecting channel to many working channels will commonly be used, namely N-to-one system. In this case final working channel is one channel as is CENTO system, the former is permissible but in case several final channels become necessary, the former necessitates ratio devices nearly twice as much the latter and is not only uneconomical but also subject to a demerit that the limit number of channels parallely installed is decreased to nearly half the former. (If the frequency arrangement recommended by CCIR is used the one-to-one system can use 3 channels and the N-to-one system can use 5 channels.) However, as regards the improvement effect against facing, one-to-one system is superior and it has such merit as to extend repeater spacing proportionately, which should make it necessary to examine the merits and demerits involved. If the time correlation of fading is small - as in Pakistan, where the existence of reflected wave cannot be neglected in many sections correlation should become generally small — there results the following approximate difference between the ratios of improvement of one-to-one and N-to-one systems:

$$\frac{N + 1\ C2}{N} = \frac{N \quad 1}{2}$$

N is the number of working channels in N-to-one system

In the frequency arrangement of the CCIR's recommendation the biggest number of working circuits in 3, and the comparison based on N = 3 shows that one-to-one system has the improvement effect two times as much the improvement effect of N-to-one system. However, as regards the number of repeater equipment, one-to-one system needs about 1.5 times and the total construction cost of repeater station will be increased by about 30%. If this 30% of construction cost would be appropriated to the shortening of repeater spacing, it is equivalent to the N-to-one system which is decreased the repeater spacing to 77 %. As the radio of improvement of deep fading is in proportion to 3.5 times multiplication of distance, the following results can be obtained:

$$(0.77)^{3.5} = 0.4$$

and the improvement proves bigger than two times. If the repeater spacing can be made shorter, further reduction of construction cost may be possible since the height of antenna tower can be made lower and the diameter of antenna can also be made smaller. Judging from these points and also from the possibility of increasing the limit number of channels paralleled in Pakistan, N-to-one system may be recommended.

(ii) Distance of Switch-over Section

The stations which should change over working and protecting channels or the switch-over terminal stations are to be installed in the transmission sections under a certain principle, but at what intervals, of such sections, the stations should be installed may usually be decided from the ratio of devices falling in disorder and the permissible ratio of circuit disorder, but should not be decided from the viewpoint of the improvement of failure by fading. The reason is that, in a single circuit which is installed so that the generation ratio of deep fading may become satisfactorily low, the ratio of occurance of deep fading, in a single circuit, in several sections at a time is naturally low. If these occurs deep fadings at the same time in more than two sections they are seen in most cases in the neighbouring or adjacent sections, and if the switch-over sections are divided into smaller parts, the effect of such division would never be expected as long as the switch-over at every other section should not be performed. From these standpoints, this switch-over section, namely, the standard number of repeater station involved in one section is desired to be about 5.

(iii) Method of Switch-over

As a matter of course, every switch-over motion at the time of disorder or of the generation of fading must automatically be executed by means of circuit noise detection. Time required for detecting such disorder and finishing the switch-over should be generally below 50 miliseconds and, if possible below 5 miliseconds. The decreasing speed of receiving power by fading is at least 50 dB/sec at the point where the power is 40 dB below ordinary input power, and even if it takes about 50 miliseconds from the motion of noise detection to the finish of switchover, the decreasing signal-to-noise ratio is at least about 2.5 dB in this interval.

Therefore, if the starting signal-to-noise ratio by the noise detector is fixed at 32.5 dB, switch-over can be finished before the noise power reaches one million Pico-watts. If the devices are in disorder, momentary suspension of 50 miliseconds may occur, but such the occasion is less frequent that it may be safely neglected. In N-to-one system, information such as the name of channel in disorder should necessary be transmitted from receiving station to transmitting station, and for this purpose at least 2 miliseconds will become necessary. If the response time of noise detector should be extremely expedited so that the noise attains the level of detecting motion limit, there would only be the repetition of motion restoration and confusion of the control circuit will become apparent. Therefore, if the electronization and speed up of all control circuit is performed, it is rather difficult to decrease the switchover time to below about 5 miliseconds. It is desirable to cut down the necessary time of momentary suspension which originate from the motion of the circuits change-over, and it is necessary for the 50 Bauds carrier telegraphy transmission system or the 1,000 Bauds data transmission system to reduce this suspension time below about one milisecond or 50 microseconds respectively.

5.4.4. Supervisory Control and Order Line System

In order to design supervisory control system it is necessary to take the following conditions into consideration.

i) Number of messages to be transmitted.

ii) Speed of transmission

iii) Reliability

As regards the number of messages three systems are taken in according to the difference of fundamental ideas.

(a) In order to transmit analogue quantities themselves such as electric voltage and current quantities, indicating condition of the devices or the balance of fuel for engines, analogue codes must be transmitted , otherwise, very much digital codes must be transmitted. This necessitates large scale equipment.

(b) Unlike (a) system to compare the conditions of the devices with a certain standard, judge and transmit only quality, digital codes at least about 50 bits per one unattended station will be satisfactory.

(c) The third and most simple system is to give the maintenance-man the least necessary information which should instruct whether he must hurry up or is permitted to go slowly, whether he must be the specialist of radio equipment or electric machine. This system may be satisfied with only several bits against one non-attendant station.

As usual (b) and (c) systems are used, but in Pakistan where there is no need for complex control such as the changing of the program of television (c) system which can satisfy the device may be thought most suitable. The speed of transmitting information is not required to be increased, because the information for makeshift of restoration work may be permitted to take several seconds throughout the whole system.

Finally, the reliability of information must be explained. The causes of generation of errors may be divided into two causes, namely, one is the error of motion originates from the disorder of supervisory devices themselves and the other is the error derives from the noise on transmission routes and level variations etc.. The incorrect motion of supervisory control system, if the errors are only those of indication, may not be very important. Among others, erroneous indications originating from noise burst on transmission route may easily be corrected by repetition. However, if the supervisory control system should not only transmit warning signals but also operate remote controls on the starting and stopping of dynamotor and also on the on and off of other devices, erroneous motions may inevitably lead to serious results, hence the adoption of devices of good quality, better than usual, will become necessary.

5.4.5. Controlling Circuit

As regards controlling circuits, there are two systems. One is the way to use the outside part of the base band of main circuits, and the other is further divided into two, the one which uses the same frequency band as the main channels and the one which uses different frequency band such as VHF etc.. Every system has merits and demerit, but in Pakistan the system which uses VHF band is thought most suitable. Because, the first system which uses the outside part of base band of main circuit is most economical, but when one stand-by circuit is commonly used for several main circuits now in operation, N-to-one system is difficult to use in transmitting of directive information concerning the channel switch over, for the controlling circuits of the system will be disconnected at the time of disorder, and in the case when the television signal is transmitted the outside part of base band cannot be used.

In operating the second system, the antenna of both V and H polarized waves must be installed from the starting time of installation of only one or two radio frequency channels in operation. The construction cost of auxiliary circuit is expensive as compared to the third system. On the other hand, the third system which uses the VHF band has its advantages that not only its construction cost is low but also the installation of local transmission circuit is considered possible under this system. That is, the system of VHF with the capacity of about 24 CH should be brought into use for auxiliary circuit, and among these 24 CH, 6 CH may be used for the auxiliary circuit of control and order, and the remaining 18 CH may be applied for the use of telephone circuits in small towns.

5.4.6. Construction Method of Telephone Circuit

Putting aside the end terminal stations such as Karach. and Peshawar, the switch-over terminal stations like Sukkur and Sargodla are not required to insert modulator and demodulator into every channel but only into the channels which have the necessity of dropping below super group . This is because of the fact that by this means construction cost may be curtailed and the quality of circuit will improve. However, in this case, the channel switch-over may be controlled in intermediate frequency band or between intermediate and video frequency band. (As regards actual construction please refer Chapter 6.2)

In order to use microwave circuit in small towns scattered in the west part of the Indus Basin ranging from Karachi to D.I. Khan, it is desirable not to discriminate main circuit in many places but to utilize the auxiliary circuit which is paralleled for the purpose of supervisory control of non-attendant stations.

5.4.7. Construction Method of Television Signal Transmission System

In the midst of circuit, e.g., in Sargodha and D.G. Khan, in order to insert and discriminate the signal of telecasting intermediate frequency band is advantageous. Because it needs not modulate and demodulate circuit every time and discrimination and insertion can be switched on intermediate frequency band. As regards television signal transmission, when the frequency of uses is not frequent it can be designed to construct one-sided transmission line with the possibility of inversion from up-line to down-line, but this is not advisable, for the structure of devices of remote control and wave guide system may become complicated.

5.4.8. Antenna and Feeder System

As regards antenna and feeder system the following must be examined. These are the decision of the kind of antenna and feeder, the height of antenna above ground and the method of construction of antenna.

(i) Kinds of devices

In accordance with the frequency arrangement of CCIR's recommendation neighbouring channels must use different polarization plane. Therefore, ideally, it is advisable to use the common polarized wave antenna for vertical and horizontal polarized wave, but the cost is rather dear (about 150% of the cost of single polarized wave antenna) and the adjustment at the time of construction is difficult. For this reason its construction expenses are proved almost same as 2 single polarized wave antennas. Therefore excepting the case where the supplement of circuits after the construction of the fourth system should become necessary in a short time, it is better to install at the beginning the antenna for vertical or horizontal polarized wave and to supplement another set of antenna for polarized wave at the time of increase of the fourth system. In Pakistan 2 frequency method (same transmitting or receiving frequency is used for both direction of repeater equipment)is used and the antenna with good Front-to-Back ratio must be used, and consequently the antenna with mesh-mirror type or of small aperture angle should not be adopted. As feeder system wave guide may be used. Periscopic reflector is not to be used on 2 frequency method.

(ii) Height of Antenna above Ground

In consideration of clearance and reflected wave from ground the height of antenna above ground may be decided. The computation formula of clearance is shown herebelow. The clearance hc above the ridge having the height of hs at the point with the distances of d_1 and d_2 km from both repeater stations is calculated as follows:

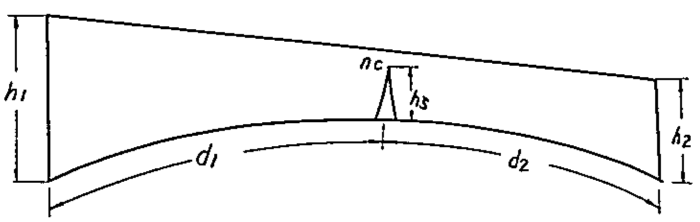


Fig. 5.4.1 Relation of Clearance

$$hc = \frac{h_1 d_2 + h_2 d_1}{d} - \frac{d_1 d_2}{2Ka} - hs$$

d = Distance between repeater stations (KM)

h_1, h_2 = Heights above sea level at the points of both repeater stations (KM)

hs = Height of ridge above sea level (KM)

d_1, d_2 = Distances between ridge and both repeater stations (KM)

K = Effective radius index of earth

a = Radius of earth (KM)

For the sufficient clearance in connection with the smallest K it can be permitted to add the height of obstacle to 60% of the first fresnel zone. Fig. 5.4.2 show the formula to get the radius of first fresnel zone. For the smallest

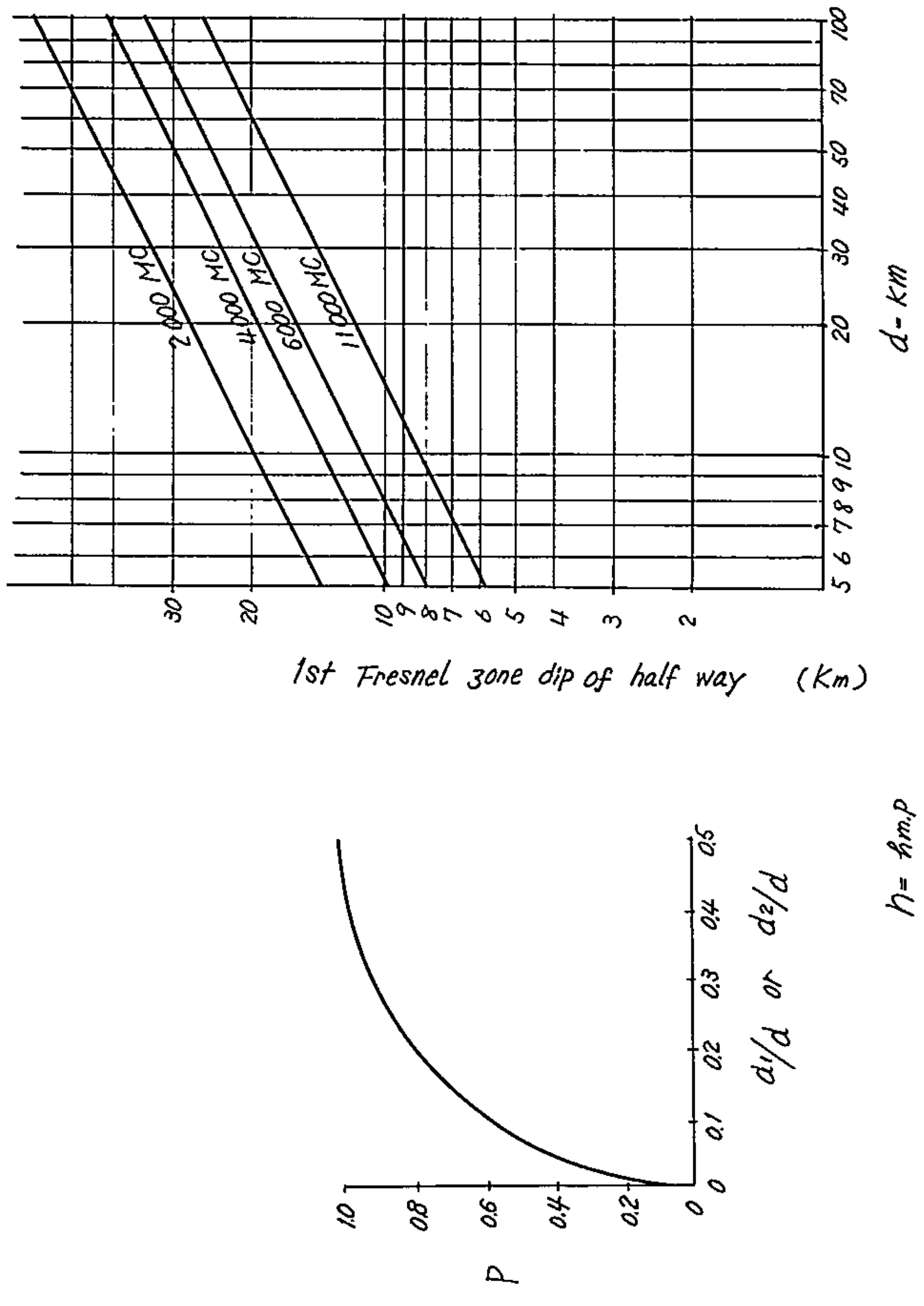


Fig. 5.4.2 Depth of the first fresnel zone

Fig. 5.4.2 Depth of the first fresnel zone

K, 0.8 is sufficient. Actual results of calculation of clearance in Pakistan is shown in Appendix.

Concerning the height of antenna above ground at the time of the generation of big reflected wave over the prairie district it is not sufficient to decide if only in consideration of the obstacles above ground but it must be decided necessarily at the position where the phase of reflected wave may not become antiphase against direct wave. For this purpose, path difference Δ between direct wave and reflected wave must be taken.

$$\Delta = \frac{2 h_1' h_2'}{d}$$

d ; Distance of repeater spacing

h_1, h_2 ; Equivalent heights of antenna at both repeater points.

$$h_1' = h_1 - \frac{d_1^2}{2Ka}, \quad h_2' = h_2 - \frac{d_2^2}{2Ka}$$

d_1 and d_2 are the distances between the reflection point and both terminating points. These figures are taken from the following formulae.

$$d_1 = d\,\frac{b+1}{2}$$

$$d_2 = d - d_1$$

Figures for calculation b is shown as Fig. 5.4.3. m and c are taken from the following formulae.

$$m = \frac{d^2}{8Ka\,(h_1 + h_2)}$$

$$c = \frac{h_1 - h_2}{h_1 + h_2}$$

Fig. 5.4.4 give the relation between direct wave and reflected wave taken from this formula. As these figures indicate, on the assumption of $k = 0.8$, if the clearance should be taken for the sum of 0.6 times of the first fresnel zone plus the height of obstacle above ground (generally about 10 meters), the height of antenna at the general value of K (about 4/3) always tends to receive antiphase reflected wave. Therefore if the power of reflected wave is big the height of antenna must be changed. That is, when $k = 0.9$ and the profile line is designed

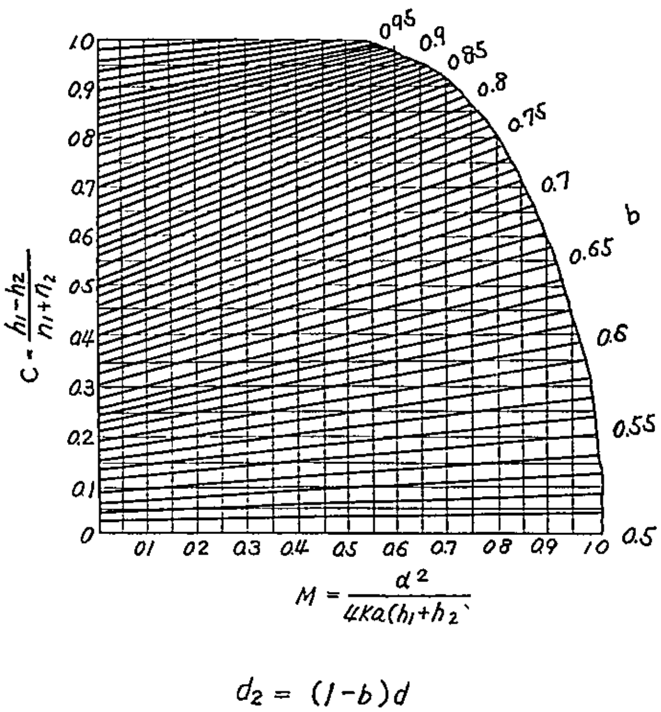


Fig. 5.4.3 The figure for the calculation of b

as to touch the surface of ground the receiving power will drop 6 dB at the risk of 10^{-4} . In reality, it can be permitted to ensure clearance in the height which is the equivalent to this added with the margin of 10 m. (The margin against the obstacle above ground and the errors of measurement). The relation between the height of antenna and repeater spacing in connection with the above case is shown in Fig. 5.3.6. In this figure, time ratio by which the phase of reflected wave will exceed the first point of antiphase is shown together.

As this figure shows, at the point over 50 KM of repeater spacing the ratio changing to antiphase become suddenly high and some protection such as the setting of antenna of anti-reflected wave may become necessary.

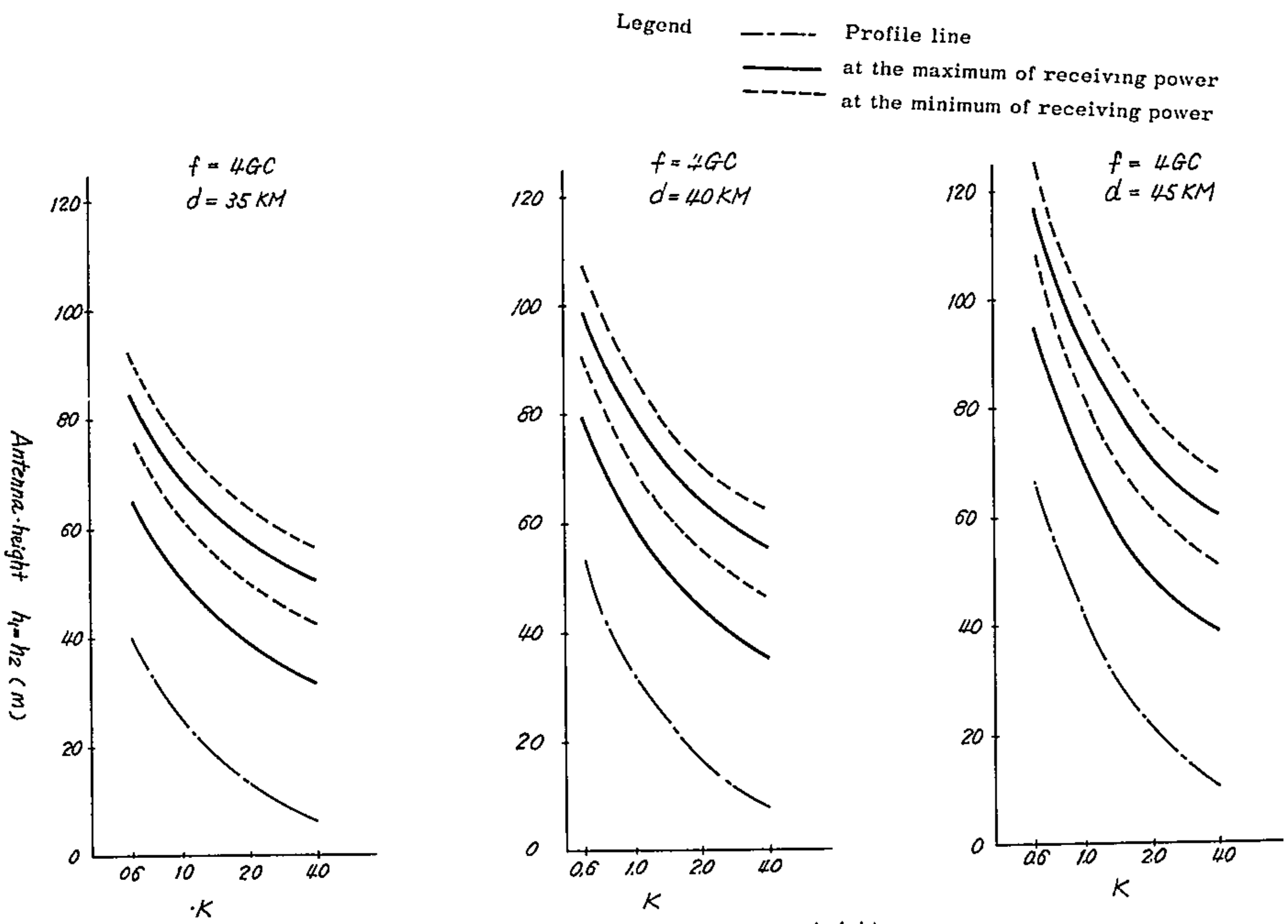


Fig. 5.4.4 Relation between K and antenna height.

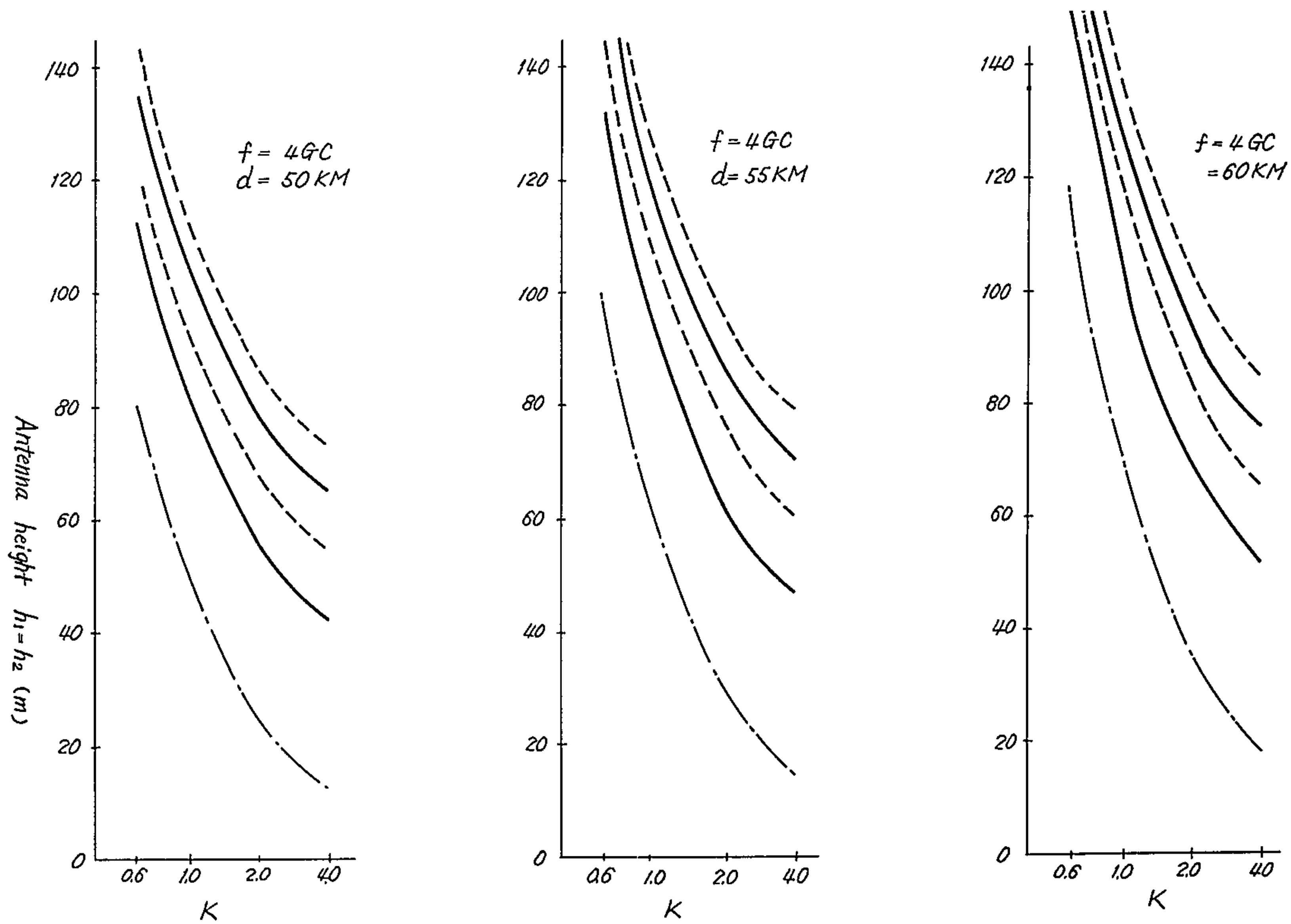


Fig. 5.4.4 (b) Relation between K and antenna height.

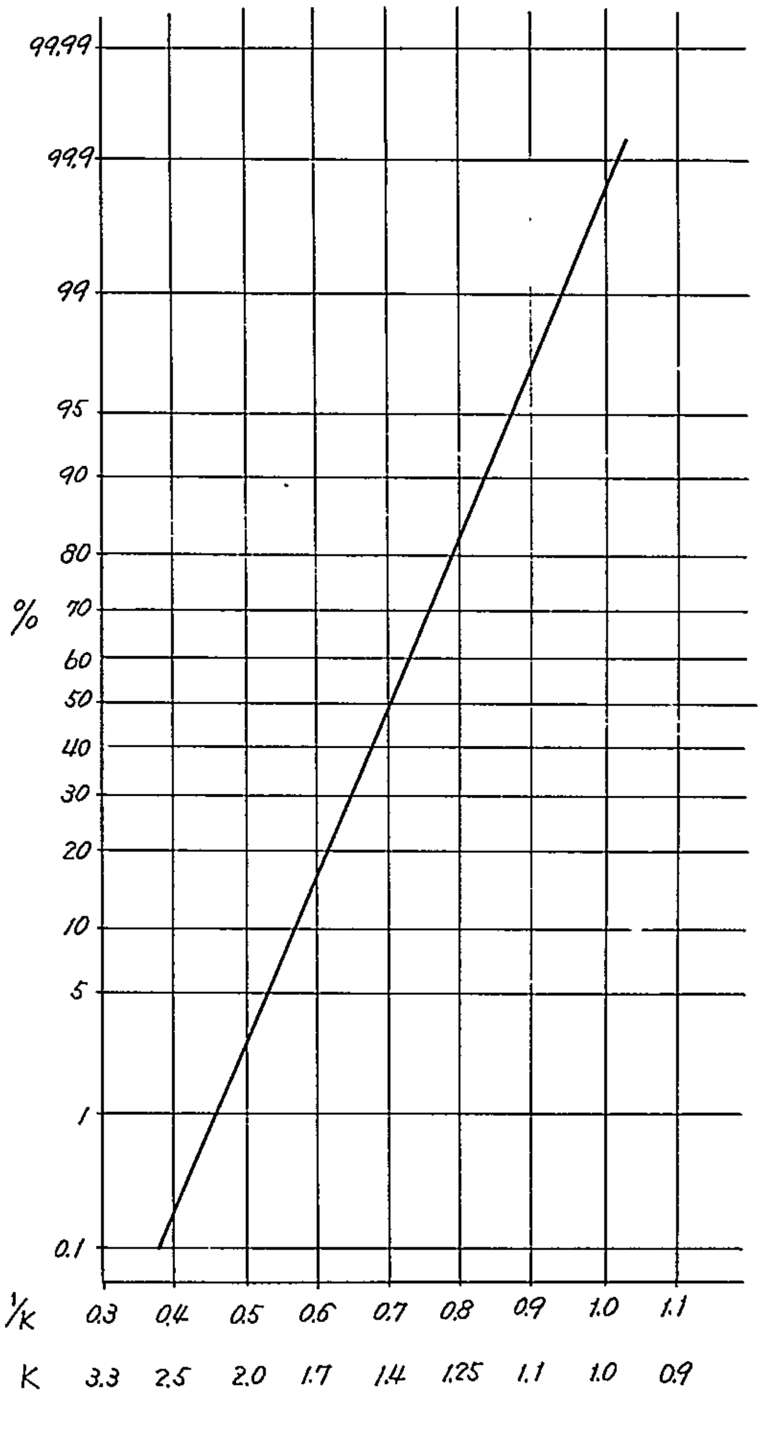


Fig. 5.4.5 Distribution of K

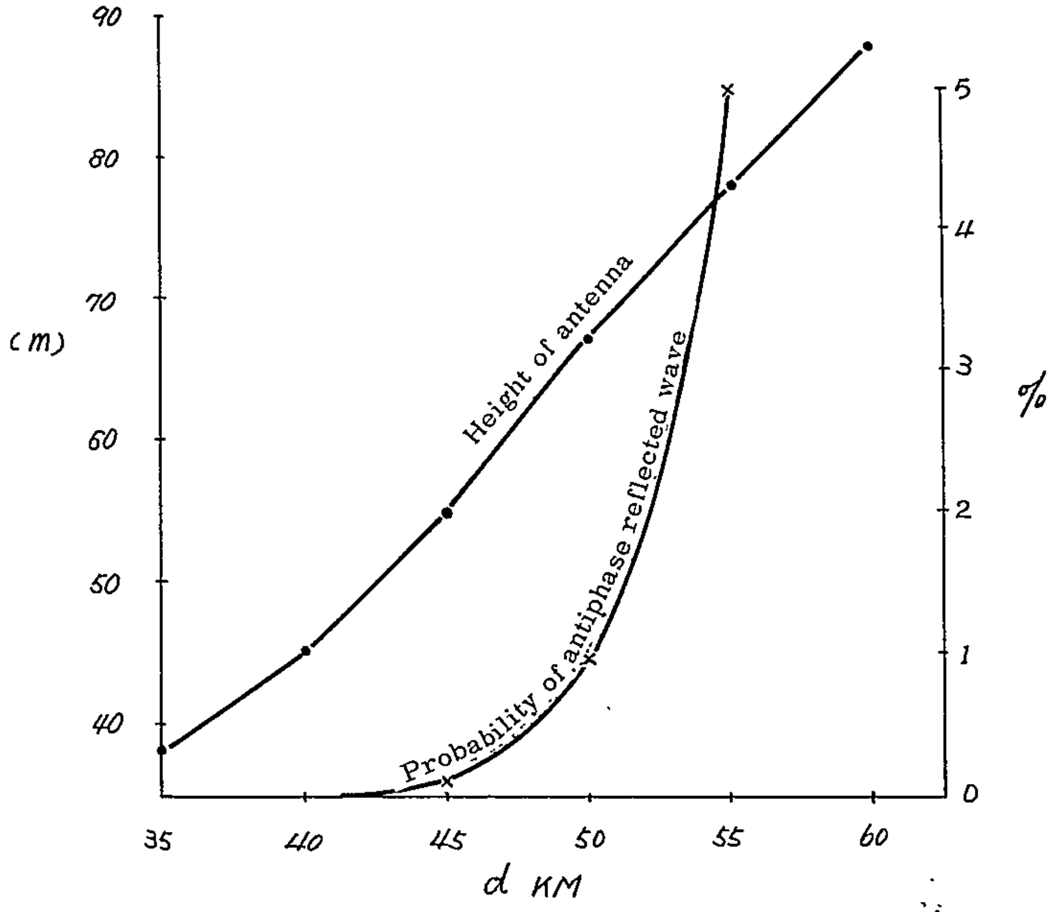


Fig. 5.4.6 The height of antenna and repeater spacing

5.4.9 System of Power Source

As regards the non break power source for the utilization of transistorized equipments the floating battery system is most economical. The capacity of the battery is decided by the method of maintenance and is 18 hours on the average, but at the station where commercial power is in use any stand-by engine is not necessary. However, in this case it is necessary to station a power source car (which is equipped with dynamotor) at the rate of one unit to several station and to prepare for the accidents. Even the stations where commercial power source can be arranged, and which tends to meet with long frequent break of power attaining to the capacity limit of battery, or the stations which are liable to paralysed traffic in the snow or in flood, may safely be advised the installation of stand-by engines. At the stations which cannot provide commercial power source it is advisable to install 2 sets of dynamotor for alternate operation. At the stations functioning in parallel with the CENTO SYSTEM, and which are already equipped with non break power sources, floating battery are not necessary but only rectifiers are recommended for equipment.

6. OUTLINE OF THE NEW MICROWAVE SYSTEM

6. Outline of the New Microwave System

6.1 Outline of the Location of the System

The results of our field investigations, dealing with the following sections of the route ranging from Karachi to Peshwar via Rawalpindi, are.shown in the Table 6.1. The profile and the relative figures are attached at the end of this report. The route has been selected to be the first in our order of construction, in conformity with the conclusion treated of in the fourth chapter of our report.

Karachi - Sukkur (Lakhi) - Rojhan - D.G. Kahn - D.I. Kahn -
Sargodha - Rawalpindi - Peshawar

As to the characters of radio wave propagation over level ground, more detailed investigation including actual propagation tests is thought necessary, but it could not be executed in relation with time or others, and therefore, the execution of research of the fundamental characters of propagation, such as the distribution of fading, may be recommended, if possible, after choosing representative sections at a proper time. We should add that actual reinvestigation of reflection, e.g., as to the condition in reflected areas, at least in the time of designing, may be necessary.

Table 6.1.1 Table of various data (Karachi-Sukkur)

Order	Name of repeater station	Location			Approach road	Power line	Kind of repeater station	Aerial		Distance	Remarks
		Longitude	Latidude	Altitude				Height	Diameter		
								m	mø	km	
1	Karachi	67°03'40"	24°53'40"	( )	-	CENTO system's power	Terminal station	65	3.3	48.0	
2	Gharo	67°32'10"	24°46'50"	( )	-	CENTO system's power	through	" "	" "	52.8	
3	Hillaya	68°03'08"	24°53'37"	( )	-	CENTO system's power	through	" "	" "	56.0	
4	Kotri	68°16'56"	25°21'54"	( )	-	CENTO system's power	I.F. and baseband repeating terminal station	" "	" "	44.0	
5	Gopang	68°17'15"	25°45'44"	27m (90')	-	CENTO system's power	through	" "	" "	45.6	
6	(Ks-5)	68°03'9	26°06'9	34m (110')	50m	-	through	" "	" "	45.6	
7	(KS-6)	67°48'6	26°27'6	37m (120')	50m	6km Sehwan	through	" "	" "	45.6	
8	(KS-7)	67°44'8	26°52'3	37m (120')	50m	15km Dadu	through	" "	" "	45.6	
9	(KS-8)	67°49'2	27°15'2	38m (125')	50m	-	through	" "	" "	45.6	
10	Larkana	68°12'10"	27°33'45"	49m (60')	-	CENTO system's power	through	" "	" "	54.2	
11	Sukkur (Lakhi)	68°42'25"	27°51'30"	( )	-	CENTO system's power	I.F. and baseband repeating terminal station	" "	" "		

Table 6.1.2 Table of various data (Sukkur - D.I. Khan)

Order	Name of repeater station	Location			Approach road	Power line	Kind of repeater station	Aerial		Distance	Remarks
		Longitude	Latitude	Altitude				Height	Diameter		
1	SUKKUR (LAKHI)	68°42'25"	27°51'30"	63m (207')	-	CENTO system's power	I.F. and baseband repeating terminal station	m 50	mø 3.3	km	
										40.6	
2	(SG-1)	68°59'5	28°07'4	60m (200')	1.5km	-	through	" "	" "		
										40.2	
3	(SG-2)	69°16'1	28°23'4	70m (230')	-	16km Kandhkot	through	" "	" "		
										40.7	
4	(SG-3)	69°42'1	28°28'2	75m (295')	-	10km Kashmor	through	" "	" "		
										41.0	
5	ROJHAN (SG-4)	70°01'1	28°42'4	85m (280)	-	-	I.F. and baseband repeating terminal station	" "	" "		
										41.0	
6	(SG-5)	70°18'8	28°58'1	90m (295')	-	-	through	" "	" "		
										42.9	
7	(SG-6)	70°20'0	29°21'1	108m (354')	jeepable	-	through	" "	" "		
										43.0	
8	JAMPUR (SG-7)	70°36'1	29°40'2	110m (360')	-	-	through	" "	" "		
										42.8	
9	D.G. KHAN	70°38'5	30°03'1	122m (400')	-	commercial power	I.F. and baseband repeating terminal station	" "	" "		
										43.2	
10	(GI-1)	70°43'6	30°26'2	138m (450')	-	-	through	" "	" "		
										42.9	
11	(GI-2)	70°34'9	30°47'7	208m (680')	jeepable	15km Taunsa	through	" "	" "		
										37.8	
12	(GI-3)	70°42'0	31°07'0	156m (510')	jeepable	-	through	" "	" "		
										41.2	
13	(GI-4)	70°44'6	31°29'0	162m (530')	-	-	through	" "	" "		
										40.6	
14	D.I.KHAN	70°54'4	31°49'8	177m (580')	-	commercial power	I.F. and baseband repeating terminal station	" "	" "		

Table 6.1.3 Table of various data (D.I. Khan - Sargodha)

Order	Name of re-peater station	Location: Longitude	Location: Latitude	Location: Altitude	Approach road	Power line	Kind of repeater station	Aerial: Height	Aerial: Diameter	Distance	Remarks
								m	mø	km	
1	D.I.KHAN	70°54'4	31°49'8	177m (580')	-	Commercial power	I.F. and baseband terminal station	50	3.3	40.5	
2	(IS-1)	71°20'2	31°49'0	183m (600')	-	22km Darya Khan	through	〃	〃		
								〃	〃	34.5	
3	(IS-2)	71°35'6	32°02'0	186m (610')	-	-	through	〃	〃		
								〃	〃	36.0	
4	(IS-3)	71°58'1	32°05'2	180m (590')	-	-	through	〃	〃		
								〃	〃	36.0	
5	(IS-4)	72°20'2	31°58'4	183m (600')	-	Commercial power	through	〃	〃		
								〃	〃	34.5	
6	Sargodha	72°39'8	32°05'0	188m (615')	-	Commercial power	I.F. and baseband terminal station	〃	〃		

Table 6.1.4 Table of various data (Sorgodha - Rawalpindi)

Order	Name of re-reater station	Location			Approach road	Power line	Kind of repeater station	Aerial		Distance	Remarks
		Longitude	Latitude	Altitude				Height	Diameter		
								m	mφ	km.	
1	Sargodha	72°39'8	32°05'0	188m (615')	-	Commercial power	I.F.and baseband repeating terminal station	50	4	73.15	space-diversity system required
2	(SR-1)	72°56'52"	32°42'14"	937m (3074')	3km	4km Saidun Shah	through	50	4		
								50	3.3	48.0	
3	(SR-2)	73°04'06"	33°10'11"	544m (1780')	jeepable	-	through	25	3.3		
								65	3.3	46.6	
4	Rawalpindi	73°03'01"	33°35'36"	510m (1670')	-	Commercial power	Baseband repeating terminal station	75	3.3		

Table 6.1.5 Table of various data.(Rawalpindi-Peshawar)

Order	Name of re-peater station	Location			Approach road	Power line	Kind of repeater station	Aerial		Distance	Remarks
		Longitude	Latitude	Altitude				Height	Diameter		
								m	m	km	
1	RAWALPINDI	73°03'01"	33°35'36"	510m (1670')	-	commercial power	Baseband repeating terminal station	75	3.3		
										44.0	
2	(RP-1)	72°34'39"	33°36'47"	655m (2150')	about 3km	8km Fathejang	through	20	3.3		
								20	4		
										66.1	
3	CHERAT' (RP-2)	71°54'51"	33°49'48"	1385m (4596')	-	commercial power	through	10	4		
								10	3.3		
										39.1	
4	Peshawar	71°32'47"	34°00'26"	335m (1100')	-	commercial power	terminal station	30	3.3		

Table 6.1.6 Table of various data (D.I.Khan - Sakesar - Sargodha)

Order	Name of re-peater station	Location			Approach road	Power line	Kind of repeater station	Aerial		Distance	Remarks
		Longitude	Latitude	Altitude				Height	Diameter		
								m	m∅	km	
1	D.I.KHAN	70°54'4	31°49'8	177m (580')	-	commercial power	I.F.and baseband terminal station	50	3.3		
										47.6	
2	(IS-5)	71°06'30"	32°12'36"	361m (1100')	2km	18km	through	" "	" "		
										38.5	
3	(IS-6)	71°30'6	32°12'7	195m (640')	-	-	through	" "	" "		
										53.0	
4	Sakesar (IS-7)	71°55'57"	32°32'32"	1492m (4900')	-	commercial power	through	" "	" "		
										46.1	
5	(IS-8)	72°15'00"	32°13'26"	183m (600')	-	8km	through	" 10	" "		
										42.7	
6	Sargodha	72°39'8	32°05'0	188m (615')	-	commercial power	I.F. and baseball terminal station	20	"		

6.2 Designing of Devices

6.2.1. Structure of Circuit

With the intention of maintaining the good quality of circuit, the route between Karachi and Peshawar may divided into 8 sections of switch-over, and the kind of a repeater should be decided in accordance with the extent of its necessity, namely upon consideration whether one would be under the base-band repeating system, or I.F. repeating system, or even the mixture of both. Excepting through repeater station these stations should be attended and be carefully decided, for the devices would necessitate adequate equipment worthy of note. Accordingly, the terminal stations in such towns with no need of telephone or telecasting in the beginning, I.F. switch-over system should be installed, and modulator and demodulator for only telephone channel should be provided with the system of base band switch-over when circumstances in future would necessitate the installation. As regards the television signal transmission in future, it would be economical that I.F. switching system is installed. Fig. 6.2.1. shows an example of the structure of circuit. As aforementioned, if VHF is used for auxiliary circuit, 18 channels can be applied for telephone calling as well as the channels for order, the codes of switchover and remote control for supervision, and if the telephones circuits such as D.G. Khan and D.I. Khan would install this VHF, these dependent exchanges can be economically designed, in the beginning, for only I.F. repeating terminal station like Kotri and Rojhan. Of course, in future, these stations can be changed into baseband repeating terminal station. All of the terminal stations of the mixed system of I.F. and base band shown in Fig.6.2.4 are to be arranged with the devices of base band switchover of telephone circuit and I.F. switch-over of the circuit for television signal. Therefore, if these stations necessitate the signal for telecasting, the signals can be separated and used directory from the circuit without remodelling the systems of switch-overs. If the unattended station neibouring the terminal station is in disorder or in suspension for a long interval of electric power, those in charge of maintenance must run to such unattended station. For this purpose, the time of running from the terminal station to the unattended station plays an important role and the structure of circuit recommended in Fig. 6.2.1 are designed so as to limit such time at least within 4 hours.

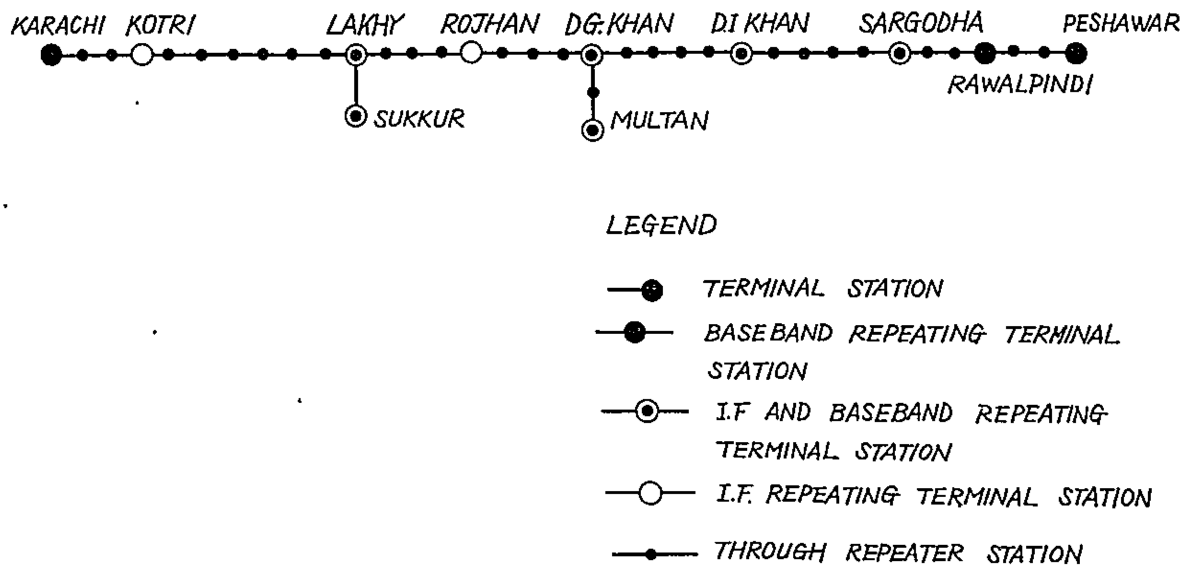


Fig. 6.2.1 Structure of Circuit

6.2.2 Inside Structure of Station

Figures from 6.2.2 to 6.2.6 show the standard inside structure of stations. All these equipment except travelling wave tube are transistorized, small sized and need not consume so much power and yet have much stability. The transmission capacity per a radio frequency channel is 960 telephone channels of CCIR's Recommendation or one television signal transmission channel.

In order to decrease the rate of disorder and to prolong the life of equipment, installation of the adjusting devices of temperature and moisture in machine room is desirable. In the terminal stations which are to be equipped with many and complicated apparatus installation of those adjusting devices is necessary. The introduction of control desk provided with various devices, other than those shown in the figure, such as those for the supervision of television signal, handling keys, lamps for accident, meters and intra-company telephones is thought advantageous when occasion calls.

The transmitting and receiving apparatus of the signals of telephone and television are completely one and the same and only the devices for modulation and demodulation are a little different. However, for the service of stand-by channel, the commonly used modulator or demodulator can be utilized.

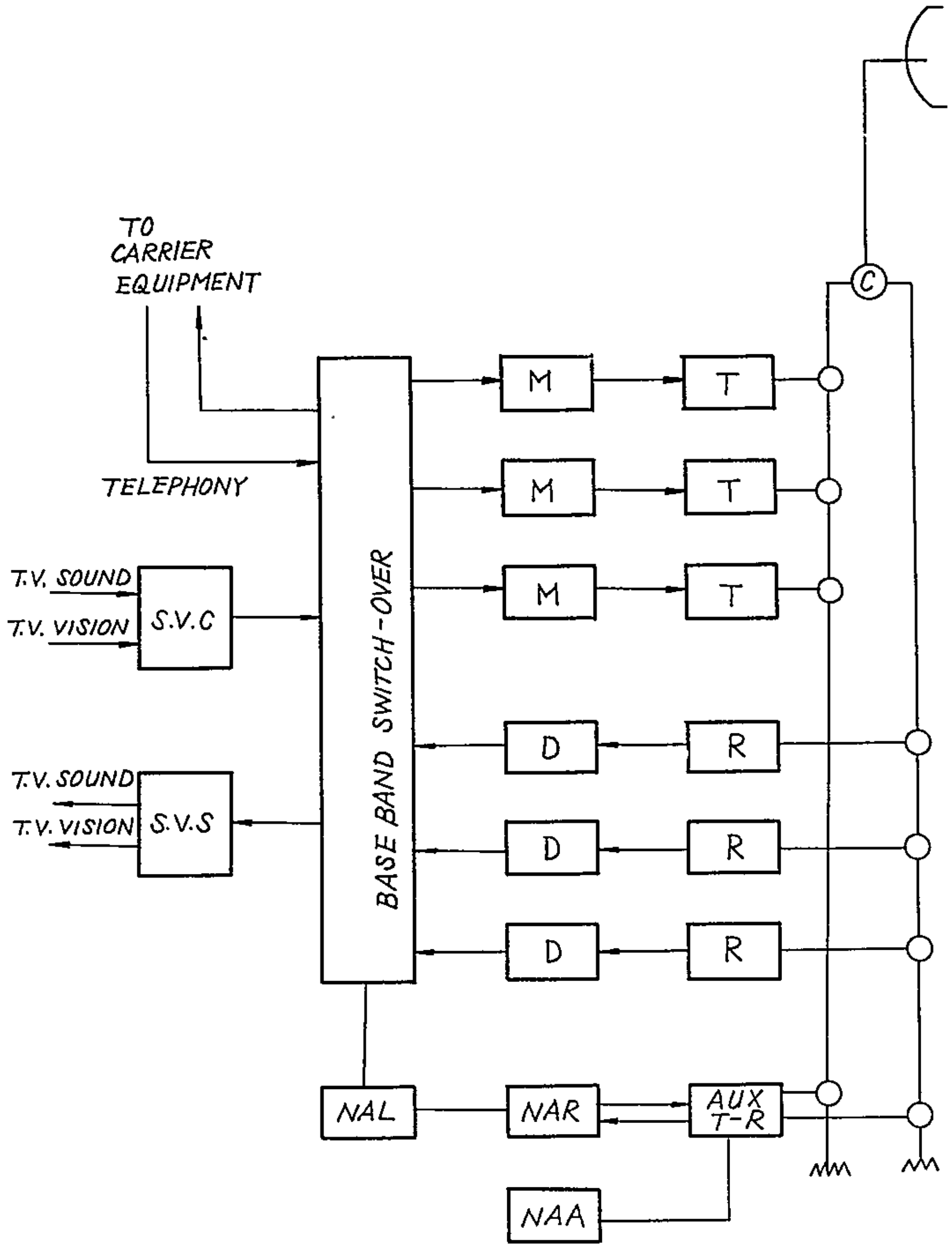


Fig. 6.2.2 Terminal station (Karachi, Peshawa

Legend

T	: Transmitter
R	: Receiver
M	: Modurator
D	: Demodurator
Aux T-R	: Auxiliary transmitter-Receiver
SVC	: Sound/vision combiner
SVS	: Sound/vision separater
○	: Branching filter
Ⓒ	: Circurater
NAL	: Switch-over control equipment
NAR	: Supervisory equipment
NAA	: Order wire multiplexing equipment

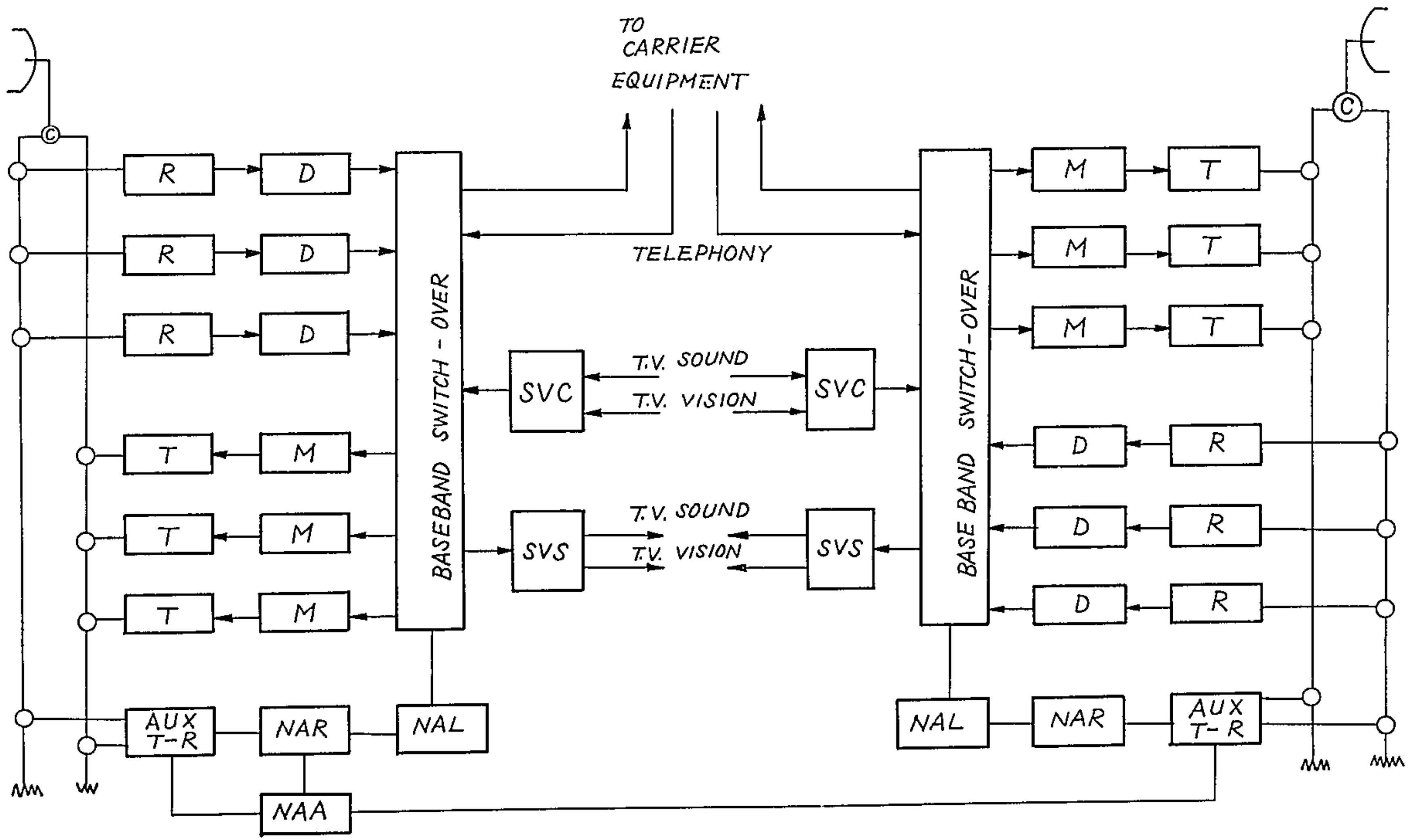


Fig. 6.2.3 Baseband repeating terminal station (Rawalpindi)

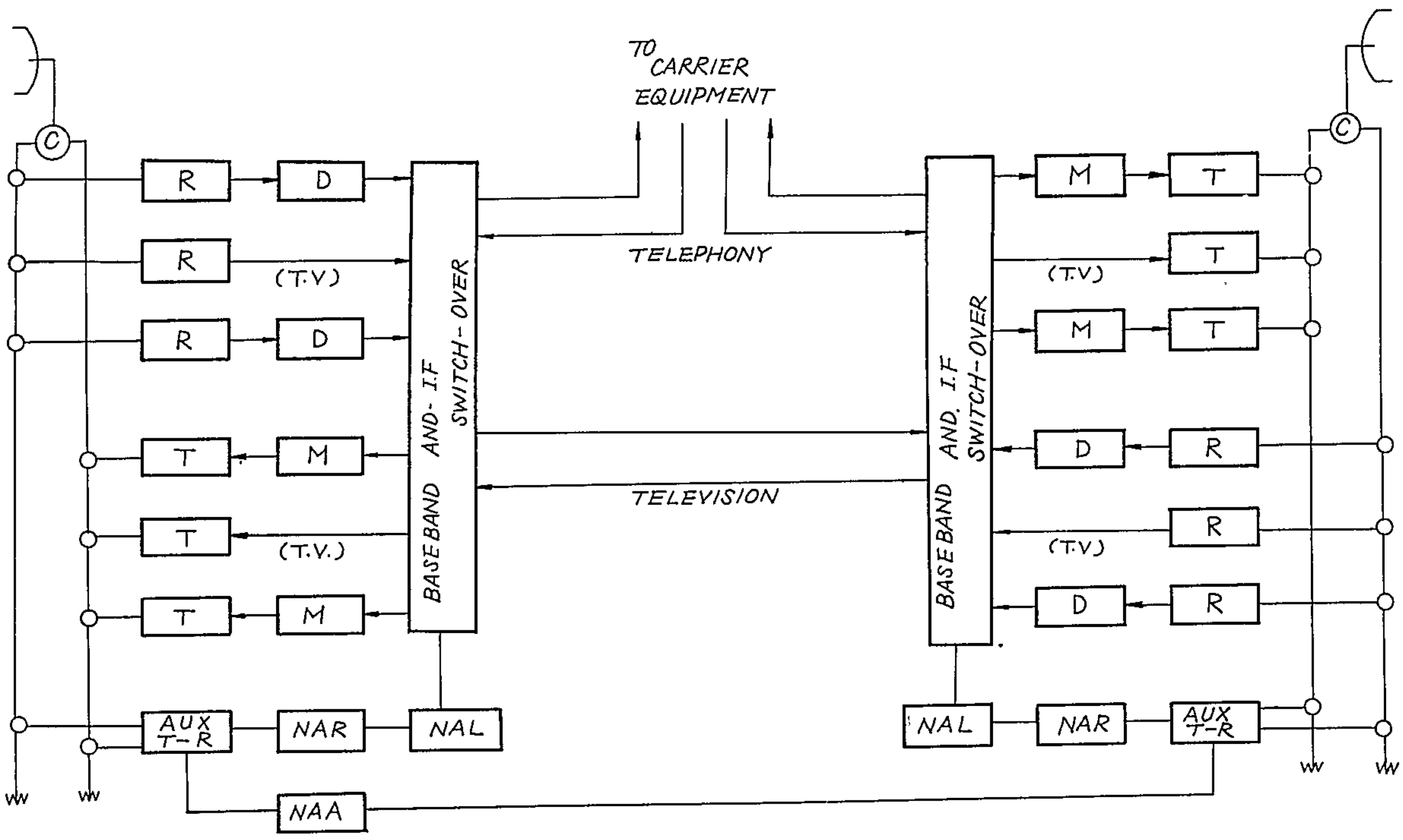


Fig. 6.2.4 I.F. and baseband repeating terminal station (Sargodha, D.I. Khan, D.G. Khan, Sukkur)

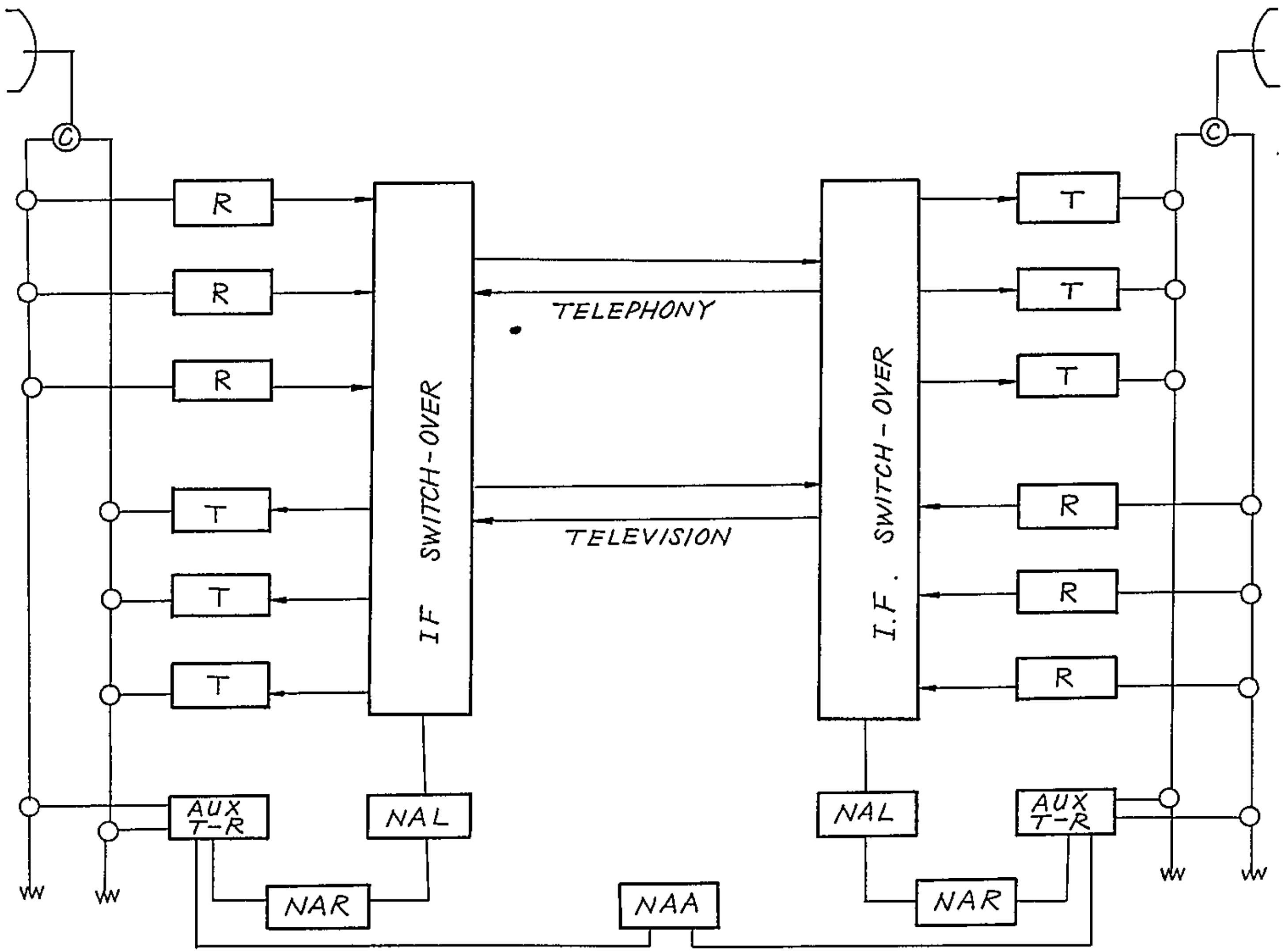


Fig. 6.2.5. I.F. repeating terminal station (Kotri, Rojhan)

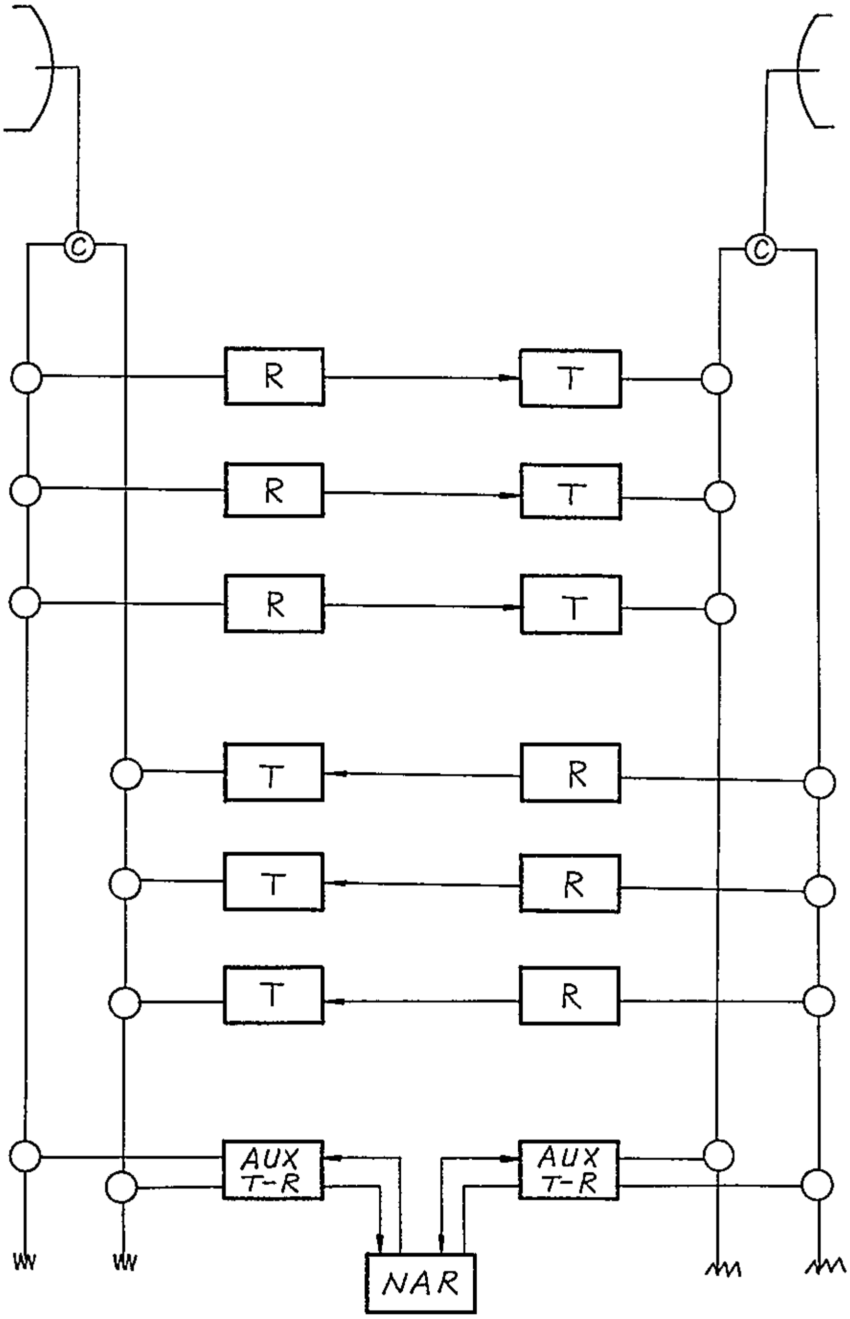


Fig. 6.2.6 Through repeater station

6.2.3. Electric Power Equipment

As all equipment are transistorized, direct current is adequate and the power is just enough if it is about 5 KW in through repeater stations and about 10 KW in terminal stations respectively. The system of power source is divided into the following four main classes.

(i) Commonly equipped stations with the CENTO microwave system. These stations are supposed to be equipped with alternating no-break current power source of enough capacity. The power may be used through rectifier.

(ii) Stations without the facilities of commercial power. These stations are to be furnished with 2 sets of dynamotor, one is for current use and the other is for stand-by, and they are to be operated cyclically during 24 hours. However, the consumption of current is small and the equipment will not be of a big scale as compared with the apparatus of CENTO microwave circuit.

(iii) Stations with only unstable power. The system suitable for these stations is shown in Fig. 6.2.7. This system applies floating battery system and is not affected by voltage variation (about 10%) or momentary suspension, etc.. If current interruption lasts long, say over 18 hours, the dynamotors will start automatically and they may also be operated by the remote control in a supervisory station.

(iv) Stations available of stable commercial power. These stations may apply the same system as aforementioned except dynamotors. However, as the storage capacity of battery is limited only for 18 hours the disposition of power-source cars at the terminal stations will become necessary. Examination in every detail was not possible with our survey under review, however, our judgement has been that among all 35 stations 7 stations should belong to the case (i), 13 stations to (ii), 5 belong to (iii) and the remaining 10 belong to (iv).

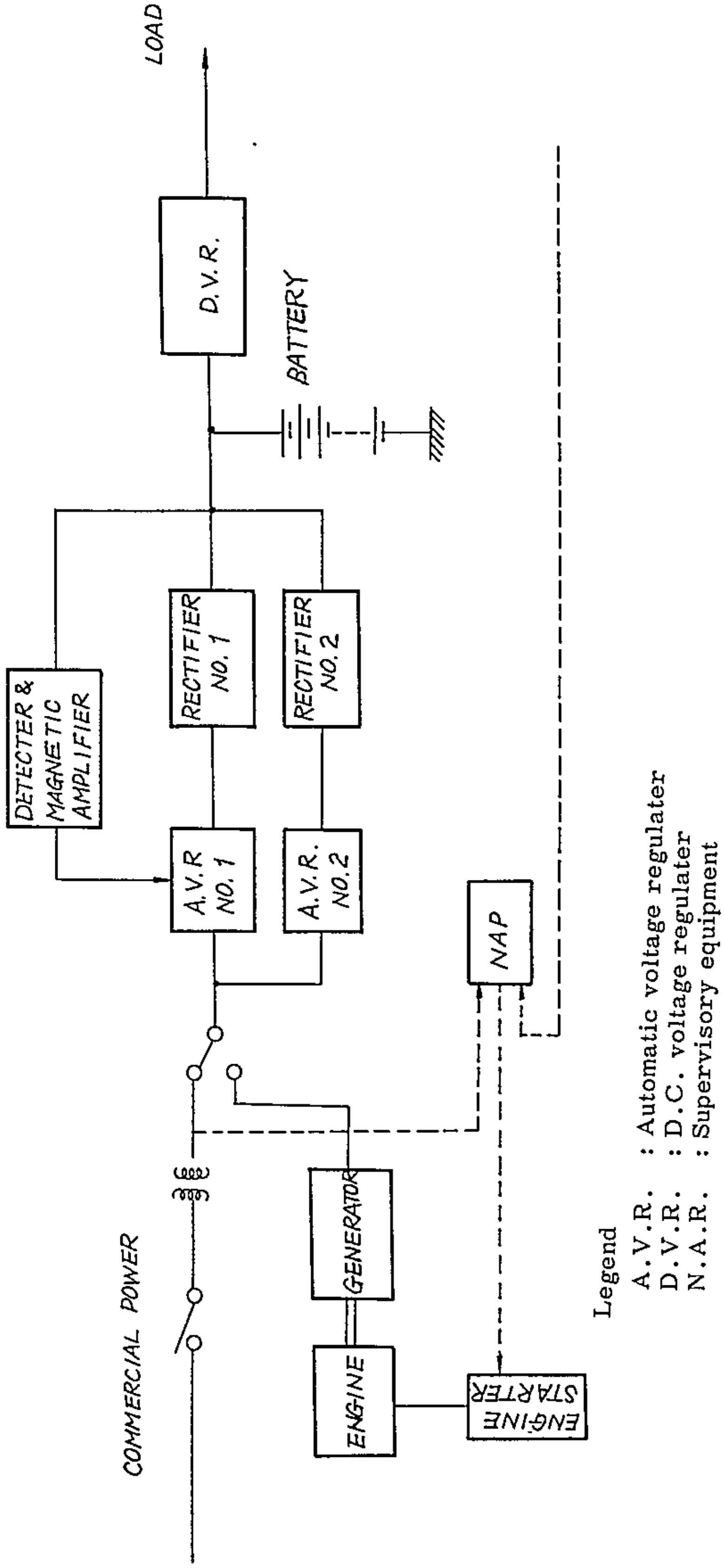


Fig. 6.2.7 Apparatus of Power Source

6.3 Station Building

Fig. 6.3.1 shows an example of building of through repeater station. As regards building materials available on the spot, there is almost nothing other than bricks and all the buildings except those in great cities are to be constructed as one-storied. Of course there is no restriction to make a wide change of building as may be required by the circumstances on the spot.

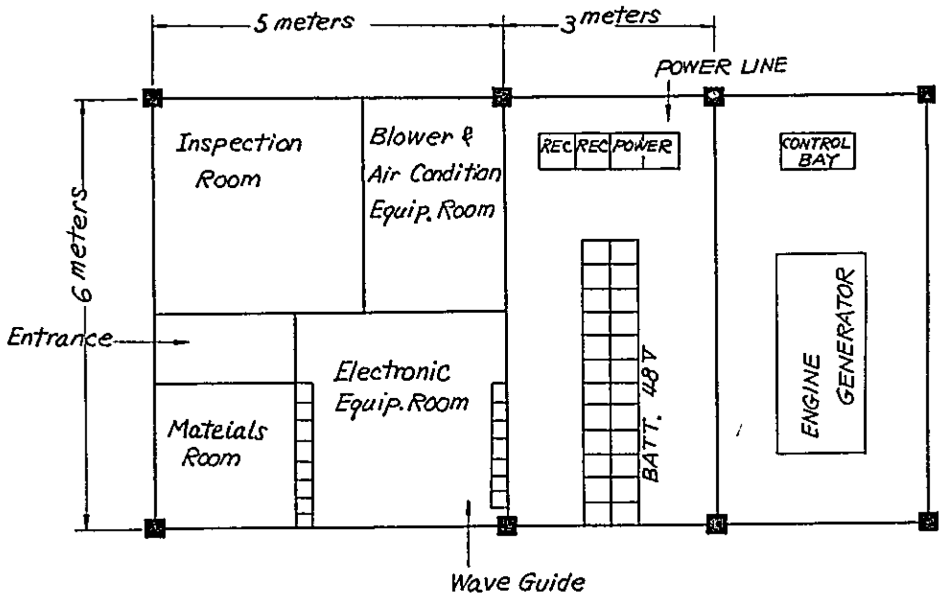


Fig. 6.3.1 Example of through repeater station building

7. NECESSARY COST OF CONSTRUCTION

7. Necessary Cost of Construction

Estimation of construction cost is difficult as it is subjected to wide fluctuations. However, as the planning itself cannot be performed without such estimate, we consider it fit to the purpose to explain the standard cost of construction under the systems we recommend, which is shown as follows;

7.1 Road

Judging from the results of the construction of CENTO microwave systems, the unit construction cost for road in mountainous areas is presumed Rs 0.93 lac/KM, and for road in plain land Rs 0.66 / KM. The systems recommended will necessitate the total length of mountainous roads to be about 6 KM and of plain land roads to be about 1.7 KM, and the total cost of road construction will amount to 6.7 lac of Rupees.

7.2 Steel Tower

The unit construction cost of stayed steel tower would be about Rs 990/meter for the part lower than 45 meters and about Rs 1,700/meter for the part from 45 meters to 100 meters. The application of this estimate shows the fact that steel towers will need about 30 lac of Rupees.

7.3 Station Building

The unit construction cost of station buildings which mainly consist of bricks is generally about Rs 250/M^2 if located in the villages and about Rs 330/M^2 if located far from the villages. As regards co-equipped stations with CENTO system if the buildings are to be used commonly in charge of CENTO system, the cost in connection with buildings will need about 13 lac of Rupees.

7.4 Electric Power Equipment

As aforementioned, provided that the power source for the CENTO system can be used in the co-equipped stations with the CENTO system, the necessary cost including the construction cost of power transmission line and the car of power source will be totalled at 53 lac of Rupees.

7.5 Wireless Communication Apparatus

The cost for construction of wireless apparatus including the system of antenna and wave-guide, etc. is roughly estimated as follows;

	Number of stations	Super multiplex telephone transmission circuits; channel Television signal transmission circuit; 1 channel for each direction Stand-by circuit; 1 channel	Super multiplex telephone transmission circuit; 1 channel Stand-by circuit; 1 channel
Terminal stations	2	7.1 lac of Rupees	4.9 lac of Rupees
Base band repeating terminal stations	1	12.8	8.9
I.F. and base band repeating terminal stations	4	11.9	8.9
I.F. repeating terminal stations	2	9.7	7.5
Through repeater stations	26	5.6	4.4
Total Cost	35	238.5	182.7

7.6 Carrier Equipments of Terminal Station

If under supposition that the trunk circuits for telephone scheduled to be constructed should include the following circuit shown in Fig. 3.5.2, the construction cost will be estimated at 10.5 lac of Rupees for the carrier equipments of terminal stations. If one circuit containing about one super group must be constructed in Sukkur, D.G. Khan, D.I. Khan and Sargodha, an additional cost of Rs 11.8 lac will be necessary. However, the cost for the construction of the channel translating equipments is not included in either case.

7.7 Total Construction Cost

The total construction cost aforementioned is shown in the following table.

(Unit; lac of Rupees)

	Road	Steel tower	Building	Power equipment	Radio equipment	Carrier equipment	Total
Super multiplex telephone transmission circuit; 1 channel Television signal transmission circuit; 1 channel for each direction Stand-by circuit; 1 channel	6.7	30	13	53	238.5	10.5	351.7
Super multiplex telephone transmission circuit; 1 channel Stand-by circuit: 1 channel	6.7	30	13	53	182.7	10.5	295.8

This table shows a summary of the total construction cost under an assumption that the average repeater spacing is to be about 40 - 45 km. As mentioned in Chapter 5.3.3, if it is possible that this distance is extended to 50 KM as the result of the propagation test over the plain land, four through repeater stations and one I.F. repeating station (Rojhan), totalling 5, may be eliminated from construction. Consequently, the gross construction cost, covering one system for telephone circuits, one transmitting and receiving systems each for television signal and one stand-by circuit, will be reduced by about 31.9 lac of Rupees, but if only one circuit for telephone use and one stand-by circuit are to be constructed the total cost will be reduced by about 25 lac of Rupees. In other words, the total construction cost in the former case would be about 319.8 lac of Rupees and in the latter case about 270.8 lac of Rupees.

8. APPENDIX

8. At the End;

Cities in west Pakistan lie scattered in the vast plain extending along the Indus Basin and located in the north and south of this plain. The transportation and communication facilities in such a country should have very important bearings not only for her industrial and economic progress but also in respect to the maintenance of public peace and order and the emergent communications at the time of disasters, or any other administrative measures. The means of transportation such as railway and road facilities in west Pakistan appear to be under fairly developed condition, but communication facilities are yet to be developed. In the circumstances, the construction and establishment of this extra broad band transmission route under microwave system should play an important role in future advancement of the nation's industry and economy, and we do look forward to her early fulfilment of the national requirements in every field through due accomplishment of the current microwave project.

APPENDIX

1. The profiles and the relative figures of recommended station sites.

These figures show the names of repeater stations, repeater spacings and angles, followed by the locations on maps and the profiles between each sections.

(Note 1) As regards profiles only the cases under standard condition of atmosphere (K = 4/3) are shown, but in further consideration is taken into for the cases under worse atmosphere condition which are common with the transmission route over level ground.

(Note 2) As a rule, to draw up the sketches maps of 1:50,000 scale are used, but where it is difficult to obtain such maps, those of 1:25,000 scale are used.

1.1 Karachi-Sukkur (Lakhi)

As the present CENTO microwave route has been decided to be used as much as possible through this section, the stations between Karachi and Gopang and the stations of Larkana and Lakhi are to be situated at the same sites. Present station building and power equipment may be satisfactorily utilized, but a new steel tower must be constructed on account of its structure. The height of antenna at the post of each station must be decided eventually after detailed investigation of the reflected areas.

(Note 1) The positions of Ks-6 and KS-7 must be decided on the basis of new map of 1:50,000 scale after taking road conditions fully into consideration.

(Note 2) As regards the stations KS-5 and KS-6, the height of antenna of KS-5 in the direction to KS-6 must be constructed lower than those of KS-6, in connection with the fact that if the heights of antenna in both stations would be made to have same altitude, the point of reflection would come to the same level of the surface of water of the River Indus and the effect of reflected wave would originate.

(Note 3) As to the section between KS-7 ard Larkana there extends a plain which involves a fear of strong reflected wave, and the location of KS-8 may be decided after the detailed investigation of places which may avert the effect on account of villages, woods and dikes. In this case, attentions should be turned to the over-reach from SG-2 and if unavoidable, the change of the location of SG-2 should come necessary.

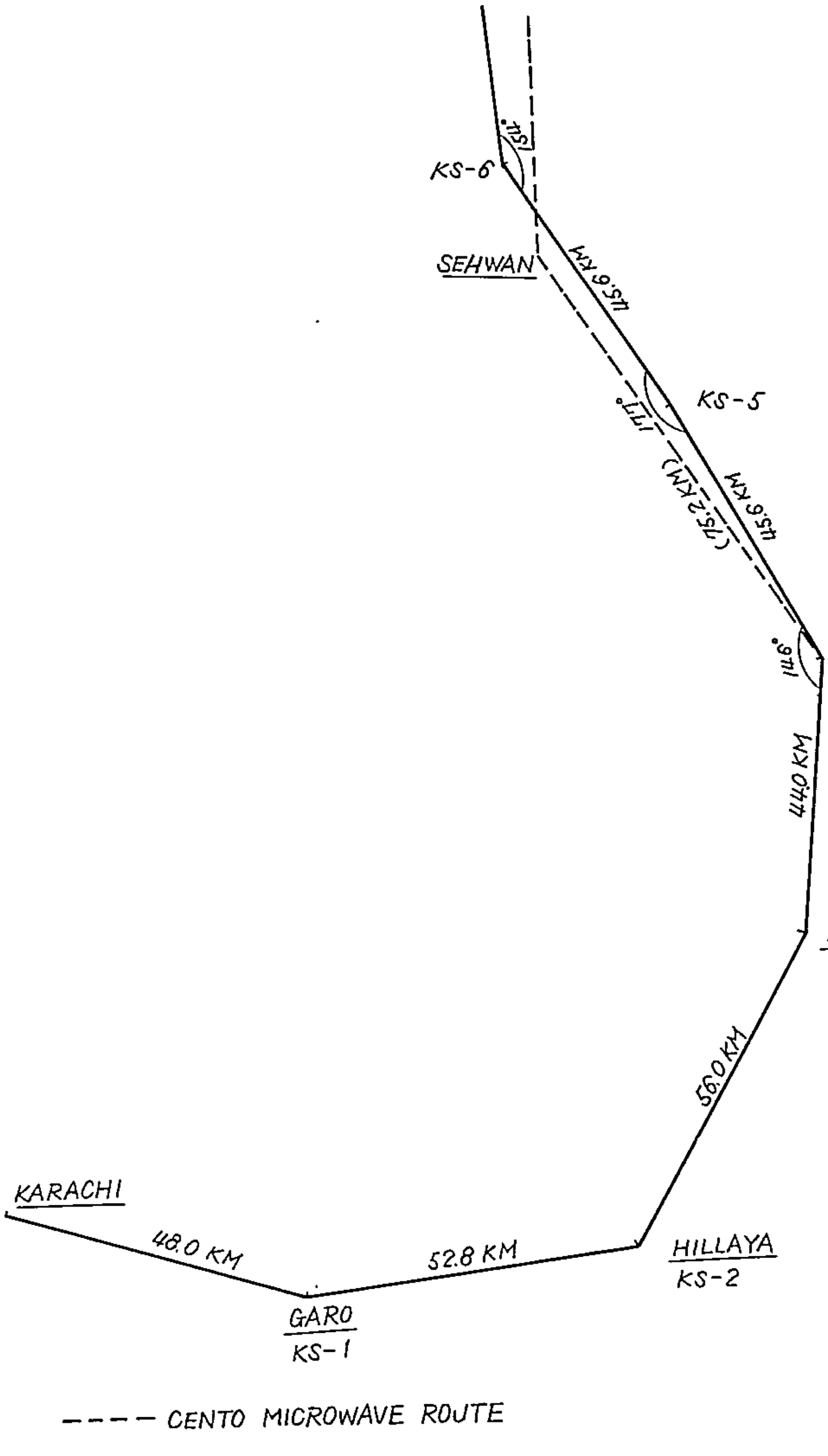


Fig. 1.1.1 Angles and repeater spacings (Karachi-Sukkur) (1)

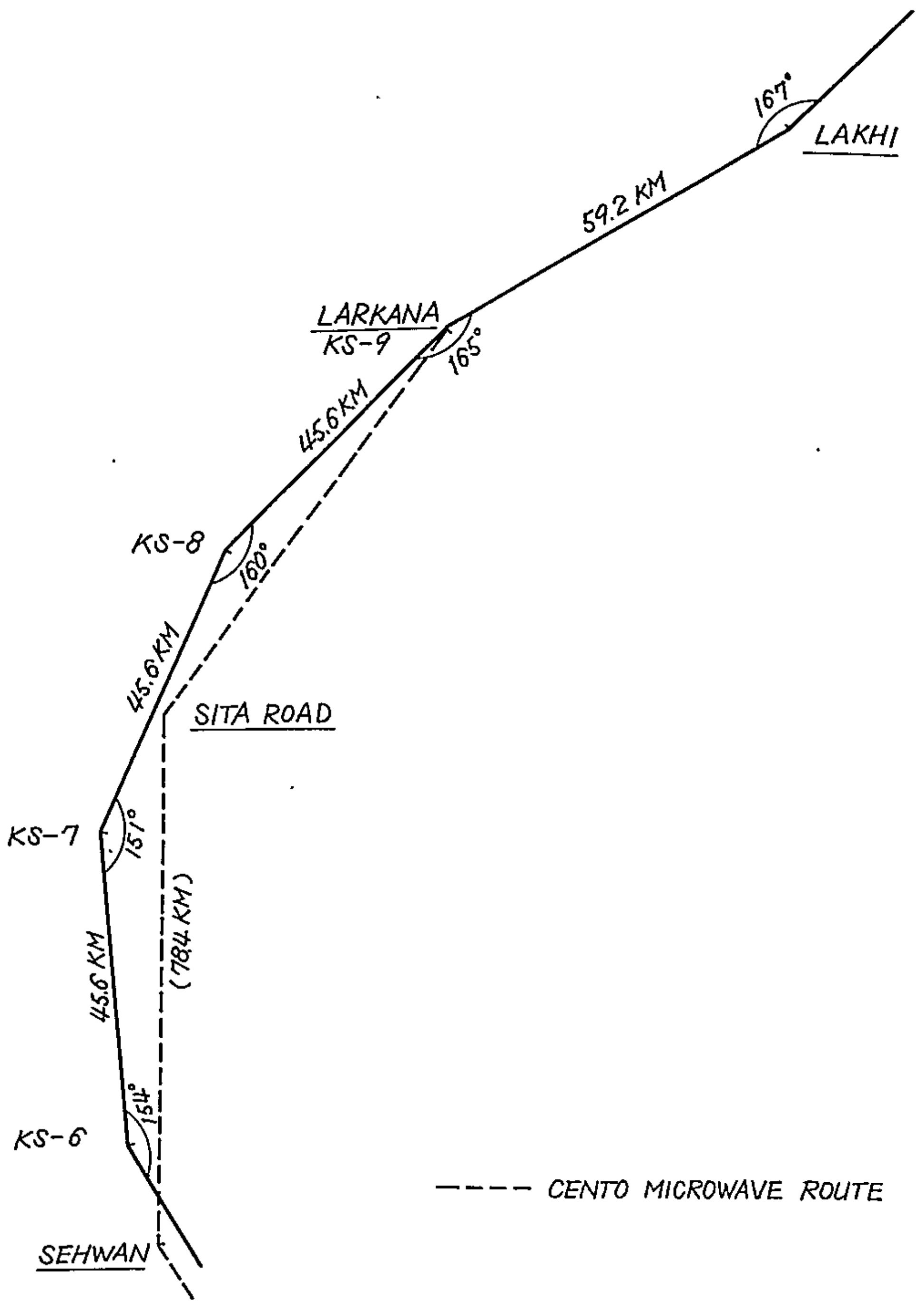


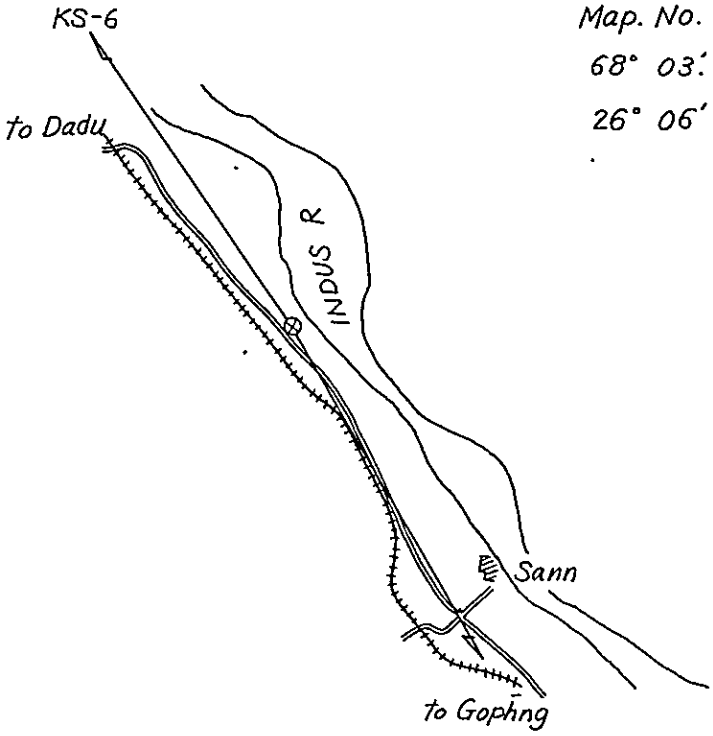
Fig. 1.1.1 Angles and repeater spacings (Karachi-Sukkur) (2)

Rep No. KS-5

Map. No. 40 B

68° 03.' 9 E

26° 06' 9 N



Rep. No. KS - 6

Map. No. 35 N

67° 48' 6 E

26° 27' 6 N

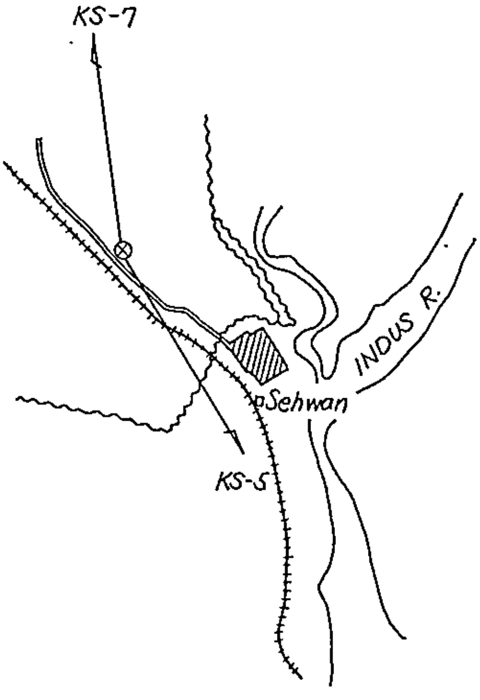


Fig. 1.1.2 Sketch maps of the station sites (Karachi-Sukkur) (1)

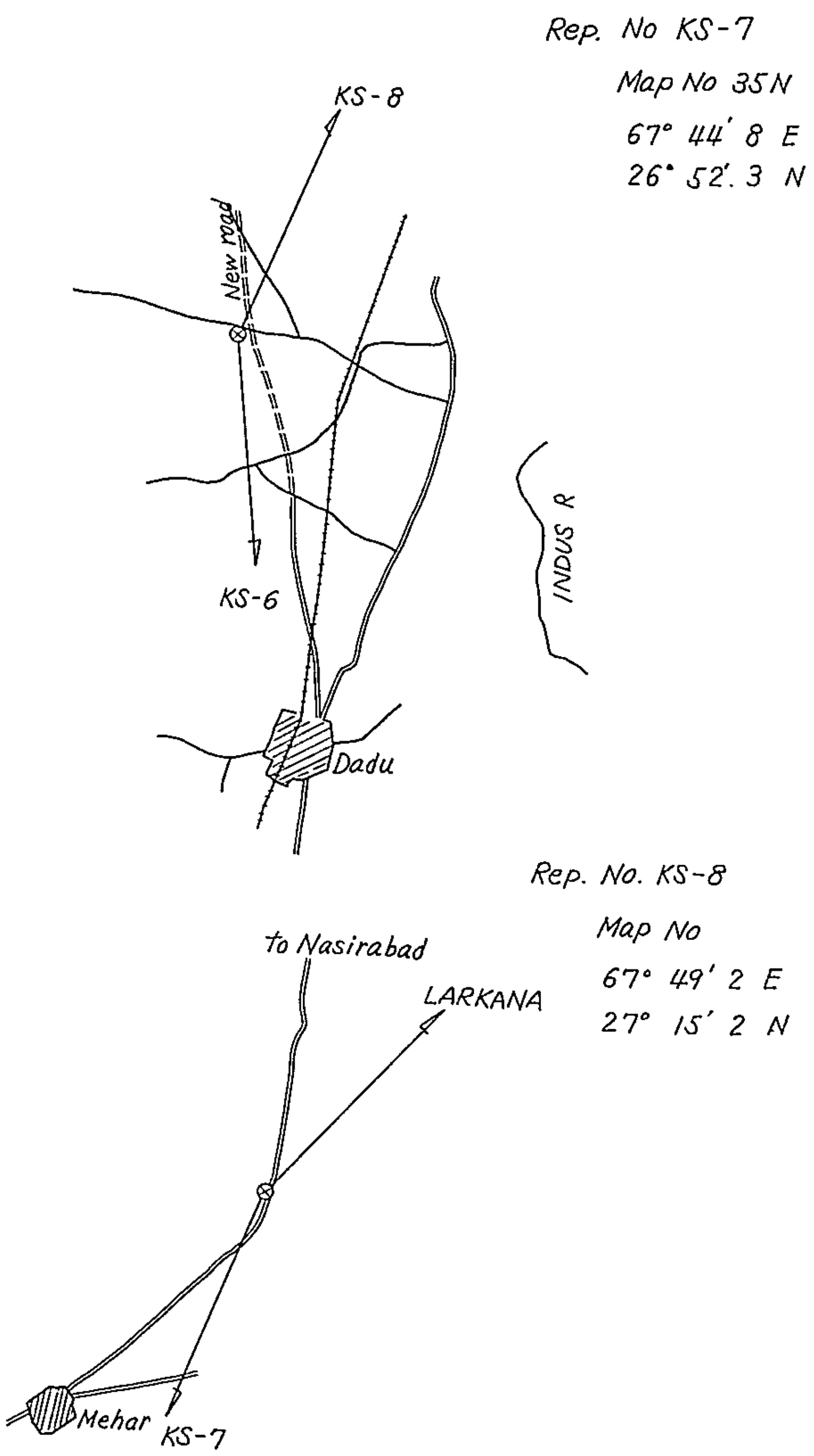


Fig. 1.1.2 Sketch maps of the station sites (Karachi-Sukkur) (2)

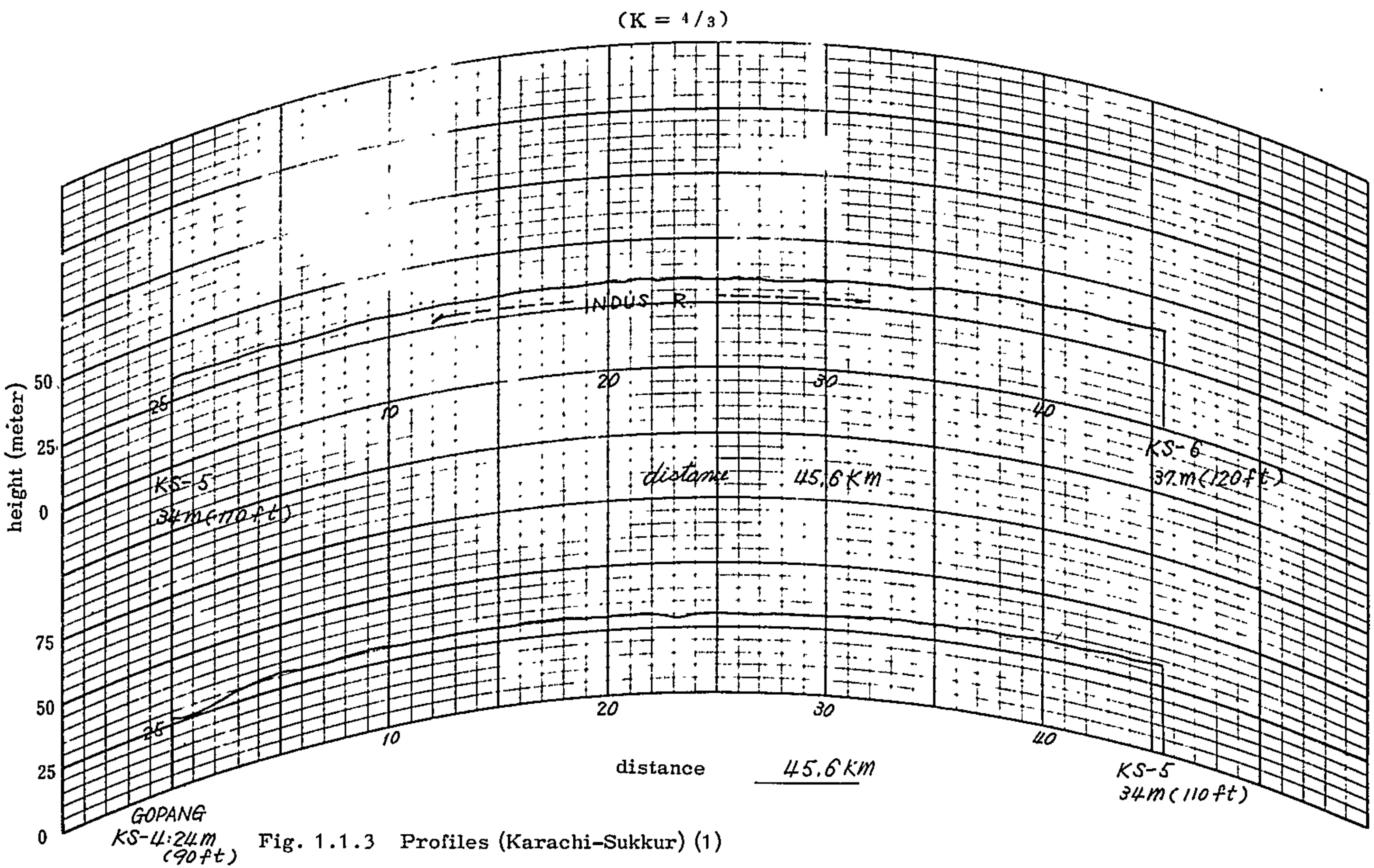


Fig. 1.1.3 Profiles (Karachi-Sukkur) (1)

(K = 4/3)

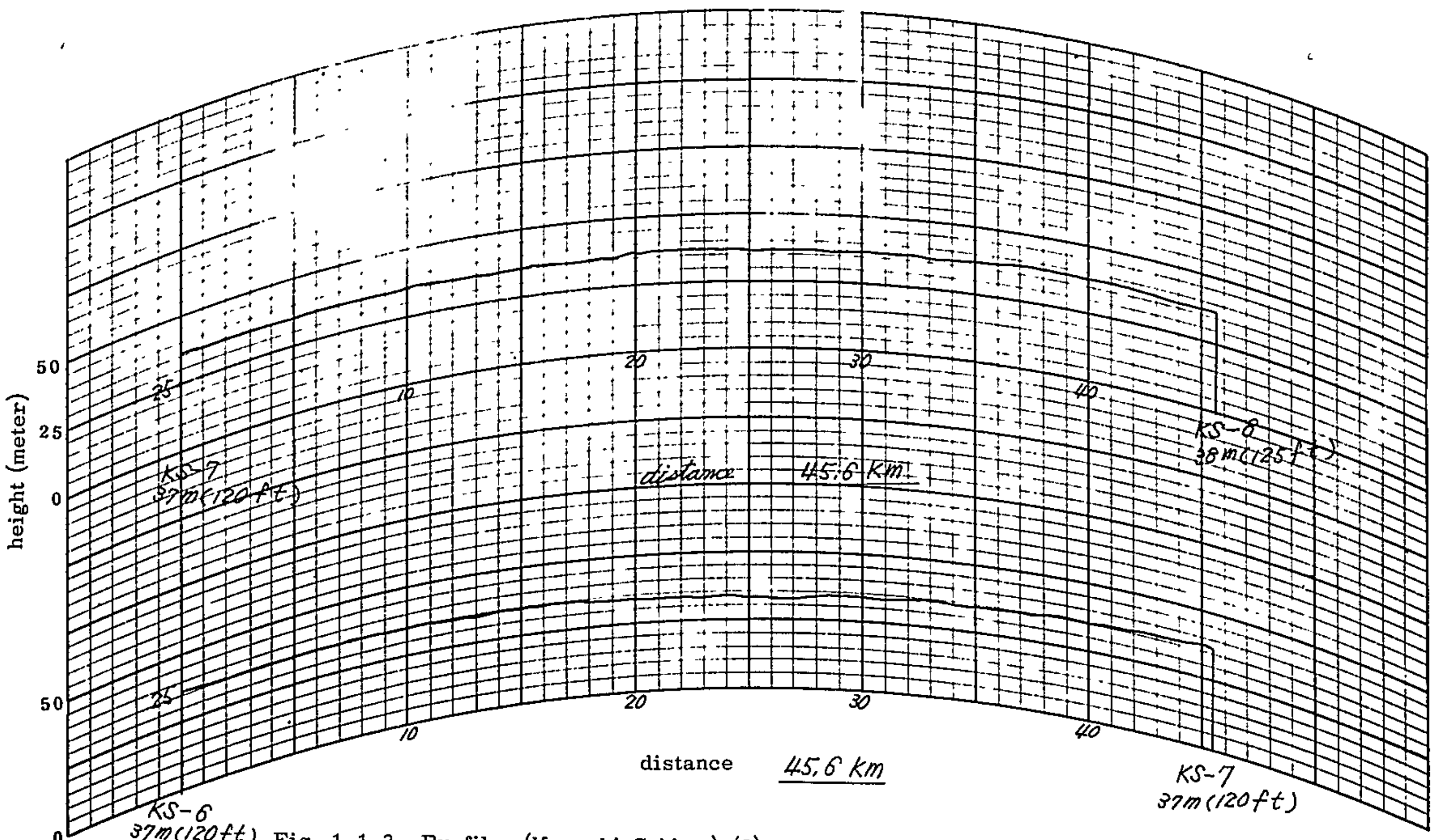


Fig. 1.1.3 Profiles (Karachi-Sukkur) (2)

(K = 4/3)

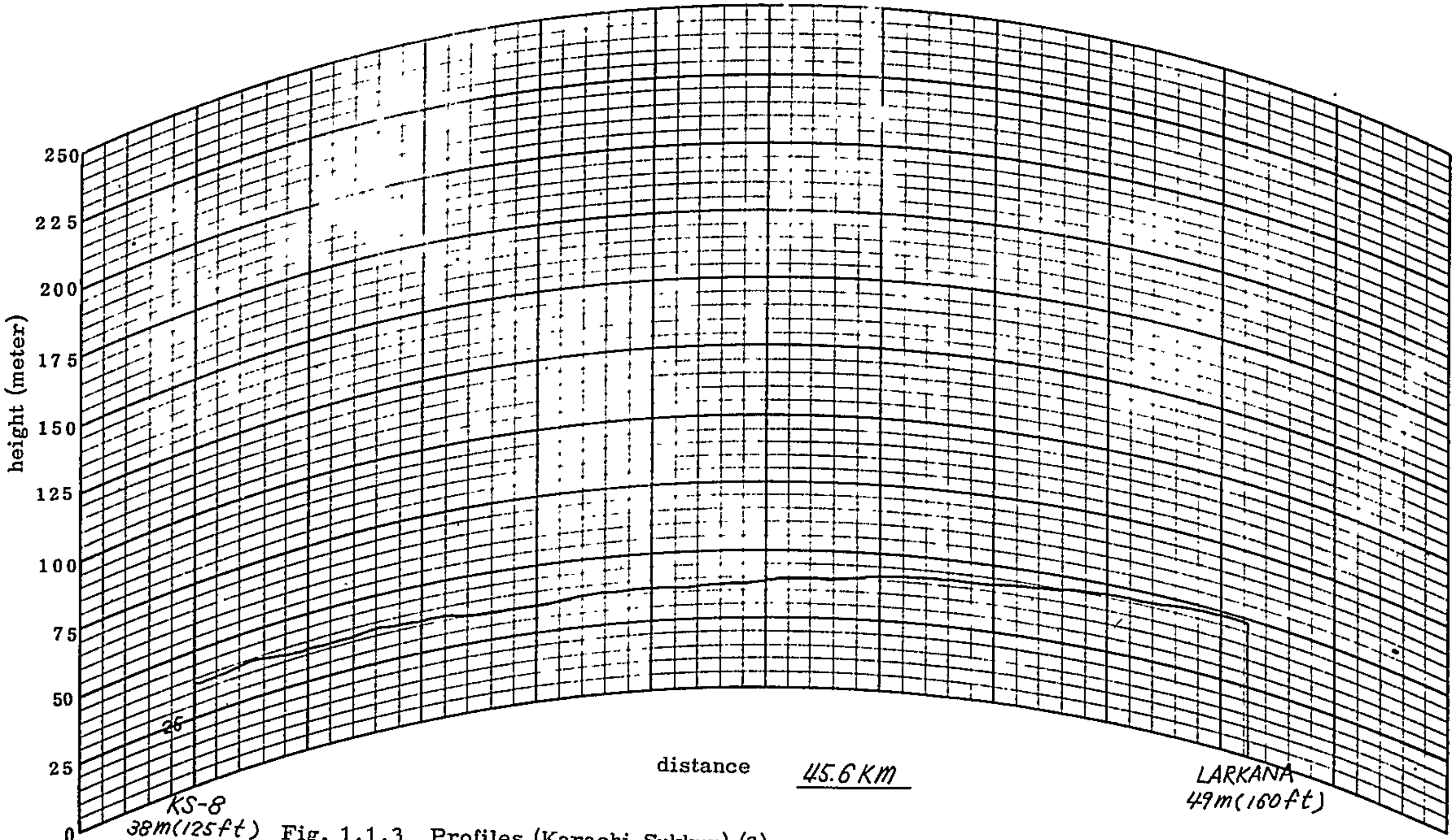


Fig. 1.1.3 Profiles (Karachi-Sukkur) (3)

1.2 Sukkur (Lakhi) - D.G. Khan - D.I. Khan

Owing to the selection of the locations which have the most easy access to the highway already constructed along the west side of the River Indus, this route is to become the criterion of low-altitude transmission route passing through the whole section. Therefore as mentioned hereinbefore, the standard distance between each repeater station which measures 50 KM is designed to be reduced by about 10 - 20%. As regards the problems of the post of reflection and over-reach, deep consideration at the time of selection is to be taken into, but as to the height of antenna final decision must be made after the detailed investigation of each reflected areas like the selection between Karachi and Sukkur.

(Note 1) In the section between Lakhi and SG-1 close attention must be given because of the great effect of reflected wave.

(Note 2) SG-1 is selected to be situated at the post about a mile off the highway in order to avoid the over-reach from KS-8.

(Note 3) Between Kashmor and Rojhan there is no highway, and during rainy season the traffic is feared to be stopped. Therefore, SG-2 (Kashmor) should be taken care of from the quarters of Lakhi and SG-4 (Rojhan) from the Rajampur quarters respectively.

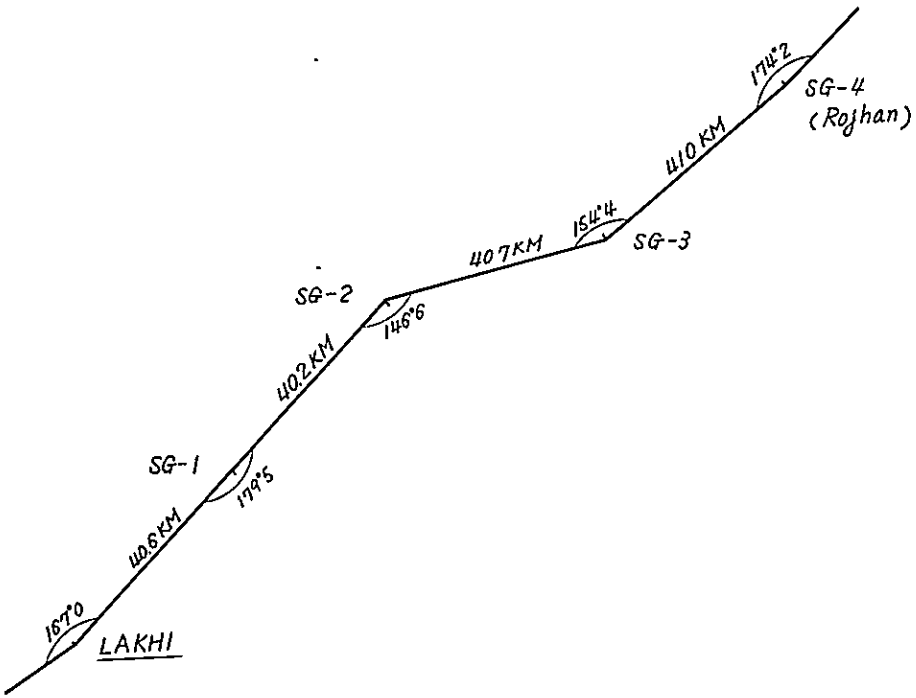


Fig. 1.2.1 Angles and repeater spacings (Sukkur-D.I.Khan) (1)

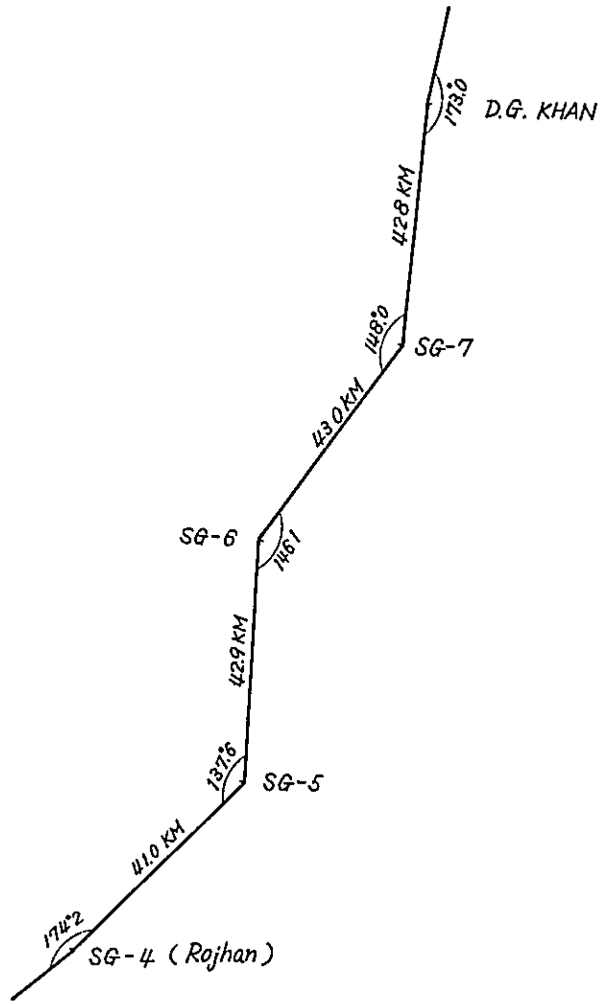


Fig. 1.2.1 Angles and repeater spacings (Sukkur-D.I.Khan) (2)

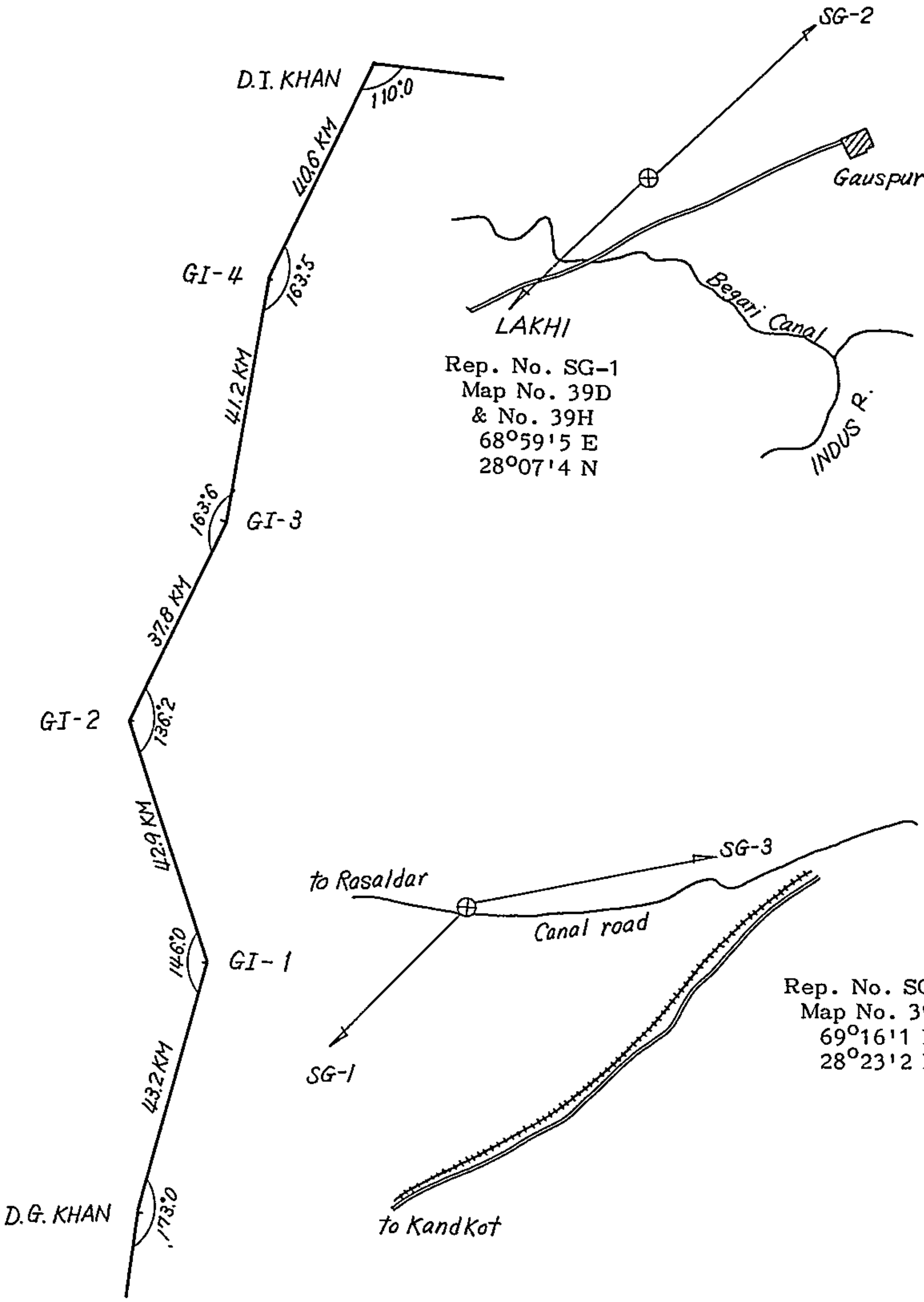
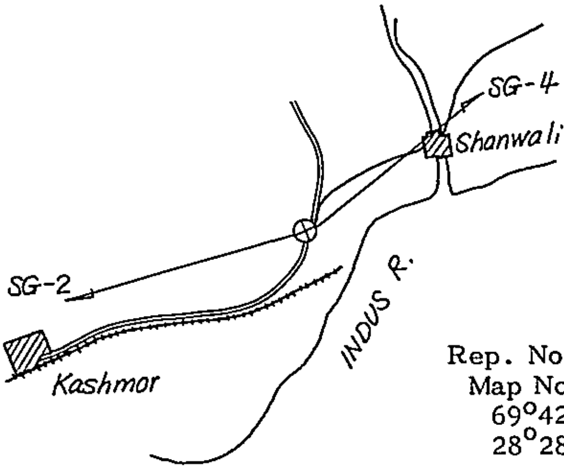
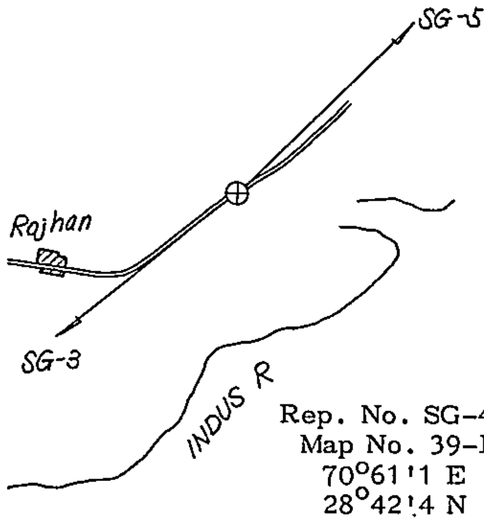


Fig.1.2.1 Angles and repeater spacings (Sukkur-D.I.Khan) (3)



Rep. No. SG-3
Map No. 39-H
69°42'1 E
28°28'2 N



Rep. No. SG-4 (Rojhan)
Map No. 39-L & No. 39-H
70°61'1 E
28°42'.4 N

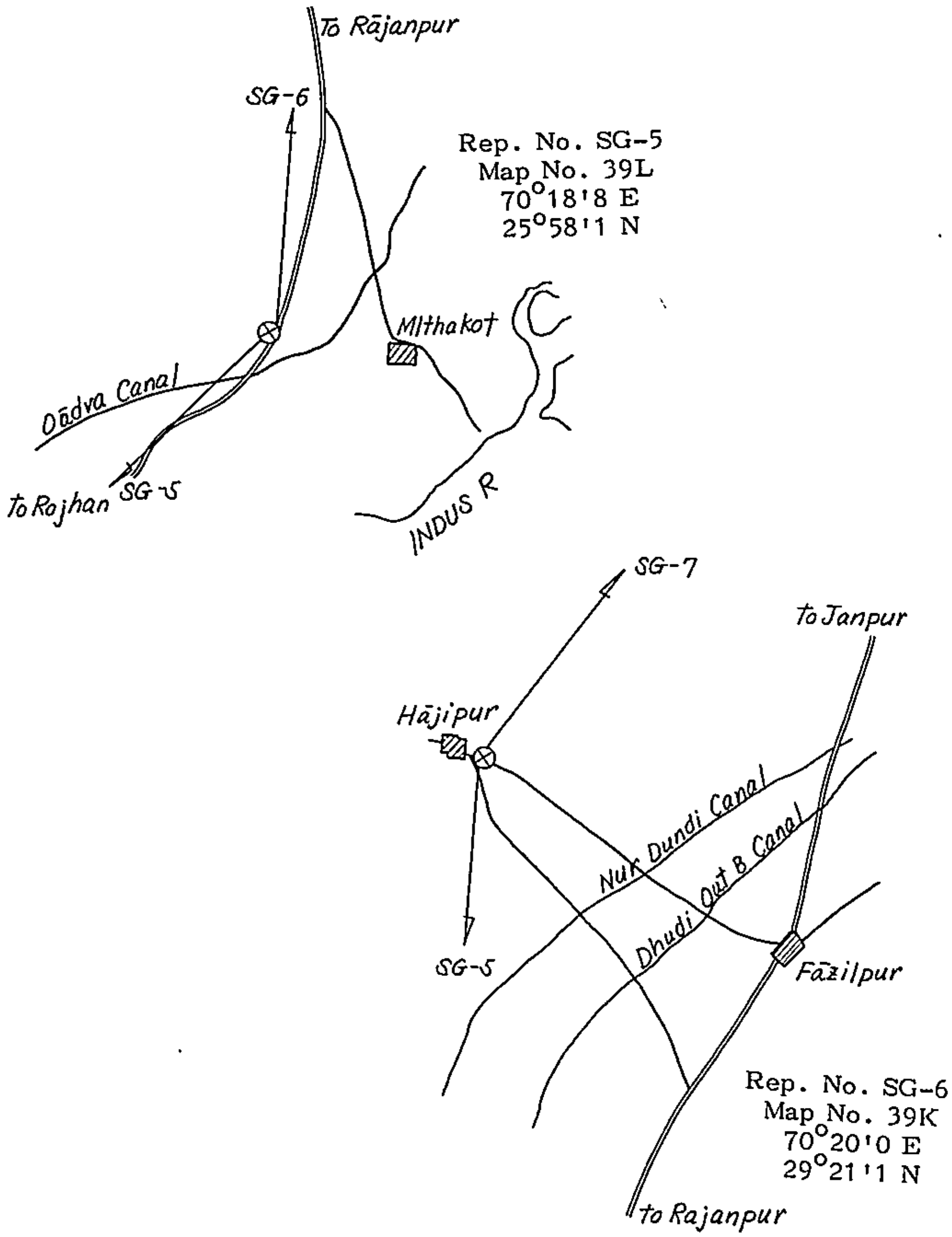
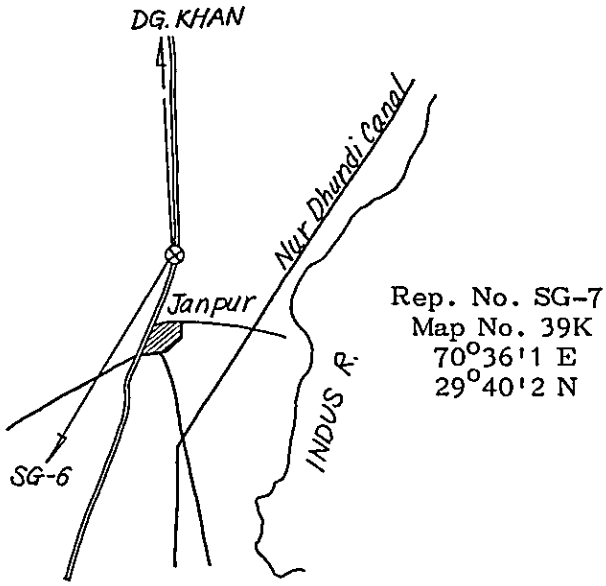
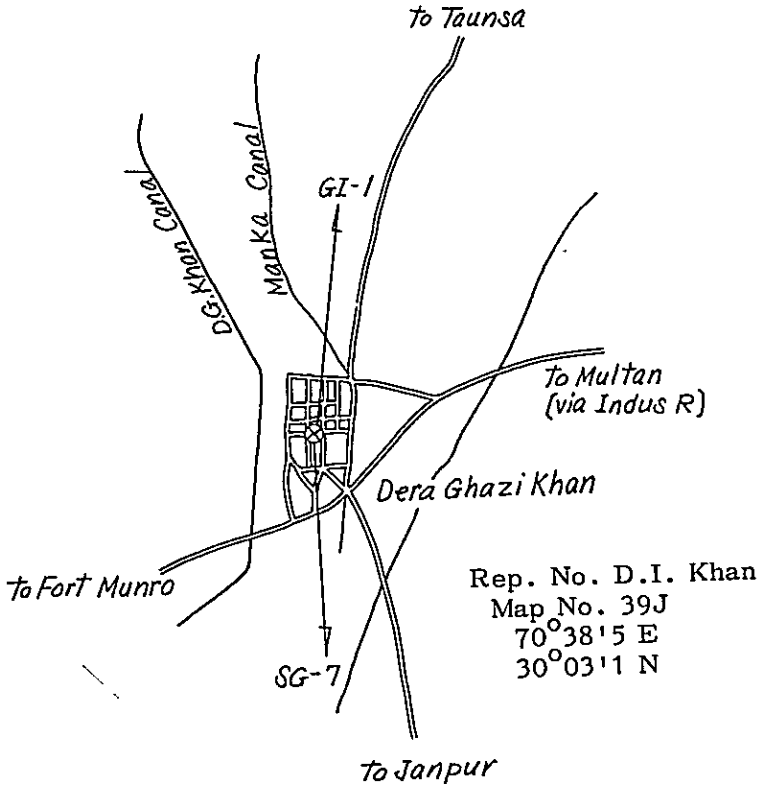
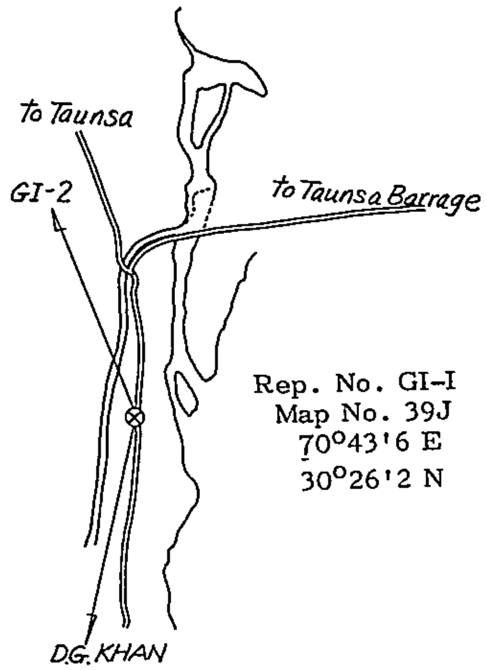


Fig. 1.2.2 Sketch map of the station sites (Sukkur–D.I. Khan) (1)


DG. KHAN
Nur Dhundi Canal
Janpur
Rep. No. SG-7
Map No. 39K
70°36'1 E
29°40'2 N
INDUS R.
SG-6


to Taunsa
D.G.Khan Canal
Manka Canal
GI-1
to Multan
(via Indus R)
Dera Ghazi Khan
to Fort Munro
Rep. No. D.I. Khan
Map No. 39J
70°38'5 E
30°03'1 N
SG-7
to Janpur



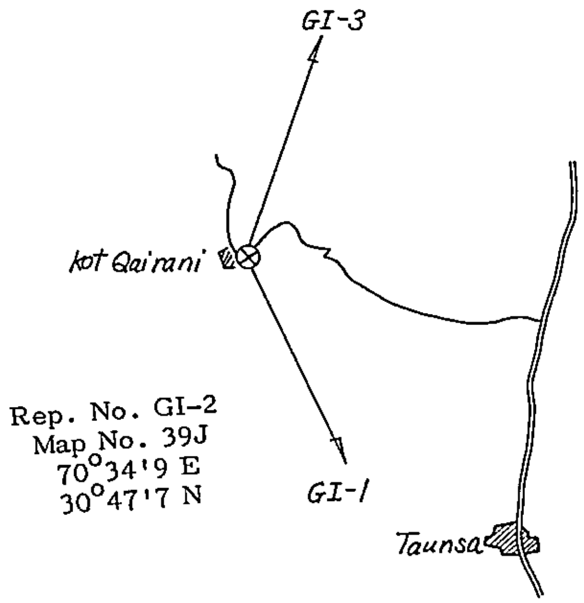
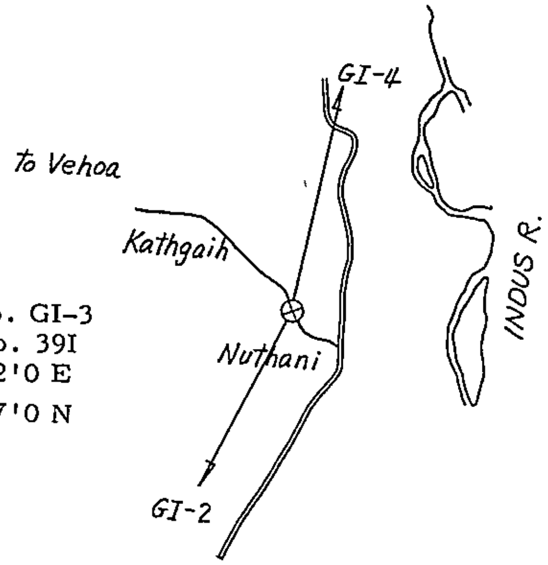
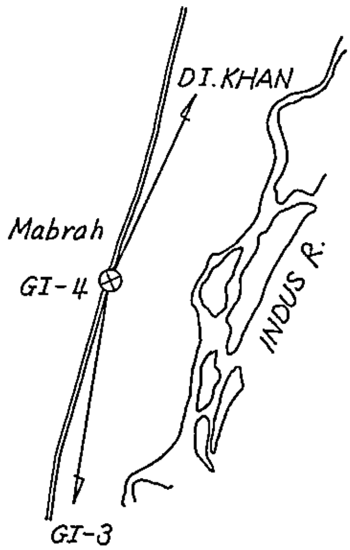


Fig. 1.2.2 Sketch maps of the station sites (Sukkur-D.I. Khan) (2)



Rep. No. GI-3
Map No. 39I
70°42'0 E
31°07'0 N



Rep. No. GI-4
Map No. 39 I
70°44'6
31°29'0

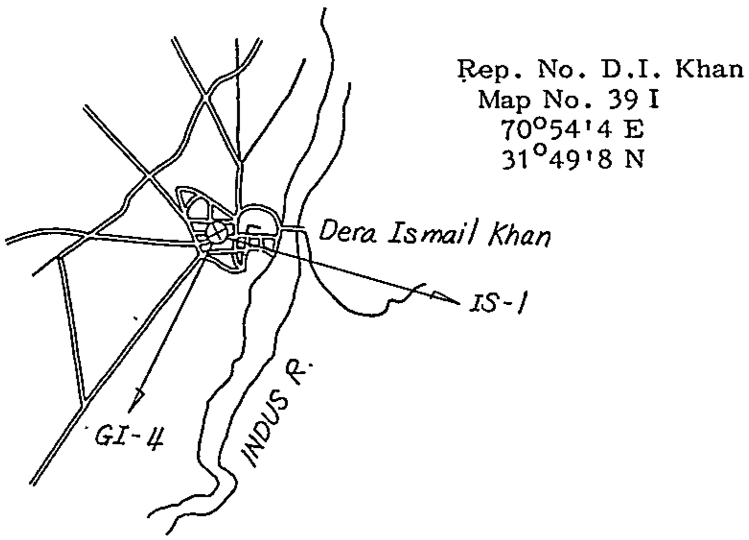


Fig. 1.2.2 Sketch map of the station sites (Sukkur-D.I. Khan) (3)

(K = 4/3)

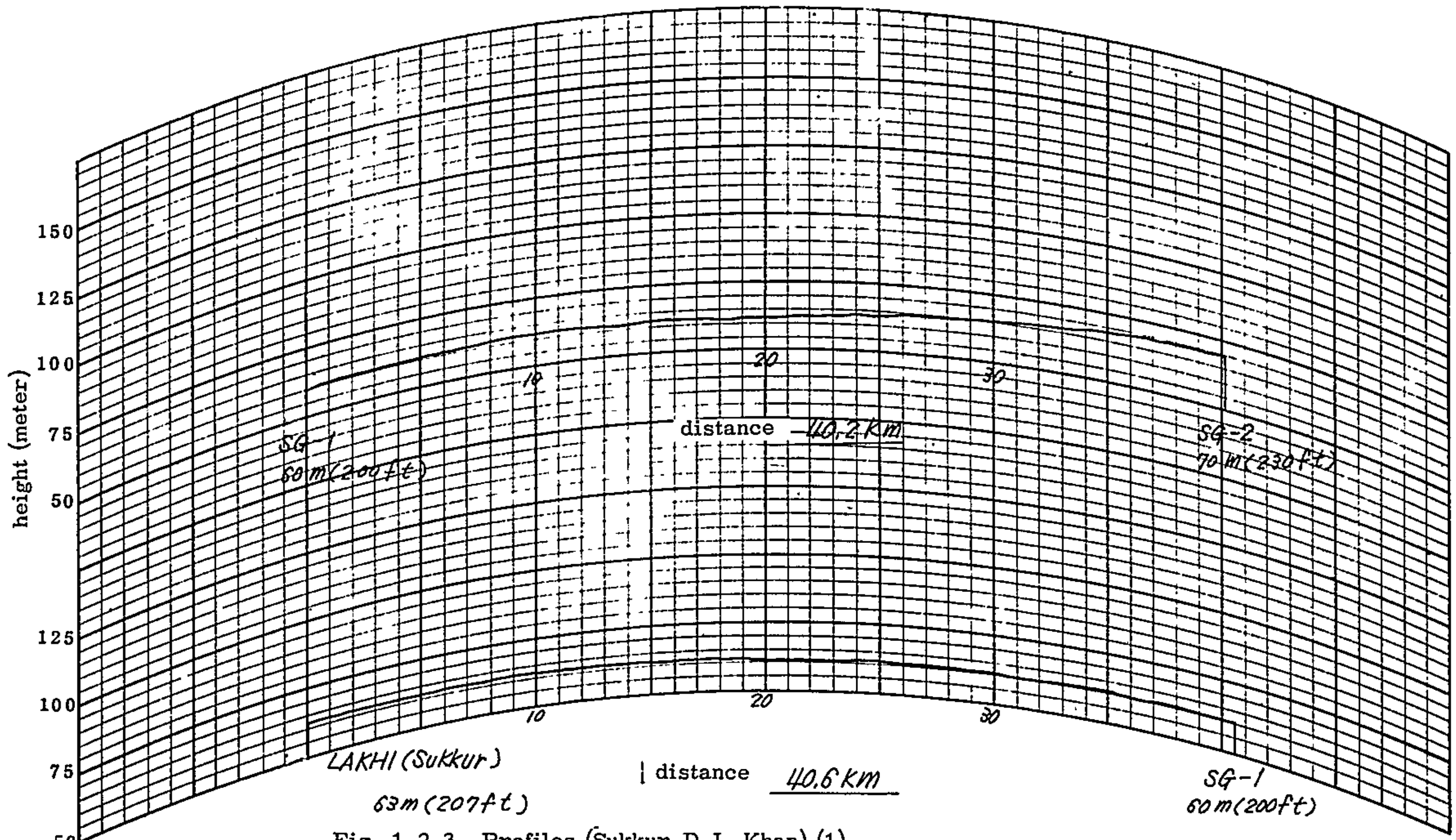


Fig. 1.2.3 Profiles (Sukkur-D.I. Khan) (1)

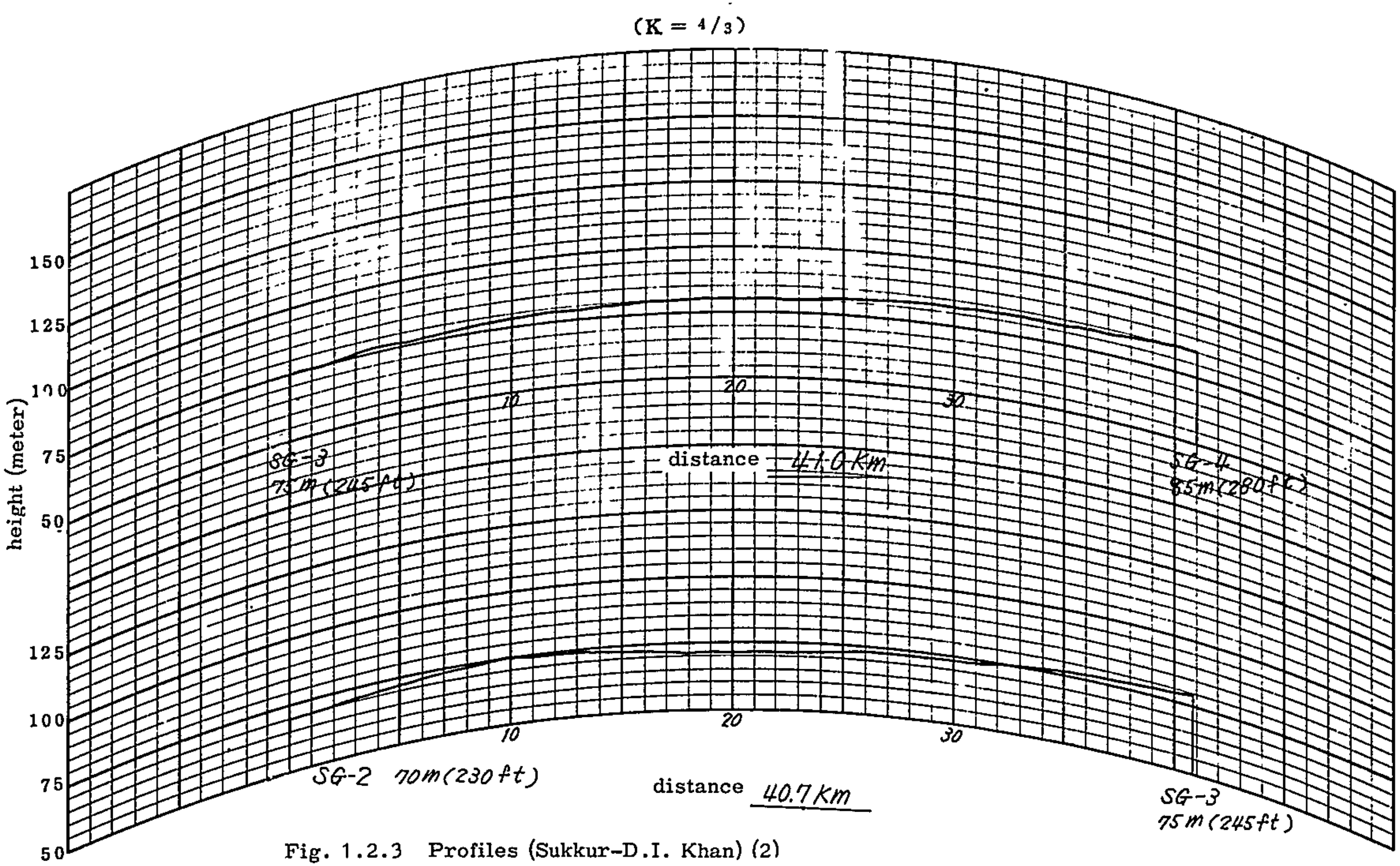


Fig. 1.2.3 Profiles (Sukkur-D.I. Khan) (2)

(K = 4/3)

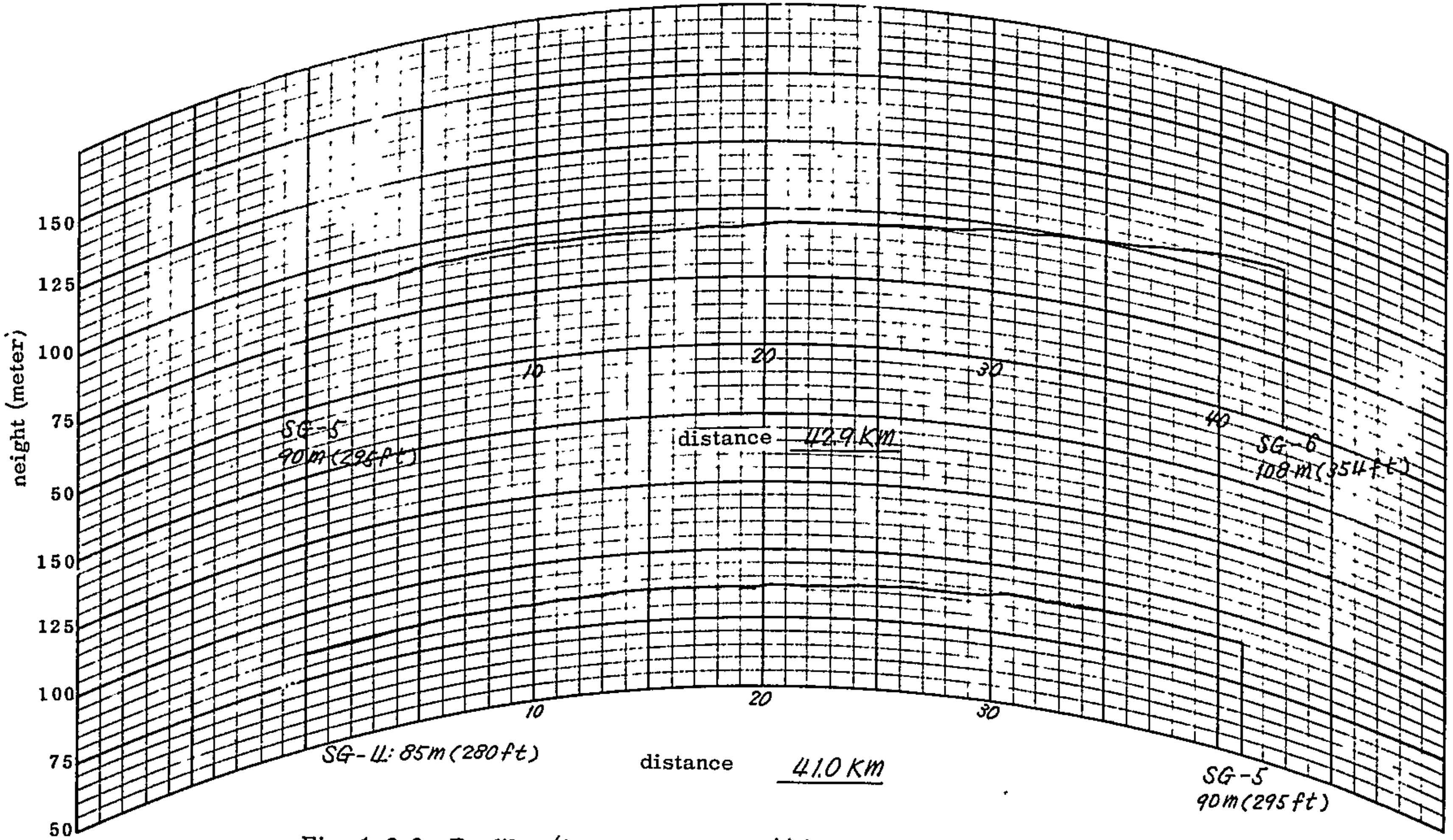


Fig. 1.2.3 Profiles (Sukkur-D.I. Khan)(3)

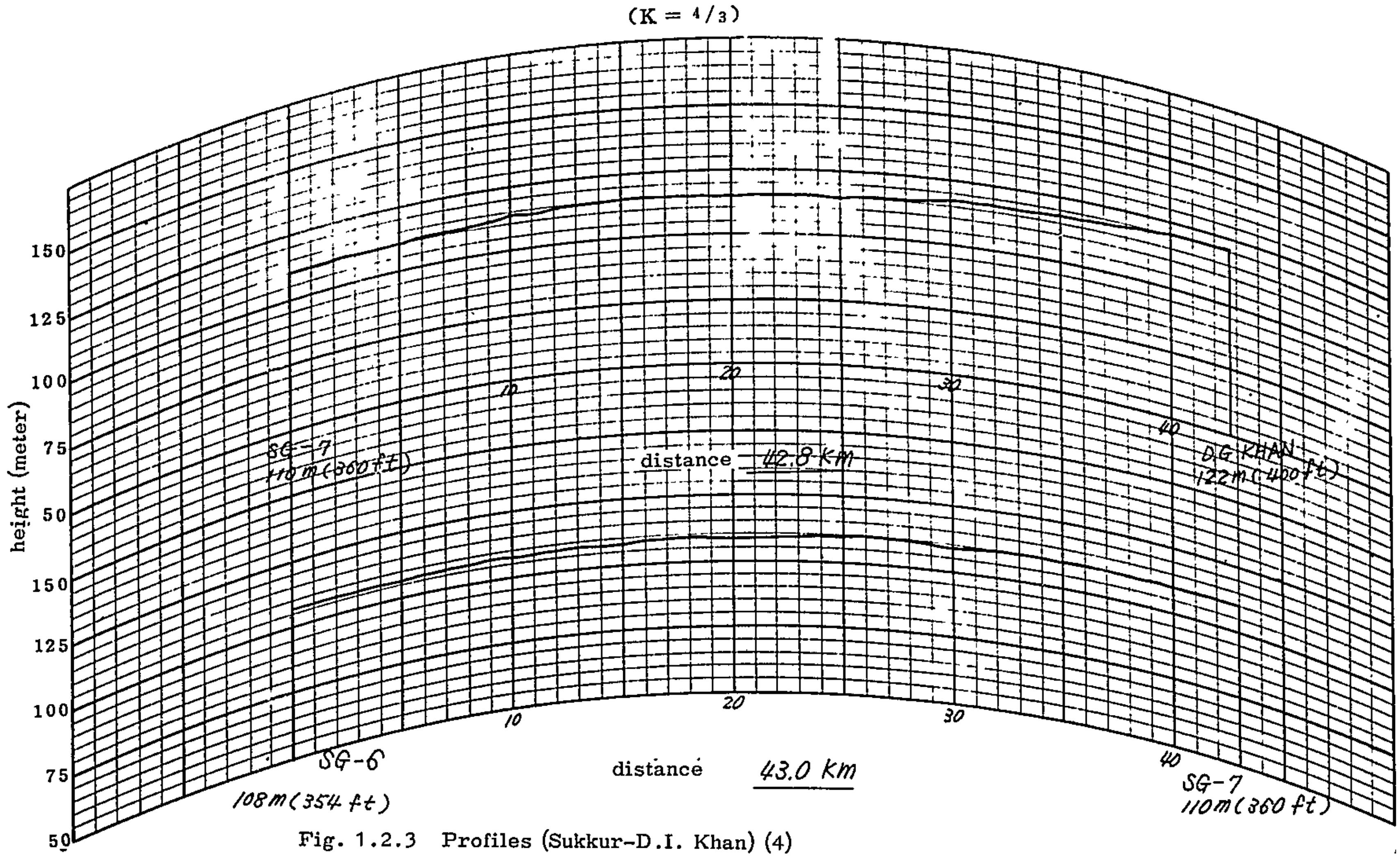


Fig. 1.2.3 Profiles (Sukkur-D.I. Khan) (4)

(K = 4/3)

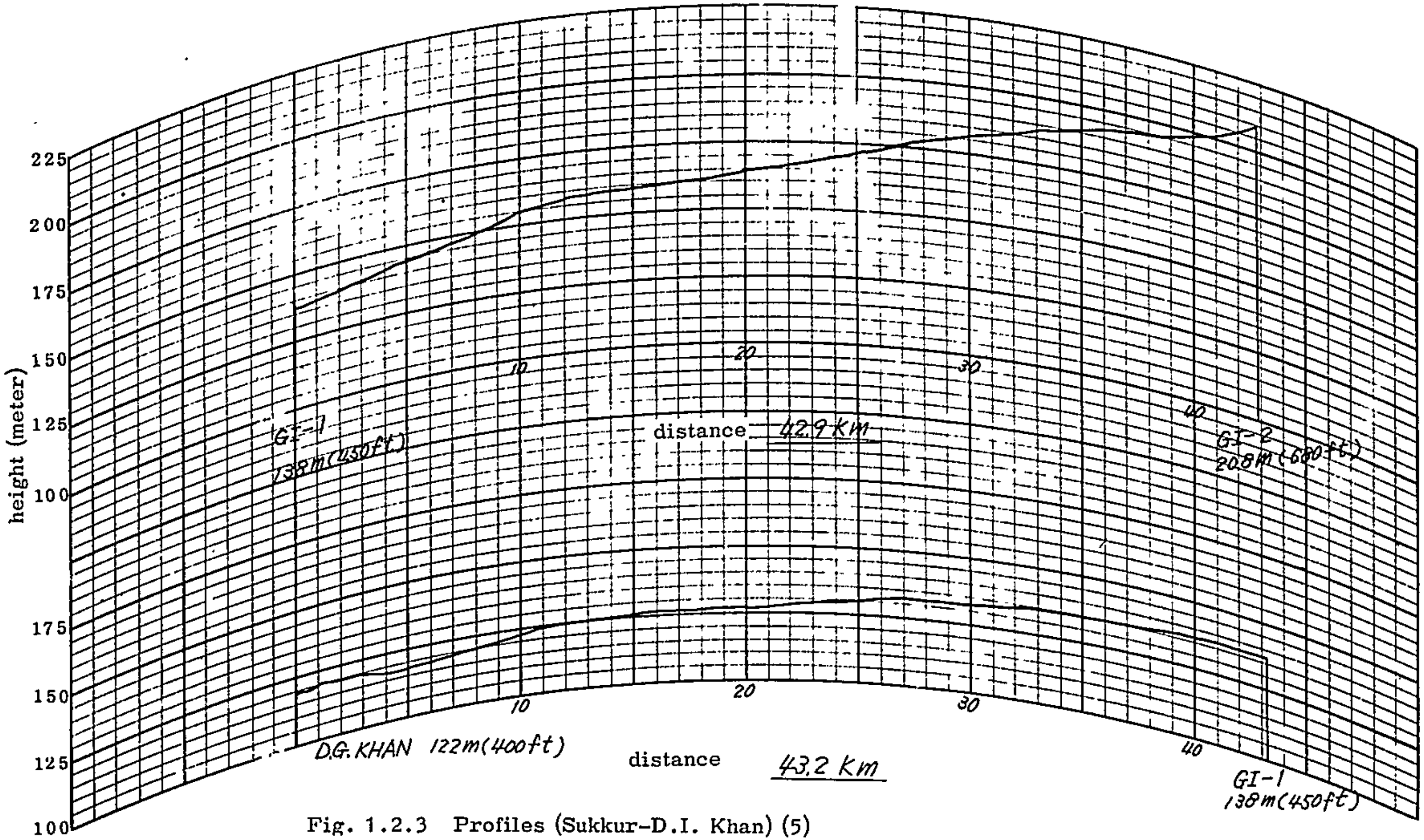


Fig. 1.2.3 Profiles (Sukkur-D.I. Khan) (5)

(K = 4/3)

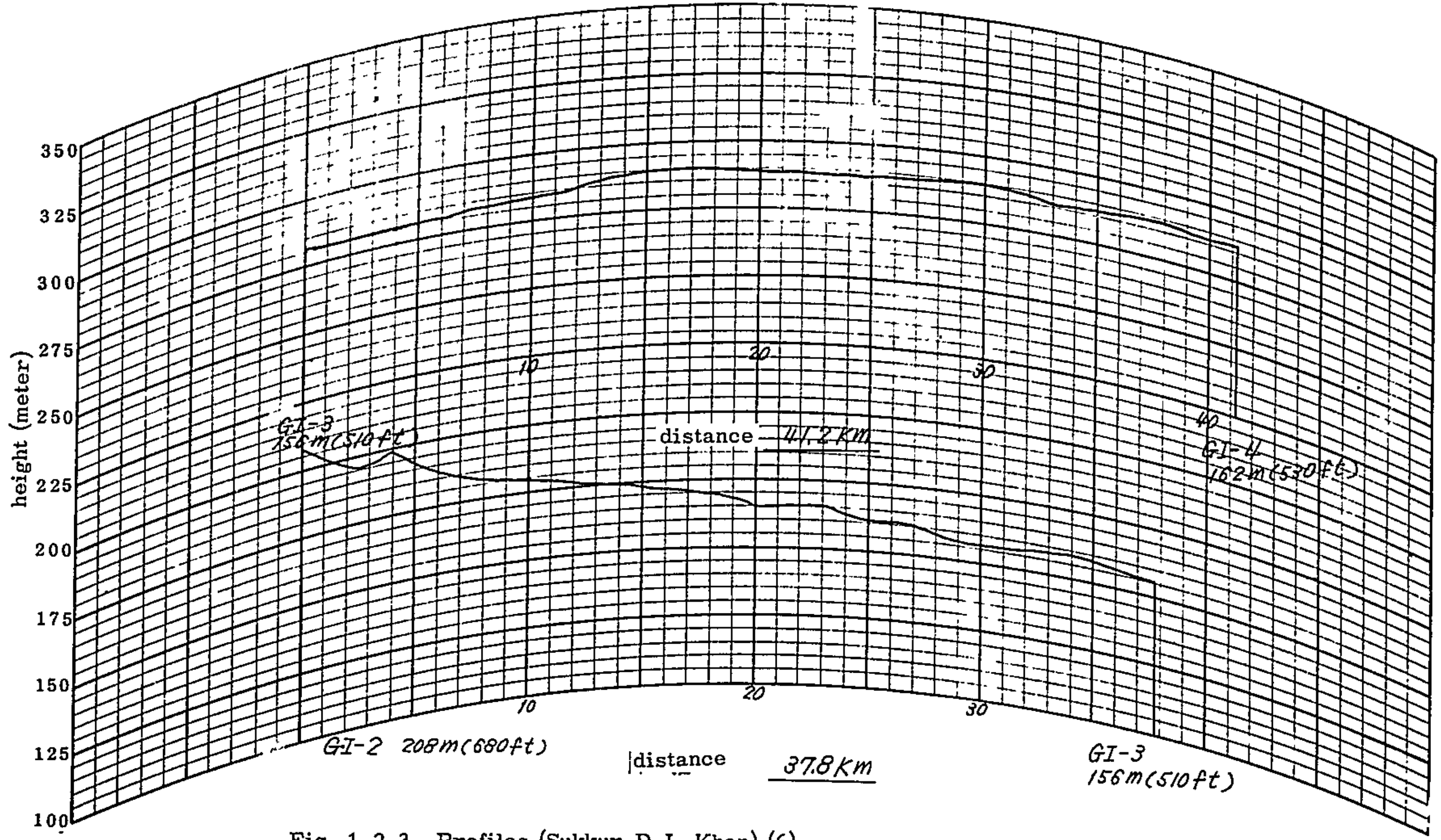


Fig. 1.2.3 Profiles (Sukkur-D.I. Khan) (6)

(K = 4/3)

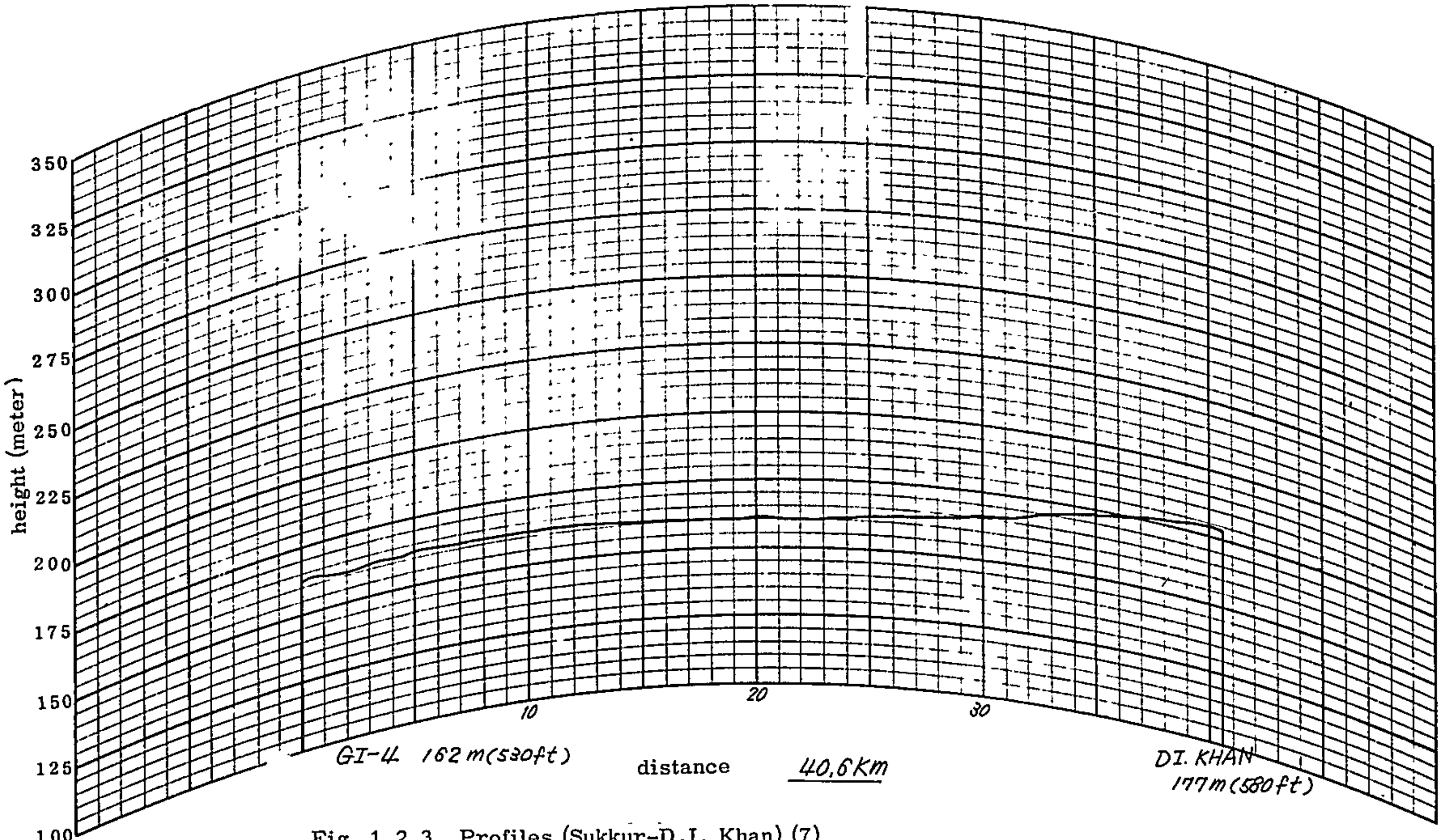


Fig. 1.2.3 Profiles (Sukkur-D.I. Khan) (7)

1.3 D.I. Khan-Sargodha

A great part of the configuration of the transmission route is uneven and bears noticeable ups and downs, but no big difference is apparent pertaining to the conditions, as the route is of low-altitude same as the one aforementioned. However, the road conditions are very good and in this section there is almost no question in relation to construction and maintenance.

(Note) Between D.I. Khann and IS-1 attention must be paid to the reflected wave for the route is to cross the River Indus. Therefore, the height of antenna from IS-1 to D.I. Khan is needed to be installed lower than those of D.I. Khan.

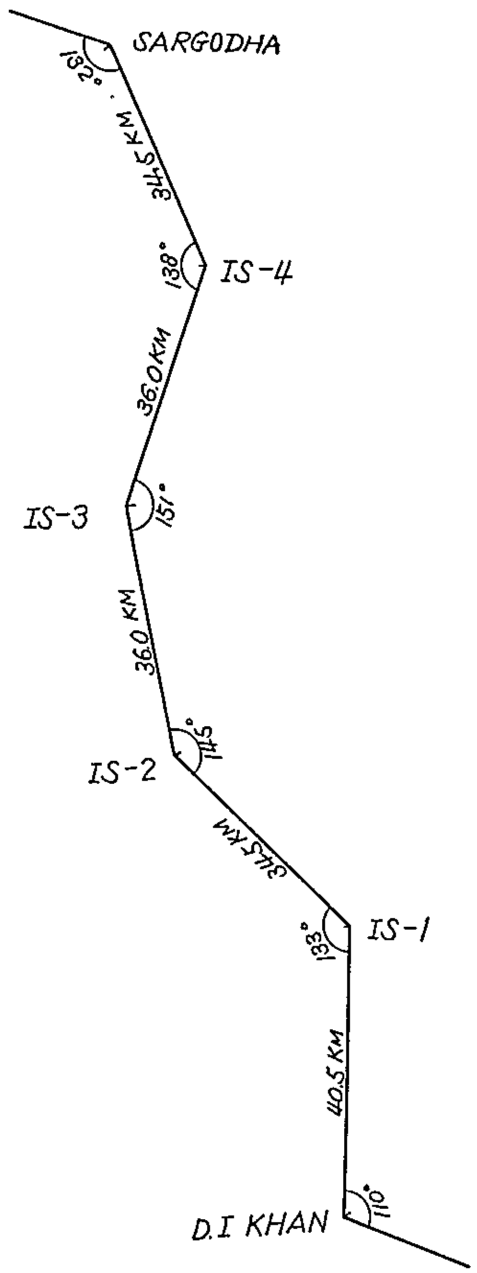


Fig. 1.3.1 Angles and repeater spacings (D.I. Khan-Sargodha)

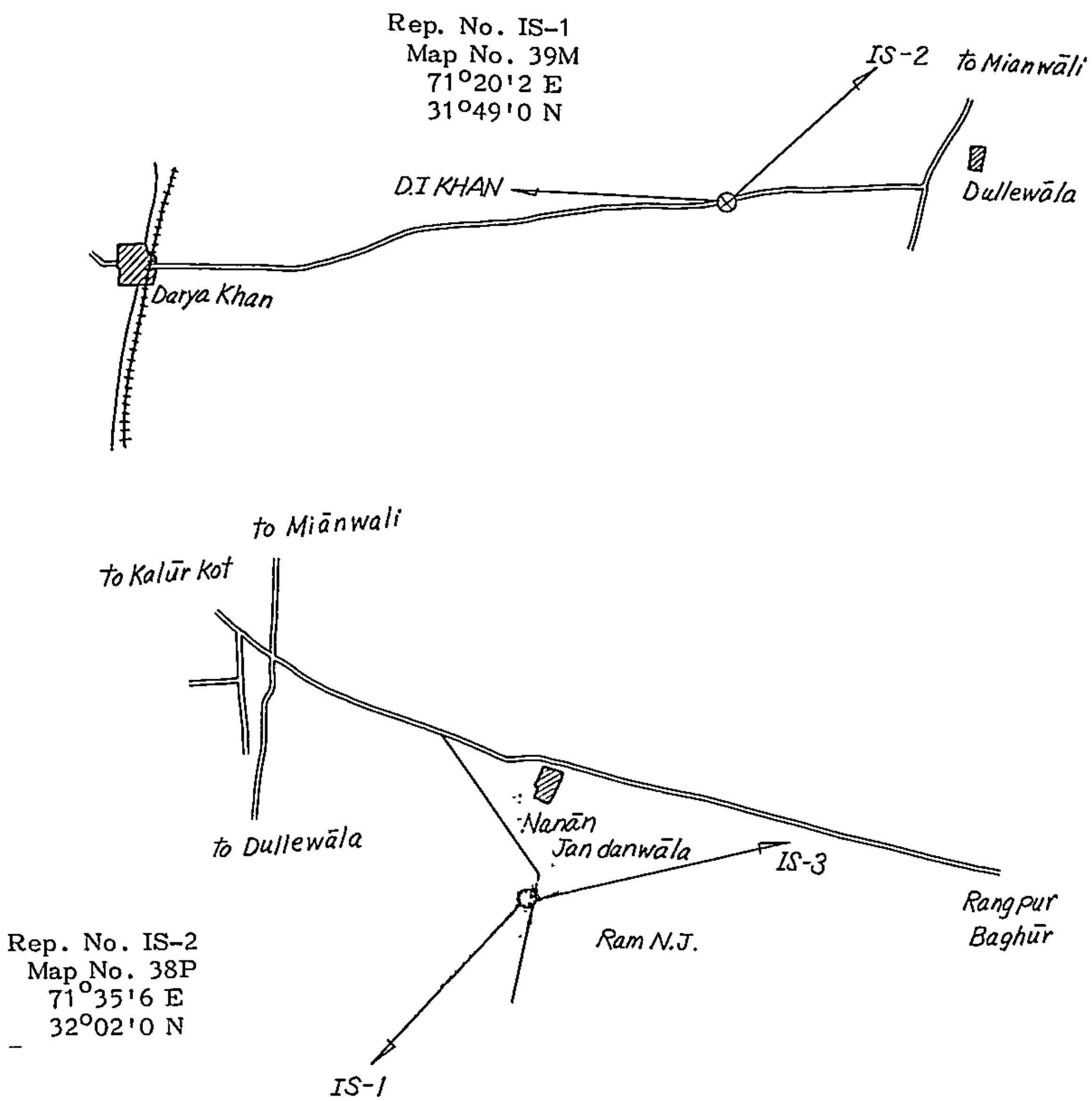
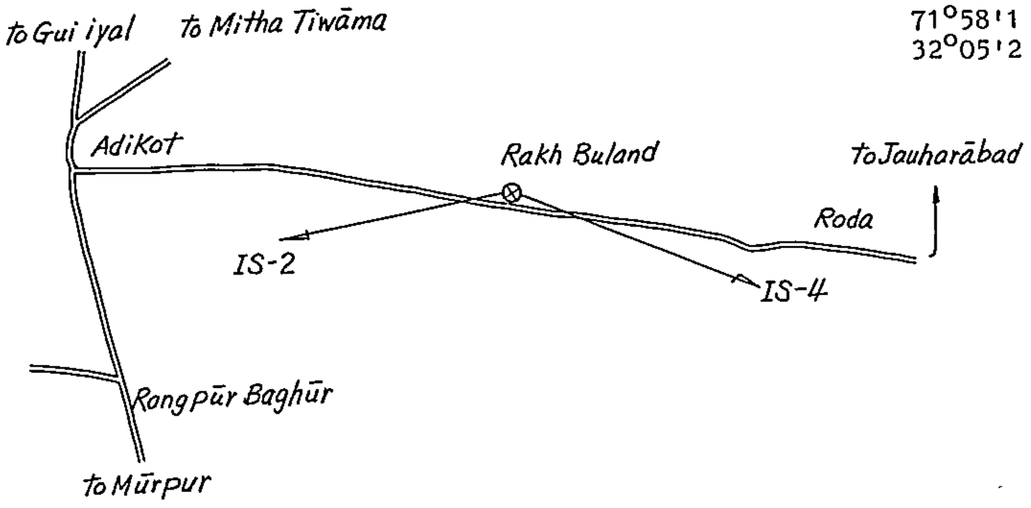
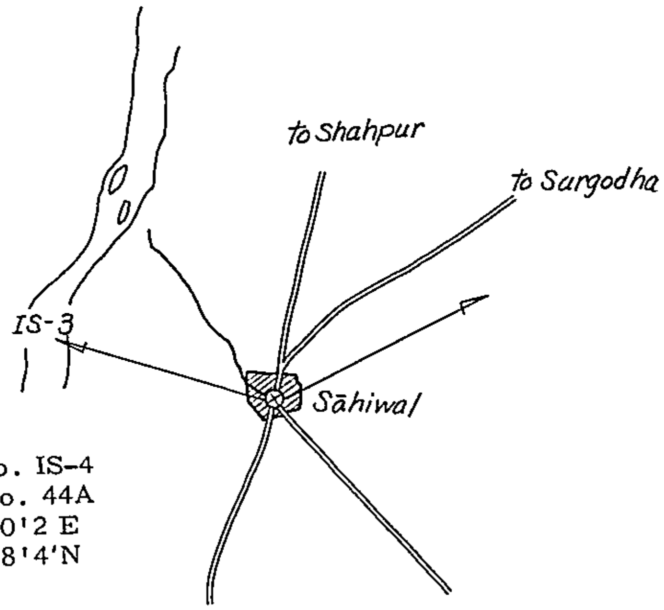


Fig. 1.3.2 Sketch map of the station sites (D.I. Khan-Sargodha) (1)

Rep. No. IS-3
Map No. 38P
$71^{\circ}58'1$ E
$32^{\circ}05'2$ N





Rep. No. IS-4
Map No. 44A
$72^{\circ}20'2$ E
$31^{\circ}58'4'$N

Rep. No. SARGODHA
Map No. 43D
73°39'8 E
32°05'0 N

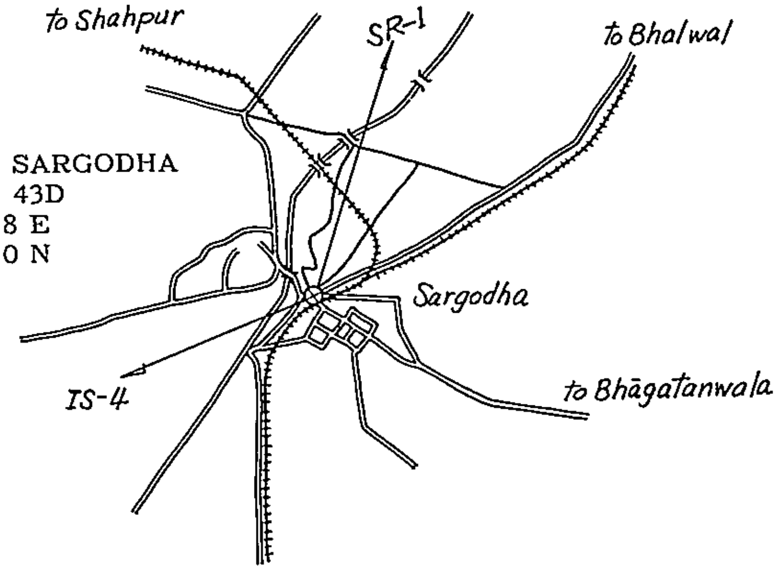


Fig. 1.3.2. Sketch map of the station sites (D.I. Khan–Sargodha) (2)

(K = 4/3)

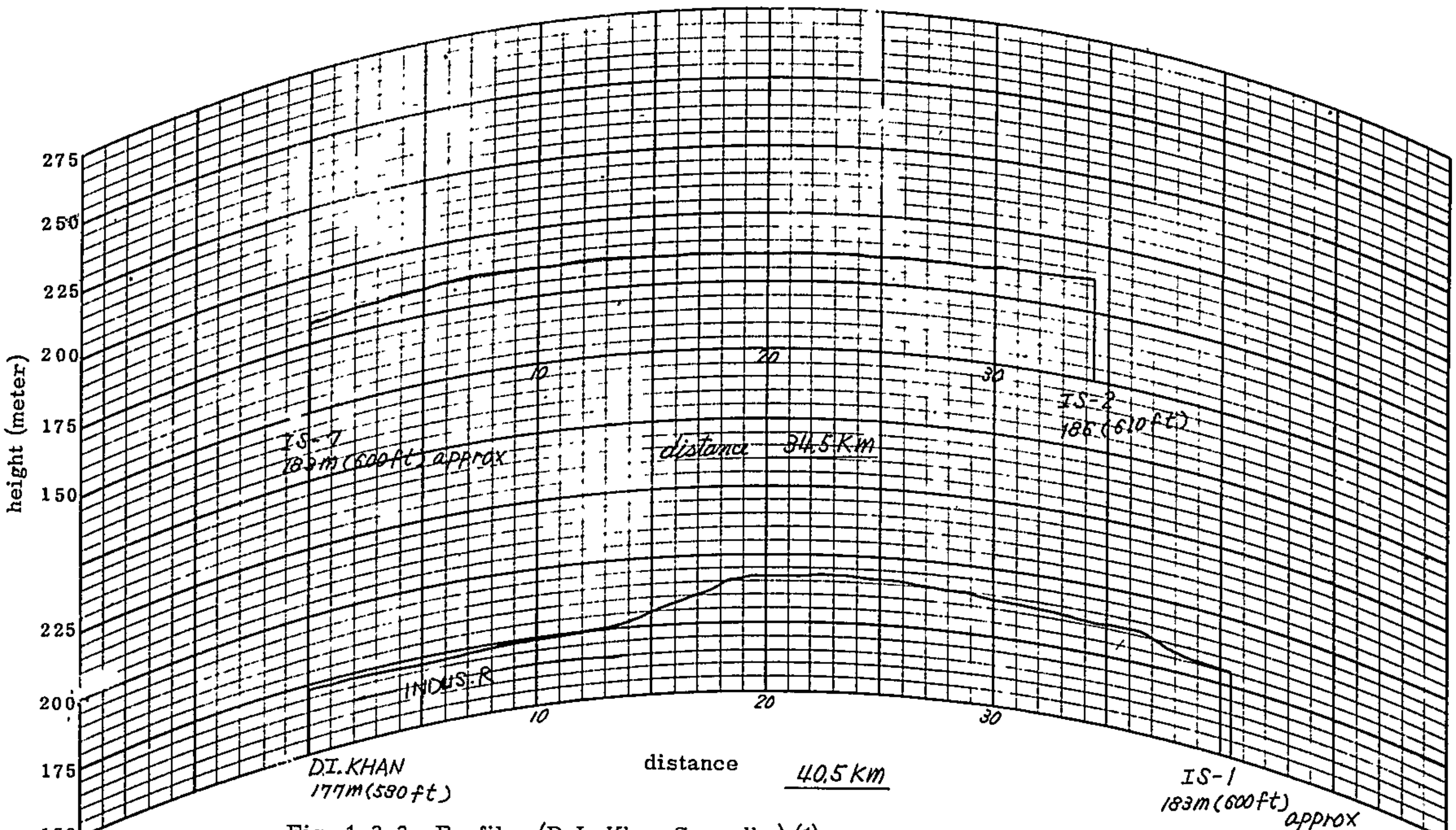


Fig. 1.3.3 Profiles (D.I. Khan-Sargodha) (1)

(K = 4/3)

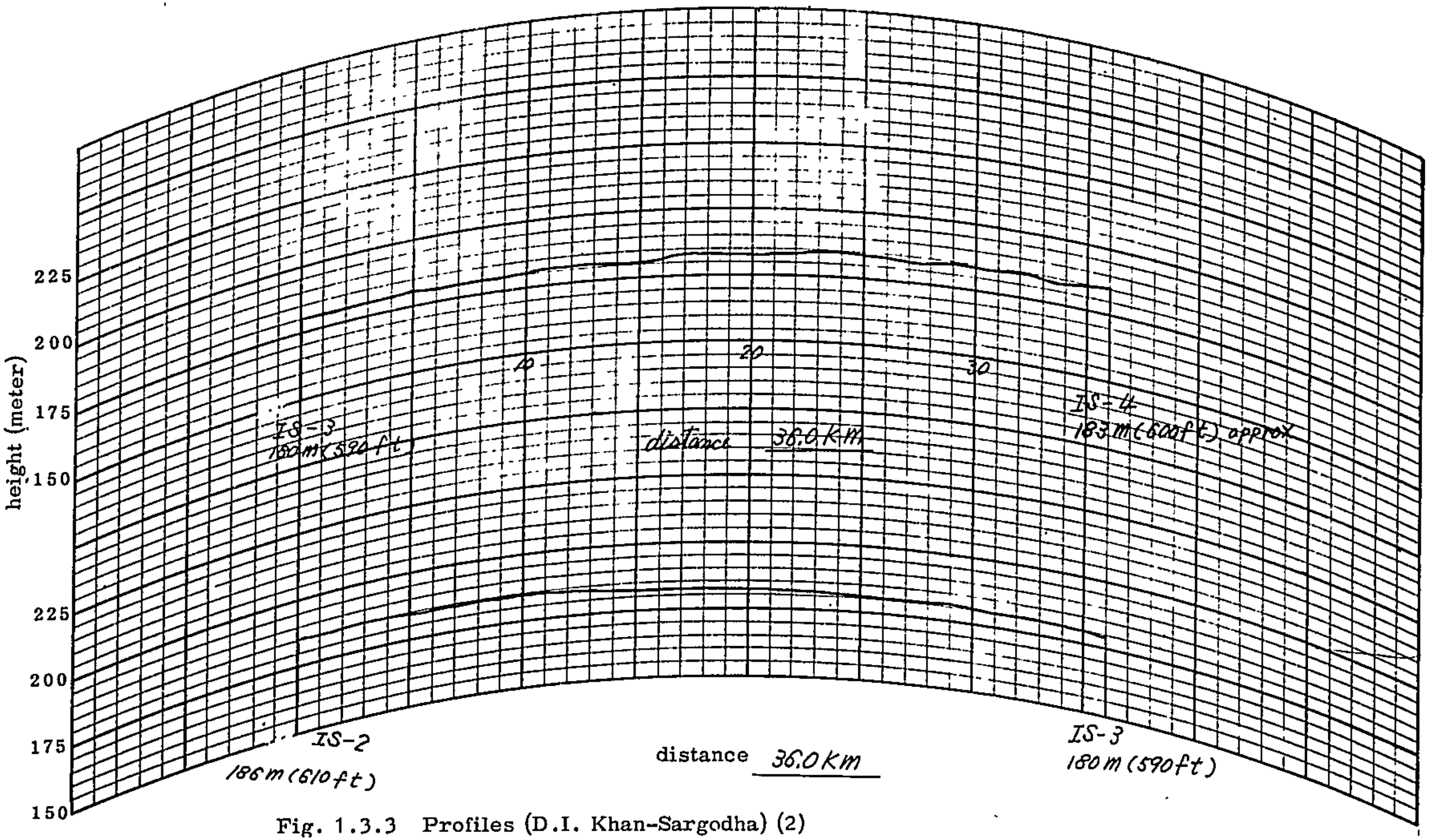


Fig. 1.3.3 Profiles (D.I. Khan-Sargodha) (2)

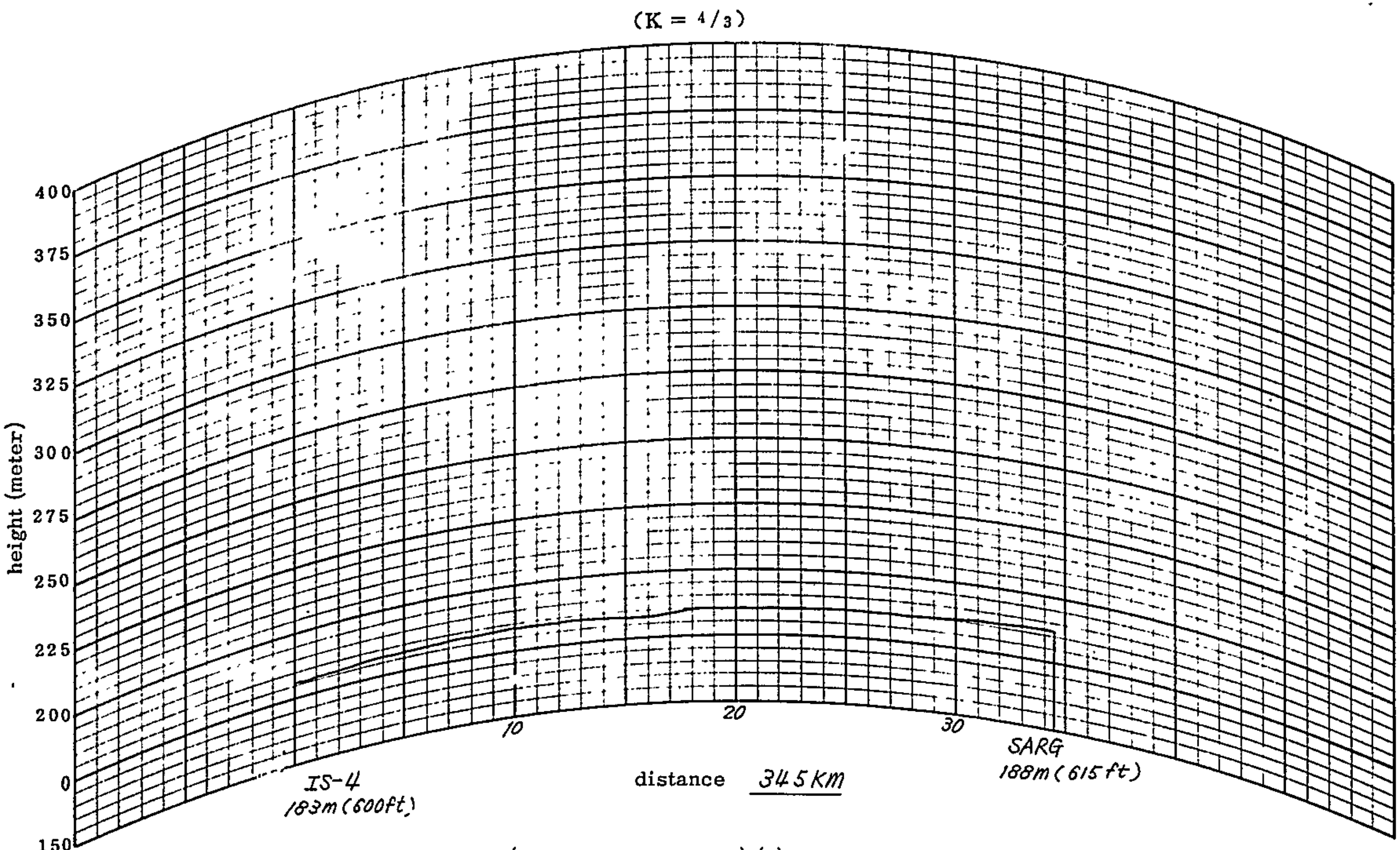


Fig. 1.3.3 Profiles (D.I. Khan-Sargodha) (3)

1.4 Sargodha - Rawalpindi

The areas north of Sargodha gradually becomes mountainous and the conditions for propagation improves, but it is necessary to pay close attention to the clearance of ridge near the route. There is not so much problem in relation to the construction of the access road for exclusive use.

(Note 1) As regards the section between Sargodha and SK-1, concurrent use of the space diversity system is most desirable.

(Note 2) The site of the location of SR-1 should be set at the place, scraping north slope of the triangle point at the post scheduled. The height of antenna at the point of SR-1 should be decided after the strict measurement of the clearance of the ridge (About 6.5 km from SR-1 to the direction of SR-2)

(Note 3) There is a ridge almost in the middle between SR-2 and Rawalpindi and the height of antenna of both sections should be decided upon strict measurement of clearance of this ridge.

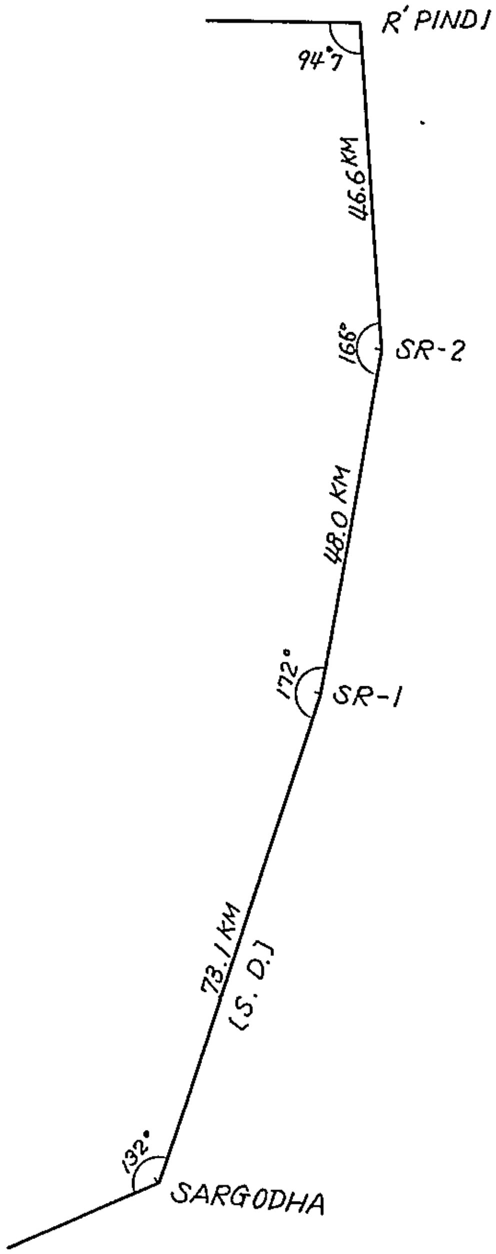
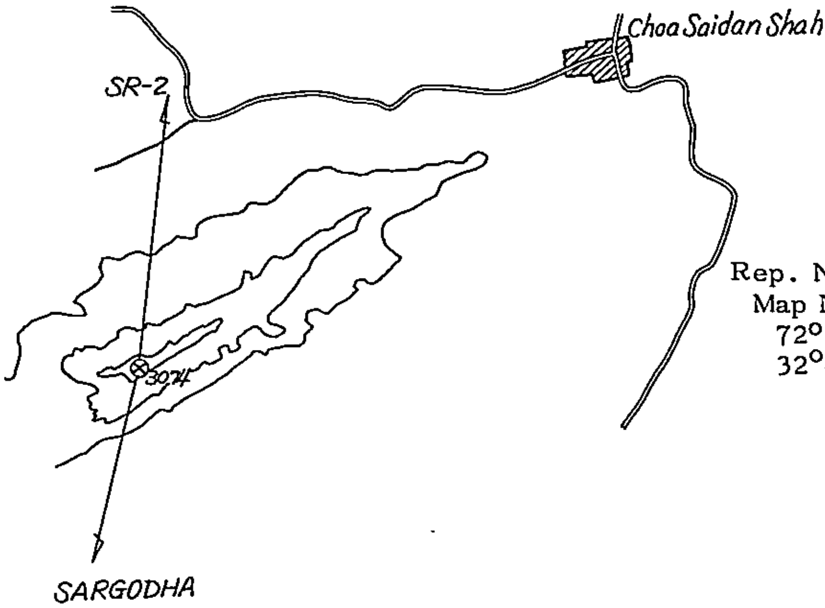
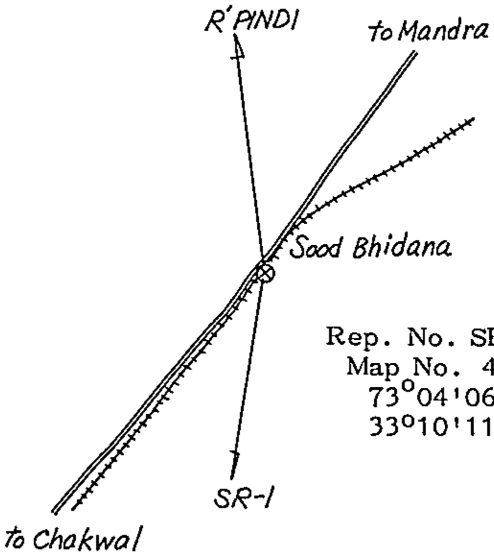


Fig. 1.4.1 Angles and repeater spacings (Sargodha-Rawalpindi)



Rep. No. SR-1
Map No. 43D/14
72°56'52"E
32°42'14" N



Rep. No. SR-2
Map No. 43G/4
73°04'06"E
33°10'11"N

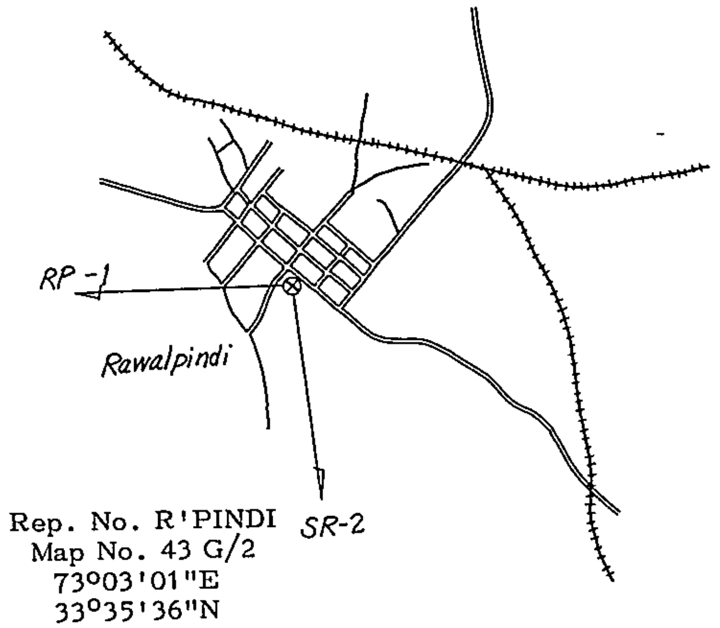


Fig. 1.4.2 Sketch map of the station sites (Sargodha-Rawalpindi)

(K = 4/3)

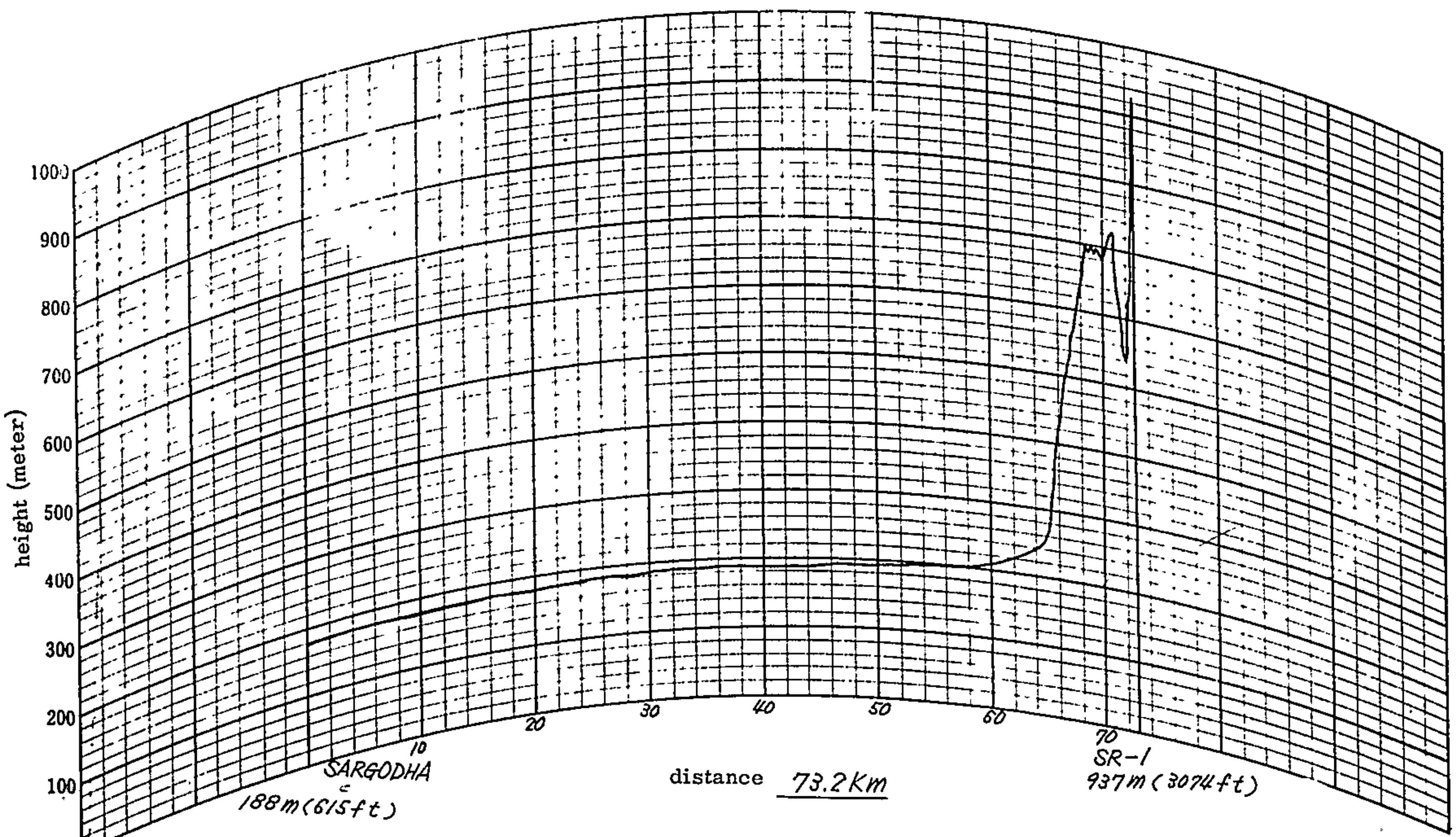


Fig. 1.4.3 Profiles (Sargodha-Rawalpindi) (1)

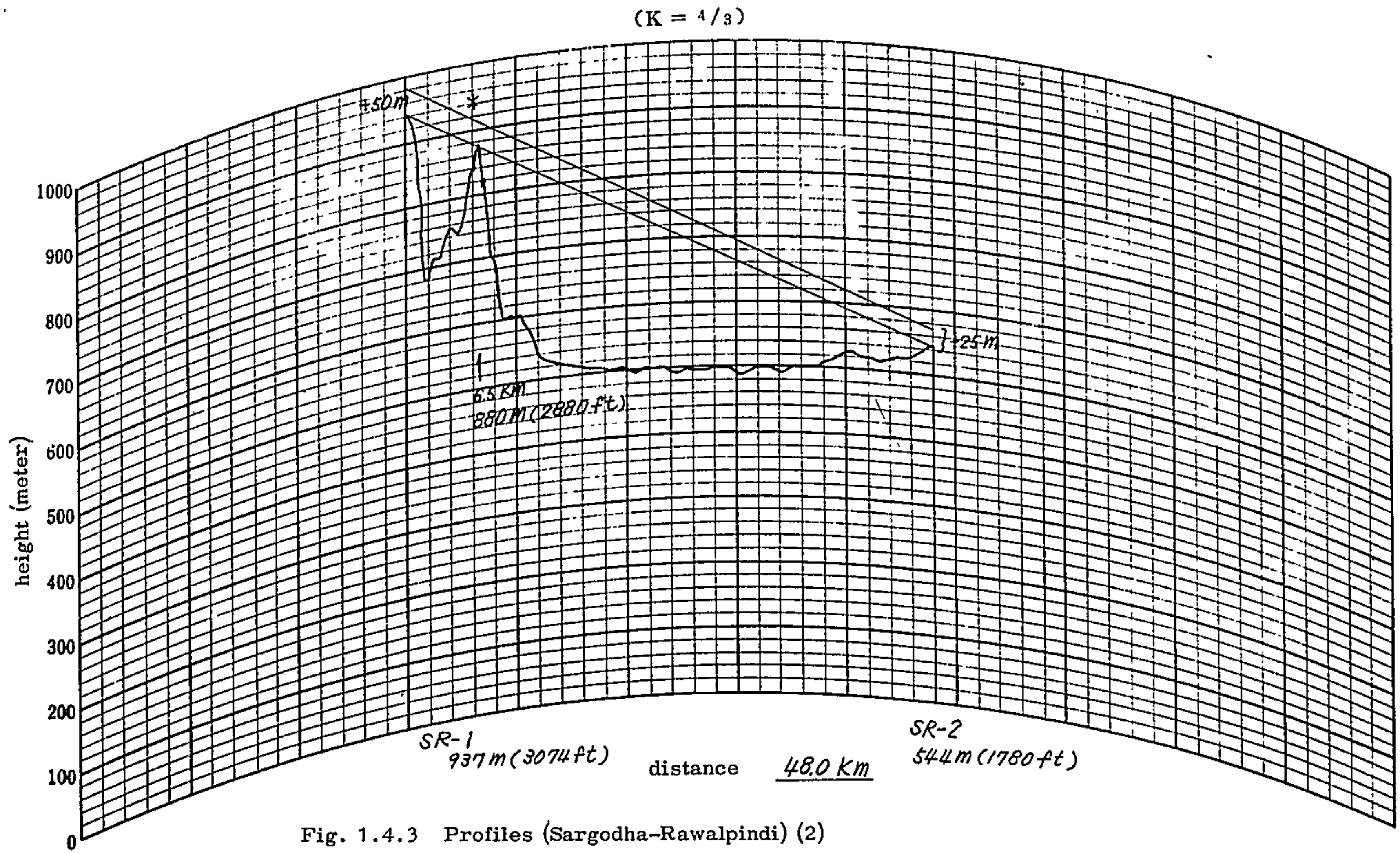


Fig. 1.4.3 Profiles (Sargodha-Rawalpindi) (2)

(K = 4/3)

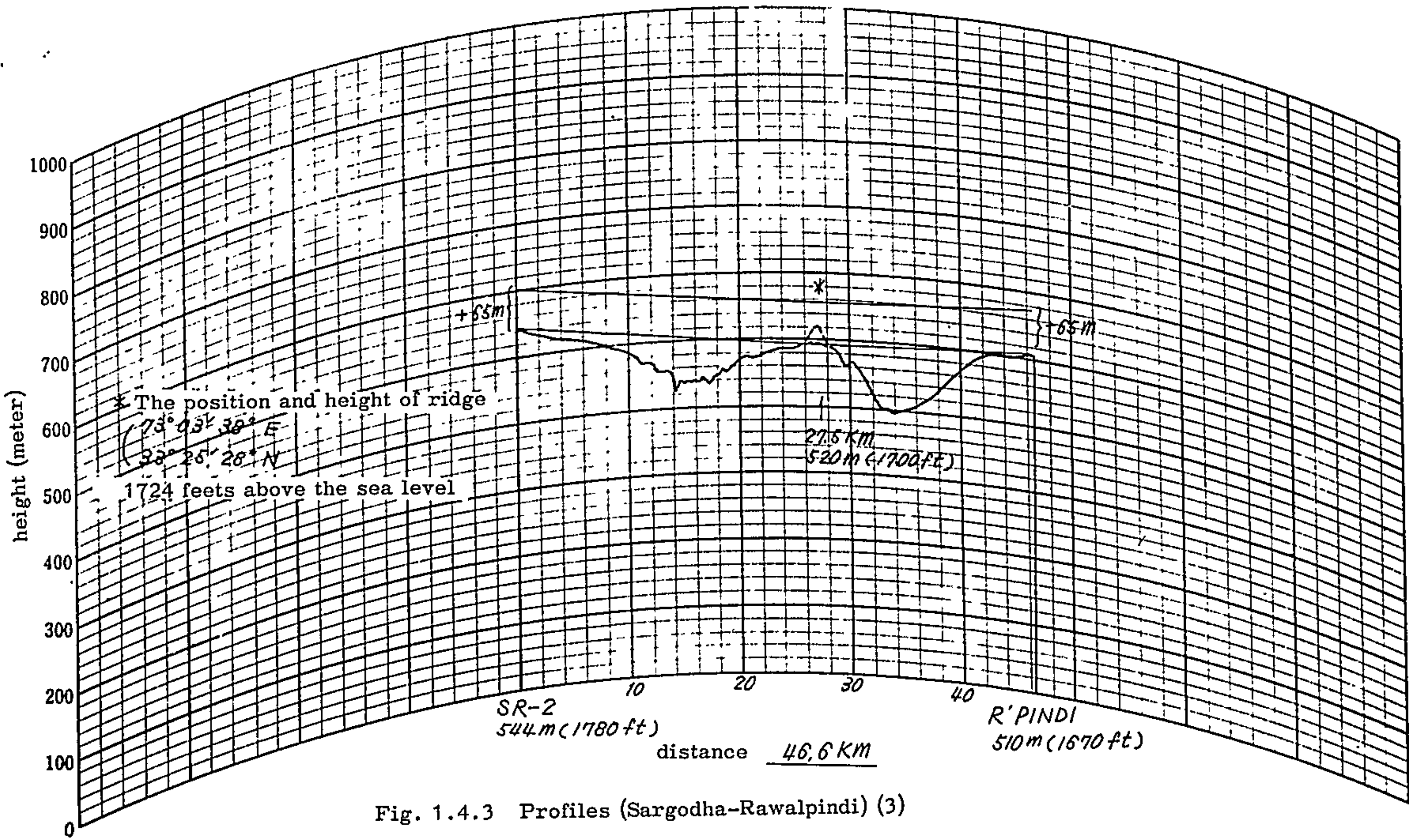


Fig. 1.4.3 Profiles (Sargodha-Rawalpindi) (3)

1.5 Rawalpindi - Peshawar

The propagation in this section is comparatively good and there is no problem in other respects.

(Note 1) There is no direct prospective between Rawalpindi and RP-1 owing to the obstruction of a slow slope (Koh-I-Noor) near Rawalpindi. The necessary height of antenna above ground for Rawalpindi is supposed about 75 m, but the final decision must be made after strict measurements.

(Note 2) Between RP-1 and RP-2 there is a ridge at the point of about 9 km from RP-1 and the height of antenna at RP-1 should be decided according to the results of strict measurements after confirming the prospective sight by mirror testing. The repeating distance of this section is presumed to attain 66 km and the application of space diversity system should be suitable.

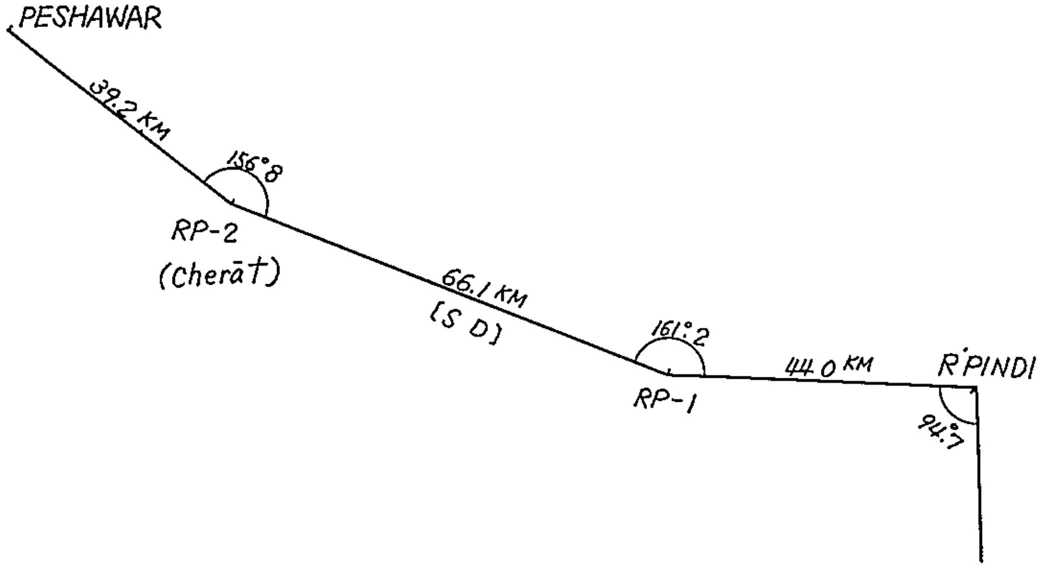


Fig. 1.5.1 Angles and repeater spacings (Rawalpindi-Peshawar)

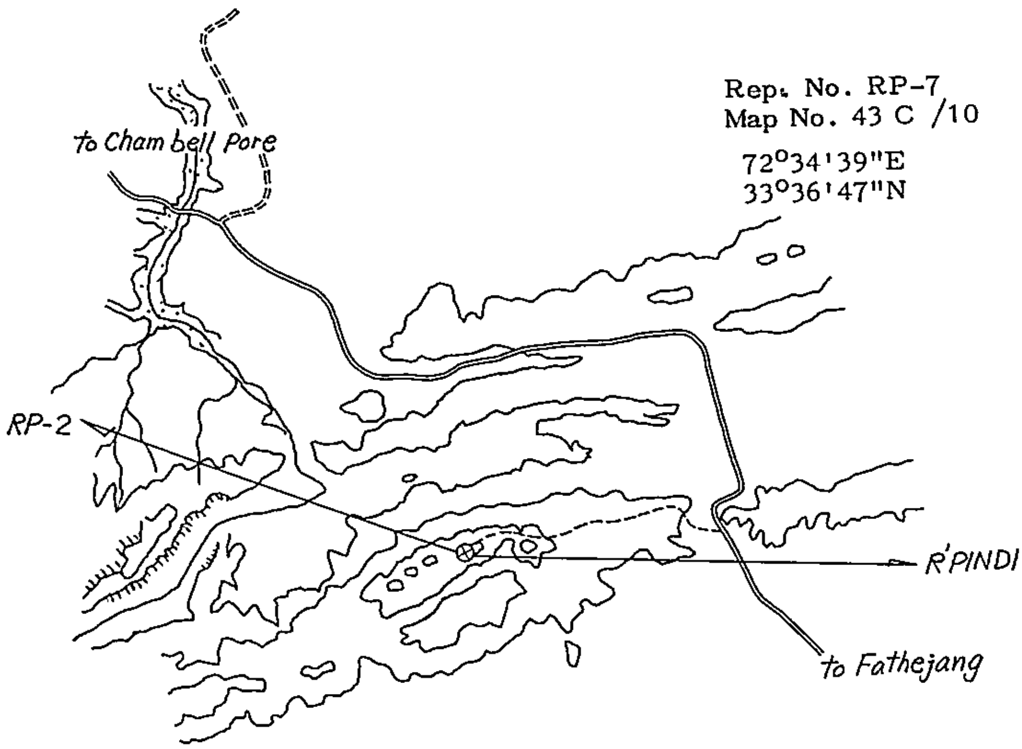


Fig. 1.5.2 Sketch map of the station sites
(Rawalpindi-Peshawar)

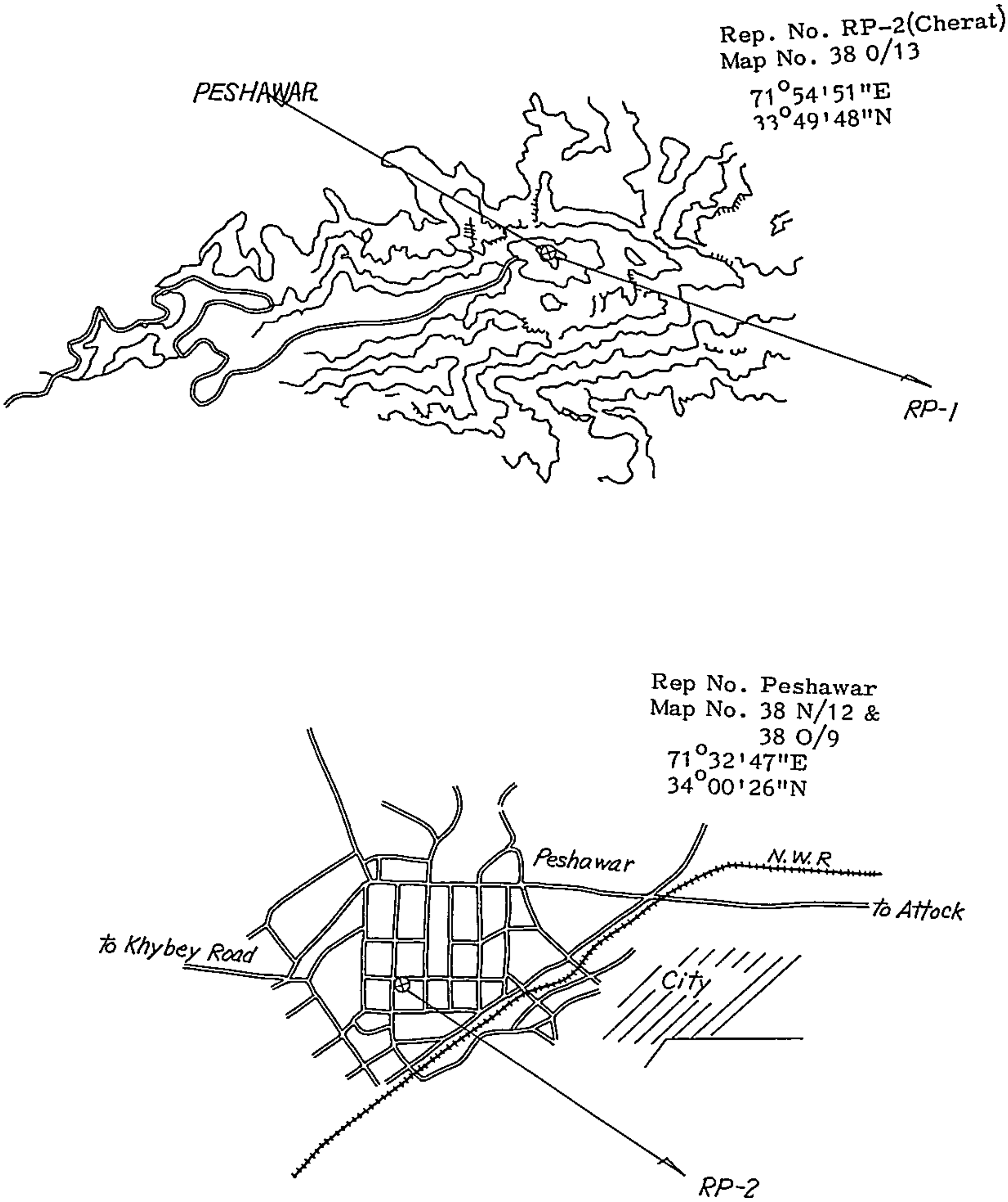


Fig. 1.5.2 Sketch map of the station sites (Rawalpindi-Peshawar)

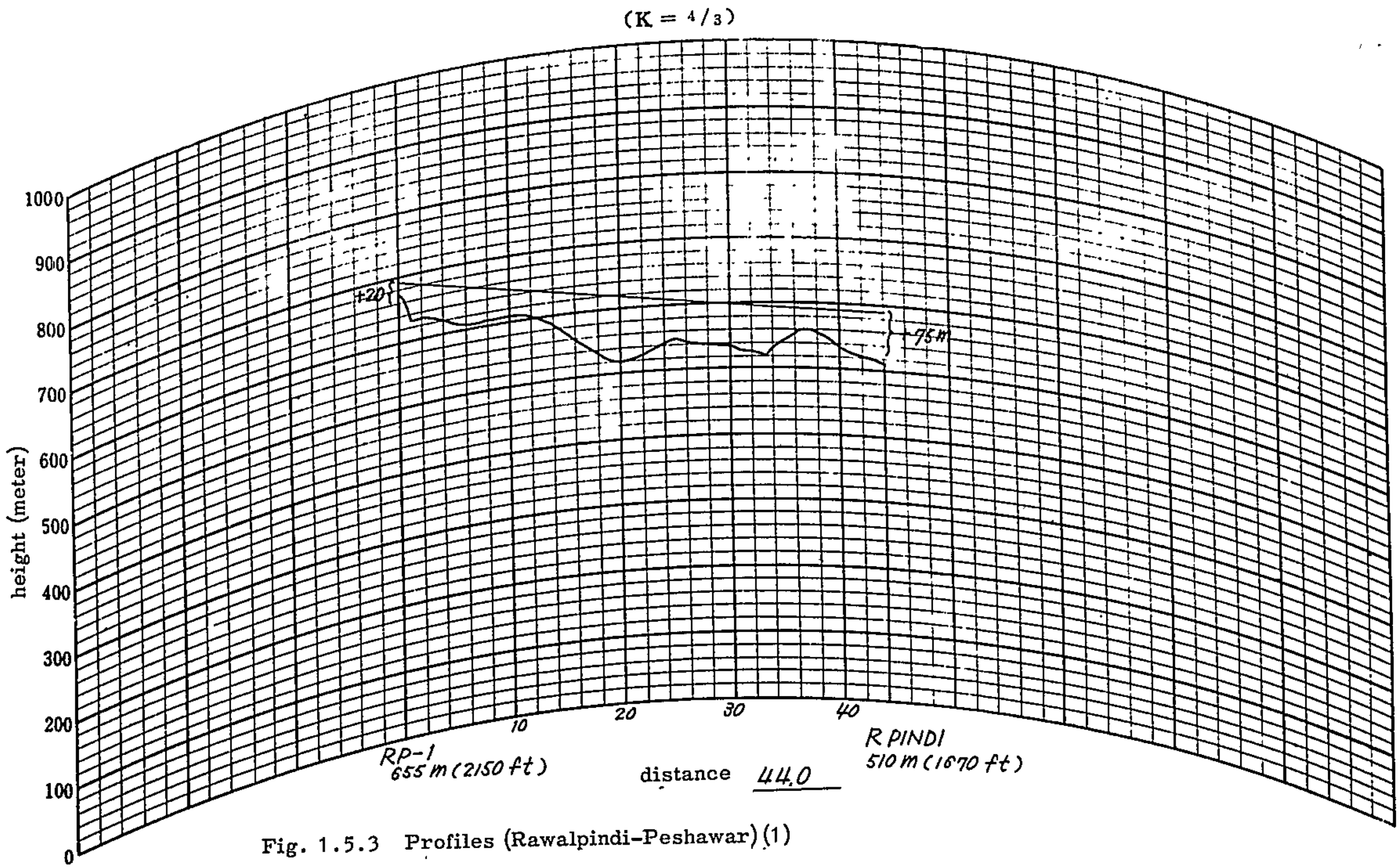


Fig. 1.5.3 Profiles (Rawalpindi-Peshawar) (1)

(K = 4/3)

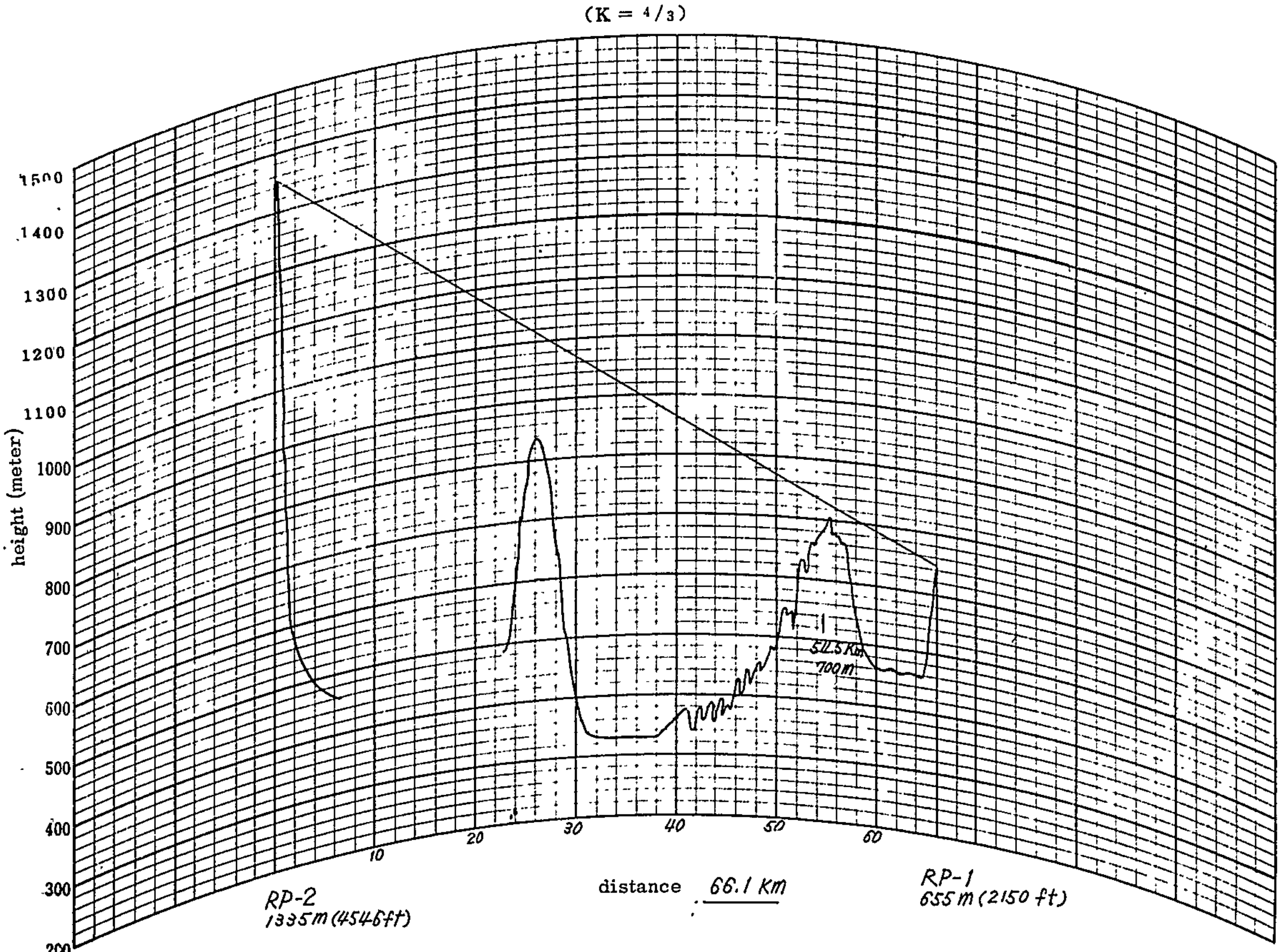


Fig. 1.5.3 Profiles (Rawalpindi-Peshawar)(2)

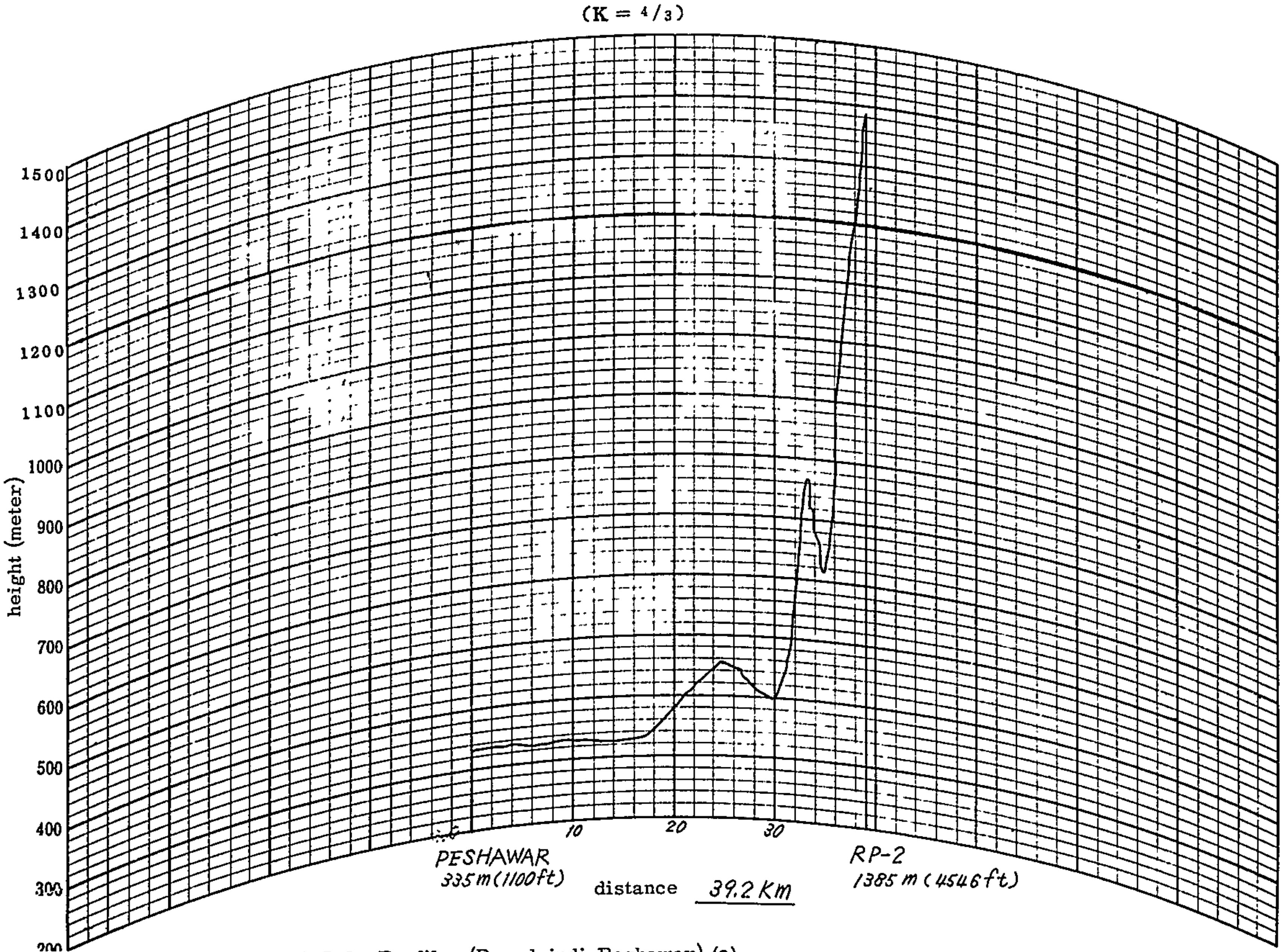


Fig. 1.5.3 Profiles (Rawalpindi-Peshawar) (3)

1.6 D.I. Khan - Sakesar - Sargodha

The propagation conditions in this section may be regarded rather good as compared to the aforementioned third section, owing to the advantage of mountainous areas, but the number of stations and the economic character is almost the same. The idea of utilizing Sakesar will present itself a very promising factor in providing a base worthwhile for the construction of a new route in this district in future.

(Note) Between D.I. Khan and IS-5, a strong reflected wave is feared to prevail, and in order to drop the point of reflection as low as possible to the street, the height of antenna above ground in D.I. Khan must be controlled about 20 meters.

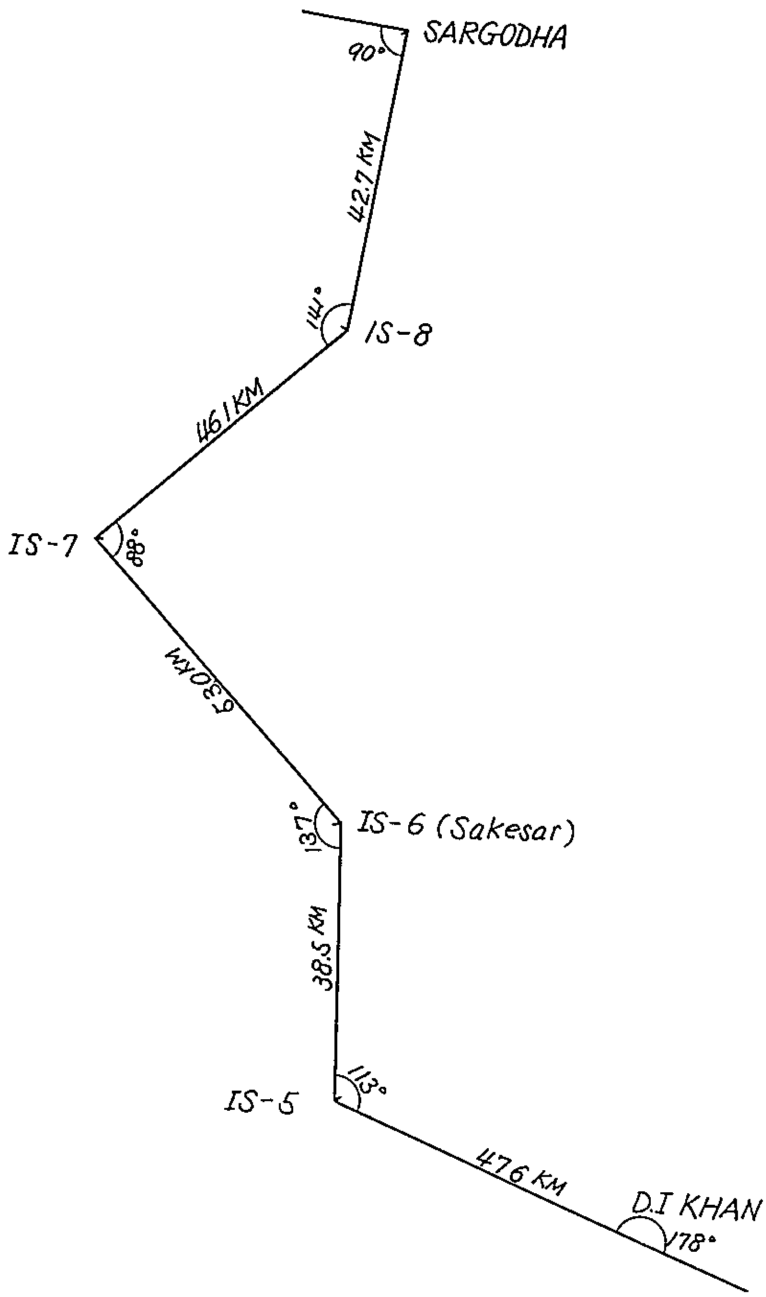
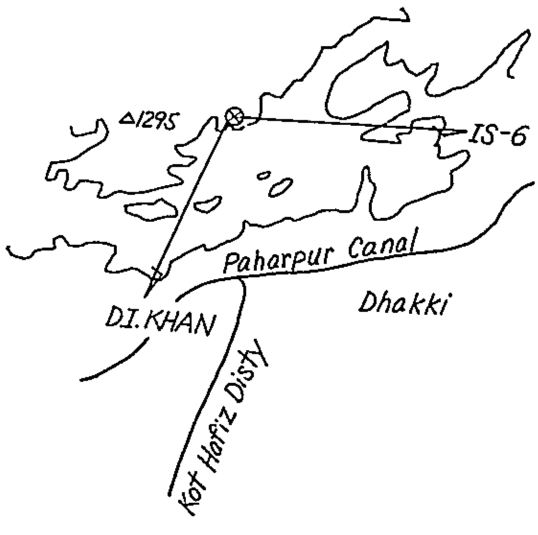
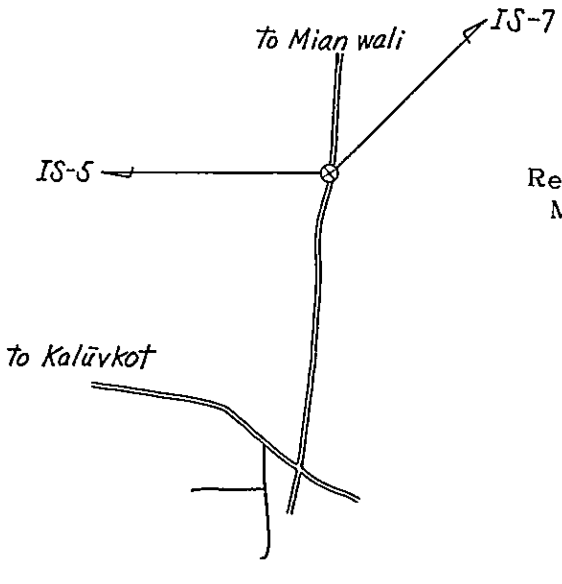


Fig. 1.6.1 Angles and repeater spacings (D.I. Khan-(Sakesar)-Sargodha)

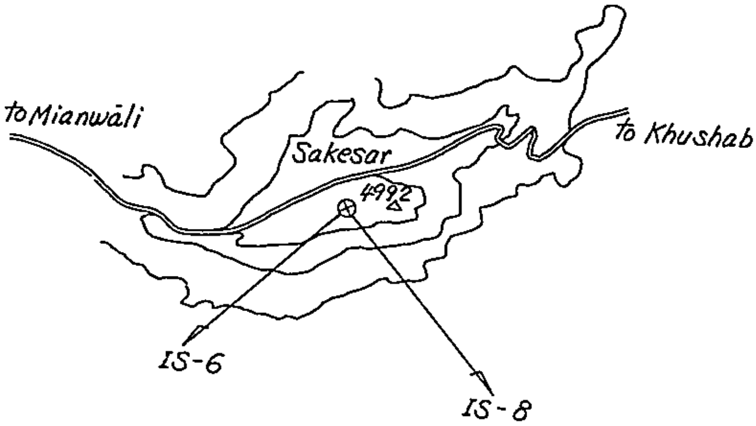


Rep. No. IS-5
Map No. 38 P/4
71°06'30"E'
32°12'36"N

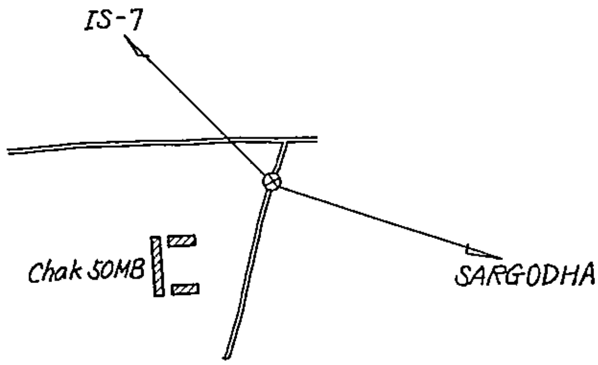


Rep. No. IS-6
Map No. 38 P
71°30'6 E
32°12'7 N

Fig. 1.6.2 Sketch map of the station sites
(D.I. Khan-Sakesar-Sargodha)



Rep. No. IS-7: (Sakesar)
Map No. 38 P/14
71°55'57"E
32°32'32"N



Rep No. IS-8
Map No. 43 D/4
72°15'00"E
32°13'26"N

Fig. 1.6.2 Sketch map of the station sites (D.I. Khan-Sakesar-Sargodha) (2)

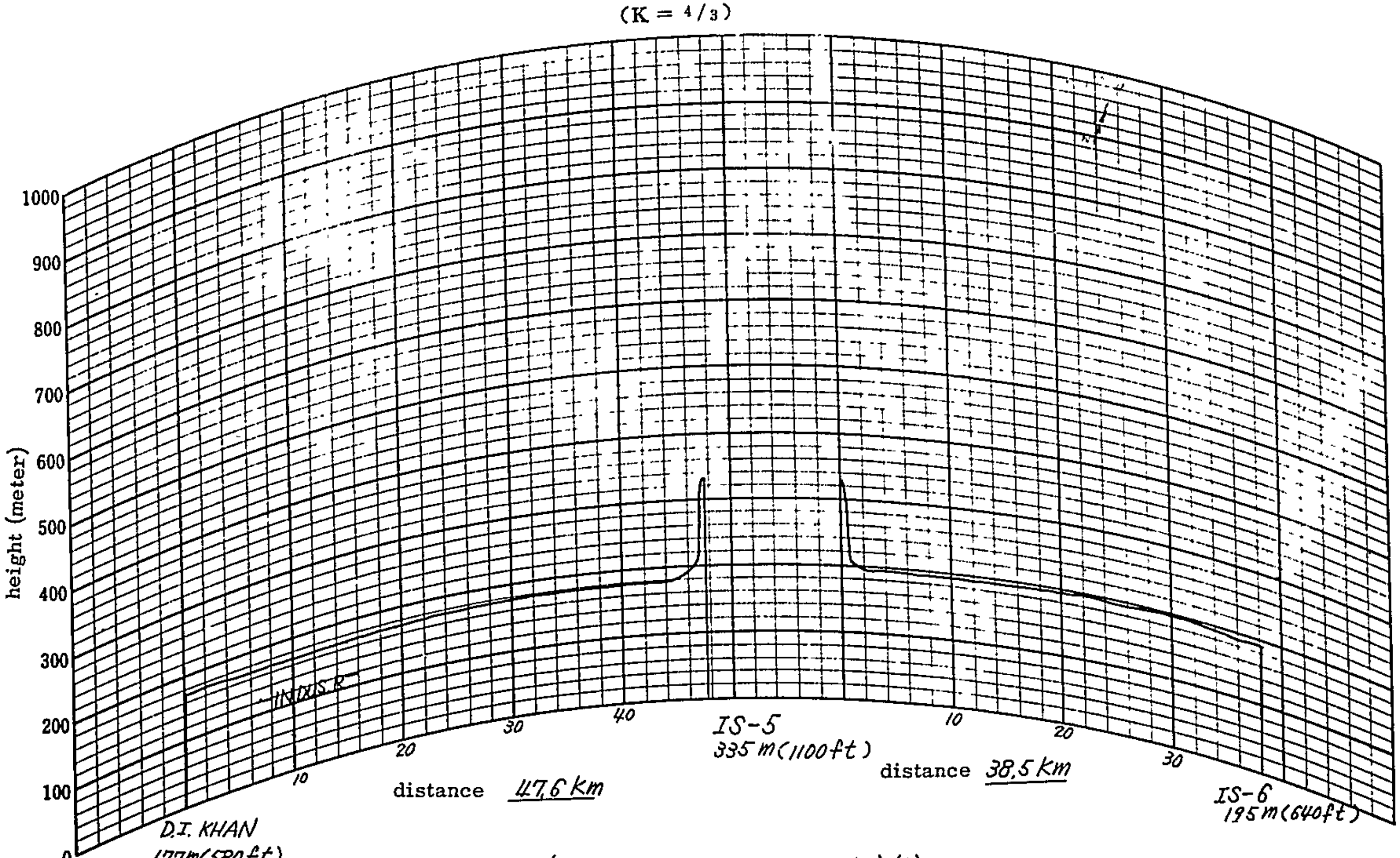


Fig. 1.6.3 Profiles (D.I. Khan-Sakesar-Sargodha) (1)

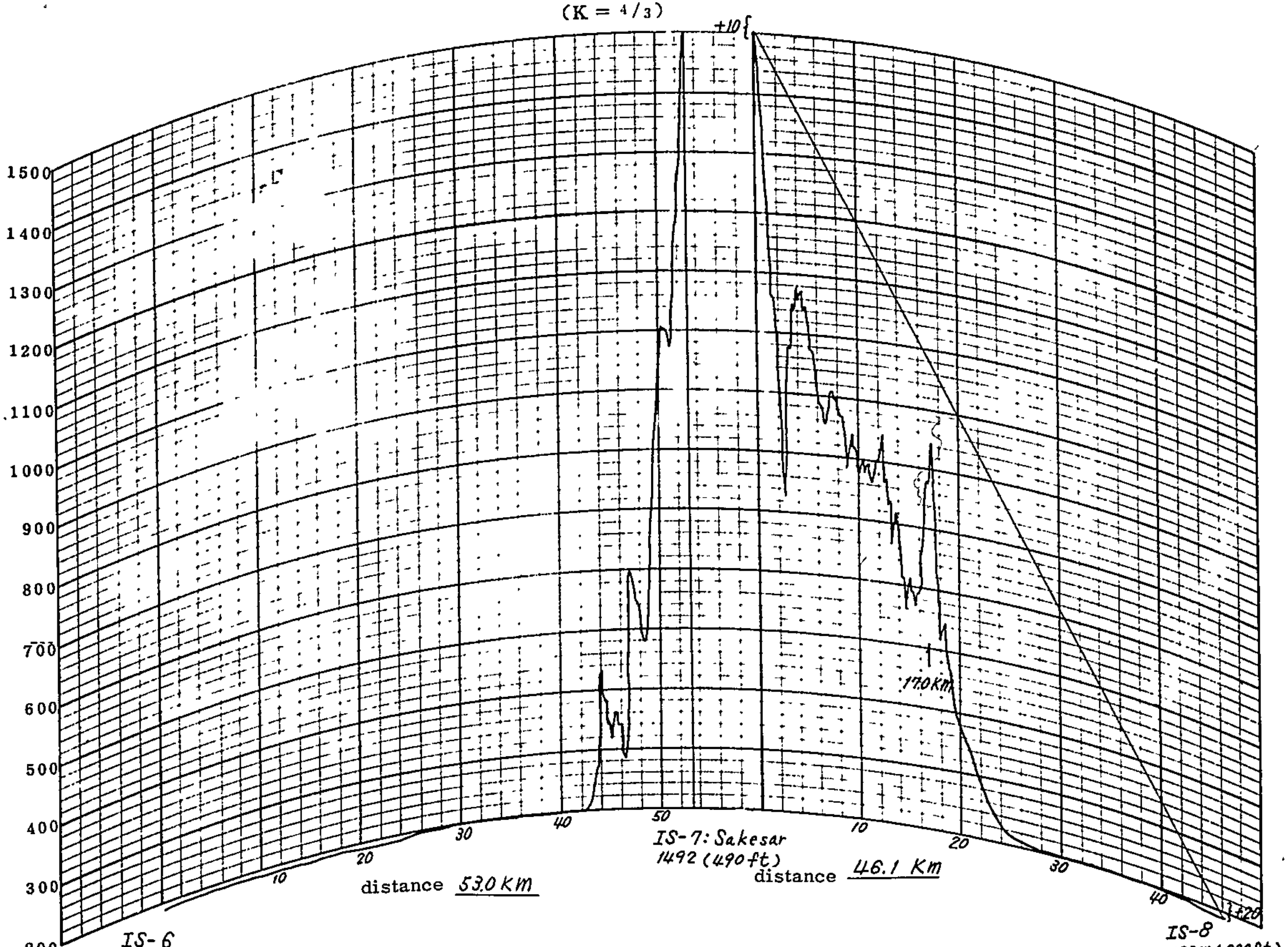


Fig. 1.6.3 Profiles (D.I. Khan-Sakesar-Sargodha) (2)

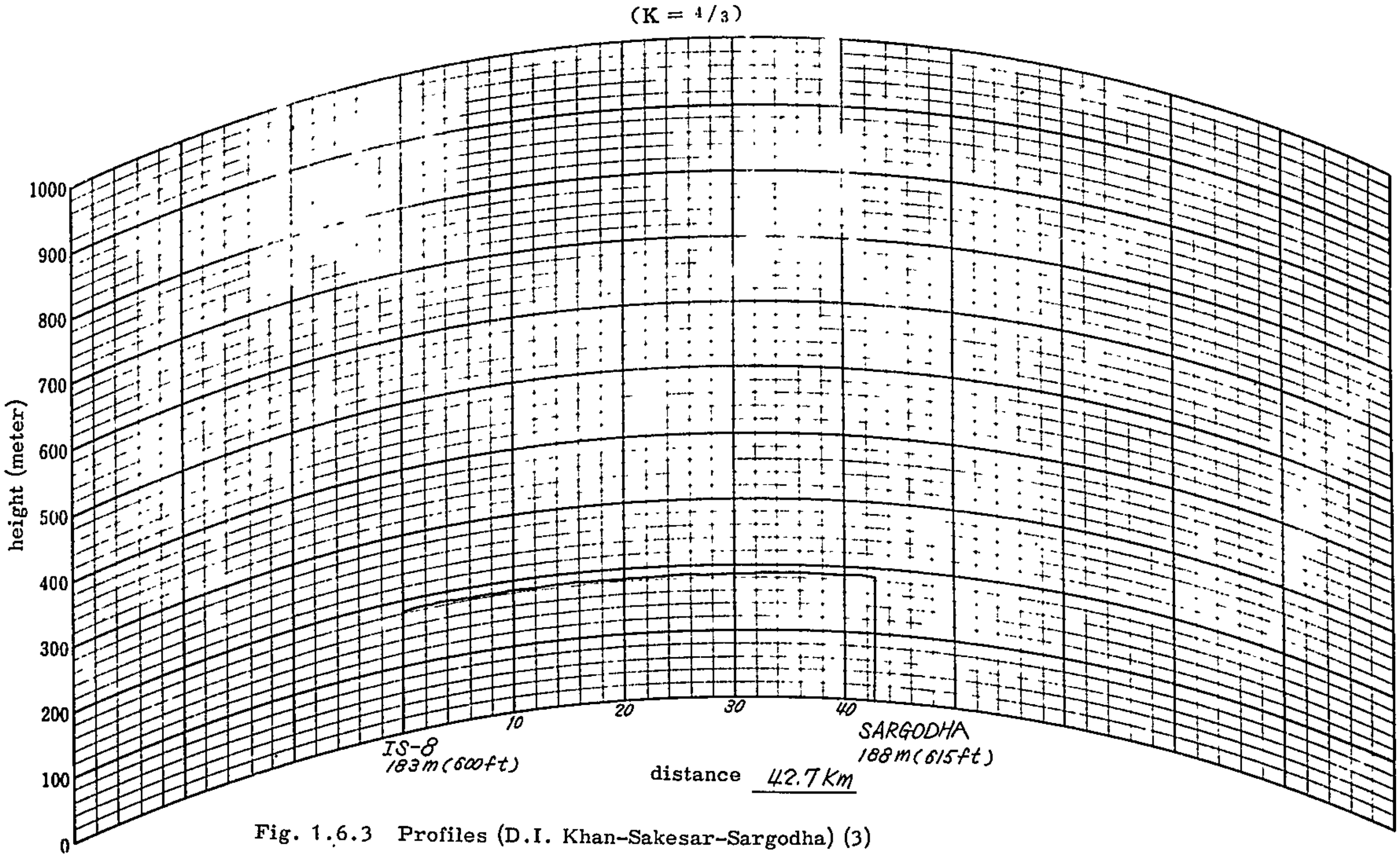


Fig. 1.6.3 Profiles (D.I. Khan-Sakesar-Sargodha) (3)

2. Other Routes

As regards the sections D.I. Khan - Peshawar of the center route and Quetta - Peshawar of the west route which had been excluded from the first order of consideration in this on-the-spot survey, the outline of the results of our survey will be presented hereinafter only for reference. The east route may be taken as almost same as the center route, for the most part of it passes through the plain fields.

2.1 D.I. Khan - Bannu - Kohat - Peshawar

This route forms the shortest part of center route from D.I. Khan to Peshawar, forms the mountainous propagation route through Bannu and Kohat (the branching station) and at Bannu this route meet the west route running from Quetta.

Geographical conditions of this route are almost alike those of the west route which passes through underdeveloped districts, and all the stations are to be inevitably situated at the places of steep mountainous areas, and much difficulties are anticipated in relation not only to the construction of access roads and the equipment concerned but also to the maintenance after construction.

(Note 1) Between IP-1 and IP-2 space - diversity system is thought necessary because of its long section distance.

(Note 2) In the branching route of Kohat, at the point of IP-5 other frequency band, for example, 11-GC is to be used.

(Note 3) Between IP-4 and IP-5 there are two ridges. One is to be found near IP-4 and the other is near IP-5. Strict measurement would be necessary.

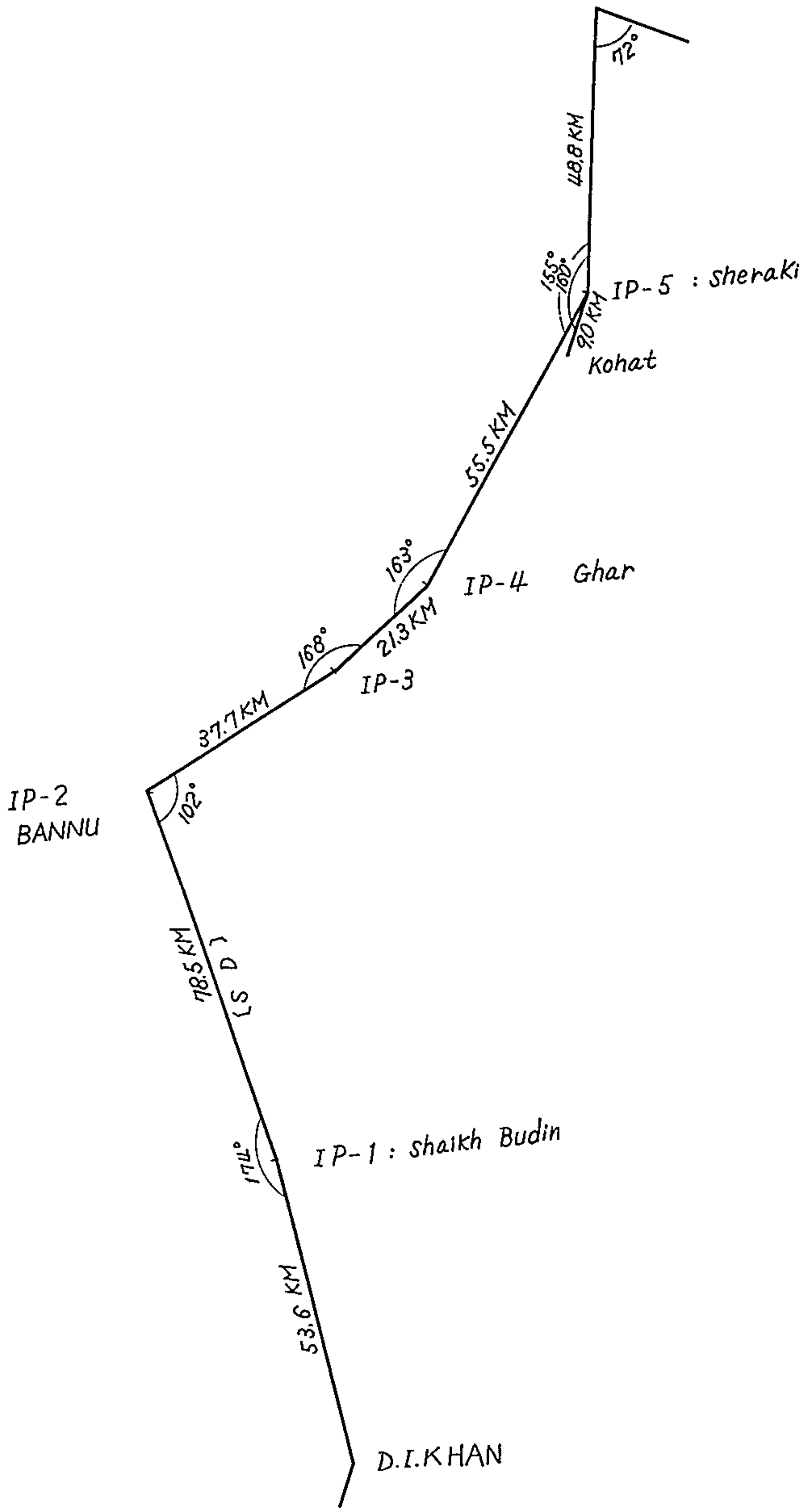
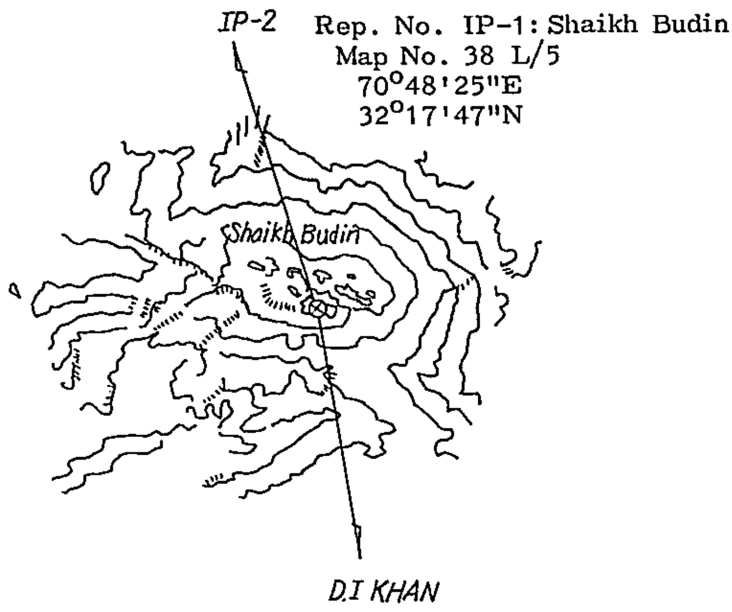
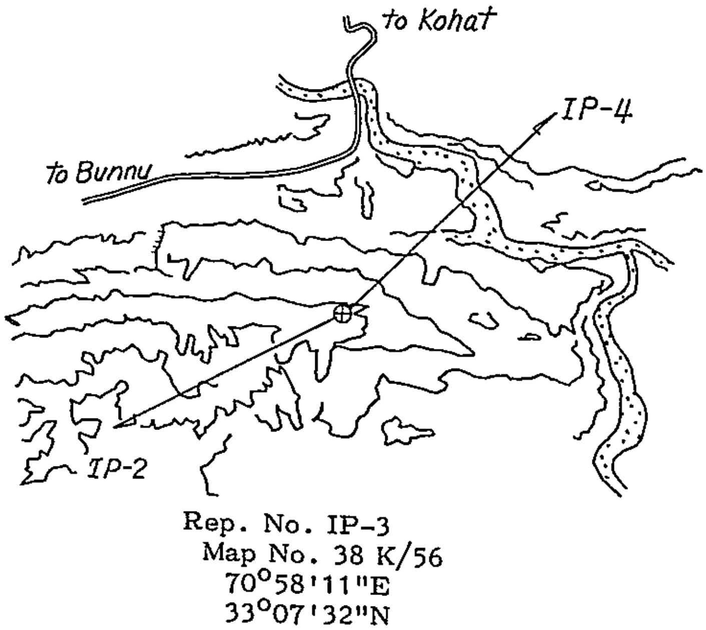


Fig. 2.1.1 Angles and repeater spacings (D.I. Khan–Peshawar) (1)





Rep. No. IP-3
Map No. 38 K/56
70°58'11"E
33°07'32"N

Fig. 2.1.2 Sketch map of the station sites (D.I. Khan-Peshawar)(1)

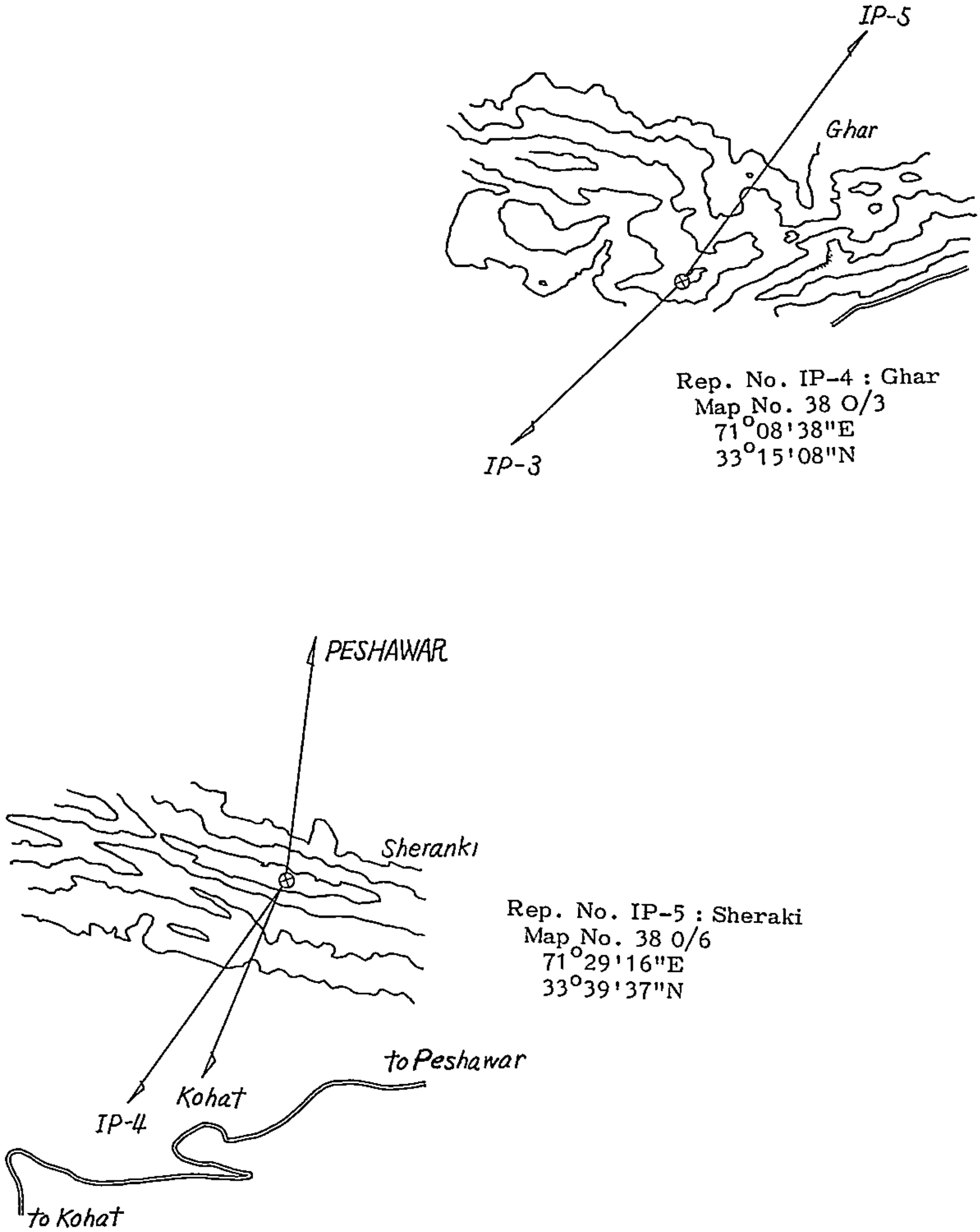


Fig. 2.1.2 Sketch map of the station sites (D.I. Khan-Peshawar) (2)

(K = 4/3)

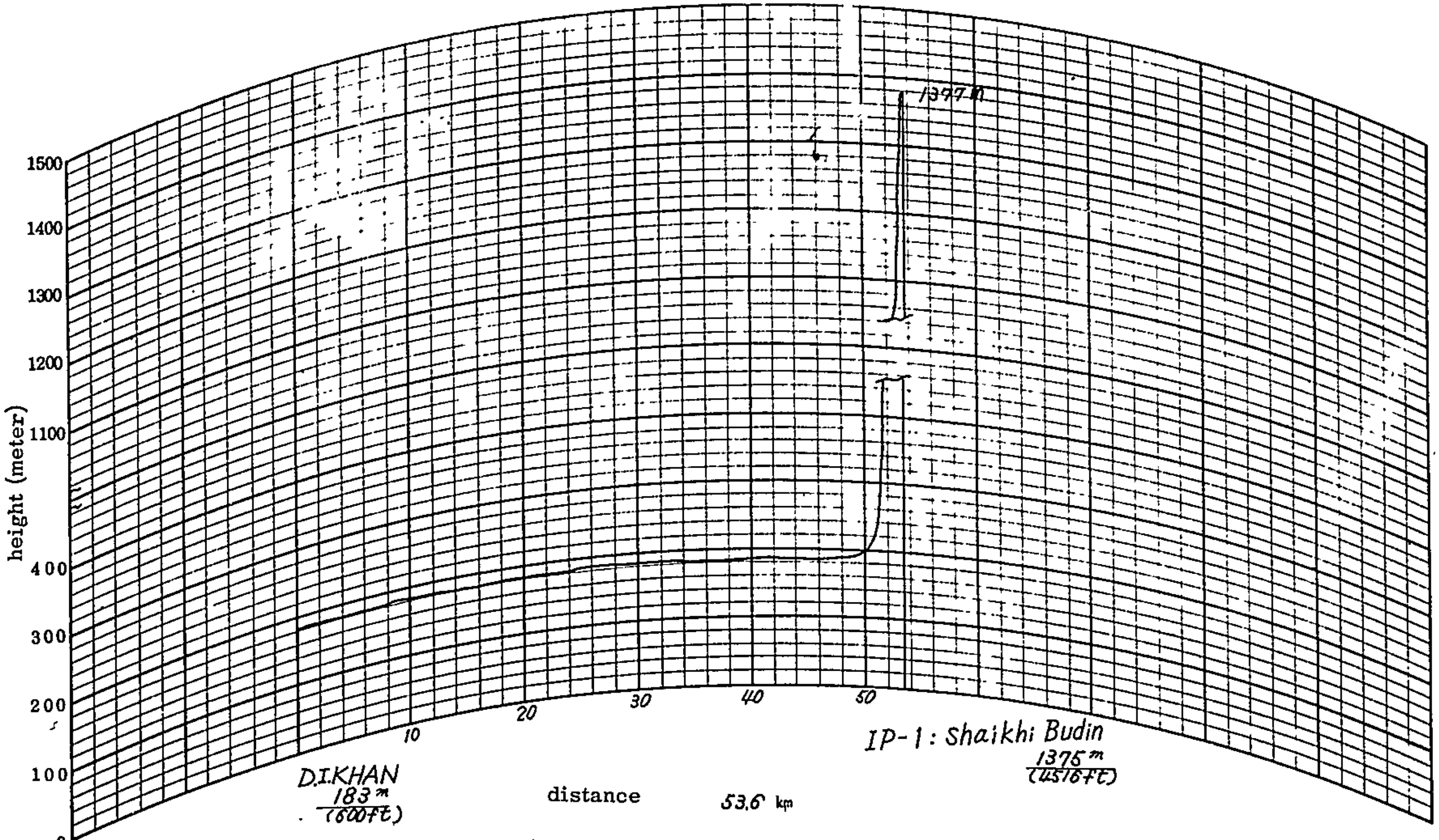


Fig. 2.1.3 Profiles (D.I. Khan-Peshawar) (1)

(K = 4/3)

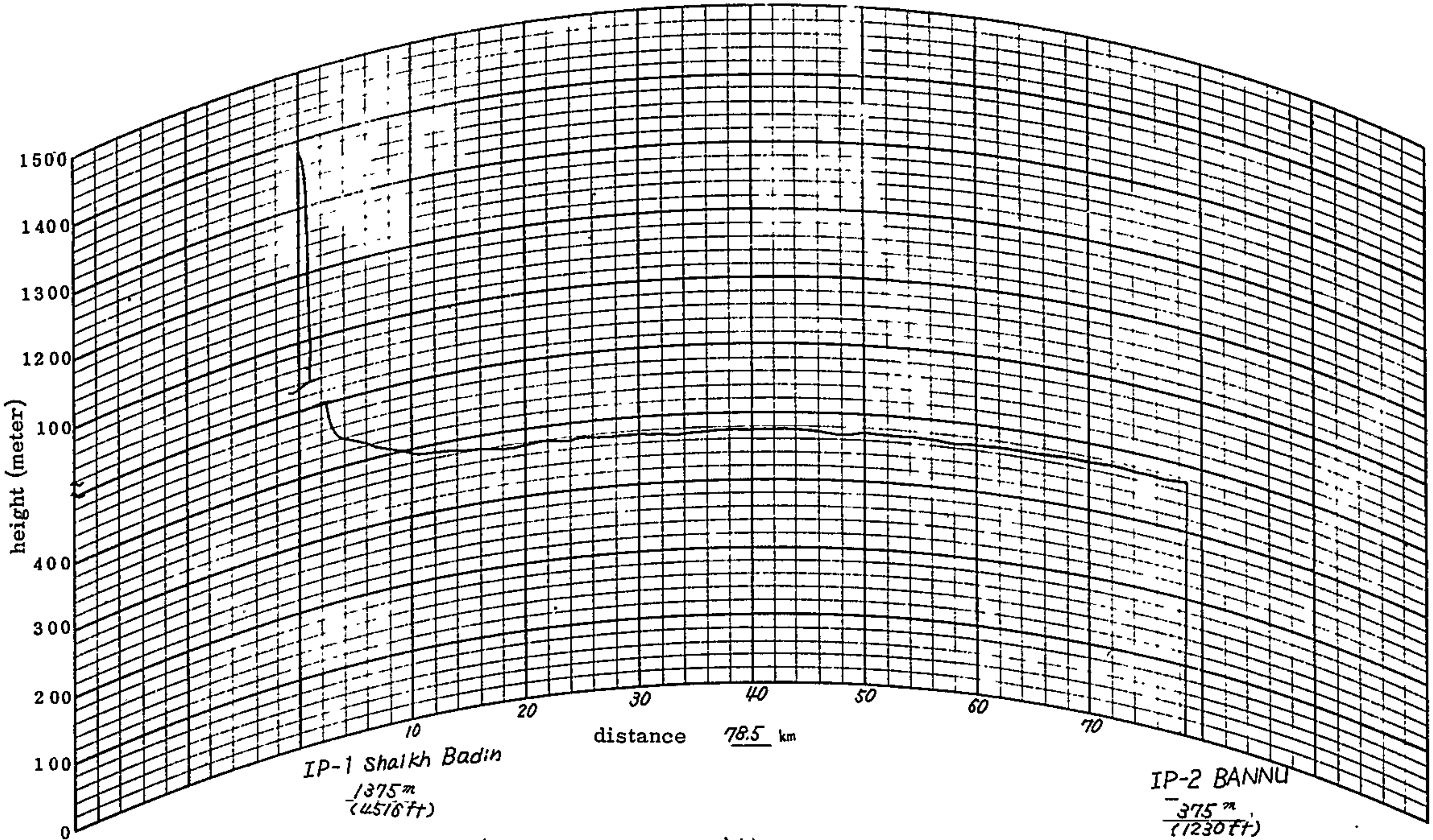


Fig. 2.1.3 Profiles (D.I. Khan-Peshawar) (2)

(K = 4/3)

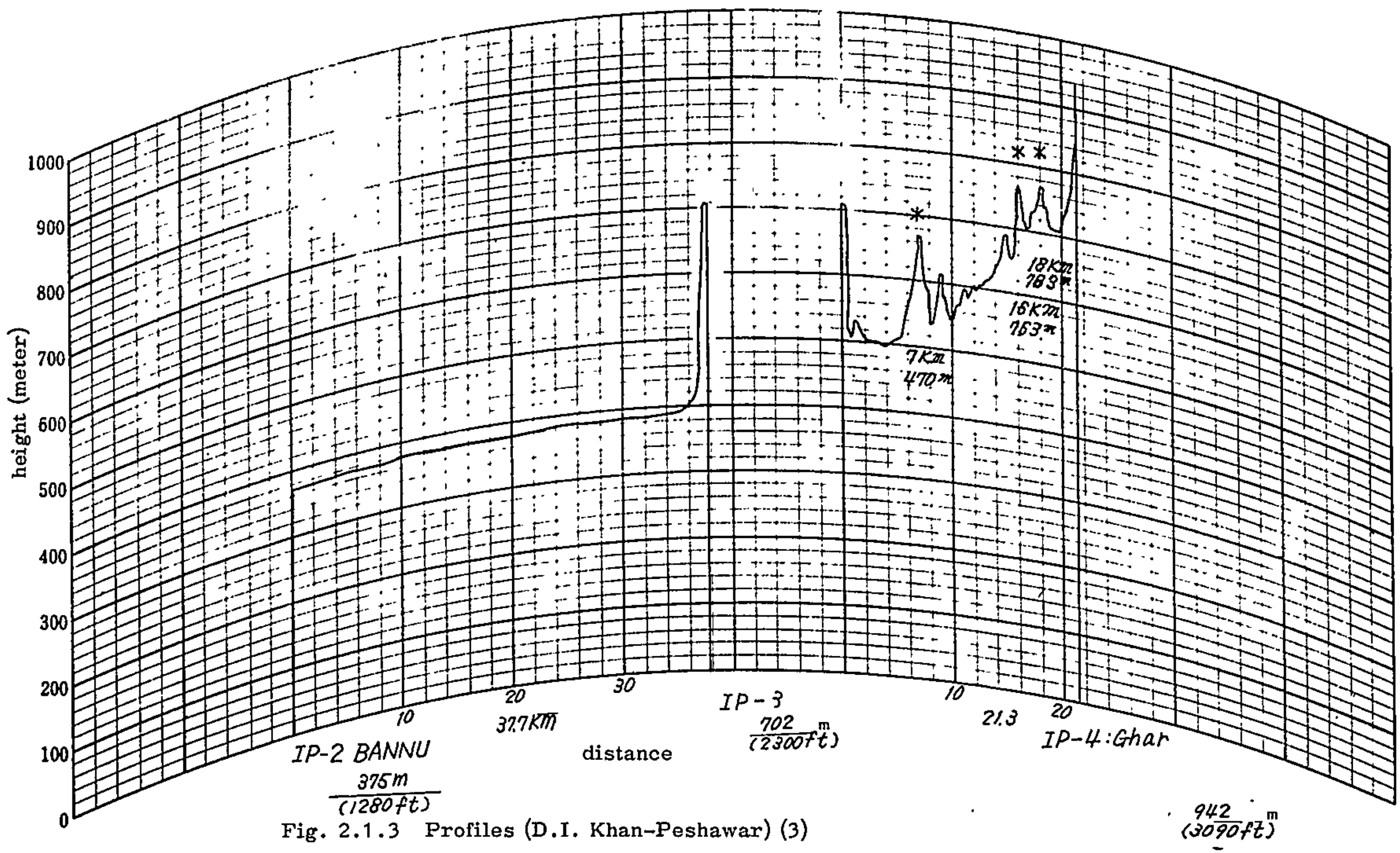


Fig. 2.1.3 Profiles (D.I. Khan-Peshawar) (3)

(K = 4/3)

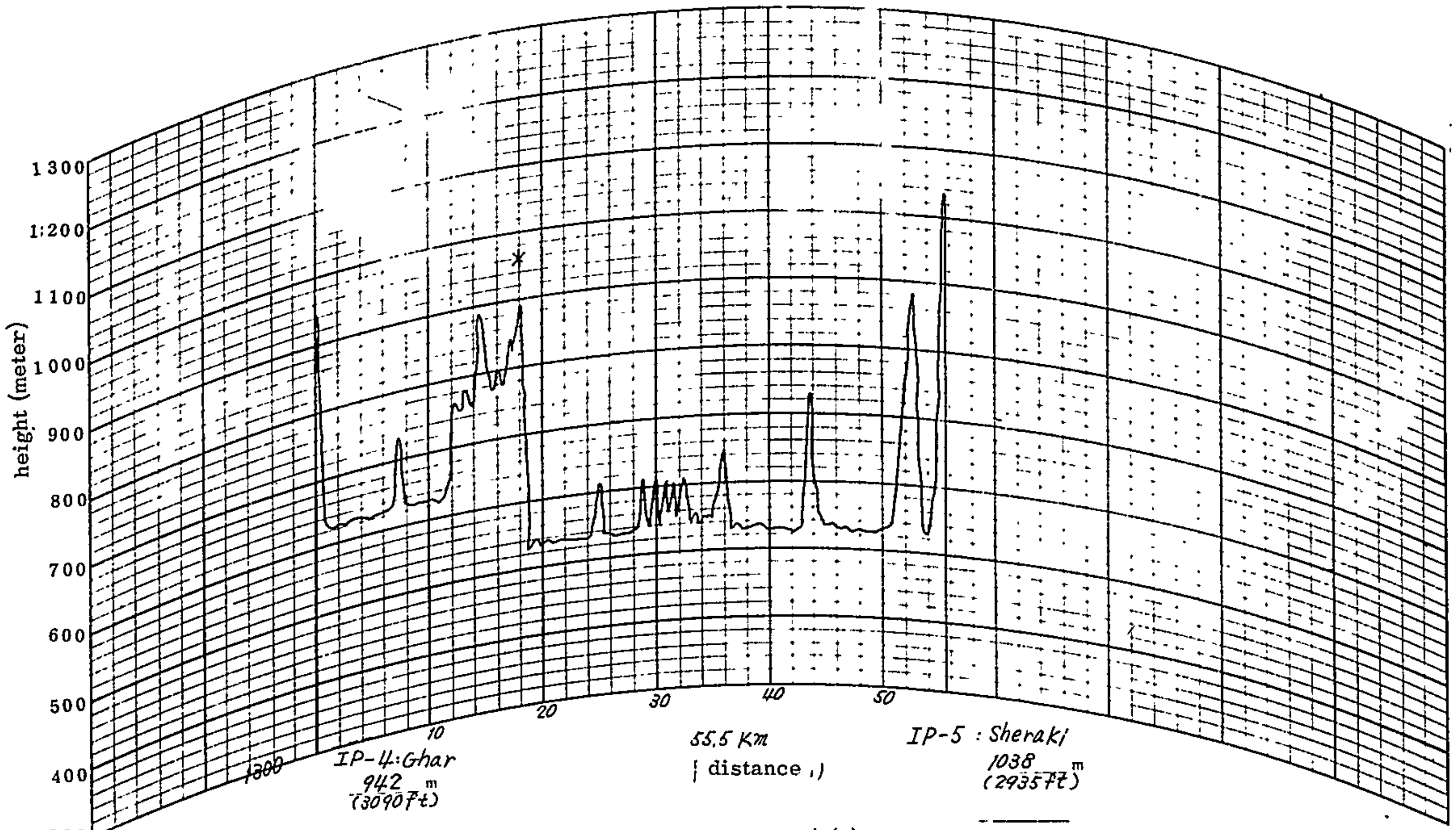


Fig.2.1.3 Profiles (D.I. Khan-Peshawar) (4)

(K = 4/3)

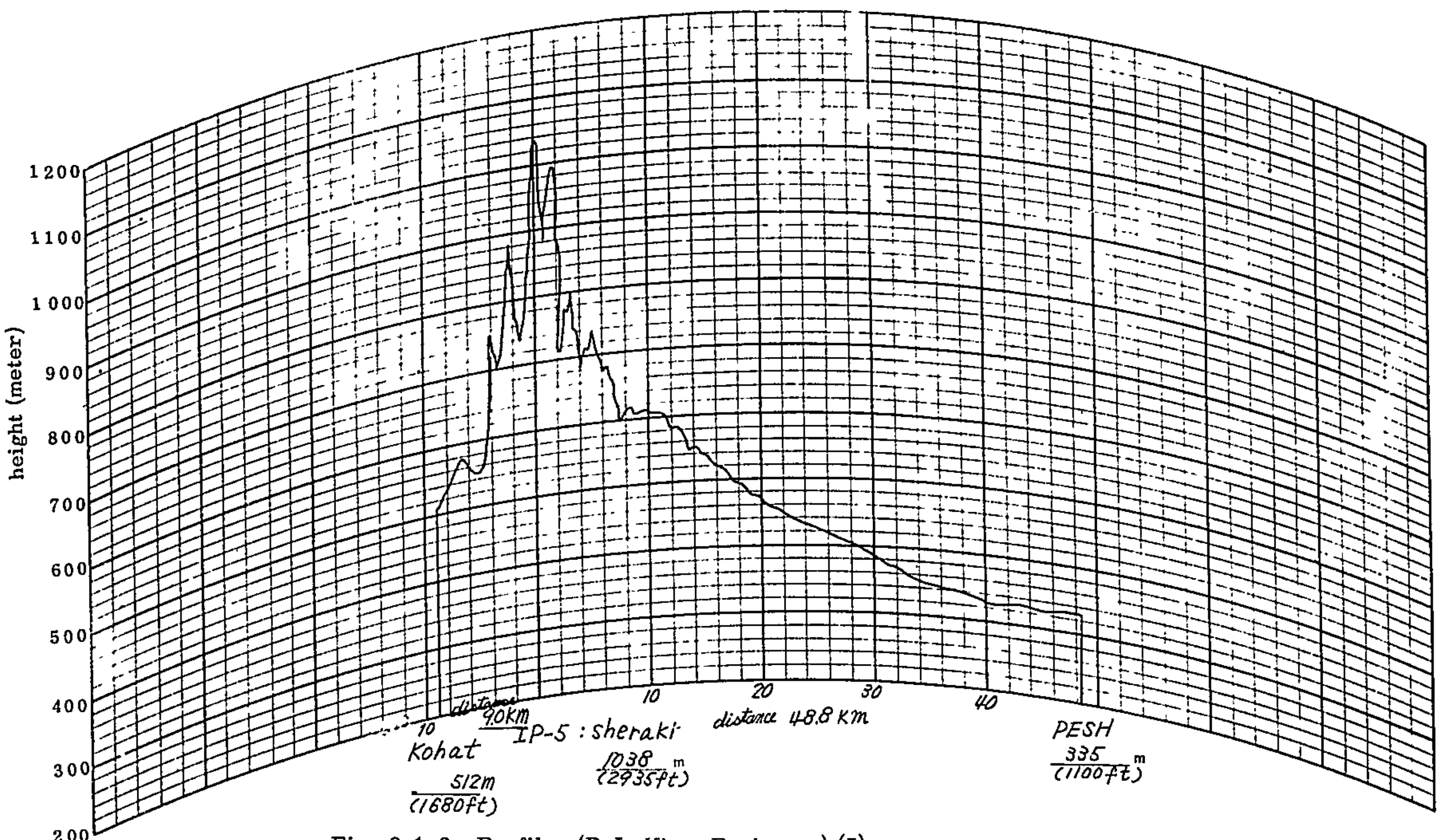


Fig. 2.1.3 Profiles (D.I. Khan-Peshawar) (5)

2.2 Quetta - Fort Sandeman - Peshawar

Geographical conditions between Quetta and Fort Sandeman are generally alike those propagation routes running through the plain, and the locations of stations are designed to be situated at comparatively short intervals. However, the section between Fort Sandeman and Peshawar is a typical mountainous propagation route.

(Note 1) There are ridges at the points near QP-2 and QP-3 between QP-1 and QP-2 and between QP-2 and QP-3 respectively. The height of antenna should be decided after detailed measurements.

(Note 2) Between QP-5 and QP-6 and between QP-6 and QP-7 there extend plain fields and the heights of antenna must be decided upon close consideration in relation to the points of reflection.

(Note 3) As regards the section between QP-11 and Bannu attention to the same effect must be given to the selection of the points of reflection.

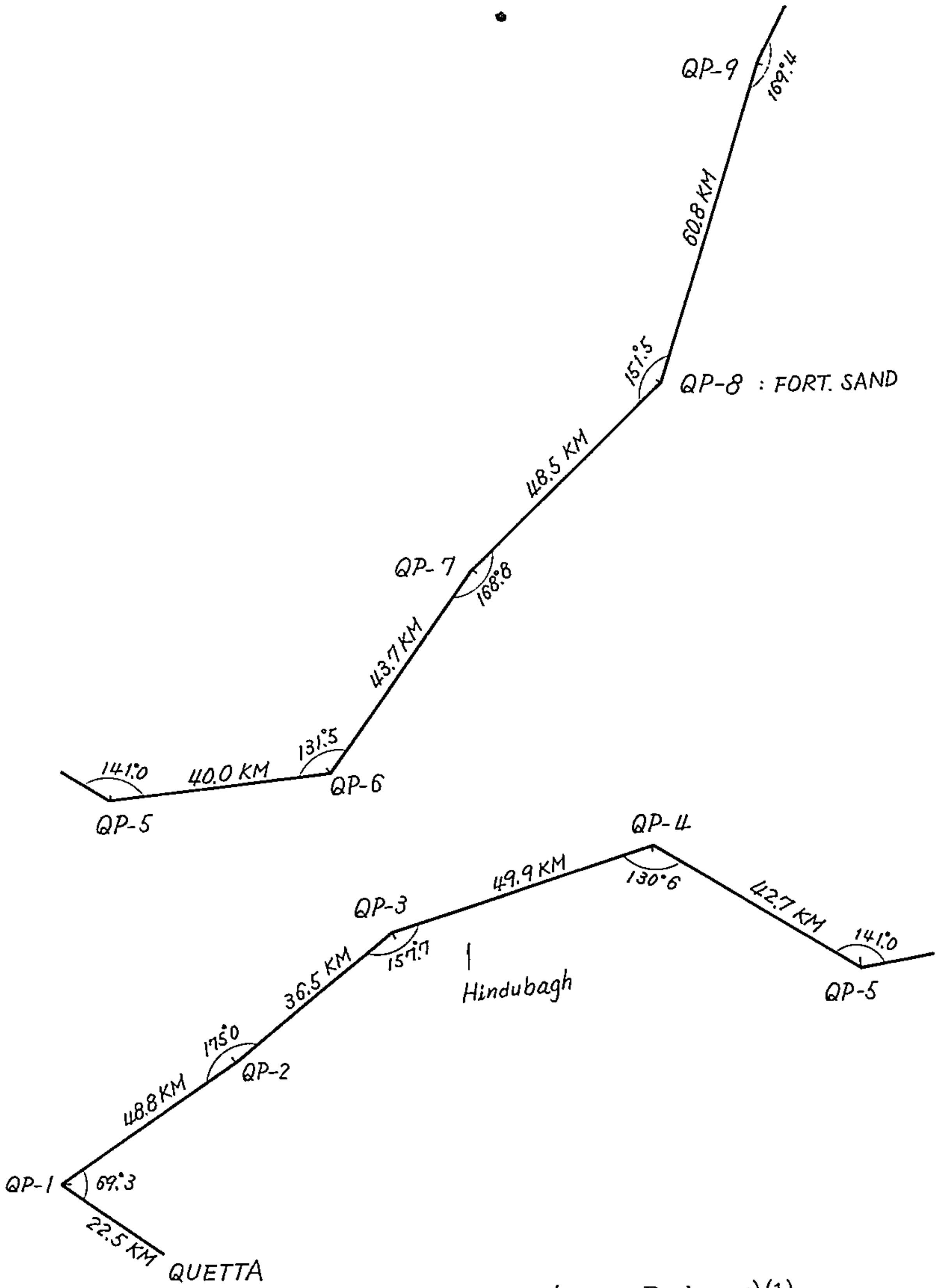


Fig. 2.2.1 Angles and Repeater spacings (Quetta–Peshawar) (1)

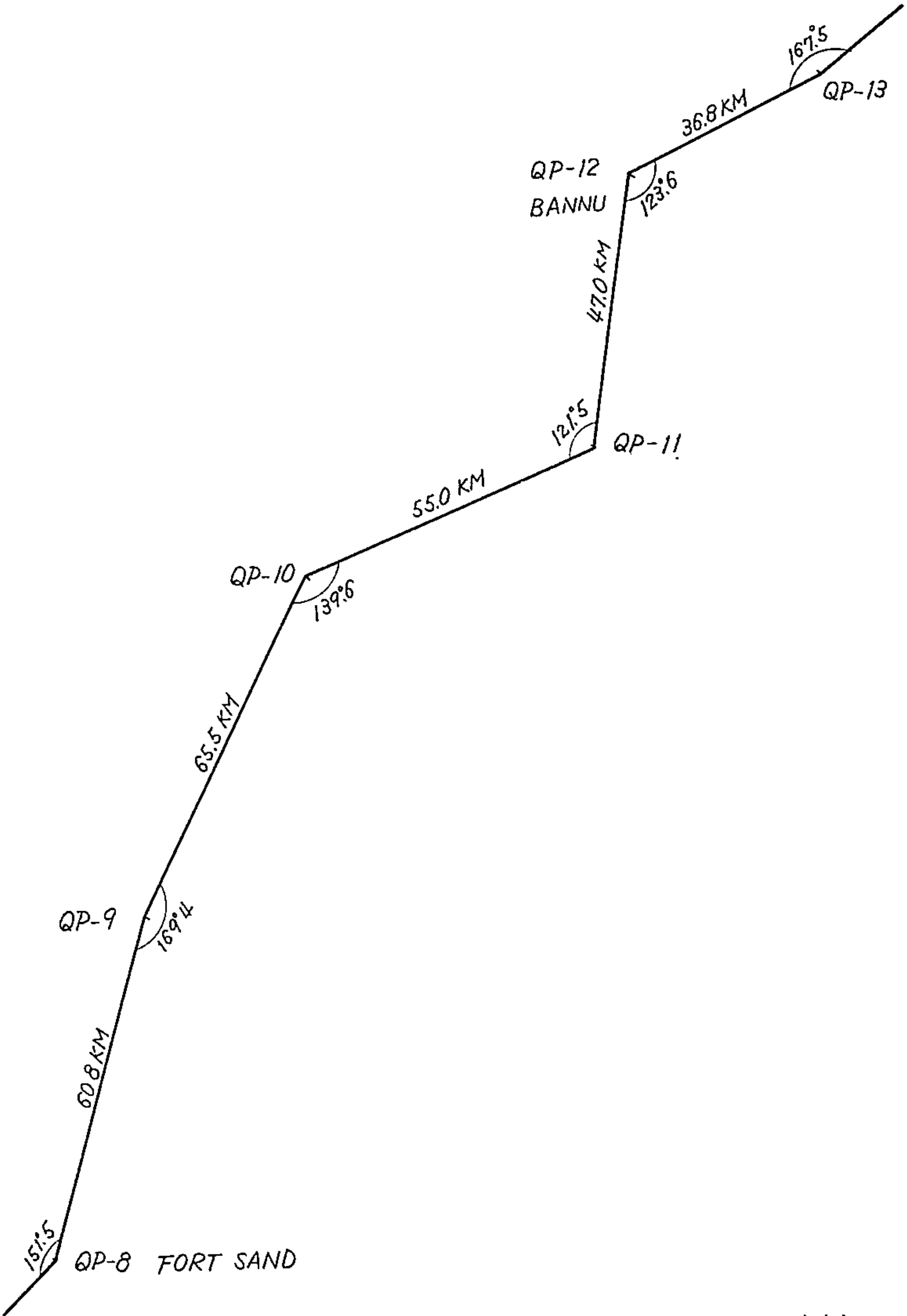


Fig. 2.2.1 Angles and Repeater spacings (Quetta-Peshawar) (2)

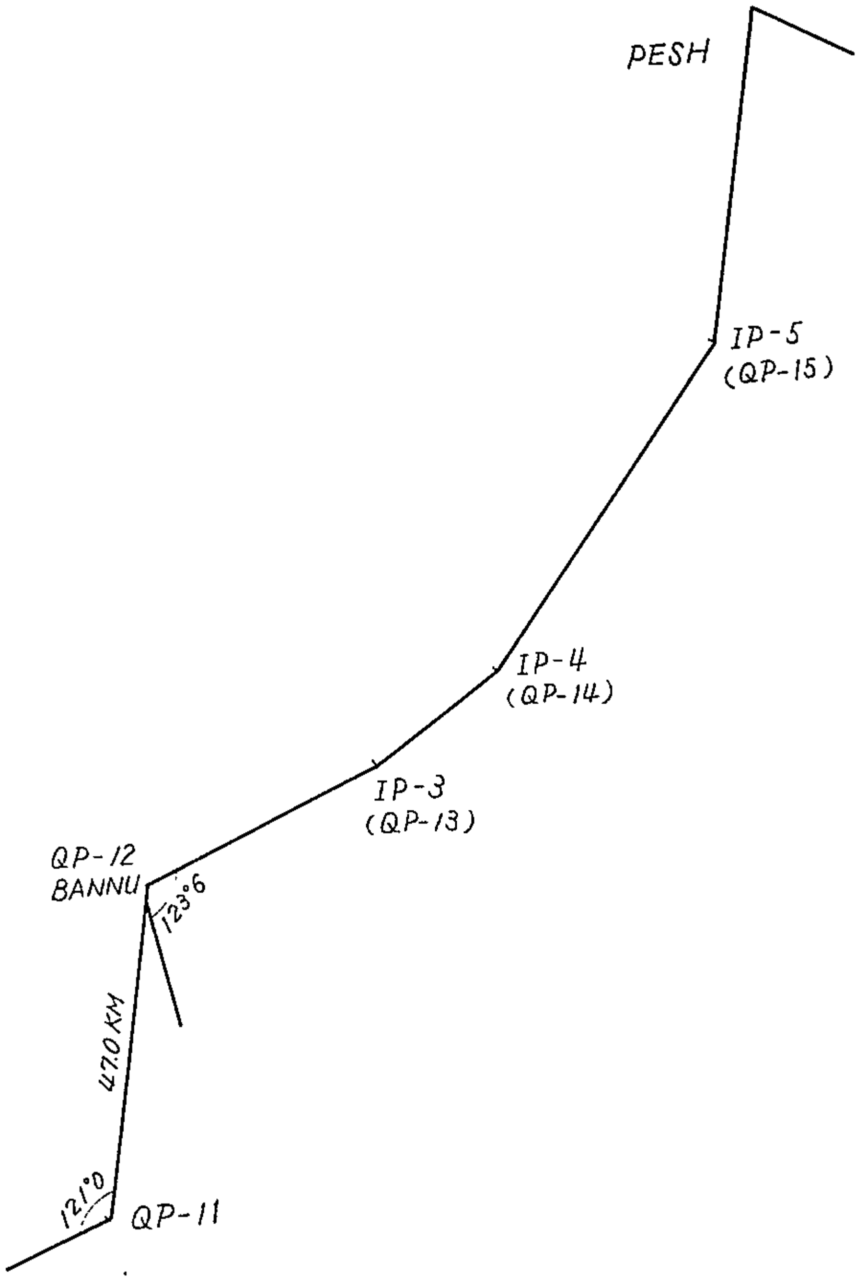


Fig. 2.2.1 Angles and Repeater spacings (Quetta-Peshawar) (3)

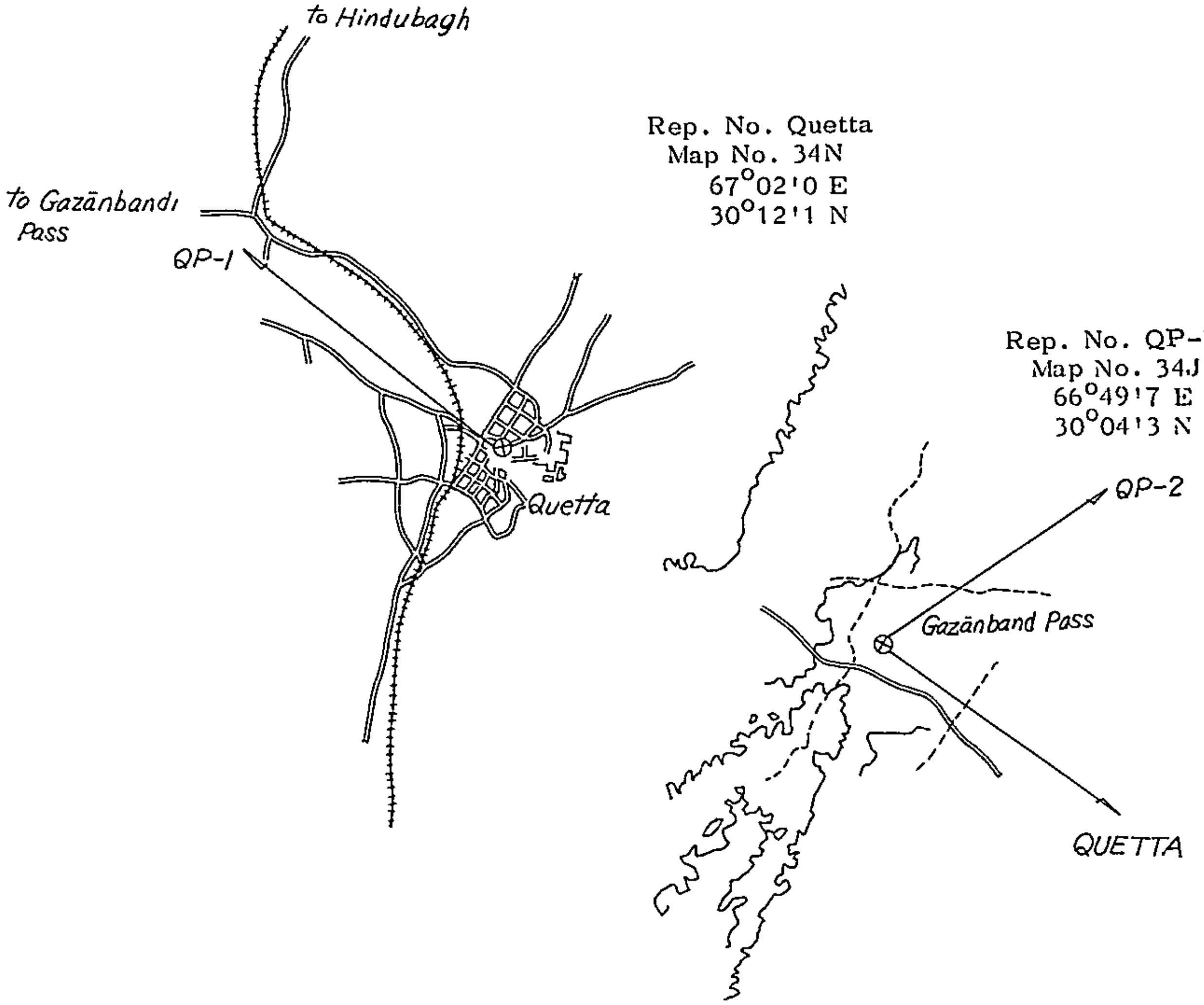
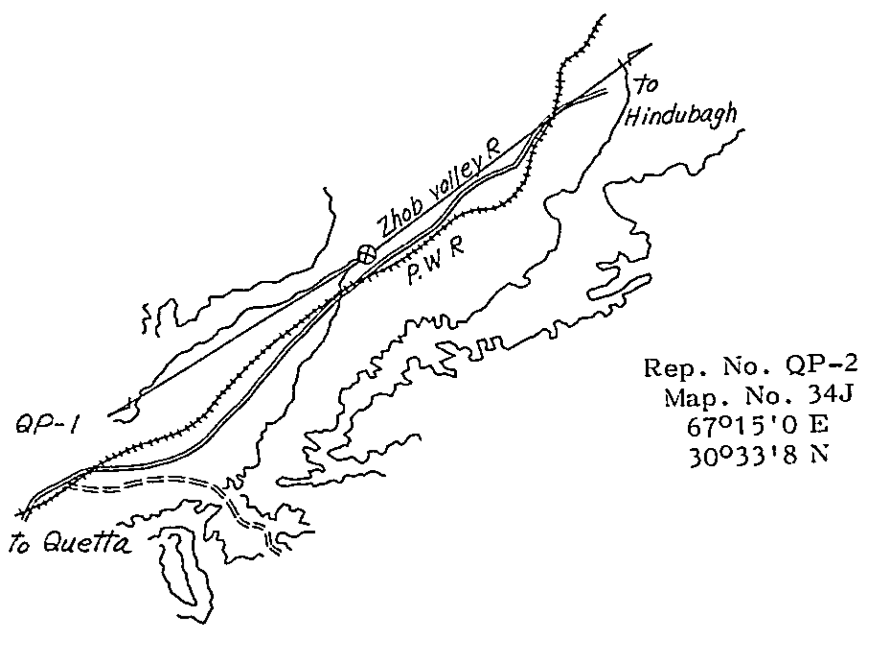


Fig. 2.2.2 Sketch map of the station sites (Quetta-Peshawar) (1)



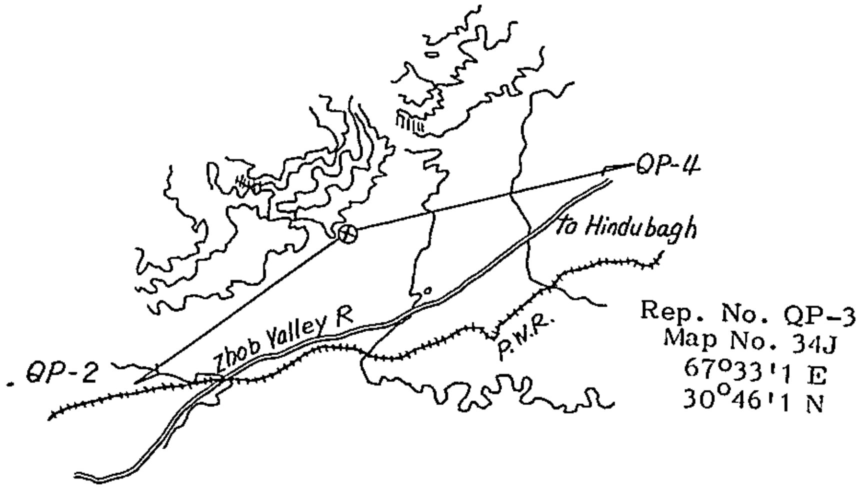
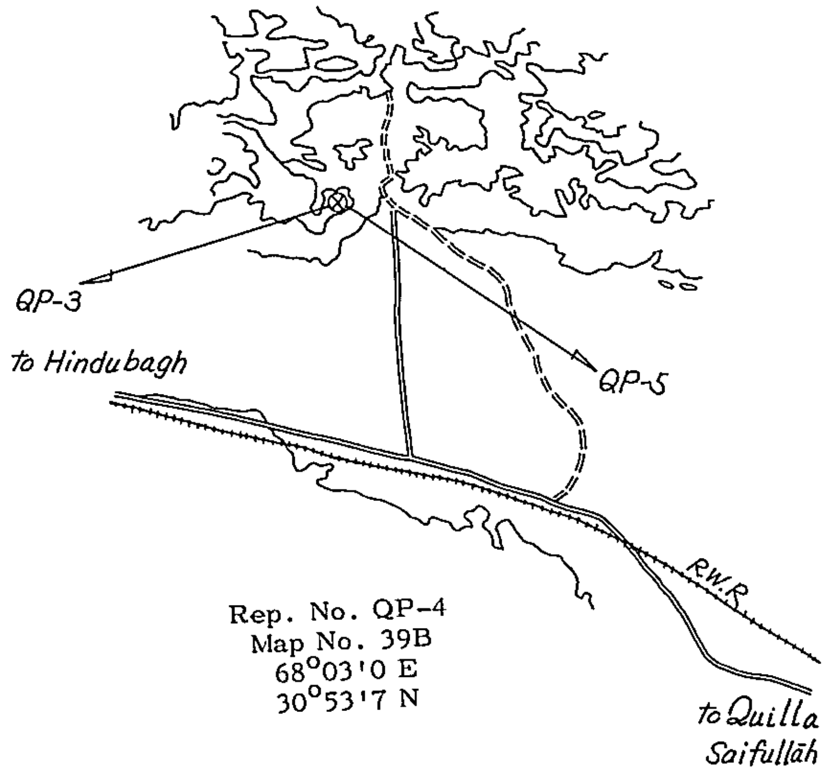
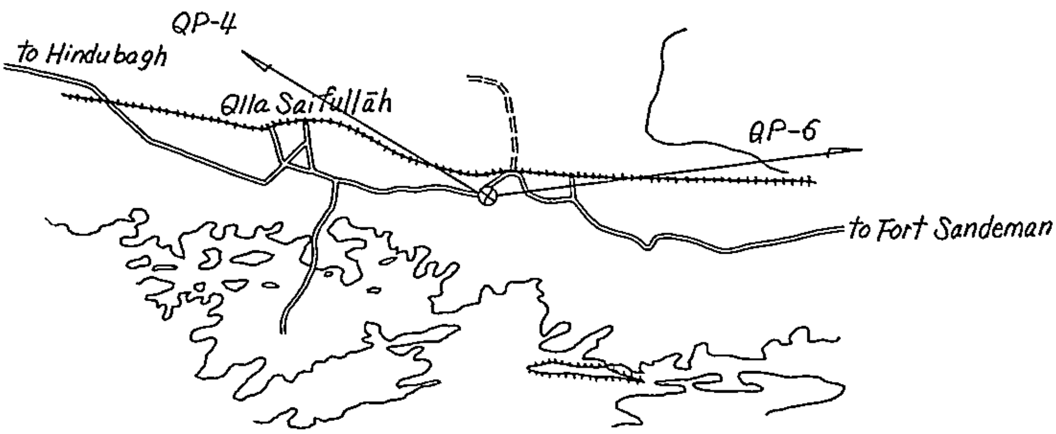


Fig. 2.2.2 Sketch map of the station sites (Quetta-Peshawar) (2)

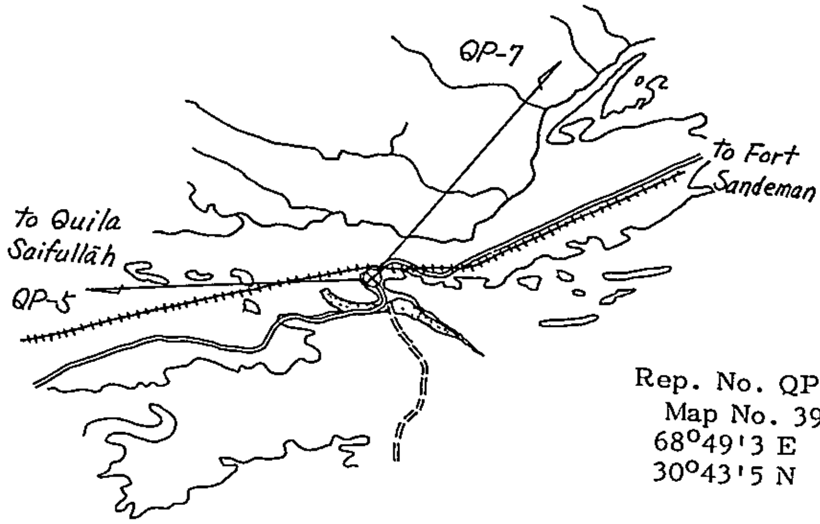


Rep. No. QP-4
Map No. 39B
68°03'0 E
30°53'7 N

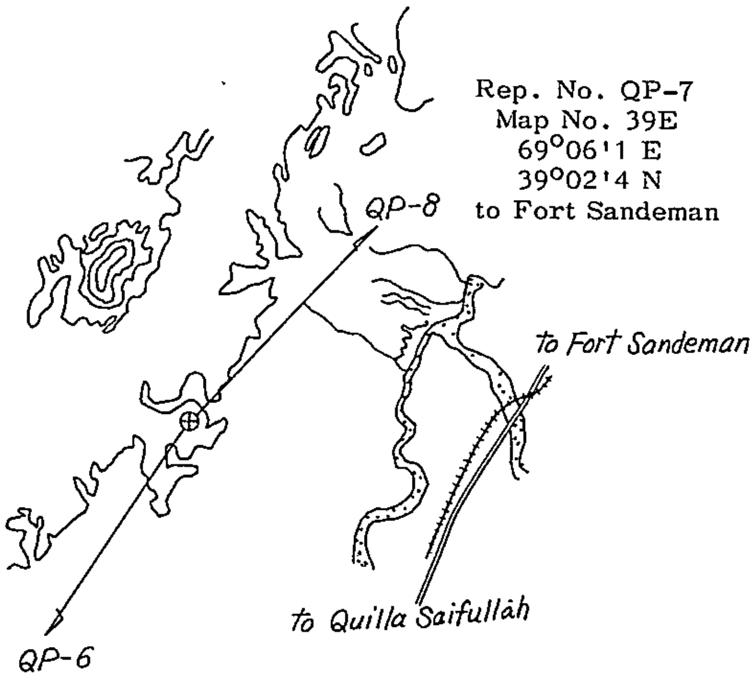


Rep. No. QP-5
Map. No. 39B
68°25'5 E
30°40'7 N

Fig. 2.2.2 Sketch map of the station sites (Quetta-Peshawar) (3)



Rep. No. QP-6
Map No. 39B
68°49'3 E
30°43'5 N



Rep. No. QP-7
Map No. 39E
69°06'1 E
39°02'4 N
to Fort Sandeman

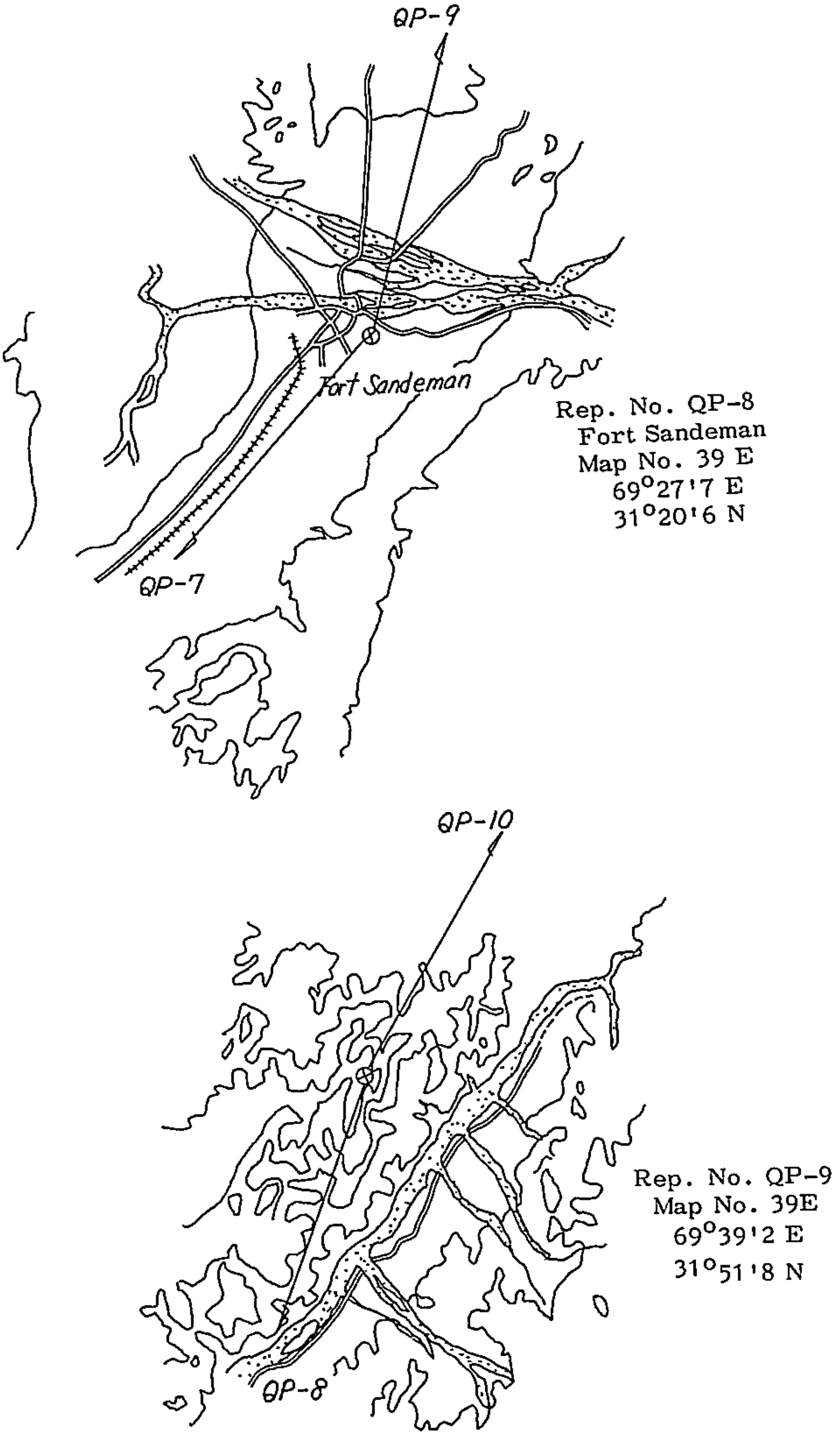


Fig. 2.2.2 Sketch map of the station sites (Quetta-Peshawar) (4)

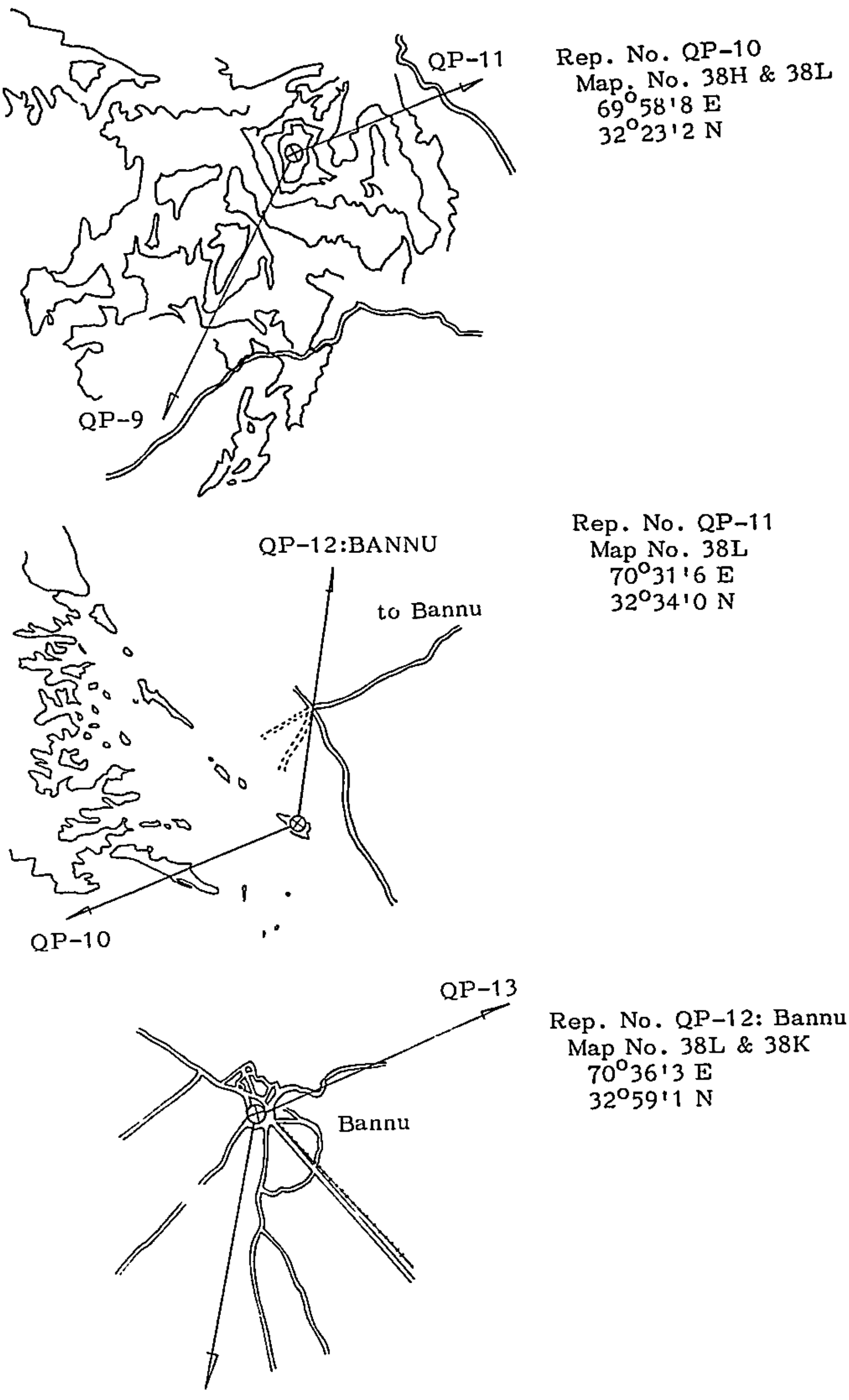


Fig. 2.2.2 Sketch map of the station sites (Quetta-Peshawar) (5)

(K = 4/3)

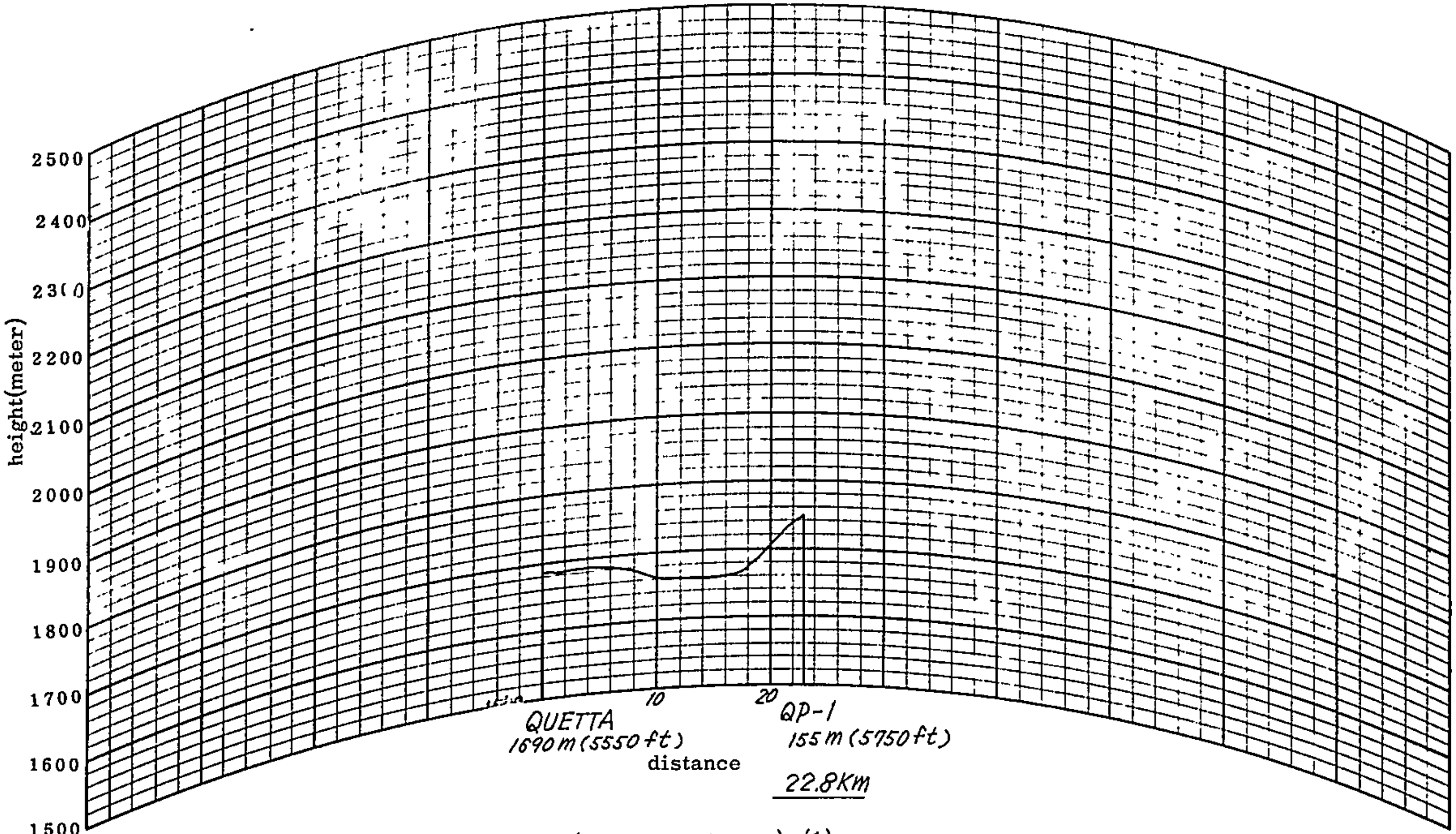


Fig. 2.2.3 Profiles (Quetta-Peshawar) (1)

(K = 4/3)

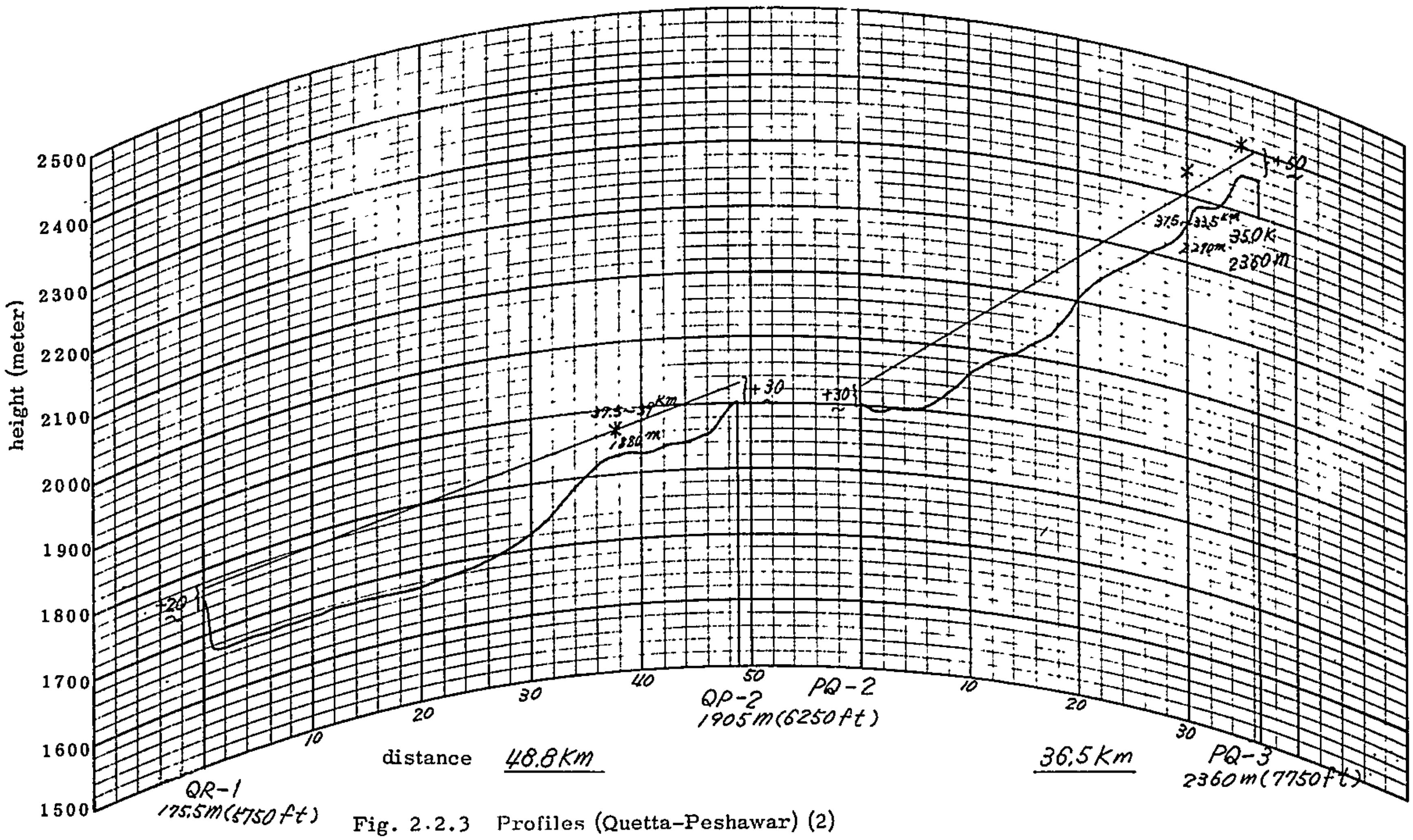


Fig. 2.2.3 Profiles (Quetta-Peshawar) (2)

(K = 4/3)

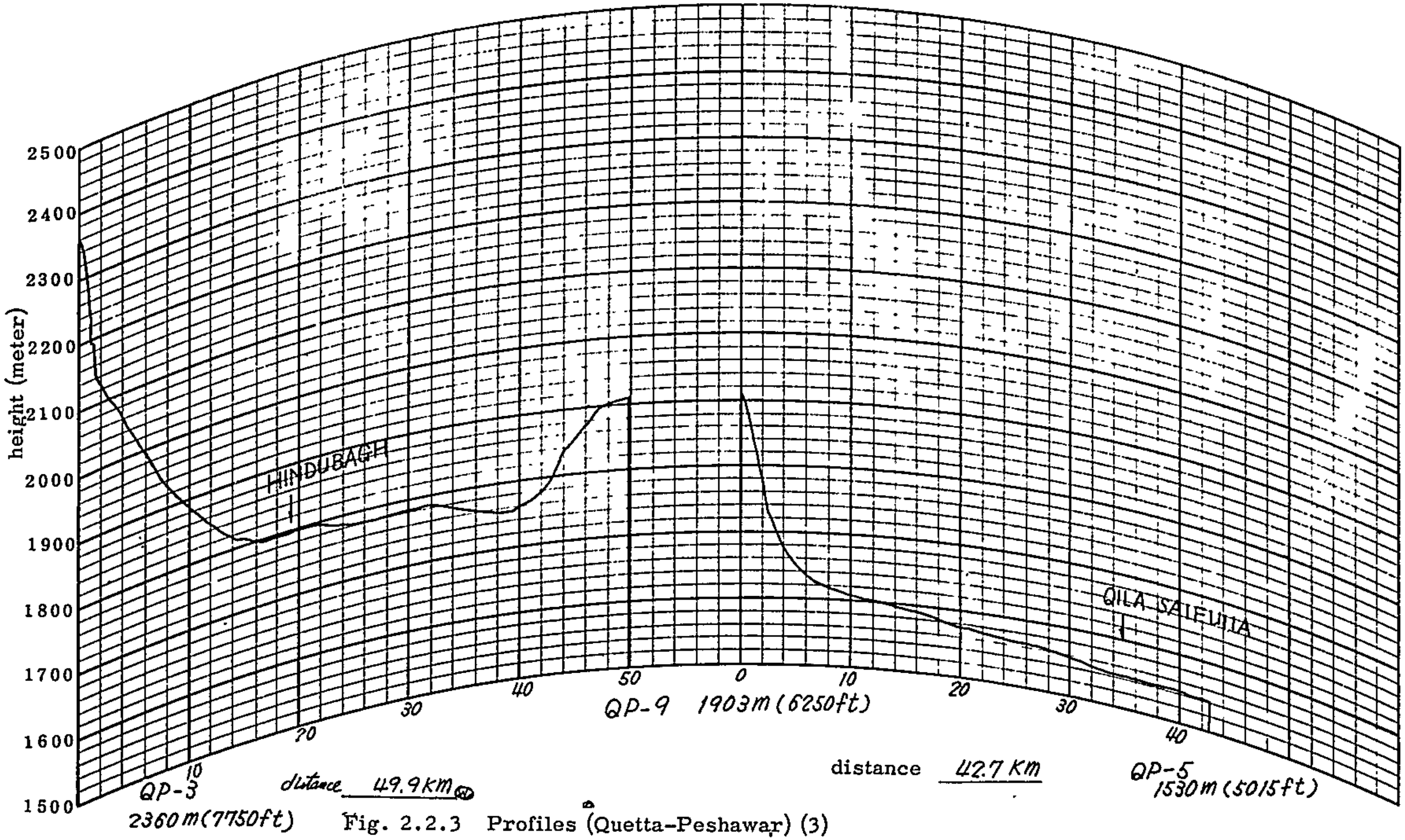


Fig. 2.2.3 Profiles (Quetta-Peshawar) (3)

(K = 4/3)

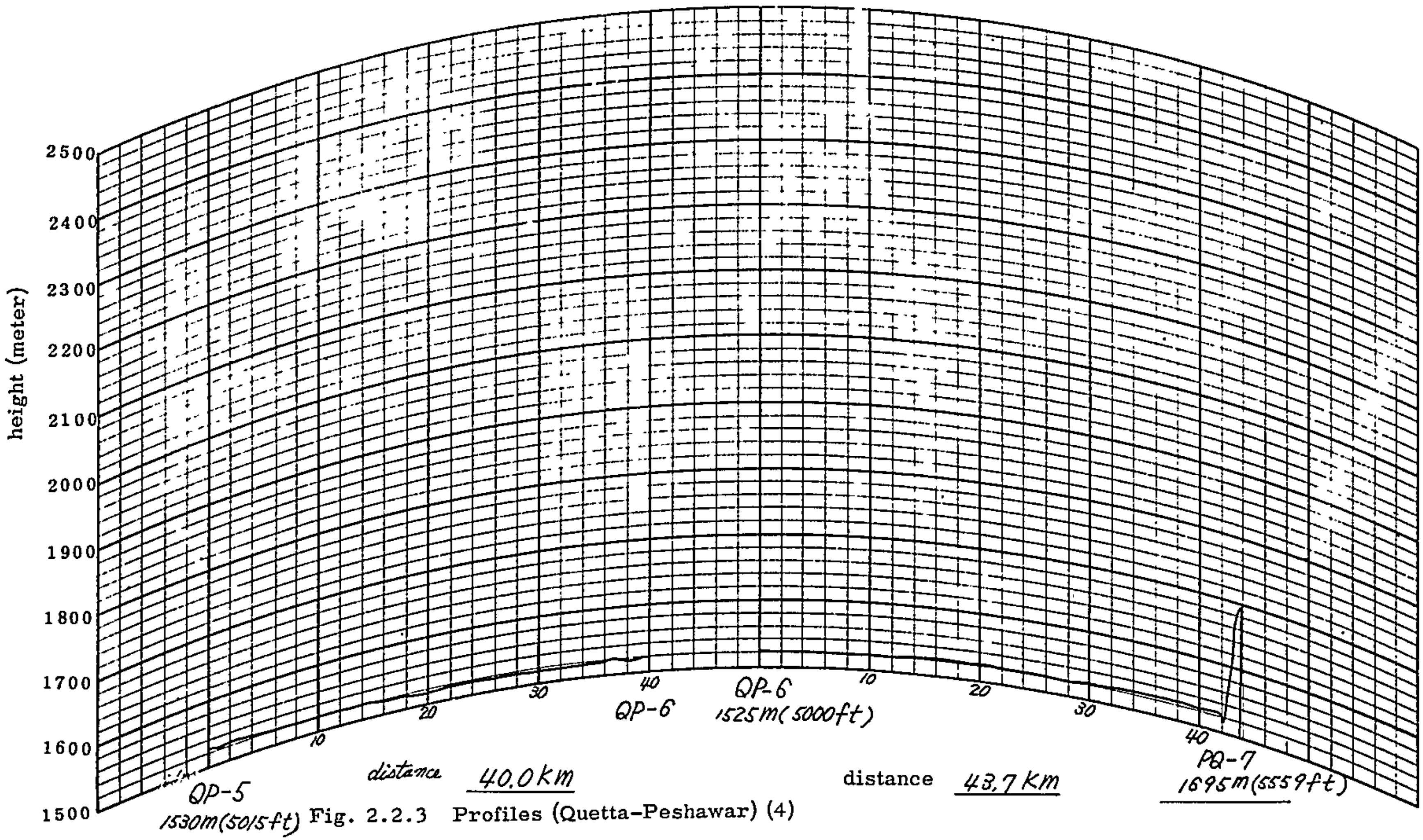


Fig. 2.2.3 Profiles (Quetta-Peshawar) (4)

(K = 4/3)

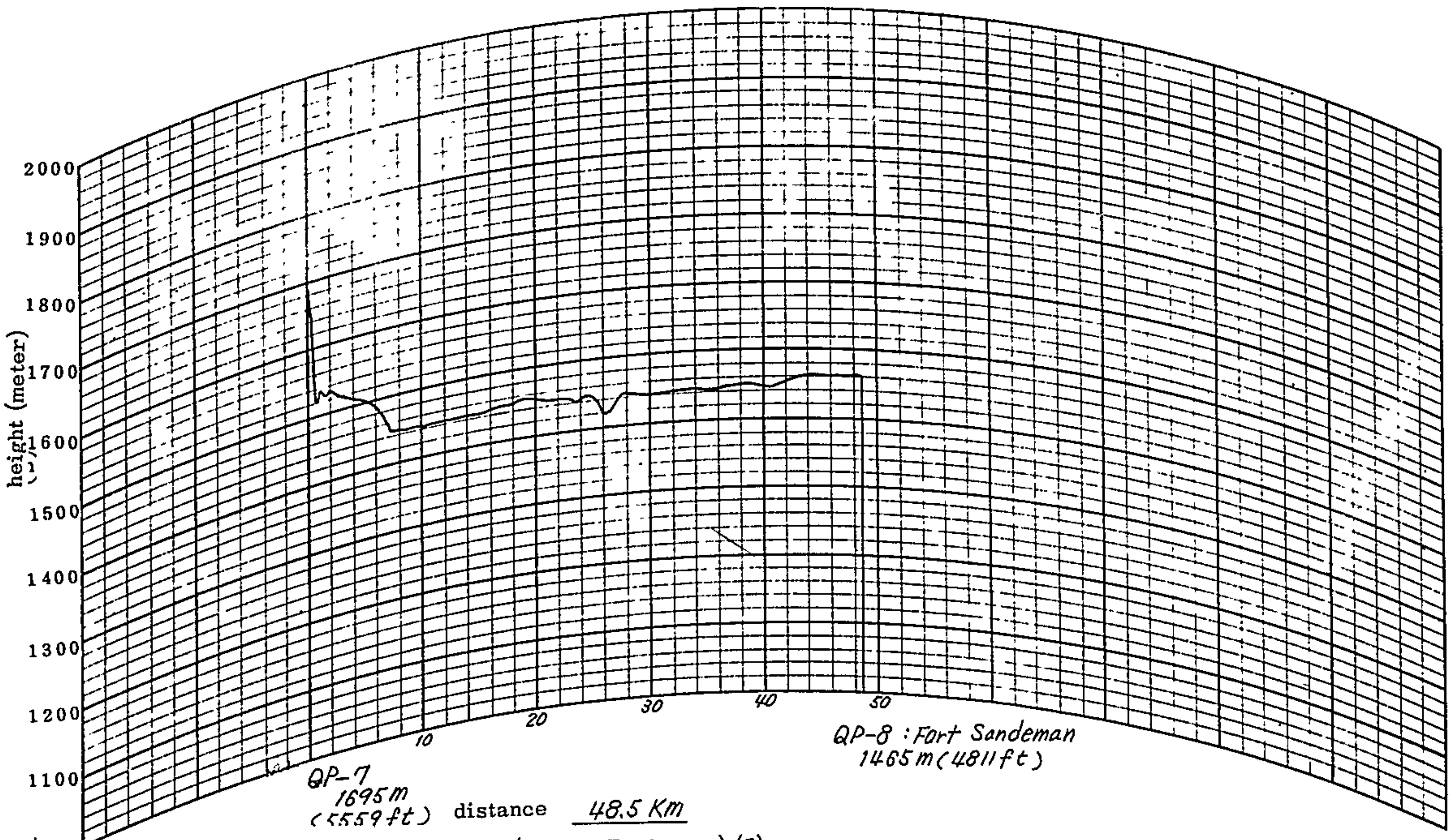


Fig. 2.2.3 Profiles (Quetta-Peshawar) (5)

(K = 4/3)

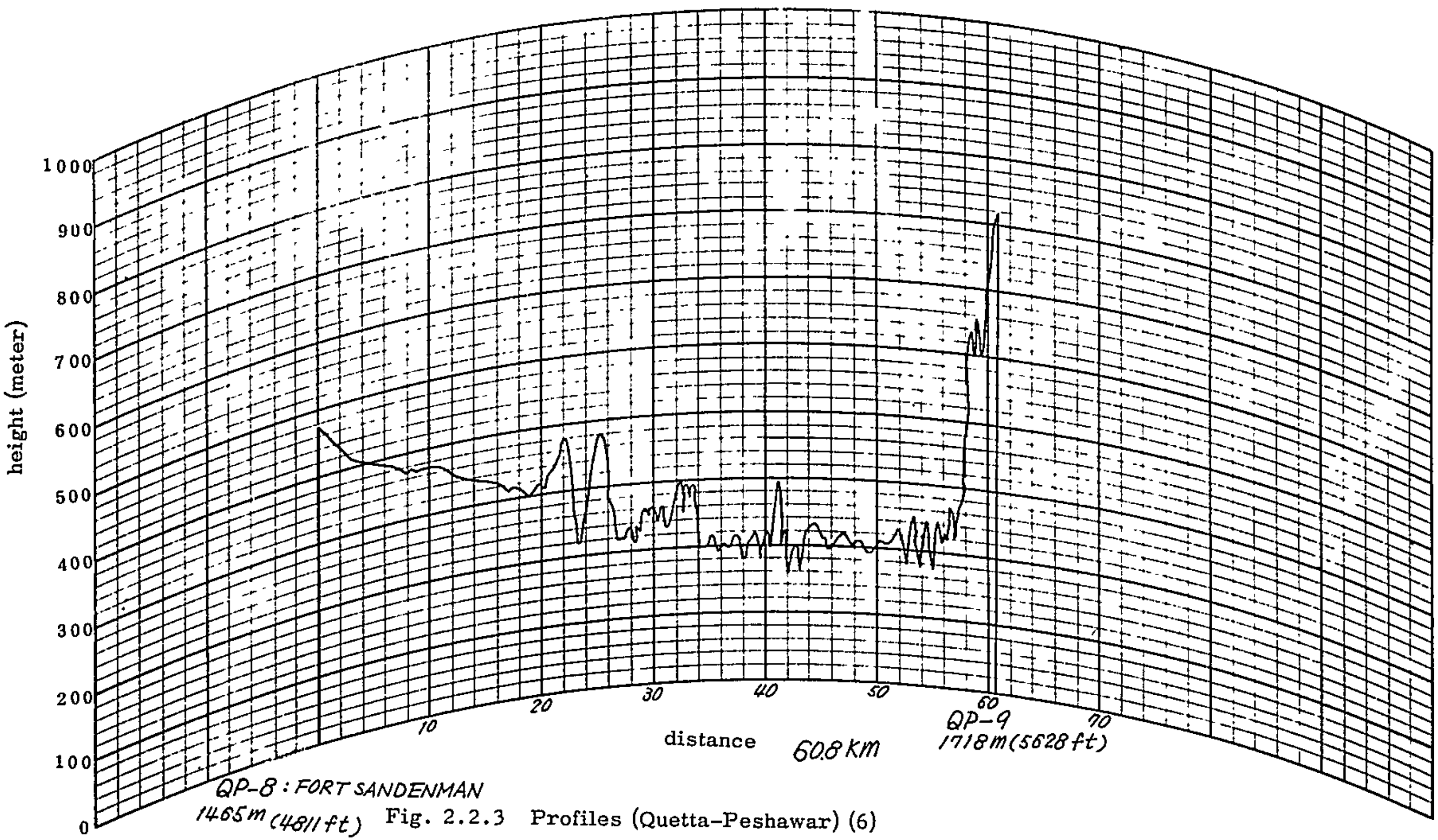


Fig. 2.2.3 Profiles (Quetta-Peshawar) (6)

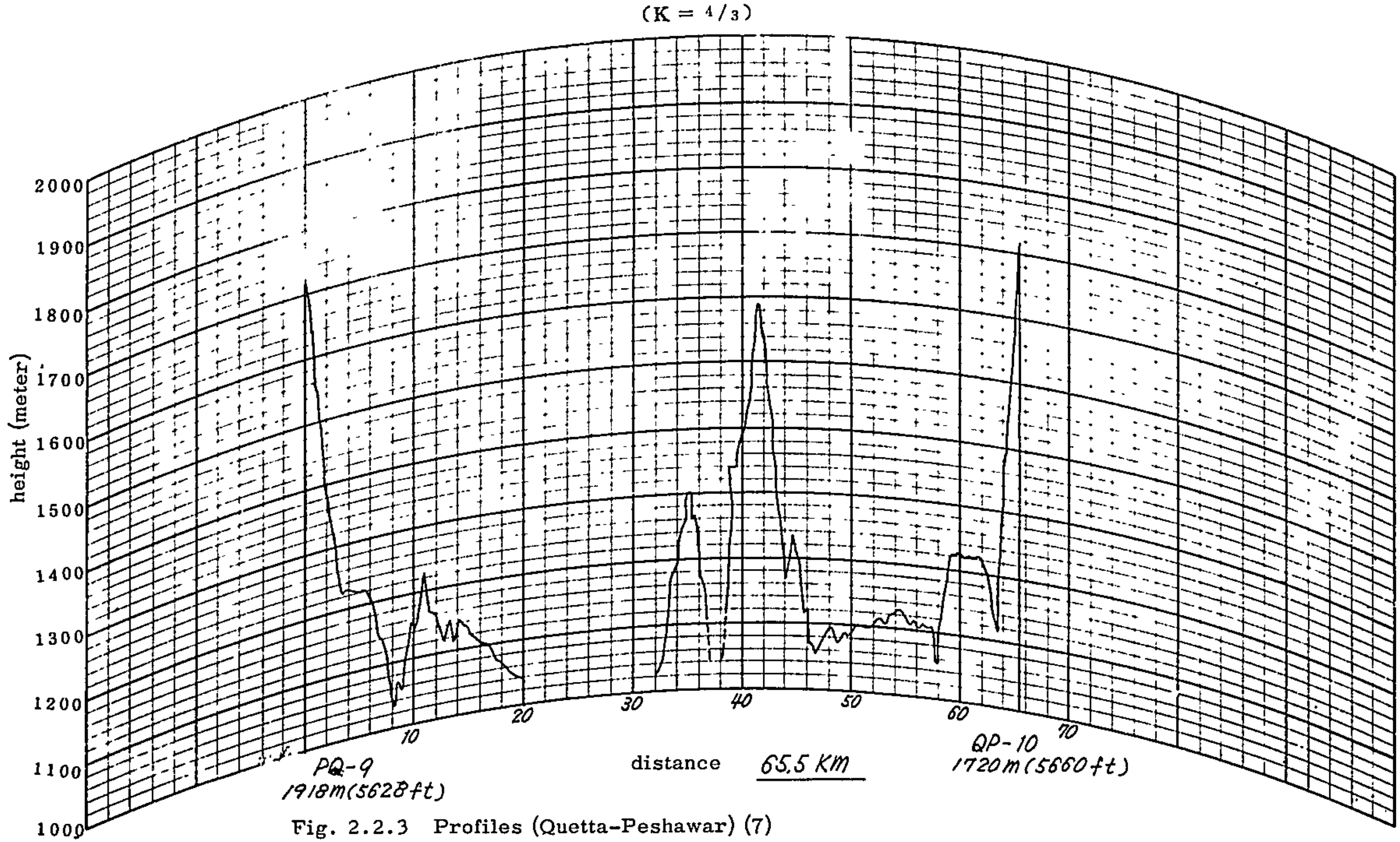


Fig. 2.2.3 Profiles (Quetta-Peshawar) (7)

(K = 4/3)

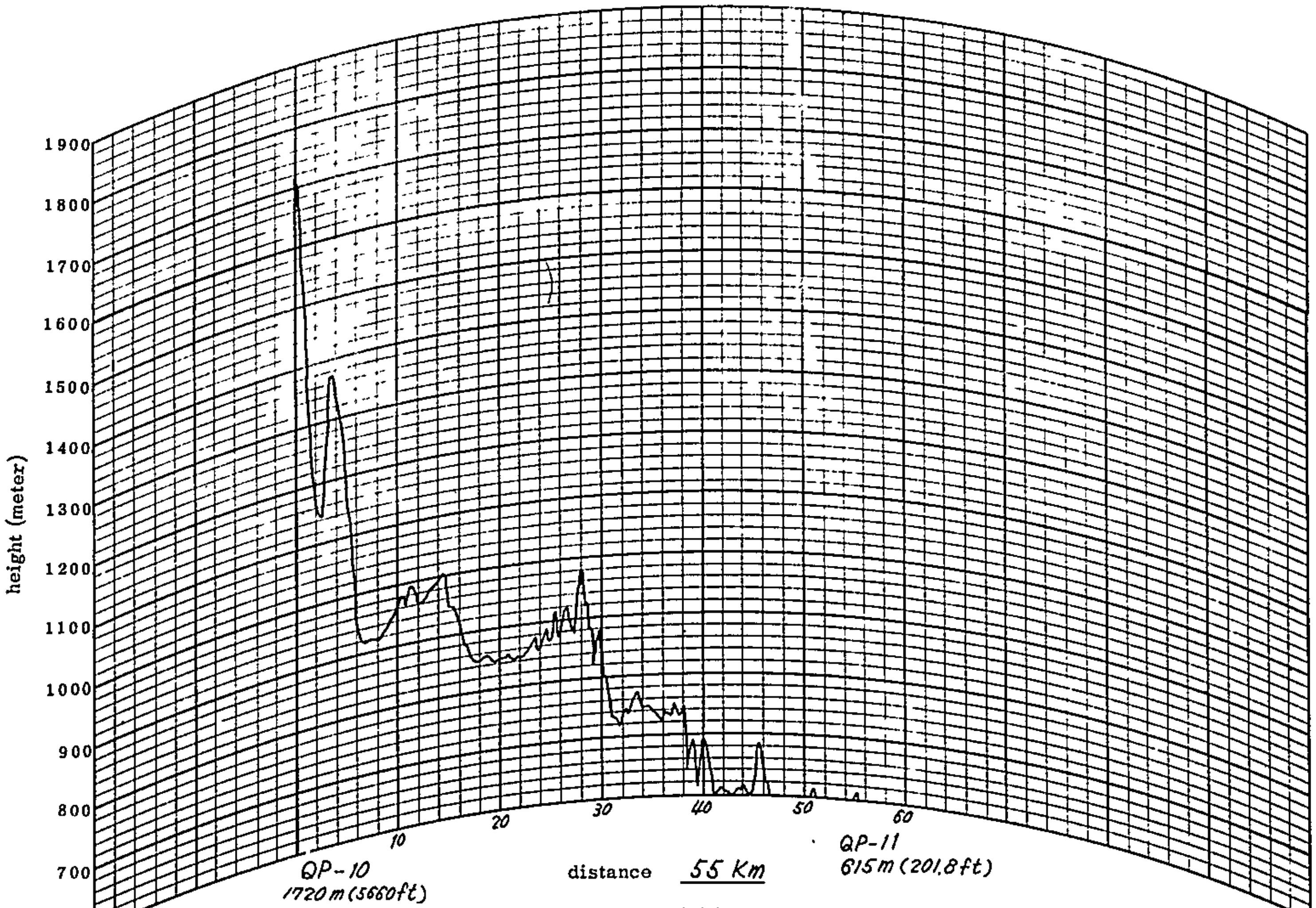


Fig. 2.2.3 Profiles (Quetta-Peshawar) (8)

(K = 4/3)

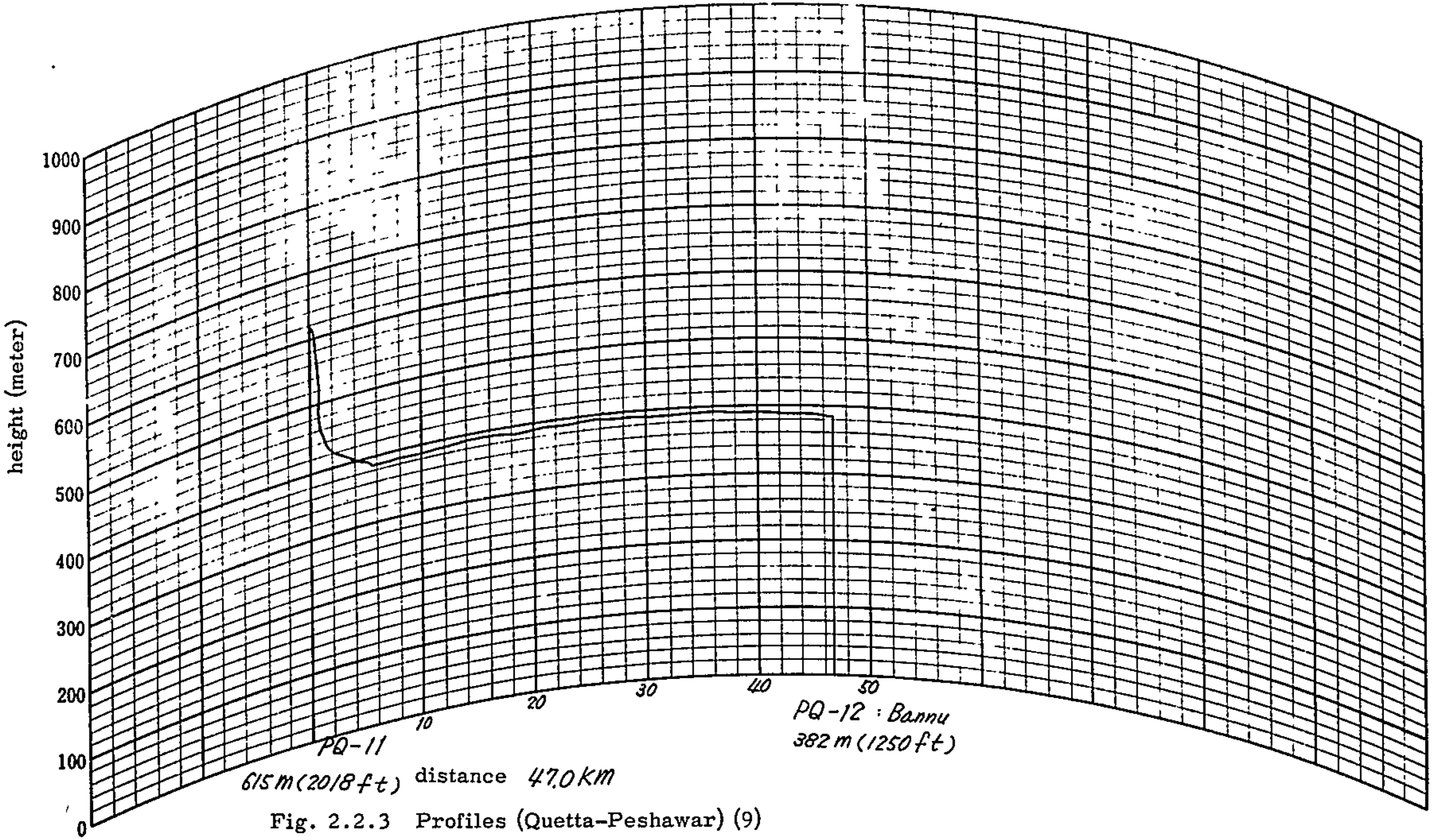
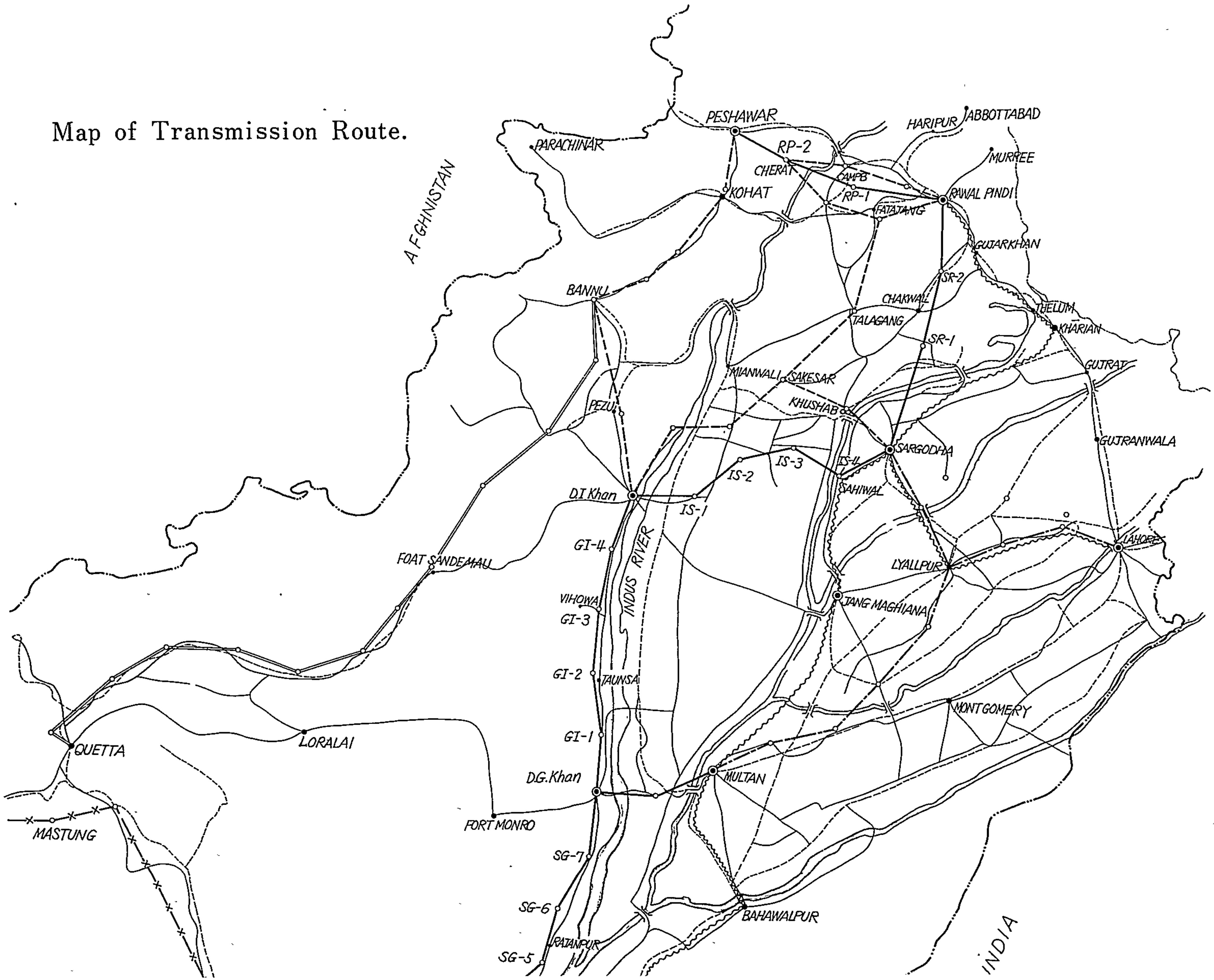
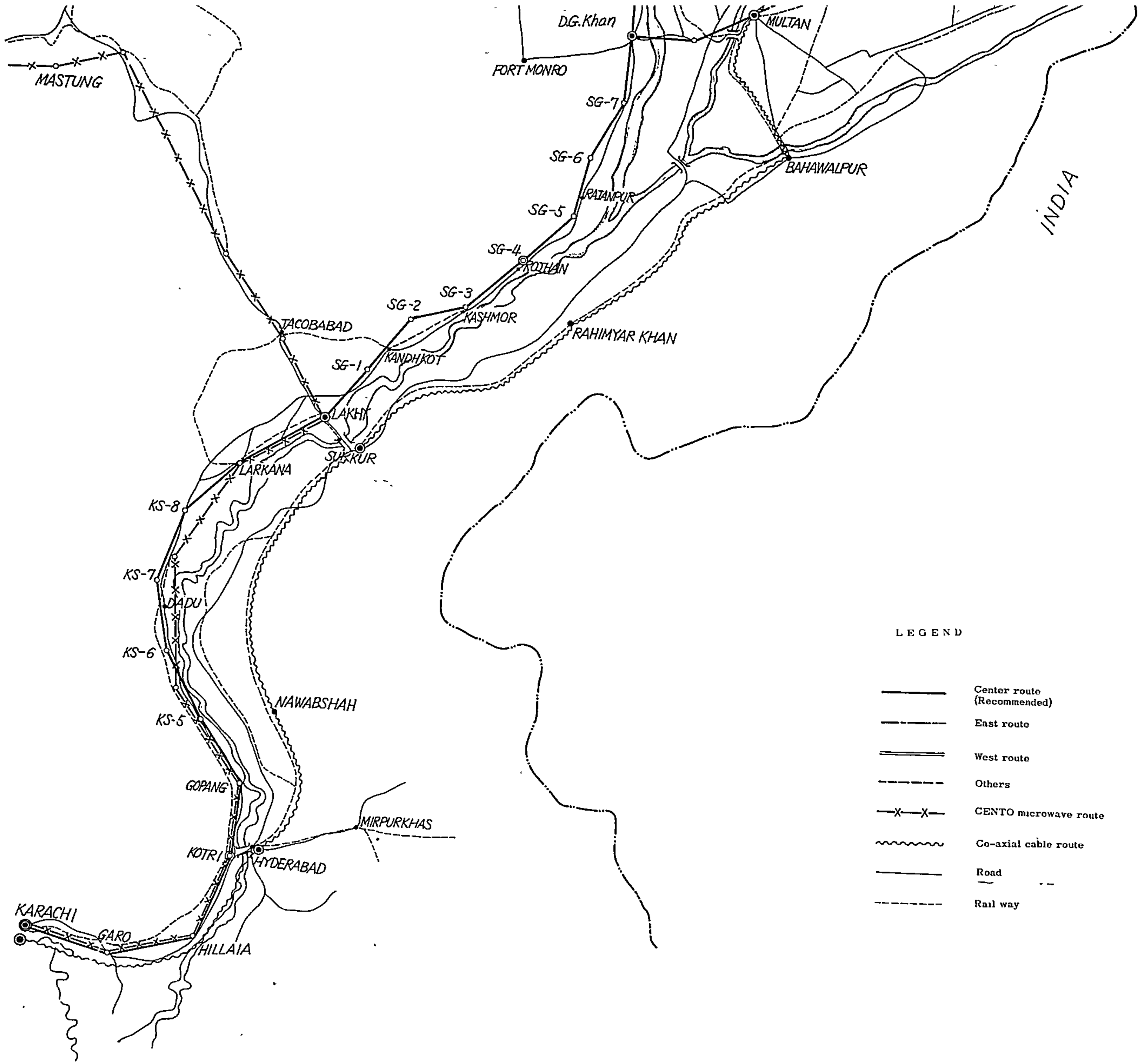


Fig. 2.2.3 Profiles (Quetta-Peshawar) (9)

Map of Transmission Route.




MASTUNG
D.G.Khan
FORT MONRO
MULTAN
SG-7
SG-6
SG-5
SG-4
SG-3
SG-2
SG-1
RATANPUR
KOTHAN
KASHMOR
KANDHKOT
BAHAWALPUR
INDIA
RAHIMYAR KHAN
TACOBABAD
LAKHI
SUKKUR
LARKANA
KS-8
KS-7
DADU
KS-6
KS-5
NAWABSHAH
GOPANG
MIRPURKHAS
KOTRI
HYDERABAD
KARACHI
GARO
HILLAIA
LEGEND
Center route (Recommended)
East route
West route
Others
CENTO microwave route
Co-axial cable route
Road
Rail way