REPORT ON THE SURVEY FOR EAST-WEST PAKISTAN COAXIAL SUBMARINE CABLE PROJECT

FEBRUARY 1965

OVERSEAS TECHNICAL COOPERATION AGENCY

JAPAN

REPORT ON THE SURVEY FOR EAST-WEST PAKISTAN COAXIAL SUBMARINE CABLE PROJECT

FEBRUARY 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 undertake a basic survey for the Submarine Cable Project for linking East and West Pakistan, and entrusted the Overseas Technical Cooperation Agency of Japan with the task of conducting the field survey.

The Agency, considering the importance of providing the communication artery by means of submarine cable in order to cope with the rapidly increasing demand for telecommunication services between the two wings, has dispatched to Pakistan a survey mission consisting of eleven members headed by Mr. Takeshi Ueyama, Chief of Planning Section of Planning Department, the Kokusai Denshin Denwa Co., Ltd. The field survey has been smoothly conducted and completed with results contained in the present report.

The Agency was established as an executive organ of the overseas technical cooperation adopted by the Japanese Government in June 1962, and since then has rendered services in various technical cooperation in accordance with the government's projects. We sincerely hope that this report will prove helpful to implement the East and West Submarine Cable Project, and eventually to bring the two wings into closer political, economical and cultural contact by establishing the newest means of telecommunication, and to contribute toward enhancement of more intimate relationship 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, particularly by the Telegraph and Telephone Department.

December 1964

Shinichi Shibusawa

S. Shibusawa

Director General
Overseas Technical Cooperation
Agency of Japan

CONTENTS

INTRODUCTION

1. Purpose of Survey

The purpose of the survey was to prepare a technical and economic feasibility report for Submarine Cable Project for linking East and West Pakistan in line with the agreement between the governments of Pakistan and Japan. To accomplish this purpose, a survey team was organized and despatched to Pakistan by the Overseas Technical Cooperation Agency, an agent acting in behalf of the Japanese Government.

2. Member of Survey Team

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

Takeshi Ueyama	Chief of the survey team
Junkichi Okada	Estimate of traffic demand, channel requirements, revenues, etc.
Sakio Satomi	do.
Hideo Wada	Investigation for the communication system from landing points to Trunk Traffic Centres
Fujio Kinoshita	Submarine cable engineering
Yuichi Suzuki	Ocean survey engineering
Shimeo Segawa	do.
Keiji Tsuruoka	do.
Fumio Yoshihara	Advisor of the survey team
Kyoitsu Kurematsu	Submarine cable engineering
Kiyosuke Mizuno	Estimate of traffic demand, channel requirements, revenues, etc.

3. Period of Survey

The survey was favourably conducted during the period from the 13th of september to the first of November 1964, according to the following schedule.

Economic feasibility Sept. 13 - Oct. 12

Mainly in Karachi and Dacca

Technical feasibility Oct. 4 - Nov. 1

At cable landing sites and shallow waters around

Karachi, Chittagong and Cox's Bazar

4. Summary

4.1 Future traffic demand, channel requirements, income and expenses in regard to the execution of the cable project were estimated, mainly using as a basis the data furnished by the Pakistan Telegraph and Telephone Department and some other materials in the field of economic activities.

4.2 Physical investigation, including echo-sounding, of the local shore ends was conducted with unstinted assistance of the Pakistan Navy and the Telegraph and Telephone Department, off the coast of Karachi, Chittagong and Cox's Bazar.

4.3 Field investigation, including land lines connecting the landing points and the central exchanges, was also conducted with aid of the T & T Dept., around Karachi, Chittagong and Cox's Bazar.

4.4 On the 9th 1964, a preliminary report on the estimation of traffic demand, channel requirements, annual revenues and expenaes was submitted to the Economic Affairs Division of President's Secretariat, the Government of Pakistan, and copies of which were presented to the Pakistan Telegraph and Telephone Department. As for the actual survey of land and sea, summarization was reported, on the 26th of October 1964, orally to the T & T Department.

5. Acknowledgment

The survey team would like to take this opportunity to express their deepest appreciation for the assistance and courtesy extended during the survey by the following authorities:

President's Secretariat, Economic Affairs Division, Karachi;

Secretary, Ministry of Communications, Rawalpindi;

Pakistan Telegraph and Telephone Department, Karachi;

Regional Telecommunication Organizations in Dacca, Chittagong and Cox's Bazar; and

Pakistan Navy, Karachi and Chittagong.

I MEMORANDUM

1. Main Features of the Proposed Submarine Cable System including the Anticipated Reliability of the System as a Whole

1. 1 Trend of the Intercontinental Communication

The worldwide trend to use coaxial submarine cable for carrying a vast volume of traffic between the continents across the ocean has its origin in the inauguration of the Transatlantic Telephone Cable No. 1 (TAT-1) in September 1956. New cables have since been laid one after another. The system used in the early days has been greatly improved by constant efforts to provide more stable channels at a lower cost.

1. 2 Comments on the Pakistan East-West Communication

To provide a new communication artery between the two wings of Pakistan separated by Indian Peninsula, the coaxial submarine cable is considered best suited to the purpose, considering stability of communication, protection of secrecy and quality of the service rendered. Needless to say, however, it has to be able not only to render a satisfactory service for a considerably long period, but also to accommodate a sufficient number of channels to meet the rapidly growing demand; judging from the remarkable progress of industries in both wings of Pakistan, it is estimated that more than 250 channels will be required to cater for the increased traffic after 10 years. For these reasons, the SD cable used for the Transpacific Cable is recommended as the best type of cable to be used for the coaxial submarine cable between the East and West wings of Pakistan.

1. 3 Outline of the SD Cable System

Principal features of the SD cable system are;

Transmission frequency band	0. 1 - 1. 1 Mc/s
Number of channels	128 - 138 channels of 3 Kc band Up to 250 channels available with TASI equipment
Maximum distance of Power feeding	3, 500 n. m.

Repeater spacing	20 n. m.
Maximum number of repeaters to be used in a feeding interval	180
Ocean block length	192 n. m.
Transmission quality	35 dba for 3, 500 n. m.

1.4 S. D. Cable

This type of cable is, except for shallow water cable, armorless cable containing tensility steel wire in its core, instead of external steel armor as used for conventional cables. It is free from troubles caused by twisting in course of cable laying which are inevitable with externally armored cables. Its transmission characteristics are kept stable for quite a long duration because of its simple structure. Its another feature is cheapness of cost.

It is produced under very strict quality control; for instance the permissible defference of the outer diameter of its inner insulator is only 1/1000 of an inch. The general view and features of SD cable are shown in the annexed specification.

1.5 Repeater

In this type of cable, 180 repeaters, inserted at intervals of 20 n. m. in a feeding span of 3, 500 n. m., are used to compensate the total loss of 9, 000 db. The repeater is housed in a cylindrical case of 1 foot in diameter, 3 feet in length, enduring a high pressure of several thousand atms. It is capable of accommodating the direction filter, which had to be left out because of small space in the flexible repeater used in the early days; incorporation of the direction filter in a repeater has made it possible to utilize one cable simultaneously in two way communication and introduction of duplicated amplifiers, which brought about improvement of reliability. The repeater, being composed of choice components, each guranteed of 20 year life, offers very high stability and reliability.

1.6 Life of the Cable System

As stated above, cable, repeaters, etc. constituting this cable system have very high stability and reliability. Every component part used in the system is guaranteed to work for 20 years without fail. Therefore the cable system of this type is assured durable for 20 years at least.

1.7 Quality of the circuits

In support of the excellent transmission characteristics of this system, the actual results revealed by the Transpacific Cable now in operation are cited below;

Transmission loss	0.5 db, on Tokyo-Oakland circuit (15,000 km) and on Tokyo-London circuit (25,000 km.)
Transmission linearity	Satisfying CCI's Standards
Noise	do.
Level fluctuation	Negligible

1.8 Connection with International Circuits

As the circuits made available through this system offer very high quality as described above, the East-West Pakistan cable, if constructed with this type of cable, will be possibly connected, not only with the domestic network, but also with the CENTO Microwave Link at Karachi and with another microwave network from Chittagong, Cox's Bazar on to Burma, from where it may become possible to be linked with the SAFE Cable (the South Asia and Far East Cable System under project).

2. Estimate of Traffic Demand and Channel Requirements between the Two Wings

2.1 Present Status of the East-West Telecommunications

The annual volume of traffic carried between East and West Pakistan in the past ten years is shown in Table 1 attached hereto.

The telephone traffic has made a favourable increase year by year and as you notice, the traffic volume has increased by five and a half times in ten years. Though fluctuations are seen in past years, figures of the telegraph traffic in the last five years show a steady upward trend. Telex is a new service, but its volume has been almost doubled in the five years.

At present telecommunications between the two wings have to depend upon high frequency radio circuits. The existing direct East-West channels as of September 1964 are shown in Table 2.

2.2 Estimated Traffic Demand and Channel Requirements

The estimate of the number of required channels is given in Table 3. The estimate of demand for telecommunication for each successive five-year period was first worked out on the basis of the traffic volume in the past and present in consideration of future development, especially the 3rd Five Year Plan. Channel requirements by the type of service have been calculated on the basis of the above-mentioned demand estimate.

Pakistan Telegraph and Telephone Department has given an estimate, in a booklet called "Satellite Communications and Pakistan", of the number of channels required between East-West Pakistan. Comparison between our estimation and the number of channels estimated by the T & T is shown below for your reference.

Year	By Japanese Survey Team	By T & T Dept.
1965/66	30	24
1970/71	143	150
1975/76	348	600
1980/81	830	-
1985/86	2, 040	2, 250

(in voice grade channels)

The grounds for the estimation of traffic demand and channel requirements by the type of service will be described hereinafter.

2. 3 Estimated Traffic Demand and Channel Requirements by the Type of Service

(1) Telephone

Estimated telephone traffic and channel requirements are given in Table 4, worked out on the following basis;

a. The average rate of traffic growth in the past five years has been 16% per annum.

b. After the inauguration of the cable system, it is expected that the growth rate will rise to around 20% per annum, as a result of improvement of operational efficiency effected by the adoption of Subscriber Trunk Dial System and eventually more use of telephones by the customers will be induced.

c. It is generally seen that when a HF radio circuit is replaced by a high quality and broad bandwidth circuit, a rapid increase of traffic follows. Judging from the instance of Dacca-Chittagong VHF link, the East-West telephone traffic in this case is expected to increase by about three times in course of a year.

d. It has generally been accepted that one channel would be required for each 45, 000 chargeable minutes per annum, plus 20% of channels in consideration of future automatic operation.

As for the relations between traffic demand and number of channels required, please refer to Fig. 1.

(2) Telegraph

Estimated telegraph traffic and channel requirements are given in Table 5, based on the following grounds;

a. The rate of traffic growth in the past years has been 13% on the average.

b. Considering the expansion of inland telegraph network and introduction of GENTEX system etc. according to the 3rd Five Year Plan, which is expected to improve the service, the growth rate of 13% will be maintained in the foreseeable future.

c. 9, 000 words per day (2. 7 million words per annum) will require one telegraph channel.

As for the growing tendency of the traffic demand, please refer to Fig. 2.

(3) Telex

Estimated telex traffic and channel requirements are given in Table 6, which is based on the following assumptions;

a. The increase of teleprinters (2, 100), the increase of inland telex circuits (949 in the West and 860 in the East) according to the 3rd Five Year Plan, and the opening of service over the Submarine Cable will double the telex traffic in the initial year. There after, the yearly growth rate will be around 20%.

b. After ten years of the cable construction, the growth rate will gradually be decreased to about 15%.

As for the growing tendency of the traffic demand and channel requirements, also refer to Fig. 3.

(4) Photo-telegraph

Estimated photo-telegraph traffic and channel requirements are shown in Table 7, which is based on the following assumptions;

a. It is rather difficult to estimate the traffic growth of this service, since the past results show unstable fluctuations. However, taking into consideration the general improvement of telecommunication services and economic activities, the growth rate per annum of 20% has been tentatively adopted.

b. 3,000 square inches of traffic will necessitate one voice grade channel.

(5) Leased Channels and Others

The estimated demand for leased telephone, leased telegraph and other new services is given in Table 8, which is based on the following assumptions;

a. With the growth and popularization of classical services, demand for leased telephone and telegraph channels will be doubled in every five years.

b. New services such as Program Transmission Service and Data Transmission Service will be opened one after another. Therefore, the demand for the circuits will also be doubled in every five years.

I-2. Table 1. Statistics showing the traffic between East and West Pakistan

Year	Telephone		Telegraph		Telex		Photo telegraph	
	Thousand mins	Index	Thousand wds	Index	Minutes	Index	sq.inches	Index
1954/55	100	100	11,705	100				
1955/56	145	145	11,050	94				
1956/57	172	172	10,767	92				
1957/58	198	198	11,558	99				
1958/59	306	306	12,798	109	18,963	100		
1959/60	351	351	10,079	86	27,283	144	89	100
1960/61	414	414	10,861	93	11,255	59	126	142
1961/62	481	481	12,412	106	27,642	146	145	163
1962/63	479	479	13,968	119	31,532	166	53	60
1963/64	546	546	15,295	131	37,032	195	96	108

I-2. Table 2. Existing Direct HF Radio Circuits between The Two Wings

(as of September, 1964)

Type of service	Circuits between;			Total
Telephone	Karachi -	Dacca	5	11
	Karachi -	Chittagong	2	
	Rawalpindi -	Dacca	4	
Telegraph	Karachi -	Dacca	3	3
Telex	Karachi -	Dacca	1	1
Photo-telegraph	Karachi -	Dacca	1	1
Leased telephone	Karachi -	Dacca	3	3
Leased telegraph	Karachi -	Dacca		
	Full speed		1	1
	Half speed		1	1
	Quarter speed		3	3

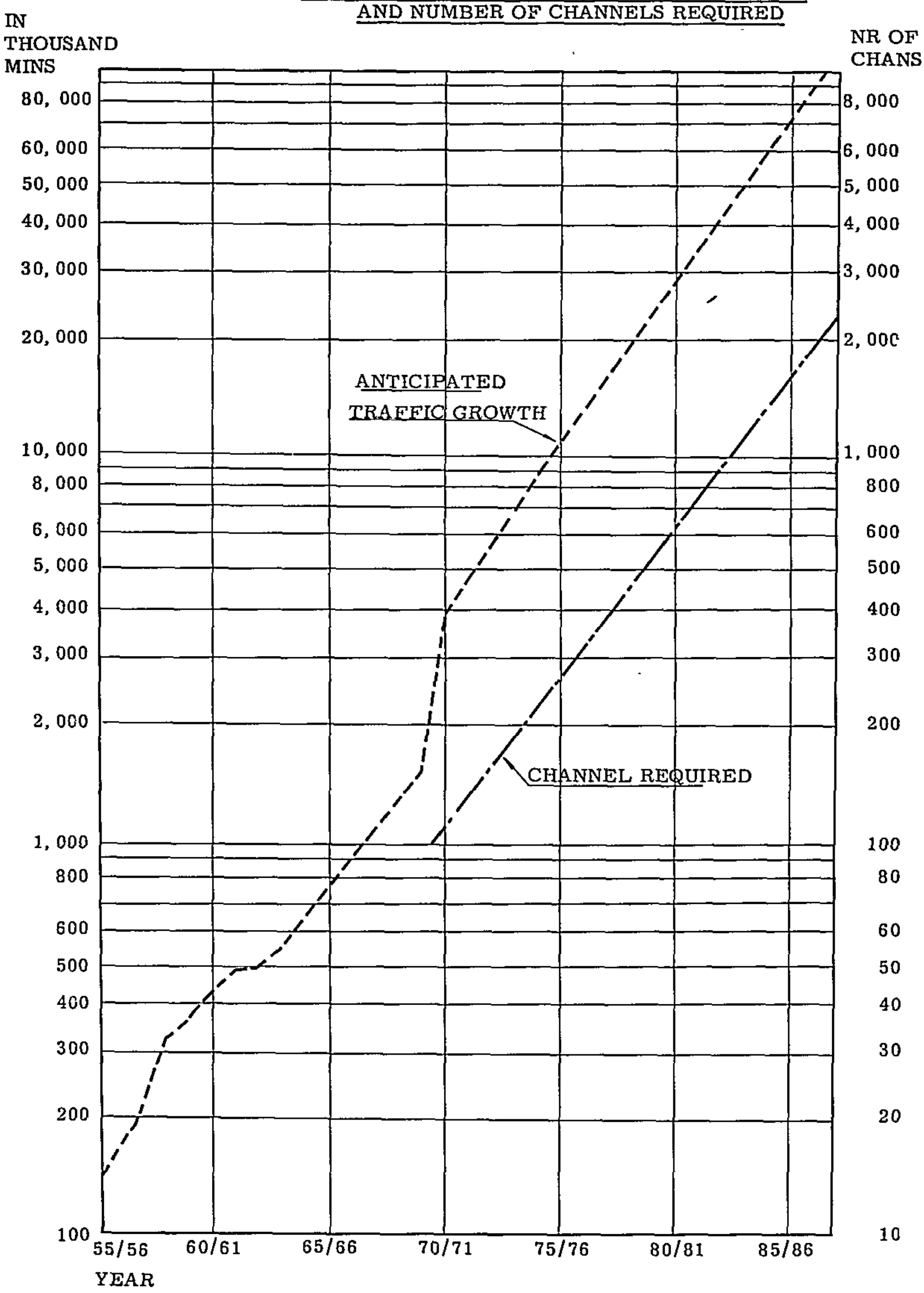
I-2. Table 3. Estimated number of channels required between East-West Pakistan

Year	Telepnone channels			Telegraph channels					No. of VF channels required
	Commercial	Lease	PIX PTS OTRS	Telegraph	Telex	Lease	Total	Total in VF chs	
1963/64	11	3	1	3	1	2.25			
1965/66	24	4	1	7	2	3.25	12.25	1	30
1970/71	131	8	2	14	5	6.50	25.50	2	143
1975/76	325	16	4	25	12	13.00	50.00	3	348
1980/81	784	32	8	47	30	26.00	103.00	6	830
1985/86	1,950	64	16	76	61	52.00	189.00	10	2,040

I-2. Table 4. Estimated Telephone Traffic and Number of Channels Required

Year	Traffic (in thousand mins)	No. of chs (Manual opns)	No. of chs (Automatic opns)
1963/64	546	11	
1965/66	787	24	
1970/71	4,896	109	131
1975/76	12,182	271	325
1980/81	29,378	653	784
1985/86	73,103	1,625	1,950

I-2. Fig. 1 GROWTH OF INTERWING TELEPHONE TRAFFIC AND NUMBER OF CHANNELS REQUIRED



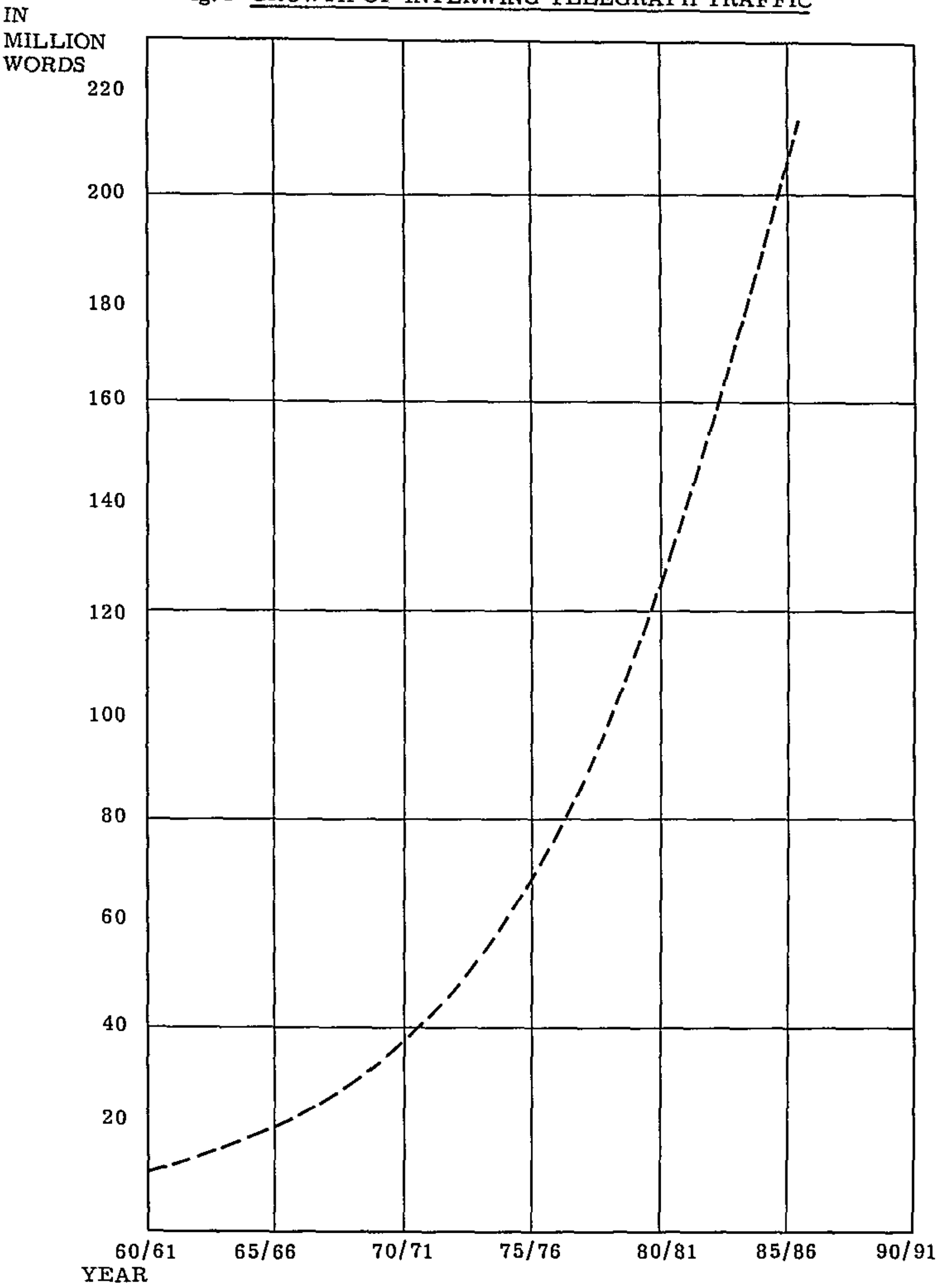
I-2. Table 5. Estimated Telegraph Traffic and Number of Channels Required

Year	Traffic (in thousand wds)	No. of channel
1963/64	15,295	3
1965/66	20,155	7
1970/71	37,135	14
1975/76	68,419	25
1980/81	126,057	47
1985/86	205,533	76

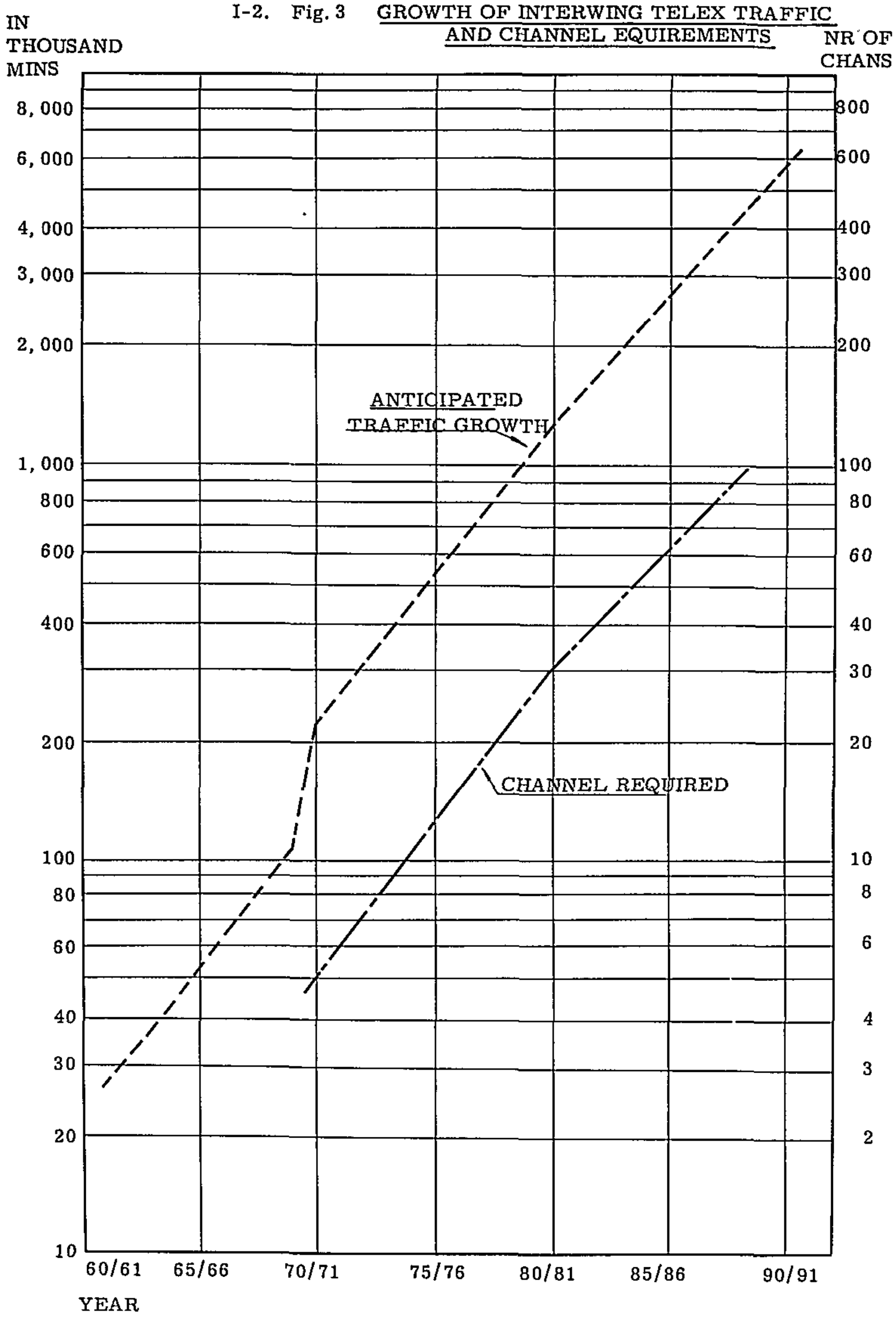
I-2. Table 6. Estimated Telex Traffic and the Number of Channels Required

Year	Traffic (in minutes)	No. of channels
1963/64	37,032	1
1965/66	53,326	2
1970/71	221,152	5
1975/76	550,296	12
1980/81	1,369,312	30
1985/86	2,754,175	61

I - 2. Fig. 2 GROWTH OF INTERWING TELEGRAPH TRAFFIC



I-2. Fig. 3 GROWTH OF INTERWING TELEX TRAFFIC AND CHANNEL EQUIREMENTS



I-2. Table 7. Estimated Photo-telegraph Traffic and Number of Channels Required

Year	Traffic (in square inch)	No. of channels
1963/64	96	1
1965/66	138	1
1970/71	344	1
1975/76	857	1
1980/81	2, 132	1
1985/86	5, 305	2

I-2. Table 8. Estimated Demand for Leased Telephone, Leased Telegraph and Other Services

Year	Leased Telephone	PTS, other New Services	Leased Telegraph			
			Full	Half	Quater	in Full speed chs
1963/64	3	1	1	1	3	2. 25
1965/66	4	1	1	2	5	3. 25
1970/71	8	2	2	4	10	6. 50
1975/76	16	4	4	8	20	13. 00
1980/81	32	8	8	16	40	26. 00
1985/86	64	16	16	32	80	52. 00

3. Estimated Cost of Construction with Necessary Particulars

The following cost of construction of the East-West Pakistan Cable has been calculated on the assumption that the cable system consists of submarine cable of SD system and communication systems from the landing points to the Trunk Traffic Centres; at the west end the cable is directly led into the Trunk Traffic Centre at Karachi, and at the east end microwave relaying system is used between the landing point and the Trunk Traffic Centre. Details of the cost is given in Table 1.

(in thousand dollars)

Cable Laying	26, 012
Terminal Stations	3, 484
Total	29, 496

Assuming that four TASI equipments which cost about 3, 000, 000 U. S. dollars each are applied to every group of 36 voice channels, the proposed system may provide as many as around 250 message telephone channels, and the construction cost per channel will be less than 166 thousand U. S. dollars (800 thousand Rupees).

Regarding a loan to be sought in order to meet the construction cost of the proposed submarine cable project, there are several international monetary organs, from which necessary funds may be raised; IBRD (The International Bank for Reconstruction and Development) and IDA (the International Development Association) are among them.

Also we might mention the names of the Export-Import Bank of Japan and the Overseas Cooperation Fund of Japan as organs of supplying funds for developing countries under a long-term repayment basis as well as a defered payment basis of Japanese yen credit.

I-3. Table 1.

Construction Cost of the East and West Pakistan Coaxial Cable

(in thousand U. S. dollars)

1. Cable Laying

List-1 Cable	11, 200 ($4, 000 x 2, 800n. m.)
List 3 & 4 Cable	1, 447 ($7, 200 x 201n. m.)
Repeater	10, 205 ($65, 000 x 157)
Equalizer	795 ($53, 000 x 15)
Laying Works	2, 365
Total	26, 012

2. Terminal Station

Karachi	1, 431
Cox's Bazar	855
1st Repeating Station	186
2nd Repeating Station	177
Chittagong	835
Total	3, 484

3. Grand Total 29, 496

4. Estimate of Income by Operating the System

The estimate of income, as shown in the following table, was worked out from the estimated demand by applying the rates now in force. The revenue for each type of service has been estimated for each successive five year period.

Table showing annual revenues

Item	1963/64	1970/71	1975/76	1980/81	1985/86
Telephone	1, 397	12, 534	31, 188	75, 210	187, 146
Telegraph	1, 530	3, 714	6, 842	12, 606	20, 553
Telex	65	399	987	2, 460	4, 952
Photo-telegraph	-	-	-	1	3
Leased telephone	900	2, 400	4, 800	9, 600	19, 200
Leased telegraph	261	775	1, 550	3, 100	6, 200
Total	4, 153	19, 822	45, 367	102, 977	238, 054
(in thousand U.S. dols)	(872)	(4, 164)	(9, 531)	(21, 634)	(50, 011)

The method and basis of calculation are shown in the tables from 1 to 6.

I-4. Table 1. Telephone Revenue Estimate

Year	Traffic (in thousand mins)	No. of three minute calls	Revenue (in thousand Rs.)
1963/64	546	182	1, 397
1970/71	4, 896	1, 632	12, 534
1975/76	12, 182	4, 061	31, 188
1980/81	29, 378	9, 793	75, 210
1985/86	73, 103	24, 368	187, 146

Notes;

Charge;

Between Karachi - Dacca " Rawalpindi - Dacca	Rs 7. 20	For a unit call of 3 mins
Between other places in West and East Pakistan	12. 00	"

Percentage of Traffic;

Between Karachi - Dacca	80%
Rawalpindi - Dacca	10%
Others	10%

Average charge per call;

Rs 7. 20 x 0. 90 = 6. 48
" 12. 00 x 0. 10 = 1. 20

Rs 7. 68

I-4. Table 2. Telegraph Revenue Estimate

Year	Traffic (in thousand wds)	Revenue (in thousand Rs)
1963/64	15, 295	1, 530
1970/71	37, 135	3, 714
1975/76	68, 419	6, 842
1980/81	126, 057	12, 606
1985/86	205, 533	20, 553

Notes;

Charge;

Other than Press

		Rs.
ORD	First 10 words	1. 00
	Each additional word	0. 10
Express	First 10 words	2. 00
	Each additional word	0. 20

Press

ORD	First 40 words	0. 75
	Each additional 5 words	0. 07
Express	First 40 words	1. 50
	Each additional 5 words	0. 14

Charge per word;

To simplify the calculation, Rs 0. 10 per word has been used in the above table.

I-4. Table 3. Telex Revenue Estimate

Year	Traffic (in thousand mins)	No. of 3 minutes call	Revenue (in thousand Rs.)
1963/64	37	12	65
1970/71	221	74	399
1975/76	550	183	987
1980/81	1,369	456	2,460
1985/86	2,754	918	4,952

Notes;

Charge;

	Rs.	
Between Karachi - Dacca	4.00	For a unit call
" Lahore - Dacca	8.50	of 3 mins

Percentage of Traffic;

Between Karachi - Dacca	69%
" Lahore - Dacca	31%

Average charge per call;

Rs 4.00 x 0.69 = 2.76
8.50 x 0.31 = 2.635

Rs. 5.395

I-4. Table 4. Photo-telegraph Revenue Estimate

Year	Traffic (in sq. inches)	Revenue (in Rupees)
1963/64	96	46
1970/71	344	165
1975/76	857	411
1980/81	2,132	1,023
1985/86	5,305	3,546

Notes;

Charge;

Between Karachi - Dacca		Rs.
ORD	For the first 25 sq. inches	12.00
	For each 10 sq. inches above 25 sq. inches	6.00
Press	For the first 25 sq. inches	10.00
	For each 10 sq. inches above 25 sq. inches	5.00

Average charge per square inch;

To simplify the calculation, Rs. 12.00/25 = Rs. 0.48 per sq. inch has been used in the above table.

I-4. Table 5. Leased Telephone Channel Revenue Estimate

Year	No. of channels	Revenue (in thousand Rs)
1963/64	3	900
1970/71	8	2, 400
1975/76	16	4, 800
1980/81	32	9, 600
1985/86	64	19, 200

Notes;

Charge;

Rs 200. 00 per mile, per annum

Distance;

Karachi - Dacca about 1, 500 miles

Average charge per channel;

Rs 200 x 1, 500 = Rs 300, 000

I-4. Table 6. Leased Telegraph Channel Revenue

Year	Speed	No. of chs	Revenue (in thousand Rs)	Total Rev. (in thousand Rs
1963/64	F	1	100	261
	H	1	60	
	Q	3	101	
1970/71	F	2	200	775
	H	4	240	
	Q	10	335	
1975/76	F	4	400	1, 550
	H	8	480	
	Q	20	670	
1980/81	F	8	800	3, 100
	H	16	960	
	Q	40	1, 340	
1985/86	F	16	1, 600	6, 200
	H	32	1, 920	
	Q	80	2, 680	

Notes;

Charge;

Between Karachi - Dacca

Full speed	Rs. 100, 000	per annum	(24 Hrs)
Half speed	60, 000	"	(")
Quarter speed	33, 500	"	(")

5. Estimate of Expense to Operate the System including Depreciation and Maintenance Charges

To operate the cable system, it is necessary to install the SD cable terminal equipment at the Trunk Traffic Centres at Karachi and Chittagong, and the landing station at Cox's bazar, and to man them for 24 hour operation. The expense necessary for operation and maintenance, including cost of supplies necessary for maintenance of these terminal and landing facilities, depreciation and interests, amounts to 3,786 thousand U.S. dollars per annum.

Expense for Operation and Maintenance of the East-West Pakistan Cable System

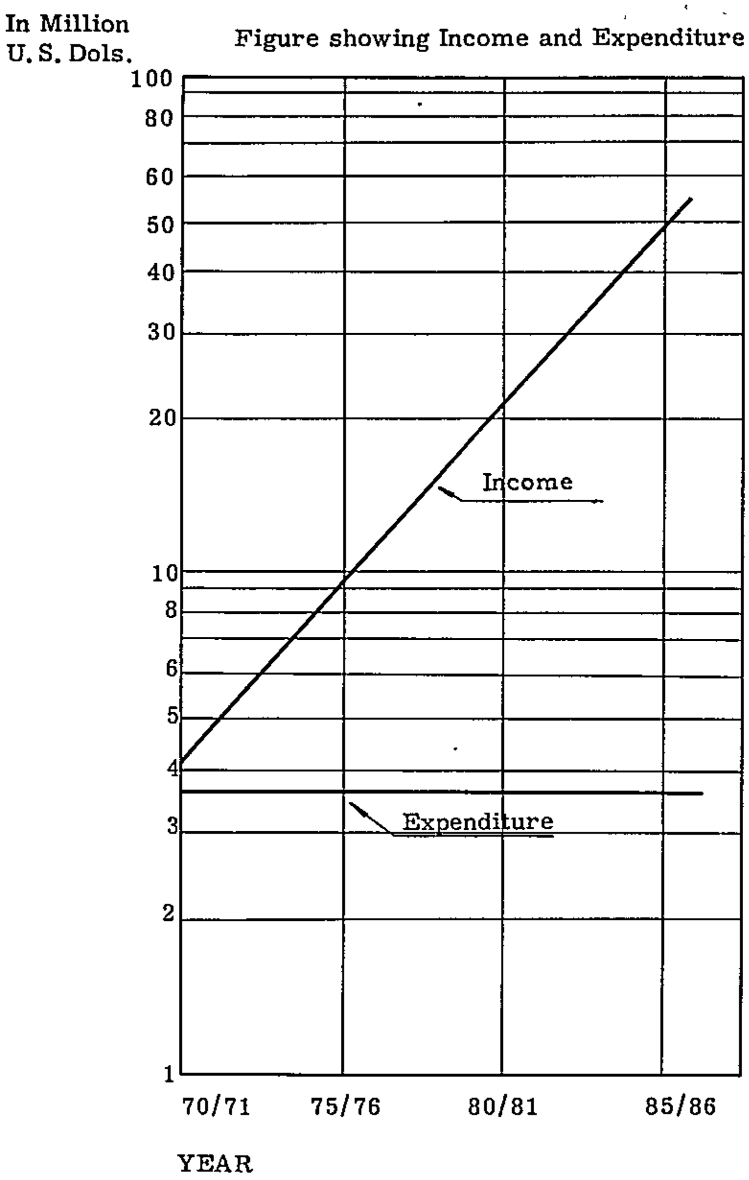
			(in U.S. dollars)	
1.	Personnal Expense			
	Divisional Engineers	3 @3,000	9,000	
	Assistant Engineers	18 @2,000	36,000	
	Engineers Supervisors	70 @1,200	84,000	
	Sub Total		129,000	
2.	Cost of Supplies			
	129,000 (personnal expense) x 0.5		64,500	
3.	Depreciation and interests			
	Cable: 26,012,000 (construction cost) x 0.11			2,861,320
	Terminal and Landing Equipment:			
	3,484,000 (construction cost) x 0.16			557,440
	Sub Total			3,418,760
4.	Maintenance (for the overland link)			
	3,484,000 (construction cost) x 0.05			174,200
5.	Grand Total (1+2+3+4)			3,786,460

6. Balance

From the estimated income given in I-4 and the annual expenditure in I-5, it is seen, as shown in the following graph, that the income is sufficient to cover the expense from the very first year of operation.

However, it must be pointed out that the operating expenditure in the Trunk Traffic Centres is not taken into account. If this is included, the expense will be a little over the income for the initial one or two years. Besides, we have to allow for the cost of repairing the cable in case of damage, for full descreption of which please refer to III-9.

On the other hand, as a part of the cable circuit will be used for international communication, some income will be obtained from the service.


In Million
U.S. Dols.
Figure showing Income and Expenditure
100
80
60
50
40
30
20
10
8
6
5
4
3
2
1
Income
Expenditure
70/71
75/76
80/81
85/86
YEAR

II PHYSICAL INVESTIGATION

1. Investigation of the Local Shore Ends by Means of Echo-sounding Equipment at Karachi and Chittagong

1.1 Fundamental Conception of the Investigation

The investigation of the landing points of the East-West Pakistan Cable was carried out with an aim to find suitable places as close as possible respectively to the Trunk Traffic Centres at Karachi and Chittagong where the terminal equipment of the cable system are to be installed. It was also in the fundamental conception of the survey to choose landing points, of which vicinity is least subjected to ravages by sediment from the Ganges or the Indus, and where the shallow waters that the cable has to pass through could be the shortest.

1.2 Investigation in West Pakistan

In West Pakistan, Miami Bay, Hawks Bay, Sandspit and Clifton Beach were proposed as suitable places for landing in the vicinity of Karachi.

Before surveying shallow waters by echo-sounding, we made a field survey of these places on shore and as a result we omitted Miami Bay, for it is too far away from Karachi and there are military yards near the place. Hawks Bay was also rejected as unsuitable because we saw numerous rocks on the shore and the place is the proposed site of the nuclear power station.

Therefore, sounding was only made in shallow waters of Sandspit and Clifton Beach. The results of the survey are given in Table 1. The investigation revealed that there is, off Sandspit, a belt of underwater reef, 6-8 fathoms deep and 150 meters wide, running parallel to the coast-line, which is a fatal defect for a cable landing place.

1.3 Investigation in East Pakistan

In East Pakistan, a field survey was made of the neighbourhood of Chittagong and the coast from Cox's Bazar to Elephant Point, which were proposed as landing places. There stand hills 150-300 feet high close to the seashore from Cox's Bazar, Kelatari village to Elephant Point, forming a steep cliff with gravel beach. Such a coast usually has rough bottoms at several places in the offing, and was considered unsuitable for cable-landing.

Therefore the shore north of Kelatari village near Cox's Bazar was decided to be a proposed landing point.

In the neighbourhood of Chittagong, a field survey was conducted on the south and north of the mouth of the Karnaphuli, but it was revealed that on the south there is a swampy area of about 500 meters in close to seashore, from where extends a vast wilderness without a road to approach the shore. Therefore the south side was considered unfit as a landing place, and a place near the Beacon Tower to the north of the mouth was chosen.

Consequently, a survey in shallow waters was made in the area near the Beacon Tower north of the mouth of the Karnaphuli River and along the beach north of Kelatari village near Cox's Bazar. The results of the survey are shown in Table 2. Near Chittagong, there flows a strong tidal current, which will render cable-laying very difficult.

II-1. Table 1.

Comparative Features of the Proposed

Landing Point in East Pakistan

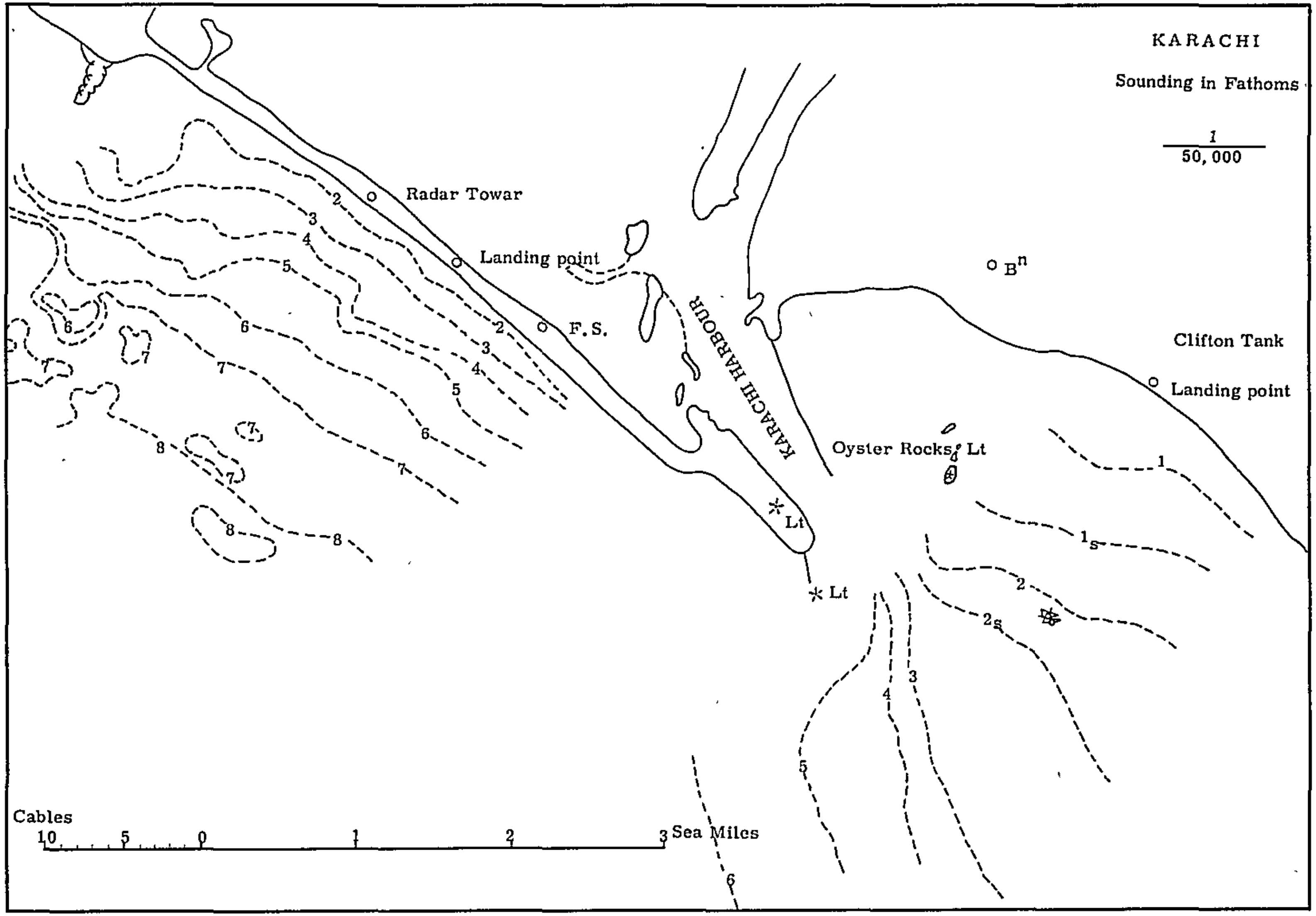
	Sandspit	Clifton Beach
Nature of soil of the beach	Coarse sand	Fine sand
Results of Echo-sounding of shallow waters	Belt of rocky bottom, 150m wide, 6-8 fms deep, in parallel with the coast line from Buleji Point (see Fig. 1, 2, 3 and 4)	No problematic undulation or rocky bottom (see Fig. 1, 2, 3 and 4)
Length of shallow waters (less than 30 fms)	10 n. m.	14 n. m.
Bottom of shallow waters	Fine sand and rocks	Fine sand
Tidal current (max.)	2 n. m. /H	2 n. m. /H
Fishery	At present, there is no fishing that would inflict damages to cable, but in consideration of being rich fishing grounds, cable should be protected by burying against possible damages in case developed method of fishing introduced in future	
Anchorage	There is Karachi Harbour anchorage in front, but it can be kept away by taking a detour route	It is possible to keep away from the anchorage of Karachi Harbour, but as the cable crosses the route of ships entering part, cable should be buried
Weather	Monsson season	Monsoon season
Distance to T. T. C.	To Karachi 11. 2 s. m.	To Karachi 7 s. m.
Power	No commercial power, Independent power generation	Commercial power available
Difficulty of cable-laying	Cable-landing easy, but cable burying in shallow waters impracticable	Both cable-landing and cable-burying easy
Transportation	Difficult	Convenient
Suitability	X	O

II-1. Table 2. Comparative Features of the Proposed Landing Point in West Pakistan

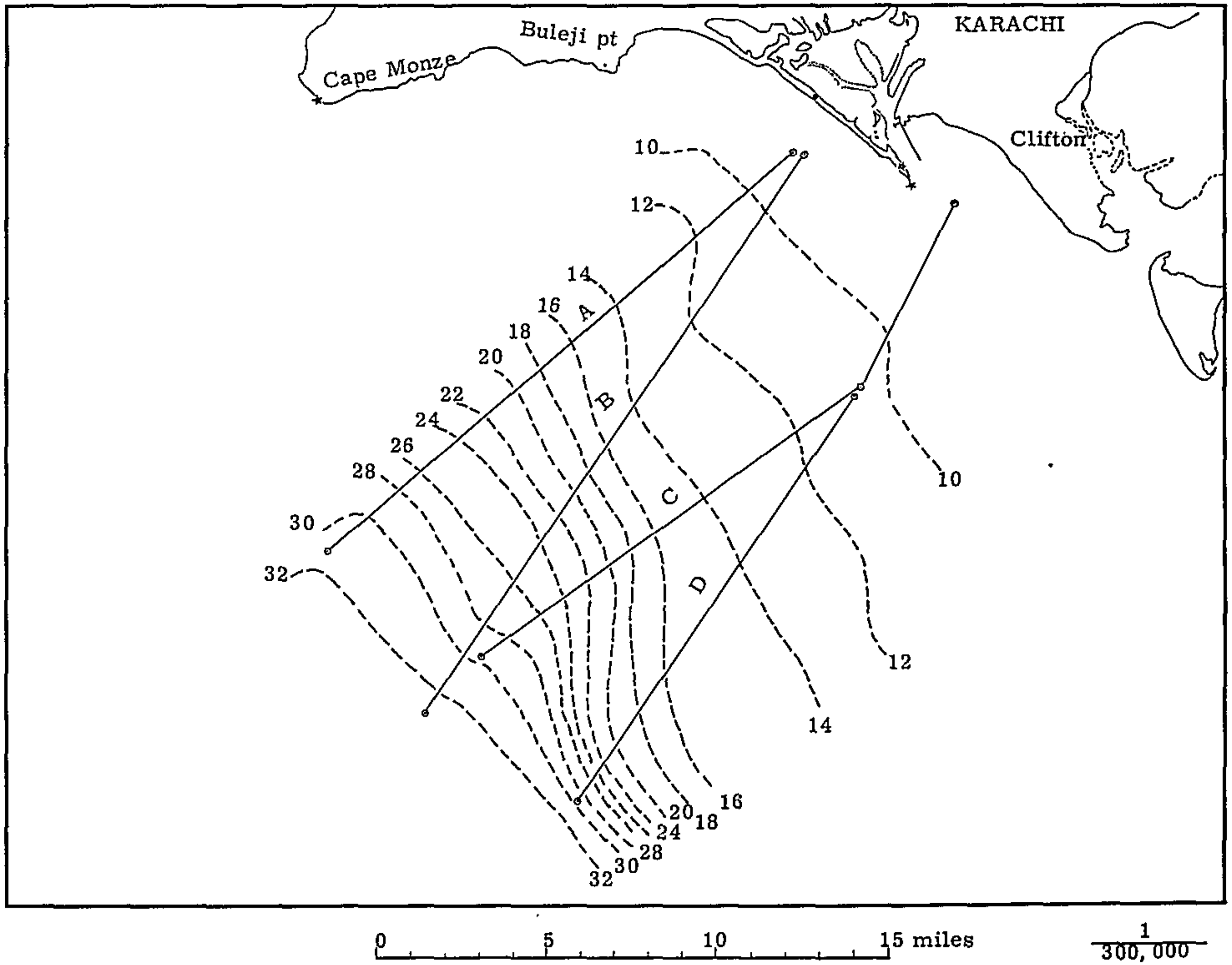
	Near Chittagong (North of the Karnaphuli)	North of Kelatari (Near Cox's Bazar)
Nature of soil of the beach	Fine sand	Fine sand
Results of Echo-sounding of shallow waters	No problematic undulation or rocky bottom	No problematic undulation or rocky bottom
Length of shallow waters (less than 30 fms)	60 n. m.	15 n. m.
Bottom of shallow waters	Fine sand	Fine sand
Tidal current (max.)	6 n. m. /H	4. 5 n. m. /H
Fishery	At present, there is no fishing that would inflict damages to cable, but in consideration of being rich fishing grounds, cable should be protected by burying against possible damages in case developed method of fishing introduced in future	
Anchorage	There is Chittagong Harbour anchorage in front. Therefore the part of cable crossing it must be buried	No anchorage in the vicinity
Weather	Cyclon season (June-Oct.) (monsoon)	Cyclon season (June-Oct.) (monsoon)
Distance to T. T. C.	To Chittagong 9 s. m.	To Chittagong 65 s. m.
Power	Commercial power available	No commercial power, Independent power generation
Difficulty of cable-laying	Both cable-landing and cableburying difficult due to strong current	Cable-landing rather easy, but burying operation difficult a little
Transportation	Fairly convenient	Inconvenient
Suitability	X	O

Note; Judging from the above, Clifton Beach in West Pakistan and a place north of Kelatari village near Cox's Bazar in East Pakistan were chosen as the cable landing point.

II-1. Fig. - 1. Result of Bottom Survey at Shore Ends

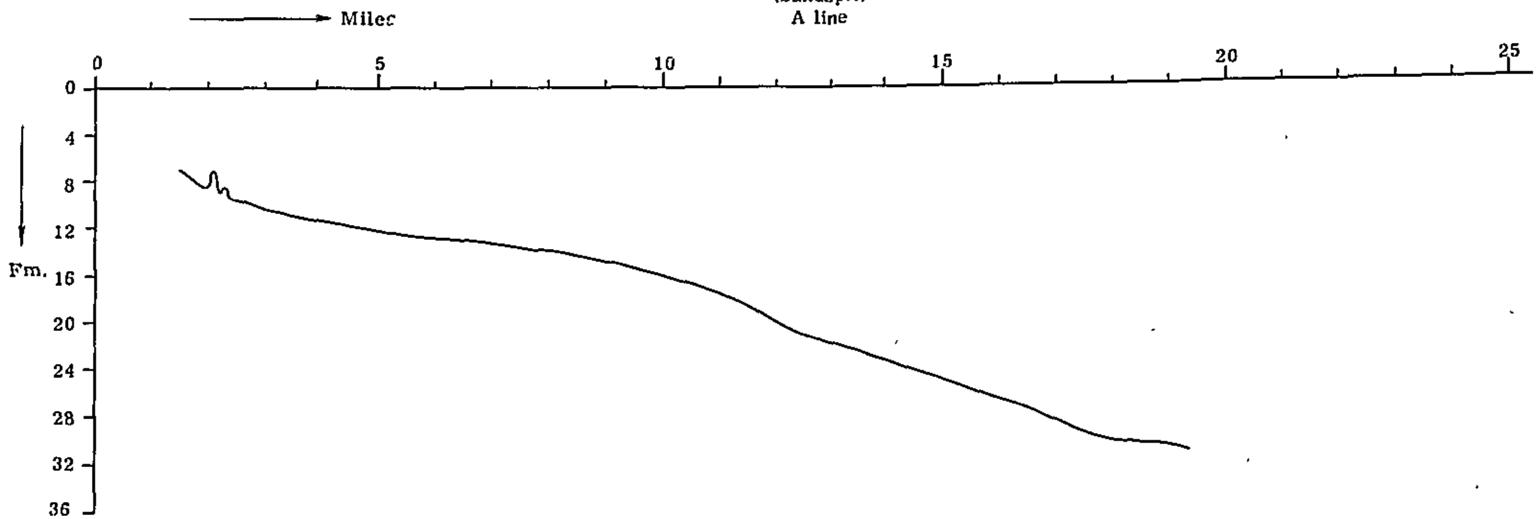


II-1. Fig. - 2. Surveid Lines

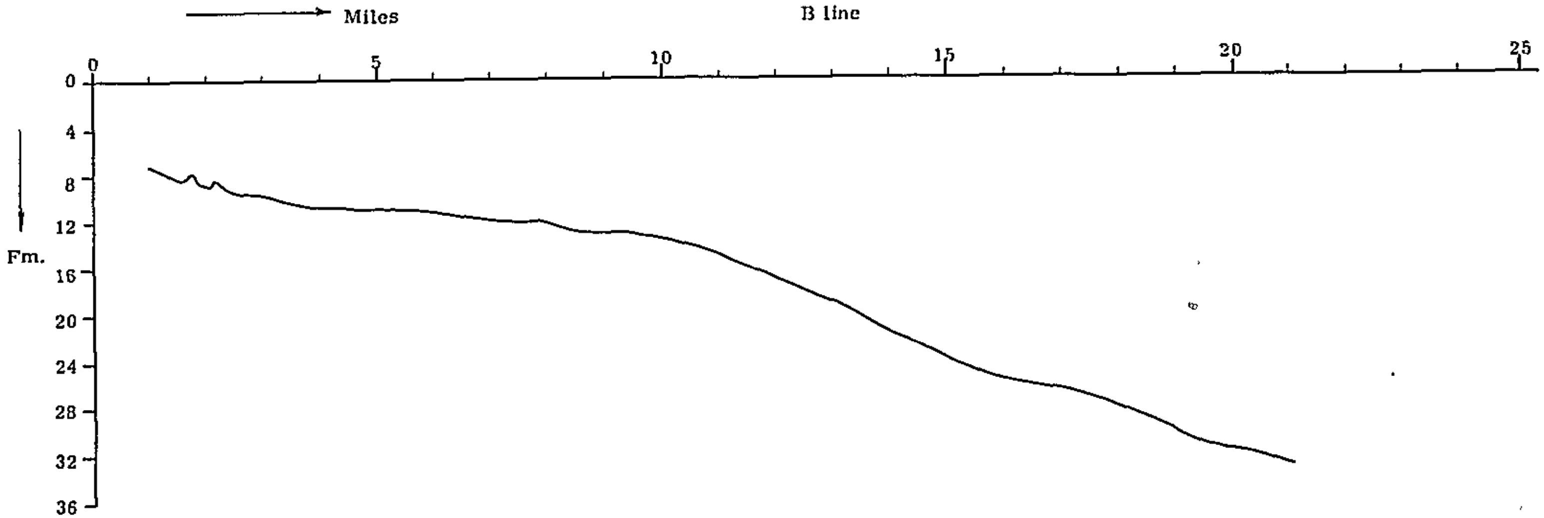


II - 1. Fig. - 3. Bottom Profile of Cable Route at Sharrow Waters (Sandspit)

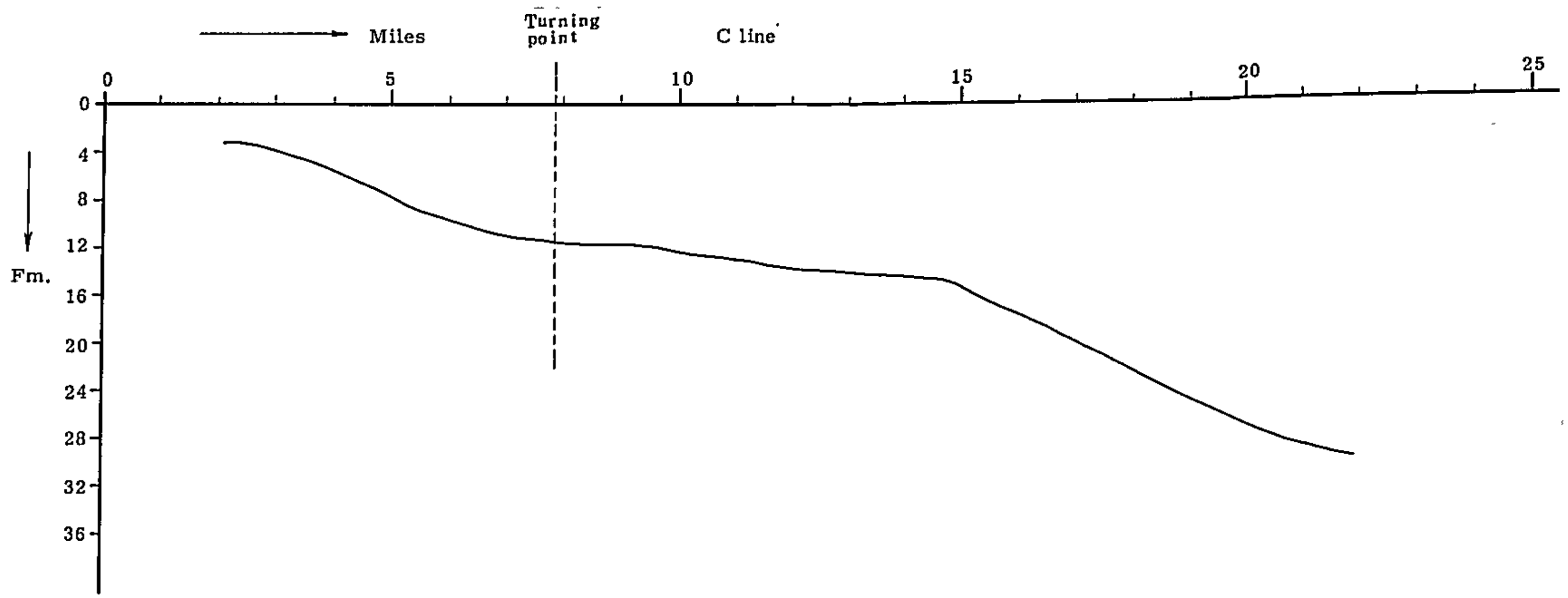
(Sandspit)
A line

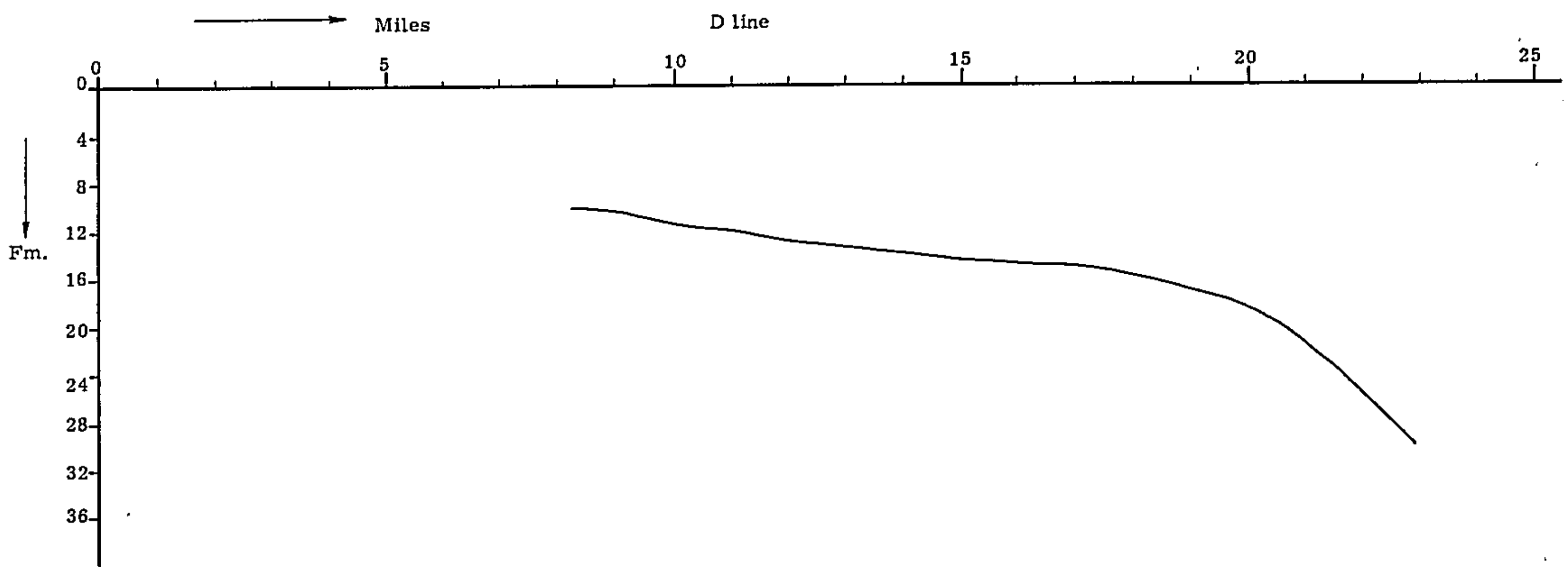


B line

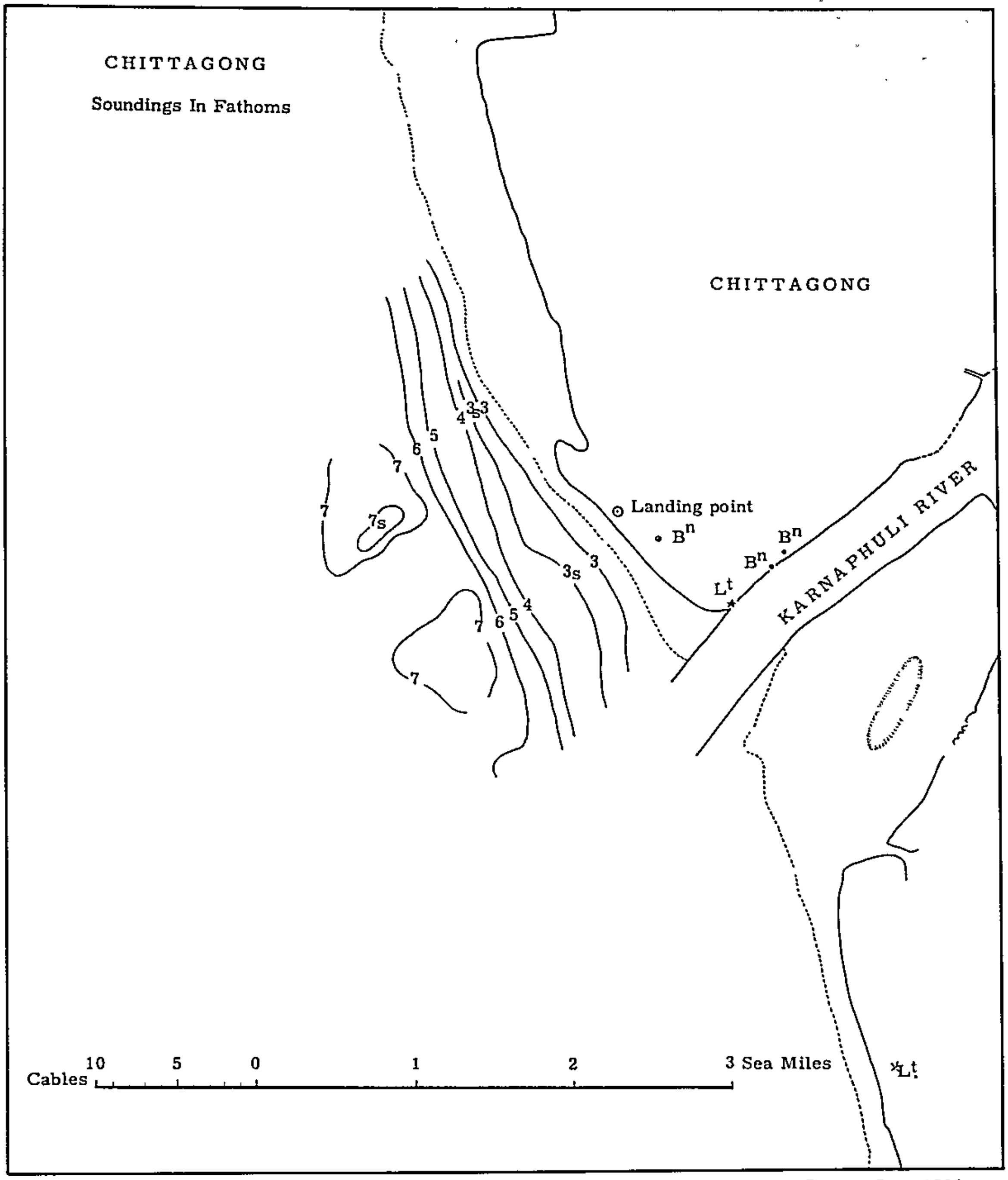


II - 1. Fig. - 4. Bottom Survey of Cable Route at Shallow Waters (Clifton Beach)



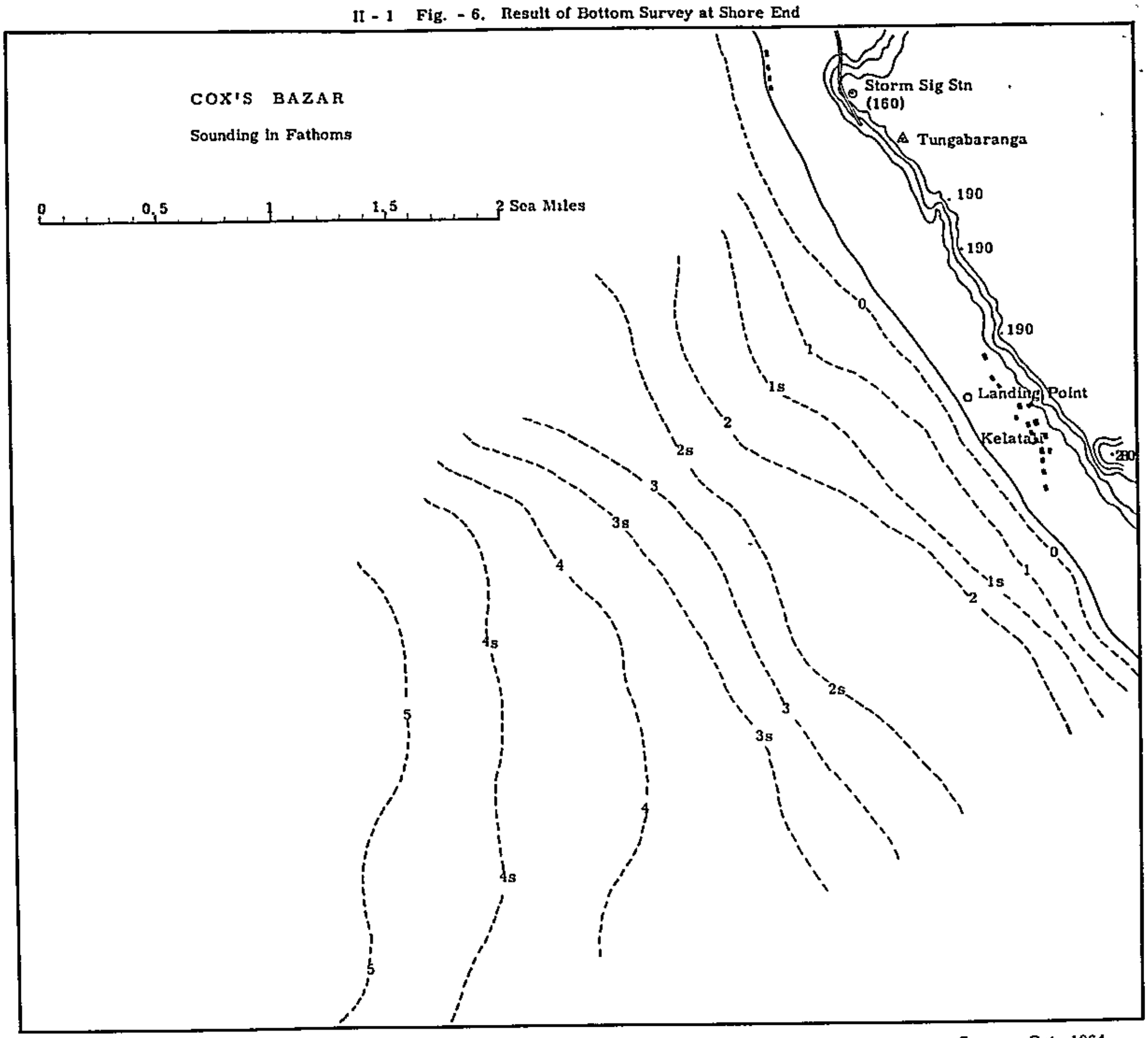


II - 1. Fig. - 5. Result of Bottom Survey at Shore End



Survey Oct. 1964

II - 1 Fig. - 6. Result of Bottom Survey at Shore End



Survey. Oct 1964

2. Investigation for the Communication System from the Landing Points to the Trunk Traffic Centres

For connection between the landing point and the Trunk Traffic Centre, either coaxial cable or microwave relay system may be used. There is hardly any difference in technical characteristics between the two systems. Therefore the investigation was made chiefly on comparison of the two in regard to difficulty of construction and the amount of cost required.

As Cox's Bazar and Clifton Beach were chosen as the proposed landing points according to the results of the shore end survey, the communication system from these points were studied. In West Pakistan, as the landing point is very near to the Traffic Centre, the end of the submarine coaxial cable can be directly led into the Centre. Therefore possibility of extending it to overland connection was also examined.

2.1 Investigation in West Pakistan

When compared in regard to leading-in, Clifton Beach is far more advantageous than Sandspit; the length of coaxial cable to be used is 9 s.m. for the former and 19 s.m. for the latter; the microwave relay link covers either distance at one hop, but Clifton is better in propagation, in locational conditions and in maintenance than Sandspit.

Consequently, a comparative study on problems in construction was made of three systems of connection from Clifton, the proposed landing point; namely, coaxial cable system, microwave link system and extension of SD cable.

As to a microwave relay system, the following points have been made clear:

(1) As the monsoon wind is not so strong as in East Pakistan and there occur few earthquakes in this district, no serious trouble is expected in constructing antenna towers and station buildings.

(2) Though the temperature is high, its fluctuation is not so large and the percentage of humidity is rather low. Therefore a simple air conditioning equipment will serve the purpose.

(3) The landing station, which is to be built on sandy ground, needs scrupulous foundation work.

If the existing 350 ft steel tower at the Traffic Centre could be made use of, 100 ft might be a sufficient height for the antenna tower at the landing station (to be located on a hill to the west of Clifton Park), though the propagation path passes through the centre of Karachi City.

As to coaxial cable connection, subjects to be studied are similar in either case of submarine cable or land cable, except that the former, having a larger diameter, is less convenient for transportation and has more joints in the same span than the latter. In either case, the following consideration is necessary;

(1) For most part of the route, cable can be laid under unpaved sidewalk of the road, but for several hundred yards near Metropole Hotel, as the road is completely paved and has rather a heavy vehicular traffic special consideration will have to be made in laying work.

(2) Another difficult point is the over-bridge of Clifton Road across the railway, but cable can either be fixed to the bridge girder or be buried by horizontal auger method under the railway.

Taking all these points into consideration, we have made an estimate of the cost of construction, which is shown in Table 1. The cost shown in the table, is, for over-land coaxial cable, that of 300 channel small core coaxial cable, for submarine coaxial cable, that of single armored cable and for microwave relay system, that of all-solid system eliminating use of vacuum tubes.

According to the figures given in the table, the cost of construction is nearly the same for any of the 3 systems, but the extension of submarine cable on shore seems the most advantageous for the reasons cited hereunder:

(1) No need of building a landing station, hence, expenses for operation and maintenance can be dispensed with.

(2) No deterioration of circuit quality owing to insertion of instruments necessary for system conversion.

It does not, however, mean that the other two systems are not able to satisfy the requirements laid down in the C. C. I. 's standards.

2.2 Investigation in East Pakistan

This district of East Pakistan is very hot, damp, and frequently ravaged by cyclones and floods in summer. Neither microwave relay system nor coaxial cable is very suitable in this district. Monthly temperature and humidity, and the highest wind velocity ever recorded in past 17 years are cited in Table 2.

Under such weather conditions, radio relay system will require special consideration as described below.

(1) The maximum wind velocity 125 statute miles per hour, presumed to be the instantaneous speed of a gust, is not an inconceivable speed as compared with 135 s. m. / hour, as used in Japan as the maximum wind velocity which an antenna tower must be designed to stand. It is, however, considered advisable to use 150 s. m. /hour as the maximum velocity in designing a tower in this district, for safety's sake taking into account the lack of correct and comprehensive wind records.

(2) As the microwave antennas have very sharp directivity, a self-supporting tower is preferable to prevent the antenna from shaken by wind. A stayed tower is less stable.

(3) Air-conditioning, which is desirable but not imperative in West Pakistan, is indispensable for maintaining stability in East Pakistan.

As the sites of intermediate relay stations of the microwave relay system connecting Chittagong and Cox's Bazar, the two points indicated on the attached map (Fig. 1) are considered suitable. They were chosen on an assumption that the 350 ft tower (proposed) near Chittagong can be used for this purpose. The line-of-sight profile of each span is shown in Fig. 2.

The proposed first relay station next to Cox's Bazar is located on a hill 700 ft high, and seemingly inconvenient to approach, but the road between Chakaria and Manikupur which is under development will be paved by the end of 1964 and there is a jeepable road between Manikupur and the site of the relay station (about 4. 5 s. m.), which can be paved at a reasonable cost and used as an access road for construction and maintenance. The station will be operated unattended and remotely monitored from Cox's Bazar.

This radio relay circuit operated on 2 Gc/s with all-solid equipment will give circuit characteristics sufficiently satisfying the C. C. I. 's standards as shown in Table 3. This system, if provided with required carrier terminal equipment, will be able to accommodate 240-300 voice channels of superior quality. Eventually it will cater for telephone channels between Chittagong and Cox's Bazar to be increased in future, and further will be used for international connection to Thailand and Malaysia through Burma.

The Table 4 shows the estimate of the cost of the system constructed with group connection.

In case the connection is made by means of coaxial cable, the length of the cable required will be about 100 s. m. The road where the cable has to be buried has the paved centre about 10 ft wide and both sides unpaved, which latter parts are soft surfaced and ready for burying cable. When the survey was made in October 1964, there was not very much water in rivers, and no difficulty was foreseen in crossing the rivers except a crossing point of the Darnaphuli northeast of Chittagong.

The cost of laying a 4 tube small coaxial cable, except that of carrier terminal equipment, for this connection is estimated at about 2, 420, 000 U. S. dollars, considerably more expensive than that of microwave relay system, 534, 000 U. S. dollars.

II-2. Table 1. Comparison of Estimated Cost for Various Types of Lead-in System to T. T. C. in West Pakistan

(U. S. dollars)

	Microwave Sys.	Land Cable Sys.	Sub. Cable Sys.
Carrier Terminal (at T. T. C.)	180, 000	180, 000	180, 000
Carrier Terminal (at L. St.)	5, 000	5, 000	
Signalling Equipment	70, 000	70, 000	70, 000
Echo Suppressor	116, 000	116, 000	116, 000
Measureing Equipment	112, 000	112, 000	110, 000
Shipping & Installation	193, 000	193, 000	190, 000
2 Gc Radio Equipment	46, 000		
Antenna & Feeder	21, 000		
Measureing Equipment	21, 000		
Shipping & Installation	35, 000		
Antenna Tower (including Shipping & Installation)	31, 000		
Small Coaxial Cabele		90, 000	
Gas Equipment		4, 000	
Repeater etc.		10, 000	
Shipping & Laying		121, 000	
L-4 Submarine Cable			160, 000
Shipping & Laying			150, 000
Power Supply			
Carrier Terminal	130, 000	130, 000	120, 000
Microwave Equipment	34, 000		
Land Cable Repeater		15, 000	
Submarine Cable Repeater	240, 000	240, 000	240, 000
Building (including Air-Con.)	130, 000	130, 000	95, 000
Land	1, 000	1, 000	
Total	1, 365, 000	1, 417, 000	1, 431, 000

II-2. Table 2. (a) Monthly Temperature and Humidity in East Pakistan (Furnished by the Chittagong Meteorological Department)

	CHITTAGONG				COX'S BAZAR			
	Temperature in deg. F.		Mean Relative humidity in percenage		Temperature in deg. F.		Mean Relative humidity in percentage	
Month	Highest	Lowest	0000 GMT	1200 GMT	Highest	Lowest	0000 GMT	1200 GMT.
January	89	45	91	59	91	46	88	60
February	93	46	89	58	93	49	88	64
March	99	51	91	67	97	52	90	72
April	102	59	93	70	99	62	91	72
May	98	65	92	78	95	62	88	79
June	98	68	95	84	97	70	92	86
July	94	67	95	86	92	72	93	88
August	93	72	96	86	93	67	95	88
September	95	71	95	84	94	71	94	84
October	94	62	96	79	93	63	93	77
November	93	52	94	71	92	57	91	70
December	88	47	95	68	89	48	91	66

Based on observations from 1911 to 1940

* : Mean of 4 years (1959 - 1962)

Table 2. (b) Maximum wind Velocity as avilable from the record since 1947 to October 1964

Station	Date	Time	Wind Velocity	Direction
CHITTAGONG	28. 5. 63	1943 GMT	125 m/h	South East
COX'S BAZAR	28. 5. 63	1700 GMT	100 m/h	South East

II-2. Table 3. System Performance of Microwave Link in East Pakistan

Parameters

Frequency	2, 000 Mc (1700 - 2700 Mc)
Number of Channels	128 ch
Modulation	SS-FM
Relay System	IF Heterodyne
Protection	set stand-by system

Specification

RF Output Power	200 mW
Frequency Stability	better than 5×10^{-6}
Noise Figure	less than 11 dB
Intermediate Frequency	70 Mc ± 5 Mc
Antenna Gain	above 34 dB
Feeder	wave guide
Modulation Degree	200 kc rms/ch
Input Level	-25 dBm/ch
Output Level	-15 dBm/ch

Calculated Noise Power in Worst Channel

	C. B. —— 1st R. S.	1st R. S. —— 2nd R. S.	2nd R. S. —— C. T. G.
Thermal Noise	54 pW	27 pW	31 pW
Intermodulation Noise	15	13	13
Interference Noise	44	92	124
Sub Total	113 pW	132 pW	168 pW
Total Noise Power	413 pW → 63. 8 dB		
Psophometrically Weighted S/N	66. 3 dB		
CCIR Standard for 120 km	64. 5 dB		

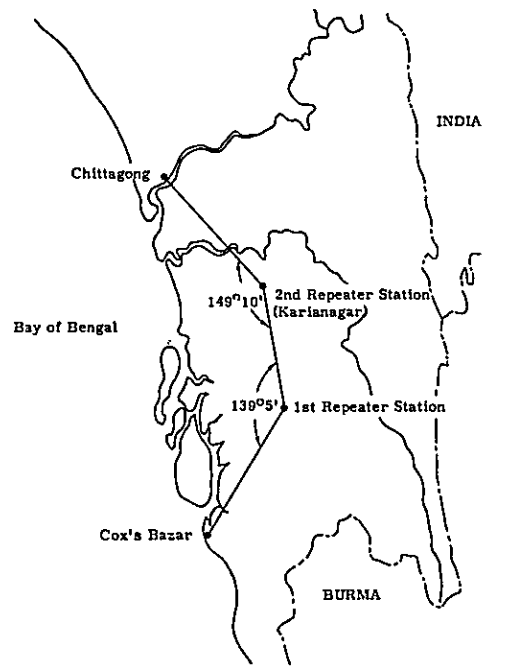
The percentage of time which the noise power exceeds 47, 500 pW is calculated to be 0. 002%, and better than (120/2500) x 0. 1% in CCIR standard.

In case of 240 ch, the noise power will be able to keep 66 dB with emphasis.

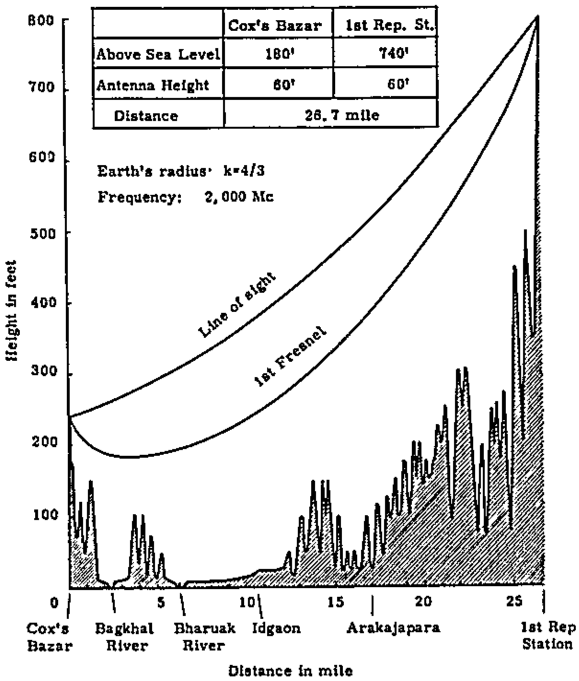
II-2. Table 4. Construction Cost of Microwave System between Cox's Bazar and Chittagong (U.S. dollars)

	Cox's Bazar	1st Repeating Station	2nd Repeating Station	Chittagong
Carrier Terminal	126, 000			154, 000
Signalling Equipment				70, 000
Echo Suppressor				116, 000
Measureing Equipment	70, 000			42, 000
Shipping & Installation	78, 000			153, 000
2 Gc Radio Equipment	23, 000	40, 000	40, 000	23, 000
Antenna & Feeder	5, 500	11, 000	16, 200	14, 000
Supervisory Equipment	4, 100	4, 100		
Measureing Equipment	6, 000			15, 000
Shipping & Installation	15, 400	21, 900	22, 800	21, 000
Antenna Tower (including Shipping & Installation)	12, 000	12, 000	60, 000	
Power Supply (including Shipping & Installation)				
Carrier Terminal	120, 000			120, 000
Microwave	20, 000	30, 000	25, 000	12, 000
Cable Repeater	250, 000			
Building (including Air-Con.)	115, 000	10, 000	12, 000	95, 000
Land	2, 000	400	1, 000	
Access road	8, 000	56, 600		
Total	855, 000	186, 000	177, 000	835, 000
				2, 053, 000

II-2. Fig 1 Route of Microwave Relay System in East Pakistan.

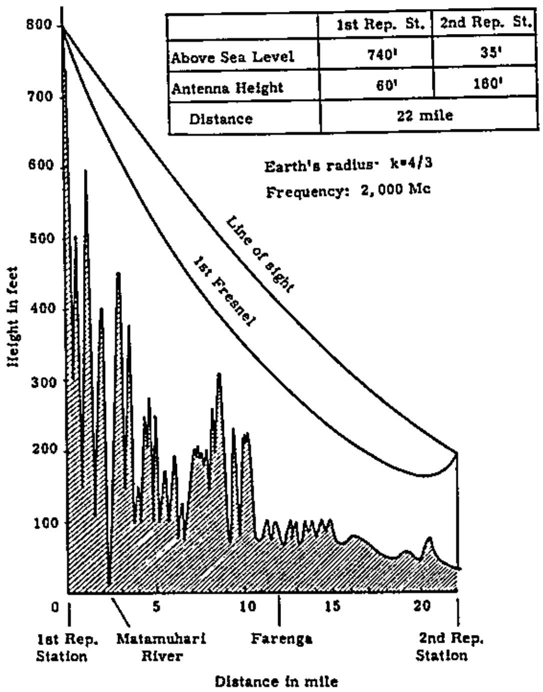


II-2. Fig. 2 (a) Profile between Cox's Bazar and 1st Repeater Station.



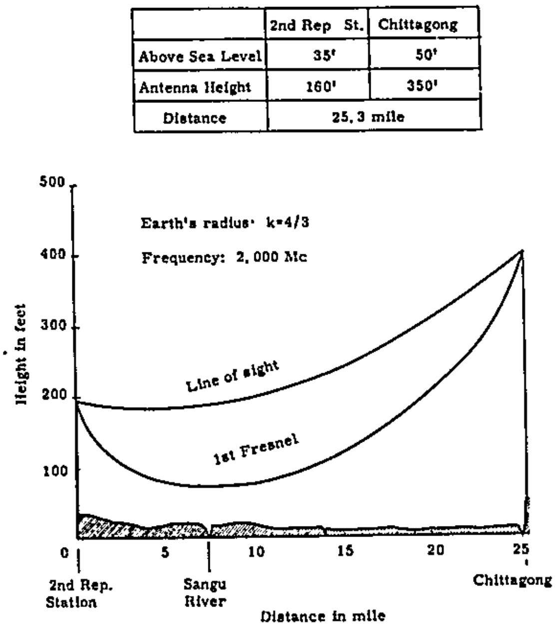
	Cox's Bazar	1st Rep. St.
Above Sea Level	180'	740'
Antenna Height	60'	60'
Distance	26.7 mile	

II-2 Fig 2 (b) Profile between 1st Repeater Station and 2nd Repeater Station (Karianagar).



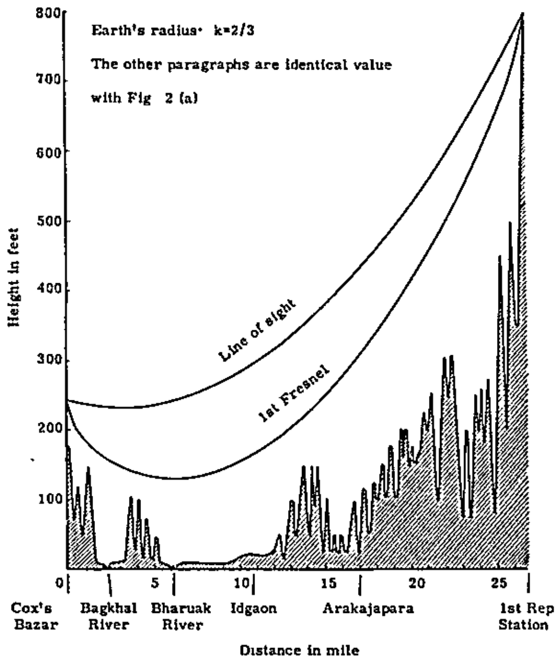
	1st Rep. St.	2nd Rep. St.
Above Sea Level	740'	35'
Antenna Height	60'	160'
Distance	22 mile	

II-2 Fig 2 (c) Profile between 2nd Repeater Station (Karianagar) and Chittagong.

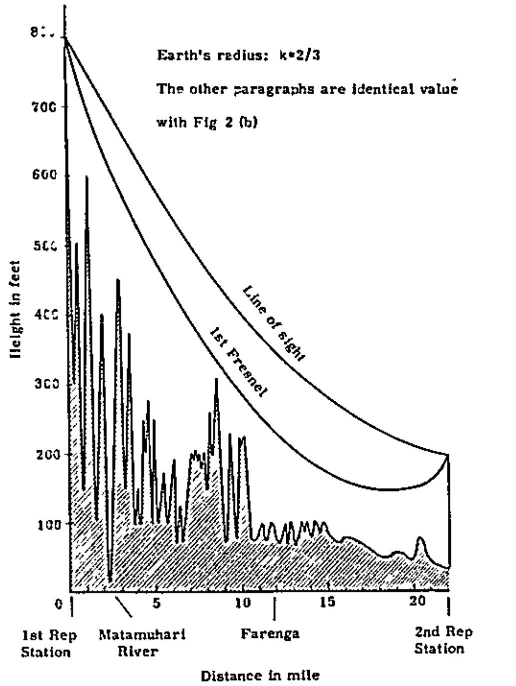


	2nd Rep St.	Chittagong
Above Sea Level	35'	50'
Antenna Height	160'	350'
Distance	25.3 mile	

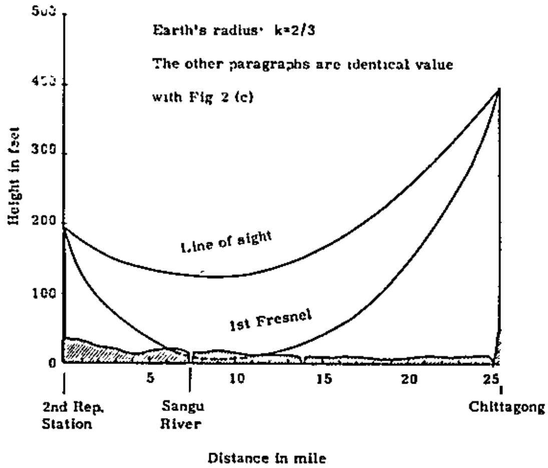
II-2 Fig. 2 (a') Reference profile for Fig. 2 (a) i e. change of Earth's radius, between Cox's Bazar and 1st Repeater Station.



II-2 Fig 2 (b') Reference profile for Fig 2(b), i e change of Earth's radius, between 1st Repeater Station and 2nd Repeater Station (Karianagar)



II-2 Fig 2 (c') Reference profile for Fig 2(c), i e change of Earth's radius between 2nd Repeater Station (Karianagar) and Chittagong



III RECOMMENDATION

1. The Most Suitable Type of Communication System between Karachi and Chittagong

As the most suitable type of communication system between Karachi and Chittagong, the adoption of the Type D Coaxial Submarine Cable (SD Cable) system is recommended for the following reasons;

1. 1 Comparative Study of Practicable Wideband Communication Systems

Three types of communication systems considered suitable for linking East and West Pakistan have been comparatively studied from economical and technical viewpoints, and the characteristics of each system are compared in the following table.

System	No. of Chs.	Quality Ranking	Cost		Frequency (M c/s)	Remarks
			Total (M. $)	Per Ch. (Th. $)		
VHF Scatter	60	2nd	6. 5	108	2, 000	Three intermediate relay stations are necessary
VHF Scatter	24	3rd	8. 0	333	40	No relay station are necessary
SD Cable	128	1st	29. 5	233	-	The two Wings are directly connectable

From the table, the following can be observed;

(1) The submarine cable system can provide the largest number of channels. There exists substantial traffic demand between the two wings at present. Once a communication highway is constructed, a bursting increase in the demand is foreseen. SD cable system, having the largest capacity, will be the most suitable one to cope with that demand.

With the present level of technical standards, about ten more channels can be added to the capacity of 128 channels, and if the Time Asignment Speech Interporation (TASI) Equipment is used, capacity for telephone traffic can be almost doubled.

(2) The submarine cable system is superior in quality, reliability and stability to

other systems. Owing to natural changes taking place in the ionosphere or the troposphere, communication systems making use of these layers are constantly subject to fading, distortion or complete interruption. On the other hand, the submarine cable system is free from all such difficulties.

(3) In the economic comparison, the UHF scatter system is the cheapest and next comes the submarine cable system. The VHF system is somewhat more expensive than the cable system.

(4) The scattered wave system requires not only large radiation power, but are liable to cause harmful interference to other communication systems.

(5) In respect of keeping secrecy, no other systems superior to a submarine cable have yet been developed.

(6) Submarine cable system is the easiest to maintain except in case of interuption, which is of course very rare.

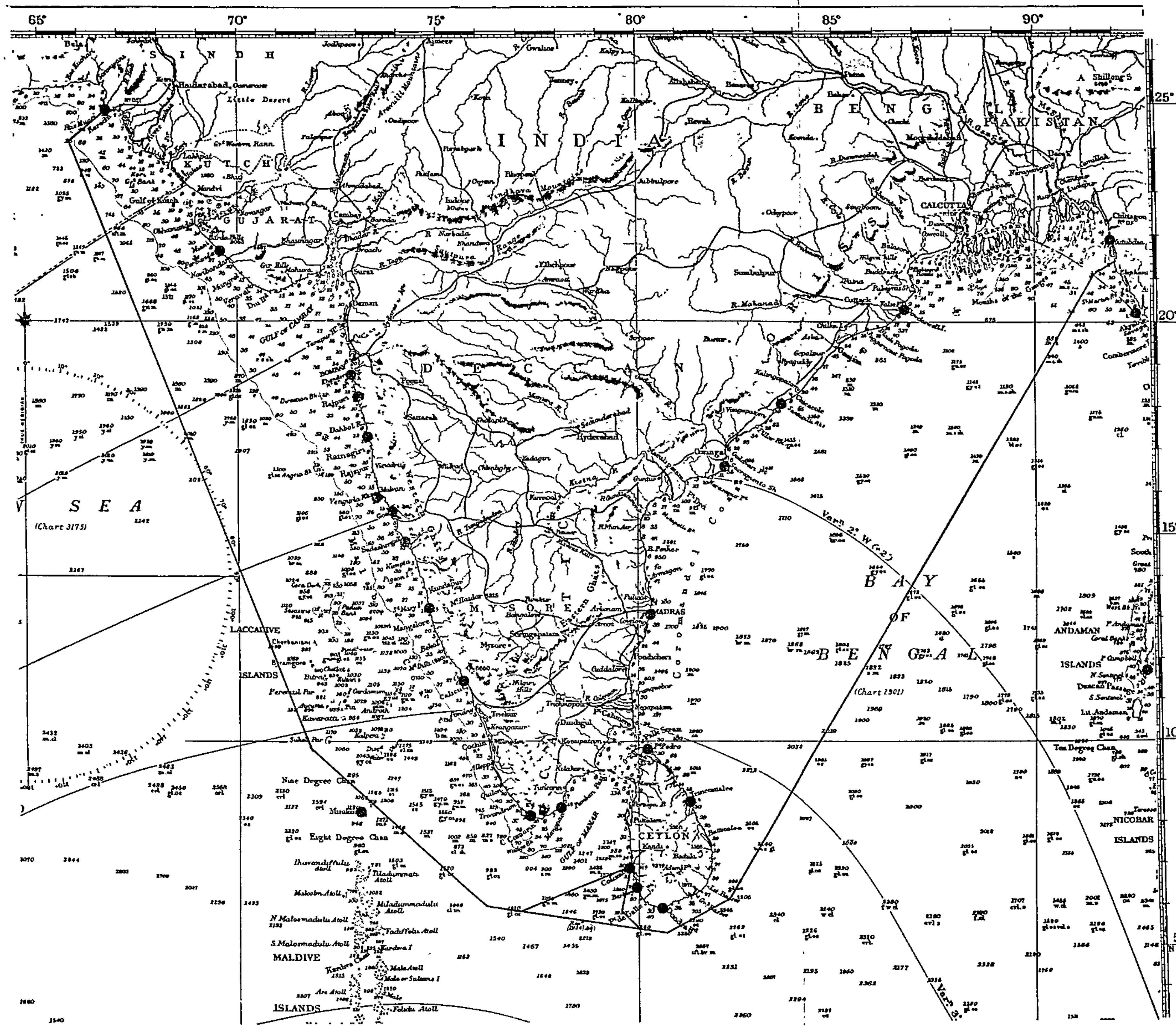
For these reasons, the most suitable system linking East and West Pakistan, though slightly expensive in the initial capital cost, should be SD cable system.

2. Selection of the Course of the Cable Route

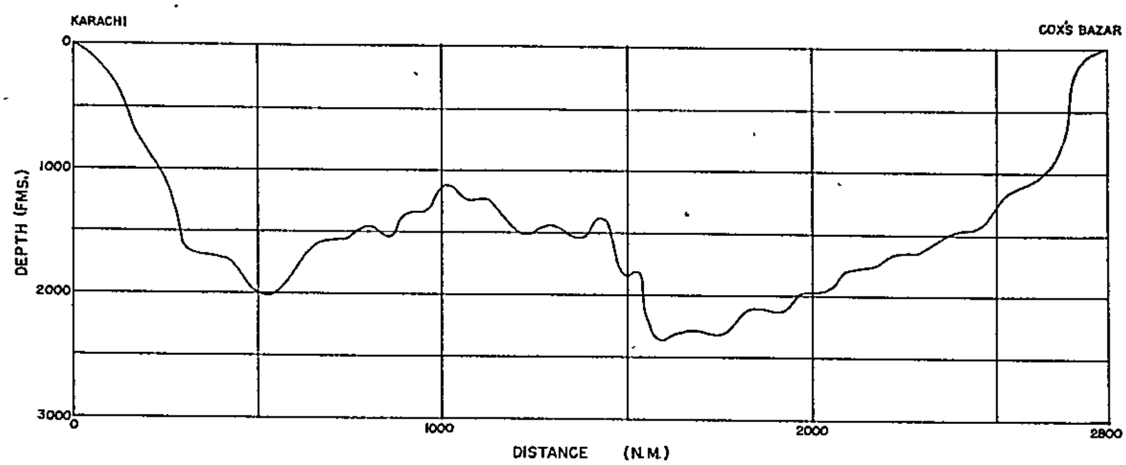
The cable route linking the two wings of Pakistan follows a course from Clifton Beach, Karachi, keeping away from the anchorage of Karachi Harbour, takes the shortest shallow water path to reach deep waters, from there goes southward along the Indian coast keeping distance of 150 n. m., passes by the west of Laccadive Islands, goes round from the north of Madlive Island to the south of Ceylon, then turns to the north, goes up the Bay of Bengal and reaches the seashore north of Kelatali village near Cox's Bazar.

The cable route is shown in Fig. 1, and the profile of the route in Fig. 2.

The deepest part on the route is 2,667 fathoms deep, located to the south of Ceylon.


65°
70°
75°
80°
85°
90°
25°
20°
15°
10°
5° N Lat.
S I N D H
K U T C H
G U J A R A T
I N D I A
B E N G A L
P A K I S T A N
D E C C A N
M Y S O R E
CALCUTTA
MADRAS
CEYLON
B A Y O F B E N G A L
S E A
(Chart 3175)
(Chart 2301)
LACCADIVE ISLANDS
MALDIVE ISLANDS
ANDAMAN ISLANDS
NICOBAR ISLANDS
Nine Degree Chan
Eight Degree Chan
Ten Degree Chan
GULF OF CAMBAY
GULF OF MANAR
Gulf of Kutch
Little Desert
Hyderabad
Madura

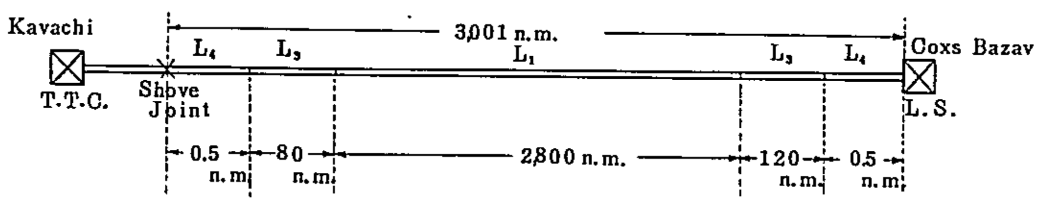
III-2. Fig. 2 BOTTOM PROFILE OF E-W PAKISTAN CABLE ROUTE



3. Kinds of Cable Necessary for Installation in Deep Waters and Shallow Waters

Of the proposed Cable System, for the section from Karachi Trunk Traffic Centre to Clifton Beach (9 s. m.) L4 cable is laid underground and connected with the submarine part at Clifton Beach. L4 cable is used from the above-mentioned joint to the beach, from where L3 cable is laid for 8 n. m. (30 fathoms deep) in shallow waters, then L1 cable is laid along the route described under III 2. Fig. 1 for 2, 800 n. m. until it reaches a point 120 n. m. from the landing point of Kelatali village near Cox's Bazar; there again laying of L3 cable is started and led to the landing point, where it is jointed to L4 cable and let into the landing station.

The above statement is illustrated in the following figure:



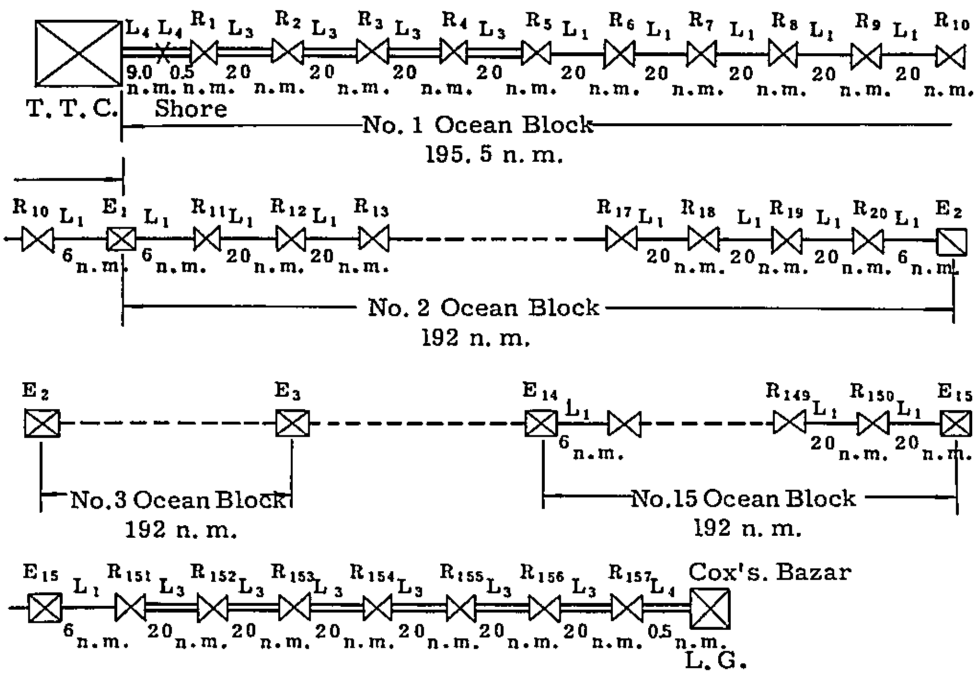
Notes:		
	T. T. C.	Trunk Traffic Centre
	L. S.	Cable landing station
	L1	Armorless coaxial submarine cable
	L3	Single armored coaxial submarine cable
	L4	Single armored magnetic shielded coaxial submarine cable

4. Requirements, by Type and Quantity, of Coaxial Submarine Cable, Submerged Repeaters and Equalizers to be used

Fig. 1 shows the block diagram of the proposed Cable System. The quantity of necessary cable, repeaters and equalizers, as obtained from the diagram, will be:

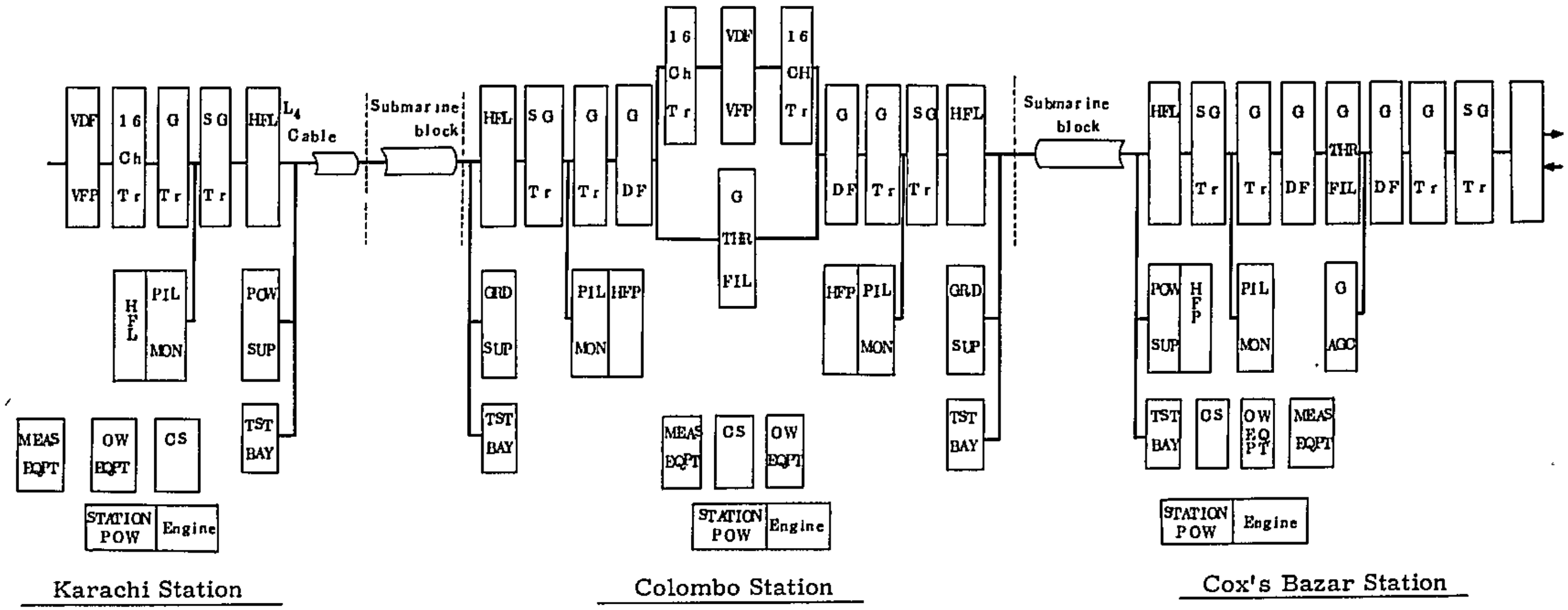
Armorless SD Deepsea Coaxial Cable (L1)	2,800 n. m.
Single Armored SD Shallow Water Coaxial Cable (L3)	200 n. m.
Single Armored SD Shallow Water Magnetic Shielded Coaxial Cable (L4)	1 n. m.
Repeaters for SD Cable System (R)	157
Equalizers for SD Cable System (E)	15

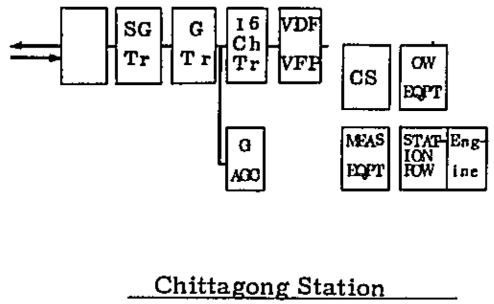
III - 4. Fig. 1 Block Diagram for E - W Pakistan SD Cable System



Remarks: T. T. C. : Trank Traffic Center
L. S. : Cable Landing Station
R. : Repeaters
E. : Equalizers
X. : Cable Joint

III - 4. Fig. 2 Block Diagram of Terminal Stations





Note: i) Floor space required for each station above is 500 square meters but for Chittagong 400 square meters.

ii) The ambient temperature at which the carrier terminals and associated equipment are operated must be controlled to be below 35°C.

iii) Some of the measuring equipment provided for Chittagong should be used jointly with Cox's Bazar station.

5. Communication System for Connection between the Landing Points and the Trunk Traffic Centres

5.1 West Pakistan

The crowline distance between Karachi Trunk Traffic Centre and the landing point at Clifton Beach is only 7 statute miles, but it requires considerable expenses, not only for construction but also for operation and maintenance, to build a landing station at the landing Point. Therefore, it is recommended to adopt a method to extend submarine cable on shore and directly lead it into the Trunk Traffic Centre.

In such a case, single armored cable may be laid underground at a depth of 5 feet or more, preferably protected with troughs or cement plates.

5.2 East Pakistan

As stated in II-2.2, the microwave relay system is recommended for economy's sake. The frequency band to be used is 2 Gc/s and all solid type radio equipment using transisters and diodes will be adopted. 2 Gc/s band is less subject to Rayleigh fading than 4 Gc/s or 6 Gc/s, and specifically fit for a swampy area like East Pakistan where radio duct phenomena are apt to take place.

The all solid type equipment not only enables miniaturization and stabilization of equipment, but permits the use of secondary batteries, convenient and stable failure-free power source, which is particularly suitable for a relay station where commercial power supply is not easily available.

Note; Rayleigh fading is severe fading caused by radio duct phenomena, in which field intensity changes give rise to Rayleigh distribution.

6. Construction Schedule and Season Recommendable for Installation

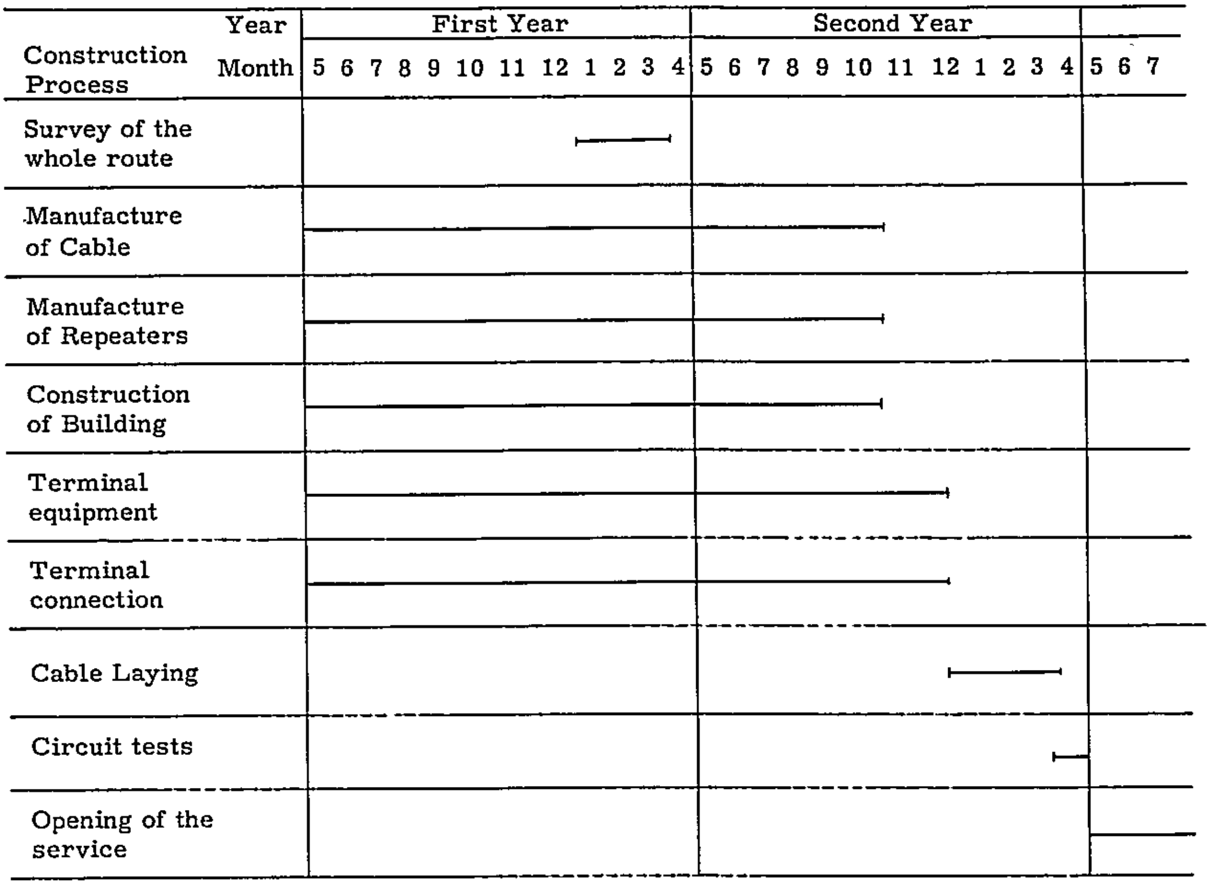
As manufacture of cable and repeaters necessary for the proposed Submarine Cable System will take about 18 months, cable-laying will be started when all the supplies are ready for the work. By the time the laying is started, Karachi Trunk Traffic Centre, Chittagong Trunk Traffic Centre and Cox's Bazar Kelatari Landing Station must be completed, and ready for leading in the ends of the cable. Consequently manufacture of terminal equipment and building of Centres and Stations have to be started at the same time with manufacture of cable and repeaters.

Cable should preferably be laid during the months of January, February and March, when weather on sea is most favourable to cable-laying. Therefore, the start of all the manufacture and construction can be counted backward from this period.

All this is shown in Fig. 1 "Construction Schedule of the East and West Pakistan Coaxial Submarine Cable". About two years would be required to carry out the construction of this system.

III-6 Fig. 1

Construction Schedule of E-W Pakistan Coaxial Submarine Cable



7. Cable Laying Procedure

The East and West Pakistan Submarine Coaxial Cable System has the whole length of 3.000 n. m. There is no cable ship in the world that can carry such a large volume of cable at a time. Therefore, it will be necessary to divide the whole length of cable into two parts and lay one part first and next the other, as described below: (Ref. Fig. 1)

(1) The base of the cable ship is located at Karachi.

(2) Cable, repeater, etc. for the first 1, 500 n. m. are embarked the cable ship. and those for the other 1, 501 are shipped to Karachi and stored there.

(3) At first, the cable ship, after having landed an end of the cable loaded on board the ship on Clifton Beach near Karachi, starts laying the first part of 1, 500 n. m. cable along the predetermined route, and fixes a buoy to the other end of the cable.

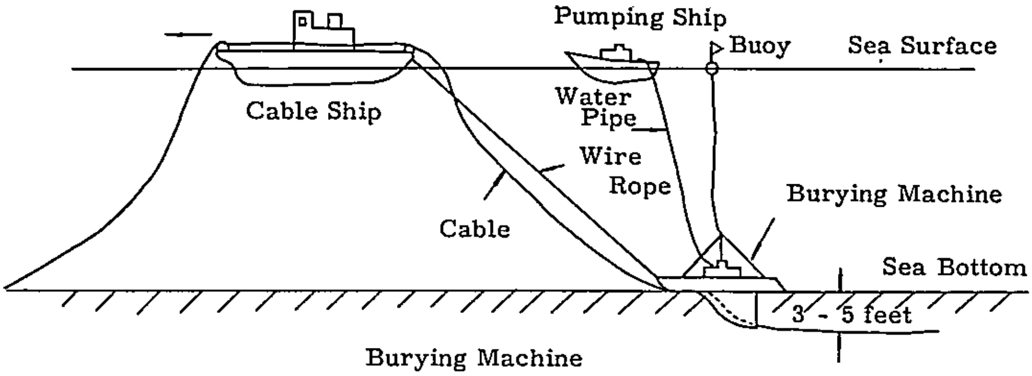
(4) The ship returns to Karachi and embarks the second part of the cable (1,501 n.m.).

(5) Upon reaching the site of the buoy, the ship splices the ends of two parts of the cable and resume laying the rest of cable along the route to Cox's Bazar, where the other end of the cable is landed.

The proposed Submarine Cable System has considerably long shallow-water parts at both ends. Damages on submarine cables frequently take place in shallow waters, mostly caused by trowling fishery and anchoring. Consequently it is an important problem to protect shallow-water cables from dangers of fishery and anchoring.

In laying cable in shallow waters, therefore, the burying method is recommended. In this method, cable is laid 5 feet deep under the sea-floor. The method is illustrated in the following sketch (Fig. 1). Shallow water cable is thus completely protected from damages inflicted by fishery or anchoring. This method has been widely introduced in Japan in laying submarine cables among islands and crossing harbours with successful results.

III - 7 Fig. 1. Outline of Cable Burying method



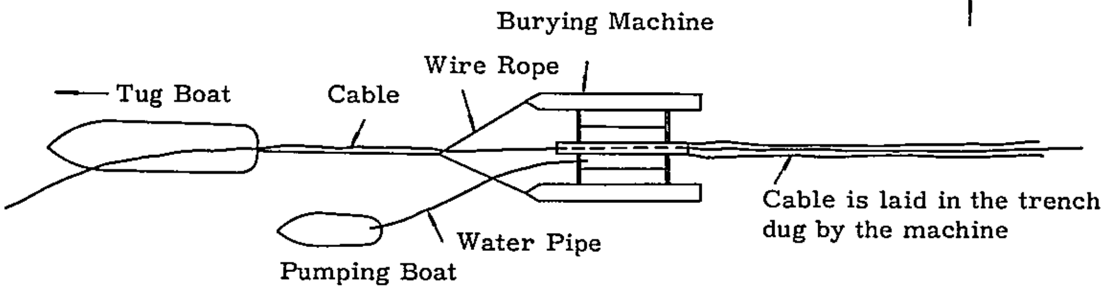
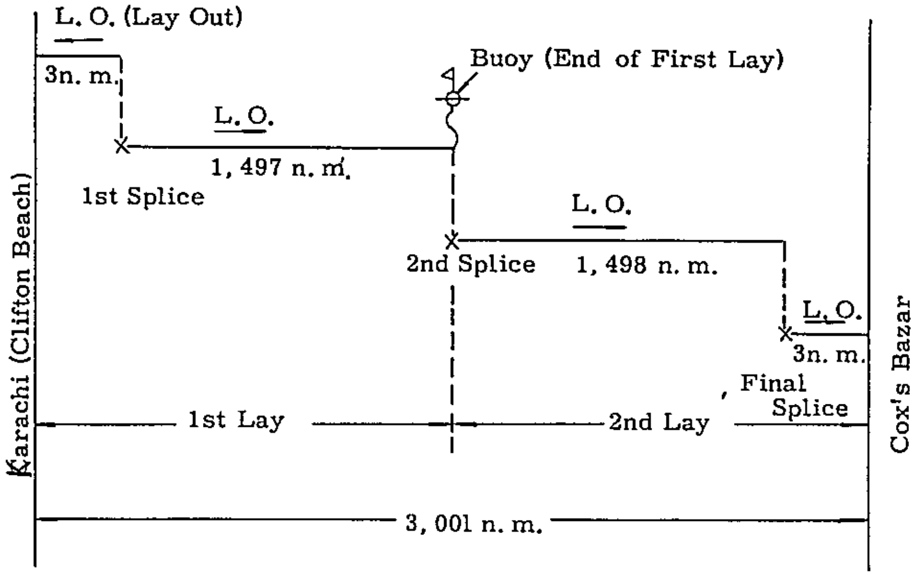


Diagram of Cable - Laying



8. Expense of Ocean Survey for the Whole Route

8.1 Main objectives of the survey lately conducted were to find suitable courses in shallow waters and suitable landing points. Therefore, before launching upon cable laying, detailed survey on the under-mentioned points will have to be conducted for the whole route, such as measuring of depth of the sea-floor by an echo-sounder, measuring of temperature at places considered necessary and sampling analysis of the sea-bottom soil.

(1) Examination of sediments at the edge of the continental shelf or the border of shallow waters and deep sea, and investigation of probable occurrence of turbidity current.

(2) Detailed survey of parts of the route passing by the west of Laccadive Islands and between Laccadives and Maldives.

(3) Detailed survey of the deepest part of the cable route south of Ceylon.

8.2. The survey will take about 95 days, and 53 workers. The cost of the survey is estimated at 144,000 U.S. dollars. For particulars, please refer to Table 1. The cost is included in the estimate of construction of the cable system.

III-8 Table 1

1. <u>Time required for the survey</u> (by a Japanese ocean survey boat)

Tokyo - Chittagong - Tokyo	40 days
Survey of continental shelf (at 2 places)	20 "
Route survey around Laccadives and Maldives	10 "
Route survey south of Ceylon	5 "
Depth measuring, temperature measuring and sea-bottom analysis	20 "
Total	95 days

2. <u>Personnel</u>

Ship crew	40
Surveyors	10
Others	3
Total	53

3. <u>Expenses</u> (in thousan U.S. dollars)

(1) Survey ship		88.5
(2) Fuel		14.9
Heavy oil	(12.1)	
Lubrication oil	(2.8)	
(3) Supplies		10.2
(4) Travelling expenses		30.4
Preparatory allowances	(11.1)	
Voyage "	(7.2)	
Meal "	(7.4)	
Air navigation "	(2.3)	
Hotels "	(1.3)	
Fares "	(1.1)	
Total		144.0

9. Maintenance of the Cable System

In order to secure smooth operation of the proposed Cable System, linking the two wings of Pakistan by SD cable, the following maintenance must be kept of terminal equipment and cable.

9.1 Maintenance at Terminal Stations

At Karachi Trunk Traffic Centre and the Landing Station near Cox's Bazar, monitoring of feeding voltage and current, and level fluctuation of carrier transmission current, and testing of repeater gain must be conducted periodically. In the event of cable interruption, the site of trouble must be immediately located by means of a fault localizing tester and take necessary steps for repair. As the periodical test and fault localization require special skill and advanced technology, technician to be engaged in such tests must be trained.

9.2. Maintenance of Cable

Repair of submarine cable is not necessary unless a fault takes place. SD cable offers high stability, and as its shallow-water part where most troubles occur is buried underneath the seafloor, occurrence of faults is considered very rare. However, once the cable is interrupted, the repair will take about 18 days and about ~~2,000,000~~ 280,000 U.S. dollars, as shown in Table 1. With a view to have it repaired in as short a time as possible, some spare cable and repeaters for replacement must be stored at Karachi, and some at Chittagong.

9.3 Training

Japan is ready to provide the training facility for technicians to be engaged in operation and maintenance at terminal stations as well as to send our experts to Pakistan. In case of constructing various kinds of telecommunication cable plant in Pakistan, it may be possible that the assistance from Japan be extended, through relevant organizations, by sending manufacturing experts or providing training facilities.

III-9 Table 1

Time and Expense Required for Repair

1. Time

Bringing the cable ship to Karachi or Chittagong	7 days
Embarcation of supplies	2 "
Bringing the cable ship to the site of the fault	4 "
Repair	5 "
Total	18 days

2. Expense (in thousand U.S. dollars)

Cable	80
Cable ship	200
Others	10
Total	290

IV SUBMARINE CABLE PROJECT FOR LINKING EAST AND WEST PAKISTAN VIA CEYLON

The proposed cable route is intended to link the two wings of Pakistan, a purely domestic artery. It is, therefore, considered undesirable to make it pass an area under foreign jurisdiction, for keeping of secrecy and for safety's sake.

In case two countries construct an international cable as a joint venture, a certain number of channels are jointly owned by the two countries according to an international agreement, as are seen in the instances of the existing cables in the Atlantic and the Pacific. In such a case, an agreement must be concluded between the countries concerned in regard to construction and maintenance for a term extending over 20 years. It must also be seen to that it does not conflict with domestic laws and regulations.

For reasons stated above, we consider best to build a direct cable route for this system, but we have studied a route via Ceylon at the request of T & T.

1. Estimate of Traffic Demand and Channel Requirement

1.1 Present Status of Pakistan-Ceylon Traffic

There are at present two direct radio circuits one for telegraph and another for telephone between Pakistan and Ceylon. Statistics of the traffic volume for the past few years is shown in Table 1 below:

IV-1 Table 1

Traffic Volume between Pakistan and Ceylon

Year	Telephone		Telegraph	
	Calls	Index	in thousand words	Index
1960/61	343	26		
1961/62	1,214	100	485	100
1962/63	1,230	101	543	112
1963/64	1,303	107		

Note; The telegraph circuit was opened in 1961.

1.2 Estimated Traffic Demand

Though it is difficult to estimate future traffic from insufficient data, the estimation has been made on the basis of the past traffic statistics and the materials prepared specifically by the Pakistan Telegraph and Telephone Department. It has also been made on the following conditions and presumption.

The results are shown in Table 2.

IV-1 Table 2

Estimated Traffic Demand between Pakistan and Ceylon

Year	Telephone (in thousand mins.)	Telegraph (in thousand wds.)	Telex (in thousand mins.)
1962/63	18	543	
1965/66	28	722	
1970/71	112	961	173
1975/76	225	1,230	279
1980/81	452	1,390	448
1985/86	908	1,571	721

(1) Telephone

a. It is generally observed that the growth rate of the demand for international telephone conversations comes between 10% and 15%. T & T also has adopted 15% in its estimation:

Judging from these facts, annual growth rate of 15% has been used in the estimation.

b. Considering the actual traffic increase as a result of inauguration of submarine cable in the Atlantic and in the Pacific, the demand for the first year is presumed to be doubled.

(2) Telegraph

a. The annual growth rate is presumed to be 10% until the direct telex service is opened, judging from the past results of Pakistan-Ceylon traffic.

b. Telegraph traffic is usually affected by the opening of telex service. It is unknown to us when the direct telex service will be opened between Pakistan and Ceylon. There appear, however, figures showing the telex demand between both countries in the estimate for 1968 prepared by the T&T. Therefore, it has been tentatively assumed that the direct service will be opened in that year. Then the annual growth rate of the telegraph traffic would be about 5% until 1975/76, and thereafter 2.5% up to 1985/86.

(3) Telex

a. According to the estimation done by the T & T, the telex demand in 1968 will be a hundred minutes per day. On the other hand, the tendency of traffic increase in the period immediately following the inauguration of the cable system is mostly as follows;

The second year .... 3.5 times of the first year

The third year .... 5.5 times of the first year

b. Five per cent is the supposed rate of increase in the first year of cable laying incidental to the introduction of the high efficiency cable service.

c. The yearly growth rate after 1970 has been estimated at 10%.

1.3 Estimated Number of Channels Required

The number of channels to be required to carry the estimated traffic is given in Table 3.

IV-1 Table 3

Channel Requirements between Pakistan and Ceylon

Year	Telegraph Channels				Telephone Channels		No. of VF Channels Required
	Tele-graph	Telex	Total	Total in VF chans.	Comm-ercial	Others	
1962/63	1		1		1		
1965/66	1		1		1		
1970/71	1	4	5	1	3	1	5
1975/76	1	7	8	1	5	1	7
1980/81	1	10	11	1	11	2	14
1985/86	1	16	17	1	21	3	25

The calculation is based upon the following grounds;

(1) Estimated Number of Telegraph and Telephone Channels

The relations between the traffic demand and the number of channels that may be required to carry the traffic:

Per day	per annum	No. of chs.
Telephone 150 mins.	or 45,000 mins.	= 1 telephone ch.
Telegraph 9,000 wds.	or 2,700 thousand wds.	= 1 telegraph ch.
Telex 150 mins.	or 45,000 mins.	= 1 telegraph ch.

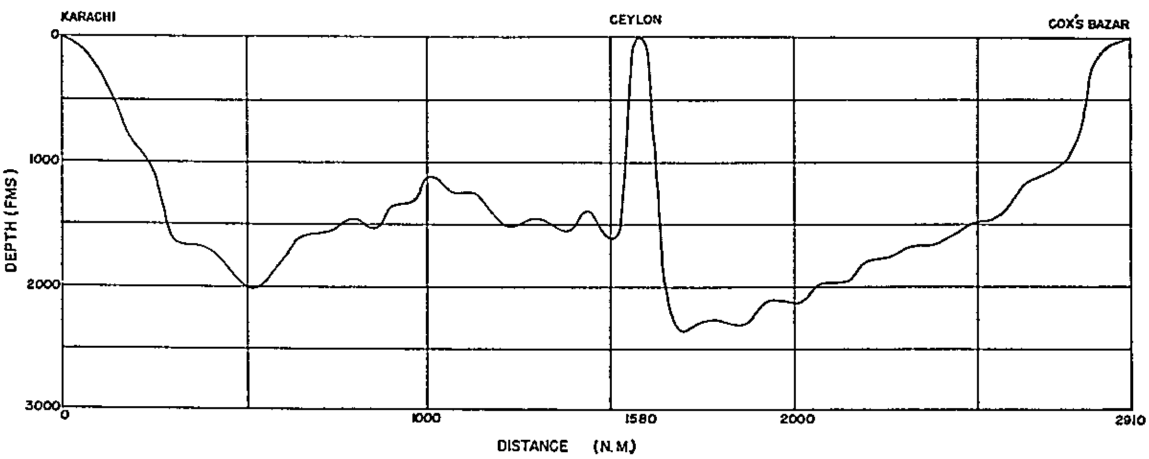
(2) Channels for Other Services

As for leased channels, program transmission, data transmission and other new services, ten per cent of the commercial telephone channels has been appropriated.

2. Selection of the Course of the Cable Route

The route of the East and West Pakistan Submarine Cable, in case laid via Ceylon and landed at Colombo will follow the course illustrated in III-2 Fig. 1 and its profile of the ocean floor as shown in the following Fig. 1.

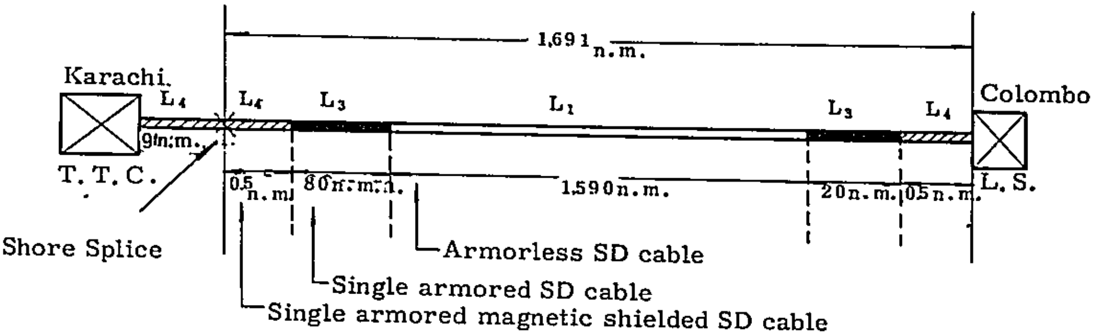
IV-2. Fig. 1 BOTTOM PROFILE OF E-W PAKISTAN CABLE ROUTE

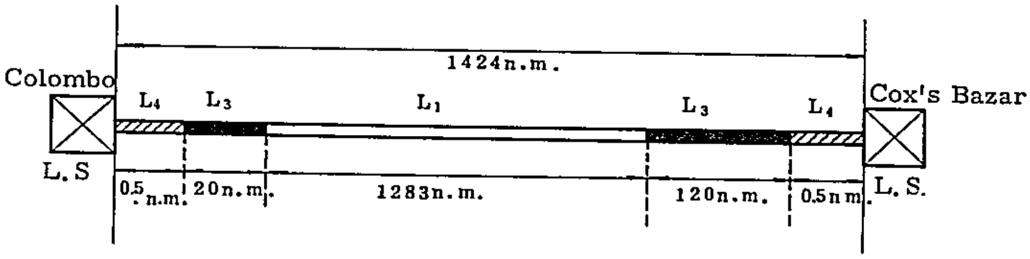


3. Kinds of Cable Necessary for Installation

The East and West Pakistan Cable via Ceylon is divided into two sections. Karachi-Colombo and Colombo-Cox's Bazar, with their respective cable composition as illustrated below.

IV-3. Fig. 1





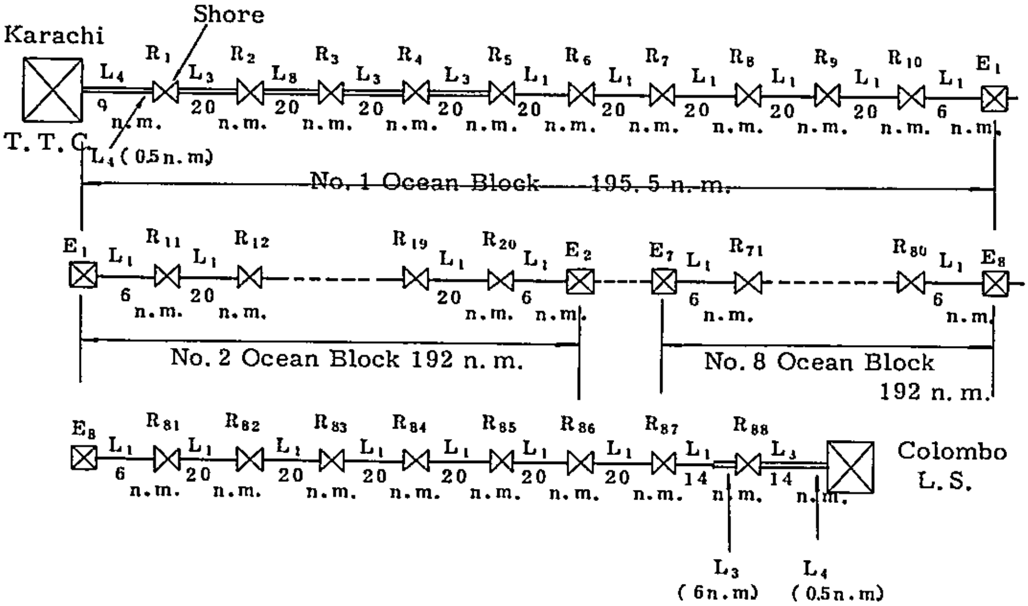
4. Required Quantity of Cable, Repeaters and Equalizers

The block diagram of the cable system via Ceylon for each section of Karachi-Colombo and Colombo-Cox's Bazar is shown in Fig. 1. Types and quantity of cable, repeaters and equalizaers required for the respective sections are as follows;

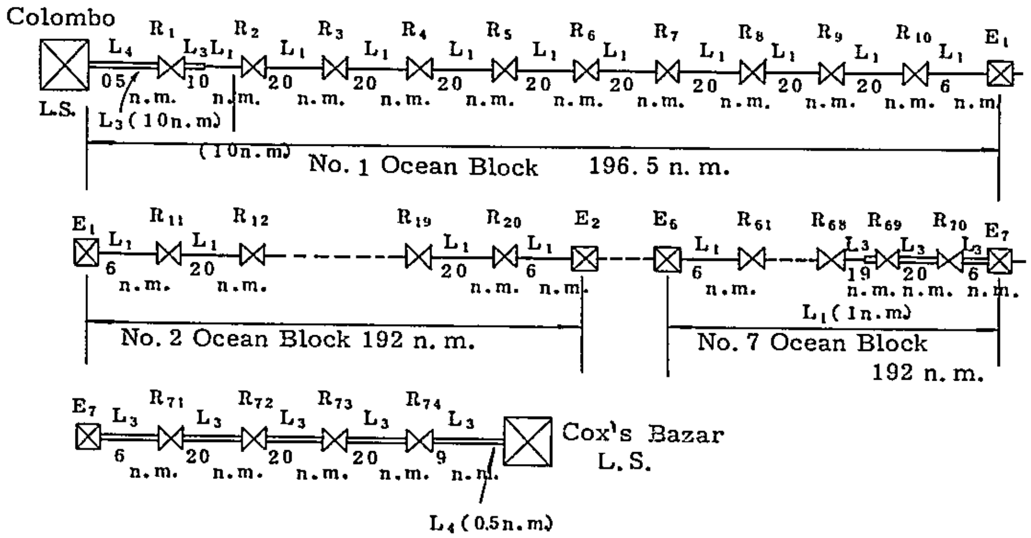
Article	Karachi-Colombo	Colombo-Cox's Bazar	Total
Armorless SD cable	1, 590 n. m.	1, 283 n. m.	2, 873 n. m.
Single armored SD cable	100 n. m.	140 n. m.	240 n. m.
Single armored magnetic shielded SD cable	1 n. m.	1 n. m.	2 n. m.
SD cable repeaters	88	74	162
SD cable equalizers	8	7	15

IV-4 Fig. 1 Cable System Block Diagram

(1) Karachi-Colombo



(2) Colombo-Coxs Bazar



5. Estimated Cost of Construction

In the East and West Pakistan Cable System via Ceylon, one group (16 channels of 3 Kc/s) will be sufficient for each of East-Pakistan ~ Ceylon and West-Pakistan ~ Ceylon communication (see IV-1.3 "Estimated Number of Channels Required"). Therefore all the direct circuits between the East and West Wings just pass through the Group Through Filters at Colombo.

The cost of construction thus estimated amounts to 31,224.000 U.S. dollars, which is shown in details in Table 1.

IV-5 Table 1.

Construction Cost of East and West Pakistan
Cable via Ceylon

1. Cable Laying (in thousand U.S. dollars)		
List-1 Cable	11,492	($4,000 x 2,873 n.m.)
List-3 & 4 Cable	1,728	($7,200 x 240 n.m.)
Repeater	10,530	($65,000 x 162)
Equalizer	795	($53,000 x 15)
Laying Works	2,455	
Total	27,000	
2. Terminal Stations		
Karachi	1,431	
Cox's Bazar	855	
1st Repeating Station	136	
2nd Repeating Station	177	
Chittagong	835	
Ceylon	740	
Total	4,224	
3. Grand Total	31,224	

6. Estimated Revenues

The present rates were applied to the estimated demand, and annual revenues of the main services were calculated, which are shown in Table 1.

IV-6 Table 1. Estimated Revenues

(in thousand Rupees)

Item	1962/63	1970/71	1975/76	1980/81	1985/86
Telephone	54	336	675	1,356	2,724
Telegraph	119	211	271	306	346
Telex	-	519	837	1,344	2,163
Total	173	1,066	1,783	3,006	5,233
(*)	(36)	(224)	(375)	(632)	(1,099)

* Figures in parenthesis are shown in thousand U.S. dollars.

Notes;
1) Telephone and telex charges:
   For the first three minutes Rs. 18.00
   For each additional minute Rs. 6.00

2) Telegraph charge:
   Per ordinary word Rs. 0.44

3) Division of tolls were presumed to be 50:50 between both parties.

V. OUTLINE PROJECT SPECIFICATION TO INVITE TENDER

Pakistan Telegraph & Telephone Department
Karachi West Pakistan

Date: ____________

East-west Pakistan
Coaxial Submarine Cables
Tender No. ____________

INVITATION

Proposals hereby are requested for your furnishing to Pakistan Telegraph & Telephone Department Karachi the equipment and material and installation as described in the attached specification.

It is understood that proposals shall be made in accordance with conditions of bidding attached hereto and made a part of this invitation to bid.

Proposals shall be submitted in sealed envelopes and shall be sent in triplicate to Pakistan Telegraph and Telephone Department sufficiently early to assure receipt by the close of business on ________________.

Envelopes containing proposals should be marked distinctly as follows:

East-West Pakistan
Coaxial Submarine Cables
Tender No. : ____________
Closing Date: ____________

All prices shall be quoted in US Dollars and also in terms of the currency of the country in which the equipment and material is to be manufactured.

BID DATA:

Bidders are requested to furnish with their quotation the following data:

1. Detailed specifications, dimensional drawings and illustrated catalogue sheets, giving full description of and engineering information on, as also showing

essential dimensions of the material offered, all in triplicate. Bidders are requested to note that, if their offer does not contain all the information required in triplicate, same will be considered to be incomplete and will be subject to rejection.

2. Prices to be indispensably quoted in U.S. Dollar and the currency of Bidder's country, separately for each item as follows:

   a. Unit and item prices for the supply of the equipment at the installation and/or laying site. These prices to include all tests required before shipment as provided for in the attached Specifications, but not to include import duty for equipment imported from abroad as T&T will apply for being exempted from payment of such duty.

   b. A lump sum price for the installation and/or laying, connection, final testing and commissioning of the equipment, in accordance with attached specification.

   Attention:

   It is understood that bids will be acceptable on condition only that they cover both the supply and the installation of the complete equipment required.

   Bidders should quote prices only as specified above.

   It is understood that prices quoted for the cables offered will be subject to adjustment on the basis of the rate of copper ruling on the London Metal Exchange on the first working day following the day at which successful bidder will receive confirmation of the order. Bidders are requested to state the basic rate of copper. For the adjustment of the prices bidders shall give full and precise data (i.e. weight of copper per unit weight of material offered, method of calculation of adjustment price or coefficient to be applied, etc.) on the basis of which the new price of the material offered will be computed in case of fluctuations in the above basis price of copper on the London Metal Exchange market. It is stressed that, in the event Bidder does not submit adequate information in this connection, his offer will not receive any consideration.

3. Commission, if any, included in prices quoted and name and address of Pakistan Agent, if any.

4. Terms of payment. See Conditions of Bidding.

5. Delivery promise. It should be noted that all the material called for should be delivered, laid and commissioned by blank. Bidders are therefore requested to state clearly in their offer the earliest date from notification of an award within which they are in a position to effect delivery, as also, separately, the earliest dated within which they are in a position to complete installation, connection and commissioning, it being understood that special consideration shall be given to offers promissing an early completion of the whole work.

6. Location of factory in which the material offered will be manufactured.

7. Origin point of shipment.

8. Bidders are requested to deposit with their bid a bid bond in the form of Bank Letter of Guarantee covering 1% on the total value of the proposal.

9. The successful Bidder(s) will be requested to deposit after the award a Performance Bond in the form of Bank Letter of Guarantee covering 3% on the total value of the contract.

Conditions of Bidding

1) Definition of Terms

In construing these conditions of bidding and/or other attachments to the invitation to bid, the following words shall have the meanings herebelow indicated:

a) The "Purchaser" shall mean and refer to Pakistan Telegraph & Telephone Department, Karachi. (hereafter referred to as T & T).

b) The "Bidder", "Seller" or "Contractor" shall mean and refer to the party(ies) submitting a bid(s) on this invitation to bid, or the Supplier and/or erector of the equipment and/or material to whom an order or contract may be awarded based upon the bid received.

c) The "Bid" or "Quotation" or "Offer" shall mean and refer to the proposal submitted by Bidder to T & T.

2) Bid Schedules

Bids are requested covering all or any of the items included in the attached specification, drawn up in accordance with requirements of the invitation to bid.

3) Bid Data

Information relating to the equipment, materials and/or work proposed shall be supplied with Bidder's quotation, as specified in the specification attached hereto.

4) Submission of Bids

When submitting their bids, Bidders are requested to pay special attention to the following conditions:

a) Bids have to be submitted by the close of business on the date specified in the invitation. Bids received after said date and time will not be considered.

b) The bid should be divided in two parts, each made out on separate sheet(s) of paper. Part one should contain the price schedule, comprising item and unit prices as required and as numbered in Schedule "A" incorporated herein, as also terms of payment, delivery schedule etc. and Part two should contain the detailed description of the material offered and/or work to be carried out.

c) Bids must be submitted in sealed envelopes, on which the number of the tender, the material called for and the closing date for submission of offers must indispensably be indicated.

d) Cables offers will not be considered.

5) Comparison of Bids

Other factors, in addition to cost(s), terms of payment time of delivery and conformity of the bid to the terms and the conditions of the invitation, will also be considered in awarding the contract, such as, but not limited to the Bidder's record as a manufacturer of the equipment and/or material and/or as a contractor of the work of the classification covered by the invitation, the Bidder's reputation as regards integrity in commercial transactions, other features considered as affecting the appearance, life, cost of operation of the equipment and/or material and/or execution of the work involved.

6) Purchaser's Reservations

Purchaser reserves the right to increase or decrease the quantities called for by up to 20%, not to award the contract to the lowest Bidder, to split up the award amongst more than one Bidders, to award part only of the material required and to reject any or all offers.

7) <u>Validity of Bids</u>

Unless otherwise specified in Bidder's proposal, it shall be understood that bids shall be valid for a ninety (90) days' period as from the closing date of the tender. The validity of the bids may be extended for a further period of time, by mutual agreement between Bidder and the Purchaser.

8) <u>Terms of payment</u>

Bidders should note that the comparison of the bids will be carried out on the basis of prices established for payment in cash against presentation of shipping documents through the prime bank in Pakistan and that, therefore, bids should indispensably specify such terms of payment. In addition to these, Bidders should also submit proposals for credit terms of payment with the rate of interest required on the credit granted. Preference shall be given to the longer credit payment terms. Bidders are responsible for obtaining the approval for such credit terms of payment from the Government of the country of origin.

Specification

- General Requirements -

Scope:

This specification covers the construction, installation, connection and testing of coaxial submarine cable linking East and West Pakistan.

The whole installation shall be delivered ready for operation to Pakistan Telegraph & Telephone Department.

Type of cable:

Armourless coaxial submarine cable of having the capacity of at least 120 channells with necessary repeaters, equalizers and armoured cable for shore ends of East and West Pakistan. Detailed specification is as per the following "Specific Requirements"

Cable route:

Prior to the submission of bids, Bidders are requested to conduct the preliminary survey of the shore ends around the landing points proposed by bidder, result of which should be submitted as a specification and/or information described below. Bidders who didnot conduct such survey will be disqualified.

Proposals should be made for:

(A) Continuous cable system linking Karachi and Chittagong, and

(B) Cable system including Ceylon as a calling point.

In both cases, the cable route should be properly far from any main land, other than Ceylon.

Terminal Stations and Micro Wave Facilities:

Bidders are requested to submit the proposals for Terminal stations and Coaxial cable system and/or Micro-wave facilities connecting such terminal stations to the Traffic Centres in Karachi and Chittagong.

Sear Survey:

Prior to the actual laying of cable from West to East Pakistan a Sea Survey should be conducted by the constructor over the entire route to ensure that no uncharted hazard exist. Cost of such survey should be included in the proposal.

Specification and information to be provided by bidder:

As a result of the preliminary survey mentioned above, Bidders should submit the following specification and information together with their bid.

1) Full description, drawing and list of quantities of cable repeaters and other accessories required.

2) Drawing showing the proposed cable route and conditions of the shore upto about 20-25 miles far from the landing points proposed.

3) Full description and drawing for terminal stations, micro-wave facilities and/or coaxial cable system proposed.

4) Cable Laying Procedure.

5) Type and time of guarantee for normal operation of cable. The guarantee should at least cover for three year the value of materials and installation.

Proposals should be made separately for all of the following items, further breakdown of which should also be furnished.

A) Cable Construction

  1) Armourless cable
  2) Single armoured cable
  3) Repeaters
  4) Equalizers
  5) Cable laying

B) Terminal stations

  1) Land & Buildings
  2) Terminal Equip
  3) Karachi
  4) Chittagong

C) Micro-wave Facilities and/or Coaxial cable system.

  1) Karachi
  2) Chittagong

Attention:

Bidders should state the items and their amount which can be procured or manufactured in Pakistan. For example, Buildings to house the terminal equipment will be built by P. T. T. and no credit would be required for these or any other apparatus of Pakistan origin that was used on this project.

ANNEX

S. D. CABLE SPECIFICATION

Specification Preface

KS 16773

CABLE

DESCRIPTION

This is an ocean telephone coaxial cable primarily intended for use in the SD Submarine Cable System. The cable consists of an inner conductor composed of a coper-jacketed steel strand, a polyethylene dielectric, a concentric copper outer conductor, and an ethylene plastic jacket. List numbers as follows have been assigned to identify cable having the single jacket and cable having additional materials over the jacket:

List 1 - Single jacket of ethylene plastic, 1-1/4 inch OD.

List 2 - List 1 plus two layers of metallic tape armor plus an ethylene plastic jacket, 1-1/2 inch OD.

List 3 - List 1 cable with an annealed copper inner conductor, plus a single layer of 15 neoprene-coated steel armor wires.

List 4 - List 1 cable with (1) an annealed copper inner conductor, (2) metallic strip electromagnetic shielding over the 1-1/4 inch ethylene plastic jakcet, (3) a second ethylene plastic jacket, 1-1/2 inch OD, and (4) a single layer of 17 neoprene-coated steel armor wires.

List 5 - List 4 cable with a second layer of 23 neoprene-coated steel armor wires.

This product is intended to be furnished as part of the KS-16767 cable assemblies.

ORDERING INFORMATION

Orders for this product shall specify: CABLE, KS-16773 L(number), length in miles*

* The word "mile" refers to a telegraph nautical mile of 6087 feet.

CHANGE CLASSIFICATION

The changes shall be incorporated in all products manufactured hereafter.

1. GENERAL

1.01 This specification covers the requirements for ocean telephone coaxial cable. It does not cover the manufacture of the product in detail, but is intended only to define the special arrangements in which the purchaser is directly interested. In all respects not covered by this specification, the product shall be in accordance with the standard practice of the supplier.

1.02 No deviations from this specification shall be made without written approval. If such approval is given, it will be through the purchaser's representative, the Resident Project Supervisor, hereinafter called the Supervisor. Similarly, where apparatus or processes are required to be approved, such approval will be given through the Supervisor. In some instances, the Supervisor may designate a representative to act in his stead.

1.03 Adequate facilities shall be provided for all manufacturing, assembly, storage, and testing operations. These facilities shall include machinery and any special devices called for in this specification. Any facility not capable of handling 20-nm splicefree lengths will not be approved.

1.04 All facilities used in connection with the manufacture of the cable shall be open to the inspection of the Supervisor at all times, and the manufacturer shall make all reasonable arrangements to correct undesirable conditions which are brought to his attention by the Supervisor.

1.05 All machinery and other devices shall be of sufficient capacity and accuracy to provide the requisite control over the quality of the product at all times, and shall be maintained in good operating condition at all times.

1.06 Prior to manufacture, the manufacturer's processing arrangements and sequences shall be subject to approval, and the approved operating arrangements shall be followed subsequently. If, however, unforeseen circumstances necessitate changes after approval which are unavoidable in the manufacturer's judgment, the manufacturer shall notify the Supervisor for his consideration of the changes to be made.

1.07 The abbreviation "nm" wherever used in the specification refers to a telegraph nautical mile of 6087 feet.

1.08 All electrical constants are given in "Absolute Units" as defined by the International Committee of Weights and Measures.

1.09 A right-hand or left-hand lay as used in this specification is defined as providing a clockwise or counterclockwise rotation respectively of the given unit of material in an end view of the cable.

2. PRECAUTIONARY MEASURES

2.01 The tolerance limits applied to each nominal dimension listed in this specification are provided to allow for the errors inherent in measurements and are not intended as permission to depart consistently from the nominal design values.

2.02 Every reasonable precaution shall be taken to prevent the contamination of or damage to the finished cable or any of its components either in the raw material state or during processing, transportation, or storage.

2.03 Any polyethylene compound that becomes contaminated at any time shall be rejected completely and so disposed of that there will be no possibility of its being present in the finished cable.

2.04 Stores of raw materials shall be isolated from stores of similar material to be used for other purposes.

2.05 When practicable, current supplies of raw materials shall be maintained in anorderly fashion in areas adjacent to the areas where they are processed. Materials rejected during process shall be disposed of immediately to avoid their being confused with acceptable material.

3. DESCRIPTION

3.01 The cable consists of an inner conductor composed of a copper-jacketed steel strand, a polyethylene dielectric, a concentric copper outer conductor, and an ethylene plastic jacket. List numbers as follows have been assigned to identify cable having the single jacket and cable having additional materials over the jacket.

List 1 - Single jacket of ethylene plastic, 1-1/4 inch OD.
See B-191543.

List 2 - List 1 plus two layers of metallic tape armor plus an ethylene plastic jacket, 1-1/2 inch OD.
See B-552115.

List 3 - List 1 cable with an annealed copper inner conductor, plus a single layer of 15 neoprene-coated steel armor wires. See B-552116.

List 4 - List 1 cable with (1) an annealed copper inner conductor, (2) metallic strip electromagnetic shielding over the 1-1/4 inch ethylene plastic jacket, (3) a second ethylene plastic jacket, 1-1/2 inch OD, and (4) a single layer of 17 neoprene-coated steel armor wires. See B-552117.

List 5 - List 4 cable with a second layer of 23 neoprene-coated steel armor wires. See B-552118.

4. MATERIALS AND DIMENSION

4.01 The steel strand shall be composed of 41 steel wires per KS-16580. The list numbers and arrangement of the wires shall be as shown on B-191187.

4.02 The completed strand shall be encased within a welded tube formed from copper strip per KS-16861 L1. The tube shall then be reduced in size and compacted on the strand to form a composite inner conductor.

4.03 The outside diameter of the inner conductor shall be 0.330 ± 0.001 inch. The effective wall thickness of the copper, determined by computations and measurements, shall be 0.023 inch but in no case less than 0.0225 inch.

4.04 The inner conductor shall be covered with an extruded dielectric coating of polyethylene per KS-16857 L1.

4.05 The diameter of the dielectric material shall be 1.000 ± 0.001 inch at 20 C before application of the outer conductor. The temperature coefficient of the diameter is 30×10^{-5} inch per degree C, for the temperature range from 15 to 25 C.

4.06 The eccentricity (conductor displacement from true center) shall be not greater than 0.005 inch.

4.07 The outer conductor shall be formed from copper strip per KS-16861 L2 and applied with an overlap seam parallel to the axis of the insulated conductor.

(See B-191543 and B-191544)

4.08 A jacket of ethylene plastic per KS-16858 L1 shall be applied over the outer conductor.

4.09 The diameter over the jacket shall be 1.250 ± 0.010 inches. The minimum wall thickness shall be 0.090 inch.

4.10 The metallic strip armor for list 2 cable shall be aluminum bronze strip, per KS-19014 L1, and shall be applied in two helical layers with right-hand lay. The second layer shall bridge the butt seam of the first. See B-552115. The strip shall be as closely butted as possible but shall in no case be separated by greater than 1/8 inch.

4.11 A jacket of ethylene plastic per KS-16858 L1 shall be applied over the metallic armor strip.

4.12 The diameter of the list 2 cable shall be 1.500 ± 0.010 inches. The minimum wall thickness of the outer jacket shall be 0.080 inch.

4.13 Inner conductor for list 3, 4, and 5 cable shall be copper wire per KS-16861 L3. Fabrication through the 1-1/4 inch jacket for these cables shall be identical to list 1 cable except for the inner conductor.

4.14 The neoprene-coated steel armor wires for list 3, 4 and 5 cable shall be in accordance with KS-16693 L1.

4.15 The length of lay of the armor wire for list 3 cable shall be 21 ± 1 inches. The direction of lay shall be left hand.

4.16 The length of lay of the armor wire for list 4 cable shall be 13 ± 1 inches. The direction of lay shall be left hand.

4.17 The length of lay of the inner armor wire for list 5 cable shall be 13 ± 1 inches. The length of lay of the outer armor wire for list 5 cable shall be 21 ± 1 inches. The direction of lay of both layers shall be left hand.

4.18 Metallic shielding for list 4 and 5 cable shall be of soft iron strip per KS-16541. A longitudinal strip shall be applied first with a nominal 1/4-inch overlap seam parallel to the axis of the cable. Over this shall be applied four helical strips with alternately opposite directions of lay.

4.19 The innermost helical strip shall be applied in the same direction as the overlap in the longitudinal strip. The lay angle at the helical strips shall be 45±4 degrees with the axis of the cable, and the strips shall be as closely butted as possible but in no case separated by more than 1/8 inch.

4.20 A jacket of ethylene plastic per KS-16858 L1 shall be applied over the shielding tapes.

4.21 The diameter over the jacket shall be 1.500 ± 0.010 inches. The minimum wall thickness shall be 0.070 inch.

4.22 The length measurement of finished cable shall be made with an accuracy of 0.04 per cent or better.

5. ELECTRICAL REQUIREMENTS

5.01 The cable shall be at 10 ± 0.2 C when the electrical measurements are made, except that the voltage breakdown test may be at ambient temperature.

Attenuation

5.02 Cable attenuation measurements for acceptance or rejection of product shall be made on 1-1/4 inch jacketed cable.

5.03 The attenuation of each length of cable shall be measured at 50-kc intervals from 50 to 1200 kc. The measured values shall then be divided by the cable length to determine α in db/nm.

5.04 The attenuation values determined shall be those listed in Table A ± 0.004 αl, where l is cable length, or ± 0.03 db, whichever is greater. The tolerance applies at all measured frequencies from 100 to 1050 kc.

Table A Design Characteristic of Attenuation DB/NM at 10 C and Zero Fathoms

Frequency kc	α db/nm	Frequency kc	α db/nm
50		650	
100		700	
150		750	
200		800	
250		850	
300		900	
350		950	
400		1000	
450		1050	
500		1100	
550		1150	
600		1200	

5.05 The measurement shall be made with the test set furnished by the customer.

5.06 The measurement shall be repeated on each length for the opposite direction of transmission, and both measurements shall meet the requirements.

Maximum Internal Echo

5.07 The maximum internal echo shall be at least 60 db below the incident pulse at the point of irregularity.

5.08 The transmitted pulse shall be a raised-cosine pulse, 0.25 microsecond wide at half amplitude. The cable shall be terminated with Z_C.

5.09 Allowance for the attenuation of the pulse during its passage toward the point of reflection and during its return passage shall be made in accordance with the attenuation values listed in Table B.

Table B Attenuation Allowance as a Function of Distance to Discontinuity

usec	db
10	2.448
20	4.884
30	7.233
40	9.541
50	11.718
60	13.823
70	15.797
80	17.660
90	19.398
100	20.976
110	22.441
120	23.736
130	24.956
140	26.011
150	27.099
160	27.886
170	28.734
180	29.444
190	30.154

5.10 This requirement applies at each end of every length.

Voltage Breakdown

5.11 Each length of cable shall withstand a direct current potential between inner and outer conductors of not less than 33,000 volts for a continuous period of 1 minute. Voltage in excess of 40,000 volts shall not be applied. The outer conductor shall be grounded and both positive and negative potentials shall be applied to the inner conductor.

The voltage breakdown test shall be made only after all other electrical measurements are made, excepting 5.146, attenuation on finished list 2, 3, 4, and 5 cable.

Insulation Resistance of Dielectric

5.12 The dc insulation resistance between the inner conductor and the outer conductor shall be 100,000 megohm-miles minimum. A test voltage of at least 500 volts shall be used, and the insulation resistance shall be determined after the voltage has been applied for one minute.

Insulation Resistance of Jackets

5.13 The insulation resistance of each cable jacket shall be a minimum of 15,000 megohm-miles. It shall be measured to an accuracy of 5.0 per cent and with a potential of from 500 to 1,000 volts.

Other Electrical Tests

5.14 Other electrical measurements shall be made to the accuracy stated below, while the cable is at 10.0 ± 0.2 C.

5.141 Impedance at 1 mc to an accuracy of 0.1 per cent.

5.142 Delay at 1 mc to an accuracy of 0.01 per cent.

5.143 DC resistance of outer conductor to an accuracy of 0.05 per cent.

5.144 DC resistance of inner conductor to an accuracy of 0.05 per cent.

5.145 Low frequency capacitance to an accuracy of 0.1 per cent.

5.146 Attenuation of list 2, 3, 4, and 5 cables at ambient temperature. The temperature shall be measured to an accuracy of ± 1.0 C.

6. GENERAL REQUIREMENTS

Steel Wires

6.01 Steel wires in the finished cable shall continue to meet the requirements of KS-16580 except as follows:

6.011 Where necessary to repair a broken wire prior to stranding the requirements of 8.02 through 8.06 shall apply. Repairs to the individual wires in the outer strand layer after the strand is formed may be made in accordance with 8.02 through 8.06 by splicing in a new piece of wire at least 30 feet in length and without damaging the rest of the strand.

6.012 Wires may show a slight flattening due to the strander closing die.

Steel Strand

6.02 Repair welds in individual wires shall be at least 30 feet away from any other weld in any of the 41 wires of the completed strand.

6.03 The summation of the deviations from nominal wire sizes of the 41 wires used in forming the strand shall not exceed ± 0.010 inch.

6.04 The minimum diameter permissible for the strand closing die is 0.288 inch.

6.05 The length of lay shall be 6 ±1/4 inches. The direction of lay shall be left hand.

6.06 No lubricant or other material shall be added to the strand.

Inner Conductor Copper

6.07 Oil film left on the inner copper strip for shipping purposes may be removed by cleaning. Residue after cleaning shall meet the requirements of 7.01.

6.08 The edges of the inner conductor strip may be slit to provide a ffresh edge for the seam weld. In any event the tube shall not be formed from strip wider than 1.6 inches or narrower than 1.5 inches.

6.09 The tube formed from this copper strip shall be continuously seam-welded by an electric arc in an inert gas atmosphere. The electrode used shall be a nonconsumable metal electrode.

6.10 The seam weld shall be full depth, and tubing so made shall meet the requirements of 7.09.

6.11 Weld skips may be rewelded and repairs made to the copper only while the tubing is at 0.460 inch diameter or larger.

6.12 Only petroleum derivatives shall be used for quenching between weld and repair weld stations.

6.13 Jointing of successive copper strips shall be in accordance with 8.07 through 8.10.

Composite Inner Conductor

6.14 Minimum bending radius for composite inner conductor shall be 36 inches except that approved wire-straightening rolls may be used prior to extrusion of the dielectric.

6.15 Surface finish of the composite inner conductor shall be 32 microinches, root mean square, or better.

6.16 The composite inner conductor shall be cleaned just prior to the application of the dielectric, and it shall be shielded from contamination in the interval from the cleaning station to the extruder. Residue after cleaning shall meet the requirements of 7.02 through 7.04.

6.17 No holes are permitted in the copper of composite inner conductor.

6.18 Composite inner conductor once formed may not be repaired in any way other than that described in 8.11 through 8.19.

6.19 The minimum distance between composite inner conductor repairs shall be 1.5 nm.

6.20 The minimum distance from composite inner conductor repair to either end of an ordered length of cable shall be 3 nm.

6.21 The maximum number of composite inner conductor repairs in an ordered length of cable is two.

Copper Inner Conductor

6.22 Copper inner conductor for list 3, 4, and 5 cable shall continue to meet the requirements of KS-16861 L3 when dielectric is applied, except for the tensile requirements at joints.

6.23 Joints between sections of copper inner conductor may be made only by techniques described in 8.20 and 8.21.

6.24 Copper inner conductor shall be cleaned just prior to the application of the dielectric, and it shall be shielded from contamination in the interval from the cleaning station to the extruder. Residue after cleaning shall meet the requirements of 7.02 through 7.04.

6.25 At least 998 feet of conductor shall be used for each 1,000 feet of extruded core.

Core

6.26 The dielectric shall be free of voids.

6.27 The dielectric shall be free of any foreign particulate substance having any dimensions greater than 1/32 inch and shall be free from any discolored area having any dimension greater than 1/16 inch. Detectable inclusions larger than 0.015 inch and smaller than above are not permitted closer to each other than 1 inch and no more than three per foot of cable core.

6.28 The dielectric shall not be repaired in any way other than that described in 8.22 through 8.25 or 8.26 through 8.30.

6.29 Waviness, ellipticity, matte finish, or other minor irregularity of the outer surface of the dielectric material shall not be so pronounced that it interferes with the measurement of or otherwise prevents the achievement of the diameter tolerance.

6.30 The core shall be shielded from direct sunlight and shall not be exposed to concentrated ozone or concentrated ultraviolet light.

6.31 Tests for dielectric shrinkage shall not give results in excess of 10 per cent. Tests shall be made in accordance with 7.08.

6.32 The outer surface of the dielectric shall be free of any foreign materials as the outer copper is applied over it.

6.33 The extruded core material shall continue to meet the melt index requirements of Specification KS-16857.

Outer Conductor Copper

6.34 Oil film left on the outer conductor strip for shipping purpose shall be removed. Residue after cleaning shall meet the requirements of 7.05 through 7.07.

6.35 At least 995 feet of strip shall be used per 1000 feet of cable.

6.36 The strip shall be formed around the core so as to minimize the lack of contact between strip and dielectric. (See B-191544)

6.37 Jointing of successive copper strips shall be made in accordance with 8.31 through 8.35.

6.38 Outer copper once formed about the core may not be repaired in any way other than that described in 8.36 through 8.38.

Jackets

6.39 The jackets shall be free of voids and seal marks.

6.40 Waviness, ellipticity, matte finish, or other minor irregularity of the outer surface of the jacket materials shall not be so pronounced that it interferes with the measurement of or otherwise prevents the achievement of the diameter tolerance or the minimum wall thickness requirement.

6.41 Tests for jacket shrinkage shall not give results in excess of 50 per cent for KS-

16858 material. Tests shall be made in accordance with 7. 08.

6. 42 Jackets may not be repaired in any way other than that described in 8. 39 through 8. 46.

Aluminum-Bronze Strip

6. 43 Strip for list 2 cable shall be cleaned prior to application to the cable. Residue after cleaning shall meet the requirements of 7. 05 through 7. 07 except that the organic contaminant change, the conductivity change, and the pH change values shall be 1 mg, 1 micromho, and ± pH0. 1, respectively. After application and prior to the second jacketing operation, the cable shall be handled and stored in such a manner as to preclude other contamination.

6. 44 Joints between successive lengths of strip shall be in accordance with 8. 47 and 8. 48.

6. 45 The metallic strip shall continue to meet the requirements of KS-19014 after application, and shall be applied and the taped cable handled in a manner to assure a smooth compact product for extrusion of the 1-1/2 inch OD jacket.

Soft Iron Shielding Strip

6. 46 Soft iron strip for electromagnetic shielding shall be free from contamination when applied to the jacketed cable except for a light residual coating of an approved rust preventive. After application and prior to the second jacketing operation, the cable shall be stored and handled in a manner to minimize further contamination.

6. 47 The several strips shall be applied in a manner to assure compactness in the structure, and the cable, prior to jacketing, shall be subjected to a minimum of handling.

6. 48 Joints in successive coils of strip shall be made in accordance with 8. 49.

6. 49 After application and at any subsequent time, the strip material shall meet the permeability requirements of 7. 10.

Neoprene-Coated Armor Wires

6. 50 The armor wires for lists 3, 4, and 5 cable shall continue to meet the requirements of KS-16693 L1 after the wire is applied to the cable.

6. 51 The application of the armor wires to the cable shall result in a smooth, uniform

product, with uniform back-tensions applied to each wire.

6.52 Joints in the neoprene-coated wires shall be in accordance with 8.50 through 8.55.

Finished Cable

6.53 In the finished cable, the lack of contact between the outer copper strip and the dielectric shall not exceed 0.0001 square inch in a cross-section view of the cable as shown on B-191544.

6.54 In the finished cable the lack of contact between the first jacket and the outer copper shall be minimized. Any waviness which appears in the outer copper after ten reverse bends on a 36 inch radius shall not exceed 0.010 inch peak-to-valley amplitude and such peaks and valleys shall not occur closer than 1/16 inch.

6.55 No cracks visible to the naked eye shall occur in the outer copper conductor after 50 reverse bends at 36-inch radius.

7. SPECIAL TESTS

Residue Test on Inner Copper Strip

7.01 Pass the cleaned and dried copper strip through a recirculated distilled water spray. Remove the film of water remaining on the strip after spraying and return it to the recirculated test solution. The conductivity change of the resulting solution is a measure of the residue of conducting salts on the length of copper strip subjected to the test. The tolerable change in conductivity is 1 micromho per centimeter for 1 foot of strip passing through 1 liter of test solution. The conductivity of the test solution shall not be allowed to exceed 400 micromhos per centimeter.

Residue Test on Composite Inner Conductor and Copper Inner Conductor

7.02 Pass the cleaned and dried inner conductor through a recirculated spray of KS-16235 L1 trichloroethylene or other approved organic solvent. Remove the film of solvent remaining and return it to the recirculated test solution. The change in the proportion of organic contaminants in the resulting solution is a measure of the residue on the length of inner conductor subjected to the test. The proportion can be determined as follows: remove a sample of solution, evaporate to dryness, and weight the residue. The tolerable change is 31 mg per liter of sample for 100 feet of conductor passing through 1 liter of test solution. The proportion of contaminants in the test solution shall not be allowed to exceed 1 gram per liter.

7.03 Pass the cleaned and dried copper conductor through a recirculated distilled water spray. Remove the film of water remaining on the conductor after spraying and return it to the recirculated test solution. The conductivity change of the resulting solution is a measure of the residue of conducting salts on the length of copper conductor subjected to the test. The tolerable change in conductivity is 32 micromhos per centimeter for 100 feet of conductor passing through 1 liter of test solution. The conductivity of the test solution shall not be allowed to exceed 400 micromhos per centimeter.

7.04 In the same distilled water test solution, check also for the pH change as a measure of the alkalinity or acidity of the residue on the length of copper inner conductor subjected to the test. The tolerable change is ± pH0.2 for 500 feet of conductor passing through 1 liter of test solution. The pH of the test solution shall not be allowed to exceed pH7.5 or drop below pH6.5.

Residue Test on Outer Copper Strip

7.05 Pass the cleaned and dried copper strip through a recirculated spray of KS-16235 L1 trichloroethylene or other approved organic solvent. Remove the film of solvent remaining and return it to the recirculated test solution. The change in the proportion of organic contaminants in the resulting solution is a measure of the residue on the length of copper strip subjected to the test. The proportion can be determined as follows: remove a sample of solution, evaporate to dryness, and weight the residue. The tolerable change is 2 mg per liter of sample for 1 foot of copper strip passing through 1 liter of test solution. The proportion of contaminants in the test solution shall not be allowed to exceed 1 gram per liter.

7.06 Pass the cleaned and dried copper strip through a recirculated distilled water spray. Remove the film of water remaining on the strip after spraying and return it to the recirculated test solution. The conductivity change of the resulting solution is a measure of the residue of conducting salts on the length of copper strip subjected to the test. The tolerable change in conductivity is 2 micromhos per centimeter for 1 foot of strip passing through 1 liter of test solution. The conductivity of the test solution shall not be allowed to exceed 400 micromhos per centimeter.

7.07 In the same distilled water test solution, check also for the pH change as a measure of the alkalinity or acidity of the residue on the length of copper strip subjected to the test. The tolerable change is ± pH 0.25 for 100 feet of strip passing through 1 liter of test solution. The pH of the test solution shall not be allowed to exceed pH7.5 or drop below pH6.5.

Shrinkage Test for Extruded Plastics

7.08 A talc bed approximately 1/4 inch in depth shall be placed in an air oven for a period of at least 1 hour at a temperature of 130 to 132 C for KS- 16857 and KS- 16889 material and 150 to 152 C for KS- 16858 material. After this preheating period, place specimens of the extruded plastic upon the talc bed for 1 hour at the same temperature. Specimens of core material shall be carefully prepared half sections of core approximately 3 inches in length. Jacket samples shall be sectioned pieces of the nominal thickness approximately 1-1/2 inches in length and 1/2 inch in width. The long dimension shall be in the direction of extrusion. All samples shall be prepared with clean square edges. After annealing, the specimens and the talc bed shall be removed and allowed to cool at room temperature. The per cent change in length shall be the shrinkage value. Measurements shall be made near the midportion of the specimen and shall be to the nearest 1/32 inch. If the gauging surfaces have become inclined during heating, measurements shall be made at both pairs of edges and averaged.

Flare Test

7.09 The welded seam of the unreduced copper tube shall not fracture when the end of a section of tube is expanded to a 35 per cent increase in diameter. Expansion shall be accomplished by forcing a hardened steel cone having an apex angle of 60 degrees into one of the tube ends.

Permeability Test

7.10 Permeability of the soft iron shielding strip shall be determined by the following method, or an approved equivalent. Ten annular rings of 1 inch OD and 11/16 inch ID shall be punched from the strip and stacked with paper separators. Twenty turns of twinned wire shall be applied to the stack to form a toroidal mutual inductor. Permeability shall be determined by a measure of mutual inductance on bridge at a frequency of 2 kc and with a field not exceeding 0.1 amp/meter. Permeability of the longitudinal strip shall be not less than 100, and of the helical strip, not less than 120.

8. REPAIRS AND JOINTS

8.01 All operations shall be performed by qualified operators using qualified equipment. Qualification shall be certified by the Supervisor.

Joints in Steel Wires

8.02 When required, the steel wires shall be butt-welded by a resistance welding method. The ends of the wires to be joined shall be repared by shearing just prior to welding.

8.03 Flash at the welded joint shall be removed.

8.04 After removal of the flash, the wire shall be annealed to a distance of 1-1/2 to 3 inches on each side of the joint.

8.05 The finished joint shall have a minimum tensile strength of 120,000 psi.

8.06 The finished joint shall be capable of being wrapped 3 times around a mandrel having a diameter 3 times the diameter of the wire. The weld shall be in the center turn.

Joints in the Inner Conductor Strip

8.07 Joints shall be butt-welded by an electric arc in an inert gas atmosphere using a nonconsumable metal electrode. The weld shall make an angle of from 65 to 70 degrees with the edge of the copper strip. The ends of the strips to be joined shall be sheared just prior to welding.

8.08 The weld shall be full depth and shall extend to the edges of the strip. If the strip is subsequently to be slit, the weld need extend only to the edges of the slit strip.

8.09 The finished joint shall have a minimum tensile strength of 20,000 psi.

8.10 The finished joint shall be capable of withstanding without fracture two 90-degree bends over a 1/64-inch radius. The second bend shall be in the opposite direction.

Joints in the Composite Inner Conductor

8.11 Joints shall be made with sleeve B-191700. A compensating cylinder assembly, B-193454, shall be placed on one of the conductors before the joint is completed.

8.12 The copper jacket shall be removed from the end of each conductor for a distance of 2-15/16 inches. Care shall be exercised in removing the copper to avoid any damage to the strand wires.

8.13 The strand wires shall be spread apart as much as possible without flaring the copper jacket and cleaned for approximately 30 seconds in an ultrasonic bath of KS-16235 L1 trichloroethylene or approved equivalent.

8.14 When dry, the cleaned strand shall be dipped in thinned clear lacquer consisting of 2 parts lacquer and 1 part thinner.

8.15 While the lacquer is still wet, the strand shall be dusted thoroughly with beryllium-copper powder (such as Berylco No. 20 CR), mesh 80 to 270, and allowed to dry. Caution must be used in handling beryllium-copper powder as it is a toxic material.

8.16 When dry, the strand shall be relaid and the outer surface relacquered, redusted, and allowed to dry.

8.17 The joint shall be completed by crimping the sleeve as shown on B-193459. Strand from the two conductor ends shall butt at the center of the sleeve. After crimping, any fins produced shall be removed.

8.18 After completion of the joint, the crimped sleeve and the compensating cylinder assembly shall be coated with bonding material. The bonding material shall be furnished by the customer.

8.19 The finished joint shall have a minimum tensile strength of 15,500 pounds and a dc resistance of 2×10^{-3} ohms maximum as measured with a Kelvin bridge. The resistance of each joint shall be measured just prior to the core molding operation.

Joints in Copper Inner Conductor

8.20 Joints between successive lengths of copper inner conductor shall be made by butt-brazing using brazing materials per KS-14827 L5 or 5A.

8.21 Completed joints shall be smooth and square and shall have a minimum of 90 per cent of the tensile strength of the copper conductor.

Patching Dielectric

8.22 Repairs to the dielectric shall be made with polyethylene per KS-16857 L1.

8.23 Repairs shall be made without damage to or contamination of the inner conductor.

In the event of contamination, the inner conductor shall be cleaned with KS-1092 denatured alcohol, which shall be completely evaporated before molding.

8.24 The molded repair shall meet the requirements of 6.26 through 6.33.

8.25 The tensile strength and elongation across the molded-to-extruded interface shall be a minimum of 90 per cent of the corresponding values for extruded material. The test specimen shall be of uniform thickness and shall be prepared from a radial cut of the core.

Patching Dielectric over Joints in the Composite Inner Conductor

8.26 Repairs to the dielectric shall be made with polyethylene per KS-16857 L1.

8.27 Repairs shall be made without damage to the inner conductor. The inner conductor, splice sleeve, and compensating cylinder assembly shall be cleaned prior to molding dielectric with KS-1092 alcohol which shall be completely evaporated before molding.

8.28 The compensating cylinder assembly shall be located as shown on B-193459. Special care shall be taken not to damage the bonding material on the compensating cylinder assembly and splice sleeve.

8.29 The molded repair shall meet the requirements of 6.26 through 6.33 except that those portions of the molded repair which are over the sleeve and compensating cylinder assembly shall be free of any foreign particulate substance, or discoloration.

8.30 The tensile strength and elongation across the molded-to-extruded interface shall be a minimum of 90 per cent of the corresponding values for extruded material. The test specimen shall be of uniform thickness and shall be prepared from a radial cut of the core.

Joints in the Outer Conductor Copper Strip

8.31 Joints shall be made with abrazed overlap seam using brazing materialsper KS-14827 L5 or 5A. The joint shall be at an angle of 65 to 70 degrees with the edge of the strip. The ends and matching faces to be joined shall be sheared and cleaned just prior to brazing. The width of overlap shall be not greater than 1/4 inch.

8.32 The braze shall be continuous and uniform throughout the area of contact between the ends to be joined. The amount of brazing material to be used shall be such that there will be no excess brazing material next to the joint after completion of the braze.

8.33 The edges of the joined strip shall be trimmed prior to application to the core as shown on B-552119. The trimmed edges shall be smooth and clean.

8.34 The finished joint shall have a minimum tensile strength of 25,000 psi.

8.35 The finished joint shall be capable of withstanding without fracture two 90-degree bends over a 1/64-inch radius. The second bend shall be in the opposite direction.

Repairs to the Formed Outer Conductor

8.36 Repairs to the outer conductor shall be made by brazing, using a section of formed outer conductor.

8.37 The section shall be brazed in place with a 1/2-inch overlap at each end using KS-14827 L5 or 5A brazing alloy in sufficient quantity to completely wet the overlap surface area. The joint shall be at an angle of from 65 to 70 degrees with the axis of the cable.

8.38 Repairs shall be made without damage to or contamination of the dielectric. During brazing, the dielectric shall be shielded from excess heat by the insertion, between the dielectric and joint, of a suitable temporary heat shield.

Patching Cable Jacket

8.39 Repairs to the cable jacket shall be made by welding, using a length of extruded jacket and solid filler rod of the same material as the jacket. The heating medium shall be commercially pure dry nitrogen, and only electric torches arranged to heat the nitrogen under controlled temperature shall be used.

8.40 The material to be welded shall be prepared by chamfering the edges with a clean tool immediately prior to welding. Filler rod and weld groove shall be kept free of foreign materials and shall be wiped with KS-16235 L1 trichloroethylene, or approved equivalent, immediately prior to use. Avoid recontamination including contact with fingers.

8.41 The completed weld shall be annealed by being held at 102 to 105 C for 15 minutes, followed by cooling in still air.

8.42 Welds in the jacket shall blend smoothly with the parent material, and there shall be no evidence of crevices or porosity.

8.43 Welds in the jacket of list 1 cable shall preferably be flush with the adjacent surface but may protrude up to 1/64 inch. In no event shall a finished weld in list 1 cable jacket be recessed. For list 2, 3, 4, and 5 cables, welds on the list 1 cable jacket shall preferably be flush with the adjacent surface but may be underflush to 1/64 inch. In no event shall such welds protrude above the adjacent jacket surface.

8.44 After annealing and aging, the tensile strength shall be a minimum of 50 per cent of the tensile strength of the corresponding values of extruded material. Elongation shall be at least 20 per cent across the weld.

8.45 Repairs shall be made without damage to the outer conductor.

8.46 If moisture is admitted to the outer conductor or core due to damage to the jacket during extrusion or subsequent operations, such moisture shall be removed to the satisfaction of the Supervisor prior to jacket repair.

Joints in Aluminum-Bronze Strip

8.47 Joints between successive lengths of strip shall be made by butt-welding or butt-brazing. Consumable filler material or welding or brazing materials may be used as long as the joint is of uniform width and thickness.

8.48 Joints so made shall have a minimum tensile strength of at least 40 per cent of the strength of the original strip.

Joints in Soft Iron Strip

8.49 Joints between successive lengths of strip shall be made with a spot-welded or brazed overlap seam. The length of overlap shall be not more than 1 inch and the joint shall be smooth and true and, if brazed, without excess brazing material.

Joints in Neoprene-Coated Armor Wire

8.50 Joints in neoprene-coated armor wires shall be made by buttwelding with a resistance welding method after having carefully removed a suitable length of neoprene coating from the ends to be joined.

8.51 After welding, flash shall be removed from the joint and it shall be annealed for a distance of 1-1/2 to 3 inches on both sides of the weld.

8.52 The finished weld shall have a minimum tensile strength of 75,000 psi, and it shall be capable of being wrapped 3 times around a mandrel 5 times the diameter of the wire without failure, with the weld in the center turn.

8.53 The gap in the neoprene coating shall be filled by the insertion of a tightly fitting length of longitudinally slit coating obtained from a piece of scrap wire.

8.54 The filler piece shall be bound into place by the application of a suitable bandage consisting of, for instance, successive layers of AT-7167 C Cement, half lapped 3/4 inch wide by 0.015 inch thick neoprene tape, stretched from 50 to 100 per cent and slightly lapped Scotch Brand No. 5 or 54 pressure sensitive mylar tape.

8.55 The completed joint shall be capable of passing through the closing die at the cable armoring machine without tearing or jamming.

Complete Cable Splices

8.56 Splices joining together pieces of completed 1-1/4 inch cable shall be a series of operations each covered independently in specification Part 8, Repairs and Joints. Because of the interrelationship of the effects, both electrical and mechanical, of the several operations, particular care must be taken to assure high quality work, in particular, in cleanliness, size, concentricity, and physical properties of materials.

8.57 Insofar as possible, sections of cable combining list 2, 3, 4, and/or 5 cable, in lengths no greater than 20 nm, shall be made without splices between different lists of cable, by applying the various outer coverings to a continuous length of 1-1/4 inch cable.

8.58 If splices in either aluminum-bronze strip or soft iron shielding strip in finished cable must be made, they shall be made by welding or brazing the facing surfaces of up-set tabs of metal, not less than 1/2-inch in length. The several tabs made shall be positioned throughout the splice area to minimize the increased diameter and the tabs shall be bent back onto the surface of the strip.

8.59 If splices between shielded and nonshielded cable must be made, the termination of the shielding tape shall be bound in place and covered by a smoothly tapered mold section between the 1-1/4 inch and 1-1/2 inch jackets.

8.60 If splices in neoprene-coated armor wires on finished cable must be made, they shall be made with a metal ring splice of minimum size to transfer the full cable strength.

9. STORAGE OF CABLE AND IN-PROCESS LENGTHS

9.01 Ends of all completed cable shall be sealed against moisture except when under test.

9.02 Ends of all in-process lengths shall be suitably brazed or sealed.

9.03 The number of times to which jacketed cable is subjected to bending shall be kept to a practicable minimum. Where necessary to bend jacketed cable the radius of employed shall be as generous as is practicable but not less than 36 inches. In any event the finished cable shall continue to be capable of meeting the requirements of 6.54 and 6.55 when it is submitted for next assembly.

9.04 After next assembly further bending shall not be permitted except as required by loading or other shipping instructions.

10. MARKING

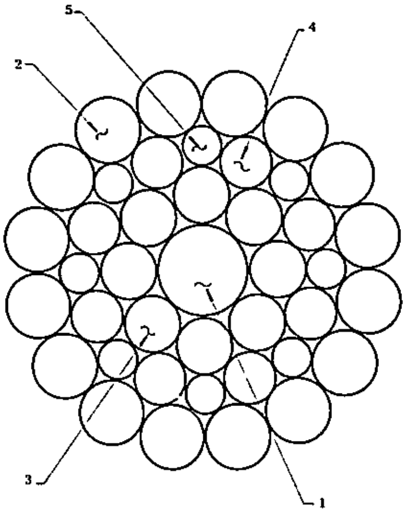
10.01 Each end of each length of cable shall be tagged to show the KS number and list number, date of completion of manufacture, the date of electrical measurements, the length, and the manufacturer's serial number for the length of cable.

10.02 Each length of cable, during final manufacturing operations, shall be tagged with mile markers as specified by the purchaser. The accuracy of placement shall be ± 1 per cent with respect to length.

10.03 If specified by the purchaser, certain of the neoprenecoated armor wires in list 3, 4, and 5 cable shall be color coded for identification purposes. Color coding shall be either by the addition of pigment to the neoprene or by wrapping the coated wire with colored PVC tape.

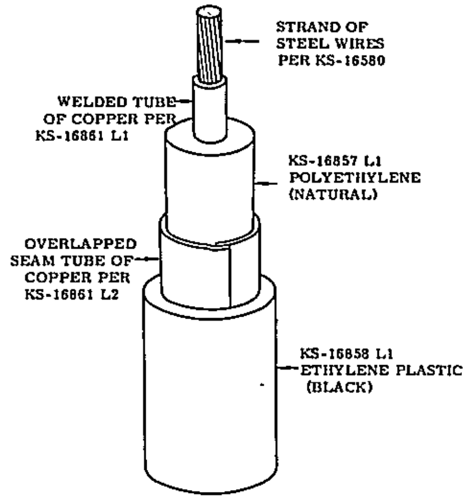
CHANGES COVERED BY REISSUE OF SPECIFICATION

Issue 3 - Lists 4 and 5 cables added. Additional tests included.



STRAND ASSEMBLY

B-191187



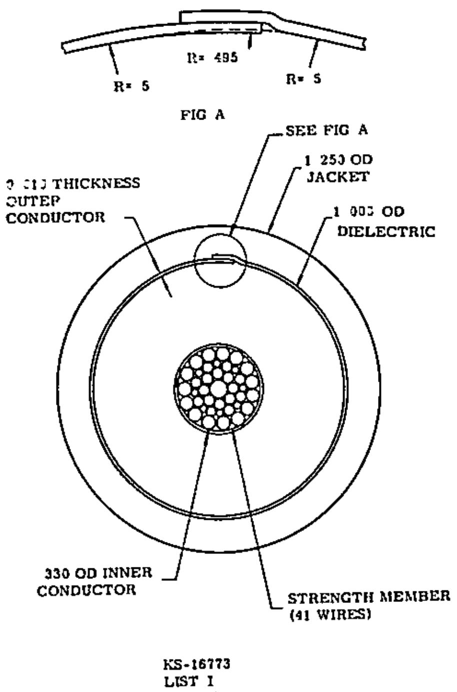
KS-16773
LIST I
CABLE

B-191543

NOTES

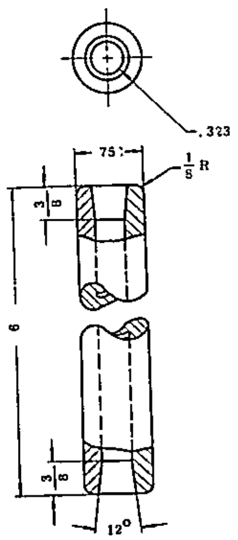
1 COPPER PLATE, 560A ON OUTSIDE SURFACE AND TAPERED PORTION OF BORE TO A THICKNESS OF .006 - .008

2 BRASS PLATE OVER COPPER TO A THICKNESS OF .0001 COMPOSITION OF BRASS TO BE 70% COPPER & 30% ZINC.



KS-16773
LIST I
CABLE
CROSS SECTION

B-191544



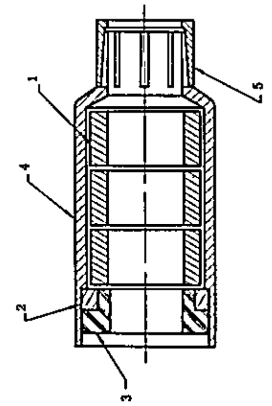
SLEEVE, SPLICE

B-191700

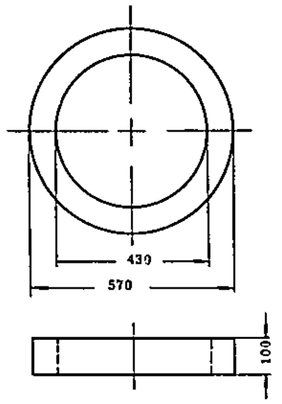
NOTES

1 FERRITE CORES, ITEM 1, WILL BE FURNISHED BY THE CUSTOMER

B-193454



COMPENSATING ASSEMBLY

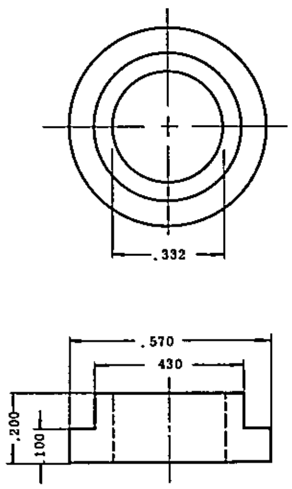


BACKING RING

B-193455

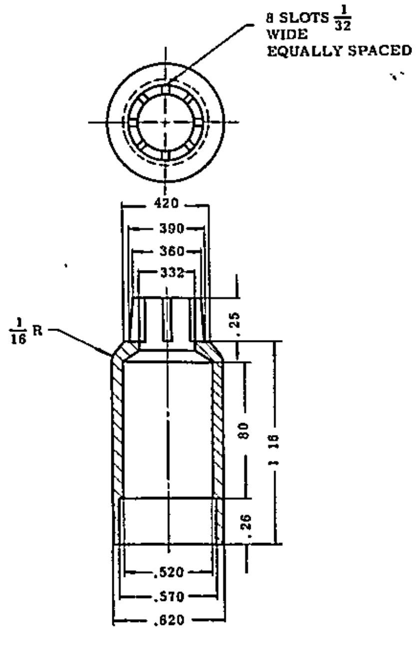
NOTE·

1 BRASS PLATE TO A THICKNESS OF 0001 COMPOSITION OF BRASS TO BE 70% COPPER & 30% ZINC.



TEFLON RING

B-193456

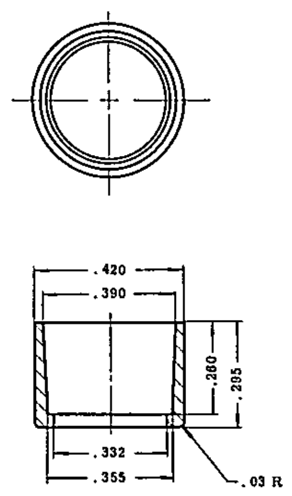


STRESS CELL

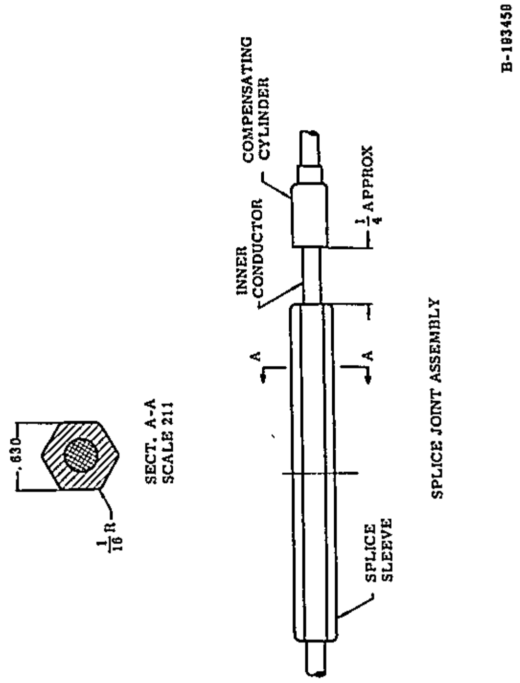
B-193457

NOTE:

1. BRASS PLATE TO A THICKNESS OF .0001. COMPOSITION OF BRASS TO BE 70% COPPER & 30% ZINC.



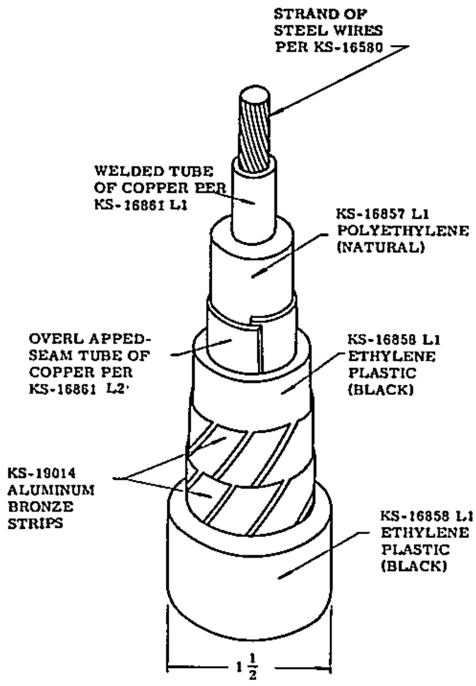
END RING



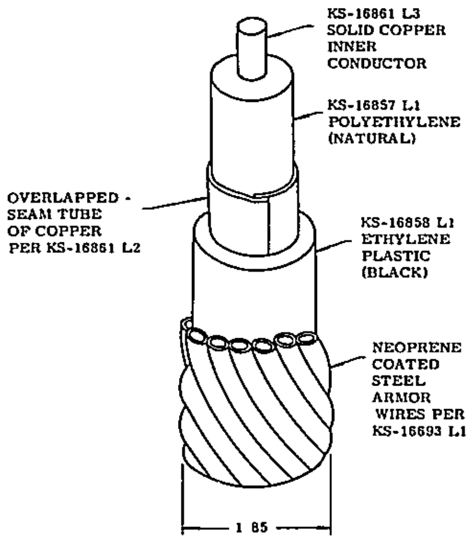
SPLICE JOINT ASSEMBLY

B-193459

B-193459



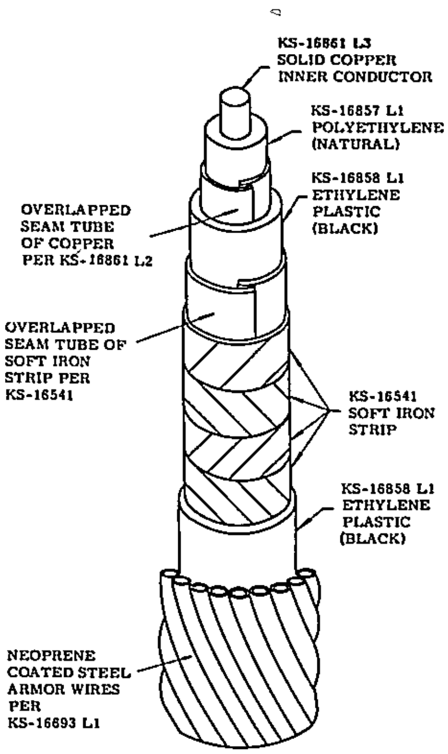
KS-16773 LIST 2 CABLE



KS-16773 LIST 3 CABLE

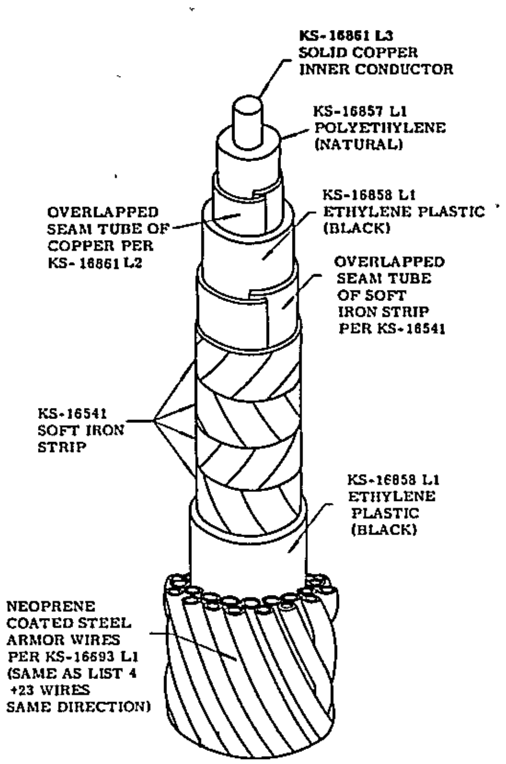
B-552116

B-552115



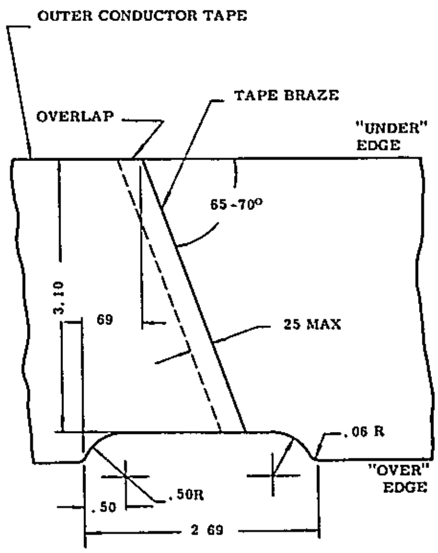
KS-16773
LIST 4
CABLE

B-552117



KS-16773
LIST 5
CABLE

B-552118



ARMORLESS
OCEAN CABLE-
TAPE BRAZE
CUTOUT

B-552119