REPORT ON THE SURVEY
FOR
SOUTH ASIA AND FAR EAST
COAXIAL SUBMARINE CABLE PROJECT
IN
THE KINGDOM OF THAILAND

JULY 1966

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

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F O R E W O R D

The Government of Japan, at the request of the Government of the Kingdom of Thailand, has decided to undertake a basic survey in the Kingdom of Thailand for the South Asia and the Far East Submarine Cable Project, and entrusted the Overseas Technical Cooperation Agency of Japan with the task of conducting the field survey.

The Agency, in view of the importance of constructing international communication links by means of coaxial submarine cable to cope with the rapidly increasing demand for international communication services, has dispatched to the Kingdom of Thailand a five-member survey team headed by Mr. Atsushi Watanabe, Concilor of Telecommunications, Ministry of Posts and Telecommunications.

The survey team stayed in the Thailand for 30 days, commencing its work on March 24, 1966, and successfully completed the field survey with the assistance and cooperation of the Thailand Government, resulting in the submission of this report.

The Agency, which is the executive organ of the overseas technical cooperation program adopted by the Japanese Government, sincerely hopes that the present report will prove to be a contribution toward completion of the South Asia and the Far East Submarine Cable Project.

In closing, the Agency hereby expresses its deepest sense of gratitude for the earnest support and cooperation extended by the Thailand Government authorities, especially by the Post and Telegraph Department and his staff.

July 1966

S. Shibusawa

Shinichi Shibusawa
Director General
Overseas Technical Cooperation Agency
of Japan

C O N T E N T S

I INTRODUCTION

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1 Purpose of Survey

The main purpose of the survey was to examine various questions possibly arising in connection with the implementation by Thailand of the project for South Asia and Far East Submarine Cable System (SAFEC) which has been considered desirable by the countries concerned to be completed at an early opportunity

The survey included the following subjects:

(1) Cable route.

(2) Circuit layout and performance.

(3) Estimates of traffic demand, circuit requirements and revenue and expenditure.

(4) Legal aspects in connection with international cable agreement

2 Summary

(a) Since Thailand is situated on an important point of the transportation, telecommunication and economics in the Southeast Asian region and also reflecting the high level of economic and trade development of this country, the international telecommunication demands in this country are expected to grow up to a greater extent than those estimated at the international conference on the SAFEC project held in Tokyo in 1964. This proves that the construction of a high quality and large capacity communication system is essential for Thailand and will, also from the commercial point of view, bring about a great benefit and profit to the country.

(b) Along the coast of Thailand there is a wide expanse of shallow waters This does not necessarily offer the suitable conditions for cable laying, because these shallow waters would require burying of cable or otherwise the use of armored cable for some long distance. However, upon making the field survey as well as the map survey of the three points on the coast of the south-eastern and the western parts of the Gulf of Thailand and near the mouth of Mea Nam Chao Phraya, it is confirmed that the south-eastern coast near Rayong is the one best suited for cable landing, from every technical consideration of such as the sea-bottom materials, submarine topography, fishing activities, etc. The existing domestic communication facilities connecting Rayong to the gateway office of Bangkok will be usable for the time being, although some difficulties may arise in meeting the future demands for high quality communication services No other problems were observed from the technical point of view that will fundamentally prejudice the construction of the cable system

(c) From the legal point of view, there are some minor problems to be solved in connection with the cable landing on this country and with the concluding of the cable agreement between Thailand and the other countries It is believed however that necessary adjustment or amendment to the existing legal system of Thailand would easily be made by cable agreement and domestic arrangement

3. Period of Survey

The survey was efficiently conducted during the period of 30 days from March 24 to April 22, 1966 according to the time schedule mentioned below:-

DATE		SURVEY WORK
March	24	Arrived at Bangkok (1730H)
	25)) 30)	Consultations with the organizations concerned
April	31)) 6)	Collecting necessary materials and information
	7)) 10)	Field Survey around Rayong on the south east coast of the Gulf of Thailand
	11	Field Survey at sea near the mouth of the Mae Nam Chao Phraya.
	12)) 17)	Collecting necessary materials and information, and study thereof.
	18)) 20)	Field Survey around Petburi and Hua Hin on the west coast of the Gulf of Thailand Drafting the report of survey results.
	21	Printing the draft report and its submission to Director General of Post and Telegraph Department
	22	Meeting on the report at Post and Telegraph Department and the Embassy of Japan Leaving Bangkok

4. Members of Survey Team

Atsushi Watanabe (Chief)	Legal aspects
Seiichi Shimura	Submarine cable and connecting facilities
Eizo Endo	Estimates of traffic demand, channel requirement, revenue, etc
Fujio Kinoshita	Ocean survey
Utaka Hidaka	General affairs

The survey team takes this opportunity to express its deepest appreciation for the cooperation extended during its stay in Thailand by:

Ministry of Communications

National Economic Development Board

Department of Technical and Economic Cooperation

Post and Telegraph Department

Telephone Organization of Thailand

Hydrographic Department

Map Department

Port Authority

Fishery Department

ECAFE Geologist

Embassy of Japan

Bangkok Office of Nippon Telegraph and Telephone Public Cooperation

Particularly, the survey team owes its successful works to the splendid assistance given throughout the duration of the survey by the Director-General and the sraff officers of the Post and Telegraph Department.

5. Outline of the Submarine Cable Project for South Asia and Far East

(1) Progress of the Project

The Submarine Cable Project for South Asia and Far East (SAFEC) was proposed by Japan at the Plan Sub-Committees of the International Telecommunication Union (Tokyo May 1959 and New Delhi, November 1960), and was finally adopted at the Plan Committee held in Rome in 1963. The Committee recognized that this project was desirable to be implemented by 1968.

The international meetings of the countries concerned on SAFEC Project were held in Tokyo, twice, in April 1962 and in March 1964 The participating countries recognized the necessity of laying the cable system in spite of recent development in satellite communications and agreed to proceed further with their study and consultation toward the implementation of the SAFEC project

(2) Features of the Cable System

(a) Route: Japan -- Taiwan -- Hong Kong / -- the Philippines -- Viet Nam -- Cambodia --Thailand -- Malaysia/Singapore -- Indonesia

(b) Total Length: Approximately 5, 400 N M

(c) System: Both-way single coaxial submarine cable

(d) Capacity: 128 telephone circuits

(e) Construction Cost: $73, 000, 000

(3) Sharing of Construction Cost

The SAFEC system is constructed as a joint venture of the telecommunication enterprises in the participating countries. The construction cost for submarine cable associated with submerged repeaters and landing terminal facilities shall be borne by these participating enterprises in proportion to the ratio of the number of circuits to be allocated for their use The circuit allocation will be made on the basis of the number of circuits estimated for 1970

(4) Steps to be Taken for Construction

(a) A Construction Board composed of the representatives of the participating enterprises shall be established and the details of the construction project will be decided at this Board

(b) It is contemplated that a special company will be established in Japan to undertake the construction and maintenance works of SAFEC system As to the arrangement for entrusting such cable works to that company will be decided by the Construction Board.

(5) Form of Agreement

As in the case of new-type submarine coaxial cable systems recently laid down in the Pacific and the Atlantic Oceans. the SAFEC system shall be constructed, maintained and operated by the participating parties on an equal interest basis. The form of agreement for the SAFEC system is therefore to follow the existing cable agreement of such new-type cable system. The details of the agreement shall be examined by the Construction Board.

(6) Operation of Cable System

The cable system will be operated jointly by the international telecommunication entities of all the participating countries such as the Post and Telegraph Department of Thailand, Directorate General of Telecommunications of Republic of China, Telecommunication entity of the Philippines, KDD of Japan, etc.

The revenue due from the international telecommunication services furnished through this cable system should be shared on a 50/50 basis between the countries concerned in the services.

II CABLE ROUTE STUDY

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II CABLE ROUTE STUDY

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1. General View

The cable route study including cable landing site selection and connecting land line engineering is the first thing to be done in order to proceed with the planning of submarine cable system. Especially, cable route study in the sea portion is very important from the viewpoint of system reliability, because if we fail to select proper route, the system constructed thereon will be liable to fall in failures.

On November 18, 1929, for example, 13 cables on the edge of Grand Banks of New Foundland all failed in a period of 13 hours following earthquake, and oceanographic theory was developed that these failures had been caused by a giantic under water landslide called turbidity current of the silt of Grand Banks. The cable route must therefore avoid areas where there is a likelihood of under water earthquake, landslide, sea mounts, rock and reef areas which might strain and break cable, and busy fishing ground where trawlers might accidentally snag a cable.

Regarding a possible turbidity current on the route from Manila toward Bangkok, the most deliverate consideration should be given to the vicinity of the point 110° E and 10° N, where the cable goes up along the slope from the deep sea portion to the continental shelf toward the Gulf of Thailand.

In order to study the landing points on Thailand side, we selected three prospected landing points: the first is the one for direct landing at the Bangkok Plains, the second for landing at the west coast and the third for landing at the southeast coast of the Gulf of Thailand, and then compared these three landing points taking the following factors into consideration.

From the marine side:

Geological nature of the cable landing point.

Fishing, especially trawling activity.

Cable laying and buring conveniences.

Restricted areas where cable laying and landing is not permitted.

From the land side:

Connecting land line engineering toward Bangkok.

Construction and maintenance of the cable landing station.

2. Geological Study

Described in a theory set up in 1963 jointly by K. O. Emery and Hiroshi Niino (See Appendix-2), the geological history of the Gulf of Thailand begins with the accumulation of thick Paleozoic sediments in a geosyncline. During Late Paleozoic time the eastern-most part of the geosyncline became intensely folded. During Late Triassic and Late Jurassic times the western part of the geosyncline from the Thai-Burmese border to the tip of Malaya was compressed into a series of almost north-south trending folds and intruded by granite. In the eastern part of the area (Korat Plateau and Part of Cambodia) these folds are buried under younger continental strata of the Korat Series. During Late Tertiary time the region of the Korat Plateau was uplifted, while at the same time the belt along the Chao Phraya River was depressed. These movements were accompanied by some intrusive and much volcanic activity. At that time the Ocean reached several hundred Km north of Bangkok. Subsequently marine and continental sediments filled the depression to the present head of the Gulf of Thailand. The region is now rather stable tectonically with very few earthquakes. In fact this region lies between the earthquake zone in the west coast of the Pacific Ocean and the east coast of the Indian Ocean, with statistically few big earthquakes, which indicates that this region is very suitable for placing the cable from the geological point of view.

3. Fishing Activities

(1) Fishing activities

In the Gulf of Thailand with its vast sea basin, the sea depth is as shallow as 75 meters even at the deepest point and this part extends 100-200 Km from the shore to the offing, thus making this part as the golden fishing ground. But, in the center of the Gulf where sea depth is more than 50 meters, fishing is not operated because the sea water does not contain enough oxygen for fish to live.

For reviewing fishing activities of Thailand, Table II-1, II-2 show the amount of fish catch and the number of fishing boats for 6 years from 1959 to 1964. These tables show that the amount of fish catch had grown 3. 5 times and the number of fishing boat 1. 9 times. Although, the total number of fishing boats has rather small tendency of increase, the number of mechanized boats had grown 4 times while the number of non mechanized ones had decreased down to 1/20. Judging from these facts, the fishing of Thailand is enjoying a greater prosperity year by year.

The fishing method and operational conditions in Thailand at the present day are as follows.

(a) Purse seine fishing

This is popular in the shallow water part remarkably in the Inner Gulf (northern part of the line linking Sattaheep and Hua Hin). As for the nets, about two hundred sets of 2-boats pulling type and about one hundred sets of 1-boat pulling type are now under operation. The boats used for the operation are of 15 - 20 tons class.

(b) Dragnet fishing

This method is operated in the shallow water part in general.

(c) Trawling

Trawling is generally operated in the sea of less than 50 meters in depth and its busy areas are shown in the Fig. II-1. About 200 boats, up to 90 tons are being operated. The otter board is iron made, sizing 2. 5 meters in width, 1. 5 meters in height and weighing about 500 Kgs.

(d) Floating driftnet fishing.

Approximately 200 sets are now under operation.

(e) Bamboo stick fishing

This fishing is operated in the shallow water part of approximately 15 -16 meters in depth. The method, being a kind of the fixed nets, is to wedge the bamboo sticks into the sea bottom to which the nets are attached. This is widely operated in the Inner Gulf and there are some movable ones at the mouth of the Menam Chao Phraya.

(2) Measures for cable protection against the fishing activities

Among the fishing activities in the Gulf of Thailand, trawling and bamboo stick fishing are liable to cause damages to the cable. Especially, the trawling is the most dangerous one for the cable in view of the fact that the Transatlantic Cables have frequently been damaged by this activity. Therefore, protective measures should be taken to ensure the safety of the cable. The following countermeasures are considered practical for this purpose.

(a) To place the cable route away from the areas where the trawling and bamboo stick fishing are frequently operated.

(b) To establish a prohibited area of trawling and bamboo stick fishing along the cable route.

(c) To bury the cable under the sea bottom at the depth of about one meter in the areas where the trawling and bamboo stick fishing are operated.

4. Survey in Shallow Water Parts

In connection with the cable laying and burying, it is necessary to select a cable route of the shortest possible distance from the shore to the offing with the depth of 50m so as to protect cable damages caused by fishing especially by trawling and also it is necessary to avoid rocky bottoms. Taking these factors into consideration, we studied the geological and topographical conditions of the Gulf of Thailand. As to the sea bottom in the Gulf we consulted with the geologist of ECAFE and obtained useful information as shown in the Fig. II-2 and 3. Furthermore, in the shallow water parts where there are many problems on the cable laying. we made field surveys at the three estimated landing points to examine the sea depth and the bottom condition. These works were carried out aboard a boat and the results are shown in Fig. II-4, 5 and Table II-3, 4. As to the survey at the mouth of Menam Chao Phraya, the water was not so deep that the survey boat could not approach the shore and only the bottom condition was examined. The main features of the three points can be summarized as follows

(1) Offing of Rayong

The coast consist of granite-natured sand. The contour line of 5 meters lies within 0.2 Km and that of 50 meters lies within 100 Km off the shore. These distances are fairly short compared with that of the other two points. Sea bottom is of sand, sand-shell and partly clay.

(2) At the mouth of Menam Chao Phraya.

Classified as a wet zone, the coast consists of tender clay. The contour line of 5 meters lies about 6.5 Km while that of 50 meters lies about 210 Km off the shore. These distance is longer than that of other two points. The bottom is of silt and its thickness is party more than 15 meters.

(3) Around Hua Hin

The coast consists of fine sand. The contour line of 5 meters lies 1.2 Km and that of

50 meters lies 150 Km off the shore. Sea bottom condition is of sand up to 10 meter's depth and beyond 10 meter's it changes of clay. The clay in this area is silty.

5. Prohibited Areas of Cable Landing

Followings have been revealed in connection with the areas where landing of the cable is not permitted.

(1) Harbor

(a) The area about 20 Km from the mouth of Menam Chao Phraya where is under harbor regulation.

(b) The area between Chantaburi and Trat is planned for the construction of a new harbor.

(2) Anchorage area

The ships going in and out of the Bangkok Port let fall anchors around the island of Gok, Stn-Sichang (13° 15' N).

(3) Others

In the view of military concerned, it is suggested that following areas should be avoided from cable routing.

(a) Sattaheep

(b) The islands offing Sattaheep

(c) The mouth of inner Gulf

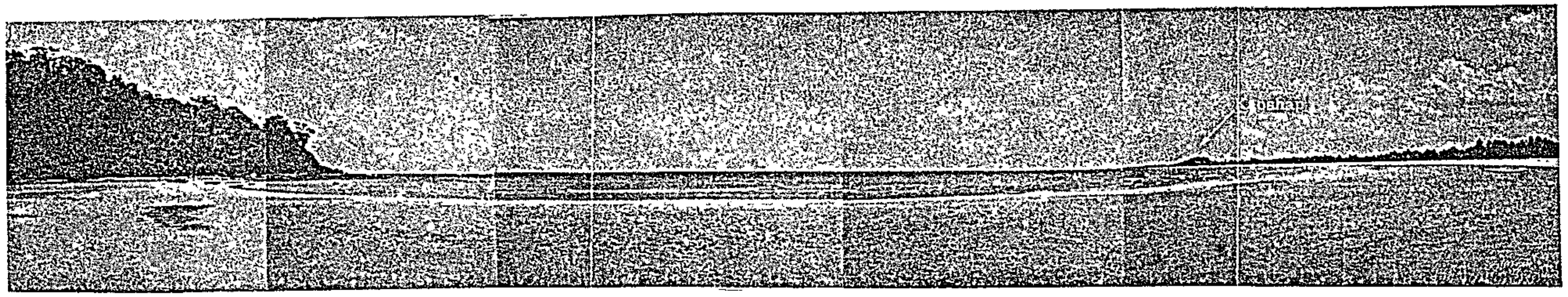
(d) The islands southward of Hua Hin

6. Land-line Engineering

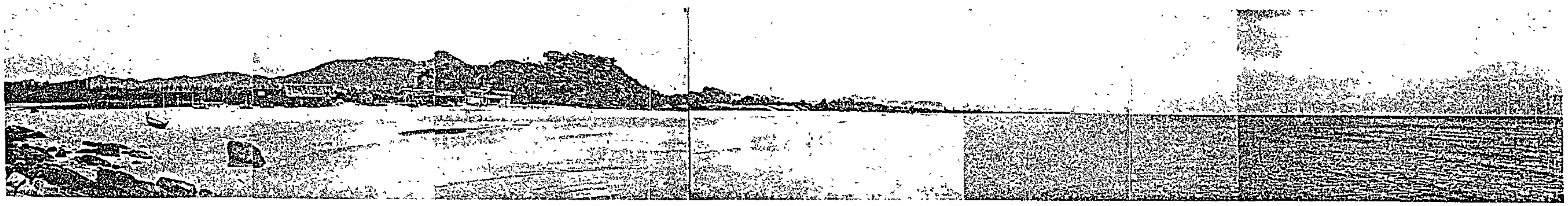
Regarding the engineering of the connecting line between the landing station and the gate office in Bangkok, we were given brief information on the domestic telecommunication facilities concerned.

As shown in Fig. II-6, at the west side of the Gulf of Thailand, there exists a land line from Bangkok to Petburi. In case the cable is landed at the northern coast of petburi, it will be easy to extend the cable circuits to the gate office by using this line, but if the cable is landed at the southward coast of Petburi, there is no land line available at present. The new micro wave system, however, from Bangkok to Malaysia, which will be completed within two

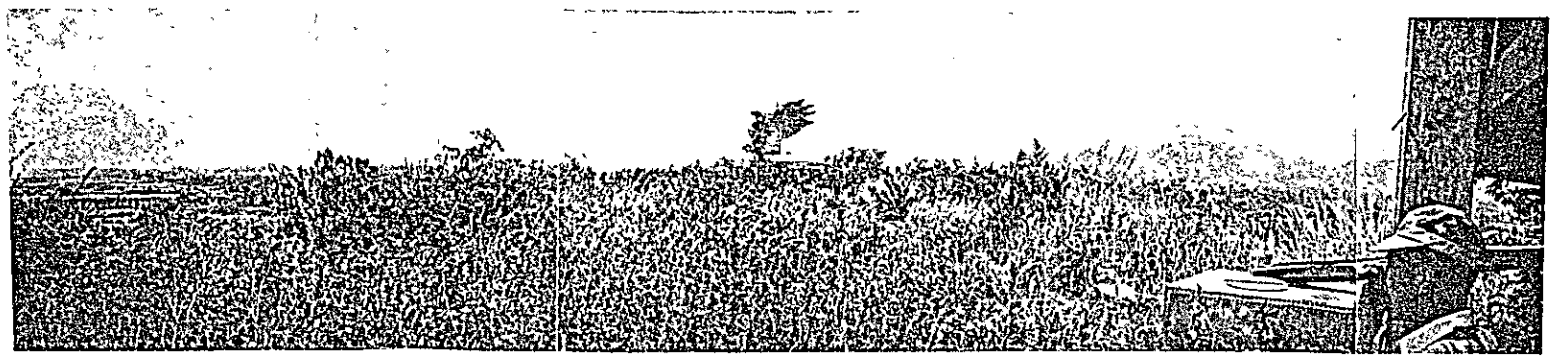
Rayong (Estimated Cable Landing Point)



Hua Hin (Estimated Cable Landing Point)



View from Kao Shap to estimated an unattended microwave repeating station



years, will be available for extending the cable circuits to the gate office.

On the other hand, at the southeast side of the Gulf of Thailand, existing carrier cable system is extended from Bangkok to Chantaburi via Rayong. Therefore, if the cable is landed near Rayong, this carrier cable can be used for connecting the cable circuits with the gate office. But, as this carrier cable is designed for domestic use and companders are applied to reduce the noise and cross talk, it is desirable to construct a new land line in future for transmitting a high quality international communication service such as voice and data alternative use.

Regarding this new high quality land line, we would recommend a micro wave system for the following reasons.

(a) It is possible to use in common the planned micro wave system between the planned satellite ground station at Banpla and the gate office in Bangkok.

(b) In this case, the new micro wave system can be engineered between Rayong and Banpla with an unattended repeater station on a hill near Sattaheep which can easly be accessed.

(c) Therefore, it is expected that construction and maintenance of this system will be favourably carried out from economical and technical points of view.

The profile charts of the micro wave route between landing station near Rayong and proposed satellite ground station is as given in Fig. II-7. In addition, we tried to find out the suitable site for the cable landing station around Rayong, which is the most desirable point for cable landing, and as the result, we found two sites, one is near the shore and the other is located 2 Km north of the shore. Attached photo shows the view taken from the former site of the expected place for the unattended micro wave repeating station (See photo above.)

7. <u>Study of Cable Landing Points</u>

Upon our deliverate study of the estimated landing points we have come to the following conclusion.

(1) Direct cable landing to the Bangkok plains

This is considered to be difficult because very shallow region with muddy soft at the bottom extends vast down to the south from the Bangkok plains where no skilled cable laying or burying methods will be applicable. In addition, the east coast of the inner gulf would not be suitable for the cable landing because the offing of its northern part is the anchoring area of large ships coming to the oil refinery at Siracha, and its southern part might belong to or is near the Sattaheep naval bases.

(2) Cable landing at the west coast of the Gulf of Thailand between Petburi and Hua Hin.

The distance from the shore end to the contour line of 50 meters depth is fairly long at the offing of Hua Hin and much longer at the offing of Petburi. Therefore cable landing at these points is not so easy.

Regarding the connecting land line, the existing one is extended from Petburi to Bangkok, through which cable circuits can be engineered to enter Bangkok gate office. The cable circuits landed at Hua Hin might be engineered to extend to the Bangkok gate office via newly planned micro wave system (West Germany loan project) in a few years, which should be engineered to be of higher standard transmission performance in accordance with the CCITT's New Transmission Plan (Blue Book Vol. III) to meet future overseas telecommunication service.

(3) Cable landing at the southeast of the Gulf of Thailand (Rayong).

The sand beach extending from Rayong to the Point Latem-Ya is the best for cable landing along the coast line between Sattaheep and Chantaburi for the following reasons:

(a) Fishing activity is not so busy compared with the other two estimated landing points.

(b) Sand and sand-shell of sea bottom is suitable for cable laying.

(c) The sea bottom contour is steeper than the others which enables the cable to reach the bottom deeper than 50 meters depth at the shortest distance in those estimated three landing points.

(d) No such restriction as to prohibit cable landing is expected in this area at present.

(e) In addition, suitable cable landing site with adequate high (more than 10 meters) for constructing and maintaining cable landing station can be picked up at this region.

The comparison of said three estimated cable landing points are shown in Table II-5.

TABLE II-1. PRODUCTION OF CATCHES BY FISHING GROUNDS, IN KILOGRAMS AND PERCENTAGE, 1959-1964 (estimated)

Production of Catches by Fishing Grounds, in Kilograms and Percentage, 1959 - 1964 (estimated)

Fishing Grounds	2502 (1959)		2503 (1960)		2504 (1961)		2505 (1962)		2506 (1963)		2507 (1964)	
	Catch		Catch		Catch		Catch		Catch		Catch	
	Kilograms	Percentage	Kilograms	Percentage	Kilograms	Percentage	Kilograms	Percentage	Kilograms	Percentage	Kilograms	Percentage
TOTAL	147,770,275	100.00	146,470,903	100.00	233,275,200	100.00	269,709,200	100.00	323,373,977	100.00	494,196,000	100.00
No. 1	65,243,375	44.16	73,764,309	50.36	154,777,068	66.35	147,559,896	54.71	183,164,415	56.60	291,730,400	59.03
No. 2	17,095,340	11.57	9,356,855	6.39	20,230,280	8.66	31,519,760	11.69	41,952,300	12.99	57,280,400	11.59
No. 3	57,000,390	38.57	52,618,617	35.92	52,738,973	22.62	77,569,225	28.76	89,846,715	27.80	123,215,170	24.93
No. 4	8,431,170	5.70	10,731,122	7.33	5,528,879	2.37	13,060,319	4.84	8,410,547	2.61	21,970,030	4.45

TABLE II-2. NUMBER OF REGISTERED THAI FISHING BOATS, 1954-1964

Number of Registered Thai Fishing Boats, 1954 - 1964

Years	Mechanized		Non-mechanized		TOTAL	
	Number	Gross Tonnage	Number	Gross Tonnage	Number	Gross Tonnage
2497 (1954)	586	11,001	2,936	18,182	3,522	29,183
2498 (1955)	645	12,098	3,355	19,960	4,000	32,058
2499 (1956)	1,082	14,232	2,068	15,557	3,150	29,789
2500 (1957)	1,769	20,722	1,582	10,166	3,351	30,888
2501 (1958)	1,832	19,941	1,442	9,771	3,274	29,712
2502 (1959)	2,557	30,918	1,020	7,219	3,577	38,137
2503 (1960)	3,551	27,328	868	6,208	4,419	33,536
2504 (1961)	4,443	30,295	523	3,395	4,966	33,690
2505 (1962)	4,923	35,330	523	4,139	5,446	39,469
2506 (1963)	4,885	39,316	539	3,735	5,424	43,051
2507 (1964)	5,136	42,609	141	1,023	5,277	43,632

Remarks The low required the registration of all mechanized, and non-mechanized boats of 6 tons gross and upwards.

FIG. II-1. BUSY TRAWLING AREA AND NONE FISHING AREA

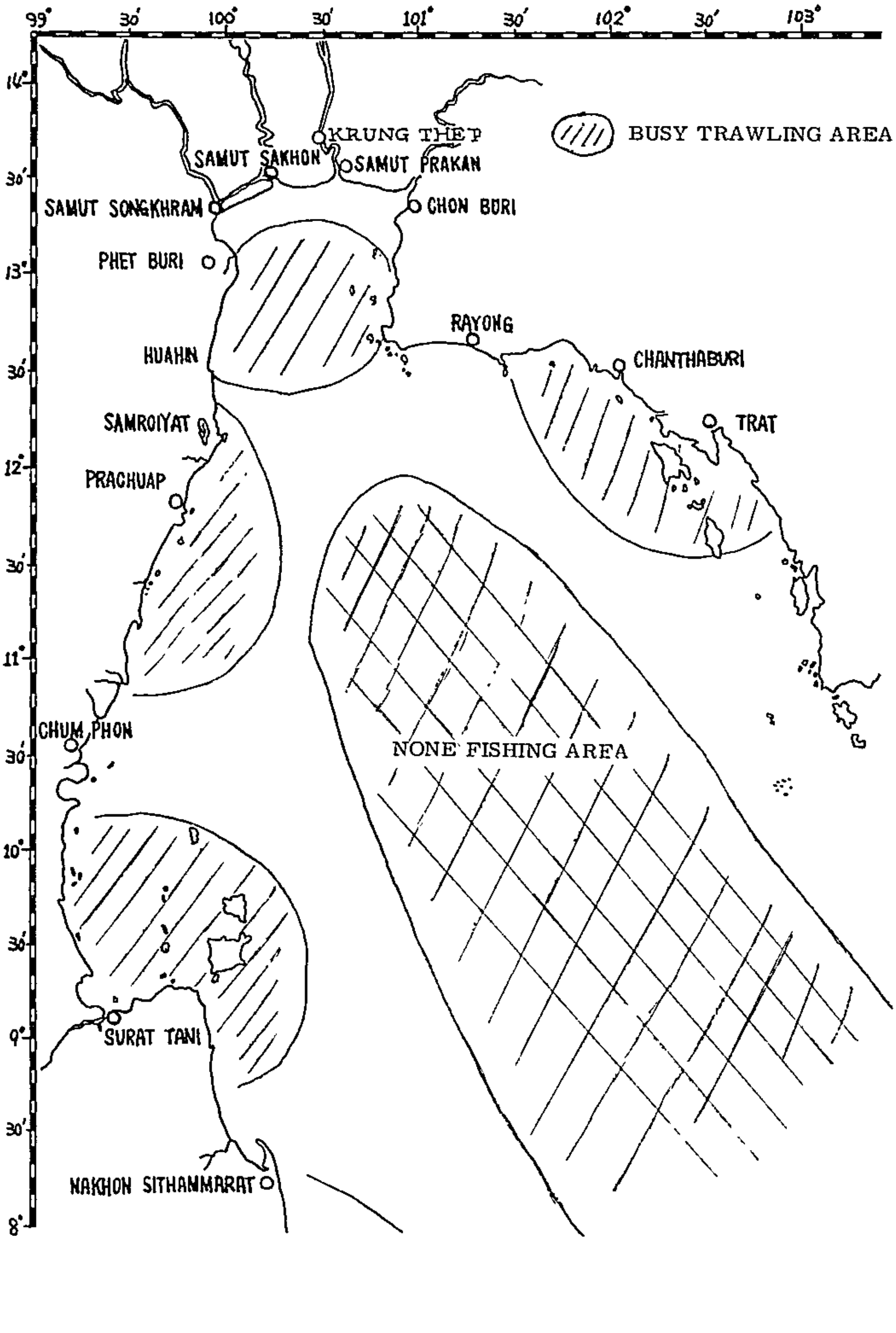
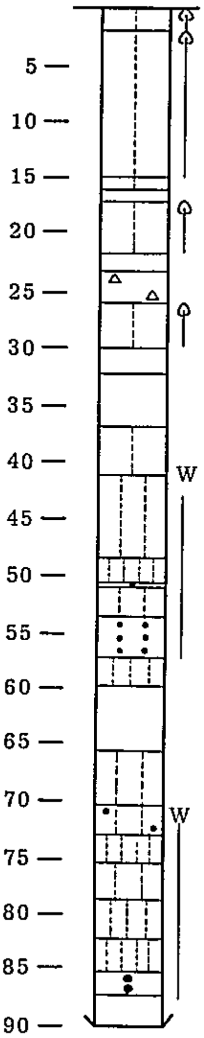
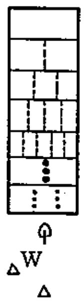


FIG. II-2. COLUMNAR SECTION OF WATER WELL DRILLED BY ASAHI GLASS COMPANY, THAILAND AT PAPADEN, SOUTH OF BANGKOK, THAILAND



Sample No.	Remarks
1	Dark grey sandy soil with plant remains
2	Grey sandy mud with plant remains
3	Brownish grey sandy clay
4	Light brown clay
5	Yellow grey sandy mud with plant remains
6	Brownish grey clay
7	Grey clay with carbonations matter
8	Brownish grey sandy clay with plant remains
9	Whitish grey clay with limonite rust
10	Brownish grey clay
11	Brownish grey sandy clay
12	Brown fine sand
13	Brown coarse sand, max. diam 5 mm
14	Brown granule, max. diam. 10 mm.
15	Whitish gray fine sand
16	Pebble
17	Whitish gray medium sand
18	Browish gray clay
19	Brown fine sand
20	Brown fine sand with pebble of quartz and clay max. 15 mm
21	Whitish gray coarse sand
22	Whitish gray fine sand
23	Whitish gray medium sand
24	Whitish gray coarse sand
25	Whitish gray granule
26	Brownish gray clay

LEGEND



Clay & mud
Sandy mud or clay
Fine grain sand
Medium grain sand
Coarse grain sand
Granule
Pebble
Plant remain
Water
Carbonaceous matter

Prepared by Mineral Resources Development Section, Industries Division,

ECAFE Secretariat, Bangkok, Thailand

11 August 1964

FIG. II-3

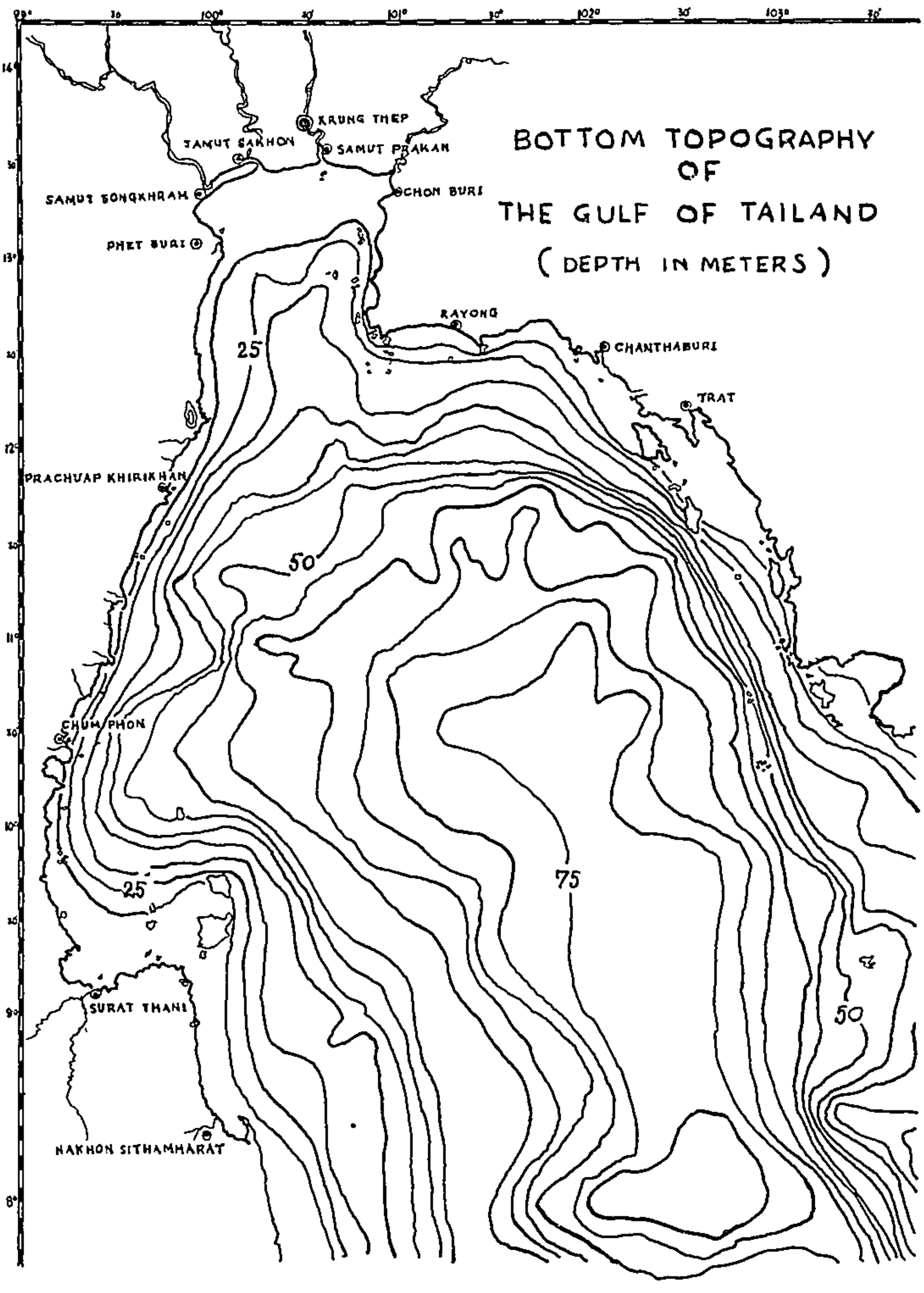

BOTTOM TOPOGRAPHY
OF
THE GULF OF TAILAND
(DEPTH IN METERS)
KRUNG THEP
SAMUT SAKHON
SAMUT PRAKAN
SAMUT SONGKHRAM
CHON BURI
PHET BURI
RAYONG
CHANTHABURI
TRAT
PRACHUAP KHIRIKHAN
CHUMPHON
SURAT THANI
NAKHON SITHAMMARAT
25
50
75
25
50

FIG. II-4. SURVEY AT OFFING RAYON

(April 8, 1966)

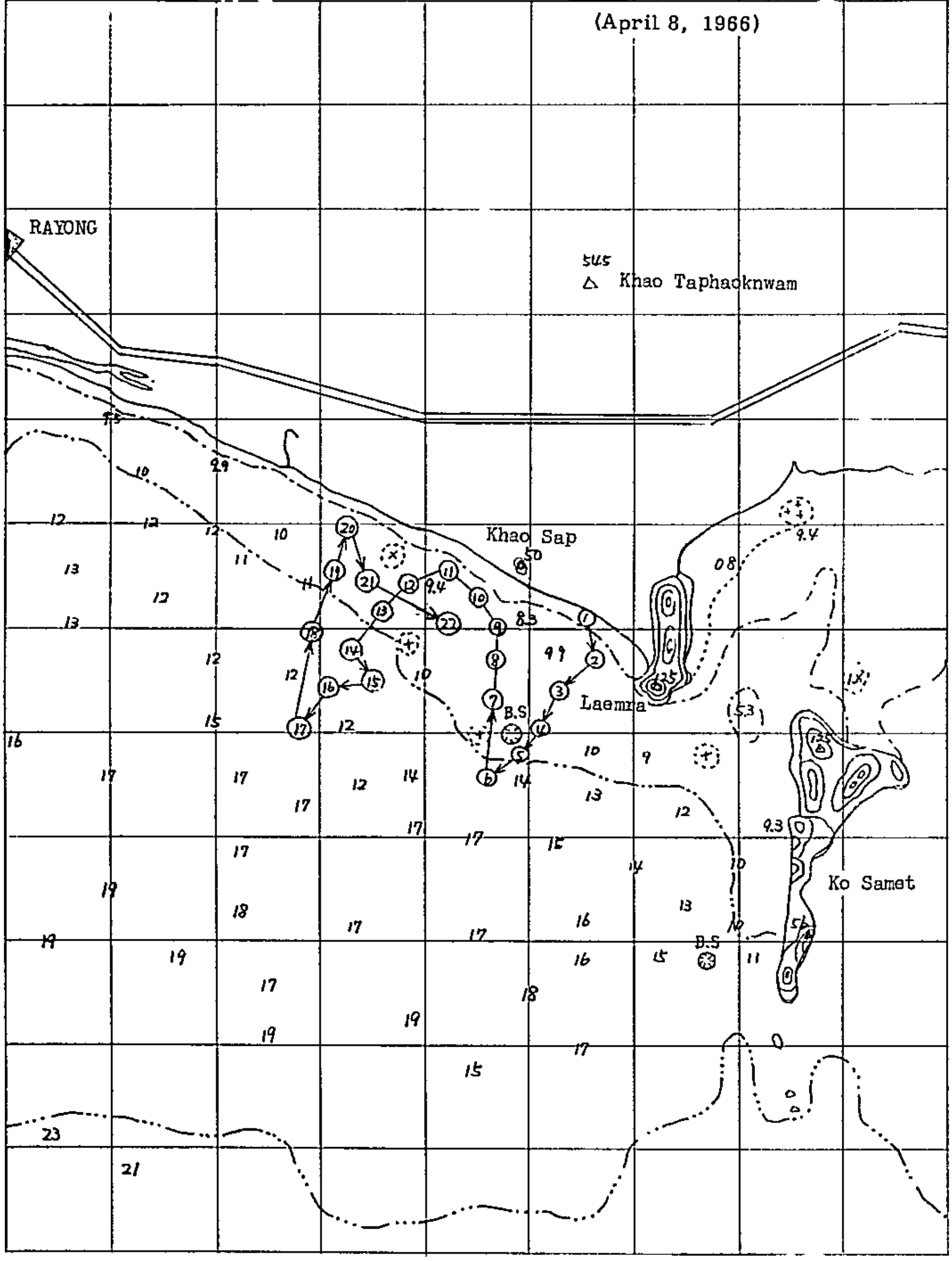


TABLE II-3. BOTTOM CONDITION AT OFFING RAYONG

	Depth	B. C.		Depth	B. C.
1	2.5	S	12	9.5	R
2	6.0	S	13	10.0	S. Sh
3	9.0	S	14	11.0	S. Sh
4	10.0	S. Sh	15	10.5	S. Sh
5	11.0	S. Sh	16	11.1	M. S.
6	13.0	S. Sh	17	14.0	M. S
7	10.0	S. Sh	18	12.0	S. Sh
8	9.0	S. Sh	19	10.0	S. Sh
9	8.7	S	20	7.5	S. Sh. G
10	8.2	S	21	9.0	G. Sh
11	8.5	S	22	9.5	

FIG. II-5. Survey at Offing of HUA-HIN

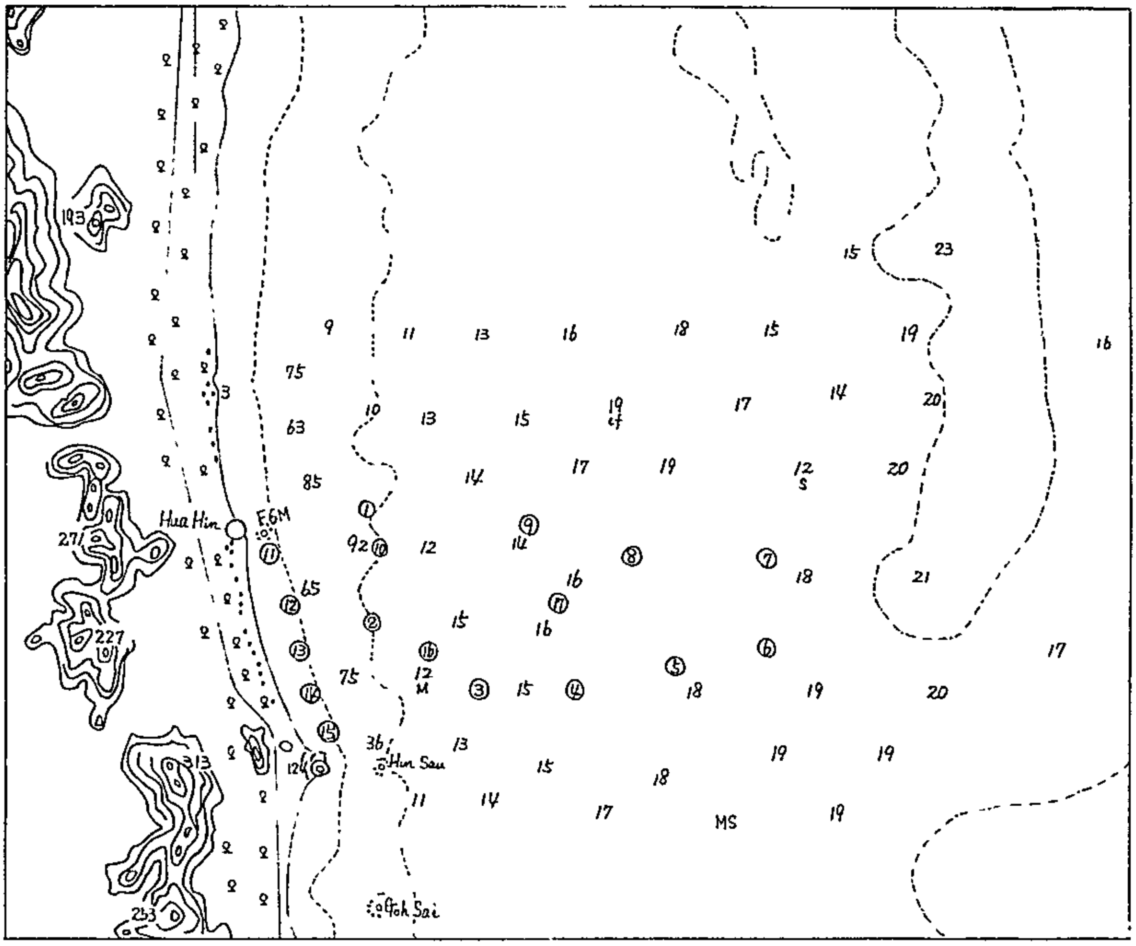


TABLE II-4. BOTTOM CONDITION AT OFFING HUA HIN

Pt	Depth	Bottom Cond
1	9 m	Clay (Silt)
2	9 m	Clay (Silt)
3	11 m	Clay (Not so soft)
4	13.5 m	Clay (Soft)
5	15.5 m	Clay (Not so soft)
6	17.0 m	Clay (Not so soft)
7	17.5 m	Clay (Not so soft)
8	13.5 m	Clay (Not so soft)
9	13.0 m	Clay (Soft)
10	9.0 m	Clay (Soft)
11	3.0 m	Sand
12	4.0 m	Sand
13	2 m	Sand
14	2.5 m	Sand
15	3.0 m	Sand
16	11.5 m	Clay (Soft)
17	13.5 m	Clay (Not so soft)

FIG. II - 6 EXISTING LAND LINE CHART AVAILABLE TO CONNECT THE CABLE CIRCUITS

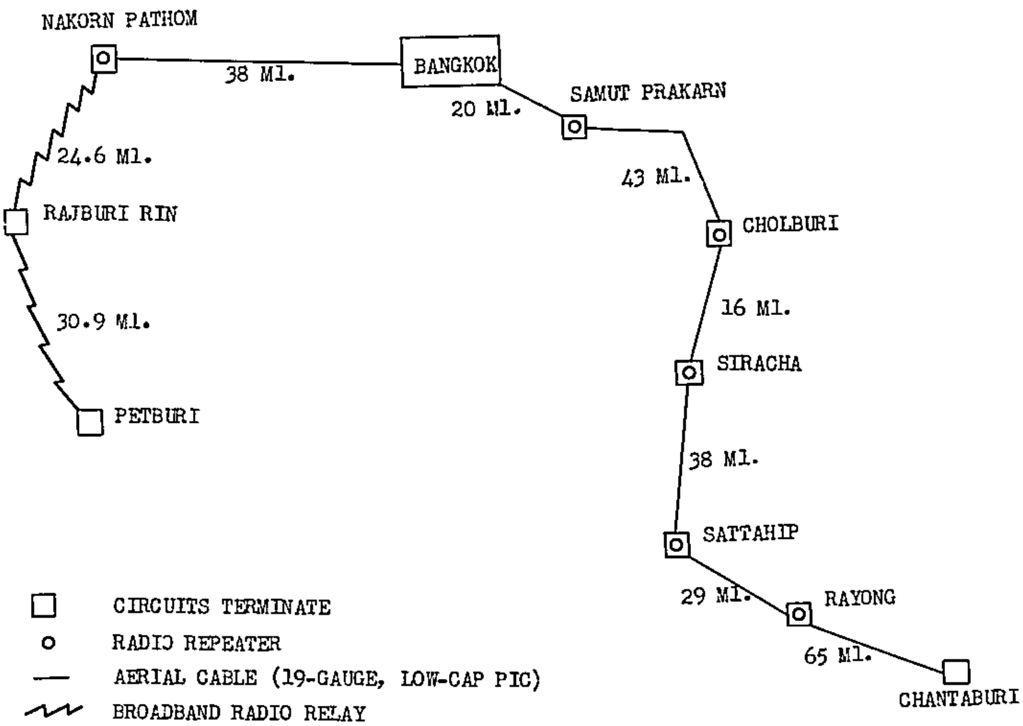


FIG. II - 7(a) PROFILE CHART

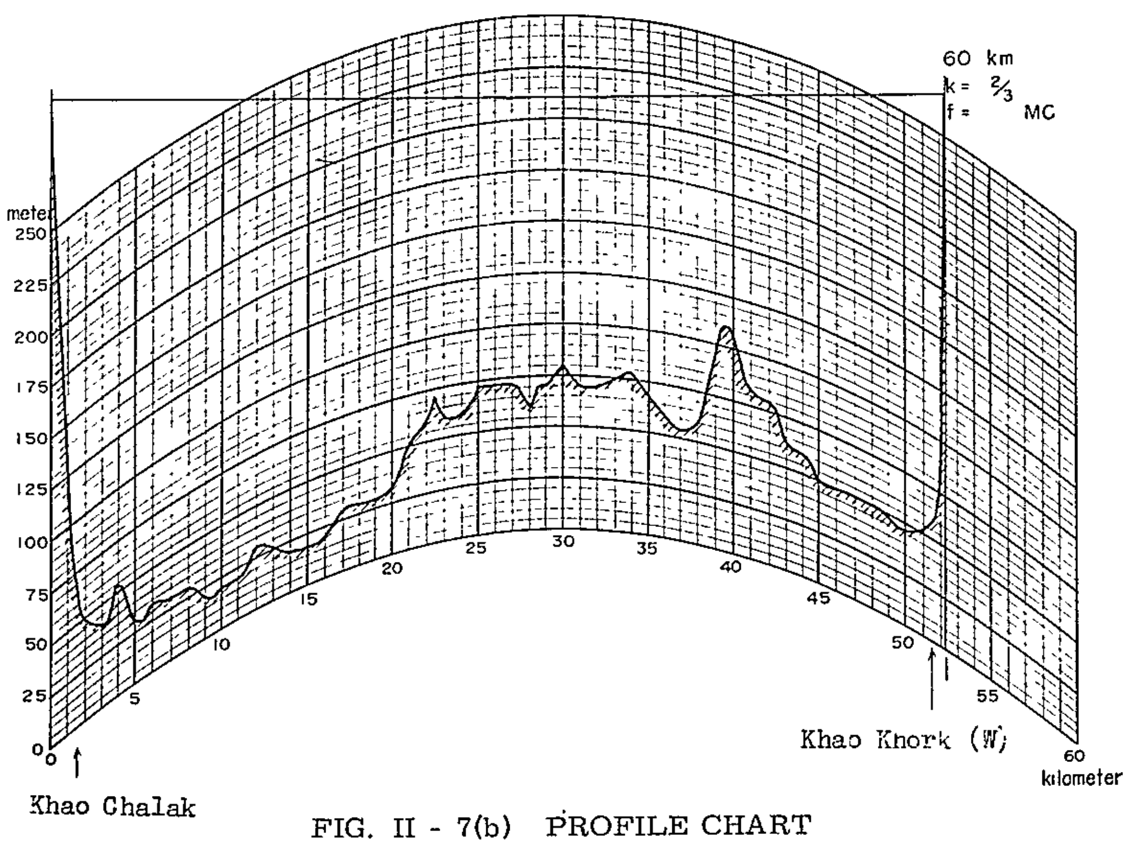


FIG. II - 7(b) PROFILE CHART

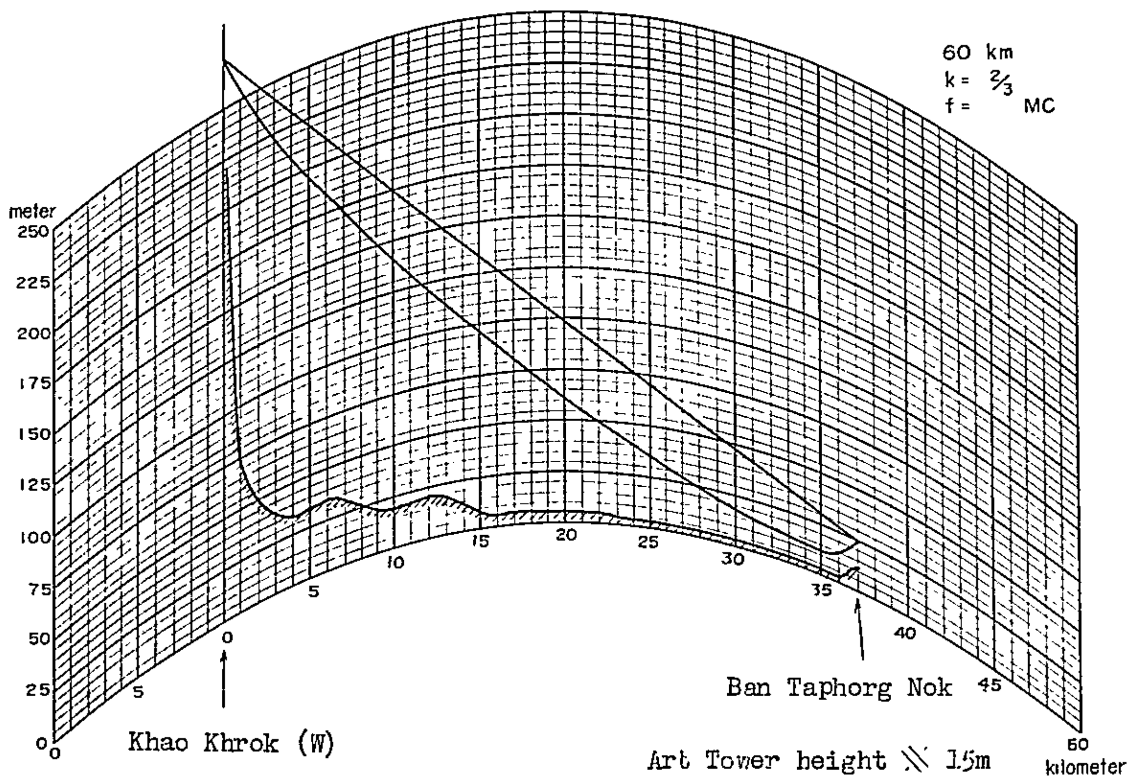


TABLE II-5. COMPARISON OF THE THREE ESTIMATED CABLE LANDING POINTS

Items / Estimated Landing pt	Rayong	Bangkok	Petruri / Hua Hin
Shore conditions	Sandy	Mudy	Sandy
Sea Bottom of Shore	Sand & Shell	Silt	Sand and Mud
Distance up to 5 m Contour line	0 2 km	6. 5 km	1. 2 km
Distance up to 20 m Contour line	15 km	50 km	18 km
Distance up to 45 m Contour line	100 km	210 km	150 km
Current	Max. 5 Kts	Max. 5. 6 Kts	Max 2 0 Kts
Regulated Area	None	Mouth of Chaophraya River (Dredge)	None
Trawling Activity	Not so busy	Busy	Busy
Ship Anchoring	None	Near to the Anchoring area of Bangkok port	None
Difficulty of Cable laying			
(1) Landing	Not so Difficult	Difficult	Comparatively Difficult
(2) Buring	Not so Difficult	Impossible	Comparatively Difficult

III SUBMARINE CABLE SYSTEM LAYOUT AND CIRCUIT PERFORMANCE

III SUBMARINE CABLE SYSTEM LAYOUT AND CIRCUIT PERFORMANCE

1. Submarine Cable System Layout

Based upon the landing site survey already accomplished with the cooperation of the Post and Telegraph Department of Thailand, a communication system layout shown in Fig. III-1 to Fig III-7 might be considered. (See Fig. III-1 to Fig. III-7)

In the land portion of Manila side, microwave system is expected to connect cable landing site with Manila. On the other side, in the land portion of Bangkok , also microwave system can be engineered to link cable landing site with the Bangkok gate office via four hops. Some 1, 700 n. m. sea portion between both landing sites of Thailand and the Philippen's sides is assumed to consist of SD type submarine cable, submerged repeaters and equalizers.

The overall system provides 128 channels of 3 kc band voice frequency circuits between Bangkok and Manila. However, it will be possible to provide 138 channels of 3 kc spaced voice frequency circuits by small additional installation of the translating equipments at both terminal stations.

2. Circuit Performance Expected

The system affords the circuits which conform to the C. C. I. T. T. standards and in addition meet the following transmission objectives.

Any voice grade circuit may carry 22-channel voice frequency telegraph systems with frequency modulation according to the C. C. I. T. T. standards, and the remaining circuits are loaded with mean power of approx. -10 dbmO, so that it is possible to install some programme channels of the C. C. I. T. T. quality and/or TASI equipment (See Fig. III-9). The system may be used with 4 kc/s channel translating equipment, if required (See Fig. III-8).

(1) Attenuation distortion

The attenuation/frequency characteristics in both directions of transmission do not exceed 3/5 of the C. C. I. T. T. requirements (Red Book III, p. 23, see Fig. III-10).

(2) Variation of transmission loss with time under usual maintenance.

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(1) Attenuation distortion

The attenuation/frequency characteristics in both directions of transmission do not exceed 3/5 of the C. C. I. T. T. requirements (Red Book III, p. 23, see Fig. III-10).

(2) Variation of transmission loss with time under usual maintenance.

The preferred standard deviation in transmission loss of any frequency in any time is expected within 1 db. (See Table III-1.)

(3) Circuit noise (see portion only)

Under the rated loading of all channels except test channel, total noise of every channel with 3 kc/s bandwidth shall not exceed 2 pw/km x (route length) during the system life of 20 years. Actual expected performance may be less than 1.3 pw/km. (See Table III-1) Penalty of the noise performance due to the seasonal change of the sea bed temperature would be calculated less than 5 db if we adjust the transmitting level in respons to the temperature change.

(4) Crosstalk

Intelligible crosstalk shall not exceed -58 dbmO.

(5) Phase distortion

Phase/frequency distortion, which the differences in transmission time over the system, do not exceed the following values:

$$t_m - t_{min} \leq 20 \text{ ms}$$

$$t_M - t_{min} \leq 10 \text{ ms}$$

where, t_m represents the group delay at the nominal lowest frequency transmitted: and t_M the group delay at the nominal highest frequency transmitted: and t_{min} the minimum value of the group delay throughout the band of frequencies to be transmitted. Fig. III-11 shows the characteristics of the delay distortion of the circuit with two 16 channel banks. In the case of exceeding the above described limit and using the high speed data transmission. it will be recommended to use delay equalizers:

3. System Maintenability

(1) Supervisory facilities

The supervisory facilities shall be such that the performance of every repeaters can be monitored, and also fault can be localized in case of cable failure, from the landing station(s). The frequencies to be used for monitoring purpose are outside the commercial transmission band.

(2) Service circuits

Two telephone channels and a vehicle channel for at least two VF telegraph channels are provided for the order-wire purpose. These channels are allocated outside the commercial channels. (See Fig. III-12.)

(3) Pilots

Group pilots are inserted in each group so that the maintenance personnel can supervise the variation of levels. Alarm, recording facilities and AGC equipment associated with the pilots shall be prepared in the terminal offices. Seasonal changes of the levels can be adjusted by AGC's which are installed at the both terminal stations. (See Fig. III-13 & Fig. III-14.)

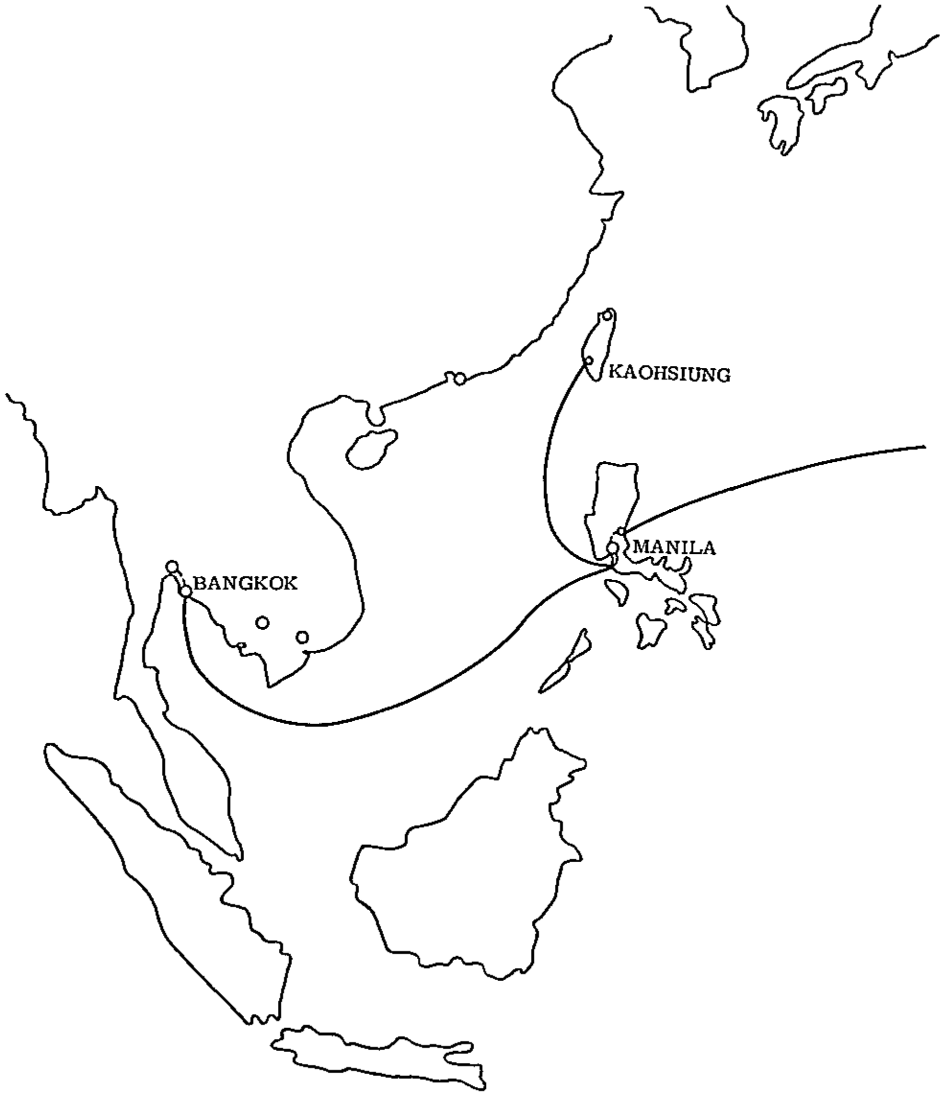
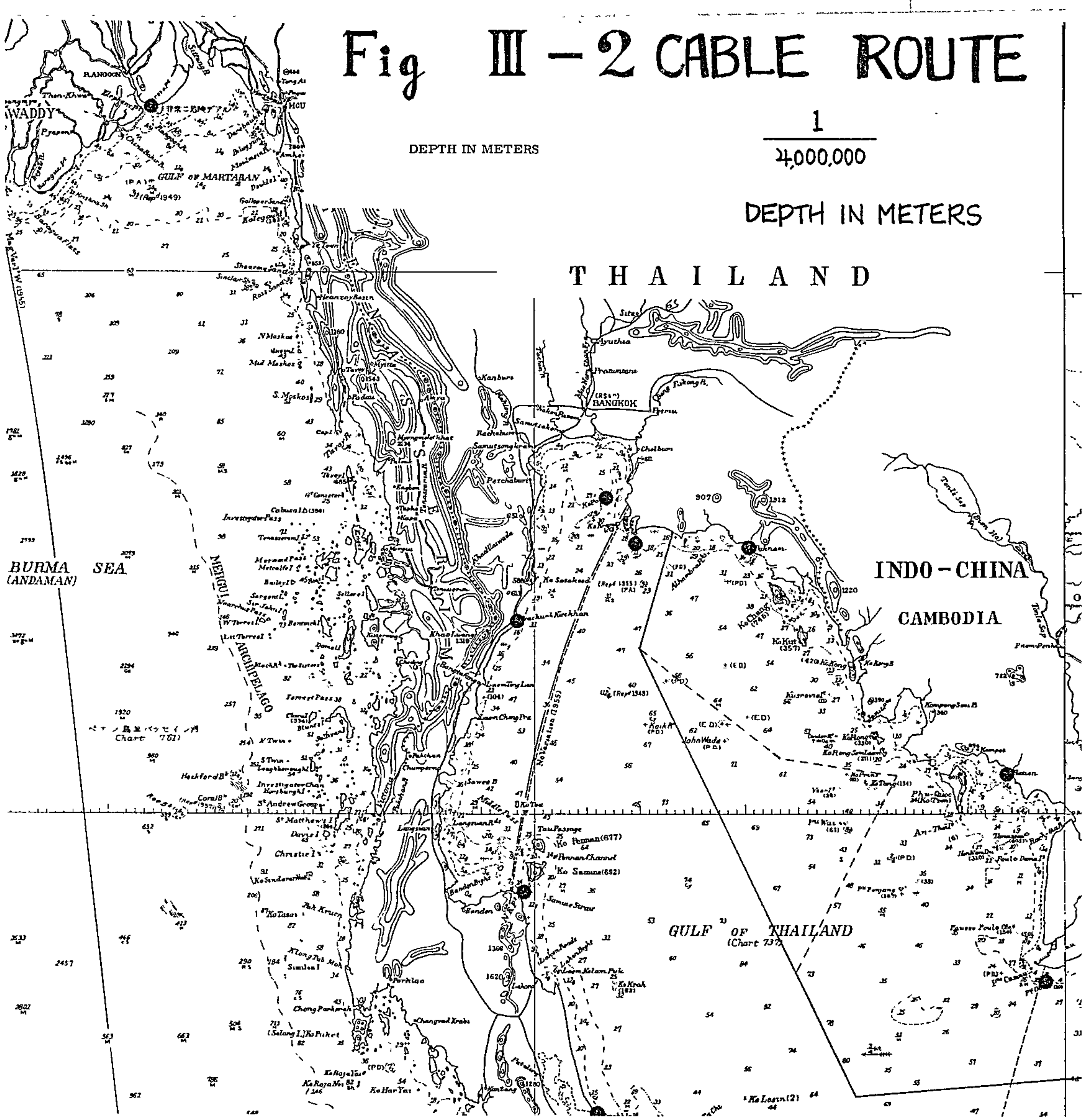


FIG. III - 1 SAFEC CABLE PROJECT ROUTE
(FIRST IMPLEMENTATION PLAN)

Fig III-2 CABLE ROUTE



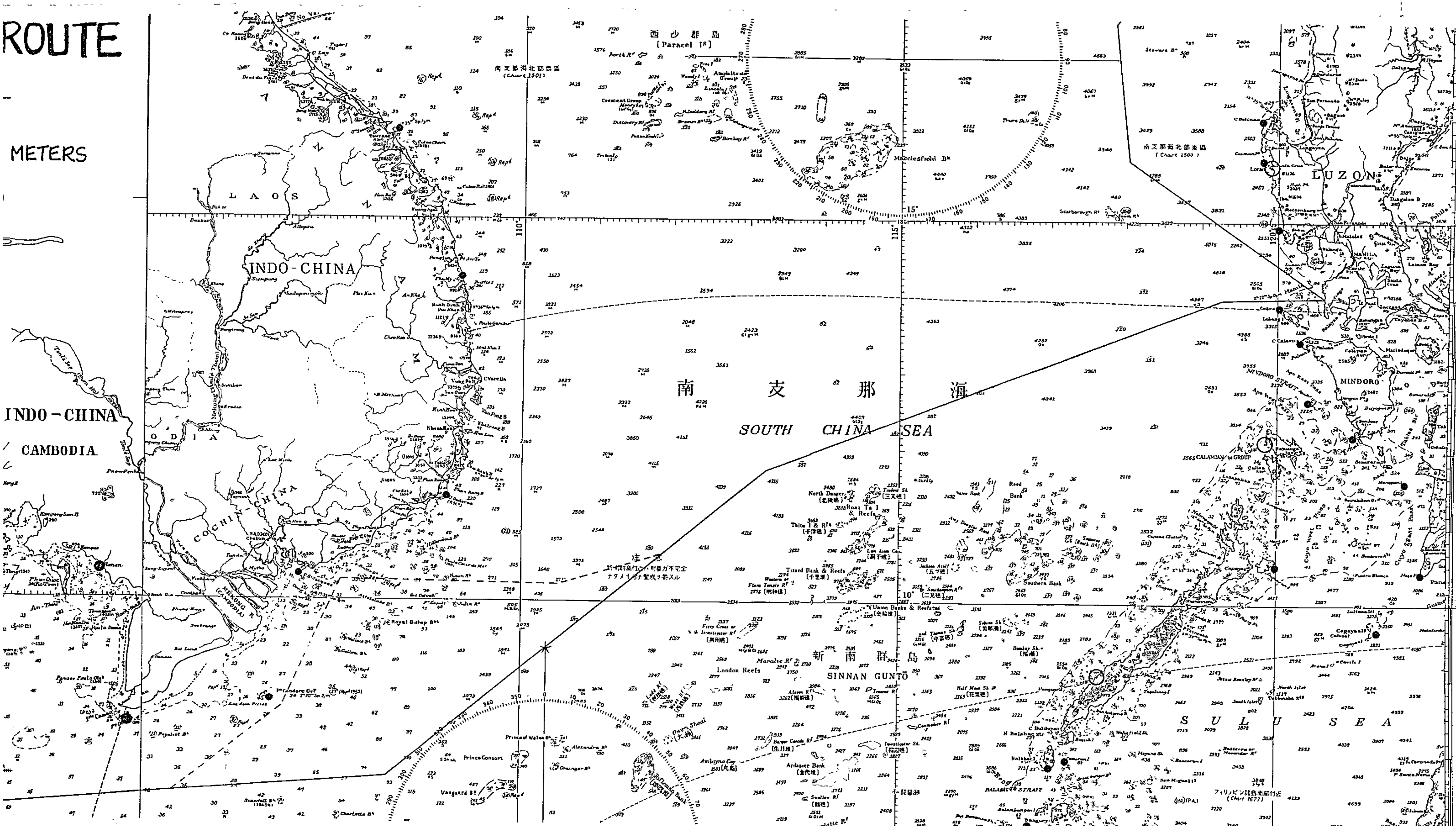
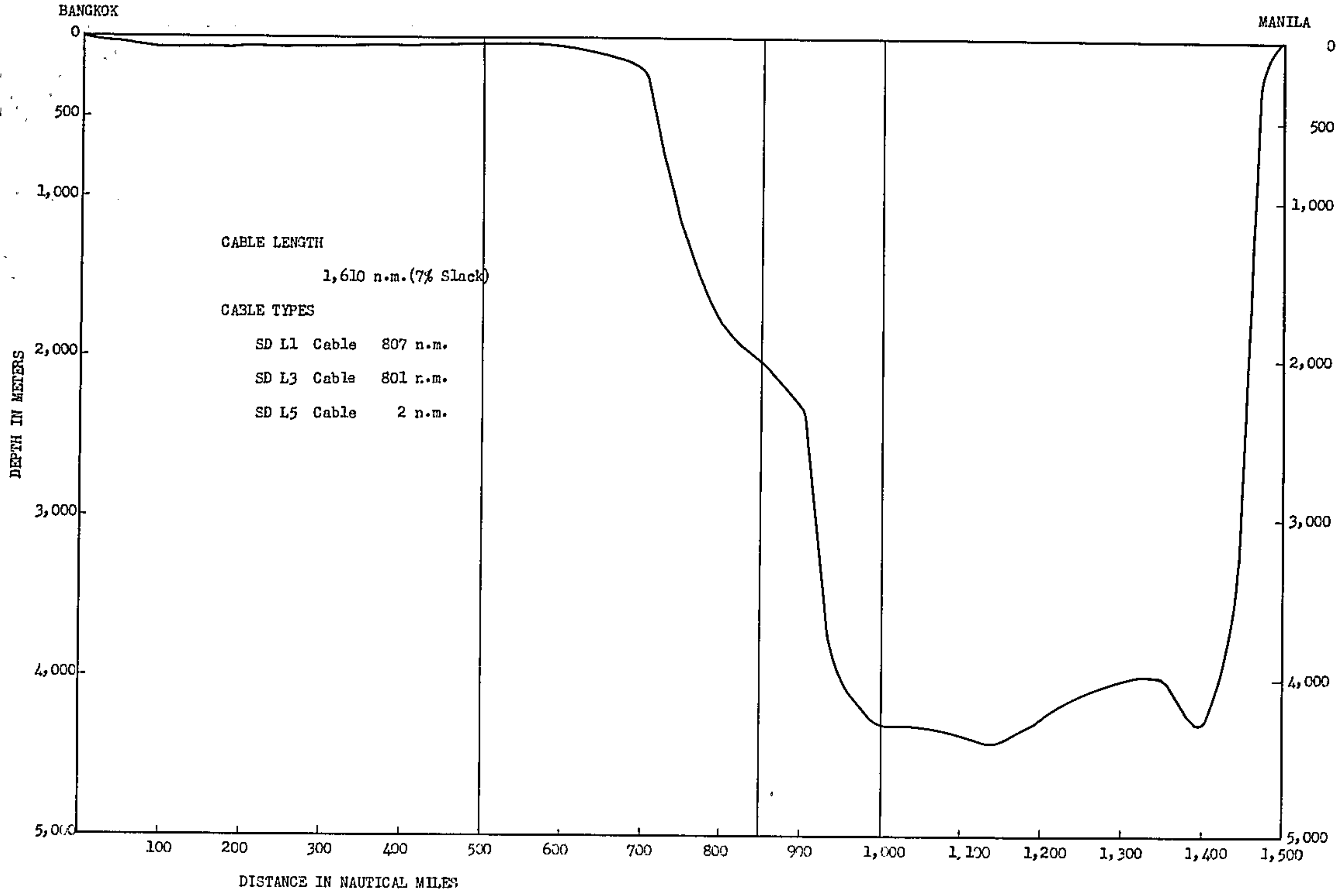

ROUTE
METERS
INDO-CHINA
CAMBODIA
LAOS
INDO-CHINA
COCHIN-CHINA
SAIGON
MEKONG R.
西沙群島
[Paracel Is]
Amphitrite Group
Crescent Group
Macclesfield Bk
Scarborough Rf
南支那海
SOUTH CHINA SEA
新南群島
SINNAN GUNTO
North Danger
Thitu I & Rfs
Tizard Bank & Reefs
Union Banks & Reefs
London Reefs
Royal Bishop Bk
Prince of Wales Bk
Prince Consort
Vanguard Bk
Ardasier Bank
LUZON
MANILA
MINDORO
MINDORO STRAIT
CALAMIAN GROUP
BALABAC STRAIT
S U L U S E A

FIG. III - 3 PROFILE OF OCEAN FLOOR
BANGKOK - MANILA SUBMARINE CABLE



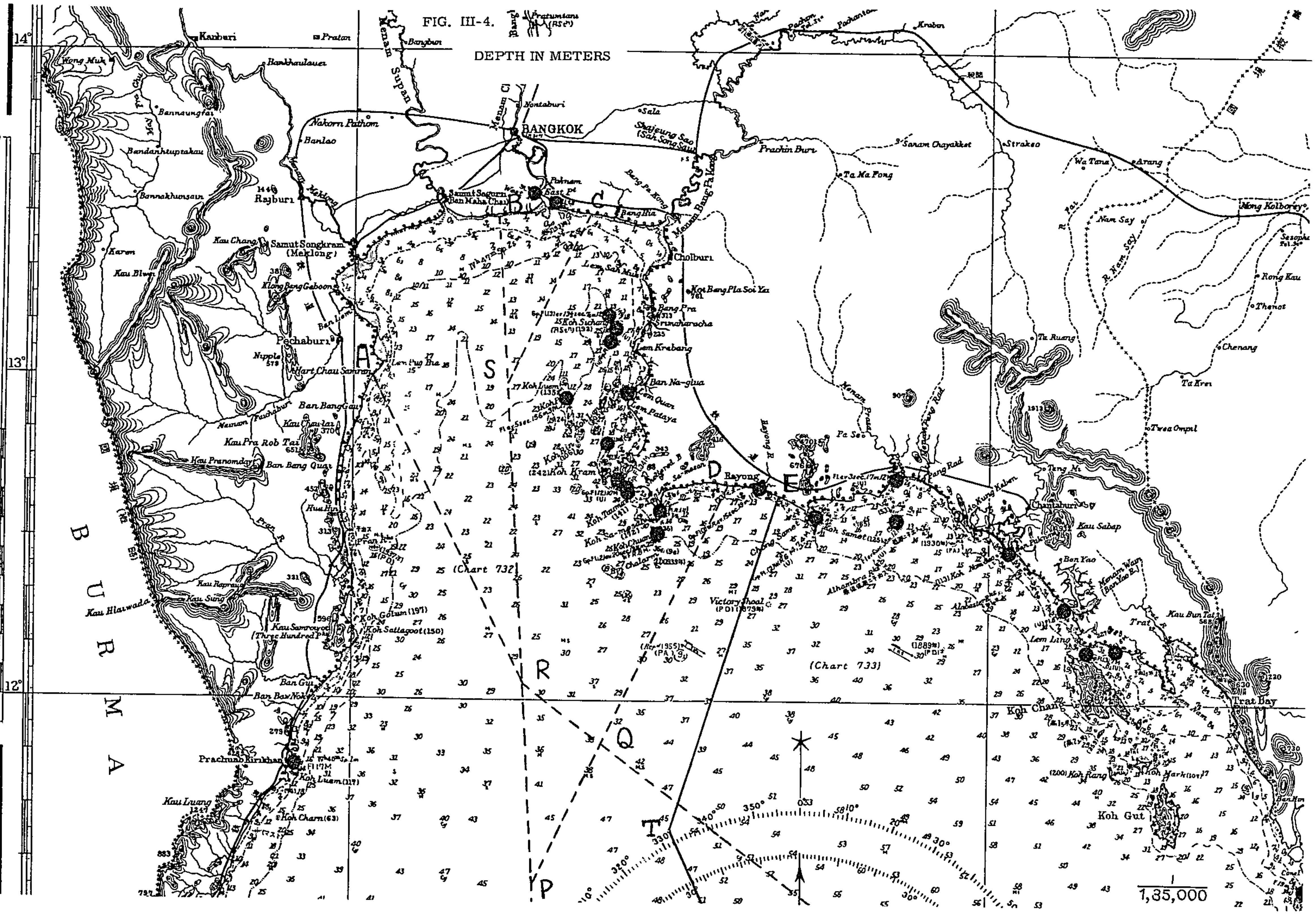


FIG. III-4.

DEPTH IN METERS

FIG. III-5 PROFILE OF OCEAN FLOOR
BANGKOK - MANILA SUBMARINE CABLE
GULF OF SIAM No. 1

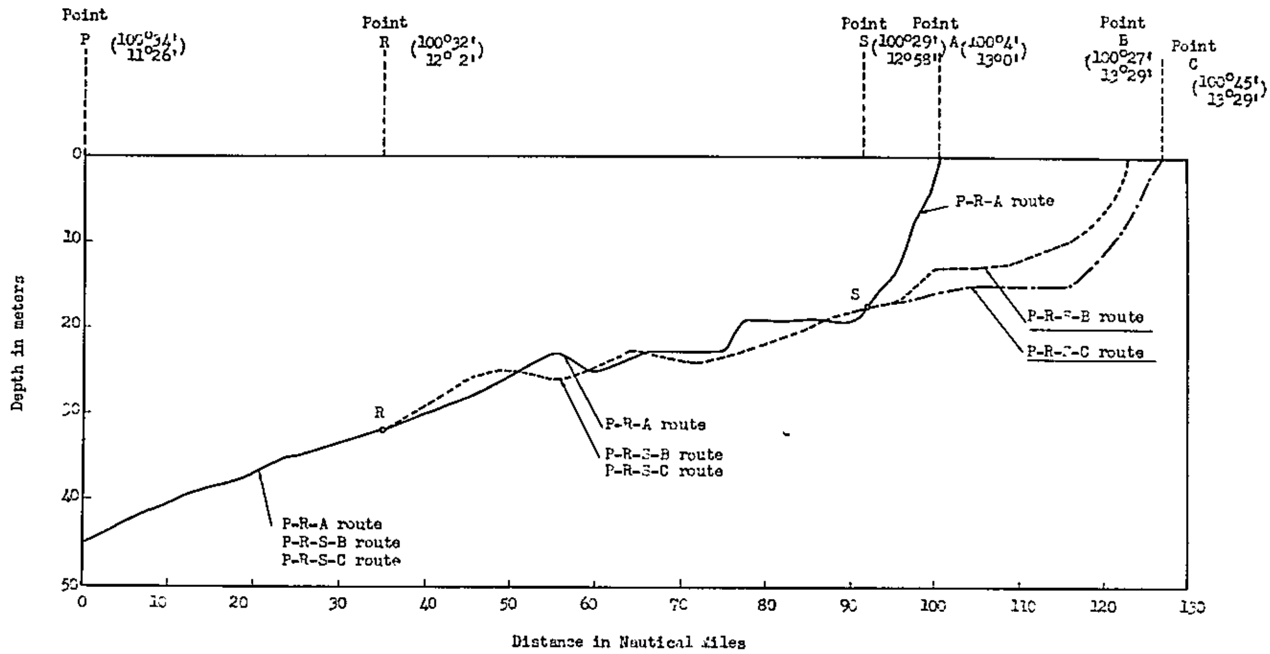


FIG. III-6 (a) PROFILE OF OCEAN FLOOR
BANGKOK - MANILA SUBMARINE CABLE
GULF OF SIAM No. 2

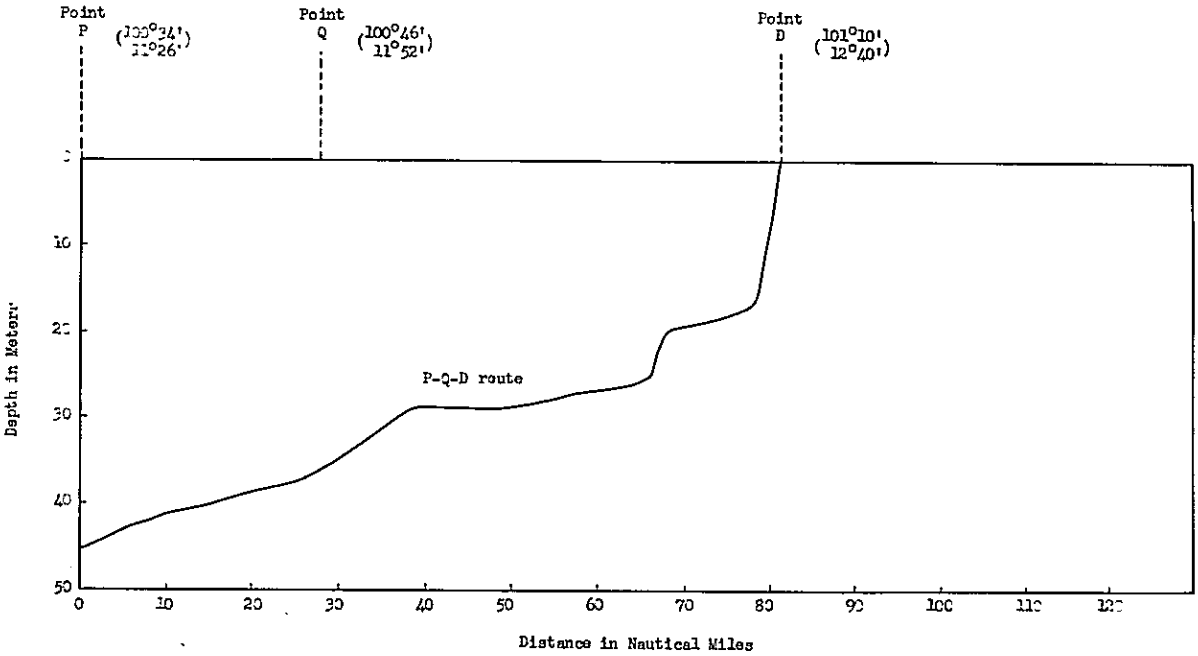
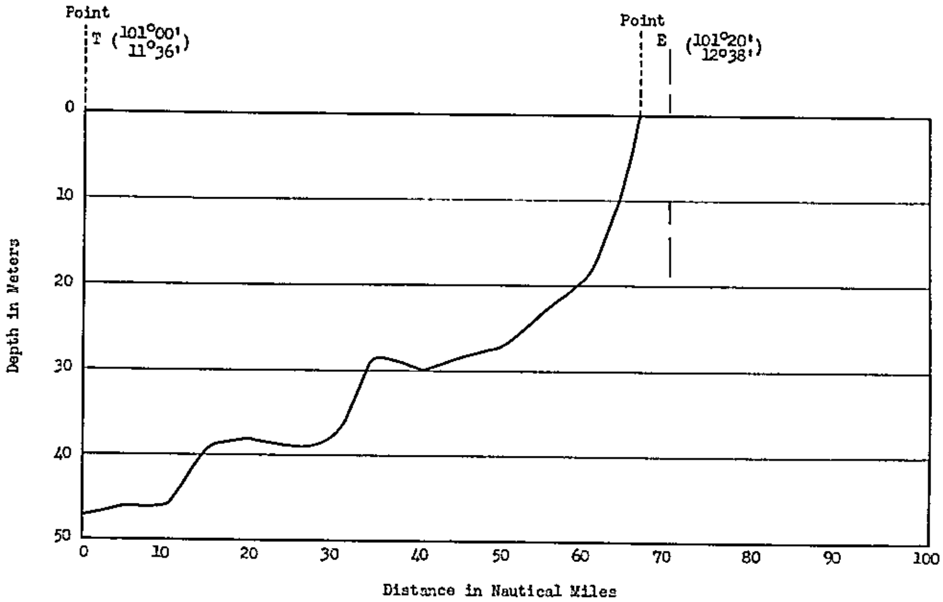


FIG. III - 6(b) PROFILE OF OCEAN FLOOR
BANGKOK - MANILA SUBMARINE CABLE
GULF OF SIAM



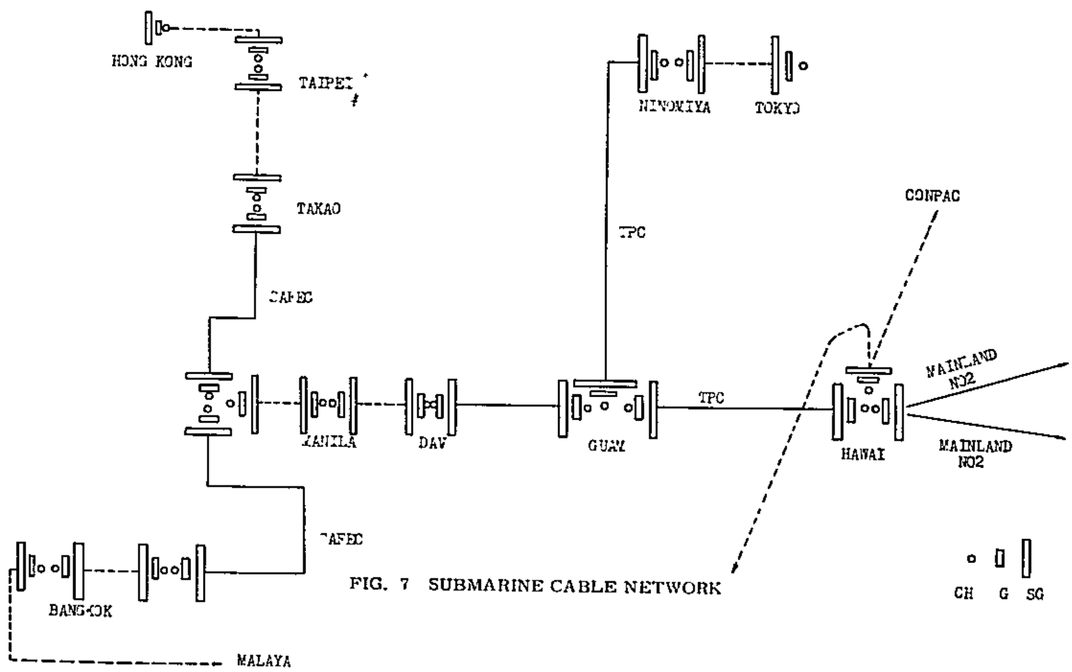


FIG. 7 SUBMARINE CABLE NETWORK

TABLE 1. TRANSMISSION PERFORMANCES

	Objectives			Actual Performances				Expectant Performances			
	C.C.I.T.T. (2,500 km)	C.C.I.T.T. (25,000 km)	SD System (6,500 km)	TOK-HONO (10,000 km)	TOK-OAK (15,000 km)	TOK-VCR (15,000 km)	TOK-LN (25,000 km)	BGK-MNL (3,000 km)	BGK-KAO (4,200 km)	BGK-TOK (8,700 km)	BGK-OAK (17,300 km)
Band of Freq. effectively transmitted	300 - 3400 c/s	300 - 3400 c/s (200-3000, 3kc)	200 - 3050 c/s	200 - 3050	200 - 3050	200 - 3050	200 - 3050	200 - 3050	200 - 3050	200 - 3050	200 - 3050
Attenuation Distort.	Attached Fig. 1 (or See Red Book III, p. 23)			Fig. 1							
Group Delay	≤ 150 ms (prefer 100ms)	≤ 150 ms (max 400 ms)		56 ms	82 ms	85 ms		17 ms	23 ms	48 ms	96 ms
Phase Distortion	$t_m - t_{min} \leq 20ms$ $t_M - t_{min} \leq 10ms$	$t_m - t_{min} \leq 30ms$ $t_M - t_{min} \leq 15ms$			Fig 2						
Variation of Overall Loss with Time	std dev < 1 dB	std dev < 1 dB*		standard deviation < 0.7 dB							
Average Loading per Channel (Load Assumption)	-15 dBmO	-15 dBmO	-9.6 dBmO								
Linear X'talk between Different Cct	> 58dB : 90% ≥ 52dB : 100%	> 58dB : 100%*									
Near-end X'talk	> 35 dB for telephony	> 43 dB **		> 60 dB	> 60 dB	> 60 dB	> 60 dB				
Noise (weighted) at the End of Cct. (Relative Level)	10,000 pW (-50 dBmOp), i.e. 4pW/km	50,000 pW (-43 dBmOp), i.e. 2pW/km	-49 dBmOp, i.e. 2pW/km	-49 dBmOp, i.e. 1.3pW/km	-47 dBmOp, i.e. 1.6pW/km	-47 dBmOp, i.e. 1.5pW/km	-45 dBmOp, i.e. 1.6pW/km	*** -54 dBmOp (1.3pW/km)	*** -52 dBmOp (1.3pW/km)	*** -49 dBmOp (1.3pW/km)	*** -46 dBmOp (1.3pW/km)
Freq. Difference at two Ends of a Carrier Circuit	2 c/s	2 c/s		< 1 c/s	< 1 c/s	< 1 c/s	< 1 c/s				

* These values apply to single 4-wire circuit ** See Recommendation G 1 151D. *** Excluding land line.

FIG. 8 ATTENUATION DISTORTION OF 12 CHANNEL BANK

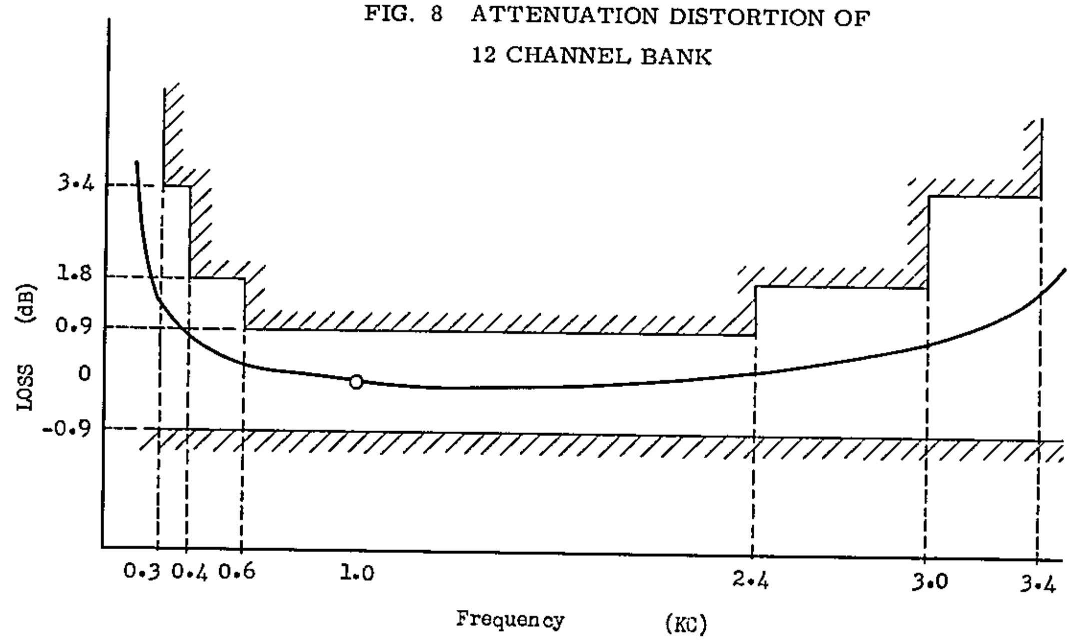
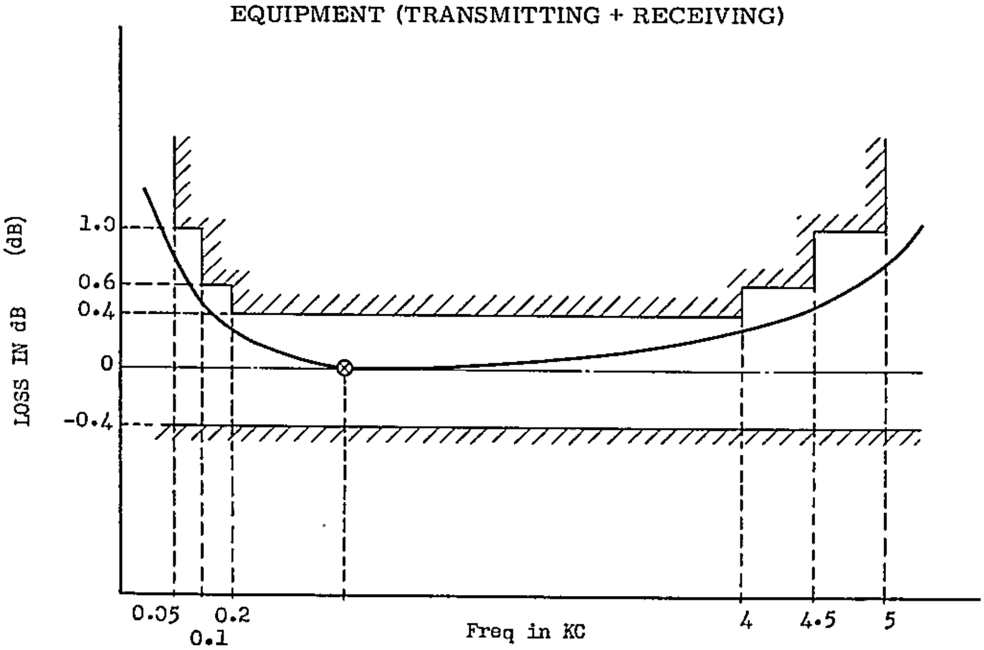


FIG. 9. FREQUENCY CHRACTERISTICS OF P.T.S. TERMINAL EQUIPMENT (TRANSMITTING + RECEIVING)



FIG, 10 ATTENUATION DISTORTION OF VARIOUS TPC CIRCUITS. (TYPICAL)

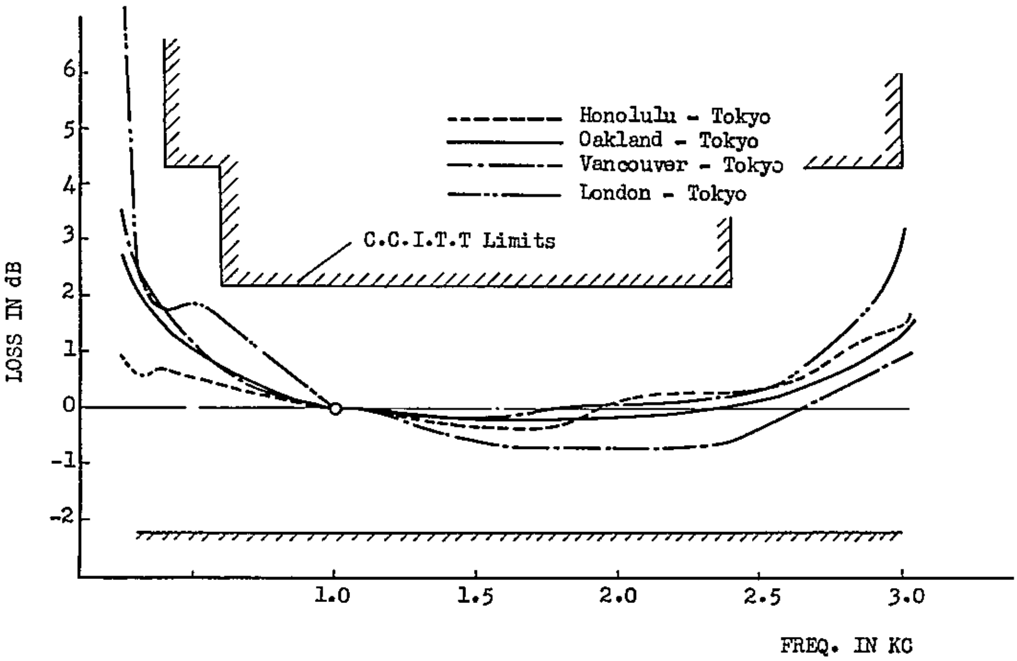


FIG. 11 DELAY DISTORTION OF OAKLAND - TOKYO CIRCUIT. (TYPICAL)

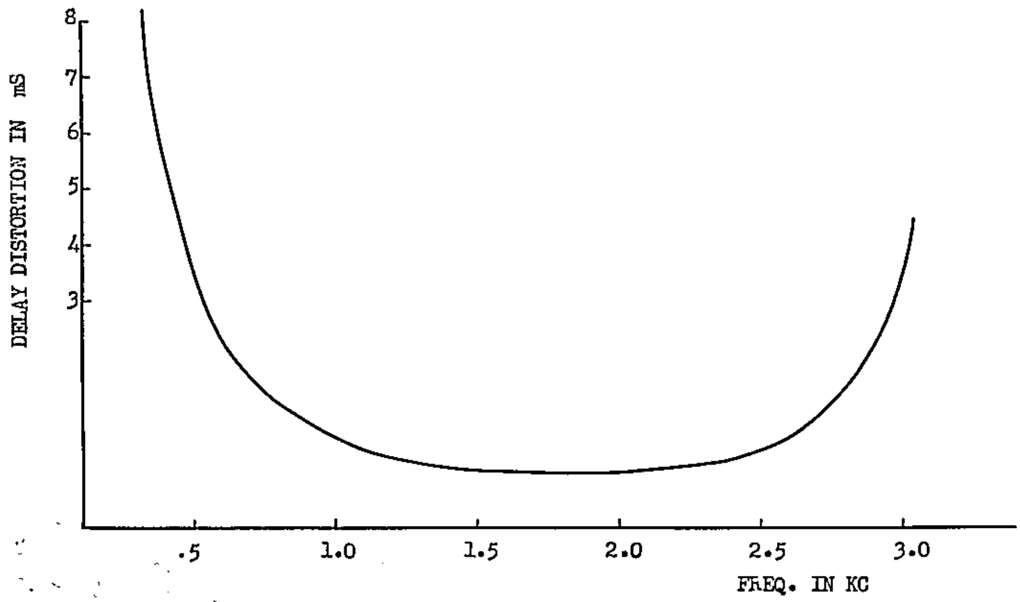


FIG 12 OW BLOCK SCHEMATIC

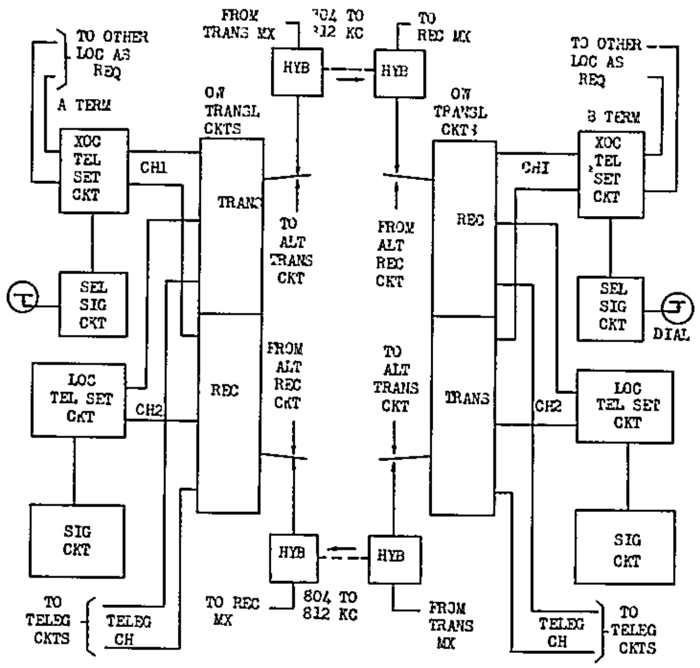


FIG. 13 CABLE TERMINAL EQUIPMENT

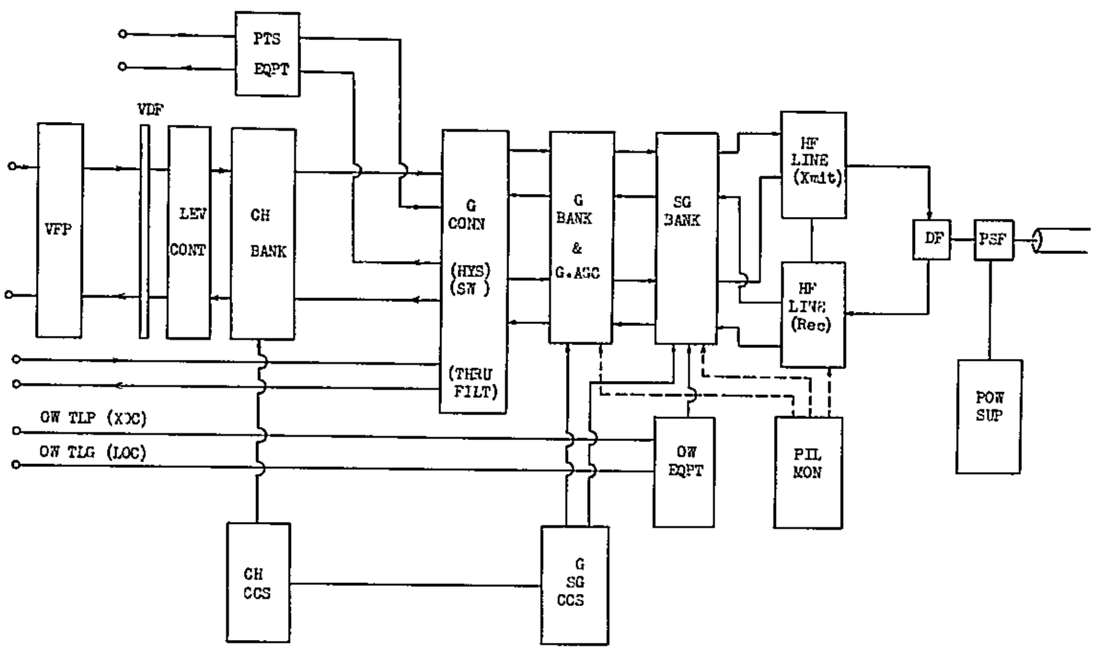
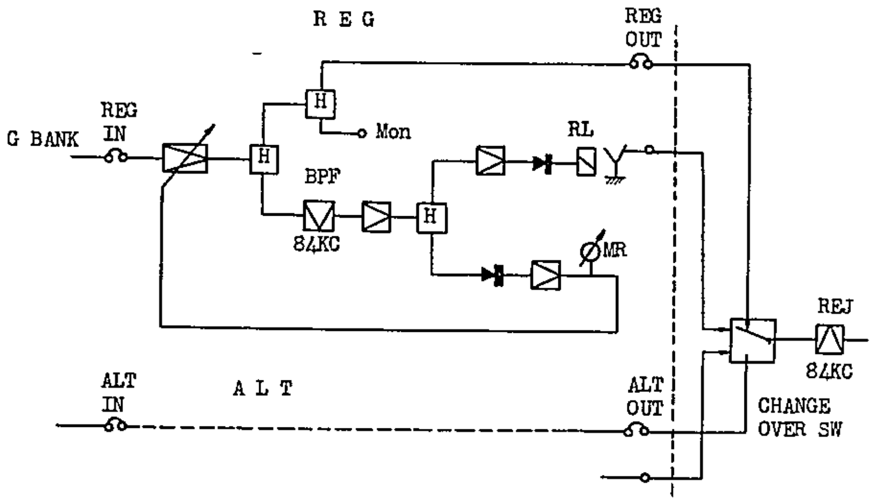
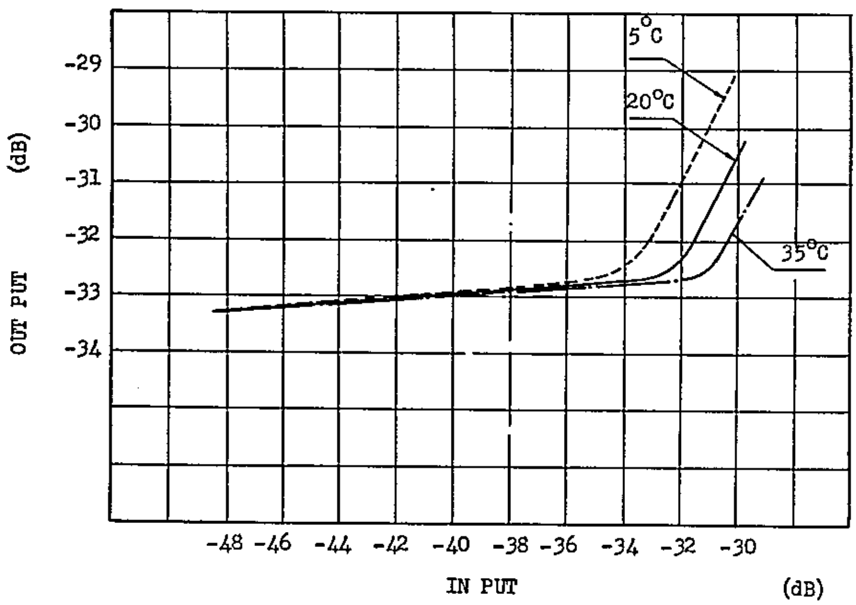


FIG. 14 A G C

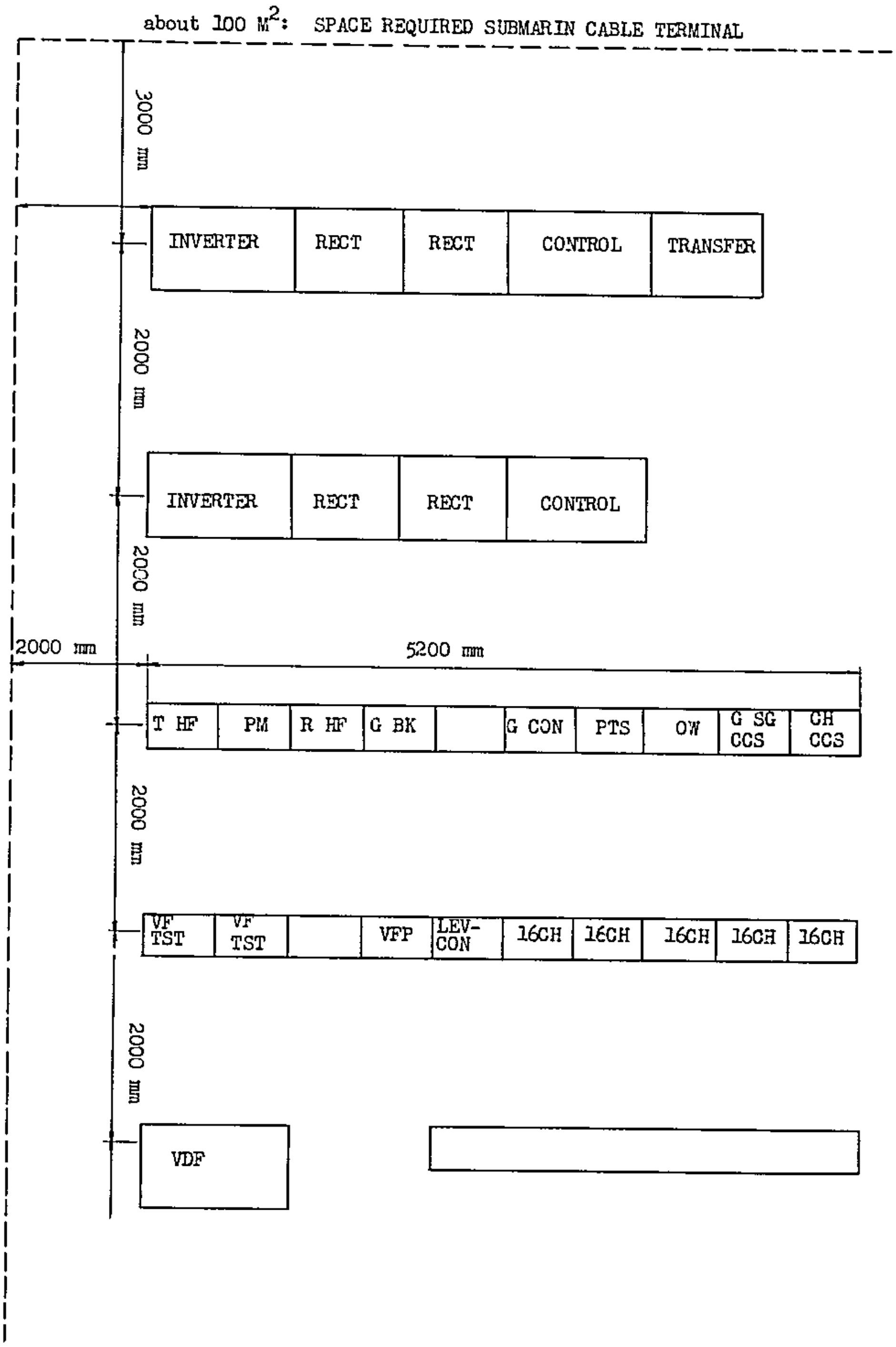


R E G
REG OUT
G BANK
REG IN
H
H
Mon
RL
BPF
84KC
H
MR
REJ
84KC
ALT IN
A L T
ALT OUT
CHANGE OVER SW



5°C
20°C
35°C
-29
-30
-31
-32
-33
-34
(dB)
OUT PUT
-48 -46 -44 -42 -40 -38 -36 -34 -32 -30
IN PUT
(dB)

FIG. 15 TYPICAL FLOOR PLAN OF CABLE SYSTEM



APPENDIX I.

SD SYSTEM DESIGN

The basic objective of the SD system is to make available a highly reliable transoceanic facility which would be comparable in quality to the land plant of the continents to be connected, at a cost per channel-mile substantially lower than the earlier relatively narrow-band systems. Consistent with the trend to establish more stringent noise requirements on long continental circuits, noise of 41 dbrn at the zero level transmission point over the life of a 4000-statute mile system is taken as a design objective.

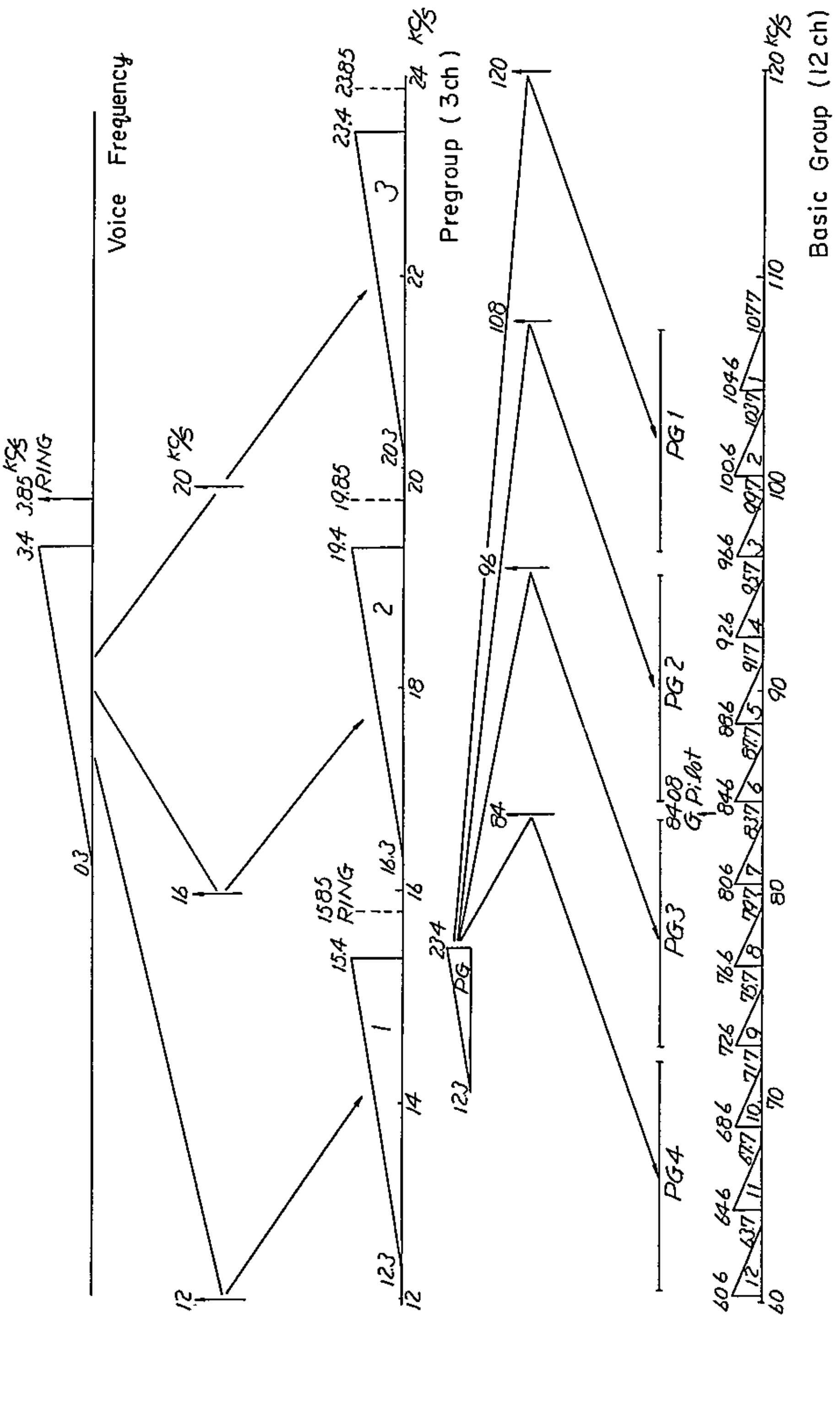
The length of cable between repeaters is approximately 20 nautical miles (nm). An ocean-block equalizer to correct misalignment is located in the section following every tenth repeater in the direction of the cable lay. The length of cable between ocean-block equalizers and adjacent repeaters is 6 nm. The adjustable equalizer loss is thus approximately equivalent to the loss of 8 miles of cable. Transmission in one direction is carried in the frequency band of 108 to 504 kc and in the other direction by the band 660 to 1052 kc. These frequency allocate 128 3 kc band channels. After a system is installed it is possible that an additional 10 channels will meet requirements. When these channels are used the frequency bands are expanded to 90 to 516 kc and 630 to 1052 kc. The two directions of transmission are amplified in a common amplifier by the use of directional filters.

The cable used for the major part of a system has an over-all diameter of 1 1/4 inches and a breaking strength of 18, 000 pounds. Armored cable designs are available for use in shallow water to give protection against anchor or fishing damage. A shield may also be added to the cable structure at locations where radio or similar electromagnetic interference might be expected. The length of the shore-end section is restricted to the range 5 to 15 nm to minimize noise disturbances.

Power for operating the repeaters is supplied from the shore over the central conductor of the cable. A positive dc voltage is supplied to the cable at the A terminal between the central conductor and ground and a negative potential is supplied at the B terminal. The current path is thus over the cental conductor, returning via the ocean. The power supplies provide precise regulation of cable current to a value of 389 ma. The voltage drop in the undersea system is approximately 60 volts per repeater section in armorless cable and

50 volts per repeater section in armored cable. A 3500-nm system will require a nominal supply voltage of 5500 volts at each terminal.

At the shore terminal the signals to be transmitted are frequency multiplexed and pre-emphasized in preparation for transmission through the undersea system. Signals received over the cable are equalized, aplified, demodulated and separated for transmission beyond the shore terminal. Monitoring of performance and trouble location are the other important functions at the shore station.


Voice Frequency
0.3
3.4
3.85 kc/s RING
12
16
20 kc/s
12.3
15.4
15.85 RING
16.3
19.4
19.85
20.3
23.4
23.85
12
14
16
18
20
22
24 kc/s
1
2
3
Pregroup (3ch)
23.4
PG
12.3
84
96
108
120
PG 1
PG 2
PG 3
PG 4
84.08 G. Pilot
60.6
64.6
68.6
72.6
76.6
80.6
84.6
88.6
92.6
96.6
100.6
104.6
107.7
60
70
80
90
100
110
120 kc/s
Basic Group (12 ch)

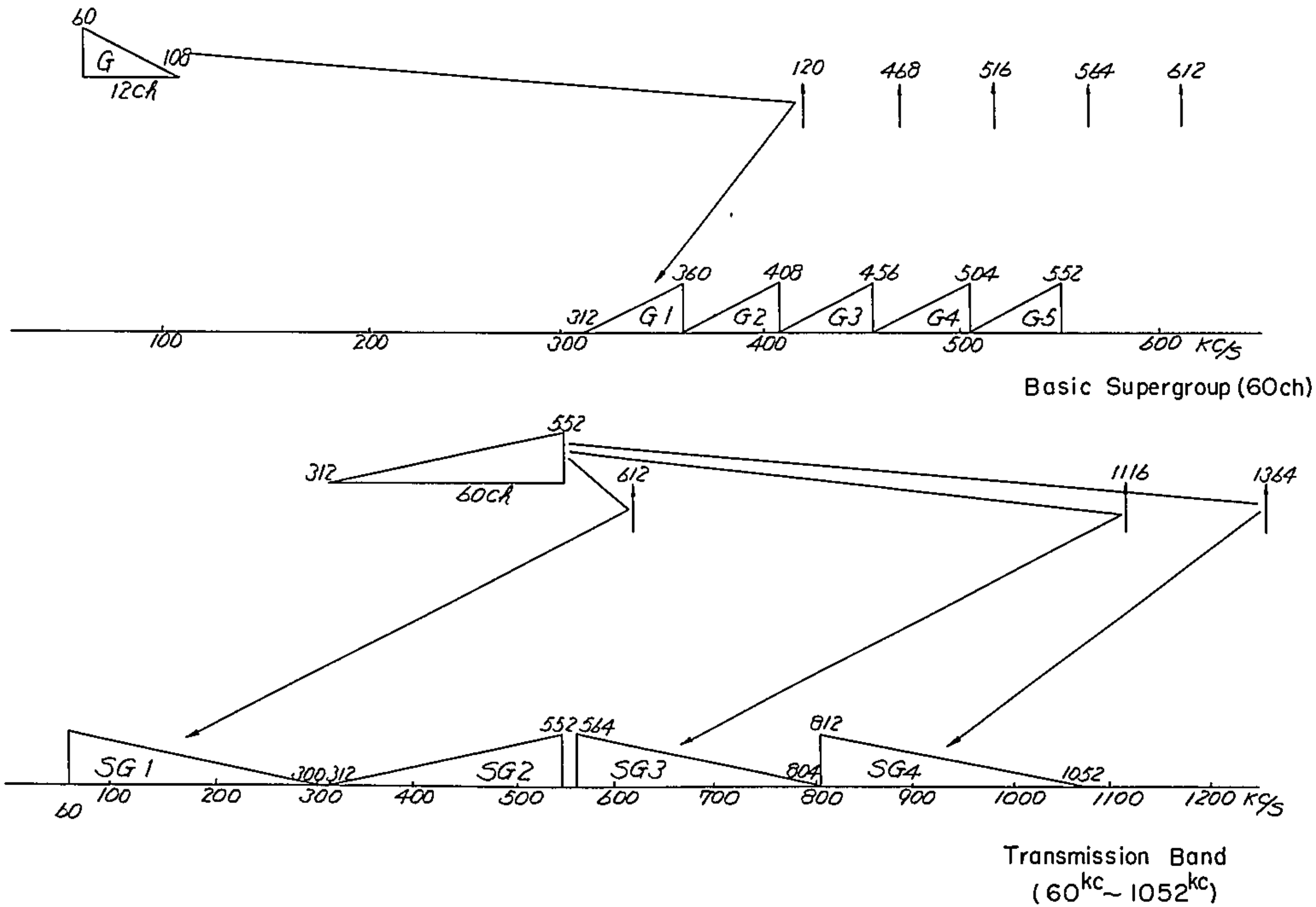


Fig A - I FREQUENCY ALLOCATION

Ⅳ COMMERCIAL ESTIMATION

IV COMMERCIAL ESTIMATION

1. General View

Demands for telecommunications are, needless to say, quickly influenced by the rise and fall of the national economic activities. Particularly, international telecommunication demands are closely related to the foreign trade activities.

It is proved according to the statistics prepared by the Post and Telegraph Department of Thailand that a great majority of international telecommunication traffic to and from Thailand are utilized by trading firms; 80% of total telegrams, 85% of telex calls and 90% of telephone calls are related to the trading business.

According to a report of the Bank of Thailand, the trade indices of Thailand shows a phenomenal growth resulting in:

Year	Export	Import
1958	100	100
1964	191.53	173 01

It is believed that this upward tendency of trading activities will further be accelerated by the existing stable economic conditions and also with the successful implementation of the six year national expansion plan.

Thus, the demands for international telecommunications in Thailand show a vigorous growth, reflecting the high level of economic development. It is therefore safely assumed that traffic demands, circuit requirements on the planned SAFEC system will continue to grow at a high rate with the result of favorable balance between income and expenditure. The growing tendency of traffic demands are as seen in Fig. IV-1

2. Basic Assumption

(1) As the first stage of the project, the construction of SAFEC System is assumed to take place for the segments of Taiwan--the Philippines--Viet Nam--Thailand, measuring 2,370 N. M. in length and to be completed at the beginning of 1968.

(2) The above cable segments will then be interconnected in the Philippines with the existing cable to Guam and in Taiwan with the planned tropospheric system to Hong Kong as

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(2) The above cable segments will then be interconnected in the Philippines with the existing cable to Guam and in Taiwan with the planned tropospheric system to Hong Kong as

well as in Thailand with the planned micro-relay system to Malaysia, thereby making it possible to extend the broadband communication system to such countries beyond the above segments as Japan, the United States, Hong Kong, Malaysia, Singapore and Australia.

(3) The remaining sections, Japan-Taiwan, Taiwan-Hong Kong and Thailand-Malaysia-Singapore-Indonesia will be constructed to be in service from 1970.

3. Traffic Demand

Traffic Demands are, in principle, estimated in connection with the correlation between the traffic volume and the trade amount for the past years as well as the trend of actual traffic volume, data of which have been supplied by the Post and Telegraph Department of Thailand.

The estimates are worked out for various services each for years of 1967, 1968, 1970, 1975 and 1980 in the following manner:

(1) Telegram

It is assumed from the actual data that the amount of trade will grow up at the annual rate of 11% as seen in Fig. IV-2 and that the trade elasticity of demand for telegraph traffic will be 0. 72 times. The annual growth rate of telegraph traffic is therefore 8% (11% x 0. 72).

Meanwhile, since telegram demands are adversely affected by a continuous expansion of telex service, it is also estimated that the above growth rate will decrease by 25%, resulting in a 6% annual growth rate (8% x 0. 75). Based on the actual demand in 1965, the estimates of future demands are worked out as shown in Table IV-1.

(2) Telex

Ever since telex service was opened in Thailand in 1963, the telex demand showed a rapid increase, and, in view of the telex being still a young service, the growth rates are assumed on a firm basis as follows:

up to 1967	30%	
up to 1975	24%	Upon completion of SAFEC system, leased channel effect is taken into consideration.
after 1976	20%	

Thus, the future telex demands are estimated as given in Table IV-2.

(3) Telephone

During the period of the past several years, the demand for international telephone calls grew up to a great extent and the trade elasticity of demand for telephone traffic is calculated at 1.8, from which the annual growth rate of telephone demand is estimated at 20% (Trade growth 11% x 1.8).

Judging from the past experience in the telephone service via cable routes such as the Atlantic cables and the Pacific cables, telephone demand over the SAFEC route is assumed to increase in 1968 (when the SAFEC is expected to be brought in service) at the rate of:

200% ..... for the areas which are now served by the direct radio circuits

300% ..... for other service areas

Furthermore it is generally observed that the annual growth rate of the cable service is much higher than that of radio service. However, the same 20% growth rate as for the radio service is assumed to continue for the cable service via SAFEC after 1969 on a conservative estimate.

On the above assumption, the future demands are calculated as shown in Table IV-3.

Remarks: The following increase of telephone traffic was observed during the several months immediately after the opening of Transpacific cable service.

Cable Circuit Tokyo -	Growth Rate
Oakland (USA)	210%
*Honolulu	440
Vancouver	210
*London	600
*Auckland (NZ)	670
*Agana (Guam)	1070
Manila	200

*No direct circuit via radio was operated before opening the cable service.

(4) Leased Channel

There has been a very small demand for leased channel service in Thailand, from which it is difficult to estimate the future demand. However, in view of the world trend, this service involves a big demand potentiality.

Based on the experience in the Transpacific cable service, it is assumed that the number of leased teleprinter channels (equated 50 baud channels) on SAFEC will amount to half the number of telex channels up to 1970 and will increase thereafter at the annual growth rate of 10%.

Several voice grade leased circuits can be expected as seen in the Pacific cable service, but such lease demands are considered to be of rather unusual nature and are therefore disregarded in this SAFEC estimation for the time being.

Remarks: Number of telex and leased channels on the Transpacific Cables

(as of Jan. 1966)

between Japan and	Telex	Lease VFT	Lease VG
U.S.A.	46	26	15
Philippines	6	4	5
U.K.	20	11	-

(The annual growth rates above estimated for various services are illustrated as shown in Fig. IV-3)

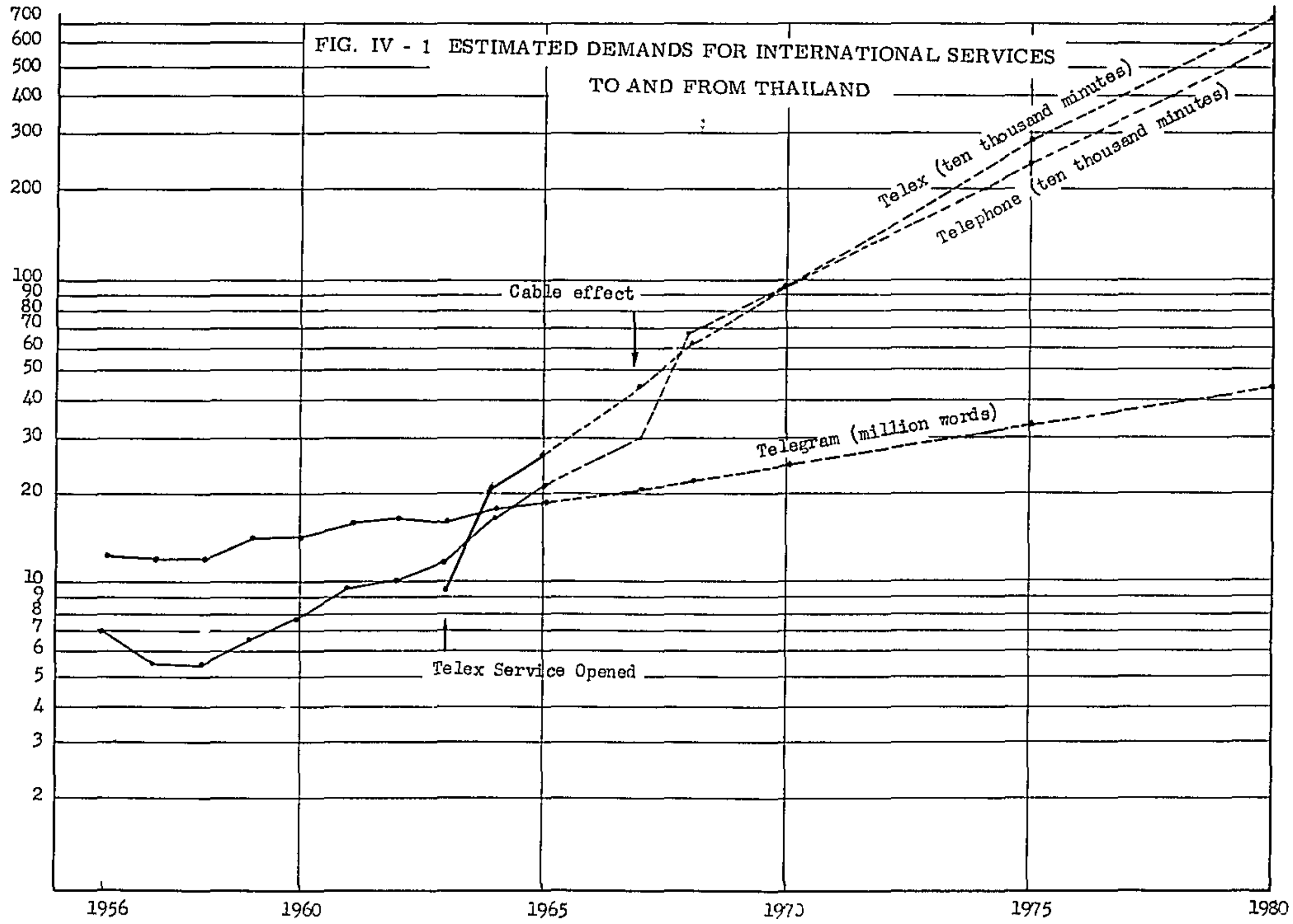


FIG. IV - 1 ESTIMATED DEMANDS FOR INTERNATIONAL SERVICES TO AND FROM THAILAND

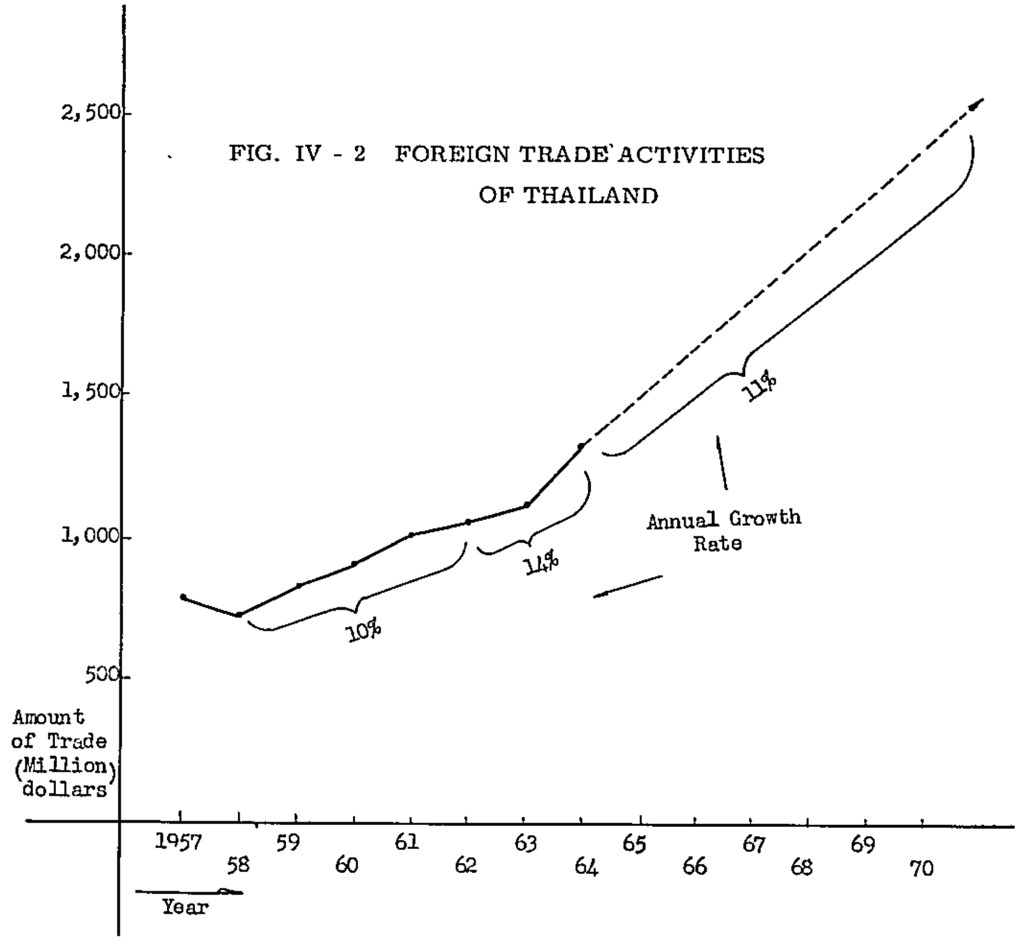
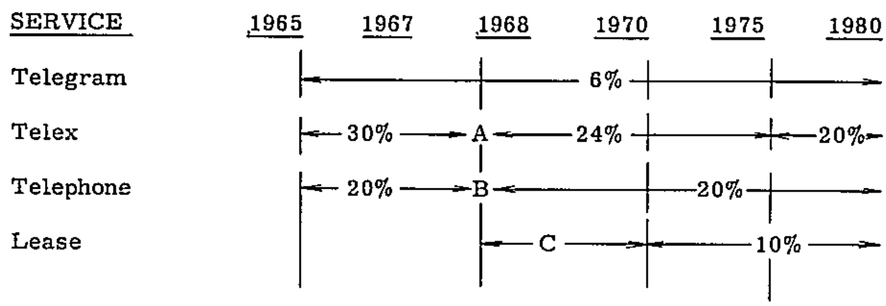


FIG. IV - 2 FOREIGN TRADE ACTIVITIES OF THAILAND

FIG. IV-3. ESTIMATED ANNUAL GROWTH RATE



Note: A ..... Cable effect of 50% increase is assumed for transit traffic and even direct traffic handled via low efficient radio circuits.

B ..... Cable effect of 100% increase is assumed for direct traffic and 200% for transit traffic handled via existing radio circuits.

C ..... One half of the number of telex channels is assumed as the demand for 50 baud leased channels.

TABLE IV-1. TELEGRAM DEMAND

(in thousand words)

Year / Country	Actual 1965	ESTIMATED 1967	1968	1970	1975	1980
Japan	3,457	3,884	4,117	4,626	6,191	8,285
Hong Kong	2,100	2,360	2,501	2,810	3,761	5,033
Philippines	2,029	2,280	2,417	2,715	3,634	4,863
Taiwan	281	316	335	376	503	673
Malaysia & Singapore	3,359	3,774	4,001	4,495	6,015	8,050
Indonesia	552	620	657	739	988	1,323
*India	461	518	549	617	826	1,105
*Israel	27	30	32	36	48	65
*Pakistan	17	19	20	23	30	41
*Ceylon	44	49	52	59	79	105
*Burma	112	126	133	150	201	268
U.S.A.	1,938	2,178	2,308	2,593	3,471	4,645
Hawaii (via U.S.A.)	22	25	26	29	39	53
Canada (via H.K.)	50	56	60	67	90	120
S. America (via U.S.A.)	15	17	18	20	27	36
*Germany	672	755	800	899	1,203	1,610
*U.K.	1,500	1,685	1,787	2,007	2,686	3,595
*Switzerland	648	728	772	867	1,160	1,553
Australia	260	292	310	348	466	623
New Zealand (via Australia)	46	52	55	62	82	110
*Africa	45	51	54	60	81	118
S. Viet Nam	918	1,031	1,093	1,228	1,644	2,200
Total	18,553	20,846	22,097	24,826	33,225	44,464

* ..... remains via radio routes

TABLE IV-2. TELEX DEMAND

(in thousand mins.)

Year / Country	Actual 1965	ESTIMATED 1967	1968	1970	1975	1980
Japan	189	319	396	609	1,785	4,442
Hong Kong	5	8	10	16	47	118
*Philippines	2	3	6	10	28	71
*Taiwan	1	2	3	5	14	35
*Malaysia & Singapore	8	14	25	39	113	282
*Israel (via Japan)	5	8	16	24	71	176
*U.S.A.	4	7	13	19	57	141
*U.K. (via H.K.)	11	19	35	53	156	388
*Other Europe (via Japan)	8	14	25	39	113	282
*Australia & New Zealand	16	27	50	77	227	564
Others (via Japan) (via H.K.) (via Philippines)	19	32	60	92	269	670
Indonesia			3	5	14	35
S. Viet Nam			1	1	3	7
Total	268	453	643	989	2,897	7,211

* ..... cable effect of 50% increase was assumed

TABLE IV-3. TELEPHONE DEMAND

(in thousand mins.)

Country \ Year	Actual 1965	ESTIMATED 1967	1968	1970	1975	1980
Japan	53	76	153	220	547	1,361
Hong Kong	92	132	265	382	949	2,362
Philippines	0.6	1	3	4	9	23
Taiwan	5	7	22	31	77	193
Malaysia & Singapore	38	55	164	236	588	1,464
*India	2	3	3	5	12	31
*Pakistan	0.2	0.3	0.3	0.5	1.2	3
*Burma	2	3	3	5	12	31
U.S.A.	5	7	22	31	77	193
U.K. (via H.K.)	1.5	2	6	9	23	58
Other Europe (via U.S.A.) (via Berne)	7	10	20	29	72	180
Australia & New Zealand	1	1.4	4	6	15	39
Indonesia			3	4	10	25
S. Viet Nam			1	1	3	7
*Others	12	17	21	30	74	185
Total	220	315	690	994	2,469	6,155

* ..... remain via radio routes

4. <u>Circuit Requirement</u>

The number of circuits required each for 1968, 1970, 1975 and 1980 is calculated as shown Table IV-4 on the following assumption and conditions:

(1) Establishment of direct circuits

(a) Upon completion at the beginning of 1968 of the SAFEC Thailand-Philippines-Taiwan section, Thailand will have direct cable circuits with Japan, Hong Kong, the Philippines, Taiwan, Viet-Nam, Malaysia/Singapore, Australia and U. S. A.

Note: By 1968, the Thailand-Malaysia microwave relay link and the Kaohsiung-Hong Kong tropospheric link will become available for interconnection with the SAFEC system.

(b) Upon completion of the remaining sections of SAFEC system, the direct cable circuits between Thailand and Indonesia will become operative in 1970.

(2) Standard Traffic Volume per Channel

The following are the standard traffic volume to be covered by one channel which are the same as those adopted at the Rome Plan Committee in 1963.

Telegram --- 2. 7 million words per channel per year

Telex --- 45 thousand minutes per channel per year

Telephone --- 45 thousand minutes per channel per year

In case where traffic volume does not reach the above level, minimum two voice grade circuits are to be assigned to such direct connection - one for telephone use and the other for VF telegraph system.

(3) VFT Channels

Each group of twenty VFT channels or fraction thereof over a given direct connection is converted into one voice grade circuit.

(4) Routing of Traffic

Traffic will, in principle, be handled under the existing routing procedures except the following:

(a) Thailand-U. S. A. telegraph circuit to be established via cable will handle telegraph traffic with all points in North, Central and South Americas except traffic with Canada which will be routed via Hong Kong.

(b) Thailand-Australia circuits will carry all kinds of traffic with Australia and New

Zealand.

(c) Telephone calls with U. K. will be routed via Hong Kong, and a half of the other European telephone traffic will be routed via U. S. A. (the remaining half via Berne radio as at present.)

(5) Others

(a) Phototelegraph and audio program transmission services will be furnished by using the telephone circuits on a common basis, because not a big demand is estimated for these services.

(b) Demands for lease of voice grade circuits and high speed data circuits are not included in this estimation because of uncertainty of such demands.

(c) The number of telephone circuits is calculated on the basis of manual operation service. If the circuits are designed for semiautomatic or fully automatic operation, additional capacity of 20 - 30% will be necessary, particularly in relation with the intra-regional service where time difference is not big.

TABLE IV-4-1. ESTIMATES OF CIRCUIT REQUIREMENT

for 1968

Direct Communication between Thailand and	No. of VFT channels					Telephone ccts.	Total V.G. ccts.
	Telegram	Telex	Lease	Total	Equivalent V.G. ccts.		
Japan	2	11	6	19	1	4	5
Hong Kong	1	2	1	4	1	6	7
Philippines	1	1		2	1	1	2
Taiwan	1	1		2	1	1	2
Viet Nam	1	1		2	1	1	2
Australia	1	2	1	4	1	1	2
U.S.A.	1	1		2	1	1	2
Malaysia & Singapore	2	1		3	1	4	5
Indonesia							
Total	10	20	8	38	8	19	27

for 1970

Direct Communication between Thailand and	No. of VFT channels					Telephone ccts.	Total V.G. ccts.
	Telegram	Telex	Lease	Total	Equivalent V.G. ccts.		
Japan	2	16	8	26	2	5	7
Hong Kong	2	3	2	7	1	9	10
Philippines	2	1		3	1	1	2
Taiwan	1	1		2	1	1	2
Viet Nam	1	1		2	1	1	2
Australia	1	2	1	4	1	1	2
U.S.A.	1	1		2	1	1	2
Malaysia & Singapore	2	1		3	1	6	7
Indonesia	1	1		2	1	1	2
Total	13	27	11	51	10	26	36

TABLE IV-4-2. ESTIMATES OF CIRCUIT REQUIREMENT

for 1975

Direct Communication between Thailand and	No. of VFT channels					Telephone ccts.	Total V.G. ccts.
	Telegram	Telex	Lease	Total	Equivalent V.G. ccts.		
Japan	3	46	13	62	4	13	17
Hong Kong	2	7	3	12	1	22	23
Philippines	2	3	2	7	1	1	2
Taiwan	1	1		2	1	2	3
Viet Nam	1	1		2	1	1	2
Australia	1	6	2	9	1	1	2
U.S.A.	2	2	1	5	1	3	4
Malaysia & Singapore	3	3	2	8	1	14	15
Indonesia	1	1		2	1	1	2
Total	16.	70	23	109	12	58	70

for 1980

Direct Communication between Thailand and	No of VFT channels					Telephone ccts.	Total V.G. ccts.
	Telegram	Telex	Lease	Total	Equivalent V.G. ccts.		
Japan	4	114	20	138	7	31	38
Hong Kong	2	17	5	24	2	54	56
Philippines	2	7	3	12	1	1	2
Taiwan	1	1		2	1	5	6
Viet Nam	1	1		2	1	1	2
Australia	1	13	3	17	2	1	3
U.S.A.	2	4	2	8	1	7	8
Malaysia & Singapore	3	7	3	13	1	33	34
Indonesia	1	1		2	1	1	2
Total	17	165	36	218	17	134	151

FIG. IV-4. CIRCUIT REQUIREMENT BY SECTION

INDONESIA

YEAR		TOTAL
1968	-	-
1970	2	2
1975	2	2
1980	2	2

MALAYSIA/SINGAPORE

YEAR			TOTAL
1968	-	5	5
1970	2	7	9
1975	2	15	17
1980	2	34	36

THAILAND

YEAR								TOTAL
1968	7	2	2	5	2	2	2	22
1970	10	2	2	7	2	2	2	27
1975	23	3	2	17	2	2	4	53
1980	56	6	2	38	2	3	8	115

VIET NAM

YEAR							TOTAL
1968	7	2	5	2	2	2	20
1970	10	2	7	2	2	2	25
1975	23	3	17	2	2	4	51
1980	56	6	38	2	3	8	113

PHILIPPINES

YEAR							TAIWAN	GUAM
1968	7	2	–	5	2	2	9	9
1970	10	2	7	-	2	2	19	4
1975	23	3	17	-	2	4	43	6
1980	56	6	38	-	3	8	100	11

TAIWAN / **GUAM**

YEAR					
1968	7	–	5	2	2
1970	10	7	-	2	2
1975	23	17	-	2	4
1980	56	38	-	3	8

HONG KONG | JAPAN | AUSTRALIA | U.S.A.

5. Income and Expenditure

Just for reference in studying the SAFEC undertaking, the revenue accruing to Thailand from services furnished over the SAFEC route and the expenditure thereof are roughly estimated in the following manner:

(1) Revenue

The amounts of revenue accruing to Thailand from the operation of cable circuits are worked out as given below:

(a) Revenue by service by year (in thousand U.S. dollar)

Service	1968	1970	1975	1980
Telegram	1,318	1,556	2,082	2,786
Telex	892	1,378	4,040	10,053
Telephone	741	1,071	2,665	6,631
Lease	378	516	1,026	1,608
TOTAL	3,329	4,521	9,813	21,078

(b) Conditions on which the above estimates are made.

(i) Traffic demands are as estimated in Item IV-3 above.

(ii) Cable circuit requirements are as estimated in Item IV-4 above

(iii) The existing rate/divisions for telegram, telex and telephone (revenue from direct services to be shared on a 50/50 basis) are applied as set forth in Table IV-5.

(iv) Tariff for leased channels is assumed from the rate standard (see Table IV-6) now being adopted for the Transpacific Cable service as follows:

50 baud Channel

Between Bangkok and	Total Rate per Month	Remarks
Tokyo	US$ 8,000	Half the total revenue will accrue to Thailand
Sydney	8,000	
San Francisco	8,000	
Hong Kong	7,000	
Taipei	7,000	
Manila	6,000	
Singapore	5,000	
Saigon	5,000	

TABLE IV-5 RATE/DIVISIONS FOR TELEGRAM, TELEX AND TELEPHONE

(in U.S. dollar)

Destination	Division of Revenue to Thailand		
	Telegram*	Telex	Telephone
	(per ord. word)	(per min.)	(per min.)
Japan	0.134	1.5	1.33
Hong Kong	0.186	1.5	1.25
Philippines	0.07	1.5	1.5
Taiwan	0.215	1.5	1.0
Malaysia & Singapore	0.036	1.5	0.72
Indonesia	0.154	1.5	1.0
U.S.A.	0.142	1.5	1.7
Australia & New Zealand	0.37	1.5	2.0
S. Viet Nam	0.097	1.5	1.0
U.K.		1.0	1.0
Other Europe		1.0	1.0
Others		1.0	

* Taking into account the reduced rate service (Letter Telegram and Press telegram) actual revenue is assumed to be two-third of what are calculated at the Ordinary Rate.

TABLE IV-6. STANDARD OF ESTABLISHING THE RATE FOR LEASED CHANNEL VIA CABLE

Distance between two Gateway Offices (statute mile)	Voice Grade	50 baud
- 1,000	US$12,500	US$5,000
1,001 - 2,000	15,000	6,000
2,001 - 3,000	17,500	7,000
3,001 - 4,000	20,000	
4,001 - 5,000	22,500	8,000
5,001 - 6,000	25,000	
6,001 - 7,000	27,500	
7,001 - 8,000	30,000	
over 8,000	32,500	8,500

Note: In principle, the rate for leased channel service is determined on the basis of distance between the two gateway offices measured in the Great Circle statute mile. However, when a circuit is set up via more than one cable section, the distance is measured through the turning points of the cable systems.

(2) Expenditure

The amount of investment required by Thailand for its acquisition of the number of circuits and the annual expenses thereof are calculated as given in Table IV-7 by applying the unit costs (see Fig. IV-5) of the cable circuits which have so far used in the SAFEC plan submitted by Japan.

As seen in Table IV-7 the amount of investment and annual expenses include those for connecting circuits beyond the SAFEC system. The annual expenses consist of depreciation of the capital cost, capital interest and operating and maintenance cost, and are estimated at 15% of the total amount of investment, viz;

depreciation of 20 years:	5% per annum
capital interest:	6% per annum
operating and maintenance:	4% per annum

In addition to the above annual expenses, it is necessary to include the expenses for the following if overall expenditures for cable operation are examined:

(a) Spare capacity of cable circuits

(b) Connecting facilities between the cable landing station and the gateway office

(c) Radio facilities necessary for the backup of cable circuits

(d) Staffing and operation for cable service at the gateway office

(e) Administration for the above

———————— 0 ————————

As an example, the expenditure on Thailand side for 1968 is estimated on a certain assumptions as described below:

(a) International circuits:

Annual expense for actual use	$644, 000
SAFEC circuits	$322, 000
beyond circuits	$322, 000
Annual expense for spare*	$322, 000

* The same number of circuits as for the actual use is assumed to be retained by Thailand in the SAFEC Thailand-the Philippines-Taiwan section as spare for future use.

(b) Connecting facilities between Rayong and Bangkok:

In the foregoing ITEM II. 6., the availability of the existing carrier cable route along the Southeast coast of the Gulf of Thailand is discussed, and the construction of a microwave system between Rayong and Bangkok is recommended. In case of constructing such a microwave system, the cost is estimated as given in TABLE IV-8.

Annual expense (25% of the construction cost for microwave system)

.... $205, 000

(c) Additional facilities for cable service at Gateway Office:

The items of these equipments and the costs thereof are assumed as given in TABLE IV-9.

Annual expense (25% of the above) $120, 000

(d) Operation at Gateway Office:

A way of calculation for the operating expense at Gateway Office is shown in TABLE IV-10.

Annual expense $536, 000

(e) Stand-by radio facilites:

In view of the existing SEACOM system Singapore - Hong Kong - Guam, it may be almost unnecessary to retain the radio facilities for backing up the SAFEC circuits. However, for securing all the more a safe guard in the event of cable emergency, four radio systems are assumed to be maintained on Thailand side. (@$40, 000 x 4 systems)

Annual expense $160, 000

(f) Total expenditure for 1968: $1, 987, 000

The balance between the estimated revenue amounting to $3, 329, 000 and the above expenditure of $1, 987, 000 clearly shows that the SAFEC undertaking by Thailand will pay fairly from the initial stage.

TABLE IV-7. ESTIMATE OF EXPENDITURE FOR CIRCUITS IN INTERNATIONAL SECTION

Section	Estimated Cost per cct. US$ (000)	Initial Amount for 1968 cct/US$ (000)		Additional Amount for 1970 ccts/US$ (000)
Bangkok-Saigon	91	22/2,002		5/455
Saigon-Manila	86	20/1,720		5/430
Manila-Kaohsiung	63	9/567		10/630
Kaohsiung-Hong Kong	46	7/322		3/138
Manila-Guam-Tokyo	304	5/1,520		5/1,520
Tokyo-Kaohsiung	114	-		7/798
Manila-Guam-San Francisco	737	2/1,474		-
Manila-Guam-Sydney	400	2/800		-
Bangkok-Singapore	38	5/190		4/152
Singapore-Djakarta	67	-		2/134
Total (thousand US$)		8,595		1,217
Amount to be borne by Thailand		4,298	+	608=4,906
Annual expenses (15% of the above)		644	+	91=735

Note: Necessary expenditure for a certain number of spare circuits may be added to the above amount.

FIG. IV - 5 LENGTH AND APPROXIMATE COST PER CIRCUIT

(Thousand U.S. dollars)

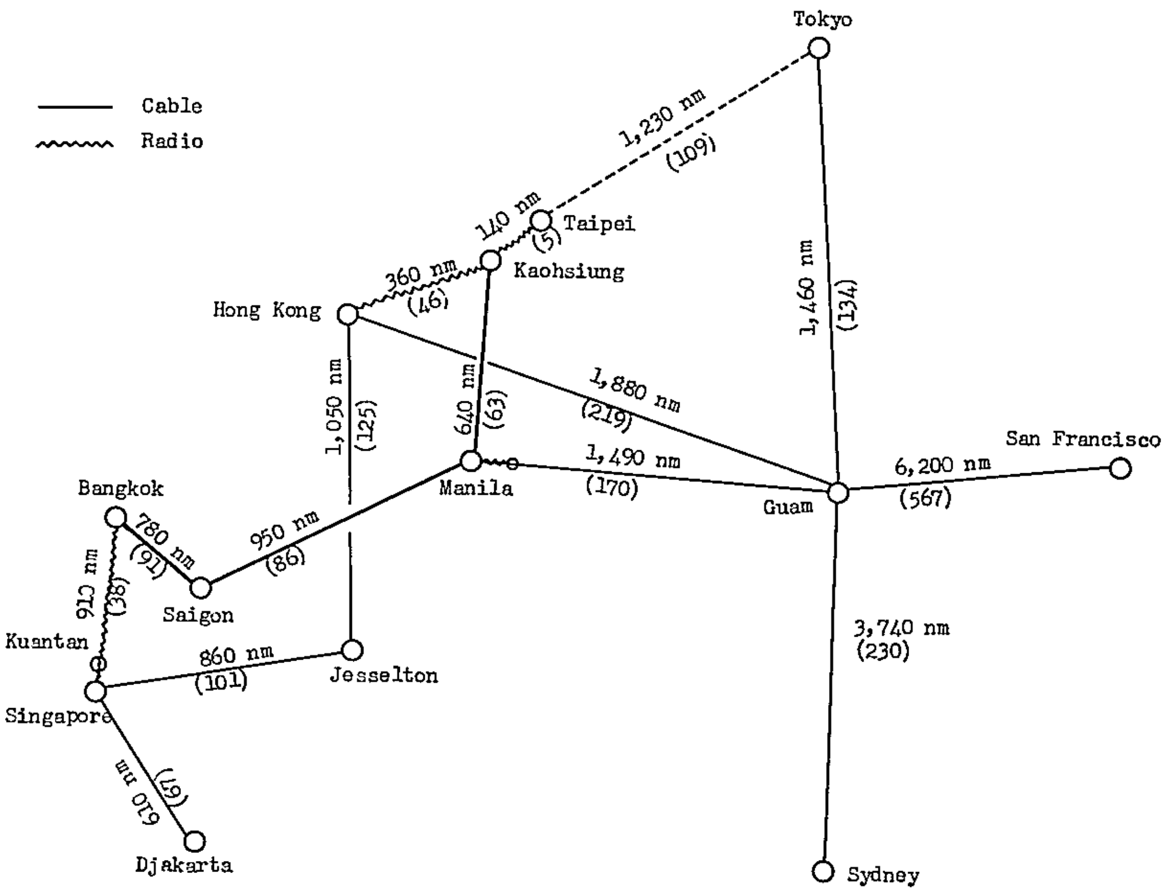


TABLE IV-8. ESTIMATED COST FOR MICROWAVE SYSTEM *1

	Ban Taphlong Nok	Khao Khrok	Khao Cahlk *2	Ban Phili Nol *2	Krungthep *2
Radio Equipment *3	64, 000 US$	78, 000 US$	103, 000 US$	110, 000 US$	85, 000 US$
Antenna Tower (Height)	8, 000 (20m)	---	---	60, 000 *4 (70m)	110, 000 (100m)
Power Supply	---	34, 000	32, 000 *5	21, 000 *5	---
Building	---	31, 000	---	---	---
Access Road	---	84, 000	---	---	---
Land	---	(1, 000m²) *6	---	---	---
Total	72, 000	227, 000	135, 000	191, 000	195, 000
Grand Total					820, 000

Note:

*1. 2 Gc, All Solid, FDM-FM, 240 CH.

*2. The already planned system KHAO CAHLK-BAN PHILI NO1 - KRUNGTHEP is assumed to be used as a part of the Rayong (BAN TAPHLONG) - Bangkok (KRUNGTHEP) system for the cable services.

*3. Not including Carrier Terminal Equipment.

*4. In case of using a constructed tower, this is unnecessary

*5. Not including Engine Generator.

*6. The price of land is uncertain. The figure shows the area required

TABLE IV-9. ESTIMATED COST FOR CABLE FACILITIES AT GATEWAY OFFICE

1. Terminal and Control Equipments: (See Fig. IV-6)

		(in thousand $)
1) Supergroup Bank (incl. Terminal Repeater)	1 bay	8
2) Group Bank (incl. AGC)	1 bay	11
3) Channel Bank	1 bay	25
4) Group and Supergroup Carrier Supply	1 bay	13
5) Channel Carrier Supply	1 bay	8
6) Signalling Equipment	3 bays	64
7) Echo Suppressor	3 bays	64
8) Order wire Equipment	1 bay	13
9) Control and Order Desk	1 desk	4
10) Test Desk	1 desk	4
11) Relay Group	1 bay	6
12) Level Control	2 bays	14
13) 4-wire Test Frame	3 bays	8
14) 2-wire Test Frame	1 bay	3
15) Voice Distribution Frame	1 set	6
16) Teletypewriter	2 seats	4
17) Intermediate Battery Supply	1 bay	3
	TOTAL	257
Design and Installation (40% of the above)		103
	GRAND TOTAL	360

2. Telephone Switchboard:

The following cord switchboard equipments for a ring down operation are assumed to be installed for cable service.

		(in thousand $)
Relay Group	100 Ccts	28
Test Equipment	2 Frames	6
Switchboard	23 Positions	51
	(Total)	85
Design and Installation	(40%)	34
	(Grand Total)	119

Remarks: When a semi-automatic operation is required, the cost thereof is estimated as follows:-

		(in thousand $)
Main Switch Frame	16 Frames	31
Trunk Circuit	215 Ccts	31
Sender Link Frame	2 Frames	4
Link Controller	2 Ccts	3
Register - sender	12 Ccts	20
Marker	3 Frames	29
Trunk Block Connector	1 Frame	3
Translator	4 Frames	14
Signal Generator	1 Frame	13
Cordless Switchboard	15 Positions	33
Switchboard Equipment	24 Frames	59
Test Equipment	12 Frames	38
(Total)		278
Design		56
Installation	(20%)	56
	(Grand Total)	390

3. Total Cost: ($479, 000)

FIG. IV-6. DIAGRAM OF TERMINAL AND CONTROL EQUIPMENTS

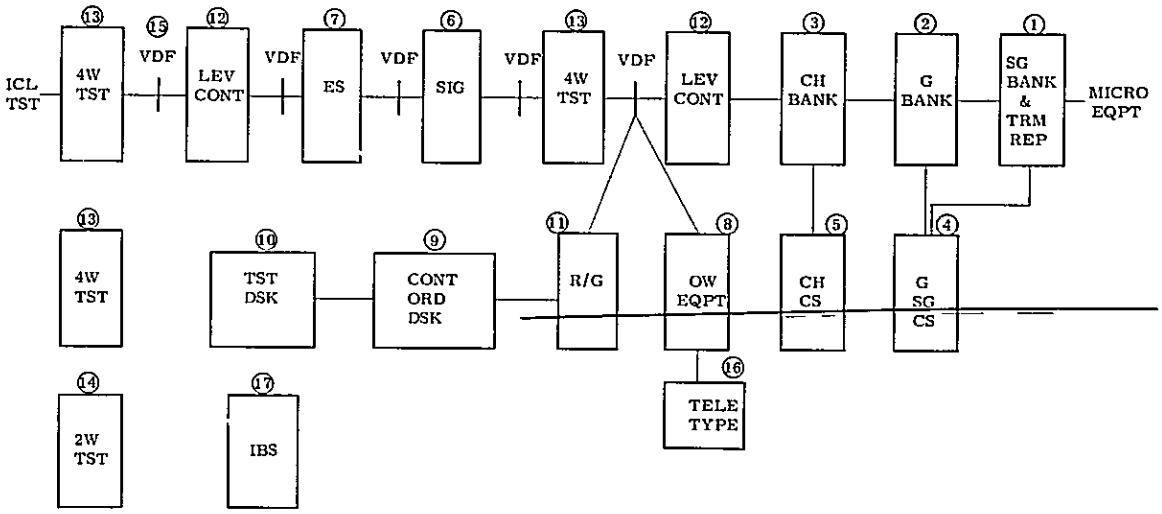


TABLE IV-10. OPERATING EXPENSES FOR CABLE SERVICES AT GATEWAY OFFICE

1. Number of operators and technicians:

Telegram	6 persons x 10 cable circuits
Telex	4 persons x 21 cable circuits
Telephone	3 persons x 19 cable circuits
Maintenance	0.25 persons x 59 (incl. 9 leased circuits)

Total .... 216 persons

2. Average wage per head per annum: $1,200

3. Staffing expense:

   $1,200 x 216 = $259,000

4. Total operating expenses

   It is usually assumed that 60% of the total expenses at gateway office are occupied by the staffing expense, viz: $\$259,000 \times \frac{1}{0.60} = \$432,000$

5. Administration expense

   A 25% of the total expenses is assumed for the administration of gateway office, viz: $432,000 x 0.25 = $104,000

6. Annual expense: $536,000

V STUDY OF LEGAL ASPECTS

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The SAFEC system is to be constructed and maintained as a joint venture of the authorized telecommunication entities in the respective countries participating in this project in accordance with an agreement to be concluded among these entities.

We have studied some legal aspects of the domestic laws and ordinances of Thailand in relation with the cable agreement, referring to the existing Transpacific cable agreement as a pattern. An outline of the the cable agreement is described in Appendix I.

The result of our study shows that there is no serious obstacles standing in the way of concluding a cable agreement by Thailand

However, there seem to be some minor points which require further studies in connection with the Thai domestic laws and ordinances concerned. Our studies of these points are summarized as follows:

1. Co-ownership of Cable Facilities

Articles 5 and 6 of the Telegraph and Telephone Act (B. E. 2477) stipulate that the Post and Telegraph Department is entitled to construct and own the telecommunication facilities within the boundaries of Thailand unless otherwise provided for.

On the other hand, it is the way of joint cable agreement that the cable system including both landing terminals is, in general, owned in undivided shares by the entities concerned; the co-ownership by the foreign entity is to exist in the territory of Thailand.

It would, therefore, be necessary to examine whether it is possible or not to exclude the application of the above provisions of the Act in view of the nature of such joint cable agreement.

2. Limitation to Term for Non-Partition Agreement on Joint Property

The cable agreements are generally made to be in force for a minimum period of 25 years. It is therefore necessary to limit the right to demand, by one of the joint parties, any partition of the co-owned cable facilities at least during the said contract period.

Under Article 1363 of the Civil and Commercial Code (B E. 2468) it is not permitted to make any non-partition agreement effective for more than 10 years except the case where

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Therefore, it is necessary to determine whether the co-ownership of the cable facilities comes under the category of such permanent character as provided for in the above Code.

Meanwhile, even if the co-ownership of the cable facilities can not be recognized as having such character, the cable agreement can be renewed every 10 years on or after the expiration of the term of 10 years (Para 2 of the above Article) by laying down in the cable agreement an appropriate provision for making the minimum 25 year contract practicable A similar arrangement has been made in the Transpacific cable agreement

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CIVIL AND COMMERCIAL CODE OF THAILAND

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A co-owner may not demand partition at an unreasonable moment.

3. Protection of Underwater Cable

A certain method of fishery and ship anchoring may cause damage to the cable laid in the shallow water around the Gulf of Thailand, even if the armoured cable is buried in the sea bed.

Therefore, in addition to the penal provisions provided for in Chapter IV of the Telegraph and Telephone Act, it would be desirable to protect the cable from such damage by setting up a restricted area where a certain method of fishery and ship anchoring is prohibited.

Further study will be necessary as to the setting up of such restricted area in connection with the present fishing method and its furture trend.

4. Acquisition of Land for Cable Landing

In view of the Chapter III of the Telegraph and Telephone Act, there will be no particular difficulty in acquiring the land necessary for cable landing and terminal installation.

APPENDIX

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OUTLINE OF AGREEMENT FOR NEW TYPE SUBMARINE CABLE SYSTEM

In order to give a brief outline of the present cable agreement based on the new form of cable management, the following chapters deal with the structure of agreement centering around the Transpacific Cable Construction and Maintenance Agreement between Japan and U. S. A.

(1) Principle of Agreement

While the old cable systems are used to be managed singly by an enterprise belonging to a certain country, the new cable systems are constructed and operated jointly by the Administrations and/or private operating agencies concerned in the joint telecommunication services to be handled through such cable systems; the new systems are entirely based on a joint venture of the parties concerned who should accordingly bear the construction and maintenance costs in proportion to the number of circuits allocated, and would receive the division of revenue due from the services furnished over such circuits on a 50/50 basis in the same way as that for the radio communication.

In this way, although the fundamental concept of the agreement takes the form of joint enterprise, it does not establish a new company or partnership. It only stipulates the relationship of the right and the responsibility between the parties concerned. In other words, the respective parties maintain its independence in the same manner as the two terminal parties do in the case of radio communications.

In the case of SAFEC project, the establishment of a special company is being considered as a managing agent of the cable construction, maintenance and so forth, in view of the great number of participating countries and financing arrangement But even in this case, a partnership is not being envisaged.

(2) Parties to Agreement

The cable agreement stipulates the right and responsibility concerning the construction and maintenance of cable systems, and the utilization of capacity of cable circuits. It contains mainly the provisions concerning property rights, and it may be said that it belongs to a private contract judging from its characteristics. Therefore, the parties to the agreement are enterprises authorized by the domestic laws and regulations of the respective countries to operate international telecommunication services.

They can be a government itself, or a private or public enterprise. It is needless to say that the government in this case is not the entity of public right but that of the public enterprise. Even if one of the parties to the agreement is a private enterprise, both of them have entirely equal rights and responsibilities.

(3) Object of Agreement

The main object to be dealt with under the cable construction and maintenance agreement is the cable system consisting of the submarine cable, intermediate repeaters and equalizers, associated cable station equipments and land and buildings appropriate for the cable landing station, costs of which are to be borne jointly by the parties concerned.

In order to operate the cable system for communication purposes, it is necessary to have domestic connecting lines from the cable landing station to the gateway office as well as necessary facilities at the gateway office. Provisions of these properties are put at the responsibility of the enterprises of each country under the agreement although they are not dealt with as the main object of the agreement; it is merely confirmed in the agreement that these domestic facilities should be provided prior to the completion of the cable system.

Furthermore, while the legal relations under the agreement of old cable systems were centered on a type of administrative act such as the governmental approval for cable landing, the new type of agreement only stipulates that the arrangements necessary for landing approval should be the responsibility of the enterprise in that country.

For accounting purposes, the terminal facilities including power supply equipment installed in the cable landing station are normally divided into two parts; one part is for the connection with the submarine cable and the other for the connection with the gateway office. Also land and buildings at the cable landing site are divided into two portions in the same way at the percentage agreed to by the parties concerned. The cable agreement normally provides only for those portions which are meant for the submarine cable.

(4) Construction and Maintenance of Cable

Construction and maintenance of the cable system is regarded as the joint responsibility of the parties concerned. In actual construction works, however, the planned cable system is divided into various sections, and the responsibility for designing, engineering, procurement and installation of these sections are shared among the parties concerned taking into account the location of territory, technical experience and other relevant factors.

Generally speaking, the provision of land and buildings at the cable landing site is made by the party of the country to which the land belongs, and the construction of submarine cable portion and the installation of terminal equipments are carried out by the party who has technical experience in the construction of cable systems.

Appendix II

SEDIMENTS OF THE GULF OF THAILAND

AND

ADJACENT CONTINENTAL SHELF

by
K. O. Emery
Hiroshi Niino

Geol. Soc. Am. Bull., v. 74, pp 541-554
1963

K. O. EMERY *University of Southern California, Los Angeles, Calif.*[1]
HIROSHI NIINO *Tokyo University of Fisheries, Tokyo, Japan*

Sediments of the Gulf of Thailand and Adjacent Continental Shelf

Abstract: A total of 111 well-distributed sediment samples from the Gulf of Thailand and the adjacent continental shelf were analyzed. The material is dominantly detrital in origin, of modern distribution in the Gulf and on the inner third of the shelf, and relict from a time of lower sea level on the outer half of the shelf. The distribution pattern of organic matter caused by seasonal winds indicates upwelling probably along both sides of the Gulf. The patterns of grain size and of organic matter also suggest that a current flows into the Gulf at the north side of its mouth and that another flows out at the south side. Geological data supported by drill and magnetic measurements show that the long wide river valley at the head of the Gulf is a structural trough formed during the Late Tertiary. In the Gulf a closed depression represents an unfilled extension of this structural trough. Both areas together form an unfilled geosyncline which is still receiving sediments.

CONTENTS

INTRODUCTION AND ACKNOWLEDGMENTS

During 1956 studies were made of nearly 1000 bottom samples from the shallow parts of the East China Sea and the South China Sea (Fig. 1) in order to learn more about the patterns of sediment distribution on broad marine platforms. Results of the studies indicated that the broadest part of the area, the Yellow Sea, is the site of a modern zeugogeosyncline, rather than an epicontinental sea atop a stable platform (Niino and Emery, 1961).

Continued efforts to investigate sediments of an epicontinental sea resulted in the as-

[1] Present address, Woods Hole Oceanographic Institution, Woods Hole, Mass.

Geological Society of America Bulletin, v. 74, p. 541–554, 7 figs., May 1963

sembly of several sets of samples from the Gulf of Thailand, just south of the limit of the previous study. Sampling began in November 1957 when Dr. F. P. Shepard (Scripps Inst. Oceanography) and Emery collected several snapper samples from the canals of Bangkok (Krungthep) during the Ninth Pacific Science Congress. During the following month Shepard obtained more samples, a total of 18, on a cruise aboard a Thai navy ship. An additional 59 well-distributed surface grab samples were

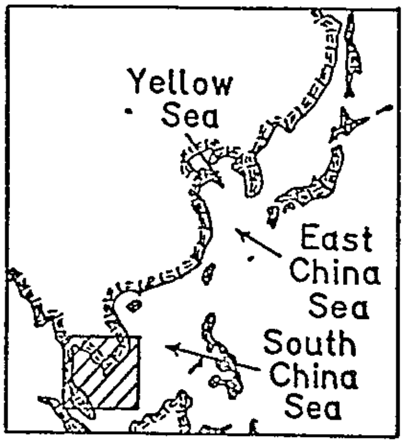

Figure 1. Index map, Gulf of Thailand and adjacent continental shelf

taken during an oceanographic survey aboard R/V STRANGER of the Naga Expedition in 1959–1960 through the cooperation of Dr. T. K. Chamberlain and Mr. James Faughn (Scripps Inst. Oceanography). Biological work of the Naga Expedition during the following year produced about 145 more sediment grab samples, but these were concentrated in only a few areas, so only seven of the samples were included in this study. Seven other samples of unknown date were made available by the U. S. Navy Hydrographic Office. To supplement these collections from offshore, an additional 20 samples from beaches and other shores of Thailand were collected and presented to the authors by Dr. T. H. F. Klompé (Dept. Geology, Chulalongkorn Univ., Bangkok).

The samples were studied during the fall of 1961 when Niino was given a leave of absence from Tokyo University of Fisheries in order to work with Emery at the University of Southern California. Funds for this study were provided by the Office of Naval Research (Contract Nonr 228-17).

TOPOGRAPHY AND GEOLOGY

Land

Detailed contour maps, by Thai and other governments of the region, are available for some areas but are lacking for most of the area. Spot elevations and generalized contours are given by marine and aerial navigation charts published by British and United States government agencies. Surface geology of the entire region is shown by maps of the Central Research Institute of Electric Power Industry (1959), of Kobayashi (1960), and of Kaufmann (1961). A more detailed presentation is given for Malaya by Alexander (1958; 1961), for Thailand by Brown and others (1951), and for Cambodia and Vietnam by Fromaget and Saurin (1952).

Along the northeast coast of the Thai-Malaya Peninsula is a coastal plain having a maximum width of about 25 km. The plain is crossed by numerous small streams originating in the jungle-covered mountains in the interior. These mountains reach elevations in excess of 2000 m and consist mainly of Paleozoic and partly of Mesozoic sedimentary rocks laced with granite and some extrusive igneous rocks. The general structural trend is north-northwest to north (more northerly than the trend of the peninsula itself).

At the head of the Gulf of Thailand, near Bangkok, and extending about 400 km northward is a broad flat valley occupied by Quaternary marine and continental sediments. Along the valley flows the largest river entering the Gulf, the Chao Phraya (Fig. 2). Locally, the tops of hills, composed mostly of Paleozoic limestone and some granite, rise above the otherwise flat plain. In the rest of the plain the Quaternary sediments are capped by laterite. This is low in silica and usually low in alumina. It is iron rich (to 70 per cent Fe_2O_3), spongy, pisolitic, and is locally mined for iron, but more commonly it serves as blocks for construction purposes, both ancient and modern. A well drilled in 1959 at Ayuthaya (65 km north of Bangkok) penetrated 1837 m of Quaternary sediments and ended at 1838 m in shale and limestone of probable Permian age (Kaufmann, 1961; Klompé, personal communication). Aerial magnetometer surveys indicate that the depth to basement (the same as the thickness of the Quaternary) increases from about 1800 m near Ayuthaya to 3300 m at the mouth of the Chao Phraya River.

Between the head of the Gulf and a point south of Pnom Penh (Fig. 2), the coast is mostly irregular and rocky with few entering streams. It consists mostly of continental sand-rounded by hills of 500 m or more. The plateau is underlain by as much as 1200 m of the Korat Series, mostly flat-lying.

The next segment of coast, extending to beyond Saigon, is the low delta of the Mekong River, the second-largest river of the region.

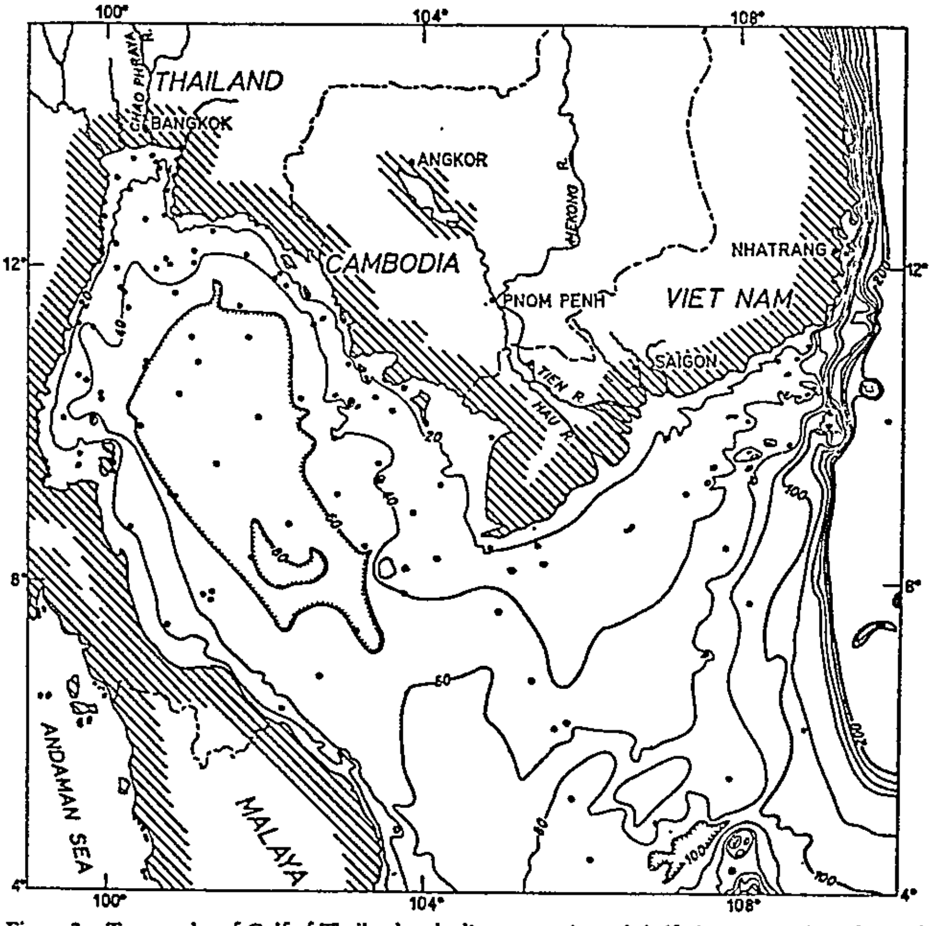

Figure 2. Topography of Gulf of Thailand and adjacent continental shelf. Contours at 20-m interval drawn from soundings on British Admiralty chart 2414 and U. S. Hydrographic Office charts 0796 and 0797. Circles indicate positions of bottom samples.

stones and conglomerates of the Triassic-Jurassic and younger Korat Series; granites, gneisses, and schists occur locally. Most of the islands consist of the Korat Series. North of this coastal segment and occupying most of the large eastern bulge of Thailand is the Korat Plateau at an elevation of 50–200 m and sur-On one of its tributaries is the large lake, Tonlē Sap (Dussart, 1962), near the shore of which was established the capitol of the ancient Khmer empire at Angkor. The delta and the broad valley of the Mekong River are intensively cultivated, as are the delta and valley of the Chao Phraya River near Bangkok.

Northeast of Saigon the coast is rugged and rocky with only small streams. Granite and other igneous rocks form the resistant coastal points between which are short sections of coastal plain underlain by Quaternary sediments. A wide variety of igneous and metamorphic rocks extends inland to the Korat Plateau. The general structural trend is northerly; but curving around the Korat Plateau. Elevations in this complex belt reach 1600 m.

The geological history (Brown and others, 1951; Kobayashi, 1960; Klompé, 1962) begins with the accumulation of thick Paleozoic sediments in a geosyncline. During Late Paleozoic time the easternmost part of the geosyncline became intensely folded. During Late Triassic and Late Jurassic times the western part of the geosyncline from the Thai-Burmese border to the tip of Malaya was compressed into a series of almost north-south trending folds and intruded by granite. In the eastern part of the area (Korat Plateau and part of Cambodia) these folds are buried under younger continental strata of the Korat Series. During Late Tertiary time the region of the Korat Plateau was uplifted, while at the same time the belt along the Chao Phraya River was depressed. These movements were accompanied by some intrusive and much volcanic activity. At that time the ocean reached several hundred km north of Bangkok. Subsequently marine and continental sediments filled the depression to the present head of the Gulf of Thailand. The region is now rather stable tectonically, with very few earthquakes (Gutenberg and Richter, 1949, p. 65).

Sea Floor

The topography of the Gulf of Thailand is known only in a general way; systematic surveys have not been made since a British one in the 1800's. Existing lead-line soundings are shown on British Admiralty chart 2414 within the Gulf and on U. S. Hydrographic Office charts 0796 and 0797 for the shelf to the east. Contours at 20-m interval based on these soundings are given by Figure 2. Along the sides of the Gulf the bottom is interrupted by hills, many of which rise above sea level as islands. The middle is flatter, forming a depression 84 m below sea level and 30 m below its sill at the mouth of the Gulf. The mouth is defined as a line between the southern tip of the Mekong Delta and the small island off Malaya (azimuth 213°). Within the Gulf the area is 320,000 square km and the average depth is 44 m.

The continental shelf seaward of the Gulf and off the Vietnam coast exhibits an irregular increase in depth to the shelf-break at about 130 m. The surface, particularly northeast of Saigon is broken by many hills. Recent echo soundings by R/V STRANGER show the presence of a deep trough parallel to shore north of about 14° latitude; these soundings also indicate at least one terrace atop the shelf having an average depth at its seaward edge of about 50 m. The entire shelf (Fig. 2) has an area of 415,000 square km and an average depth of 65 m.

The broad depression within the Gulf is not such as would be expected in an epicontinental sea. East of its sill the bottom is at least partly rocky (Fig. 3) at depths as shallow as 60 m, suggesting that the sill of the depression may be rocky and only thinly overlain by sediments. If such is true, the depression can only be tectonic in origin. Its northern extension past Bangkok is certainly tectonic, having been depressed during the Tertiary to a depth of at least 3000 m below sea level. From the scanty present knowledge it seems likely that the depression of the Gulf is related to that of the Chao Phraya River and was formed by tectonic activity during Late Tertiary time.

Rocks along the Cambodian shore of the Gulf belong mostly to the Korat Series, suggesting that these strata also extend southward toward the sill of the Gulf depression (Fig. 2). The western half of the depression is more likely to be deeply underlain by folded Paleozoic strata, as in the Chao Phraya River valley. As shown by Alexander (1958) and Kobayashi (1960), several anticlines and synclines in Paleozoic strata of Malaya apparently continue beneath the Gulf to Thailand. These strata and their structures have been buried under Quaternary sediments in the Gulf and its former northerly extension past Bangkok. The thickness of these sediments in the Gulf may exceed the 3000 m shown by the magnetic survey to be present at the mouth of the Chao Phraya River. Continued filling of the Gulf by sediments transported by the river is indicated by prograding of the delta averaging 4-5 m per year (Brown and others, 1951).

CLIMATE AND OCEANOGRAPHY

The climate within the Gulf of Thailand is tropical, with coastal areas classed as Köppen *Af* (rain forest), having nearly uniform distribution of rain throughout the year. Inland the rain is more seasonal—dry in winter—and the climate is classed *Awi* (savanna) (Goode, 1943, p. 21; Brown and others, 1951). The high temperature and high rainfall have produced widespread laterites atop various kinds of substrate.

Over the Gulf the annual rainfall probably averages about 250 cm. Runoff from the Chao Phraya River has produced a strong salinity gradient from about 5 ‰ near shore to between 31 and 32 ‰ at the mouth of the small square bay at the head of the Gulf. In the main part of the Gulf there is a variation of 28–32 ‰, with a suggestion of a preference for dilute water to be on the southwestern side of the Gulf, as revealed by the first oceanographic surveys of the Gulf made by the Royal Thai Navy in 1956 and 1957 (Penyapol, 1957). Rather sparse records at sea (U. S. Department of Commerce, 1938; Royal Netherlands Meteorological Institute, 1935) indicate an annual variation of air and water temperature of only 26–30°C. Characteristically, the waters of the Gulf are warmer than those of the adjacent open sea at all seasons. Results of one of the cruises by R/V Stranger (21 April to 2 May, 1960) show temperatures of 29–31°C at the surface, decreasing downward to less than 27°C in the depression (Robinson, 1961). The less warm water at depth may be residual from winter cooling, similar to cool patches on the floor of the Persian Gulf (Emery, 1956). Currents are as yet poorly known but are being investigated from data obtained by R/V Stranger during the Naga Expedition. Winds are of lower velocity than in the open sea, mostly less than 3 m/sec versus more than 6 m/sec. They blow into the Gulf during winter and out of it or toward the east during summer, probably influencing water movements. These winds may cause upwelling along the east side of the Gulf during winter and along the west side during summer (LaFond, 1961).

GENERAL TEXTURE AND COLOR

Prior to this study the only information about bottom materials in the Gulf of Thailand came from chart notations based upon the traces of sediment caught by tallowed leads used for the nineteenth-century soundings. These data were compiled by Shepard, Emery, and Gould (1949) for the entire East Asiatic coast. Parts of three of their bottom sediment charts (unpub. Hydrographic Office Nos. BS 2414, BS 0796, and BS 0797) occur in the area of Figure 2, and these were combined as Figure 3. Altogether about 7000 notations of bottom material are present, with about 2800 in the Gulf itself.

The chart notations show two provinces of different bottom sediments: the Gulf—dominated by muds, and the shelf—dominated by sands. Within the Gulf irregular patches of sand-and-mud, sand, gravel, and even rock occur near the sides, particularly on slight topographic highs and off irregular rocky shores. Although the shelf is mostly covered by sand, mud occurs off the mouth of the Chao Phraya River and its distributaries, across much of the shelf south of the Gulf entrance, and in deep water. Rock is common on the irregular narrow shelf off Vietnam, atop the coral reef beyond the shelf-break at 8° latitude, and around the island on the southern part of the shelf (Fig. 3).

Laboratory examination of the 111 bottom samples provided supplementary information. Using a binocular microscope, each sample was assigned to one of four types: sand (at least 90 per cent of the bulk consisting of grains coarser than 62 microns), muddy sand (50–90 per cent sand grains), sandy mud (10–50 per cent sand grains), and mud (less than 10 per cent sand grains, the rest of the bulk being silt or clay). A map (Fig. 4) of the distribution of these textures shows that the laboratory examination permitted a subdivision of the mud area shown in Figure 3. Minor differences result from the denser sampling grid of bottom notations as well as from the more precise and uniform identifications made by a single observer in the laboratory.

The color of each sample was estimated by comparison with a standard color chart (Goddard and others, 1948). Ignoring minor transitions, most samples could be assigned one of the following three colors: yellow brown (10YR 5/2), olive brown (5Y 4/4), or olive gray (10Y 4/2). The yellow brown occupies two areas—a small one near the mouth of the Chao Phraya River where it may be due to reworked laterite and a large one on the continental shelf where it is due to slight iron stain on sand grains. Olive-gray sediment occurs only in a narrow belt of mud and sandy mud near the head of the Gulf. Sediment of olive-brown color lies partly between areas of the two previous colors within the Gulf and as a southward extension of the yellow-brown sands on the continental shelf; it appears to be unrelated to grain size.

MEDIAN DIAMETER AND SORTING

Grain-size distributions were determined on whole samples because the content of calcium fractions by wet screening on 62-micron sieves. The dried coarse fractions were sieved or tubed and the fine fractions were pipetted using sodium hexametaphosphate as dispersing agent (Krumbein and Pettijohn, 1938, p. 137–142, 157, 166–172). Cumulative curves

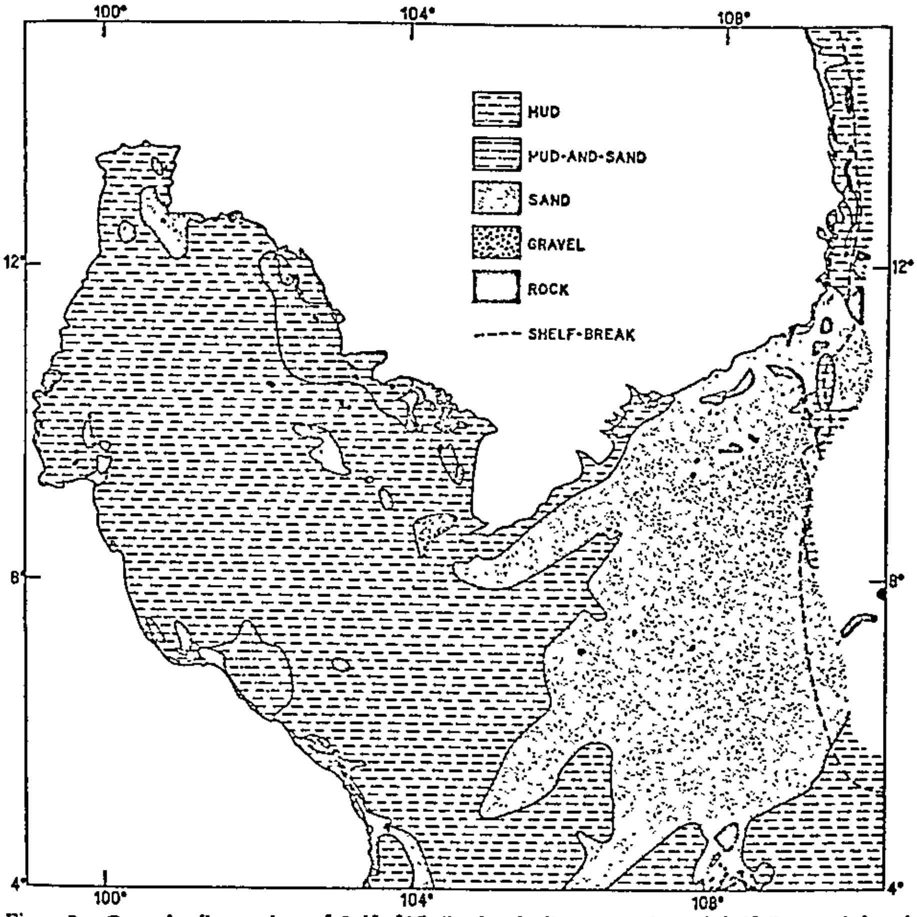

Figure 3. General sediment chart of Gulf of Thailand and adjacent continental shelf. Pattern is based upon about 7000 notations of bottom materials on navigational charts (Shepard, Emery, and Gould, 1949).

carbonate was generally so low as not to affect materially the grain size parameters. For the East China Sea and South China Sea, where calcium carbonate was more abundant (Niino and Emery, 1961), the grain-size distributions were measured on acid-insoluble residues. The procedure was to separate coarse and fine drawn on probability paper permitted the selection of median diameters and quartiles for statistical computations.

The analyses show that the coarsest sediments, sands, occupy three different kinds of areas (Fig. 4). One is near shore off rocky coasts where they constitute small beaches and their submarine extensions. Because the coast is irregular and samples are few, nearshore sediments are depicted in only a general way. The second, a band of sand across the head of the Gulf just beyond the delta of the Chao Phraya River, is of unknown origin; it does not represent a topographic sill according to existing soundings but may mark an ancient submerged beach. The third and largest area of sand covers the continental shelf, occupying a position similar to sands beyond the entrance of the Yellow Sea (Niino and Emery, 1961). Extending tonguelike through the center of the Gulf is an area of fine silt containing three subareas of clay (<4 microns). This sediment occurs in the central depression of the Gulf but is not restricted to it. The sediment is finer-grained than that of the Yellow Sea and the Gulf of Tonkin. Existing samples, though scanty, appear to indicate that this tongue of fine-grained sediment extends beyond the Gulf to cover the inner half of the continental shelf farther south—again similar to the pattern in the Yellow Sea where fine-grained sediment has been carried by a southward-flowing coastal current.

The Trask sorting coefficient (So = $\sqrt{Q_{25}/Q_{75}}$) ranges from about 1.2 to 28.9.

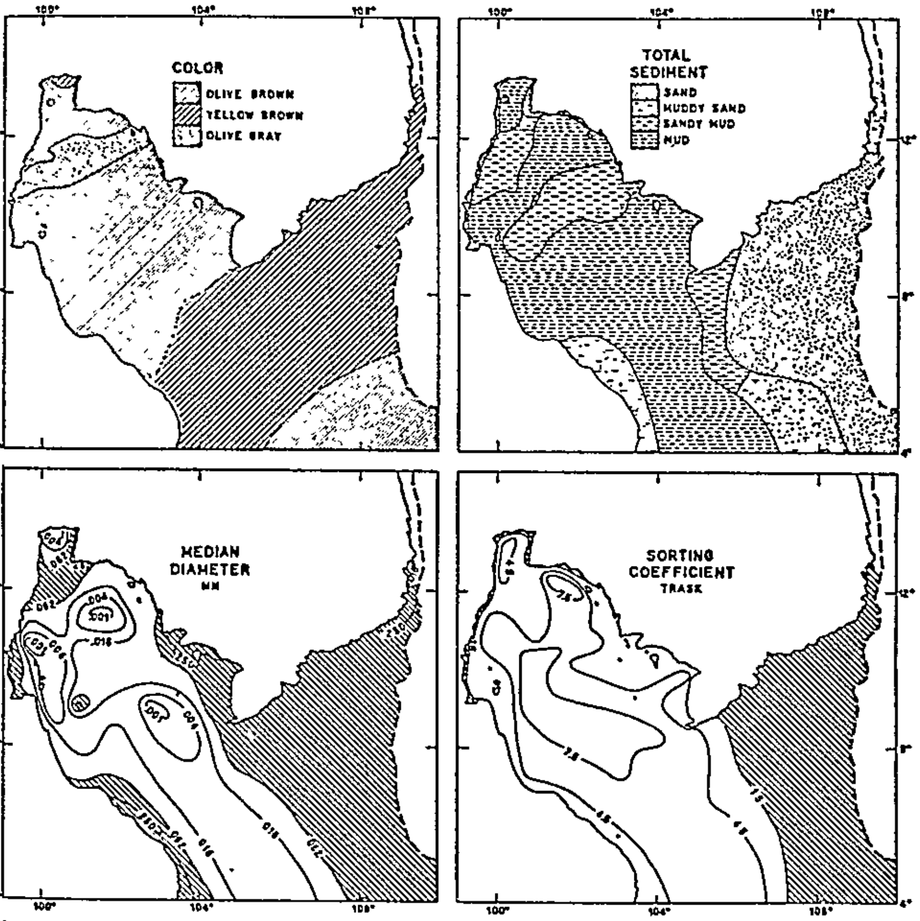

Figure 4. Colors, general descriptions of total sediment, median diameters, and sorting coefficients, Gulf of Thailand and adjacent continental shelf

As typical of sediments elsewhere, the highest sorting coefficients (poorest sorting) generally characterize the finest sediments so that the lines of equal sorting (Fig. 4) are related to lines of equal grain size.

ORGANIC MATERIALS

Calcium Carbonate

About 5 gm of sediment from 80 samples was powdered, dried, and reserved for chemical analyses. A 0.6-gm portion was used for calcium carbonate according to the gasometric method of Bien (1952). The volume of carbon dioxide liberated from each sample by acid was measured and computed as calcium carbonate, although a small percentage may actually have been combined as magnesium carbonate. For the 20 samples of beach sands the percentage of calcium carbonate was estimated visually.

The results show that the content of calcium carbonate ranges from 0 to 33 per cent (Fig. 5), except for two shelly beach sands. Low concentrations (0–10 per cent) occur in a belt around the entire shore (except for a few small beaches) and as a broad area atop the outer half of the continental shelf. High concentrations (20–30 per cent) form a narrow north-south belt along the middle of the continental shelf. Intermediate values characterize most of the Gulf, including its area of deepest water, and the shoreward third of the continental shelf south of the Gulf. Concentrations of calcium carbonate within the Gulf are similar to those of the Yellow Sea and the Gulf of Tonkin, but those of the continental shelf are only about one fifth those on the continental shelf between Vietnam and Korea (Niino and Emery, 1961). The content of calcium carbonate does not depend upon grain size (Fig. 6).

Nitrogen

A 1.0-gm portion of the powdered samples was analyzed for nitrogen content using the standard micro-Kjeldahl method (Kabat and Mayer, 1961, p. 476–483). Analyses were made for 92 samples, 10 in duplicate; most beach sands were omitted because of their obviously low content of organic matter. The results ranged from near 0 to 0.16 per cent nitrogen, all of which is considered to be organic nitrogen.

Plotted in map form (Fig. 5), the values are shown to be lowest (for the most part less than 0.025 per cent) in the sands of beaches and the continental shelf. Highest values (greater than 0.050 per cent) occur in several separate areas of fine sediment within the Gulf. These areas lie along either side of the Gulf, leaving an axial area of fine sediment with only moderate contents of nitrogen. Even though the percentage of nitrogen in the sediments is not closely defined by the grain size, there is still a general relationship between the two characteristics (Fig. 6). When plotted against percentage of clay component, nitrogen exhibits a similar relationship.

Organic Carbon

Another 1.0-gm portion of the powdered samples was analyzed for total carbon using a Leco (Laboratory Equipment Company) induction furnace, gas purification train, and automatic manometer. Thirty-eight samples were so analyzed, some in duplicate. Sands of beaches and the continental shelf were not included because of their low expected values of organic carbon. Carbonate carbon from a separate fraction of the sample was subtracted from the total carbon, yielding organic carbon. The latter ranged from near 0 to 1.3 per cent (except for two isolated higher values).

When plotted in map form, organic carbon shows a pattern similar to that of nitrogen, with highest concentrations near both shores of the Gulf and lower ones near the axis. The pattern is exaggerated over that of nitrogen, however, and the cause is to be seen in Figure 6, wherein organic carbon is shown to be unrelated to median diameter or even perhaps decreases with decrease in median diameter opposite the trend shown by nitrogen.

In order to more fully visualize the differences in distribution of organic carbon and nitrogen, their ratio was computed. The mean of 32 C/N ratios is 13, slightly higher than typical values for California basin sediments (Emery, 1960, p. 276). However, some samples have ratios exceeding 30. As shown by the map (Fig. 5), the high C/N ratios occur around the margin of the Gulf, perhaps an indication of greater abundance of high-carbon, terrestrial, organic matter near the sides than near the middle of the Gulf.

Shells and Tests

Foraminifera are present in almost every sample but are abundant only in fine sands, particularly near the entrance to the Gulf. Shells of mollusks are present both in the Gulf and atop the continental shelf. Most of them within the Gulf are of thin fragile pelecypods which live in the muddy bottom. Shells on the shelf are of heavier-walled pelecypods and gastropods, most of which have been badly broken by currents and wave action. A curious calcareous conical mud-filled form is largely restricted to the area of the depression within the Gulf. Its origin is unknown, but pteropod, of the whole sediment. Mapping of the organic remains using contours of abundance was considered impractical. In 58 samples the coarse sieve fraction (> 62 microns) contained enough calcareous material to permit the making of visual estimates of the ratio of mollusk shells to foraminiferal tests. The average ratio is 7 to

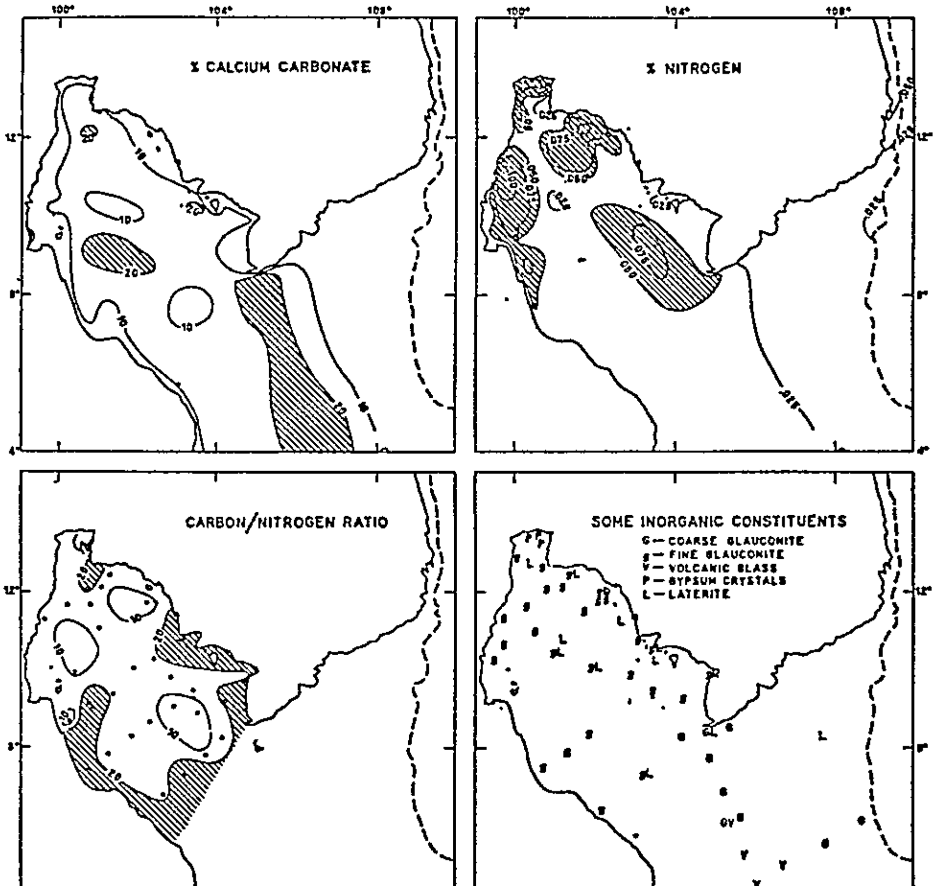

Figure 5. Distribution of contents of calcium carbonate, nitrogen, carbon/nitrogen ratio, and some inorganic constituents of the sediments, Gulf of Thailand and adjacent continental shelf

bryozoan, and polychaete worm sources were considered and rejected.

Although well-preserved shells and tests, as well as broken ones, are present in nearly all the samples, the material is generally so masked by much larger quantities of fine detrital sediment that it constitutes only a few per cent 3, but within the northern two thirds of the Gulf and atop the entire continental shelf it averages 9 to 1. At the entrance of the Gulf the ratio is 2 to 8; this is .l.. only large area where foraminiferal tests are more abundant than shell debris.

Siliceous remains were contributed by

diatoms, radiolarians, and sponges. There seems to be little regional limitation in distribution of any of these forms. Although sought, no fresh-water diatoms were found, even off the mouth of the Chao Phraya River.

LATERITE

Many samples, particularly in the northeastern side of the Gulf (Fig. 5), contain grains of laterite. The grains are easily recognizable because of their yellow-brown color, although they usually constitute much less than 1 per cent of the total sample. Most of them are irregular, soft, and earthy, but others are subspherical and concretionary with concentric layering of iron oxide. In most samples these grains are coarser than the associated detrital sediment, indicating either that they are more easily transported (earthy grains) or that they come from nearby submarine outcrops of laterite. A few samples, unfortunately of unknown position but probably from the head of the Gulf, contain pieces of laterite as large as 4 cm.

AUTHIGENIC FRACTION

Glauconite of the region consists of two types. Most samples from atop the continental shelf contain round dark-green grains as large as 1 mm in diameter and possibly reworked from some shale. Within the Gulf this kind of glauconite does not occur (Fig. 5); instead, many samples contain fine-grained (usually about 50 microns) angular light-green glauconite. This material may be forming now in the Gulf sediments.

Three samples contain tabular crystals of opaque white gypsum as long as 5 mm, much larger than associated detrital minerals, and obviously untransported. All three samples are ones collected by Shepard during 1957 in the shallow region off the mouth of the Chao Phraya River (Fig. 5). It is possible that the crystals formed in the sample bottles owing to very slow drying of the sediment during storage. However, Emery has noted crystals of gypsum and even replacement of calcite shells by gypsum in other sea floor areas not subject to extreme evaporation. Possibly they are due to reaction with calcium by sulphate ions formed by oxidation of hydrogen sulphide which rose from an anaerobic environment at depth to the aerobic waters at the sediment surface.

Other common authigenic marine sediments, phosphorite and manganese oxide, were noted in none of the samples.

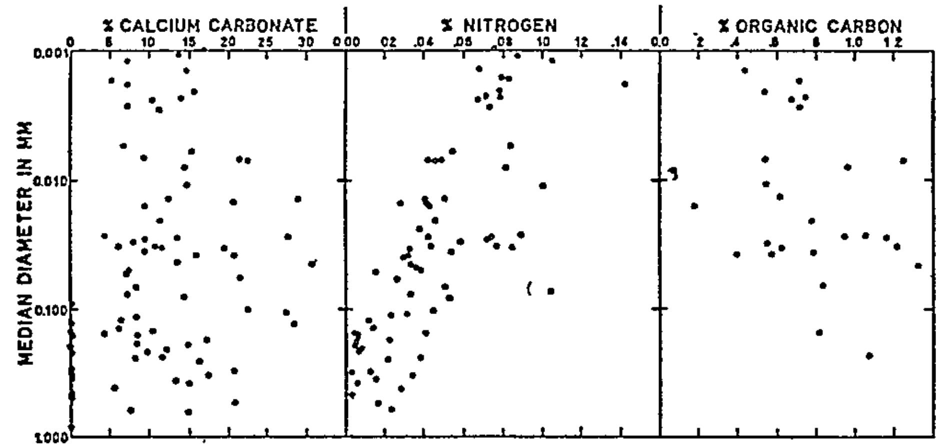

Figure 6. Relationship of calcium carbonate, nitrogen, and organic carbon to median diameter of sediments, Gulf of Thailand and adjacent continental shelf

VOLCANIC FRACTION

Several of the samples from the southern part of the continental shelf contain shards of volcanic glass as large as 1 mm (Fig. 5). The presence of volcanic glass here is not surprising because this area is only about 1000 km from Krakatoa which had a notable eruption in 1883 that produced much ash and extensive rafts of floating pumice. Still other active volcanoes occur in Java and Sumatra.

SEDIMENTS IN CORES

At 40 stations of the Naga Expedition the surface grab samples were accompanied by cores, all shorter than 40 cm. Three other cores, to 72 cm, were taken at stations of the U. S. Hydrographic Office. Because all the cores are short and many exhibit considerable disturbance due to drying and handling during shipment, they were examined only cursorily.

Most of the cores, 24, exhibit no obvious change in sediment with depth. Eighteen are coarser-grained at depth and one is finer. The cores which are coarser at depth occur throughout the Gulf with a preference for nearshore areas.

SUMMARY AND CONCLUSIONS

Sources of Sediment

Sediments on the floor of the Gulf of Thailand and the adjacent continental shelf are of six types: organic, authigenic, volcanic, residual, relict, and modern detrital (Emery, 1960, p. 204). Those of organic origin consist of calcareous and siliceous hard parts and of soft organic matter. The percentage of calcium carbonate, all assumed to be of direct organic origin, was estimated for the Gulf and the shelf by the areas between the contours of Figure 5. The results are similar in both regions. —13.3 and 11.6 per cent (Table 1), respectively. Nitrogen was measured similarly from the contours of Figure 5 and converted to total organic matter by multiplying by the factor 17, yielding less than 1 per cent total organic matter. Siliceous remains of diatoms, radiolarians, and sponges were estimated visually, and only approximately, as 0 2 per cent. The total percentage of all three forms of organically derived sediment is less than 15 per cent for both Gulf and shelf. At no place are organic sediments abundant enough to form a distinct type, but they exist only as minor constituents of another type (Fig. 7).

Sediments of authigenic and volcanic origin are minor and according to visual estimation comprise not more than 0.3 per cent of the total (Table 1). Many samples contain similar low concentrations of laterite possibly derived from underlying strata and thus best considered as of residual origin. A few other samples contain weathered shale also suggestive of residual origin. In no area do authigenic, volcanic, or residual components dominate and so they are not included in Figure 7.

TABLE 1. ORIGIN OF SEDIMENTS, GULF OF THAILAND AND ADJACENT CONTINENTAL SHELF

Sediments	Gulf		Shelf	
Organic				
Calcium carbonate	13.3 per cent		11.6 per cent	
Silica	0.2		0.2	
Organic matter	0.8		0.5	
		14.3 per cent		12.3 per cent
Authigenic and volcanic		0.3		0.3
Residual		0.4		0.4
Relict		5.0		60 0
Modern detrital		80.0		27.0
		100.0 per cent		100.0 per cent

The bulk of the sediment, 85 and 87 per cent (Table 1), is detrital in origin but of two different general dates of deposition. That which occurs atop the outer half of the continental shelf is coarse, slightly iron-stained, and most is rounded; it is probably relict beach sand left from a Pleistocene time of glacially lowered sea level. A similar sand occurs at the mouth of the large square bay near the head of the Gulf. Estimates of the amount of relict sediment (Table 1) are based on the percentage of the total area which is dominated by sediment of this type, mostly sands (Fig. 7). Most of the detrital sediment within the Gulf and along the inner third of the continental shelf is of modern derivation, as indicated by its fresh appearance and seaward gradation in median diameter. Its source must be the rivers which drain the adjacent land areas. Coarse-grained sediments line the sides of the Gulf and only fine-grained ones occur immediately off the mouth of the Chao Phraya River at the head of the Gulf (Fig. 4). Thus filling of the Gulf is proceeding from the sides as well as from the head of the elongate water body.

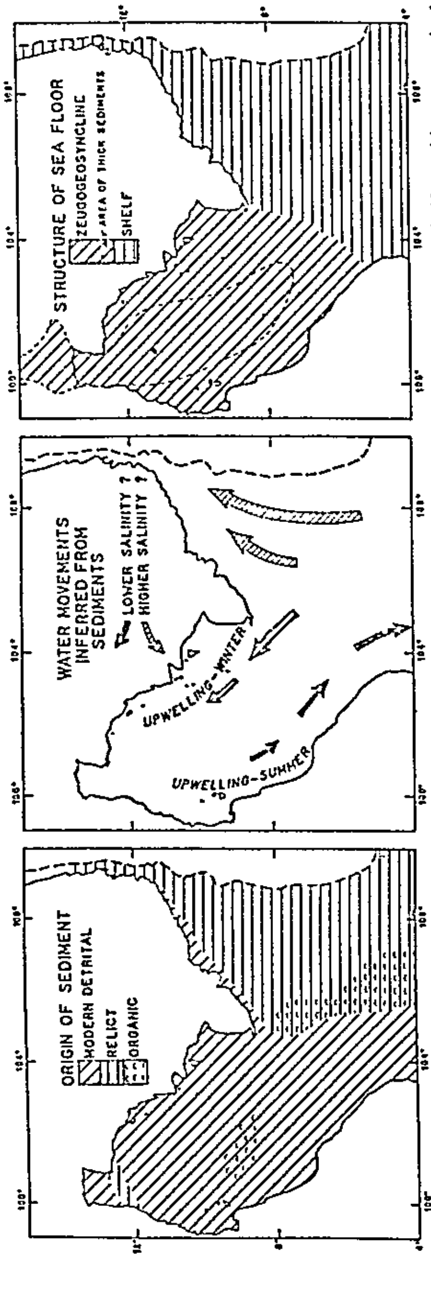

Figure 7. Origin of sediments, water movement, and general structure, Gulf of Thailand and adjacent continental shelf. Authigenic, residual, and volcanic sediments are also present but nowhere dominant.

Water Movements Inferred from Sediments

Supplementing the scanty pre-1960 oceanographic data, the sediment patterns provide a basis for inferring the water movements of the region. The belts of high content of nitrogen (organic matter) along each side of the Gulf (Fig. 5) are only partly related to the fine grain size of the enclosing sediments, because elsewhere in the Gulf equally fine-grained sediment contains less organic matter. A possible explanation is that these two lateral belts represent areas of greater productivity than elsewhere owing to upwelling produced by seasonal winds. The winter winds from the east tend to blow surface water away from the northeastern shore, and the summer winds from the west tend to blow surface water away from the southwestern shore (LaFond, 1961). The rising of deeper water to replace this surface water should give rise to seasonally high nutrient content in the water, followed by high productivity of phytoplankton and rapid deposition of organic debris (Fig. 7).

Currents also can be inferred from the sediments. The belts of coarse-grained sediment and the sediment containing a high percentage of nitrogen within the northeastern side of the mouth of the Gulf (Figs. 4, 5) may have been deposited by a current entering the Gulf from the open sea (Fig. 7). Similarly, the belt of fine-grained sediment protruding from the mouth of the Gulf southward along the inner third of the continental shelf probably indicates transportation and deposition of fine-grained river-contributed sediment by a current leaving the Gulf. Such a pair of currents entering and leaving the Gulf has its counterpart in the Yellow Sea (Niino and Emery, 1961). Coriolis force (earth rotation) also requires that the currents flow on their own right-hand side of the entrance as indeed they do. Absence of fine-grained sediment atop the outer half of the continental shelf (Fig. 4) accords with the probable presence of a moderately fast current in that area, very likely one flowing northward as in the region farther north in the South China Sea (Niino and Emery, 1961).

Structure of the Sea Floor

Geological mapping shows that the valley of the Chao Phraya River near Bangkok is a structural trough formed during the Late Tertiary. Data from well drilling and magnetic surveys indicate that the valley is underlain by a thick fill of Quaternary sediments reaching 3300 m near the mouth of the river. In the central part of the Gulf of Thailand is a large closed depression (Fig. 2) extending about 30 meters below its sill. This depression is probably a seaward extension of the structural trough (Fig. 7) and is probably underlain by even thicker sediments which pinch out near the entrance of the Gulf where rock outcrops occur on the shelf. The term, geosyncline, may properly be applied because of the inferred structural origin, thickness of sediments, and general shape. According to Kay's (1951) classification it could be termed a zeugosyncline, similar to, but smaller than, another in the Yellow Sea and Gulf of Pohai (Niino and Emery, 1961). Seaward of the geosyncline is a continental shelf (Fig. 7). Neither area can be considered a modern representative of a stable platform covered by an epicontinental sea of the kind that occupied the central United States during the Paleozoic era.

The longitudinal pattern of sediments in the Gulf (Figs. 4, 5) has its counterpart in other modern geosynclines such as the Yellow Sea (Niino and Emery, 1961), the Persian Gulf (Emery, 1956), and the Gulf of California (Byrne and Emery, 1960). The transverse pattern which might be expected in an elongate basin having its chief river mouth at one end does not seem to exist in modern seas.

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