THE ROUTE SURVEY REPORT

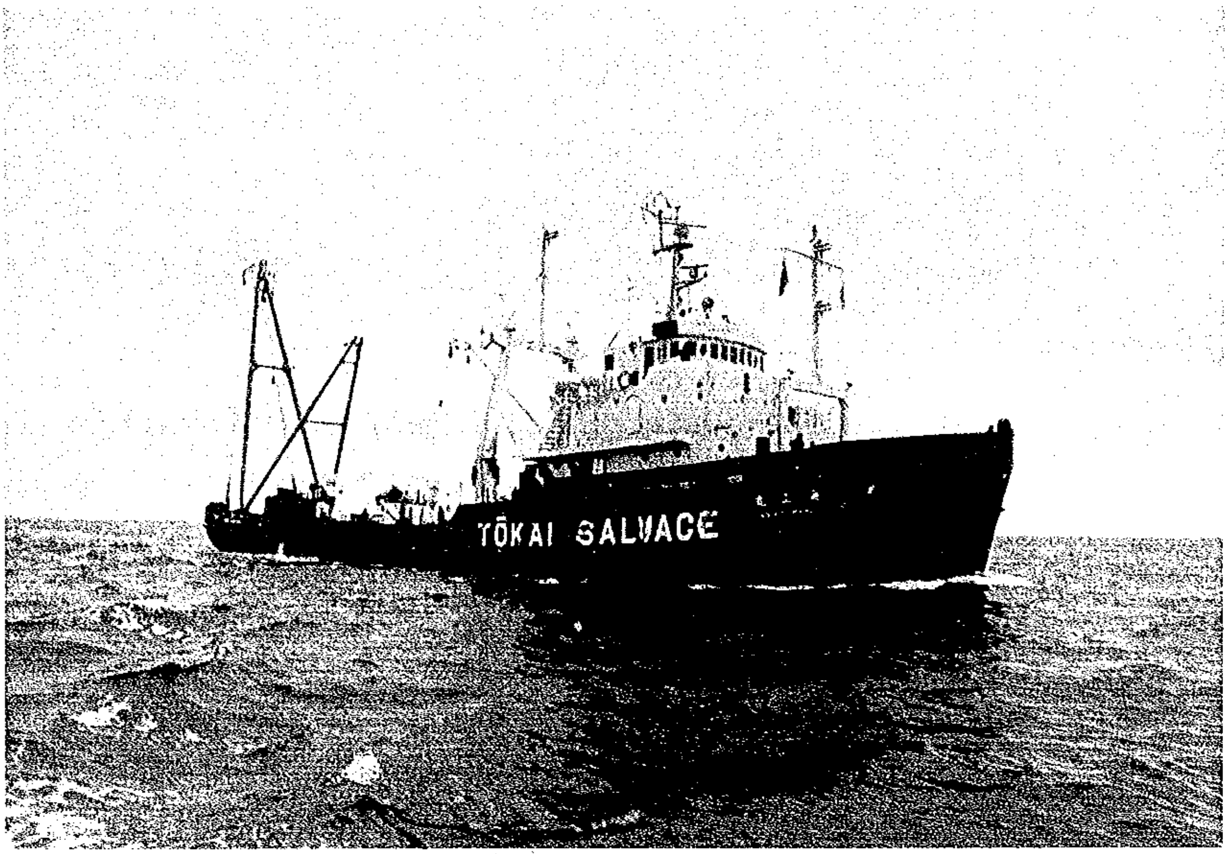
OF

THE ASEAN SUBMARINE CABLE PROJECT

(THAILAND-MALAYSIA-SINGAPORE ROUTE)

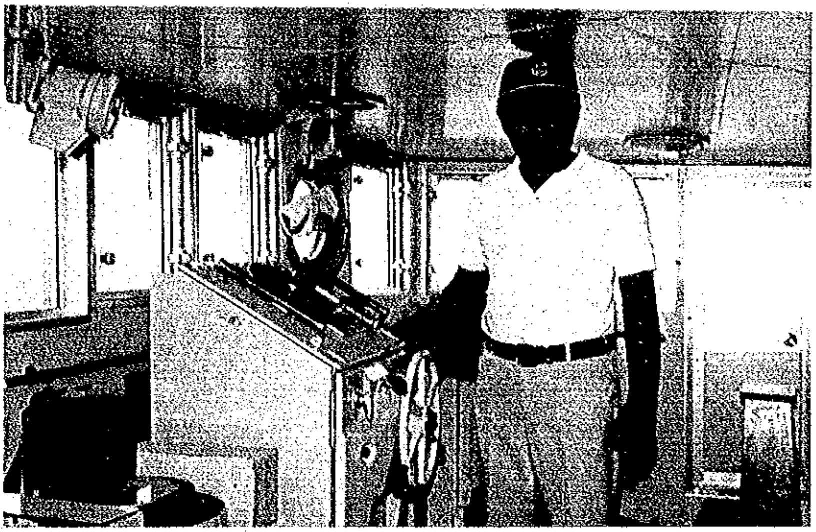
SEPTEMBER 1978

JAPAN INTERNATIONAL COOPERATION AGENCY



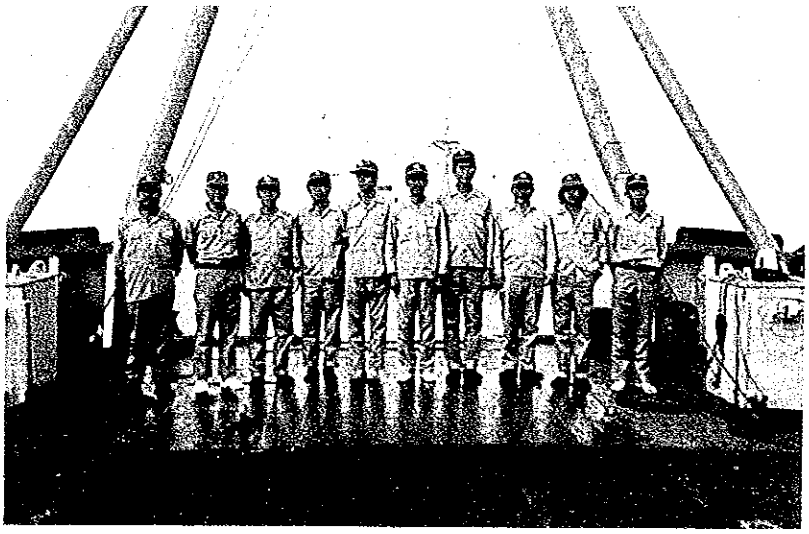
Survey Ship KAIKO MARU No.3

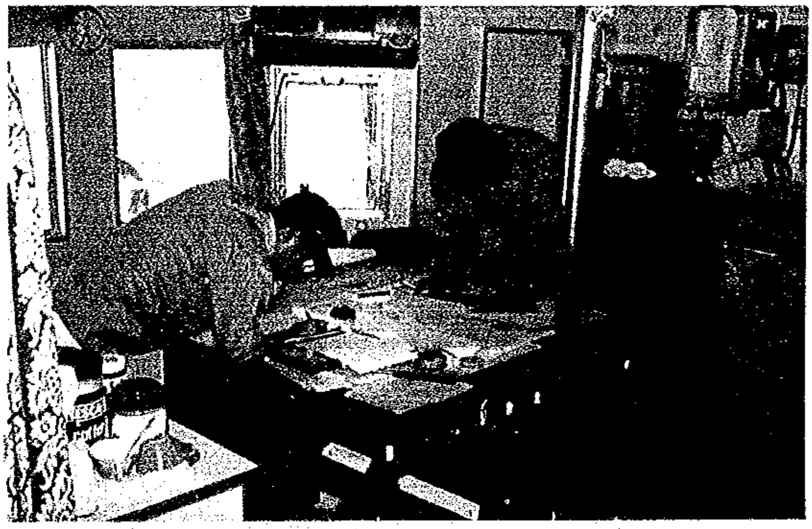
Length Overall	49.95 m
Moulded Breadth	9.00 m
Moulded Depth	3.81 m
Loaded Draft	3.35 m
Gross Tonnage	497.86 tons
Cruising Speed	13 Knots
Main Engine	Diesel 2,400 HP
Screw	3 blades C.P.P.
Main Power Generator	130 KVA x 2
Main Winch	10 tons
Owner	Tokai Salvage Co., Ltd.



Mr. Sudhorn Limpisthien, CAT at his visit to survey ship

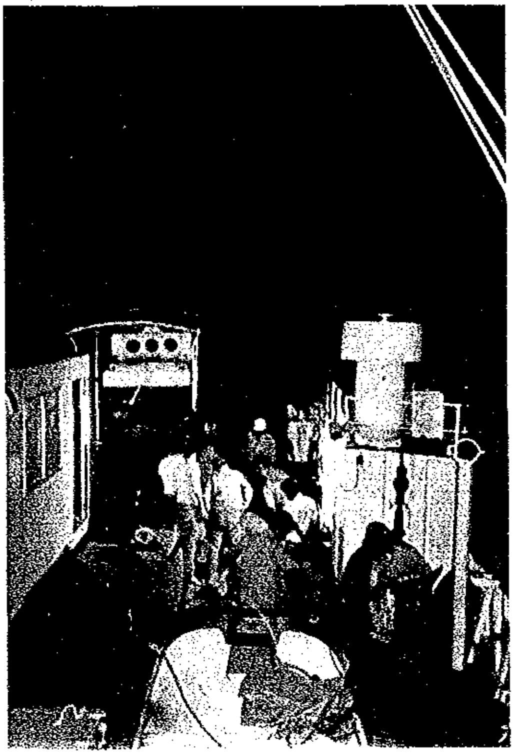
Japanese survey team and counterparts





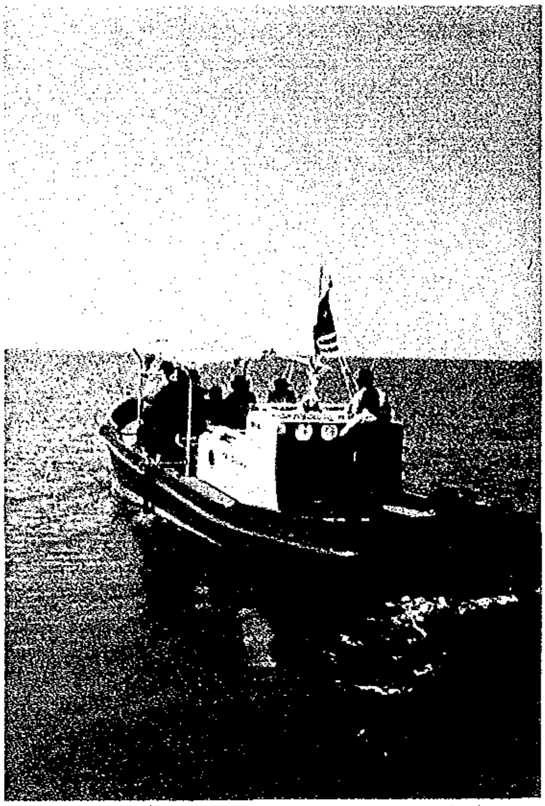
Positioning work at Bridge

Preparation of Bottom
Photographing System



Survey work at night

Land survey at Pechaburi
(Ban Hat Chao Samran)



Work boat for the survey in the shore portion

Preparation for bottom sampling

A sample taken from the sea bottom

PREFACE

In response to the request of the governments of Thailand, Malaysia and Singapore, the Government of Japan decided to carry out a survey of the Thailand-Malaysia-Singapore route of the ASEAN Submarine Cable Project as part of Japan's overseas technical cooperation programs, and the survey was executed by the Japan International Cooperation Agency (JICA).

JICA sent to the above three countries a preliminary study team of 7 experts, headed by Mr. Yozo Kanemitsu of the Ministry of Posts and Telecommunications, from February 23 to March 16, 1978 and an ocean survey team of 6 experts,,headed by Mr. Teruo Shibata of the Kokusai Denshin Denwa Co., Ltd., from April 23 to June 8, 1978, to make a preliminary study and a route survey, respectively.

The preliminary study and ocean survey were carried out very smoothly with full cooperation of the three countries. An interim report on the route survey was submitted to the authorities concerned of the three countries by the ocean survey team soon after completion of the survey.

After careful review in Japan of the results of the route survey, this report has been finalized for submisstion.

I sincerely hope that the report will contribute to the progress of the project and promotion of friendly relations between the three countries and Japan.

Finally, I would like to express my deep appreciation to all the officials concerned of the governments of the three countries for their full cooperation extended to the survey teams.

September, 1978

Shinsaku Hogen
President
Japan International Cooperation Agency

CONTENTS

9 Applicable water depth and burying depth by "Water Jetting method"

10 Repair technique for buried cable

11 Various types of cable used in buried cable systems shown in Table 3.6.2 of the Report

12 The relation with current speed and declination of the moon

I SUMMARY

1. SUMMARY

Cable route survey was carried out by the Japan International cooperation Agency (JICA) for laying a submarine cable system to interconnect Thailand, Malaysia and Singapore (The Submarine Cable System will consist of ASEAN M-S and ASEAN M-T Systems and hereinafter reffered to as a whole, the Cable System) at the request of the governments of these three countries. Survey was conducted in two phases, preliminary study and cable route survey, and a survey team was sent to the three countries in each survey phase.

In the preliminary study conducted in February and March 1978, the Japanese delegates and those concerned of these governments held meetings to agree over the scope of work for the cable route survey, collected information necessary for cable route survey including information on fishery activities, sea bottom resource exploration and existing cable routes, etc., and inspected the proposed cable landing sites.

A survey route was settled and requirements for the cable route survey were formulated.

The proposed survey route was selected along the coasts of Thailand and Malaysia keeping away from the submarine gas pipeline proposed to be laid from near Bangkok to Songkhla through the center of the Gulf of Thailand and the oil exploration areas off Trengganu in Malaysia. In the Singapore Strait, the route passed off the south coast of East Johore, clear of the existing SEACOM cable, other proposed submarine cables, anchorage, and ammunition dumping area.

In April 1978, the survey team of the JICA and survey ship KAIKO MARU NO.3 (500 tons) were sent to Singapore and the survey team and counterpart from the governments of the three countries embarked in the survey ship. The survey was conducted over the entire survey route of about 3100km (including both going and returning ways) from offshore Katong in Singapore through Kuantan of Malaysia Pechaburi (Ban Hat Chao Samran) of Thailand and back to Katong and completed on May 24th. Sounding, scanning the bottom surface, subbottom profiling, bottom sampling, water temperature observation, bottom photographing and cable landing point measurement were conducted in the survey. As a result of the survey, there were no serious obstacles observed for laying a submarine cable, and the proposed route was found suitable. Meanwhile, considerable damage to the cable by fishing activities and anchoring was anticipated. It is necessary to protect the cable from these factors. The survey route measured about 1558.8km (841.7nm) in total length, which includes the Thailand-Malaysia section of about 1151.4km (621.7nm) and the Malaysia-Singapore section of about 407.4km (220.0nm).

2 INTRODUCTION

2. INTRODUCTION

The governments of Thailand, Malaysia and Singapore have a plan to establish a wideband submarine cable system for connecting the three countries in part of the ASEAN Submarine Cable Project for improving international telecommunication in these areas by using actual INTELSAT satellite communication system interdependently.

The governments of the three countries requested the Japanese Government to provide technical assistance on this project. In compliance with the request, the Japanese Government made arrangement for the implementation of cable route survey by the Japan International Cooperation Agency.

From February 23 to March 16, 1978, a preliminary study team, headed by Mr. Y. Kanemitsu, was sent to the three countries to make preparations for translating the survey program into practice. The scope of work to be undertaken by the Japanese Government was agreed and requirements for cable route survey were stipulated between the Japanese team and the Government officials of the three countries as described in Appendices 1 to 3 respectively.

The survey team visited proposed cable landing sites at Pechaburi (Ban Hat Chao Samran) in Thailand, Kuantan in Malaysia and Katong in Singapore, and confirmed that these sites are suitable for terminating the submarine cable.

From April 23 to June 8, 1978, an ocean survey team, headed by Mr. T. Shibata, was sent to the three countries.

The team joined a Japanese survey ship "KAIKO MARU No.3" at Singapore port and carried out a route survey by attendance of the following counterparts from the three countries:

Thailand

Mr. Pongsuk Potisiri
Engineer
International Telecommunication Division
Communications Authority of Thailand (CAT)

Mr. Tosporn Simtrakan
Engineer
International Telecommunication Division
CAT

Malaysia

Mr. Tengku Abdul Rahman Bin Tengku Ngah
Assistant Controller
Telecommunication Department

Singapore

Mr. Chua Yeow Hua
Technical Officer
Telecommunication Authority of Singapore

Through agreement in the scope of work an interim report on the main survey results was submitted by the team to the governments of the three countries immediately after completion of the survey work.

Presented herein is a final report on the route survey of the Thailand-Malaysia-Singapore submarine cable which includes all results of the cable route survey. The itineraries and team members of the preliminary study and ocean survey are as follows.

(i) Preliminary Study

(Team members)

Mr. Yozo KANEMITSU (Leader)
Counsellor of Telecommunications
Ministry of Posts & Telecommunications (MPT)

Mr. Kunito ABE (Sub-leader)
Vice Counsellor of Telecommunications
MPT

Mr. Hikaru CHONO
Assistant to Director General of Telecommunications
MPT

Mr. Teruo SHIBATA
Assistant to Manager
Engineering Department
Submarine Cable Construction Headquarters
Kokusai Denshin Denwa Co., Ltd. (KDD)

Mr. Rokuro KITSUTA
Assistant to Manager
Construction Department
Submarine Cable Construction Headquarters
KDD

Mr. Taisuke KITAMURA
Assistant Chief of Marine Engineering Section
Construction Department
Submarine Cable Construction Headquarters
KDD

Mr. Akio ITOH (Coordinator)
Special Assistant to Director
Social Development Cooperation Department
Japan International Cooperation Agency (JICA)

(Itinerary)

Feb.	23	Lv. Tokyo 10:20 JL465 Ar. Bangkok 17:50
	24	Visit to DTEC, PTD and CAT
	25	Collection of data
	26	Preparation of supplementary note for the Scope of Work
	27	Observation of proposed cable landing site at Ban Hat Chao Samran
	28	Meeting at Posts & Telegraph Department (PTD)
Mar.	1	Visit to Ministry of Communications (MOC) and ASEAN office
	2	Lv. Bangkok 12:45 MH831 Ar. Kuala Lumpur 15:05
	3	Meeting at Telecommunication Headquarters
	4	Lv. Kuala Lumpur 10:15 MH152 Ar. Kuantan 11:05 Observation of proposed cable landing site at Cherating
	5	Lv. Kuantan 14:00 MH153 Ar. Kuala Lumpur 14:50
	6	Collection of data
	7	Visit to Economic Planning, Unit Prime Minister's Department (EPU)
	8	Meeting at Telecommunication Headquarters
	9	Lv. Kuala Lumpur 10:15 MH605 Ar. Singapore 11:00
	10	Visit to Ministry of Communications and Telecommunication Authority of Singapore

11 Collection of data

12 Preparation of supplementary documents for meeting at TELECOMS

13 Observation of proposed cable landing site at Katong

14 Meeting at TELECOMS

15 Survey of Singapore Port for ocean survey ship

16 Lv. Singapore 09:00 SQ008 Ar. Tokyo 20:15

(ii) Ocean Survey

(Team members)

Mr. Teruo SHIBATA (Leader)
Assistant to Manager
Engineering Department
Submarine Cable Construction Headquarters
KDD

Mr. Taisuke KITAMURA
Assistant Chief of Marine Engineering Section
Construction Department
Submarine Cable Construction Headquarters
KDD

Mr. Kyoji SERIGUCHI
Manager of Survey Department
Sanyo Hydrographic Survey Co., Ltd. (SSS)

Mr. Yasuo NISHIYAMA
Deputy Manager of Osaka Branch Office
SSS

Dr. Shigeaki KUBO
Manager of Geological Department
SSS

Mr. Akio ITOH (Coordinator)
Special Assistant to Director
Social Development Cooperation Department
JICA

(Itinerary)

Apr.	23	Lv. Tokyo 10:55 JL711 Ar. Singapore 16:20
	24	Pre-survey meeting between Japanese survey team and observers from the three countries
	25	Survey team and observers join the survey ship
	26 to 28	Going-run survey from Katong to Kuantan
	29 to 30	Shore survey at Kuantan
May	1 to 3	Going-run survey from Kuantan to the intermediate point, navigation to Songkhla Port for immigration formalities
	4 to 7	Navigation to the intermediate point, going-run survey to Pechaburi (Ban Hat Chao Samran)
	8	Meeting at CAT in Bangkok on the proposed cable landing site
	9 to 10	Shore and land survey at Pechaburi(Ban Hat Chao Samran)
	11 to 14	Returning-run survey from Pechaburi (Ban Hat Chao Samran) to the intermediate point, navigation to Songkhla Port for immigration formalities
	15 to 20	Navigation to the survey area, returning-run survey from the intermediate point to Katong
	21	Study of survey data
	22 to 24	Shore survey at Katong

25 to 29		Preparation of interim report
	30	Submission of interim report to TELECOMS
	31	Collection of supplementary data
June	1	Lv. Singapore 11:30 MH832 Ar. Kuala Lumpur 12:15
	2	Submission of interim report to Telecommunication Headquarters
	3	Collection of supplementary data
	4	Lv. Kuala Lumpur 13:00 MH832A Ar. Bangkok 14:20
	5	Submission of interim report to CAT and DTEC
	6	Submission of interim report to PTD
	7	Collection of supplementary data
	8	Lv. Bangkok 11:45 JL464 Ar. Narita 19:35

3 CABLE ROUTE SURVEY

3. CABLE ROUTE SURVEY

3.1 Outline

An ocean survey for selecting a route of the Cable System was conducted in the period of April 26th to May 24th 1978 by using the KAIKO MARU NO.3 (500 tons) from Japan.

The objectives of the cable route survey were to determine the shortest and suitable route for the submarine cable to be laid to interconnect Pechaburi (Ban Hat Chao Samran) in Thailand, Kuantan in Malaysia, and Katong in Singapore and provide information on the sea bottom and ocean conditions along the proposed route to allow the design of the submarine cable system and planning of cable laying work.

Survey method and procedures were determined on the basis of the agreements reached by the preliminary survey. The survey ship entered the Port of Singapore before and after the survey work, where six Japanese survey team members led by Mr. Teruo Shibata and the counterpart from the three countries of Thailand, Malaysia, and Singapore embarked and left the survey ship.

3.2 Survey Area

The survey route had been proposed by the preliminary survey team and agreed in the meetings held during the preliminary survey. The survey route lay from Pechaburi(Ban Hat Chao Samran) through Kuantan to Katong, passing along the coasts of Thailand and Malaysia through the offing of the south coast of East Johore, as shown in Figure 3.2.1. Although it is desirable to select deep sea for the submarine cable route, the above-mentioned coastal route was selected for the following reasons. There are petroleum and natural gas mining areas in the central area of the Gulf of Thailand and off Trengganu. There is a plan of laying a submarine pipeline expected to pass from near Bangkok down southward through the center of the Gulf of Thailand to be landed near Songkhla and some portion of the pipeline near Bangkok has been already laid. Another petroleum exploration area spreads about 120 miles off Trengganu Malaysia and also a proposed pipeline for the oil platform to the coast of Trengganu. In addition, the SEACOM cable and Philippines-Singapore cable have been laid from Katong through the Singapore Strait and the Kuantan-Kuching Domestic Cable and Indonesia-Shingapore cable are expected to be laid. The Strait of Shingapore also includes Anchorage and ammunition dumping area. Accordingly, the above-mentioned coastal route was selected so as to keep the cable clear of existing and planned pipelines and submarine cables as well as hazardous areas and not to increase the cable length.

Fig. 3.2.1 SURVEY AREA AND PROPOSED CABLE ROUTE

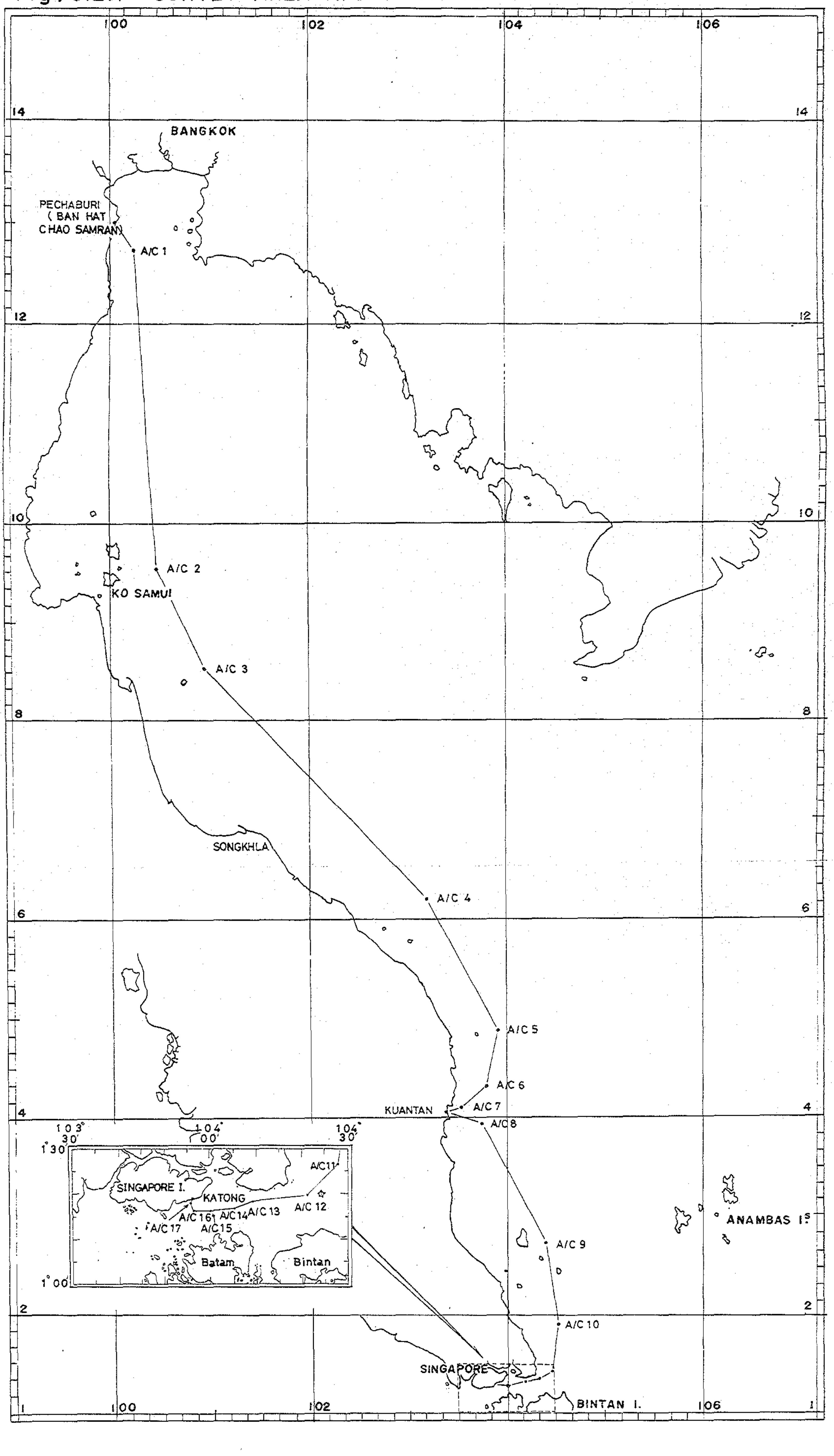


Table.3.2.1 PROPOSED CABLE ROUTE POSITIONS AND DISTANCE

(1NM=1852m)

		POSITION		DISTANCE		DISTANCE(SUM)	
		LAT	LONG	K.M	N.M	K.M	N.M
Pechaburi	L.P.	12-59.90	100-03.80				
A/C	1	12-44.30	100-15.70	35.92	19.40	35.92	19.40
	2	9-32.50	100-29.00	354.40	191.36	390.32	210.76
	3	8-33.20	100-58.00	121.53	65.62	511.85	276.38
	4	6-13.00	103-10.00	354.60	191.47	866.45	467.85
	5	4-54.00	103-55.00	167.63	90.51	1034.08	558.36
	6	4-19.00	103-47.00	66.17	35.73	1100.25	594.09
	7	4-07.50	103-31.00	36.40	19.66	1136.65	613.75
Kuantan	L.P.	4-06.34	103-23.15	14.68	7.93	1151.33	621.68
				SUB TOTAL		1151.33	621.68
Kuantan	L.P.	4-06.34	103-23.15				
A/C	8	3-58.00	103-43.00	39.82	21.50	39.82	21.50
	9	2-45.00	104-22.00	152.69	82.44	192.51	103.94
	10	1-55.00	104-31.00	93.64	50.56	286.15	154.50
	11	1-26.50	104-28.50	52.72	28.47	338.87	182.97
	12	1-20.30	104-19.80	19.77	10.68	358.64	193.65
	13	1-18.35	104-09.20	19.98	10.79	378.62	204.44
	14	1-16.80	104-05.50	7.43	4.01	386.05	208.45
	15	1-16.45	104-00.00	10.22	5.52	396.27	213.97
	16	1-16.45	103-56.20	7.04	3.81	403.31	217.78
	17	1-17.33	103-54.97	2.80	1.51	406.11	219.29
Katong	L.P	1-17.88	103-54.47	1.37	0.74	407.48	220.03
				SUB TOTAL		407.48	220.03
				TOTAL		1558.81	841.71

3.3 Cable Route Survey Work

The survey was conducted by dividing the survey area into two portions: offshore portion which was more than about 4km off shore (more than about 8 meters in depth) and which was to be surveyed by KAIKO MARU NO.3 and shore portion which, including in-shore and on-shore portions and expected cable landing site, was to be surveyed by using the work boat provided on KAIKO MARU NO.3.

3.3.1 Survey Work in Offshore Portion

In the offshore portion, survey was conducted in two runs, going and returning, respectively along the main and sub survey tracks, with the latter track set about two nautical miles off and in parallel with the former track.

In the going run,

(1) bottom sounding by using a shallow water type depth recorder,

(2) subbottom profiling with a sparker for obtaining sediment thickness and detecting any existence of base rock under bottom surface, and

(3) detection of obstacles on the bottom by using a side scan soner

were made simultaneously at ship speed of 4 ∿ 5 knots along the main survey track. During the survey the ship position was determined at intervals of 10 minutes by using the Navy Navigation Staellite System (NNSS) or radar wherever targets were available. Survey tracks, ship position measuring points, and radar targets used are shown in Figures 3.3.1-1 and -2 and Table 3.3.1.

In the returning run,

(1) bottom sounding at ship speed of about 10 knots along the sub survey track and compensation of the going run where considerable displacement from the main survey track was encountered.

(2) collection of bottom sediment samples,

(3) photographing of bottom surface, and

(4) water temperature observation

were made. Survey items (2), (3), and (4) were conducted by stopping the ship at positions on the main survey track which had been chosen from the result of analysis of data recorded in the preceded going run.

Fig. 3.3.1-1 GOING-RUN SURVEY TRACKS AND POSITIONS (WITH RADAR COVERAGE)

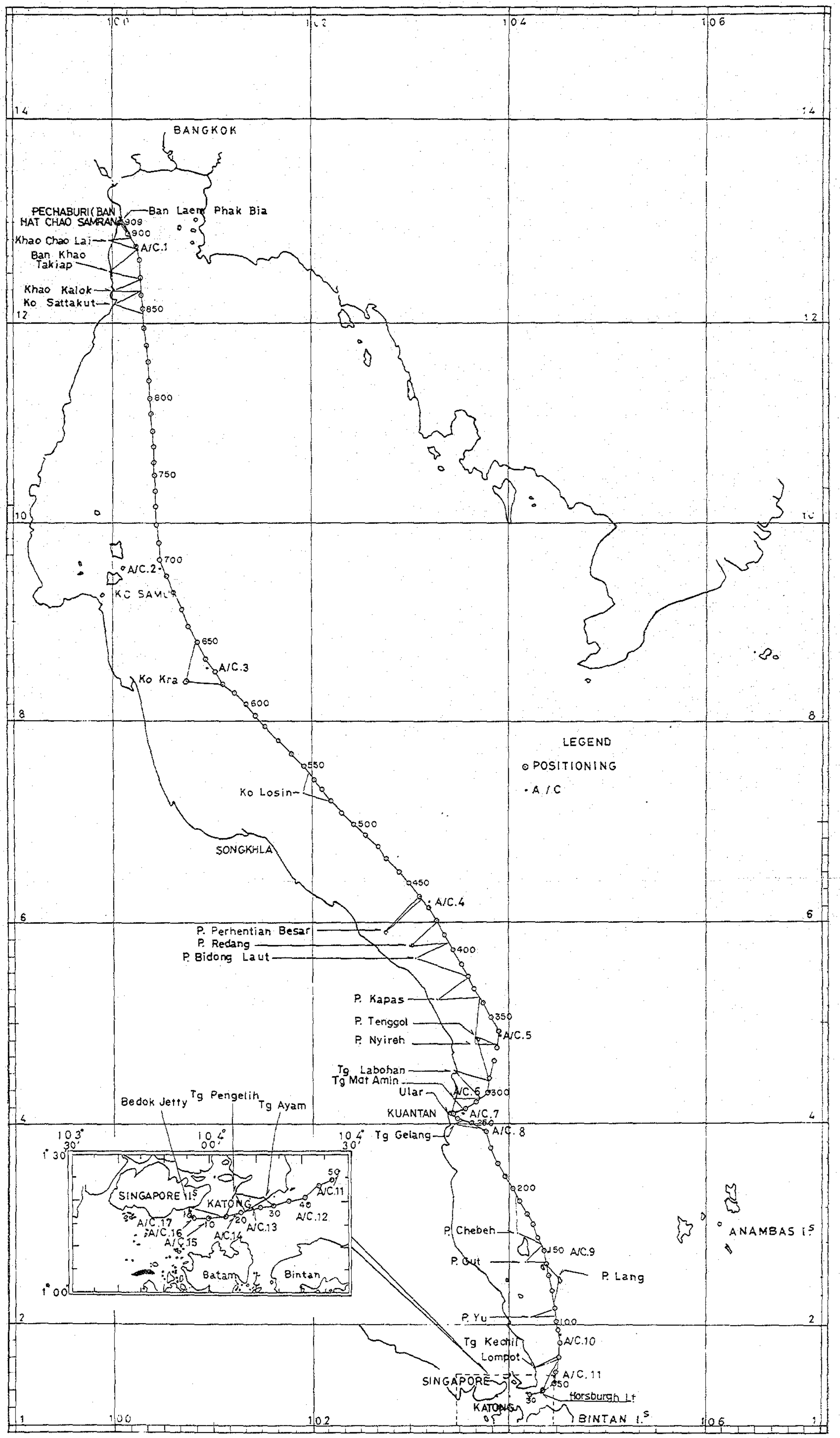
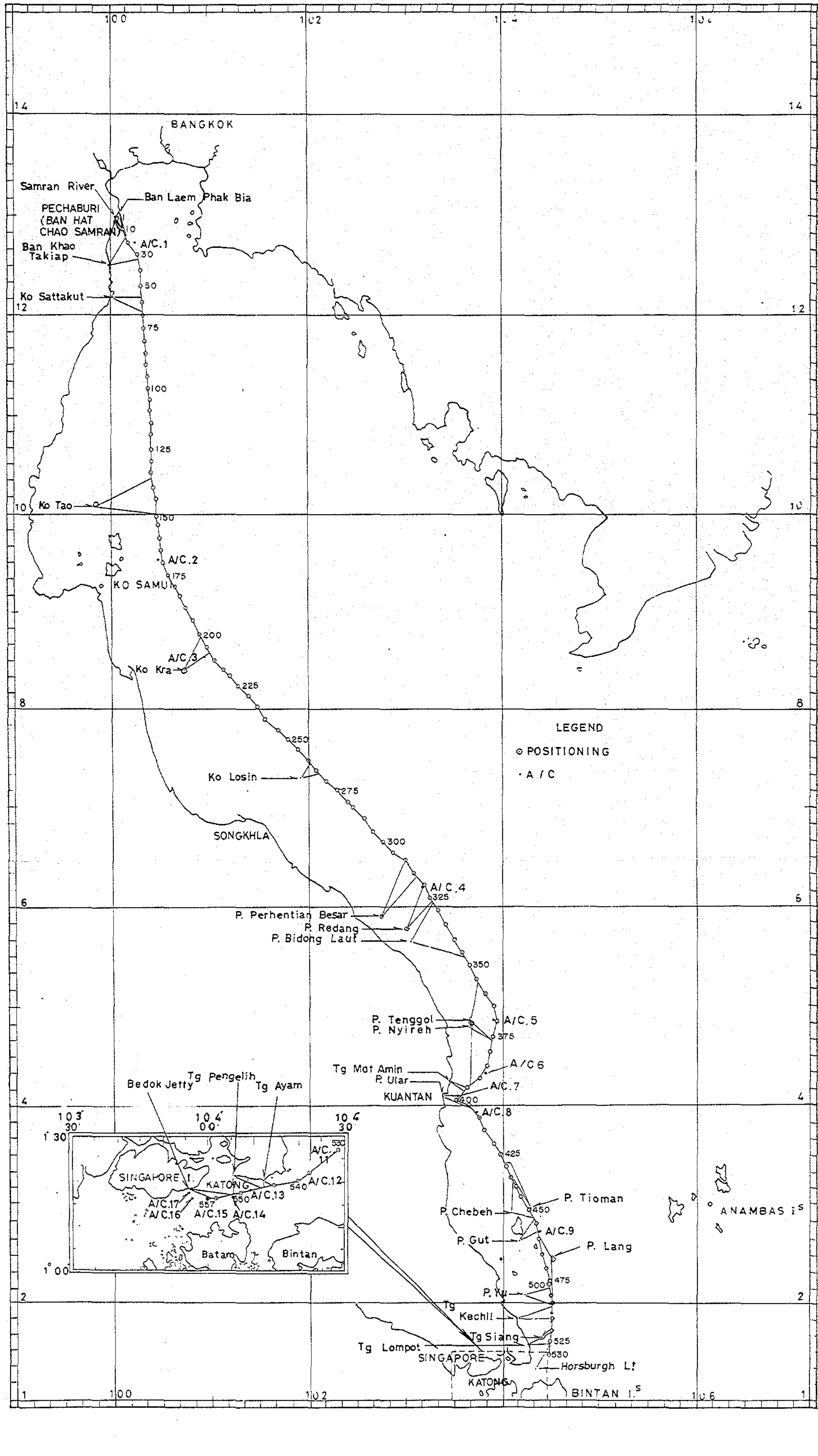


Fig. 3.3.1-2 RETURNING-RUN SURVEY TRACKS AND POSITIONS (WITH RADAR COVERAGE)



Targets	Lat.	Long.
Ban Laem Phak Bia	13-02.40	100-05.70
Samran River	12-59.40	100-03.45
Khao Chao Lai	12-49.50	99-57.00
Ban Khao Takiap	12-30.70	99-59.20
Khao Kalok	12-20.00	100-00.30
Ko Sattakut	12-12.20	100-02.00
Ko Tao	10-05.75	99-51.00
Ko Kra	8-24.10	100-45.20
Ko Losin	7-19.00	101-56.25
P. Perhentian Besar	5-54.50	102-46.00
P. Redang	5-46.50	103-02.00
P. Bidong Laut	5-37.50	103-04.00
P. Kapas	5-13.00	103-16.00
P. Tenggol	4-48.50	103-41.00
P. Nyireh	4-51.00	103-40.00
Tg Labohan	4-31.30	103-28.20
Tg Mat Amin	4-14.05	103-27.30
P. Ular	4-03.50	103-24.50
Tg Gelang	3-57.75	103-26.30
P. Tioman	2-53.50	104-10.60
P. Chebeh	2-56.00	104-06.00
P. Gut	2-39.80	104-10.10
P. Lang	2-28.00	104-29.50
P. Yu	2-07.20	104-15.10
Tg Sedili Kechil	1-51.00	104-09.50
Tg Siang	1-39.00	104-15.00
Tg Lompot	1-35.00	104-15.75
Horsburgh	1-19.82	104-24.46
Tg Ayam	1-20.30	104-12.19
Tg Pengelih	1-22.13	104-05.45
Bedok Jetty	1-18.30	103-56.60

Table.3.3.1 RADAR TARGETS AND POSITIONS

3.3.2 Survey Work In and On Shore

The following items were surveyed in the in-shore and on-shore portions near Pechaburi (Ban Hat Chao Samran), Kuantan, and Katong by using the survey boat lowered out from KAIKO MARU NO.3.

(1) Bottom sounding

(2) Subbottom profiling

(3) Detection of obstacles on bottom surface

(4) Collection of samples of bottom sediments

(5) Water temperature observation

Survey was conducted along three parallel tracks with the central track being the main route and the side tracks 250 meters apart from the central track, in the range from shore to 3∿4 nautical miles offshore. Ship position was obtained by determining the distance and direction measured by using in combination a transit at a predetermined leading point and a radio distance meter (Hydrodist).

Surveying near the cable landing site in Pechaburi (Ban Hat Chao Samran) was conducted in parallel with the in-shore survey. Wooden stakes were placed at the landing point and others, and positions of neighboring trees, fences, roads, houses, etc., relative to the route were obtained for assuring ease of relocation of the route in the future.

3.4 Survey Equipment

The major items of equipment used in the route survey are as follows.

(1) Depth recorder for sounding	PS-10 Depth Recorder for Shallow Water and RS-61 Depth Recorder for Shallow Water*
(2) Subbottom profiler	NE-19C Sparker (NEC)
(3) Bottom sonar for detection of obstacles on bottom	MARK 1B Side Scan Sonar (EG & G)
(4) Sampler for collecting bottom sediments	Piston Corer, Gravity Corer*, and Smith McIntyre Grab Sampler
(5) Thermometer for water temperature observation	ET-5 Electric Thermometer
(6) Positioning equipment	JLE-3100 Satellite Navigator (JRC), Radar and Distance Meter (Hydrodist)*
(7) Sea bottom photographing system	Camera for deep sea use (Benthos)

(* Equipment used only in shore.)

Outfitting of the survey equipment on KAIKO MARU NO.3 is shown in Figure 3.4.1.

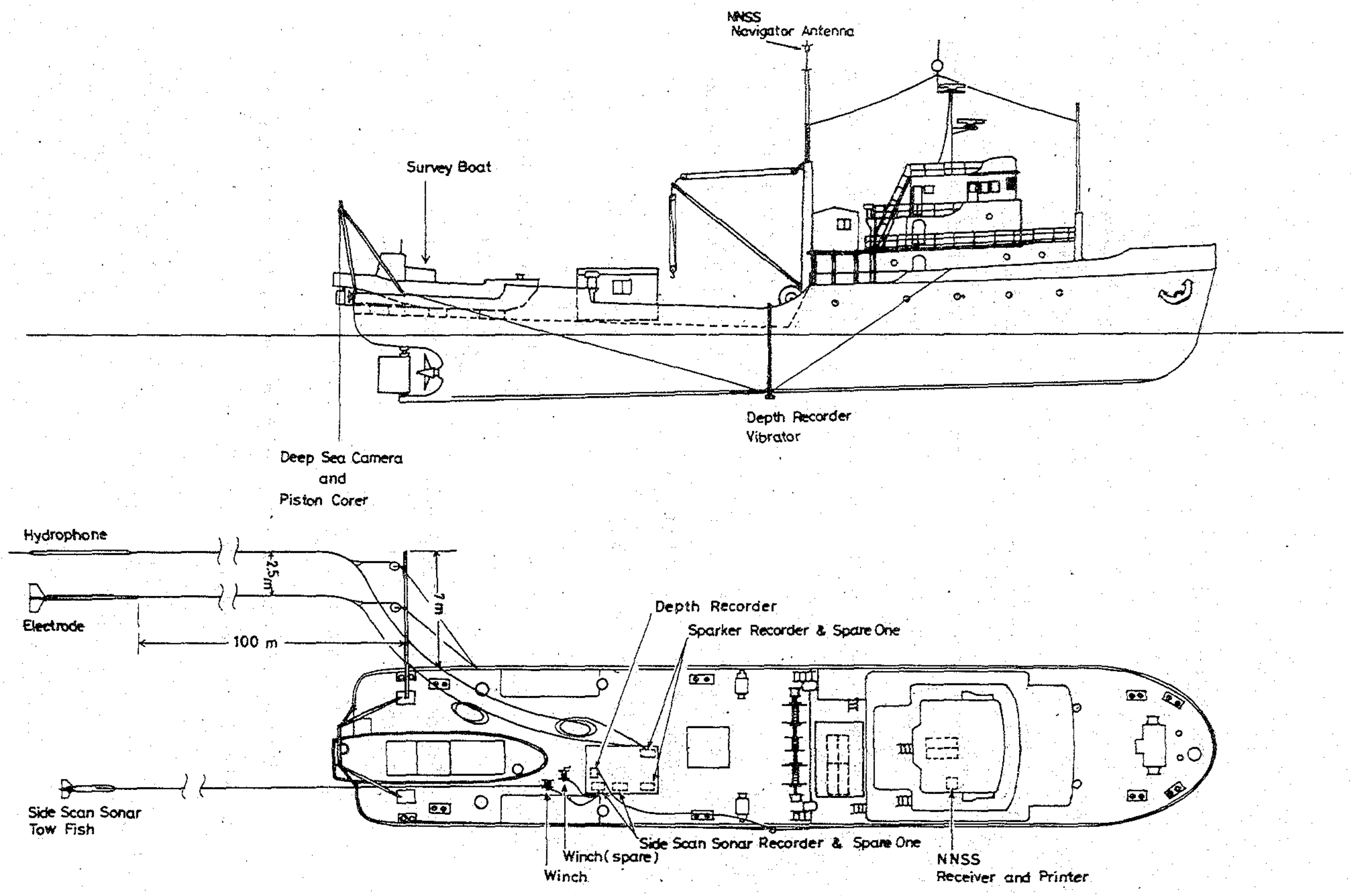


Fig. 3.4.1 OUTFITTING OF SURVEY SHIP KAIKO MARU NO.3

3.4.1 Echo Sounder

An echo sounder is essential for surveying the bottom topography. It gives the sea depth directly beneath the survey ship by measuring time interval between the time of transmitting a sonic pulse down to the sea bottom and the time of receiving the reflected pulse from the bottom surface.

PS-10 Depth Recorder for Shallow Water equipped on the KAIKO MARU NO.3 was employed in the survey of the offshore portion and RS-61 Depth Recorder for Shallow Water in the survey of the in-shore portion. Both PS-10 and RS-61 are compact, lightweight precision class echo sounders using transistor circuitry.

PS-10 Depth Recorder for Shallow Water

The PS-10 operates from a 12V DC power and allows operation and adjustments all on its recorder. Depth recording is made by a recording pen which rotates coaxially around the axis of dry type discharge recording paper formed in a semi-cylindrical shape.

The recording pen is driven by a sync motor synchronized with the 50Hz output signal from a sync oscillator. Transmission is controlled by a photo-transistor using a disc synchronized with the recording pen, and the transistor output is converted to accoustic pulses by a converter to be transmitted into the sea. Received echo pulses are converted to electrical pulses by a converter, which are passed through a transmit/ receive switching circuit to a receiver to be amplified to the required level and fed to the recording pen for recording the profile of the continued bottom topography on the recording paper.

Since this equipment is designed for an accoustic propagation speed of 1500m/sec in water, actual depth must be determined through water depth compensation by bar checking or compensation for water temperature, salt content, water pressure, etc., by calculation. In this survey, bar checking was employed for compensation. The RS-61 resembles the PS-10 in specifications, the specifications of only the PS-10 are described below.

1) Power supply: DC 12V ± 5%, 7A

2) Recording ranges

Shallow ranges: 0 ∿ 13m, 10 ∿ 23m, 20 ∿ 33m, 40 ∿ 53m, 50 ∿ 63m, 60 ∿ 73m and multiples of these ranges

Deep ranges: 0 ∿ 26m, 20 ∿ 46m, 40 ∿ 66m, 66 ∿ 86m, 80 ∿ 106m, 100 ∿ 126m and multiples of these ranges

3) Recording method: Inner disc, straight-line recording

4) Recording accuracy: $\pm 0.05 + 10^{-3}D$ (m)

5) Recording paper dimensions: 150mm wide, 10m long

6) Paper feeding speed: 60mm/min. ± 5%

7) Transmit/receive frequencies: 201.5kHz

8) Transmitter output: more than 30Wp-p

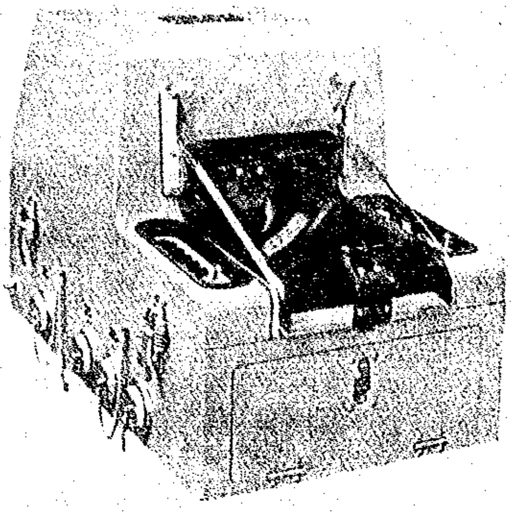
9) Receiver output frequency: 24kHz

10) Amplification degree of receiver: more than 140dB

11) Receiver output: more than 6W

12) Transmit/receive beam angle: 6°

Figures 3.4.2 and 3.4.3 show a block diagram of the PS-10 Depth Recorder for Shallow Water and sounding by the depth recorder, respectively.



RECORDER

TRANSDUCER

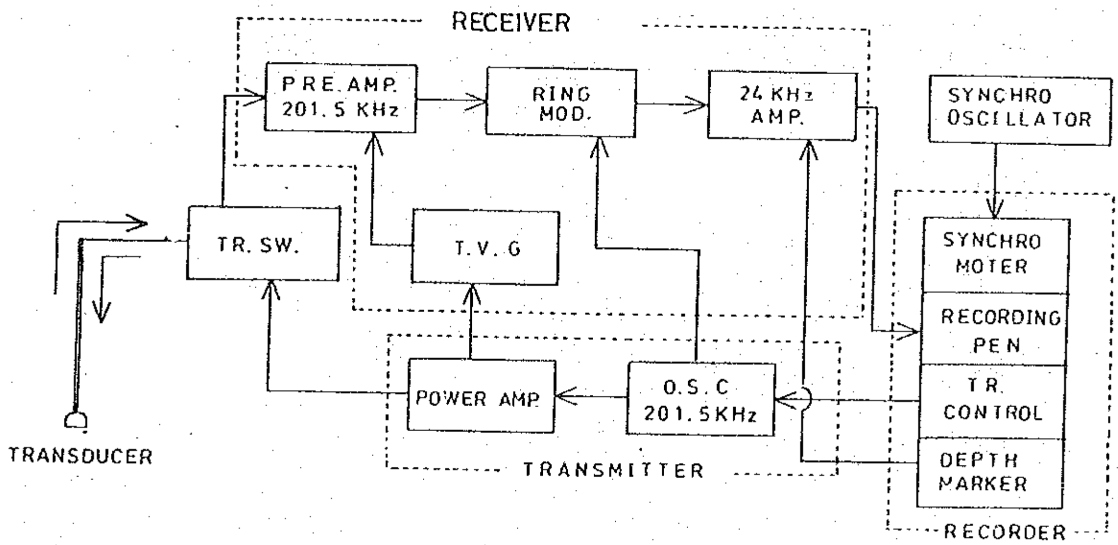


Fig. 3.4.2 BLOCK DIAGRAM OF PS-10 DEPTH RECORDER

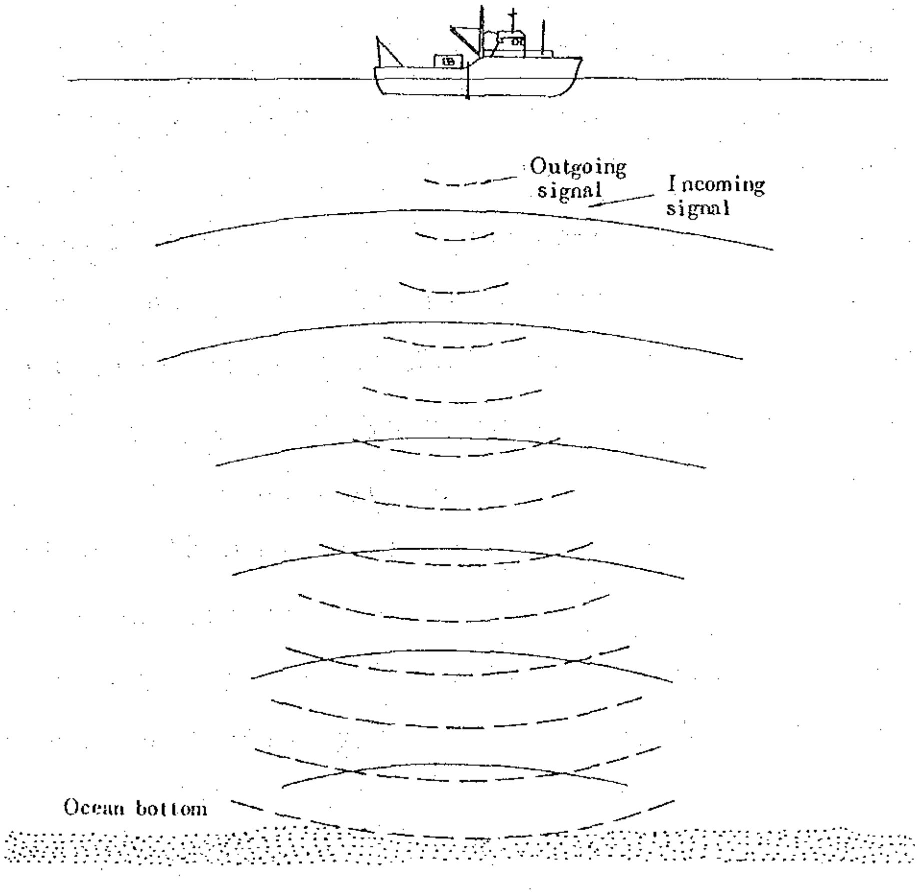


Fig.3.4.3 SOUNDING BY DEPTH RECORDER

3.4.2 Subbottom Profiler

Subbottom profilers are intended for surveying subbottom structure by using the sonic waves' property of making reflection on boundaries between subbottom layers. Sonic waves of high powers and low frequencies are obtained by various oscillation methods.

A high-power, low-frequency sonic wave emitted into the sea is partially reflected by the sea bottom and partially penetrates into subbottom, thus repeating reflection on boundaries of subbottom layers and gradually fading away. Reflected signals are received by the receiver, and after being amplified, fed to the recorder to be recorded as geological profile on the recording paper.

In principle, the recording depth of a subbottom profiler increases with decreased frequency and increased power of the sonic wave used its resolving power lowers accordingly, making it difficult to profiling fine geological structure.

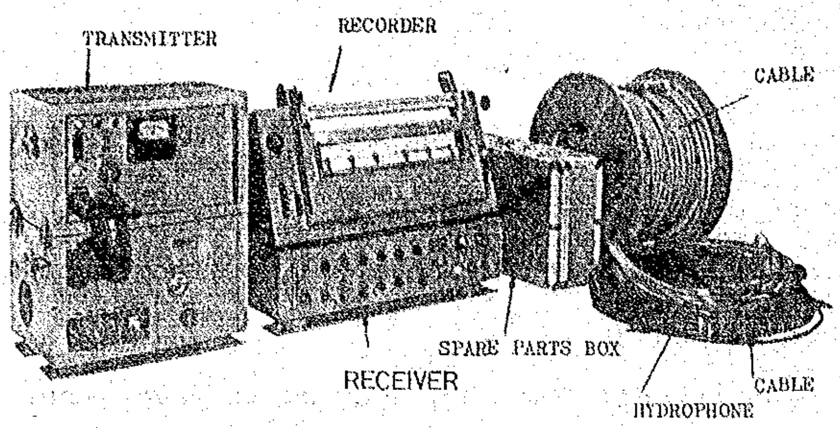
In the subbottom profiler (NE-19C) used, a low frequency sonic wave is obtained by discharging an instantaneous large current between discharge electrodes in water. The configuration and operating principles of the NE-19C Sparker (discharge type subbottom profiler) are described below. (See also Figures 3.4.4 and 3.4.5.)

In the transmitter, the AC voltage stepped up by the transformer is rectified to obtain a DC voltage for storage on a high-voltage capacitor. The high-voltage switching circuit is switched on by trigger pulses from the receiver and DC voltage is fed to the electrodes in water to cause discharge.

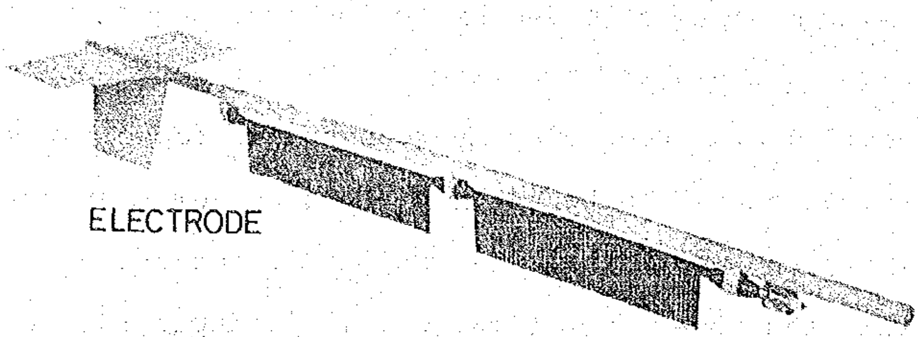
The strong, low-frequency sonic wave generated by the discharge is passed through water, penetrates into sub-bottom, is mostly reflected by various boundaries of layers and returns again through water. The reflected sonic wave is received by a receiving hydrophone and converted to an electrical signal to be sent to the receiver. In the receiver, the weak signal is amplified, and through filtering, control, and power amplification, it is depicted with proper contrast on the recording paper.

Specifications of NE-19C Sparker (NEC)

Transmission energy:	200 Joule
Recording ranges:	100, 200, 400, and 800m
Recording paper width:	200mm x 2 stages
Paper feeding speed:	120 and 60m/min.
Receiving frequency range:	100 ∿ 5000Hz



OUTLINE, NE-19C SPARKER



ELECTRODE

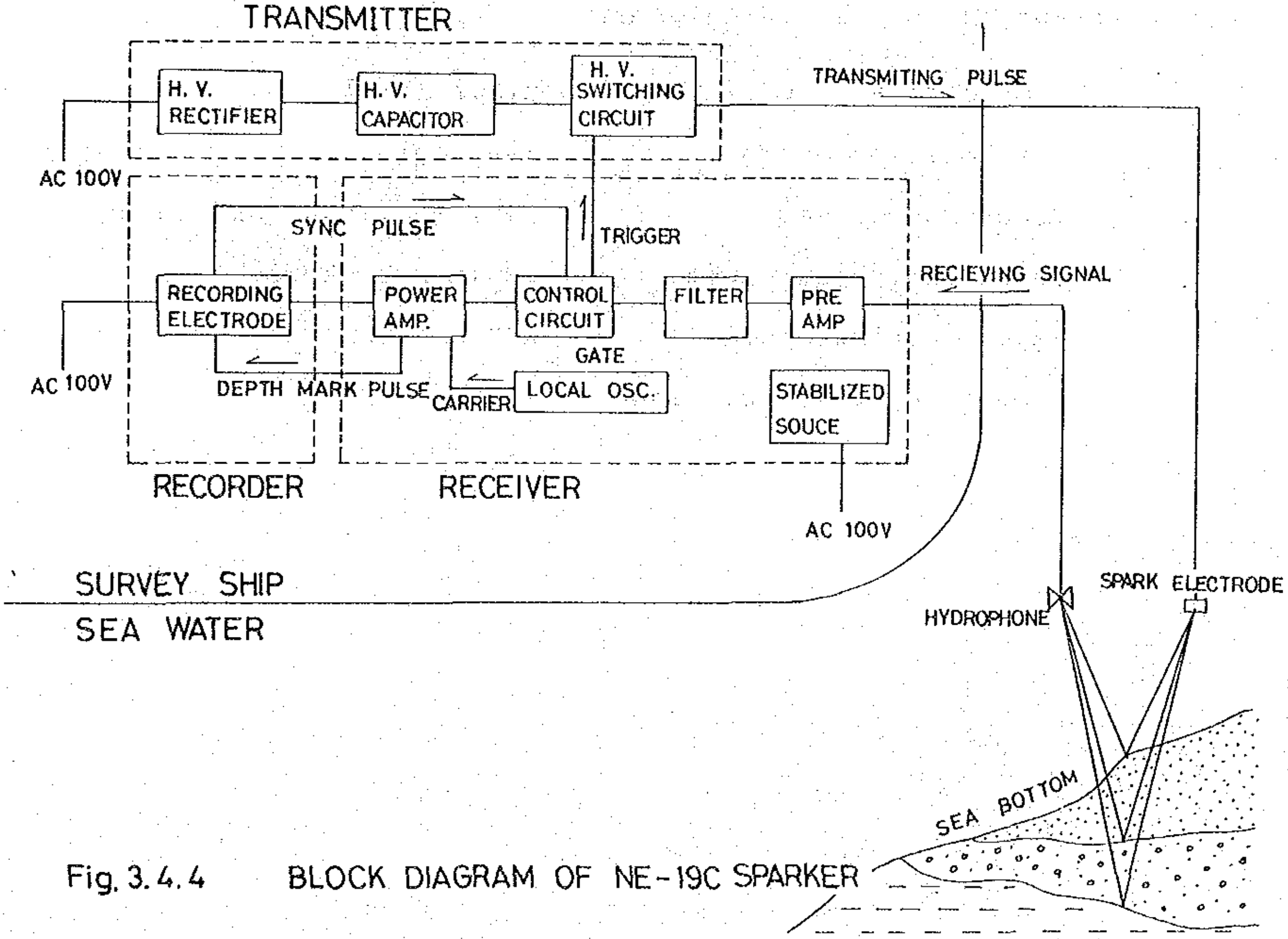


Fig. 3.4.4 BLOCK DIAGRAM OF NE-19C SPARKER

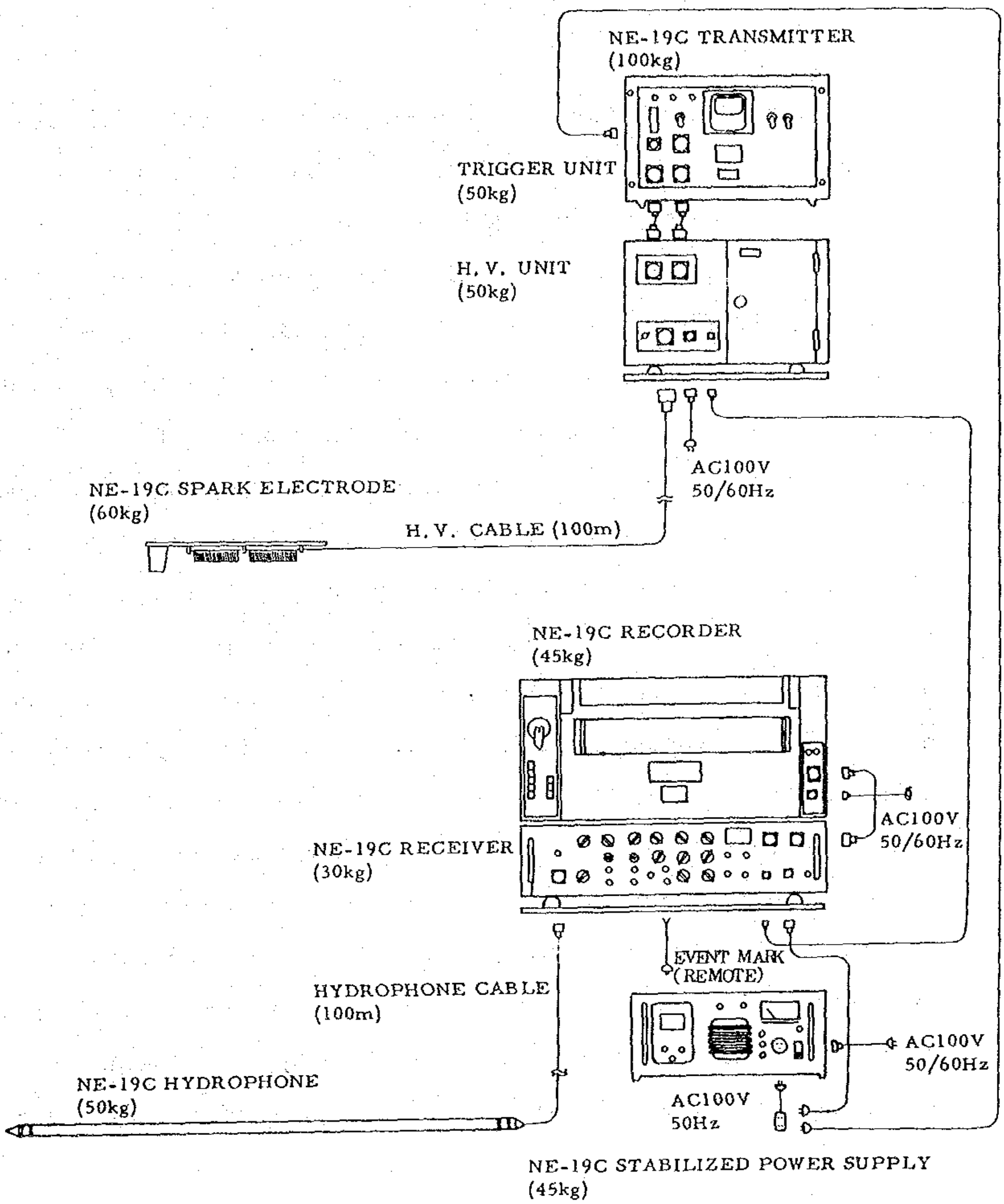


Fig.3.4.5 CONNECTION DIAGRAM OF NE-19C SPARKER

3.4.3 Side Scan Sonar

Side scan sonar is intended to investigate the configuration of the bottom surface. Its basic functions are similar to those of a depth recorder. With a depth recorder acoustic pulses are transmitted directly downward in a narrow beam by a transmitting element located near the water surface, while with a side scan sonar pulses are emitted slantly to the bottom surface by transmitting elements mounted on a "fish" towed near the bottom. Transmitting and receiving transducer elements are mounted on both sides of the "tow fish" so that they may be directed perpendicularly to the towing direction, and acoustic wave pulses are transmitted to cover as wide an angle as several tens of degrees in a vertical plane and as narrow an angle as about one degree in a horizontal plane as shown in Figure 3.4.6. Reflected acoustic waves are received continuously with time delay corresponding to the distance between the "tow fish" and the place of reflection on the bottom. An acoustic wave undergoes attenuation according to its propagation distance. Differences in strength of received signals corresponding to respective propagation distances are equalized by a gain amplifier which varies its gain with time.

The output signal of the amplifier is printed at a position, on the recorder paper, corresponding to the distance between the tow fish and the place of reflection.

By towing the fish, the configuration of the bottom surface is recorded in two dimensions as in a photograph with patterns of proper contrast depending on ups and downs of the bottom surface.

An external view of MARK 1B Side Scan Sonar and its block diagram are shown in Figure 3.4.7.

Specifications of Mark 1B Side Scan Sonar (EG & G)

Recorder

Depth ranges:	50, 100, 125, 200, 250 and 500 meters
Scale lines:	every 25 meters
Paper feeding speed:	40, 60, and 80 lines/cm (100, 150, and 200 lines/inch)
Input power:	24-30V DC, 4 ∿ 8A depending on depth range
Recording paper:	Moist paper, 28cm(11") x 37m (120 ft)
Weight:	38kg (84 lb.)
Dimensions:	28cm(11") high, 84cm(33") wide, 44cm(17") deep

Tow Fish

Operating frequency:	105 ± 10kHz
Pulse length:	0.1msec
Peak output:	128 dB ref 1 ubar at 1 meter
Horizontal beam width:	1.2° (3 dB points)
Vertical beam width:	20° or 50°
Coverage:	up to 1000 meters
Towing speed:	0 ∿ 28km/hr. (0 ∿ 15 knots)

Max. depth:	600M (2000 ft.)
Weight:	22kg (48 lb.)
Dimensions:	118cm(47") long, 30cm(12") tail, 11.4cm(4.5") diameter

3.4.4 Bottom Sampling Devices

Piston corer, Smith McIntyre grab sampler and small gravity corer were used for collecting samples of bottom sediments in the survey. These sampling devices are shown in Figure 3.4.8.

Piston corer is dropped from about two meters above the bottom surface by a lever action initiated by bottom touching of a weight having been lowered to the bottom. When the corer is pulled up, a piston brings bottom material into an acrylic pipe and hold them in it. A brass catcher at the mouth of the corer, which allows only inward moving of core material, also holds the material while lifting the corer. From the depth of the corer's penetration into the sea bed, plowability by a cable burying machine can be roughly estimated.

Smith McIntyre grab sampler catches bottom material in the grab by releasing the pre-strained springs upon touching the bottom.

Gravity corer has fins, weights and a cylinder with a catcher and is simply thrown into water for collecting samples.

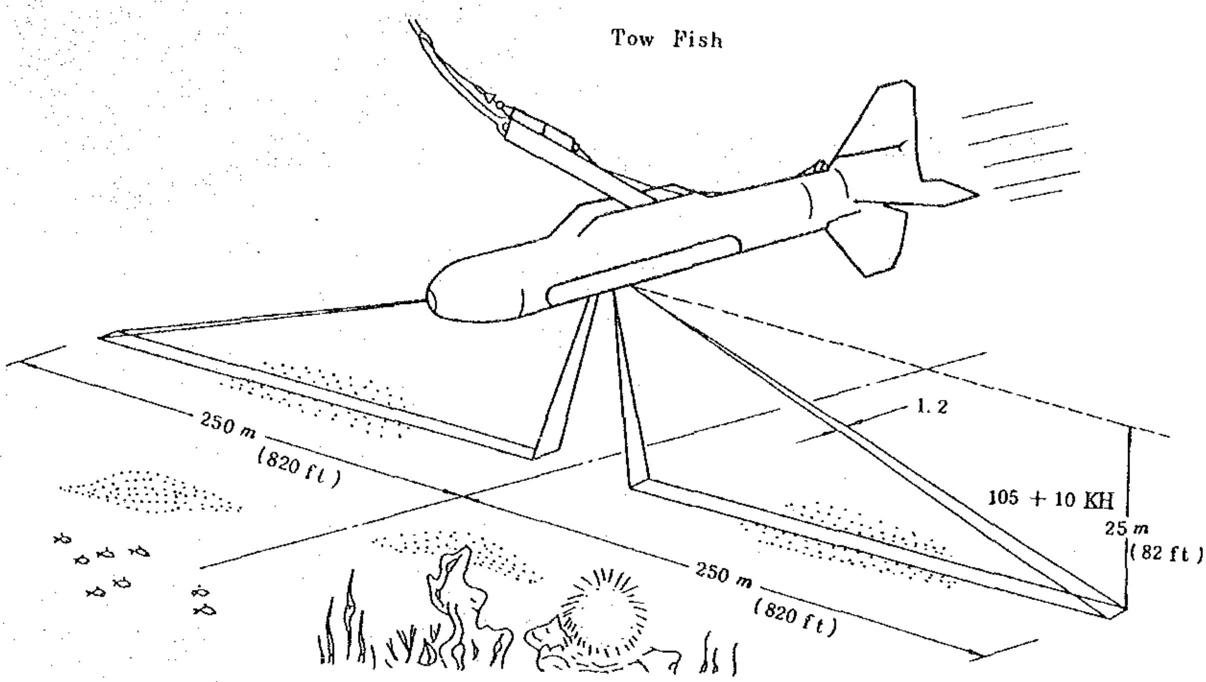
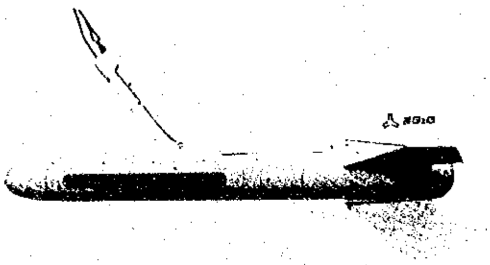
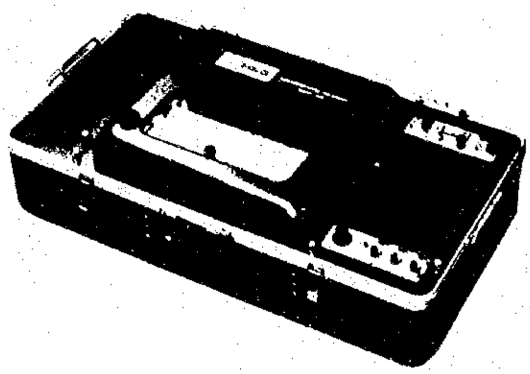


Fig.3.4.6 SCANNING COVERAGE OF SIDE SCAN SONAR



Tow Fish



Recorder

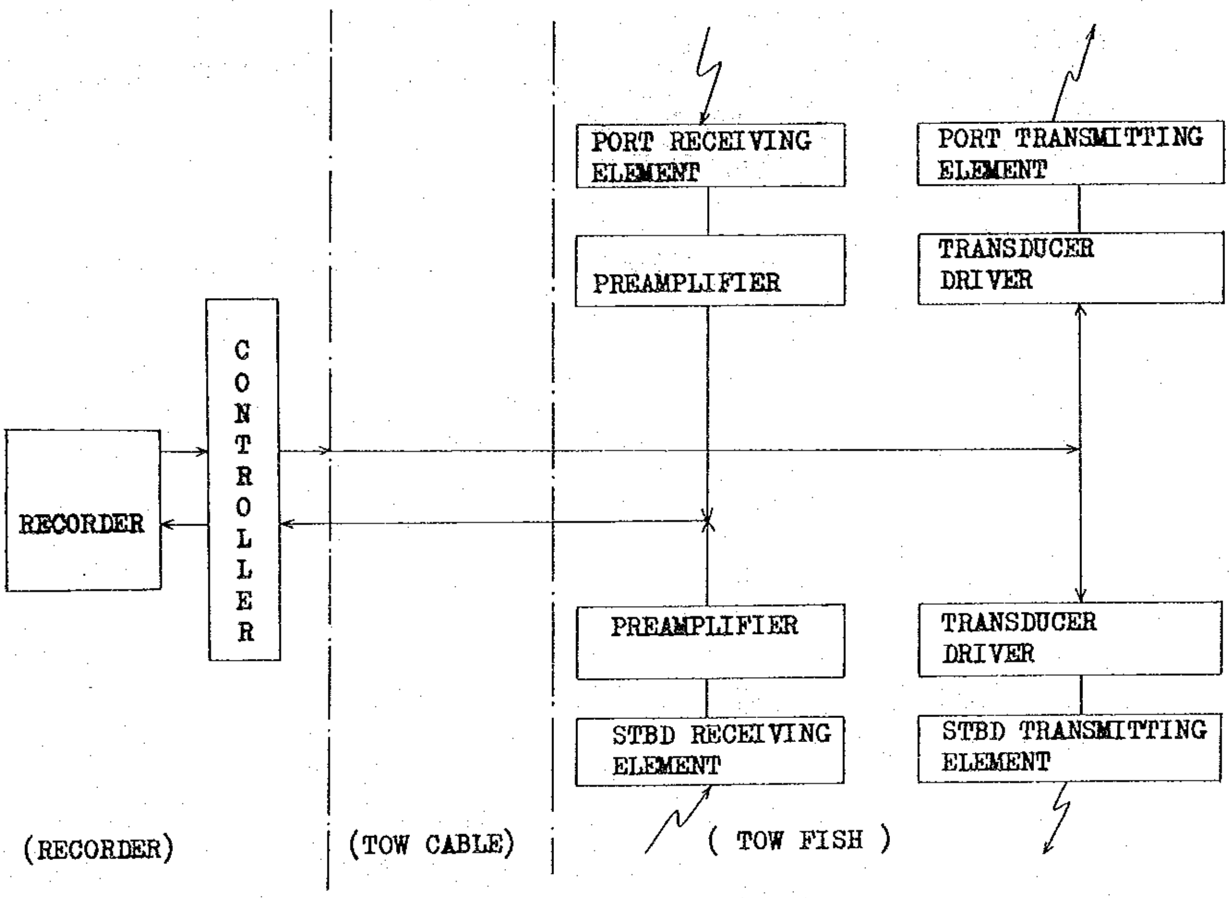
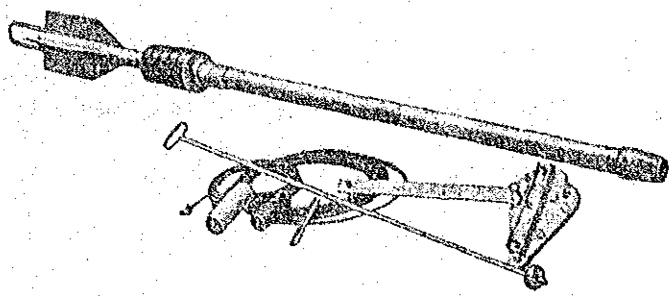
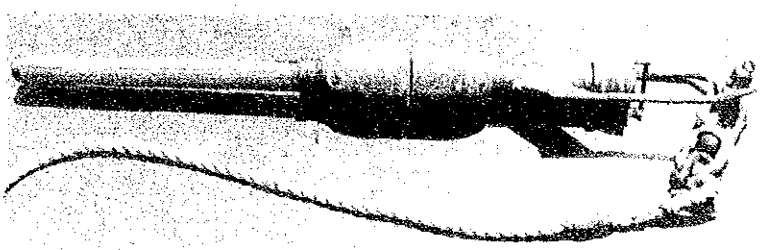


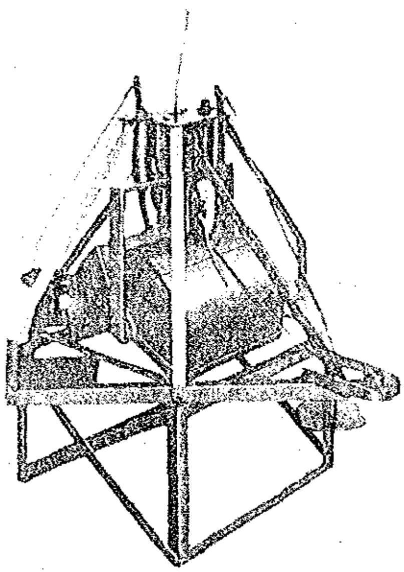
Fig.3.4.7 MARK 1B SIDE SCAN SONAR



Piston Corer



Gravity Corer



Smith McIntyre Grab

Fig. 3.4.8 BOTTOM SAMPLING DEVICES

3.4.5 Thermometer

ET-5 Electric Thermometer (shown in Figure 3.4.9) was used for temperature observation in the survey.

ET-5 Electric Thermometer is intended for obtaining the water temperature by measuring the resistance of thermistor lowered from the ship down into water through lead lines attached to it. The ET-5 allows temperature observation in a -5°C to 40°C (or 23°F to 104°F) range with a minimum scale of 0.1°C.

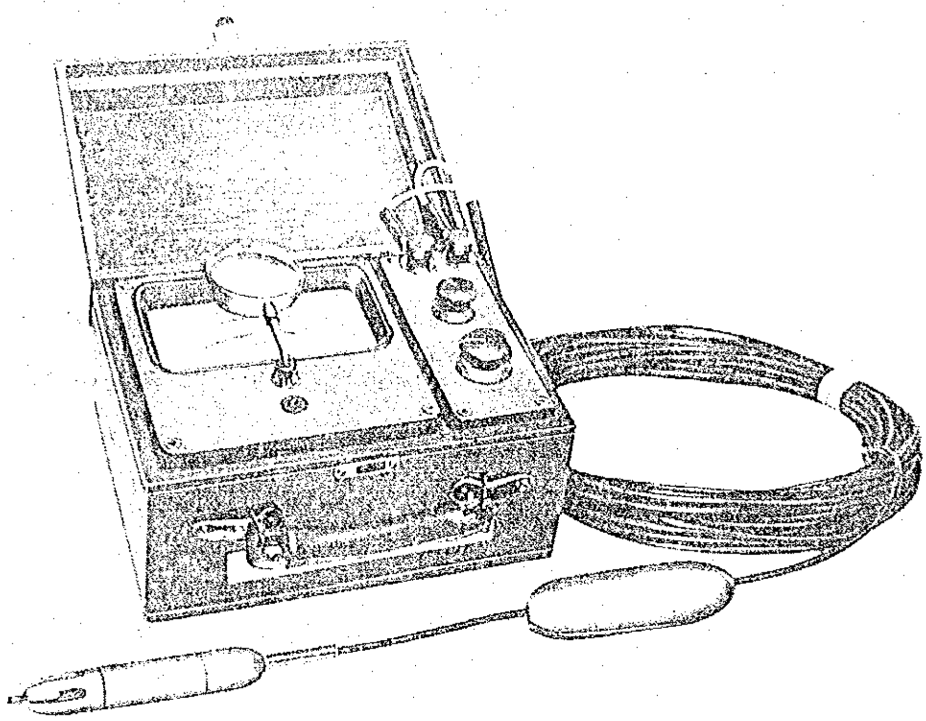


Fig.3.4.9   ET-5 THERMOMETER

3.4.6 Positioning Equipment

(1) Navy Navigation Satellite System (NNSS)

The Navy Navigation Satellite System (NNSS) operated at present consists of six navigation satellites which move around the earth on a circular orbit over the North and South poles at a period of about 108 minutes at an altitude of about 11,000km and a ground station which measures the orbits of these satellites and sends orbit data to each satellite. The orbit arrangement of the satellites is as shown in Figure 3.4.10(a). The period of satellites obtained from orbit data is about 108 minutes, during which the earth rotates itself eastward by about 26.5°. Thus, the six satellites can be utilized one after another as the earth moves around itself. (The figure shows four satellites for simplification.)

The principles of positioning by the NNSS system are as follows.

Each satellite in the NNSS system transmits two frequencies ($f_1 = 399.968$MHz and $f_2 = 3/8f_1 = 149.988$MHz), a time signal at intervals of 2 minutes, and data necessary for positioning calculation. Each satellite transmits a time signal at times t_0, t_1, t_2,...... while moving on the circular orbit, as shown in Figure 3.4.10(b). Thus, t_1-t_0, t_2-t_1,......, t_i-t_{i-1},...... become equally 2 minutes. The distances between the satellite and the earth are $D(t_0)$, $D(t_1)$,...., $D(t_i)$,.... and the satellite gradually approaches the earth at first and then goes away, finally sinking below the horizon. At this time, the receiving frequency is measured. It is understood, by application of the Doppler effect, that the Doppler shift becomes zero, when the distance between the satellite and earth becomes minimum and the integration of transmitting frequency for one period of 2 minutes (399.968MHz x 2 minutes) can be counted. Actually, however, the satellite is moving continuously and the actual integration differs from this. That is, the variation in distance between the satellite and the receiving point can be obtained when the wavelength of the radio wave transmitted is known.

The points where distance difference, $D(t_i)-D(t_{i-1})$, becomes constant form a hyperboloidal plane with focuses at t_i and t_{i-1}. It is then understood, by adding the condition that the ship is on the surface of the earth, that the line produced by the intersection of the hyperboloidal plane with the earth surface is none other than the line on which the ship exists.

The positioning principle of the NNSS is a type of hyperboloidal navigation method similar to those in Loran and Omega systems.

Figure 3.4.11 shows a block diagram of the NNSS and Figure 3.4.12 a connection diagram of JLE-3100 Navigation Satellite System.

Specification of JLE-3100 Navigation Satellite System

Positioning error:	0.1 NM (RMS) for still ship
	0.5 NM (RMS) for sailing ship
Receiver	
Receiving frequency:	399.968MHz ± 12kHz
Tuning:	Automatic
Minimum sensibility:	-145dBm
Dynamic range:	145dBm - -90dBm
Power supply	
Voltage:	AC 100/110/220V ± 10%
Frequency:	50/60Hz, single phase

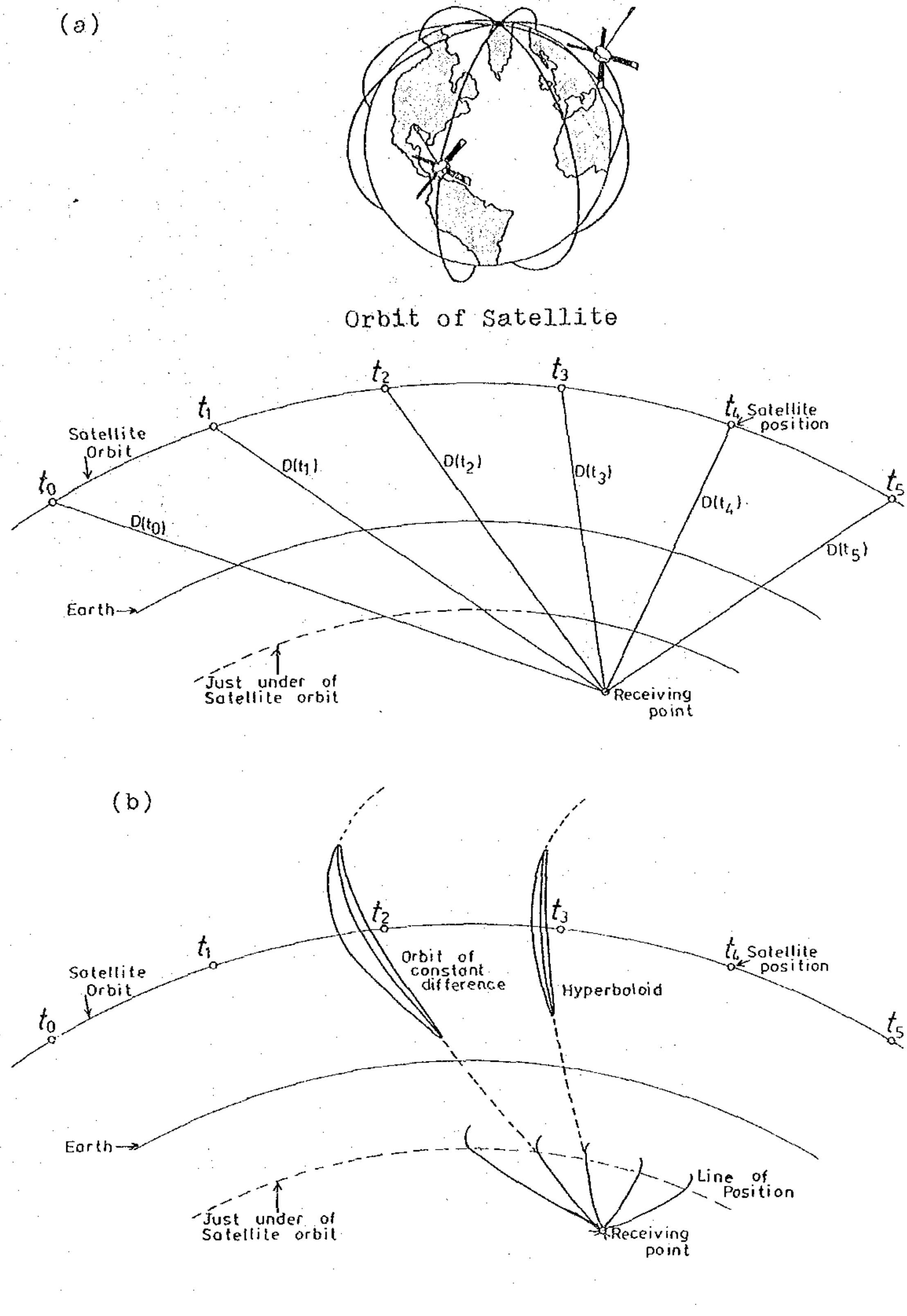


Fig.3.4.10 PRINCIPLE OF NNSS MESUREMENT

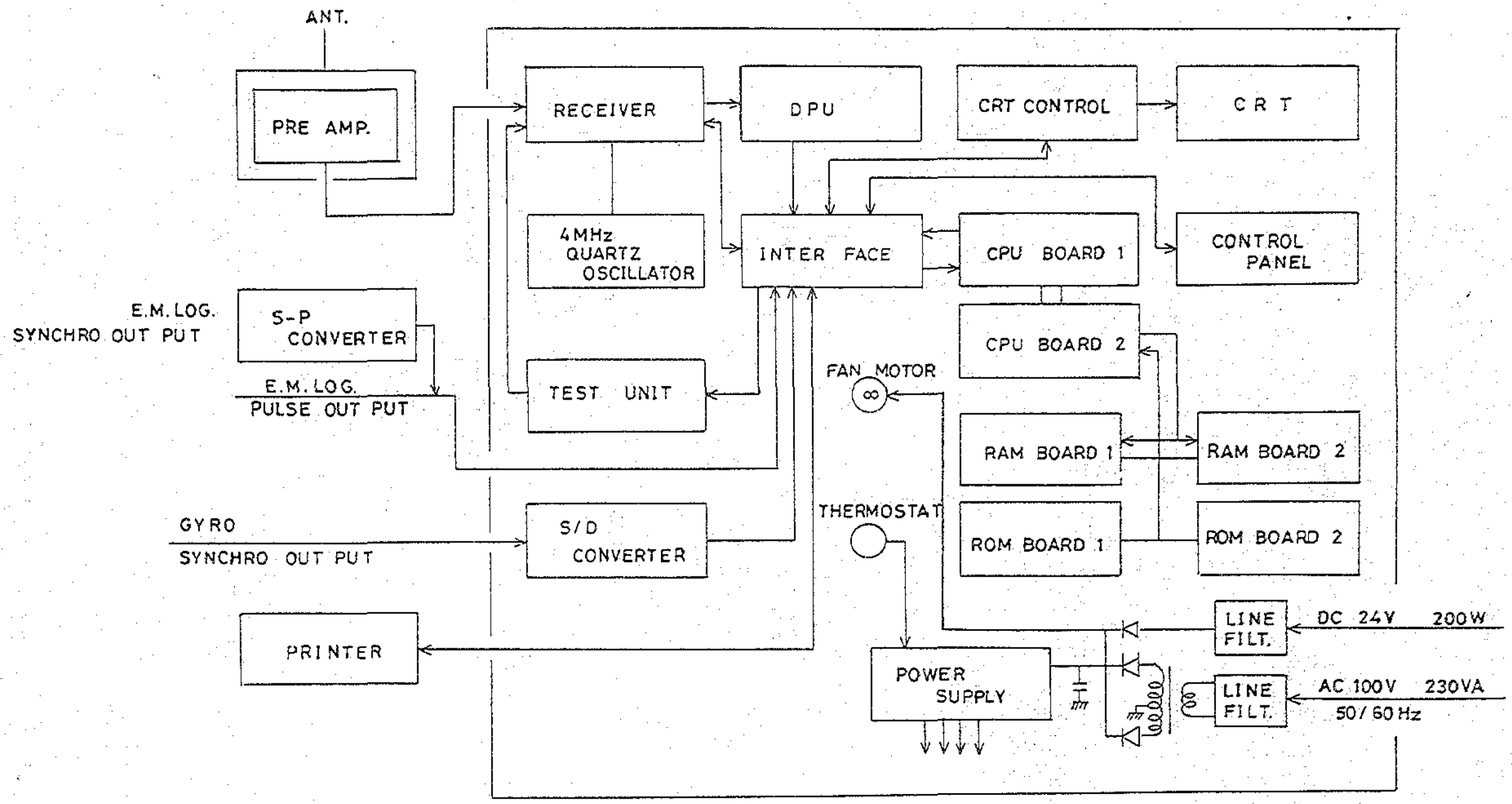


Fig.3.4.11 BLOCK DIAGRAM OF JLE-3100 NAVIGATION SATELLITE SYSTEM

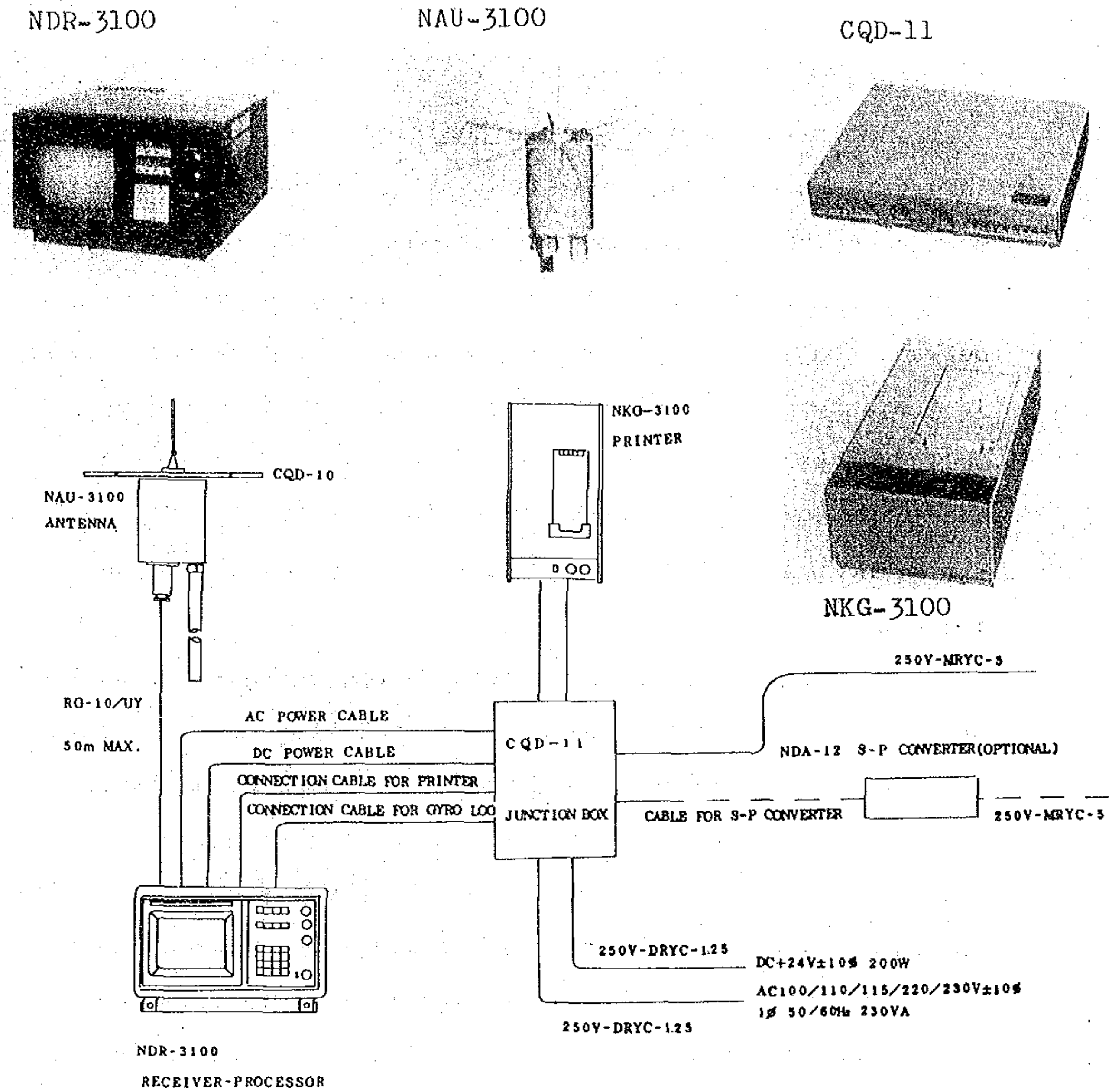


Fig.3.4.12 CONNECTION DIAGRAM OF JLE-3100 NAVIGATION SATELLITE SYSTEM

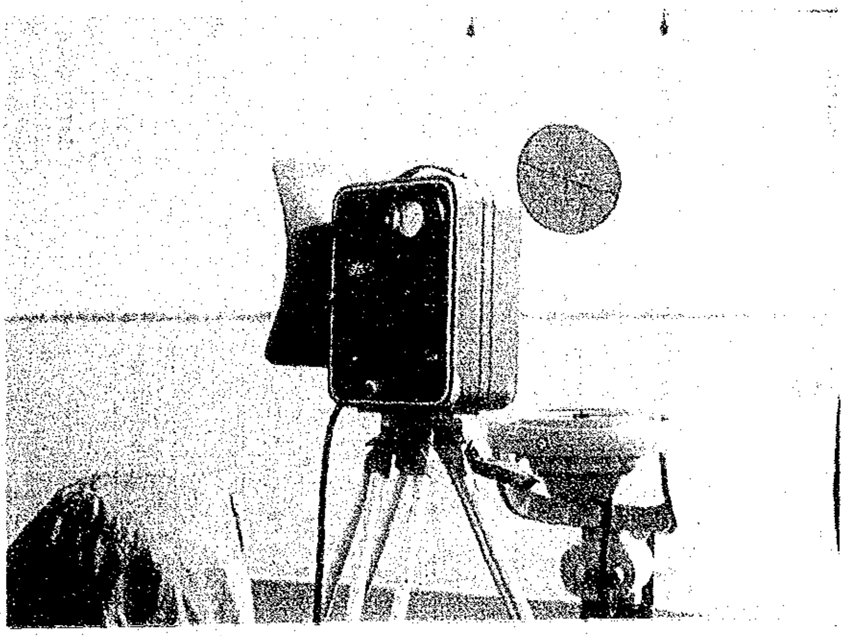
(2) Hydrodist

Hydrodist is a microwave positioning system used in survey in shore. Hydrodist consists of a master equipment mounted on board and a remote equipment installed at a given point on land, allowing directly obtaining the distance between the master and remote equipment. The Hydrodist used in the survey was MRB2 Hydrodist System manufactured by Tellurometer Co., of which the master and remote equipment are shown in Figure 3.4.13 and a block diagram in Figure 3.4.14.

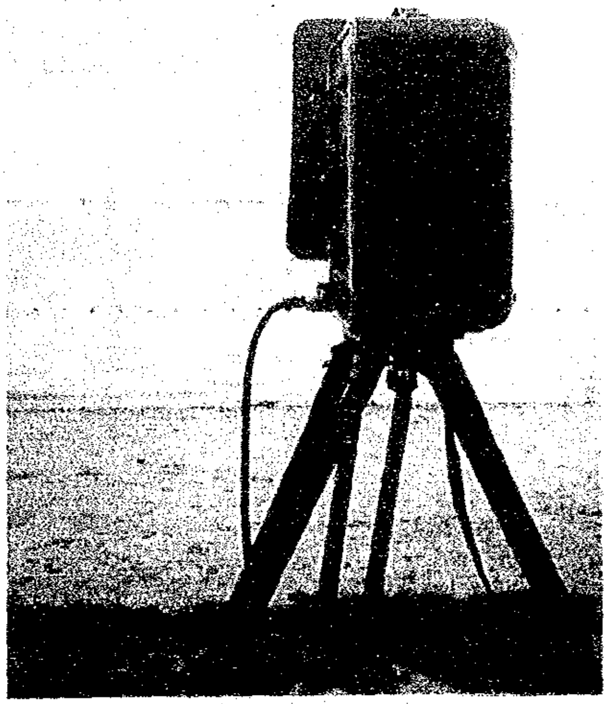
The principles of measurement by Hydrodist are as follows.

The master equipment modulates the microwave signal of about 3000MHz with the measuring signal of f_1 and transmits the microwave modulated to the remote equipment on land. The remote equipment transmits a measuring signal of f_2 and a microwave frequency modulated with a beat signal of f_1-f_2. The master equipment makes phase comparison between signal f_1 obtained in it and the beat signal of f_1-f_2 from the remote equipment, measures the delay time corresponding to the time interval required for transmission between the master and remote equipment, and displays the delay time on a CRT.

In practice, three frequencies, called pattern frequencies A, C and D are used for developing the measuring accuracy. Measurement is achievable up to 99.9m by using pattern A, from 100m to 999.9m by using patterns A and D, and 1000m to 9999.9m by using patterns A and C.



MASTER



REMOTE

Fig. 3.4.13   HYDRODIST

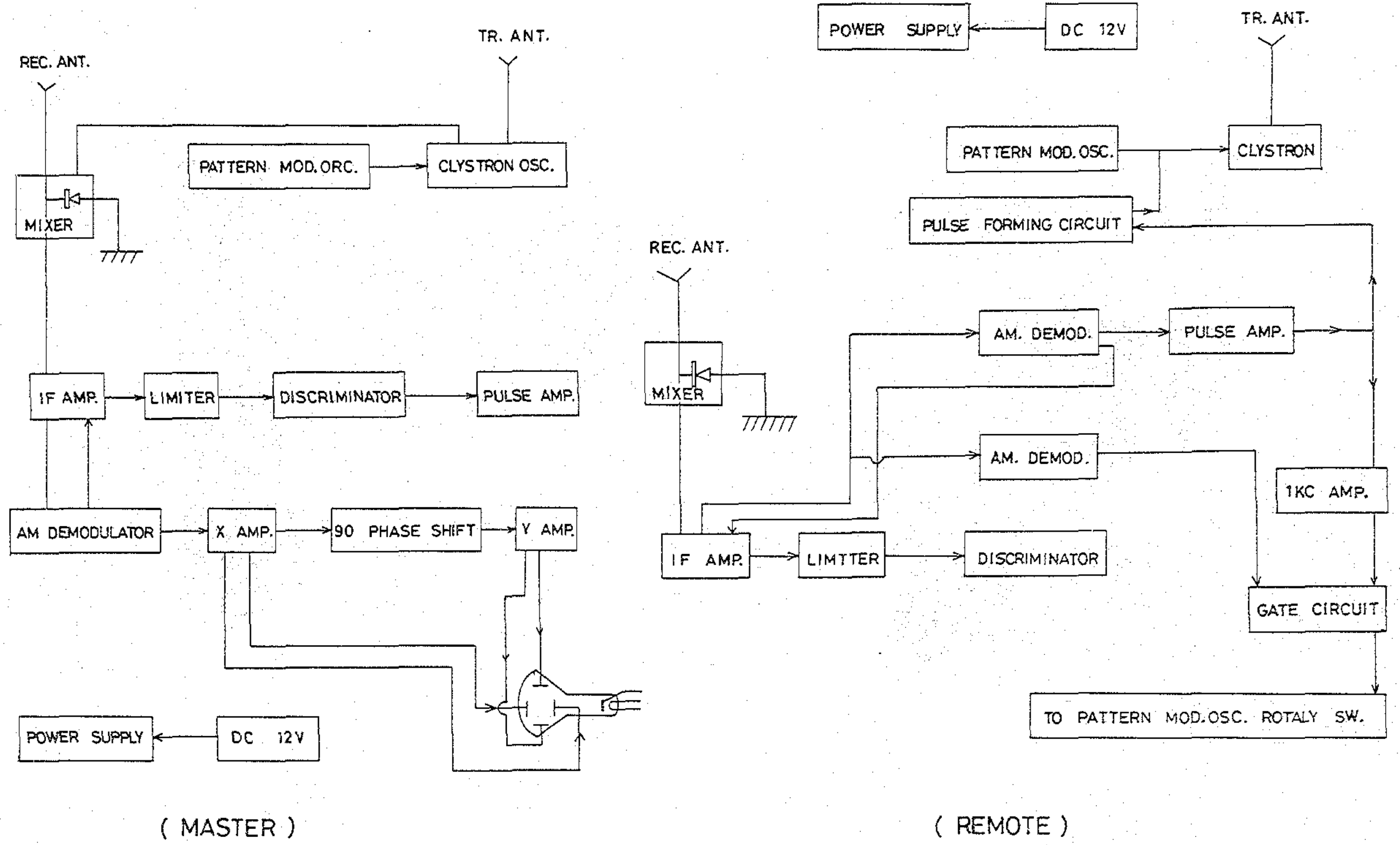


Fig. 3.4.14 BLOCK DIAGRAM OF HYDRODIST

3.4.7 Bottom Photographing System (Camera)

A 35mm deep sea standard photographing system manufactured by Benthos (United States), which consists of a camera section, a flash section, and a pinger section, was employed for photographing bottom topograph in the survey.

The flash section provides illumination by flashlight from a xenon lamp and power for rolling the film.

The camera section consists of a film roller, a shutter, a lens mount and a data chamber. Film is rolled, one frame after another, by a film driving motor powered from the flash section.

The distance to the object to be photographed and focal depth are set by control knobs located on the lens shutter mount. The data chamber displays the date and time (in date/hour/min./sec.) and station No. as shown in Figure 3.4.15 at a corner on the film frame.

The pinger section emits 12kHz sonic pulses so that the direct wave from the pinger and reflection by the bottom can be recorded by the recorder on the ship. Measurement of the time difference between the times of recording these two waves allows obtaining the distance between the pinger and the sea bottom.

The specifications of the sea bottom photographic system are as follows.

- Camera

Number of standard films:	800
Film length:	30.2m (100 feet)
Case dimensions:	64.3cm(length) x 12.5cm(diameter)
Weight:	21.0kg (in air)
	16.0kg (in water)
Shutter speed:	2/5 sec. ∿ 1/50 sec.
Required power:	DC 28V ± 5V, 1A
	(fed from Model 382 Flash)

- Flash

Flash tube input:	100W/sec.
Flashing times:	3200 times (when fully charged)
Flashing duration:	1/1000 sec.
Case dimensions:	90.5cm(length) x 21cm(max. diameter)
Weight:	31kg (in air)
	23kg (in water)
Timer set time:	0 ∿ 200 min.
Shutter speed control:	40 ∿ 400mS
Internal between exposure:	3 sec. ∿ 2 min.

- Pinger

Operating frequency:	12.0kHz ± 12Hz
Output level:	93 dB
Pulse repetition rate:	1 pulse/sec.
	1 pulse/0.5 sec.
Pulse width:	0.5mS
	2mS
	10mS

Case dimensions:	67.3cm(length) x 12.7cm(diameter)
Weight:	25kg (in air)
	18kg (in water)

Figure 3.4.16 shows the external view of the 35mm standard photographing system and Figure 3.4.17 its block diagram.

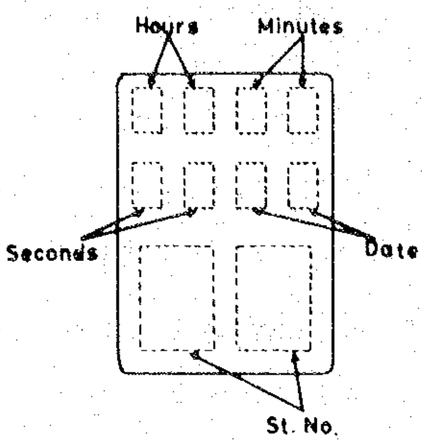


Fig. 3.4.15 DATA CHAMBER DISPLAY

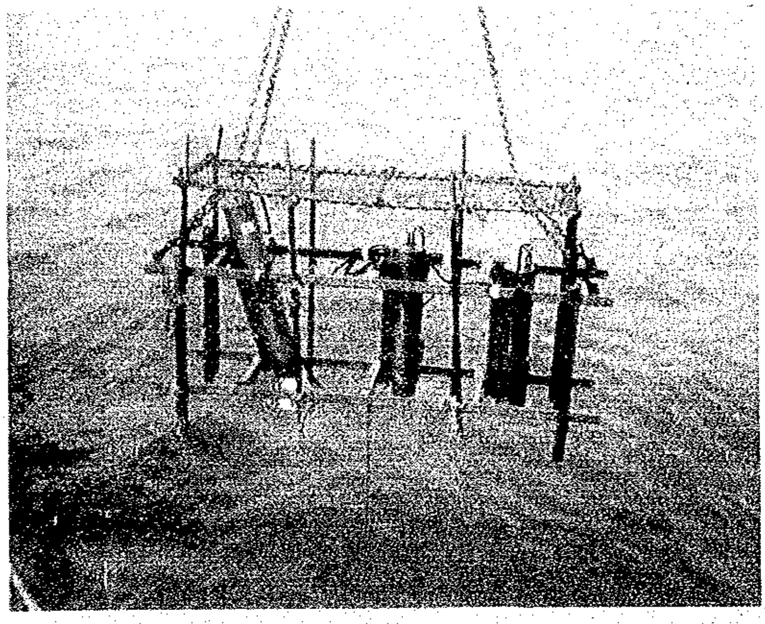
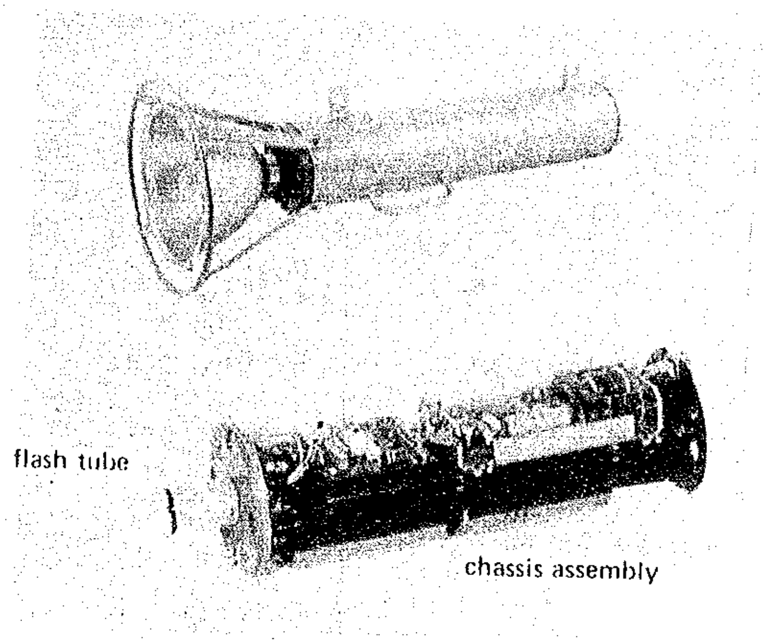
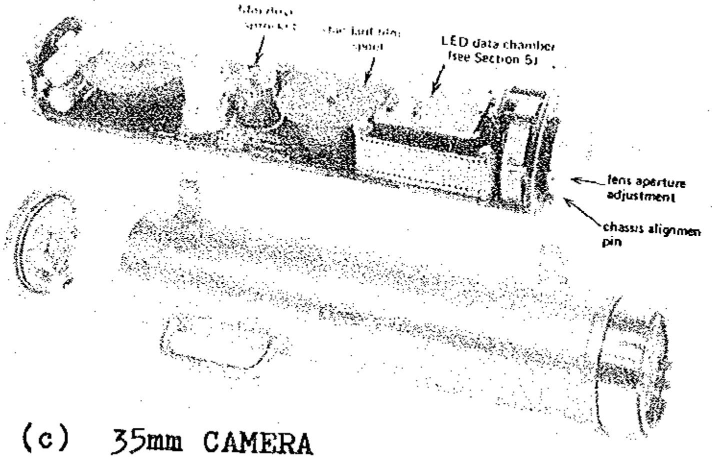


Fig. 3.4.16(a) 35mm STANDARD PHOTOGRAPHING SYSTEM



(b) Flash



(c) 35mm CAMERA

Fig. 3.4.16(b),(c) 35mm STANDARD PHOTOGRAPHING SYSTEM

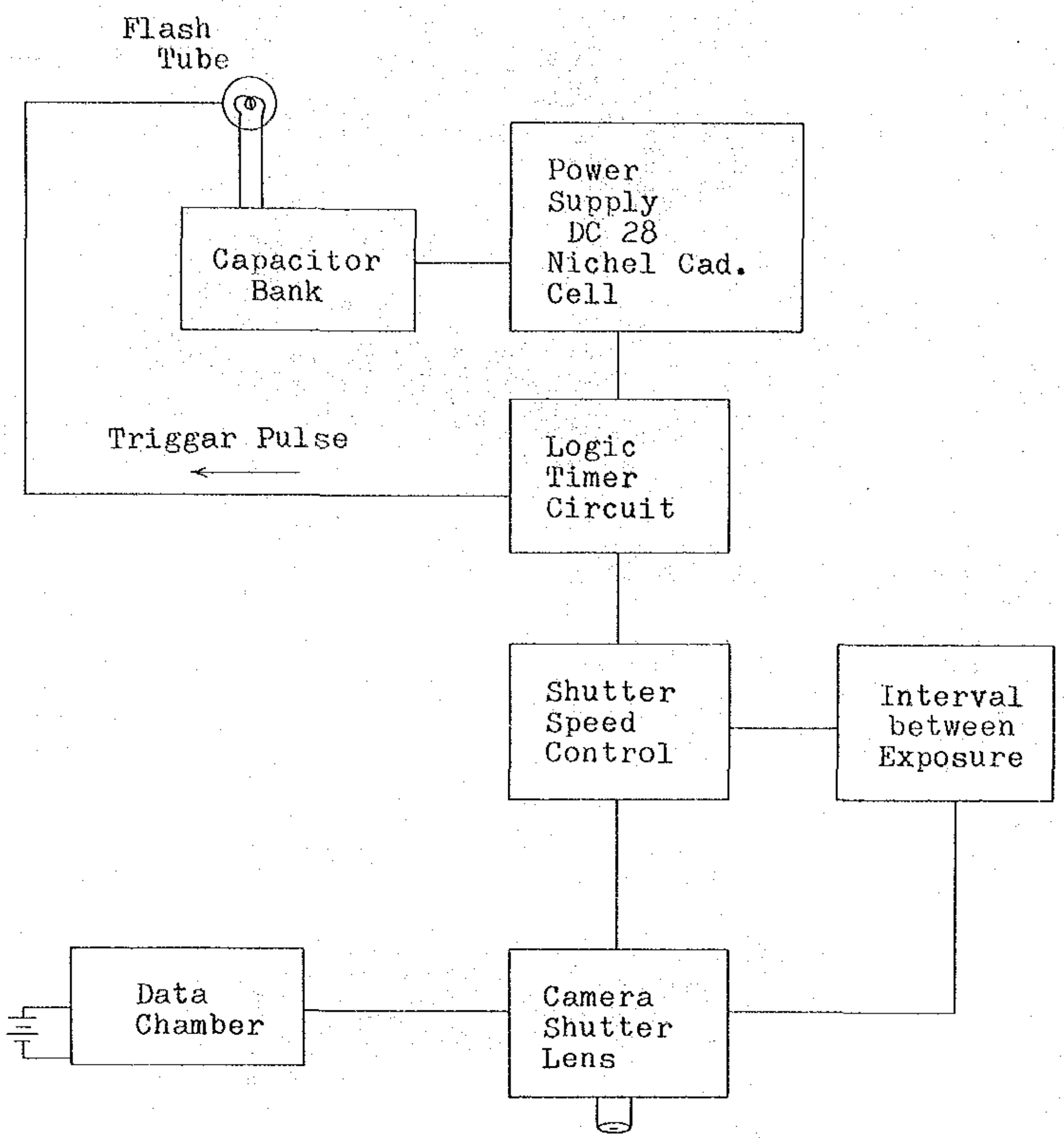


Fig.3.4.17 BLOCK DIAGRAM OF 35mm STANDARD PHOTOGRAPHING SYSTEM

3.5 Results of Survey

3.5.1 Geological Features

The survey route passed the Gulf of Thailand and the western part of the Northern Sunda Shelf along the Malay Peninsula. A sedimentary basin exists in the Gulf of Thailand and Northern Sunda Shelf. This basin, called the Gulf of Thailand Basin, ranges from the northen part of the Gulf of Thailand to near Ananbas Island.

This basin still undergoes sedimentation of mud and sand from the land, and the sediment thickness estimated by the seismic prospecting is reported to exceed 2km. In geological history, the basin appears to have started its formation together with the folding movement of the Paleozoic Era, arranged its form nearly completely in the Late Jurassic Period and, experiencing the tectonic movement in the Late Tertiary Period, reached the present condition. At present, the whole area is exceedingly stable in geological structure and scarecely encounters earthquake or the like.

The survey route is situated on the peripheral portion of the basin. Under the survey route, sedimentary rocks continue in a thickness of about 500 meters to Paleozoic Sedimentary rocks or the base.

3.5.2 Bottom Topography

The survey area extended over the western part of the Gulf of Thailand, the southern part of the South China Sea and the strait of Singapore, and the survey route ran along shores (maximum 70 nautical miles off shore) in the area. Thus the survey route was in shallow seas of less than 70 meters in depth.

Data obtained by sounding underwent tide level correction and sound velocity correction. For tide level correction, the entire survey route was divided into 12 sections and tide level correction values in the respective sections were determined by obtaining expected tide levels by using data from the International Hydrographic Organization. Sound velocity correction was made by conducting bar checking several times during the survey. The datum level was used as the reference level. The bathymetric chart of the offshore portion is shown in Figure 3.5.1, the bottom profile of the survey route (including subbottom layers) in Figure 3.5.2, and the bathymetric and contour chart in shore of Pechaburi, Kuantan and Katong in Figures 3.5.3 ~ 3.5.5. The offshore portion of the survey route was divided by bottom topography and geological features into 8 sections: Pechaburi slope, flat portion in the Gulf of Thailand, offing of Samui Island, Thailand-Malaysia flat section, Kuantan slope, offing southeast of Malaysia, the Singapore Strait and Katong slope.

Position numbers appearing hereunder are those used in the going run shown in Figure 3.3.1-1.

a) Pechaburi slope (landing point to positon No. 788)

This slope extends 120 nautical miles (222.2km) on the survey route from Pechaburi (Ban Hat Chao Samran) shore to a depth of 55 meters. The slope bottom goes down while gradually increasing the depth at rates of 1/1000∿2/1000, reaches a flat plane of 25 meters in depth, then again goes down gradually increasing the depth at an average rate of 1/1000 until it reaches a flat portion in the Gulf of Thailand. The moderate slope is nearly flat and involves small ups and downs. From 2.7nm (5km) off, small depressions of 0.5m∿1.5m in depth appear here and there. The maximum inclination of these small depressions is 16/100.

b) Flat section in the Gulf of Thailand (Pos. No. 788 to 696)

The flat section having an inclination of 1/10,000 reaches a depth of 62m. Then, remarkable ups and downs appear, which continue to the offing of Samui Island. These ups and downs form irregular trapezoidal convex with recessed tops. The longitudinal axis of each trapezoidal convex is in the direction of northwest-southest. Each convex portion is 20m∿1000m wide and 1m∿8m high with a maximum inclination of 25/100.

c) Offing of Samui Island (Pos. No. 696 to 620)

The bottom feature having specific ups and downs disappears in this section off Samui Island and, instead, a smooth slope of 5/10,000 inclination without ups and downs appears, which reaches the most shallow portion of 34m in depth. Then, the bottom gradually increases the inclination toward the south and reaches a flat portion of 54m in depth. On the way, small concaves appear on the inclined portion. These concaves are 0.6m ∿ 2.5m in depth and have a maximum inclination of 25/100.

d) Thailand-Malaysia flat section (Pos. No. 620 to 317)

This bottom section is the longest portion ranging from the Gulf of Thailand to the east coast of Malaysia and forms a flat plane with depths mostly exceeding 50m. The bottom repeatedly experiences moderate ups and downs, flat portions, and small concave and convex portions and reaches the deepest portion (69m) northeast of Kuantan. Partially inclined portions which appear in the small concave and convex portions have a maximum inclination of 35/100.

e) Kuantan slope (Pos. No. 317 to 245)

After passing the deepest portion in the route, the bottom ascends a slope to the cable landing point in Kuantan at a moderate inclination of 7/10,000, increases the inclination as it approaches the shore, and finally reaches the shore at an inclination of 3/1000. The bottom is mostly smooth although some small concave and convex portions are seen at nearly the center in this section. After reaching the shore of Kuantan, the survey route goes down on a smooth, moderate slope at nearly equal inclination and drops into a depression of 34m in depth. No small ups and downs appear on the way.

f) Offing southeast coast of Malaysia (Pos. No. 245 to 43)

After experiencing the depression, the survey route passes a moderate asent of 23m in depth and again increases the depth, reaching a flat plane of about 50m in average depth. Then moderate ups and downs and small concave and convex portions appear here and there to the Strait of Singapore. Sand waves appear regularly in areas Pos. No. 209 and Pos. No. 58. Sand waves have wave heights of 0.5m∿6m and wavelength of 20m∿500m with a maximum inclination of 15/100.

g) Singapore Strait (Pos. No. 43 to 1)

This section of the survey route undergoes strong tidal current and the bottom features unique topography with ups and downs throughout the route. Numbers of conspicuous peaks and troughs measuring 10m∿15m appear on flat or moderately inclined planes. Some large ups and downs contain small ups and downs. However, the inclination is comparatively moderate on the whole and is about 10/100 at the maximum.

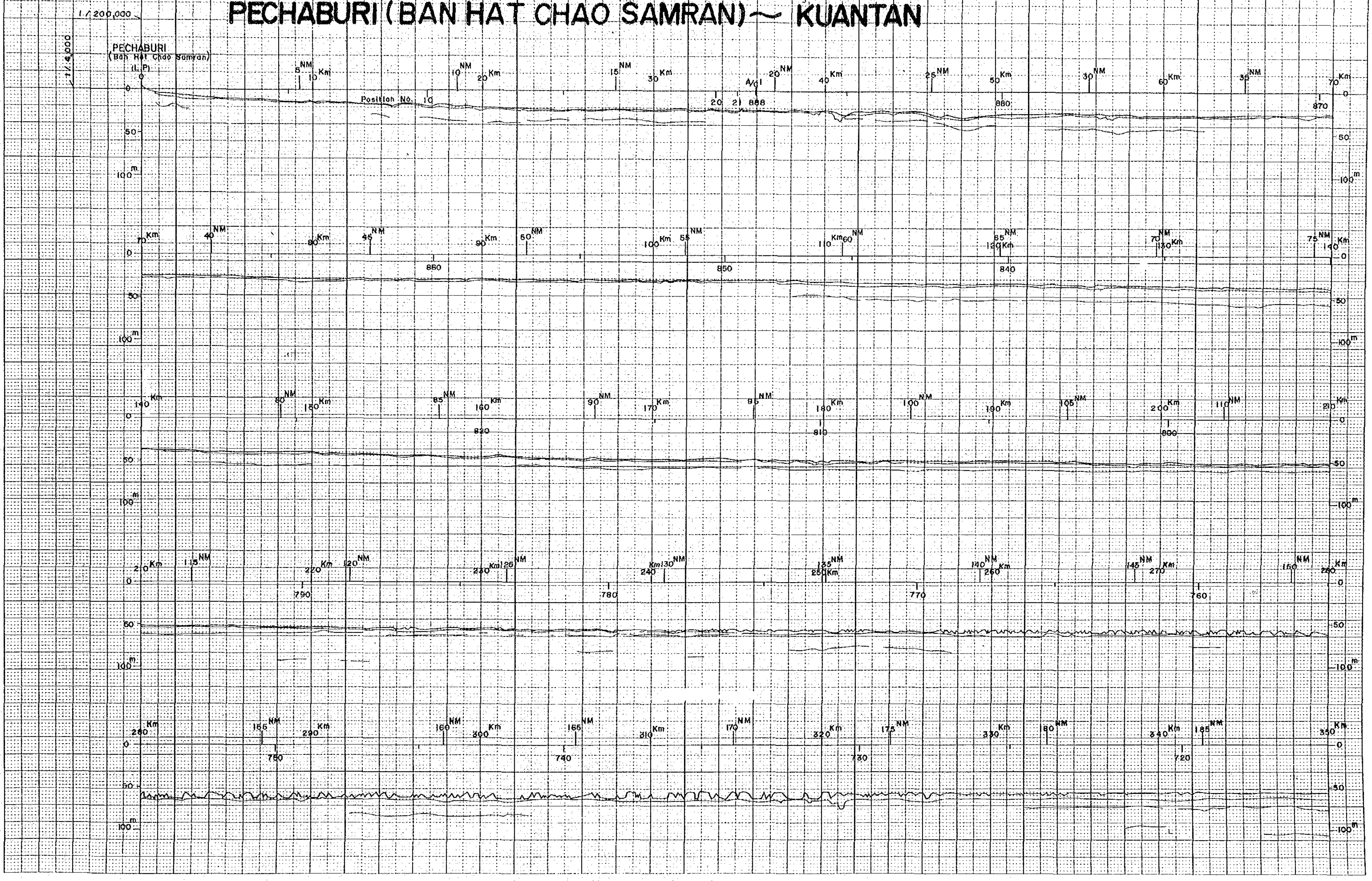
h) Katong slope (Pos. No. 1 to landing point)

The bottom repeating marked ups and downs finally reaches the shore of Katong at an inclination of about 2/100.

The bottom and subbottom profiles in the in-shore portions of Pechaburi (Ban Hat Chao Samran), Kuantan, and Katong are shown in Figures 3.5.6 ∿ 3.5.8. The inclination in the shores of Pechaburi (Ban Hat Chao Samran), Kuantan, and Katong are respectively 3/100, 4/100, and 7/100.

Fig.3.5.2(a) BOTTOM AND SUB-BOTTOM PROFILES

PECHABURI (BAN HAT CHAO SAMRAN) ~ KUANTAN



Dia Section

Fig.3.5.2(b) BOTTOM AND SUB-BOTTOM PROFILES

PECHABURI (BAN HAT CHAO SAMRAN) ~ KUANTAN

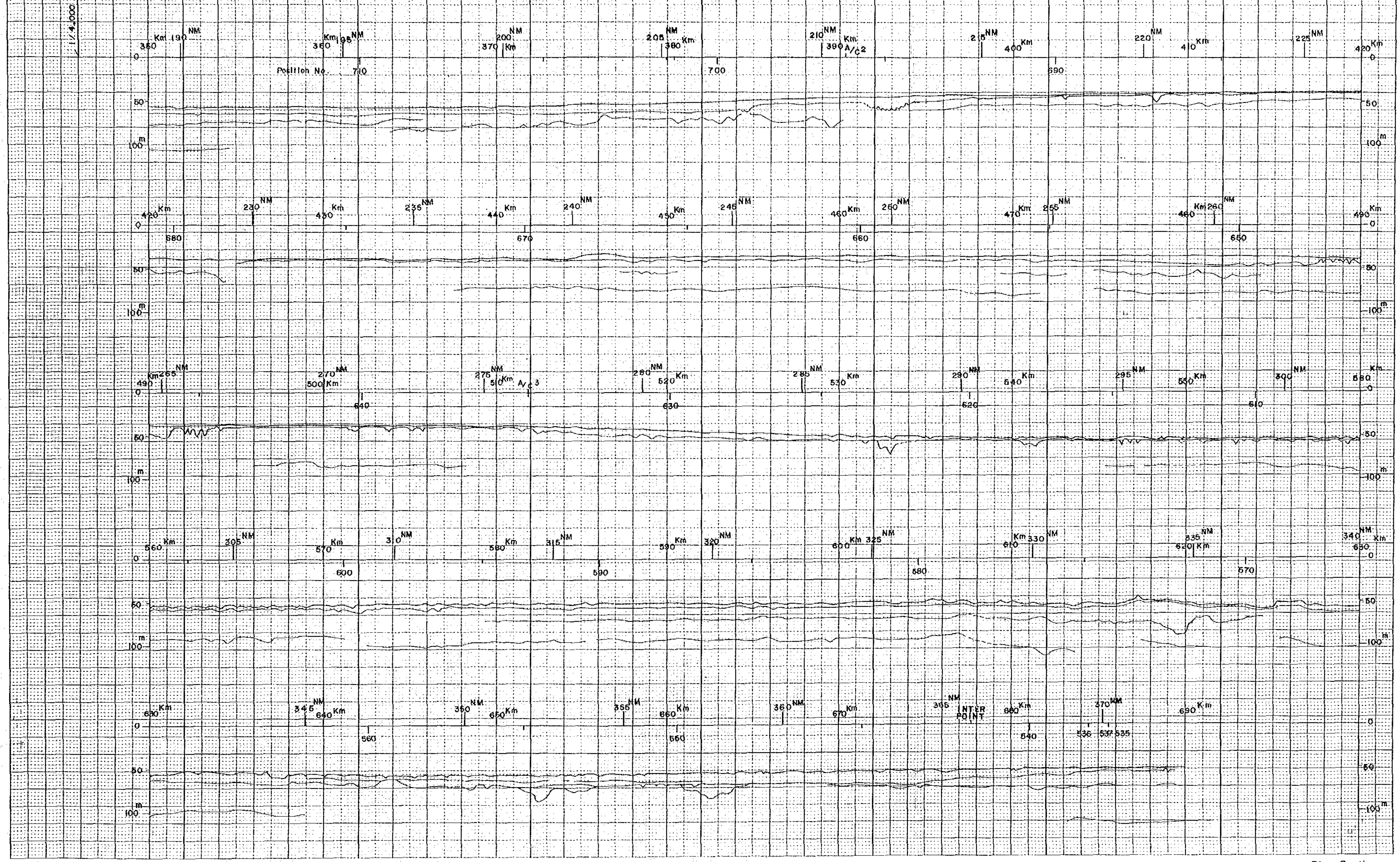


Fig.3.5.2(c) BOTTOM AND SUB-BOTTOM PROFILES
PECHABURI(BAN HAT CHAO SAMRAN) ~ KUANTAN

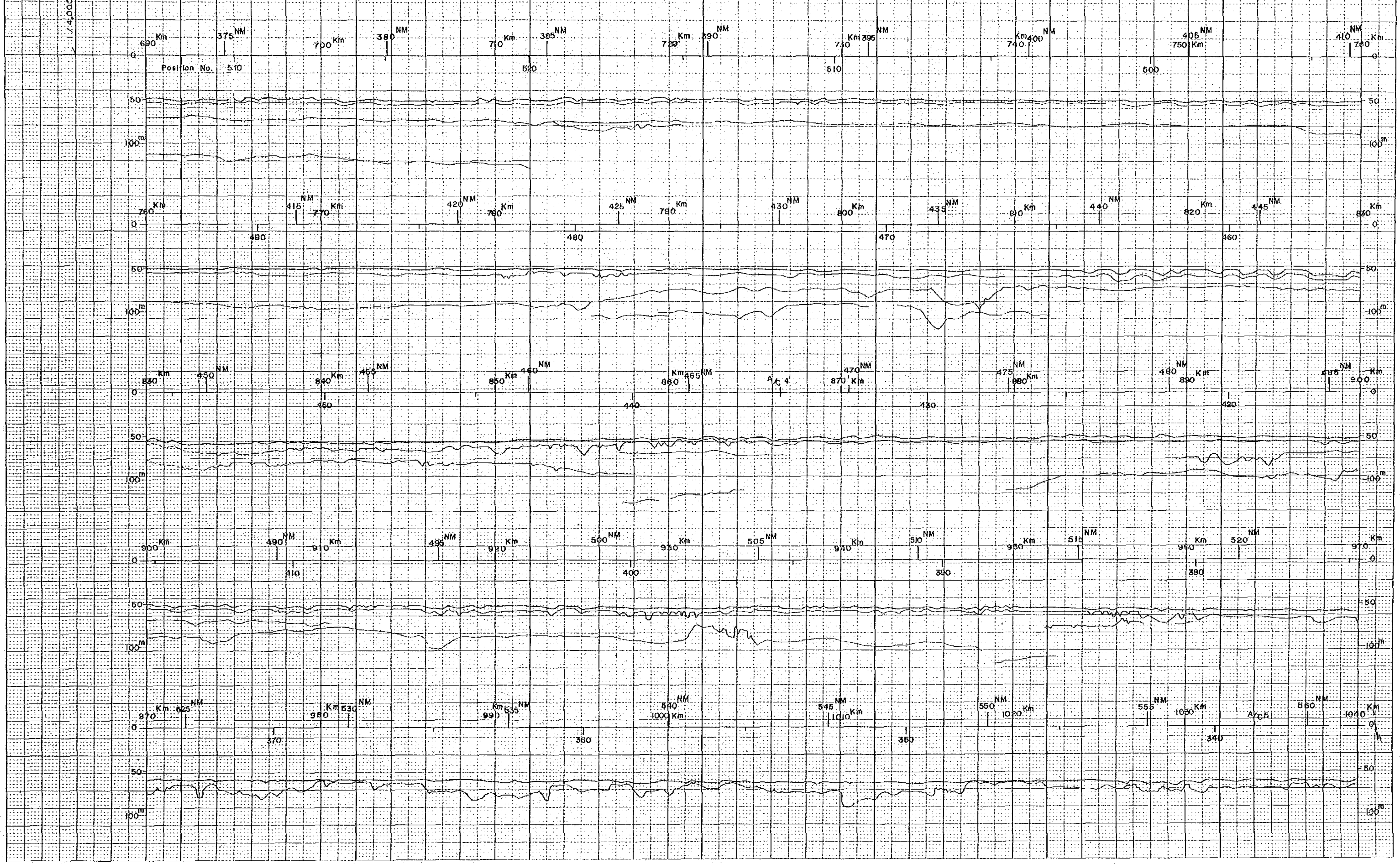


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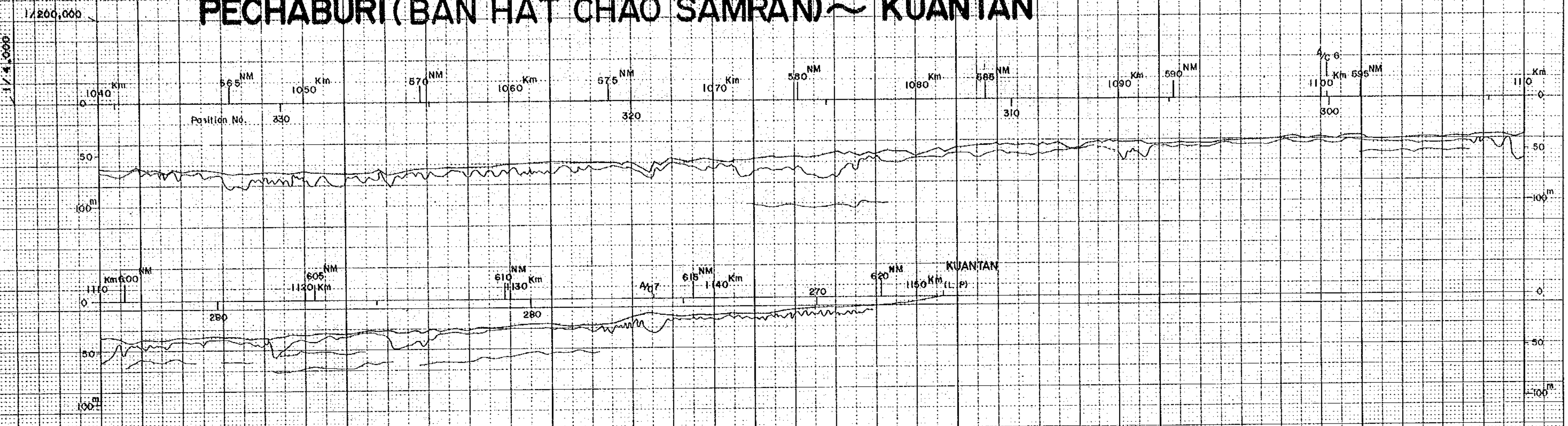
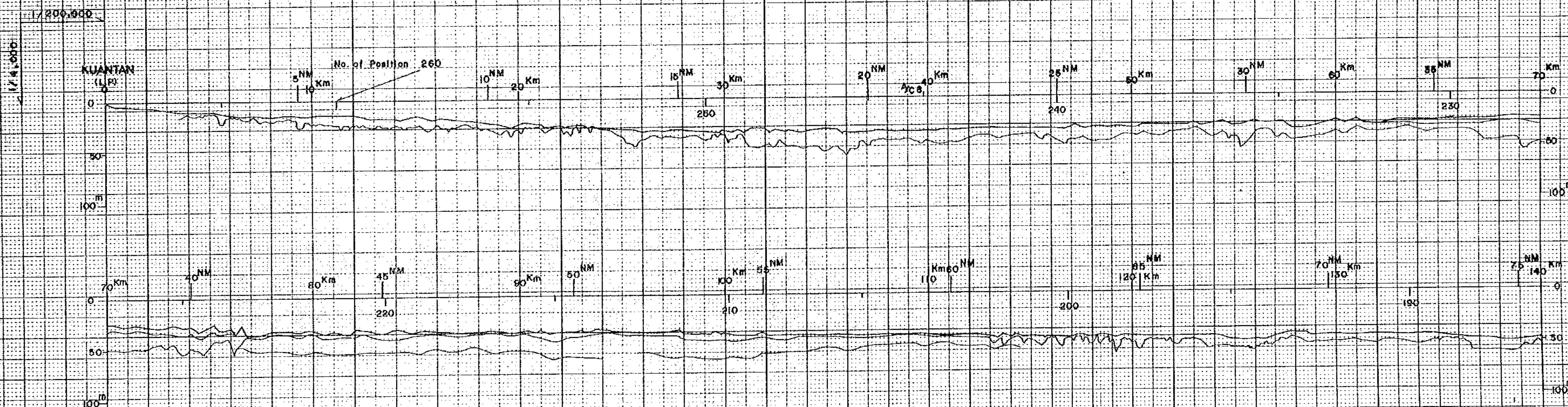
Fig 3.5.2 (d) BOTTOM AND SUB-BOTTOM PROFILES

PECHABURI (BAN HAT CHAO SAMRAN) ~ KUANTAN



KUANTAN ~ KATONG



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