APPENDICES

Appendix 1. Summary of Survey Vessel's Log Book and Magnetic Survey Diary

The survey vessel's log book states the Ocean survey from the date of vessel entered the Surabaya Port on February 5th, to the date of vessel departed from Surabaya on February 25th, 1986 after completion of survey. On the other hand, the magnetic survey diary states the magnetic survey from the date of surveyors shifting from Surabaya to Bankalang on February 5th to the date of surveyor's returning from Bankalang to Surabaya on February 23rd, 1986 after completion of the magnetic survey. The survey area was in the Jawa Sea between Bumi Anyar, Madura Island and Takisung, Kalimantan in connection with both L.Ps over a total distance of about 380 km.

On the Ocean survey, the Team extensively examined together with counterparts concerning the contents of the survey. Instruments were arranged and adjusted suficiently for smoother survey.

The following contents of the survey works were abstracted from the survey vessel's log book and the magnetic survey diary.

(1) The Summary of Survey Vessel' Log Book

N.P ..... Noon position

Wr ..... Weather

Sc ..... Sea condition

W.D ..... Wind direction

W.F ..... Wind forces

* The observation was made at noon.

Feb. 5th 1986 Wed. N.P at Surabaya

Wr: fine, but cloudy; W.D: NW; W.F: 2; Sc: smooth

1100 "No.5 KAIKO MARU" alongsided on Derumaga Jamrud Pier at Surabaya Port.

1600 Survey team, 4 counterparts members and 2 navy officers embarked.

Feb. 6th Thu. N.P at Surabaya

Wr; fine, but cloudy; W.D: N; W.F: 1; Sc: smooth

- o "No.5 KAIKO MARU" moored at pier in Surabaya Port all day long.
- o Preparation of Survey instrument was carried out.

Feb. 7th Fri. N.P at Surabaya

Wr: fine, but cloudy; W.D: W; W.F: 2; Sc: smooth

Preparation of survey instrument was carried out.

1325 Banker oil and foods were supplied.

1550 Fresh water was supplied.

2050 "No.5 KAIKO MARU" left Surabaya for Bumi Anyar offshore.

Feb. 8th Sat. N.P lat. 6°-52.3'S, long. 113°-06.03'E

Wr: fine, but cloudy; W.D: NW; W.F: 2; Sc: smooth

0130 "No.5 KAIKO MARU" arrived at Bumi Anyar offshore.

0600 Coastal survey commenced.

Survey items were as follows:

- o Control survey (Ship's position was fixed by NNSS and Audister)
- o Installation of current meters
- o Preparation of magnetic survey barge

Feb. 9th Sun. N.P: lat. 6°-52.9'S, long. 113°-06.6'E

Wr: fine, but cloudy; W.D: W; W.F: 4, Sc: moderate

0600 Coastal survey commenced.

Survey items were as follows:

- o Checking the current meter using a local boat.
- o Sounding, Sea Bottom Scanning and Subbtottom Profiling. (Using local boat at area between 700 m and 1500 m from L.P)
- o Bottom sampling at dried up area
- o Control survey (Survey vessel shifted westward and vessel's position was fixed by NNSS and Audister)

Feb. 10th Mon. N.P lat. 6°-52.5'S, long. 113°-06.75'E

Wr: fine, but cloudy; W.D: NW; W.F: 4; Sc: Moderate

0600 Coastal survey commenced.

Survey Items

- o Checking current meters at sea using local boat
- o Sounding, sea bottom scanning and subbtottom profiling (in area between 1500 m and 4500 m from L.P using "No.5 KAIKO MARU")
- o Bottom sampling at St.AM-1.
- o Earth specific resistivity survey (shore in front of L.P)

Feb. 11th Tue. N.P lat. 6°-52.6'S, long. 113°-06.1'E

Wr: fine, but cloudy; W.D: NW; W.F: 4; Sc: moderate

0600 Offshore survey commenced

Survey Items

- o Bottom sampling, water thermometry and seabed photographing (using "No.5 KAIKO MARU" at St. AM-101, 102, 103, 104, and 105)
- o Levelling survey at dried up area.
- o Earth specific resistivity survey (Shore in front of L.P)

1800 GOING RUN survey commenced.

Survey Items

- o Sounding, subbottom profiling and sea bottom scanning (commenced at area 4500 m offshore)

Feb. 12th Wed. N.P lat. 5°-39.9'S, long. 113°-38.9'E

Wr: cloudy; W.D: W; W.F: 3; Sc: moderate

Ocean survey was continuously conducted.

Survey Items

o Sounding, subbottom profiling and sea bottom scanning

1900 Passed distance 107 miles off St. A/C 2

Feb. 13th Thu. N.P lat 3°-45.7'S, long. 114°-29.9'E

Wr:fine, but cloudy; W.D: NW; W.F: 1; Sc: smooth

Ocean survey was continuously conducted.

Survey Items

o Sounding, subbottom profiling and sea bottom scanning

1100 GOING RUN survey in the Ocean area completed.

1400 Survey vessel "No.5 KAIKO MARU" left for Banjarmasin Port from Takisung offshore.

1500 Pilot boarded at No.1 buoy off Banjarmasin.

1858 Vessel arrived at Banjarmasin Port and anchored.

Feb. 14th Fri. N.P: lat. 3°-18.9's, long. 114°-34.5'E

Wr: cloudy; W.D: N; W.F: 1; Sc: smooth

Emigration procedure was carried out.

1000 Members of site survey left vessel for L.P survey, then shifted to Takisung via shore.

Peg of Control Point was burried at Takisung L.P

1355 "No.5 KAIKO MARU" left Banjarmasin and proceeded to Takisung offshore.

1835 Vessel arrived at Takisung offshore and anchored.

Feb. 15 Sat. N.P: lat. 3°-51.6'S; long. 114°-34.0'E

Wr: cloudy; W.D: WNW; W.F: 3; Sc: slight

0600 Coastal survey was carried out.

Survey Items

- o Control survey (Position fixing by NNSS and Audister)
- o Earth specific registivity survey on beach in fron of L.P
- o Bottom sampling at dried up area
- o Leveling on shore beach
- o Shore topographic feature survey

Feb. 16 Sun. N.P: lat. 3°-53.5'S, long. 114°-33.5'E

Wr: cloudy; W.D: W; W.F: 2; Sc: slight

0600 Coastal survey commenced.

Survey Items

- o Control point survey
- o Sounding, Subbottom profiling and sea bottom scanning (in the area 5000 m away from L.P (by local boat))
- o Shore topographic feature survey

Feb. 17 Mon. N.P: lat. 3°-53.2'S, long. 114°-33.8'E

Wr: cloudy; W.D: W; W.F: 2; Sc: slight

0600 Coastal survey commenced.

Survey Items

- o Bottom sampling and water thermometry at St. BM-3,4,5,6 and 7
- o Sounding near the shore line (using local small boat with outboard engine)

1400
- o Withdrawn current meters at St.B-1 and B-2 (by No.5 KAIKO MARU)
- o Bottom sampling at St.0-1

Feb. 18 Tue. N.P: lat. 3°-53.5'S, long. 114°-33.0'E

Wr: cloudy; W.D: NW; W.F.: 3; Sc: slight

0600 RETURNING RUN survey commenced

Survey Items

- o Sounding, bottom sampling, water thermometry, current observation and seabed photographing

0600 Fixed point observation at st.0-2 (Bottom sampling, water thermometry, current observation and seabed photographing)

0730 Bottom sampling at St.0-3

0800 Supplement survey was carried out over an area 7 km off Takisung (Sounding, sea bottom scanning)

1200 Bottom sampling at St.0-3 (By vibrocorer)

1700 Fixed point observation at St.0-4.

2100 Fixed point observation at St.0-5.

* Sounding survey was carried out between every fixed station on Return Run course.
(This description will be omitted hereinafter.)

Feb. 19 Wed.　N.P: lat. 5°-23.2'S, long. 113°-43.8'E

Wr: cloudy; W.D: NW; W.F: 4; Sc: moderate

0100　Fixed point observation at 0-6.

0530　Fixed point observation at 0-7.

0930　Fixed point observation at 0-8.

1400　Fixed point observation at 0-9.

1800　Fixed point observation at 0-10.

2230　Survey vessel anchored at 0-11 and waited.

Feb. 20 Thu.　N.P: lat. 6°-35.8'S, long. 113°-12.9'E

Wr: cloudy; W.D: NW; W.F: 4; Sc: moderate

0600　Fixed point observation at 0-11.

1030　Fixed point observation at 0-12.

1400　Fixed point observation at 0-13.

1730　Returning run survey in the Ocean area completed.

1830　Survey vessel anchored at off Bumi anyar.

Feb. 21 Fri.　N.P: lat. 6°-52.7'S, long. 113°-07.4'E

Wr: cloudy; W.d: NW; W.F: 3; Sc: slight

Survey vessel "No.5 Kaiko Maru" anchored at off Bumi Anyar through a day.

0700　Sea bottom scanning was carried out using a local boat in the area around magnetic anomaly point discovered in front of Bumi Anyar shore.

- o The ocean and coastal survey data processing was made.
- o The instruments used for magnetic survey were reloaded on to the survey vessel.

Feb. 22 Sat.　N.P: lat. 6°-49.5'S, long. 112°-54.5'E

Wr: fine, but cloudy; WD: W; W.F: 3; Sc: slight

- o Data processing for the Ocean and coastal survey was carried out.

o The instruments for magnetic survey were reloaded on to survey vessel.

1000 The current meters were withdrawn at St. A-1 by using "No.5 Kaiko Maru".

1100 "No.5 Kaiko Maru" proceeded to Surabaya anchorage

1300 "No.5 Kaiko Maru" arrived at Surabaya anchorage area and anchored.

Feb. 23 Sun. N.P: Surabaya Port

0715 Survey vessel hove up anchor.

0750 Pilot boarded and survey vessel proceed to Surabaya berth.

0940 Survey vessel alongsided on Surabaya wharf.

1100 Survey vessel took fresh water in.

o Data processing for the ocean survey was made.

o The counterparts and Navy officers disembarked.

Feb. 24 Mon. N.P: Surabaya port

Wr: fine, but cloudy; W.D: NW; WF: 3; Sc: smooth

Entering port procedure cleared

1500 All members of survey team disembarked.

Feb. 25 Tue N.P: Surabaya port

Wr: fine, but cloudy; W.D: NE; WF: 2; Sc: smooth

1150 Pilot boarded and "Kaiko Maru" departed at Surabaya port and sailed to Japan.

1345 Pilot left the vessel.

1430 The vessel set her course at 310°.

(2) Magnetic Survey Diary

Feb. 5 Wed. 1986 Wr: fine

- o Magnetic surveyors shifted to Bankalan from Surabaya.

Feb. 6 Thu. Wr: fine

- o Reconnaissance at Bumi Anyar

Feb. 7 Fri. Wr: fine

- o Same as above.

Feb. 8 Sat Wr: fine

- o Control point survey was carried out.
- o The instruments for magnetic survey were installed on the magnetic survey boat.
- o Survey charts were drawn.

Feb. 9 Sun. Wr: fine, Sc: moderate

- o Control point survey (leading point established)
- o Magnetic survey was carried out at dried up area by man-walking.

Feb. 10 Mon. Wr: fine; Sc: moderate

- o Equipped a large magnetic boat.
- o Data processing

Feb. 11 Tue. Wr: cloudy; Sc: rough

- o No magnetic survey conducted at costal area due to bad weather.
- o Levelling survey at dried up area.
- o Data processing

Feb. 12 Wed. Wr: cloudy; Sc: rough

- o No magnetic survey at coastal area due to bad weather.
- o Magnetic survey at dried up area was conducted by man-walking.

Feb. 13 Thu. Wr: fine, but cloudy weather; Sc: smooth

- o Magnetic survey was conducted at coastal area, using a large local boat.
- o Equipped a small magnetic boat

Feb. 14 Fri Wr: fine, but cloudy; Sc: smooth

- o Magnetic survey was conducted at coastal area, using a small local boat.
- o Data processing

Feb. 15 Sat. Wr: fine, but cloudy; Sc: slight

- o Magnetic survey was conducted in coastal area, using by a large local survey boat.
- o Data processing

Feb. 16 Sun. Wr: fine, but cloudy; Sc: slight

- o Magnetic survey was conducted in coastal area, using a large local boat. (Magnetic survey at offshore area was completed.)

Feb. 17 Mon. Wr: fine, but cloudy; Sc: moderate

- o Magnetic survey was conducted in dried up area by man-walking
- o Data processing

Feb. 18 Tue Wr: fine, but cloudy; Sc: rough

- o Magnetic survey was conducted in dried up area by man-walking.
- o Magnetic survey was started, using a small local boat, but stopped due to bad weather.

Feb. 19 Wed. Wr: fine, but cloudy, then cloudy; Sc: smooth

- o Magnetic survey was conducted in dried up area by man-walking.
- o Magnetic survey was conducted in coastal area, using a small local boat.

Feb. 20 Thu. Wr: fine, but cloudy; Sc: slight

- o Magnetic survey was conducted in dried up area by man-walking.
- o Magnetic survey was started, using a small local boat but stopped due to bad weather.
- o Data processing

Feb. 21 Fri. Wr: fine, but cloudy weather; Sc: smooth

- o Magnetic survey was conducted in dried up area and completed in this area.
- o The peg for control point was burried at L.P in Bumi Anyar shore.
- o Topographic survey was conducted around the L.P.
- o Data processing

Feb. 22 Sat. Wr: fine, but cloudy; Sc: slight

- o The instruments for magnetic survey were cleared.
- o The instruments were reloaded onto "No.5 Kaiko Maru".
- o Representative surveyors called on the governer of the State of Madura island and the that of Bangkalan

prefecture as well, and reported on the completion of the magnetic survey.

Feb. 23. Sun. Wr: fine

o Magnetic surveyors moved to Surabaya from Bangkalan.

Appendix 2. Survey Vessels

When conducting the route survey, the survey vessel "Kaiko Maru No.5" was used in the ocean area and the local survey boats "Bintang Selatan II" at Bumi Anyar and "Jadi Jaya" at Takisung were used in both coastal areas. Local small boats were also used for magnetic survey and as traffic boats at the time.
The vessel and boats were selected as the cable route survey vessel (boats) to perform full capability. Details of vessel (boats) used for the route survey are given below, and outfitting of "Kaiko Maru No.5" is shown in Figure 2-1.

Survey vessel "Kaiko Maru No.5" (Owner: Tokai Salvage Co., Ltd.)

Length, overall	: 48.30 m
Length between perpendiculars:	41.80 m
Moulded width	: 10.00 m
Moulded depth	: 4.60 m
Planned draft	: 3.50 m
Thruster	: Bow thruster (2.3 tons)
Speed	: 13 knots
Fuel tank capacity	: 265 kl
Fuel consumption	: 12 kl/day
Classification	: NK (NS MNS)
Navigation area	: Limitted ocean going (International)
Gross tonnage	: 499.59 tons
Main engine	: 1,600 BHP x 2
Propeller	: V.P.P. x 2
Main generator	: 220 kvA x 2
Auxiliary generator	: 50 kvA x 2
Square of working deck	: 180 m^2
Hold capacity	: 500 tons

Lifting gears : Large A shape frame (10 tons)
Winch (3), Capstern (2)

Max. crews onboard : Crews (14), others (26)

Navigation aids : Radar, NNSS and Electro-magnetic log

Conmmunications : 500 W wireless telegram
400 W wireless telephone
International VHF telephone
Facsimile

Survey instrument : Echo sounder, Echo sounder (for deep sea)

Observation room : Observation room and data processing room

Local Survey Boat No.1 "Bintang Selatan II" (Figure 2-2)

Nationality : Indonesia

Type : Fishing boat

Gross tonnage : About 30 tons

Local Survey boat No.2 "Jadi Jaya" (Figure 2-2)

Nationality : Indonesia

Type : Traffic boat

Gross tonnage : About 12 tons

Local Survey boat No.3 4 local small boats (Figures 2-3, 2-4)

Nationality : Indonesia

Type : Fishing boats

Gross tonnage : Each about 0.5 to 2 tons

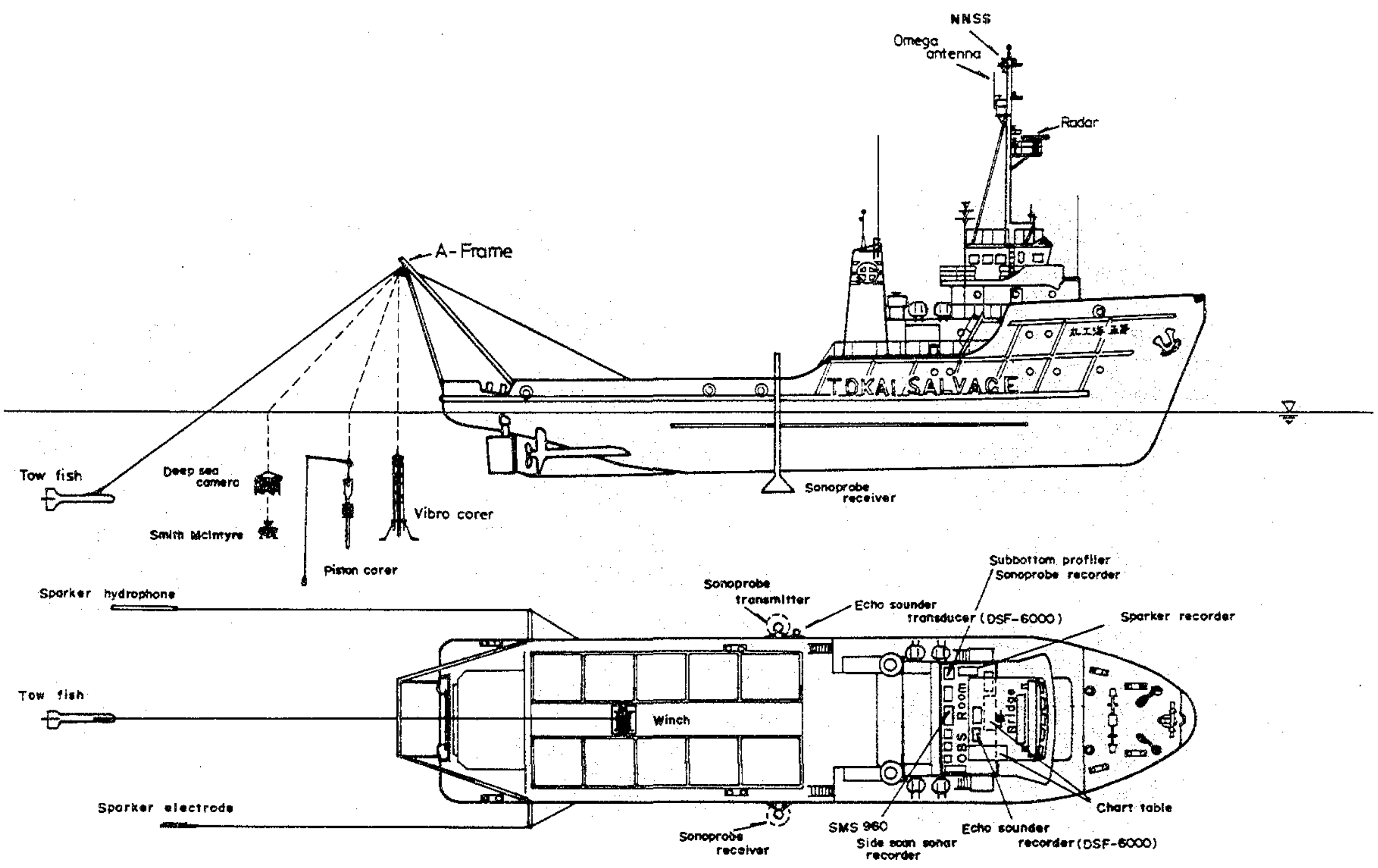
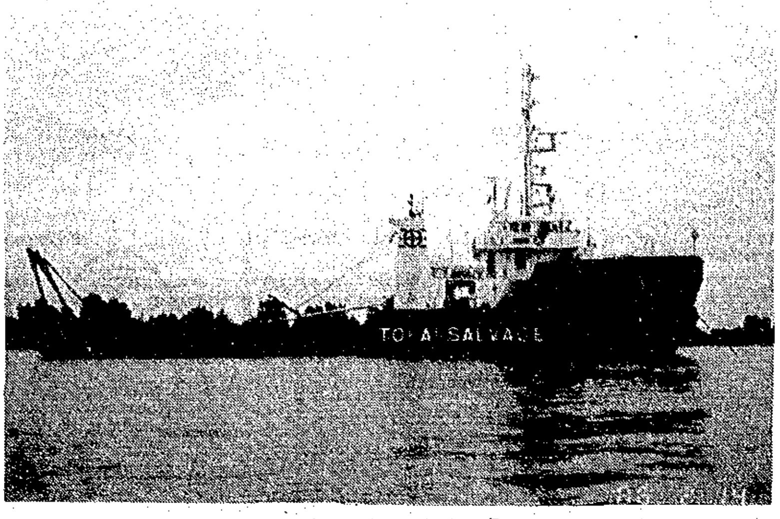
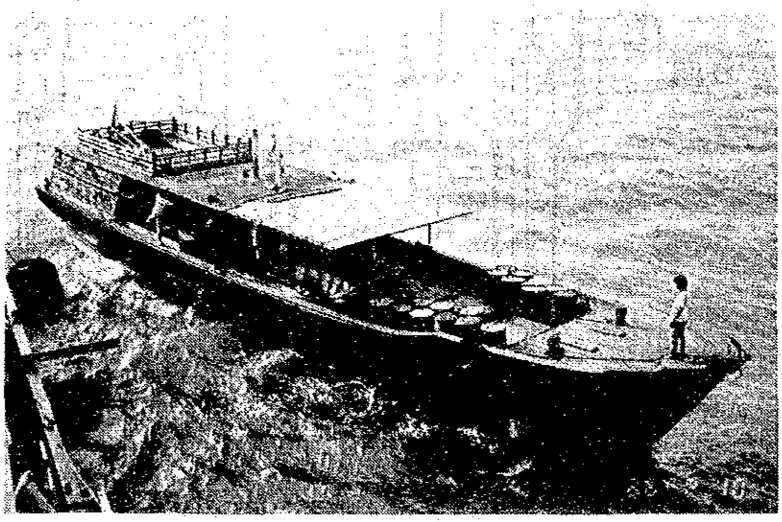


Figure 2-1   OUTFITTING OF "KAIKO-MARU No5" FOR SURVEYING



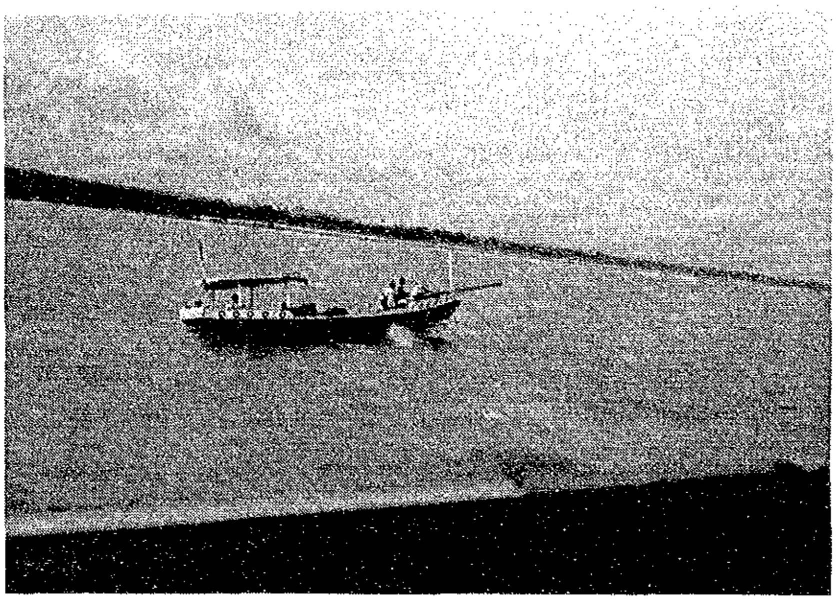
KAIKO-MARU No5



BINTANG SELATAN II

JADI JAYA

Figure 2- SURVEY SHIPS



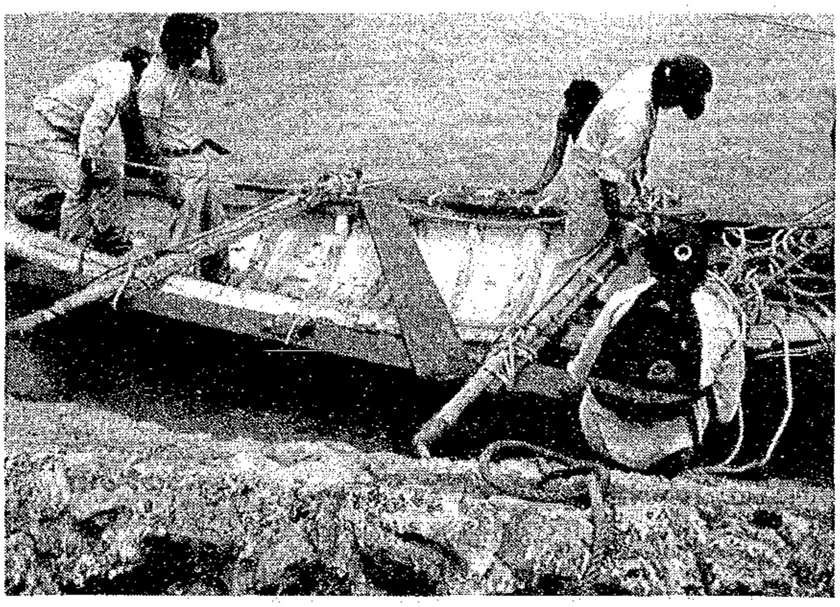


Figure 2-3 LOCAL SMALL BOAT (BUMI ANYAR)

Figure 2-4 LOCAL SMALL BOAT (TAKISUNG)

Appendix 3 Survey Equipments and Survey Methods

Main equipment used for the route survey are given in the table below.

Survey Items	Name of Equipment	Q'ty	Manufacturer	Model
Positioning	NNSS OMEGA Radar Electronic positioning system " Transits Sextants	1 1 1 1 1 3 4	J.R.C. " " Telluro-meter SPC Sokkisha Tamaya	JLF-3850 JLA-104 JMA-252 MRD-1 9D Reading 10" "
Sounding	Echo-sounder for shallow sea Portable echo-sounder "	1 1 1	Raytheon Senbon Denki Rasa Denshi	DSF-6000 Digital type PDR-101 RS-61
Subbottom profiling	Sparker Sonoprobe	2 1	NEC Kaijo Denki	NE19C SP-3
Sea bottom scanning	Side scan sonar "	1 2	EG & G	SMS960 (Deep sea) Mark-1B
Bottom sampling	Vibro corer Pistone corer Smith-Mcintyre	1 2 1	Toho-Chika Rigo-sha "	Soft landing type Piston type
Water thermometry	Electric thermometer	3	Toho-Dentan	ET-5
Current observation	Aanderaa current meter	9	Aanderaa	RCM-4
Photographs of seabed	Deep sea camera Handy underwater camera	1 1	Benthos Nikon	
Survey on land	Distance meter Level Earth specific resistance meter	1 2 1	K&E Sokkisha Yokogawa-Hokusin-Denki	Autoranger-J Automatic 3244 type
Magnetic survey	Magnetic meter	2	Daiwa Tansa	DTM-2 (for sea) DTM-1 (for shore)

(1) Positioning

1) Navy Navigation Satellite System (NNSS)

The Navy Navigation Satellite System (NNSS) is consists of five navigation satellites currently in operation and a command earth station capable of measuring orbits of the satellites and transmitting their orbital data to the satellites.

These satellites all fly on a circular polar orbit which passes just above the north and south poles located at both ends of the axis of the earth. The satellites fly around the earth at an altitude about 1,100 km and cycles of about 108 minutes, and the earth rotates on its axis eastward by about 26.5° during this period. The five satellites can, therefore, be successively used one by one as the earth rotates on its axis (refer to Fig. 3-1).

The area where the survey was conducted is located in a range between the latitudes of 3° S and 7° S, and the number of satellites which fly over this area is about twenty (20) per one day.

The positioning principles of the NNSS are as follows: A satellite of the NNSS transmits signals of two frequencies; f_1 = 399.968 MHz and $f_2 = 3/8 \cdot f_1$ = 149.988 MHz and time signals as well at two-minute intervals and data required for calculating the satellite position, as illustrated in Figure 3-1.

The satellite transmits time signals at positions (time) of t_0, t_1, t_2 ..... rotating on a circular orbit. Consequently, the time of $t_1 - t_0$, $t_2 - t_1$, ... $t_i - t_{i-1}$ are all two minutes. At this time, the satellite gradually approches the earth in the order of D (t_0), $D(t_1)$ ..... $D(t_i)$, leaving the earth thereafter in the reverse order, and sinking below the horizon. The receiving frequency is counted at this time. Applying the Doppler effect to the above proves that a doppler shift is zero when the distance between the satellite and the earth becomes minimum, and accumulation at one cycle is counted, assuming that the transmitting frequency of the satellite is 399.968 MHz x 2 minutes. On the other hand, since the satellite always moves in reality, the accumulated value differs from the value mentioned above. In other words, variations of the distance between the satellite and a receiving point can be found if the wavelength of radio wave is know.

Point where the distance difference $D(t_i) - D(t_{i-1})$ thus obtained becomes constant form a hyperboloid of revolution, and considering the condition that a ship is on the surface of the earth, a line on which the hyperboloid and the surface of the earth cross each other represents a positional line of the ship. The positioning principles of the NNSS is a sort of hyperbolic navigation similar to the Loran or OMEGA system.

Specifications of Satellite Navigation System JRC-JLF3850

Positioning accuracy	: 0.1 nm when ship is at rest. 0.2 nm to 0.5 nm when ship is cruising.
Power	: DC 10 to 40 V below 19W. AC 100/220 V 30VA
Operating temperature	: 0°C to 50°C -25°C to 70°C (antenna section)

Receiver

Receiving frequency	: 399.968 MHz ±10 MHz
Tuning	: Automatic tuning
Sensitivity	: -145 dB
Dynamic range	: -140 to -80 dB

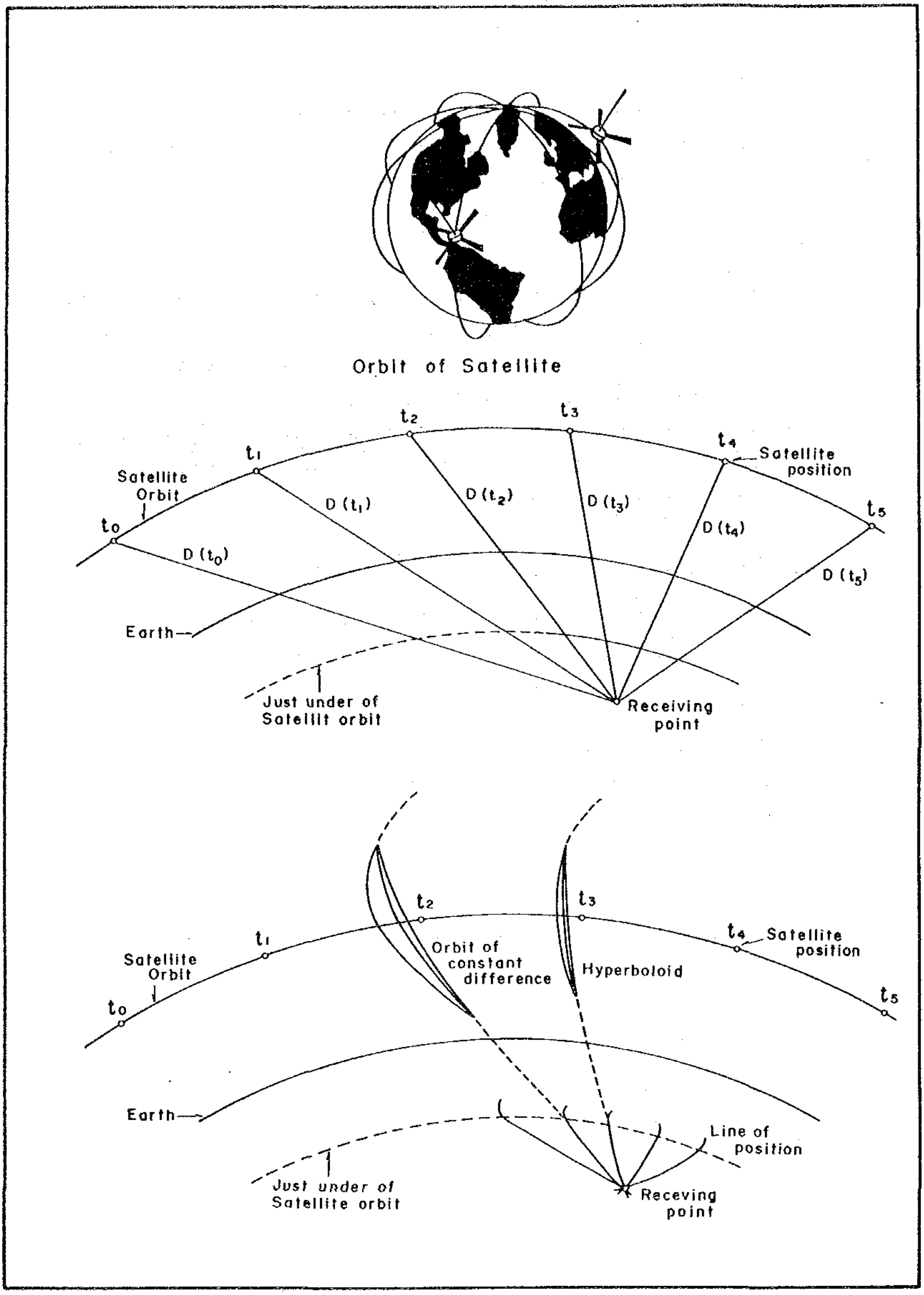


Figure 3-1 PRINCIPLE OF POSITIONING BY NNSS

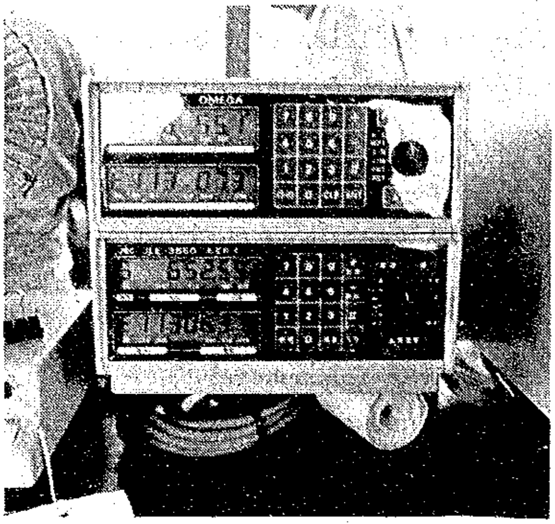
2) OMEGA System

The OMEGA system adopted for the route survey is used as a hybrid navigation system, which is combined with the NNSS as an auxiliary system, for continuously determining the position of the survey ship at other time except during the positioning using a satellite.

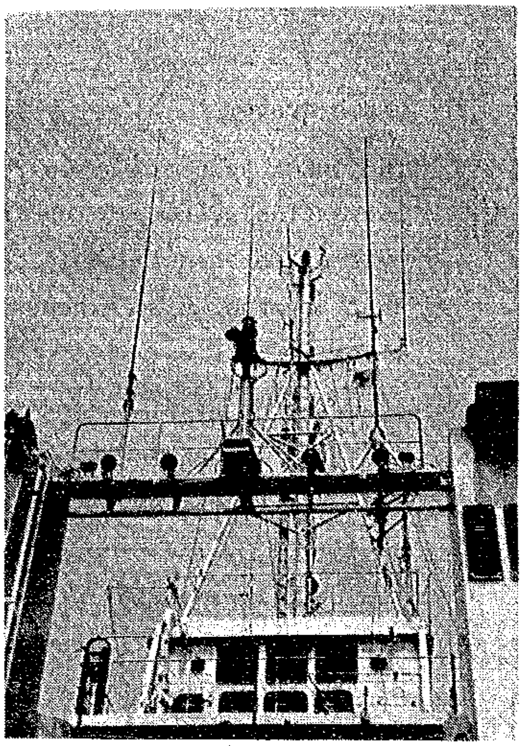
Eight OMEGA stations are located on the earth, and the ship's position can be found by this system. By combining this OMEGA system with the NNSS, the positioning is achieved by correcting a deviation of the propagation characteristic of the OMEGA wave (which always varies with conditions of the ionosphere). Figure 3-2 shows the hybrid navigation system consisting of a combination of the NNSS and OMEGA system.

Specifications of Omega Receiver JLA-104

Receiving frequency	: 10.2 kHz, 11.33 kHz, 13.6 kHz
Sensitivity	: below -20 dB (100 Hz BW)
Dynamic range	: 80 dB
Phase tracking	: 3 frequency automatic tracking at 8 stations
Phase indicating resolution	: 1/100 cycle
Segment synchronization	: Automatic synchronization
Power	: AC 85 to 135V/165 to 265V 45 to 65 Hz, 27VA Auxiliary power DC18 to 35V, 17W



Receiver (NNSS and OMEGA)



Antenna

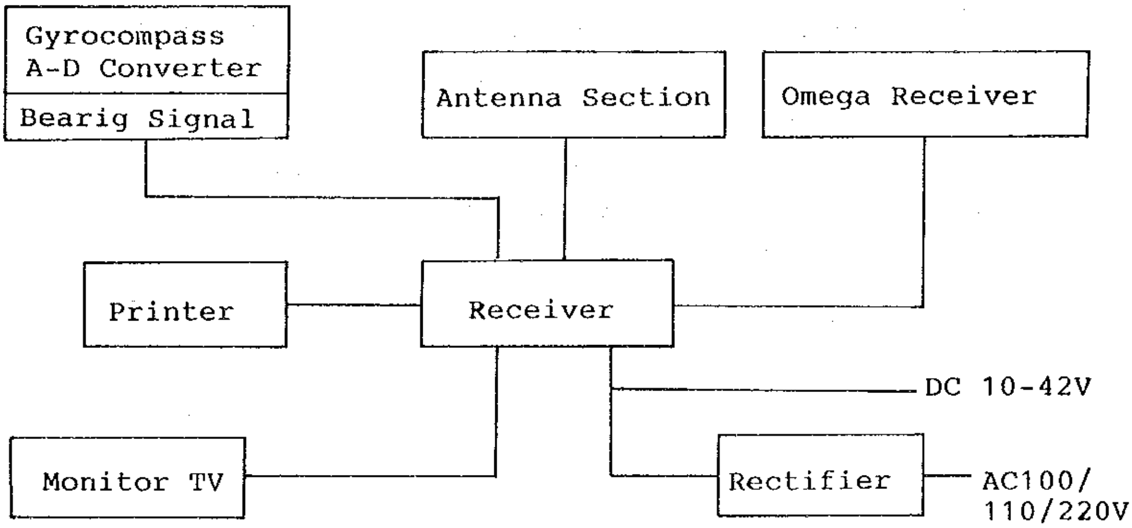


Figure 3-2 HYBRID NAVIGATION SYSTEM CONSISTING OF A COMBINATION OF NNSS AND OMEGA

3) Radar

The radar is a device for determining the ship's position by detecting the distance (range) and bearing of a target utilizing radio waves transmitted from an antenna. In the route survey, the radar was used for determining the ship's position except the position fixing by one satellite and that using a next satellite in the ocean area. The radar consists of a transmitter, a receiver and an antenna as shown in Figure 3-3.

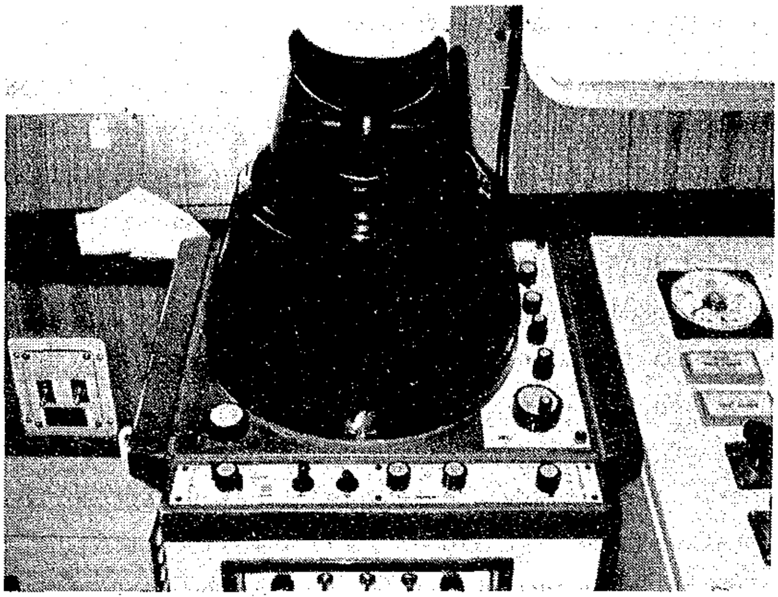
The radar transmits and receives radio waves at same point, and utilizes rectilinear propagation, constant speed and reflectivity characteristics of radio waves. It transmits directional waves from the antenna, receives waves reflected from objects such as conspicuous targets and makes them depict an image on the cathode-ray tube (CRT), thus allowing the positioning to be conducted by measuring the distance (range) and bearing. Specifications of the Radar JMA252 are given below:

Indicating system	: PPI
Indicating plane	: 305 mm (12 inches), valid dia. 279 mm
Distance range	: 0.75, 1.5, 3, 6, 12, 24, 48, and 96 miles
Minimum detecting distance	: Less than 25 m
Bearing accuracy	: Less than 1°
Bearing resolution	: Less than 1°
Reading bearing system	: Relative and true
Power	: AC 100/110/115V, 50/60 Hz, 1ϕ
Consumed power	: 700VA
ANTHENA	
Directivity	: Horizontal beam width 1° Vertical beam width 20°
Revolution	: 22 rpm (60Hz), 18 rpm (50Hz)
Driving motor	: AC 100/110/115V, 50/60Hz, 3ϕ, 200W

RECEIVER-TRANSMITTER

Frequency output : 9.365 to 9.455MHz

Peak transmitting output: 25kW



JMA-252 Radar

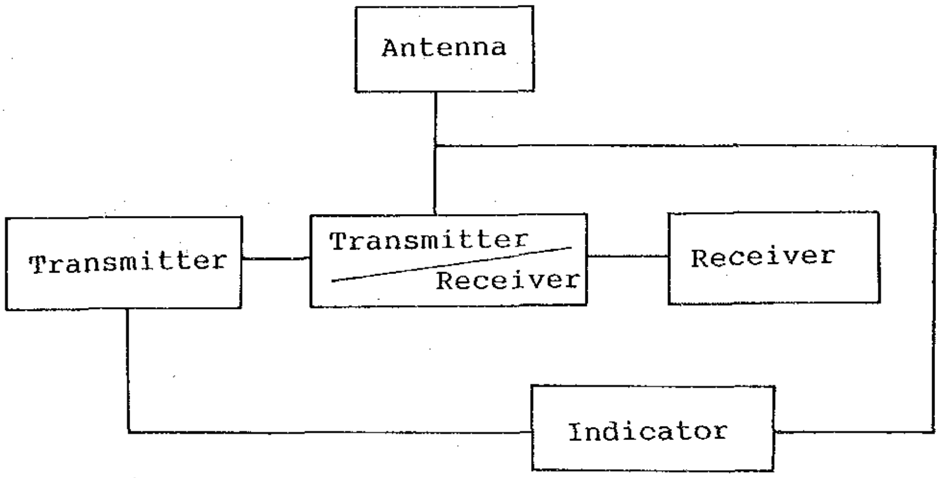


Figure 3-3 RADAR SYSTEM

4) Electronic Positioning System

The electronic positioning system (Audister and MRD-1) are a highly accurate distance measuring device using microwaves. This device was used in coastal area of Bumi Anyar and Takisung. The position was determined based on the 2-distance method using an Audister and MRD-1 and one distance one direction angle method with using theodlite. The Audister and MRD-1 each consist of a master station (Interrogater) on a survey ship and a slave station (responder) on the land. (figure 3-4, Figure 3-5)
The theory of operation of electronic distance meter is described here under. A radio weve (f_1) signal is transmitted from the master station, and (f_2) signal is transmitted from the slave station units. The wave transmitted from the slave station is a composite two-frequency (f_1-f_2) signal consisting of a combination of the (f_2) signal and (f_1) signal received from the master station.

The master station combines the (f_2) signal received from the slave station with its own (f_1) signal to obtain the (f_1-f_2) signal, and compares the phase of this composite signal with that of the (f_1-f_2) signal received from the slave station. Therefore, the propagation time required for the f_1 signal of the master station to return from the slave station is measured, and the distance between these two station is measured accordingly.

Specification of the Audister and MRD-1 are given below.

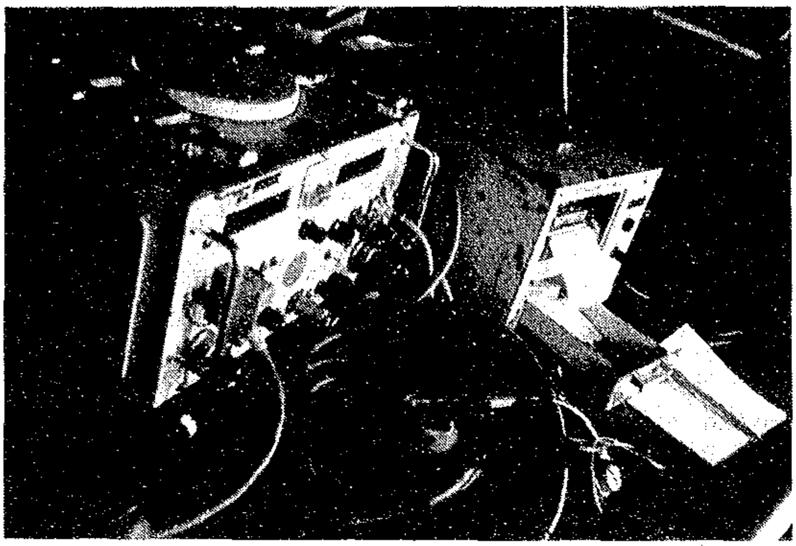
Audister

Maximum measuring distance	:	20 km
Maximum indicating value	:	99999.9m
Measuring accuracy	:	±0.1m
Frequency		
Master station	:	8960 MHz
Slave station	:	8860/8850MHz

Power output	:	0.3W
Power voltage and consumpted power		
Master	:	AC 100V ±10%, below 150VA
Slave	:	AC 100V or DC 24V below 50VA

MRD-1

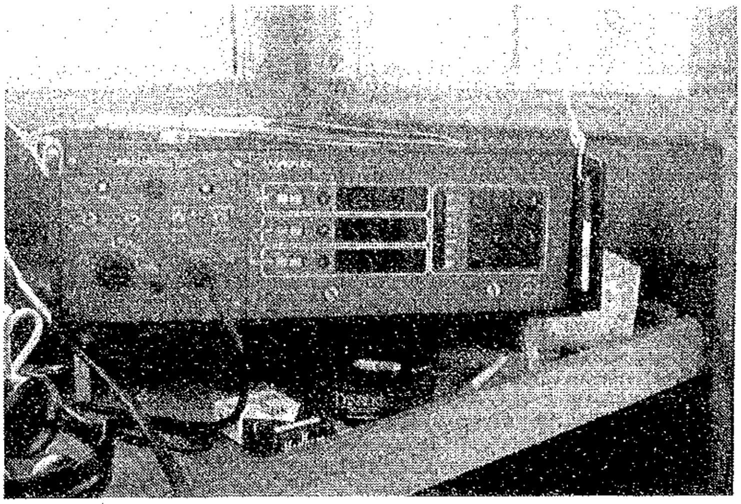
Maximum measuring distance	:	100km
Maximum indicating value	:	99999.9m
Measuring accuracy	:	1m $\pm 3 \times 10^{-6}$D (D: measured distance)
Frequencies	:	Master 2977 MHz Slave (1) 3010 MHz Slave (2) 3020 MHz
Power output	:	1W
Power voltage and consumpted power		
Master	:	10.5 to 34V DC 90W
Slave	:	10.5 to 16V DC 40W



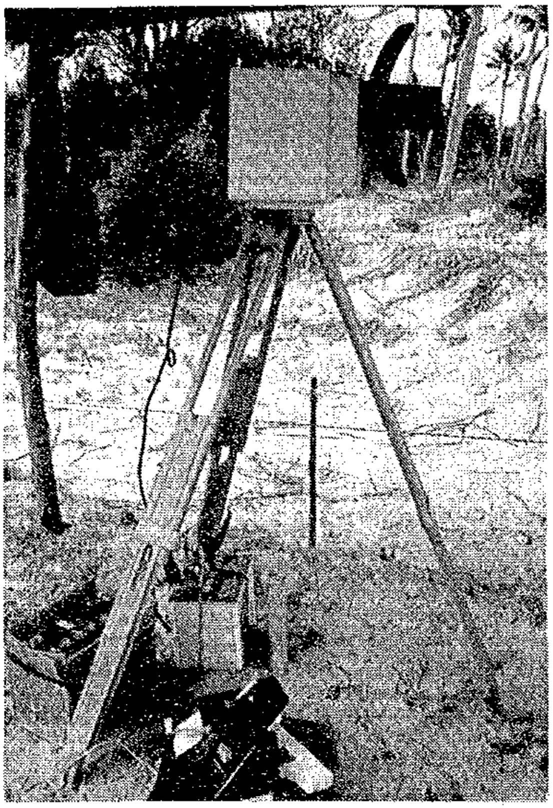
Master device

Slave device

Figure 3-4 AUDISTER ELECTRONIC POSITIONING SYSTEM



Master device



Slave device

Figure 3-5 MRD-1 ELECTRONIC POSITIONING SYSTEM

(2) Echo Sounding

The echo sounder shown in Figure 3-6 and Figure 3-7 is composed of a recorder, transducer, signal processor, etc. It finds the water depth just below a survey ship with an acoustic pulse emitted to the seabed, and the time required for the pulse reflected from the seabed return to the ship measured.

When conducting a route survey in the ocean area the digital echo sounder (DSF-6000) and the portable echo sounder (PDR-101), those are mounted aboard the survey ship, "Kaiko Maru No.5", were used. When conducting the survey in the coastal area, a portable echo sounder mounted aboard a small work boat was used.

Each echo sounders are light in weight and small in size with high precision. The DSF-6000 digitale type echo sounder consists of a recorder, a signal processor, a transducer and a digitizer.

Since this device is able to obtain sounding record with high resolution up to depth of 3000m at deep sea with two frequency supersonic waves of 24 and 100KHz or 40 and 200KHz output at the same time.

The echo sounders (PDR-101 and RS-61) for shallow sea are a lightweight and small-sized echo sounder fully employing transistors and IC's. Its water depth recording system is that receiving signals are recorded on a dry discharge recording paper, and the water depth is depicted with a recording pen which moves rotationally.

A noise, which is produced when the recording pen rotates, is reduced by adopting a DC brushlss motor for driving the recording pen.
The transmission is made by the phototransistor system. In this system a rotary slit disk is incorporated into the echo sounder, and a phototransistor receives light generated by a photodiode when the light passes through the slit, and generates an electric pulse. This pulse is converted into an acoustic pulse by being passed through a separate converter, and sent to the seabed from the transducer.

The signal reflected from the seabed and reached the transducer is converted into an acoustic pulse, and supplied to the receiver through a duplexer. The recorder records both of these signals and a transmitting pulse, thus depicting a topography of the seabed.

The water depth recorded in the above method is subject to adjustment according to the underwater sound speed, draft, tidal heigh, etc. So, a real water depth is now indicated.

* The water depth recorded were corrected by tidal correction (adopted tidal level at Surabaya and Tabanio) and sound speed (by Bar-check method) and actual water depth were calculated. The water depth level in coastal area was principally based on the level listed on the marine chart.

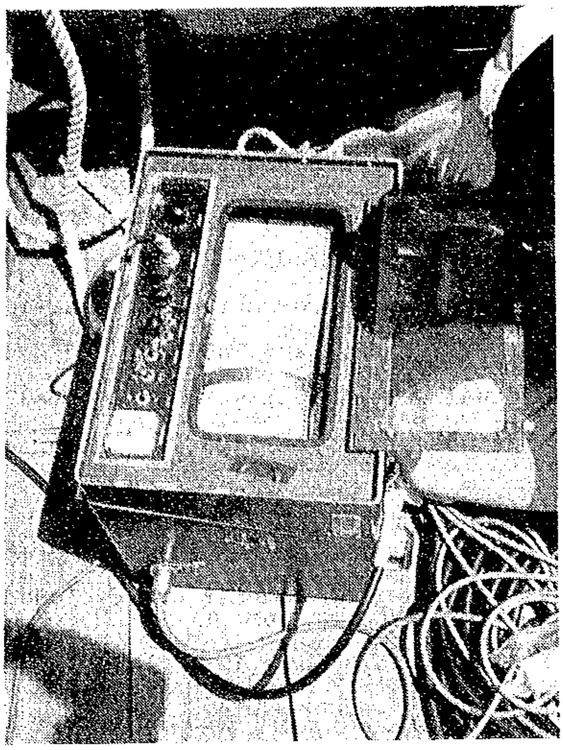
Specifications of the echo sounder (PDR-101 and DSF-6000 digital type) are as follows. RS-61 type echo sounder was excluded for the reason that it is similar to PDR-101 type.

o PDR-101 type echo sounder

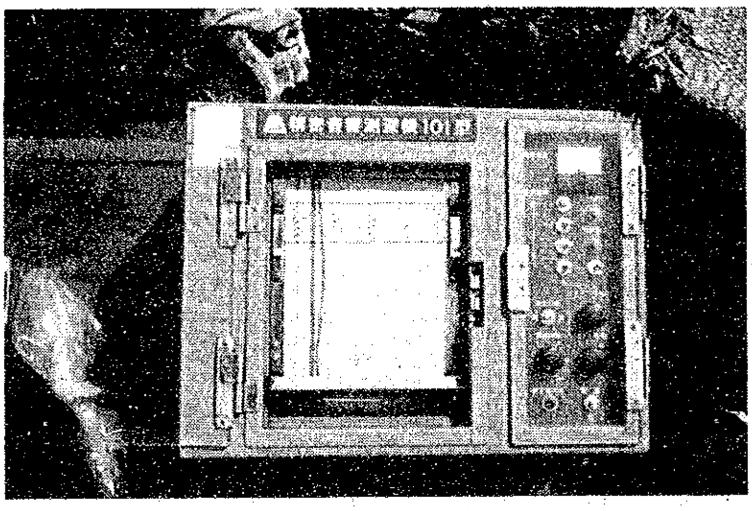
Recording range	:	0 to 60m (shallow sea).
		0 to 120m (deep sea).
Accuracy angle	:	±3 cm + D/1000 (D: depth m)
Beam angle	:	6° (beam width)
Frequency	:	200kHz
Power	:	DC 24V 1.5A

o DSF-6000 type digital echo sounder

Recording range	:	Low frequency 2.5 to 2000m at 40kHz
		High frequency 1 to 500m at 200kHz
Accuracy	:	Water depth recorded x ±0.1% ±max. 0.7m
Resolution	:	0.025% Scale measured
Beam angle	:	20° at Low frequency
		10° at High frequency
Power	:	DC 24V or 12V, about 90W
Digital expression	:	a number of 4 figure

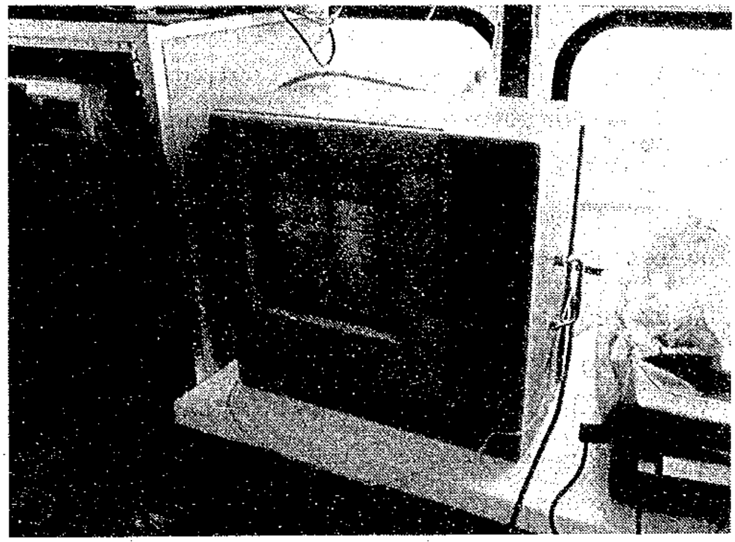


RS-61 Recorder



PDR-101 Recorder

Figure 3-6 RS-61 AND PDR-101 ECHO SOUNDER SYSTEM



DSF-6000 Digital Recorder

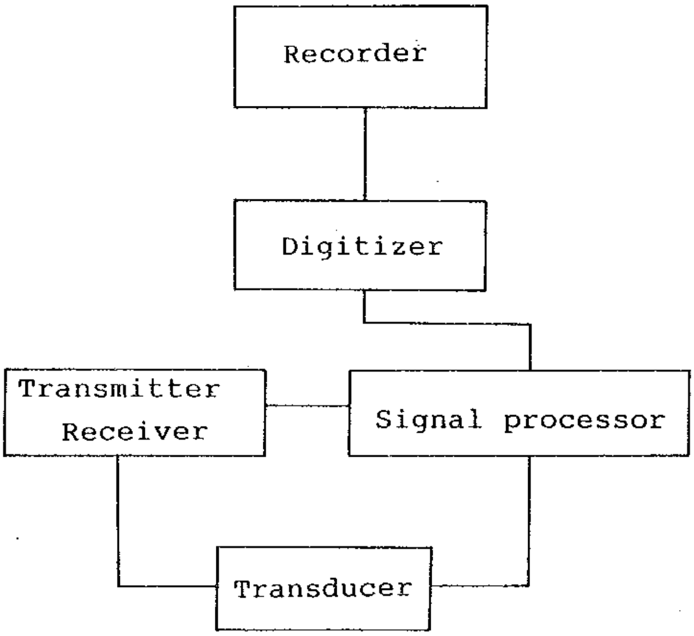


Figure 3-7 ECHO SOUNDER SYSTEM

(3) Seismic Prospecting

A low-frequency acoustic wave with a large output is used for investigating the geological structure under the seabed. Although a part of it is reflected from the seabed, this low-frequency large-output acoustic wave penetrates under the seabed, and gradually attenuates while repeating reflection at each boundary between strata.

On the other hand, acoustic waves reflected from the seabed are amplified after having been received by the transducer, to depict a geological profile on the recording paper. Theoretically speaking, lower the frequency, or the larger the output is, the deeper the exploration range reaches, but, on the other hand, the resolution deteriorates, and it becomes difficult to grasp a minute geological structure.

Seismic profiler used for the route survey is a discharge type (sparker), magnet striction and vibration type (Sonoprobe). They are used according to their prospecting capabilities. Outlines of these seismic profiler are described below.

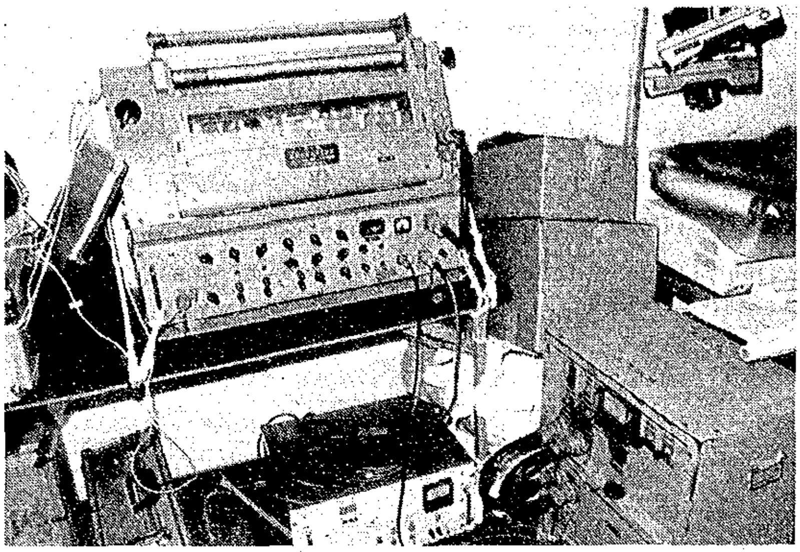
1) Discharge type (Sparker)

In the transmitter, voltage boosted by a transformer is rectified to DC high voltage, and stored in a high-tension capacitor. A high voltage on-off circuit is actuated by a starting trigger from the receiver, and high-voltage DC charge is supplied to an underwater discharge electrode to make it discharge.

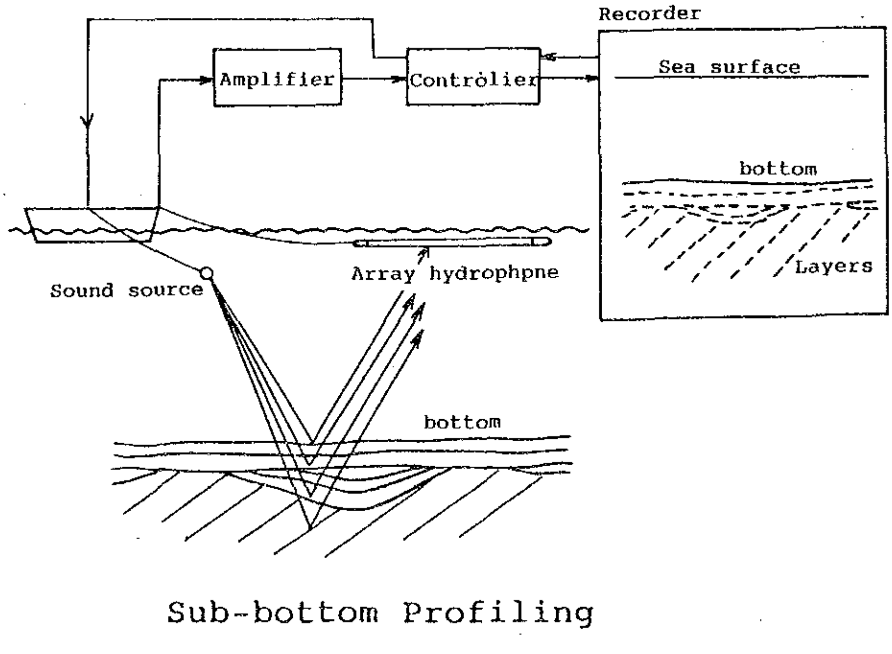
A powerful low-frequency acoustic wave generated by discharge propagates through water and under the seabed, and is reflected from various acoustic boundaries, and then returns again into the water. This reflected acoustic wave is caught by a towed transducer, converted into a voltage signal, and sent to the receiver. In the receiver, this feeble signal is amplified, filtered, controlled and amplified. Thus light and dark patterns are depicted on the recording paper. (Figure 3-8)

Specifications of Speaker NE-19C

Transmitting energy	:	200 joules
Recording range	:	100, 200, 400 and 800 m
Width of recording paper	:	200 mm x 2 tracks
Recording paper feed speed	:	120 and 60 mm/min.
Receiving frequency band	:	100 to 5,000 Hz



Sparker



Sub-bottom Profiling

Figure 3-8 SUB-BOTTOM PROFILER (SPARKER)

2) Magnet striction and vibration type (Sonoprobe)

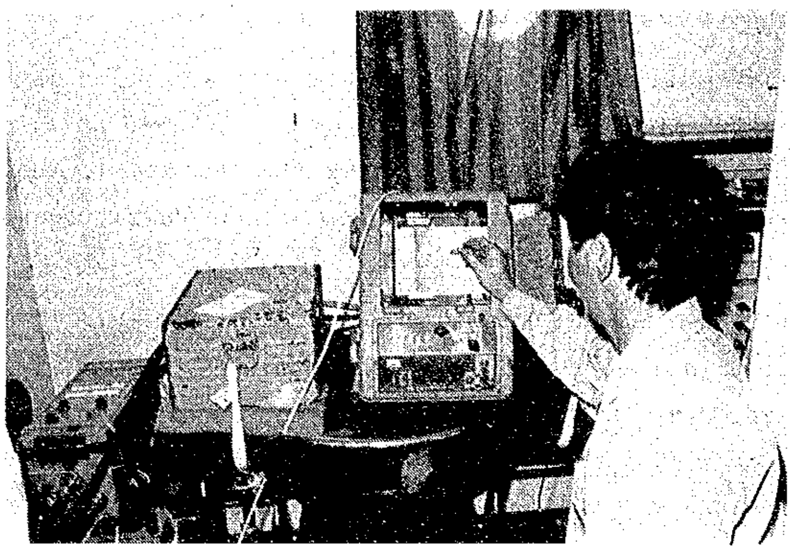
The principles of device are that the acoustic pulse is transmitted from a transmitting-transducer, fixed on ship's side, and that the pulse propagate through the sea down to the seabed and under the seabed, reflected from an acoustic boundary and returns again into the water.

The refrected acoustic wave is received by the hydrophone, and converted into an electrical signal and send to amplifier. In amplifier, this feeble signal is used for amplification, processing signal, control and power amplification. This light and dark patterns are recorded on the recording chart.

Fig. 3-9 shows a block diagram of sonoprobe.

Specifications of sonoprobe are as follows.

Recording system	:	Straight line recording by belt.			
Recording range	:	Shallow	0 to 25m		
		Deep	0 to 50m		
Shifting step	:	Shallow	5m x 20 steps		
		Deep	10m x 20 steps		
Recording chart	:	Dry chart width 150mm, length 10m			
Chart feed speed	:	Shallow	80mm/min,	Deep	40mm/min.
Oscillation	:	Shallow	360mm/min,	Deep	180mm/min.
Amplification	:	Straight amplification			
Transmission-Reception	:	Independent pulse transmission & reception			
Power supply	:	AC 100V, 50/60Hz, 2KVA			



SONOPROBE

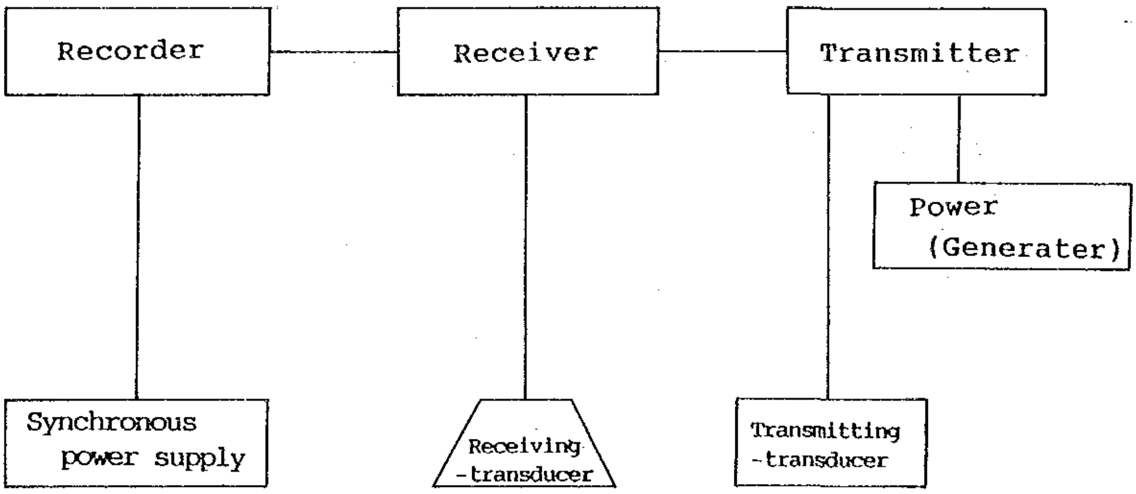


Figure 3-9 SONOPROBE SUB-BOTTOM PROFILER

(4) Bottom Scanning

When conducting the route survey, two type of side scan sonar (MARK 1B and SMS-960) were used for investigating the seabed surface conditions. (See Figure 3-10)

The side scan sonar is a device for investigating uneven conditions of the seabed surface, and its fundamental functions are the same as a echo sounder. In the case of a echo sounder, a transmitting element positioned near the sea surface emits an acoustic pulse downward just below it in a narrow beam. On the other hand, in the case of a side scan sonar, a pulse is emitted obliquely to the seabed from a transmitting element attached to a "tow fish" which is towed near the seabed surface.

Transmitting and receiving elements are arranged on both sides of the "tow fish" so that they point to the direction which is at a right angle to the towing direction, and an acoustic pulse is transmitted so that it covers a wide angle of several ten degrees in a vertical plane, and an angle of about one degree in a horizontal plane.

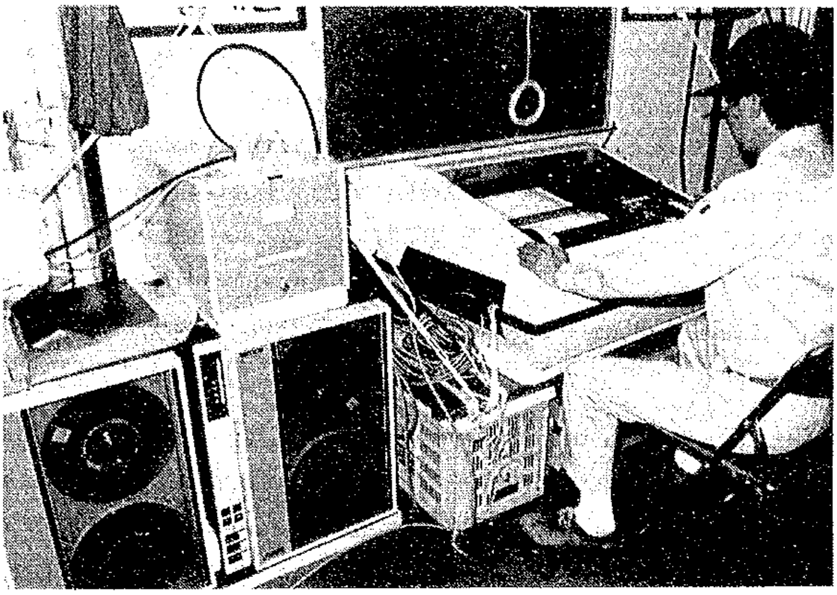
Acoustic waves reflected from the seabed are continuously received by being accompanied by the delay the time corresponding to the distance between a "tow fish" and an acoustic wave reflecting point. Since an acoustic wave is attenuated according to the propagation distance, the difference in receiving signal intensity is equalized by a time equalizer, the gain of which varies with time.

Output signals of the receiving amplifier are recorded on the chart paper at positions corresponding to the distance between the "tow fish" and the acoustic wave reflecting point. As fish is towed, the conditions of the seabed surface are recorded in two dimensions just like a photo showing light and dark patterns corresponding to the unevenness of the seabed surface. It also has such functions that the strain of a seabed record is corrected real time, depending upon the range and ship's speed and that the record is scaled down by an aspect ratio of 1:1, and also that the topography of the seabed is shown like an aerial photograph.

The specification of the side scan sonars for shallow sea (MARK 1B and SMS-960) are as follows:

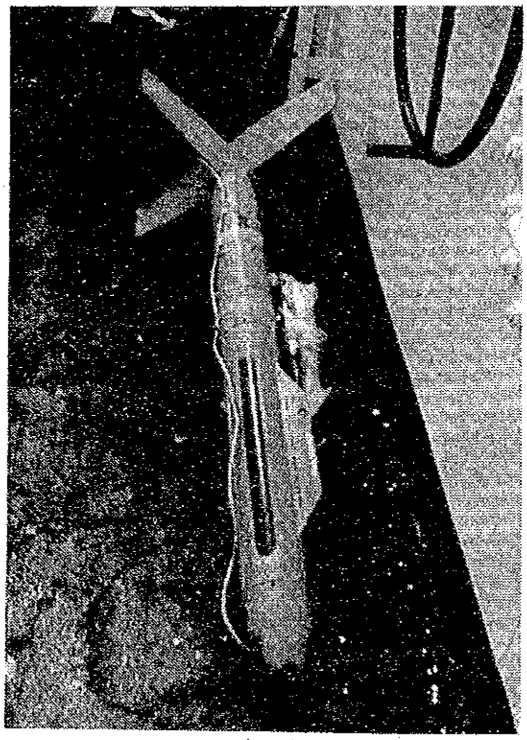
	MARK 1B	SMS-960
Range scale	50,100,125,200,250, 500 m	100,150,200,300,400,500 m
Scale line	Every 25 m	Every 25 m
Input power	24 ∿ 30V DC, 4 ∿ 8A	115V AC
Recording paper	Wet, 28 cm x 39 m	Dry, 28 cm x 50 m
Weight	38 kg	75 kg
Dimensions	28 cm x 84 cm x 44 cm	94 cm x 72 cm x 45 cm

	272 Tow Fish
Operating frequency	105 ±10KHz
Pulse Duration	0.1mm/sec
Peak output	128 dB
Horizontal beam pattern	1.2°
Vertical beam pattern	20 or 50° wide
Operating depth	0 to 600 m
Normal tow speed	0 to 15 knots
Weight	24kg in air 16kg in water
Dimension	140cm length, 30cm height, 11.4cm in diameter



SMS-960 recorder

MARK-1B Recorder



Tow fish

SMS-960 AND MARK-1B SIDE SCAN SONAR

(5) Bottom Sampling

A vibrocorer, a piston corer and a Smith-McIntyre sampler were used for sampling sediments of the seabed. These bottom samplers are shown in Figure 3-11.

Outlines of these bottom samplers are described below.

1) Vibrocorer

The vibrocorer is a bottom sampler utilizing the principles of liquefying phenomenon of sand caused by vibration, unlike conventional types of bottom samplers. It consists of an hydrolic vibrator, a hydraulic hose, battery, a hydraulic control unit, etc.

The vibrocorer suspended from a survey ship down to the seabed samples the sandy sediments of the seabed by with the vibrator actuated at the upper end of the corer by operating the hydraulic control unit, which is submerged in the sea, from an ultrasonic device mounted aboard the survey ship.

Specifications of the vibrocorer are as follows:

Specificaion	
Power for vibration	1000 kgs
Frequency of vibration	1500 cpm
Dia. of core barrel	76.3 mm
Length of core barrel	4 m, 8 m
Dia. of core	58 mm

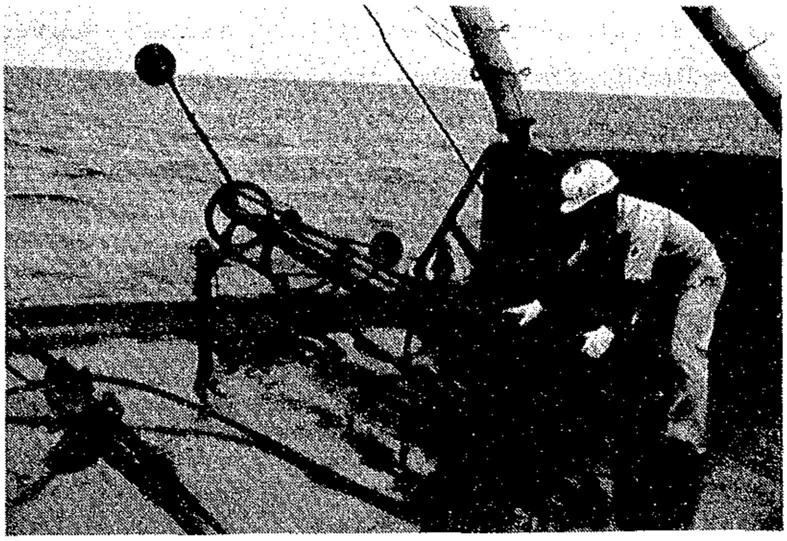
2) Piston corer

The piston corer is dropped down to the seabed from 2 m above the seabed by the lever action which is made when a weight, which reaches the seabed, prior to a bottom sampler reaches the seabed. When lifting up the piston corer, the piston sacks up the sediments of the seabed into an acryl pipe and holds them.

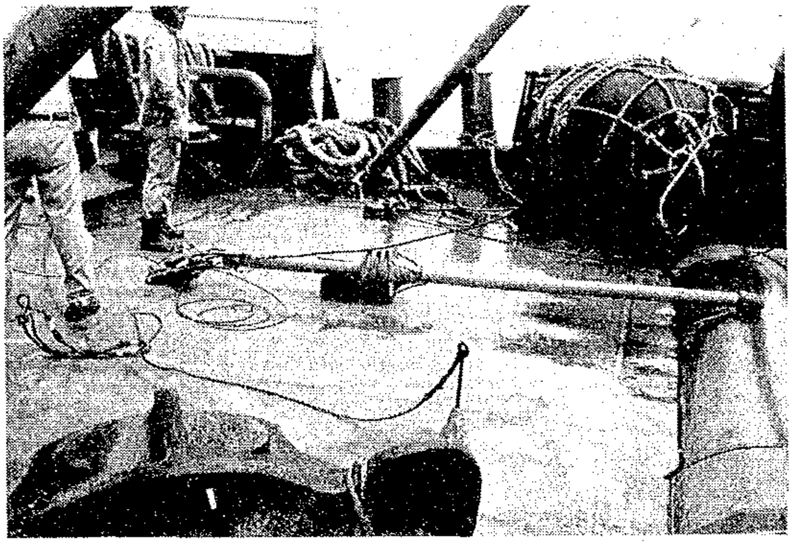
A stainless steel catcher at a port of the corer also serves to prevent the sediments from flowing into the water during recovery of the piston corer by means of such a mechanism as that allows an object to move only in the inward direction. The seabed excavating depth of a cable layer can be roughly estimated from the seabed penetrating depth of the piston corer.

3) Smith-McIntyre sampler

The smith-McIntyre sampler of grab type is so designed that when it reaches the seabed, a spring in it is released, and that the sediments of the seabed are taken in a grab.



Vibrocorer



Piston corer

Figure 3-11 BOTTOM SAMPLING DEVICES

(6) Current Observation

The mooring methods of current meter used for the current observation are shown in Figure 3-12. After current meter were recovered, the recorded magnet tape (MT) were analyzed by a computer which had been placed in vessel' observation room. The results were used for preparing an interim report (Figure 3-13). Also, the M.T was brought to SHS's head office in Tokyo, and noises in the record were removed and then the records were analyzed.

The final results were used for preparing a Final Report.

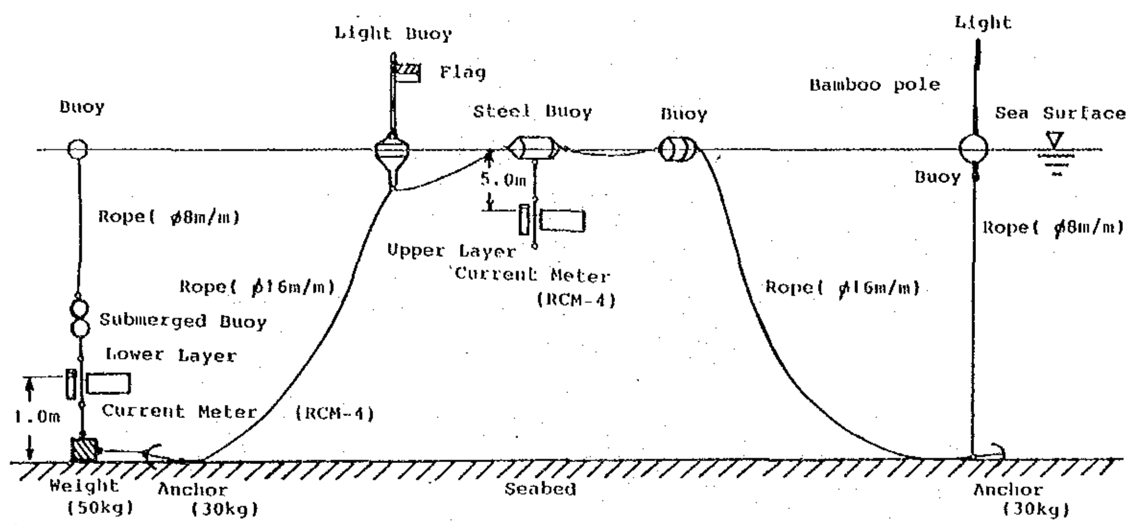
* Aanderaa Current Meter

The specifications of the current meter are as follows.

Measurement Items	Measurement Range
Current direction	0° to 360°
Current velocity	2.5 to 250 cm/sec
Water temperature	-0.34 to 32.17°C
Electric conductivity	0 to 70 mmho/cm

A measuring interval is selectable to 0.5 to 30 minutes.
A especially designed 9V battery is used for a power supply, which allows this current meter to be usable time of 10,000 intervals.
The pressure with-standing depth is 2,000 m.

Current observation at Bumi Anyar, Takisung off shore



Current observation at ocean area

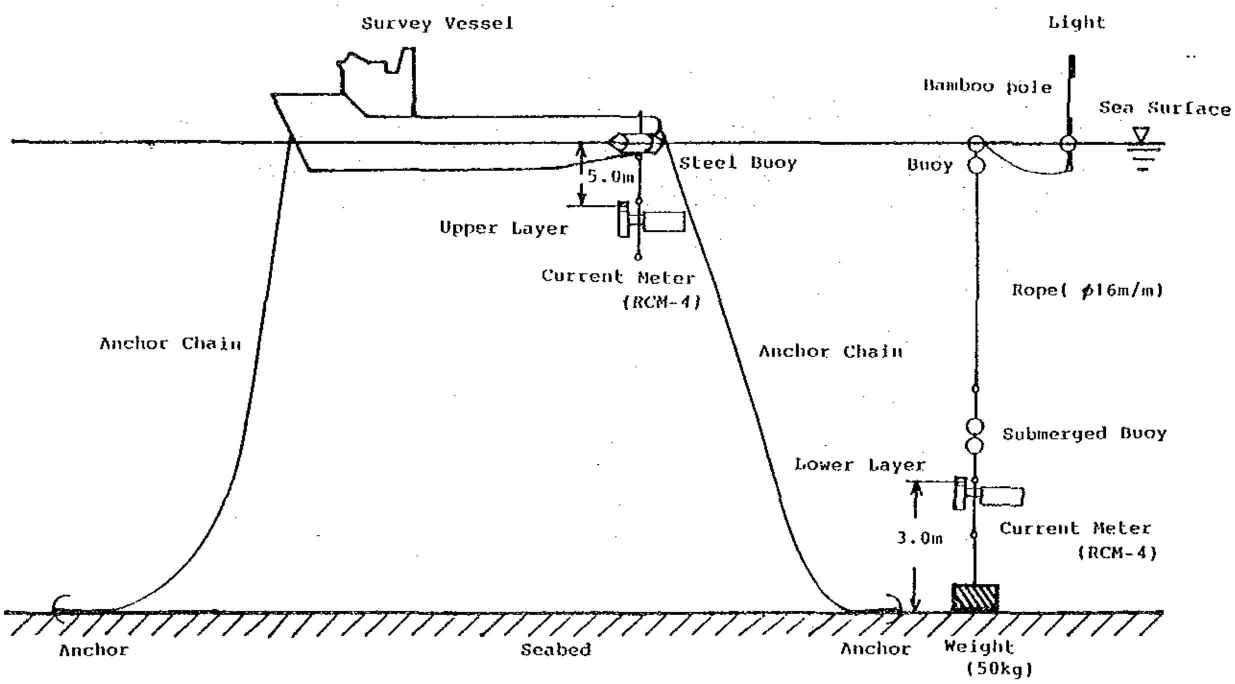
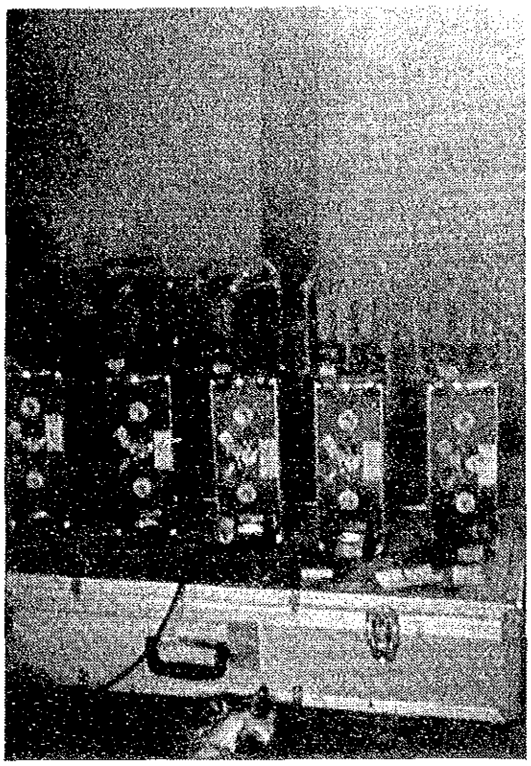


Figure 3-12 METHOD OF CURRENT OBSERVATION



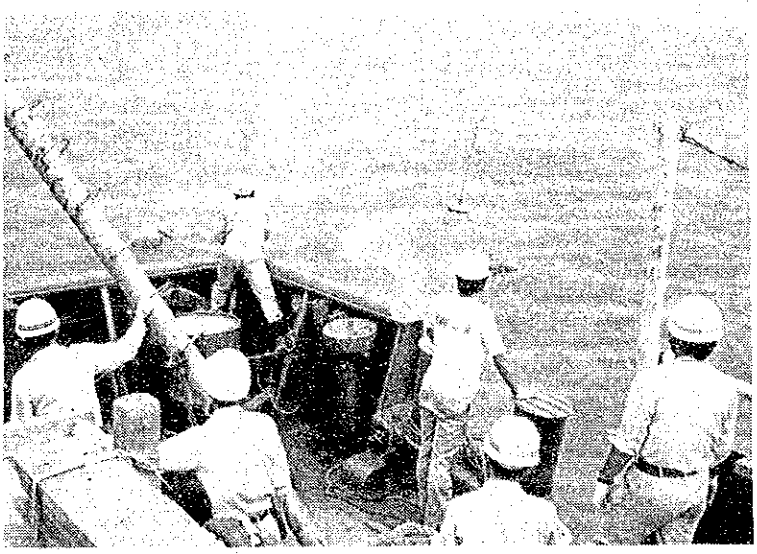


Figure 3-13 AANDERAA RCM-4 CURRENT METER

(7) Water thermometry

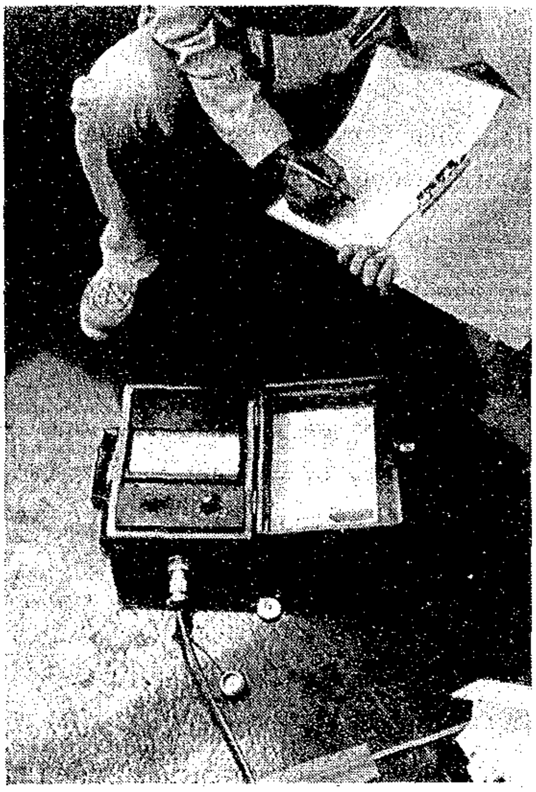
Water thermometry was carried out each 5 stations in the both coastal areas and 11 stations in the ocean area. Stations were 21 in total. The observation was carried out in way of lowering sensor with an electric cord from deck after vessel completely stopped. The value at each observation layer was read at the recording part of electric thermometer (ET-5) onboard.

Before and after observation at each station, an index error was checked by using a standard thermometer, and the obtained value was corrected as required.

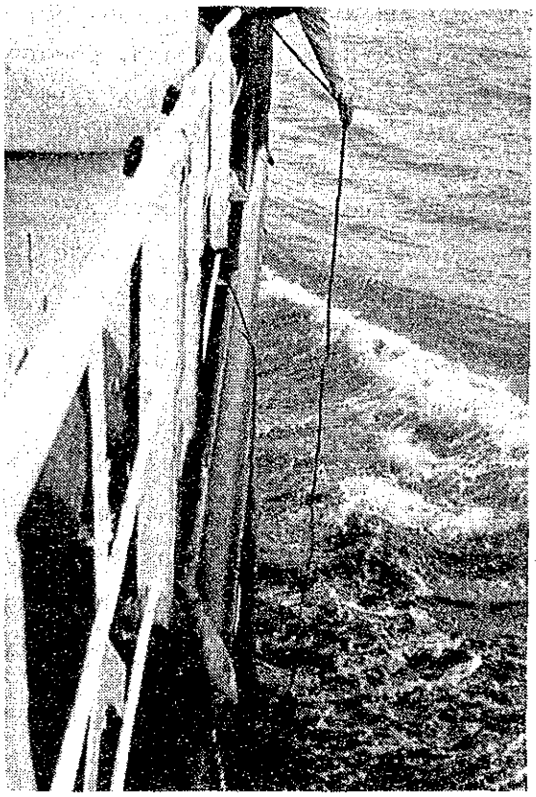
The layers of observation were water depth 0.5m deep, 1, 2, 3, ... 10m with 1m pitch upto 10m layer, and 10m, 20m, deep each 10m pitch at station where is deeper than 20 m in water depth, and the deepest layer was 1m above seabed.

The specifications of ET-5 are as follows:

Measuring range	:	-5° to 40°C, minimum scale 0.1°C
Response speed of sensor power	:	2 to 3 sec.
Power	:	U-2 battery, 1.5V x 2pcs
With-standing depth	:	Up to 1000m



ET-5 Indicator



Sensor into the sea

Figure 3-14 ET-5 ELECTRIC THERMOMETER

(8) Seabed Photographing

Cameras used for the route survey are a deep sea camera (Benthos, U.S.A) and an underwater camera (NIKON, Japan) (See Fig. 3-15).

The photographing stations of using a deep sea camera were ten every 20 miles between the station 15 miles off Takisung L.P and the station 9 miles off Bumi Anyar L.P. Photographing by divers with use of an underwater camera was conducted at 2 stations in the coastal area at Bumi Anyar, but this could not be accomplished due to the turbid current. Similarly, turbidity of current was so bad near Takisung that photographing had to be suspended.

The photographing in dried up areas at both L.P areas was conducted while wallking.
The deep sea camera is a 35mm deep pressure resistant type camera consisting of a camera and a flashgun.

The flashgun illuminates the seabed with the flash of a xenon tube, and supplies a shutter pulse and driving power for taking up a film to the camera. The camera consists of a film take-up, shutter, lens and date chamber. When even taking a photograph, power is supplied from the flashgun to the film driving motor, and a film is taken up one frame.

The photographing distance and depth of focus are set by using a knob on the lens shutter mount. A date, hours, minutes and seconds of photo-taking, and the station No.are displayed.

The bottom switch parts consist of a main body, a weight and joinning ropes for combining them.

At the same time, when the weight is landed on the seabed, the rope tension got slack, acting on the bottom switch now the shutter pulse is transmitted. With the rope length adjusted in advance for photographing from a point 3m above seabed, the camera is moved up and down at the photographing point to carryout photo-taking.

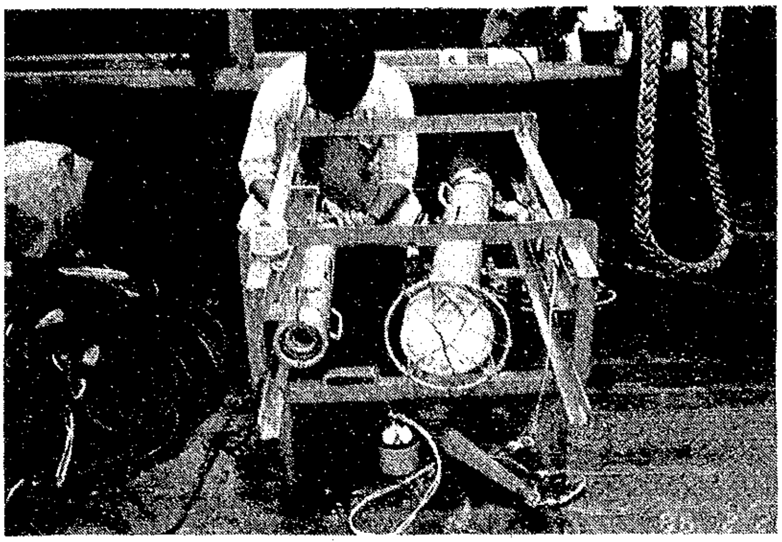
Specifications of the deep sea camera are as follows:

Camera	
Type	: Benthos model 372
Standard number of films for taking photographs	: 800 photos.
Film length	: 30.5 mm (100 ft)
Dimensions of case	
Length	: 64.3 cm
Diameter	: 12.5 cm
Weight	
In air	: 21.0 kg
In water	: 16.0 kg
Shutter speed	: 1/50 sec. to 2/5 sec.
Power	: DC 28 ±5 V 1A; supplied from flashgun Model 382.
Flashgun	
Type	: Benthos model 382
Flash bulb input	: 100 W/sec.
Number of flashing	: 3,200 times when fully charged
Flash time	: 1/1000 sec.
Dimensions of case	
Total length	: 90.5 cm
Maximum diameter	: 21.0 cm
Weight	: 31 kg in air

The underwater camera consists of an outer case, mechanical section and lens. The photographs were taken by divers.

Specifications of the underwater camera are as follows.

Type	: NIKONOS IV-A
Film	: 35 mm film
Picture size	: 24 x 36 mm
Standard lens	: W-NIKOL 35mm F2.5
Range scale	: ∞ ∿ 0.8m
Picture angle	: 46°30' (in water)
	62° (on air)



Setting deep sea camera
(Left:CAMERA Right:Flash)

Photographing under water camera by divers

Figure 3-15 PHOTGRAPHING HANDY UNDER WATER CAMERA AND DEEP SEA CAMERA

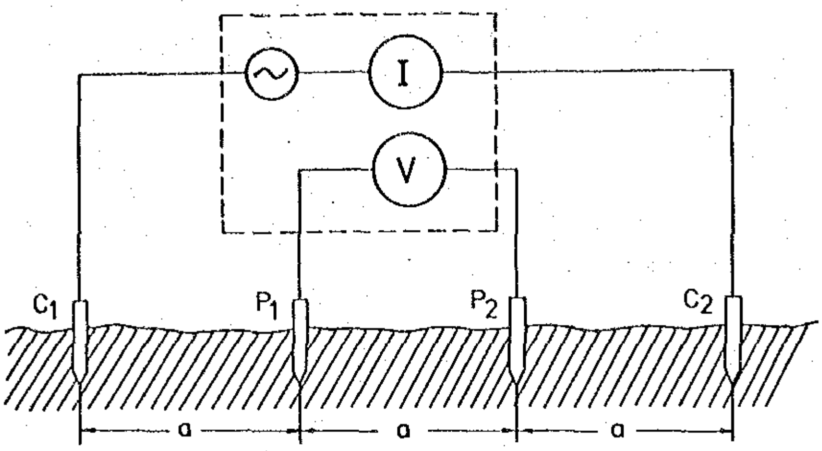
(9) Earth Resistivity (Geological Search by Wenner's Method)

There are several methods of measuring earth resistivities (specific earth resistances), most of which are variations of the method originally conceived by Wenner. In Wenner's four driven-rod electrode method, four electrical contacts are made with the ground by driving into the ground the metal spikes, called electrodes, C_1 P_1, P_2 and C_2 placed in a straight line at equal intervals of a (m). Between the current electrodes C_1 and C_2, a current I (A) is passed and the resulting voltage drop (V) between the potential electrodes P_1 and P_2 is measured. If the ground has uniform resistivity ρ, an equation of measurement is attained:

$$\rho = 2\pi aV/I = 2\pi ar \ (\Omega.m) \qquad R = V/I \ (\Omega)$$

Where R is the resistance measured between the potential electrodes. The above equations are called Wenner's formula, which proved to be very practical in case the depth of driven electrodes is within 1/20 of the electrode interval separation a. Therefore, earth resistivity ρ can be calculated from the measured value of R.

The earth resistivity ρ in the wenner's formula is constant irrespective of the electrode separation distance if the ground has a uniform structure. However, the ground is generally composed of more than one layer involving rocks of differing resistivity. Therefore, the resistivity calculated from the above formula will not refer to any specific rock or layer, but will be a mean value of the individual resistivities of distributed rocks and layers. Such a measured value is called "apparent resistivity" which varies depending upon the electrode separation a and the position of the electrode system. By obtaining the relations between a and ρ with respect to a particular ground, it is possible to roughly conjecture geological structure, layer formation and location of underground water supplied. Standard and auxiliary curves showing the relation between a and ρ are available, and by placing upon them an a-ρ curve made from actual measurement, the apprximate resistivity and depth of each layer involved may eaily be obtained on the curve. The resistivity thus obtained is generally taken as a guide for elucidating the nature of the layer.

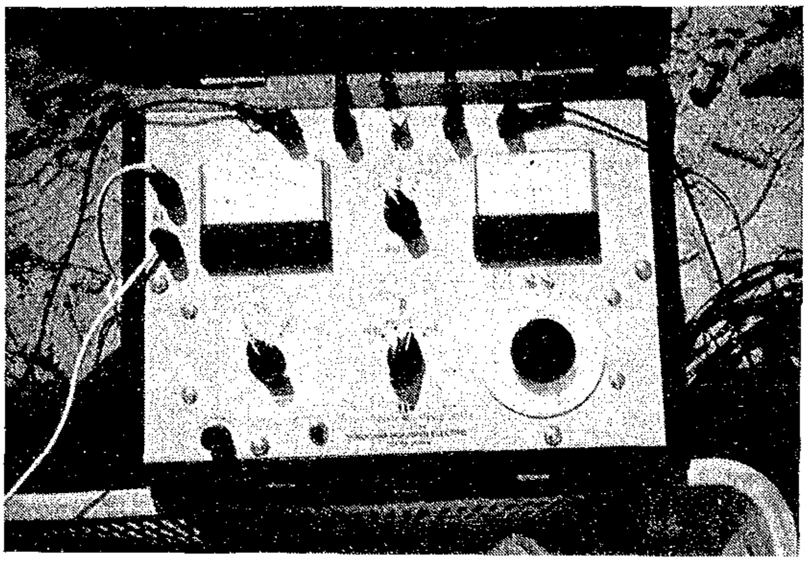


L-10 Type Specific Earth Resistance Tester M55401
(Yokogawa electric Works Ltd. Japan)

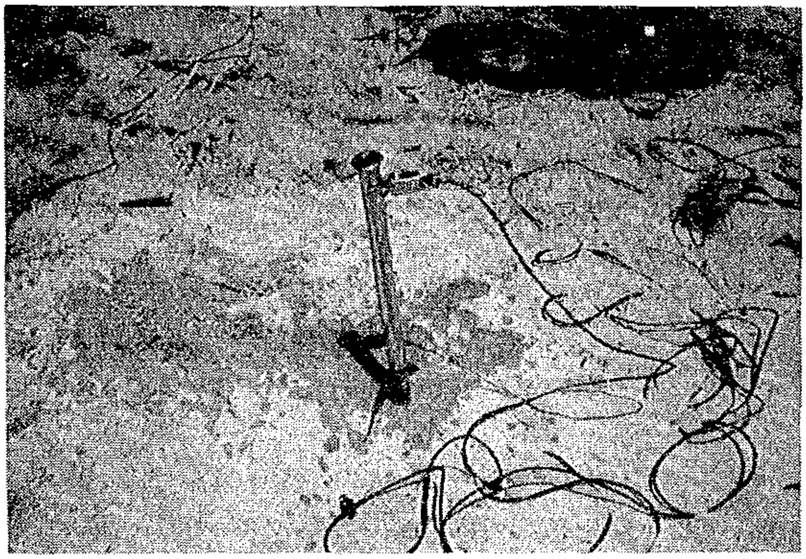
Specifications

Method of Measurement	: Wenner's four-electrode method
Operating Principle	: AC potentiometric system (free of polarization, and capable of direct reading of specific earth resistanca)
Method of Power Supply	: Hand drive of generator
Measuring Range	: 0 - 0.3 / 3 / 30 / 300 Ω
Measuring Dial Scale	: 0 - 30 Ω, 1 Ω / div.
Multiplier Dial	: X0.01, X0.1, X1, X10
Accuracy	: ±3% of indicated value in the scale range of 10 - -30 Ω ±1% of full scale value in the scale of less than 10 Ω

Output Voltage	:	350 V at more than 150 rpm
Measuring Frequency	:	more than 65 Hz/s
Accessories	:	5 pcs. of earth spikes/as electrode with landwires



Reading part



Electrode pole

Figure 3-16 SPECIFIC EARTH RESISTANCE METER

TYPE 3244

(10) Magnetic Survey

The twin coil magneticmeter is used in the magnetic surveys to measure the spatial changes of magnetic field. When the coil is moved in the magnetic field where a spatial magnetic anomaly exists, the magnetic flux density across the coil changes, in turn inducing the electromotive force at both ends of the coil. Exsistence of iron material, say, a mine, spatialy disturbs the magnetic field of the Earth in their surroundings.
By measuring the position and magnetic intensity of this anomaly, it is possible to estimate the location and size of irons (e.g. mines).
Rotating or shaking a coil in the constant magnetic field, causes e.m.f. to be induced in a coil. This is one of noises encountered in the magnetic survey. To prevent this noise, a detector having two coils conected in reverse turn on the same axes with some interval. In this case the e.m.f. generated in two coils through rotation or shaking in the magnetic field is cancelled each other. On the other hand, at the partial anomaly of magnetic field, a defference of induced e.m.f. between the coils can be detected. This induced e.m.f. (signal) is recorded on the pen-recorder passing through a amplifier. (See Figure 3-17)
Mechanism and structure of this equipment are simple and straighforward, So, data taken on this equipment is highly accurate.

Magnetic anomaly is discriminated from the field record, and the rough size of object and distance from detector to object are estimated based on the shape of magnetic anomaly record.
The size of anomalous object is generally represented in terms of the quantity of magnetic charge, gauss cm^2.
Magnetization of a iron material consists of residual magnetization that owns the object and induced magnetization by external magnetic field, the earth's field. A residual magnetization is caused by manufacturing process and is inherence. On the other hand, magnetization is induced by the intensity of the magnetic field at the place of material. So it's quantity is varied according to the place of the field, the shape, and derection

etc. of the material. In the case of mine, induced magnetization is much larger than residual one. In Japan, total magnetic intensity of the earth field is about 46000 γ and inclination is about 49° (at Kakioka). On the other hand, these are about 44000 γ and 32° (at Tangarang) in Indonesia. Total magnetic intensity in Japan is larger than in Indonesia, but the horizontal component in Indonesia is larger than in Japan. So, it is found that the anomalous value of buried iron material in Indonesia is the same as, or a little larger than, that in Japan. As stated above, the quantity of magnetic charge on has much to do with location, size, shape, direction, contents, manufacturing process of iron material. On the mine, the range of quantity of magnetic charge is

$$25 \text{ gauss}\cdot\text{cm}^2 \text{ to } 300 \text{ gauss}\cdot\text{cm}^2$$

This range is estimated from the result of the measurement of mines, and verified by many survey results in Japan over a period of 20 years with safety allowance taken into consideration.

In this investigation, the survey was operated by the following four types under varying field conditions (See showing Fig. 4.18).

1) Type of towing observation barge at the sea.

   In the area of the enough water depth, the survey was operated by towing observation barge on the measuring leading line, towing the detector frame, being suspended from the stern of barge. The detector frame was constructed by 5 detectors arranged at 2 meters, clearances, fixed with wooden frame. The detector frame was adjusted by electromotor winch on the barge to be kept submerged 1 meter above sea bottom, with measuring for depth of the detector and sea bottom measured by a echo sounder. The clearance of measuring line was 10 meters, which is the effective width of detection (2 meters x 5 detectors).

   The position of observation barge was determined by measuring the distance from main station on the barge to remote station R1 setting up on land, using electric distance meter with micro wave near the L.P. Every 50 meters going forward on the line, the positioning mark was recorded on the magnetic chart paper and echo sounding paper.

2) Type of towing detector frame by a small boat at the sea.
In the area of the water depth shallower, survey was operated by towing detector frame which had been suspended from a observation small boat. The detector frame was constructed of 2 detectors arranged, 2 meters clearance. It was adjusted by hand with winch on the boat, to keep the barge submerged 1 meter above sea bottom, with the depth of frame and sea bottom measured by echo sounder. The clearance of measuring line was 4 meters, which is an effective width of detection (2 meters x 2 detectors).
The position of observation boat was determined by measuring on angle by transit setting at R2 point, about 500 m west from the L.P., every 30 sec.

3) Type of fixing detector frame on a small boat.
In the area of very shallow water, the survey was operated by proceeding a boat fixed the detector frame, which was constructed of two detectors arranged at 2 meters clearance. Positioning of boat was same as type 2).

4) Survey on land.
In the area of land or seashore, the survey was operated in the way of carrying a detector by man-handling on the measuring line. Measuring line clearance was 2 meters. The survey line was 100 meters long. The survey area is divided into sub-areas, every 100 meters. Starting and ending points of a survey line was determined by measuring the distance from the leading point using a measuring tape and leading the direction of survey line in parallel with the planned cable route by transit and sextant. At starting and ending of a line survey mark was recorded on the magnetic chart paper.
The founded magnetic anomaly was re-surveyed and was tixed a position by the distance reading measuring tape on measuring line. Some small iron segments found on the surface of the ground were withdrawn. Then, the re-survey was done.

Specification of Magnetic Survey Device

Detector	DTM-II	
Type	Twin coil type	
Resistance	14 KΩ	
Interval of twin coils	2000 mm	
Amplifier	MAG 8406	Applied to barge measurement
	MAG 8301	Applied to on land
Type	Balance type	
Gain	40 dB, 60 dB.	
Frequency	DC 2 Hz	
Power	DC 12 V	
Recorder	U631	Applied to barge measurement
Type	Balance desk top type	
Channel	6 ch	
Mechanism	Digital input (A/D and D/A 12 bits, sumpling 8 mmsec)	
Width of recording paper	250 mm	
Speed of paper	Key input 0.1 ∿ 100 cm/sec, 0.1 ∿ 799 cm/sec, 799 ∿ 0.6 sec/cm	
Amplifier	DV 101 multi-range DC voltage input unit	
Range	1, 2, 10, 20, 50, 200 mV or V, and 500 mV	
Input impedance	1 MΩ	
Power	AC 100, 115, 200, 220, 240 V 10%, 75 VA (Max. 140 VA)	
Amplifier	MAG 8301	Applied on the other case.

Same type with MAG 8406, but one channel

Recorder	EPR 131A
Type	DC servomechanism
Channel	3 ch
Width of recording paper	150 mm
Speed of paper	10, 20, 30, 60, 120, 180, 300, 600 mm/h or mm/min
Amplifier renge	0.5, 1, 2.5, 10, 25, 50, 100, 250 mV or V

Imput impedance about 2 MΩ

Power Dry cell (1.5 V) x 6, 12 VA

Observation barge made of FRP and load capacity 30 tons

Electromotor winch, hanging capacity 1 ton x 2

Generator 20KVA

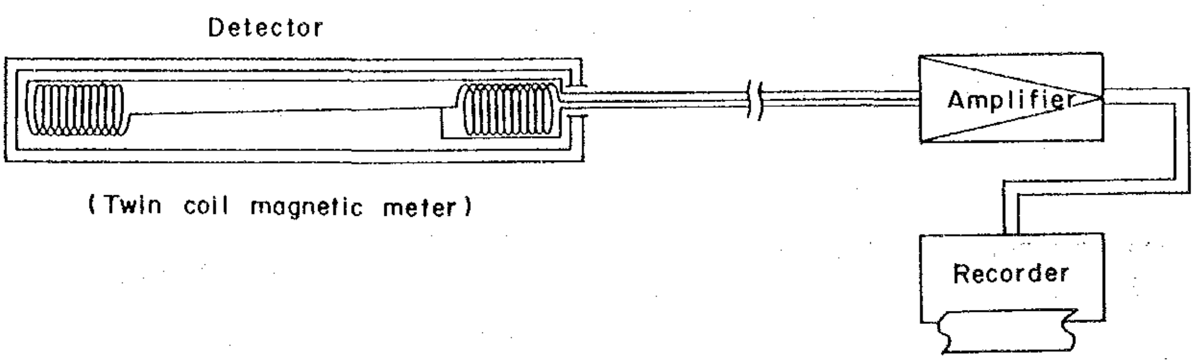
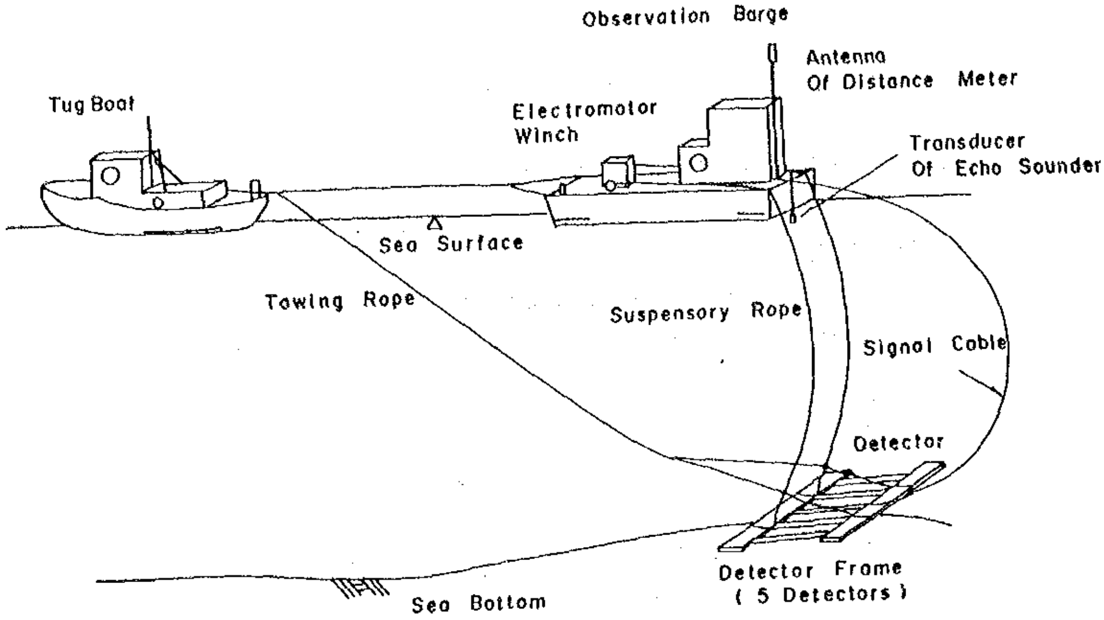
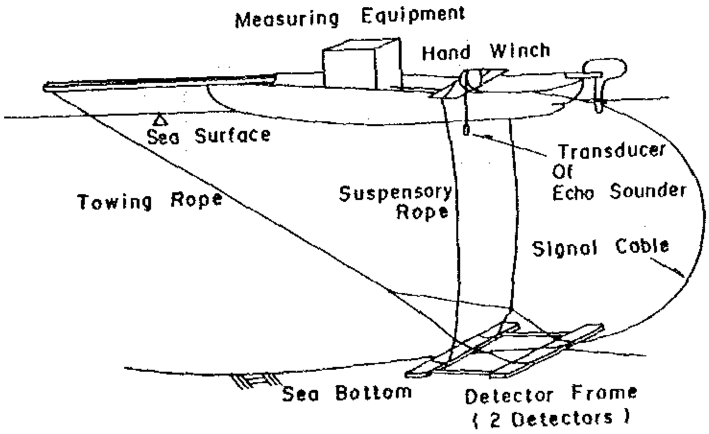


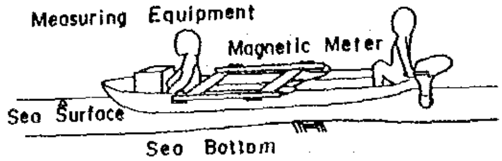
Figure 3-17 MAGNETIC SURVEY SYSTEM



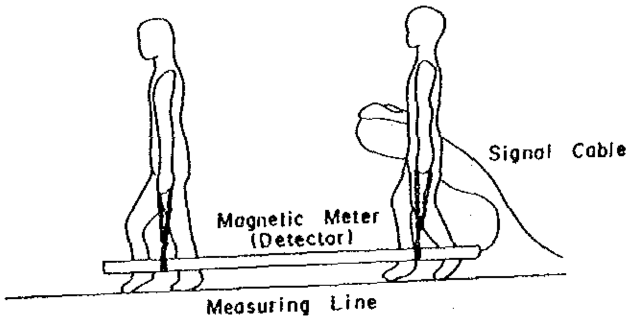
1) OBSERVATION BARGE



2) SMALL BOAT

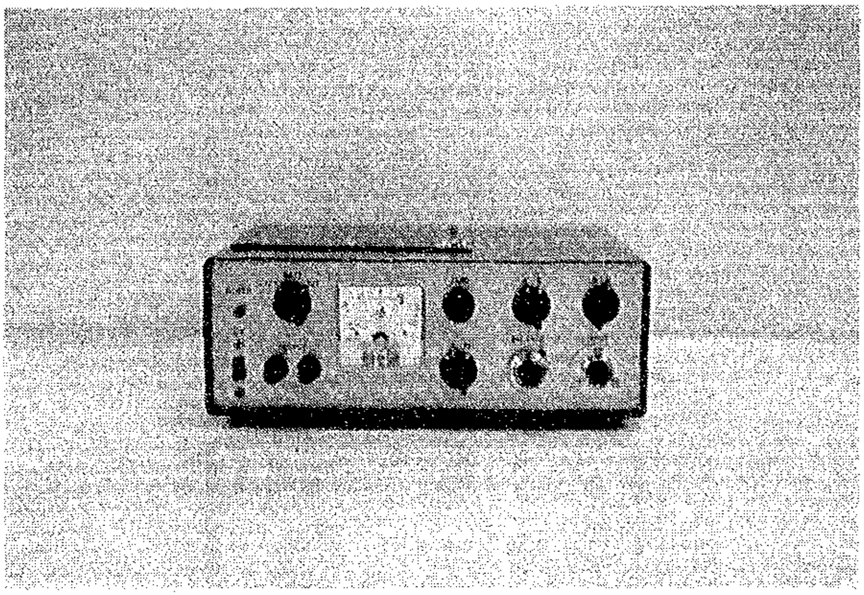


3) SMALL BOAT FIXING DETECTOR FRAME

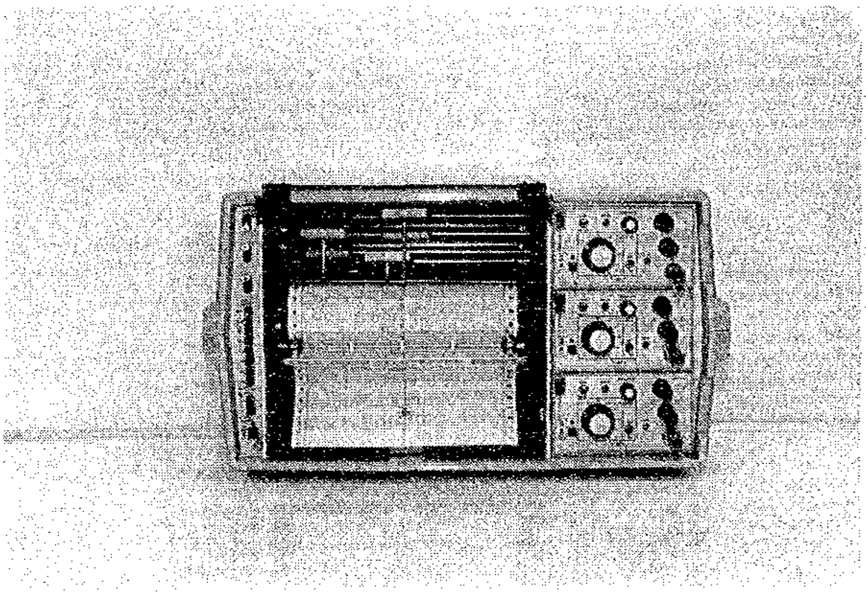


4) MAN POWER TO MOVE A DETECTOR

Figure 3-18 METHOD OF MAGNETIC SURVEY

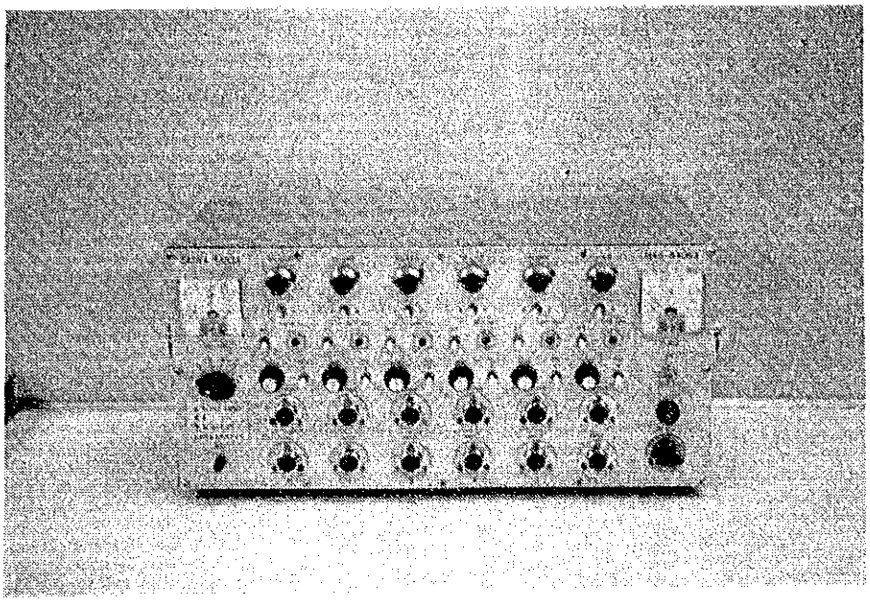


MAG-8301 Amplifier

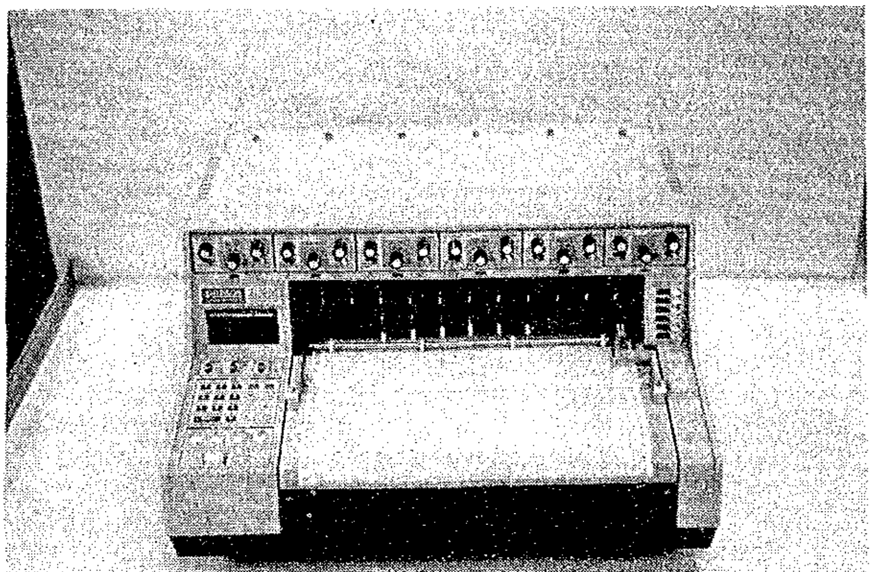


EPR-131A Recorder

Figure 3-19 USING ON SHORE MAGNETIC METER

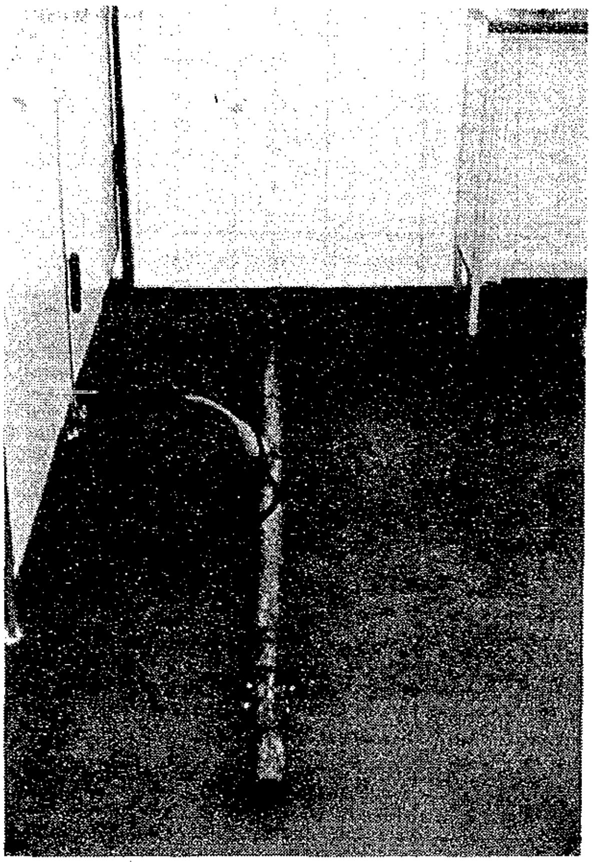


MAG-8406 Amplifier



U-631 Recorder

Figure 3-20 USING OFF SHORE MAGNETIC METER



DTM-II Twin coil magnetic meter

Figre 3-21 USING ON SHORE AND OFF SHORE MAGNETIC METER