II-1-2-3 Survey methods

1) Survey Boat

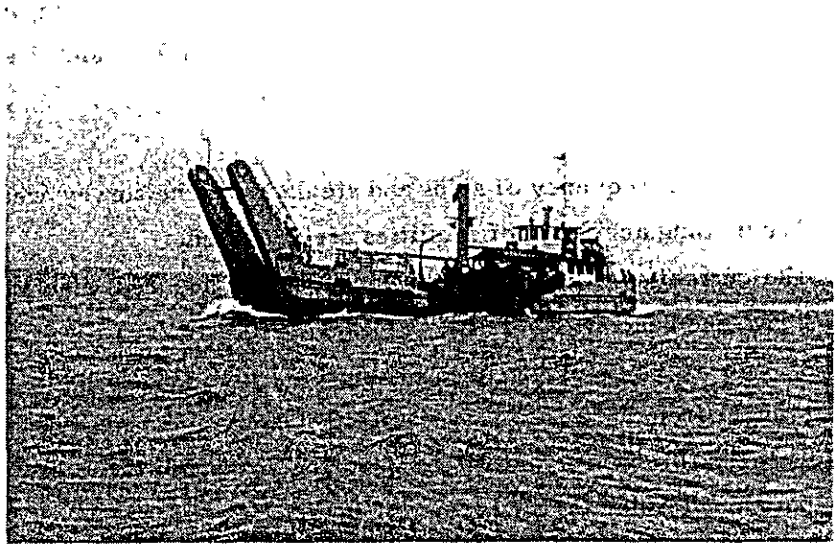
Two kinds of survey boats have been used for the current survey. The one is for mooring the current meters and for withdrawing the current meters after the observation is completed. The another one is for the patrols and tape changes.

Table II-1-2-(10) shows the boats used for the current survey.

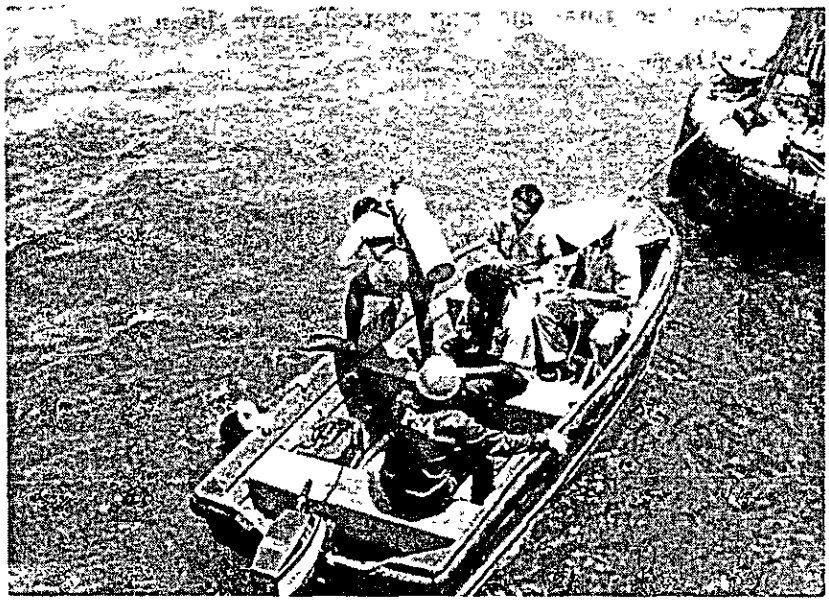
Table II-1-2-(10) Survey boats used for current survey

	Survey items	Boats	Belonging
(1)	Mooring & withdrawal of current meters	PSA "PESEK" and attached motor-boat	PSA (Port of Singapore Authority)
(2)	Tape change & patrol	Midium size launches	Local ships arranged by JTC at Jurong Town Pier & Changi Pier

Fig. II-1-2-(10) shows the pictures of PESEK and other survey boats employed for the current survey. For the transportation of survey team, the above (2) launches were used.



PSA survey boat Pesek.



Motor-boat

Fig. II-1-2-(10) PSA survey vessel "PESEK"

2) Mooring and withdrawal of current meters

Prior to plan the mooring schedule in this study, the following information have been provided by the Authorities concerned through JTC and Preliminary Survey Team who visited Singapore in December 1980.

(1) Navigation frequency of ships and steamers at the survey areas is high.
(2) The missing accidents of facilities are expected.
(3) The current meters are recommended to be moored with the existing light buoys and beacon-towers.
(4) TC1 to TC3 of Tekong Area are necessary to set the light buoys which are brought from Japan.
(5) The floating buoys and other mooring materials are recommended to be positioned under the surface.
(6) The current velocity is fast.
(7) The sudden turn of tidal current is expected.

Taking the above information in consideration, and with the recommendation of PSA officers, the final mooring systems have been determined as shown in Fig. II-1-2-(11).

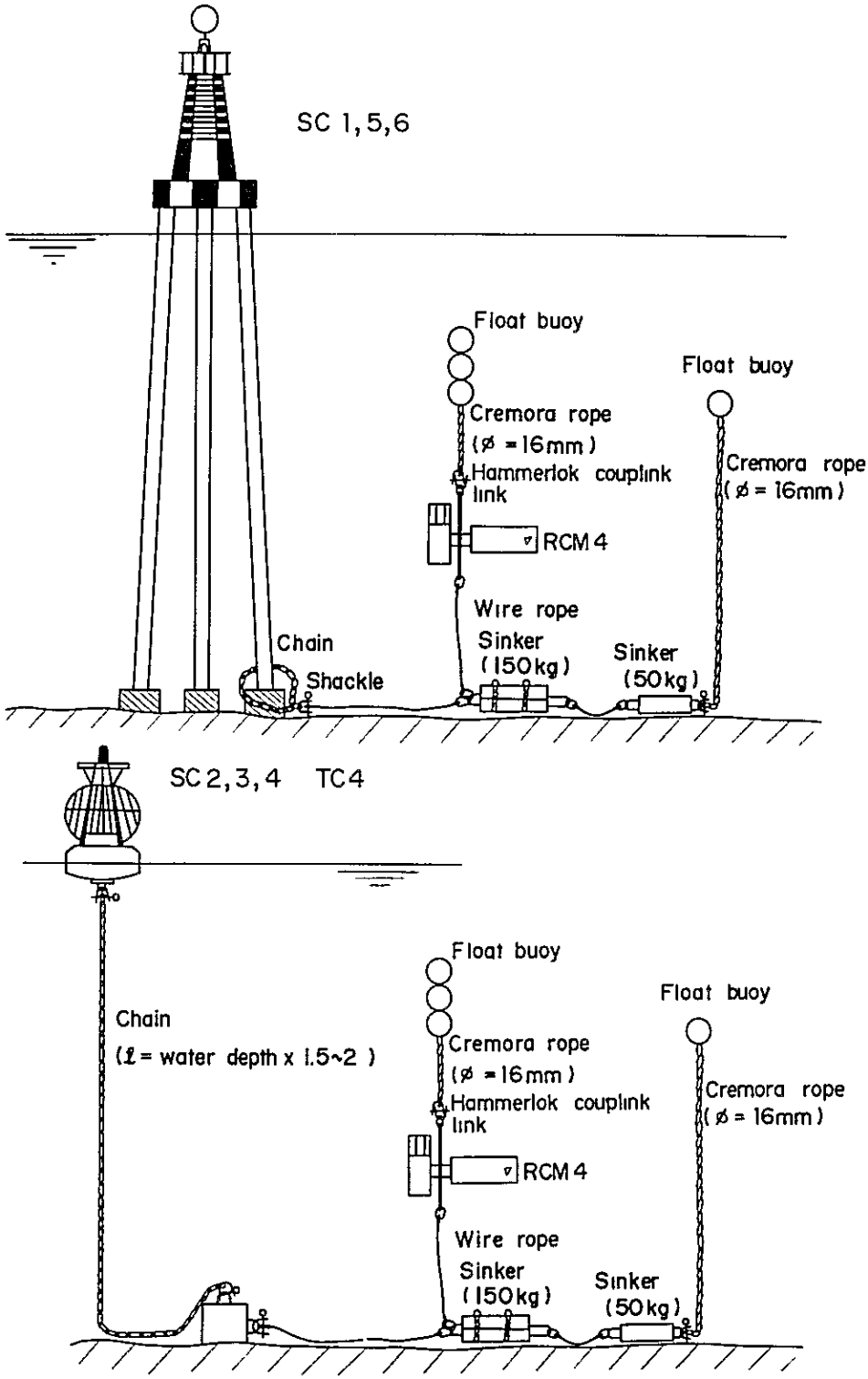


Fig. II-1-2-(11) Mooring systems of current meters (1)

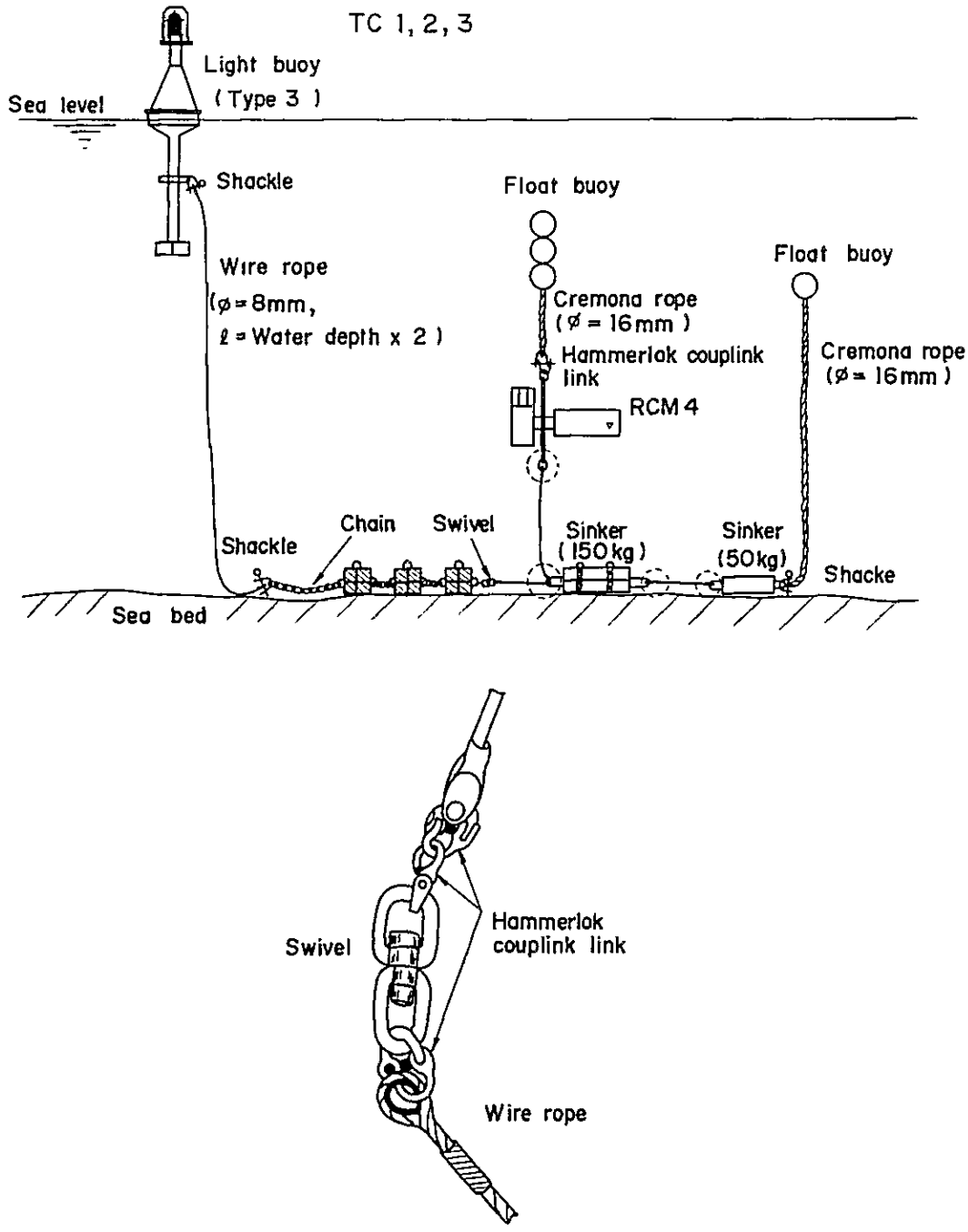


Fig. II-1-2-(11) Mooring systems of current meters (2)

According to the mooring systems mentioned in Fig. II-1-2-(11), the moorng of current meters have been conducted on the 23rd and 24th February 1981 at Seraya Area and on the 26th and 27th February 1981 at Tekong Area.

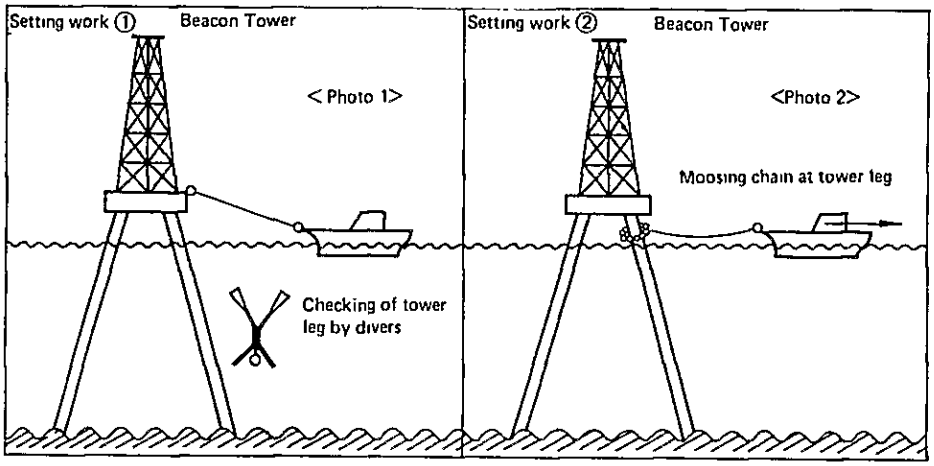
These mooring works have been engaged by Japanese survey team, JTC officers, PSA officers, crews of PESEK, divers and local employees.

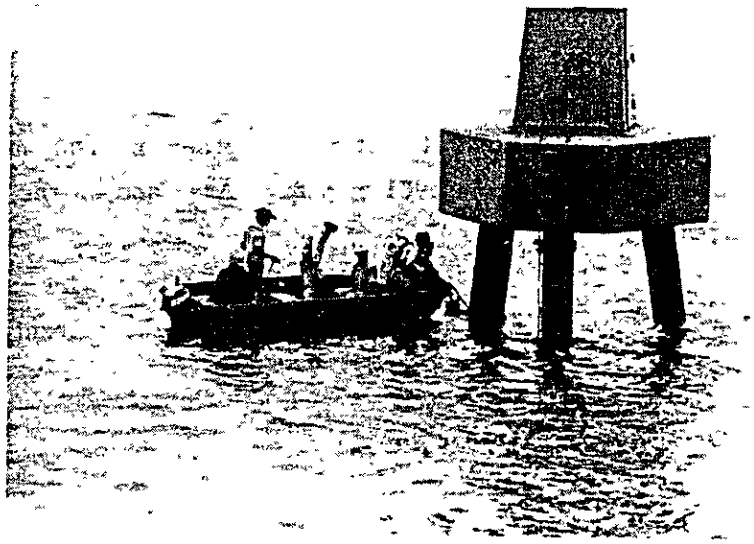
The necessary instruments and materials have been transported by lorries from JTC godwon to Jurong Marine Base (JMB) and loaded on "PESEK" in the morning of February 23rd 1981.

Fig. II-1-2-(12) shows the mooring process of current meters. The related works include sub-surface operation by divers, works on board, and steering of the survey vessel.

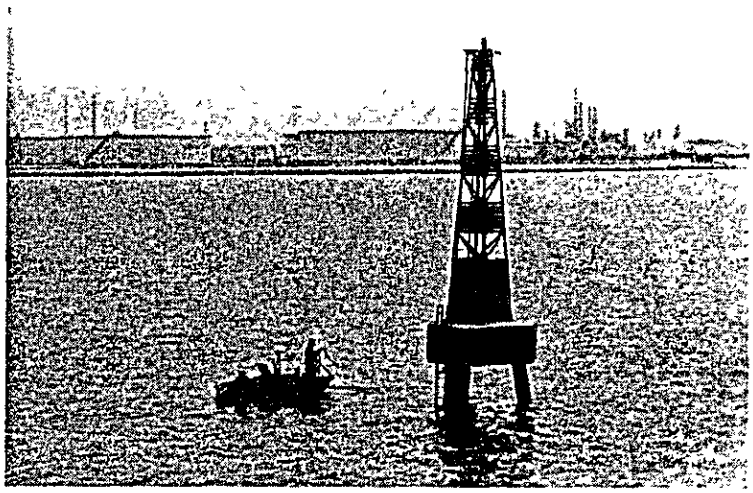
The withdrawal of the current meters and other mooring materials has been conducted on the 13th March 1981 at Seraya Area and on the 17 March 1981 at Tekong Area.

Fig. II-1-2-(13) shows the process of withdrawal of the current meters and other mooring materials.



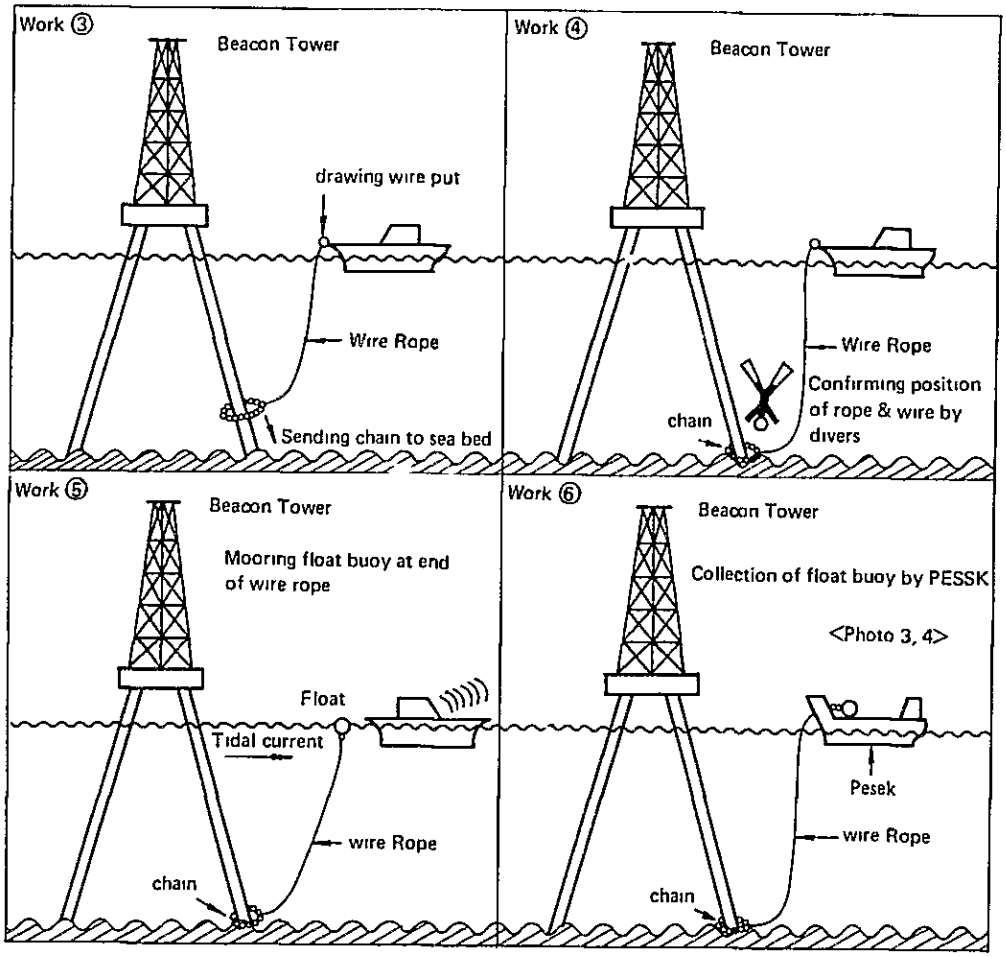


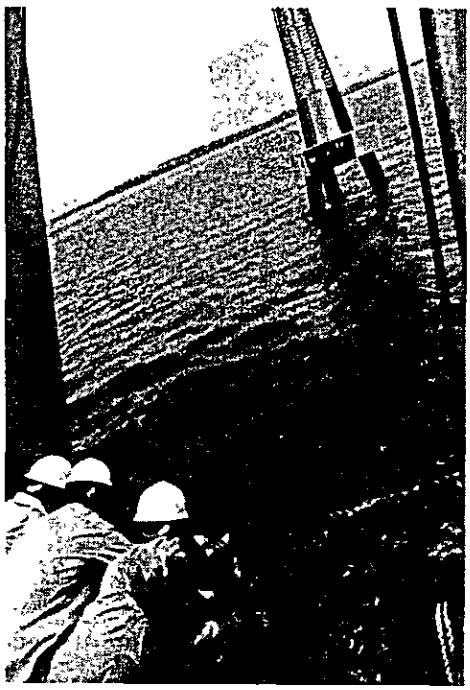
Work ① Beacon Tower <Photo 1>



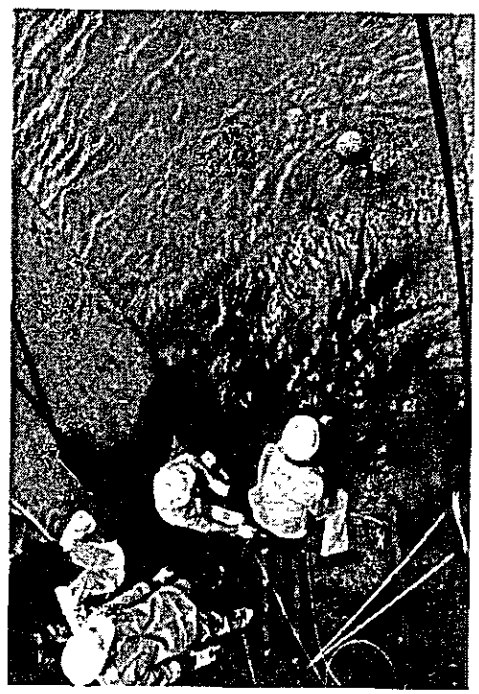
Work② Beacon Tower <Photo 2>

Fig. II-1-2-(12a) Mooring process of current meter at Seraya Area (1/11)



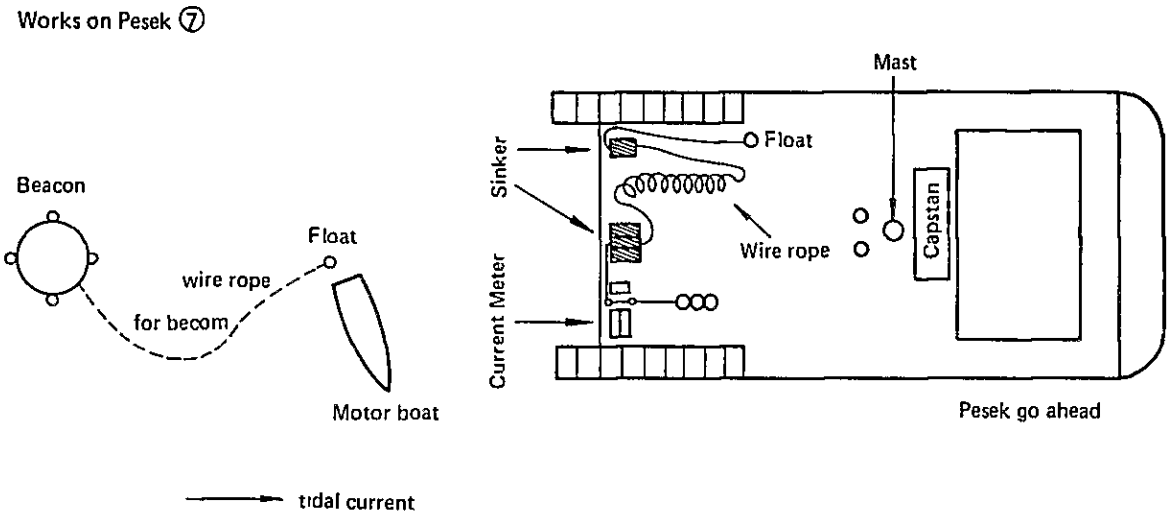


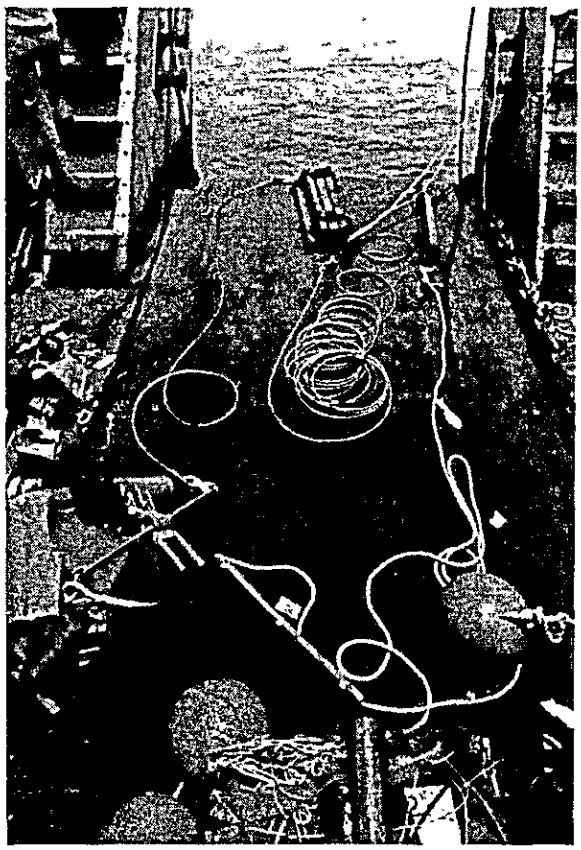
Setting work ⑥ <Photo 3>



<Photo 4>

Fig. II-1-2-(12a) Mooring process of current meter at Seraya Area (2/11)

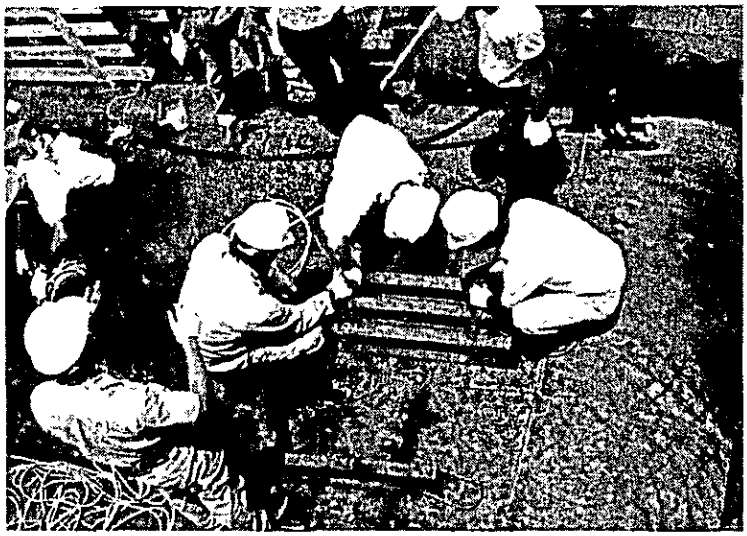




Current meter prepared for setting <Photo 5>

Photo 6 ~ Photo 13 shows works on PESEK

Fig. II-1-2-(12a) Mooring process of current meter at Seraya Area (3/11)

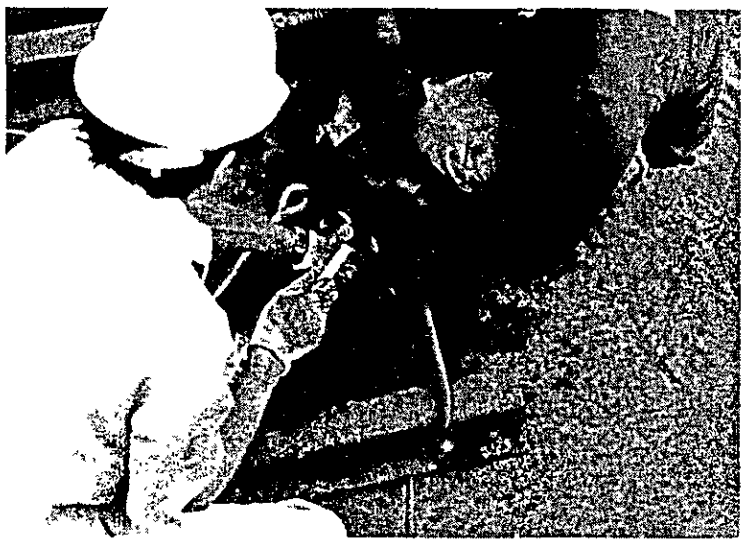


Sinker mooring to current meter

<Photo 6>

Connecting wire rope with sinker

<Photo 7>



Sinker mooring to float for collection

<Photo 8>

Fig. II-1-2-(12a) Mooring process of current meter at Seraya Area (4/11)

<Photo 9>

Checking of current meter by printer

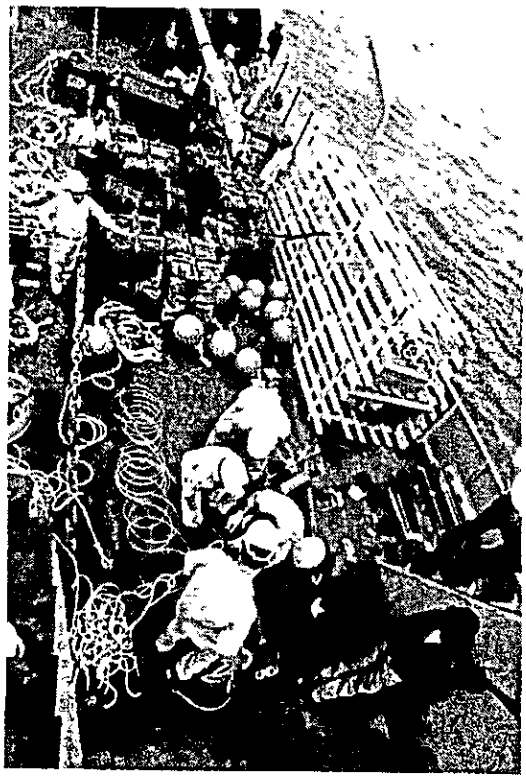
<Photo 10>

Connecting recording unit with vane

<Photo 11>

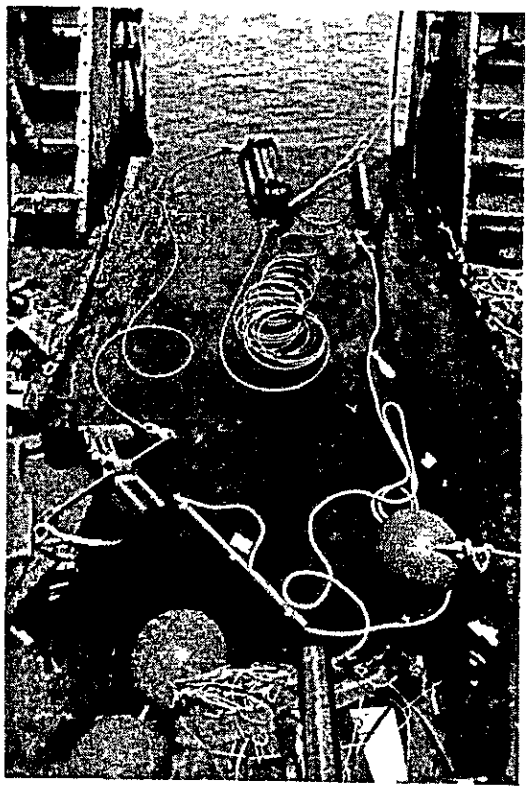
Connecting recording unit with vane

Fig. II-1-2-(12a) Mooring process of current meter at Seraya Area (5/11)



final checking

<Photo 12>



Ready for setting

<Photo 13>

Fig. II-1-2-(12a) Mooring process of current meter at Seraya Area (6/11)

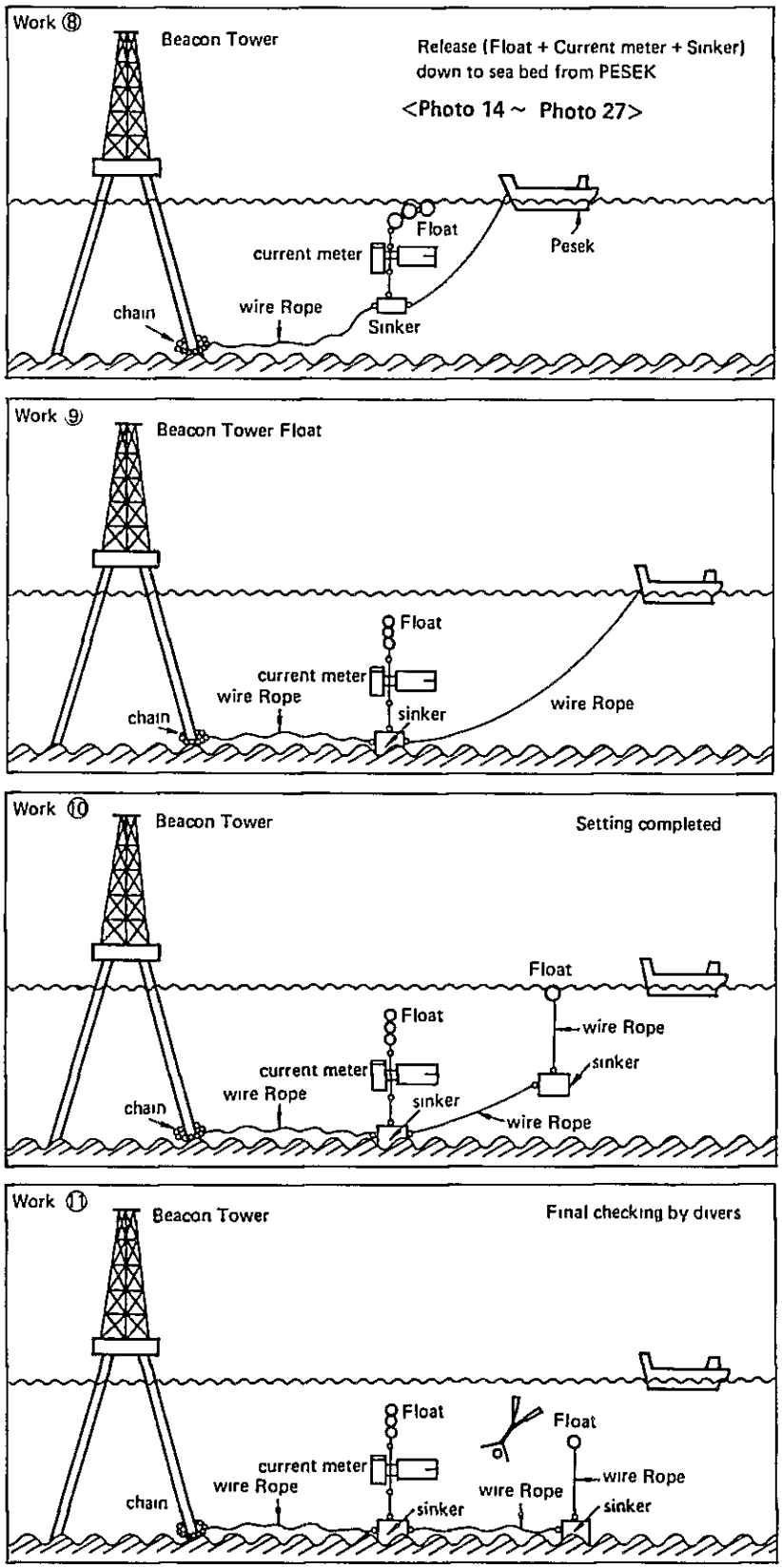
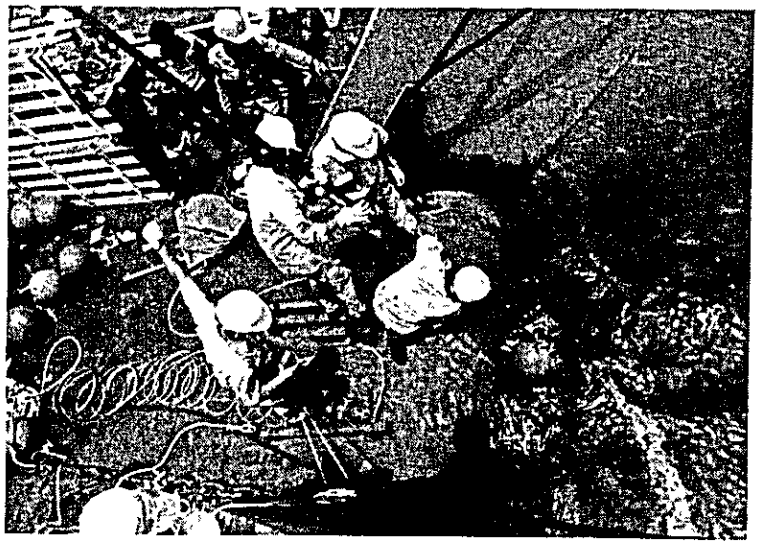
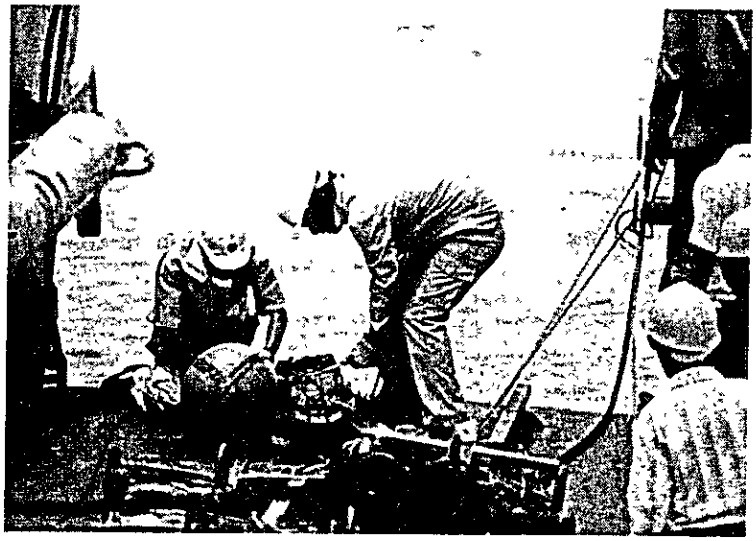


Fig. II-1-2-(12a) Mooring process of current meter at Seraya Area (7/11)



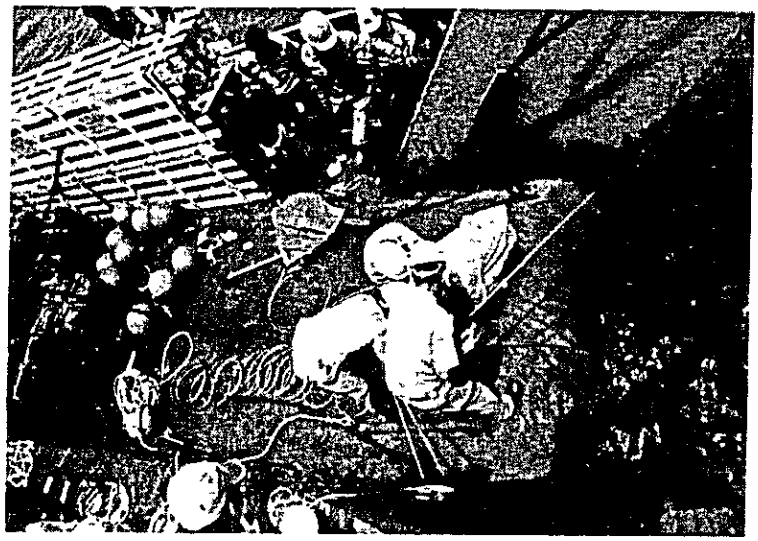
Collection of float buoy released from motor boat.

<Photo 14>



Wire rope after taking off from float connects with sinker of current meter side.

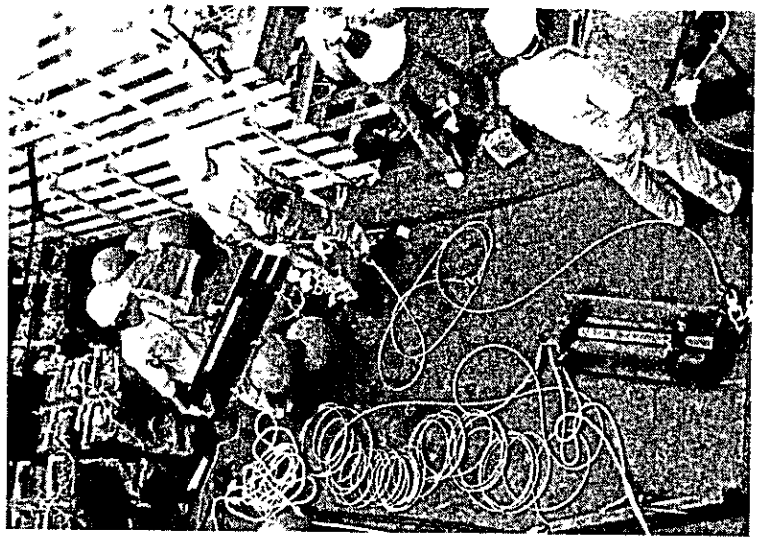
<Photo 15>



Ready for setting and final checks on connectings.

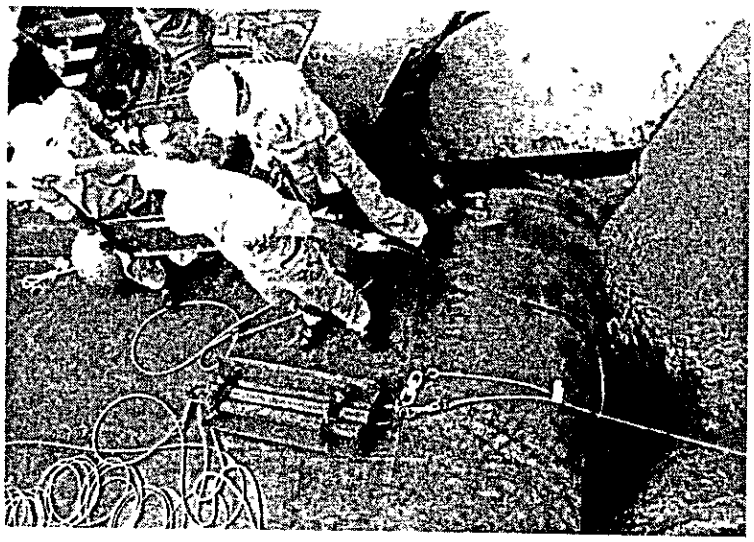
<Photo 16>

Fig. II-1-2-(12a) Mooring process of current meter at Seraya Area (8/11)



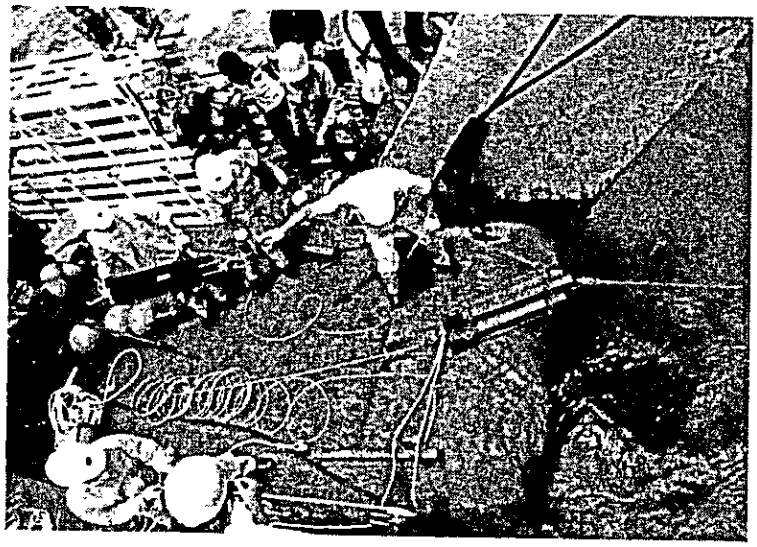
Checking of wire turist by holding current meter.

<Photo 17>



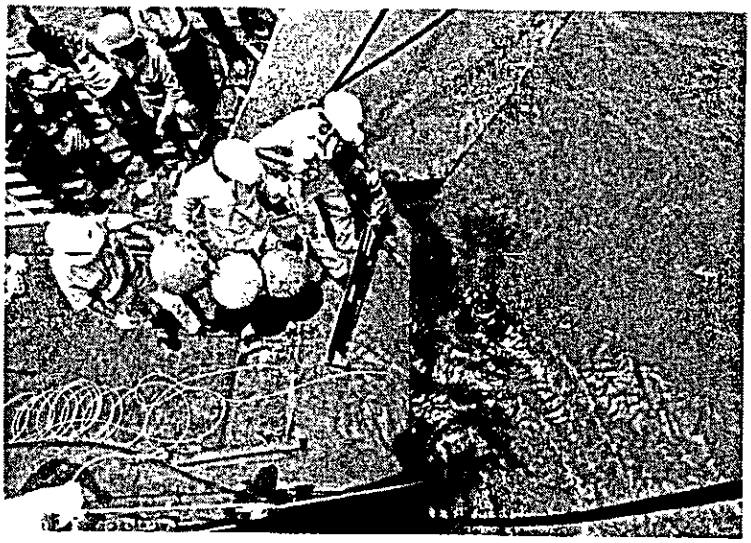
Send signal to captain for commencement of setting.

<Photo 18>



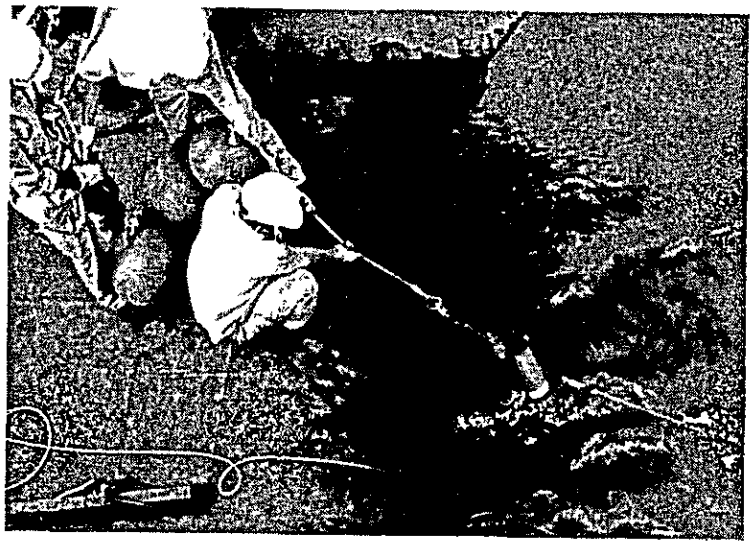
Sinker of current meter side is just throwing into sea.

<Photo 19>



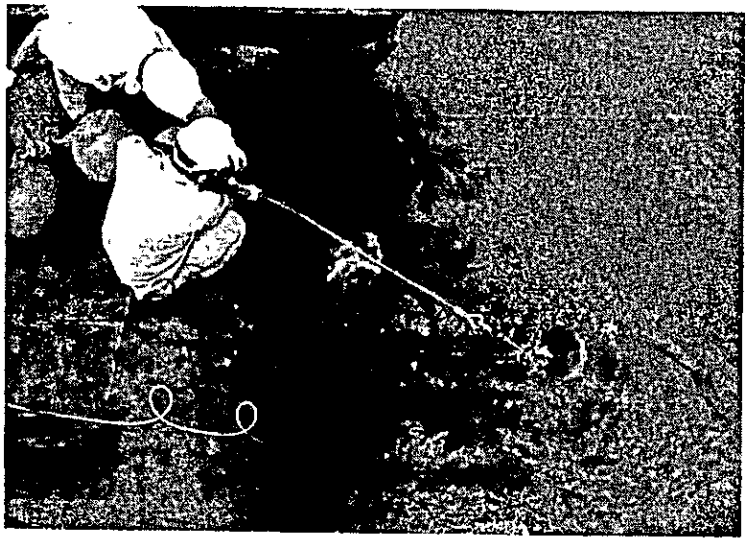
Follouring to sinker, current meter & float buoys are going to throw down into sea.

<Photo 20>



Current meter is just throwing down.

<Photo 21>



Current meter is getting into sea.

<Photo 22>

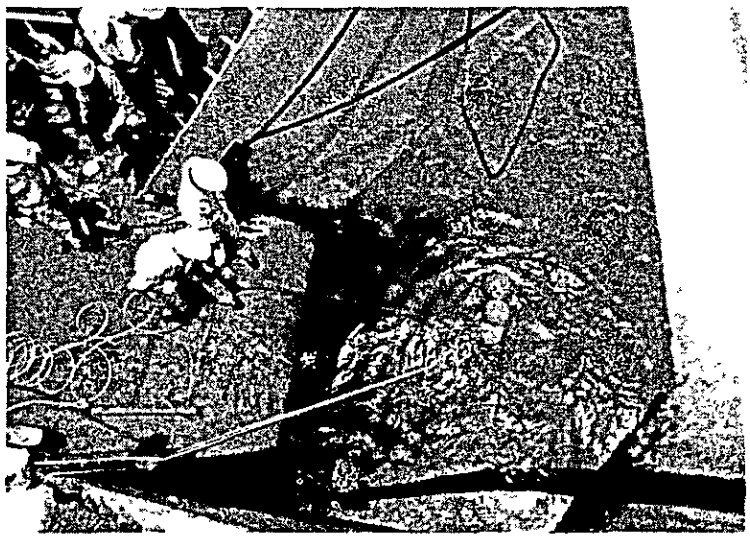
Fig. II-1-2-(12a) Mooring process of current meter at Seraya Area (9/11)

Float buoys are following after current meter.

<Photo 23>

Float buoys are following after current meter.

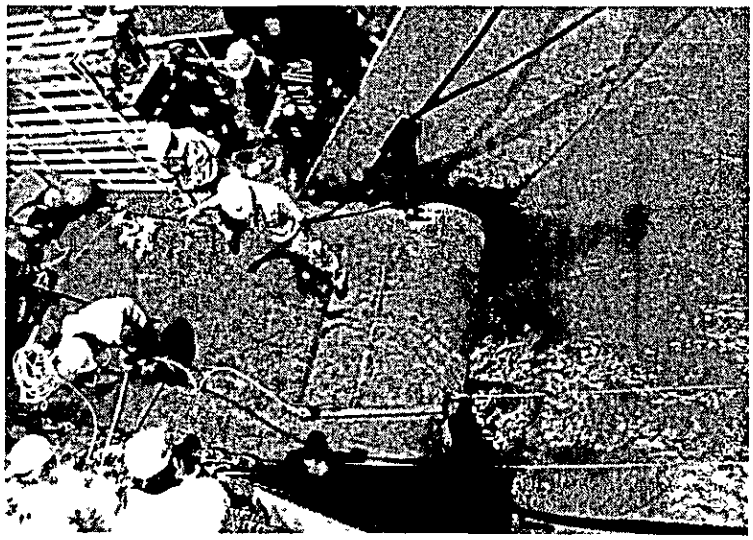
<Photo 24>



Float buoys are following after current meter.

<Photo 25>

Fig. II-1-2-(12a) Mooring process of current meter at Seraya Area (10/11)



Sinker connected with float buoy for collection is ready for setting.

<Photo 26>

Float buoy for collection is throwing down.

<Photo 27>

Fig. II-1-2-(12a) Mooring process of current meter at Seraya Area (11/11)

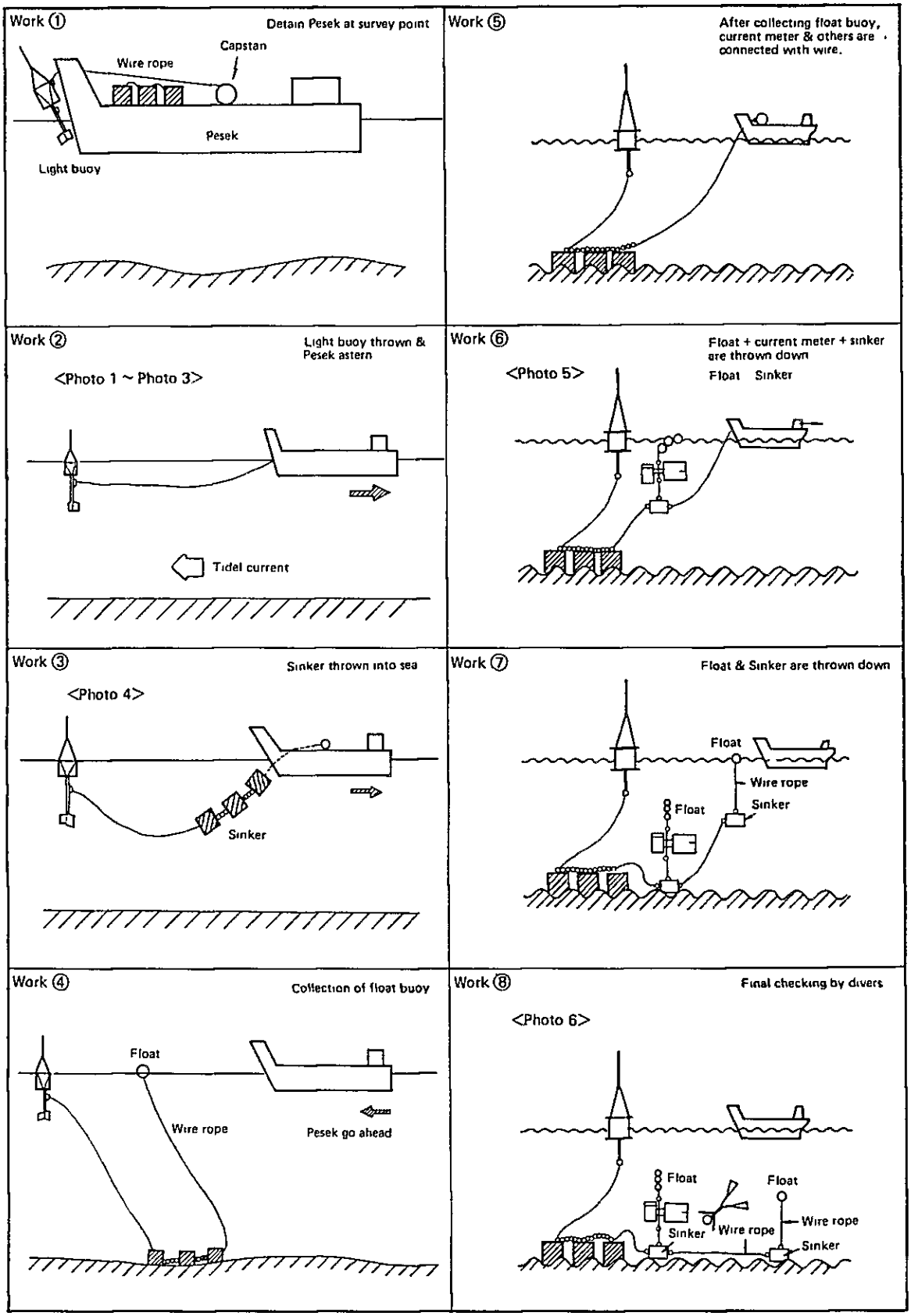
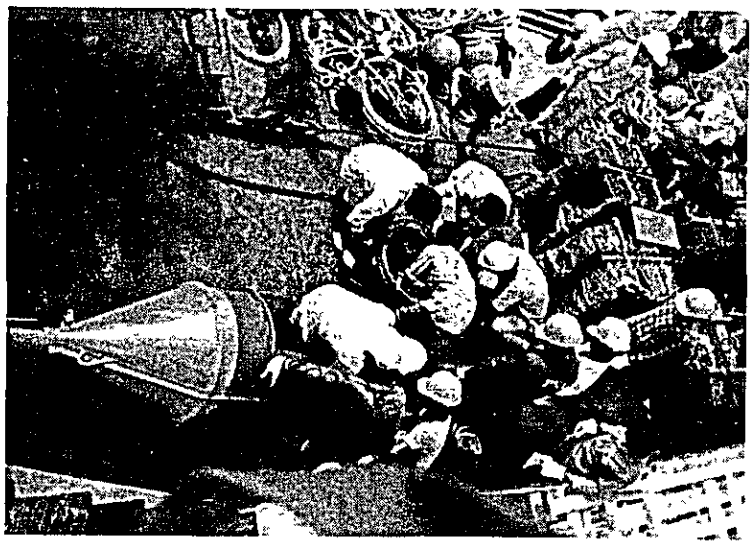
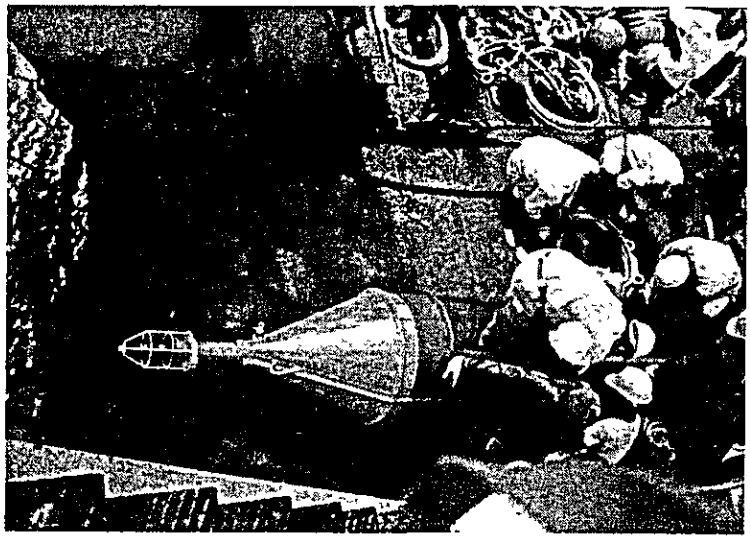


Fig. II-1-2-(12b) Mooring process of current meter at Tekong Area (1/3)

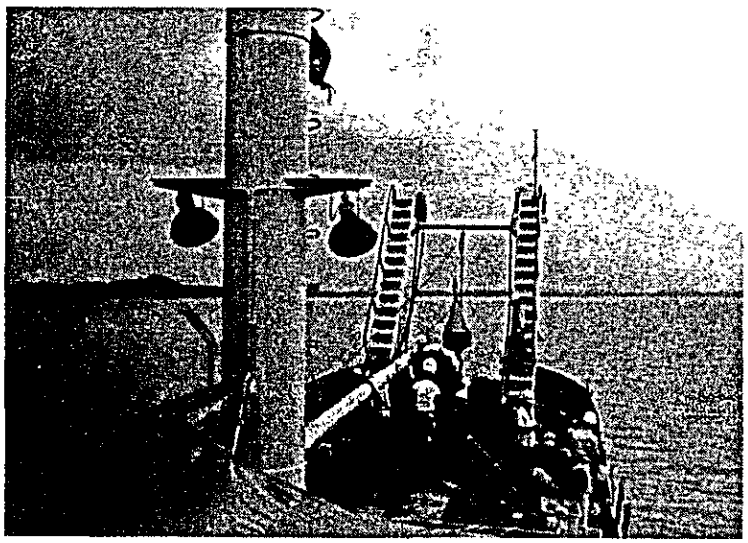


Preparation works for Zeni-light buoy setting

<Photo 1>



<Photo 2>

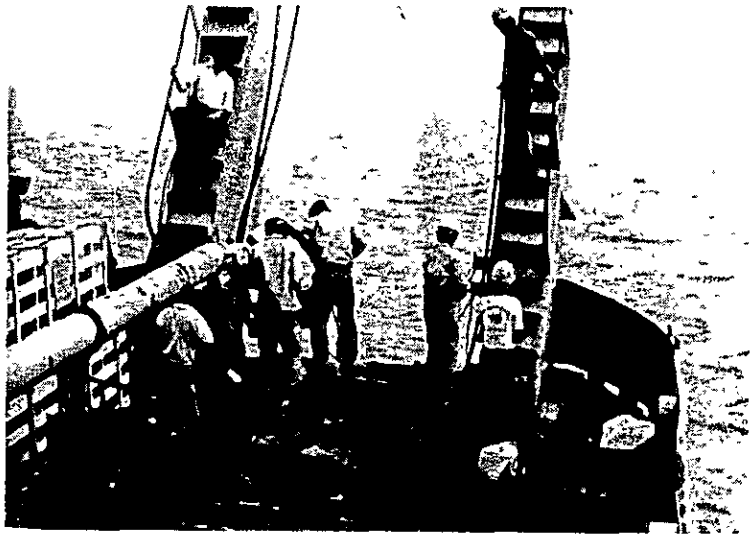


Setting work of Zeni-light buoy

<Photo 3>

Fig. II-1-2-(12b) Mooring process of current meter at Tekong Area (2/3)

<Phtoo 4>



Setting work of current meter

<Photo 5>

Setting completed

<Photo 6>

Fig. II-1-2-(12b) Mooring process of current meter at Tekong Area (3/3)

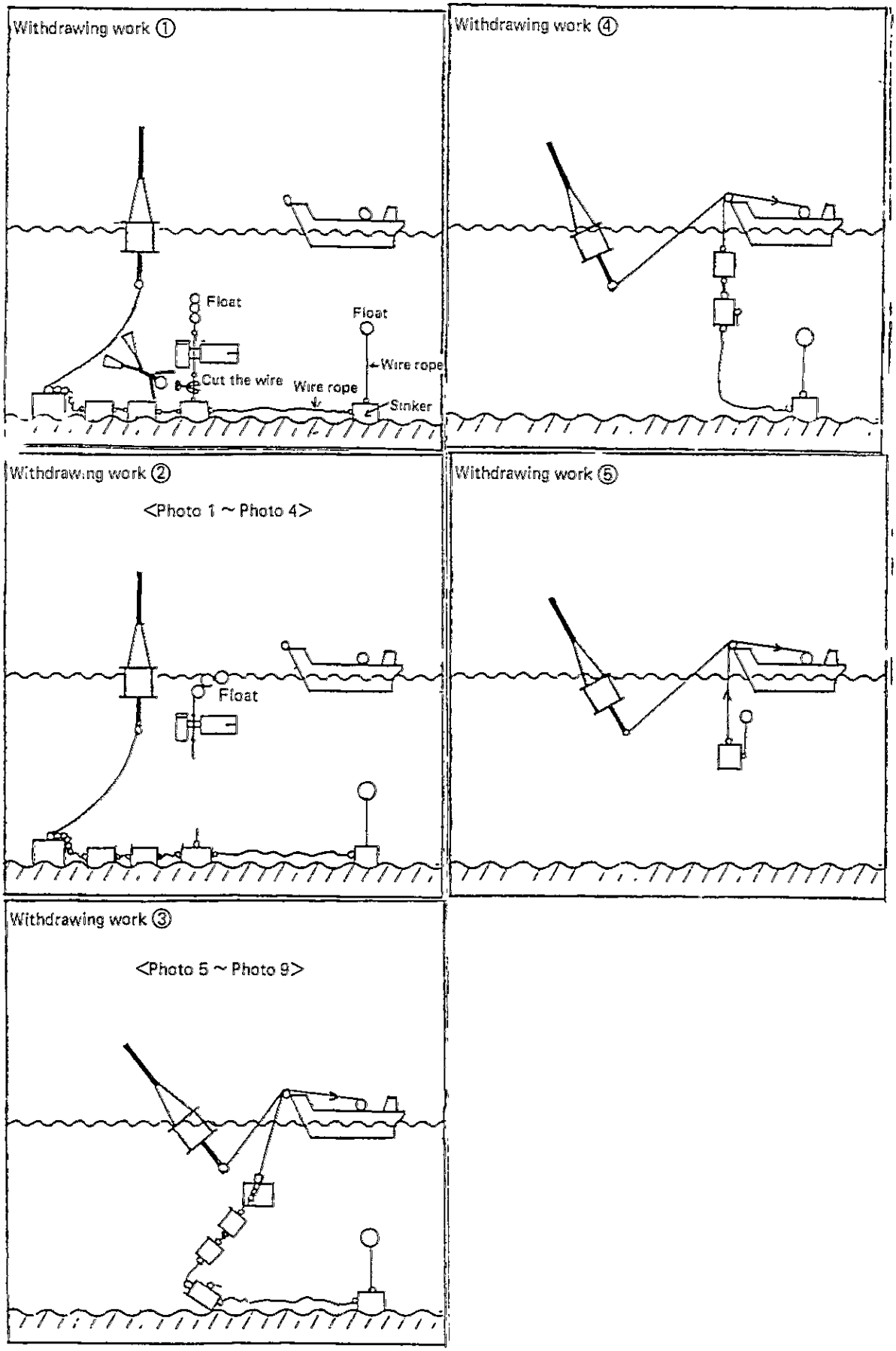
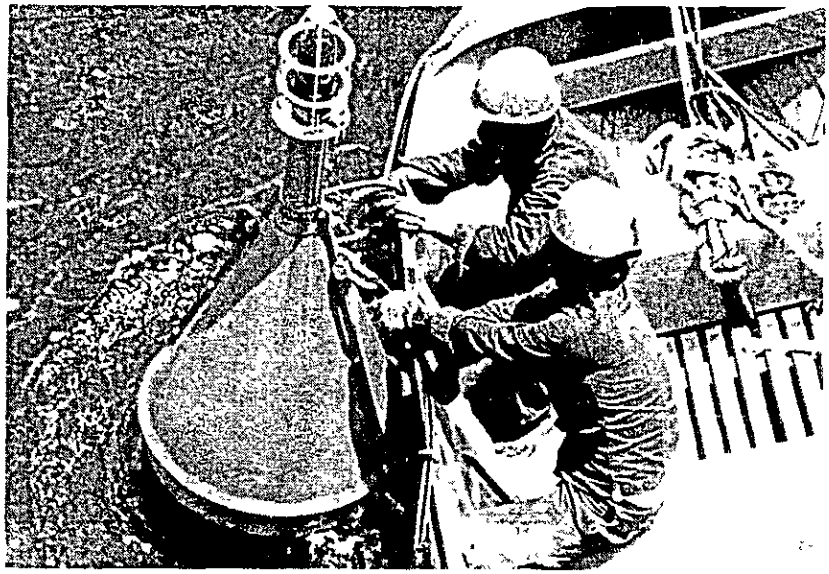
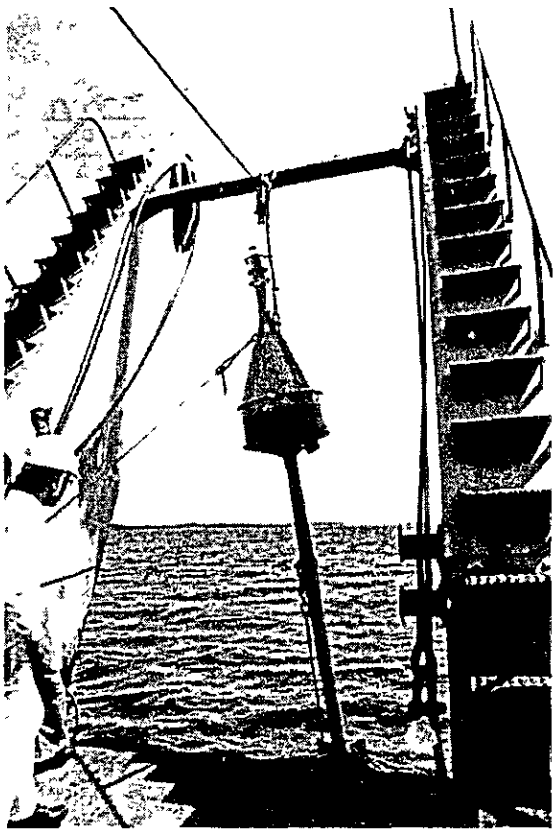


Fig. II-1-2-(13) Withdrawing process of current meter (1/4)



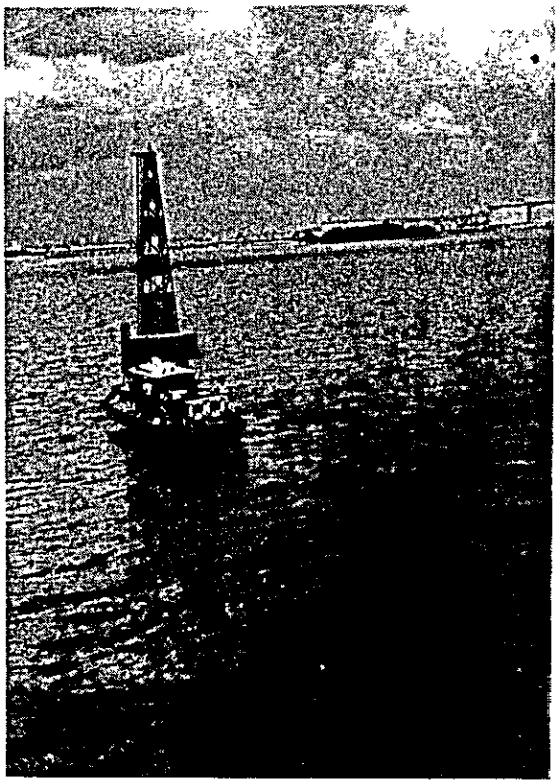
<Photo 5>



<Photo 6>

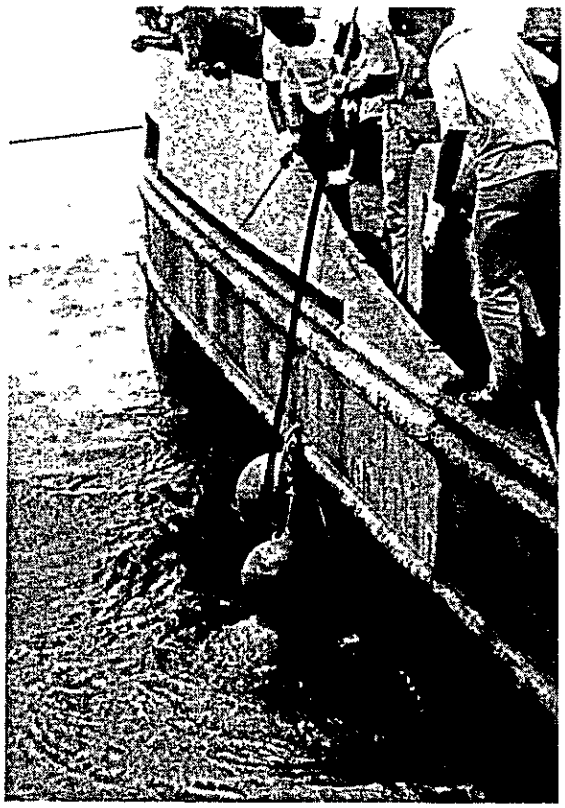
<Photo 7>

Fig. II-1-2-(13) Withdrawing process of current meter (2/4)



<Photo 1>

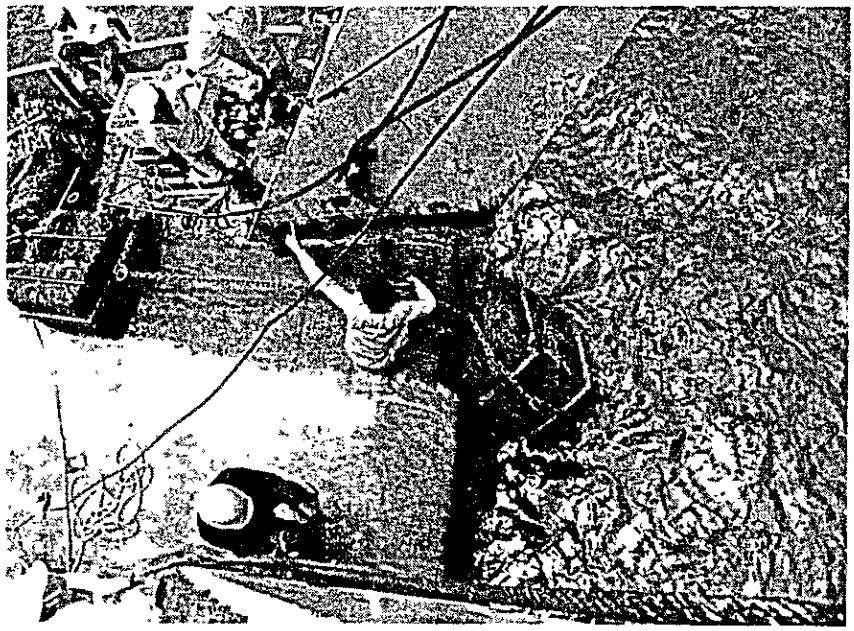
<Photo 2>



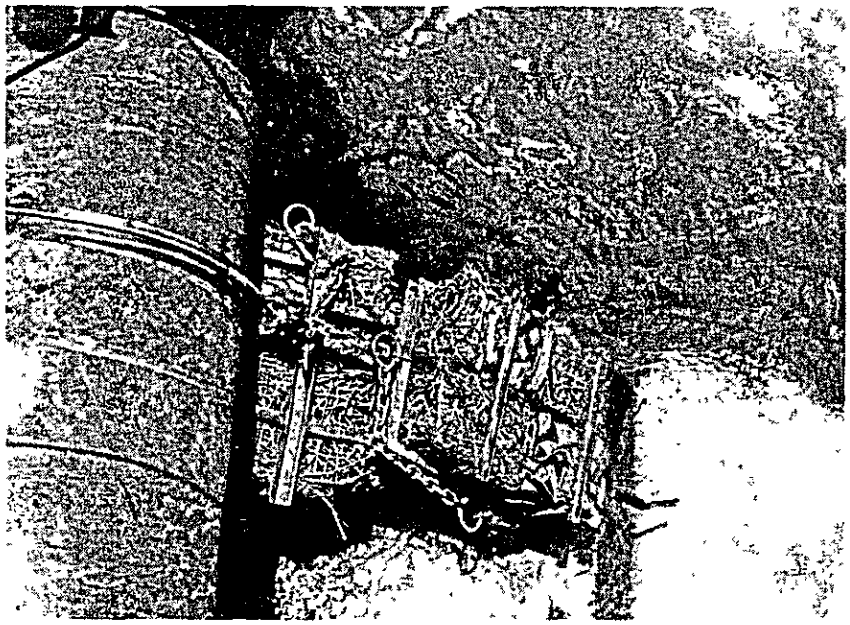
<Photo 3>

<Photo 4>

Fig. II-1-2-(13) Withdrawing process of current meter (3/4)



<Photo 8>



<Photo 9>

Fig. II-1-2-(13) Withdrawing process of current meter (4/4)

3) Patrol and collection of data

Through the period of the current survey, the patrol and collection of data have been carried out by the launches.

The relative information is shown in Table II-1-2-(8) and Table II-1-2-(11).

Table II-1-2-(11) Patrol and collection of data

Name of Area	Patrol	Tape change	Duration
Seraya Area			
SC 1	4 times	3 times	about 19 days
SC 2	5 times	2 times	about 19 days
SC 3	5 times	2 times	about 19 days
SC 4	5 times	2 times	about 18 days
SC 5	5 times	2 times	about 18 days
SC 6	5 times	2 times	about 18 days
Tekong Area			
TC 1	7 times	2 times	about 20 days
TC 2	7 times	2 times	about 20 days
TC 3	7 times	2 times	about 20 days
TC 4	7 times	2 times	about 19 days

— Patrol

The patrol is conducted for the purpose of confirming whether the current meter and other mooring systems are functioning properly.

Aanderaa current meter is capable to be monitored from the boat by the monitor system. This monitoring system is shown in Table II-1-2-(12).

For the specifications of the instruments, it is described in the paragraph II-1-2-(4).

Table II-1-2-(12) Monitoring system of Aanderaa current meter

	Name	Capacity	Installed part
(1)	Acoustic transducer	Transmit data from surface by supersonic waves	in recording unit of current meter
(2)	Electrical terminal	Transmit data by electrical waves	in recording unit of current meter
(3)	Hydrophone receiver	Catch waves transmitted from transducer	independent
(4)	Deck unit	Print caught waves on chart	independent
(5)	Printer	Print caught waves on chart after A/D conversion	independent

At patrol, the hydrophone receiver is fallen down in the sea to catch the supersonic waves transmitted by acoustic transducer installed in the current meter. The waves are transmitted in order of reference, temperature, conductivity, depth, direction and velocity.

Fig. II-1-2-(14) shows the example of patrol using the hydrophone receiver.

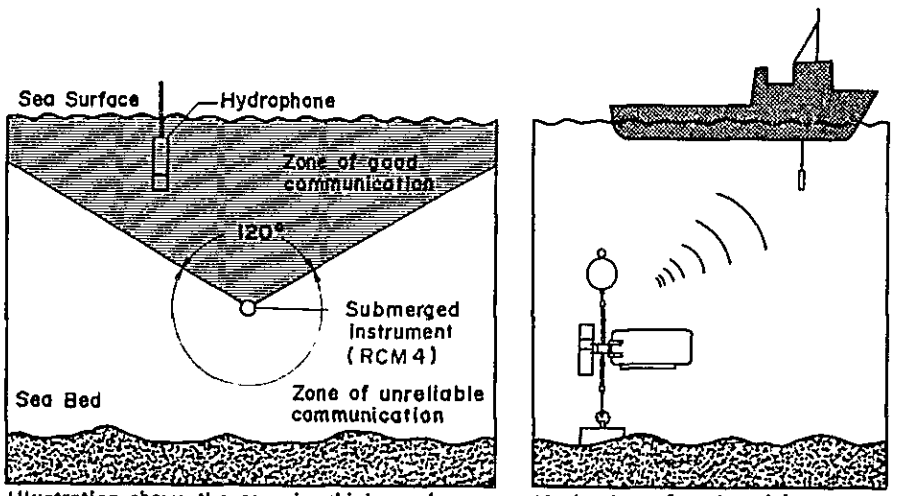


Fig. II-1-2-(14) Patrol by hydrophone receiver

— Collection of data

The collection of magnetic tapes have been carried out for the purpose of avoiding the data lack, missing of the current meters and checking the current meter itself.

The works involved are the underwater operation by the divers and tape change on the board. The diver's works are:

(1) Collection and resetting of recording unit of the current meter
(2) Checking of current meter (situation of rotor, electrical terminal and conductivity cell)
(3) Checking of mooring system (wire, shackle, clips and so on)
(4) Checking of subsurface part of light buoys (moorng rope and so on)

The works on board are to take out the magnetic tape from the recording unit which divers collected and to set the new spool of magnetic tape in the rocording unit.

The tape thus taken out from the recording unit is connected with the printer for the confirmation of data recording. The data are printed as shown in Table II-1-2-(13).

Table II-1-2-(13) Monitor waves printed by printer

— 01	0322	———— reference
— 02	0855	———— temperature
— 03	0000	———— conductivity
— 04	1023	———— depth
— 05	0441	———— direction
— 06	0065	———— velocity

Fig. II-1-2-(15) shows the collecting methods of recording unit by divers and Figs. II-1-2-(16) and II-1-2-(17) show the pictures of data collection.

1) Tools for withdrawal of recording unit

A. Float buoy (30 cm ϕ)

B. Rope with ring

2) Operation

2-1 Divers tie the rope (with ring and float buoy: Photo 1)

to recording unit (Fig.①)

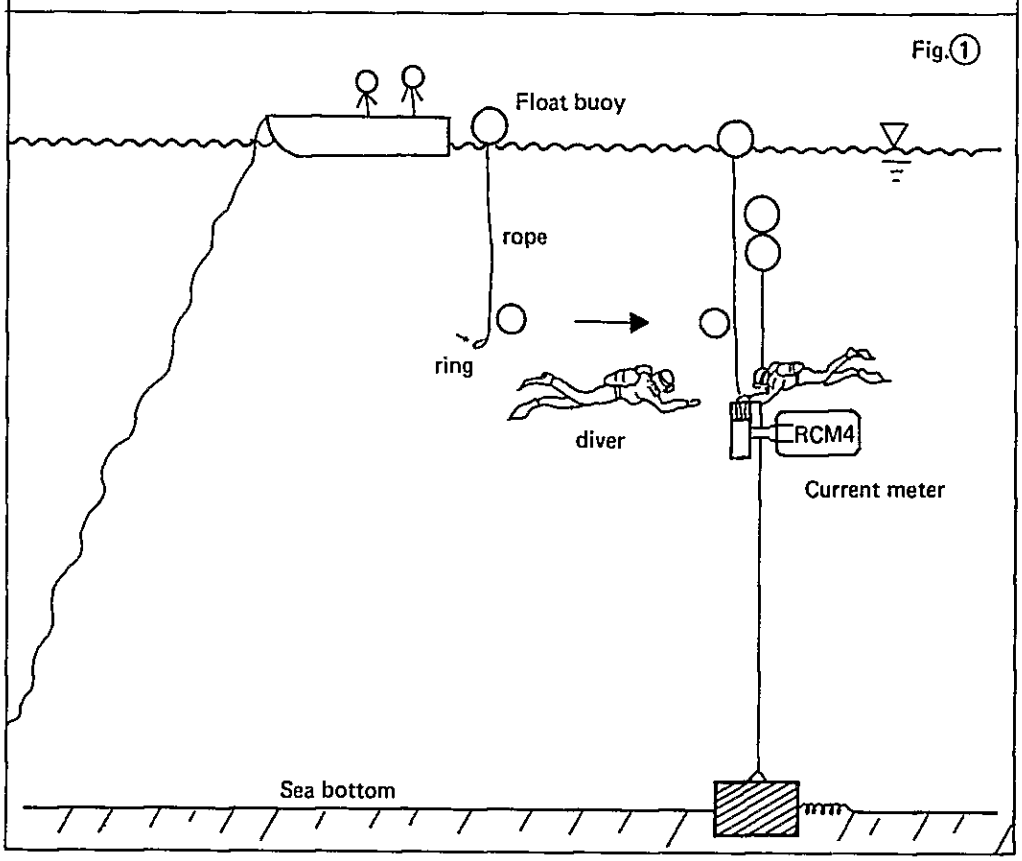
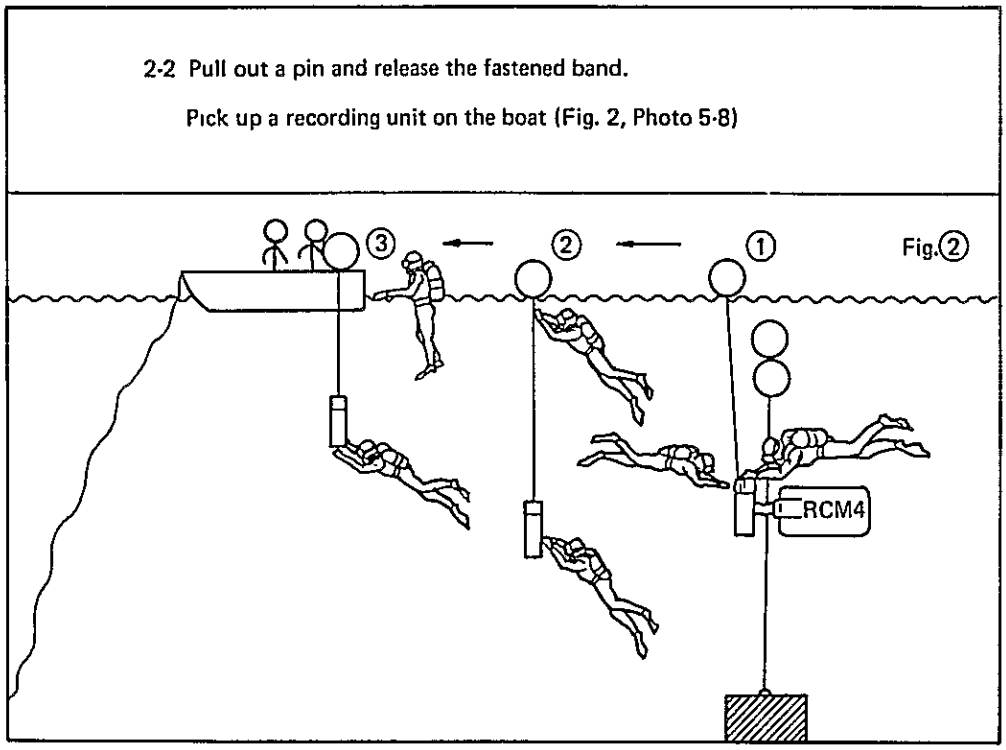


Fig. II-1-2-(15) Exchange method of magnetic tape (withdrawal of recording unit) (1/3)



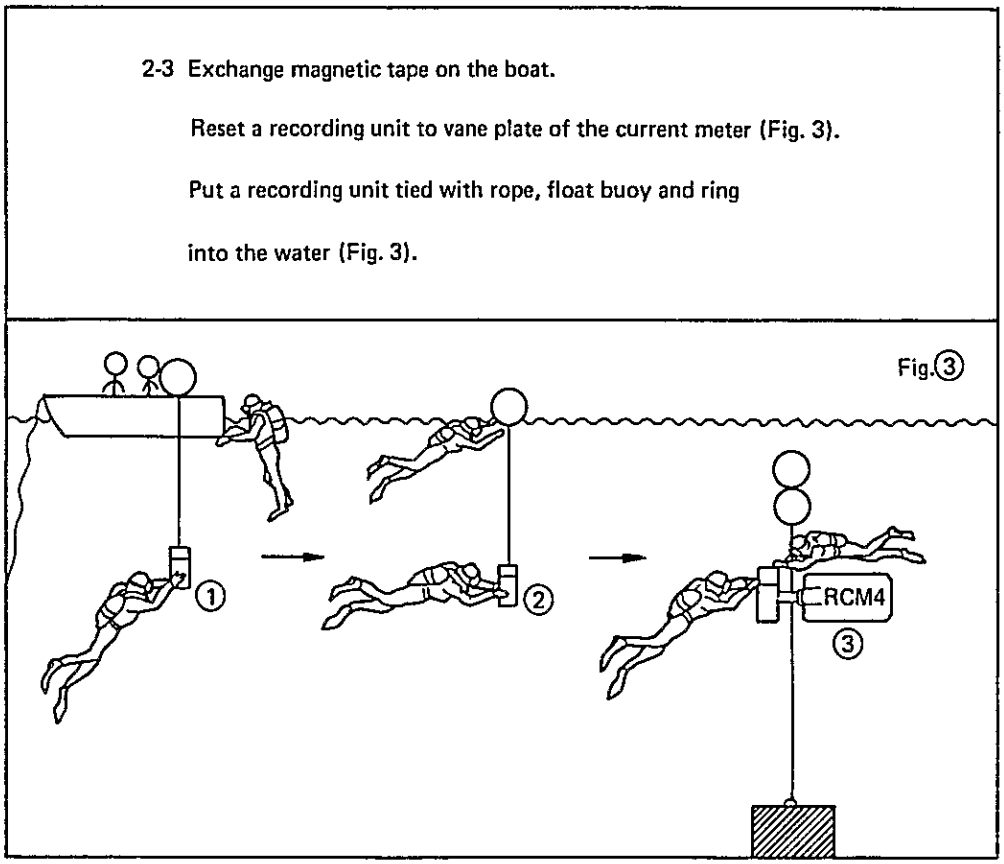


Fig. II-1-2-(15) Exchange method of magnetic tape (withdrawal of recording unit) (2/3)

3) Releasing method of recording unit

3-1 Tie the rope (with ring and float buoy) to recording unit (Fig. 4).

3-2 Pull out a pin (Photo 9).

3-3 Release a fastened band (Photo 10).

Fig. 4

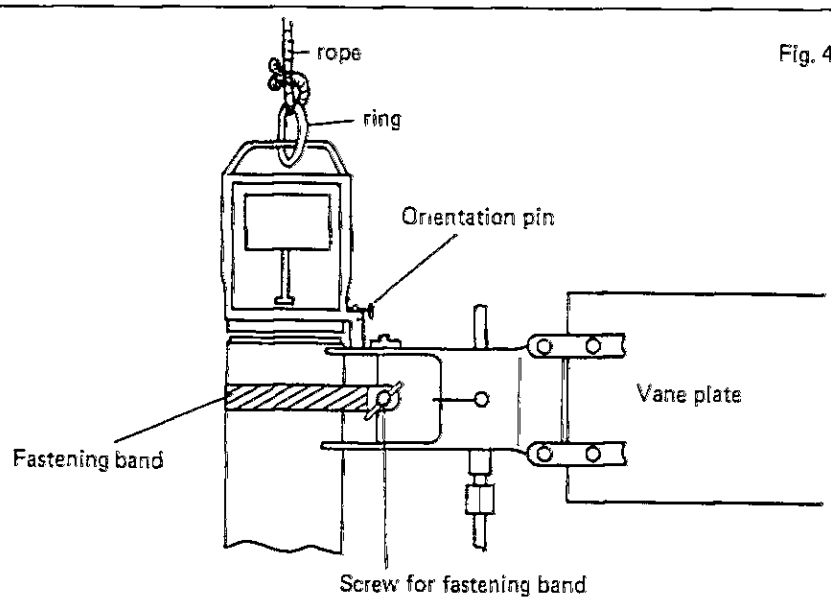
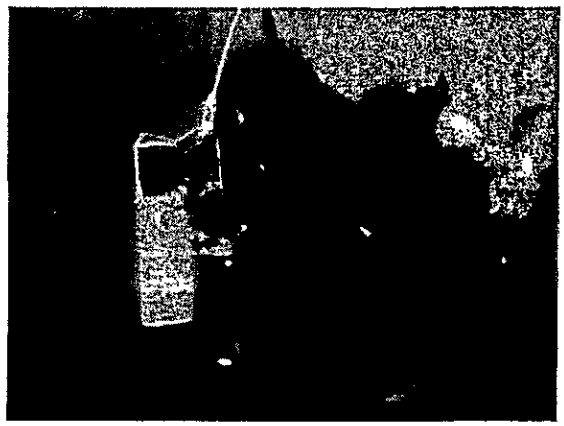
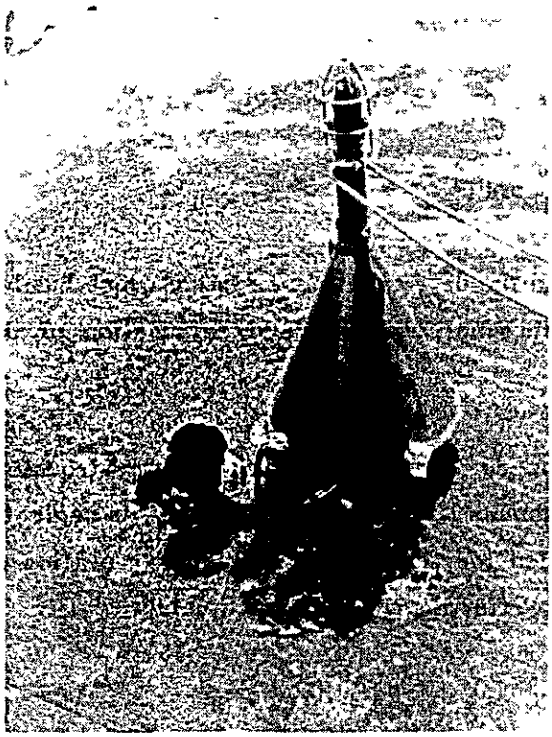


Fig. II-1-2-(15) Exchange method of magnetic tape (withdrawal of recording unit) (3/3)

(Collection of recording unit on boat)



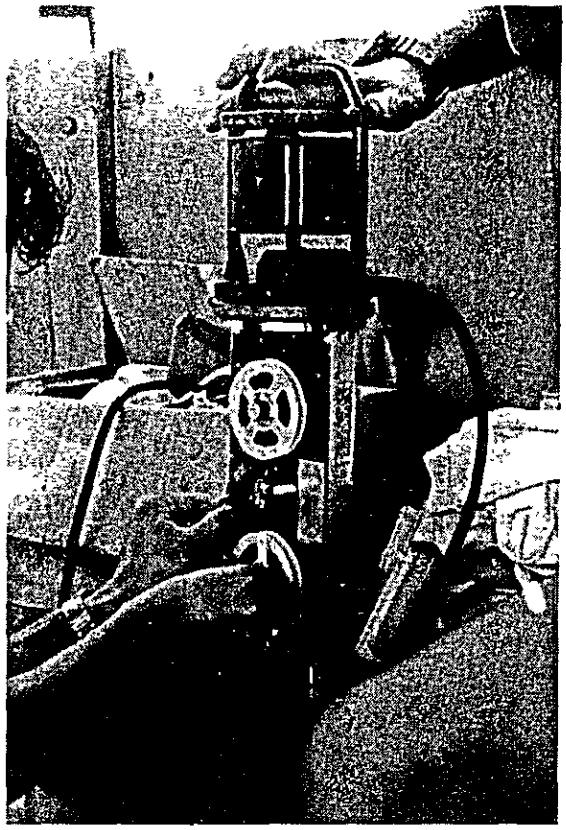
Releasing recording unit from current meter



Checking of Zeni-light Buoy

Replacing recording unit to original position

Fig. II-1-2-(16)



Detaching work of spool

Removal of recording unit clamp

Fig. II-1-2-(17) Data collection on survey vessel

4) Checking and confirmation of data recording

The collected data have been put into the data treatment system which has been installed in JTC office for the purpose of checking and cofirmation of data recorded by the current meters.

This process is enable to change the current meter soon afte any trouble or accident in the function of the instruments is found. If this process is neglected, it may happen that the data recorded for the whole observation duration are found as the trouble-data or data-lack after the survey is completed.

The data treatment system is designed to convert the magnetic tape's signal directly into the data. The system is composed by (i) the tape reader, (ii) the mini-computer for data calculation and (iii) the data printer together with the paper puncher. It is operated by A/C currency. Fig. II-1-2-(18) shows the composition of the data treatment system.

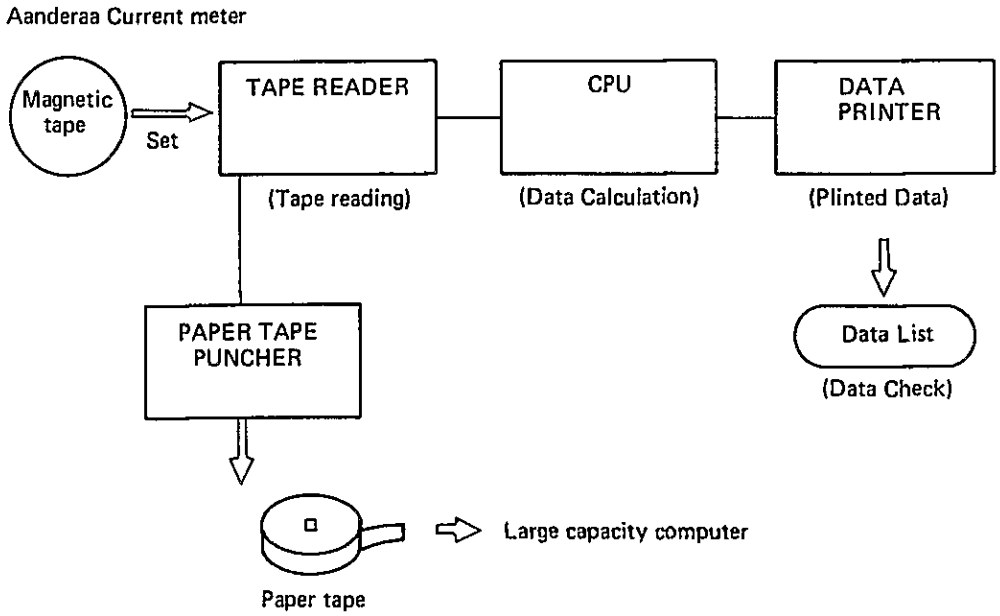


Fig. II-1-2-(18) Composition of data treatment system

Fig. II-1-2-(19) shows the picture when the data processing system is under operation.

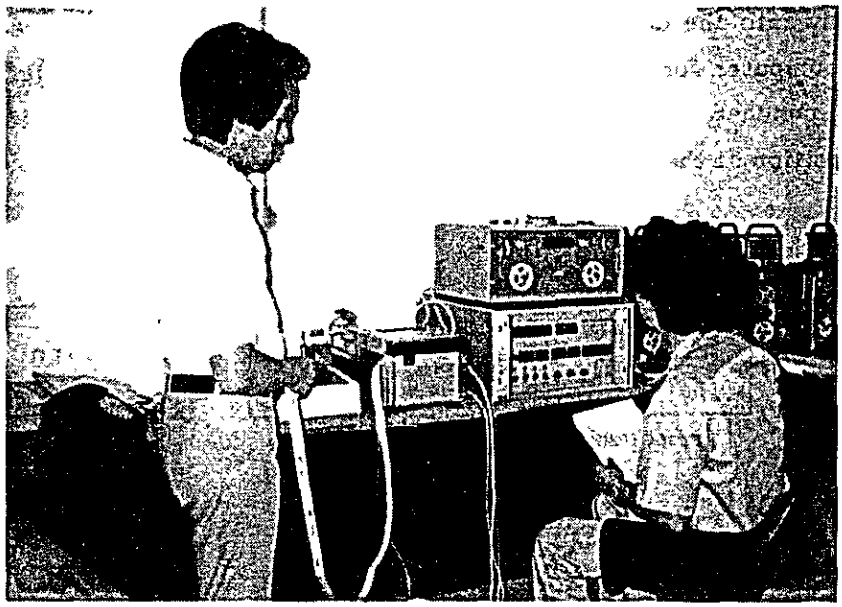


Fig. II-1-2-(19) Data processing system under operation

Table II-1-2-(14) shows the data list printed out from the data printer. The data are checked by this list.

Table II-1-2-(14) An example of data list

R. NO	DATE TIME M D H M	TEMP. C	COND. mmhos	SAL. ppt	DEPTH m	DIR DEG	SPEED cm/s	N cm/s	E cm/s
341	02, 29, 16 : 40	18.4	53.44	41.08	0.0	314	28.4	19.5	−20.6
341	02, 29, 16 : 45	18.4	53.27	40.90	0.0	310	29.5	19.0	−22.6
341	02, 29, 16 : 50	18.4	53.59	41.21	0.0	310	31.2	20.0	−23.9
341	02, 29, 16 : 55	18.4	53.59	41.18	0.0	309	31.2	19.8	−24.1
341	02, 29, 17 : 00	18.4	53.66	41.27	0.0	310	31.2	20.2	−23.8
341	02, 29, 17 : 05	18.4	53.66	41.27	0.0	306	31.7	18.7	−25.6
341	02, 29, 17 : 10	18.4	53.66	41.24	0.0	310	31.7	20.4	−24.3
341	02, 29, 17 : 15	18.4	53.81	41.40	0.0	308	32.9	20.0	−26.0
341	02, 29, 17 : 20	18.4	53.74	41.31	0.0	308	29.5	18.1	−23.3
341	02, 29, 17 : 25	18.5	53.74	41.25	0.0	311	32.9	21.7	−24.6
341	02, 29, 17 : 30	18.4	53.81	41.34	0.0	310	33.4	21.3	−25.7
341	02, 29, 17 : 35	18.5	53.81	41.31	0.0	309	35.1	21.9	−27.4
341	02, 29, 17 : 40	18.4	53.74	41.33	0.0	309	37.3	23.3	−29.2
341	02, 29, 17 : 45	18.4	53.74	41.36	0.0	313	40.1	27.3	−29.4
341	02, 29, 17 : 50	18.4	53.81	41.37	0.0	308	42.4	25.8	−33.6
341	02, 29, 17 : 55	18.4	53.81	41.42	0.0	308	41.8	25.5	−33.1
341	02, 29, 18 : 00	18.4	53.88	41.46	0.0	307	45.2	26.9	−36.3
341	02, 29, 18 : 05	18.4	53.88	41.46	0.0	307	44.1	26.4	−35.2

II-1-2-4 Instruments

The specifications of the instruments used in this study are described and those pictures are also shown.

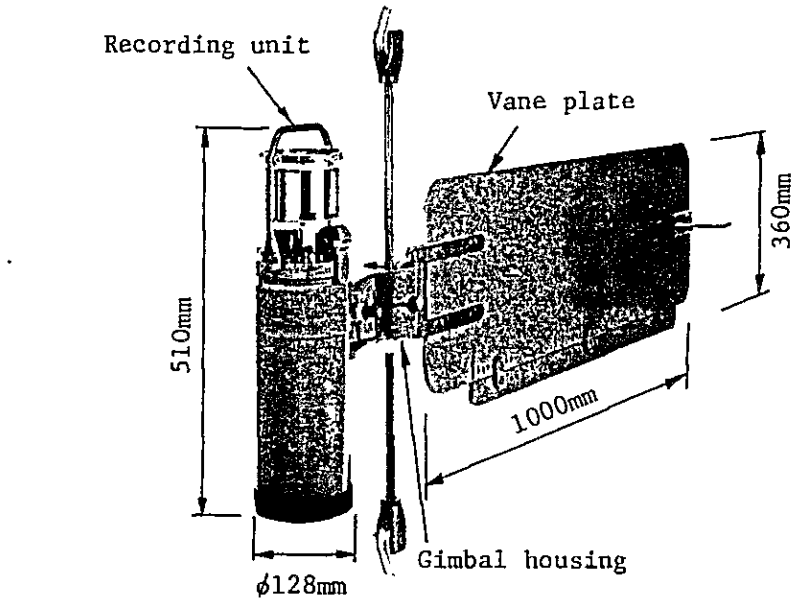
1) Specifications of AANDERAA current meter

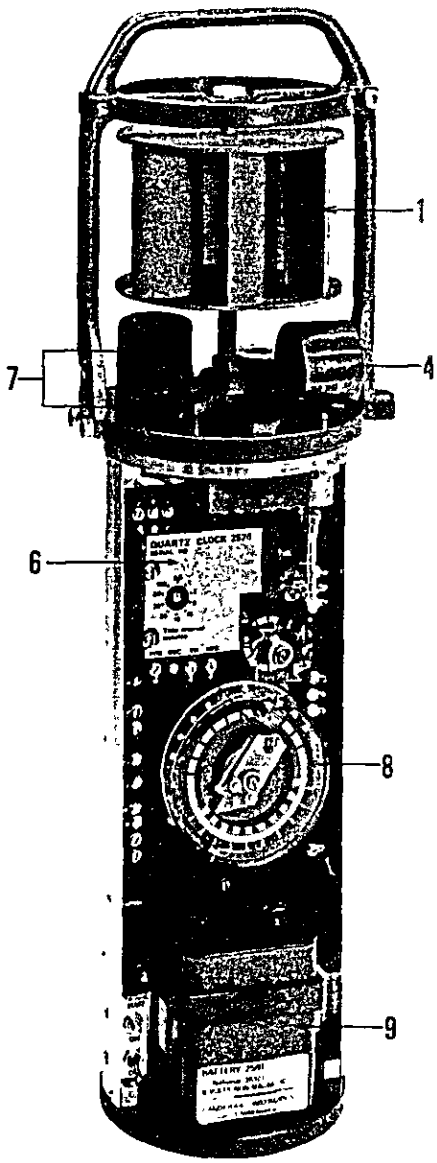
AANDERRAA current meter is the continuous monitoring and self-recording current meter, and it is composed by a recording unit and a vane plate.

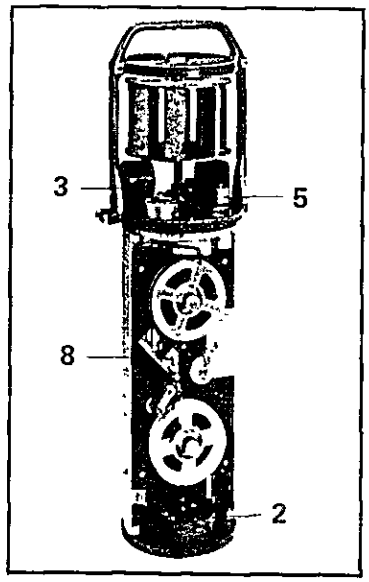
At the upper part of the recording unit, the savonius rotor type current velocity sensor, the thermo-sensor for water temperature, the conductivity sensor, the pressure sensor, the acoustic transducer, and the electrical terminal are installed.

In the pressure case, the transmission system by rotor revolution counting circuit, the magnetic compass for the current direction, the control circuit, the clock, mangetic tapes and the power supply battery are installed.

Taking the characteristics of Singapore sea into consideration, the thermo-sensor for water temperature has been set at the high range of 10.08^{o} to 36.00^{o}C, the electro-conductivity sensor has been set at the standard range of 0 to 70 mmho/cm, and the measurment has been conducted by every 5 minute sampling intervals. (Fig. II-1-2-(20))







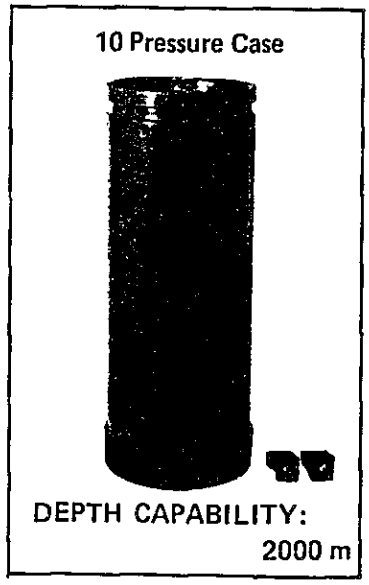


Fig. II-1-2-(20) Specification of Aanderaa current meter

1. CURRENT SPEED:

Principle: Rotor with magnetic coupling through instrument case. The number of rotations during the period between two samplings are counted by an electronic counter.
Range: 2.5 to 250 cm/sec.
Accuracy: ±1 cm/sec., or ±2% of the actual speed, whichever is greater.
Starting Velocity: 2.0 cm/sec.

2. CURRENT DIRECTION:

Sensor Type: Magnetic compass with needle on to potentiometer ring
Resolution: 0.35°
Accuracy:
±7.5° speed within 2.5 to 5 cm/sec., or 100 to 200 cm/sec.
∓5° speed within 5 to 100 cm/sec.
Maximum Compass Tilt: 12° from horizontal.

3. TEMPERATURE:

Sensor Type: Thermistor (Fenwal GB32JM19)
Range:
Low Range: −2.46°C to 21.48°C (standard).
High Range: 10.08°C to 36.04°C.
Wide Range: −0.34°C to 32.17°C.
Accuracy: ±0.15°C
Resolution: 0.1% of range selected.
63% Response Time: 12 seconds.

4. CONDUCTIVITY:

Sensor Type: Inductive cell.
Range: 0 to 70 mmho/cm., (standard).
22 to 64 mmho/cm.
Resolution: 0.1% of range.

5. PRESSURE: (optional)

Sensor Type: Bourdon tube driving a potentiometer.
Range: 0-100 PSI, 0-200 PSI, 0-500 PSI, 0-1000 PSI and 0-3000 PSI.
Accuracy: ±1% of range
Resolution: 0.1% of range.
Calibration: Lowest calibrated pressure 14.24 PSI.

6. CLOCK:

Type: Quartz Clock 2574.
Accuracy: Better than ±2 sec/day within 0°C to 20°C.
Sampling Intervals: 0.5, 1, 2, 5, 10, 15, 20, 30, 60 and 180 minutes, selected by interval selection switch.
External Triggering: For calibration purposes, a six volts positive pulse to terminal on top end plate will activate the instrument.

7. TELEMENTRY:

Acoustically:
By switching on and off carrier from acoustic transducer.
Frequency. 16,384 KHz ±5 Hz.
Detection Range: Typically 800 meters with Hydrophone Receiver 2247.
By Cable:
5 volts negative, short and long pulses from terminal on top end plate may be used for real time readings and for calibration purposes by use of Printer 2152.

8. RECORDING SYSTEM:

Type Reel to reel 1/4 inch magnetic tape
Coding: 10 bit binary words (short and long pulses) in serial form.
Storage Capacity: 10,000 samplings using 600 feet of magnetic tape on three inch reels.
Channels: 1ch Reference
2ch Temperature
3ch Conductivity
4ch Pressure
5ch Current direction
6ch Current speed

9. POWER:

Battery: 9 volts, non-magnetic.
Size: 63 x 50 x 80 mm
Capacity: suffichient for 10,000 samplings.

NET WEIGHT:

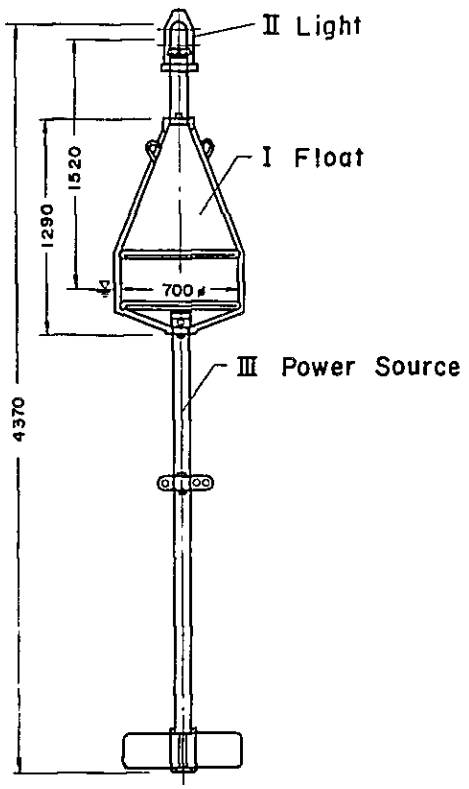
Recording Unit,	in air	13.7kg
	in water	9.2kg
Vane Assembly,	in air	12.9kg
	in water	8.1kg

2) Specifications of mooring system of current meter

The specifications of the materials used for mooring the current meter are shown in Table II-1-2-(15).

Table II-1-2-(15) Specifications of materials used for mooring Aanderaa current meter

Name of materials	Purpose	Remarks
(1) Light buoy (Zenilight buoy type)	Beacon light	Used only at TC1, 2, & 3 Refer to Fig. II-1-2-(21)
(2) Wire rope and cremone rope	Mooring rope	Used at all points Refer to Fig. II-1-2-(22)
(3) Chain and Sinker	Weight for mooring	Used at all points Refer to Fig. II-1-2-(23)
(4) Schackle	Clasp	Used at all points Used both hammer type and standard type Refer to Fig. II-1-2-(24)
(5) Swivel	Anti-twist	Used at all points Refer to Fig. II-1-2-(24)
(6) Buoy (subsurface) mooring	Mooring the current meters	Used at all points Refer to Fig. II-1-2-(25)

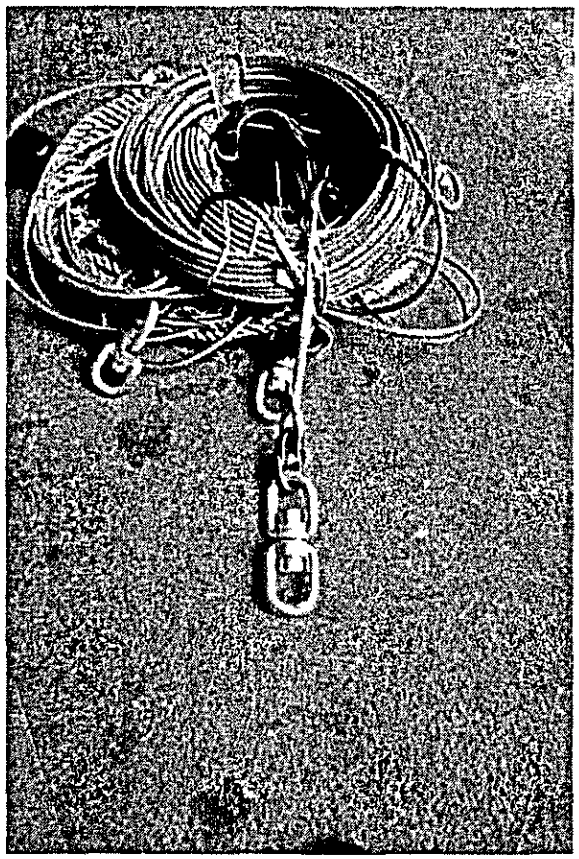


LIGHT BUOY
(ZENI LITE BUOY TYPE 3)

■ SPECIFICATIONS:

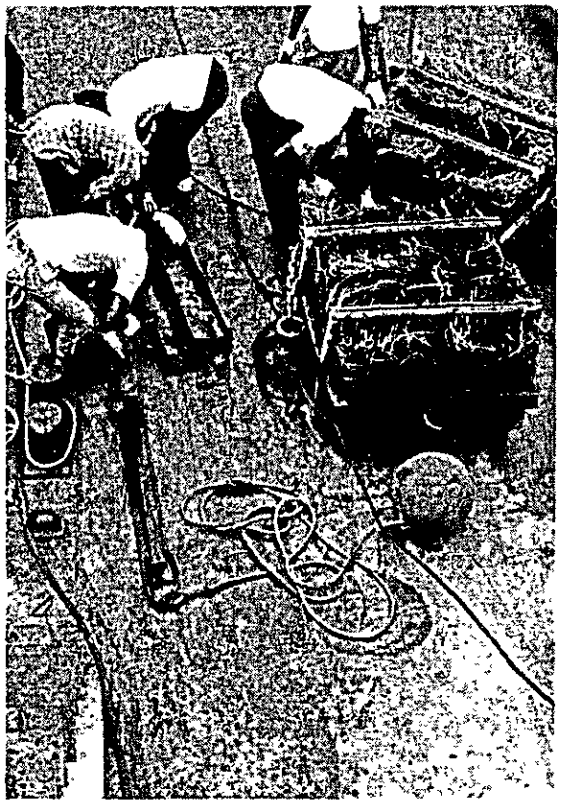
I	Float Diameter	70 cm dia.
	Overall Length	4.39 m
	Focal Plane Height	1.52 m
	Total Weight	100 kgs.
	Total Buoyancy	310 kgs.
	Pain Material	Anti-corrosive aluminum alloy (JIS A5052) Polyurethane foam filled
	allowable Current	3 knots
II	Lantern	72 mm Lerns, Marine Lantern ZL-72
	Bulb	6V, 3W (Shock Proof Type)
	Luminous Intensity	13 cd (72 mm clear lens)
	Range	2.5 mm (T = 0.74, 72 mm clear lens)
	Light Character	1 flash every 2 seconds
III	Power Source	80 pcs. of UM-1D, Double Folded Polycarbonate Case
	Service Period	4 months

Fig. II-1-2-(21) Light buoy and its specifications

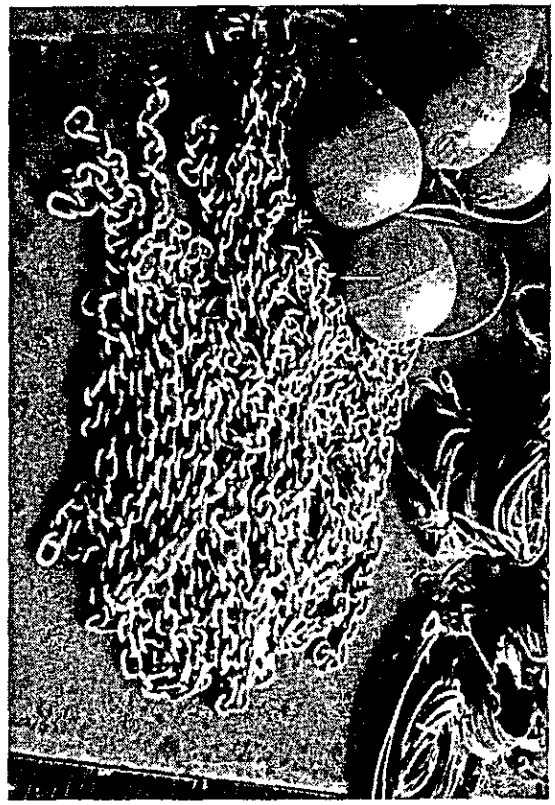


Wire Rope with Hammerlok type shackle and Swivel

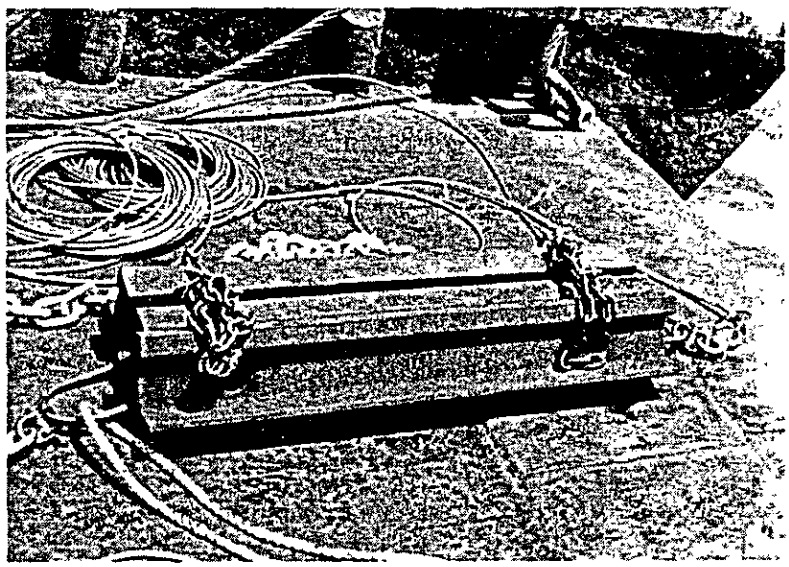
Fig. II-1-2-(22) Wire rope



Sinker (large type)



Chain



Sinker (small type)

Fig. II-1-2-(23) Chain and sinkers

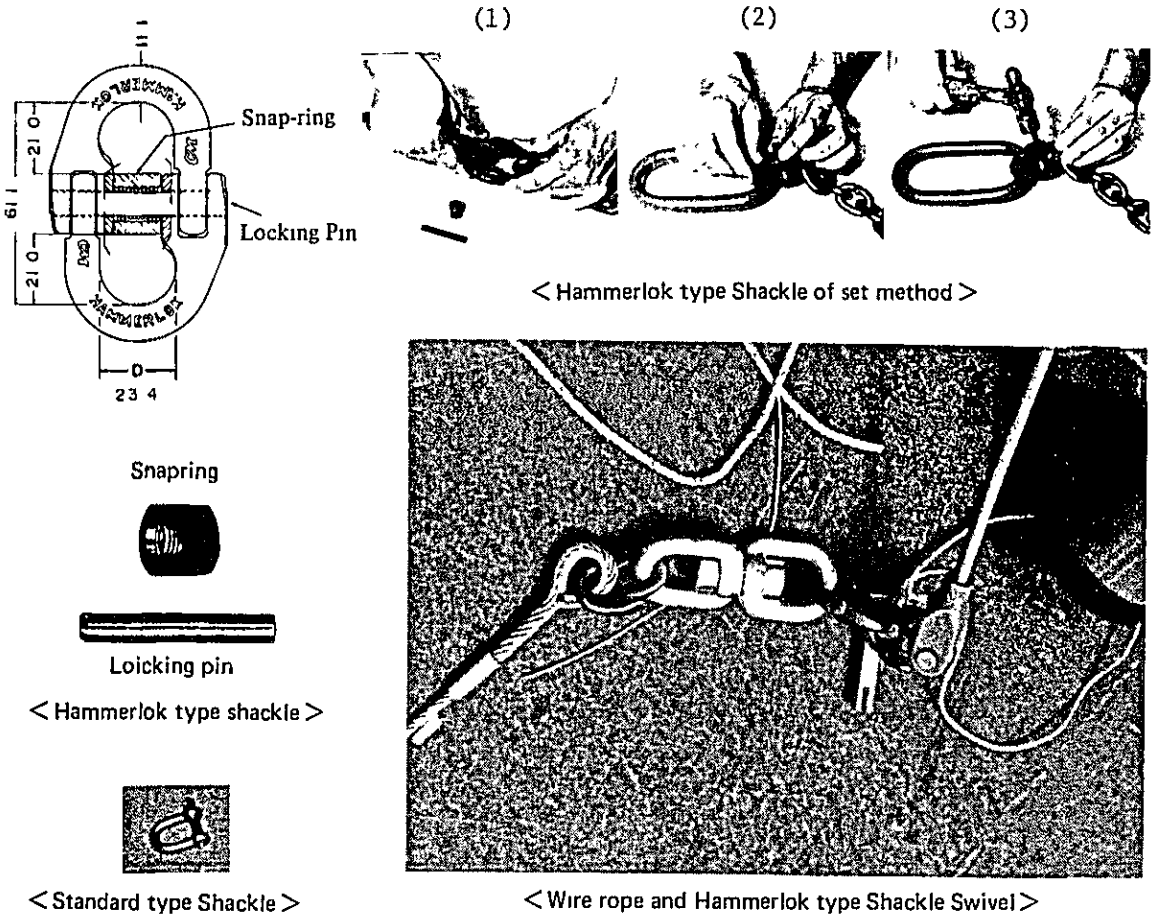


Fig. II-1-2-(24) Shacle and swievel

Fig. II-1-2-(25) Mooring buoys

3) Specifications of other instruments

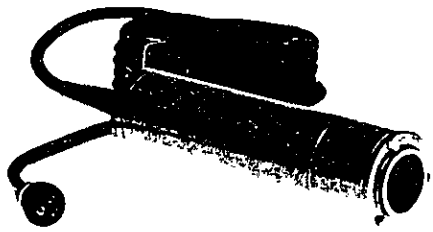
a) Monitor-system (hydrophone receiver, deck unit, and printer)

The hydrophone receiver, deck unit and printer are the monitor-instruments of AANDERAA current meter. At patrol of measuring points, the hydrophone receiver is dropped into the sea for receiving the signals transmitted from the transducer of the current meter which is transformed in the deck-unit as the measuring values.

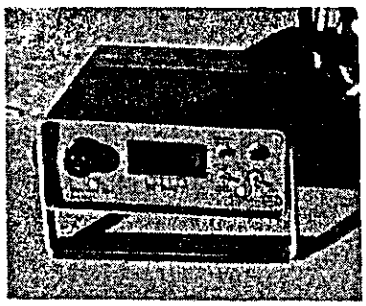
Before setting the current meter, the current meter is connected with the printer by wire for confirmation of operational status. Fig. II-1-2-(26) shows the monitor system and specifications.

SPECIFICATIONS

HYDROPHONE RECEIVER 2247

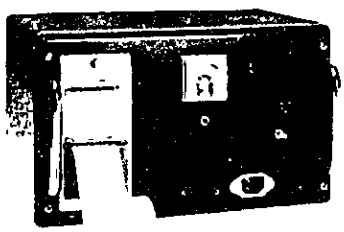


Detection Range:	Typically 800 meters
Operating Frequency:	16,384 Hz
Supply Voltage:	6 to 9 volts, supplied from Printer 2152 or Deck Unit 2675
Current Consumption:	3 mA
Operating Temperature:	-10°C to +40°C
Output Signal:	5 volts negative
Bandwidth:	200 Hz
Cable:	Three conductor, Neoprene cable
Cable Length.	25 meters
Plug:	Belling Lee L 1349 FS
Weight: (with 25 meter cable)	5.3 kilograms



DECK UNIT 2675

Supply Voltage:	9 volts battery, Part Not. 2591 or equivalent
Current Consumption:	8 mA maximum (will vary according to amount of data displayed)
Operating Temperature:	-10°C to + 40°C
Input Signal:	10 bit binary code, 5 volts negative
Receptacle:	Belling Lee L 1349 CP
Weight:	1.8 kilograms



PRINTER 2152

Fig. II-1-2-(26) Monitor system and specifications

b) Data treatment system (tape reader, tape puncher and printer)

The tape reader, tape puncher and printer are the instruments to treat the data at the field survey site. For the checking of data recording, the collected magnetic tapes are put into the tape reader which transmit the calculated values to the printer. For further detailed analysis, the tape reader and the tape puncher are connected for producing the punched paper tapes which will be processed later by large capacity computers. Fig. II-1-2-(27) shows the data treatment system.

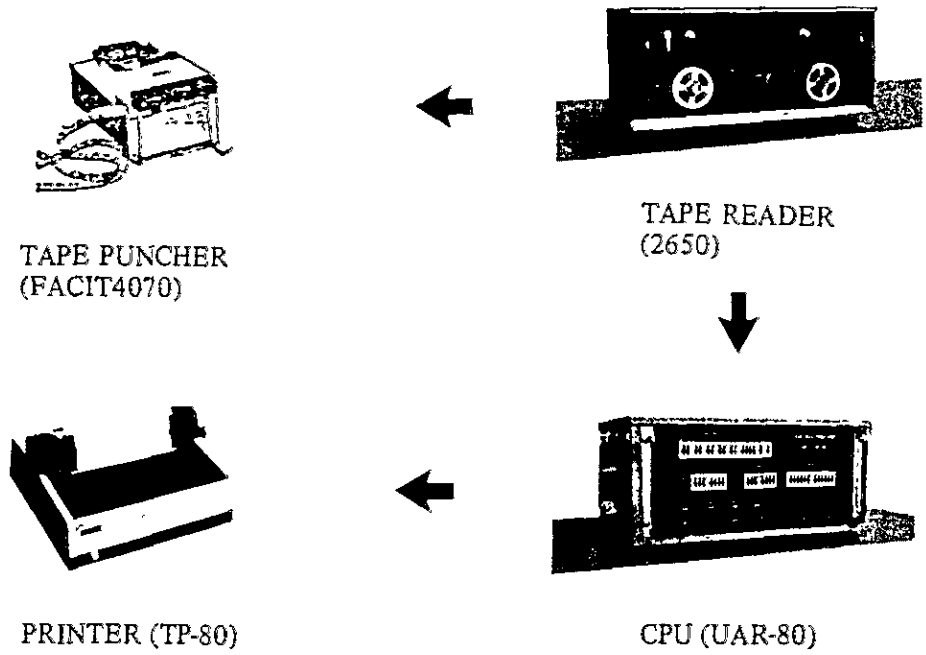


Fig. II-1-2-(27) Data treatment system

II-1-3 Collecting Current Survey Data Conducted by Other Organizations at Singapore Sea Areas

Prior to the field survey, the past current survey conducted by other organizations and authorities have been investigated and two reports have been obtained as under.

(1) The current survey conducted by Singapore side at the construction of petrochemical plant on one of the southern islands and (2) the survey jointly conducted by Singapore, Indonesia, Malysia and Japan. These data have been analysed and commented in comparison with the field survey conducted in this study. The results of analysis are described in the later paragraph.

The reports obtained are:

(1) Report on Boring and Survey for Petrochemical Complex at Pulau Ayer Merbau of Singapore for Petrochemical Corporation of Singapore, October 1979

(2) Report on Joint Production of Common Datum Charts of the Straits of Malacca and Singapore.

II-1-4 Analysis of Data

II-1-4-1 On analysis of data

The measured data on current direction, current velocity, water temperature and salinity obtained through the field survey are processed into A/D conversion and analysed by the large capacity computers for finding the characteristics of every data.

The results of analysis are used as the materials to show the present current conditions of the proposed sea areas and are put into computers for the reproduction of the present current conditions.

The past survey data, in other hand, supplied by Singapore side are also put into computers as a part of materials of the present current conditions and used as the reference materials for the future assessment.

The methods and processes of the data analysis are described in this paragraph. Fig. II-1-4-(1) shows the process of data analysis.

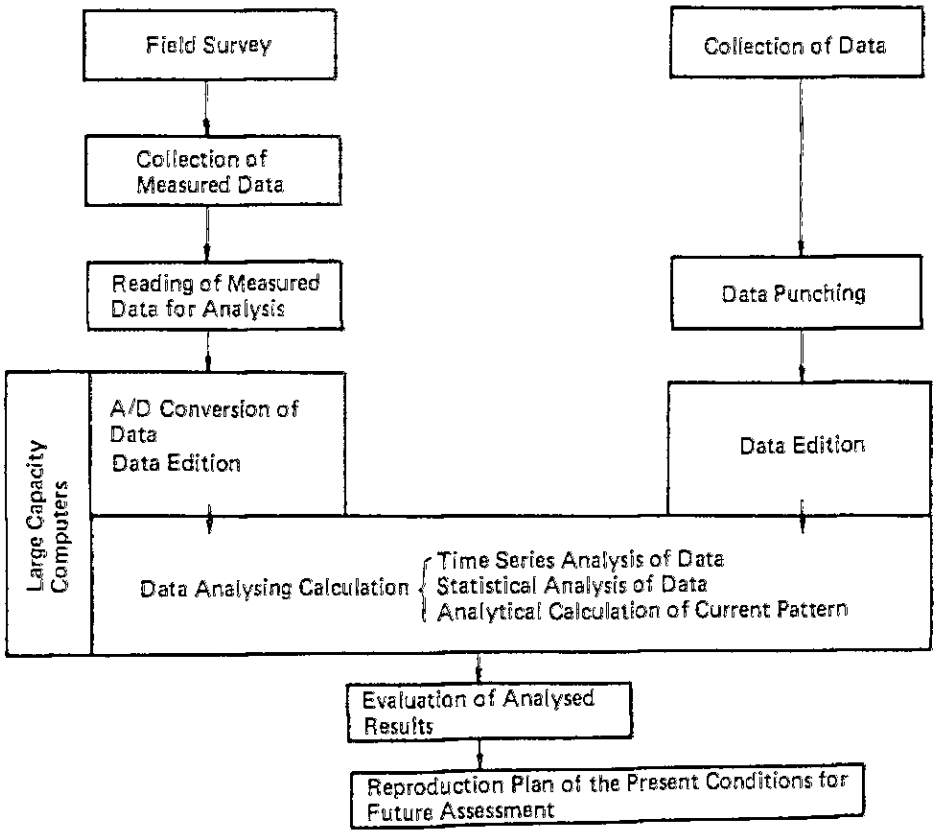


Fig. II-1-4-(1) Process of data analysis

II-1-4-2 Analysis of field survey data

The recorded data by the current meters through the field survey are processed by the tape reader and converted into numerical data. The numerical data are edited after necessary amendment or supplement, and with analytical calculation, the data of the present current conditions of the survey aras are obtained.

Fig. II-1-4-(2) shows the flow of data analysis. The analysis is carried out according to the process shown in flowchart.

(1) Collection of recorded data
(2) Reading of measured data
(3) A/D conversion and edition of data
(4) Time series analytical calculation
(5) Statistic analysis calculation
(6) Analytical calculation of current pattern

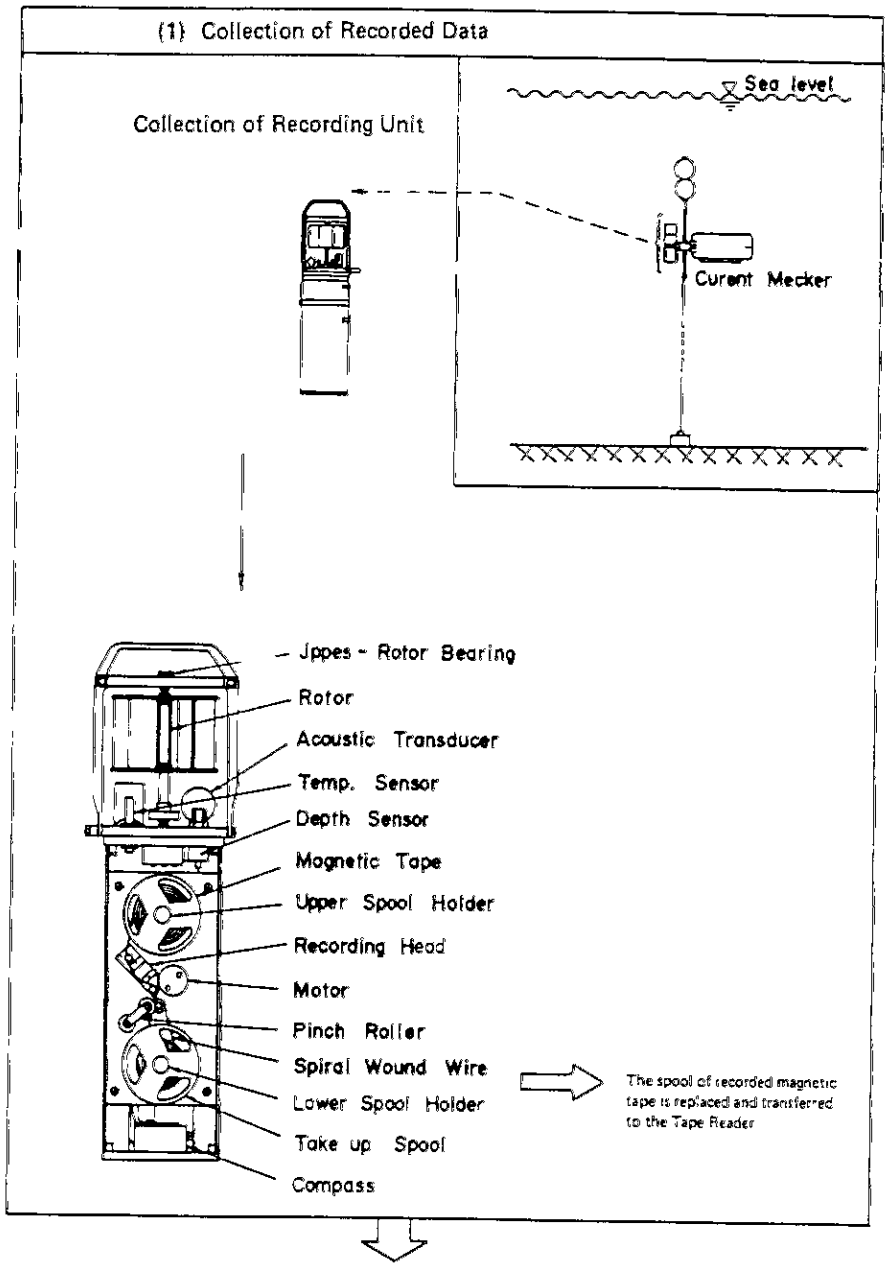


Fig. II-1-4-(2) Flowchart of data analysis (1/4)

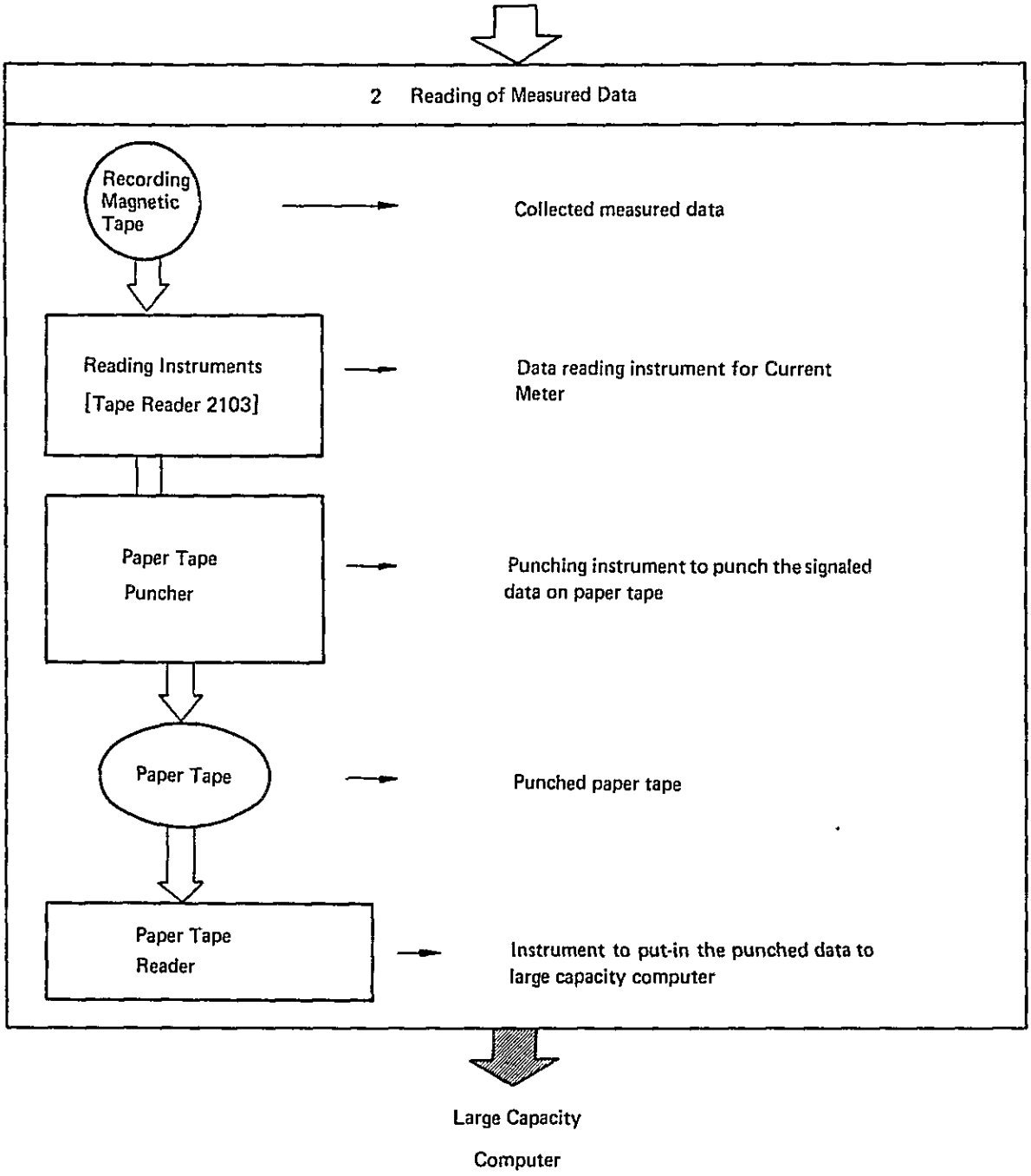


Fig. II-1-4-(2) Flowchart of data analysis (2/4)

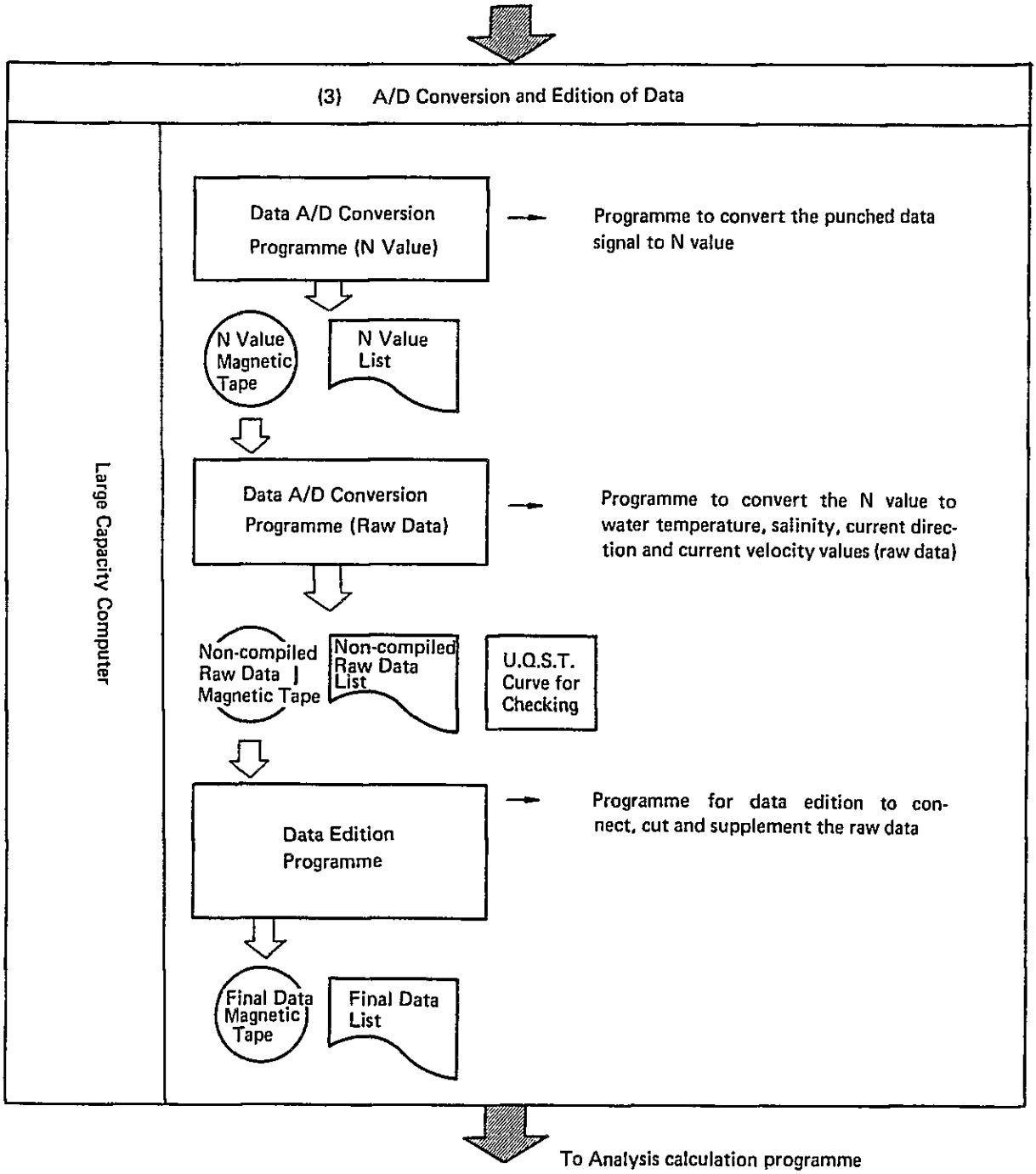


Fig. II-1-4-(2) Flowchart of data analysis (3/4)

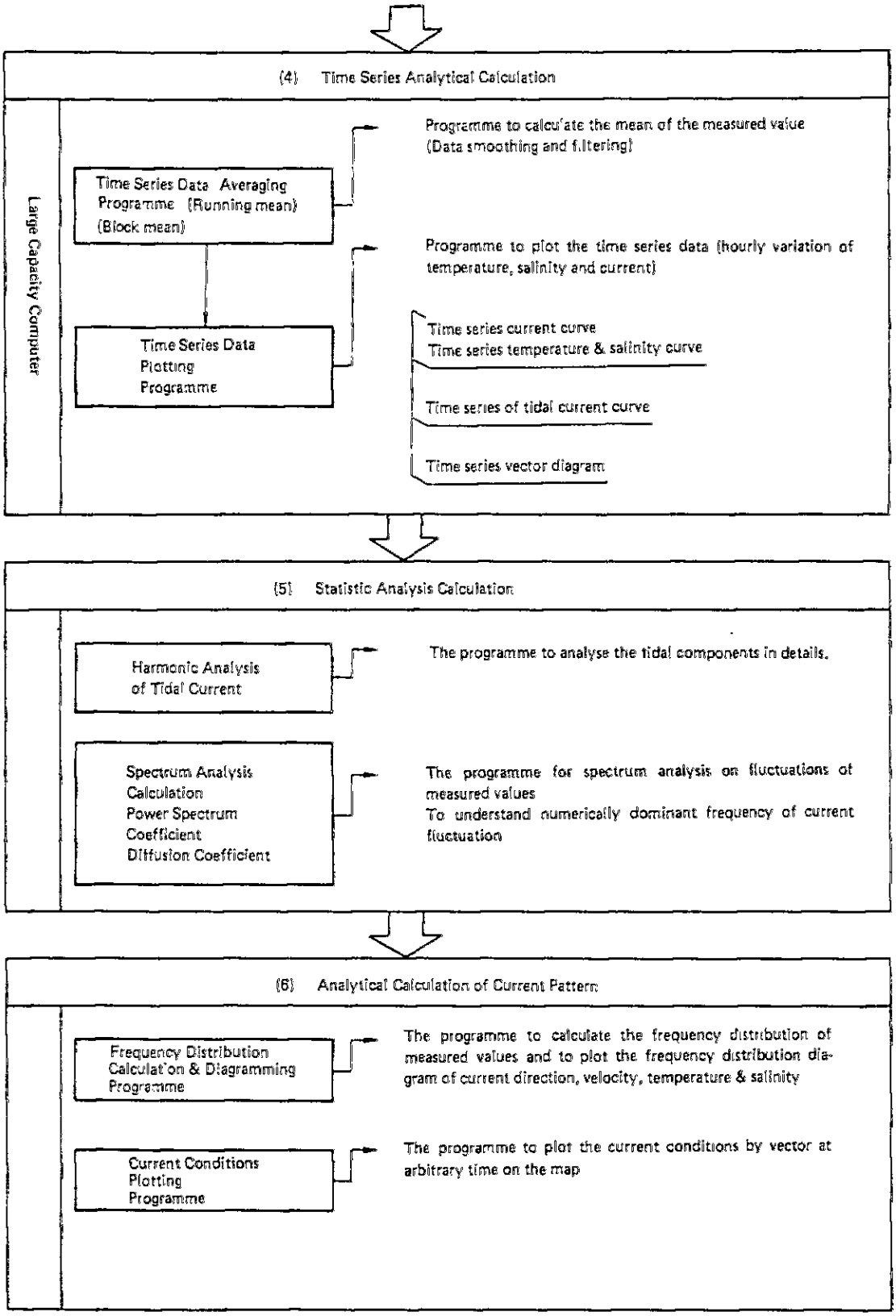


Fig. II-1-4-(2) Flowchart of data analysis (4/4)

II-1-4-3 Analysis of past survey data

The collected data of the past survey have been selected and arranged together with other data of tide survey and meteorological survey.

The analytical methods of data are shown in Fig. II-1-4-(1) of the last paragraph and the data are put into computer after punched on the card.

These data have been treated by the same analysis program with the field survey data in this study. This is for observing these two results of analysis on the same view point.

The tide and tidal current survey of the Straits of Malacca and Singapore are found that the data had been processed by the same analytical methods and so further analysis has not been conducted. Table II-1-4-(1) shows the contents of punched data.

Table II-1-4-(1) List of punched data

	Survey items	Survey point	Layers	Period
(1)	Current survey conducted by Singapore side	St 1 - St 5	-3 m	Aug. 7 to 25, 1979
(2)	Tide survey	Slave One	-	Feb. 23 to Mar. 17, 1981
		Jurong Wharf		Feb. 23 to Mar. 17, 1981
	Predicted tide	Victoria Dock		Feb. 1 to Mar. 31, 1981
		Jurong Wharf		Feb. 1 to Mar. 31, 1981
(3)	Meteorological survey	Changi Air Base		Feb. 23 to Mar. 17, 1981
		JTC Flatted Factory (Jurong)		Feb. 23 to Mar. 17, 1981

II-1-5 The Results of Analysis of Field Survey Data

II-1-5-1 Collection of recorded data

The sensor of the current meters commence measuring of 6 factors, which are reference, temperature, conductivity, pressure, direction and velocity from channel 1 to 6 respectively as shown in Table II-1-5-(1), when the switch installed in the recording unit is turned on.

The values of channel 1, referece, are the identification of the respective current meters. (In this study, the pressure sensor is not installed.)

Table II-1-5-(1) The sensors of current meter

Ch.	Factors	Sensor	Range
1.	Reference	Fixed resistance	------
2.	Temperature	Thermistor	W -0.34 - 32.17°C L -2.46 - 21.48°C H 10.08 - 36.04°C
3.	Conductivity	Magnetic induction cell	Standard 0 to 70 mmho/cm High sensitivity 22 to 64 mmho/cm
4.	Pressure	Burdon tube	RCM - 4:0 - 3000 PSI RCM - 5:0 - 8000 PSI
5.	Current direction	Magnetic compass	0 to 360°C
6.	Current velocity	Rotar and rotar counter	2.5 to 250 cm/sec

Measured values of 6 factors are converted by rotary encorder installed in the current meter into digit signals of two characters for each 10 bit binary words.

The magnetic tapes are ¼ inches open reel type. (Hereinafter referred to as "Rec.MT") In this study, the current meters have been set at the time interval of 5 minutes and so the measured data are recorded every 5 minutes from channel 1 to 6 in order and one recording process is completed with the sync pulse at its final stage. An example of recording format of Rec.MT is shown in Fig. II-1-5-(1).

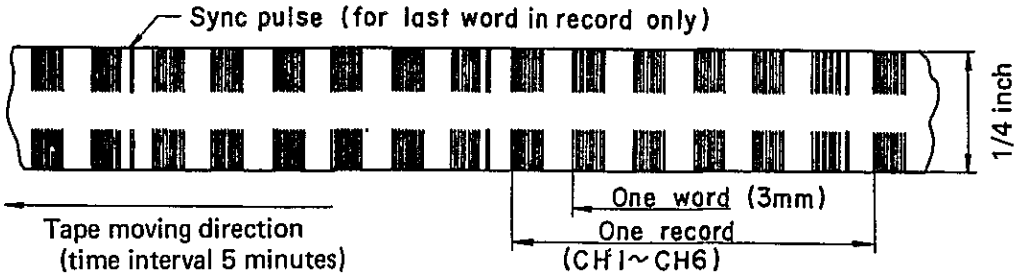


Fig. II-1-5-(1) Recording format

The collection of measured data is conducted at the survey areas by releasing recordng unit of the current meter from the mooring system and taking off the spool from the recoring unit.

II-1-5-2 Reading of recorded data

Collected spools are set in the Tape Reader for reading the signaled values and are punched on the paper tape by Paper Tape Puncher. From this process, the recordig and measurement status are confirmed and checked.

The reason to convert the Rec.MT to the paper tape is for the use of large capacity computers and the data punched on the paper tape are input into the large capacity computers through the paper tape reader.

The paper tape used in this study is 8 channel punched paper tape, code FFI-PS, of 25 mm wide.

On the paper tape, as shown in Fig. II-1-5-(2), the data are punched by binary scale values from channel 1 to channel 6 in order.

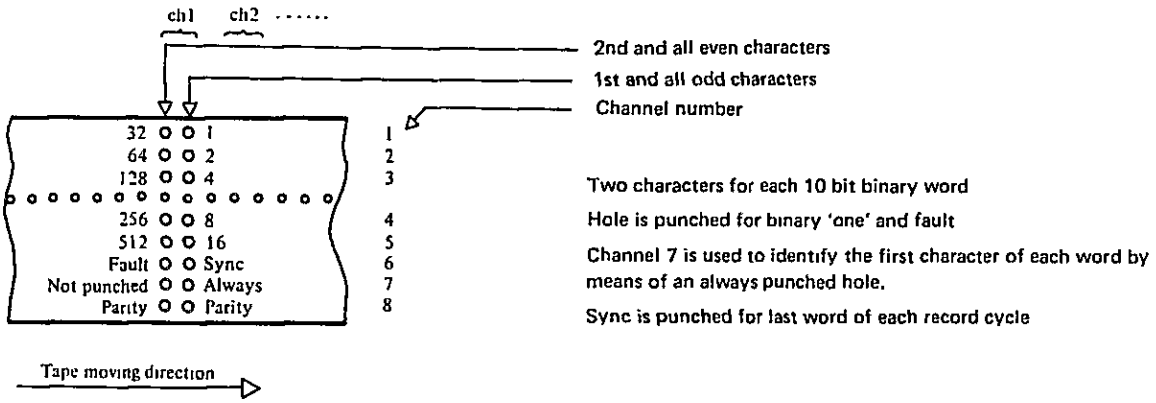


Fig. II-1-5-(2) Punched paper tape format

Fig II-1-5-(3) shows Tape Reader 2103 and Paper Tape Puncher. The collected spool taped up with data is set at the right side of the front pannel of Tape Reader and rolled to the vacant spool of the left side and after such process, Rec.MT is transferred to the vacant spool of the right side for reading and simultaneously the tape puncher commence operating and punched tape is produced.

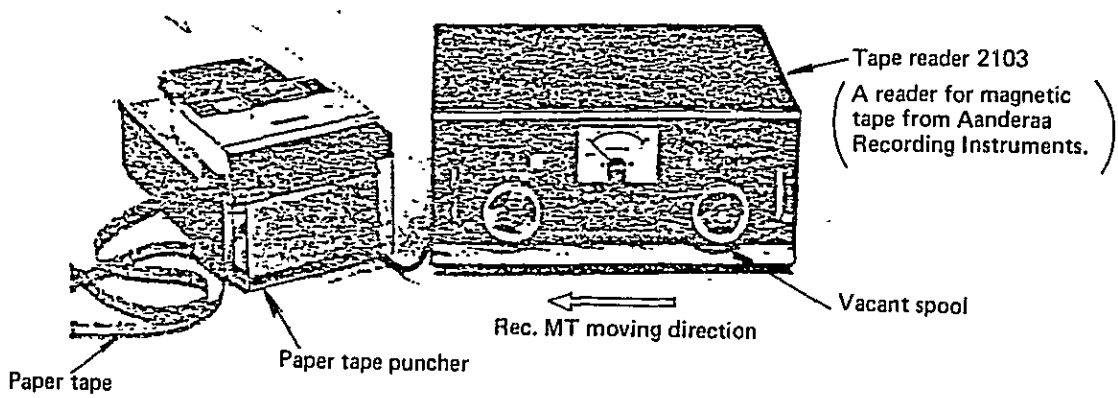


Fig. II-1-5-(3) Tape Reader and Paper Tape Puncher

II-1-5-3 A/D conversion and edition of data

The measured values input in the large capacity computers through Paper Tape Reader are calculated and A/D converted. The converted data include at this stage the error data and missing data (for example, data is missing for the time period of collecting tapes of current meter on board) and in order to avoid any influence on the accuracy of statistical analysis of data, the edition works are conducted to cut the error data, to connect and supplement the data.

After finally checked, the edited data are transferred to the statistical analysing calculation.

A/D conversion of data is divided in 2 processes. The first step is to convert the data recorded in paper tape (binary scale value) to decimal values. The decimal values are called as 'N Value' which are the initial values not converted to the values of current direction and velocity. At this step, the data list and magnetic tapes of N Values are produced, from which the second stage checking is conducted. A part of N Values list is shown in Table II-1-5-(2). The values mentioned in this list show the data of TC-1 measured at every 5 minutes during 11:50 to 12:05 hour of the 26th February 1981.

The vlaues mentioned in this list are the values not converted and those are still not in a position to be employed for calculation.

Table II-1-5-(2) Measured values of each channel by N Value

Ch 1 (reference)	Ch 2 (temperature)	Ch 3 (conductivity)	Ch 4 (pressure)	Ch 5 (direction)	Ch 6 (velocity)
11:50 210	752	695	1023	932	47
11:55 210	752	695	1023	929	49
12:00 210	752	695	1023	928	49
12:05 210	752	695	1023	928	51

The second step is to convert N Values to the values of temperature, conductivity, current direction and velocity by the corresponding conversion equations respectively.

Through this process, the converted values of temperature, conductivity, salinity, current direction, velocity, North-component and East-component of each measuring point are obtained.

Among these data, the value of salinity is calculated from the value of conductivity. The North-component and East-component are obtained by calculating from the values of current direction and velocity. An example of above mentioned data is shown in Table II-1-5-(3) as the Result from AANDERAA Recoirding Meters Model 4.

This table is based on the data obtained at TC1 during 11:00 to 13:00 hour of the 26th February 1981. And from this table, it can be confirmed that the current meter has been set for operation in the sea water at the time between 11:45 to 11:50.

Table II-1-5-(3) Final data list

*** RESULTS FROM AANDERAA RECORDING METERS MODEL 4 ***

AREA : SINGAPORE
ST. : TC1 LAYER : 0.5M
MAG.N : 0.
LAT. : 1. 25.0 N LONG. : 104. 0.1 E
INSTRUMENT SERIAL NO. : 2854
SAMPLING INTERVAL : 5 MIN
SERIES BEGIN : 1981 Y 2 M 26 D 8 H 0 MIN

Reference,	Date, M D	Time, H M	Water Temperature °C	Conductivity, MMHOS	Salinity, PPT	Direction, DEG	Velocity, CM/S	North Component, CM/S	East Component CM/S
209	2 26	11 0	29.1	-0.7	-0.61	206.	0.	0.	0.
209	2 26	11 5	29.2	-0.7	-0.61	206.	0.	0.	0.
209	2 26	11 10	29.2	-0.7	-0.61	205.	0.	0.	0.
209	2 26	11 15	29.3	-0.7	-0.61	205.	0.	0.	0.
209	2 26	11 20	29.3	-0.7	-0.61	206.	0.	0.	0.
209	2 26	11 25	29.4	-0.7	-0.60	206.	0.	0.	0.
209	2 26	11 30	30.2	-0.7	-0.60	294.	2.1	0.8	-1.9
209	2 26	11 35	31.7	-0.7	-0.59	351.	4.3	4.2	-0.7
209	2 26	11 40	33.6	-0.7	-0.58	349.	0.	0.	0.
753	2 26	11 45	28.6	(-)	(-)	(-)	(-)	(-)	(-)
210	2 26	11 50	30.4	52.2	30.59	327.	27.8	23.3	-15.2
210	2 26	11 55	30.4	52.2	30.59	326.	28.9	23.9	-16.3
210	2 26	12 0	30.4	52.2	30.59	325.	28.9	23.8	-16.4
210	2 26	12 5	30.4	52.2	30.64	325.	30.1	24.7	-17.1
210	2 26	12 10	30.4	52.2	30.64	323.	31.2	25.0	-18.0
210	2 26	12 15	30.4	52.2	30.64	326.	31.7	26.2	-17.9
210	2 26	12 20	30.4	52.2	30.64	327.	32.5	27.7	-17.7
210	2 26	12 25	30.4	52.2	30.64	323.	31.2	25.0	-18.6
210	2 26	12 30	30.4	52.2	30.59	325.	29.5	24.1	-17.1
210	2 26	12 35	30.4	52.2	30.64	326.	29.5	24.6	-16.5
210	2 26	12 40	30.4	52.2	30.64	329.	30.6	26.1	-16.0
210	2 26	12 45	30.4	52.3	30.69	328.	32.9	27.8	-17.5
210	2 26	12 50	30.4	52.3	30.71	326.	34.5	28.7	-19.3
210	2 26	12 55	30.3	52.3	30.73	333.	36.4	32.8	-16.7
210	2 26	13 0	30.3	52.3	30.75	335.	37.3	34.0	-15.5

Table Setting current meter