XVIII. SEAFLOOR MEASUREMENT OF BOTTOM MATERIAL AND INSTRUMENTAL COMBINATION

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Introduction

Experiment of in-place measurement on the engineering properties of sea bottom materials combined with bottom photography and sampling of a large quantity of manganese nodules was carried out at two stations for the purpose of obtaining data for the exploitation of deep sea mineral resources.

For the experiment a dragging vessel of seafloor instrument combination, called the SIC Mk-II, was constructed. It consists of in-place measurement apparatus for the cutting resistance of sediment, a still camera system, and bottom samplers arranged within a frame with sled for sliding over the bottom.

The in-place measurement apparatus was constituted with an electonic amplifier, magnetic tape recorder, and sensors for cutting resistance, dredging speed, vertical acceleration, and sound. The camera system consisted of a camera and strobo, each of which was contained in a glass sphere housing and was operated automatically. Samplers were a chain bag and small tube.

At one station, St. 407A, we succeeded in getting satisfactory results, but the experiment at another station, St. 433, was unsuccessful, due to electrical and mechanical troubles. Here, the apparatus and the results of the successful esperiment at St. 407A are described. Also, some comments are given about the practical test of the glass sphere housing in relation to the above experiment and about the practical use of the Boomerang corer which was first applied by the writers in the present cruise.

Seafloor instrument combination

Construction

The combination of instruments consisting of the following parts was arranged as shown in Figs. XVIII-1, 2; 1) towing wire rope, 2) camera and strobe, 3) framework and tube sampler, 4) amplifier and recorder, 5) timer, 6) transducer for cutting resistance, 7) cutting blade, 8) dredging speed transducer, and 9) chain bag.

The framework was designed to be 1.2 m wide, 1.0 m high, and 1.7 m long, and the chain bag of 1.0 m length. The 12 cm wide and 1.5 m long sleds were attached to the lower side of the framework. The SIC Mk-II weighed about a total 300 kg.

Amplifier and recorder

A small strain amplifier and an analog magnetic cassette data recorder were remodeled and combined within a vessel for the particular purpose of underwater use. They worked by a time switch and self-contained DC 12V battery, and were able to measure and record seven kinds of data including sound datum during 1.5 hours. They were contained in a water-and pressure-proof vessel which was made of NCM-steel with dimensions of 32 cm dia. and 62 cm length and a weight of 80 kg. The vessel was

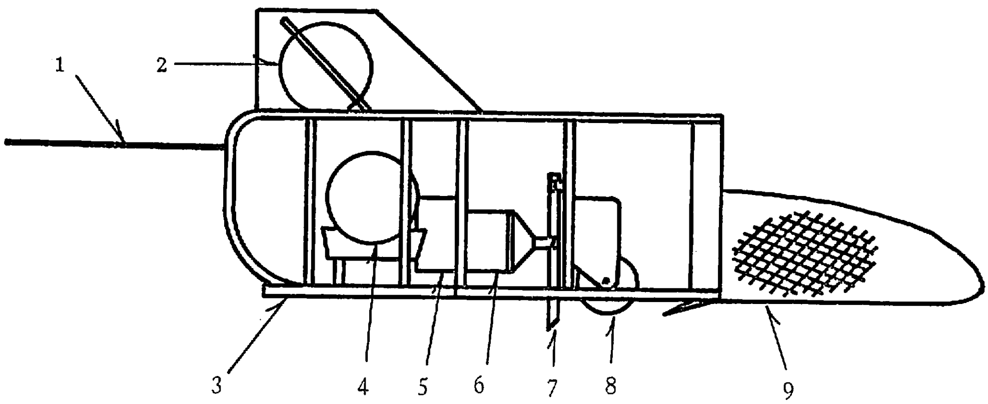

Fig. XVIII-1 Construction of the SIC Mk-II. Explanation for each part shown by a numeral is given in the text.

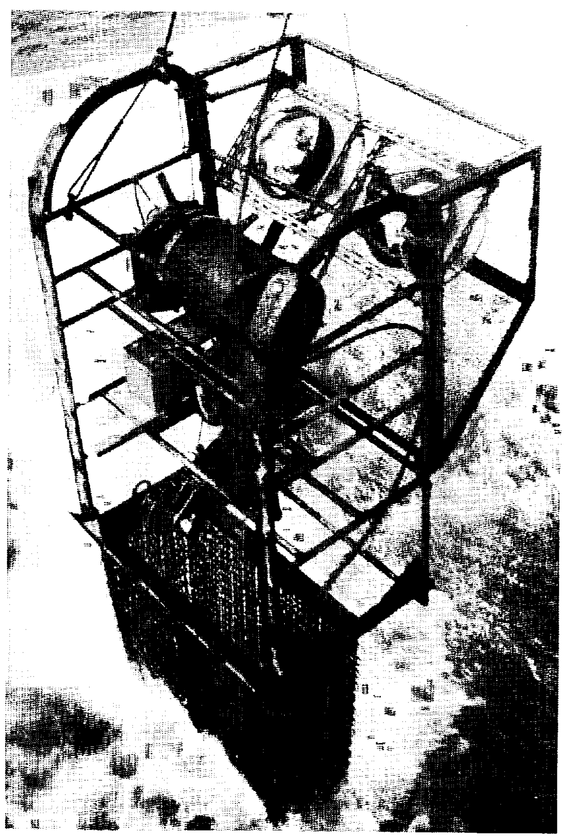

Fig. XVIII-2 The SIC Mk-II just pulled up from the sea surface.

designed to withstand an outer pressure of up to 600 kg/cm^2. The recorded data were reproduced after recovery and connected into a reproducing unit.

Sensors

The cutting resistance sensor consisted of a transducer and cutting blades. The transducer was a strain gauge type load cell (100 kg) contained in the insulated oil filled vessel which was sealed with a flexible rubber plate on the back side in order to buffer water pressure influence. Two cutting blades of different width were used, because the sediment strength would be defined by measuring the cutting resistances on two different blades. They were 5 and 10 cm wide each and 10 cm deep, and were supported by levers through which the cutting resistance was transmitted to the transducer at the middle point.

The dredging speed sensor consisted of a microswitch and a wheel. The microswitch was contained in an insulated oil filled capsule sealed with a rubber plate at the side. The wheel had many vanes between the two radial disks and the wheel shaft had a cam at the end in the capsule. The diameter of the wheel was 20 cm and the wheel jutted out 2 cm from the sled plane. The microswitch produced one pulse signal per rotation of the wheel and the signal was recorded on the magnetic tape.

A small strain gauge type acceleration meter was rigged in the amplifier-recorder vessel in order to analyze the behavior of the apparatus during descending and dragging on sea bottom. A microphone was also set up in the vessel.

Still camera system

The camera system, consisting of an automatic camera with control circuit and electronic light source, were used for sea floor observation. The prototype of the present system was developed by the Japan Marine Science and Technology Center (JAMSTEC) and the second model was assembled by the authors for this study.

The automatic camera assembly is composed of a combination of a single lens reflex 35 mm camera, Olympus OM-1 MD, with a f=24 mm wide angle lens, motor drive gears, 250 exposure film magazine, control circuit, small speed light, and batteries. They were fixed on an acrylic base plate in a pressure proof glass housing (Fig. XVIII-3). In another glass housing a powerful electronic speed light with remote synchronizing sensor and batteries were installed in the same way (Fig. XVIII-4). For the simultaneous working of both instruments in two housings, an optical path was used only.

The control circuit using ICs was given the following three functions; 1) starting the camera system on a delay time from 35 minutes to 3 hours, 2) regulating the time interval of shot from 8 seconds to 90 seconds, and 3) stopping the camera system working on a time delay after starting from 10 minutes to 2 hours and 40 minutes. The intensity of the main light source was variable up to GN 40 in meter scale for ASA 100 film.

The glass housing consisting of two hemispheres was 36 cm in outside diameter and 32 cm in inside diameter. It weighed 16 kg in air and had 8.4 kg of buoyancy in water. The weight of the camera assembly was 315 kg and the main light assembly weighed 1.9 kg. Therefore, the total weight of the camera system was about 40 kg in air, having a 10 kg buoyancy in water.

To keep the housing completely waterproof the pair of hemispheres were carefully wrapped with PVC adhesive tape along the joint on the equator of the sphere. Two pairs

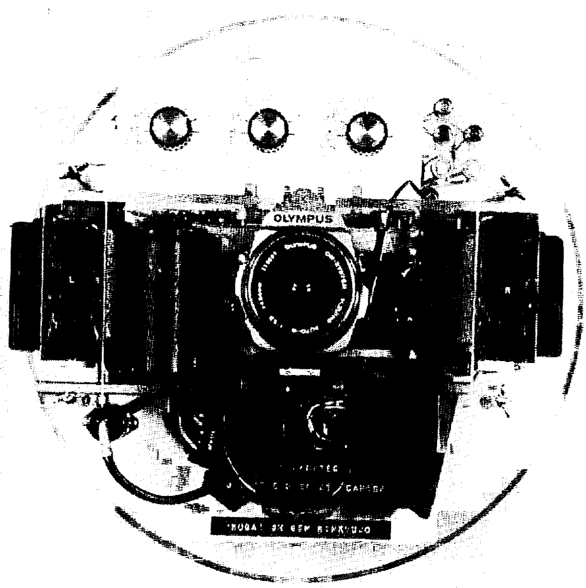

Fig. XVIII-3 Automatic camera assembly.

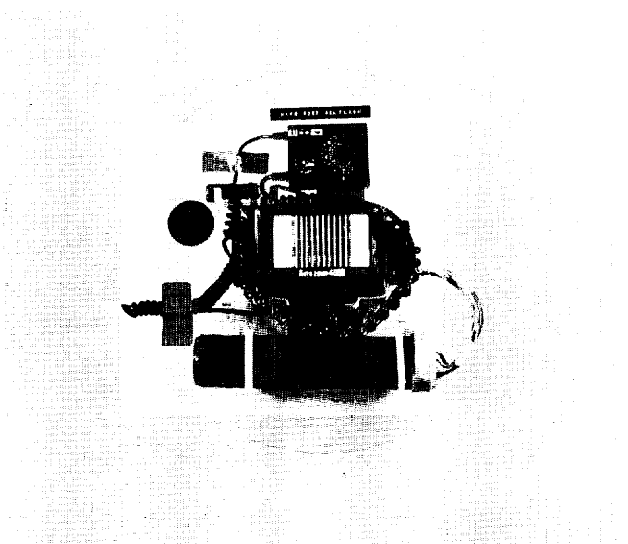

Fig. XVIII-4 Main light source assembly.

of achrylic flat rings and frame were used for mounting the camera system within the framework or hanging down to the wireline directly.

Samplers

Samplers used are a chain bag and small tubes. The chain bag was designed for manganese nodules as large as 1 m wide, 0.4 m high and 1.0 m long with a bite at the lower side of its mouth. The mesh of the chain was some 3 cm × 5 cm and a fishing net of 1 cm mesh was set within. The tube was for bottom sediment sampling and it was 3 cm in diameter and 60 cm in length. It was attached onto the sled and its mouth jutted out from the front bend of the sled. Its back end was sealed with porous material.

Procedure and results of the experiment

At St. 407A the SIC Mk-II was towed as shown in Fig. XVIII-5. In order to tow the measuring apparatus horizontally just above the sea floor, a weight of 100 kg was attached on to the main wire rope 100 m in front of the apparatus, and the pinger was attached 10 m in front of the weight to monitor the towing condition.

After setting of the weight and pinger, the wire rope was wound out with a speed of 60 m/min. for about 1.5 hours till the apparatus hit bottom. The bottom hitting was monitored by the pinger record of the PDR and also by the wire rope tension record. After bottom hitting the SIC Mk-II was dragged with the drifting of the ship, and the wire rope was wound up and/or let out to keep the pinger between 10–30 m above the sea bottom. This resulted in the horizontal dragging of the apparatus. The wire rope was wound in after 70 min. of dragging and the SIC Mk-II was recovered. The dragging distance was as much as 1.8km. Table XVIII-1 shows the time table of this experiment at St. 407A.

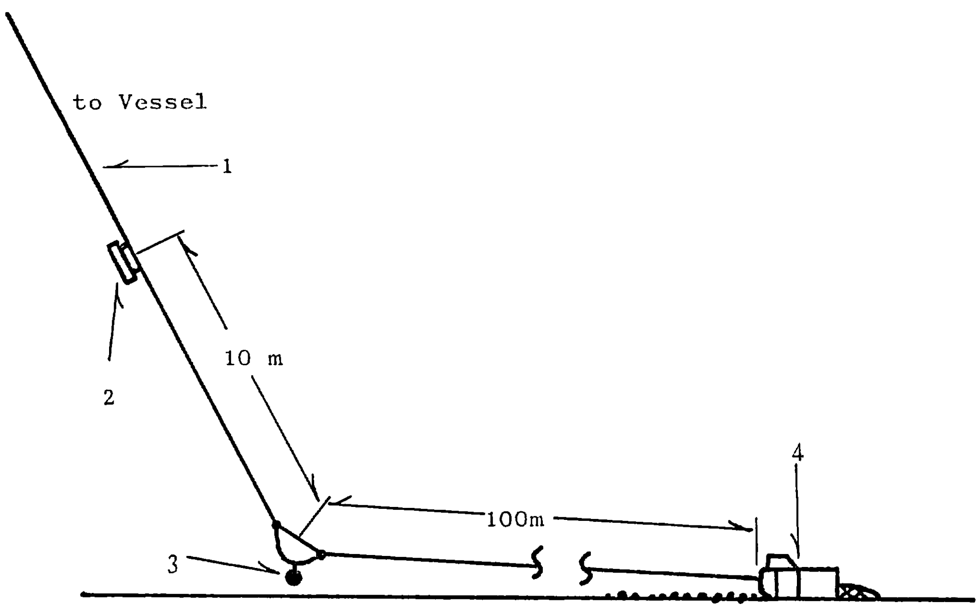

Fig. XVIII-5 Arrangement of towing system of SIC Mk-II. 1. main wire rope; 2. pinger; 3. weight (100 kg); 4. Measuring apparatus.

The cutting resistance recorded at St. 407A is shown in Fig. XVIII-6. The record shows that the maximum cutting resistance on the 5 cm wide blade was as large as 20 kg at a dragging speed of about 1 m/sec. and the mean value was 6.3 kg. Its frequency was similar to the swelling frequency of the ship. The record also shows clearly the leaving from bottom and rearriving at bottom of the apparatus at around 40 and 50 min. later since the start of the record which was 10 min. after the first bottom hitting. A detailed analysis of this record will be carried out in the laboratory hereafter.

Table XVIII-1 Time table of the experiment.

Station no.	GH76-1-407A-D137(N)	Weather	cloudy
Date	25 Feb. 1976	Wind	ENE 10 m/sec
Locality	08°59′N	Water depth	5,860 m
	174°00′W	Swell	4 m

Time	Passing time		Wire rope length	Notes
	From beginning	From arriving on bottom		
08:45	0 min.		0 m	Lowering of apparatus
48	3		100	Setting of weight
55	10		110	Setting of pinger Lowering
10:31	106	0 min.	5,998	Arriving on bottom of apparatus
34	109	3	6,072	Arriving on bottom of weight
	Properly winding out of wire rope to keep the pinger 10 ~ 30 m above bottom			
11:14	149	43	6,260	Winding up for 190 m
23	158	52		Leaving from bottom of apparatus
29	164	58	6,070	Winding out of wire rope
32	167	61	6,135	Rearriving on bottom of apparatus
	Properly winding out of wire rope			
42	177	71	6,291	Winding up of wire rope
50	185	79		Leaving from bottom of apparatus
12:39	234			Recovering onto the ship of apparatus

Table XVIII-2 The diving tests of glass spheres (No. 1 and 2).

St. no./Date	Sphere number	Water depth	Max. diving depth	Diving time (apprx.)			
				Total	over 3,000 m	over 4,000 m	over 5,000 m
416/Jan. 30	1 and 2 (1st)	5,780 m	5,005 m	3h04m	1h41m	1h06m	0h05m
407A/Feb. 25	1 and 2 (2nd)	5,860	5,860	4 53	2 46	2 08	1 34
433/Feb. 27	1 and 2 (3rd)	5,950	5,950	4 38	2 38	2 06	1 35
				12 35	7 05	5 20	3 14

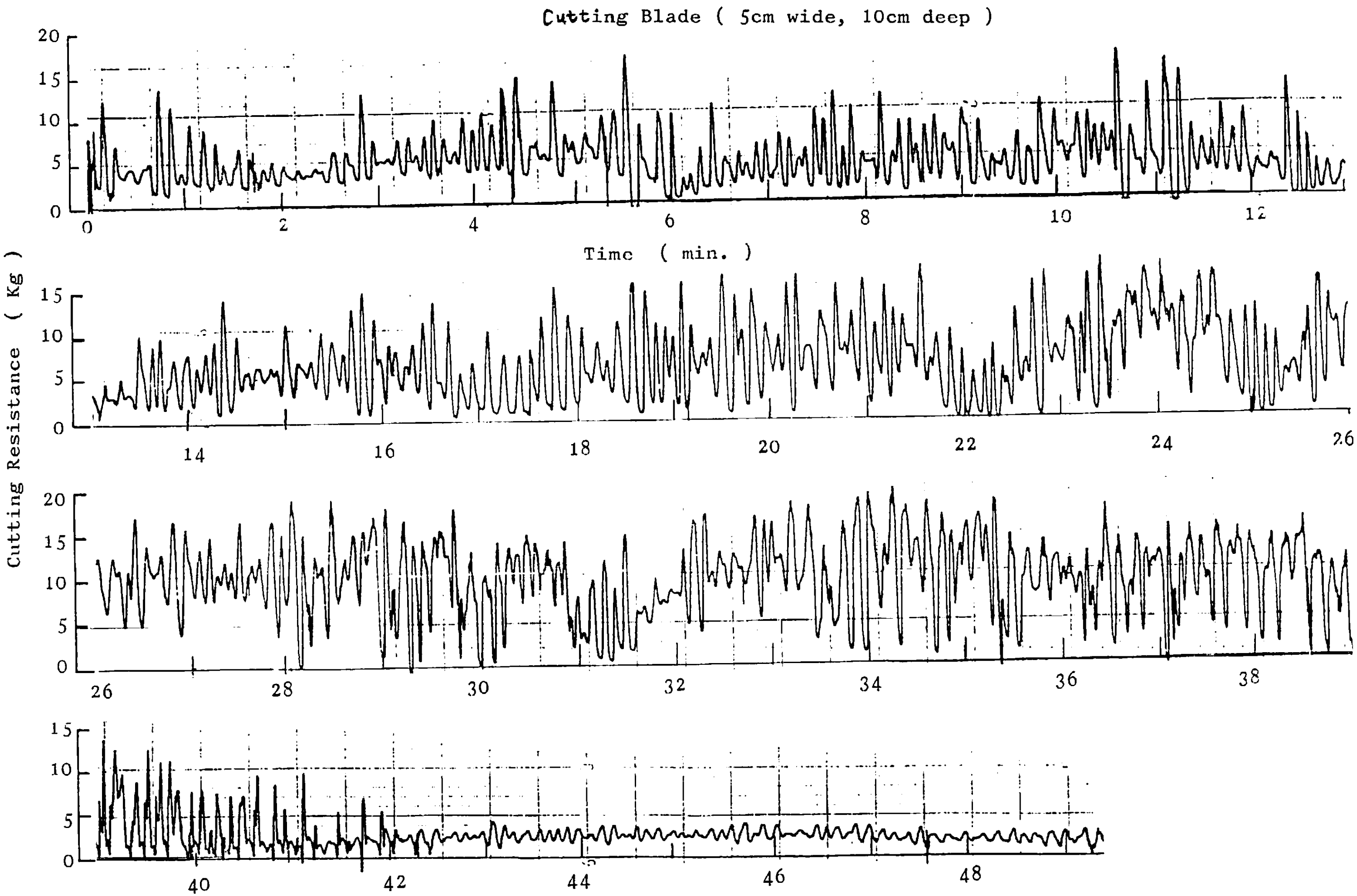

Fig. XVIII-6 Cutting resistance records.

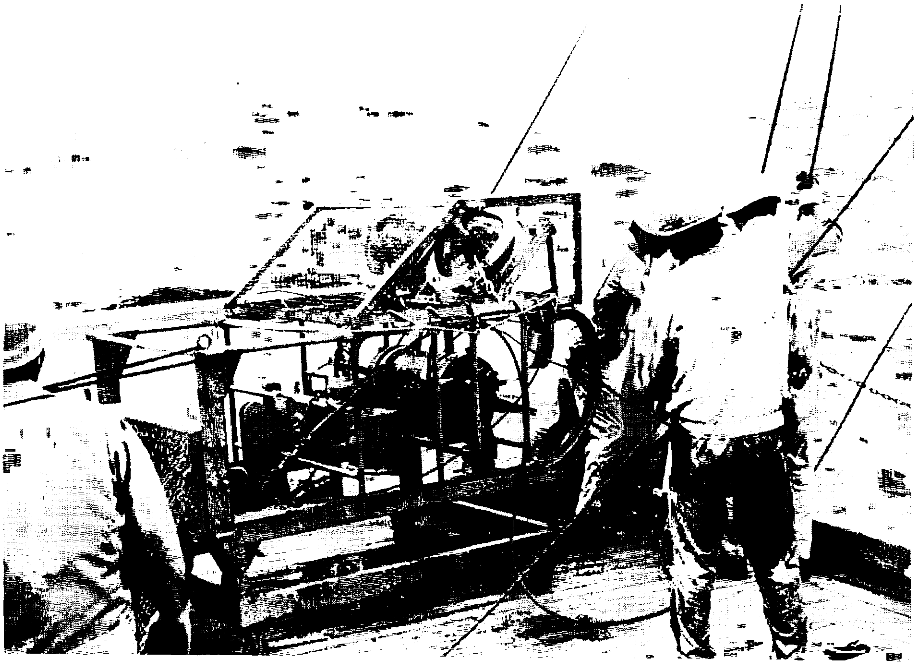

Fig. XVIII-7 The camera system mounted within SIC Mk-II frame at St. 407A.

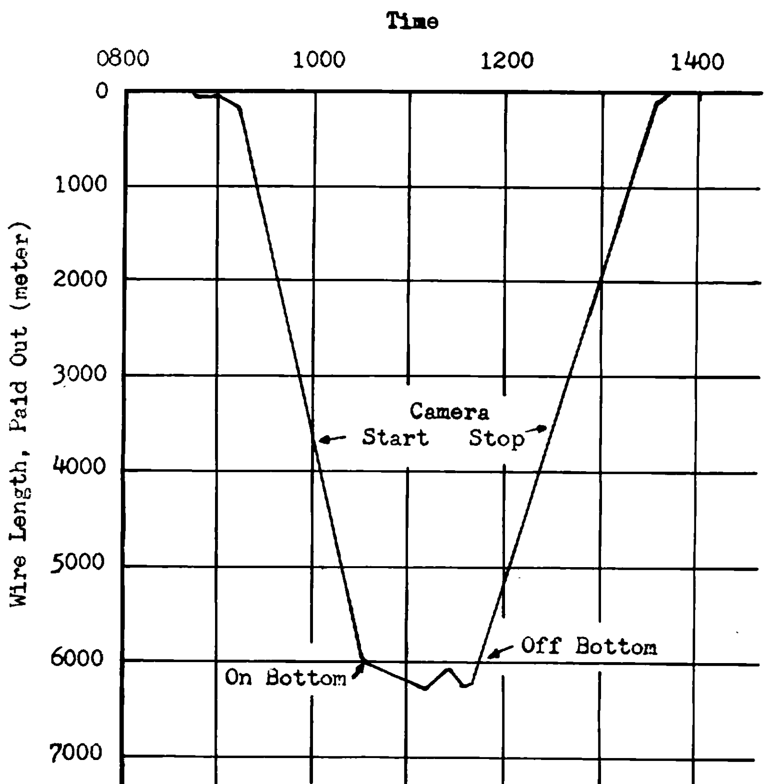

Fig. XVIII-8 Working record of the camera system at St. 407A.

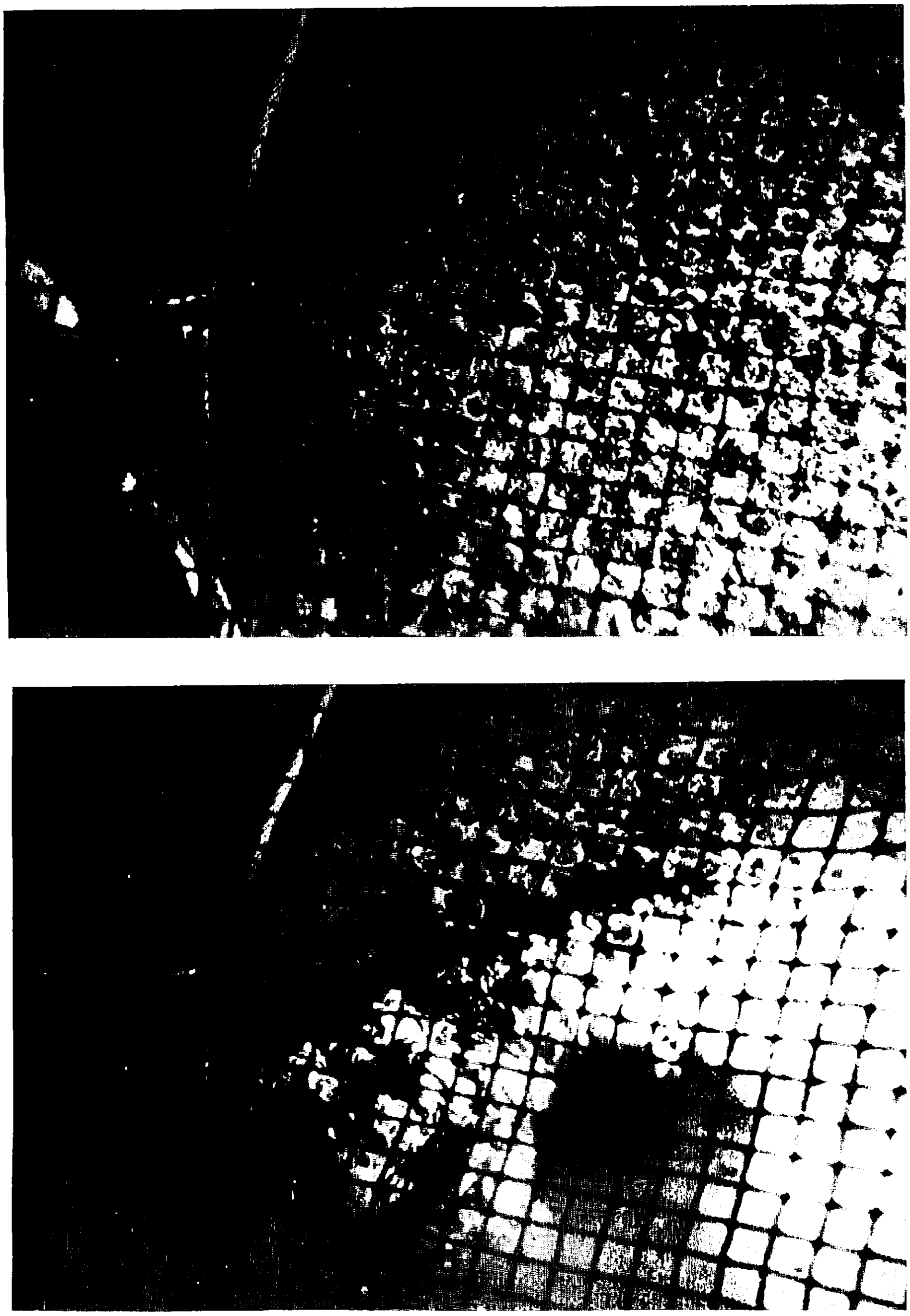

Fig. XVIII-9 Selected pictures taken at St. 407A. The upper figure shows the sea floor surface paved with manganese nodules and the lower shows the mud cloud caused by dragging of the instrument on the sea floor.

The acceleration sensor and microphone were not operated at this station.

The automatic still camera system was mounted on upper front of the framework of the SIC Mk-II to simultaneously observe the sea floor condition and behavior of the apparatus during working. A 35 mm film of 250 exposures length, Kodak Tri-X, was loaded into the camera. F-stop and shutter speed of the camera were set in connection with distance, intensity of the light source and other photographic conditions. The timers of the control circuit were set as the camera system started before bottom hitting of the apparatus and stops after it leaves the bottom. In Fig. XVIII-7 the camera system mounted on the framework is illustrated.

The camera system was recovered on board after 4 hours and 40 min. from a deep of up to 5860 m as shown in the working record of Fig. XVIII-8. No damage occurred and no trouble was experienced except a small amount of chipping of the inner edge of glass hemispheres. Relatively good pictures of 220 frames were obtained, during about two and half hours with an interval of about 30 seconds. They show the swing of the apparatus during rolling up and down, abundance of manganese nodules and mud

Fig. XVIII-10 Glass hemispheres after the 2nd diving at St. 407A (water depth: 5860m), showing a small tipping of inside edge.

Fig. XVIII-11 Boomerang corer on board.

Fig. XVIII-12 A sediment core recovered by the Boomerang corer.

clouds caused by dragging of the apparatus on the sea bottom. Fig. XVIII-9 shows some typical pictures selected from the long strip of film.

By means of the chain bag some 20 kg of manganese nodules were sampled, and a small amount of bottom sediment was recovered by the tubes.

Appendix—Some technical notes

Experiments other than those mentioned above were carried out during the present cruise. One was the performance test of the Boomerang corer and another was a practical test on glass sphere housings for the SIC Mk-II experiment.

Glass sphere housings test

The glass housings, made by Fukushin Glass Industry Co., Ltd. Tokyo, have been under development and fundamental tests had been carried out in laboratory and also in shallow water by JAMSTEC, while the practical test for large depths remained to be performed. Therefore, the use of the housings by the writers for sea bottom photography also aimed at their testing in a great depth.

The first test was done at St. 416 (water depth: 5,780 m) without any trouble. Based on the satisfactory result at that station, the spheres were brought down with a camera system at St. 407A and 433 (water depth: 5,860 and 5,960 m respectively), where rather good results were also obtained. The working record of the tests were shown in Table XVIII-2. After the tests no cracks or leakage of water was found except for a small amount chipping of the inside edge during the second and third tests (Fig. XVIII-10).

Boomerang corer test

Several sets of the Boomerang corers manufactured by Benthos Inc. (Fig. XVIII-11) were tested during this cruise following tests in shallow water. The first test during this cruise was conducted at St. 406 (water depth: 5,980 m) together with the freefall grab sampling operation. The second and third tests were done at Sts. 414 (5,430 m) and 432 (5,910 m).

Discovery of a float portion was made only by electronic flash signal after dark. The recovery point was less than 1.8 km from the lowering point, and complete cores of over 1.1 m long were obtained at Sts. 414 and 432 (Fig. XVIII-12). This provided significant information regarding lithofacies and physical properties of the surface sediments.