THE IOS BOX CORER: ITS DESIGN, DEVELOPMENT, OPERATION AND SAMPLING.

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Abstract

The design and development is described of a simple reliable box corer for the sampling of interfaces without disturbance, in a range of sedimentary areas. The corer generally samples the underlying sediment to a depth of 20-60 cm. There appear to be no problems of sample contamination and both the interface and the sub-surface sediment can be satisfactorily sub-sampled for a whole range of chemical analyses.

INTRODUCTION

The air-sea and water-sediment boundaries are the two most important interfaces involved in the geochemical cycling of material throughout the marine environment. Of particular interest to geochemists are the possible fluxes of inorganic anions and cations, gases and organic molecules across the sediment-water interface, the role of the interface bacterial populations in the diagenesis of the sedimentary organic natural products which originate in the overlaying water column, and the possible existence of specific chemical/physical processes which may be peculiar to the sediment-water interface.

In order to determine specific chemical or bacterial properties of the interface and to quantify any fluxes which occur across the sediment-water interface, the first priority must be the development of good sampling techniques. At I.O.S. Wormley there has been a dual approach to this problem. Firstly, the development of a system for the *in situ* sampling of the sediment pore waters from the interface down to 1-2 m; secondly, and the subject of this report, the development of a system for collecting and recovering the interface and the underlying sediment for subsequent detailed sampling and preliminary analysis on board ship.

The requirements of this sediment interface sampler were as follows:-

1. To be able to collect and recover an undisturbed interface of approximately $0.1m^2$ together with a core of the underlying sediment to a depth of 0.5 - 1.0m.
2. For there to be a minimum of contamination of the sample by the corer (i.e., metals, grease, etc.) during the sampling and recovery.
3. For the corer to be built in such a way that the interface and underlying sediment could be cleanly and easily sub-sampled on board ship whilst still in its natural orientation.
4. For the corer to be deployed and recovered in a range of sea states.
5. For the corer to be as simple and reliable as possible.

DESIGN AND DEVELOPMENT

The corer design commenced with some initial reference to a corer developed by A. Soutar of Scripps Institute of Oceanography. The major innovation was the opening and closing mechanism. Closure at the top and bottom of the I.O.S. corer was achieved by pivoted shovel arms working in a scissor mode. As the load in the lifting strops increased when the corer was withdrawn from the sediment this caused the arms to rotate and the shovels to close off the top and bottom ends of the corer. Thus there was no possibility of losing a core due to the bottom shovels not closing when the corer was pulled out of the sediment, unless of course a large solid object became trapped between the leading edges of the bottom shovels.

The preliminary designs led to a relatively large and complicated corer (Fig. I). A brief description of this corer's operation is as follows:

The corer complete with its support frame, is lowered slowly onto the sea-bed; on touching the bottom the load comes off the no-load release, allowing the weighted core box to go into the sediment guided by the piston rod; when the weight comes on the main cable to retrieve the corer the two closing cables come under tension, via the triangular plate; the top shovels start to close and the bottom shovels cut their way into the sediment to close off the bottom of the core box; when the shovels have closed the core box is pulled clear of the sediment.

This prototype corer was built during 1974 and tested fairly successfully in Barry Dock (S. Wales) and the Bristol Channel. It was then taken to sea on R.R.S. Discovery Cruise 79 off the North West African coast and attempts made to obtain core samples in a water depth of 6000 m. It became obvious that the corer was unnecessarily large and complicated and also was difficult to handle on board in anything of a sea. During the second core drop there had been a considerable angle of pull out due to the ship's drift and the corer was recovered with a badly damaged piston rod.

The main function of the framework was to house the piston assembly and therefore facilitate a slow lowering of the corer into the sediment. It was felt that the main winch could give a slow, controlled descent rate and so modifications were carried out in order to use the corer without the main framework or piston assembly. This was done by fitting a 2.5 ton S.W.L. eye bolt into the centre of the "U" bracket and using it as the main lifting point (see Fig. 2). The cross arm for the main lifting strops and piston assembly (see Fig I) were completely removed and the strops shortened. The no-load release mechanism was then modified to facilitate the attachment of the arm holding wires.

These modifications meant that the triangular plate and no-load release were now very close to the top of the corer and there was a possibility of the top shovels being fouled when closing. A 25 kg buoyancy float was therefore attached 20' up the main warp to keep both the assembly and the main warp clear of the corer when it was on the bottom and so avoid this situation.

On stations 9129 and 9130, in water depths of 5570 m and 5940 m, the winch paid out at 1 m sec. until the corer was approximately 50 m from the bottom, this distance being indicated by a pinger 100 m up the main warp. The corer was then lowered at a rate of 0.5 m sec. until it reached the bottom, a further 20 m of slack being paid out in order to avoid any heaving effect from the ship whilst the corer was in the sediment.

On recovery, the traces of mud on the sides of the box indicated that the shovels had been closed before reaching the bottom and that the corer had fallen over onto its side on hitting the bottom. The sea state had been very rough causing considerable heaving of the ship and this was thought to have caused the no-load release to activate in mid-water.

The weather conditions improved and with a calm sea on station 9131, in a water depth of 4000 m, a good, undisturbed sample was obtained (See Fig. 3)

It was obvious, on completion of this cruise that further modifications were necessary and the following work was carried out:-

1. New arms were made with a central pivot point.
2. The box section was shortened to facilitate modification No. 1.
3. Two side panels were fitted for in situ sub-sampling.
4. A protective guardrail was fitted around the corer.
5. A stand was manufactured for use as a working platform during corer deployment and recovery and for transportation of the corer (see Fig. 4).
6. Due to modification No. 1 the arm holding wires were no longer necessary.
7. In order to keep the weight supported by the buoyancy float to a minimum the triangular plate was reduced in size.

This developed system was used on Discovery Cruise No. 88 to the

Iberian Basin and had a high rate of success. The only failure of the equipment was due to weakened no-load release springs which, being manufactured from stainless steel, tend to lose their tension. Eight cores were obtained from depths between 4000 m and 6000 m and varied in length from 34 cm to 61 cm with well preserved surfaces.

Following this cruise additional sampling ports were added to facilitate pore water collection. The equipment was then used on Cruise No. 99 to the Cape Basin area with very good results, again the only real problem being the no-load release mechanism. The springs were changed every three launches and yet there was still a tendency for the occasional pre-trip.

On stripping down the no-load release, it was found that the remotely operated lever wire tended to trip the mechanism in certain circumstances and it was therefore removed completely.

Another problem encountered occasionally during Cruise 99 was tangling of the main warp around the buoyancy float. This was not only dangerous during recovery but also damaged the main warp. The problem was completely eliminated by putting a short 8 m strop of the main cable immediately above the corer with 5 ton SWL swivels at each end and attachment eyes for the buoyancy float 5 m from one end. Thus the order and method of corer deployment finally arrived at is as follows: corer, swivel, 8 m strop with the buoyancy sphere 5 m above the corer, swivel, main warp with acoustic beacon 100 m above the corer.

On Discovery cruises No. 104 to the Eastern Mediterranean, 108 to the Nares Abyssal Plain and 110 to the Peru upwelling and S.E. Pacific there was over a 90% success rate for nearly 30 box core stations. Typical pull out figures for the cores obtained were in the region of 0.30 to 0.75 tons with a total wire load (pull out and weight of corer and wire) of 1.0 - 2.5 tons in depths varying between 100 m to 6000 m.

The dynamometer readout of a typical coring operation in a water depth of approximately 3000 m is shown in Fig. 5.

OPERATIONAL BOX CORER

As discussed in the previous section the IOS box corer has been developed over a number of cruises to provide an operational system which can routinely take good quality core samples. The following sections give a brief description of the corer and the way it is used at sea.

(i) Description

The operational system now used is as shown in Fig. 2. The corer consists of a stainless steel box, 30 cm square and 120 cm in length. The overall weight of the corer is 600 kg of which 200 kg is adjustable by the removal or addition of twenty weights. On one side the box is provided with two long perspex windows for initial observation of the core. On the opposite side there are small sampling ports down the length of the box and two large removable plates to allow side access to the core. The coring box is closed top and bottom by a pair of closely-fitting shovels mounted on pivoted arms.

(ii) Operation

The I.O.S. box corer is deployed from, and recovered to, a stand which is bolted onto the working deck. The stand keeps the corer in the upright position and there is no need to detach the core box from the corer prior to sampling a core. This makes both the deck handling and sampling fairly easy in up to moderate sea states. The corer is lowered on a commercial life-boat no-load release (RFD Type 2A) with the shovels in the fully open position (Fig. 6). The box is therefore completely open and free flooded at the top and bottom. With the corer suspended over the side of the ship, just in the water, the no-load release is activated. A 25 kg flotation sphere is attached 5 m above the no-load release onto attachment eyes in a 8 m strop and, in water depths greater than 250 m, a pinger placed 100 m up the warp.

The corer is lowered at between 0.5 - 0.7 m/sec. Too fast a speed of descent appears to increase the chances of the no-load release pre-tripping. The corer is stopped approximately 50-100 m from the bottom, the distance being indicated by the pinger further up the warp. It is then lowered into the bottom at a speed determined by the type of sediment being sampled, and the type of sample required. For soft unconsolidated sediments where an undisturbed interface is the priority the slowest possible speed is used (ca. 0.2 m/sec) with sufficient weight to get the depth of core required.

For more consolidated sediments a faster speed is used (up to 1 m/sec) with maximum weight. Approximately 10-25 m of slack wire is allowed depending on ship's heave and accuracy of the depth measurement from the pinger trace.

Impact is easily recorded on the ship's dynamometer (Fig. 5). When the corer hits the bottom the no-load release is activated (Fig. 7). The warp is then hauled slowly (0.1-0.2 m/sec) and, as the tension comes onto the wires attached to the top shovels, the shovels close (Fig. 8) and the corer is lifted clear of the bottom (Fig. 9). This is easily seen on the dynamometer by up to 0.75 tons extra load (Fig. 5).

The I.O.S. box corer has been successfully used in sea states 4 or 5 but obviously the more the heave of the ship the greater the chance of a no-load pre-trip. The chance of a pre-trip however is not usually the limiting factor. The likely condition of the sample, especially the interface, normally decides whether or not weather conditions are suitable for a box core station. If the corer swings around a lot during recovery and sampling this will obviously ruin the interface and normally the calmer the conditions the better the interface sample.

(iii) Sub-sampling

When finally recovered on board ship, the corer is placed in its stand and allowed to drain. This can be facilitated by carefully loosening the screws holding the ports and by syphoning off the water in the top of the box section. The interface can then be examined and sampled by removing the top shovels and sliding the "U" bracket to one side. Pore water samples can be taken via the small side. Pore water samples can be taken via the small side ports and finally the sampling plates removed to give complete access to both interface and the underlying sediment. The corer in a sub-sampling mode with its top sampling plate removed is shown in Fig. 4.

CONCLUSIONS

The present I.O.S. box corer has proved to be a simple, and very reliable tool for sampling relatively undisturbed interfaces in a range of sedimentary environments. The underlying sediment is generally sampled to a depth of 20-60 cm. No problems of sample contamination have yet been encountered and both the interface and sub-surface sediment can be satisfactorily sub-sampled for a whole range of chemical analysis.

Future development of the box corer will involve a modification to the box section in order to give greater accessibility to the interface of the core. Some thought has been given to the possibility of replacing the no-load release with an acoustic device. The advantage would be that the corer could be launched in a more severe sea state and so avoid the present situation where heaving of the ship can cause the no-load release to trip. However, as discussed earlier, quality of the interface is of prime importance and in higher sea states it is very difficult to maintain an undisturbed surface sample. Thus there is little advantage in being able to work in worse sea conditions. It was felt, therefore, that it would be better to retain the present simple, mechanical system which now gives extremely good results.

What would be of considerable use is a device to indicate when the arms have closed. With this development it would be possible to abort a core drop as soon as a pre-trip had occurred, thus saving a considerable amount of ship-time.

Acknowledgements

The assistance of the officers, crew and scientific party of R.R.S. Discovery during Cruises 79, 88, 99, 104, 108 and 110 is gratefully acknowledged.

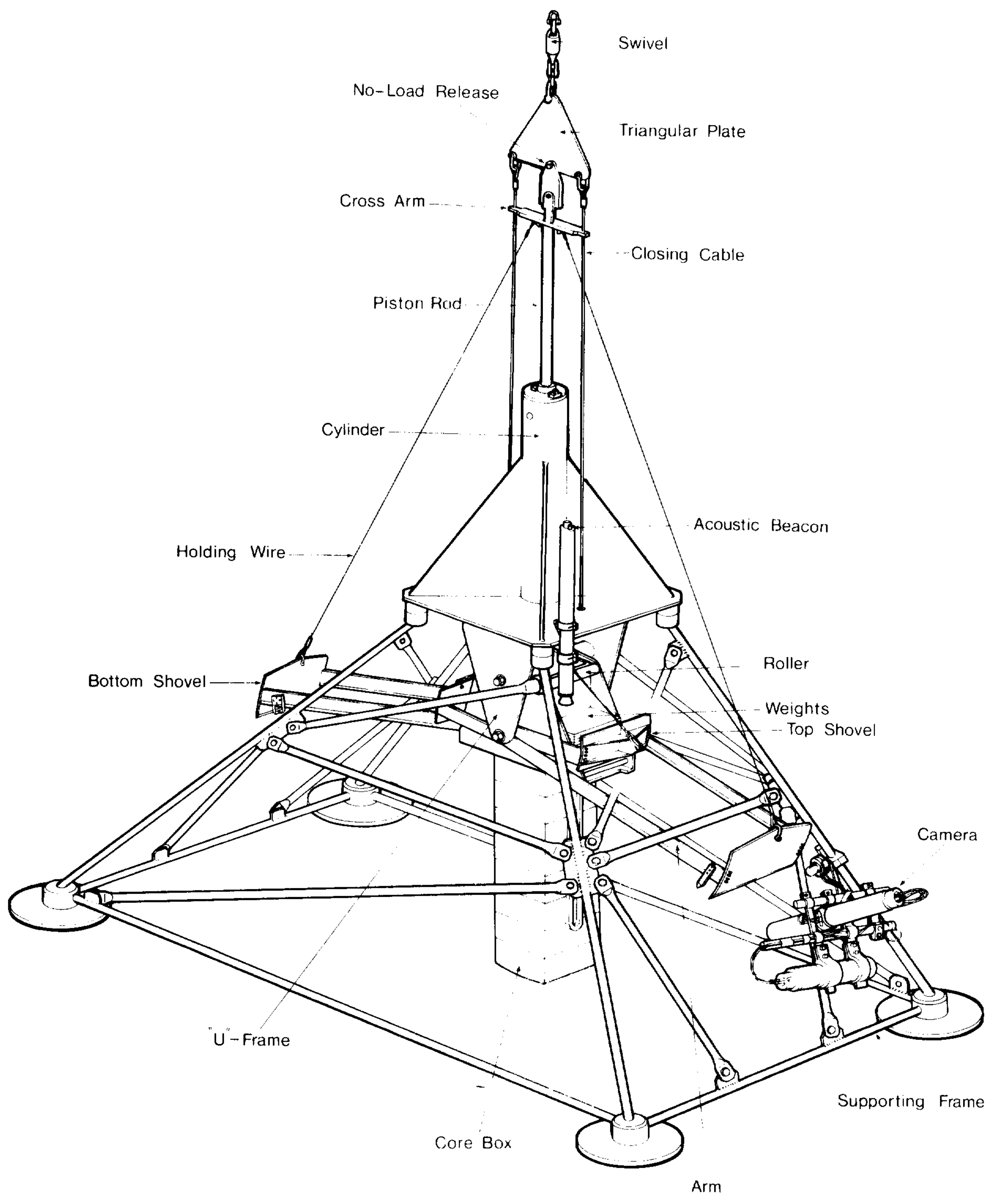

Swivel
No-Load Release
Triangular Plate
Cross Arm
Closing Cable
Piston Rod
Cylinder
Acoustic Beacon
Holding Wire
Roller
Bottom Shovel
Weights
Top Shovel
Camera
"U"-Frame
Supporting Frame
Core Box
Arm

FIG 1

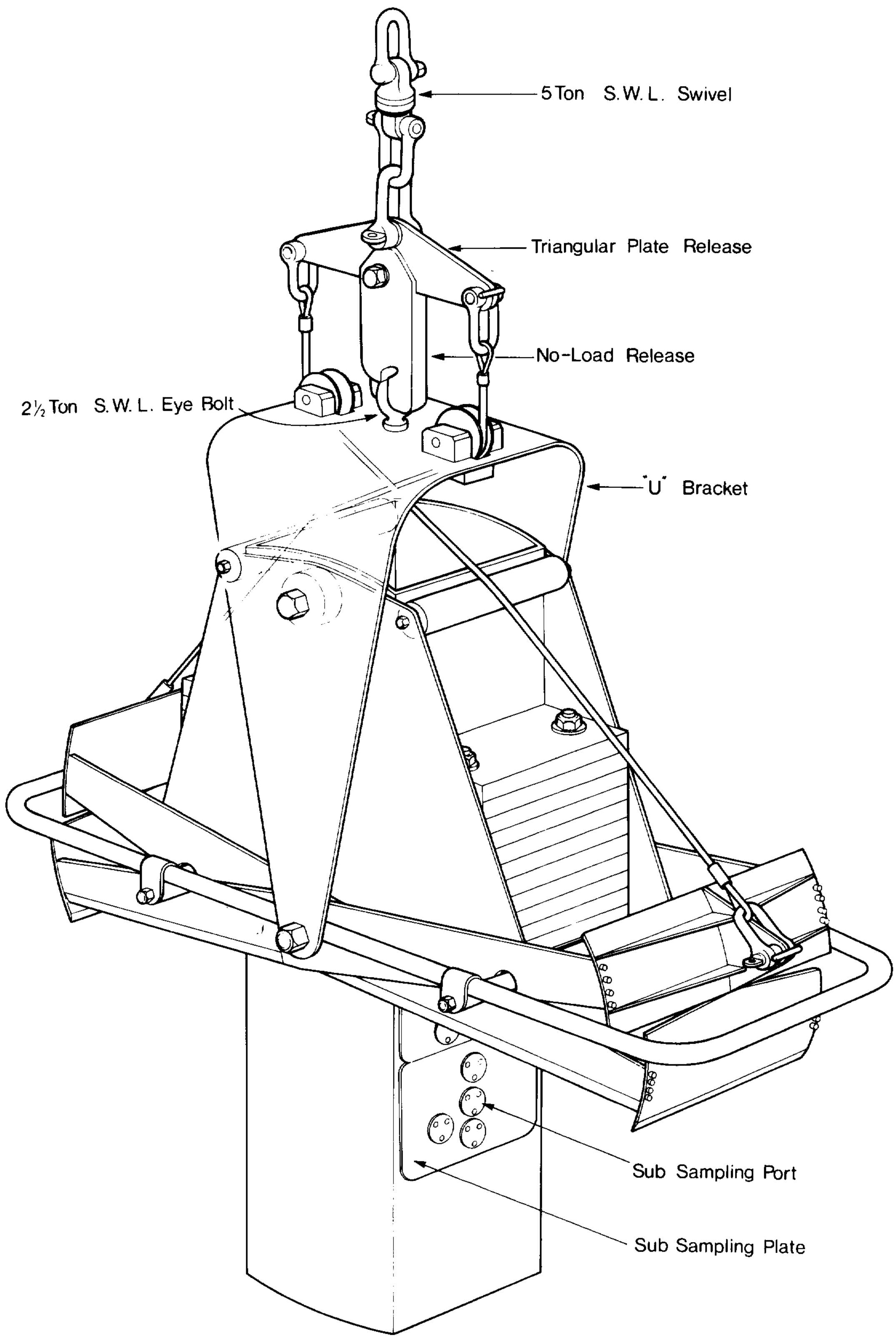

5 Ton S.W.L. Swivel
Triangular Plate Release
No-Load Release
2½ Ton S.W.L. Eye Bolt
"U" Bracket
Sub Sampling Port
Sub Sampling Plate

FIG. 2

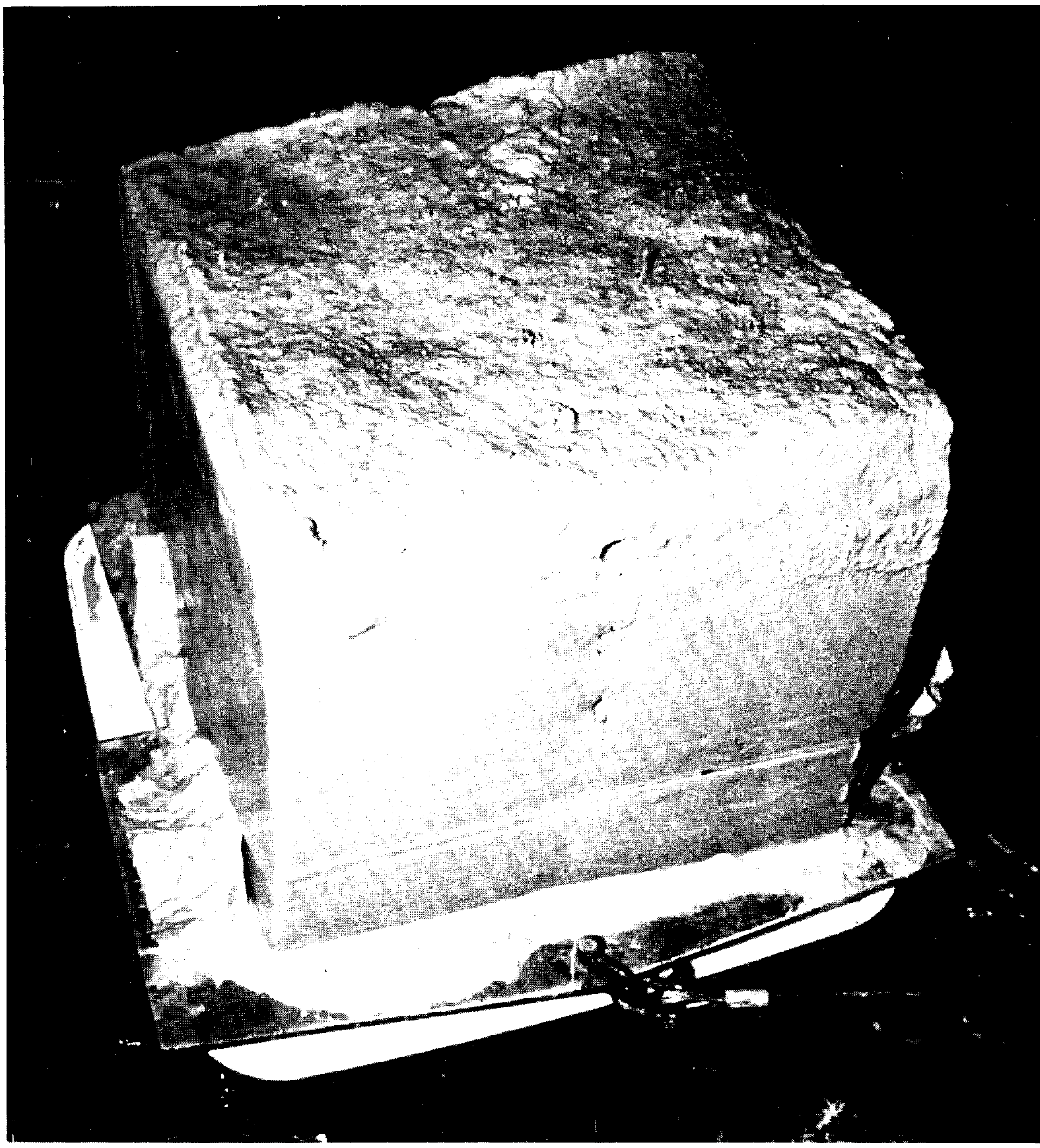


FIG. 3

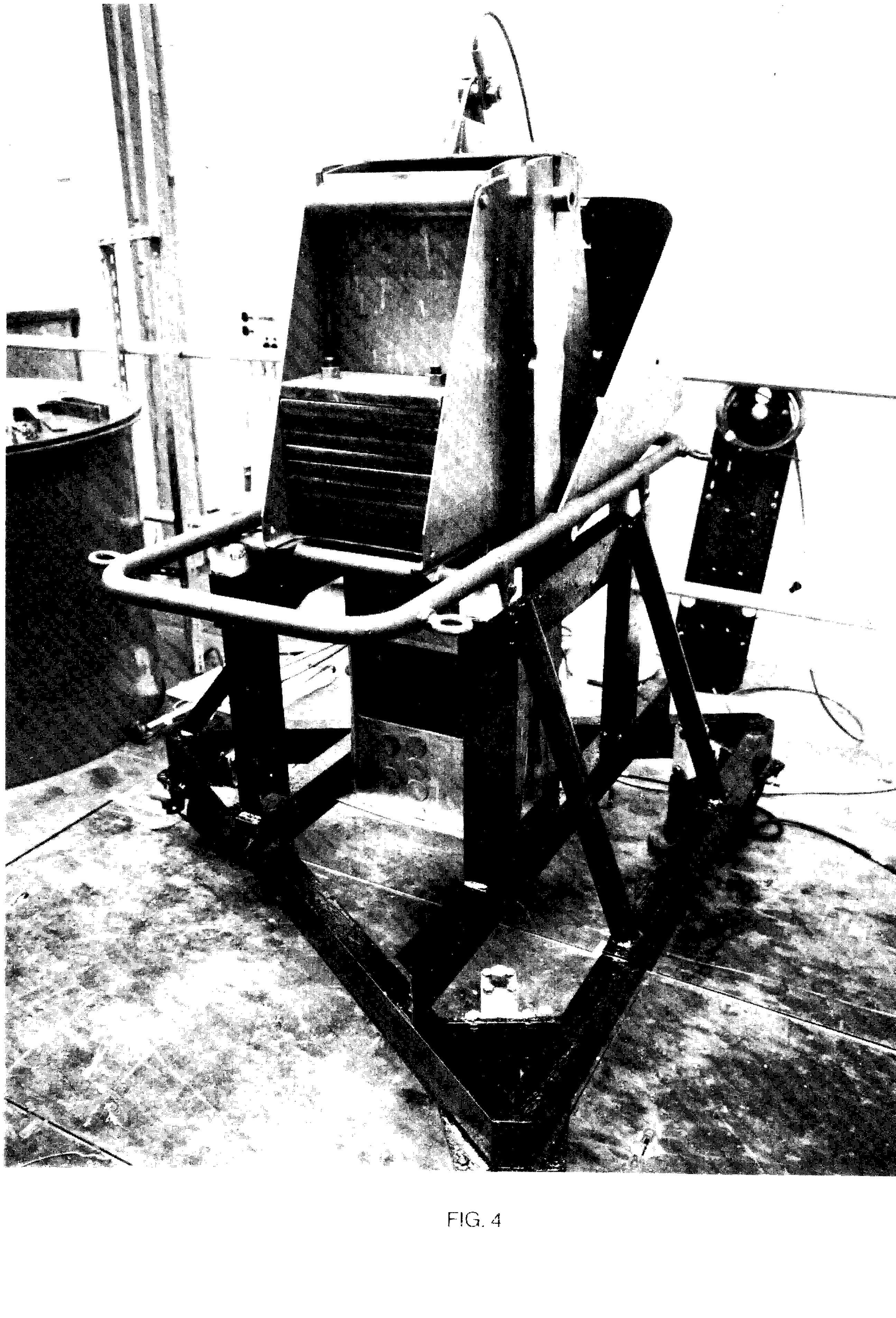
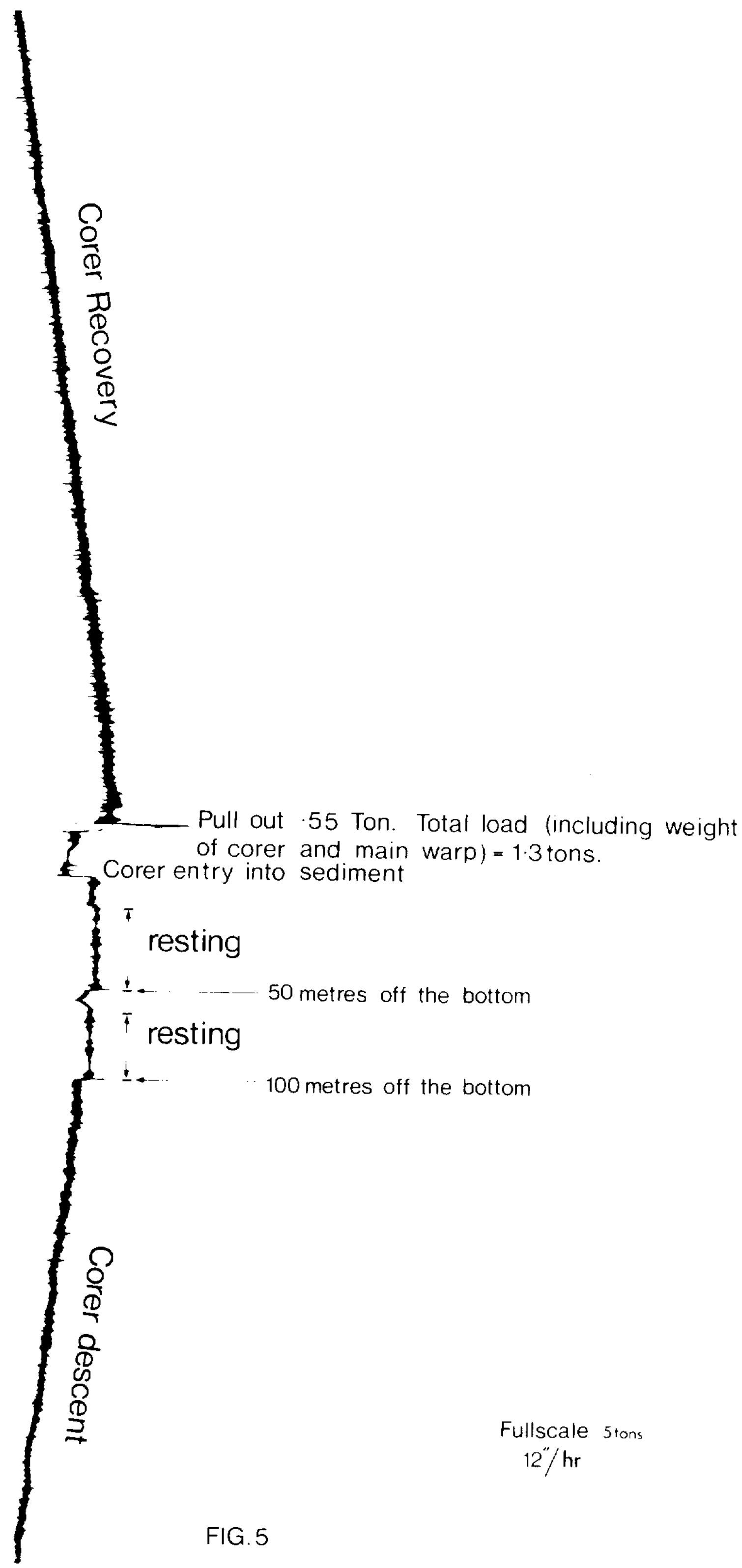


FIG. 4



Corer Recovery
Pull out ·55 Ton. Total load (including weight of corer and main warp) = 1·3 tons.
Corer entry into sediment
resting
50 metres off the bottom
resting
100 metres off the bottom
Corer descent
Fullscale 5tons
12"/hr

FIG. 5

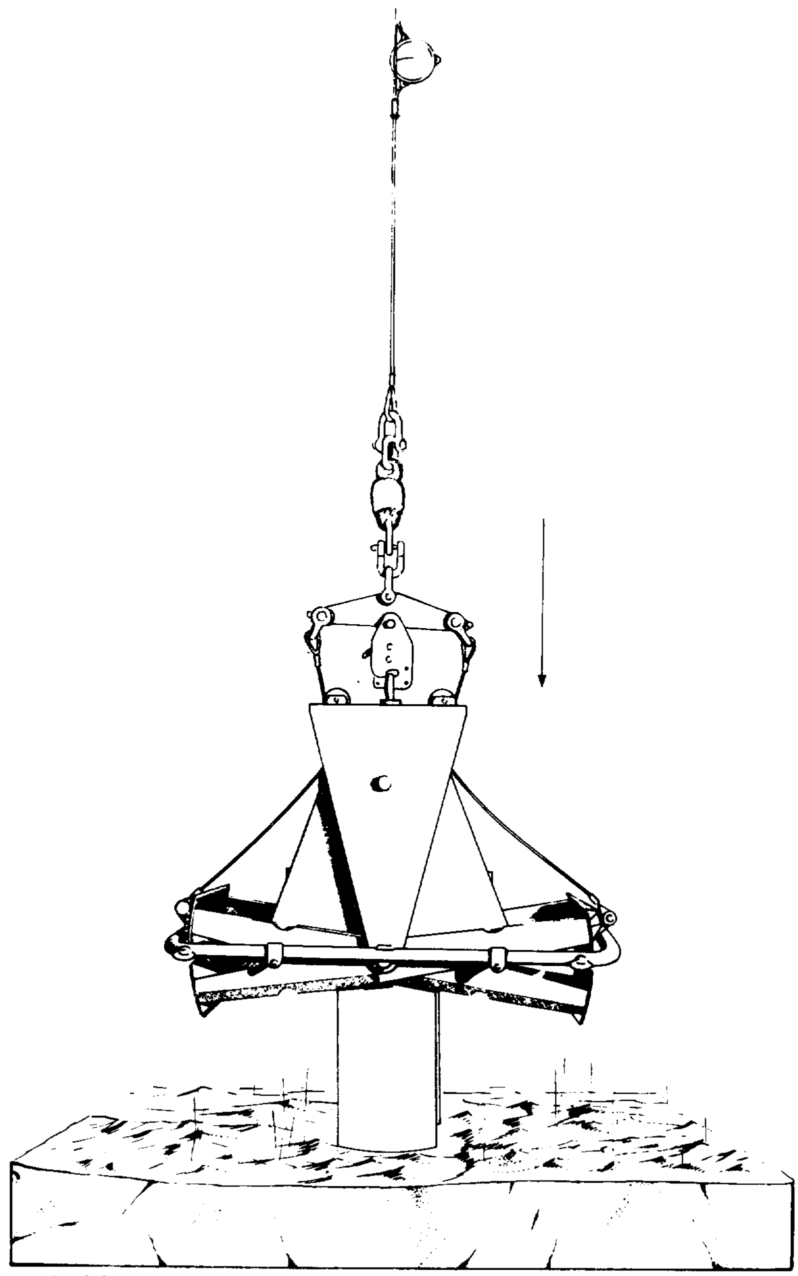


FIG. 6 DESCENT MODE WITH ARMS OPEN & NO-LOAD RELEASE SET.

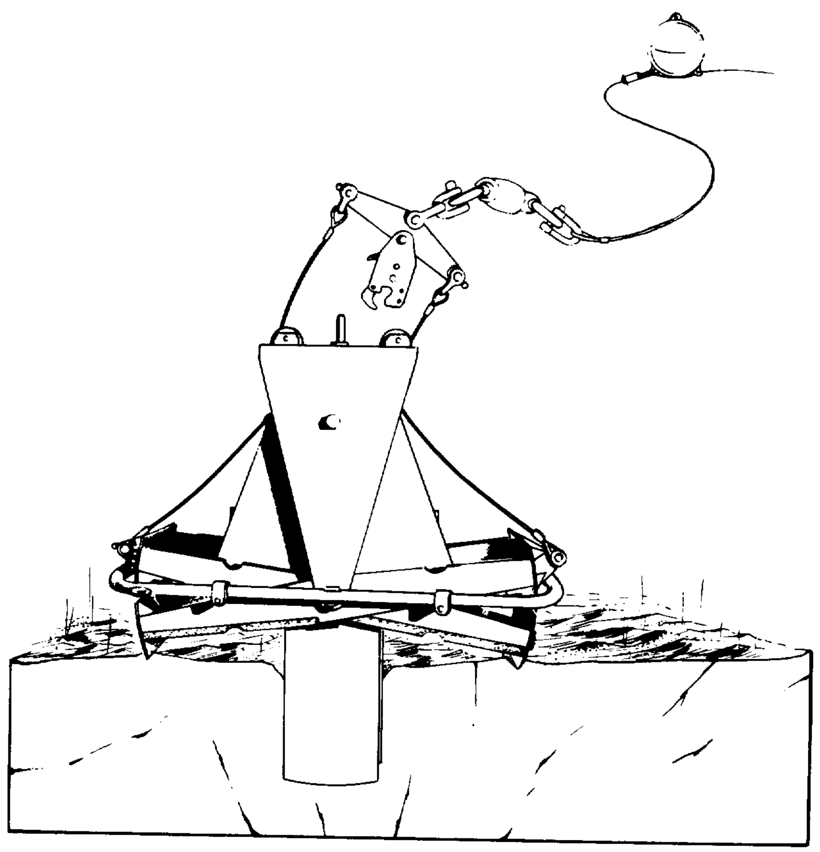


FIG.7 CORER HAVING PENETRATED THE SEDIMENT & NO-LOAD RELEASE TRIPPED.

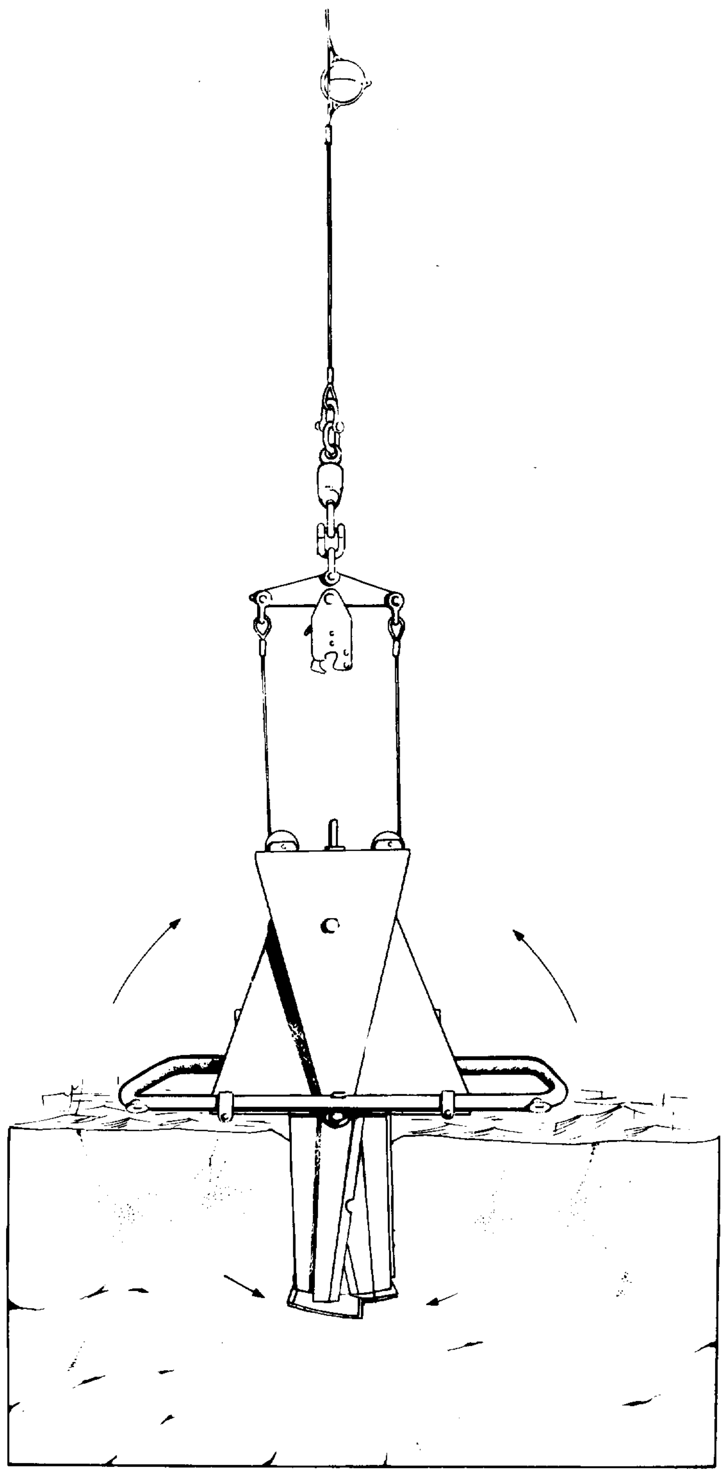


FIG. 8 PARTIAL RECOVERY SHOWING ARMS HAVING CUT THROUGH SEDIMENT

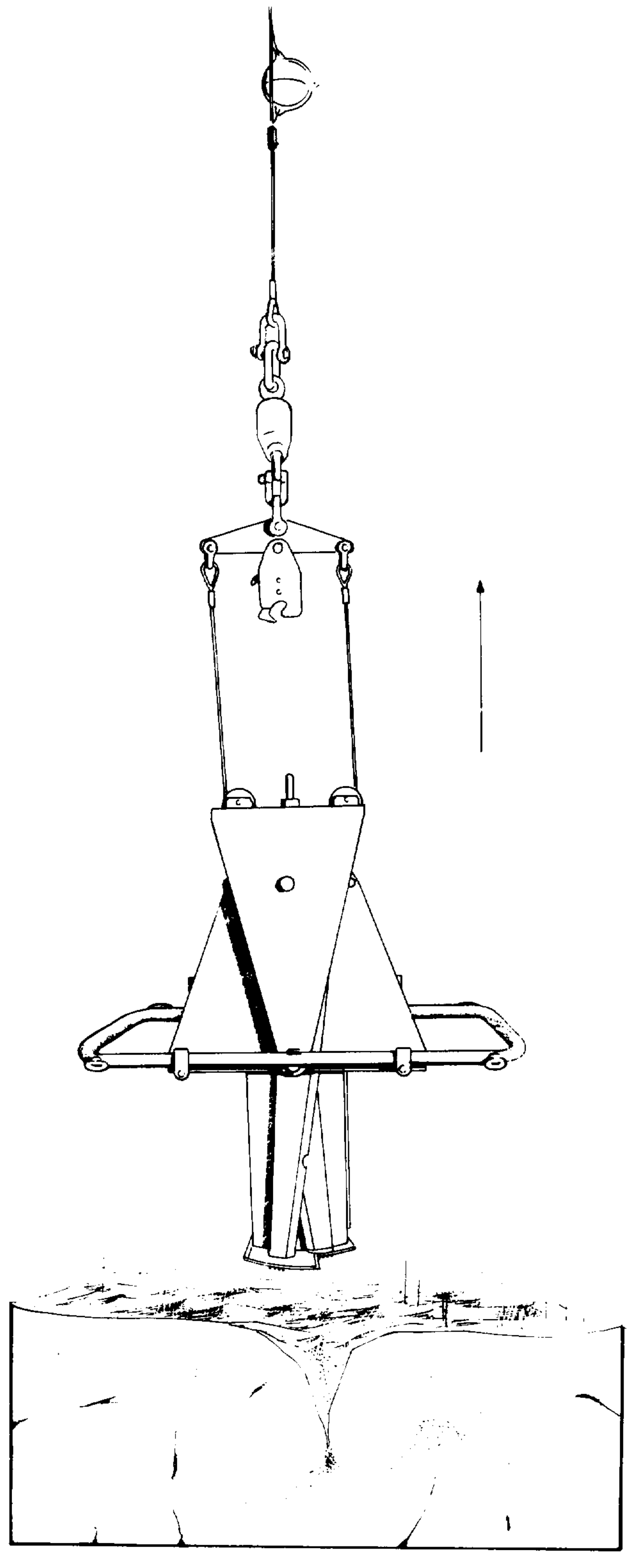


FIG.9 RECOVERY

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