I.O.S.

THE IOS MULTI-PURPOSE GRAVITY CORER

R J MORRIS & R D PETERS

REPORT NO 124

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NATURAL ENVIRONMENT RESEARCH COUNCIL

INSTITUTE OF OCEANOGRAPHIC SCIENCES

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ABSTRACT

The paper describes the design and development of a multi-purpose stainless steel gravity corer. The corer can take the following samples: first, relatively undisturbed interface samples together with a sub-surface core to a depth of 1.2 m in a square box barrel which permits quick, easy access to the samples; second, undisturbed archive core samples of 1.0 m in length in 10 cm diameter round liners; core samples of 3 m length and over in 6 and 10 cm diameter liners.

The total weight of the corer fully loaded is 300 kg and in water depths of up to 6000 m it gives a total wire load (pull out and weight of corer and wire) of less than 2 tons. The corer has its own support and sampling frame to keep the core sample in the vertical orientation and allow safe and easy handling in even moderate sea states.

There appears to be no problem of sample contamination from the square box and 10 cm diameter barrels and both the interface and sub-surface sediment can be satisfactorily sub-sampled from a square box core sample for a whole range of chemical and biological analyses.

INTRODUCTION

Recent years have seen a considerable growth and improvement in the type and quality of sediment samplers in use at IOS. The IOS 4" diameter, round barrel, stainless steel corer was the coring workhorse for many years and took uncontaminated, relatively undisturbed core samples 1-3 metres in length suitable for archiving. It did not sample the interface properly and because the cores were collected in liners there was no immediate, easy access to the sample for detailed sampling, photography or core description.

In response to research requirements for undisturbed samples of sediment interfaces the IOS box corer was developed (Peters, Timmins, Calvert & Morris, 1980) and, for this purpose, has proved to be an ideal sampling tool in a range of sedimentary environments. The sub-surface sediment is normally sampled to a depth of 20-60 cm and both the interface and sub-surface have been found to yield uncontaminated samples for a range of chemical analyses.

The box corer does not however provide samples of the deeper (>50 cm normally) sub-surface sediments. For this purpose a commercially-available gravity corer, the Kastenlot corer, was purchased. The Kastenlot corer collects large volume core samples in a square section core box (15 cm × 15 cm) upto 6 m in length (Kögler, 1963). The core boxes can be opened lengthwise into two equal halves, thus providing quick, easy access to the sample for sampling, description and photography. The samples generally show little disturbance.

The excellent sampling reliability of the Kastenlot corer is largely due to the design of the combined core nose and core catcher (Kögler, 1963). Unfortunately the core box has to be laid down horizontally in order to be opened and in soft, unconsolidated sediments this causes slumping of the top 10-20 cm of the core sample. In addition the core boxes are made of galvanised mild steel and are difficult to keep clean with the result that great care has to be taken to sample the core well away from the 'rind', particularly if metal analysis is to be performed on the samples.

Thus at coring stations it is normally necessary to use both the box corer and Kastenlot corer in conjunction to provide the sort of samples required for a thorough geological/geochemical investigation of the near surface sediments at a particular sedimentary environment (i.e. undisturbed interface and undisturbed sub-surface core of 1-2 m in length).

Such a sampling requirement involving the use of two large, heavy corers (Box corer - 600 kg fully loaded; Kastenlot corer - 1000 kg fully loaded) both with substantial pull-out loads (0.5-1.0 tons - at deep water stations the combined weight of the warp and the corer together with the pull-out load gives total loads of 2-4 tons) inevitably places restrictions on the type of vessel from which these corers can be used. The size of winch, main warp and available deck handling equipment all become limiting.

It was decided to attempt to combine, in a new corer, the advantages of the box corer (undisturbed and uncontaminated interface samples and core kept in vertical orientation at all times) together with the sub-surface sampling qualities and reliability of the Kastenlot corer. Other requirements were that when necessary the new corer could be easily adapted to take archive samples, and that the corer would be far smaller and lighter than either the box corer or Kastenlot corer thus giving greater flexibility as to the type of ship from which it could be used.

DESIGN AND DEVELOPMENT

It was decided to limit the maximum length of core which could be taken by the new corer to 1.2 metres. This is normally an acceptable length of core for Kastenlot samples and together with the weight stand represents the maximum corer height which can be easily kept in the vertical plane during launch, recovery and sampling.

The existing IOS stainless steel 4" diameter round barrel gravity corer was used as the basis for the new corer. The major developments were to convert this corer into a multi-purpose corer with detachable stainless steel barrels; one round, 10 cm (4") diameter, barrel similar to that on the original IOS gravity corer, with a clear cellulose acetate butyrate liner for collecting archive samples; one square box (15 cm × 15 cm) with sample plates enabling ready and easy access to the interface and sub-surface sediment.

The corer was to have a support frame which was to be bolted onto the ship's working deck so that corer deployment, recovery and core sampling could all take place in the vertical orientation (i.e. the natural orientation of the core sample) and would allow the handling of the corer to be as safe and easy as possible even in fairly severe sea states.

Figures 1-3 show the main parts of the new multi-purpose stainless steel corer.

(a) Square box barrel:

The dimensions of the Kastenlot core box and core nose/catcher have essentially been kept except that the stainless steel (316S) used for the present corer is significantly thicker than the mild steel used for the Kastenlot corer. This results in a rather higher area ratio (see Hvorslev, 1949) of approximately 30 for the stainless steel box + nose core compared to 22 for the Kastenlot corer, although this figure is still acceptable for effective operation. The outside clearance ratio (Hvorslev, 1949) is similar to that of the Kastenlot.

The Kastenlot core catcher/core nose has been redesigned (see Figures 4 & 5):

(i) The operating arms have been increased in length to give a greater distance to the pivot pin and this, together with larger plates, gives a much greater mechanical advantage for closing the sediment-retaining doors as the corer is withdrawn from the sediment.

(ii) The opening mechanism of the spring-loaded core-retaining doors has been given a more positive 'lock' when the doors are in the open position - in particular this was to stop any tendency of the retaining doors to pre-trip during deployment and descent of the corer to the sediment and to give better protection to careless fingers.

(iii) The core-retaining doors and trip levers have been designed to lie more flush against the side of the core nose in order to prevent damage or distortion to the sediment core as it enters the barrel.

(iv) The inside dimensions of the nose have to be made virtually the same as the inside dimensions of the barrel. This results in a reduction of the inside clearance ratio (see Hvorslev, 1949) from 0.7 for the Kastenlot corer to very close to zero.

The square box is provided with a long perspex window down one whole side (Figure 6) and a series of small sample ports and large sample plates on the opposite side (Figure 7). Pore waters, Ph, redox, etc. can be sampled through the small ports, then the plates removed to expose the whole of one side of the interface and sub-surface sediment.

The square box adaptor (Figures 1 & 2) screws onto the corer weight stand with a retaining plate to first prevent overtightening the screw thread on assembly and second stop the box adaptor from coming unscrewed when in operation. The square coring box is attached to the adaptor with 8 stainless steel screws. It is an easy matter to disconnect the square box barrel and remove the adaptor (or vice versa) whilst the corer is either in the vertical or horizontal orientation.

(b) 10 cm diameter round barrel:

This is a 10 cm ID stainless steel tube which screws directly onto the weight stand with a retaining screw to avoid over-tightening the thread and also to stop the barrel from unscrewing when in operation. The sediment is held inside a clear liner (2.5 mm wall thickness) and is retained by a core catcher consisting of stainless steel fingers which fit up inside the liner. The gauge of the fingers can be varied to suit the type of sediment being sampled. The core cutter is then bolted onto the end of the barrel (see Figures 1, 3 and 8). The dimensional ratios for the round barrel and nose core are as follows: inside clearance ratio - 1.0; outside clearance ratio - 0; area ratio - 32.2. Only a 1 m core barrel can be used in conjunction with the support frame. Larger barrels of upto 3 m have been successfully used but this necessitates that the corer is recovered on board in the horizontal orientation, thus giving the possibility of core slumping.

(c) Weight stand:

The weight stand consists of a simple bolt-on stainless steel flap-valve, a long-armed bridle handle to allow free movement of the flap, a circular metal flange plate on which the weights rest and a coarse thread onto which screws either the square box adaptor or the round barrel (Figure 1). The 25 kg dough-nut-shaped lead weights, cut in a horseshoe shape (see Figure 6) for easy removal, are held in place by two removable stainless steel studs, the length of which depend upon the number of weights being used (see Figure 1).

(d) Corer frame:

The frame is made as a tripod (Figures 6-8) and is designed to be easily portable. It is made of tubular steel, takes to pieces and conveniently packs away in a box. The corer is manoeuvred into and out of the frame via the horse-shoe slot in the top of the tripod plate. The corer barrel is allowed to hang vertically in the middle of the tripod with the flange of the weight stand resting on the top of the tripod.

The core barrels can be attached or detached from the weight stand, or the sediment core sampled in safety even in a moderate sea.

(e) 6 cm pilot core barrel:

When either longer core samples or a pilot core is required an additional modification to the corer is available. A threaded adaptor (Figure 9) is screwed onto the weight stand and any pipe material of 3" external diameter with sufficient strength can be used as a core barrel, being held in the adaptor by

4 Allen cap screws (½" BSF). A scaled down core catcher and core cutter similar to that used on the 4" diameter barrel (Figure 3) are used. With this barrel long cores (3 m and over) can be easily taken although of course with long cores the corer can no longer be kept in the vertical orientation but has to be recovered on board in the horizontal orientation.

OPERATION

The corer has been successfully used on Discovery Cruises 105 to the N.W. African upwelling region, 108 to the Nares Abyssal Plain and 110 to the Peru upwelling and S.E. Pacific. Good core samples were taken in water depths ranging from 100 m to over 5000 m. There was a high success rate for the drops of this corer, the main problem being the occurrence of consolidated sediment at a number of stations.

Typical pull-out figures for the cores obtained were in the region of 0.20-0.35 tons with a total wire load (pull-out and weight of corer and wire) of 0.5-1.5 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 Figure 10.

The overall weight of the corer is 300 kg of which 250 kg is adjustable by the removal or addition of ten weights. The corer is deployed from, and recovered to, the tripod 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 square box barrel from the corer prior to sampling a core. Obviously the round core barrel has to be detached in order to remove the archive sediment in the liner.

For operation the corer was rigged as follows: corer, swivel, 8 m strop of main warp, swivel, main warp with acoustic beacon 100 m above the corer in water depths greater than 250 m. The corer is lowered at 1-1.5 m/sec. No tendency for pre-tripping of the square box sediment-retaining doors was seen at these speeds.

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. 0.2-0.3 m/sec) with sufficient weight to get the depth of core required. Often a preliminary 'sighting' core must be taken before a satisfactory sample is obtained. For more consolidated sediments a faster 'run-in' speed is used (up to 1.5 m/sec) with maximum weight.

Impact is normally easily recorded on the ship's dynamometer (Figure 10) and approximately 10-25 m of slack wire is allowed depending on the ship's heave and accuracy of the depth measurement from the pinger trace. The warp is then hauled slowly (0.1-0.2 m/sec). As the corer is pulled from the bottom sediments the extra load (pull-out - up to 0.35 tons) is clearly seen on the dynamometer (see Figure 10).

The new corer has been successfully used in sea states of 4 or 5 and being a smaller, lighter corer has proved to be much easier to control during rough weather than the box corer or Kastenlot corer.

CONCLUSIONS

The new multi-purpose gravity corer has proved to be a simple, reliable tool for taking a range of sediment samples without requiring main warp loads in excess of 1.5-2.0 tons.

Interface samples taken with the square box barrel, whilst not normally as good as those taken by the IOS box corer, which of course has a much larger sampling area, are more than adequate for many purposes. If the length of the core is sacrificed and a slower sediment entry speed is employed, the quality of the interface sample improves.

The interface and sub-surface sediments are very quickly and easily accessible in the square box barrel. From the corer being brought into its tripod, it is only a matter of moments to remove the sample ports or plates and start sampling. The ability to sample the sediment so rapidly has considerable advantages particularly for pore water work and bacterial studies.

Contamination does not appear to be a problem for any of the samples and, from the apparently undisturbed worm structures observed in the square box cores taken on Discovery Cruise 110, core shortening does not seem to be occurring.

ACKNOWLEDGEMENTS

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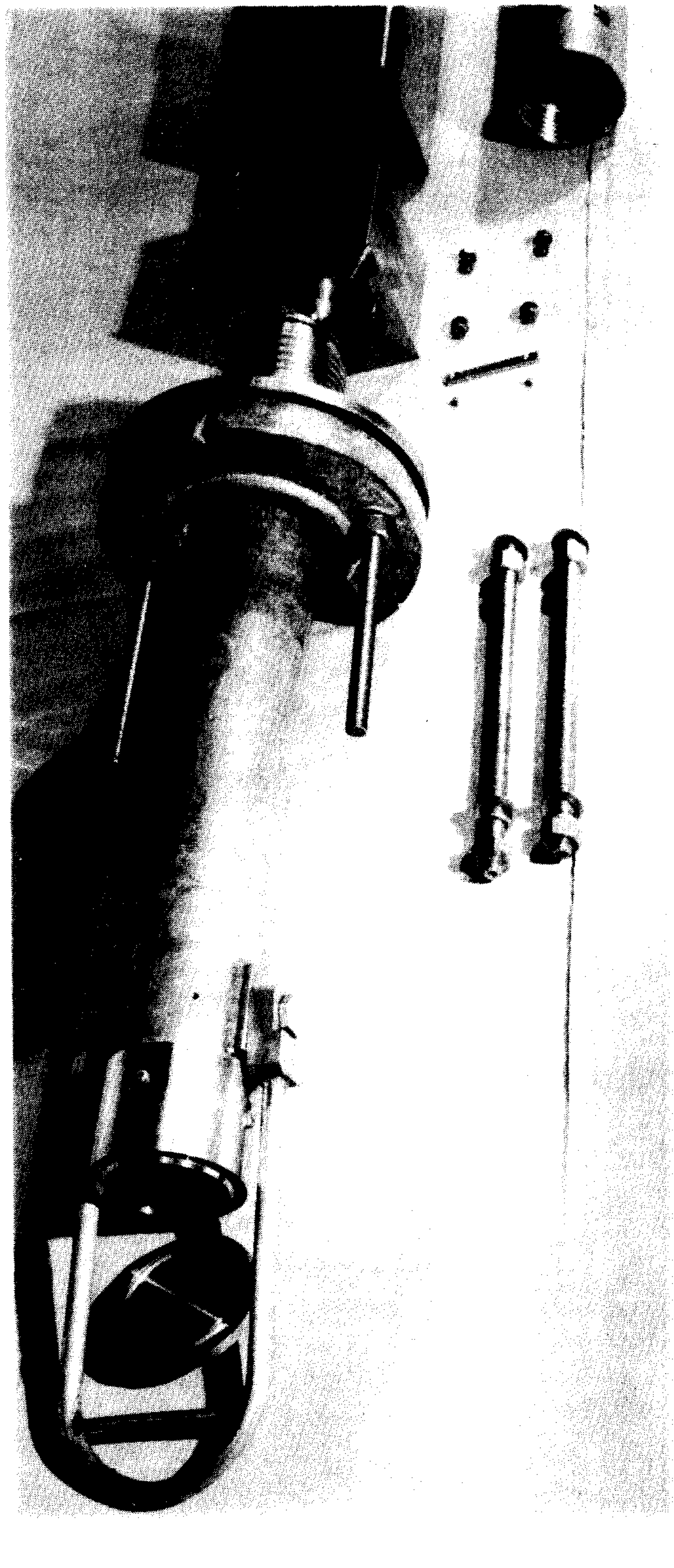

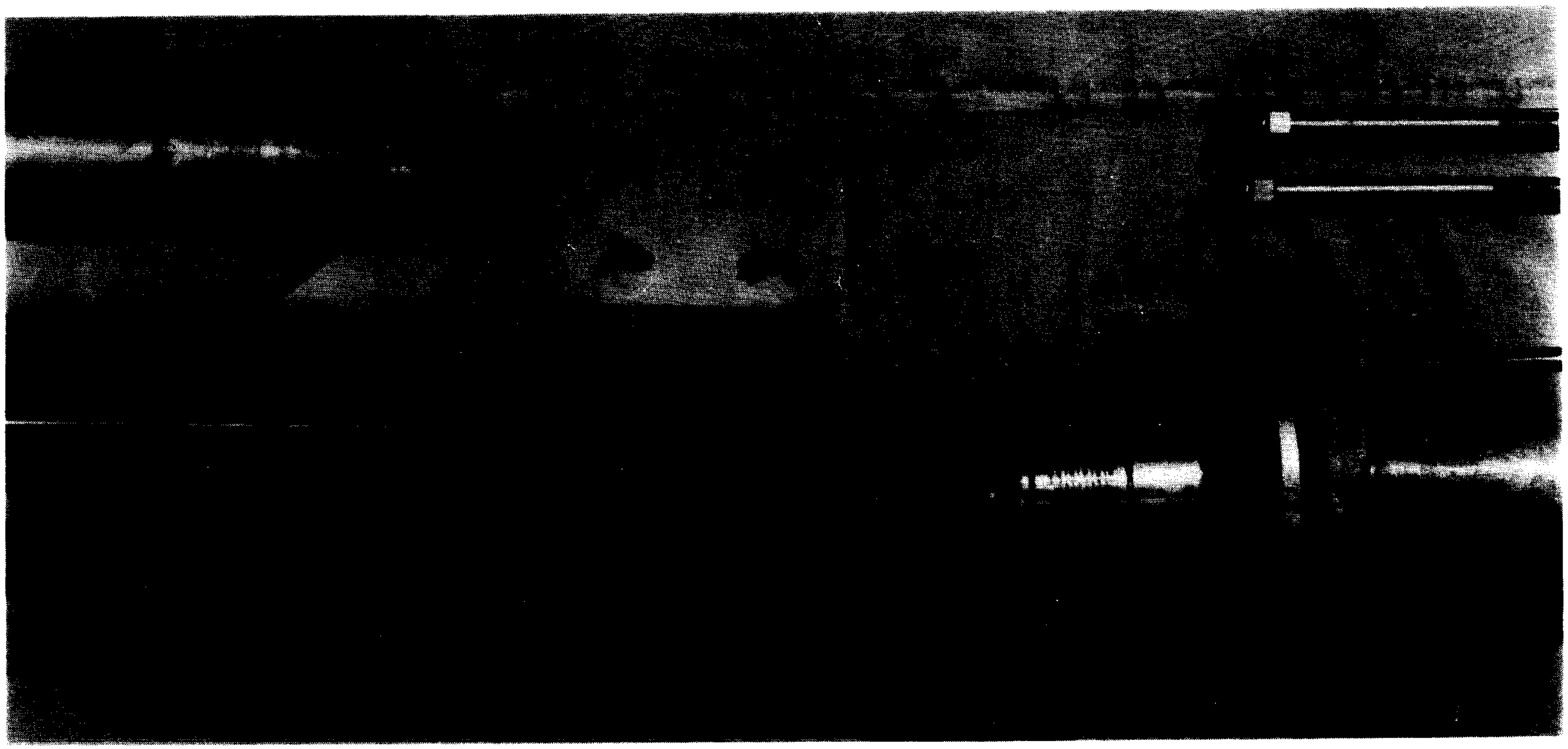

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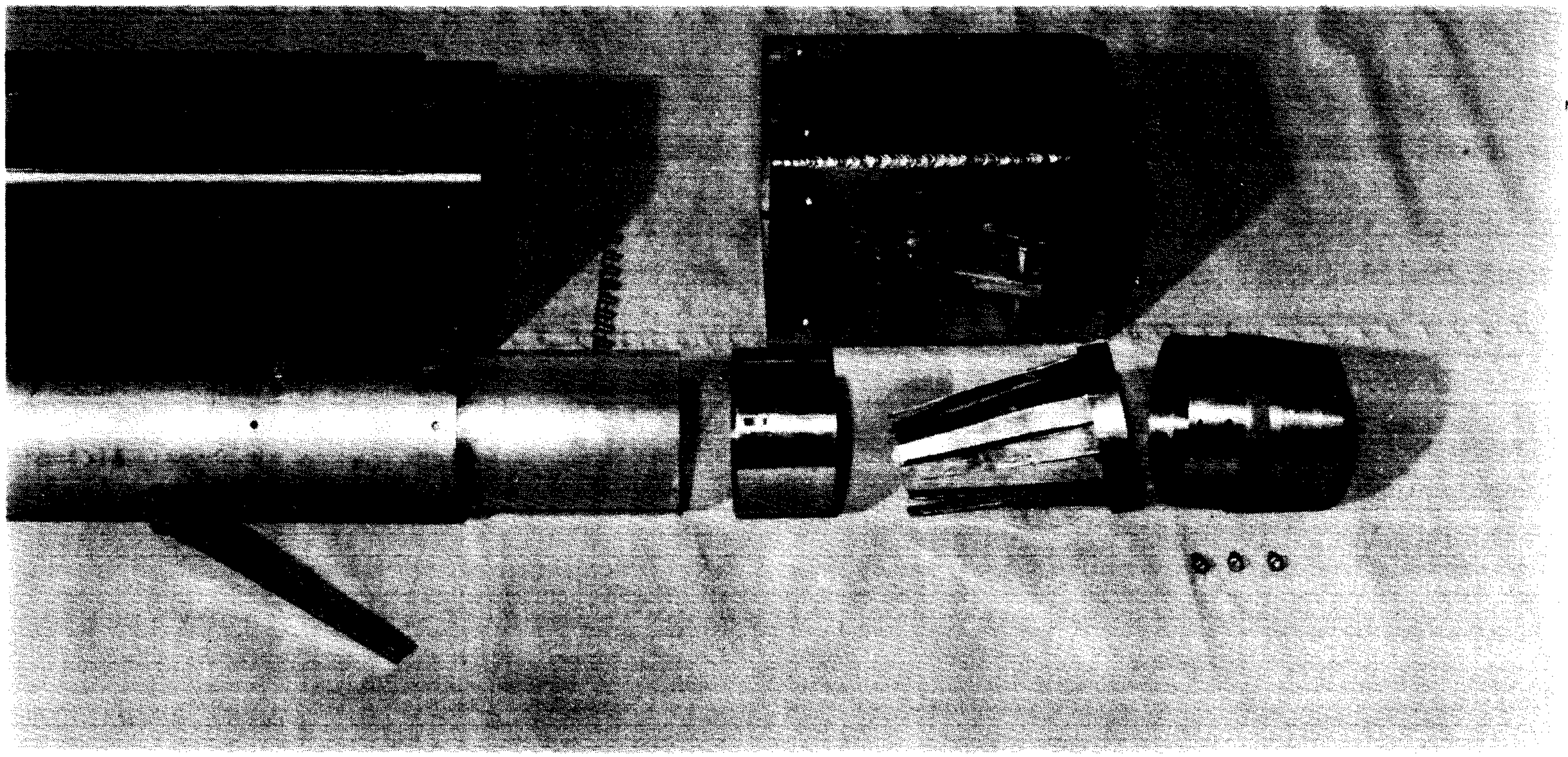

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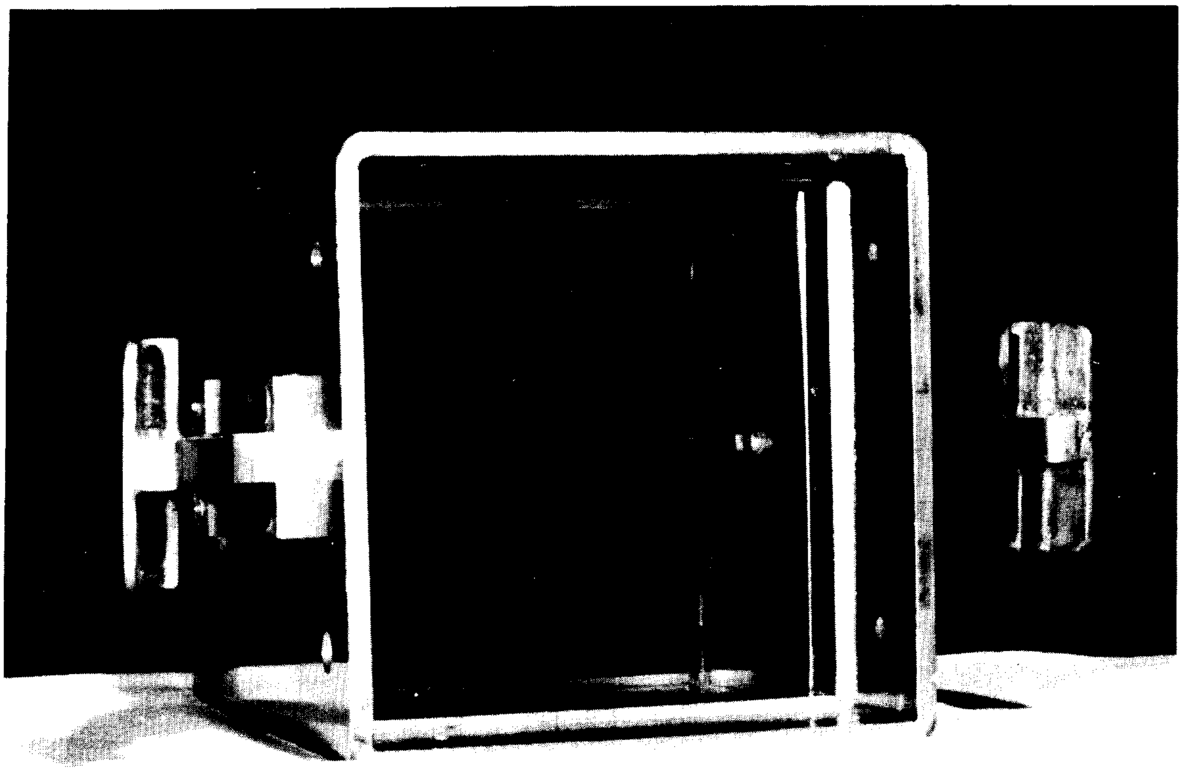

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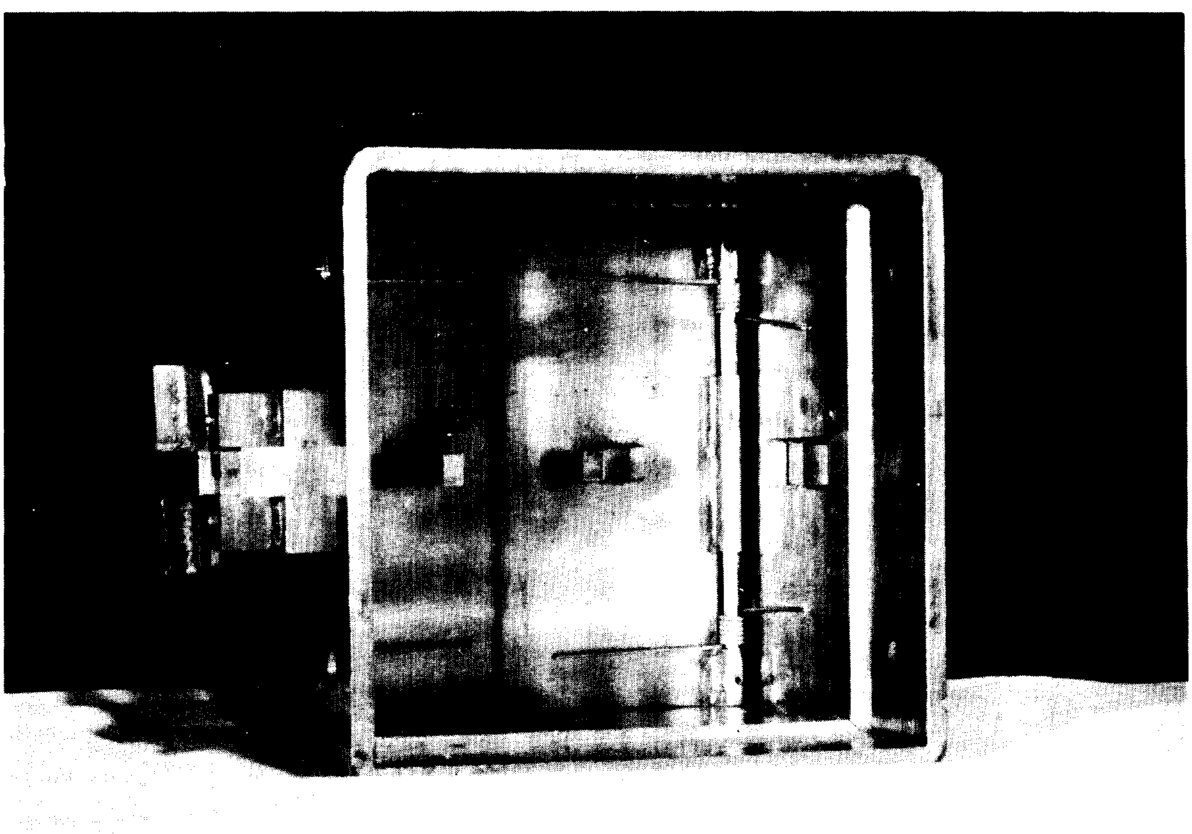

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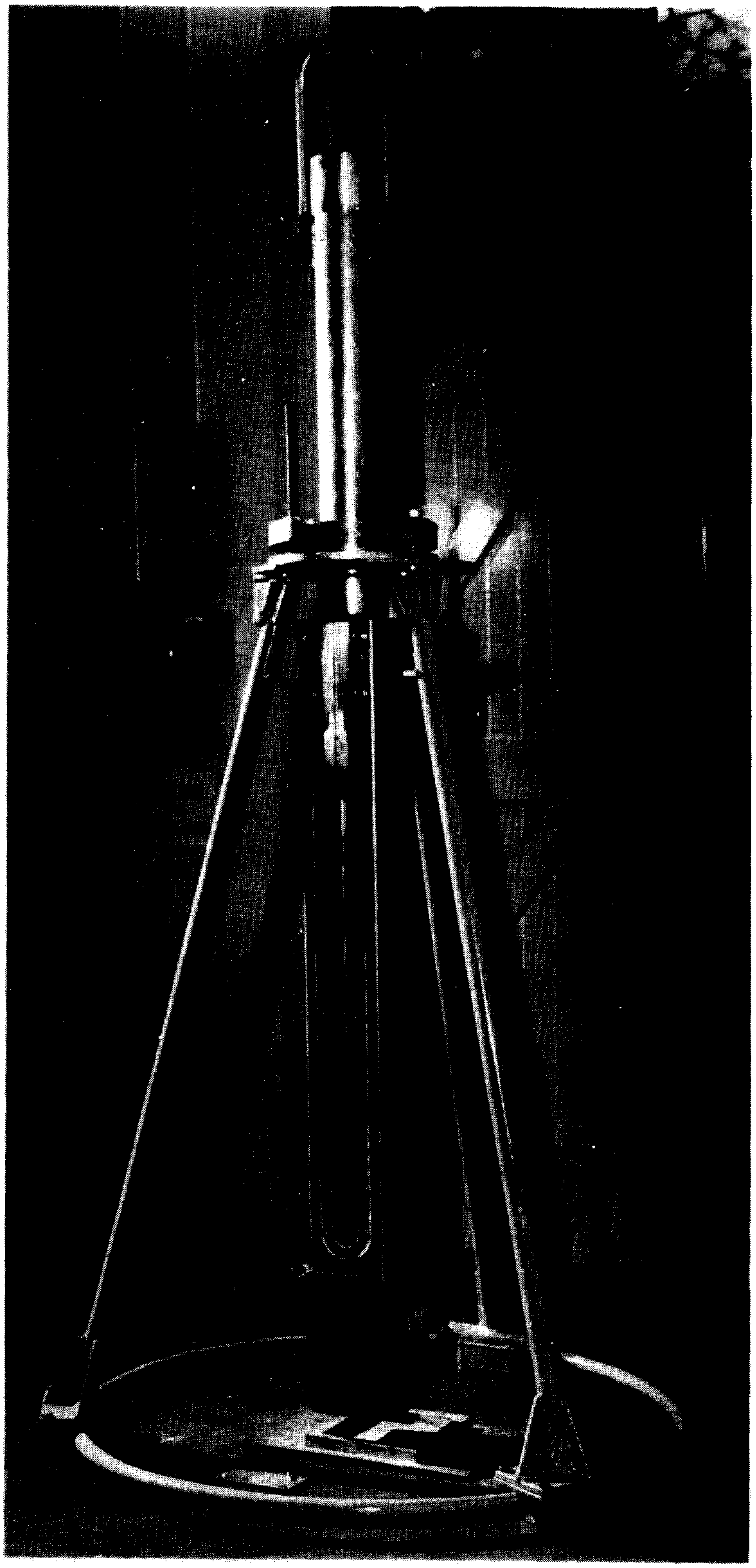

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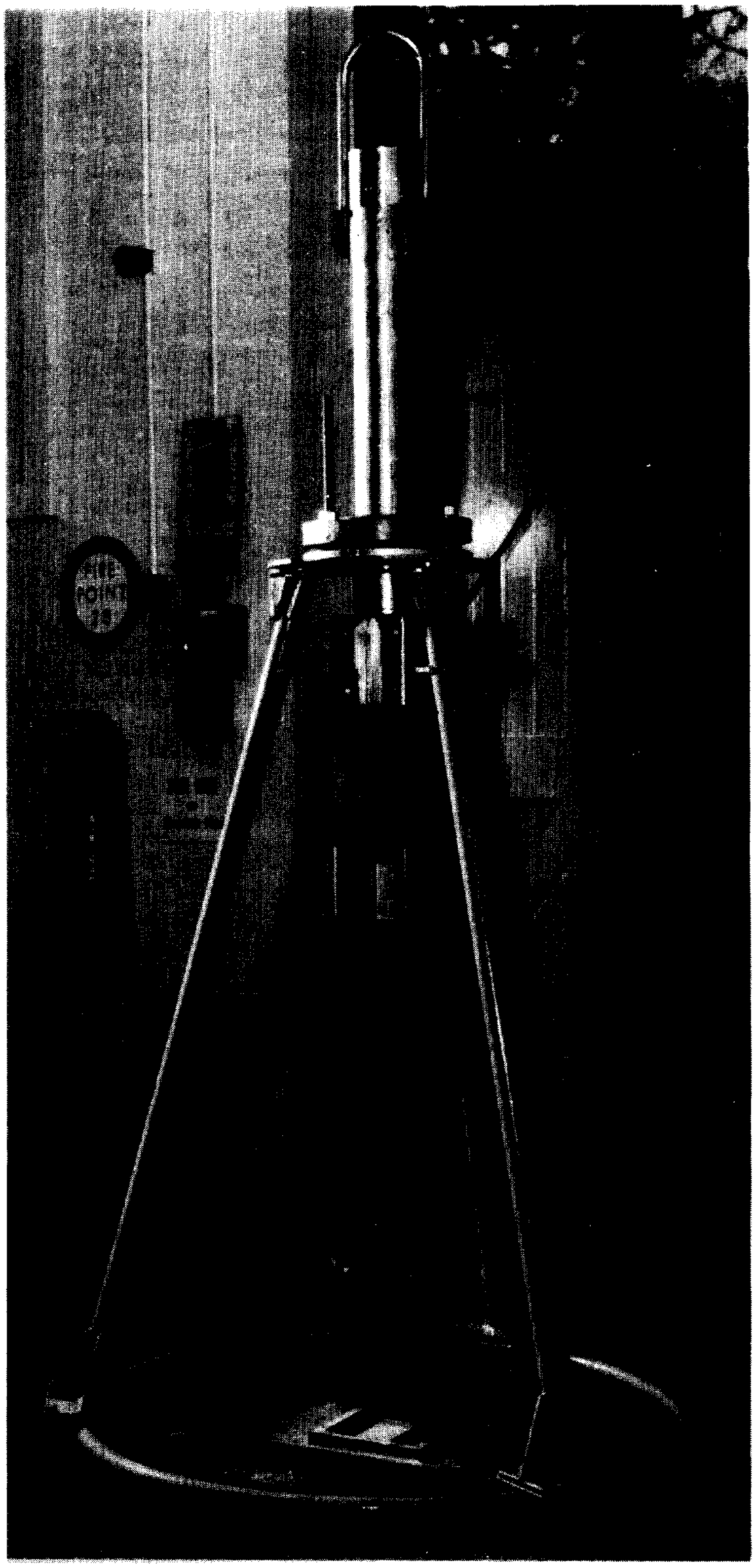

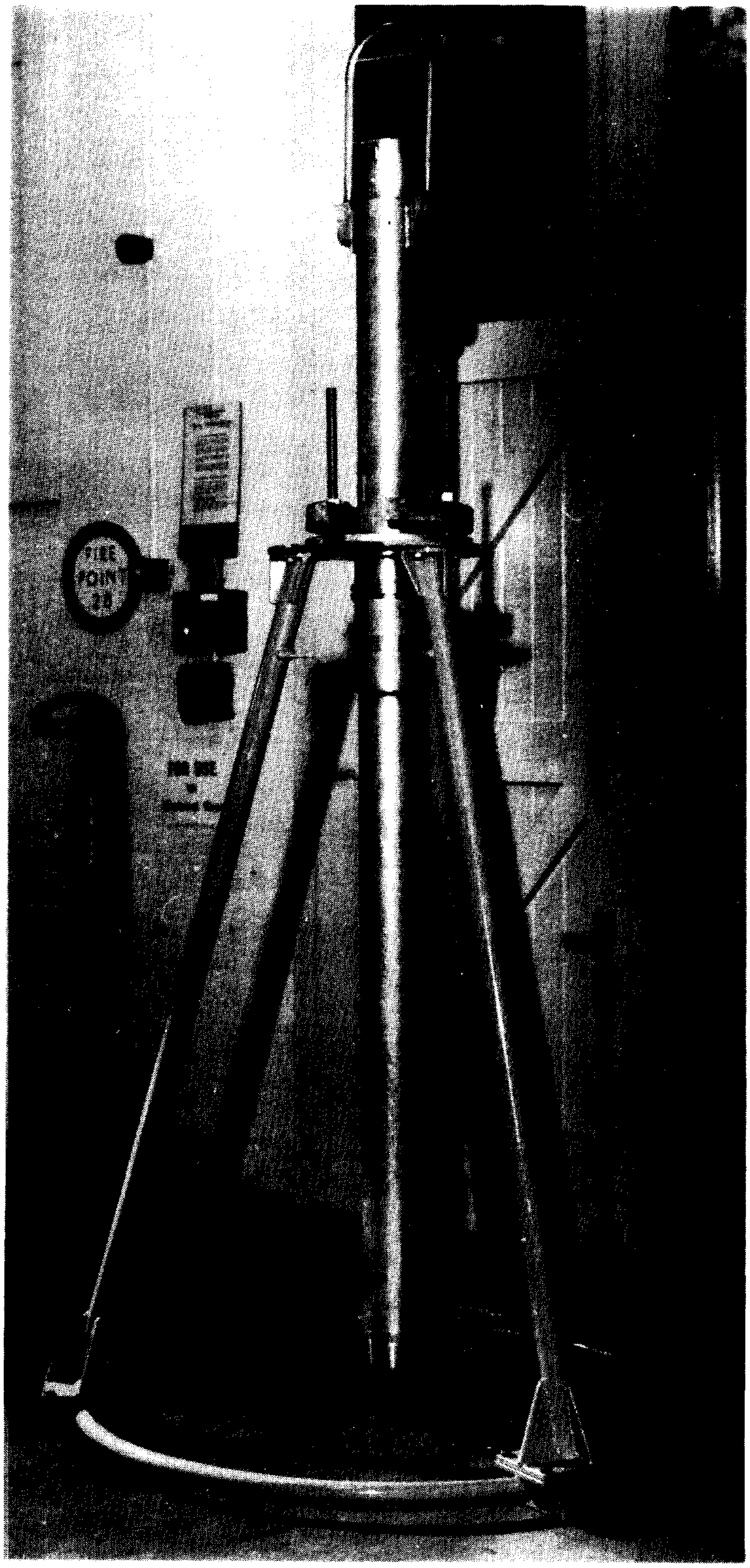
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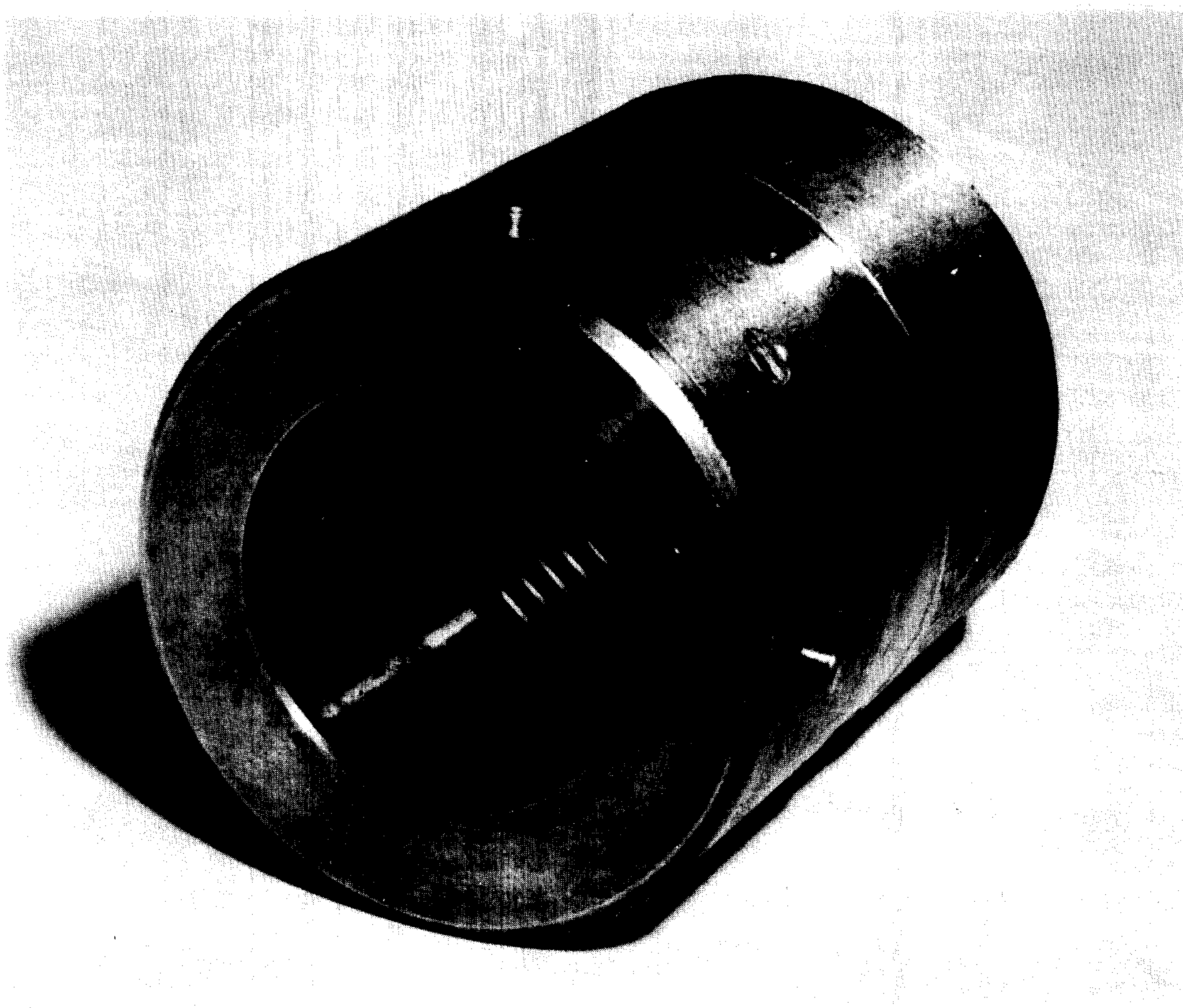

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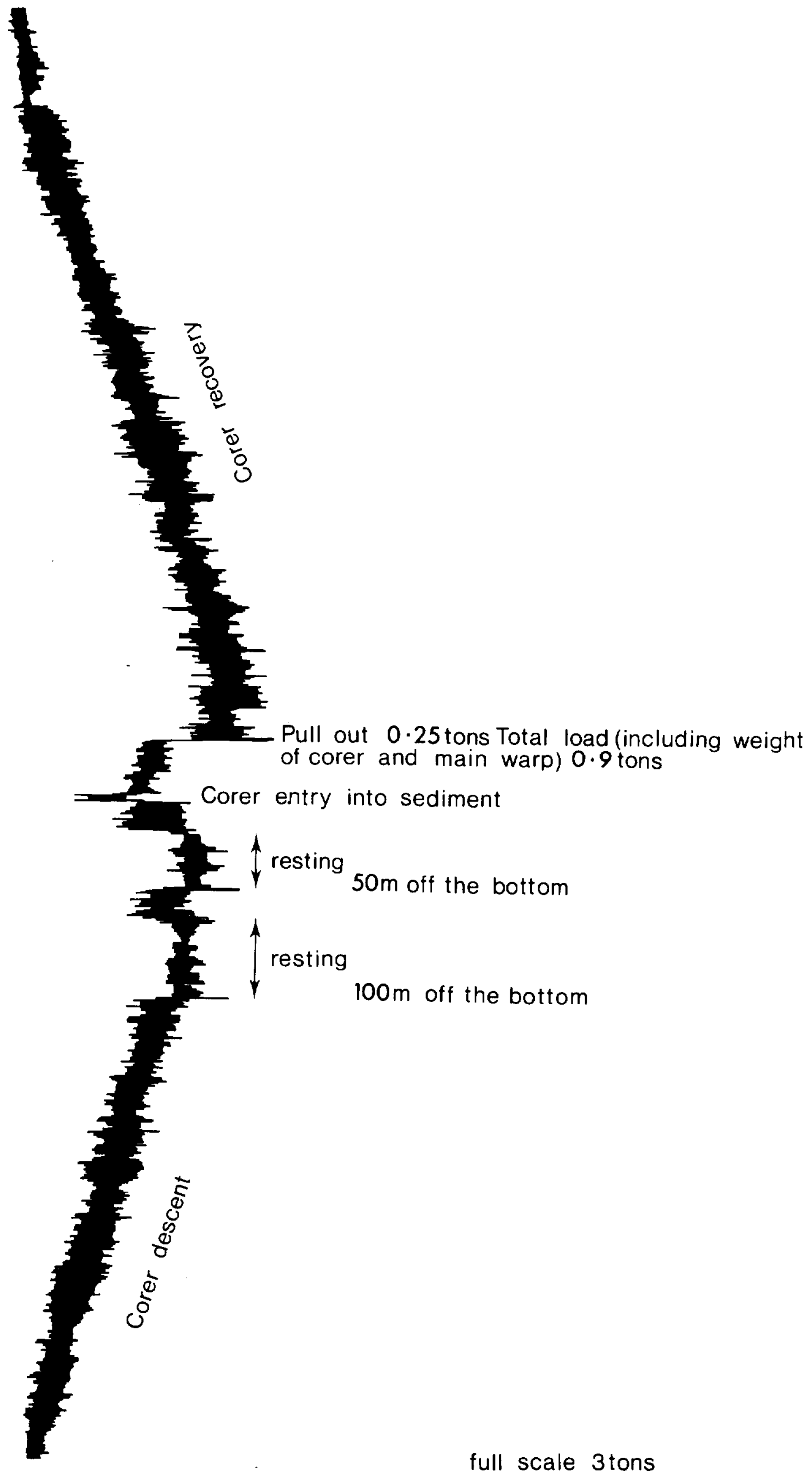
Corer recovery
Pull out 0·25 tons Total load (including weight of corer and main warp) 0·9 tons
Corer entry into sediment
resting
50m off the bottom
resting
100m off the bottom
Corer descent
full scale 3tons