DEPARTMENT OF OCEANOGRAPHY UNIVERSITY OF WASHINGTON

Technical Report No. 41

A PISTON CORING DEVICE FOR SEDIMENT SAMPLING

Office of Naval Research
Contract N8onr-520/III
Project NR 083 012

Reference 55-4
February 1955

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UNIVERSITY OF WASHINGTON DEPARTMENT OF OCEANOGRAPHY
(Formerly Oceanographic Laboratories)
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A PISTON CORING DEVICE FOR SEDIMENT SAMPLING

by

Richard G. Bader and Robert G. Paquette

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ABSTRACT

A new piston corer is described which is a modification of the Kullenberg coring tube, but eliminates some of the disadvantages of the latter. A cable-clamping device, termed a piston immobilizer, prevents the upward movement of the piston after penetration into the sediments has ceased. This prevents drawing in large quantities of sediments from a single level. The collapse of the liner tube and leakage at the liner joints are eliminated and disruption of the core sample is kept to a minimum. An improved core-retaining device and a flange connector between weight stand and core barrel are also described.

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

The theory, desirability and use of piston coring devices have been amply discussed by Kullenberg (1947). In general the basic design of a piston coring device is such that the difference in pressure, produced by the piston between the mouthpiece of the coring tube and the top of the sediment core, overcomes the frictional resistance between the sediment core and the internal wall of the coring tube. Ideally, the piston should remain fixed at the level of the sediment surface during the penetration of the coring tube, under which condition a relatively undisturbed vertical section of sediment may be obtained. This is to be contrasted with the simple gravity-driven coring tube where various distortions of the core occur due to retardation of the entering material by friction.

Several experimental problems are inherent in the piston corer as used heretofore. When the coring tube has failed to penetrate to its full length, the piston, during the process of extracting the corer, will be pulled up the tube to the limit of its travel. Sediments from essentially one level will continue to be drawn into the tube in a mixed condition during this process. In addition, with the thin-walled metal tubing commonly used as a liner, the liner may collapse due to the differential pressure immediately below the piston, and water from the outside may enter the core through joints in the liner sections, thus disrupting the core.

The modifications in the design of this coring tube have been made primarily to eliminate the above difficulties. This has been accomplished by: (1) designing and constructing a device, the piston immobilizer, which prevents further movement of the piston shortly after penetration of the corer into the mud has ceased and before the corer is extracted; and (2) the use of thick-walled liners with threaded and sealed joints. Other modifications include a positive-acting core-retaining device, a simplified flange arrangement for connecting the core barrel to the weight stand, and an improved counterbalance weight.

The most important consideration is the prevention of piston movement after core penetration. This can be accomplished in three basic ways after maximum penetration has been reached: (1) the piston cable may be detached from the hauling cable; (2) the common piston and hauling cable may be clamped firmly to the body of the corer so as to immobilize the piston; or (3) two separate cables, reaching from the corer to the surface, may be used for piston and for hauling. The latter method may be dismissed immediately as unsuitable except in very shallow water. The first principle has been used by Emery and Broussard (1954), but since detachment of the piston cable from the hauling cable is effected by a messenger, the method is adaptable only to moderate depths. Moreover, the complications and dangers of fouling are increased considerably by the necessity of having two cables and, when free fall is used, two loops of cable. Therefore, the remaining alternative of clamping a common piston and hauling cable has been chosen for the present device. The hauling cable is firmly clamped to the head of the corer by a mechanism actuated by a timer which will function at all depths.

DESCRIPTION OF PARTS

The piston immobilizer is a device, fastened to the top of the weight stand, which grips the supporting cable a short period of time after the corer is released, and sustains the forces of extracting and hoisting the corer. The piston meanwhile remains fixed at the level it reached at maximum penetration of the corer.

The cable-gripping device (Fig. 1) consists of a pair of parallel steel jaws faced with copper which move on rollers along flat steel faces, which are inclined slightly toward the axis of the cable. These are driven into the gripping position by springs, and as soon as the cable is gripped, are pulled tighter by the tension on the cable itself. In laboratory tests the device has sustained 1,000 pounds of weight while allowing the cable to slip only about 1-1/2 inches during the gripping process. The jaws are built into a heavy steel frame designed to withstand the large forces involved.

The actuation of the piston immobilizer is accomplished by means of a timing device which releases the two jaws simultaneously through a trigger mechanism called the second trigger (Fig. 2). The timing device itself is set into operation by a first trigger operated by a trigger wire from the corer release mechanism. Timing is effected by means of a spring-driven hydraulic piston controlled by the viscous flow of oil through a small hole in the piston. The extruding piston rod actuates the second trigger. Rotation of the two arms of the second trigger releases the cams from the mating fixed lugs and permits the sears, together with the

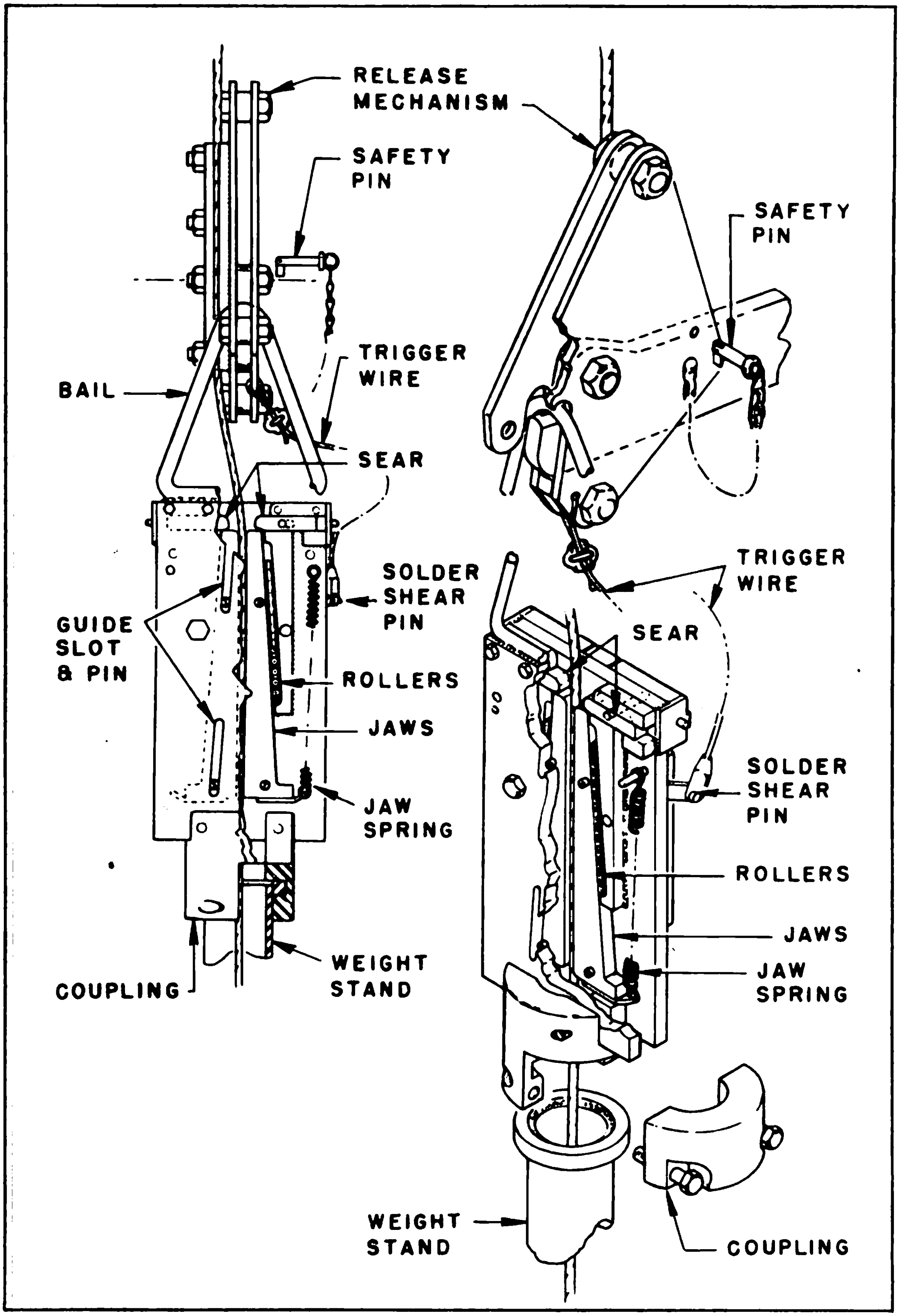

Figure 1. Release mechanism and piston immobilizer, internal construction.

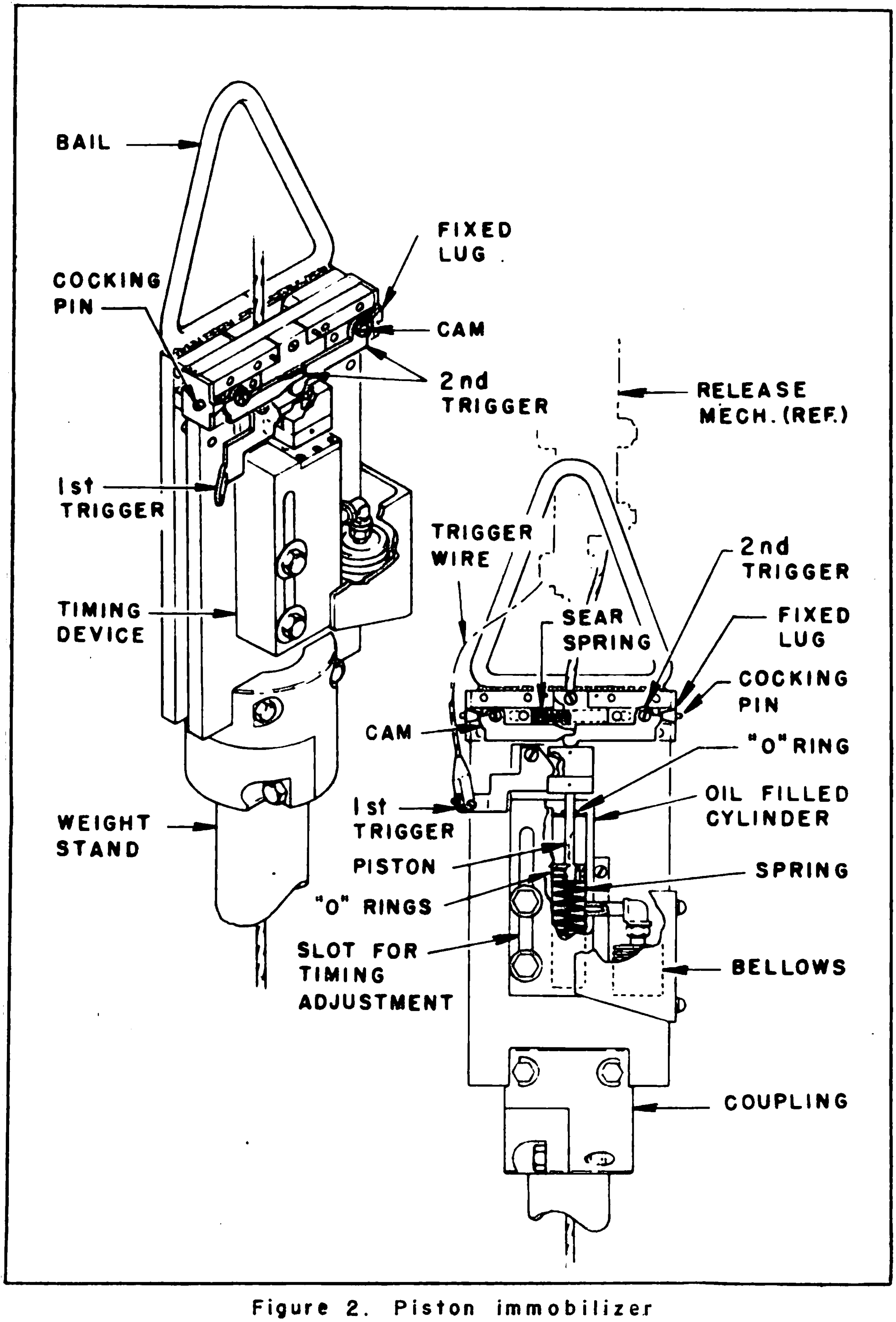

Figure 2. Piston immobilizer showing timing device.

triggers, to be driven outward by the sear spring. This action releases the jaws which are driven into gripping position by the jaw spring.

Gross adjustments in time of operation may be made by changing the viscosity of the oil. Fine adjustments are made by a movement of the timing device, with respect to the trigger mechanism. At present the maximum operating time is 45 seconds at 70° F, and the minimum time may be set as small as desired. In practice a period of about 10 to 15 seconds is used, making allowance for the water temperature at the coring site. It is believed that maximum penetration will have been attained in this period for moderate core lengths.

An essential feature of the hydraulic piston mechanism is the sylphon bellows which transmits the external pressure to the interior of the oil chamber. The device is thus insensitive to hydrostatic pressure except insofar as the pressure may affect the viscosity of the oil.

Next in importance is the nosepiece of the corer. Reference to the drawings (Figs. 3 and 4) will clarify its operation. It is probably similar to the one described by Kullenberg (1947), but the drawings in the reference are too small to confirm this. The nosepiece performs the functions of cutting, providing clearance for the descent of the core tube, and housing and actuating the core retainer. The latter is a metal tongue generated from a segment of tubing of the same radius as the core liner, and designed to fit closely in the bore when lying across the latter at an angle of 60° from a hinge at the base of the tongue. During the descent the core retainer is in a fitted recess and held flush with the bore by a catch. The catch is released by a short downward motion of the nosepiece as the corer is withdrawn from the sediments. The nosepiece is fastened to the end of the retainer housing by means of a bayonet joint having sufficient longitudinal freedom of motion (1/8 inch) to release the core retainer. This motion is prevented during handling and lowering by a safety wire which is weak enough to fail by bending when the corer is extracted. Once free the core retainer is projected into the core by a spring, and any slippage of the core tends to carry the retainer across the bore and seal it.

Two types of core barrel are used with the equipment, and the nosepiece and weight stand are made adaptable to both. Core barrels up to 10 feet long are made from extra strong 2-inch I.P.S. steel pipe. Those 20 feet long and longer are made from seamless cold-rolled steel tubing, 2 inches i.d. x 3 inches o.d. For lengths longer than 20 feet, the individual sections will be coupled by 29°, 4 pitch, tapered Acme threads with 3-1/2 inches o.d. reinforcing sleeves that are 6 inches long.

The weight stand is made from cold-formed seamless tubing 2-3/8 x 1-5/8 inches, and is capable of carrying twenty 50-pound weights. It is bolted to the coring tube by means of standard 2-inch steel pipe flanges, welded in place (Fig. 3). This produces a coupling stronger than the pipe and eliminates difficulties due to concentration of stresses at threads, or bending and jamming within a sleeve. The weights are cast in 50-pound cylinders slotted on one side so as to facilitate assembly. Cast iron was used both for reasons of economy and because the units could easily be cast with interlocking lugs and recesses, which lock them together when they are stacked with the slots alternately in opposing positions.

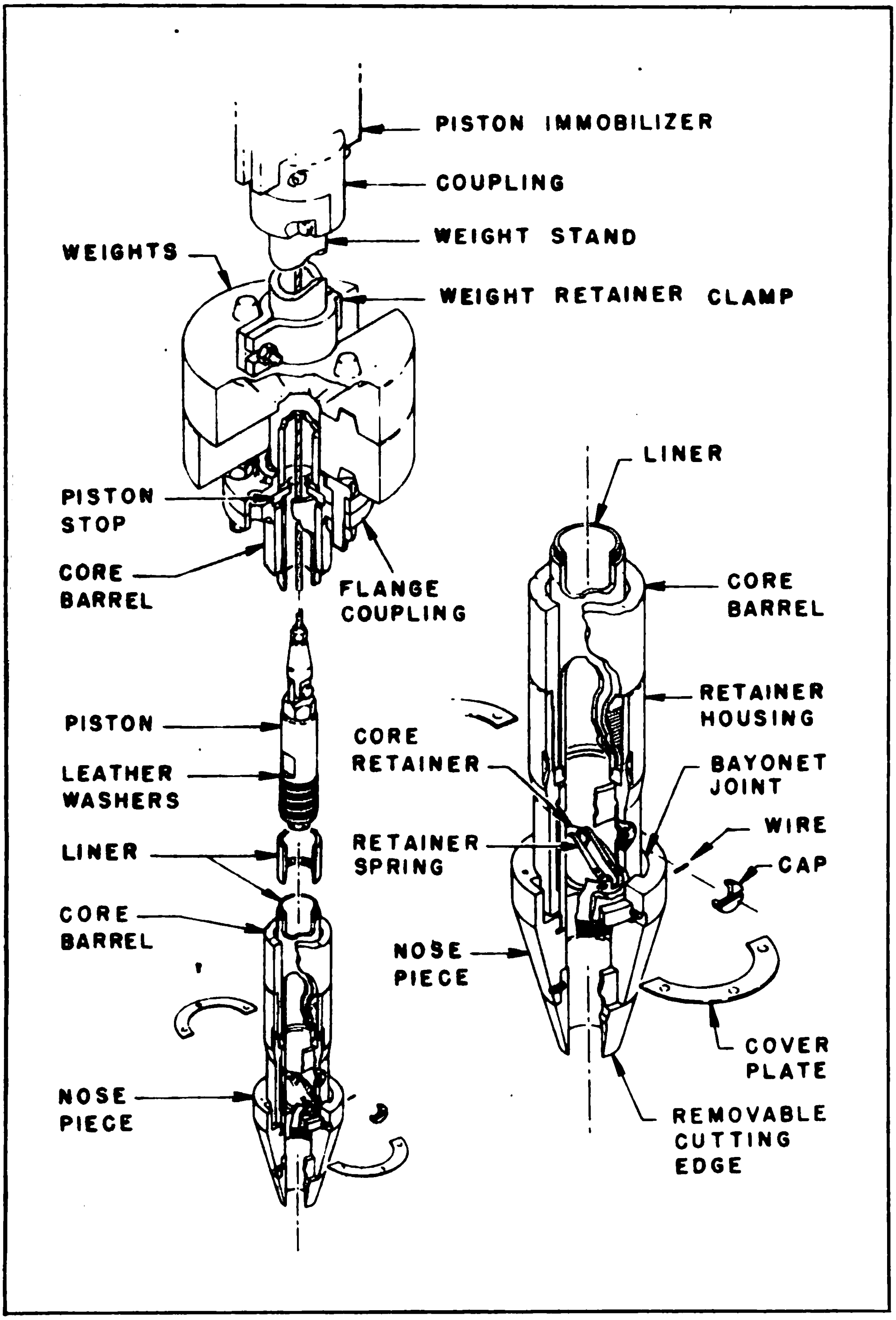

Figure 3. Nose piece assembly, weight stand and coupling.

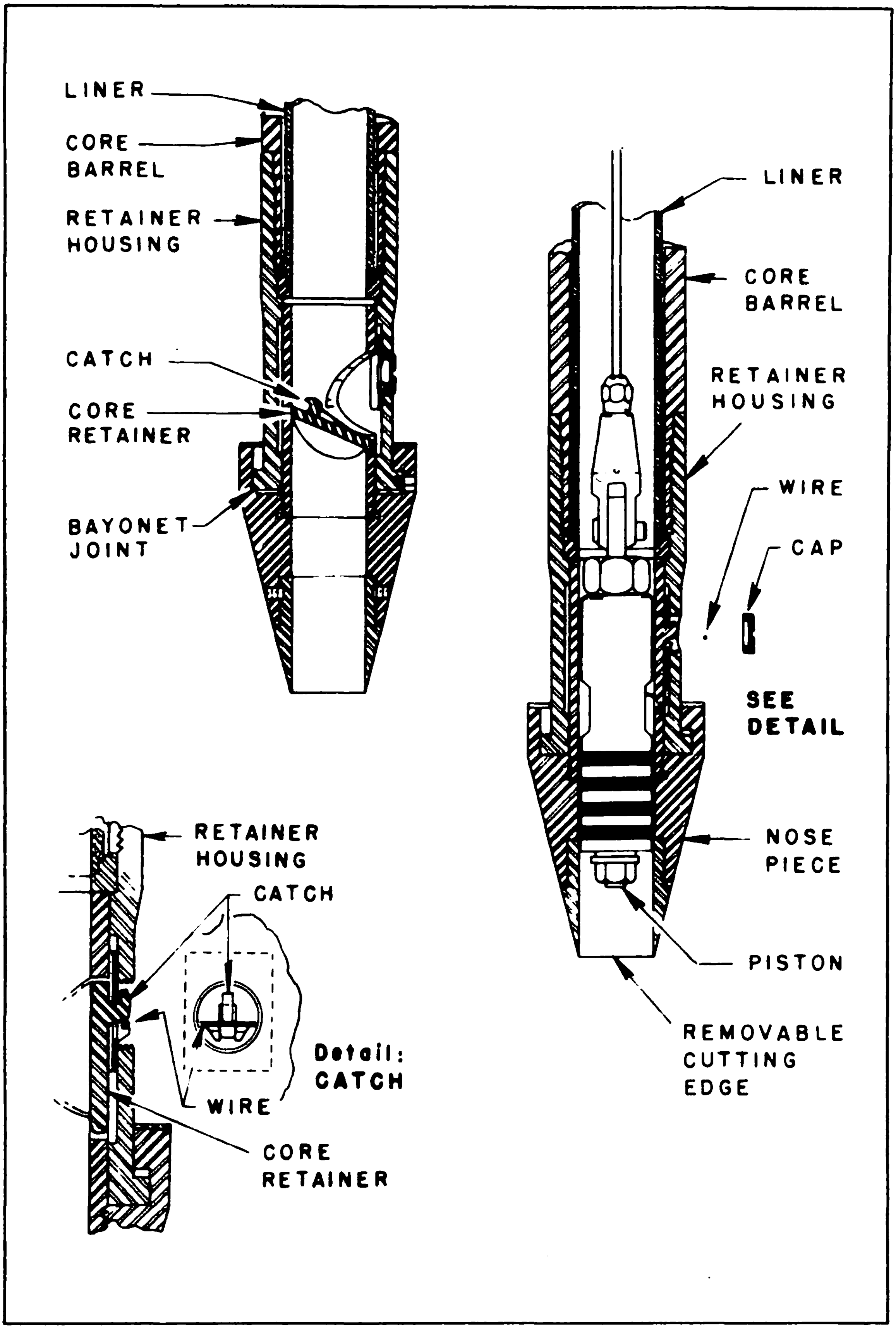

Figure 4. Detail of nose piece assembly and core retainer.

There is perhaps a certain novelty to the use of heavy core liners. The liner used in the present corer is made from 1-1/2-inch I.P.S. aluminum tubing which fits the inside of either light or heavy-walled core barrels with moderate clearances, 0.015 inch and 0.050 inch radial, respectively. It is made in 22-inch pieces which screw together with straight threads. A short adjustable section used at the top of the corer permits the total liner length to be adjusted for any core length. The threads are kept lubricated with a heavy adherent grease to prevent seizing. A shallow groove is turned in the outer surface at the joint to take a wide band of thin rubber cut from 2-inch "gooch" tubing, which completes the seal against leakage under differential pressure.

Corrosion of the liners can be a problem and storage of cores therein for any considerable period is undesirable. In practice the sections are unscrewed and the core is extruded into glass storage tubes immediately after hoisting. The liners are then rinsed in fresh water. With this treatment no difficulty has been experienced. There is some disadvantage in the displacement volume occupied by a thick-walled liner, but it is believed that this is more than outweighed by effective prevention of leakage at the joints and of collapsing liners which are common with thin tubes.

The piston is of conventional design consisting of alternate washers of metal and leather compressed and attached to a stainless steel body by a bolt (Fig. 4). Connection to the line is made by means of a stainless steel Fiege fitting. At present the design is for 1/4-inch

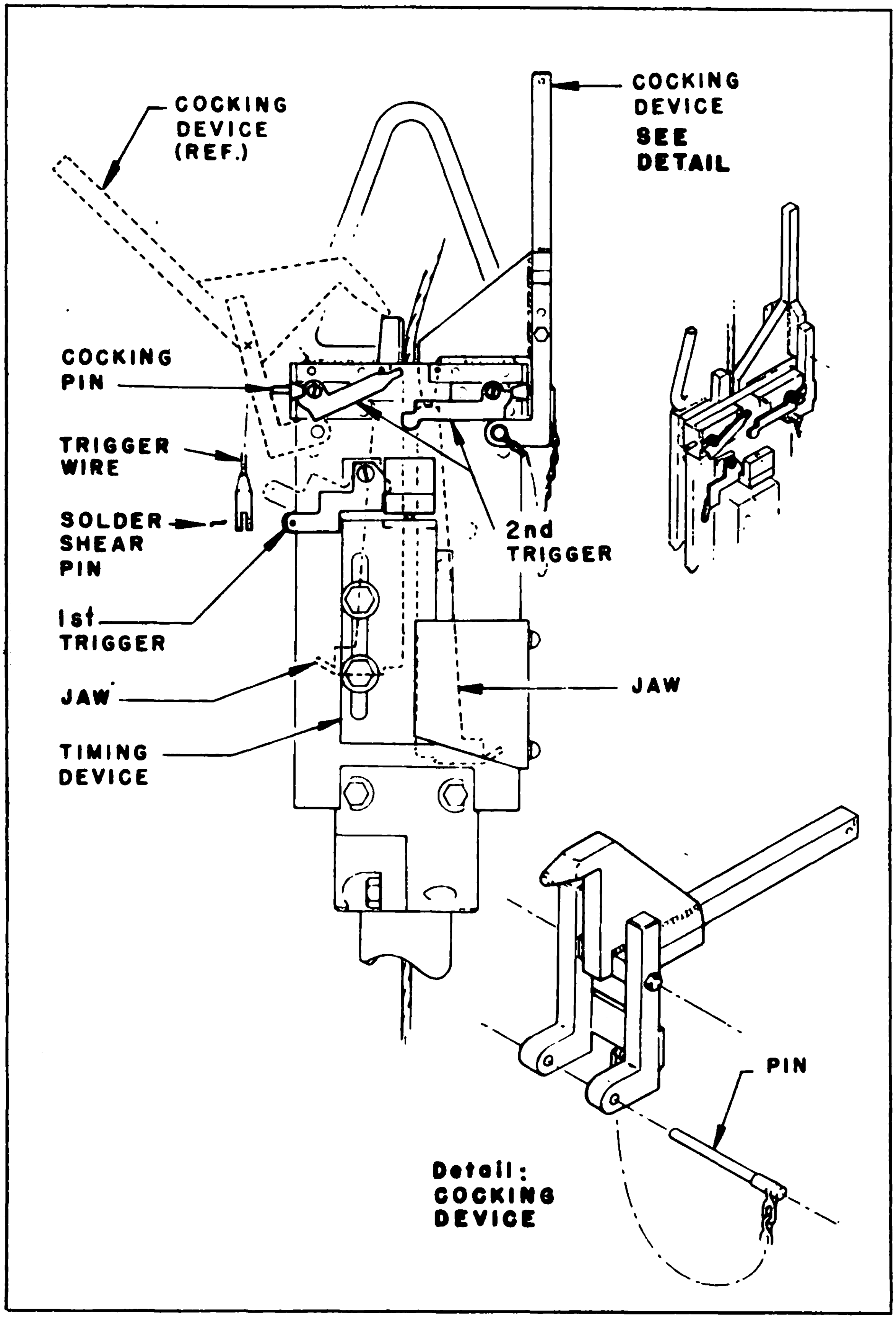

Figure 5. Cocking proceedure for piston immobilizer and detail of cocking device.

wire rope, but it will be modified for the 7/16-inch rope needed at greater depths.

The release mechanism is conventional in principle (Fig. 1). See for example Hvorslev and Stetson (1946), Silverman and Whaley (1952).

Some improvement in the counterbalance weight has been achieved by mounting it in the center of a 24-inch disk of heavy wire mesh. It is believed that this causes it to respond more readily when contacting the very soft surface of the sediment.

It was found necessary to devise a tool for cocking the spring-loaded jaws of the piston immobilizer. The device and its use are illustrated in Figure 5.

NOTES ON HANDLING AND OPERATION

Figure 6 illustrates the release, penetration and hoisting of the coring tube and schematically presents the functioning of the piston immobilizer. During lowering, the coring tube is held in the release mechanism and the piston is at the nosepiece of the corer. The cable supporting the coring tube is free in the open jaws of the piston immobilizer. Upon the impact of the counterbalance weight on the bottom, the coring tube falls free of the release mechanism and begins to penetrate the sediments. The trigger wire is pulled taut by the release, and before shearing the solder shear pin, rotates the first trigger. This activates the timing device on the piston immobilizer. During penetration the jaws of the immobilizer remain open and the coring tube slides down around the piston. When the corer has attained maximum penetration,

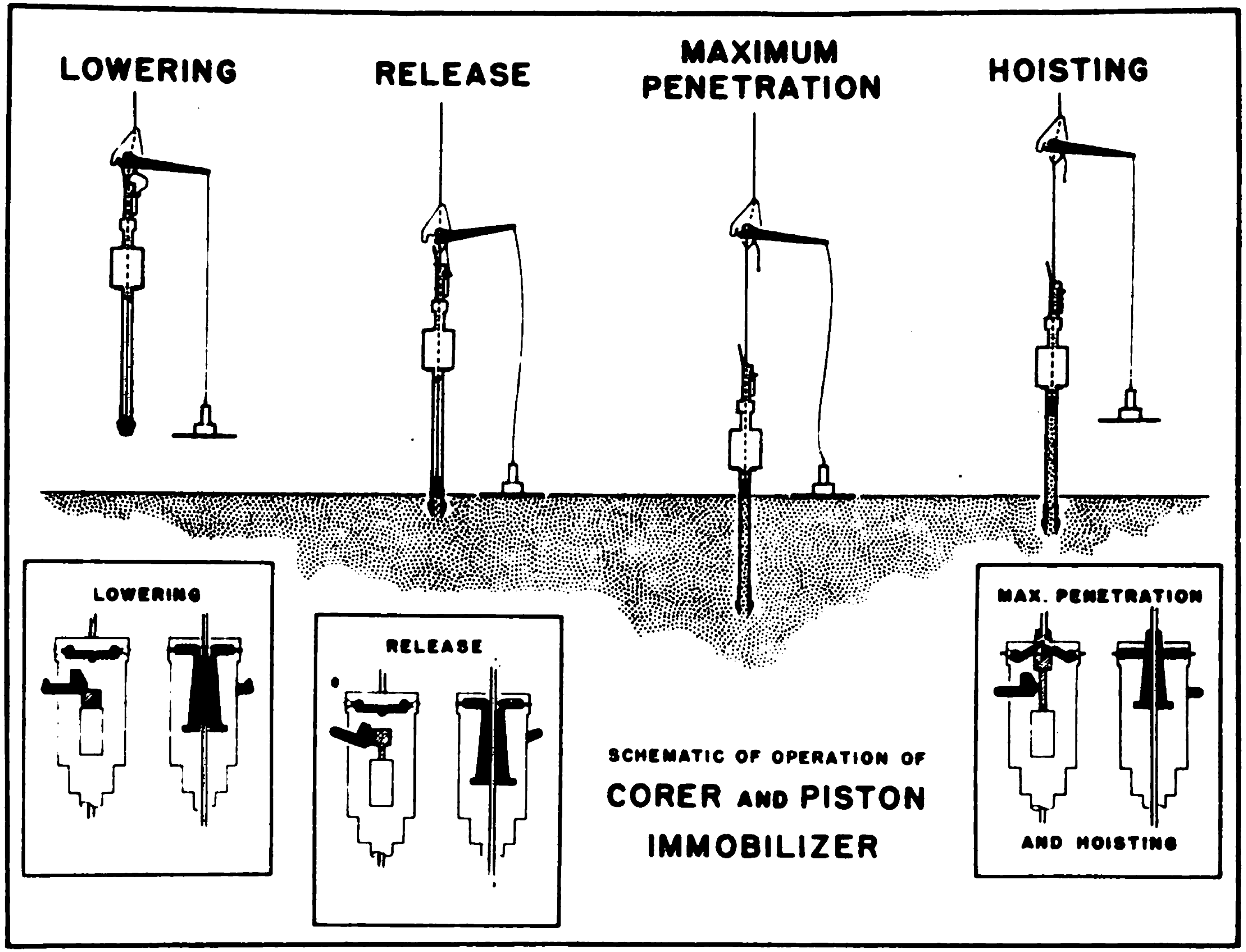
LOWERING
RELEASE
MAXIMUM PENETRATION
HOISTING
LOWERING
RELEASE
SCHEMATIC OF OPERATION OF
CORER AND PISTON IMMOBILIZER
MAX. PENETRATION
AND HOISTING

Figure 6.

and after the lapse of a predetermined time interval, the extruding piston of the timing device completes its rotation of the second trigger. This allows the jaws of the immobilizer to clamp the wire. During the process of extracting the corer from the sediments and hoisting, the piston does not move up the tube.

To date the equipment has been tried on a number of occasions in shallow water with 10- and 20-foot tubes and has functioned perfectly. In these first experiments the corer was assembled on deck and rigged over the side by a combination of winch power and power-operated tackles. Since that time a rack for assembling and handling the corer outboard of the rail has been constructed and tested (Fig. 7). This consists essentially of a very rugged collapsible framework holding a cradle for storage of the weight stand in a horizontal position, and a pivoted slotted plate into which the coring tube is fastened; this facilitates the operation of lowering it into the horizontal position after hoisting. The only hoisting device required, aside from the main winch, is a small winch aft which serves to hoist and lower the nose of the tube, using appropriate devices for attaching the cable to the corer. Thus the use of dangerous hand-manipulated tackles is avoided. Auxiliary supports are provided for the tube so that assembly and disassembly may be carried out when the corer is horizontal. The addition or removal of weights is done with the weight stand vertical.

Present plans call for operating the corer without free fall. Experience to date has shown that when free fall is used, the loops of spare cable very frequently become kinked and damaged and much time is

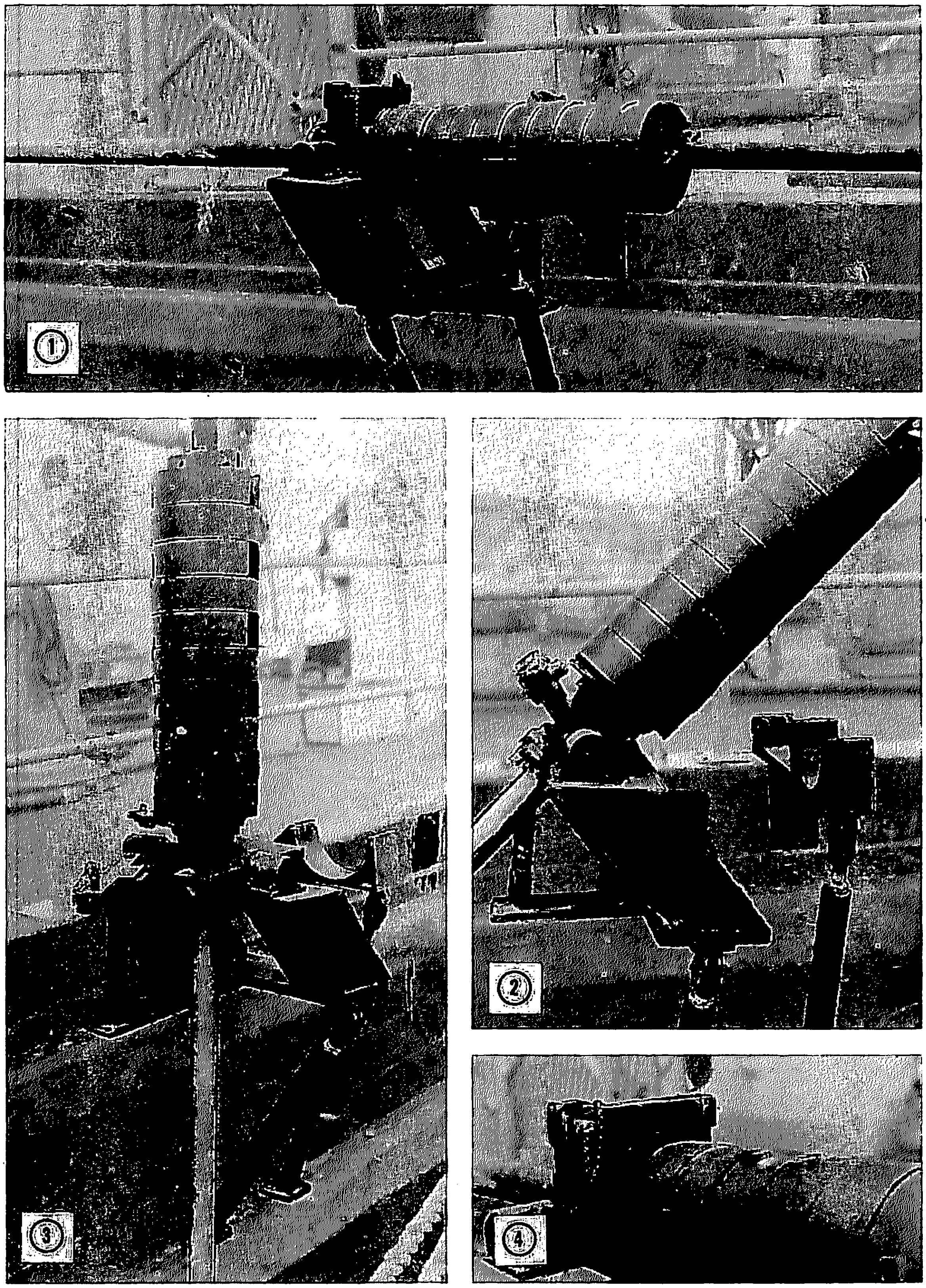

Figure 7. Rack for assembling and handling coring tube. 1. Coring tube in horizontal position. 2. Raising tube to the vertical. 3. Coring tube ready for lowering. 4. Safety latch.

wasted cutting out the damaged portion. It is believed that this problem can be eliminated by further research.

CONCLUSIONS

It is believed that the piston immobilizer and thick-walled liner tubes are satisfactory and reasonably simple solutions to several difficulties inherent in previously described corers.

The tongue-like core retainer is much more satisfactory than the simpler spring bronze orange-peel type. It has functioned in both soft and stiff sediments. The orange-peel type, if strong enough to retain a long core, is so rigid that it causes serious mixing of the sediment as it passes into the corer.

The steel pipe flange used to connect the weight stand to the upper part of the core barrel is a simple and very strong connection. It eliminates at least one very likely cause of failure.

Approximately fifteen cores have been taken to date with this new corer, in lengths up to 20 feet and at depths up to 200 feet, with no failures attributable to the mechanism. The cores obtained show no appreciable distortion; individual layers in varved clays are flat except for about a 1/16-inch curvature at the very edges. There appears to be no reason why the device will not function as well at great depths and with longer core barrels. Both of these extensions in its use are planned for the near future.

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