A GRAVITY CORER RELEASE MECHANISM:
DESIGN AND TESTING

by

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United States
Naval Postgraduate School

THESIS

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ABSTRACT

The corer release mechanism is a device which serves as the
vehicle that permits free-fall coring. Analysis of existing release
mechanisms has led to design of a versatile device which employs an
upper lever arm safety that enables it to be armed after the corer has
passed below the water surface. A quick-acting wire clamp is also
included to assist in recovery procedures. The gravity corer operational
tests that have been made provide a means of comparison when the
device is and is not used. Variable free-fall heights were used with
five different gravity corers and for four of the tested corers; best
results were attained with a free-fall setting of five to seven feet.

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ACKNOWLEDGEMENTS

I. INTRODUCTION

Gravity corers have been used for more than a century for marine sediment sampling. The first well documented use, as noted by Donovan [1967] was in 1866 for a survey of the Straits of Dover by Henry Marc Brunel. He is generally acknowledged as being the inventor of the simple gravity corer. Few improvements were made in the basic design until development of the Ekman corer in 1905. This represented the first markedly improved sampler, and it has served as a model for numerous more recent ones.

At about the time of the development of the Ekman corer attention was beginning to be directed toward applying more energy in order to increase the penetration. The normal method of sampling had been to attach the corer to the hydrographic wire and lower it into the bottom at the maximum safe speed and this is still in use today. It has been found, however, that greater penetration can be attained through one of several techniques. The possible energy-producing forces are explosives, hydrostatic pressure, partial vacuums, and by free-falling the sampler a predetermined distance. Hvorslev and Stetson [1946] note that the latter is by far the simplest as it does not require increasing the size of the sampler and does not produce any great increase in cost. The release mechanism makes free-fall coring possible.

Release mechanisms are presently used in a variety of coring operations that involve both gravity and piston corers. The simplest

release mechanism consists of a lever-like trip arm that is held in place by a suspended trigger weight. The corer hangs from the end of the shorter lever and is counterbalanced by the trigger weight on the longer arm. When the suspended trigger weight strikes the bottom the counter-weight action is effectively removed, and the corer then free-falls the remaining distance into the bottom. While there are numerous variations in design, all simple release mechanisms generally act in this manner.

A.   PROBLEMS ENCOUNTERED WITH RELEASE MECHANISMS

The corer release devices now in use are highly varied both in design and principle of operation. Many of these devices are so specialized that they can be utilized only with a specific corer. This becomes more apparent with piston coring and the requirement that piston deactivators be incorporated into the release mechanism. For the present work, discussion is limited to gravity corers constructed so as to be suitable for free-fall sampling.

A release mechanism must ensure that the corer is released at the desired height above the sea floor in a positive manner. It must also be possible to connect the corer and the release mechanism on board the research vessel and then safely put the entire sampling assemblage into position for lowering. During this process the release device must be locked in closed position. This locking is generally accomplished by means of a safety pin that passes through the frame of the release device and locks the lever arm in place. Once the corer is over the side and ready for lowering, the safety is manually removed. In that this is done

before the corer and release mechanism enter the water, it is essential that the lever arm not come in contact with the side of the ship so as to cause a premature release and possible injury to personnel or loss of equipment. This problem becomes more acute at higher sea states with a rolling ship increasing the danger of premature triggering. Additionally, the higher waves tend to lift the trigger weight as it passes into the water or in some instances, the lever arm itself. The passage of the assemblage from the air through the interface is a critical evolution.

There is also the possibility of rotation of the unit as it is being lowered resulting in the wrapping of the trigger weight line around the corer to cause a faulty release, or perhaps in the released corer striking the trigger weight. While this is not generally a problem with shorter corers, it has been observed to cause premature triggering when lengths in excess of six meters have been used. The likelihood of this taking place appears to increase when the hydrographic cable is used for purposes other than coring, as for example for trawling.

The lever arm ratio must provide for a sufficient safety factor between the weight of the sampler and the trigger weight to prevent uneven winch speeds and heavy rolls of the ship from causing the corer to release prematurely.

It is essential for the corer to contact the bottom with a vertical attitude, and this is determined by the manner in which it is dropped free by the release mechanism. A horizontal force component must not be imparted to the sampler. The distance above the bottom that the

corer is allowed to free-fall is also of importance. As pointed out by Burns [1966] gravity corers maintain a vertical attitude for varying heights of free-fall, depending on the absence or presence of stabilizing fins.

Another question to be considered is the ease of shipboard handling of the corer during the recovery process. Many of the release mechanisms are attached to the end of the hydrographic wire with the sampler then attached to the base of it by a separate length of wire or chain. This creates difficulties during the recovery in that when using some winches and booms the corer cannot be lifted free of the water as the release mechanism blocks the sheave. This is generally solved by utilizing a wire clamping device which permits the release mechanism to be removed; hence, the recovery operation is greatly simplified. The wire clamp is generally designed so as to be detachable with a minimum of time and effort in view of reaching over the side.

B.   OBJECTIVES OF THIS WORK

Richards and Parker [1968] report the use of gravity corers is currently increasing due in part to problems involved in obtaining un-disturbed cores with piston samples. Gravity cores can be taken with rapidity, particularly if a release mechanism is not used. An increasing number of surveys are being conducted using relatively lightweight free-fall corers, as these smaller samplers permit a greater number of coring attempts to be made and can be handled on smaller ships with more limited winch capabilities.

One objective of this work is therefore the design of an optimum release mechanism to accommodate a wide variety of different samplers. Requirements are that this device should be simple, rugged, and of reasonable size and weight for convenient handling on board smaller ships. It should have a minimum of moving parts since the possibility of failure increases in direct proportion to the level of complication.

Special emphasis is placed on ease of handling with particular regards to the provision of a safety mechanism that can be armed as late as possible in the lowering operation. This is to reduce the interval over which the wave action and ship motion may produce premature triggering, that is, from the deck edge to just below the water surface.

Simplification of the recovery operation is stressed, as sample loss often results in this crucial stage. It is imperative that the corer be removed from the water as swiftly and safely as can be done.

A secondary objective of this work was to determine an optimum method of utilizing a release mechanism. This necessitated a systematic sampling program involving testing of the release mechanism with a variety of lightweight gravity corers. The free-fall settings were varied in order to recommend the most efficient use of gravity corers. These results are compared with samples collected without using a release mechanism.

A thorough study of corer release mechanisms has not been done to date. The literature involving coring operations generally treats release mechanisms in a secondary manner. This work, therefore, attempts to provide some input to this area.

II. THEORY OF CORING

The principles involved in free-fall gravity coring are graphically illustrated by Figure 1. Four steps are involved in the operation of the sampler. The chief components of this system are the release mechanism, with attached trigger weight, and the gravity corer. The length of the line to the trigger weight is preset to provide the desired free-fall distance.

When the trigger weight strikes the bottom, a counterweight to the corer is effectively removed and it falls free into the sediment. The winch is stopped upon receiving an indication that triggering has occurred, and the corer is then withdrawn and recovered.

A.   GRAVITY CORING

The penetration of a corer into the sediment and the subsequent collection of a sample depends upon a number of variable conditions. Briefly, according to Emery and Dietz [1941], these are the shape and cutting angle of the corer nose, the physical dimensions of the barrel, the overall weight of the sampler, the velocity with which it impacts the sediment, and the nature of the sediment itself. The effect of the latter factor is reduced in the present study in that all testing took place within a very small area of Monterey Bay.

The amount of energy available for penetration of a coring tool is the sum of the potential and kinetic energy. In simple gravity coring
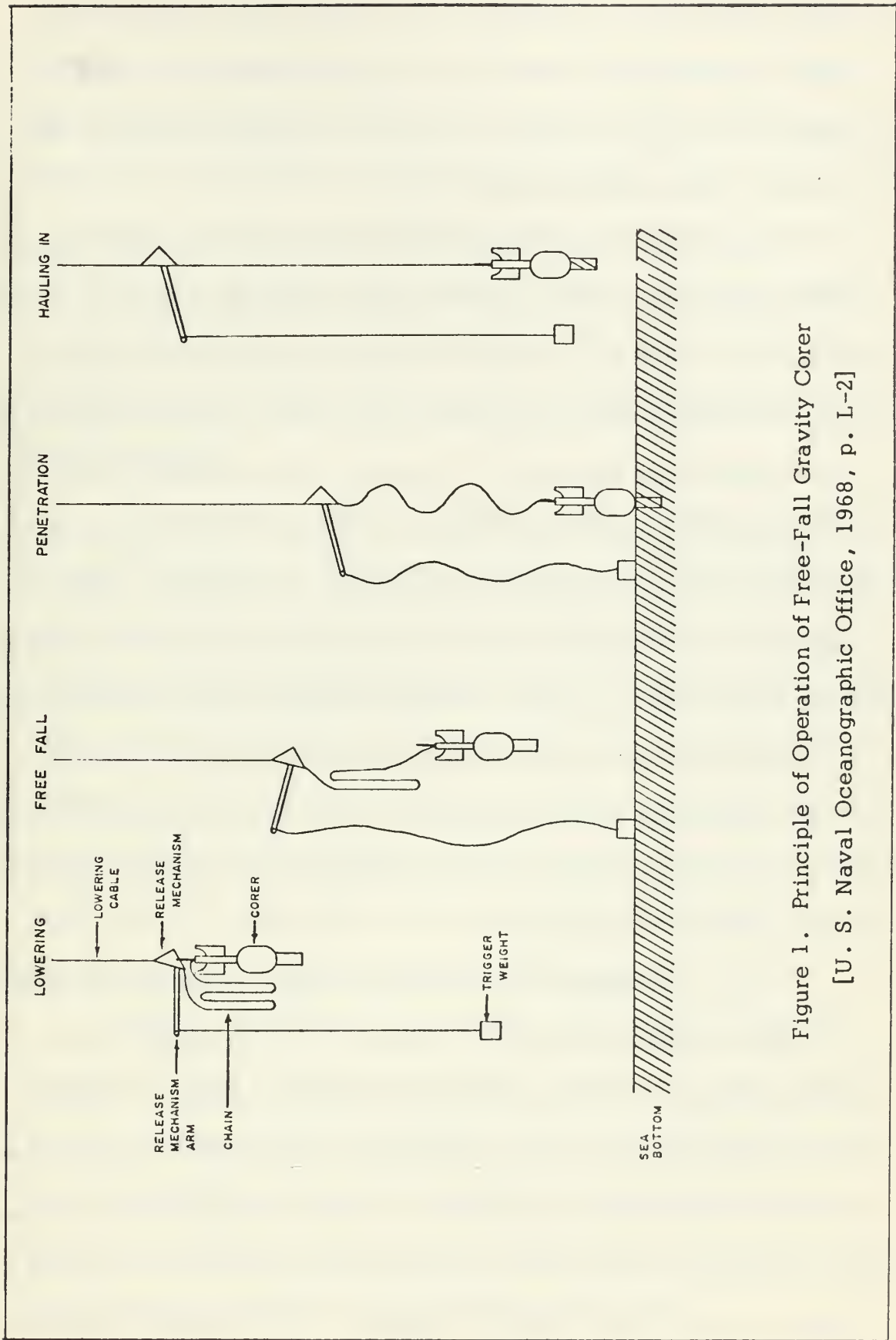
Figure 1. Principle of Operation of Free-Fall Gravity Corer
[U. S. Naval Oceanographic Office, 1968, p. L-2]

not involving free-fall, the sampler is lowered into the bottom at a velocity which is governed by both the winch and the weight of the corer. Emery and Dietz [1941] report achieving descent velocities varying from 12 to 21 feet per second with a 590 pound sampler. Not all winches can attain such velocities.

While a corer is being lowered the tension in the cable is equal to the weight of the sampler in water plus the weight of the line. When the sampler strikes the bottom and begins to penetrate the sediment, this tension diminishes and becomes equal to the difference between the sampler weight and the sediment resistance. The potential energy is therefore divided, part being wasted on the cable with the remainder converted into the useful work of overcoming the sediment. When the resistance of the sediment equals the weight of the sampler the tension in the cable is zero. Further penetration depends upon the small amount of kinetic energy resulting from the relatively slow unwinding speed. The amount of potential energy available for useful work when gravity corers are employed in this manner has been estimated by Kullenberg [1955] to be less than 50% of the total.

A higher percentage of the potential energy is available for useful work when the free-fall principle is used, and this permits use of a smaller sampler than the simple gravity technique allows. Hvorslev [1949] notes that the velocity attained from the free-fall portion of the procedure is decreased somewhat by the water resistance and the drag. The retarding factors are functions of the cross-sectional area and the degree of streamlining of the drive weight. This resistance increases

approximately with the square of the velocity. As the height of free-fall increases, the resistance becomes equal to the submerged weight of the corer, thus reaching a maximum or terminal velocity which has been estimated to be between 60 and 90 feet per second. Even when the corer is released only a few feet above the bottom, the velocity increases until the drag and penetration resistance equal its submerged weight. In this circumstance, the energy available to force the sampler into the sediment is nearly twice as great as that of a simple gravity corer lowered from the surface.

The choice of an optimum free-fall height has been discussed by several investigators. Kullenberg [1955] found one meter to be adequate for a large piston corer while Hvorslev [1949] utilized a 10 to 15 foot free-fall that was sufficient to bury a 15 foot coring tube in the sediment, except for hard clay bottoms. More recently, Burns [1966] found the optimum free-fall distance for a general class of small corers to be two to three meters with the terminal velocity attained within this distance. Burns also notes that corers without stabilizing fins tended to be un-steady, particularly after a free-fall of three meters.

Vertical stability is of paramount concern during any coring endeavor in order to obtain an undisturbed sample. Rosfelder [1966] found the primary factors in securing such a sample depend upon slow steady penetration of the coring tool with a minimum degree of entry angle. An angled entry yields reduced penetration, increased disturbance, and increased probability of bending the coring barrel.

B. CORE SHORTENING

Most cores collected by the gravity method suffer some degree of physical shortening. A portion of the kinetic energy available when the sampler strikes the sediment is consumed by overcoming the outside wall friction of the tube and the inside friction resulting from contact between the contained core and the inner walls. Additionally, resistance from the sediment opposes its being pushed aside or down-warped at the lower end of the sampler. During the first stages of sample collection there is little resistance from the short core as it is pushed up into the tube. Mud at the nose piece is readily pushed aside with only part of the sediment entering the tube. As the collected core becomes longer, the internal resistance builds up. Water content of sediment normally decreases with depth and the reduced lubrication results in the formation of a solid plug which terminates growth of the sample. This explains the difference between the depth of penetration and the actual length of the collected sample.

C. WIRE ELASTICITY

The weight of the corer extends the hydrographic wire elastically. At great depths the weight of the wire itself will contribute to this elongation. This stretching can retard the penetration of a simple gravity corer that is lowered directly into the bottom.

When free-fall is utilized, an elastic longitudinal wave runs up the wire to the winch. Scott [1968] found that the wave can be of such magnitude that when it is reflected back down to the corer it can influence

the sampling process. This wave is generated by the triggering of the

release mechanism and sharply registers on a dynamometer serving as

a signal to stop the winch. Such is not the case for simple gravity

coring when the tension in the cable gradually decreases. This is

difficult to observe on a dynamometer and excessive wire may be played

out resulting in tangling.

III. RELEASE MECHANISM

The procedures followed in the design of the gravity corer release mechanism are presented herein. As a first step, the literature was examined and a collection of numerous designs was assembled for study. Secondly, brochures and advertising circulars from suppliers of marine equipment were examined. Field trips were taken to inspect existing release mechanisms and to discuss the problems of gravity coring with knowledgeable investigators.

A.   DESIGN CONSIDERATIONS

Hopkins [1964] presented guidelines to follow when designing marine bottom sampling equipment. They are: (1) a minimum number of moving parts, (2) the use of corrosion-resistant materials, (3) sturdy enough equipment to withstand rough shipboard handling, (4) proper orientation before contacting the bottom, and (5) the simplest possible recovery procedures. Additionally, a release mechanism should accommodate a large variety of corers and possess the highest degree of reliability.

The greatest number of release mechanisms in use today employ the simple lever principle. This lever has two unequal arms, the longer supports the trigger weight while the shorter one holds the sampler. These unequal arms provide a mechanical advantage which enables a small trigger weight to counterbalance a large corer with a comfortable factor of safety.

The most standard release mechanism design is that of Hvorslev and Stetson [1946]. It is used extensively with both gravity and piston corers; however, in the case of the piston corer it is necessary to also include a device to deactivate the piston on completion of the sampling operation. When a deactivator is included in the basic design the mechanism becomes more complicated. This feature is not included in this study because such a device is unnecessary for "standard" gravity coring. However piston corer release mechanisms were inspected in order to consider those features which are adaptable to both types of release mechanisms.

The release mechanism is usually a separate device which is attached to the hydrographic wire. The corer is secured to the release mechanism by a separate length of line or chain or it can be directly connected to the end of the hydrographic wire. The latter method necessitates clamping the release mechanism to the wire and is a widespread practice utilizing a variety of clamping devices. For example, McManus [1965] designed a release mechanism with the clamp being an integral part of the release mechanism, while Marlowe [1967] uses a separate commercial clamp. Some of the release mechanisms with integral wire clamping devices can accommodate only one size of wire.

An important aspect of clamping devices is how they adhere to the wire. Removing several bolts with a wrench while standing on a rolling platform can be time-consuming and awkward; therefore, the clamp should release quickly to permit removal with a minimum of effort. Also it is important that the clamp not physically harm the wire.

A release mechanism employing a different type of wire clamp is one which uses a separate metal wedge. As described by W. Preslan [personal communication] this particular model is assembled by bolting together two plates which loosely encircle the wire. A grooved metal "wedge" is inserted into the rectangular void through which the wire passes and hammered into place, forming a positive grip on the wire. During recovery the "wedge" is removed, allowing the wire to continue being winched in. The release mechanism stays on the wire but does not hamper its movement or interfere in the corer's being raised to the surface.

Numerous variations of trigger weights are in use; but, in general, they can be put in two categories. The first is a streamlined weight, usually of lead. The second type uses a small gravity corer in conjunction with a larger piston sampler allowing a collection of two samples during each coring attempt. Methods of securing the trigger weight to the lever arm vary. Wire, chain, or some type of rope are commonly used, all of which perform satisfactorily.

Marlowe [1967] describes an unusual release mechanism consisting of two small levers and a slotted support lug which has a mechanical ratio of 138:1. The assembly is mounted on a six inch metal plate. The normally extended lever arm is eliminated to permit coring through ice holes; consequently, the trigger weight hangs quite close to the coring tube and tends to wrap itself around the core barrel during uneven winch operation. However, since coring over ice is from a stable platform, this problem can easily be overcome by smooth, steady lowering.

Jonasson and Olausson [1966] describe a release mechanism where the conventional lever arm supports the counterweight, but it does not act as a simple lever. It employs a mechanical linkage that connects to a crescent-shaped device with a hook which supports the corer. When the lever arm is lifted, the crescent-like device rotates and this motion releases the corer.

Possibly the most vital part of any release mechanism is the safety which locks the lever arm or other movable part in place while the apparatus is being rigged and prepared for lowering. Failure of this device can result in serious injury to personnel and possible loss of valuable equipment.

The most common safety is a pin passing through the base plates and lever arm to lock it in position. This pin acts in the horizontal plane and is removed when the corer is in place for lowering, but before the release mechanism is in the water.

It is possible to design a safety that can be actuated after the corer has been lowered by utilizing a push-rod that activates a spring-loaded safety pin. This device could be armed by a messenger when the corer nears the bottom, but, then such factors as wire angle and travel time of the messenger become important. This becomes more complicated with increasing depths.

A pressure actuated safety is manufactured by Benthos Incorporated of North Falmouth, Massachusetts. This device locks the release mechanism until hydrostatic pressure overcomes the shear

strength of calibrated shear pins which are available for depths down to 7000 meters and are accurate within five percentage according to the manufacturer.

Other types of release triggering systems are made. One of these is an electrical system used by the "Sphincter" corer which was designed by Kermabon et al. [1966]. This system uses a mercury switch that is insensitive to the accelerations that are involved. The power source for this is a pair of capacitors contained in a power pack together with the mercury switch. The capacitors are charged by a 24 volt battery on the ship, after which the unit is suspended from the lever-arm and connected by armored cable to a solenoid which holds the mechanical linkage in position. Beneath the power pack is a counterweight which first impacts with the bottom. The mercury switch then tilts 60° from the vertical and closes discharging the capacitors into the solenoid and opening it. This frees the mechanical linkage which in turn releases the corer. This system has reportedly been used to depths of 4000 meters.

Other commercially available release devices include timed re-leases employing substances that dissolve in sea water within a certain period of time. Explosive releases are used mainly with instrument packages or with buoys. There are also various command systems triggered by an external signal, for example, acoustic, but these are all overly complicated for coring purposes.

B.   DESCRIPTION OF THE RELEASE MECHANISM

The final design is shown by Figures 2 and 3 and it was constructed of stainless steel and brass for corrosion resistance. The body of the mechanism consists of the two base plates, spacer bolts, and a lever stop. The lever arm has brass bushing plates and a larger spacer bolt to act as the fulcrum. Two safety pins and a commercial wire clamp connect the release mechanism to the wire. The trigger weights are lead spheres. The total weight of the release mechanism, less the trigger weight, comes to seven pounds. Figures 4 through 6 present views of the assembled device and a detailed description of the various components is included below.

1.   Support Plates

The two stainless steel support plates are held together by four brass spacer bolts. A fifth larger, stainless steel spacer bolt additionally serves as the lever arm fulcrum as shown by Figure 7. The upper edge of the plates has a 3/4 inch hole to enable connecting the release mechanism to the wire clamp by means of a U-bolt. The two positions for the lever fulcrum, as shown in Figure 8, permit changing the lever arm ratio. A 1/4 inch hole passes through both plates and the lever arm which accommodates the safety pin. The slot for the bail of the corer has its inner edge slanted toward the fulcrum in order to avoid a binding of the bail when the mechanism does not hang in an exactly horizontal position. There is normally some inclination of the mechansim toward the trigger weight. Had this slot not been included, there would sometimes be a force vector developed to impart an unfavorable horizontal

NOTES:
1. All dimensions in inches
2. All corners rounded
3. Two base plates 1/8 in. thick, 1/2 in. apart
4. Four brass spacer bolts, posit. A,B,C,D
5. Upper lever arm safety and lever stop of brass and silver brazed to back of base plate B
6. Brass spacer on lever arm silver brazed to arm
7. Safety pin of brass
8. All other parts of stainless steel

Base Plate A

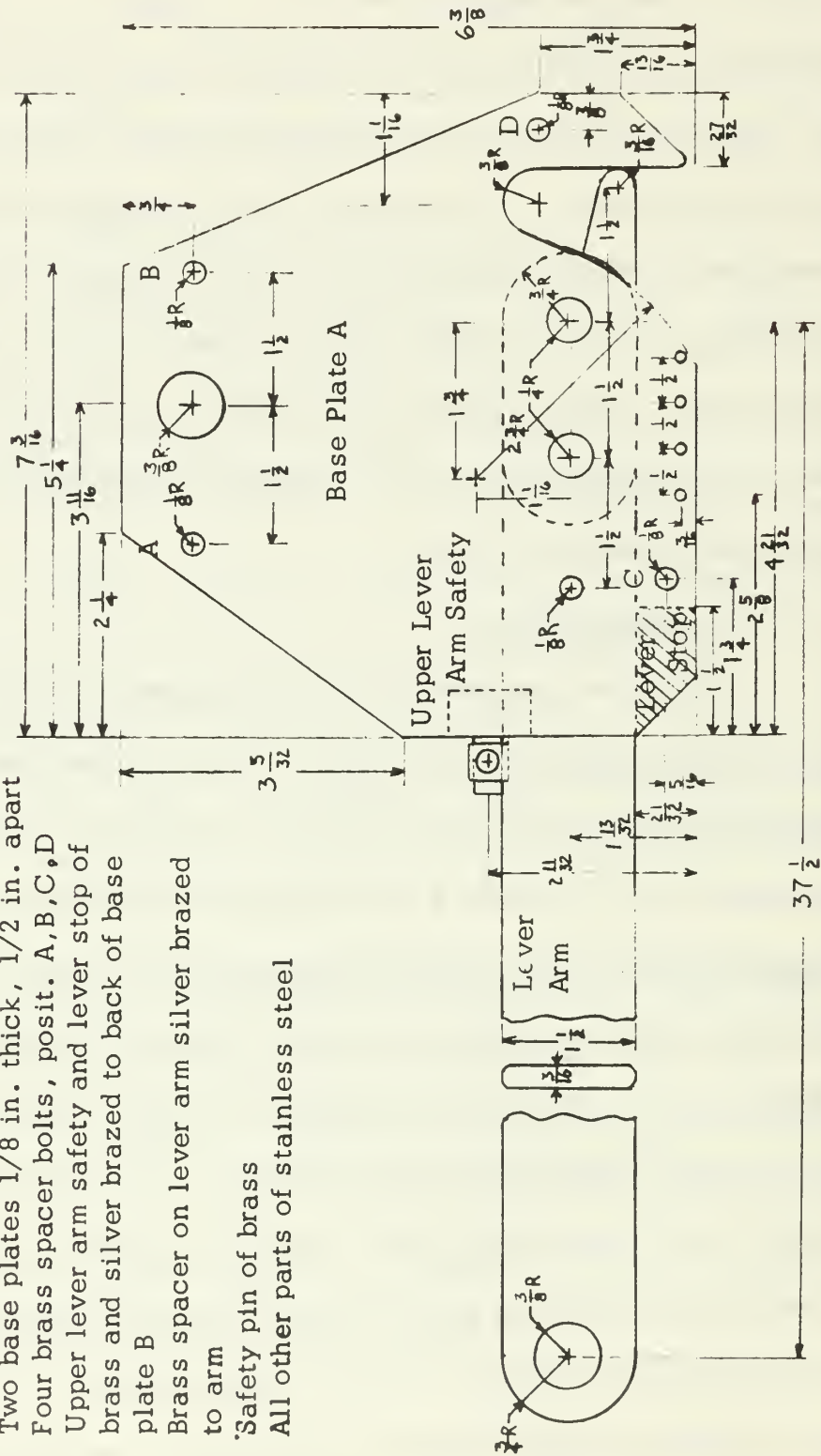Upper Lever Arm Safety

Lever Arm

Figure 2. Detailed Drawing of Release Mechanism
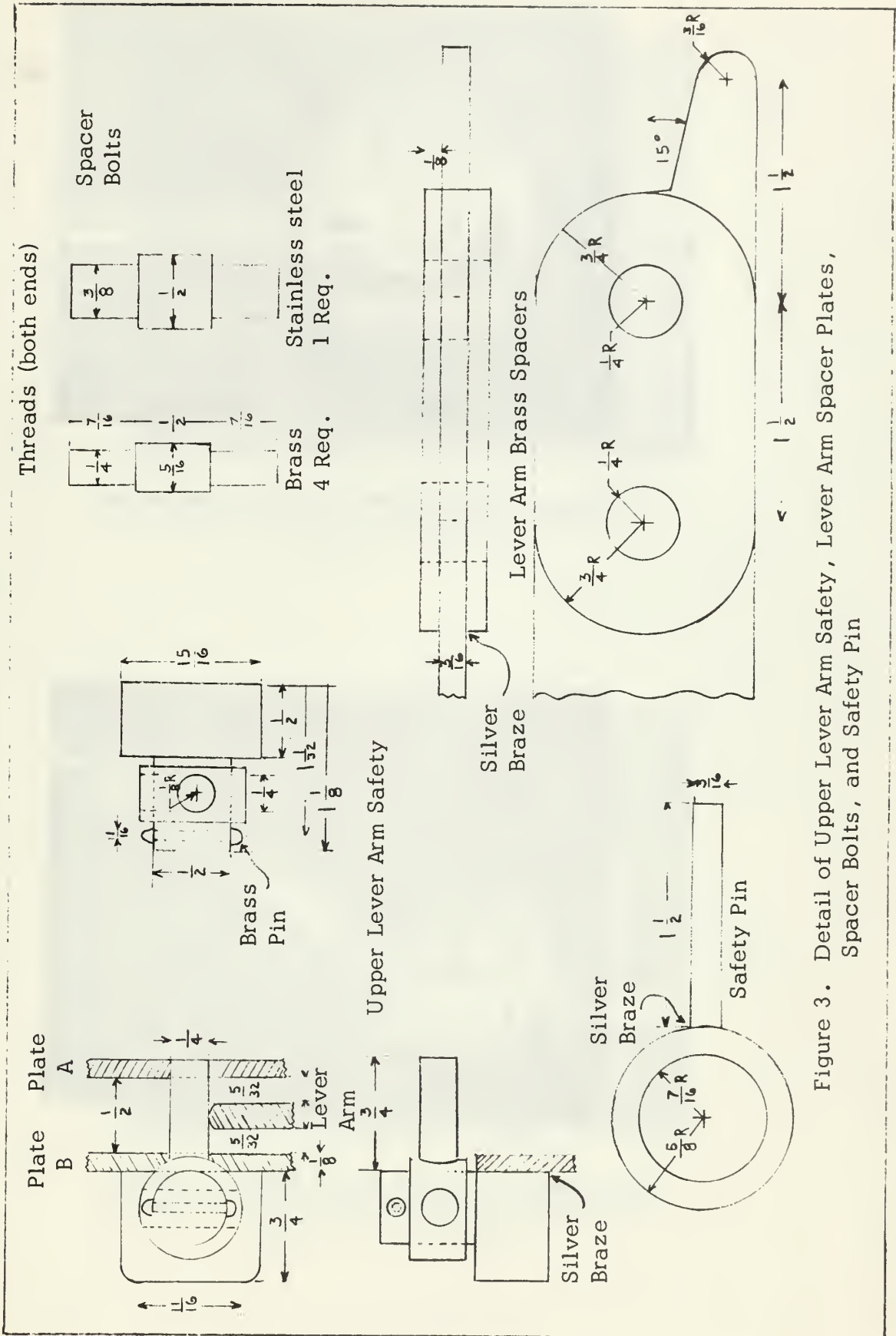
28

Figure 3. Detail of Upper Lever Arm Safety, Lever Arm Spacer Plates, Spacer Bolts, and Safety Pin
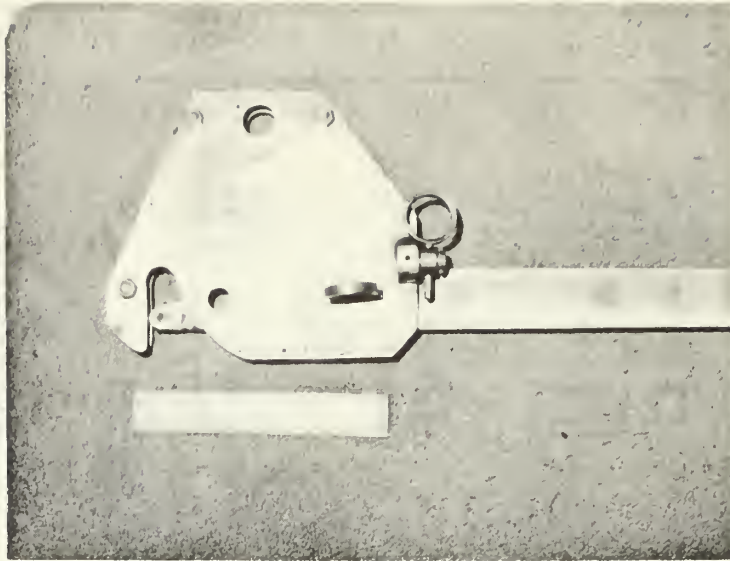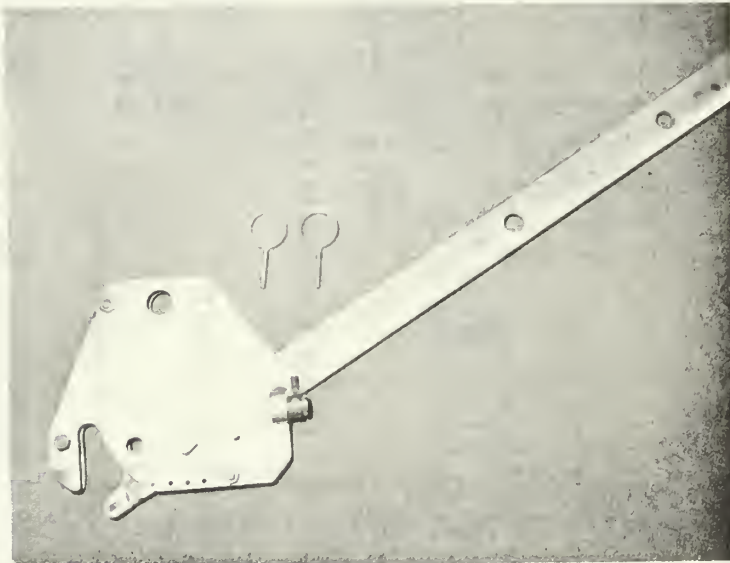
29

Figure 4. Side View of Release Mechanism

Figure 5. Lever Arm in Raised Position

Figure 6. Release Mechanism and Drive
Weight on Test Wire
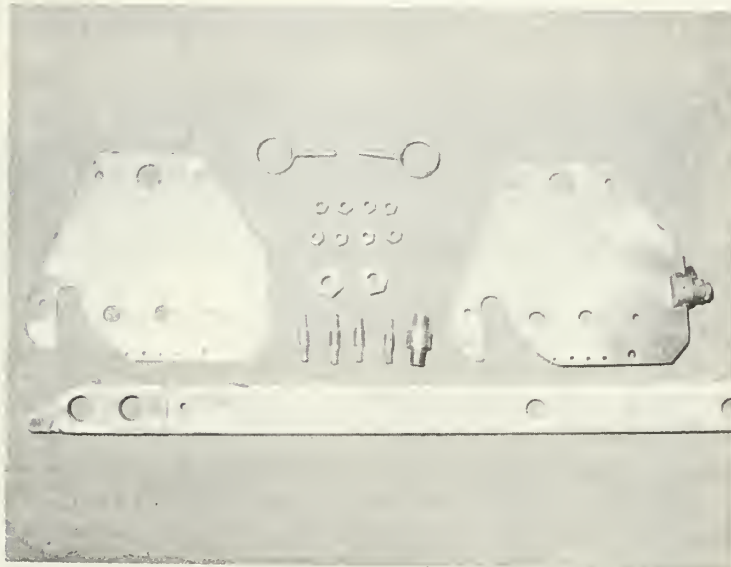
Figure 7. Disassembled Release Mechansim
Showing All Components

thrust to the corer during release. The slot is made to accommodate bails up to 3/4 inch diameter. Four small holes along the lower edge allow the wire to the corer to be coiled and tied up by string.

The two base plates are identical in plan. The lever arm stop and upper lever arm safety are silver brazed to one of the plates, designated plate "B", to permit ease of dismantling and changes of lever-arm ratio. The lever arm stop is made of brass. Figures 8 and 9 give views of these components.

2.   Lever Arm

The length of the lever arm is 40 inches. The two fulcrum positions permit lever arm ratios of 1:12 and 1:25. The four positions for the trigger weight line attachment further increases the versatility. The additional trigger line positions enable the release mechanism to be kept in a near-horizontal attitude when working with small corers. Figure 10 presents a description of the lever arm.

Two stainless steel lever arms were fabricated, one of 1-1/2 x 3/8 inch stock and the second of the same stock but with approximately one-half of the 1-1/2 inch dimension of the extended arm removed. The heavier arm has been designated as arm I, the lighter as arm II with a comparison of their characteristics presented in Table I.

Figure 8. Plate "B" Removed Showing Lever Stop

Figure 9. View of Both Lever Arms and
Disassembled Release

Fulcrum Position 1
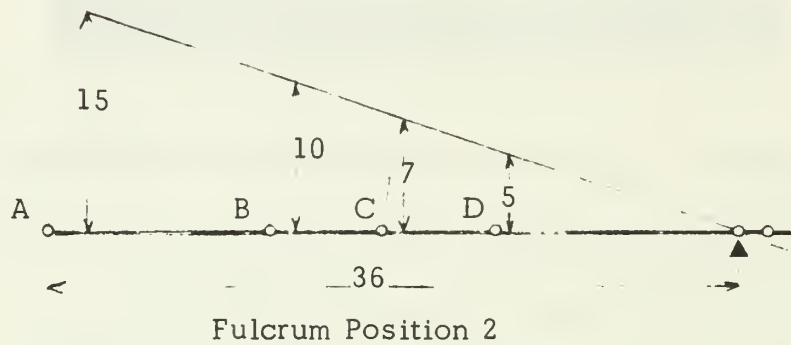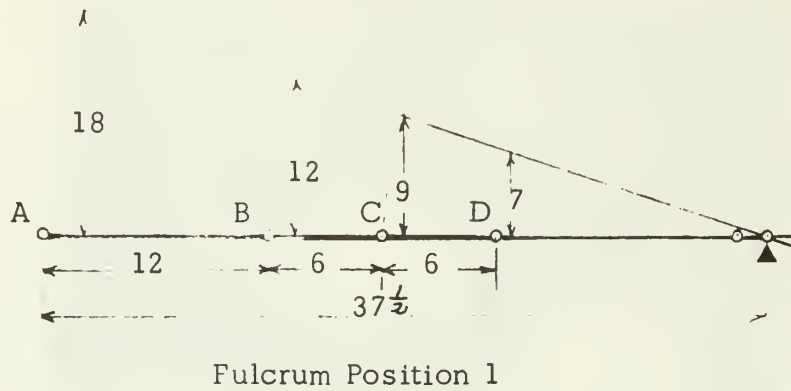
Fulcrum Position 2

All Dimensions in Inches

<u>LEVER ARM RATIOS</u>

Trigger Line Position	Fulcrum 1	Fulcrum 2
A	25:1	12:1
B	17:1	8:1
C	13:1	6:1
D	9:1	4:1

Figure 10. Lever Arm I – Distance Arm Raises
Before Release; Ratios Available

TABLE I

COMPARISON OF LEVER ARMS

	Arm "I"	Arm "II"
Length overall	40 in	40 in
Weight	41 lbs	2-1/2 lbs
Number of trigger line positions	4	1
Number of fulcrum positions	2	2
Force to trip, 12:1 Ratio	21 lbs	9 lbs
Force to trip, 25:1 Ratio	72 lbs	32 lbs

The short arm of the lever has an angle of inclination 15°
below the horizontal to keep the corer bail flush against the wall of
the bail slot. This serves to act as a guide to prevent imparting a
horizontal velocity at the moment of release. Instead of standard
washers serving as bearing surfaces at the fulcrum, two highly polished
brass plates have been silver brazed to both sides of the lever arm and
these are large enough to serve both fulcrum positions. This type of
bearing has served favorably with the elimination of moving parts.

3.   Trigger Weights

Spherical lead trigger weights of 10, 15, and 25 pounds
were utilized with this release mechanism. The spherical shape pro-
vided adequate streamlining and the diameter proved large enough to
ensure positive action with the bottom sediment. No evidence of the
weights sinking completely into the sediment was noted and tape that
had been affixed to them indicated that approximately one-half of the

sphere became immersed in the bottom. All testing was done over near-shore sediments.

The trigger weight is attached to the lever arm with polypropylene line, which served satisfactorily though some minor twisting was noted.

4.   Wire Clamp

A standard commercial wire clamp is used to attach the release mechanism to the hydrographic wire. The particular one selected is manufactured by the Crescent Tool Company of Jamestown, New York. It is adjustable to fit wires from 5/32 to 5/16 inches in diameter, with a recommended safe load of 5,000 pounds. The clamp is attached to the upper hole in the base plates by means of a U-bolt. It is positioned so that the wire falls on the opposite side of the release mechanism from the upper lever arm safety or away from the ship.

A modification was made to the wire clamp consisting of a short stainless steel arm welded to the bolt that provides the positive clamping action. This arm served to simplify the removal of the wire clamp and thus the entire release mechanism from the wire, thereby permitting the wire to be winched in until the sampler is in a position to be handled. The bolt arm modification eliminates the need for an additional tool for removal of the clamp which is complicated by adverse sea conditions.

The bolt arm is installed so as to point downward when the wire clamp is in position on the wire in order to lessen the chance of

the wire inadvertently tangling or snagging on it. This modification limits the use of the modified clamp to a particular wire size if the bolt arm is always in the desired position. These clamps are readily available and can be easily modified.

     5.   Safety Pins

        There are two safety devices incorporated into the design and they are illustrated by Figures 11 and 12. One of these is a standard safety which is found on many release mechanisms consisting of a pin that passes through the base plates and the lever arm so as to lock it in position when inserted. This pin is actuated by horizontal movement and must be removed when the sampler is ready for lowering. The point in the lowering procedure when it must be removed varies for different ships, but it must be done at the deck edge. In any case, both the sampler and release mechanism are at least partially above the water surface and hence are subject to direct wave action. Additionally, should the lever arm make contact with the ship during this period, there is a high probability of a premature release.

        The upper lever arm safety has been designed to help circumvent the above problems. This safety consists of a brass L-shaped base and stud to which a free-swinging arm is attached. This arm lies on the upper edge of the lever arm when in place prior to lowering. A hole drilled through both the ring portion of this small arm and the stud to which it is attached is for the safety pin. When the pin is inserted it locks the small safety arm in place preventing it from moving upward.

Figure 11. End View of Safety Devices
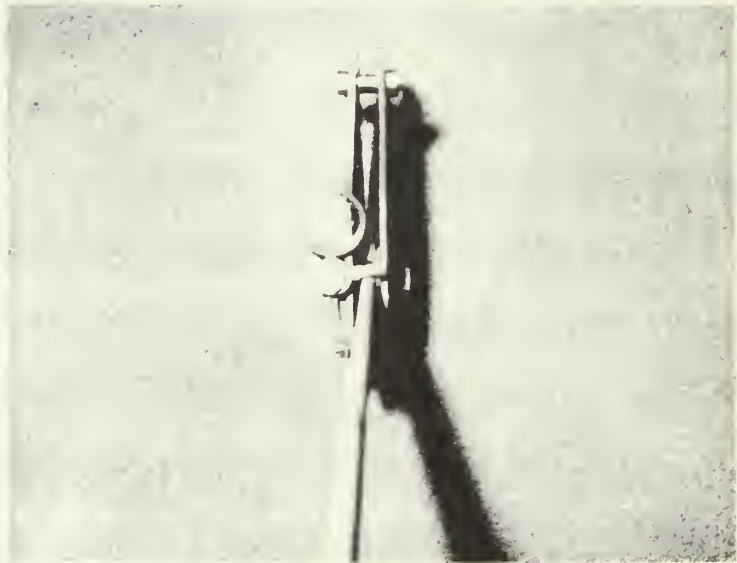
Figure 12. Upper Lever Arm Safety

The lever arm is restricted from movement in the opposite direction by the fixed lever arm stop. This safety pin acts in a vertical direction and fits loosely in the hole. The entire corer and release mechanism is lowered to a position below the water surface before the pin is removed by an attached light line. The safety assembly is made completely of brass, and is silver brazed to the forward edge of base plate "B". In use it has proved very successful, easy to operate, and no malfunctions were experienced.

The force to trip the release mechanism is tabulated in Table I. This measurement was obtained by attaching the release mechanism to a wire and with the safety pins removed a spring scale was used to measure the downward force required to raise the unloaded arm to the release position. Four measurements were made at each position and the results averaged.

IV. OPERATIONAL TESTING

The operational testing of the release mechanism was done in two phases. The first of these was laboratory testing and the second involved more extensive testing at sea.

A. LABORATORY TESTS

The laboratory test program consisted of simulating as closely as possible the operational use of the release mechanism. The mechanism was attached to a length of hydrographic wire suspended from a block and tackle. A corer drive weight was then attached to a chain fall and so adjusted that when the drive weight was dropped, it would not impact the floor. Raising and lowering the device with the block and tackle permitted the drive weight to be released some distance above the floor allowing the various aspects of the release mechanism to be checked.

The attitude of the combined release mechanism and corer was checked and the lever arm was modified by increasing the number of trigger line attachment positions. The corer bail slot was also enlarged so as to handle a greater variety of corers. Lever arm ratios were verified and the weights required to trip the unloaded arms were measured as is shown by Table I. The distance which the lever arm must raise to release the corer was determined and these measurements are presented in Figure 10.

B.   SHIPBOARD TESTING

The shipboard testing of the release mechanism was conducted using the Hopkins Marine Station vessel TAGE and the Naval Postgraduate School's (NPS) hydrographic research vessel. A total of 94 coring attempts using the release mechanism were made, eighty-three of which secured samples. Eight of the unsuccessful attempts were attributable to failure of a corer component, and three others were due to a premature tripping of the release mechanism. The accidental trips occurred during periods of extremely heavy rolling while using a small corer (55 pounds) with a ten pound trigger weight suspended from hole "B". The lever arm was in position "two". This combination did not provide sufficient leverage to withstand the effects of the heavy seas. Relocation of the trigger line to position "A" alleviated the difficulty. Lever arm I was used for all shipboard testing.

Five different coring tools were used during the testing program. The characteristics of these corers are compiled in Table II. The operational testing procedures were patterned after the techniques suggested by Kullenberg [1955], Hvorslev [1949], and Burns [1966]. One of the primary objectives of the field testing was to compare the use of the release mechanism and free-fall with sample lengths collected using simple gravity coring without a free-fall. The free-fall heights were also varied in order to determine optimum settings.

It was decided to collect at least four samples at each setting. Corers "A" and "C" were tested on the TAGE, with the NPS vessel used as the platform for the "B", "D", and "MONO" corers.

IV. OPERATIONAL TESTING

The operational testing of the release mechanism was done in two phases. The first of these was laboratory testing and the second involved more extensive testing at sea.

A.   LABORATORY TESTS

The laboratory test program consisted of simulating as closely as possible the operational use of the release mechanism. The mechanism was attached to a length of hydrographic wire suspended from a block and tackle. A corer drive weight was then attached to a chain fall and so adjusted that when the drive weight was dropped, it would not impact the floor. Raising and lowering the device with the block and tackle permitted the drive weight to be released some distance above the floor allowing the various aspects of the release mechanism to be checked.

The attitude of the combined release mechanism and corer was checked and the lever arm was modified by increasing the number of trigger line attachment positions. The corer bail slot was also enlarged so as to handle a greater variety of corers. Lever arm ratios were verified and the weights required to trip the unloaded arms were measured as is shown by Table I. The distance which the lever arm must raise to release the corer was determined and these measurements are presented in Figure 10.

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TABLE II

CHARACTERISTICS OF GRAVITY CORERS TESTED

	A	B	C	D	"MONO"
TYPE	Modified Phleger		Phleger		Large Diameter
Length Core Barrel,(FT)	2	8	2	8	6
Weight,(LBS)	38	59	55	76	205
Minimum Inside Diameter Barrel (Ds),(IN)	1.38	1.38	1.38	1.38	3.97
Minimum Inside Diameter Cutter (De),(IN)	1.37	1.30	1.37	1.30	3.94
Inside Clearance Ratio (Ci), (%)	0.75	5.8	0.75	5.8	1.52
Maximum Outside Diameter Barrel (Dt), (IN)	1.63	1.91	1.63	1.91	4.5
Maximum Outside Diameter Cutter (Dw), (IN)	1.64	2.16	1.64	2.16	4.6
Outside Clearance Ratio (Co), (%)	0.61	11.6	0.61	11.6	2.2
Area Ratio (Ca), (%)	41.7	57.1	41.7	57.1	36.3
Stabilizing Device	NONE	NONE	FINS	FINS	STREAMLINED SHROUD

$$C_i = \frac{D_s - D_e}{D_e} \times 100$$

$$C_o = \frac{D_w - D_t}{D_t} \times 100$$

$$C_a = \frac{D_w^2 - D_e^2}{D_e^2} \times 100$$

The cores that were collected without utilizing the release mechanism were obtained as follows. The sampler was attached to the hydrographic wire and placed in the water. The winch brake was then released and the corer allowed to descend to the bottom. The average speed of descent was approximately six feet per second for corer "A", seven feet per second for corers "B", "C", and "D", with the "MONO" corer attaining a velocity of six feet per second. The velocities increased as the weight of the corer increased, except for the "MONO" corer which descended at a lesser velocity. This is believed attributable to the large cross-sectional area of the sampler and resulting increase of drag.

When the release mechanism was utilized, settings were determined as illustrated by Figure 13 and the height of free-fall varied. The assembly was lowered at slower speeds than those above in order to ensure smooth operation of the release mechanism. It is believed that the free-fall settings were attained to an accuracy of two or three inches. The average penetration of the trigger weight was approximately one-half of its diameter and this was taken into account during the adjustment of free-fall heights.

Visual inspection of the samples suggested that the sampler struck the bottom very close to the vertical. Visible sediment layers were not always present, but some other form of evidence was usually available. In at least four instances when the release mechanism was not used there were indications that non-vertical impacts occurred.

All sampling was done in Monterey Bay using Buoy "C" as a reference point. The area sampled was restricted in order to limit as
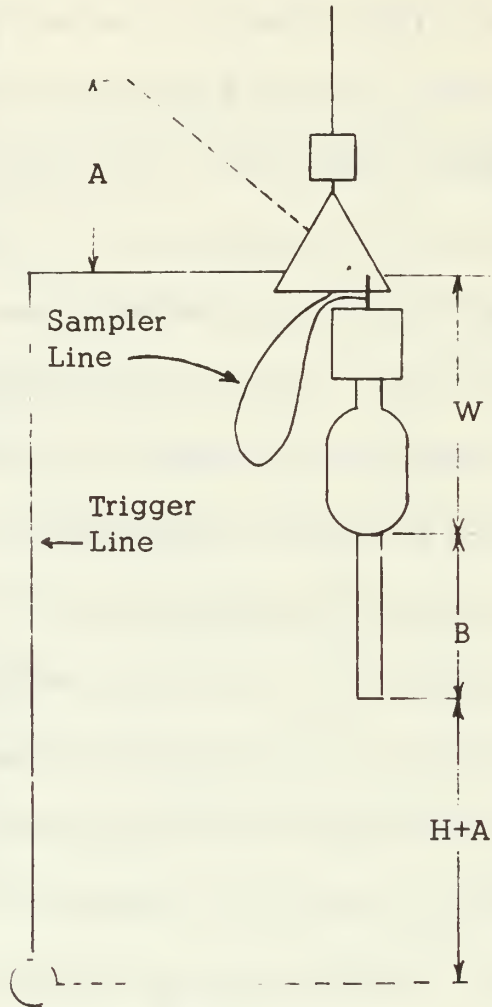
Trigger Line Length = H + A + B + W
Sampler Line Length = H + A + B

A   - Distance Lever Arm Must Rise Before Release
B   - Coring Barrel Length
H   - Height of Free-Fall
W   - Drive Weight Assembly Length

Figure 13. Computation of Free-Fall Heights

much as possible variations in the physical properties of the sediment. All coring was done on the seaward side and within 100 yards of the reference point. Numerous repositioning moves were required, but it was possible to maintain station fairly closely. The depth of the water at Buoy "C" is 220 feet.

Visual examination of the samples collected revealed the presence of only slight variations. The color was black to blackish green and it consisted of a very fine grained mixture of mud and fine sand with sticky mud predominating. The sediment was found to be firm rather than soft.

The depth of penetration was estimated by measuring the sediment adhering to the outside of the coring tube. Masking tape was also affixed to the barrel and gave a good indication but required frequent replacement. The length of the collected sample was measured within its clear plastic liner. The core was then extruded and discarded. Figure 14 illustrates the measurements that were taken and the method of computation of the total recovery ratio.

The release mechanism performed satisfactorily, with the exception of the three premature trips previously noted. The corrective action involved sampling technique rather than a design consideration. The wire clamp made removal of the release mechanism from the wire an easy operation and the upper lever arm safety release worked well. This safety virtually eliminated the possibility of an early trip during the first lowering stage. Figures 15 through 18 illustrate the major steps of the shipboard testing procedure.
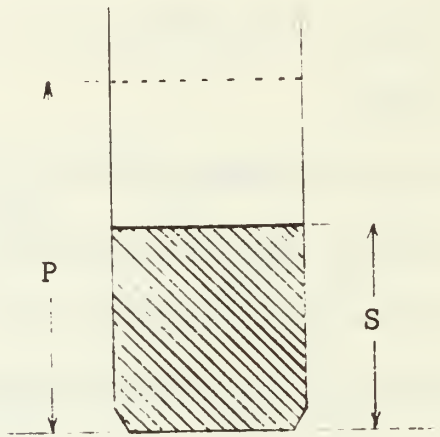
P = Estimated Penetration of Sampler

S = Length of Sample

TOTAL RECOVERY RATIO:

$$\frac{P}{S} \times 100 = \quad \%$$

Figure 14. Sample Measurement

Figure 15. Release Mechanism
In-Place on Wire Ready for
Lowering

Figure 16. Removal of
Horizontal Safety Pin

Figure 17. Removal of the
Upper Lever Arm Safety Pin

Figure 18. Removal of Release
From Wire Prior to Recovery

C.   ANALYSIS OF DATA

The data collected is presented in Figures 19 through 27. The parameters examined were depth of penetration, length of sample, and the total recovery ratio. The comparisons were made with different free-fall settings and the physical dimensions of the samplers involved.

There is considerable scatter in the collected data. In order to better interpret the results, the arithmetic mean of the three variable parameters has been computed and is represented as a line of the graphs. It is not intended that this line be interpreted as a curve, rather it represents a connection of the means of the various parameters for ease of visualization.

The results of the tests with corers "A", "B", "C" and "D" indicate that optimum sampling performance is obtained utilizing the release mechanism with a free-fall setting of five to seven feet as shown by Figures 19 through 24. This conforms with the results obtained by Burns [1966]. The trend is found consistent throughout the testing program of these corers. The spread of results attained when the release mechanism is not utilized is large. The recovery ratios presented in Figures 21 and 24 are an example; the highest recovery ratios were attained in this manner as well as the lowest. This indicates that the corers do not maintain stability when the release mechanism is not used. Corers "C" and "D" had stabilizing fins while "A" and "B" did not, but this does not appear to have influenced the results. The probability of attaining a sample is higher with the stabilized corers "C" and "D" as illustrated by Table III.

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Figure 19. Height of Free-Fall vs. Sample Length
Corers "A" and "C"

Figure 20. Height of Free-Fall vs. Sampler Penetration Corers "A" and "C"

Figure 21. Height of Free-Fall vs. Total Recovery Ratio
Corers "A" and "C"
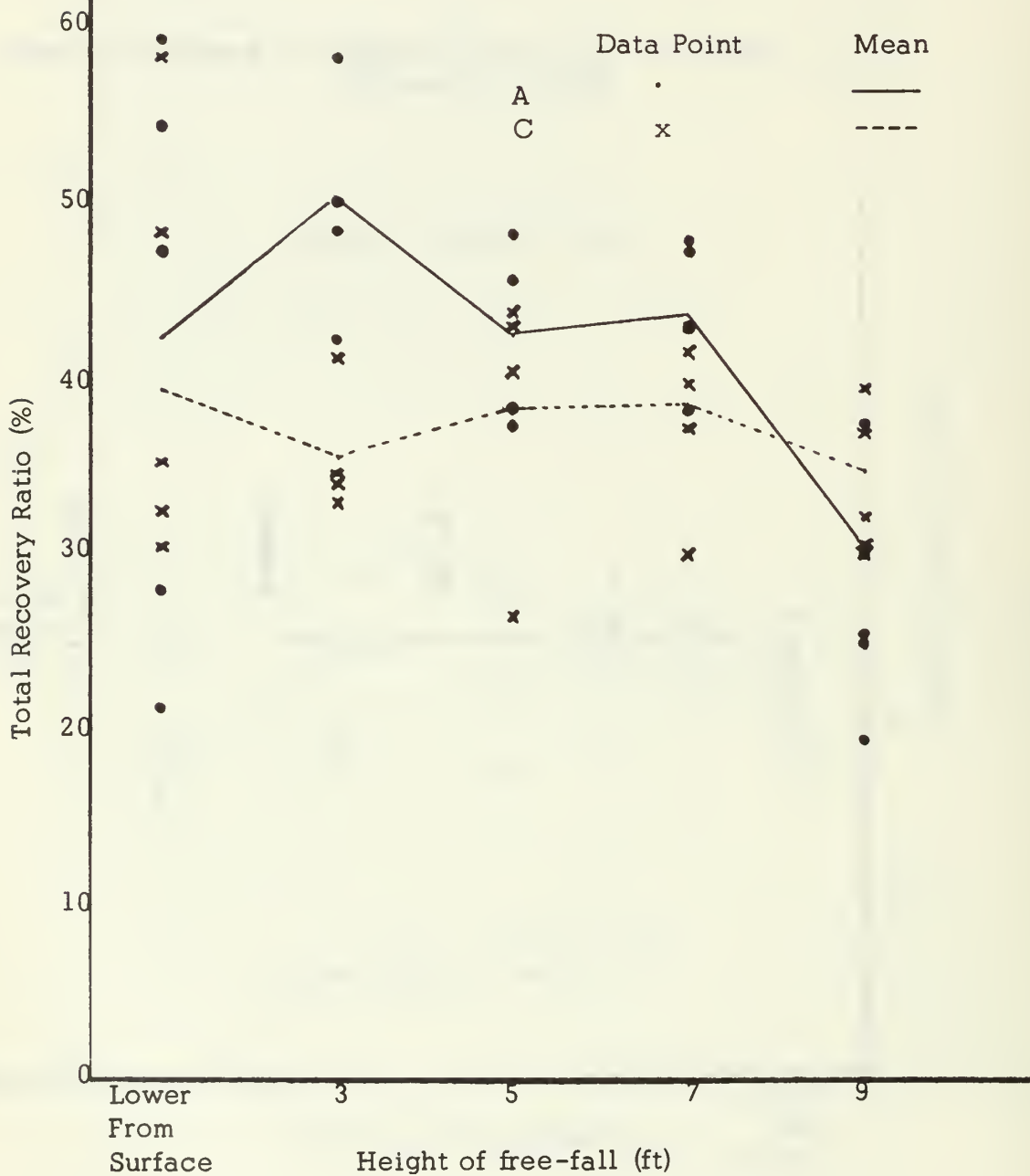
Figure 22. Height of Free-Fall vs. Sample Length Corers "B" and "D"
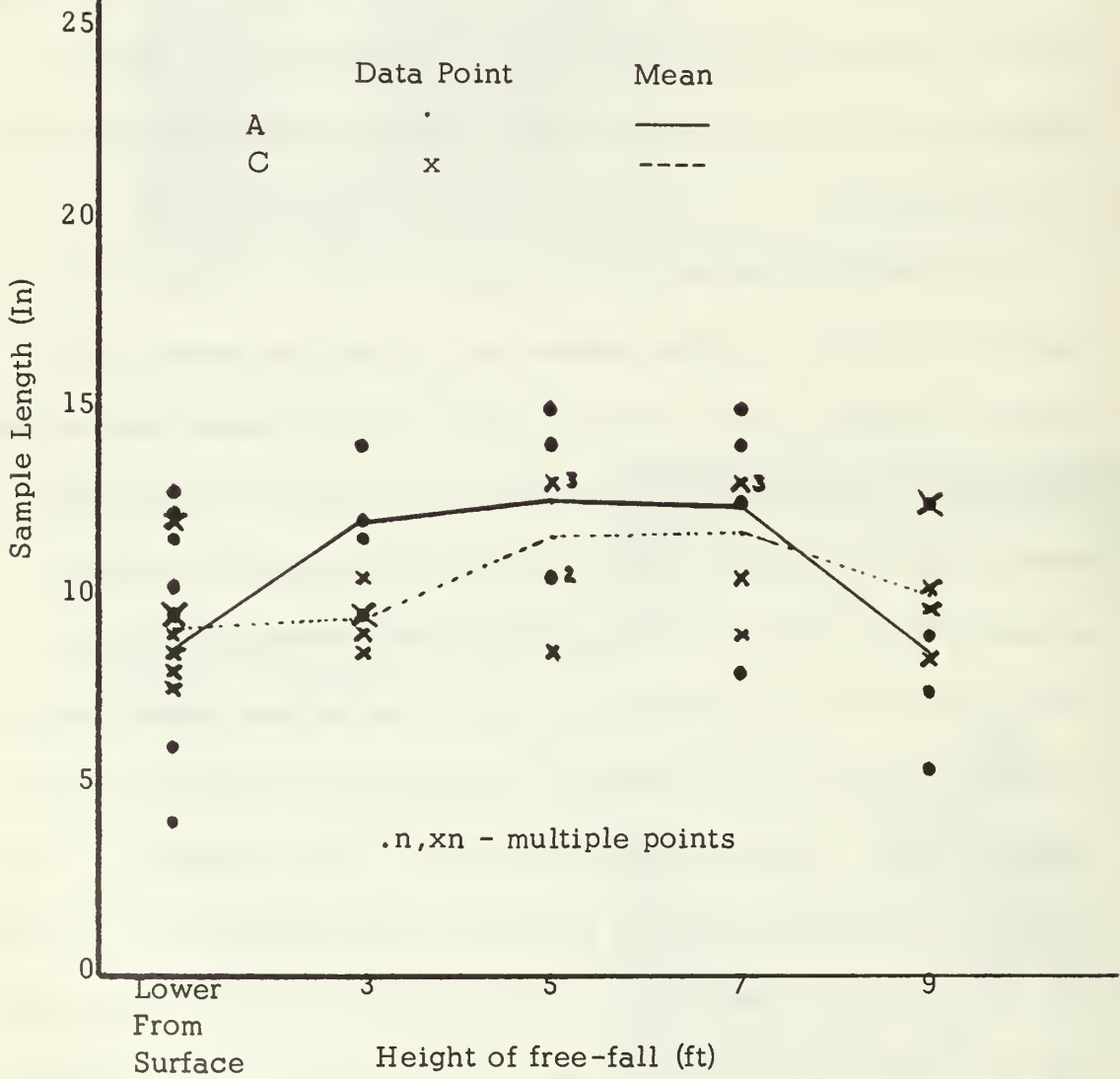
.n,xn – multiple points

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Figure 23. Height of Free-Fall vs. Sampler Penetration
Corers "B" and "D"
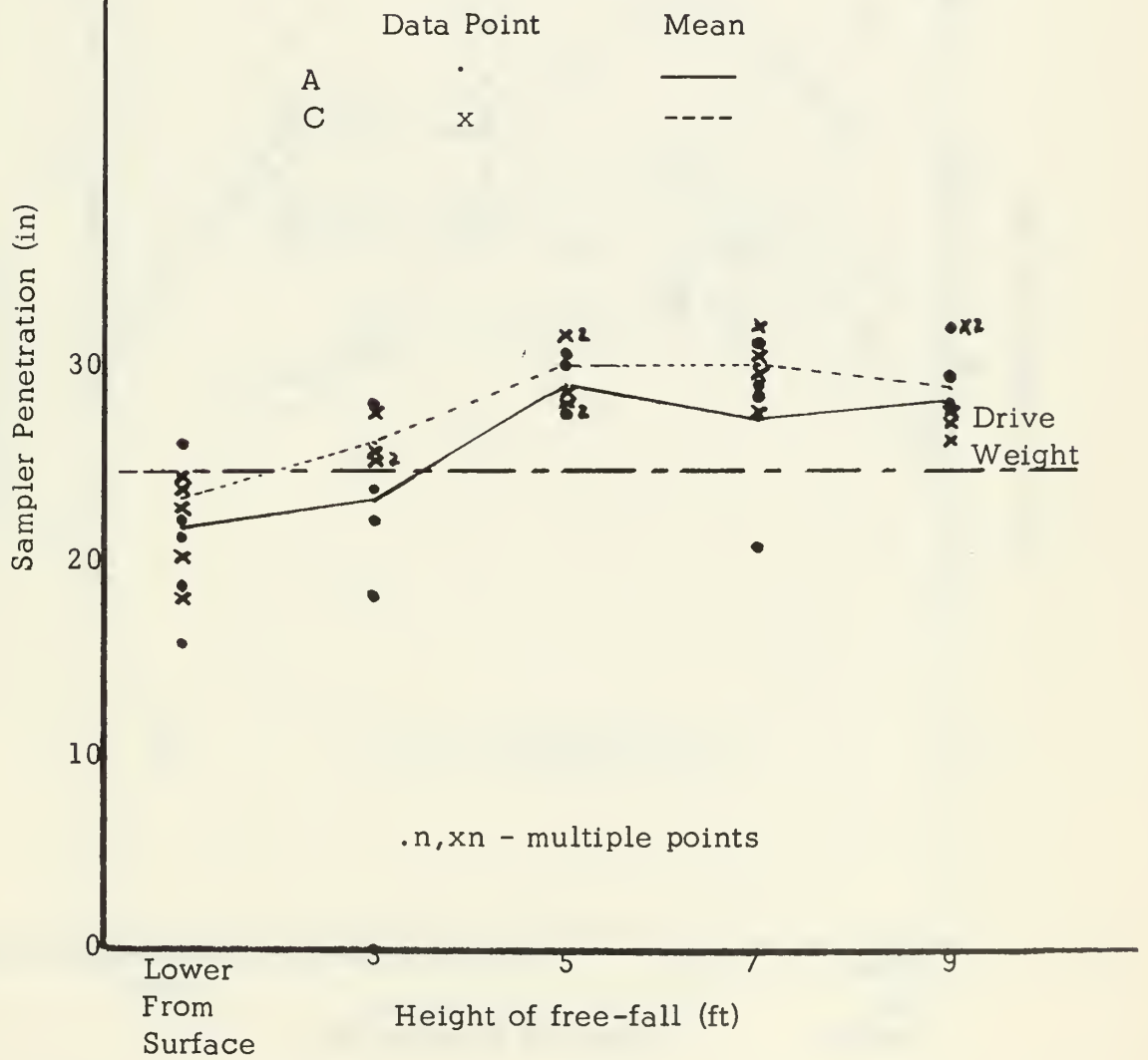
Figure 24. Height of Free-Fall vs. Total Recovery Ratio
Corers "B" and "D"

Figure 25. Height of Free-Fall vs. Sample Length
"MONO" Corer

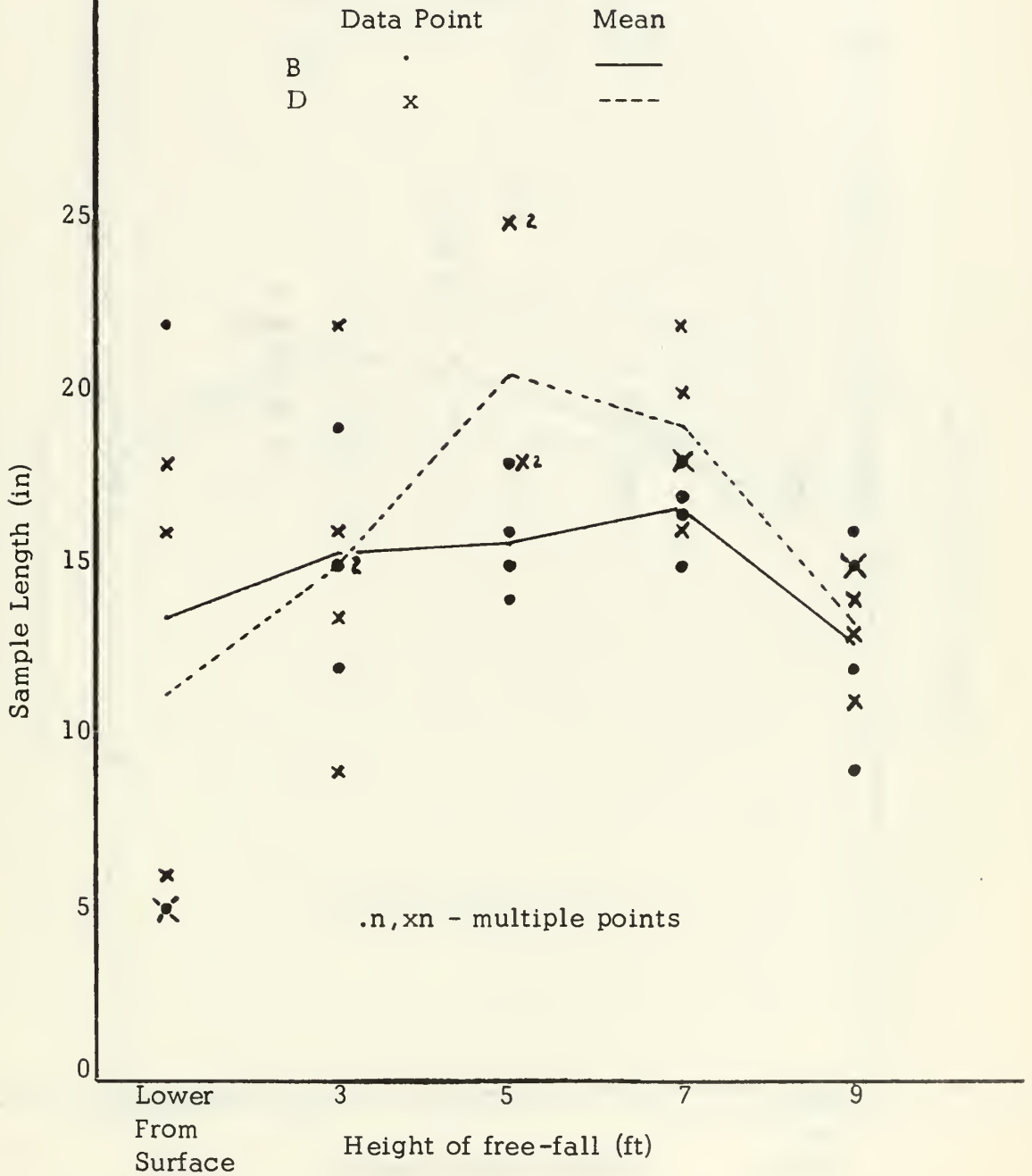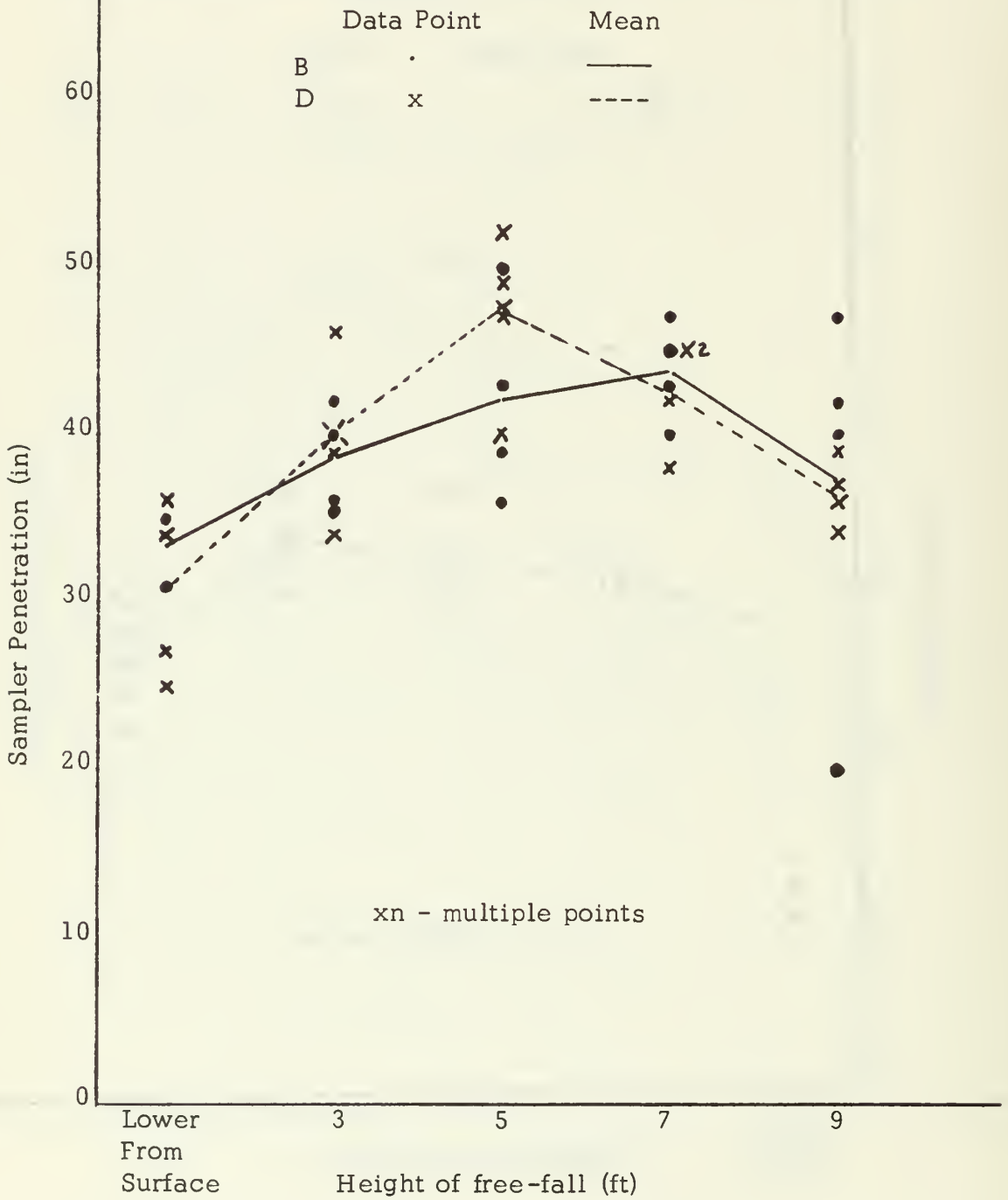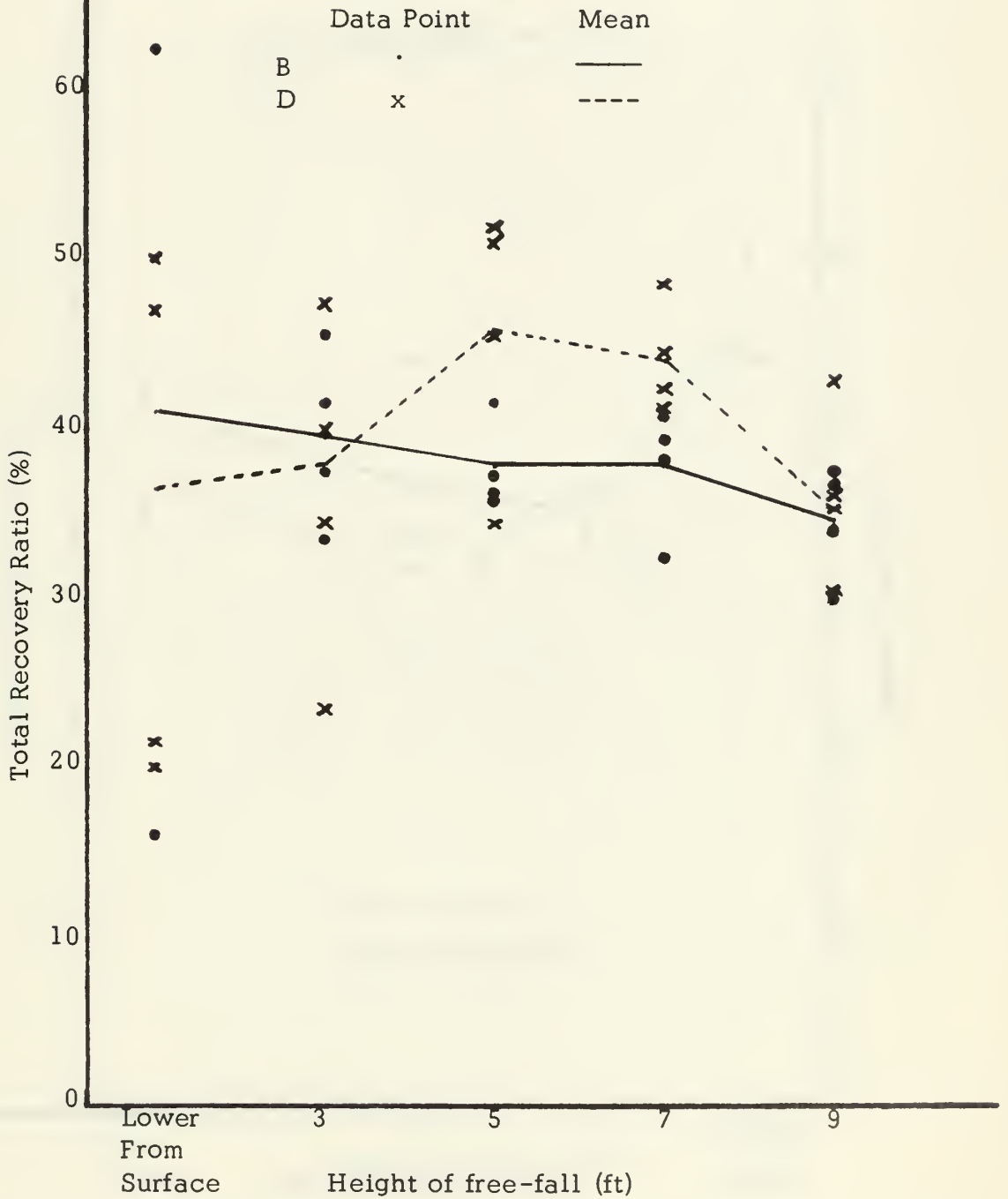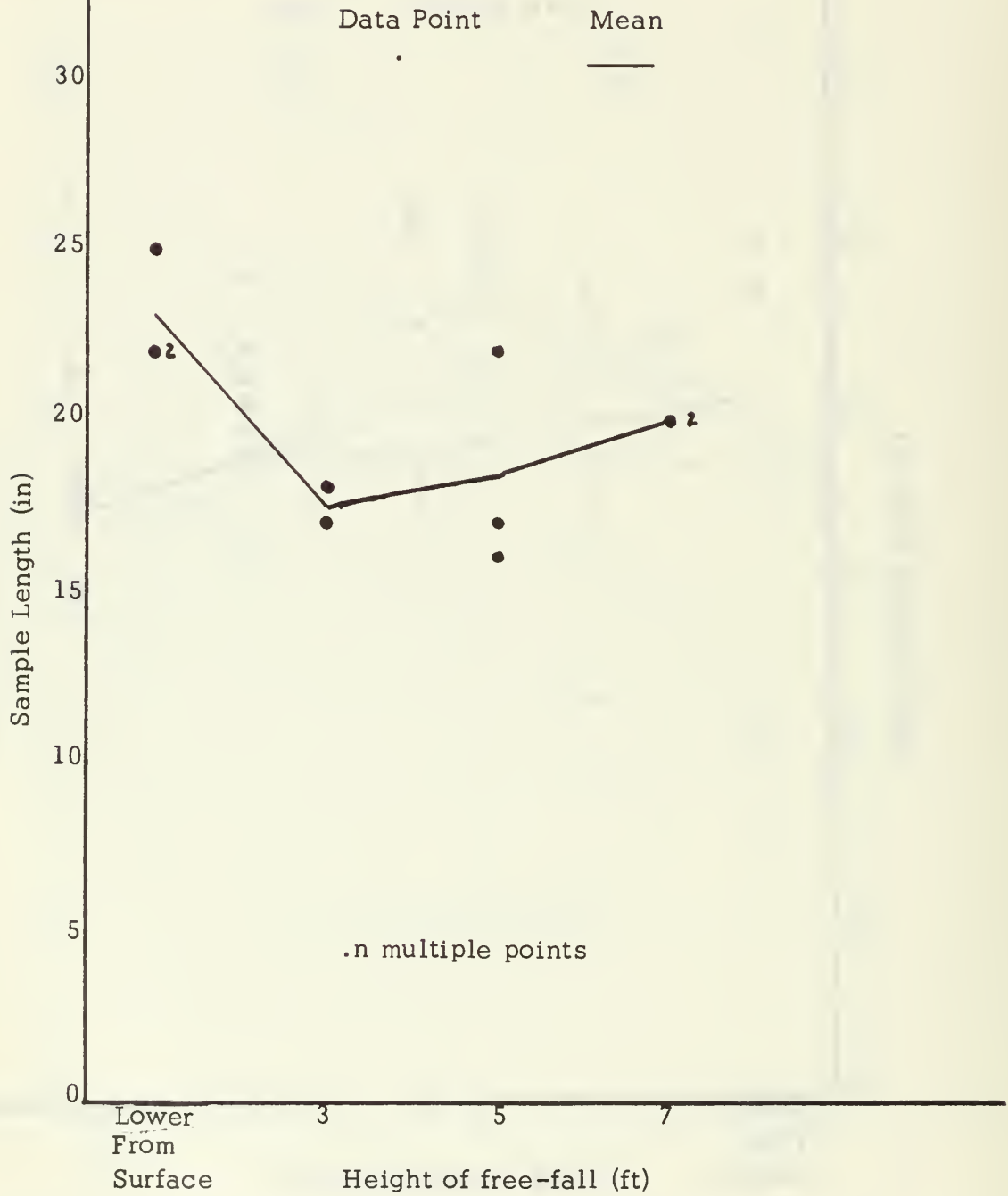Figure 26. Height of Free-Fall vs. Sampler Penetration
"MONO" Corer

Data Point   Mean
.

.n multiple point

57

Figure 27. Height of Free-Fall vs. Total Recovery Ratio
"MONO" Corer

Data Point   Mean

.   ———

58
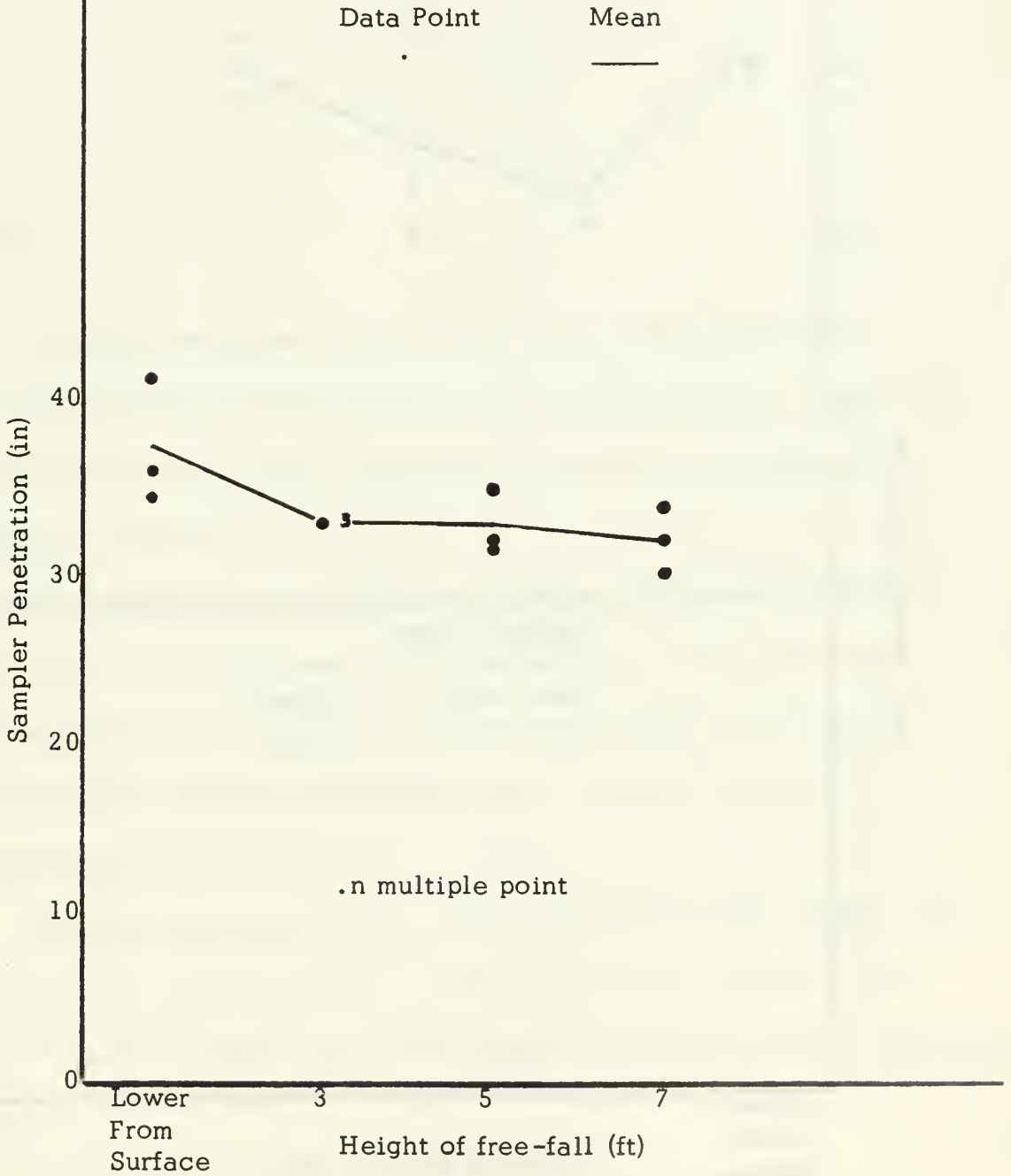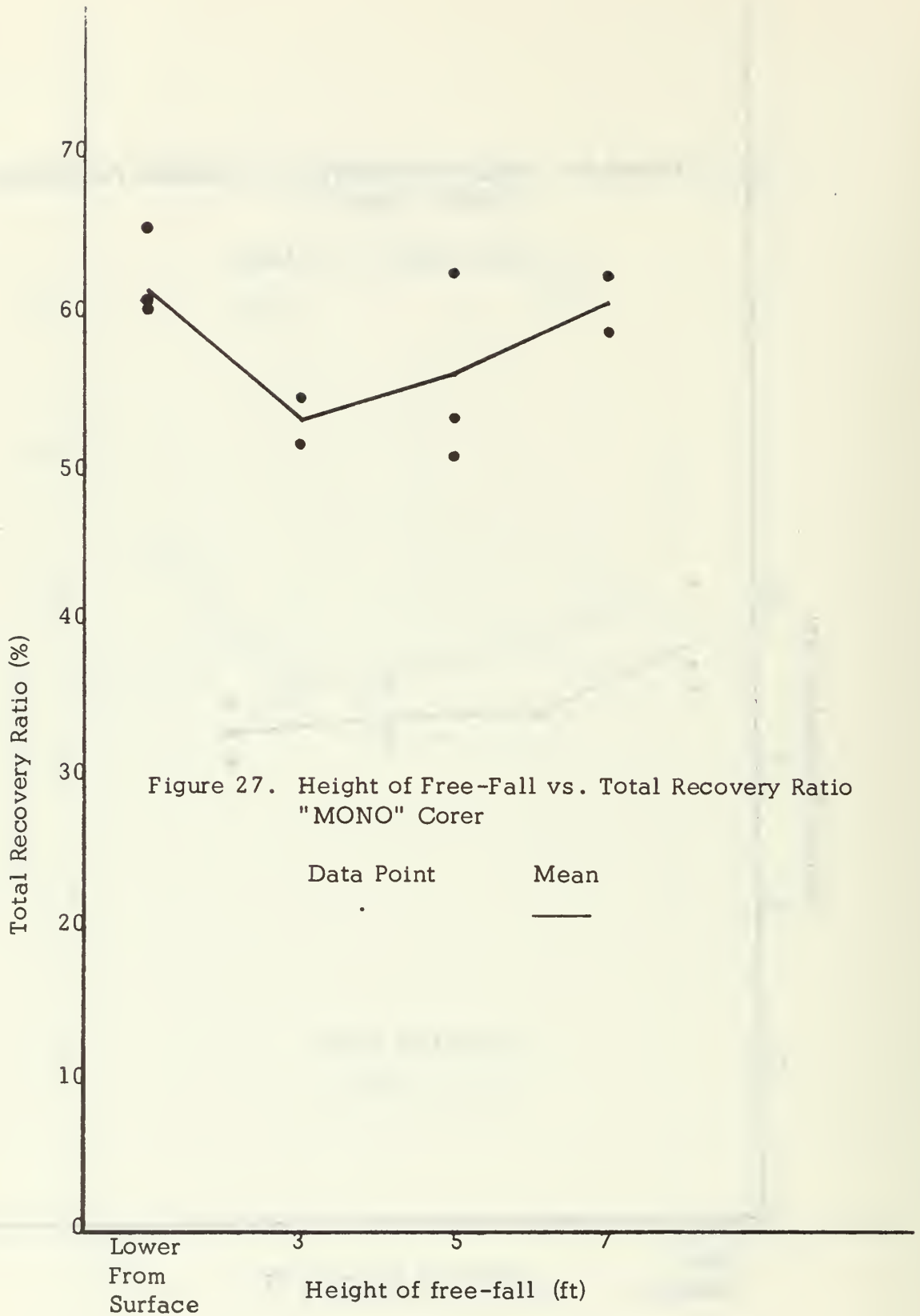
TABLE III

CORER SUCCESS RATE WHEN
RELEASE MECHANISM WAS NOT USED

Corer	Successes	Failures	Success Percentage
A	6	1	85.6
B	2	6	25.0
C	6	0	100.0
D	4	0	100.0
MONO	3	0	100.0

Corer "B" performed poorly in part, as a result of the slight disparity in weight between the barrel and the driveweight. It was not designed to be used with a barrel of this weight and length and its stability is impaired.

The depth of penetration of corers "A" and "C" was inhibited by the contact of the drive weight with the sediment. The barrel length of these corers was 24 inches and those penetrations that exceeded this distance have been influenced by this. Figure 20 presents a graphical display of this data.

The recovery ratios for "A", "B", "C" and "D" were not very high due in part to the small diameter barrels and cutters involved. The larger diameter "MONO" corer gave better results which always exceeded 50%.

The data collected by the "MONO" corer was not as extensive as that of the smaller sampler due to handling difficulties. Accordingly,

it is difficult to interpret the data, but initial results indicate better

performance was attained when the release mechanism was not used.

Free-falls of three, five, and seven feet were investigated with incon-

clusive results. Both the large diameter and large cross-sectional

area of this sampler contributed to increased water drag. The optimum

free-fall setting for this corer has not been determined but it will

possibly exceed the five to seven foot optimum of the smaller samplers.

V. CONCLUSIONS

The release mechansim has operated satisfactorily in all tests.
The unique upper lever arm safety has proved to be a useful modification
to the standard Hvorslev-Stetson type release. It provides an advance
in safety and decreases the possibility of equipment loss due to an
early release. The wire clamp ensures quick, easy removal of the
release from the hydrographic wire simplifying the recovery operation,
particularly when larger corers are involved. The release mechanism is
highly versatile and can be configured to permit a variety of lever arm
ratios, yet it is simple in principle and lightweight for easy handling.
This device will function at any depth with a very high degree of
reliability.

The results obtained from operational tests conform to the findings
of previous investigators. It appears that free-fall settings and the
desirability of utilizing a release mechanism depend largely upon the
nature of the investigation. Other factors that must be considered are
depth of water, physical characteristics of the sampler, properties of
the sediment, sea-state, and capabilities of the research platform.

VI. RECOMMENDATIONS FOR FUTURE RESEARCH

The following items are considered worthy of future research in this area:

a.   Perform static load testing on the release mechanism in order to ascertain a maximum safe load limit for the lever arm and other components.

b.   Conduct a series of tests using a winch with variable lowering speed capability in order to determine an optimum lowering speed for gravity coring with and without the release mechanism.

c.   Complete testing of the "MONO" corer to determine the optimum free-fall setting and to compare these results with those obtained when the release mechanism is not used.

d.   Obtain an intermediate diameter corer such as the Hydro-Plastic (PVC) corer and conduct similar tests with and without the release mechanism.

e.   Conduct an _in situ_ study of the release mechanism by actually observing the triggering process and free-fall behavior. Possibly such a study could be conducted by a diver alongside a pier or other structure.

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13. ABSTRACT

The corer release mechanism is a device which serves as the vehicle that permits free-fall coring. Analysis of existing release mechanisms has led to design of a versatile device which employs an upper lever arm safety that enables it to be armed after the corer has passed below the water surface. A quick-acting wire clamp is also included to assist in recovery procedures. The gravity corer operational tests that have been made provide a means of comparison when the device is and is not used. Variable free-fall heights were used with five different gravity corers and for four of the tested corers; best results were attained with a free-fall setting of five to seven feet.

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Gravity Coring						
Release Mechanism						
Coring Instrument						
Bottom Sampling						
Free-Fall Corer						
Free-Fall Release Mechanism						
Corer Release Mechanism						
Core Sampler						
Sediment Sampler						
Bottom Sampler						