

YALE PEABODY MUSEUM

P.O. BOX 208118 | NEW HAVEN CT 06520-8118 USA | PEABODY.YALE. EDU

JOURNAL OF MARINE RESEARCH

The *Journal of Marine Research*, one of the oldest journals in American marine science, published important peer-reviewed original research on a broad array of topics in physical, biological, and chemical oceanography vital to the academic oceanographic community in the long and rich tradition of the Sears Foundation for Marine Research at Yale University.

An archive of all issues from 1937 to 2021 (Volume 1–79) are available through EliScholar, a digital platform for scholarly publishing provided by Yale University Library at <https://elischolar.library.yale.edu/>.

Requests for permission to clear rights for use of this content should be directed to the authors, their estates, or other representatives. The *Journal of Marine Research* has no contact information beyond the affiliations listed in the published articles. We ask that you provide attribution to the *Journal of Marine Research*.

Yale University provides access to these materials for educational and research purposes only. Copyright or other proprietary rights to content contained in this document may be held by individuals or entities other than, or in addition to, Yale University. You are solely responsible for determining the ownership of the copyright, and for obtaining permission for your intended use. Yale University makes no warranty that your distribution, reproduction, or other use of these materials will not infringe the rights of third parties.



This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.
<https://creativecommons.org/licenses/by-nc-sa/4.0/>



Oriented Marine Cores: A Description of New Locking Compasses and Triggering Mechanisms¹

André M. Rosfelder and Neil F. Marshall

*Scripps Institution of Oceanography
University of California, San Diego*

ABSTRACT

While core-orientation data are becoming more and more necessary for marine sedimentological studies, there are no rugged, inexpensive, or convenient compasses that are insensitive to the ambient pressure, the inclination of the corer, and the bottom impact. This paper describes some instruments designed in an attempt to overcome these problems. A hemispherical compass, a free-floating spherical compass, an inexpensive "compass smasher," and some proposed simplified models of these are described. The triggering mechanisms consist basically of a stretched wire fastened to a yielding point on the corer, this point being (i) a glass shear pin snapped off by the sediment, (ii) a tiny nose lever turned up in the same way, or (iii) a releasing lock positioned on a mobile part of the corer.

Introduction. With the advances in sedimentology, particularly in micro-structure, fabrics, and paleomagnetism, core orientation data have become very necessary. It is foreseeable that corers soon will not be sent to the sea floor without a device to record the core orientation (Rosfelder 1966).

So far as we know, the first attempt to obtain orientation data under water was made 120 years ago in the Bay of Algiers by G. Aime for the purpose of measuring currents. Since then a large number of subsea compass recorders have been developed to obtain orientation data, mainly for current studies; most of these devices could be applied to corers. The ingenuity and variation in design is striking, as can be seen in the following list, which is limited to oceanographic devices that work at ambient pressure without protective casings: (i) a locking disc having a circumferential line of pins that drop down and lock the compass needle (Aime 1845) or the compass disc (Bouma 1964); (ii) small balls that fall into a partitioned compass disc (Ekman 1905); (iii) a pointed pendulum that punches a hole in the compass disc (Ekman 1901,

1. Contribution from the Scripps Institution of Oceanography, University of California, San Diego. Accepted for publication and submitted to press 21 April 1966.

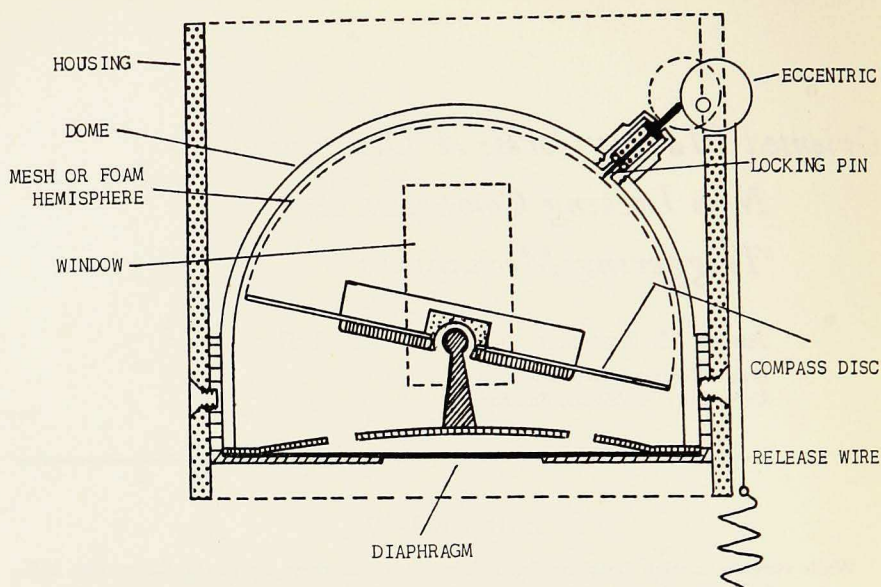


Figure 1. Hemispherical compass.

Nansen 1906); (iv) a compass disc with raised numbers that stamps an aluminum foil (Dahl and Fjeldstadt 1949); (v) a compass needle with a raised point that punches "north" on an acetate film (Felsher 1964); (vi) a sliding pivot that pushes and jams the compass against the cover glass (Meyer 1877, quoted from Richard 1908); and (vii) a compass secured in position by means of a jellifying compound (Carruthers 1958).

A list of devices protected from the ambient pressure by a casing would be far more extensive; such devices would include magnetic compasses or gyrocompasses, time-delay devices, photographic devices, mechanical locks, electrical telemeters, tape recorders, radio transmitters, etc. These have been used by either oceanographers (e.g., Johnson and Wiegel 1958) or oil-well surveyors and have been listed since the turn of the century in scientific and patent literature.

However, to date, the compasses designed by Bouma (1964), Felsher (1964), and Harrison et al. (in press), and those occasionally converted from inclinometers used in oil-well work are the only ones that have been effectively used in oceanographic coring.

Although photoelectronic devices are now highly developed, we have found that they involve excessive shipboard handling problems. This observation has led us to seek a mechanical compass that will give both orientation and inclination, will be reliable, accurate, small, compact, and easy to set, and will require a minimum of handling. While the gyrocompass allows the use of

magnetic metal on the sampling devices, we discarded it because it has the disadvantage of involving a power source, a pressure case, and consequently higher cost. Pressure cases were avoided since they necessitate more handling.

Hemispherical Compass. Our first design incorporated the use of a standard fluid navigational compass such as that used on sailboats. This compass has a pivot that allows it to operate under a high angle of inclination. A lightweight hemispherical dome of permeable synthetic foam was attached to the compass disc, which could be locked with a double pin mounted on the glass dome (Fig. 1). For the prototype we used a single pin that was insufficient to give true inclination data but easier to engineer. The spring-restrained pin was actuated by the release of an eccentric loaded with a torsion spring. The compass worked successfully at sea during several cruises in 1965.

A second model employed two matched pins and a light stainless-steel sieving cloth (1-mm mesh) instead of the foam. The cloth was easier to shape into a hemisphere than the foam, which required machining while frozen. However, while working on this modified model, we developed a new design that has two rather useful features for oceanographic purposes: no fragile pivot point, and six degrees of freedom.

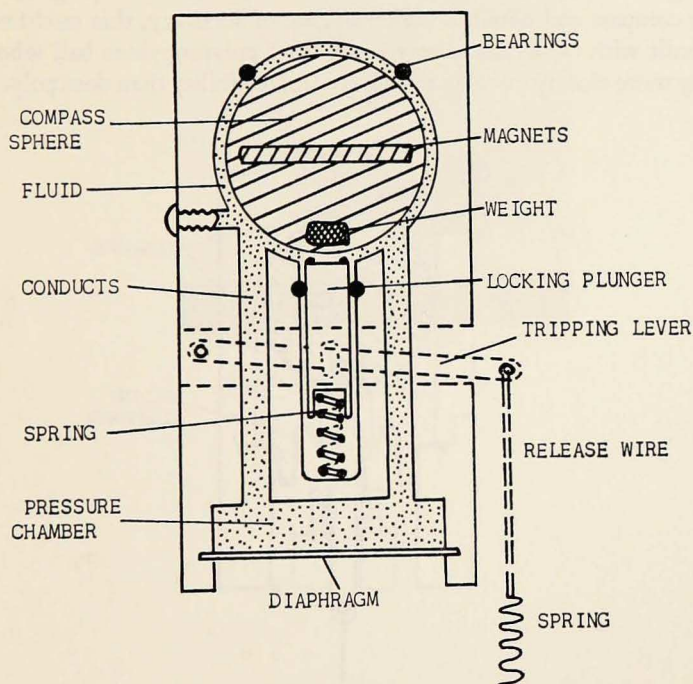


Figure 2. Free spherical compass.

Hemispherical Free-floating Compass. This design (Fig. 2) consists of a polyethylene ball (3.8 cm in diameter) into which two magnets and an orienting balance-weight have been set. This ball is placed in a spheroidal chamber and immersed in a fluid of the same density; the fluid, which is chemically inactive toward polyethylene, is merely a mixture of water and glycerine that produces the proper density and viscosity. We found that, by giving the ball a slight positive buoyancy and placing three tiny sapphire bearings on the upper wall of the chamber, the compass maintained a free and stable motion. The compass chamber is pressure-stabilized through a second connecting chamber containing a diaphragm. The compass is locked by a spring-loaded plunger, which is cocked in an open position by a lever under tension of the triggering wire.

Two of these compasses were built (Fig. 3), and both were successfully tested at sea in September 1965 during a cruise of the R/V HORIZON. We are currently using them on large box corers (Reineck 1958, 1963, Bouma and Marshall 1964) designed to obtain heavy, bulky cores from canyon and fan areas. The two models match within 10° of maximum difference, which indicates the accuracy of these prototypes.

A simpler and more compact version has been designed to reduce construction costs, mainly by using a cylindrical chamber and a rolling diaphragm, thus eliminating the lower stabilizing chamber and plunger seal (Fig. 4). To improve the compass and obtain a higher degree of accuracy, this modified design is being built with closer tolerances and with a polypropylene ball whose compressibility more closely matches the fluid compressibility than does polyethylene.

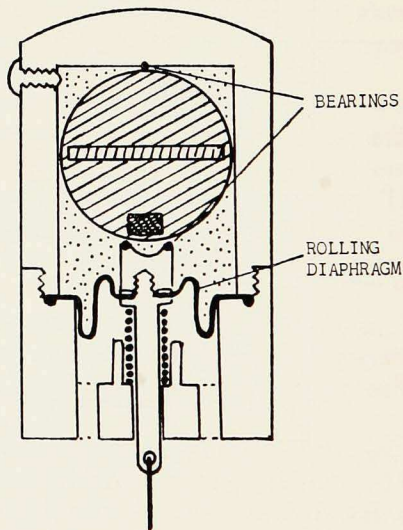


Figure 4. Free spherical compass (proposed simplified design).

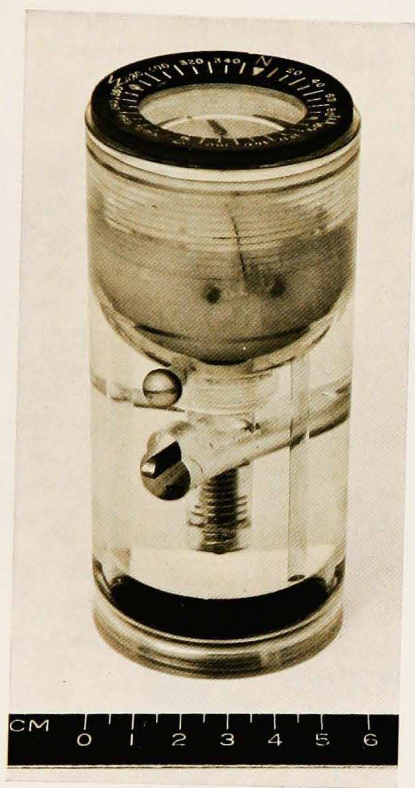


Figure 3. Free spherical compass.

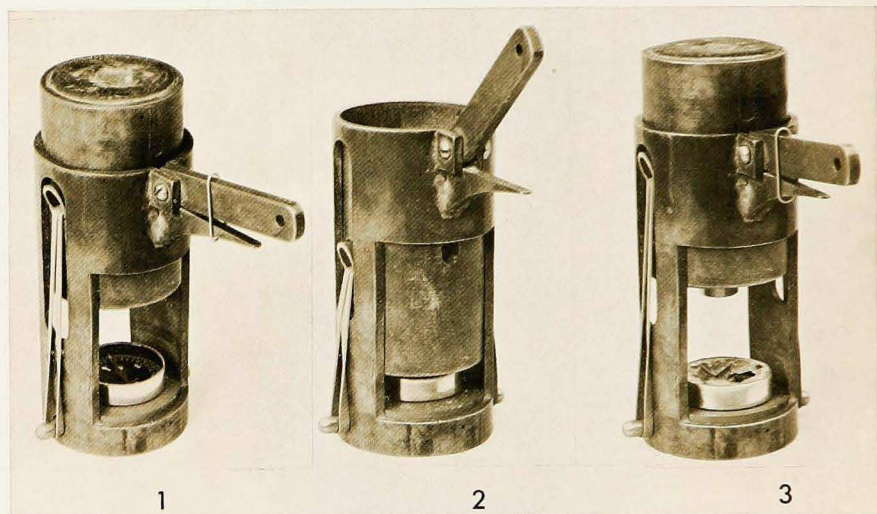


Figure 5. Compass smasher. 1, cocked position; 2, smashing position; 3, open position after smashing, showing the crushed expendable compass.

Compass Smasher. This device (Fig. 5), completed the day before the spherical compass was first used at sea, was designed and built in order to have a substitute if the spherical compass was lost, damaged, or did not work. The compass smasher is merely a destructive device that smashes an inexpensive compass and jams its needle and pivot on the case. It worked surprisingly well, but obviously it did not provide the same accuracy as the compasses described above. It used either compasses sealed with a fluid or compasses open to the seawater, which acts as a compass fluid and eventually improves the stability of the needle. The first model was built with a weight, which was locked with a lever and then dropped down with the help of large rubber bands. The lever is actuated by the release of the triggering wire, as in the preceding compasses. These features, as shown in Fig. 5, were incorporated only to obtain the same outside dimensions as the spherical compass and to fit a similar housing on the corer.

Fig. 6 shows a modification of this compass smasher, using a spring instead of a gravity-driven weight.

The compasses used at sea were inexpensive toy compasses. The main inconvenience with this type of compass was the swelling of the cardboard, which jammed the needle after about 20 minutes underwater. This difficulty can obviously be avoided when necessary by dismantling and spraying the

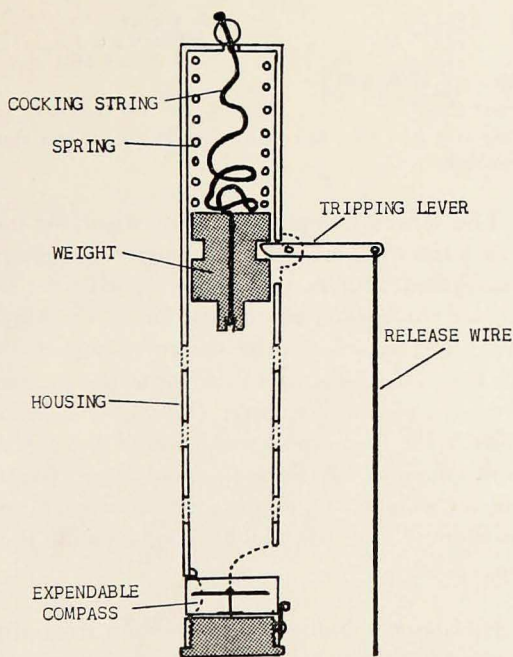


Figure 6. Compass smasher (proposed compact design).

compass with a plastic film, or by using fluid-filled card compasses that are more expensive but are also available on the toy market. The reliability of this compass smasher was better than $1/12$ of the circle, and in two-thirds of the cases its data matched within 10° the data from the spherical compass.

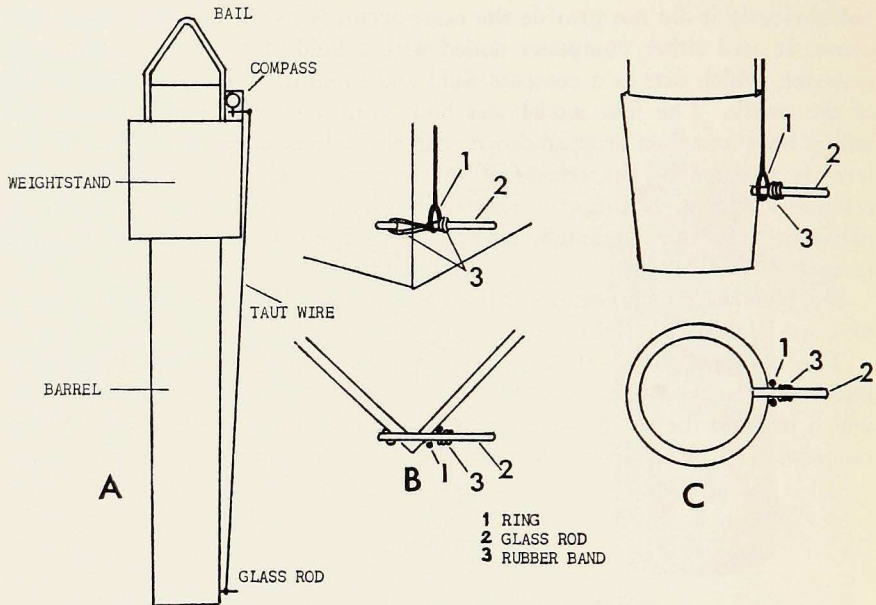


Figure 7. Triggering with glass rods. A, over-all view; B, rod set in a square nose; C, rod set in a cylindrical nose.

Comments. The spherical compass is convenient for use with large corers designed for the purpose of studying the microsedimentary or paleomagnetic features of undisturbed samples that require good orientation. The compass smasher would give cruder orientation data, but it is a cheaper and more rugged tool. Both devices are not affected by the corer impact on the sediment.

To avoid the magnetic influence of the corer, the compasses were positioned on a protruding arm on the box corer (Bouma and Marshall 1964, Bouma 1964). Error due to the metal mass was lowered to less than 5° by positioning the compass in this manner. On the long square corers (Rosfelder and Marshall, in press), the upper weightstand is made of nonmagnetic metals and the compasses are housed directly on the weightstand, avoiding the handling risks of a protruding arm.

Triggering Mechanisms. None of the common triggering mechanisms used on grabs or corers to initiate their closure or their free-fall (through a change in tension of the main wire, through a change in load of the instrument when

reaching or leaving the sea floor, through a tripping weight, or through a mercury switch acting on bottom contact) seemed reliable and simple enough for the specific purpose of triggering a compass lock. Our mechanical system afforded a very simple but reliable triggering mechanism; it consists basically of: (i) loading the compass latch-lever with a spring or rubber band, (ii) keeping the latch-lever open under tension with a wire stretched by a stronger spring or a shock cord, and (iii) fastening the wire extremity to a yielding point on the instrument itself in order to have a rigid link between the latch and the releasing point on the corer until contact with the bottom is made. The yielding point to which the wire is fastened can be a mobile part of the corer that is actuated on bottom contact—the blade lever of the box corer previously mentioned, or a device specifically fitted on the corer for this purpose. On the large gravity corers and on the Phleger-type corers used by us, equally satisfactory results were obtained with a glass shear pin or a tiny permanent lever.

Fig. 7 shows two ways of adjusting the glass shear pin on a square or cylindrical core nose. A slight scratch on the glass provides a reliable rupture at the desired point. The wire is fastened on the pin with a ring held in position by a rubber band near the scratch.

In Fig. 8 we have plotted experimental rupture data pertinent to the use of glass pins. These values are based on actual tests at sea. The usable sizes range between two limits: (i) low ratio length/diameter, when a short and thick pin will not be broken in the sediments with a slow winch speed, and (ii) high ratio when a long and thin pin will snap off prematurely under the strain of water resistance with a high winch speed, during a free fall, or under occasional acceleration. The recommended sizes between these two limits agree with an optimum ratio length/diameter = 10 for common laboratory glass rod.

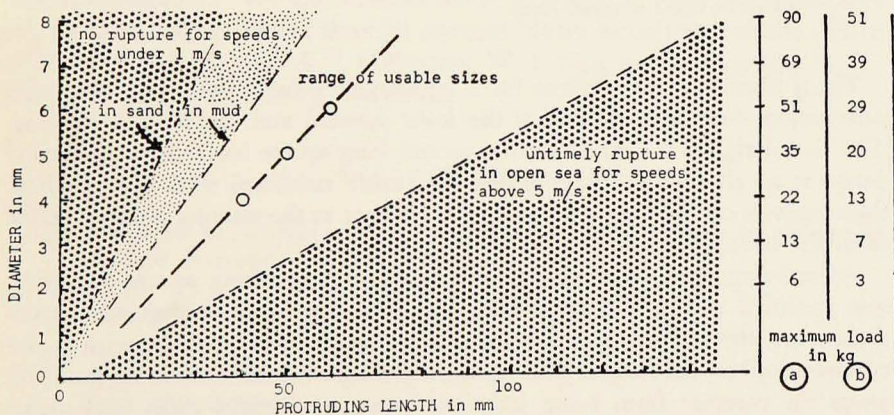


Figure 8. Use of glass rods as triggering mechanisms. On the right, maximum load for (a) rods without a rupture scratch, (b) rods with a rupture scratch.

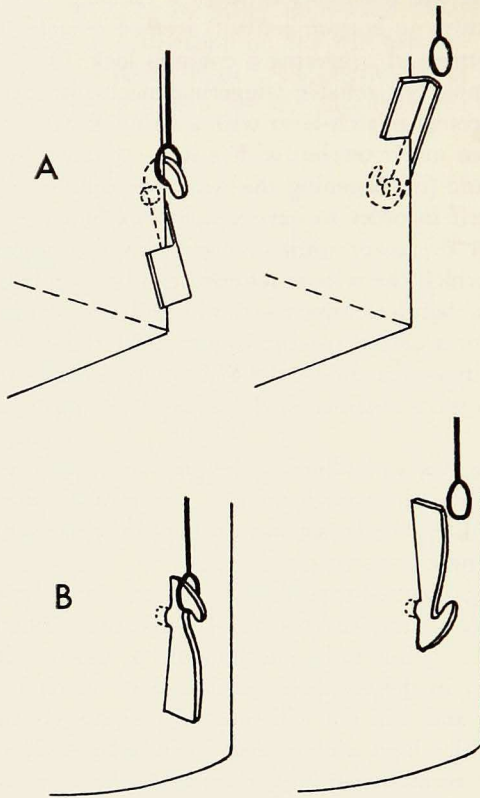


Figure 9. Triggering with a nose lever. A, design effectively used on a square nose; B, alternative design for round or square noses.

Fig. 9 illustrates two designs for a permanent lever on the core nose. On penetration, the sediment pushes the lever upward and the wire is released. The first design was used efficiently on our long square box corer; the second design is an alternative solution. Should a more stabilized reading be desired, these releases can be reversed so that they release as the sampler is being pulled from the sediment.

After being used at sea during several cruises, this long square box corer was modified with a sliding weight, and the release mechanism was placed directly on this weight, using the device shown in Fig. 10. The wire is disconnected when the weight goes up during the penetration of the corer. This keeps the compass from being unlocked when the weight slides back down during ascent of the device.

Details not given here may be obtained by writing directly to the authors.

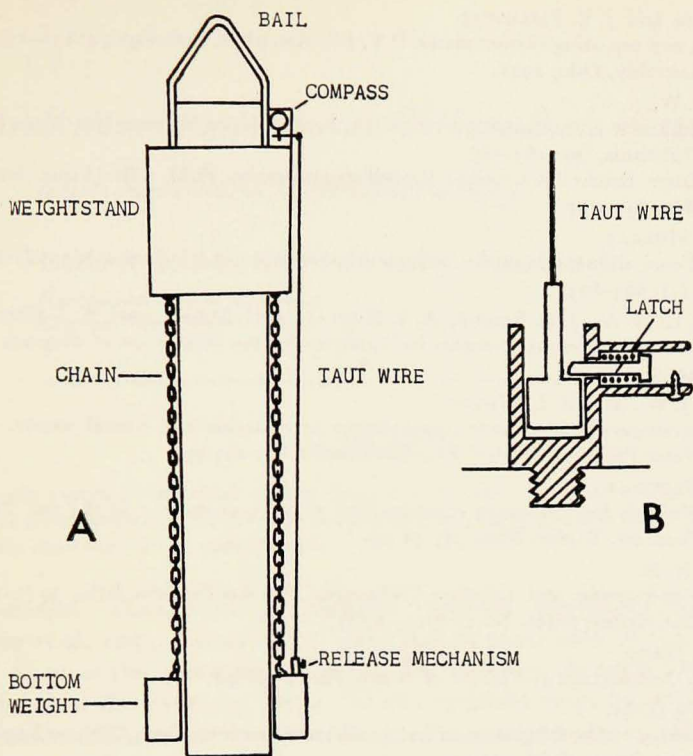


Figure 10. Triggering with a stabilizing weight. A, over-all view; B, release-mechanism detail.

Acknowledgments. We are indebted to: F. P. Shepard, under whose auspices this work was accomplished through contract NONR 2216(23) with the Office of Naval Research; and A. J. Okleshen, W. J. Cox, and particularly N. T. Powers for their engineering assistance.

REFERENCES

AIME, GEORGES

1845. *Recherches de physique générale sur la Méditerranée. Exploration Scientifique de l'Algérie.* Imprimerie Royale, Paris. 211 pp.

BOUMA, A. H.

1964. Self-locking compass. *Mar. Geol.*, 1 (2): 181-186.

BOUMA, A. H., and N. F. MARSHALL

1964. A method for obtaining and analysing undisturbed oceanic sediment samples. *Mar. Geol.*, 2 (1, 2): 81-99.

CARRUTHERS, J. N.

1958. A leaning-tube current indicator ("Pisa"). *Bull. Inst. oceanogr. Monaco*, 1126; 34 pp.

DAHL, ODD, and J. E. FJELDSTAD

1949. A new repeating current meter. *P. V. Int. Ass. phys. Oceanogr.*, 4: 131-132. General Assembly, Oslo, 1948.

EKMAN, V. W.

1901. On a new current-meter invented by Prof. Fridtjof Nansen. *Nyt Mag. Naturvid., Christiania*, 39: 163-187.

1905. Kurze Beschreibung eines Propell-strommessers. *Publ. Circ. Cons. int. Explor. Mer*, 24: 4 pp.

FELSHER, MURRAY

1964. A core-aligner designed to recover oriented recent marine cores. *Limnol. Oceanogr.*, 9 (4): 603-605.

HARRISON, C. G. A., J. C. BELSHÉ, A. S. DUNLAP, J. D. MUDIE, and A. I. REES

In press. A photographic compass inclinometer for the orientation of deep-sea sediment samples.

JOHNSON, J. W., and R. L. WIEGEL

1958. Investigation of current measurement in estuarine and coastal waters. *Publ. St. Water Pollution Control Bd., Sacramento*, 19; 233 pp.

NANSEN, FRIDTJOF

1906. Methods for measuring direction and velocity of current in the sea. *Publ. Circ. Cons. int. Explor. Mer*, 34; 42 pp.

REINECK, H. E.

1958. Kastengreifer und Lotröhre "Schnepe." *Senckenbergiana leth.*, 39 (1-2): 45-48.

1963. Der Kastengreifer. *Natur Mus.*, 93 (2): 65-68.

RICHARD, JULES

1908. *L'Océanographie*. Vuibert et Nony, Paris; 398 pp.

ROSFELDER, A. M.

1966. Subsea coring for geological and geotechnical surveys. *Proc. Offshore Explor. Conf., Long Beach, Calif.*; 32 pp.

ROSFELDER, A. M., and N. F. MARSHALL

In press. Problems in obtaining large, undisturbed and oriented samples in deep water. *Res. Conf. on Marine Geotechnique*, May 1966, Univ. of Illinois, Champaign, Illinois.