THE BALL-BREAKER, A DEEP WATER BOTTOM SIGNALLING DEVICE[1]

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ABSTRACT

A simple device for signalling the arrival of a deep cast on bottom has been developed and is now in routine use. The device is used either in line with corers or is suspended below as a pilot. When contact of either the ball-breaker or other apparatus is made with the bottom, a small glass sphere in the former is imploded and the resultant signal at the surface is amplified and reproduced over a loud speaker system. The device has been used successfully at depths to 2,700 fathoms.

General. With the present-day trend toward deep water oceanography, many difficulties have arisen which were not encountered in shallow water operations. Among these difficulties is the problem of determining the exact time when a piece of oceanographic equipment reaches bottom. This is not serious in shallow water, since sensitive dynamometers have been constructed which indicate to the observer aboard ship the moment that the tension on the cable is relieved. However, in deep water the weight of the equipment is often only a small fraction of the total weight of cable and of variable loads imposed by the ship's roll; therefore, no conclusive effect upon tension can be observed when the apparatus encounters bottom.

Obviously, the answer to this problem may be found by employing some device which is independent of both the ratio of equipment to cable weight and the depth of the water. To meet this need, an instrument was developed which imploded a small glass sphere when the apparatus hit bottom. The resulting implosion, picked up at the surface by a simple hydrophone, is amplified and reproduced audibly over a loudspeaker system.

Development. The original method used to trip the mechanism and to break the glass sphere is shown schematically in Fig. 1. The apparatus is very simple; it merely employs a piston fitted with a sharp point which is allowed to fall when the equipment contacts the bot-

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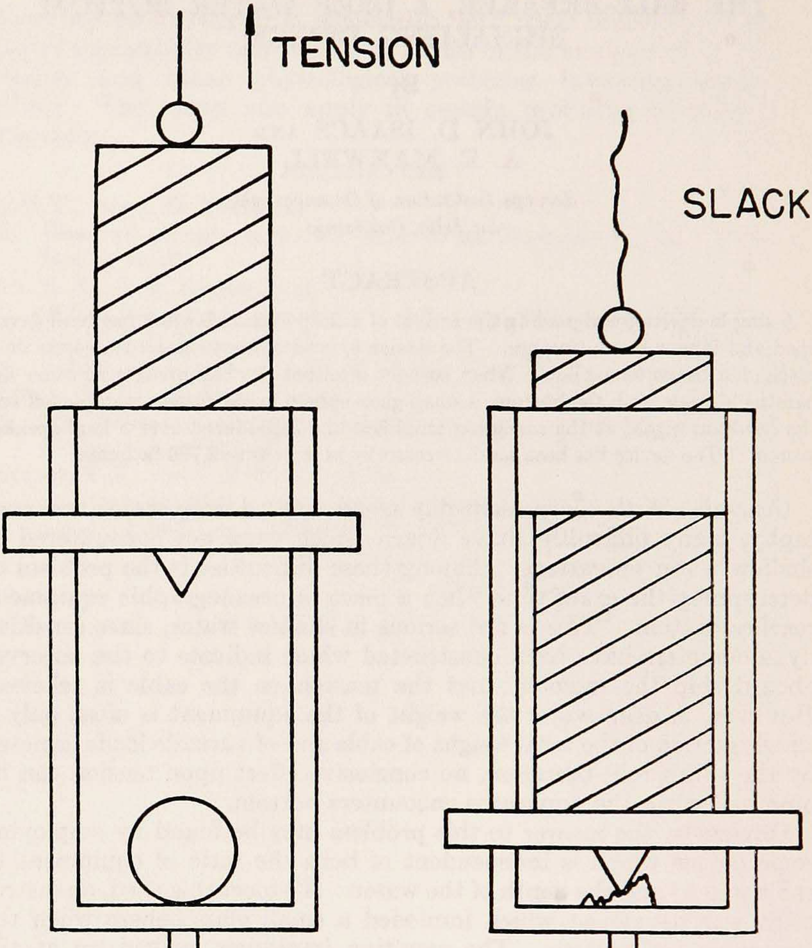

Figure 1. Schematic of early model ball-breaker showing method of tripping.

tom, thus imploding the glass sphere. Such a straight-forward device would seemingly present no problem in its initial design; however, as is often the case in oceanographic operations, equipment which appears to be encouraging on the drawing board and which works well in test tanks may fail entirely when lowered into the ocean. Such was the case with the early models of this device.

The first model functioned satisfactorily in shallow water, but in deep water the point succeeded only in chipping the glass ball and was therefore ineffective. It was thought that the cable stretched elastically under the loads and then contracted as the equipment reached bottom, thus allowing the piston to lower gently upon the glass sphere. This problem was solved by incorporating a tripping mechanism in the device to allow the piston to drop freely on contact with bottom.

However, with this new model a great many failures in breaking the ball were experienced, since some balls were entirely fractured but were held together by the pressure; thus they failed to implode. It became apparent that the glass balls acquired great strength under compression in much the same manner as an arch can carry greater concentrated loads under a large dead load than it can with a small dead load. To eliminate this difficulty, the chisel point tip was replaced with a conical tip in the hope of reducing the area of impact upon the sphere, but then the conical tip and the glass wedged together in a pressure tight seal as though the glass were plastic; again implosion was prevented. To avoid sealing, the tip was relieved in three places so that shearing and bending might occur in the glass to facilitate collapse. This proved successful in all subsequent trials.

Description and Techniques. Fig. 2 shows the instrument in its present form. The glass sphere is centered by three tips and is held into place by a turn of friction tape. A more complex holding device does not appear to be practical since projections are blown off by the implosion. Located inside the cylinder is the tripping mechanism which releases the piston upon contact of the device with the bottom. The ring on the bottom provides a means of securing other instruments below the ball-breaker if it is to be used as an in-line device.

There are several types of glass spheres which are available commercially and which appear to be satisfactory. Preliminary pressure tests of various samples have shown that some of these balls are capable of withstanding pressures up to 16,000 psi. The balls, made commercially for ornamental purposes from ordinary glass, are approximately two and one-half to three inches in diameter and have an average wall thickness of $\frac{1}{16}$ inch. The glass may contain a large number of air bubbles and may often be irregular as to size and shape; but these minor irregularities do not appreciably effect the efficiency of the balls. However, care must be taken to eliminate those balls that have a small hole at the point where they are sealed, since water in the balls render them ineffective. The balls are tested by securing several balls in a cloth sack and by lowering them a few hundred meters in the water. Experience has shown that the balls should be separated

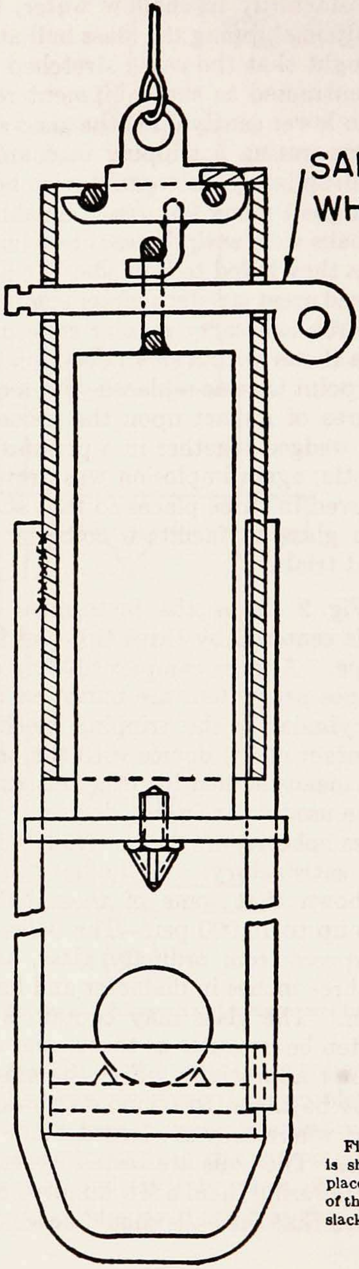

Figure 2. Section of revised ball-breaker which is shown in loaded position with safety bar in place. The tripping mechanism, located at the top of the cylinder, releases the piston for free fall when slack occurs in the suspending wire.

into two classes: thick spheres with about ⅛-inch walls for use in depths greater than 3,000 fathoms, and thinner spheres with walls approximately 1/16-inch thick for use in water less than this depth. In this way the balls are segregated into divisions which give maximum efficiency by avoiding premature failures.

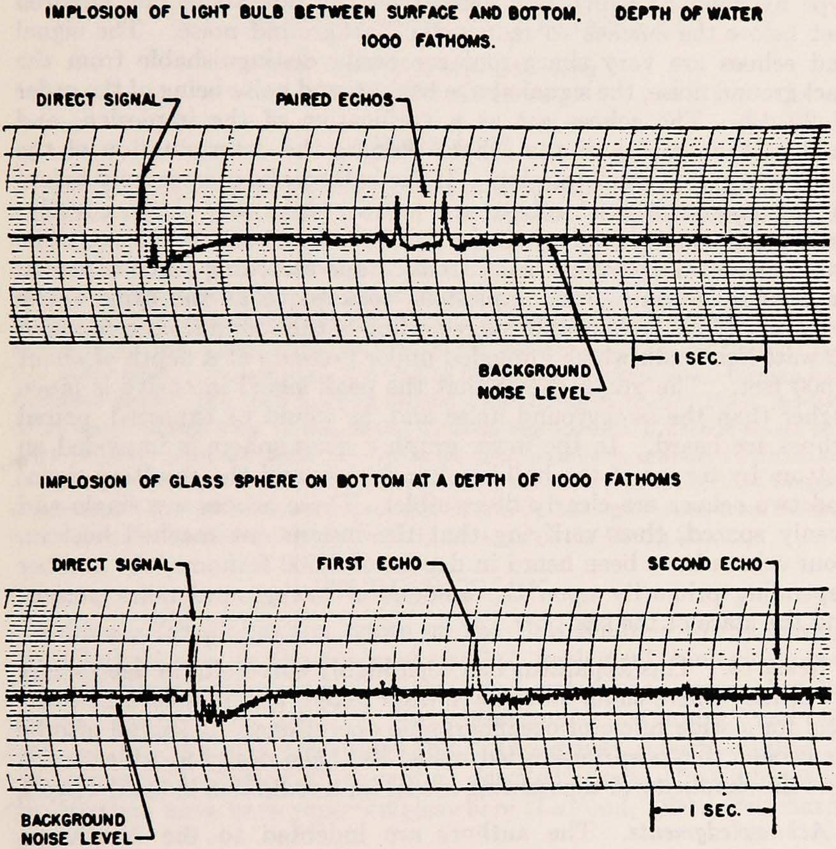

Figure 3. Traces of two implosions illustrating the different types of echoes encountered.

Surprisingly, it is found that the peak intensity of the signal received from these implosions is practically independent of the depth of implosion; that is, the increase in attenuation is offset by the increase in *peak* energy obtained at greater depths. Such appears to be the case for signals which have originated at depths from 200 to 2,700 fathoms, although no quantitative measurements have been made. Although it might be expected that an increase in the diameter of the sphere would result in a corresponding increase in the peak signal intensity, preliminary tests show that this is not the case. Possibly the larger air mass, corresponding to the larger volume, produces a cushioning effect which tends to reduce the peak energy released.

At the surface, the signal is picked up by a simple magnetostriction-type hydrophone which is lowered over the side about one hundred feet below the surface to reduce the background noise. The signal and echoes are very sharp and are easily distinguishable from the background noise, the signal above background noise being of the order of 20 d.b. The echoes act as a verification of the implosion, and further, the spacing of the echoes permits the determination of the relative depth of the implosion. If the ball breaks prematurely before hitting bottom, paired echoes are heard, while only single equally-spaced echoes are heard when the ball is broken on the bottom. The two traces in Fig. 3 were taken from a tape recording made of actual implosions at sea. Both implosions took place at the same ship's position. The upper graph is a recording of the sound from a common 25-watt light bulb which imploded under pressure at a depth of about 4,500 feet. The graph shows that the peak signal intensity is much higher than the background noise and, as would be expected, paired echoes are heard. In the lower graph a glass sphere is imploded on bottom by means of the ball-breaker device, and the resulting signal and two echoes are clearly discernible. These echoes are single and evenly spaced, thus verifying that the instrument reached bottom. Four echoes have been heard in depths of 2,500 fathoms, the number depending primarily upon the amount of background noise present and the state of the sea.

Remarks. This apparatus has been highly successful in deep-water operations where small cores have been taken, and it should be practical for a wide range of oceanographic operations. It should also be mentioned that a spring-loaded model has been designed which sacrifices the simplicity of the existing model for a reduction in total weight.

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