DEEP SEA PHOTOGRAPHY

By

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Interest of the senior author in deep sea photography stems from a desire to obtain photographs of deep sea luminous fish—not by their own light, but in their natural environment, using artificial illumination. The abundance of deep sea forms observed by Beebe (1934) from his bathysphere suggests that success might be achieved, especially if a lure could be found that would attract deep sea fish to the front of the camera.

Just before the war, a pressure chamber was designed (Harvey, 1939) and manufactured[1] that would withstand two miles of depth in the sea with a considerable safety factor. In this chamber, shown in Fig. 1, two six-volt storage batteries supplied the current to run the motor for a 16 mm. moving picture camera, a 50 candle power headlight bulb with reflector, and a timing motor. The light shone through one "herculite" glass window, while the camera took pictures through another. Anhydrous $CaCl_2$ prevented moisture condensation on the glass. A pressure gauge with electric contacts, which could be set for any depth, activated the mechanism by means of a lock relay. This relay started the timing motor, whose contacts turned on the movie camera and light for 1.2 seconds and then turned them off for 11.1 seconds, when the process was repeated. The camera was set to take 16 pictures a second, and the films when developed showed a series of 20 exposed frames between 3 dark ones, since the lamp filament took some time to reach incandescence and the motor some time to stop. In 100 feet of film with 40 frames per foot, there were about 170 chances of photographing something, and 3,400 exposures. Since the pictures were taken in the zone of perpetual darkness, a lure was hung four feet in front of the pressure chamber, and the camera (with stop f 1.5) focused on it. This lure was a wooden fish resembling a deep-sea fish, with rows of photophores painted on it with self-luminous zinc sulfide paint.

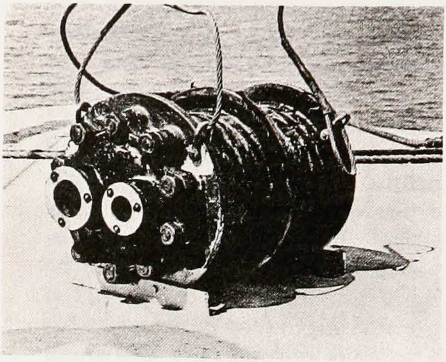
[1] The chamber was made by the Springfield Boiler Co. and was a gift of its President, Mr. Owsley Brown.

In all, seven descents[2] were successfully accomplished with this camera. Five of them took place in the region 5 to 10 miles southeast of Bermuda, where Beebe had made over 1,500 hauls with nets and many descents with the bathysphere. Three 100-ft. rolls of super XX panchromatic film were taken at 500 fathoms, one at 800 fathoms, and one at 1,320 fathoms (1½ miles). In the latter, the chamber touched bottom, knocking off a support and turning the camera out of position so that nothing appeared on this film. The other four films showed the lure clearly, but no fish or large organisms. However, 17 small organisms, the largest about one centimeter in diameter, too small to be identified, moved across the beam of light in the 300 feet of film taken at 500 fathoms, the depth where Beebe obtained most material in his hauls with the nets. The film at 700 fathoms showed only two small creatures.

Two other successful tests were made from the "Atlantis" about 500 fathoms down in the Atlantic Ocean, south and east of Boston. About 23 small organisms appeared on these two 100-foot films. Thus 600 feet of film, representing 1,020 chances of photographing something and 20,400 individual frames, revealed only 42 small organisms and no fish the size of deep sea types. The chief conclusion to be drawn from this summer's work is that deep nekton fish are not abundant and not attracted to the luminous lure that was used. Perhaps they are frightened away by the sound of the motors within the chamber.

During the war, photography of the sea bottom was carried to a high degree of perfection by Ewing, Vine and Worzel (1946), and Ewing, Woollard, Vine and Worzel (1946). The published photographs of this group are beautifully clear and some of their unpublished photographs of deep sea-bottom invertebrates are truly remarkable. These authors used a small camera (in a pressure chamber) that took single or two successive pictures, with photoflash bulbs for illumination. In their arrangement, the camera chamber and photoflash lighting are separate and fastened on a pole, held vertical by a float. In one type (the free floating camera), a ballast weight is released after the outfit has touched bottom and the exposures have been made by means of a trigger that actuates clockwork, opening the shutter and firing the photoflash bulbs. The camera then rises to the surface to be retrieved and reset. In a second type (the suspended camera), the camera and flash lights are arranged on a vertical pole as in the first type, but the assembly is

[2] Five tests of the camera were made through the kindness of Dr. J. F. G. Wheeler, Director of the Bermuda Biological Station in 1939, from the ketch "Culver," permanently stationed in Bermuda for oceanographic work. Later, in July and August, two more tests were made from the ketch "Atlantis," through the kindness of the Director of the Woods Hole Oceanographic Institution, Dr. Columbus Iselin.



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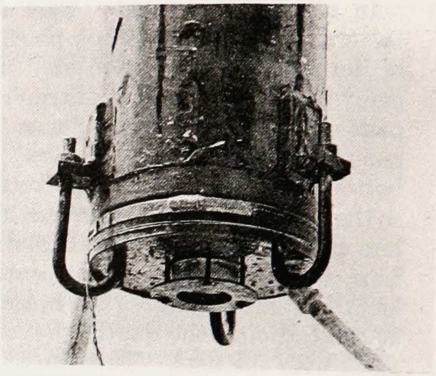

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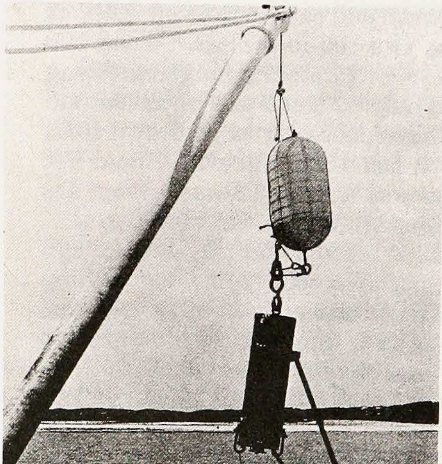

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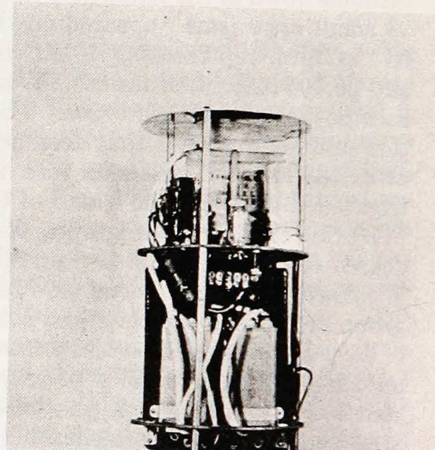

D

Figure 1

A. Front view of the 1939 deep sea camera chamber, showing cover with large glass window through which an incandescent bulb illuminates the region of the lure and the small glass window through which motion pictures are taken.

B. The black cylindrical pressure chamber of the 1946 deep sea camera hung from a boom, with attached float (above) and ballast weight and light (below). The rectangular ballast, attached to a pipe screwed into one of three brackets near the upper end of the pressure chamber, rests on the pier. The reflector and the flash tube are just above the ballast. Making a right angle at the end of the flash tube chamber is a pipe containing wires for the high voltage impulse generated within the main pressure chamber. This pipe enters the chamber through the cover. The float is an airplane oxygen tank filled with compressed air. Its purpose is to keep the whole outfit in a vertical position, without lifting it off the bottom. For a long series of pictures, the camera assembly can be attached by a cable to another float at the surface, thus recording the succession of animal events during a whole night.

Two additional brackets (not shown in picture) take two additional pipes to form a tripod, when the chamber is to be used resting on the bottom without a float. For deep sea photography above the bottom, float and ballast weight are removed.

C. Near view of the cover end of the chamber, with "Herculite" glass window held in place by a metal disk. The cover fits in smoothly machined grooves, and is held tight by three dogs. A heavy rubber band covers the joint and is squeezed tight by wire rings. As the hydrostatic pressure increases with depth the rubber band is pressed firmly on the cover-chamber joint, preventing leakage into the chamber.

D. A photograph of the internal mechanism, showing distribution of contents in three compartments. In the lower compartment are relays and clock timer (not visible in photograph), camera and motor, and the connections for wires to the flash lamp. In the middle compartment are the high voltage condenser and storage battery. In the upper compartment are transformers, interrupter, capacitances, resistors and a rectifier for generating the high voltage pulse to the flash tube.

suspended from a cable. When bottom is touched, a trigger actuates the exposures and the instrument is then drawn to the surface. The many interesting snapshots obtained with the above types of camera indicate that life on the ocean bottom is remarkably rich.

The problem of photographing deep sea fish which live well above the bottom is one involving (1) attraction of the fish and (2) a succession of rapid exposures, to increase the chance of photographing something. The situation is comparable to a photographer who aims his camera skyward at random, hoping to photograph a bird; the bird must be lured near the camera by some device. Unfortunately we know nothing of the objects likely to attract a deep sea fish and can only surmise that, unlike surface fish, they would avoid a bright steady light but be attracted to the kind of luminous lure that most nearly resembles their own pattern of photophores. Perhaps some kind of bait should be used.

With these thoughts in mind, we designed a new type of deep sea camera, self contained in all particulars, that can be lowered to depths of one half mile, the region of maximum concentration of deep sea organisms. Weight was reduced as much as possible, so that the outfit could be handled from a relatively small laboratory launch.

In the new design, the camera was an old but compact Zeiss Ikon Universal Kinamo for motion pictures, with f2.5 tessar lens, holding about 40 feet of 35 mm film, and driven by a 12 volt D. C. motor (with reducing gears) at a slow speed of one frame every five seconds. The shutter was removed from the camera and a commutator placed in the driving mechanism, to trigger a G. E. FT-10 flash tube by means of a microswitch contact every five seconds. Current from a 28 microfarad condenser, charged to about 2,000 volts, passing through the flash tube gave the illumination for instantaneous photography, with exposures of nine microseconds, sufficient to obtain clear pictures of any fish, no matter how rapid its movement.

The camera, mounted behind a herculite glass window, the motor, storage battery, relays, condensers, interrupters, and other parts of the flash tube circuit[3] were placed in a ¼″ thick steel tube, 8″ inside diameter and 25″ long, with heavy steel ends. The flash tube and trigger coil were contained in a second smaller steel chamber with a thick glass bowl on one end through which the light of the flash was directed toward objects in front of the camera. A reflector helped

[3] For the design and construction of the lighting circuit we are deeply indebted to Dr. H. E. Edgerton of the Massachusetts Institute of Technology. Thanks are also due to Mr. Harold Towne, technical assistant to Dr. Harvey, for skillful installation in the limited space of the chamber, and to Mr. Russell Mycock for machining the steel parts.

concentrate the light. Insulated wire connections between the light chamber and the main pressure chamber were made through a well braced steel pipe that also served to hold the light three feet away from the main chamber and at a 45° angle with the axis of photography. A bait or lure could be dangled before the chamber and the camera focused on it. The complete outfit weighed about 150 pounds. It is pictured with the internal mechanism in Fig. 1.

The deep sea camera could be used either (1) free, suspended from a cable at various depths, or (2) attached to a tripod so as to rest five feet above the bottom, or (3) held by a weight and float at a distance of five feet from the bottom. The camera and lighting mechanism could be started either after a given time interval, by a clock and contact within the chamber, or, by a pressure gauge and contact after a certain depth had been reached.

The camera assembly was tested during the summer of 1947 at the Bermuda Biological Laboratory[4] and proved to be a practical tool that could be handled from the 28-foot laboratory launch "Diadema," equipped with an aircraft bomb lifting winch and one eight-inch stranded steel cable. An unfortunate accident, the result of acid leaking from the storage battery, ruined the camera and prevented its use at depths of one half mile, but pictures of the bottom and of coral heads and sea weed were obtained at moderate depths. However, no living animals appeared within the field of view in over a thousand individual photographs. It is possible that the succession of flashes every five seconds actually scares animals away, an important point that should be determined for shallow water fish, where effects of the flashing light can be observed. Whether deep sea fish, whose reactions to bright lights are unknown, would behave in the same way, is another question.

The flash of light is extraordinarily bright and can be seen under water at night for long distances. In future modifications, it would probably be better to increase the interval between exposures from five seconds to one minute or perhaps more, in order to allow animals to recover from the previous flash. Dry batteries might be substituted for a storage battery or the latter placed outside the pressure chamber. With such an outfit it is believed that many problems connected with the behavior of deep sea fish might be solved.

[4] The authors express their thanks for the facilities of the Bermuda Biological Station and their appreciation of the advice and co-operation of its Director, Dr Dugald E. S. Brown.

SUMMARY

A new type of camera, in a pressure chamber, and its lighting mechanism, is described for photographing organisms in the depths of the sea. Six hundred and forty pictures, at intervals of five seconds or more, can be taken on 35 mm film before reloading. Discharge of a condenser through a flash tube is used for lighting; the exposure is about 10 millionths of a second. The total weight for depths of one half mile is about 150 pounds; for greater depths thicker walls and more weight is necessary. Some of the necessities for successful photography of deep sea luminous fish are discussed.

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