A portion of construction of equipment was carried out with support from the Office of Naval Research (NONR 2216 (01), and the National Science Foundation (NSF - Y/9. 1/51 IGY).

REFERENCES

GROVES, G. W. (1955) Numerical filters for discriminating against tidal periodicities. *Trans. Amer. Geophys. Union*, **36**, 1073–1084.

MUNK, W. H., IGLESIAS, H. V. and FOLSOM, T. R. (1948) An instrument for recording ultra low frequency ocean waves. *Rev. Sci. Instr.*, **19** (10), 654–658.

Deep-sea free instrument vehicle

(*Received* 11 *April* 1960)

Abstract—A number of free instrument vehicles have been designed and tested. These are simple, reliable, inexpensive devices that transport recording instruments or sampling equipment to the deep-sea bottom, or to intermediate depth, and return them to the surface. Vehicles are provided with radar reflectors and other location devices. In the first tests the vehicles bore fish traps and were successfully operated to 2,000 fathoms. Other instruments designed to make use of the free vehicle's unique capabilities are under development.

INTRODUCTION

THE difficulty of measuring and sampling in deep ocean waters greatly limits the conduct of oceanographic research. Oceanographers traditionally have suffered from inefficiency in their operations because of their dependence upon conventional long-wire techniques for most deep measurements. Freely descending vehicles have been used on occasion (EWING and VINE 1938), (ISAACS and KIDD 1957). These have not previously been brought to the level of design that would allow their routine mass use as general purpose oceanographic tool, however.

Development of the Deep Free Vehicle (DFV) system was undertaken to overcome some of these difficulties, to permit the small vessel to participate in deep investigations, and to add versatility and effectiveness to the large vessel. As examples, with the DFV, small vessels without heavy winches can now be used to collect water samples and benthic organisms on the deep-sea bottom, and many deep-water investigations can be added to the expedition programme of large vessels.

Thus, an expedition with a heavy programme of piston coring or other operations necessitating long-wire techniques, can simultaneously obtain other related or independent measurements by the DFV technique, and small unspecialized vessels can engage in such studies as sampling water and organisms in deep atomic waste disposal areas.

GENERAL DESCRIPTION

In brief, the system (Fig. 1) consists of :

(1) a flexible plastic float filled with gasoline that provides positive buoyancy at any depth;

(2) a separate submersible marker buoy, which enables the system to be located when it arrives at the surface;

(3) a depressing ballast weight with a release device that releases ballast at a predetermined time or depth; and

(4) one or more recording or sampling instruments, whose point of attachment in the line is adjustable.

OPERATION

In operation, the system is launched freely from a ship. It descends to the bottom where it remains until the ballast weight is released. By use of the pressure release, the system can also be programmed to descend to an intermediate depth and return to the surface.

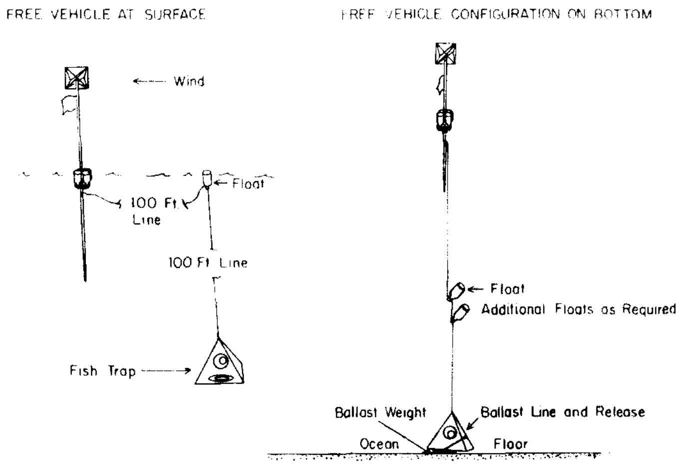


FIG. 1.

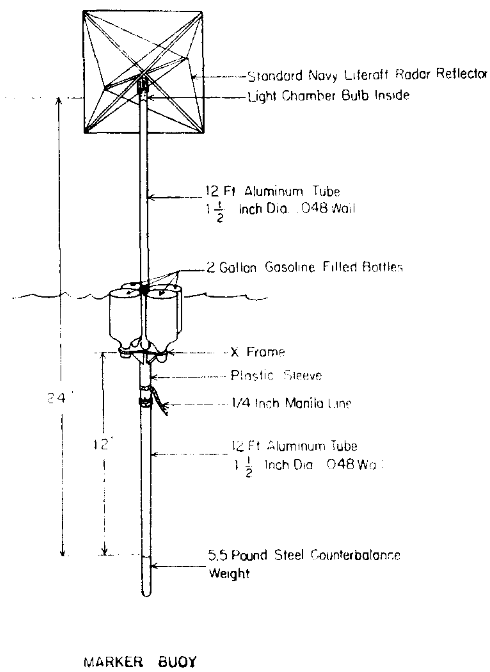
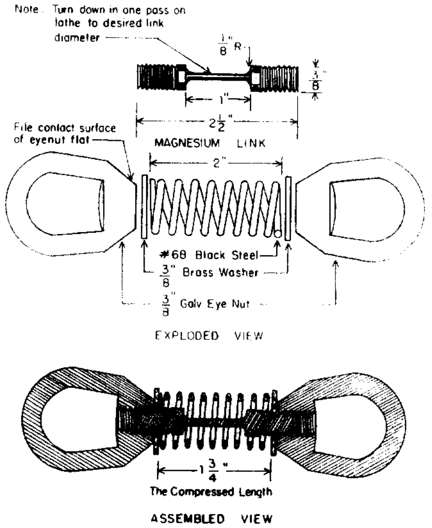


FIG. 2.

The present system has been used to depths of 2,000 fathoms (although it is not limited to this), and has remained on the bottom for periods longer than ten hours, carrying as much as 25 pounds of payload.

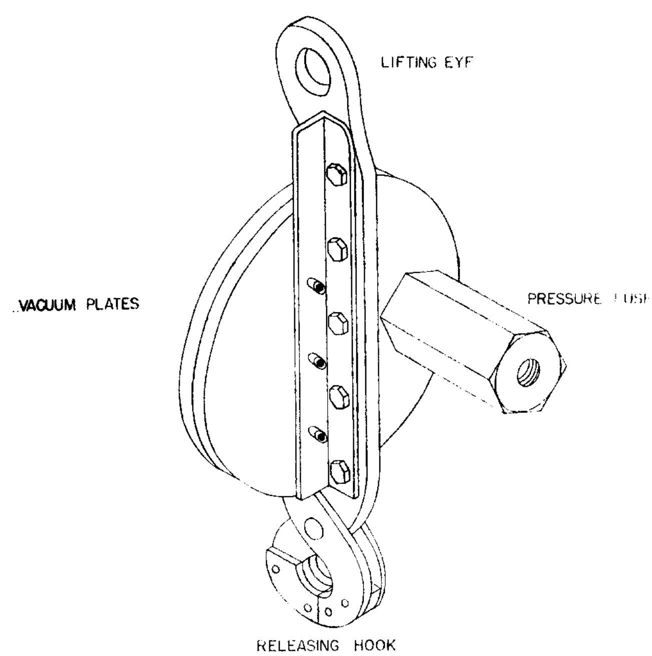
Table 1

No.	Launching Date	Depth Fm.	Location (see map)	Launching time	Sighting time	Catch
1	4/23/59	450	Test 1	11.30	14.30	6 sable fish – *Anoplopoma fimbria*; 6 hagfish – *Myxine circifrons*;
2	5/19/59	746	Test 2	11.00	15.41	3 sable fish; 3 hagfish; 1 lithodid crab; 1 Copepod; 1 octopus (partially digested)
3	6/21/59	650	Test 3	11.00	18.45	Over 50 hagfish (3 species); 5 sable fish; 1 brittlestar; 1 Pacific rattail – *Coryphaenoides acrolepis*
4	7/24/59	1107	Test 4	19.39	14.40	2 rosy snailfish – *Paraliparis rosaceus*; hagfish 5 eelpout – *Lycodes* sp. assorted small Amphipods. (Experimental model)
5	7/24/59	1107	Test 4	20.03	10.30	(with 4)
6	9/9/59	1855	Test 5	11.40	not recovered	
7	9/9/59	1840		12.25	8.20	no specimens
8	9/9/59	1970	High seas difficult	13.00	21.52	no specimens, trap damaged
9	9/9/59	2050	navigation	13.35	not recovered	
10	9/9/59	630	first large scale experiment	10.50	21.10	5 sable fish
11	9/9/59			11.40	not recovered	
12	9/9/59			11.10	not recovered	experimental model
13	10/27/59	950	Test 6	2.10	14.15	3 lithodid crabs; 3 hagfish; 1 rosy snailfish 1 Pacific rattail
14	10/27/59	945		2.20	15.00	3 crabs; 1 eelpout – *Lycodes* sp.; assorted Amphipods
15	10/28/59	1170		21.00	7.35	1 hagfish; 1 flatnose codling – *Antimora rostrata*; 5 eelpouts – *Lycodes* sp.
16	10/28/59	1170		21.15	8.36	2 hagfish (1 albino); 1 eelpout – *Lycodes* sp.
17	3/9/60	105	Test 7	1.15	6.30	1 *Sebastodes eos*
18	3/9/60	120		1.30	6.30	3 *Sebastodes eos* 1 ,, *macdonaldi*



MAGNESIUM TIME RELEASE

FIG. 3.



PRESSURE RELEASE MECHANISM

FIG. 4.

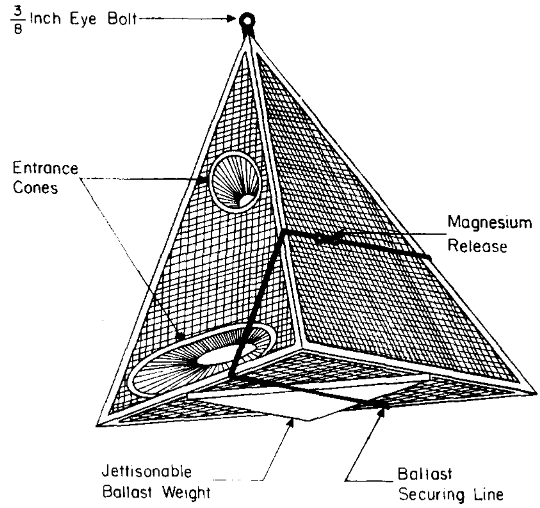
DEVELOPMENT

The DFV was designed for use on two different types of operations. Primarily the vehicles should supplement conventional oceanographic techniques. They should be suitable for quick launching and the ship should be allowed to proceed with other measurements until the vehicles resurface, with a minimum amount of time devoted both to launching and recovery. Secondly, the vehicle system should lend itself to mass deployment and large-scale sampling of the physical or biological characteristics of an area.

The type of instrumentation that the vehicle is intended to transport determines the necessary buoyancy and fixes the size and weight to a great extent.

Other factors considered in the preliminary design are: ease of handling, simplicity of fabrication and assembly, reliability of operation, and versatility.

Since ease of handling was important, the vehicle was designed to accommodate light instruments. The main buoyancy was separated from the marker buoy to reduce the size of the loads to be handled.



EXPERIMENTAL BOTTOM TRAP

FIG. 5.

Buoyancy

Polyethylene carboys filled with gasoline are used to provide the main buoyancy of the system. These 13 gallon (nominal size) containers weigh 90 pounds in air when filled with regular gasoline, and provide 31 pounds of buoyancy in sea water. Flexible containers of this type are necessary to allow for the expansion and contraction of the gasoline with temperature and pressure changes. For light weight instruments, one carboy provides sufficient buoyancy. For heavier instruments two or more carboys can be tied to the line at intervals to provide the necessary buoyancy.

Marker Buoy

Four gasoline filled polyethylene bottles (two gallons each) provide the buoyancy of the marker buoy (Fig. 2). These are assembled in a cluster around the mast and clamped to an X-shaped plastic frame. The aluminium mast is made of two 12-foot sections of $1\frac{1}{2}$ in. tubing. Each of these is plugged into the plastic centre sleeve and secured with hose clamps. A standard life boat radar reflector is fitted to the top of the mast, and a six pound counter balance to the bottom. The reflector has provided radar contact to 4 miles.

Ballast Release

The DFV system can be provided with a time delay release, a pressure (depth) release, or a bottom contact release (Figs. 3 and 4).

Early tests were carried out with a magnesium time delay release. This device makes use of the electrochemical deterioration of a magnesium weak link in sea water. The release delay time can be predicted with reasonable accuracy, and can be adjusted for from 4 to 40 hours delay by varying the diameter of the magnesium link (VAN DORN, 1953). A clock actuated release is currently under development, which will extend the release time to a year or more.

The pressure release (Fig. 4) releases the ballast weight at a predetermined depth.

Instruments

The first sampling instrument developed for use with the free vehicle was a bottom fish trap (Fig. 5). This device consisted of a pyramid shaped aluminium frame, 6 ft on a side, covered with a plastic screen. The fish are retained in the trap by virtue of the maze effect provided by the design of the entrance cones. These traps are quite successful in capturing bottom and near bottom organisms, and have been launched on seven different cruises in widely scattered areas off the coast of

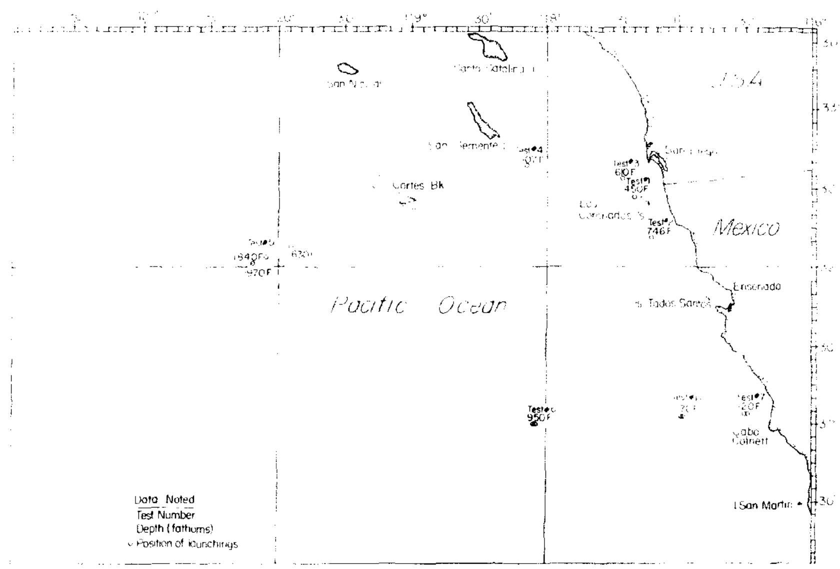


FIG. 6.

Southern California. The results of these launchings are tabulated below and in Fig. 6. The specimens are most often captured alive, but die soon after reaching the surface, due mainly to temperature changes. On one occasion, sable fish were kept alive for about 4 hours. It is believed that the use of equipment designed to maintain the proper temperature would enable many rare specimens to be preserved alive for further laboratory study.

A larger folding version of the bottom trap is presently under development, which is designed to prevent any possible escape of the trapped creatures, and to retain a sample of cold bottom water to help preserve specimens alive until transferred.

Other instruments under development or test for use with the free vehicle include: a recording deep current meter, sedimentation measuring and collecting devices, water and gas sampling gear, and multiple short coring tubes.

Acknowledgments—This paper represents one of the results of research conducted under the Marine Life Research Programme, the Scripps Institution's component of the California Co-operative

Oceanic Fisheries Investigations, a project sponsored by the Marine Research Committee of the State of California.

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REFERENCES

EWING, M., and VINE A. C., (1938) Deep sea measurements without wires or cables. *Trans. Amer. Geophys. Un. Meet.*, 248–251.

EWING, M., WOOLARD G. P., VINE A. C. and WORZEL J., (1946) Recent results in submarine geophysics. *Bull. Geol. Soc. Amer.*, 57, 909–934.

ISAACS, J. D. and KIDD, L. W. (1957) (Personal Coummunication).

RICHARDSON, W. S. (1960) Woods Hole Oceanographic Inst. Ref. No. 60-7, Atlantic Oceanography conducted during the period July 1–Dec. 31, 1959, p. 10. (Unpublished manuscript).

VAN DORN, W. G. (1953) The marine release-delay timer. *Oceanographic Equipment Report No.* 2, SIO Ref. 53–23. (Unpublished manuscript).

VINE, ALLYN, Woods Hole Oceanographic Inst. (Personal communication).