MILLER RESEARCH LABORATORIES

BALTIMORE 30, MARYLAND

ER-247-1-62

REPORT NO

SUMMARY REPORT OF UNDERWATER MARKER BUOY DEVELOPMENT PROGRAM - COVERING PERIOD 1 JUNE 1961 THROUGH 30 JUNE 1962; CONTRACT NOw-61-0948-c

PREPARED FOR

BUREAU OF NAVAL WEAPONS
DEPARTMENT OF THE NAVY
WASHINGTON 25, D.C.

25 July 1962
DATE

G. H. Jones
PREPARED

APPROVED

MILLER RESEARCH LABORATORIES
BALTIMORE, MARYLAND

FOREWORD

This summary report of the Underwater Marker Buoy Development program reviews the work accomplished and hardware delivered under Contract NOw-61-0948-c (1 June 1961 through 30 June 1962), and compares the resultant marker buoy design with the original buoy design as developed by Miller Research Laboratories under Contract NOrd 19160. A final, summary report No. 191-101 was prepared for Contract NOrd 19160, dated March 1961.

Contract NOw-61-0948-c provided for a review of the developmental design of the Underwater Explosive Ordnance Disposal Buoy produced under Contract NOrd 19160, leading to an engineering design for prototype production for evaluation (PPE) models. Various materials were investigated and design modifications made based on testing of the engineering models delivered during the contract period.

Five experimental models, 70 marker buoy assemblies, 75 float subassemblies (additional), and 75 CO_2 cylinders (additional) were fabricated and delivered under Contract NOw-61-0948-c.

Work performed, redesign improvements, and final buoy design are summarized in Section 1.0, Introduction. Contract NOw-61-0948-c specific objectives are listed in Section 2.0; Section 3.0 describes in detail buoy development from both contracts; Section 4.0 is a detailed description of the final buoy design under Contract NOw-61-0948-c; Section 5.0 discusses PPE aspects of the underwater marker buoy; and Section 6.0 gives a summary and recommendations.

A mat print, immediately following this page, shows a diver holding an underwater marker with the float inflated as designed, fabricated, and delivered under this contract.

TABLE OF CONTENTS

SECTION 1.0

INTRODUCTION

Seventy prototype production for evaluation models (PPE) of underwater marker buoys developed for the Bureau of Naval Weapons by Miller Research Laboratories under Contract NOw-61-0948-c were delivered to the U. S. Naval Explosive Ordnance Disposal Facility (NAVEODFAC) on 12 February 1962. Immediate recommendations for subsequent models, based upon preliminary evaluation of testing information, are:

a. The belt clip should be fabricated from 1/8-inch diameter brass rod.

b. The line should be more heavily waxed for smoother line payout.

c. A full-length sleeve should be provided to house the carbon dioxide cylinder to minimize the possibility of line fouling during payout.

Contract NOw-61-0948-c (effective date 1 June 1961) was received by Miller Research Laboratories on 4 August 1961 with final shipment of contract items made on 12 February 1962.

The marker buoy, intended for use by Naval EOD divers, is carried on the belts of the divers who search for items under water that are to be marked for future reference. Upon reaching the item to be marked, the diver secures the snap at the end of the marker buoy mooring line to the underwater object. Once the mooring line is secured, the unit is removed from the case on the diver's belt, the carbon dioxide cylinder is punctured, and the float inflates. As the marker buoy ascends, the mooring line pays out of the canister (still attached to the float) until the buoy surfaces. To prevent further stray line payout, the diver may secure the line to the spring clip on the bottom side of the marker.

Contract NOw-61-0948-c was awarded to redesign the underwater marker buoy previously developed by Miller Research Laboratories under Contract NOrd 19160. The resultant design differed from the previous marker in two major respects:

a. The floats were composed of different materials. The latter float can not only hold CO_2 gas for an extended period, but it is also more durable.

b. The line on the previous marker was wound on a spool; on the new design the line pays out of the canister from the center of the winding.

SECTION 2.0

CONTRACT NOw-61-0948-c

2.1 CONTRACT SCOPE

Under Contract NOw-61-0948-c, Miller Research Laboratories was to furnish the following:

a. Review the developmental design for the underwater EOD-type marker buoy produced under Contract NOrd 19160. Such work would include an investigation of various types of float materials. Miller Research Laboratories was to accomplish any recommended design modification based upon prior functional testing of the engineering models delivered under contract NOrd-19160.

b. Establish the prototype production for evaluation (PPE) design based upon the modifications derived under It A.

c. Fabricate, assemble, and furnish 75 PPE models of the underwater marker buoy assembly for technical and environmental evaluations.

d. Fabricate, assemble, and furnish 75 float subassemblies for use in testing the PPE models under Item C.

e. Furnish 75 "nonmagnetic" CO_2 cylinders, based upon Specification MIL-C-16385, for use in testing the PPE models under Item C.

f. Furnish engineering services as necessary during environmental and technical testing of the PPE models under Item C.

g. Furnish the engineering services necessary to complete the drawings and lists of drawings applicable to the underwater EOD-type marker buoy.

2.2 DESIGN CRITERIA

Following are the design criteria for the underwater marker buoy as originally established under contract NOw-61-0948-c:

a. The underwater marker buoys shall be safe for use in the presence of standard Navy types of underwater ordnance. They shall be made of nonmagnetic material to meet the requirements of MIL-M-19595 so that they will be safe in the presence of standard magnetic type ordnance.

b. The underwater marker buoy shall contain 200 feet of braided nylon line. The 220-pound test line used on the buoy resulting from Contract NOrd 19160 was considered to be satisfactory.

c. The underwater marker buoy shall be capable of being stored for extended periods within the temperature range of from -65° F to 160° F at 95 percent relative humidity without impairment of subsequent use.

d. The underwater marker buoy shall be manually actuated.

e. The surface life of the underwater marker buoy shall be two days.

f. The float shall have a reusable life of three marking operations and be capable of repeated folding without damage.

g. The color of the float shall be similar to the MK 15 drill mine float; however, color is to be selected on the basis of maximum visibility and availability of material.

h. The float shall be capable of rapid deflation.

SECTION 3.0

DEVELOPMENT OF UNDERWATER MARKER BUOY

This section describes the underwater marker buoy developed by Miller Research Laboratories under Contract NOrd 19160 and the redesign of the marker under Contract NOw-61-0948-c. Also presented are the criteria for the design as restated by project personnel in a conference held at the Bureau of Naval Weapons, Washington, D.C., on 15 June 1961. This is followed by a description of the surveys and investigations conducted to establish the best possible design; the design as it was prior to any testing; testing by personnel of the Miller Research Laboratories, Bureau of Naval Weapons, and the U. S. Naval Explosive Ordnance Disposal Facility (NAVEODFAC), Indian Head, Md.; and design changes resulting from this testing.

3.1 DESIGN RESULTING UNDER CONTRACT NOrd 19160

3.1.1 Description of Components

The underwater marker buoy (Figure 1, page 7), included: (1) an inflatable plastic film float; (2) an inflator assembly consisting of the inflator, a manifold, and a high-pressure carbon dioxide cartridge; (3) a housing; and (4) a spool of nylon line. The marker, when assembled, measured 3.5 inches diameter, 8 inches long, and weighed 3 pounds, 3 ounces.

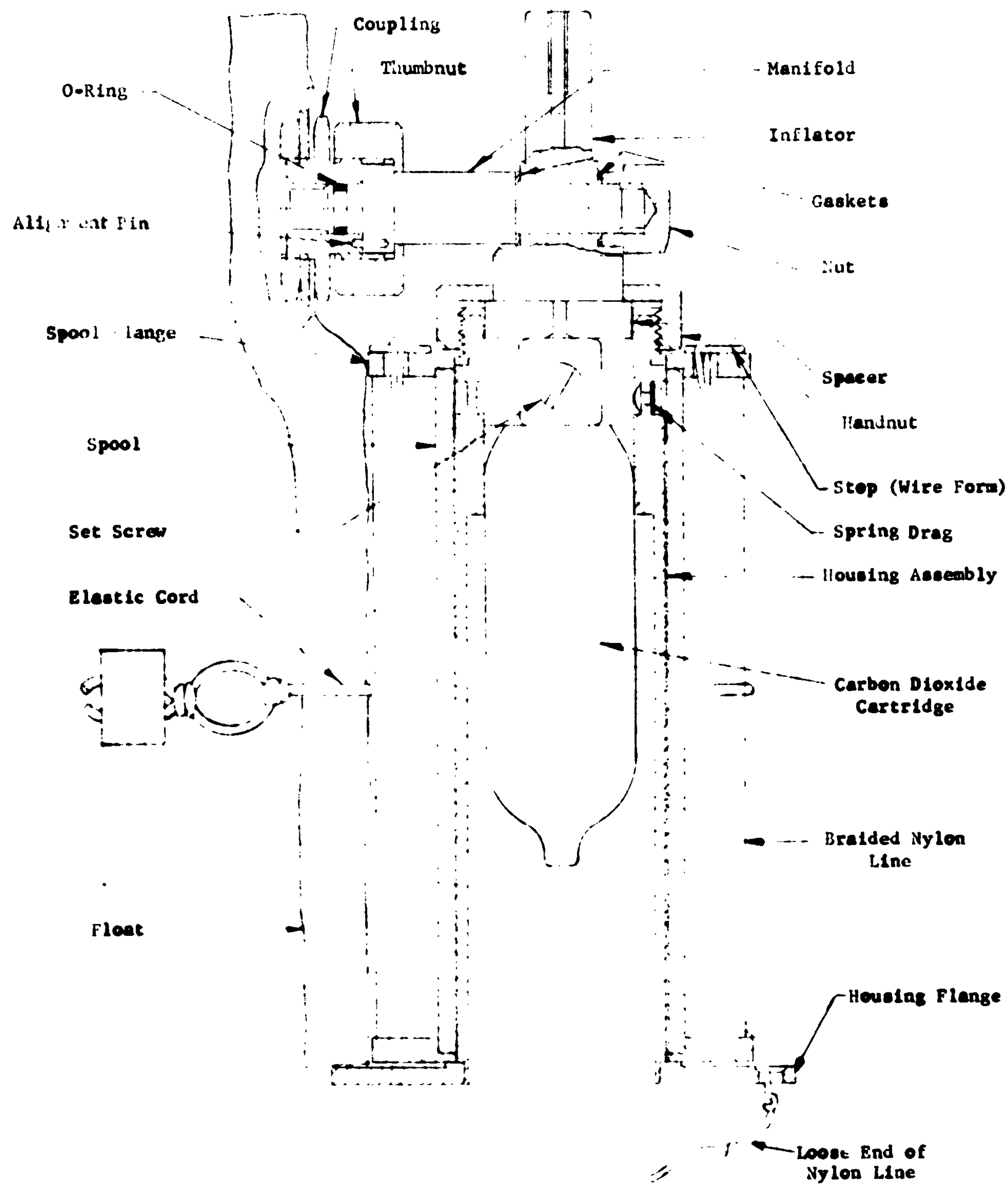

FIGURE 1 - UNDERWATER MARKER BUOY AS DESIGNED UNDER CONTRACT NOrd 19160

The float, comprised of 50A mylar/200 polyethylene laminated film, was colored fluorescent orange due to a pigmented adhesive used in the laminating process. The float, when extended uninflated, was 35.5 inches long and 18.5 inches wide at its widest point.

The spool contained 220 feet of 300-pound test nylon line mounted on the housing. A friction spring drag riveted in a groove of the cylindrical brass housing could be adjusted to control the rate of spool rotation to prevent line fouling during payout.

Two wire forms, set in the line spool at 100- and 160-foot lengths, enabled the diver to select in advance the length of the line. For depths to 100 feet, both forms remained; for 100- to 160-foot depths, the first form was removed; and for depths from 160 to 220 feet, both forms were removed.

The inflator assembly, held to the housing by a large handnut, consisted of the inflator and carbon dioxide cartridge. Manual actuation of the inflator handle punctured the carbon dioxide cartridge and released the gas into the float.

The gas escaped from the cartridge into the float through the manifold, which was attached to the float by a thumbnut.

3.2 DEVELOPMENT UNDER CONTRACT NOw-61-0948-c

3.2.1 Design Criteria

At a meeting held at the Bureau of Naval Weapons, Washington, D.C., on 15 June 1961, more specific criteria were established for the design of the underwater marker buoy under Contract NOw-61-0948-c. These criteria are in addition to those specified in the original contract, listed in paragraph 2.2 of this report:

a. The underwater marker buoy shall be a small, compact assembly that can be worn or clipped to the belt of a Naval EOD diver or swimmer until time of use.

b. Models shall be provided with a suitable carrying case or bag of nylon or other lightweight, water-resistant fabric. Ties or snaps to secure the underwater marker buoy to the diving gear harness or belt shall be included. A tab shall be provided so that the case can be held with one hand while opening it with the other (final design precluded necessity for this requirement).

c. The case shall be colored gray.

d. Negative buoyancy of the marker assembly is to be held to a minimum (i.e., not to exceed two pounds). This requirement was later changed at a conference of August 9, 1961 to maintain the negative buoyancy under one pound.

e. Visibility of the buoy configuration resulting from Contract NOrd 19160 was judged satisfactory. This buoy extended approximately two feet above the water level and was a bright orange color.

f. The underwater marker buoy shall be capable of operating in salt or fresh water at a minimum depth of 180 feet and at all water temperatures up to 90°F.

Alternate design criteria covering the possible use of internally wound line and an inexpensive (approximately $1.00) float that would be expendable after one use were:

a. If an expendable float is designed, the CO_2 cartridge, float, and necessary sealing gaskets shall be designed as an expendable package.

b. If the float is expendable, rapid deflation is no longer a consideration.

c. If internally wrapped line is used, line length selection is not to be provided.

d. A spool containing one length of line only (i.e., 200 feet) shall be used. Spools containing lesser lengths for shallow water marking operations are not considered desirable by BuWeps.

3.2.2 Surveys and Investigations

3.2.2.1 Design of Float

3.2.2.1.1 Materials Investigation. The material used on Contract NOrd 19160 to fabricate the float was basically composed of a mylar film laminate, which possessed good CO_2 permeability characteristics, but was easily damaged and unable to withstand rugged handling. Therefore, Miller Research Laboratories, under Contract NOw-61-0948-c, conducted a two-part investigation (see Table I) to find a material with both good CO_2 permeability characteristics and durability.

a. Literature search.

b. Contact of manufacturers - a total of 69 manufacturers were contacted to obtain product information, materials samples, and information on float film sealing and line winding.

Nylon coated with neoprene was selected for the float to enhance the permeability qualities. The 150 floats were purchased from the Aviators Equipment Corp., Beacon, New York, for $7.53 each.

The floats were sealed by adding to the overlapping seams three coats of solution No. M-136, Parts A and B, manufactured by the USS Chemical Company, Cambridge, Massachusetts. To ensure permanent sealing, the glued seams were then taped.

TABLE I

RESULTS OF MATERIALS SURVEY

MATERIAL	PERMEABILITY TO CO_2	DURABILITY	THICKNESS MATERIAL TESTED (INCHES)	REMARKS
Mylar	Good	Poor		Material investigated under Contract NOrd 19160
Laminated Saran	Good	Poor	2-MIL-Saran/ 8-MIL-Vinyl	Tendency of material to delaminate
Neoprene Rubber	Good	Good	(1) 1/32 (2) 1/64	Difficult to mold and/or seal by inexpensive methods
Polyvinylchloride	Poor	Good	0.0038	CO_2 Permeability rate unsatisfactory
Butyl Rubber	Good	Good	0.040	Difficult to mold and/or seal by inexpensive methods
Compound HJ-101 (Kaysam Corp)	Poor	Fair	0.008	Test balloon mfg. by Kaysam Corporation
Polyethylene	Poor	Good	0.004	Conical shaped float fabricated by General Mills
Polyurethane	Good	Good	0.006	(1) Material newly developed & not commercially available (2) Float fabricated by Union Carbide Development Company
J-22 Rubber	Fair	Good	0.015	Unsatisfactory because of excessive weight
Hypalon/Neoprene rubber	Fair	Good	0.006	-
Nylon-coated Fabric	Good	Good	0.010	Float fabricated by Aviators Equipment Corporation
Saran	Good	Good	0.001 0.002	Requires expensive electronic sealing techniques

3.2.2.1.2 Design Considerations. To produce an optimum float configuration, two important design features had to be met: (1) maximum vertical height (mast) presented to the viewer, and (2) high metacentric height.

From analytical calculations, it was verified that a conical shape presents the largest surface area as a tall mast to the viewer. Also, the center of gravity of this configuration is low, thereby incorporating a high stability feature. The finalized design of the float (Figure 4) has a volume of 567.6 cubic inches, compatible with a 17- to 20-gram CO_2 cylinder.

The second consideration was a high metacentric height. This may be described by:

$$MCH = \frac{I}{V} \quad \text{Plus distance between cg and cb}$$

where:

MCH = Metacentric height

I = Least moment of inertia of water line section

V = Volume of displaced water

cg = Center of gravity

cb = Center of buoyancy

For the float configuration of Figure 4, the metacentric height was determined to be 75.39 inches. With such high metacentric height, considering a float height above the water of 24 inches, the finalized design is extremely stable, regardless of the unit's weight. It may also be concluded that the attitude of the float will tend to be perpendicular to the surface of the water, due to the small righting moment needed for stabilization.

3.2.2.1.3 Design Modifications. In a conference with the Aviators Equipment Corporation, Beacon, New York, on 16 November 1961, it was agreed that fabrication of the float assembly would include the following modifications to the original Miller Research Laboratories design:

a. A flexible, molded rubber tube was to be inserted into the base of the float.

b. Neoprene coating was to be applied to both sides of the nylon fabric to improve CO_2 permeability.

c. Overlapped seams, reinforced with tape, were to be used for increased strength.

d. An internal baffle was to be provided in the float to minimize the possibility of CO_2 discharge directly against the float wall, which would cause freezing and consequent deterioration of the neoprene coating.

e. The check valve assembly was to be bonded directly to the flexible tube on all except the first five float assemblies.

3.2.2.2 Line and Line Payout Investigation

In order to keep the line housing to a reduced size and weight, a search was conducted by Miller Research Laboratories to locate line that would be commercially available in the 150-pound test category, established as criteria in a conference held on August 9, 1961 at the Bureau of Naval Weapons.

The decision to explore the possibilities of center line payout instead of the spool windings previously used was made due to inadequacies discovered in testing the spool winding. The reasons for this change are:

a. Line foul up occurred with the spool winding. Drag on the spring clip of the spool was difficult to adjust. If the drag was too light, the line payed out too fast; if the drag was too heavy, the float would not rise to the surface properly.

b. The internal winding lightened the weight of the marker.

c. A cost reduction resulted by eliminating spool winding parts.

The feasibility of the center payout of line was first tested with experimental windings made at MRL on a U. S. Navy Mark I Mod I Rewinding Machine borrowed from the U. S. S. Darby. The maximum measured line pull was about 3.5 pounds for the first 12 to 15 feet of line payout and negligible thereafter on the experimental windings. This indicated the need for slightly increasing the inside diameter of the windings. Although some line twist was observed during payout, no fouling or snarling occurred; therefore, the conclusion was made that line twist during payout was not necessarily objectionable.

Commercial "putups" providing payout of line from the center of the winding were used during the testing of the five experimental models by Miller Research Laboratories on 2 November 1960. These commercial putups were wound with a slightly larger inside diameter than the MRL experimental windings, and the line pull during payout was found to be negligible. Line putups of two types were obtained from Ashaway Products, Incorporated, Ashaway, Rhode Island, and one putup was obtained from Essex Mills, Essex, Connecticut. The Ashaway putups were both approximately four inches long. One type was wound on a split cardboard tube which, when squeezed, permitted easy withdrawal of the tube. The other type was a coreless winding, which was packaged in a cylindrical container to protect the putup until time of intended use. The Essex putup also was approximately four inches long and was wound on a tapered wooden mandrel provided by Miller Research Laboratories.

Each of the commercially wound putups functioned equally satisfactorily, but the Ashaway winding on the split tube provided greater handling ease coupled with a lower unit cost than the Essex winding. Hence, the Ashaway split tube winding was selected for use in the underwater marker buoy assembly.

The Ashaway line was 200 feet long, of 150-pound test solid braided nylon line, No. 842-OX. The 150 putups provided under the contract were coated with a "tan wax" finish. However, under testing by BuWeps, it was discovered that additional waxing of the line was desirable to ensure proper ascent of the float to the surface (see paragraph 3.2.4.3).

3.2.2.3 <u>Modification of Negative Buoyancy Requirements</u>

At a conference at the Bureau of Naval Weapons held on 9 August 1961 Miller Research Laboratories was instructed to maintain the negative buoyancy of the entire unit under one pound. Weight in fresh water of the final designed unit is four ounces.

3.2.3 <u>Design Prior To Testing</u>

Design of the underwater marker buoy was finalized in November 1961 and reported in Miller Research Laboratories report No. 247-2, dated 6 December 1961. This finalized design was followed in fabricating the first five experimental models tested by Miller Research Laboratories during December 1961.

The following paragraphs describe the design prior to testing.

3.2.3.1 Canister

The canister was a deep-drawn aluminum container with a 3-inch OD 4.25 inches long. A close-fitting, drawn aluminum lid was attached to the canister by a bayonet fitting. A split collar, attached to the underside of the lid, captured the CO_2 inflator mechanism.

3.2.3.2 Float

The float was fabricated from orange-colored nylon fabric, coated on both sides with neoprene. The float was attached by a flexible rubber tube, molded to the base fitting, to a brass check valve assembly. The check valve was attached to a commercial, nonmagnetic inflator mechanism and CO_2 cylinder assembly.

3.2.3.3 Line and Snap Hook

A coreless putup of 200 feet of 150-pound test, braided nylon line was housed in the canister, surrounding the CO_2 cylinder. The free end of the outside of the putup was passed through a 0.089-inch diameter hole in the lid and knotted to secure the line to the canister. The free end in the core of the putup was passed through the 1-1/8 inch diameter hole in the bottom of the canister and attached to a brass snap. The hook end of the snap was inserted under the end of the phosphor bronze spring clip on the bottom of the canister to prevent premature line payout and to provide convenient access to the free end of the line.

In operation, the snap is used to attach the free end of line to an anchor or the item being marked, and the line pays out internally from the line putup as the inflated float rises to the surface. Upon reaching the surface, the line may be snubbed under the end of the spring clip on the side of the canister to prevent stray line payout.

3.2.3.4 Case

A vinyl-coated nylon fabric carrying case, with a large flap for easy opening, was provided to house the packaged underwater marker assembly and to attach the unit to the belt of a swimmer. The case design enables the diver to attach the free end of the line to an anchor prior to removing the marker assembly from the case. A single snap fastener makes it easy to close and open the case.

3.2.4 Buoy Testing

3.2.4.1 Testing by MRL and Resultant Design Changes

First tests of five preliminary experimental models of the underwater marker buoy were conducted in the 60-foot water tank at the Naval Weapons Plant, Washington, D.C., on 2 November 1961, under the direction of personnel from Miller Research Laboratories. These tests were conducted prior to fabrication of the five experimental PPE models to be delivered for evaluation by NAVEODFAC.

During the November 1961 testing, three of the markers were lowered to the bottom of the tank with a line attached to the inflator mechanism and anchor. The markers were then actuated from above. Due to the water condition, it was not possible to see the line payout or the balloon ascend to the surface; however, there were no snags noticed in the line, and the float reached the surface of the water in approximately 10 seconds.

As a result of these tests, several modifications were made to the design and incorporated for fabrication of the five experimental PPE models to be sent to NAVEODFAC. These included: (1) simplification of the collar assembly used to attach the inflator mechanism to the lid; (2) addition of a spring clip to retain the snap hook and to snub off the line after the float reached the surface; and (3) use of a deep-drawn aluminum canister and lid to reduce weight and simplify fabrication.

3.2.4.2 Testing by NAVEODFAC and Resultant Design Changes

Tests conducted by U. S. Naval Explosive Ordnance Disposal Facility divers on 6 December and 11 December 1961 were witnessed by representatives from the Bureau of Naval Weapons, NAVEODFAC, and Miller Research Laboratories. The underwater marker buoys used during these tests were the five experimental PPE models fabricated out of the lot of 75 required under the contract.

The 6 December 1961 tests at NAVEODFAC were conducted by Navy divers who performed various maneuvers in and out of the water during actuation of the buoys. No difficulties in operation of these units was experienced by the divers.

The 11 December 1961 tests were conducted from a depth of 100 feet by NAVEODFAC personnel in the test tank at the Naval Ordnance Laboratory, White Oak, Maryland. The underwater marker buoys functioned as intended during these tests.

In a telephone conversation between Ensign A. H. Spinks, NAVEODFAC, and Mr. G. H. Jones, MRL, on 4 January 1962, a report was given by Mr. Spinks of the successful testing of the underwater marker buoy at simulated depths between 150 and 180 feet. These tests were conducted by the Project Team during the month of January.

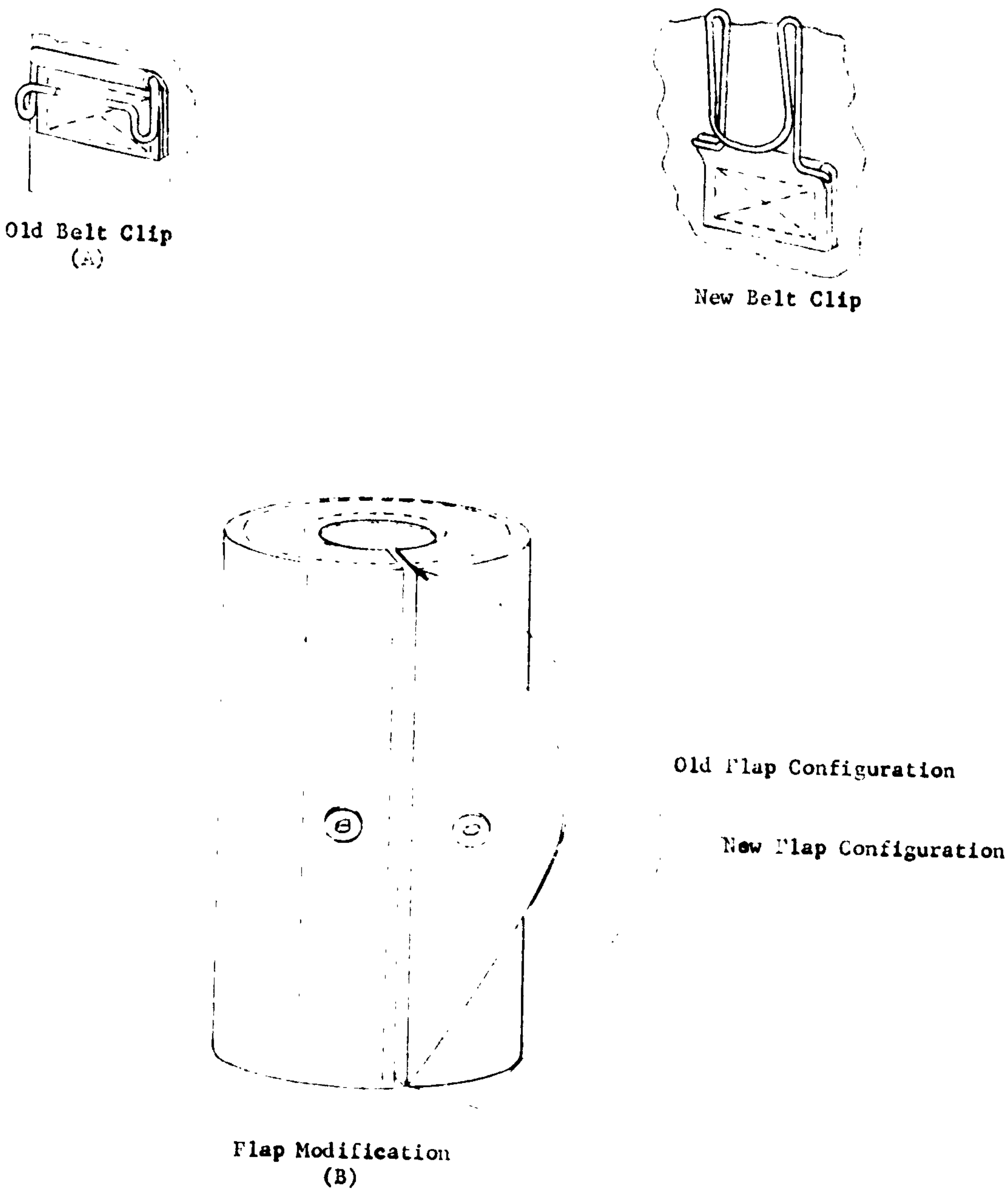

Figure 2 - Design Modifications, Belt Clip and Case Flap

Further design modifications were made to the underwater marker buoy prior to fabrication of the remaining 70 marker buoy assemblies. These changes, as listed below, resulted from testing and from requests from NAVEODFAC and the Bureau of Naval Weapons.

a. Belt clip - The clip for attaching the marker buoy carrying case to the belt had been designed for use on a .45 caliber cartridge belt. However, it was recognized that not all divers use this belt, and an universal type clip (Figure 2 page 19) was designed for use on any style belt worn by the diver.

b. Carrying Case -

(1) The carrying case material was changed from a vinyl-coated nylon cloth to a neoprene-coated nylon material, since the latter was found to be the more flexible of the two.

(2) The opening flap on the carrying case was reduced in size (Figure 2). This change was made as a result of testing, during which the divers concluded that a smaller flap would facilitate entry into the case.

c. Spring Clip - The spring clip on the bottom of the canister was coated with a fluorcarbon spray to reduce the danger of the line being cut by the clip during underwater marking operations.

3.2.4.3 Testing by BuWeps

Difficulties were encountered by the Bureau of Naval Weapons in the pay-out of the line from the canisters during March 1962 tests of some of the 70 PPE underwater marker buoys supplied 12 February 1962 through Contract NOw-61-0948-c. The tests, conducted at St. Thomas and in the 100-foot tank at the Naval Ordnance Laboratory, revealed that a certain amount of line fouling was occurring during the rise of the float to the surface of the water. The fouling was traced to the line catching on either the set screw boss on the inflator mechanism or in the recess between the CO_2 cylinder and the inflator mechanism, or both.

Line fouling was solved by two Miller Research Laboratory suggestions:

a. Winding plastic tape over the obstructions to obtain a smooth fairing.

b. Coating the lines with additional wax prior to use. (The lines were received from the supplier with a light coat of wax on them.)

Problem solution was proved in tests conducted by BuWeps personnel on 5 April 1962, run in the 100-foot tank at NOL. Waxed lines and smoothed-out fairings produced 100-percent successful results; a lightly waxed line payed out to only a 25-foot length.

SECTION 4.0

FINAL DESIGN OF UNDERWATER MARKER BUOY

4.1 MAJOR COMPONENTS AND DIMENSIONS

The marker buoy assembly as designed under Contract NOw-61-0948-c has three major components: (1) the float, which is an orange-colored, nylon fabric, coated inside and out with neoprene; (2) the canister housing, which is made entirely of aluminum; and (3) the carrying case, which is a neoprene-coated, nylon fabric. With the unit assembled in the carrying case, the package will assume the following approximate dimensions:

Diameter	4 inches
Length in carrying Case	8 inches
Weight in air	1 pound 7 ounces
Weight in water	4 ounces

With the marker buoy in the carrying case and attached to the divers' belt, the unit occupies only about 4 inches of belt length.

4.2 DESCRIPTION OF COMPONENTS

4.2.1 Canister

The canister shown as item 1 in Figure 3, is a deep-drawn aluminum container 2-25/32 OD x 4.25 long x 0.032 wall thickness.

4.2.2. Lid

The lid, shown as item 2 in Figure 3, is also a drawn-aluminum part 2-27/32 OD x 0.25 x 0.032 wall thickness.

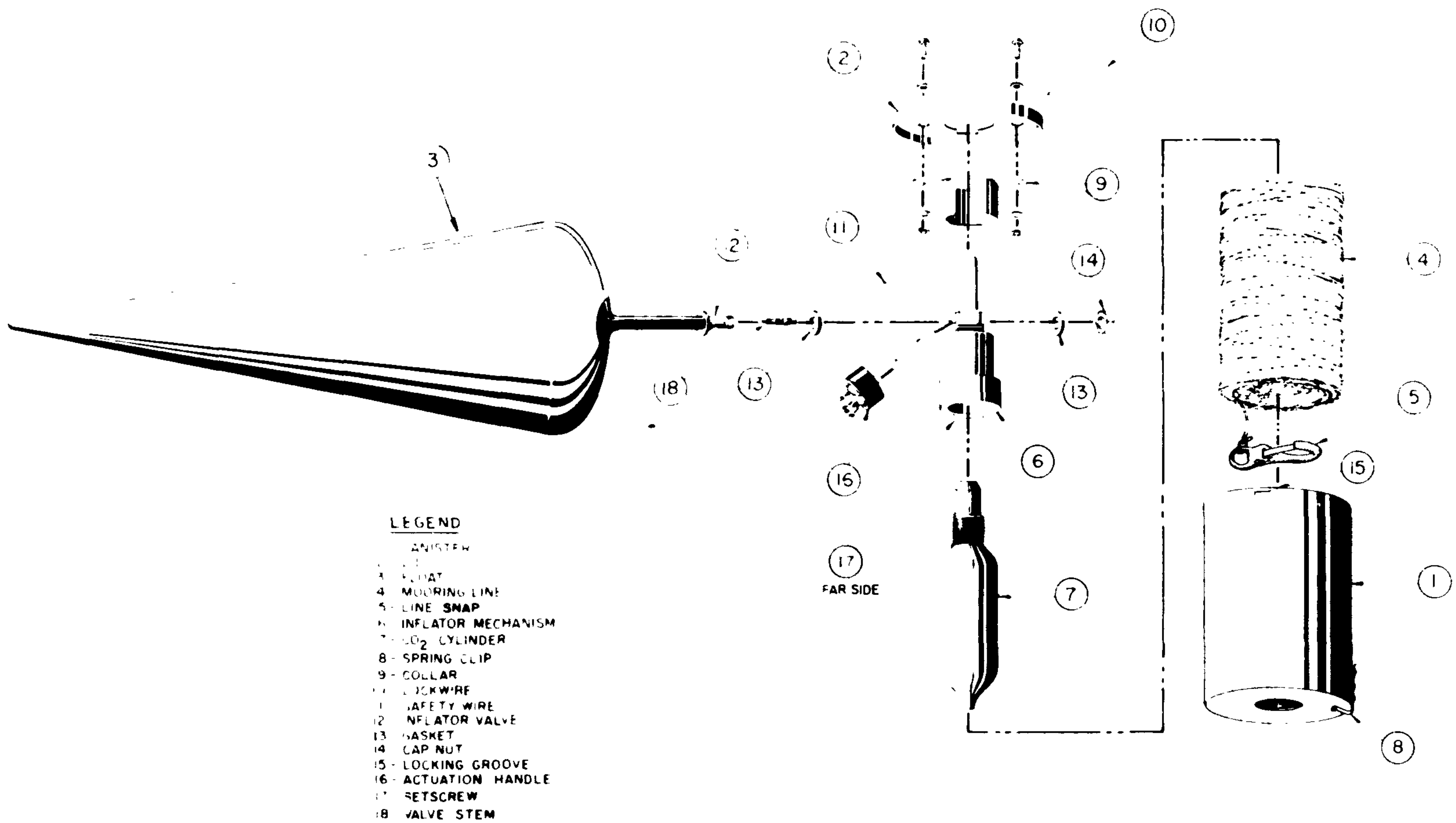

FIGURE 3 UNDERWATER MARKER BUOY COMPONENTS

4.2.3 Float

The float, shown as item 3 in Figure 3, is made of a nylon fabric coated with neoprene inside and outside, and it may be used more than once.

To produce the optimum float configuration, two important design features were incorporated: (1) maximum vertical height (mast) presented to the viewer; and (2) high metacentric height.

It was resolved that a conical shape presents the largest surface area as a tall mast to the viewer. Also, the center of gravity of this configuration is low, thereby incorporating a high stability feature. The final float configuration is shown in Figure 4, page 25.

The float has a volume of 567.6 cubic inches, which is compatible with a 17- to 20-gram CO_2 cylinder. The metacentric height was determined to be 75.39 inches. With such a high metacentric height, considering a float mast height of 24 inches, the float is extremely stable, regardless of canister weight.

4.2.4 Line

The mooring line, shown as item 4 in Figure 3, is a tan,braided nylon line with a nominal diameter of 0.062-inch and a breaking strength of 150 pounds. A spoolless winding, containing 200 feet of this line and providing payout from the center of the winding, is housed in the aluminum canister.

4.2.5 Line Snap

The line snap, shown as item 5 in Figure 3, is a small, commercially-available brass snap. The mooring line is attached to the eye of the snap, and the snap is held to the bottom of the can by the spring clip as shown in Figure 5, page 26.

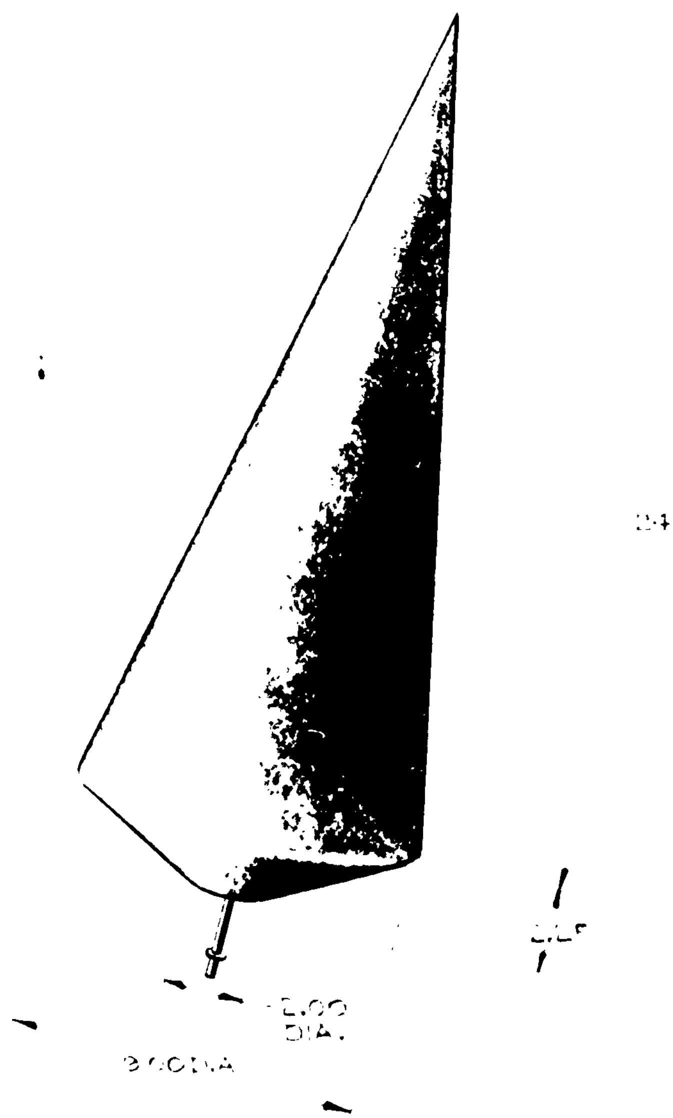

FIGURE 4 UNDERWATER DEMOLITION MARKER FLOAT

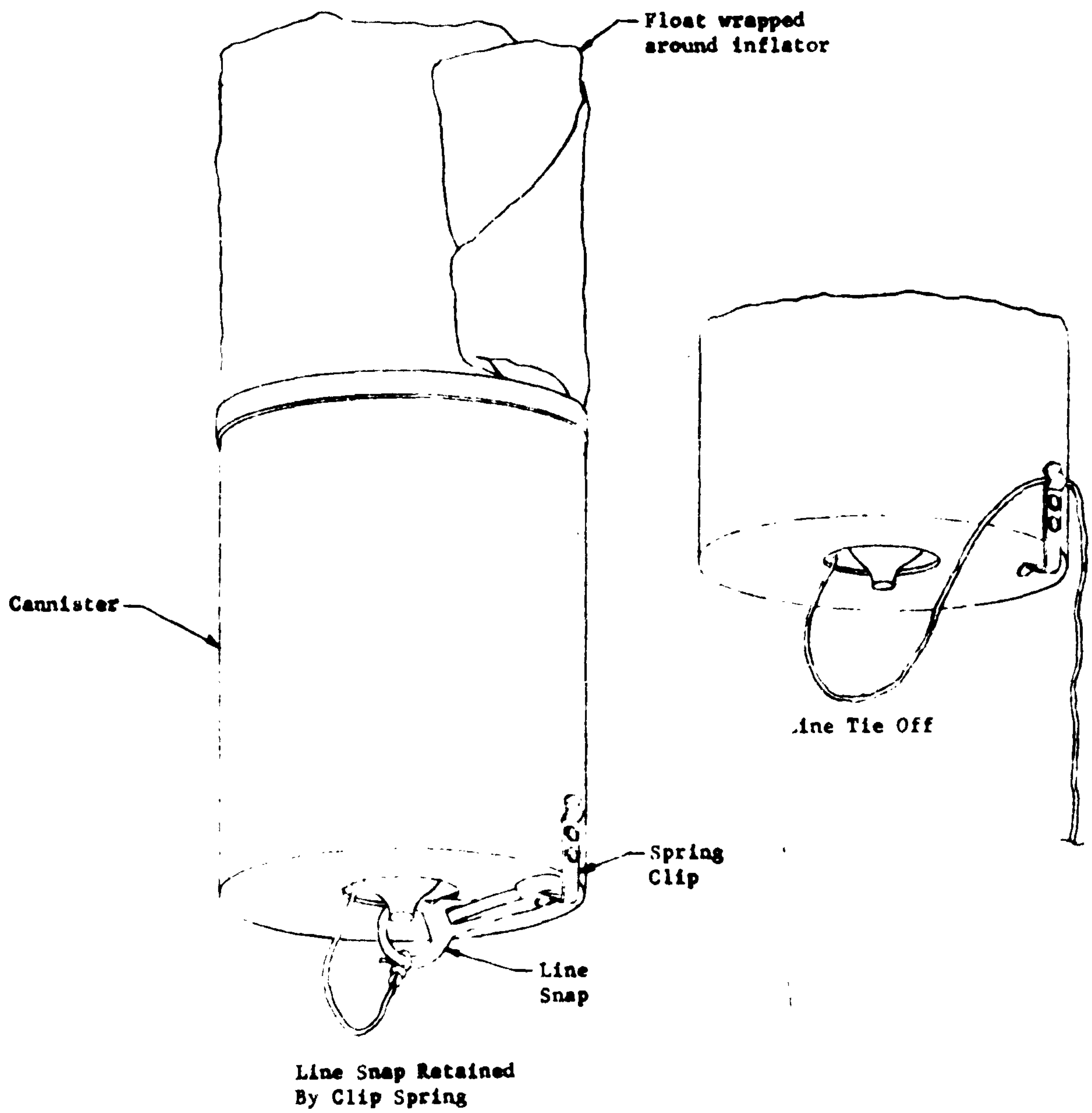

Figure 5 Snap - Spring Clip Arrangement

4.2.6 Inflator

The CO_2 inflator is a commercial, nonmagnetic mechanism used to inflate the CO_2 cylinder, MIL-C-16385B (SHIPS). The inflator is shown as item 6 on Figure 3. The aluminum collar, shown as item 9 in Figure 3, attaches the inflator mechanism to the lid.

4.2.7 CO_2 Cylinder

The CO_2 cylinder, shown as item 7 in Figure 3, is a nonmagnetic pressure vessel containing 17 to 20 grams of carbon dioxide, based upon specification MIL-C-16385.

4.2.8 Carrying Case

The carrying case as shown in Figure 6, is made of a neoprene-coated nylon material. The brass clip on the back of the carrying case attaches the marker buoy to the diver's belt. The clip is designed to fit web belts normally used by EOD-type divers. The flap on the front of the carrying case is large enough for the diver to grasp when removing the marker buoy from the case. The hole in the bottom end of the carrying case permits the diver to remove the line snap from the canister and attach it to the object to be marked before removing the marker from the case.

4.2.9 Spring Clip

The spring clip, shown as item 8 in Figure 3, is made of a phosphor bronze material and serves a dual purpose. This clip is used to retain the line snap to the bottom of the can until the diver has reached the item to be marked; also it serves as a tie-off clip to eliminate stray payout of the line once the marker has reached the surface. This is shown in Figure 5.

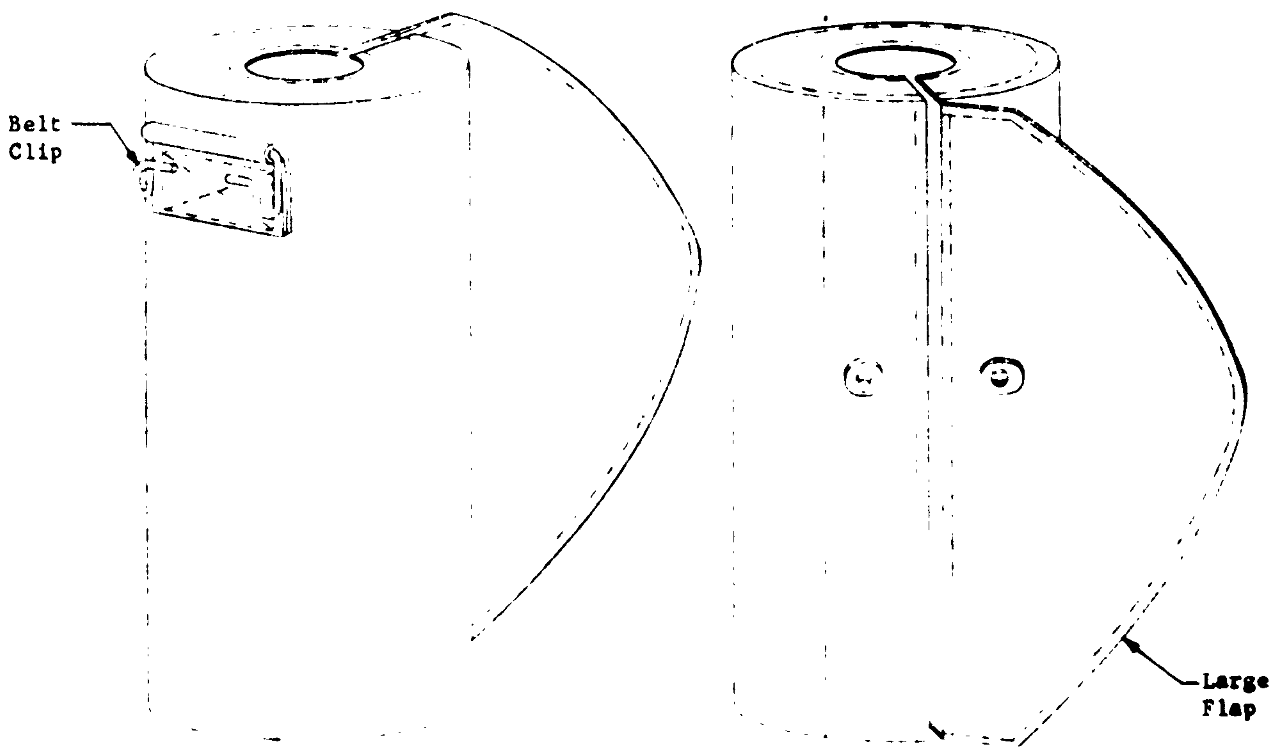

Figure 6 - Carrying Case

4.3 LIST OF VENDORS

Following is a list of the vendors from whom the major components of the underwater marker buoy were purchased:

Component	Vendor
Float (nylon, with neoprene coating)	Aviators Equipment Corp. Beacon, New York
Line (solid braided nylon, No. 842-OX)	Ashaway Products, Inc. Ashaway, Rhode Island
Carrying Case (nylon, with neoprene coating)	C. R. Daniels, Inc. Daniels, Maryland
CO_2 Cylinder Inflator Mechanism	Worcester Pressed Steel Co. Worcester, Mass.
Brass Snaps	Covert Manufacturing Co. Troy, New York
Canister and Lids (aluminum)	Hudson Tool & Die Co., Inc. Newark, New Jersey

4.4 DELIVERY OF UNDERWATER MARKER BUOYS

In accordance with the contractual requirements, Miller Research Laboratories delivered to the U. S. Naval Explosive Ordnance Disposal Facility, on 6 December 1961 the following items:

Item	No.
Underwater Marker Buoy Assemblies	5
Spare Mooring Line Windings	5
Spare Nonmagnetic CO_2 Cylinders	5
Spare Inflator Gaskets	10
Copies of Preliminary Draft of Operation and Maintenance Manual for Underwater Marker Buoy	4

NAVEODFAC tested the above items, design modifications were made, and the following hardware furnished NAVEODFAC by Miller Research Laboratories in a shipment on 12 February 1962:

Item	No.
Underwater Marker Buoy Assemblies	70
Spare Mooring Line Windings	73
Spare Nonmagnetic CO_2 Cylinders	70
Spare Snap Hooks (Used on End of Mooring Lines)	75
Spare Floats	75
Spare Hex Cap Nuts	75

SECTION 5.0

PPE ASPECTS OF THE UNDERWATER MARKER BUOY

The final design of the underwater marker buoy developed under Contract NOw-61-0948-c is an improvement over the original design of Contract NOrd 19160 in the following ways (see Table II):

a. Less parts were used to make up the marker.

b. The weight of the unit was lowered.

c. The unit cost of the marker was reduced considerably through simplification of design and the use of commercially available parts.

Although the basic design of the marker buoy remained the same, several minor modifications resulted from the testing of the five PPE experimental models by NAVDOCKS and Miller Research Laboratories personnel. These modifications are summarized as follows:

a. Simplification of collar assembly used to attach the inflator mechanism to the lid.

b. Addition of a spring clip to retain the snap hook and to snub off the line after the float reaches the surface.

c. Use of a deep-drawn aluminum canister and lid to reduce weight coupled with manufacturing simplification and economy.

d. A universal type clip to fit all belts was substituted for the clip originally designed to attach the marker buoy to .45 cal cartridge belts.

e. Carrying Case

  (1) The case material was changed from vinyl-coated nylon cloth to neoprene-coated nylon, since the latter was found to be more flexible.

  (2) The opening flap on the carrying case was reduced in size.

f. The spring clip on the bottom of the canister was coated with fluorocarbon spray to reduce the danger of the line being cut by the clip during operations.

Modifications were made to preclude fouling of the line following preliminary testing of the 70 PPE models delivered 12 February 1962. The line was found to be catching on either the set screw boss on the inflator mechanism or in the recess between the CO_2 cylinder and the inflator mechanism, or both. The moditications as suggested by Miller Research Laboratories are:

1. Plastic tape was wound over the obstructions to obtain a smooth fairing.

2. The lines were coated with additional wax prior to use.

TABLE II

COMPARISON OF UNDERWATER MARKER BUOYS

A

COMPARISON OF PARTS

Contract NOw-61-0948-c	Contract NOrd 19160
Canister	O-Ring
Lid	Alignment Pin
Float	Spool Flange
Mooring Line	Spool
Line Snap	Set Screw
Inflator Mechanism	Mooring Line
CO_2 Cylinder	Float
Spring Clip	Housing
Collar	CO_2 Cylinder
Lockwire	Spring Drag
Safety Wire	Wire Form Stop
Inflator Valve	Handnut
Gasket	Spacer
Cap Nut	Nut
Valve Stem	Gaskets
	Inflator
	Manifold
	Thumbnut
	Coupling
	Elastic Cord
	Housing Flange

B

COMPARISON OF WEIGHT

Contract NOw-61-0948-c	Contract NOrd 19160
Weight out of water - 1 pound, 7 ounces	Weight out of water - 3 pounds, 3 ounces

C

COMPARISON OF COST

Contract NOw-61-0948-c	Contract NOrd 19160
Unit cost for 1000 Markers $30.98	Estimated cost per Marker $120
Unit cost for 5000 Markers $27.00	(Note: the parts were completely fabricated within MRL)

SECTION 6.0

SUMMARY AND RECOMMENDATIONS

6.1 DISTRIBUTION AND PRELIMINARY RESULTS

The 70 PPE models of the underwater marker buoy were delivered by Miller Research Laboratories to the U. S. Naval Explosive Ordnance Disposal Facility on 12 February 1962 for evaluation testing. The 70 units were then distributed as follows:

EODU-1, Pearl Harbor - 15 units

EODU-2, Charleston - 15 units

St. Thomas, Virgin Islands - 5 units

Experimental Diver, Naval Weapons Plant - 2 units

NAVEODFAC, Indian Head - 33 units

Evaluation testing is currently in progress, thus the results are preliminary and, by no means, complete. Very limited information is presently available on the performance of the underwater marker buoys. Such information primarily concerns an early problem encountered during March 1962 tests at St. Thomas and also at the 100-foot test tank at the Naval Ordnance Laboratory, White Oak, Maryland. During these tests, the line fouled during payout by hanging on either the set screw boss on the inflator mechanism or in the recess between the CO_2 cylinder and the inflator mechanism, or both. This fault was corrected as suggested by Miller Research Laboratories in the field by winding plastic tape over the cylinder to give a smooth, faired surface over the irregularities.

The following summary and conclusions are based on the preliminary information obtained from early tests.

6.2 SUMMARY

a. The float configuration is extremely stable and presents a mast height of approximately 24 inches above the water surface.

b. The tall mast height and bright orange color combine to provide good float visibility when viewed from a boat.

c. The packaged unit is quite compact and imposes a minimum of restriction to the diver's movements.

d. The weight in fresh water of only 4 ounces permits a diver to carry several units without disturbing his buoyancy.

e. The PPE design meets all nonmagnetic requirements.

f. Adequate buoyancy at all water depths to 180 feet was proved by actual test.

g. The CO_2 permeability rate is low enough to permit the float to remain floating in a stable attitude in excess of the two-day requirement.

h. A smooth faired surface over the set screw boss on the inflator mechanism and the recess between the inflator mechanism and the CO_2 cylinder is required to prevent line fouling and permit free line payout. Most of the PPE models were so modified in the field.

i. The belt clip on the carrying case tends to straighten when subjected to the jolt imposed when a diver jumps into the water.

j. Line waxed more heavily than that furnished with the PPE models (Ashaway No. 842-OX) paid out freely during test with no tendency to foul. Most of the PPE models were so modified in the field.

6.3 RECOMMENDATIONS

a. The belt clip, on subsequent models, should be fabricated from 1/8-inch diameter brass rod instead of 3/32-inch to provide greater resistance to bending when subjected to severe jolts.

b. The line should be more heavily waxed to provide better shape retention of the winding and to provide smoother line payout.

c. A full-length sleeve should be provided to house the CO_2 cylinder, thereby providing a smooth fairing over the irregular surfaces and minimizing the possibility of line fouling during payout.