United States Coast Guard

Office of Engineering

FIELD TESTING AND DEVELOPMENT CENTER

REPORT NO. 481

PROJECT 3986/01/01

EVALUATION OF ONE PIECE WET SUIT

10 MAY 1968

Washington, D.C. 20226

UNITED STATES COAST GUARD

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TEST REPORT

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By

CHBOSN C. CUTHRELL
CHBOSN R. E. BUZHARDT
Project Officers
Field Testing and Development Center
Baltimore, Maryland 21226

Date: 10 MAY 1968

Submitted:

R. W. WITTER, CDR, USCG
Commanding Officer
Field Testing and Development Center
Baltimore, Maryland 21226

Date: MAY 17 1968

Approved:

J. M. O'CONNELL, CDR, USCG
Acting Chief, Testing and Development Division
Office of Engineering
U. S. Coast Guard Headquarters
Washington, D.C. 20591

Authority: Comdt(ETD) ltrs 3986/01/01 ser 4586 of 6 Apr 1966 and ser 5112 of 17 Feb 1967.

ABSTRACT

This report covers the evaluation of the flotation capabilities of the two-piece wet suit being used as survival equipment by Coast Guard personnel, a one-piece wet suit and a anti-exposure military flight suit. In addition, suits and the anti-exposure suit were evaluated while wearing supplemental flotation, found necessary for self-righting capability.

The report describes the tests conducted and results obtained. The report also describes additional tests conducted to determine if a downed pilot could zip closed the one-piece neoprene wet suit in the water.

A photographic record of the tests was maintained and is included as Appendix A and B.

TABLE OF CONTENTS

1. INTRODUCTION:

The purpose of this project originally was to evaluate the flotation capabilities of the wet suit used as survival equipment by Coast Guard personnel in cold weather areas. This evaluation was to determine whether the flotation capabilities are sufficient to permit the elimination of supplemental flotation when the wet suit is worn. It was immediately evident that when the wet suit alone was worn and when unconsciousness was simulated, supplemental flotation was necessary to right the subject face-up. In addition, the wet suit alone floats a conscious subject in a horizontal position and does not support the subject's head. This allows water to splash into the face unless a definite effort is made to raise the head. In a survival situation the effort necessary to raise the head is unacceptable. Consequently, testing of supplemental flotation was conducted. During the course of these tests, the project was expanded into evaluating two different one-piece wet suits that could possibly be used, primarily by pilots, as an exposure suit both in and out of the water. A photographic record of these tests and evaluations is included with this report.

2. MATERIAL TESTED:

The following is a list of the items tested or evaluated in this project.

EXPOSURE OR WET SUITS:

a. Two-piece neoprene wet suit - Figures 1, 2

b. One-piece neoprene wet suit - Figures 3, 4

c. One-piece anti-exposure military flight suit - Figure 5.

SUPPLEMENTAL FLOTATION:

a. Coast Guard work vest - Figure 6

b. Coast Guard approved life jacket - Figure 6

c. MKII Life preserver, aircrewman - Figure 7

d. Abandon ship life jacket - Figure 8

e. Adult work vest - Figure 9

f. Coast Guard approved work vest - Figure 10

g. MK-3C Life preserver, pilot - Figure 11, 12

h. LPA-1 life preserver, aircrewman - Figures 13-15

i. RNLI life jacket - Figure 17,

3. TEST CONDUCTED:

Tests were conducted in which the wet suits alone were used as flotation as well as with supplemental flotation provided by the various types of life jackets and work vests noted above. Subjects selected for the tests were small, large, tall, slim and simulated unconsciousness for test purposes.

The tests were conducted in both indoor and outdoor swimming pools. The water and air temperature during the tests in the outdoor pool varied from fairly warm (65-70° F) to relatively cold (50-55° F), after the temperatures became very cold, the tests were completed in an indoor pool.

In addition to the flotation evaluation of the various life vests and wet suits; tests were made to determine if a downed pilot could zip closed the one-piece neoprene wet suit while in the water. The reason for this test was in case the pilot would be wearing the wet suit as a flight suit, which would most likely be unzipped for comfort while in the aircraft.

A photographic record of the tests was maintained and is included with this report as Appendix A and B.

4. TEST RESULTS:

It was determined that the wet suits and exposure suit along have sufficient buoyancy to support various size subjects. Depending on the natural buoyancy of the individual, all the suits are generally equal in buoyant qualities. When wearing the suits alone, in a simulated unconscious state, the subjects were as likely to float face down as face up. See Figures 18-23. When the various types of supplemental flotation devices were tested while wearing the suits, the same results were obtained, except with the LPA-1 preserver and RNLI life jacket (see Appendix B). Only the LPA-1 and RNLI life preservers offered the greatest potential for righting an unconscious person face up. Therefore, any further testing of the devices failing to right a simulated unconscious person was not considered.

The design of all the preservers tested was based on providing flotation and righting capability for persons wearing no wet suit. The wet suit with its inherent buoyancy causes the body to assume a different attitude in the water. A normal person without any artificial buoyancy will either float or sink, dependent on weight and bone

structure. If he floats, it can be either face up or face down. The upper torso, due to the chest cavity, will float higher than the heavier lower torso and legs. In contrast, a subject wearing the buoyant wet suit will assume, when relaxed a position either face up or face down, and will likely remain so. On the back, the subject will be horizontal and "spread eagled." On the front, the forearms will droop slightly in a "spread eagle" position. In the "spread eagle" position, the arms and legs act as outriggers and resist the righting action of any supplementary flotation. As started earlier, only the Coast Guard Modified LPA-1 and the RNLI preservers had the correct geometry and sufficient buoyancy to right a wet suit clad subject.

Results of further testing of the LPA-1 preserver and RNLI life jacket are as follows:

a. LPA-1 Life Preserver:

The LPA-1 Life Preserver, providing approximately 65 pounds buoyancy, was designed, developed and tested by the U. S. Navy Aerospace Crew Equipment Department at Philadelphia, Pennsylvania. It will replace air current Navy aircrew life preservers. It has been tested by the Navy with every existing item of summer and winter flight clothing and survival equipment configuration, except the wet suit. It has been tested by the Coast Guard in combination with the wet suit. The Coast Guard tests showed that the righting qualities of the LPA-1/wet suit combination were marginal. The buoyant effect of the LPA-1 waist flotation chambers tend to "hump" the wearer's body when face down. This, plus the "spread eagle" position of the body, results in a passively stable attitude. A conscious subject can easily right himself; an unconscious subject when face down, tends to remain so. The LPA-1 was modified to attach the LPA-1 belt to the collar assembly, rather than attaching the belt to the wearer's flight suit at the stomach area and the collar to the garment at the chest area. (Refer to Figures 13 and 14). The belt to collar modification, (hereafter called CG Modified LPA-1) consisted of sewing a 1-inch wide 24-inch length of nylon tape at each side of the belt buckle. The other end of the tape terminated in two "D" rings which attach to existing snap rings on the collar. The straps are adjustable. The modification resulted in two improvements: First and most important, the waist and collar flotation chambers were drawn together in the inflated condition; this resulted in a positive righting action from a face down position and provided a better flotation attitude. Secondly, the preserver is donned like a vest and requires no attachment at waist and collar to the flight suit.

The following are the results of tests conducted at the Baltimore YMCA. Figures 29-35 are a photographic record of these tests.

(1) Standard two-piece 1/4" wet suit, flight boots and CG Modified LPA-1 preserver.

Normal floating position that is assumed is on the back with the body at an angle of approximately 20° with horizontal. Head is supported well out of the water by the collar. A face-down position can only be achieved with difficulty and can not be maintained. When assuming a face-down position and relaxing, the arms and legs drop slightly, the body arches and within five seconds the chest flotation rights the wearer by rolling him to either left or right. The movement is slow but it is positive. Although this was done in a calm pool, the fact is that the face-down position is one of instability. Therefore, any motion of the wearer caused by the sea will accentuate this instability and speed the righting action. Simulating panic motions in the face-down position also adds to the instability of that position and speeds the righting action.

(2) Standard Flight Suit and CG Modified LPA-1 Life Preserver.

Normal floating position is on the back with the body at an angle of approximately 45° from the horizontal. A face-down position can only be assumed with great difficulty and can not be maintained. The righting action is faster than with the wet suit on, and takes place in two-to-three seconds. The righting action is a combination of raising the head and rolling either left or right.

(3) Anti-Exposure Military Flight Suit and CG Modified LPA-1 Life Preserver.

Comments and results are the same as with the two-piece wet suit described in paragraph (1).

(4) One-piece neoprene wet suit or anti-exposure military flight suit with LPA-1 life preserver (Navy Method - D-ring collar assemblies and snap/loop waist assembly).

The floating position that is assumed is either face down or face up. As opposed to the CG modification which draws the collar flotation and chest flotation together, this method (Navy) holds the chest flotation down and lifts at the waist area and can not be relied on to right the wearer from face-down position. Effect of wave and sea action is not assessed.

b. RNLI Life Jacket:

The RNLI life jacket was developed by the Royal National Life Boat Institution (Great Britain). The design features include both 24 pounds of built in Kapok buoyancy and facilities for oral inflation. According

to the publication of the Tenth International Life Boat Conference (1967), "this jacket is a good self-righter when relying on the permanent buoyancy alone and is an instant self-righter when inflated."

The RNLI "Lifemaster" jacket is manufactured to specification by Vacuum Reflex Limited, London, England. This jacket has approximately 24 pounds of Kapok buoyancy and additional oral inflation to a minimum total of 48 pounds.

The following are the results of tests conducted by FT&DC personnel at the CG Yard pool.

(1) One-piece wet suit and RNLI life jacket.

The normal flotating position that is assumed is on the back. In smooth water, with the kapok buoyancy only, a face-down position can be obtained but is doubtful if it would be maintained in wave or sea action. With the jacket inflated a face-down position is never naturally assumed and can only be obtained with great difficulty. When the jacket is inflated, righting action takes place in two to three seconds by rolling the subject either to the right or left. Figures 36 thru 39 are a photographic record of the results of the tests.

c. Additional Tests of the One-Piece Neoprene Wet Suit.

An additional test was conducted on the one-piece wet suit to determine if the suit could be zipped closed while in the water. Before the test, the subject was given an opportunity to practice zipping up the suit until he was familiar with the zipper configuration. After practicing he was able to completely zip the suit in 20 seconds out of the water.

With all the zippers open and the side zipper fasteners just below the knee, the subject entered the water and attempted to zip closed the suit. It was discovered that once the suit was wet, it was impossible to zip the suit due to the zippers tightning up. Even out of the water an assisting person could not close the side zippers to the suit. Bar soap was used to lubricate the zippers, but this did not help. However, by positioning the side zipper fasteners at the top of the suit rather than below the knee, the suit could, with difficulty be zipped closed. The water temperature being 52° F and the side zipper fasteners at the top, it took an experienced man 64 seconds to completely close all the zippers. If the water temperature was much lower, it is doubtful that the suit could be zipped before the subject became numb.

5. DISCUSSION OF RESULTS:

As determined from the tests, when the wet suit or exposure suit is worn, supplemental flotation is necessary to right an unconscious person when a face-down position is assumed. Additionally, when wearing the wet suit or exposure suit and the supplemental flotation is a manually-operated inflatable type, there exists a calculated risk that the person will be unconscious when entering the water. This risk is obviated with the RNLI jacket which has built in buoyancy plus additional buoyancy when inflated. However, due to its size, suitability for aircraft operations may be somewhat restricted, but would be desirable for small boat operations when the wet suits are worn.

Coast Guard modification to the LPA-1 is required to draw the collar flotation and chest flotation together. It is this position which provides the instability when face down and the resultant righting motion. The Navy Method which holds the chest flotation down and lifts at the waist area can not be relied on to right the wearer from the face-down position, when wearing the wet suit.

6. CONCLUSIONS:

Based on the results of the tests it is concluded that:

a. The wet suits and the exposure suit have sufficient buoyancy to support the wearer. However, the buoyancy does not provide for self-righting, nor does it keep the wearer's head up and out of the water. Supplemental flotation is required.

b. The CG Modified LPA-1 and the RNLI jacket in combination with the wet suit provides the optimum survival/flotation configurations.

c. The one-piece zippered wet suit is considered impractical, in view of the effort required to close all the suit zippers in the water.

7. RECOMMENDATIONS:

Based on results of these tests it is recommended that:

a. For Coast Guard helicopter crews - CG Modified LPA-1 and two-piece, individually fitted, wet suit combination be used.

b. For Coast Guard fixed wing crews - CG Modified LPA-1 and MK-5A quick-don exposure suit combination be used.

c. For Coast Guard small boat crews - RNLI Life Jacket and wet suit combination be used.

Since the RNLI jacket has features that make it desirable for boat crews, further field evaluation should be in cold weather areas where the wet suits are worn routinely. The only in-service CG life jacket with built-in buoyancy that can even compare with the RNLI jacket on righting capability with the wet suit is the standard Abandon Ship type jacket. Therefore, the RNLI jacket should only be compared with that jacket for comfort and freedom of movement over long periods of time. It should be stressed that the work type jackets, which are normally worn with the wet suits, offer no righting capabilities when worn with the wet suits, should the person become unconscious or otherwise incapacitated (see COMMANDANT BULLETIN #3-68, Supplement 2, "Utilization of wet suits on BIBB").

APPENDIX A

Photographic record of the tests

FIGURE 1 - Wet suit - small.

FIGURE 2 - Wet suit - large.

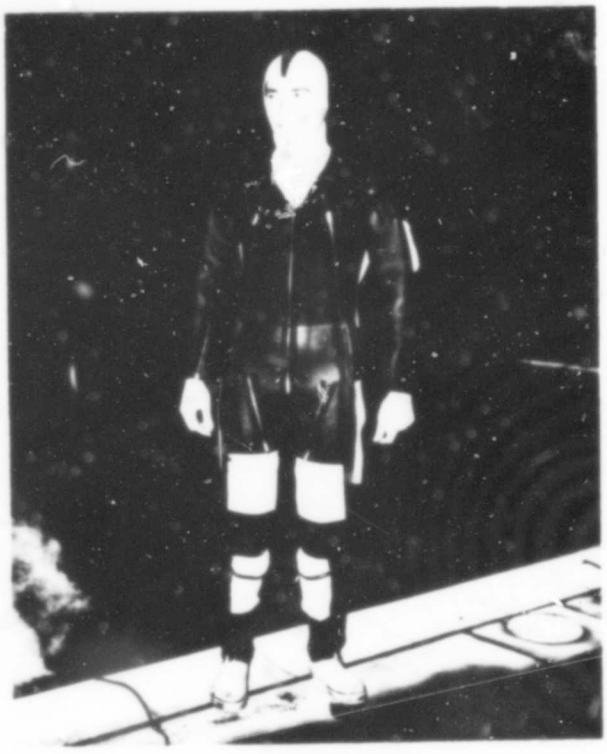

FIGURE 3 - One-piece aircraft and helicopter pilots wet suit.

FIGURE 4 - Suit unzipped for comfort.

FIGURE 5 - Anti-Exposure Military Flight Suit, Model No. GAEFS-CG-100, Mod. 1.

FIGURE 6 - Work vest (left) and Coast Guard approved life jacket (right) - collarless.

FIGURE 7 - MK II Life preserver, aircrewman.

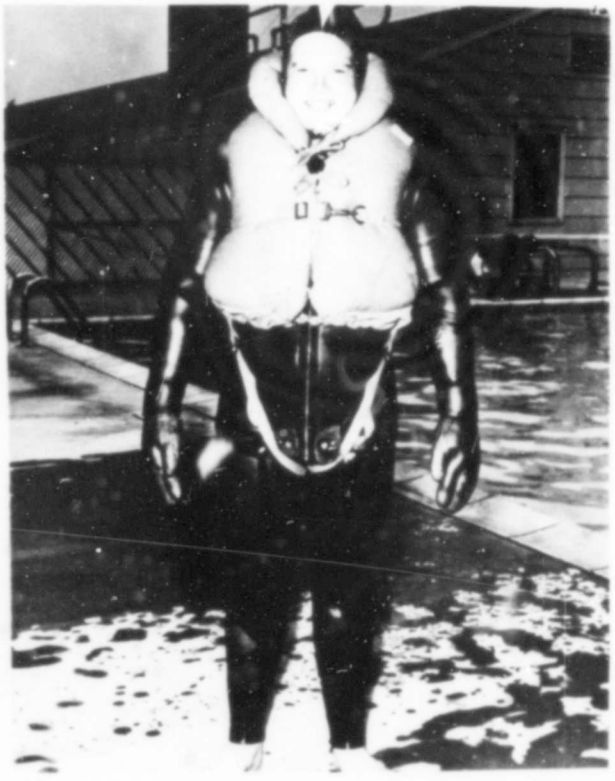

FIGURE 8 - Abandon Ship Life Jacket.

FIGURE 9 - CG Approved Adult Buoyant Vest.

FIGURE 10 - Coast Guard Approved Work Vest.

FIGURE 11 - MK 3C Life preserver, pilot before inflation.

FIGURE 12 - MK 3C life preserver inflated.

FIGURE 13 - LPA-1 life preserver with CG Modified straps.

FIGURE 14 - LPA-1 life preserver Navy

FIGURE 15 - LPA-1 Life preserver before inflation. (Center is CG Modified, left and right Navy.)

FIGURE 16 - RNLI Life jacket before inflation.

FIGURE 17 - RNLI life jacket - side view.

FIGURE 18 - Anti-exposure flight suit - subject face down (small subject).

FIGURE 19 - Anti-exposure flight suit - subject face up (small subject).

FIGURE 20 - Anti-exposure flight suit subject face up (large subject).

FIGURE 21 - Anti-exposure flight suit - subject face down - (large subject).

FIGURE 22 - Two-piece wet suit - face up (small subject).

FIGURE 23 - Two-piece suit face up (large subject).

FIGURE 24 - LPA-1 life preserver worn over flight suit provided with D-rings and waist loop snaps. (Navy photo)

A-14

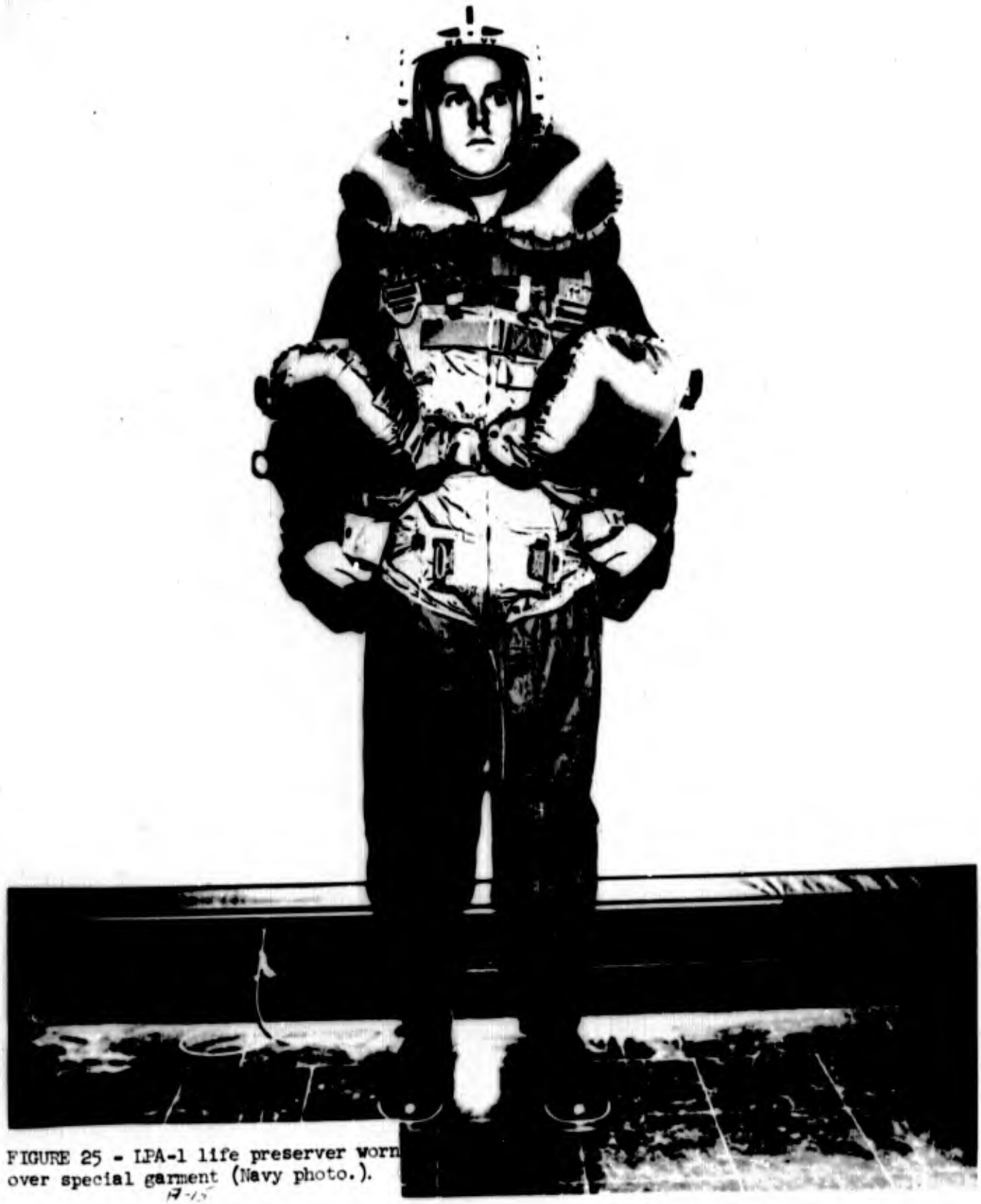

FIGURE 25 - LPA-1 life preserver worn over special garment (Navy photo.).

FIGURE 26 - LPA-1 life preserver - rear view.

FIGURE 27 - D-ring and snap/loop assemblies affixed to one-piece exposure flight suit. (Navy).

FIGURE 28 - Some difficulty is encountered in getting collar section up and around the neck when D-rings and waist snap/loop is used.

FIGURE 29

FIGURE 30

CG Modified LPA-1 Life preserver, standard two-piece 1/4" wet suit, standard flight suit and flight boots. Note instability in face-down position. Both pictures taken during righting action.

FIGURE 31

FIGURE 32

CG Modified LPA-1 draws collar flotation and chest flotation together.

FIGURE 33

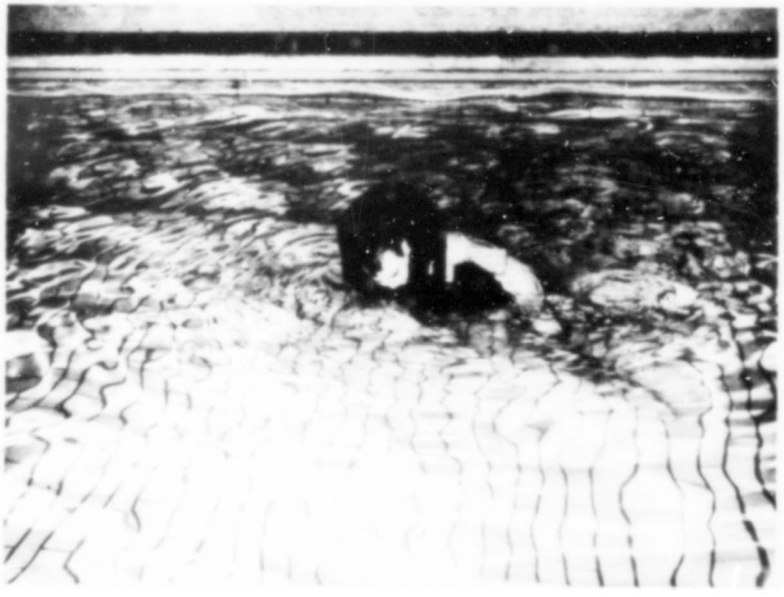

FIGURE 34

CG Modified LPA-1, and standard flight suit. Bottom picture during righting action.

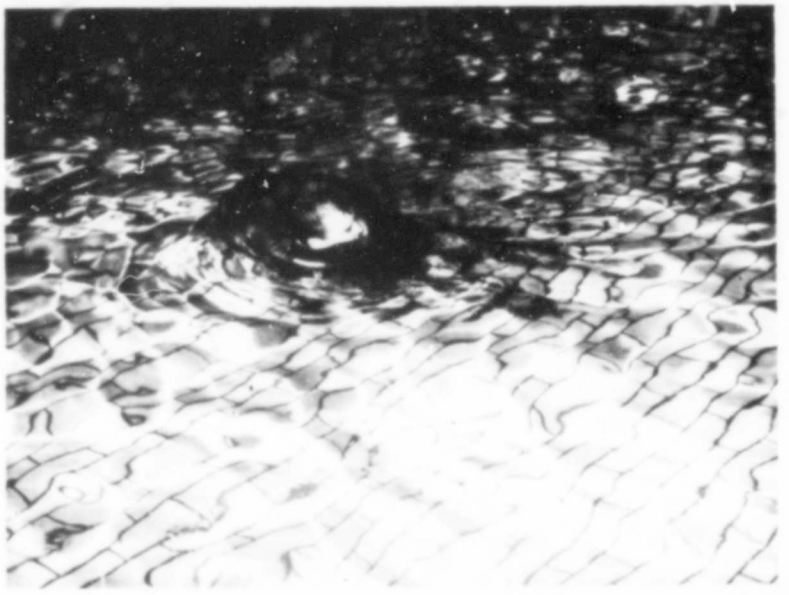

FIGURE 35 - CG Modified LPA-1 preserver and standard flight suit.

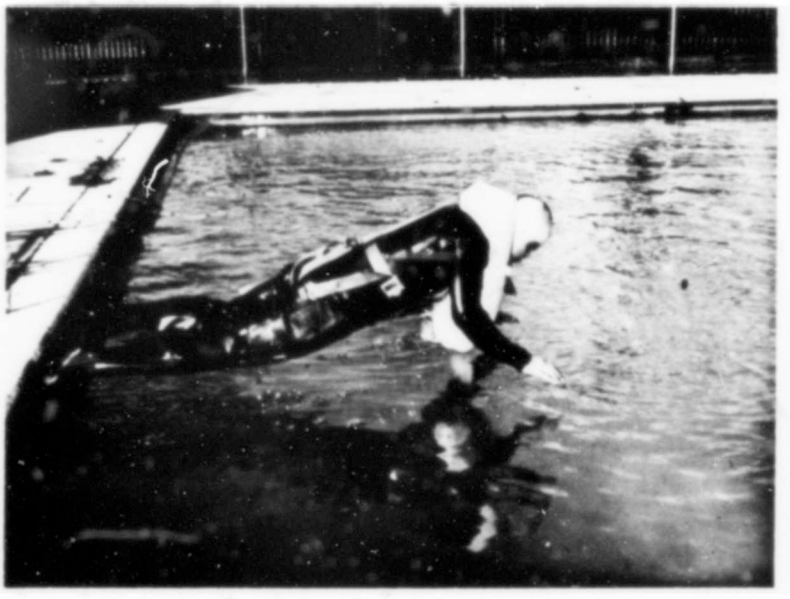

FIGURE 36 - RNLI life jacket and one-piece wet suit - entering the water face down.

FIGURE 37 - Righting takes place in two-three seconds.

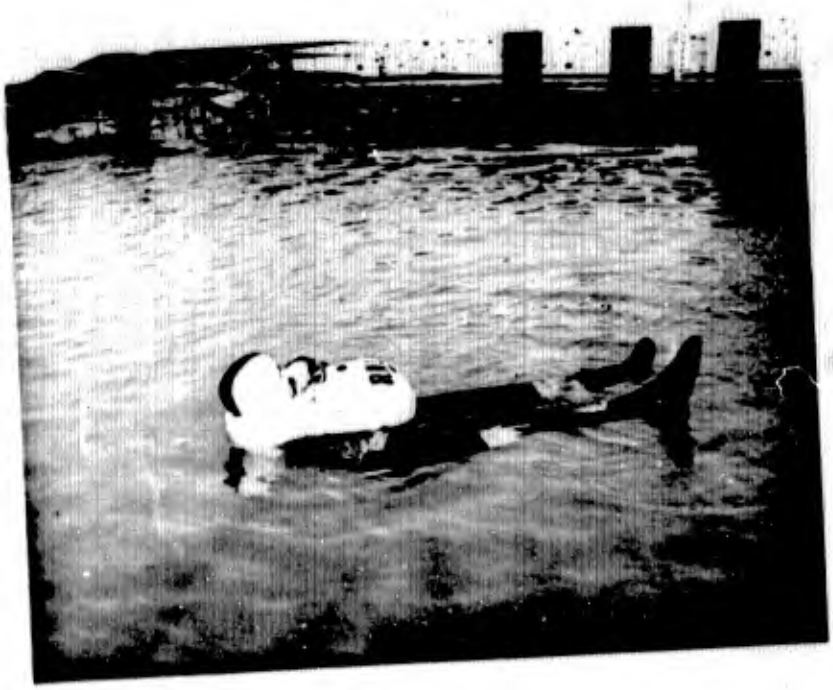

FIGURE 38 - Inflating orally in the water.

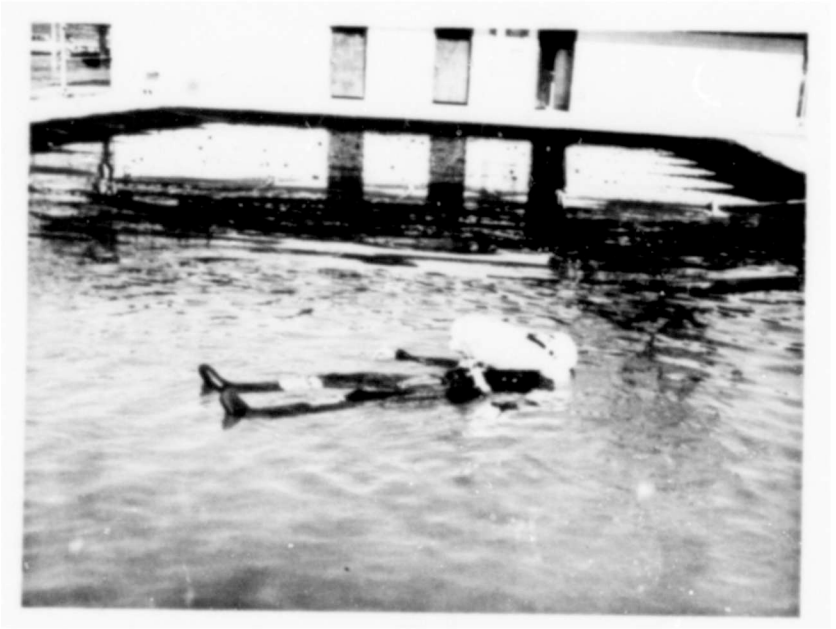

FIGURE 39 - RNLI jacket inflated. Normal position assumed.

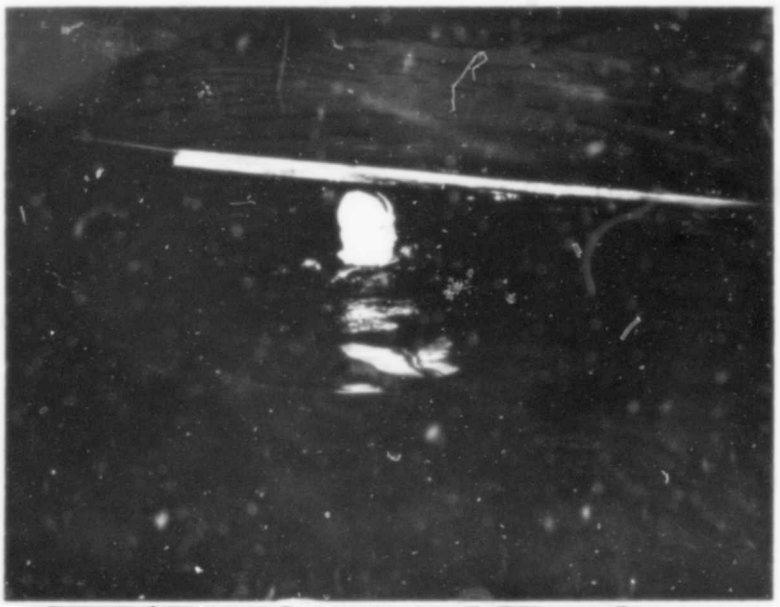

FIGURE 40 - Subject attempting to close zipper on survival suit.

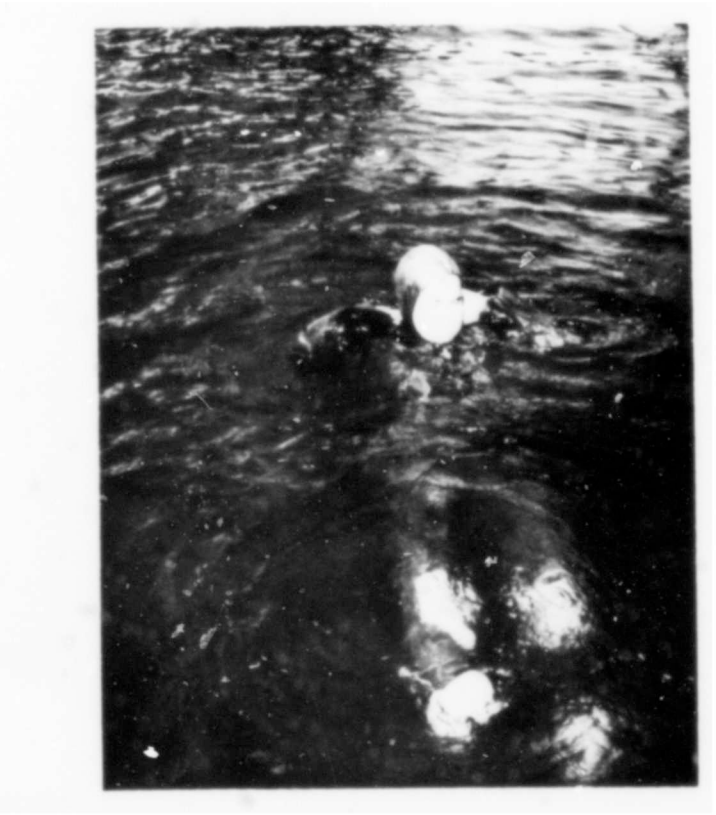

FIGURE 41 - Subject attempting to close zipper on survival suit.

APPENDIX B

The following additional photographs depict the different positions that may be assumed with the various type wet suits and life preservers other than the LPA-1 and RNLI. Note that none of these could be relied on to right an unconscious person face up.

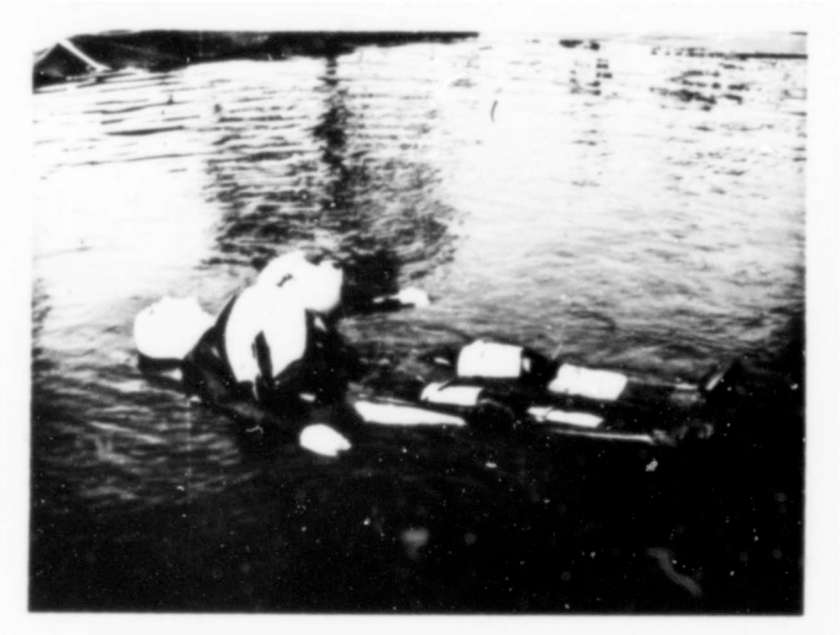

FIGURE 1

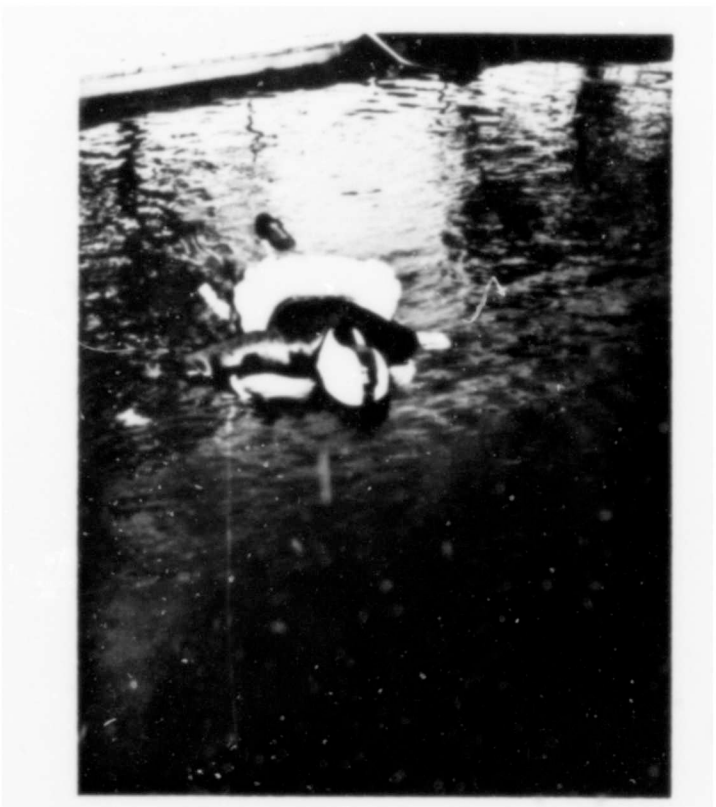

FIGURE 2

One-Piece wet suit and MK 3C Life preserver.

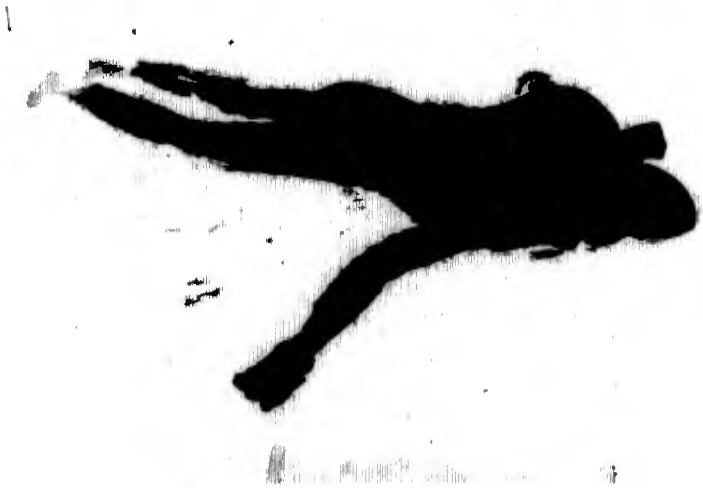

FIGURE 3

FIGURE 4

Abandon ship life jacket and two-piece wet suit.

FIGURE 5

FIGURE 6

Two-piece wet suit and adult work vest.

FIGURE 7

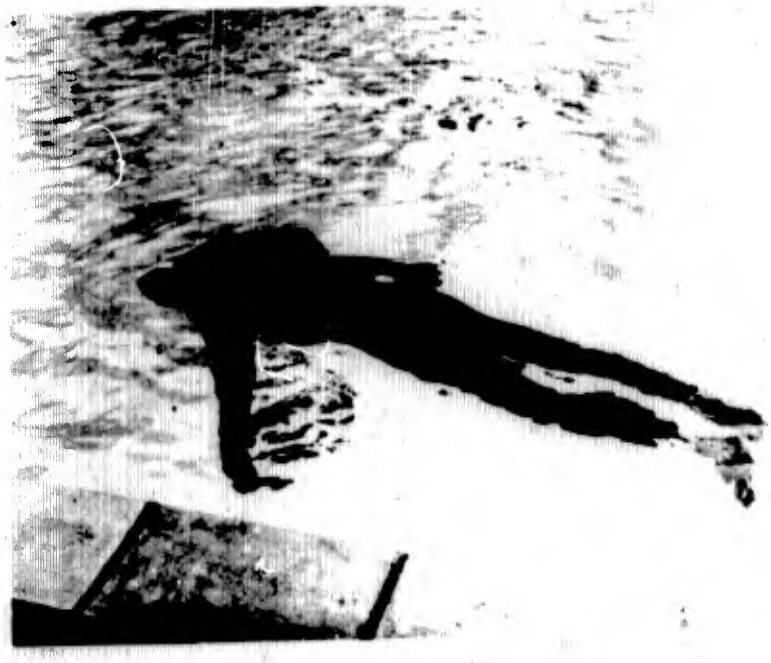

FIGURE 8

Coast Guard work vest and two-piece wet suit.

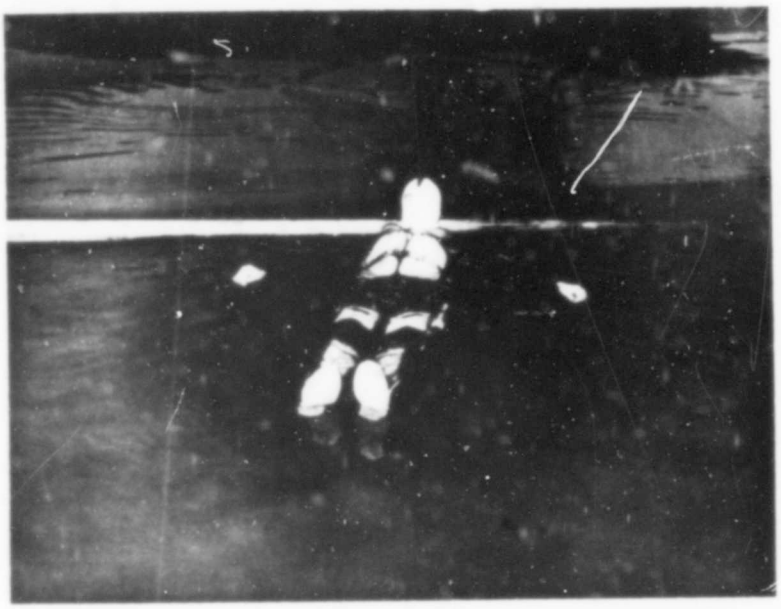

FIGURE 9

FIGURE 10

One-piece wet suit and CG approved work vest.

FIGURE 11

FIGURE 12

Two-piece wet suit and collar Coast Guard approved life jacket.

FIGURE 13

FIGURE 14

Two-piece wet suit and MK II Life preserver.