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ENTANGLEMENT OF THE SUBMERSIBLE JOHNSON SEA LINK WITH SUBMERGED WRECKAGE OFF KEY WEST, FLORIDA ON OR ABOUT 17 JUNE 1973 WITH LOSS OF LIFE

Coast Guard
Washington, D. C.

15 January 1975

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This report contains Marine Safety Recommendations M-75-5 through M-75-8.

16. Abstract

On June 17, 1973, near Key West, Florida, the submersible JOHNSON SEA LINK became entangled in a cable of the wreckage of the scuttled destroyer U.S.S. FRED T. BERRY. The JOHNSON SEA LINK had been attempting to retrieve a fish trap in the immediate vicinity of the wreckage. Before the submersible was recovered, more than 33 hours later, two of the four persons on board had died as a result of carbon dioxide poisoning.

This report contains the action taken by the National Transportation Safety Board in determining the probable cause of the casualty and in making recommendations to prevent its recurrence. The report also contains the Marine Board of Investigation report and the action taken by the Commandant, U.S. Coast Guard.

The National Transportation Safety Board determines that the probable cause of the accident was the fouling of the starboard spring-loaded moused hook and other appendages on the submersible with a cable attached to the aftermost flagpole of the scuttled destroyer.

Contributing to the carbon dioxide fatalities was the inadequacy of the carbon dioxide absorbent system in the dive chamber, and the lack of suitable rescue equipment was a factor in the inability to provide a timely rescue.

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ENTANGLEMENT OF THE SUBMERSIBLE JOHNSON SEA LINK WITH SUBMERGED WRECKAGE OFF KEY WEST, FLORIDA ON OR ABOUT 17 JUNE 1973 WITH LOSS OF LIFE

TABLE OF CONTENTS

NATIONAL TRANSPORTATION SAFETY BOARD
DEPARTMENT OF TRANSPORTATION
WASHINGTON, D.C. 20591

Submersible JOHNSON SEA LINK
Straits of Florida
17 June 1973

ACTION BY THE NATIONAL TRANSPORTATION SAFETY BOARD

This casualty was investigated by a U. S. Coast Guard Marine Board of Investigation which convened at Fort Pierce, Florida, on June 27, 1973. A representative of the National Transportation Safety Board observed part of the proceedings. The National Transportation Safety Board has considered only those facts in the investigative record which are pertinent to the Safety Board's statutory responsibility to determine the cause or probable cause of the casualty and to make recommendations.

SYNOPSIS

On June 17, 1973, the submersible JOHNSON SEA LINK dived in the immediate vicinity of the scuttled destroyer U. S. S. FRED T. BERRY, which was located on American Shoals near Key West, Florida. Attempts to retrieve a fish trap failed and shortly after 0945, while being maneuvered away from the fish trap, the submersible became entangled in a cable of the wreckage.

U. S. Navy assistance was requested immediately, and the first rescue craft arrived on scene about 6 hours later. Before the submersible was recovered at 1653 on June 18, two of the four persons on board died as a result of carbon dioxide poisoning.

The National Transportation Safety Board determines that the probable cause of the accident was the fouling of the starboard spring-loaded moused hook and other appendages on the submersible with a cable attached to the aftermost flagpole of the scuttled destroyer.

Contributing to the carbon dioxide fatalities was the inadequacy of the carbon dioxide absorbent system in the dive chamber, and the lack of suitable rescue equipment was a factor in the inability to provide a timely rescue.

Contributing to the fouling of the submersible were: (1) The position of the air-conditioning unit in the pilot sphere which prevented the pilot from observing the area off the after starboard side of the submersible; and (2) the absence in the JOHNSON SEA LINK operations manual of procedures to be followed by the pilot when operating in areas of possible entanglement.

ANALYSIS

This analysis is to be read in conjunction with the Coast Guard's Findings of Fact.

Entanglement

U.S.S. FRED T. BERRY (DD-855). -- Witnesses testified that the only sources of entanglement in the vicinity of the fish trap were the two aftermost flagpoles and various cables hanging from the main deck of the sunken U.S.S. FRED T. BERRY. A report from the U.S. Navy divers stated that the submersible seemed to be fouled on a whip antenna; however, there was no whip antenna on the wreck. While trying to retrieve the fish trap, the heading of the submersible had been moved to port. so that when the submersible attempted to back away from the area of the wreck, it would have been moving aft at an angle toward the aftermost flagpole. The pilot's testimony that after being fouled, the submersible could be maneuvered 20 feet away from the "aftermast" in each direction indicates that the most likely source of entanglement was the aftermost flagpole and its supporting cables.

None of the cables attached to the flagpole was known to be broken or adrfit before the casualty. The Coast Guard Marine Board of Investigation did not include an inspection of the wreck after the casualty. Therefore, the particular cable which fouled the submersible cannot be identified by the available evidence.

JOHNSON SEA LINK. -- The many projections from the submersible made it risky to enter into an area which contained cables. The external appendages could not be jettisoned nor were they equipped with anti-fouling devices. Appendages which can encircle a foreign object on the ocean bottom are particularly dangerous because when one becomes entangled the submarine is deprived of two of its three axes of movement. Much of the JOHNSON SEA LINK's framework appendage was capable of encircling foreign objects. Further, the spring-loaded, moused hooks mounted out of the pilot's view increased the risk of entanglement because they could hook a foreign object from more than one direction. The hooks can function like lance hooks, which were designed to hook on to a suspended cable. If a cable became caught in one of these hooks, the submersible could be freed only by breaking the hook, by manually manipulating the hook, or by cutting the cable.

Before the JOHNSON SEA LINK submerged on June 17, the hooks were not known to be damaged. A survey of the submersible after the casualty showed that the starboard hook had been damaged by a cable and that the mousing device had failed. (See Figure 1.) The mousing device could have failed when the submersible was raised from the bottom by the grapnel operated on board the A. B. WOOD II. The force exerted during this maneuver would have caused the cable to break free from the hook. Since there was evidence of damage inflicted by a cable at other points on the submersible, it could not be determined if the initial source of fouling was the snagging of the cable by the hook.

Operations Manual. -- The JOHNSON SEA LINK operations manual states that because of the unobstructed vision in the acrylic pilot sphere, the chance for entanglement is reduced. However, the air-conditioning unit, installed on the after section of the pilot sphere, decreased the intended panoramic visibility by creating a blindspot off the after starboard side of the submersible. It was in this blindspot that the cable was discovered after the submersible was fouled. The manual does not mention the blindspot nor does it provide guidelines to prevent entanglement.

Safety publications about submersibles published by the American Bureau of Shipping, Marine Technology Society, and others, usually recommend that projections on a submersible be protected in various ways or that the submersible avoid areas of possible entanglement. The external appendages attached to the JOHNSON SEA LINK were not protected and made the submersible vulnerable to entanglement. Scheduled research projects required that the JOHNSON SEA LINK operate in the vicinity of both natural and artificial reefs where risks of entanglement were high.

The operational guidelines in the JOHNSON SEA LINK operations manual should include the requirement to conduct initial surveys of areas to be traversed during a mission. The guidelines should enable the pilot of the submersible to assess readily any hazards found during the surveys. After the dangers of the potential hazards are assessed, specific instructions should be given to the pilot to assist him in safely performing the duties required to complete the mission.

Figure 1 - Starboard Spring Loaded, Moused Hook

If these procedures had been followed before the dive on June 17, swimmers from the JOHNSON SEA LINK might have been sent to retrieve the fish trap while the submersible remained a safe distance away.

Life-Support Systems

Carbon dioxide removal system. -- In order to prevent carbon dioxide (CO_2) toxicity, the CO_2 in both closed manned compartments is removed by a chemical process using Baralyme. Air which contains CO_2 is circulated through a canister of Baralyme. The capacity of Baralyme to absorb CO_2 decreases when the temperature of the reaction process decreases. However, there probably was sufficient space in the submersible's compartments to carry additional Baralyme to compensate for capacity loss because of temperature. Since Baralyme is a chemical reactant, it can lose effectiveness as a result of storage and handling if it is not properly packaged for shipboard use.

Because of the high thermal conductivity of its aluminum structure, the diver compartment lost much of its heat when the vessel operated in ocean waters colder than the compartment's inner atmosphere. Since there was no auxiliary heat, the temperature of the diver compartment dropped when the temperature differential across the compartment walls resulted in heat losses greater than the body heat output of the occupants. Thus, the resulting temperature drop adversely affected the occupants physically and caused the performance of the CO_2 removal system to deteriorate.

The JOHNSON SEA LINK was constructed according to the guidelines of the American Bureau of Shipping (ABS) 1/ and was subsequently classed as a ✠ AI Manned Submersible. 2/ These guidelines recommended that the CO_2 removal system have a capacity sufficient to provide for a margin of safety of 24 hours. 3/ The guide does not discuss explicitly the effects of temperature on CO_2 absorbents.

1/ Guide for the Classification of Manned Submersibles, American Bureau of Shipping, New York, 1968

2/ The classification ✠ AI means that the JOHNSON SEA LINK was built under the special supervision of the ABS surveyors to the full requirements of the guidelines.

3/ Margin of safety refers to the additional life-support capacity beyond design mission length.

Perceptive levels of CO_2 in diver compartment. -- About 14 hours after the dive began, two men in the diver's compartment could no longer tolerate the buildup of CO_2. By that time, the diver compartment temperature had probably dropped to between 45° F and 55° F which would affect adversely the performance of Baralyme. Probably, the emergency situation would create anxiety which would result in a higher rate of CO_2 production by the occupants. Considering the variable human responses to CO_2 and uncertainties in both CO_2 production rate and compartment temperature, the actual 14-hour duration of Baralyme effectiveness in the diver's compartment is reasonably consistent with U.S. Navy data. [4/] Based on these data, the expected time for two men, who are sitting and inactive, to exhaust the effectiveness of 22 pounds of Baralyme [5/] would be about 8 hours at 45° F and about 16.5 hours at 55° F. Effectiveness for longer times should not be expected in the relatively small compartment, since the rate at which Baralyme absorbs CO_2 decreases markedly when increased levels of CO_2 begin to pass through the Baralyme.

After the submersible became entangled, it was first estimated that the Baralyme in the diver's compartment would be depleted within 61 hours of the beginning of the dive; the estimate was based on Baralyme performance at 70° F. Again, using U.S. Navy data, two men, who are sitting and relatively inactive, would probably exhaust 22 pounds of Baralyme at a 70°F reaction temperature in about 30 hours. About 9 hours after the dive began, it became evident that the decreasing temperature was adversely affecting the absorption of CO_2. Personnel aboard the support ship then revised their estimate down to 24 hours from the start of dive; the record did not specify the temperature basis for this estimate. An incorrect temperature basis, possible errors in computation, failure to compensate for the higher CO_2 production, and possible deterioration of Baralyme contributed to these gross overestimates. A reasonably accurate assessment of life-support immediately after the entanglement together with an assessment of available rescue capabilities might have caused other more efficient rescue action to be taken. However, a reliable estimate cannot be expected when many factors must be evaluated under the stress of rescue operations.

4/ U.S. Navy Diving Operations Handbook, NAVSHIPS 0994-009-6010, 1 Jan. 1971.

5/ The investigation record indicates that 22 pounds of active Baralyme was loaded into the diver's compartment for dive 130.

Margin of Safety. -- Since the margin of safety is intended to provide life-support beyond the planned mission time, the effects of prolonged submergence must be evaluated when life-support systems are designed. Such an evaluation requires that all the significant factors which determine the performance of the life-support system be considered. Among these factors are the physiological responses of occupants to emergencies and lengthy confinement in a relatively small compartment, the effects of the ocean environment on system components, and the effects of failures in any of the submersible's systems on the life-support system. The failure of the JOHNSON SEA LINK to provide adequate life-support cannot be attributed to some unpredictable occurrence or phenomenon; temperatures below 50° F are frequently encountered at 350-foot depths. In addition, information was available regarding the effects of low temperatures on Baralyme and the effects of stress on humans. The record does not provide evidence of how these factors were considered in the JOHNSON SEA LINK's design. Any operational restrictions or special precautions which might be necessary to compensate for certain design deficiencies can be effective only if they are recorded in the Operations Manual. The Operations Manual did not specify a minimum water temperature nor the need for thermai protective clothing.

The difficulties in rescuing the JOHNSON SEA LINK and in another recent submersible incident, the Vickers Oceanics Submersible Pisces III, indicate that a 24-hour margin of safety is not sufficient; both accidents are summarized in a recent publication of the Marine Technology Society (MTS). 6/ The margin of safety should provide sufficient time: (1) To organize rescue forces and get them on scene; (2) to allow for weather conditions which restrict rescue operations; (3) to fabricate and deliver rescue equipment which may be required because of the circumstances of the casualty; and (4) to locate the disabled submersible, attach rescue hardware, remove sources of fouling, and raise the submersible. Although these time factors did not affect the rescue of the JOHNSON SEA LINK (the weather, accident location, and water depth were favorable, and special equipment did not have to be fabricated), the rescue required about 31 hours. In addition, a relatively high-risk method of rescue was used when the life-support in the forward sphere was determined to be nearly exhausted.

6/ Safety and Operational Guidelines for Undersea Vehicles -- Book II, Marine Technology Society, Washington, D.C., 1974.

Since the four factors mentioned above can hinder a timely rescue, before each dive they should be evaluated to determine whether the margin of safety is adequate. MTS has recommended at least a 72-hour reserve in life support. The Safety Board agrees that the minimum margin of safety should be 72 hours.

Rescue Equipment

At 2015 on June 17, the U. S. S. TRINGA was positioned over the general location of the JOHNSON SEA LINK. Before divers were sent down, however, the exact location of the SEA LINK had to be determined so that the divers would not be hindered by the wreck. The most effective way to determine the exact location would be to have a line attached to the submersible and extend it to the surface. The JOHNSON SEA LINK was not equipped with a releasable distress buoy whose line could have been used for that purpose. Before the TRINGA arrived, personnel of the SEA DIVER had tried unsuccessfully to lower a line from the surface to the submersible.

The U. S. Navy had no equipment immediately available that could attach a descending line to the submersible. As a result, considerable time was expended during attempts to maneuver the TRINGA precisely over the submersible. It was not until 2245 that the divers descended from the TRINGA. At 2325, the rescue attempt was aborted because the divers had landed on the U. S. S. BERRY wreck in such a position that they could not approach the submersible. Again, the TRINGA had to be repositioned, and a second rescue attempt did not begin until 0136, June 18. Even if this attempt had been successful, it would have been too late to save the persons in the dive chamber. Subsequent attempts by divers to reach the submersible were also unsuccessful.

The projected increase in the construction of small one-or two-man submersibles for use in underwater inspections of pipelines, deep-sea drillings rigs, and deep water ports indicate that the life-support systems similar to that on the JOHNSON SEA LINK may continue to be used.

U. S. Navy equipment, although not primarily developed for submersible rescue, can place a descending line on a trapped submersible. However, because of its size, transportation difficulties and other commitments, it cannot be relied upon to assist when the duration of submersibles' life-support systems approximates only

12 hours. Development and procurement of a device that could not only place a descending line on a submersible but could also be quickly available whenever needed would make the system used by the Navy in rescuing the JOHNSON SEA LINK considerably more effective.

System Safety

Specific techniques can be applied when analyzing the safety of the design and operation of a vessel. These techniques, generally called "system safety," include methods through which safety knowledge can be applied over the service life of a vessel.

By applying the techniques, hazards can be identified and safe design criteria and operational procedures can be created. A system safety review of the life-support system might insure that before each dive a sufficient amount of carbon dioxide absorbent is placed in the dive chamber in order to counter the effects of low temperatures.

Coast Guard Recommendations

Legislation. -- The Marine Board recommended that the Coast Guard actively seek legislation to regulate submersibles. The Commandant agreed, but stated that if legislation is passed, initial Coast Guard efforts would be directed toward requiring that a report of the scope and geographic area of intended submersible operations be made to the Coast Guard by those who conduct such operations.

The evidence in the casualty investigation does not support a premise that the lack of such a report contributed in any way to the casualty. However, the construction features of the JOHNSON SEA LINK created a situation which permitted entanglement and reduced the efficiency of the life-support system within the dive chamber. Additionally, the absence of a releasable distress buoy precluded a timely rescue by U.S. Navy personnel.

The Coast Guard investigative record, which revealed uncontrolled hazards in one case, does not support the need for overall regulatory control of submersibles. Although production of submersibles is increasing, the Safety Board believes that safety can be secured if voluntary use of safety designs and operations is emphasized.

Reporting Procedures. -- The Marine Board recommended, and the Commandant agreed, that the Coast Guard continue to encourage the reporting procedures noted in Commandant's Instruction 3130.7C. The instruction requests that the Coast Guard be informed of the location and operation of various submersibles. The information would be used when civilian submersibles are needed for assistance in the rescue of another submersible. To be effective, such a program would require more assistance than that of submersibles operating in the general area of a distress. The rescue of PISCES III, which sank in more than 1,500 feet of water off the coast of Ireland, was accomplished with the assistance of a U.S. Navy unmanned, cable-controlled, underwater recovery vehicle (CURV III) which was airlifted to the scene from San Diego, California. 7/

The Coast Guard should actively gather information concerning submersible rescue capabilities from shore facilities and marine craft, not only within the United States but worldwide. The information would be useful for maintaining a current inventory of available underwater search, rescue, and salvage equipment. With this inventory, systems to provide the most effective submersible rescue operations may be selected from throughout the world.

Coast Guard Rescue Equipment. -- The Marine Board recommended that the Coast Guard acquire, for use in underwater rescue operations, an underwater television unit capable of being delivered by air. The Commandant concurred in the recommendation, but stated that the acquisition of the equipment would be subject to budgetary constraints. The Coast Guard has not yet requested funding for the equipment, and such a request is not contemplated for fiscal year 1976.

The Coast Guard has continually upgraded its search and rescue facilities for distressed surface vessels. Currently, the Coast Guard has no equipment or facilities intended specifically for submersible rescue. There is no established program that would provide Coast Guard facilities in the future. Currently, the Coast Guard relies entirely on the U.S. Navy, which has no statutory responsibility for private submersible rescue operations, and on commercial resources. Although this reliance may be considered necessary as an interim step, and in view of the small number of submersible facilities as compared to others, the Coast Guard should plan for future participation and leadership in submersible rescue operations.

7/ Ibid.

This might be accomplished by joining with the U. S. Navy in a long-range research and development program which should seek to establish Coast Guard facilities for underwater rescue. The program could include the development of systems suitable for the rescue of the various types of submersibles currently in operation. The systems might include the use of Coast Guard surface craft to collaborate with the U. S. Navy in effecting rescues. Additionally, the development and use of standard attachment fittings, by both manned and unmanned rescue vehicles to permit the evacuation of persons trapped within a sunken submersible, and other hardware items could be the initial phase of submersible rescue capability in the Coast Guard.

Postaccident Corrective Measures

An Expert Review Panel was established by the Smithsonian Institution to examine the circumstances of the accident. As a result of its examination, the panel issued recommendations to submersible operators, Harbor Branch Foundation. The responses to the recommendations have recently been published; several are summarized below. 8/

Releasable distress buoy. A releasable tethered buoy has been developed for use on the JOHNSON SEA LINK. A newly designed system is being evaluated and tested for possible use.

Carbon dioxide absorbent system. The scrubber canister is equipped with an electrical heater that will warm the gas passing through the Baralyme bed, when required. Scrubber capacity is 128 man-hours per precharged canister. One additional precharged canister will be carried in each compartment of the JOHNSON SEA LINK.

Low-temperature personnel protection. The diving chamber of the JOHNSON SEA LINK will be insulated for thermal protection. A definitive thermal analysis and heat transfer model for the diving chamber has been developed and is being utilized for insulation studies. Standard operating procedures will require proper clothing and equipment to accompany personnel occupying the dive chamber.

External appendages. A redesign of attachment points have eliminated all hooks. Necessary instrumentation, transponders,

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8/ Ibid.

transducers, and lights have been lowered in profile. Mounting brackets have been redesigned to incorporate a "break-away" feature.

Nylon bolts are employed to attach necessary instrumentation to streamlined, low-profile brackets welded to the frame of the JOHNSON SEA LINK. A continuous load or pull will cause "cold flow" of the nylon bolt threads and separation. This system of "break-away" is currently employed on the JOHNSON SEA LINK.

PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of the accident was the fouling of the starboard spring-loaded moused hook and other appendages on the submersible with a cable attached to the aftermost flagpole of the scuttled destroyer.

Contributing to the carbon dioxide fatalities was the inadequacy of the carbon dioxide absorbent system in the dive chamber, and the lack of suitable rescue equipment was a factor in the inability to provide a timely rescue.

Contributing to the fouling of the submersible were: (1) The position of the air conditioning unit in the pilot sphere which prevented the pilot from observing the area off the after starboard of the submersible; and (2) the absence in the JOHNSON SEA LINK operations manual of procedures to be followed by the pilot when operating in areas of possible entanglement.

RECOMMENDATIONS

The external alterations made to the JOHNSON SEA LINK are appropriate but do not sufficiently reduce the risk of entanglement. Therefore, the National Transportation Safety Board recommends that:

1. The owners of the JOHNSON SEA LINK utilize system safety techniques to establish operational guidelines to prevent the entanglement of the JOHNSON SEA LINK. These guidelines should be incorporated in the JOHNSON SEA LINK operations manual. (Recommendation No. M-75-5.)

2. The U. S. Coast Guard actively collect information concerning worldwide submersible search and rescue capabilities so that the most effective equipment needed for use in future underwater emergencies can expeditiously be made available. (Recommendation No. M-75-6.)

3. The U. S. Coast Guard acquire as soon as possible an underwater television unit capable of being delivered by air and of providing a descending line to a submerged vessel. (Recommendation No. M-75-7.)

4. The U. S. Coast Guard and the U. S. Navy collaborate in a research and development program to develop the capability for civilian submersible rescue operations within the Coast Guard. (Recommendation No. M-75-8.)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

Adopted this 15th day of January 1975:

John H. Reed
John H. Reed, Chairman

Francis H. McAdams
Francis H. McAdams, Member

W. W. French for
Louis M. Thayer, Member

Isabel A. Burgess
Isabel A. Burgess, Member

Wm R. Haley
William R. Haley, Member

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

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5943/JOHNSON SEA LINK
A-7 Bd
26 APR 1974

Commandant's Action

on

The Marine Board of Investigation convened to investigate circumstances surrounding the entanglement of the Submersible JOHNSON SEA LINK with submerged wreckage off Key West, Florida on or about 17 June 1973 with loss of life

1. The record of the Marine Board of Investigation convened to investigate subject casualty has been reviewed; and the record, including the Findings of Fact, Conclusions and Recommendations, is approved subject to the following comments and the final determination of the cause by the National Transportation Safety Board.

REMARKS

1. Concurring with the Marine Board of Investigation, it is considered that the cause of the casualty was the entanglement of the Submersible JOHNSON SEA LINK on the submerged wreckage of the scuttled USS FRED T. BERRY (DD-858). This resulted from the operator's failure to insure an obstruction free operating area for the irregularly shaped configuration which lent itself to ensnarement on almost any type of obstruction.

ACTION CONCERNING THE RECOMMENDATIONS

1. Recommendation: That, the Coast Guard actively seek legislation to regulate the construction and operation of submersibles. Included within these regulations, but not limited thereto, should be the following requirements:

a. A report of the scope and geographic area of intended submersible operations shall be made to the Coast Guard.

b. A life support capability of specified duration.

c. A device on the submersible capable of providing rescue forces with means of accurately fixing its position.

d. A device on the submersible capable of providing rescue forces with the means of engaging its hull.

Action: The Commandant concurs with this recommendation. Legislation to implement regulations is presently in the Congress. Should legislation be enacted to regulate the construction and operation of submersibles, the Coast Guard would direct its initial efforts toward operational regulations of the type described in this recommendation.

2. Recommendation: That, the Coast Guard continue to encourage the reporting procedures set forth in Commandant, U. S. Coast Guard Instruction 3130.7C pending any legislation in this area.

Action: The Commandant concurs with this recommendation. Participation in operations reporting by submersibles, under the provisions of Commandant Instruction 3130.7C, has increased since the JOHNSON SEA LINK accident. The instruction is under revision to reflect the experience gained in the JOHNSON SEA LINK case.

3. Recommendation: That, the Coast Guard consider the acquisition, and subsequent dedication to search and rescue, of an air deliverable T.V. unit similar to that which was used to locate the sea link.

Action: The Commandant concurs with this recommendation. The Coast Guard will consider the acquisition of such equipment in light of our other budgetary demands and constraints as well as the benefits of such equipment. In addition our efforts will be directed toward improved command and control and liaison which will enable full utilization of existing Coast Guard, Navy, and available civilian resources.

4. Recommendation: That, further investigation be conducted into the possible violation of Section 103 of Title 46 United States Code on the part of the owners of the M/V SEA DIVER, O.N. 249288.

Action: The Commandant concurs with this recommendation. A Report of Violation was submitted on 7 September 1973 and is presently being processed at the Office of the Commander, Seventh Coast Guard District, Miami, Florida.

5. Recommendation: That, a copy of this report be forwarded to the Chief of Naval Operations, U. S. Navy for specific consideration of Conclusion 9 herein.

Action: The Commandant concurs with this recommendation. A copy of this report will be forwarded to the Chief of Naval Operations, U. S. Navy upon final determination of the cause by the National Transportation Safety Board.

6. Recommendation: That, a copy of this report be forwarded to the Director, Smithsonian Institution for specific consideration of Conclusions 1, 3, 4, and 10 herein.

Action: The Commandant concurs with this recommendation. A copy of this report will be forwarded to the Director, Smithsonian Institution upon final determination of the cause by the National Transportation Safety Board.

C. R. Bender

C. R. BENDER
Admiral, U. S. Coast Guard
Commandant

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

MAILING ADDRESS:

5943/Marine Board
19 December 1973

From: Marine Board of Investigation
To: Commandant (G-MVI/83)

Subj: Marine Board of Investigation, Submersible JOHNSON SEA LINK, entanglement with submerged wreckage off Key West, Florida on or about 17 June 1973, with loss of life

FINDINGS OF FACT

1. At approximately 0953 EDT on 17 June 1973 the research submersible JOHNSON SEA LINK became entangled in the immediate vicinity of the scuttled U.S.S. FRED T BERRY (DD-858). This wreckage lies in approximately sixty (60) fathoms of water on American Shoal in the Florida Keys at the approximate position of 24°27'N Latitude and 81°34'W Longitude. There were four (4) persons on board the JOHNSON SEA LINK at the time of its entanglement (Dive 130) with two of the described persons losing their lives as a result of the casualty.

2. Vessel data:

a.

Name:	JOHNSON SEA LINK (SEA LINK)
O.N.:	None
ABS Class:	Manned Submersible
Length:	23'
Breadth:	7.9'
Depth:	10.6'
Weight:	19,495#
Propulsion:	Electric (Battery)
H.P.:	20
Maximum Speed:	1.75 knots
Owner:	Smithsonian Institution 100 Jefferson Drive, S.W. Washington, D.C., 20560
Last CG Inspection for Certification:	Uninspected
ABS Certification:	Maximum operating depth, 1000'
Master/Pilot:	Archibald Menzies 1681 Fifth Court Vero Beach, Florida
Coast Guard License:	None

b. The SEA LINK, as a submersible functions as an observation vehicle and collecting platform. With a neutral buoyancy capability the submersible can hang suspended in an area of high scientific interest. With its lock-out capability and relatively large power and life support capacity it can spend many hours sitting on the bottom, cruising, moving with the current or any combination thereof. With various devices and instruments the SEA LINK is able to gather data which is external to it's two (2) personnel compartments. A variety of life support gas systems provides the submersible with a lock-out capability that is utilized in conducting scientific sea floor collections and experiments at depths of up to one thousand (1,000) feet.

c. The submersible, as a complete unit, defies comparison with any conventional ship or boat shape. Its modular construction lacks the symmetry or "fairing" normally found in both surface and subsurface vessels. This submersible can best be described as an ill defined network consisting of an aluminum framework to which various shapes, containers and appendages have been attached according to their functional value rather than a concern for symmetry. (Photograph appended)

d. Two separate pressure vessels (hulls), which provide space for five (5) persons, are attached to the frame. In the foremost section of the network is a transparent sphere approximately five and one half (5½) feet in diameter. This compartment is constructed of four (4) inch thick acrylic and provides space for the submersible's pilot and one (1) other person. The sphere closely resembles a helicopter "bubble" and provides its occupants with nearly unrestricted visibility. It is provided with a single entrance hatch which is not designed to be opened under normal circumstances while the SEA LINK is submerged. Immediately aft of this sphere is an eight (8) foot long aluminum cylindrical shaped diver's compartment. It is approximately five (5) feet in diameter with hemispherical heads welded thereto. The compartment is provided with a view port in the forward end and on both port and starboard sides. The side ports allow the three or less persons inside to observe their underwater surroundings while the forward view port provides some degree of visual contact with the pilot's sphere. Although the diver's compartment contains a single hatch it is provided with two hatch covers (inside and outside) which can be "dogged" or "undogged" independent of each other and thus provide the divers with a capability to "lock out" of the compartment. The term "lock out" for the purpose of this report shall mean that the diver's compartment will be pressurized to the ambient pressure of, or slightly over, the depth of the surrounding water in order that the divers can exit or enter the compartment without its flooding.

e. Immediately aft of the diver's compartment is a sphere used for the stowage of diving gas. The sphere has a capacity of approximately fourteen (14) cubic feet and usually contains a mixed gas at nineteen hundred (1900) p.s.i. At the time of the casualty the sphere contained a mixture of eighty six and one-half (86½) percent helium and thirteen and one-half (13½) percent oxygen. This mixed gas stowage area is supplemented by a secondary source with a capacity of approximately one third (1/3) of the described sphere.

f. Directly under the pilot's sphere is the battery supply pod. This container houses the power supply for the submersible's entire electrical system including main propulsion. Strapped to the framework immediately outboard of the battery pod are four (4) high pressure air cylinders. These cylinders, two (2) on each side, provide storage for the air used in the SEA LINK buoyancy control and life support systems. Similarly strapped outboard of the diver's compartment are two (2), one (1) each side, oxygen cylinders which are connected in such a manner so as to form another part of the submersible's life support capability.

g. On each side of the pilot's sphere are relatively large tanks which are rigidly attached to the basic framework. These tanks are used as surface flotation units and are normally flooded during diving operations. They are "blown" or pressurized by the use of compressed air during the surfacing operation of the submersible. The two tanks are capable of providing approximately one short ton of positive buoyancy which permits the submersible to ride relatively high in the water while it is on the surface.

h. Two side mounted propulsion motors (one each side) are located just outboard and slightly aft of the diver's compartment. These units are fixed and provide only forward or astern thrust. Immediately aft of, and centered between, these motors is a vertical thruster which is also rigidly mounted and therefore provides an up or down thrust to the stern. On the aftermost structure of the SEA LINK are three more propulsion motors which are mounted in a fore and aft plane on a mechanically operated column. This column can be rotated approximately one hundred and seventy (170) degrees thus providing either ahead or astern thrust and turning thrust. Just forward of the pilot's sphere are two bow thruster motors. The foremost is a vertical thruster identical to the unit near the stern. Aft of the vertical thruster is a horizontal unit which provides an additional turning capability to the submersible. All eight (8) thruster motors are identical except for their mounting planes.

i. A rod extending approximately eight (8) feet in front of the submersible was equipped with a fork-shaped device which was used in retrieving fish traps from the ocean floor. The device, identified as a "lance", was equipped with a spring across the fork opening which prevented a line or rope from passing back out of the fork. The principle of its operation being similar to a spring loaded snap hook or mousing device.

j. In addition to the specific attachments described there were many other protrusions jutting out from either these attachments or the submersible's basic framework. These appendages included among other things such items as watertight lights, valves, transducers, and snap hooks.

k. Navigation of the submersible on Dive 130 prior to the casualty was being accomplished by installed navigational equipment and was being supplemented by sonar information provided by the M/V SEA DIVER O.N. 249288. The SEA LINK equipment included both a sophisticated computerized navigational system (Doppler Sonar Navigation) and the more conventional fathometer and magnetic compass. However, at the time of its entanglement the vehicle's maneuvering was being controlled mainly by visual observation or "seaman's eye".

3. Two persons lost their lives as a result of the entanglement of the SEA LINK on 17 June 1973. Neither of the two (2) male decedents were licensed or certificated by the Coast Guard nor were they required to be by existing laws or regulations. The following is a summary of their vital statistics:

Albert Dennison Stover SSN [redacted]

[redacted]

Time and Cause of Death Source - Monroe County, Florida Certificate of Death No. 136
Time: Approximately 0100 EDT 6/18/73
Cause: Respiratory Acidosis due to Carbon Dioxide Poisoning

Edwin Clayton Link SSN [redacted]

[redacted]

Time and Cause of Death Source - Monroe County, Florida Certificate of Death No. 137
Time: Approximately 0100 EDT 6/18/73
Cause: Respiratory Acidosis due to Carbon Dioxide Poisoning

4. The surface weather conditions at the time of the casualty were excellent. The seas were reported to be calm with little or no winds. These same conditions generally prevailed throughout the entire rescue operations with maximum winds and seas of ten (10) knots and one (1) foot respectively. Water temperatures, ranging from approximately eighty (80) degrees Fahrenheit at the surface to fifty (50) degrees Fahrenheit at the three hundred fifty (350) feet depth level, were calculated on the basis of information provided by a CSTD recorder. This device can provide water conductivity, salinity, temperature and depth as well as other scientific information. The surface current was attributed to the Gulf Stream and was estimated to be two (2) knots. Estimates of the subsurface currents varied from two and one half (2½) knots at a depth of approximately two hundred eighty (280) feet to four-tenths (.4) of a knot tidal influence at the bottom.

5. a. On 16 June 1973 (all dates hereinafter will assume the year 1973 unless otherwise specified) the SEA LINK positioned a fish trap near the sunken U.S.S. FRED T BERRY (DD-858). The FRED T BERRY (BERRY) is a scuttled former United States Naval destroyer approximately three hundred and ninety (390) feet long and forty (40) feet in breadth. The Board was unable to establish a concise picture of the configuration of the BERRY wreckage because of conflicting descriptions provided by the submersible

and rescue personnel. However, a logical composite is provided herein which is based on descriptions of the wreckage and photographs representative of the BERRY at the time it was scuttled. The vessel is lying on its port side in three hundred and fifty (350) feet of water with its decks inclined slightly from the vertical and its bow inclined up from the horizontal. This attitude would bring the stern of the vessel at or near the bottom and would slightly incline any masts on the hull away from the bottom. The BERRY is oriented in a generally southwest-northeast direction with the bow slightly south of west. There were no radar or whip antennas affixed to the hull at the time of scuttling. There was no foremast on the vessel and the permanent aftermast was a derrick-shaped platform with three (3) different levels of walkways on the platform. Two of the levels were guarded by three (3) tiers of pipe handrails and the uppermost walkway was guarded by two (2) tiers. The platform mast was approximately one hundred and forty (140) feet from the vessel's stern. In addition to the permanent platform, however, there were seven (7) three (3) inch pipe flag poles mounted normal to the BERRY's decks.

b. The seven (7) flag poles were identified as reference markers which were used in determining the exact position of the vessel as it sank. The poles extended forty five (45) feet from the BERRY main deck and the aftermost of the poles is located approximately thirty (30) feet forward of the vessel's stern. This pole is welded to the BERRY main deck and is additionally supported by two (2) sets of four (4) each stays. The first set of stays originate at or near the gunwhale bars and terminate at a point on the pole approximately twenty (20) feet above the main deck. The other set of stays also originate at or near the gunwhale bars and terminate approximately forty (40) feet from the main deck. Both set of stays were constructed of three-eighths (3/8) inch steel cable.

c. The fish trap was located on the ocean floor and was identified as being approximately thirty five (35) feet to the west of the BERRY's aftermast and fifteen (15) feet south of its main deck. The approximate overall dimensions of the trap were eighteen (18) inches long and fourteen (14) inches in diameter. A short length of three-eighths (3/8) inch diameter polyprophelene line streamed upward from the trap. This line terminated in two (2) flotation balls which caused the line to remain upright in the water. The line and flotation balls were designed to provide a relatively rigid target for the retrieval "lance" of the SEA LINK. As the fork of the "lance" passed around the line the spring mousing device would restrain it within. The flotation balls were of a larger diameter than the fork aperture and therefore they could not pass through the fork. Thus, the "lance" could be maneuvered around the line at a point under the flotation balls and raised up to a point where the flotation balls, and consequently the trap, were supported by the "lance".

6. On the morning of 17 June the SEA LINK was transported from Key West, Florida out to American Shoal preparatory to a dive down to the fish trap at the BERRY. The submersible was carried on the stern of the SEA DIVER

which contains special handling equipment for the purpose of launching and retrieving the SEA LINK. In addition to providing transport to and from a dive site the SEA DIVER also serves as a surface tender for the submersible notwithstanding the fact that the SEA LINK is wholely self-supporting. The surface vessel serves as an operations and communications center for the submersible as well as providing a haven for the subsurface craft in the event of any sudden deterioration of weather. Normal surface communications between the SEA DIVER and SEA LINK is an FM transceiver which provides line of sight communications only. Subsurface communication between the submersible and the support vessel is accomplished by an underwater telephone which is compatible with its military counterpart the AN/UQC telephone. The equipment can be used for either CW or voice communications. This underwater telephone was the communications mode being utilized during the entire ill-fated Dive 130 of the SEA LINK.

7. There were four (4) occupants of the SEA LINK during its Dive 130 on 17 June. In the pilot's sphere were the pilot, A. Menzies, and Doctor Robert P. Meek. Pilot Menzies was an experienced diver and reported approximately one hundred (100) dives in the SEA LINK as its pilot prior to 17 June. Doctor Meek, who was on board as a scientific observer, is also an experienced diver and holds a doctorate in pressure physiology. The two occupants of the diver's compartment were Albert D. Stover and Edwin C. Link. Both men were described as experienced divers and were on board the submersible in the capacity of research observers. They were wearing shorts and tee shirts at the time they entered the compartment and did not plan to lock out during the dive. Doctor Meek recalled during testimony that he noted their scanty attire as they prepared to enter the submersible and remarked to them that it was cold "down there". He could not recall any acknowledgement of this observation which was precipitated by the conditions that he had encountered during a lock-out dive in the same area two (2) days previously.

8. As the SEA LINK prepared to dive on the morning of 17 June a training pilot conducted a prelaunch check of the submersible. During the course of this check he discovered that the CO_2 scrubber unit in the pilot's sphere was malfunctioning. Although the prelaunch check was reported to take approximately one (1) hour the deficiency was not reported to Pilot Menzies until he had entered the sphere preparatory to diving. He was advised that one (1) of the two (2) fans in the pilot sphere carbon dioxide (CO_2) scrubber was inoperative. In addition to these fans, the scrubber contained a seven and one-half ($7\frac{1}{2}$) pound canister of a CO_2 absorbent identified as Baralyme. Gas is drawn into one end of the cylinder where it flows radially through the absorbent thus maintaining the CO_2 concentration below a toxic level. Although neither the SEA LINK Operation Manual nor any witnesses before the Board provided discrete values of what constituted a toxic level of CO_2, the manual does suggest that a partial pressure (P.P.) in excess of 8 mmHg (slightly over one (1)

per cent at one (1) atmosphere) is a dangerous concentration. Support of this suggestion is found in the scale of the meter normally utilized to measure the CO2 concentration in the diver's compartment. This .I mmHg scale is marked in red from the 8 mmHg point through the maximum deflection of 30 mmHg. After checking the flow of air provided by the air conditioning circulating fans in the after end of the pilot's sphere and the remaining scrubber fan, Pilot Menzies determined that the compartment's CO2 absorbent capability was adequate. As the SEA LINK commenced its dive, there was no means of metering the CO2 level in the pilot's sphere. Pilot Menzies considered himself sufficiently experienced to detect an undesirable level of CO2.

9. At approximately 0836 EDT on 17 June the SEA LINK began its descent. Nine (9) minutes later (0845 EDT) the submersible was at a depth of three hundred and forty (340) feet where Mr. Menzies secured its engines in order that he could estimate current conditions based on the submersible's drift. After estimating the current to be about four-tenths (.4) of a knot and reporting the visibility at that depth to be poor he continued on toward the wreck. At 0904 EDT that date the SEA LINK sighted the BERRY's anchor chain and shortly thereafter passed over the scuttled destroyer. The submersible continued its travel until it settled to the sand of the ocean floor approximately forty (40) feet from the fish trap. The 0935 EDT, 17 June position placed the SEA LINK generally south of both the trap and the BERRY. Pilot Menzies trimmed the submersible to a slightly negative buoyancy condition in order to eliminate the danger of floating upward under the scuttled hull. Utilizing side motors, after motors, and both bow thruster motors the pilot began his approach to the fish trap. During this approach an odor of something burning began to pervade the pilot's sphere whereupon all electrical circuits were opened. The circuits were then closed individually with no odor or defects detected.

10. Continuing in a general northerly direction Pilot Menzies attempted to pick up the trap with the submersible's fork shaped retrieving lance. Although the pilot accurately maneuvered the lance around the fish trap retrieving line the operation was unsuccessful because the mousing device (spring) failed to restrain the line within the fork. The pilot maneuvered in and around the trap two (2) more times in an unsuccessful attempt at retrieval before he aborted the mission. During or immediately after, his third attempt he permitted the SEA LINK bow to fall off five (5) to ten (10) degrees to the port which caused an equal swing of the submersible's stern to the starboard or toward the BERRY's stern. At some time shortly after 0945 EDT, 17 June Pilot Menzies began backing the SEA LINK away from the fish trap until the submersible abruptly stopped with what was described as a "jerk". Various maneuvers failed to extricate the SEA LINK from a steel cable which passed up over the strongback (uppermost member of the hull framework) and disappeared from sight. There was sufficient slack in the cable to enable the SEA LINK to move approximately twenty (20) feet or rotate through approximately two hundred and seventy (270) degrees of arc. At this time the four occupants of the submersible

began to assess their tenuous position and the options available to them. Communications between the two (2) compartments was being effected by the use of an intercommunication system which permitted the diver's compartment to transmit (talk) or receive (listen) over the same loudspeaker without any switch changes. On the other hand it was necessary for the occupants of the pilot's sphere to switch from the listen mode to the talk mode to initiate any communication. This arrangement in effect provided constant audio monitoring of the diver's compartment except during a pilot's sphere transmission. Although this system was backed up by a sound powered telephone the monitoring capability was reported to be in effect during the entire thirty (30) odd hours of Dive 130.

11. Attempts to free the SEA LINK by use of its own propulsion motors were abandoned after its occupants became concerned that they might become further entangled. At 0953 EDT on 17 June the SEA DIVER was notified that the submersible was entangled. This information was relayed by the SEA DIVER to Seaman Radioman Paul W. McNamar, U. S. Coast Guard, who was on radio watch at the Coast Guard Base, Key West, Florida. The message, received by Seaman McNamar via 2182 kilohertz at approximately 1005 EDT, 17 June, related that a submarine was entangled in three hundred and sixty (360) feet of water and that they (SEA LINK) desired Navy divers. This radio exchange reflected that the submersible was apparently in "no immediate danger". Seaman McNamar passed this information first to Boatswain's Mate First Class Paul R. Adams, U. S. Coast Guard, who was the Officer of the Day (OOD), Coast Guard Base, Key West, Florida on 17 June and immediately thereafter to the Base Officer of the Day (OOD), U. S. Naval Base, Key West, Florida. Boatswain's Mate Adams in turn relayed the details of the SEA LINK's plight on to the Seventh Coast Guard District Rescue Coordination Center, Miami, Florida. This message was received at approximately 1050 EDT, 17 June by Lieutenant Junior Grade John C. Brooks, Jr., U. S. Coast Guard, who was on duty as the Controller of the Watch. Mr. Brooks initiated a call to the U. S. Navy Department Pentagon Duty Captain who indicated that the Navy was already aware of the incident and that the U.S.S. TRINGA (ASR 16) would depart Key West at approximately 1500 EDT that date.

12. In the meantime at the diving site the advisability of "locking out" the two occupants of the SEA LINK diver's compartment was being considered jointly by the submersible personnel and support personnel on the SEA DIVER. Doctor David A. Youngblood, M.D., an employee of Harbor Branch Foundation, was on board the SEA DIVER and was promptly advised of the submersible's plight. Doctor Youngblood, who possessed an extensive background in diving physiology, was an experienced diver in his own right and was active in the decision-making process throughout the entanglement of the SEA LINK. An initial proposal that one (1) man would depart the diver's compartment in an attempt to free the cable was abandoned because of the potential oxygen toxicity danger to the compartment occupants if the attempt was unsuccessful. A diver compartment oxygen partial pressure of approximately one point six two (1.62) atmospheres would be developed by the

thirteen and one-half (13½) per cent oxygen mixture at the ambient depth. This lock-out condition would sorely limit the bottom time available to the two (2) men. Doctor Youngblood personally felt that anything over two (2) hours at that partial pressure would be hazardous to the men's health. He related during testimony that this two (2) hour estimate was established by reference to Navy Diving Tables. He also indicated that he was making his recommendations to Mr. Edwin A. Link based on other Navy Tables as well. Mr. E. A. Link, who in effect was in overall charge of operations, accepted the recommendations of Dr. Youngblood and decided to await the arrival of the TRINGA. This decision was by no means unilateral as it reflected the wishes of his son, Edwin C. Link, and Albert Stover.

13. Shortly after the no lock-out decision, approximately 1030 EDT, the submersible began to experience a CO2 build up in the pilot's sphere. Pilot Menzies checked the CO2 scrubber and discovered that the unit's only remaining fan motor was inoperative. He emptied the Baralyme from the scrubber canister into his shirt which he had removed for this purpose. By holding the Baralyme laden shirt in front of the air conditioning unit he was able to take advantage of its circulating fans. The combination of these fans and the Baralyme was sufficiently effective to cause Pilot Menzies to report to the surface at 1130 EDT, 17 June that "CO2 level going down". A spare cannister was propped up in front of the air conditioning unit in order that it could utilize the circulating fans in the same manner as an installed scrubber. The Baralyme was removed from the shirt and again placed in its original cannister for later use.

14. At approximately noon (local time) the same day a small boat from the SEA DIVER attempted to get a buoy line down to the SEA LINK. This line was intended to be a down haul or descending line that could be utilized in bringing Navy divers directly down to the stricken submersible. The effort was unsuccessful as the new buoy line became fouled in an existing buoy line that served as a marking device for the wreck itself. As the SEA DIVER made all efforts to assist in the rescue of the entangled SEA LINK the Naval Command in Key West requested assistance from the U. S. Navy Submarine Development Group, San Diego, California. A Roving Diving Bell, with necessary support personnel and equipment, was prepared for air delivery to Key West. Shortly before this specialized submarine rescue equipment departed California the TRINGA arrived on the scene of the entangled SEA LINK. As all principals at the site awaited the arrival of rescue forces the preliminary calculations regarding the capability of the submersible to maintain the CO2 level within acceptable limits were completed. These original calculations based on a 70° Fahrenheit assumption, were determined to be forty two (42) hours in the pilot's sphere and sixty one (61) hours in the diver's compartment. These calculations were later revised when it became apparent that the low temperature in the diving compartment was exerting a deleterious influence on the Baralyme.

15. At approximately 1615 EDT on 17 June the TRINGA arrived at the site of the entangled SEA LINK. After determining the submersible's approximate location the TRINGA commenced maneuvering to effect a four (4) point moor over the estimated position of the SEA LINK. By 2015 EDT the same date the rescue vessel was in an eight hundred (800) yard radius four (4) point moor within twenty (20) feet of the buoy line that was assumed to terminate at or near the SEA LINK. Efforts by the surface support and rescue personnel and the submersible crew to accurately fix the position of the SEA LINK were largely unsuccessful. The lowering of lights from the surface, intended to provide the submersible with a means of determining the position of the TRINGA, and the blinking of the SEA LINK lights for possible surface detection, managed to provide what at best was a marginal target for the rescue divers. During the course of this maneuvering and location process the submersible's diver compartment Baralyme began to display its natural, and known, propensity to become less effective or efficient at reduced temperatures. The aluminum diving compartment internal temperature at this time was near the temperature of the surrounding water. Although the exact diving compartment temperatures were not obtained they were reported to the surface to be as low as 45° Fahrenheit.

16. At approximately 2200 EDT on 17 June the occupants of the diver's compartment reported that the CO2 absorbent capability of the Baralyme was exhausted. The diver's compartment was now unexplainably reporting an absolute pressure of approximately two (2) atmospheres. At 2225 EDT, 17 June the two occupants of this compartment shifted to air supplied masks as their sole source of breathing gas. At approximately 2245 EDT that date a two (2) man team of TRINGA hard hat divers began a descent to the stricken submersible which by this time was reporting a diver's compartment absolute pressure of approximately three (3) atmospheres. This chamber air pressure continued to build up until it reached an eighty (80) feet depth level at approximately 2311 on 17 June at which time the breathing gas supply was changed to the helium-oxygen mixture. The TRINGA divers by this time had reached a depth of approximately three hundred and sixteen (316) feet where their progress was impeded by the BERRY superstructure. They reported that the SEA LINK was stuck under the wreckage of the BERRY or mast thereof and indicated that their descent was stopped by a radar reflector approximately twenty five (25) feet in diameter. The divers described the SEA LINK as being fouled with its beam on a metal whip antenna. They also related that there were numerous hoses lying over the side of the wreck. Although they did not quantify their evaluation of the water temperature in the vicinity of the BERRY they emphasized that it was "very cold". Failing in their attempt to elude the BERRY hull the two (2) TRINGA divers began their ascent. At this time a lock out of the two (2) men in the diver's compartment was again considered. The men in the after chamber reasserted their desire not to lock out and this decision was concurred with by both the submersible's pilot and personnel on board the SEA DIVER. As the TRINGA divers continued their ascent the rescue vessel began repositioning to provide its divers clear access to the SEA LINK. The

pressure in the diver's compartment continued to build up as the TRINGA began its preparation to send divers down again. At 0000 EDT on 18 June the diver's compartment was reporting an absolute pressure of approximately ten (10) atmospheres.

17. At approximately 0015 EDT on 18 June the bottom hatch of the diver's compartment opened as the compartment had now reached the ambient depth equivalent of approximately twelve (12) atmospheres. A lock out of one (1) of the two (2) men in the diver's compartment was again considered at 0038 on that date. However, by this time both men were too cold to attempt such an operation. In addition to the exposure of their surrounding environment they were also being subjected to a rapid body heat loss precipitated by the helium exhalation. The TRINGA at this time was attempting to locate directly above the BERRY by maneuvering southward in response to Pilot Menzies directions from the ocean floor. The pilot was relaying instructions to the TRINGA based on his observation of lights suspended by the surface vessel for observation by the submersible personnel. Pilot Menzies reported to the surface at 0112 EDT, 18 June that the men in the after compartment were suffering from convulsions. The men in the pilot's sphere were unable to confirm this conclusion with the occupants of the after compartment because no audio exchange had taken place after about 0030 EDT, 18 June nor was any later communication ever established. The TRINGA divers began their second descent at approximately 0135 EDT, 18 June and reported themselves to be at bottom depth about eight (8) minutes later. Since they were at bottom depth and their lights were not visible to Pilot Menzies he concluded that they were to the north of the BERRY. The pilot requested that the TRINGA diver's stage be raised and deposited to the south of the BERRY hull thus providing the cumbersomely outfitted divers a reasonable chance of success in reaching the entangled submersible. Efforts by the TRINGA divers to penetrate the BERRY superstructure and the cable array extending from the scuttled vessel were unsuccessful and this dive as the first was aborted. During this hard hat diver attempt to reach the SEA LINK, the Roving Diving Bell (BELL) with its support personnel, arrived at the site and was reported to be on board the TRINGA at 0245 EDT, 18 June.

18. The BELL was lowered from the TRINGA at 0605 EDT, 18 June with two (2) divers therein. The BELL descended to two hundred and eighty two (282) feet where one (1) of the embarked divers left the compartment. The diver encountered such a strong current that he was unable to continue his descent. The buffeting received by the diver was sufficient in magnitude to cause him to become fouled in his own gear and to remain fouled for nearly fifteen (15) minutes. After freeing himself he returned to the BELL whereupon it was raised to the surface at 0920 EDT, 18 June. Determining the current to be cyclical it was calculated that the next slack would occur at approximately 1200 EDT, 18 June. Plans to lower the BELL at some time between 1100 EDT and 1200 EDT the same day were formulated. After the two (2) divers had disembarked the BELL it was again lowered with a light attached in order that Pilot Menzies could provide positioning instructions to the surface. The downward travel of the now unmanned BELL ceased

at about 0951 EDT, 18 June when it reached a depth of three hundred (300) feet. Influence exerted on the BELL by either the current or the BERRY prevented the TRINGA from raising or lowering the rescue unit.

19. The submersible PERRY CUBMARINE (P.C. 8), which had been transported out to the site earlier the same day by the U.S.S. AMBERJACK (SS 525), was launched at 1240 EDT, 18 June in order that it might make an exploratory search of the bottom in the general vicinity of the SEA LINK. An inoperative sonar on the P.C. 8 so reduced its effectiveness that it returned to the surface one and a half (1½) hours later. Shortly before the P.C. 8 surfaced the Salvage Vessel M/V A.B. WOOD II (WOOD) O.N. 501922 arrived at the site. On board the salvage vessel was an underwater television camera which could be maneuvered under water by personnel on the surface. Almost simultaneously with the WOOD's arrival the occupants in the forward compartment of the SEA LINK began breathing air from the life support high pressure air system of the submersible. This shift was necessary because the Baralyme in the compartment could not absorb any additional CO_2.

20. The underwater T.V. camera and its platform were launched at sometime after 1500 EDT on 18 June. The camera descended to a depth where it not only was in sight of the SEA LINK but also was providing surface personnel with a view of the entangled submersible. The T.V. camera and maneuvering platform were raised about twenty (20) minutes later in order to attach a four (4) prong grapnel whose tines were approximately eighteen (18) inches long. The grapnel was attached to the T.V. camera with a ten (10) foot length of steel cable and the entire network was again lowered to the SEA LINK position on the ocean floor. The submersible reported to the surface at 1641 EDT, 18 June that one (1) tine of the suspended grapnel had engaged the SEA LINK. Twelve minutes later the SEA LINK was brought to the surface still attached to the T.V. camera and its maneuverable platform. The grapnel had engaged the submersible's strongback at its juncture with the support column for the three (3) ahead/astern propulsion motors.

21. At the time the SEA LINK surfaced the pilot's sphere was at an absolute pressure of approximately two (2) atmospheres and the diver's compartment was still at twelve (12) atmospheres. Pilot Menzies and Robert Meek were transferred to the TRINGA recompression chamber where their decompression was started at 1715 EDT, 18 June. The SEA LINK was towed to the SEA DIVER and was hoisted on board the surface vessel which then went alongside of the TRINGA in order to utilize facilities of the rescue ship. A helium and oxygen mixture, of very low oxygen (4%) oxygen concentration, was used by the TRINGA to force ventilate the diver's compartment as it remained pressurized. As it was being ventilated hot water was being sprayed over the aluminum compartment in an effort to raise its internal temperature. Although Edwin Clayton Link and Albert D. Stover were visible through the compartment's view ports there was no evidence of vital signs that indicated they were alive. As efforts continued to revive the two men, the T.V. camera was again launched to aid

in recovering the still fouled roving diving bell with this operation commencing at some time near 1845 EDT, 18 June. Decompression for the two (2) occupants of the submersible's pilot sphere was successfully concluded at approximately 1915 EDT, 18 June with both men pronounced medically fit. At 2300 EDT, 18 June the BELL was hoisted on board the TRINGA and the rescue vessel remained in its four point moor with the SEA DIVER alongside.

22. A period of fourteen (14) hours had now elapsed with no signs of life in the diver's compartment. Medical doctors in attendance concluded that both men in the compartment were dead and therefore the ventilation and hot water spray operation was secured. Thus at approximately 1000 EDT, 19 June depressurization of the SEA LINK was commenced with a one (1) atmosphere pressure programmed for 2100 EDT the same day. The SEA DIVER departed the site for U. S. Naval Base at Key West arriving there just before noon on 19 June. Edwin Clayton Link and Albert Dennison Stover were removed to the Florida Keys Memorial Hospital, Key West, Florida and autopsies performed on both decedents.

23. The SEA DIVER, with the SEA LINK still on board, arrived in its home port of Fort Pierce, Florida on 28 June. During the course of a hull examination subsequent to 28 June certain sections of the SEA LINK displayed evidence of cable scraping. In the general area of where Dr. Meek observed the cable to pass up over the stern of the SEA LINK were a number of structural members that contained scratches and serrations inconsistent with the remainder of its surface. For example, the forward edge of the propellor shroud on the starboard fixed propulsion motor contained deep scratches resembling file marks. Above these abrasions were similar scratches on the plastic cover of a pneumatic valve. Immediately above this plastic cover is an aluminum pad that is welded to a support member of the starboard surface buoyancy tank. Bolted through a hole in this pad is a steel hook which is used to restrain guide lines during retrieval of the submersible but is not used as a lifting hook. The hook is approximately one and a half ($1\frac{1}{2}$) inches in diameter and five (5) inches long with a two (2) inch opening. The opening faces downward and is guarded by a spring-loaded mousing device. Both the pad and the hook displayed evidence of chafing by a hard object capable of producing a serrated effect. In addition to the scoring of the hook the spring-loaded mousing device was wrenched from its normally closed position.

24. Mr. Brooks' call to the Pentagon Duty Officer was in accordance with Commandant, U. S. Coast Guard Instruction 3130.7C of 23 December 1971 which acknowledges a lack of Coast Guard facilities intended specifically for submersible rescue. The Instruction continues by recognizing the availability of U. S. Navy underwater rescue capability. Consistent with this capability was an initial designation, on 17 June, of the TRINGA as the On Scene Commander and the later designation, the same date, of the Commander, Key West Forces (U. S. Navy) as the Search and Rescue Mission Coordinator.

25. The M/V SEA DIVER, O.N. 249288, is enrolled and licensed in New York, N. Y. as a yacht. Its current Consolidated Certificate of Enrollment and Yacht License reflects that the vessel's owner is the Sea Diver Corporation, Jamaica, New York and Edwin A. Link, Binghamton, New York is signed on the document as Master.

26. Archibald Menzies' diving experience is as varied as it is extensive. Emanating from a SCUBA diving origin his experience progressed through the hard hat stage to the position of Chief Submersible Pilot, Smithsonian Institution. He repeatedly displayed an unmistaken empathy with the TRINGA hard hat divers who were trying to reach the entangled submersible in their cumbersome gear. His testimony regarding the extreme difficulty faced by the Naval divers in making their way over any appreciable distance of the ocean floor was also reflected in his persistent concern during the rescue attempt about the surface position of the TRINGA.

27. Pilot Menzies, Doctor Meek and Doctor Youngblood reported seeing cables extending from the sunken hull of the BERRY. Dr. Meek described two (2) sets of four (4) each cables terminating on a deck of the BERRY. He further identified them as "guy" wires which were attached to the aftermast which he described as a pole approximately fifteen (15) feet in length. Pilot Menzies also observed cables extending from the mast but he estimated the pole length to be forty (40) to forty five (45) feet. Although Doctor Youngblood was unable to recall seeing the "guy" wires described by Doctor Meek he did observe "rigging" on the BERRY during a dive he participated in prior to Dive 130. He simply noted that there were cables draped over the vessel's deck and hull itself.

28. There was no pollution of the navigable waters of the United States as a result of this incident. Moreover, there was no reported damage to the SEA LINK that would materially affect its operational capability. The previously described minimal scraping of structural members was the only identified casualty-associated damage.

CONCLUSIONS

It is concluded

1. That, the primary proximate cause of the JOHNSON SEA LINK entanglement in or near the wreckage of the sunken U.S.S. FRED T BERRY was the fault of the submersible pilot for his failure to ensure that the intended maneuvering area of the JOHNSON SEA LINK was free from any obstruction. This failure is attributed to either a lack of prudence that reflects unfavorably upon his competency or possibly to the disruptive influence of incidents that took place immediately before the casualty. Concern over the unknown source of the electrical fault is assumed to have exerted a psychological influence of unknown intensity. This condition is considered to have been further aggravated by the presumed distraction caused by the failure of the "lance" to operate properly.

2. That, the primary proximate cause of the events that led up to the deaths of Edwin Clayton Link and Albert Dennison Stover was the inability of rescue forces to timely extricate the JOHNSON SEA LINK from the source of its entanglement. Such inability, however, was solely a function of circumstances and equipment limitation and is not intended to describe any individual performance by surface, subsurface or support personnel.

3. That, a principal contributing factor to the JOHNSON SEA LINK's entanglement was its hull shape. The submersible's modular construction of irregular shapes, projections, and appendages provide an excellent configuration for ensnarement by almost any type of obstruction. Shielding or faired guards over as many of these appurtenances as possible, or relocation thereof, would materially reduce the possibility of a similar casualty.

4. That, the submersible's pilot and the two occupants of the diver's compartment displayed an incredible casualness in their preparations for Dive 130, considering the inherent hazards of their operation. The pilot's reliance on his senses in lieu of a standard metering device to detect an unsafe build-up of CO_2 in the pilot's sphere is inconsistent with the known effects of CO_2 on a person's faculties. Moreover, his lack of concern for the defective CO_2 scrubber fan motor and the diver's compartment occupants' unconcern over the reported temperature of the water further supports an assessment of undue casualness.

5. That, the whip antenna described by the initial team of IRINGA divers as the source of the SEA LINK's entanglement was in fact the aftermost reference marker flag pole described by the submersible's personnel as the BERRY's aftermast.

6. That, the projection of the BERRY described by the initial team of IRINGA divers as a radar reflector was in fact a part of the after platform

mast. The configuration of the platform being presented to the divers in their descent would include the walkways with their pipe guardrails. The resulting panorama observed by the divers, under conditions of poor visibility (nighttime), could have been interpreted to be a radar antenna.

7. That, the source of the SEA LINK's entanglement was located at, or very close thereto, the aftermost reference marker flag pole which was identified as the BERRY's aftermast. The source itself is considered to be the lowest (port) forestay of this mast and/or an unidentified cable suspended from the BERRY hull. Either source is considered capable of permitting the limited maneuverability, reported by the submersible's pilot, during the SEA LINK's restraint.

8. That, the cable which was observed passing over the after end of the SEA LINK most probably was restrained by the starboard side motor propeller shroud and the retrieval guide hook located above the motor.

9. That, the scuttling of vessels containing extraneous cables, lines, hoses, wire antennas, wire guys or stays and any other identifiable source of ensnarement for man or machine, is not in the best interests of the general public. With the increased interest and activity in ichthyological studies on or near vessels scuttled to serve as artificial reefs, will come an attendant increase in potential casualties.

10. That, the lives of the two (2) decedents might have been saved if the SEA LINK diver's compartment contained some means of elevating the ambient temperature of the Baralyme.

11. That, the lives of the two (2) decedents might have been saved if the M/V A.B. WOOD T.V. camera and its maneuverable platform had arrived at the diving site on 17 June 1973. Or alternatively that their lives might have been saved if a similar air deliverable unit, dedicated to search and rescue, had been dispatched to the diving site at first notice. The ease and rapidity of the rescue once the A.B. WOOD unit was committed contrasts sharply with the difficulties and dangerous conditions encountered by the TRINGA divers.

12. That, there is no evidence that the failure of the owners of the SEA LINK to comply with the reporting procedures of the Commandant, U.S. Coast Guard Instruction 3130.7C contributed to the casualty. This conclusion is premised on the proximity of U. S. Naval rescue forces and their foreknowledge of the SEA LINK's operations.

13. That, there is evidence of violation of Section 103 of Title 46 United States Code on the part of the owners of the M/V SEA DIVER O.N. 249288.

14. That, there is no evidence that personnel of the Coast Guard or any other governmental agency contributed to the casualty or the cause of the casualty.

RECOMMENDATIONS

It is recommended

1. That, the Coast Guard actively seek legislation to regulate the construction and operation of submersibles. Included within these regulations, but not limited thereto, should be the following requirements:

   a. A report of the scope and geographic area of intended submersible operations shall be made to the Coast Guard.

   b. A life support capability of specified duration.

   c. A device on the submersible capable of providing rescue forces with the means of accurately fixing its position.

   d. A device on the submersible capable of providing rescue forces with the means of engaging its hull.

2. That, the Coast Guard continue to encourage the reporting procedures set forth in Commandant, U. S. Coast Guard Instruction 3130.7C pending any legislation in this area.

3. That, the Coast Guard consider the acquisition, and subsequent dedication to search and rescue, of an air deliverable T.V. unit similar to that which was used to locate the sea link.

4. That, further investigation be conducted into the possible violation of Section 103 of Title 46 United States Code on the part of the owners of the M/V SEA DIVER, O.N. 249288.

5. That, a copy of this report be forwarded to the Chief of Naval Operations, U. S. Navy for specific consideration of Conclusion 9 herein.

6. That, a copy of this report be forwarded to the Director, Smithsonian Institution for specific consideration of Conclusions 1, 3, 4, and 10 herein.

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Chairman

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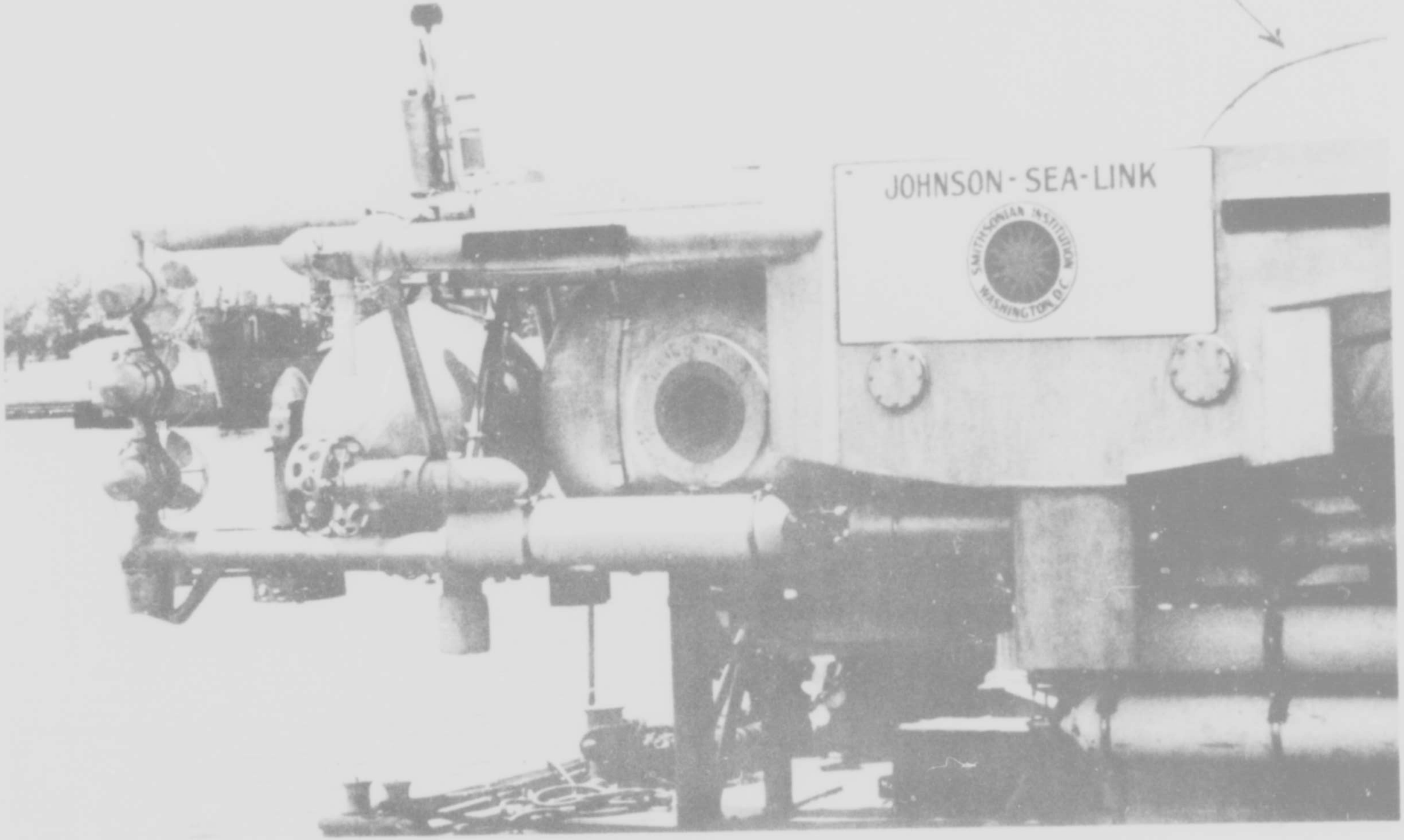
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