FACEPLATE

SUMMER 1979

RESEARCH DIVERS

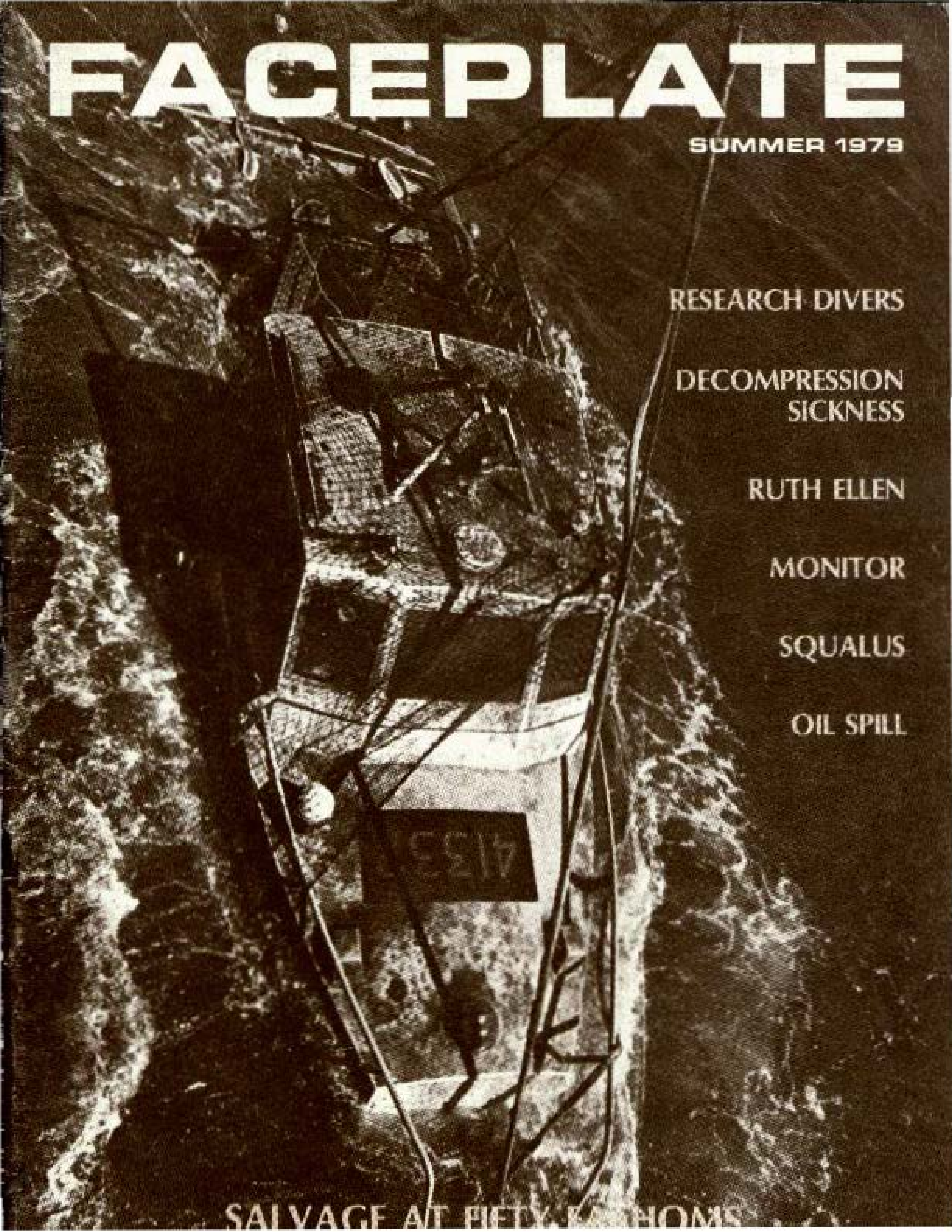
DECOMPRESSION SICKNESS

RUTH ELLEN

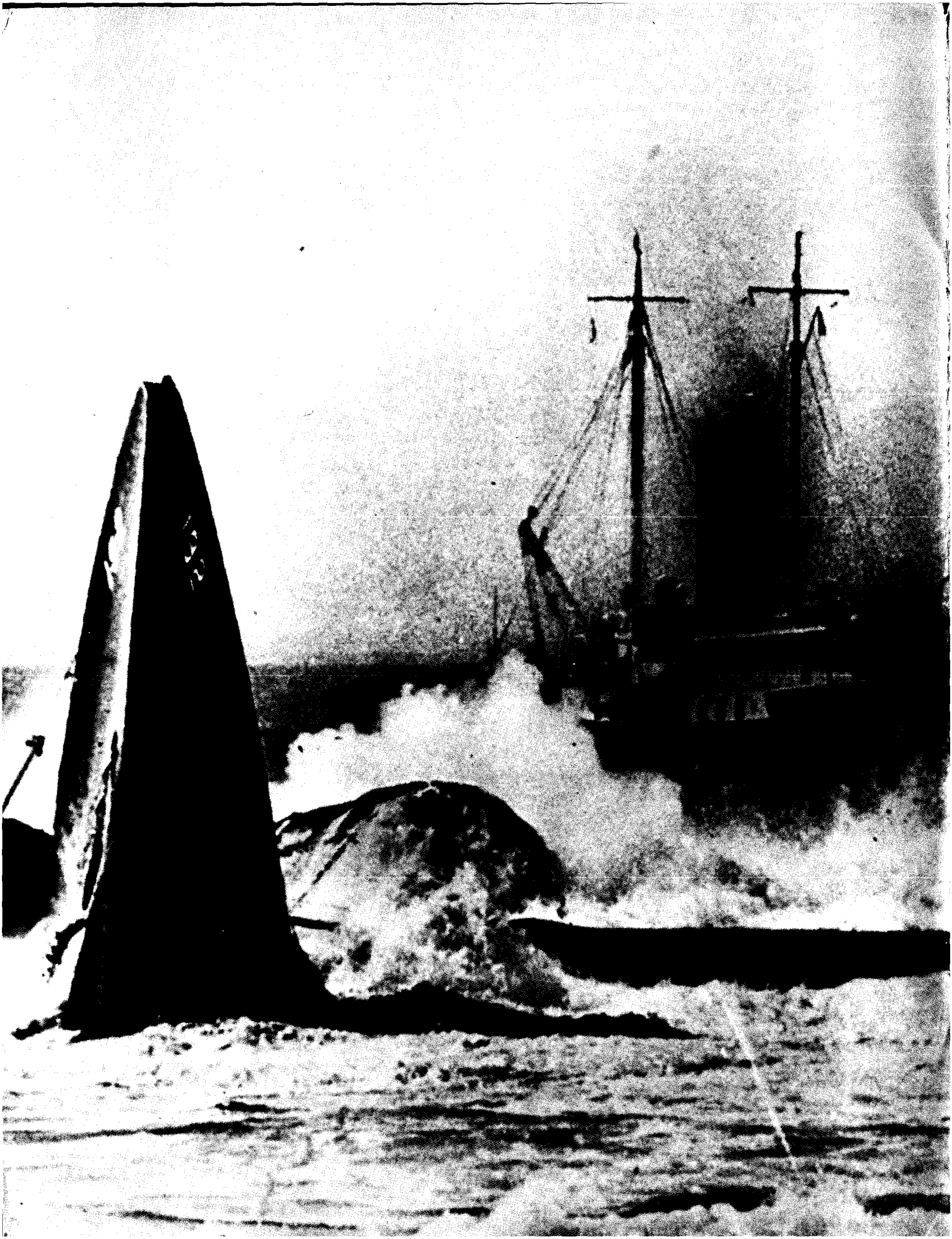
MONITOR

SQUALUS

OIL SPILL



SALVAGE AT FIFTY FATHOMS



VOLUME 10, NO.2

FACEPLATE

. . . the official magazine for the divers of the United States Navy

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FACEPLATE is published quarterly by the Supervisor of Diving to bring the latest and most informative news available to the Navy diving community. Articles are presented as information only, and should not be construed as regulations, orders, or directives. Discussions or illustrations of commercial products do not imply endorsement by the Supervisor of Diving or the U.S. Navy.

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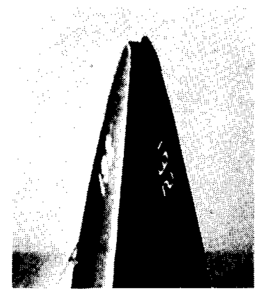

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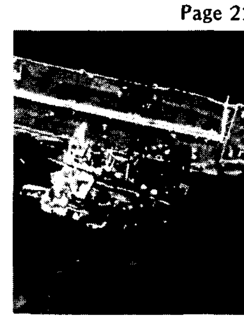

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COVER: The Coast Guard utility boat 41332 breaks the surface, climaxing a 312-foot salvage operation from *USS Pigeon* (ASR-21) off Astoria, Oregon (see page 22).

INSIDE FRONT COVER: Submarine *Squalus* breaches like a huge, steel whale, bursting chains and smashing pontoons during the famous salvage operation forty years ago (see page 16).

BACK COVER: Oil spills from the tanker *Fortune* following a collision with *USS Ranger* off Singapore. Story on the Navy's clean-up efforts on page 26.

LETTERS

DRUGS ARTICLE COMMENDED

As an old, and I mean old, Navy man, I certainly enjoyed reading a Navy oriented publication and look forward to receiving future issues. I was particularly impressed with Dr. J.M. Walsh's article, "Should Divers Use Drugs?" [*FP*, Spring '79] and would like to comment on it [in *The Triton Report*].

ALFRED L. GILMORE
PUBLISHER
The Triton Report
MIAMI, FLORIDA

MORE ON DRUGS- AND SOME DIVING HISTORY

I am somewhat surprised at how close the conclusions of both Dr. Walsh and I have come to regarding the use of drugs by divers. I have had quite a bit of feedback from divers who are habitual drug users, particularly marijuana. I suspect Hawaii has an extremely high incidence of drug use by divers since nearly every one here is a "diver" to some extent and since the use of drugs, again particularly marijuana, is so prevalent. Possibly this accounts for the very high accident rate in Hawaii's divers.

I had a note on my desk to write to *Faceplate.* During a short period in 1948 I published an in-house publication for my students and graduates at the Sparling School of Deep Sea Diving which I called *Faceplate.* Like your initial *Faceplate* this was a mimeographed publication. The first issue was a hundred or so copies; then by the fourth issue, demand was for over a thousand copies. I simply did not have time to carry on with it so eventually discontinued publication. In any event, your *Faceplate* of the 1950s and 1960s was not the first *Faceplate*.

I started my diving career onboard the old *USS Dobbin,* a destroyer tender, in 1934. I was a deck hand assigned to the pump crew and as a tender to the divers. During fleet operations in 1934 that took us to Wake and Kure Islands here in the Hawaiian chain, the dive crew finally got me under water. Most of our diving was with the old hand pumps with six-man crews, three men on each side and a total pumping crew of 18 men. At Kure we kept helmet divers at a depth of more than 100 feet with one of these old two- or three-cylinder, piston-type pumps. But the pump crew really had to work and we changed pumpers about every fifteen or twenty minutes; hence, the need for so many men in the pump crew.

Much later, in 1942, as a Warrant Boatswain, I was assigned to the Diving School at Washington, D.C., where I qualified as a diving officer. Following this I went to Pier 88 in New York for more schooling and qualified as a salvage officer. For the next several years (the balance of WW II) I served in various capacities on ATRs and ARSs. During the A-bomb tests Able and Baker at Bikini in 1946, I served as Flag Secretary to the Commander of the Salvage Unit and also did some underwater photography in the late stages of the operations. We used the first underwater TV during those operations, by the way. My last naval assignment was to Bayonne, N.J., to help establish the Salvage Diving School once located there. I resigned as a Lieutenant in late 1946 and started the Sparling School in early 1947.

The training I received in diving and many other subjects, from the very beginning on the *USS Dobbin* and later at both the diving and the salvage schools, plus the experience on salvage and diving ships, has been of tremendous help to me in organizing and operating my own businesses, both in the diving school/diving supply phases and as a commercial diver. While in the Navy I went to every school offered, took dozens of courses then available, and took every special assignment I could. I believe I have used, not once but many times, every bit of knowledge and experience gained during my 14-year naval career.

E. R. CROSS
EDITOR, TECHNIFACTS
Skin Diver Magazine
PEARL CITY, HAWAII

Letters intended for publication should be addressed to Letters to the Editor, Faceplate, *Supervisor of Diving, Naval Sea Systems Command, Washington, D.C. 20362. Because of space limitations, those published are subject to abridgment.*

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SOUNDINGS

Rear Admiral D. M. Jackson, Assistant Deputy Commander for Weapons Systems and Engineering, NAVSEA, recently visited the Naval School, Explosive Ordnance Disposal, Indian Head, Maryland, and was briefed on the school's EOD training programs. Above, Warrant Officer Katsekes, USMC, discusses a fusing mechanism with the Admiral. Also pictured are the school's Commanding Officer, Commander J. T. Kennedy, and Chief Master-at-Arms MACS Thompson. (Photo by PH2(DV) Ken Hess.)

WORKING DIVER SYMPOSIUM—1980

The 1980 Working Diver Symposium is scheduled for March 11 and 12 at Battelle Memorial Institute in Columbus, Ohio, and the program committee at Battelle invites papers from all interested authors relative to new results, technologies, or operations concerning the working diver. A 250- to 300-word abstract for review and selection should be sent to the attention of Peter Riegel at Battelle Memorial Institute, Columbus Laboratories, 505 King Avenue, Columbus, OH 43201 (telephone 614-424-4009).

DIVING OFFICER/MASTER DIVER CONFERENCE—1980

A conference for U.S. Navy diving officers and master divers has been scheduled for March 13, 1980 to follow the Working Diver Symposium at Battelle in Columbus, Ohio. Individuals interested in giving a presentation should prepare and submit a 250- to 300-word abstract to Battelle (address above) with a copy to NAVSEA OOC-DB. Funding for attendees must be borne by their parent command, so begin planning for your attendance now.

SPECIAL PROJECTS AT NSWC, DAHLGREN, VA

The Naval Surface Weapons Center (NSWC), Dahlgren, Virginia, is currently working on several SUPDIVE-sponsored special projects which affect fleet divers:

Diver's Air Filter Test Program: SUPDIVE tasked NSWC to develop a filter test apparatus and procedure for testing diver's air filters. All known filter manufacturers were invited to nominate potential filters, and those nominated were tested. Those filters passing less than 5 mg oil mist per standard cubic meter (for the established test procedure) have been added to the list of equipment approved for Navy use (NAVSEA Instruction 9597.1). While all filters included are acceptable for use, such factors as oil mist removal, size, cost, and required maintenance were considered in developing the prioritized list (by pressure category).

High Pressure Air Filter Retrofit: The filter tests discussed above revealed that the CUNO 1H1 filter passed much more oil mist than other H.P. Filters tested, resulting in its failure to meet the air purity requirements of the U.S. Navy Diving Manual. Because the CUNO is used in nearly all Navy H.P. air systems, NSWC recommended a retrofit for those CUNO filters in use in the fleet. The proposal was approved and funded by SUPDIVE, and the retrofit kits will be sent during August/September 1979 to all known activities using the filter in diver's air systems. For further information regarding shipment of the kits, contact Mr. A. W. Trigger of NSWC, Dahlgren at Autovon 249-8891, or commercial (703) 663-8891.

Portable Scuba Compressor Retrofit: SUPDIVE tasked NSWC, Dahlgren to develop or directly procure a filtration system for removing the excess amount of oil from the portable high-pressure air compressors used to charge scuba cylinders. The Dahlgren Laboratory has procured and tested a filtration unit which removes virtually all oil mist, water vapor, and particulate matter from the compressor's output air. The unit is designed for use with the Stewart Warner four-stage, 3,000-psi compressor. Modification kits, consisting of a filter, back-pressure regulator, required fittings, and instructions will be shipped directly to fleet units using the Stewart Warner compressor prior to the end of FY-80. Questions regarding the kits or intended fleet distribution should be addressed to: Commander, NSWC (Code G-52), Dahlgren, Virginia 22448 (Attention: Mr. J. McGinniss or Mr. A. W. Trigger). Autovon 249-8891, or commercial (703) 663-8891. (If your compressor is providing air which meets the Diving Manual air purity standards, discontinuing its use pending receipt of the retrofit kit is not necessary.)

Send news of events, personnel transitions, awards, upcoming conferences, etc., to: Soundings, Faceplate, *Supervisor of Diving, Naval Sea Systems Command, Washington, D.C. 20362.*

SOUNDINGS (cont'd)

INTERNATIONAL SYMPOSIUM ON MARINE SALVAGE

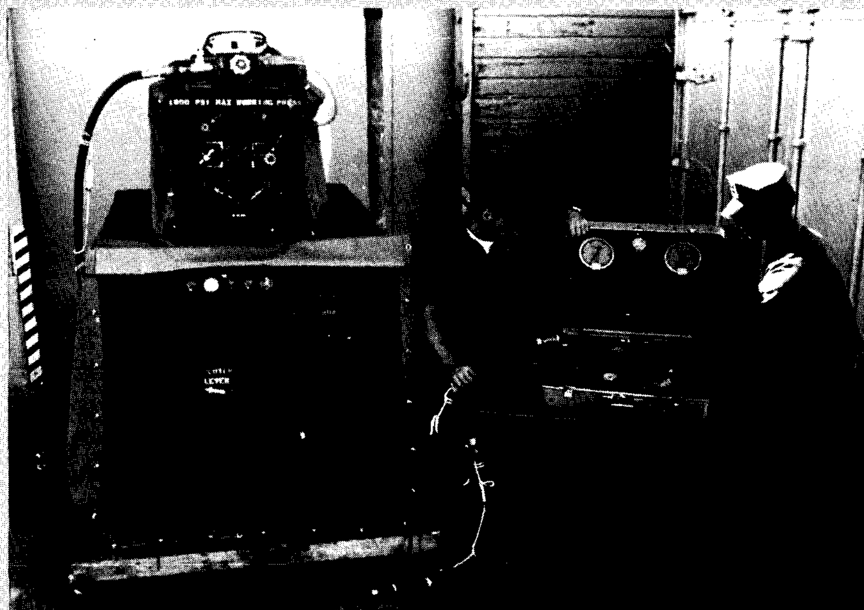
A three-day symposium featuring distinguished speakers from the international marine salvage community will be held on October 1, 2, and 3, 1979 in New York. Sponsored by the Marine Technology Society and the Port of New York, the International Symposium on Marine Salvage will "provide a forum for examination and discussion of matters of importance on this subject," including:

- Salvage operations (technical and engineering problems, rescue towing, hazardous cargo, environmental pollution, etc.)
- Legal and financial aspects (salvage contracts, salvors' responsibilities, hull and cargo insurance)
- Role of governments and international organizations (contingency planning, rules, regulations and policies concerning salvage posture)

Former U.S. Navy Supervisor of Salvage, Captain W.F. Searle, Jr., is chairing the steering committee for the conference. For information on registration, the conference program, and accommodations, write to: International Symposium on Marine Salvage, 80 Broad Street, 34th Floor, New York, NY 10004. Telephone (212) 425-5704. Telex 126808.

NEW LIFE PRESERVER

The Life Preserver Support Package (LPSP), with its primary component the Mk 4 Life Preserver, is reaching the final stages of the approval-for-service-use process. An initial procurement contract is anticipated for August 1979, with Fleet delivery to commence about six months later. The Mk 4 will replace the Mk 3 in all open-circuit scuba operations (see *Faceplate*, Summer '78). It will also be used with the closed-circuit UBAs Mk 15 and Mk 16, but cannot be used with the Mk 6 or Emerson units. Using four CO_2 cartridges, the Mk 4 will provide 20 pounds of buoyancy at 200 fsw. The LPSP contains eight Mk 4 life preservers, two spare part/test kits, and a repair kit for each. Thus, the life preserver is fully repairable in the field for all but major damage. During the test program, punctured life preservers repaired in accordance with the manual demonstrated a 98 percent reliability.



Underwater Construction Team Two, Port Hueneme, California, recently obtained certification of its surface-supplied diving systems. The compact, lightweight systems are each capable of supporting three Mk 1 Mask divers on air to 130 feet, and are transported in four separate parts: compressor, HP air flasks, control panel, and interconnecting hoses. Total weight of each system is 5,200 pounds, contained within 227 cubic feet. Above, UT2(DV) Mike Hayes (left) and EA3(DV) Jeff Hart adjust valve settings on the air control panel.

MK 15 TRAINING COMMENCES

The Mk 15 UBA has been successfully incorporated into the training program of the Basic Underwater Demolition School (BUDS) at the Naval Amphibious Base, Coronado, California. Initial reaction to the new rig has been favorable. The Mk 15 operates on a new "breathing medium" control/supply principle for the Special Warfare forces who will be the primary users. Electronic devices monitor and regulate the oxygen in the breathing system to maintain a fixed partial pressure of oxygen at any depth. Introduction of the Mk 15 to the fleet is scheduled to begin this fall.

CORRECTIONS

The article entitled "The Navy's Master Divers" which appeared in the Spring '79 issue of *Faceplate* contained two errors:

– The address for BMCM(MDV) John Lankford on page 26 is incorrect. The correct address is:

BMCM(MDV) John Lankford
(Code 8031)
Naval Undersea Warfare Engineering Station, Keyport, WA 98345

– BUCS(MDV) Dave Thompson at CEL, Port Hueneme, CA was incorrectly listed as a BMCS on page 27.

TRANSITIONS

During the spring and early summer of 1979, a number of significant personnel transfers occurred within the Navy Diving Community:

In June, **Commander Al Smith** relieved **Commander Frank Duffy** at the Diving, Salvage and Submerged Systems Branch of OP-23 at OPNAV. CDR Duffy has been named Chief of Staff at Submarine Squadron 14 at Holyloch, Scotland.

Effective June 1, **Commander W. N. Klorig** assumed the duties of the Director of Ocean Engineering/Supervisor of Salvage, relieving **Captain R. B. Moss** who became the Deputy Inspector General at NAVSEA. CAPT Moss departed NAVSEA OOC after having served in this position since May 1976. **Captain Colin Jones** will report to NAVSEA as the new Director of Ocean Engineering/Supervisor of Salvage later this summer.

On May 25, **Lieutenant Commander Ray Smith** relieved **Commander F. D. Duff** as the Supervisor of Diving. LCDR Smith is concurrently serving as Deputy Supervisor of Diving for the Special Warfare Community. CDR Duff departed the SUPDIVE position after 2½ years at NAVSEA OOC, and is currently serving on the INSURV Board as a member of the hull inspection team.

Lieutenant Commander Bill Bacon departed the Supervisor of Diving Office in June to become the 1140 Community assignment officer at the Naval Military Personnel Command. Replacing him as the Deputy Supervisor of Diving for EOD is **Lieutenant Stan Denham,** who arrives after spending six months at Fort Belvoir, Virginia, completing the Program Management course at the Defense System Management College.

Lieutenant Commander Mike Hadbavny was transferred from the Naval Material Command in June and ordered to Naval Mobile Construction Battalion Forty as the Operations Officer. **Commander Ernest T. Young** relieved LCDR Hadbavny as the NAVMAT Project Officer for Diving, Salvage, and Diving System Certification.

Commander Frank M. Richards, Executive Officer of the Navy Experimental Diving Unit and Assistant Editor-in-Chief of *Faceplate*, retired from the Navy on May 31, ending 30 years of outstanding professional service. During his retirement ceremony, CDR Richards received a number of official awards, including the Meritorious Service Medal. He also received a unique memento from the NEDU wardroom – a live, baby pig sporting triple-striped shoulder boards and a cap trimmed with a gold braid. (What a peculiar way to have scrambled eggs on bacon, Frank!) Commander James Roper, Commanding Officer of the Naval School, Diving and Salvage, delivered the principal address, citing CDR Richards' skillful management of the design and start of construction of the Navy's new Diving and Salvage Training Center in Panama City, Florida, and his unflagging efforts to create a viable career pattern for diving officers, which has culminated in the establishment of the Special Operations Officer Designator 1140.

Lieutenant Commander Bill Tageson has relieved **Lieutenant Rod Jones** as the Training Program Coordinator for Diving, Salvage, EOD, and the Special Operations Officer (1140) Community at CNTT. His address is: Chief Naval Technical Training, Code N354, Naval Air Station Memphis (75), Millington, Tennessee 38054.

CDR Richards and friend at retirement ceremonies last May.

Retiring CDR Frank Richards (at podium) was relieved as Executive Officer of NEDU by LCDR Stan Cwiklinski (right), who recently returned from exchange duty in the British Royal Navy as Officer-in-Charge of their Saturation Diving and Trials Team. LCDR Cwiklinski will also assume CDR Richards' duties as Assistant Editor-in-Chief of *Faceplate*. Seated at left are CDR Chuck Bartholomew and CDR Jim Roper.

L-r: BMCS(DV) Mantell, BM1(DV) McGraw, HTCS(DV) Smelko, and BMCM(MDV) Tolley.

FOUR RETIRE AT NAVY EXPERIMENTAL DIVING UNIT

Representing nearly a century of deep sea diving service in the U.S. Navy, a master chief, two senior chiefs and a first class petty officer retired on June 22 at the Navy Experimental Diving Unit (NEDU) in Panama City, Florida.

BMCM(MDV) James L. Tolley, the Senior Master Diver in the Navy and Master Chief Petty Officer of the Command at NEDU, closed out a distinctive Navy career spanning over 33 years, 27 of them in diving. During his tour at NEDU, he was a focal point in assisting personnel throughout the Navy in diving related matters. As a program manager and personal consultant to the Commanding Officer and his staff, he traveled extensively to both shore and fleet diving activities to keep all hands abreast of advancements in diving technology. The Navy diving community will miss Master Chief Tolley's dynamic leadership and colorful personality.

BMCS(DV) Frank J. Mantell, who completed 20 years of service, played an important role in the development of better, more efficient diving equipment both as a fleet diver and as an experienced dive subject while at NEDU. He distinguished himself perhaps most importantly as a dive subject during the development of the saturation excursion tables. Senior Chief Mantell plans to continue his diving career with the offshore commercial diving industry.

HTCS(DV) Francis J. Smelko also retired after 20 years of service. Senior Chief Smelko will probably best be remembered for his problem-solving approach to the design problems encountered in the ongoing modification and improvement of the Ocean Simulation Facility at NEDU. As a metal craftsman, he was a valuable resource at NEDU and assisted all departments in a wide diversity of their equipment and design needs. His openness and ready desire to help out has endeared him both professionally and personally to all who have worked with him.

Lastly, NEDU's very talented diving photographer, **BM1(DV) Eugene P. McGraw**, completed 23 years of honorable service. Mac's superior performance as an underwater photographer led him to document many quests into the ocean, both in support of manned dives as well as exploration by unmanned vehicles. His photo efforts will forever remain a part of the Navy diving archives, but he will be remembered by saturation divers at NEDU for his culinary expertise during the Unit's many, long saturation dives.

LEAR RETIRES AT NCSC

The new point of contact at the Naval Coastal Systems Center, Panama City, with regard to the Diver's Air Sampling Program is **HTCS(DV) C. J. Smith**. Senior Chief Smith relieved **HMC(DV) V. O. Lear**, who retired from active naval duty on June 15 after 20 years of service.

Early last June, undersea explorer Jacques Cousteau and a team of *Calypso* divers spent three days filming the famous Civil War ironclad *USS Monitor* 16 miles off Cape Hatteras.

On the eve of the expedition, Karen Brazeau, Special Assistant to Captain Cousteau, told *Faceplate* that three divers would be used, plus the diving saucer *Soucoupe.* "The plan calls for filming only. There will be no physical contact with the shipwreck," Brazeau said. "The ship is at a depth of about 210 feet and all dives will be conducted on air.

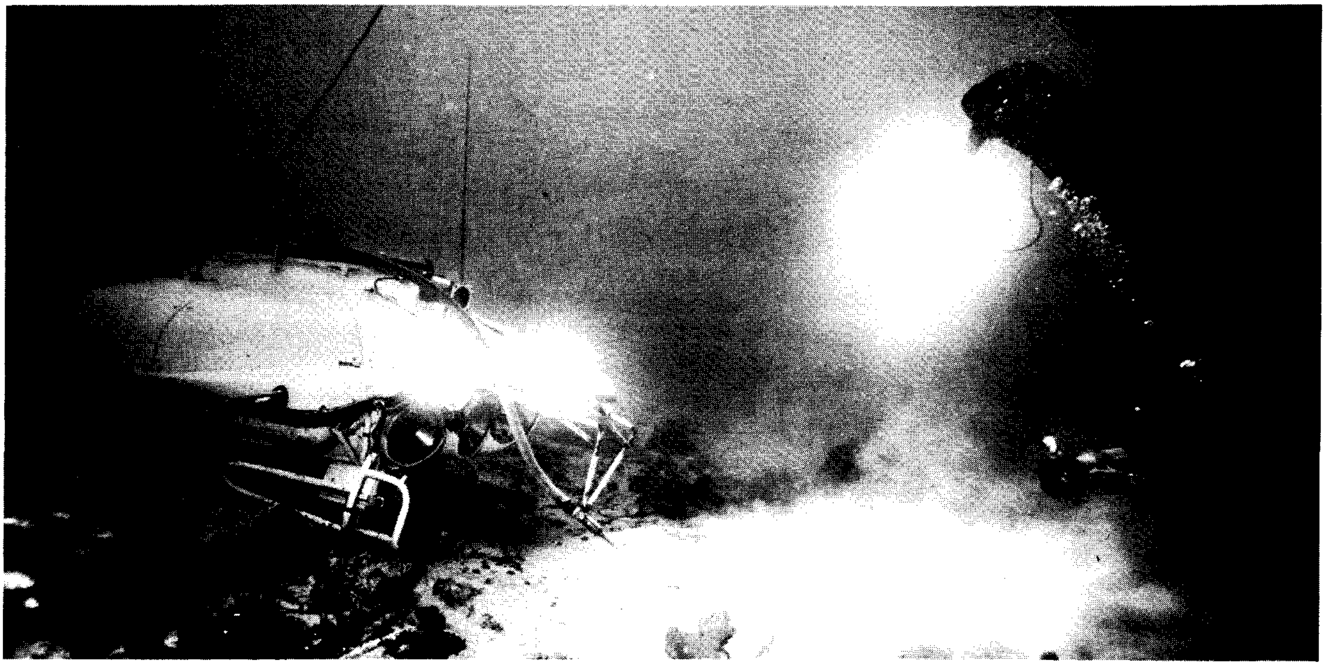
A spokesman for the Cousteau Society in New York later confirmed that *Calypso* was on-site on June 11 and that filming was in progress. The expedition was personally supervised by Cousteau along with Albert Falco, chief diver aboard *Calypso.*

The U.S. Navy took part in early efforts to locate and survey the *Monitor* wreckage five years ago in conjunction with Duke University and MIT researchers aboard *R/V Alcoa Seaprobe* [*FP*, Summer '74]. Hundreds of close-up photographs were pieced together to form a photomosaic which showed the ship to be largely intact and resting bottom-side-up in the sand. Three years later, a joint NOAA-Harbor Branch Foundation, Inc., expedition conducted a closer inspection with two Johnson-Sea-Link submarines. At that time, NOAA's Commander Phillip Johnson noted in his log book, "The *Monitor* has a dark green cast to it and the armor belt and turret look to be in very good condition – the ship appears austere and solitary . . . I wish this opportunity was available to more people."

NOTE: *At press time, a spokesman for the National Oceanic and Atmospheric Administration announced plans for a month-long, full-scale examination of* Monitor *in August, calling the expedition "the most important underwater archeological event of this century." Plans call for divers to enter the wreck for the first time, recover artifacts, and test the ship's structural soundness to determine whether or not it can be raised.*

cousteau films uss monitor

The Civil War ironclad USS Monitor *has generated a great deal of historical interest since it was discovered in 210 feet of water 16 miles off Cape Hatteras, N.C., six years ago. The most recent expedition to examine the ship that revolutionized naval architecture was conducted by Jacques Cousteau from his ship* Calypso *(left) using three diver/photographers and the "diving saucer"* Soucoupe *(below).* (Cousteau Society file photos.)



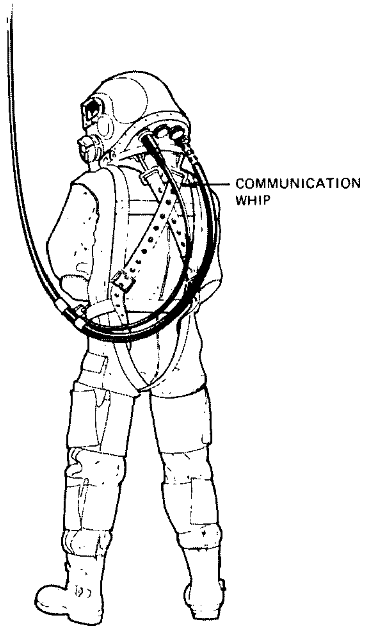
MK 12 SSDS HARDWARE COMPLETE

A bit of diving history was made inside a hangar at the Naval Surface Weapons Center in Dahlgren, Virginia, this past June. Eighty lengths of communication/strength cable, the final piece of hardware to be developed for the Mk 12 Surface-Supported Diving System, were being readied for shipment to the Navy's diving schools.

"Delivery of the cables will allow full-scale Mk 12 training in the air configuration to begin at the schools some time in August," noted Project Officer Lieutenant Mo Coulombe. Completion of the cable hardware thus opens a new chapter in modern Navy diving and brings the long era of Mk V hard-hat diving closer to an end.

Representatives from the schools and from other key diving commands were present at Dahlgren to receive instruction in the assembly and maintenance of the communication/strength cables. From the Navy Experimental Diving Unit, in addition to Lieutenant Coulombe, were ENC(DV) R. Tardy and BMC(DV) M. Hobbs. EN1(DV) D. Hima represented Service School Command, San Diego; MRCS(DV) L. Thoenes, Navy Submarine Training Center, Pearl Harbor, Hawaii; HT1(DV) R. Watts, Harbor Clearance Unit Two, Little Creek, Virginia; BMC(DV) J. Bain, Navy EOD School, Indian Head, Maryland; and GMGC(DV) W. Joslyn, NSDS, Washington, D.C.

The cables were developed at NEDU and the Naval Coastal Systems Center in Panama City, Florida. The Dahlgren laboratory, under the direction of Mk 12 SSDS project leader Bill Furchak, was responsible for procurement, assembly and documentation. BMCS(MDV) A. J. Petrasek, on loan to Dahlgren from the Office of the Supervisor of Diving, coordinated the logistics of the cable training and delivery activities.



Left: *MRCS(DV) Thoenes and ENC(DV) Tardy assembling a Mk 12 SSDS communication/strength cable connector at NSWC, Dahlgren.* Above (l-r): *EN1(DV) Hima, GMGC(DV) Joslyn and Mk 12 Project Leader Coulombe.* Top (l-r): *GMGC(DV) Joslyn, BMC(DV) Hobbs and HT1(DV) Watts with a length of cable, one of 80 that were being readied for shipment to diving schools.*

TRAINING AT SCHOOLS TO BEGIN

DECOMPRESSION SICKNESS: BUILDING AN UNDERSTANDING

Paul K. Weathersby, Ph.D.
Lieutenant, MSC, USN
Naval Medical Research Institute

A NMRI researcher discusses the kind of reasoning that has been used to design decompression schedules, and presents his own view of how well the various theoretical concepts agree with proven events in a diver's body.

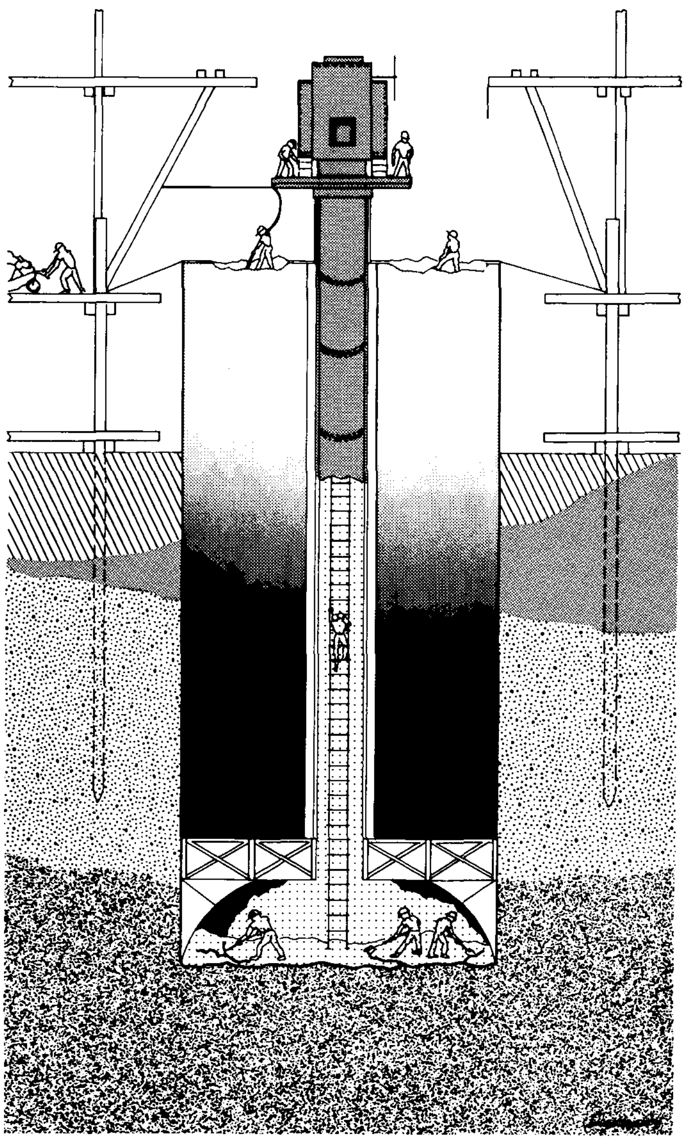
Divers are well acquainted with the U.S. Navy decompression tables. How these tables developed and how their development compares with the reasoning behind decompression tables of other navies and private organizations is not as widely known.

Decompression sickness (DCS) is a rare example of human disease in that prevention of the disease can be approached by the use of involved theoretical calculations. The theoretician follows several steps: First, he decides on the cause of the disease; he then breaks down the cause of the disease into aspects that can be solved separately; finally, he reassembles these partial solutions into a complete package that can describe the entire disease process and its prevention.

Decompression calculation procedures are thus developed from particular sets of ideas about events in the body that may cause the variety of DCS symptoms. Each set of ideas, whether based on fact, assumption, or guess, is known as a "decompression theory."

Search for the DCS Villain

Possible causes of DCS, proposed within the last century, are listed in Table 1. When workers became stricken with DCS, or "the bends," during the caisson construction of the St. Louis bridge in the 1870s, some doctors concluded that diver exhaustion was to blame. But simple physical exhaustion has failed to answer most of the questions raised by DCS, although exercise while under pressure still appears to contribute to it.



Pneumatic caissons were used widely in the late 19th century to construct bridge pilings. Work spaces were filled with compressed air to prevent water seepage. Upon returning to the surface, however, workers were often stricken with decompression sickness. Doctors called it "caisson sickness" and attributed it to physical exhaustion. Today, gas bubble theories predominate, but researchers disagree on the precise process through which the gas leads to DCS.

"... most 'practical' diving experience does not contribute to our understanding of which (decompression sickness) theories work better than others."

More recently, several groups of diving researchers have based the prevention and treatment of DCS on drugs and on procedures that affect blood cells, blood vessel walls, or the movement of fluids among various spaces in the body. These researchers could be said to follow a *biological* approach to DCS prevention.

Today, most researchers follow a *physical* approach to DCS; that is, they believe that DCS occurs after the physical process of gas formation in the body. According to this belief, DCS can be avoided if the formation and growth of gas bubbles is avoided or, at least, minimized. Furthermore, this school of thought attributes the changes in blood cells, body fluids, and blood vessels to biochemical events that occur only *after* the bubbles appear.

Emphasis on the gas bubble as primary villain in DCS has encouraged researchers who are mathematically inclined to try to solve DCS problems without worrying about the complicated biological processes that underlie the disease (which is the usual mode of operation in medical research). The processes that describe how gases move through liquids and how bubbles form and grow in supersaturated liquids are fairly well understood. At least in simple physical situations, these processes can be described with precise mathematical expressions.

Elements of Gas Bubble Theory

Elements to be considered when one evaluates DCS bubble theories are detailed in Table 2. The major elements to be addressed are (1) *the rate of gas exchange* (i.e., at what rates and in which locations does gas move in the body during a dive?), and (2) *the symptom-provoking event(s)* (i.e., what property of the gas bubble(s) causes DCS symptoms?).

Rate of Gas Exchange. Gas exchange rates probably depend, in a rather complicated way, on the properties of gas molecules as well as on the properties of body tissues. Gas transport is frequently described from two simplified viewpoints, the *blood perfusion model* and the *tissue diffusion model*. The more common blood perfusion model states that gas transport is limited by rate of local blood flow because the gas molecules can exchange very quickly between small blood capillaries and the tissue spaces near them. The tissue diffusion model states that blood can supply or remove gas quickly, so that the process of diffusion of gas molecules between or into tissue cells limits the overall rate of gas exchange. Evidence from laboratory experiments has not yet resolved which simplified approach applies to human diving. The final answer may lie between these two extremes; already, several theories contain mixtures of perfusion and diffusion elements.

Symptom-Provoking Events. The second element of any gas bubble theory requires that a decision be made on what makes bubbles "bad." For much of this century, attention was focused on the idea of bubble formation. The tactic in decompression schedule calculation was to avoid a critical ratio of inert gas supersaturation (that is, the ratio of the dissolved gas partial pressure in the body to the hydrostatic pressure at the diver's particular depth). This consideration was presumed to prevent bubble formation, and it is the basis for the present U. S. Navy tables. In recent years, however, evidence has accumulated that during many dives, divers' bodies contained gas bubbles without the divers noticing any DCS symptoms. Therefore, several theories allow for the formation of bubbles but try to prevent the bubbles from growing to a certain critical size, or deforming certain tissue structures, or exceeding a certain number.

Why So Many Bubble Theories?

Gas theories for calculating decompression tables are shown in Table 3. At the risk of oversimplification, I have listed for each theory (1) the number of "tissues"

TABLE 1

POSSIBLE CAUSES OF DECOMPRESSION SICKNESS

1. Exhaustion
2. Blood cell aggregation/clotting
3. Fluid shifts
4. Chemical changes in blood vessels
5. Gas bubbles

TABLE 2

ELEMENTS OF GAS BUBBLE THEORY ABOUT DECOMPRESSION SICKNESS

1. Rate of gas exchange:
   - Blood perfusion
   - Diffusion through tissue
   - Statistical
2. Symptom-provoking event(s):
   - Initial formation of bubble
   - Growth to critical size
   - Biology following appearance
   - Location

TABLE 3

DECOMPRESSION TABLES CALCULATED BY
DIFFERENT GAS BUBBLE THEORIES

Source	*"Tissues"*	*Gas Rate*	*Bubble Event*
Haldane (1908)	5	Perfusion	Formation
US Navy (Workman, 1956)	6–9	Perfusion	Formation
Royal Navy (Hempleman, 1967)	1	Diffusion	Formation
Swiss (Bühlmann, 1969)	6	Perf/Diff	Formation
"Thermodynamic" (Hills, 1966)	2	Diffusion	Growth
Hawaii (Yount, 1978)	1	Perf/Diff	Number

(mathematically distinct sets of gas exchange rates); (2) the procedure for calculating rates depending upon the choice of blood perfusion or tissue diffusion models, or a combination of both; and (3) the choice of bubble event that leads to DCS. Obviously, theories are available to cover most of the possible combinations.

The reasons for having a wide selection of gas bubble theories of DCS are simple: Very little experimental information is available for deciding which set of assumptions matches the events occurring in a diver's body. The gaps in our knowledge exist for many reasons. The perfusion-diffusion controversy still rages despite evidence that both assumptions are incorrect. We still do not have methods to detect or measure sizes of bubbles in most parts of the body. In addition, pain, the most common symptom of DCS, is difficult to describe biologically, much less mathematically. Finally, in spite of the inherently low incidence of DCS during thousands of dives using common decompression schedules, we cannot eliminate the possibility that chance alone may account for the differences in safety reported in dives using different decompression tables. Thus, most "practical" diving experience does not contribute to our understanding of which theories work better than others.

Several projects at the Naval Medical Research Institute are aimed at plugging these gaps in our knowledge. Commander John Hallenbeck has been able to follow the progression of biological events in spinal cord DCS that occurs after bubbles become visible. Commander Thomas Berghage has amassed a large body of information on the procedures that lead to serious symptoms of DCS in small animals—information that will serve as a reference for predictions from theoretical calculations. Commanders Edward Flynn and Kristopher Greene are preparing to measure gas exchange in divers performing at different levels of exercise. Dr. Louis Homer is developing the mathematical formulations necessary to compare special combinations of perfusion and diffusion gas exchange conditions with careful animal and human measurements. My colleagues and I are measuring gas exchange over prolonged periods in many tissues of animals, and we have developed a statistical description of gas exchange rates that avoids choosing between perfusion and diffusion assumptions.

Conclusions

- Decompression theories are not scientific theories in the sense of the law of gravity; rather, they are mathematical predictions based on unverified assumptions.
- Decompression theories do provide calculation methods for summarizing the experience of divers; they also provide starting values for developing new schedules.
- Theoretical calculations of new decompression schedules usually cannot be accepted immediately; they are revised to provide adequate safety.
- It remains for researchers to establish how fast and where gas exchange occurs and the specific processes through which the gas leads to DCS.

The author is grateful to his colleagues at the Naval Medical Research Institute, especially to Surgeon Captain E. E. P. Barnard, RN, now at the Institute of Naval Medicine, Alverstoke, U.K., for sharing their insights into decompression sickness, and to M. M. Matzen and E. S. Grunewald for their editorial assistance.

the Bio-medical research diver

Above: *Recent pressure and O_2 testing of U.S. Naval Academy midshipmen at NMRI saw HT2(DV) Lands and STG1(DV) Cross readying O_2 masks inside test chamber.* Below: *HMCS(DV) West conducts pre-dive exam.* Right: *Before a 50-minute, 41° F cold-water research dive, MR1(DV) Weaver has electrodes attached, then receives final instructions (bottom).*

NMRI's Biomedical Research Divers Take Part in a Wide Range of Diving Experiments, Enduring Probes, Electrodes and Other Discomforts so that the Diving Health, Safety, and Efficiency of their Fleet Counterparts will be Enhanced.

Michael D. Curley, Ph.D.
Lieutenant, MSC, USN
Naval Medical Research Institute

Navy divers completing 85°F warm water dives one week, then flying over 1,000 miles to take part in 41°F cold water dives the next week?

It does happen—particularly if the divers are participating in one of the biomedical diving research studies at the Naval Medical Research Institute. This past spring, research divers concluded human-performance evaluations of the one-atmosphere diving system (JIM) in warm water and one week later were at work in cold water investigating physiological and psychomotor performance. For the Navy diver who's looking for unusual and unique experiences, biomedical research diving may be the answer.

The Naval Medical Research Institute (NMRI) is located on the grounds of the National Naval Medical Center in Bethesda, Maryland. The Navy's largest biomedical research facility, NMRI has on board approximately 200 military and 200 civilian personnel. Its mission, assigned by the Secretary of the Navy, is "To conduct basic and applied research and development concerned with the health, safety, and efficiency of naval personnel." As part of NMRI's effort to carry out its mission, a biomedical diving research program has been active since the early 1940's. Within NMRI, diving support for medical investigations is primarily furnished by the Hyperbaric Support Department.

Navy divers serve a three-year tour at NMRI; most of the billets are slotted for saturation divers. On board at NMRI in the spring of 1979 were 13 divers: 2 Saturation Master Divers, 5 Saturation Divers, 2 Divers First Class, 1 EOD Diver, 1 SEAL/UDT Diver, and 2 Diving Medical Technicians. When the new 1500-psi saturation system becomes operational later this year (*FP*, Fall '77), the number of diver personnel will be increased fourfold. The operational testing and subsequent diving of this new system will provide a unique opportunity for the divers to be part of "state-of-the-art" system technology, and aid in pushing forward the frontiers of diving physiology and medicine.

The present contingent of divers at NMRI is called upon to perform a variety of tasks in support of biomedical research, in addition to the usual duties associated with a diving facility. Divers at NMRI often are asked to volunteer for diving medical experiments, experiments which may demand the utmost in diver stamina and fortitude. For example, during the past year NMRI divers participated in studies evaluating commonly used drugs (*FP*, Spring '79), cold water performance, flying after diving, heat loss in water, blood-gas exchange, and diver/operator performance in the one-atmosphere diving system. The tasks NMRI divers perform in these studies are rarely pleasant; moreover, the studies may call for extensive physiological monitoring of diver performance via electrodes and probes under conditions of extreme environmental stress (e.g., water temperature, fatigue). Successful biomedical research divers at NMRI exhibit patience in the face of lengthy and involved experimental procedures and a dedication to accomplishing the tasks in an exemplary manner. Without the cooperation and professionalism of the NMRI diver, applied biomedical diving research would falter.

Although no single investigation is typical of the experiments under way at NMRI, a study can be chosen to illustrate the tasks NMRI divers are called upon to perform. Recently, MR1(DV) Weaver participated in a study evaluating the effects of water temperature on physiological, cognitive, and motor performance by a wet-suited, scuba-equipped diver. During the experiment he completed 14 dives in water ranging from 77°F to 41°F. On each dive he performed tasks including top hatch transfer, tooker patch removal and installation, time estimation, learning and memory performance on an underwater response acquisition paddle, and torque wrench estimation. Before each dive ECG electrodes and temperature probes were applied; bottom times ranged from 30 to 50 minutes. The data gathered from this study will assist researchers in understanding the nature and extent of environmental stressors on diver performance. Once validated, this information will be passed on to the fleet with recommendations for appropriate action.

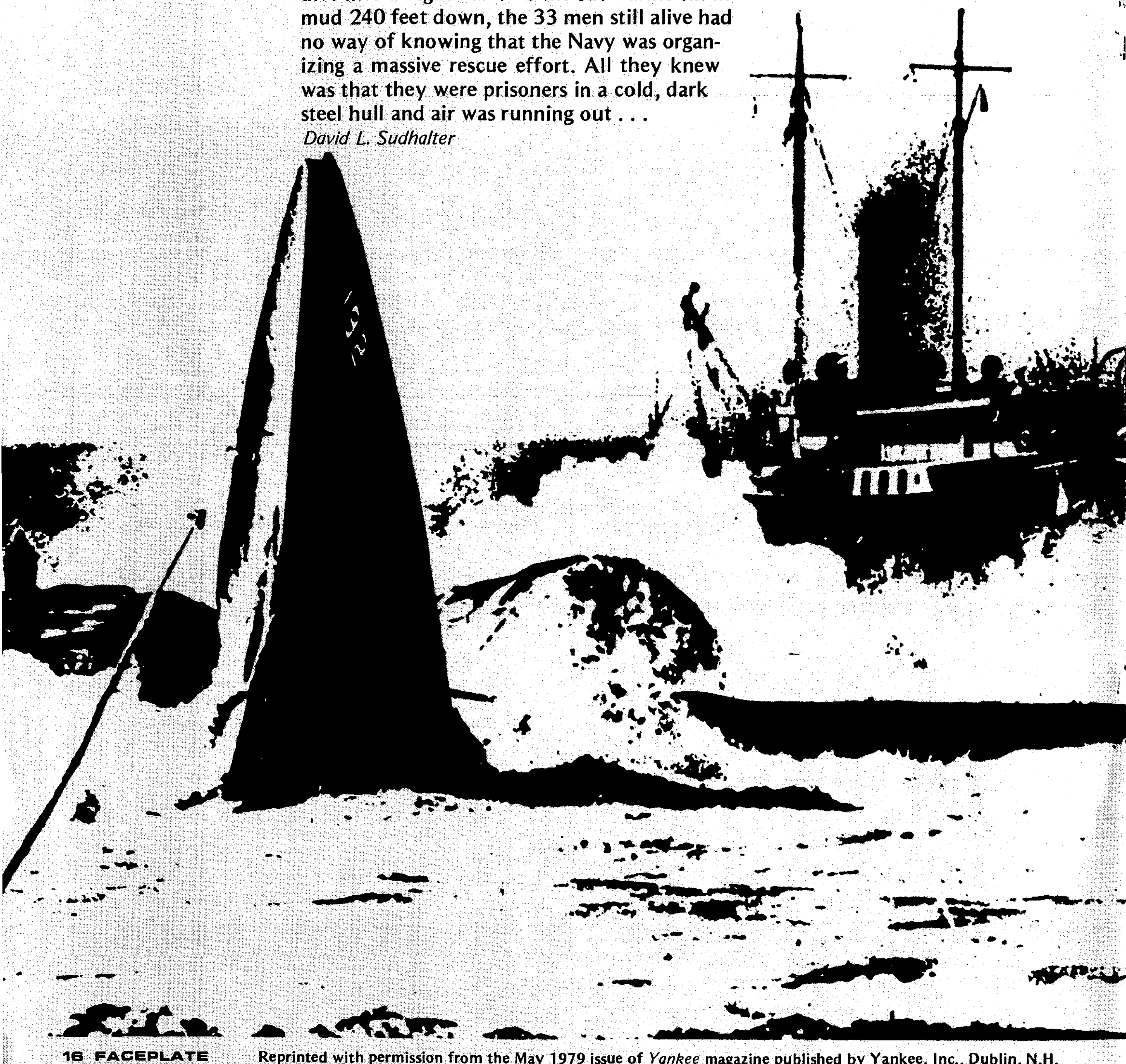
When not actively engaged in a research project, NMRI divers can be found conducting pressure and O_2 tolerance tests for U.S. Naval Academy midshipmen and diver candidates, requalification dives for Naval District Washington MC and MSC officers, hyperbaric Vickers treatments for various disorders (e.g., gas gangrene, bone necrosis), requalification dives for NMRI personnel, and recompression treatments for both military and civilian diving accidents. In addition, NMRI divers have the opportunity for travel. Among the TAD locations visited by NMRI research divers in the past year were Isle of Shoals, Maine; San Antonio, Texas; Panama City, Florida; and Columbus, Ohio.

What do the NMRI researchers think of the support provided by the research divers? The comments of Dr. J. M. Walsh are illustrative: "NMRI divers do an excellent job for us. They are cooperative and highly motivated, despite numerous discomforts and indignities they must endure for reliable data to be gathered." The NMRI biomedical research diver fills a unique and important role in advancing our understanding of the effects of hyperbaria on the human body.

Up from Oblivion

It was 40 years ago that a malfunctioning valve on *USS Squalus* turned a routine test dive into a nightmare. As the submarine sat in mud 240 feet down, the 33 men still alive had no way of knowing that the Navy was organizing a massive rescue effort. All they knew was that they were prisoners in a cold, dark steel hull and air was running out . . .

David L. Sudhalter



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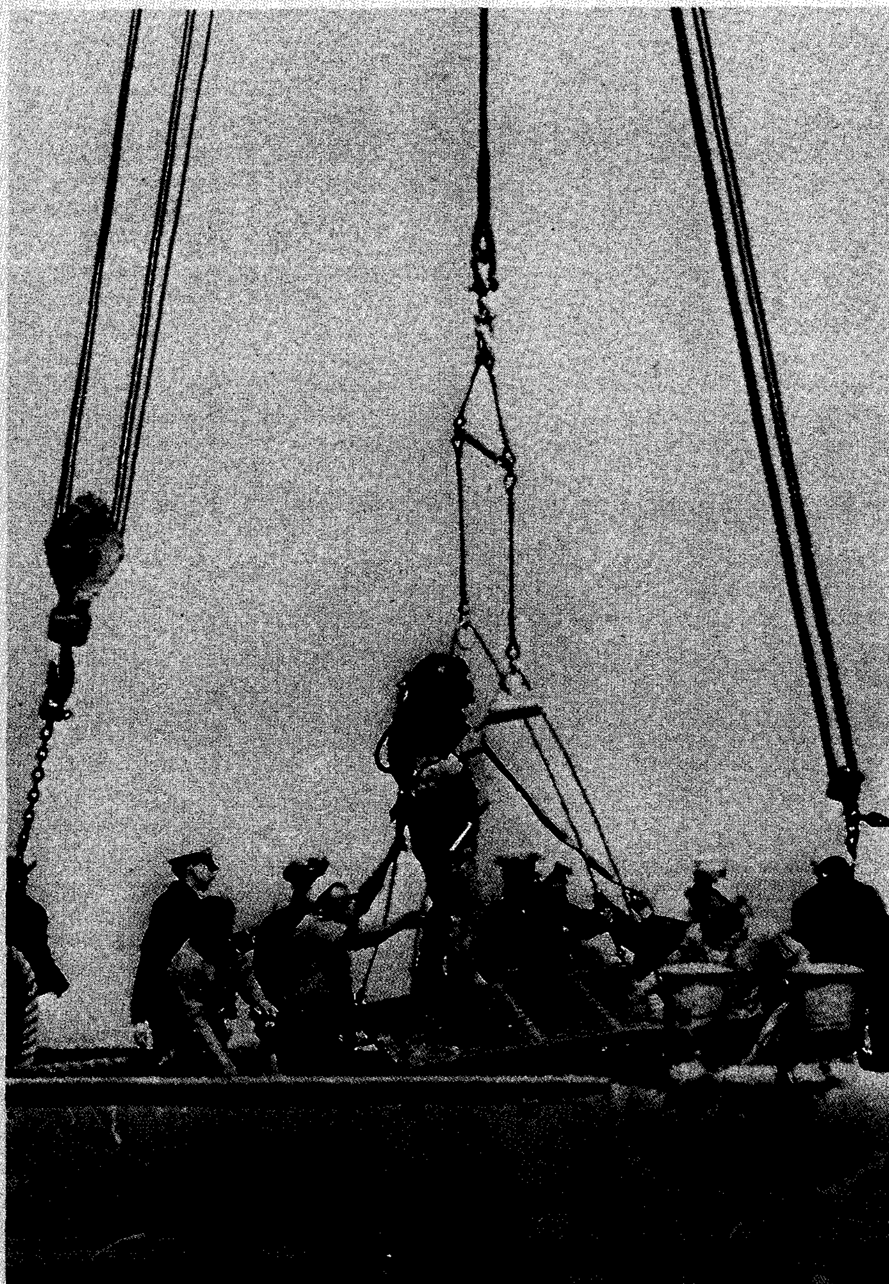
(National Archives Photos)

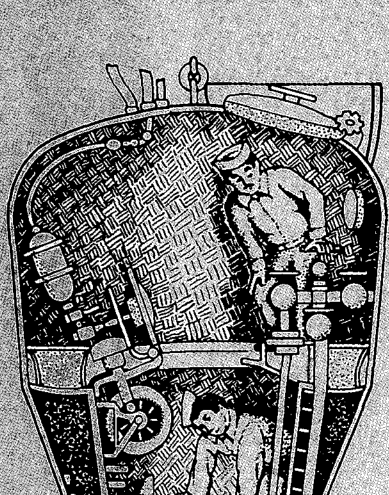
It was May 23rd, 1939. The local newspapers were carrying news of ominous events in Europe, while just outside Portsmouth Harbor, the submarine *USS Squalus* was getting under way for the last of her sea trials. The *Squalus* and her sister ship, the *USS Sculpin*, each cost $5,000,000 and represented the latest in a growing arsenal of new weapons that the Navy knew would soon be needed.

Lieutenant Oliver F. Naquin, skipper of the new submarine, had a crew of 59 experienced men with him as the *Squalus* weighed anchor and sailed out the mouth of the Piscataqua River. Most of the crew were on deck, smoking their last cigarettes and getting their last view of the open water when the order came, "Station the special sea details." Like clockwork, the crew set about the tasks that they had learned so well. Also aboard for this special sea trial was Harold C. Preble, the naval architect who knew more about the *Squalus* than anyone else, and two other civilian technicians. Their mission on this starchy May morning was to take the *Squalus* into a succession of rapid dives about 12 miles off Rye Beach. The *Squalus* had performed magnificently on her shakedown cruises. At 8:30 A.M., Lieutenant Naquin ordered full speed on the four diesels as the *Squalus* worked up to her limit of 16 knots. This dive was to simulate an emergency dive as though the *Squalus* were under attack. The vents and gear were all checked. Dials and gauges were being carefully monitored. The radioman sent out the last position signal to Portsmouth.

"Stand by to dive!" came the skipper's order as the klaxons cranked out their harsh, raspy warnings. The skipper descended from the conning tower, and spun the wheel that dogged the hatch. The indicator lights were green, showing everything in working order and ready for the dive. The diesel inductions were closed as the submarine shifted over from the noise of the diesels to the quiet hum of the powerful electric motors. The *Squalus* was now sealed tight. It was 8:40 A.M. Lieutenant Naquin and Harold Preble were watching the depth gauges and recording the diving time with great satisfaction. They had already reached 63 feet—a record dive for the *Squalus*.

The quiet atmosphere of the control room was broken suddenly by a frantic message from the engine room. The main induction valve was stuck open, and sea water was pouring in! The skipper reacted immediately. "Blow the ballast! Surface, surface! Close all watertight doors!" But the weight and rush of tons of sea water was too much for the *Squalus* to cope with, and she began to sink, as her stern fell. Men and gear crashed into each other as the sub tilted at a 45-degree angle, and in those few seconds, the lives of the crew hung in a precarious balance. At that moment Electrician's Mate Lloyd Maness was stationed by a bulkhead door to the rear compartment. As the rear compartments began to flood, Maness grabbed for the watertight door that would seal off the control room of the sub from the flooded rear compartments. The sub was already at an angle, and the 200-pound steel door had to be pulled upwards in order to close it. Maness had almost brought the door up when five shipmates appeared and shouted, "For God's sake,





The 10-foot-high rescue chamber (left), designed by U.S. Navy Commander Allen R. McCann, made four trips to the stricken Squalus, *saving all 33 of the crewmen trapped in the submarine's forward compartments. Rescue and salvage efforts were conducted from* USS Falcon *(above).*

"The crew could hear his leadweighted shoes clomping on the deck as he tried to attach a cable to the *Squalus* . . . "

leave the door open!" Maness complied, and five more men were able to escape the flooding compartment. The task of closing and dogging the watertight door was one of those superhuman feats that many people seem to achieve only in emergencies. Among the 26 men left behind in the flooded compartments and doomed to certain death was Maness' best friend, for whose wedding he was to be the best man the next Sunday.

At the same moment, Chief Electrician's Mate Gainor realized what was happening, and headed for the battery compartment. The rushing sea water would make contact with the batteries and cause fire and explosions unless they could be disconnected. Gainor entered the battery compartment and crawled over to the two big switches that would disconnect the batteries. The switches emitted a bright blue arc as Gainor finally opened them. Those two acts—closing the rear compartment door and pulling the battery switches—saved the men from immediate destruction. Now, as the *Squalus* settled on the muddy bottom, 12 miles from the New Hampshire coast in 240 feet of water, the problem was survival.

It was 8:45 A.M. Just 15 minutes had elapsed since Lieutenant Naquin first gave the order to prepare for the dive. As he looked around in the half-lighted gloom of the control room, Naquin began a head count: 23 men were alive and well in the control room; 10 more were in the forward torpedo room. In the flooded after section were 26 men for whom there could be no hope. A signal flare sent from the *Squalus* surfaced and arced over the desolate emptiness of the sea. Lieutenant Naquin then ordered the release of the telephone buoy, which floated to the surface. It bore a sign that read, "Submarine sunk here. Telephone inside." The men settled down to wait for a rescue that might never come, for they knew that at great depths, submarine rescues were still pretty shaky propositions. To preserve what oxygen there was, the men were ordered to lie still, not to talk, and not to exert themselves. Most of them huddled silently in blankets trying to keep out the gnawing cold that added to the fear and isolation of being trapped in a dead submarine. The most immediate dangers to their safety were the increasing concentration of carbon dioxide and the possibility of chlorine gas seeping from the storage batteries. If rescue came, the *Squalus* had aboard a new lifesaving device, the Momsen Lung, which could enable the crew to escape from the sunken sub and rapidly rise to the surface. But it would take at least two hours for all 33 men to lock out of the submarine and negotiate the 240 feet, and it was doubtful that anyone would be able to survive the icy water.

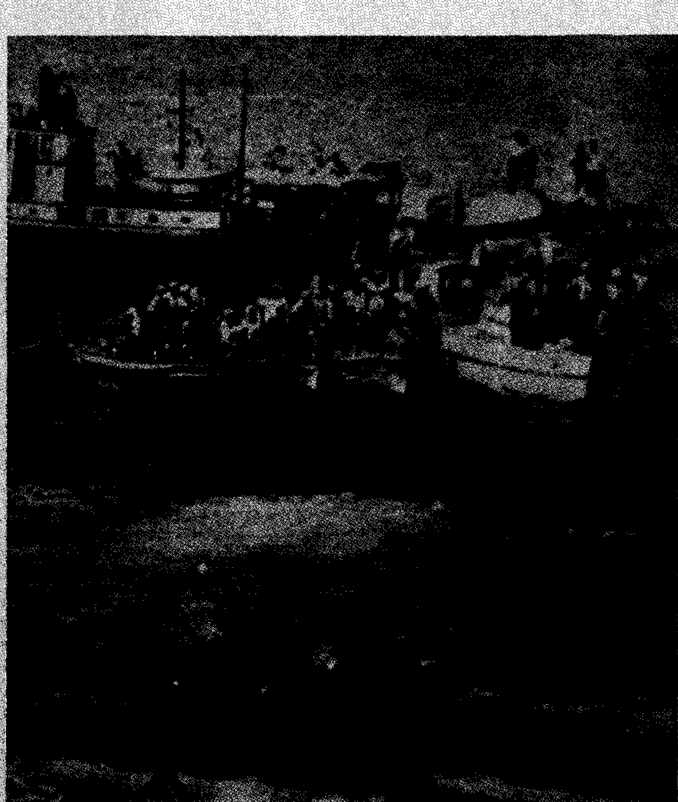
Finally, at 12:55 P.M., the anxious crew heard the beat of propellers. Their sister ship, the *Sculpin*, had located the *Squalus'* position. Just as the *Sculpin*'s skipper, Commander Wilkins, reached Lieutenant Naquin on the buoy telephone, the line snapped. There was no other means of direct communication.

In the meantime, all of the rescue facilities of the Navy began to swing into action. Amphibious aircraft, ships, and Navy divers all began to stream northward. The Cape Cod Canal was cleared as were the streets of Boston, while police escorts with wailing sirens guided the Navy divers and their equipment towards Portsmouth. For the next three days, the nation's attention would be riveted on the tiny band of men trapped in the *Squalus*, and the gathering army of rescue personnel who were in a desperate race against time to save them.

Aboard the *Squalus*, some of the men began to vomit and complain of lightheadedness, a sure sign of the increasing concentration of carbon dioxide. Since the telephone line was broken, the rescue vessels knew only the approximate position of the *Squalus*. They had to use grappling hooks to locate her. At 7:30 P.M., almost 12 hours since the *Squalus* began her fateful dive, contact was made by the tug *Penacook*. Rescue operations could not begin at night and the long wait for daybreak began. The *Falcon* arrived with a McCann rescue bell, a recently developed device that had never been tested in an actual emergency. By 10:00 A.M., the first Navy diver was able to go down to the *Squalus*, now spending her second morning on the bottom. The crew could hear his leadweighted shoes clomping on the deck as he tried to attach a cable to the *Squalus* that would anchor the McCann bell to the sub's hull.

The temperature inside the sub was now 45 degrees, the pressure was building, and the humidity was almost 100 percent. Lieutenant Naquin picked the weakest men to leave the sub first. It was almost 1:00 P.M. when the rescue bell was connected to the *Squalus* and the men waiting in the forward torpedo room were able to break the hatch open and slip into the waiting rescue bell. Fresh air lines were inserted into the open hatch of the dead sub and new, clean air from the surface began to revive the crew. The diving bell began its ascent to the surface with the first of the survivors. At 3:00 P.M., the McCann rescue chamber returned and took nine more men. Finally, at 8:00 P.M., Lieutenant Naquin and seven other survivors were the last to leave the watery grave of the *Squalus* and her dead crew of 26. Halfway up, the rescue chamber stopped suddenly. Navy divers found that the cable had been frayed, and a diver went down to cut it. The lives of the men in the chamber could not be risked by a sudden rush to the surface, so the rescue bell was lowered to the bottom once again until a new cable could be attached to the *Squalus*. Finally, after an agonizing four hours, the tiny rescue chamber began its slow ascent. At 12:30 A.M., it broke through the surface and into the glare of floodlights from the rescue vessels. Cheers greeted the haggard crew and passengers. Lieutenant Naquin and all of the 33 men who survived the sinking of the *Squalus* had been saved. Despite the loss of 26 men, it was a day of great rejoicing for Navy veterans who had witnessed many such tragedies before when rescue equipment was

Above: *This is the first group of survivors from* Squalus. *They were the first men ever to be rescued using the recently developed McCann rescue chamber.* Below: *The 113-day salvage effort draws to a close as the wooden pontoons ease the submarine to the surface.*



not available. Ironically, only a few days after the *Squalus* went down, a British sub, the *HMS Thetis,* was lost off the English coast. The *Thetis,* too, was a brand-new submarine, but her crew was not so lucky, and all hands were lost.

The work of salvaging the *Squalus* began. Never before had the Navy tried to salvage a submarine from such deep water. Several methods of salvage were discussed, including trying to drag the sunken sub along the bottom until shallow water was reached.

Finally, the idea of attaching pontoons and then blowing out the tons of water from the *Squalus* was agreed on. The salvage operation was to take 113 days, and would see the *Squalus* rise to the surface twice in a rush of compressed air, only to sink back to the bottom just as quickly, until delicate balancing adjustments were made that allowed the sub to be towed back up the Piscataqua River to the base in Portsmouth. It was now September 13th. The dead were removed from their watery grave. A malfunctioning valve was found to have caused the disaster.

Two years later, the *Squalus* was recommissioned and given the new name of *USS Sailfish*. She proved worthy of her resurrection from the deep. During World War II she torpedoed and sank six Japanese merchantmen, and won a Presidential citation for sinking a Japanese aircraft carrier during a typhoon in the Pacific. On V-J Day, September 2, 1945, the *Sailfish* was decommissioned at her old home base, Portsmouth. The career of the gallant *Sailfish* came to an end when she was sold at auction on May 3, 1948, for $43,167 to a Philadelphia scrap-metal firm. The ship is long since torn apart and melted down, but she'll never be forgotten.

NEW CABLE REEL AUGMENTS NAVY'S SUBMARINE RESCUE CAPABILITY

The Navy has developed a unique system to augment its existing submarine rescue capability. By applying modern technology to the World War II concept of the *submarine rescue buoy*, it has developed a new system with an old twist.

New-class submarines rely primarily on the Deep Submergence Rescue Vehicle (DSRV) in emergencies. However, as a backup for the DSRV, the Civil Engineering Laboratory, Port Hueneme, California, was tasked to develop an alternate system using a Submarine Rescue Chamber (SRC) and a Deep Submergence Vehicle (DSV).

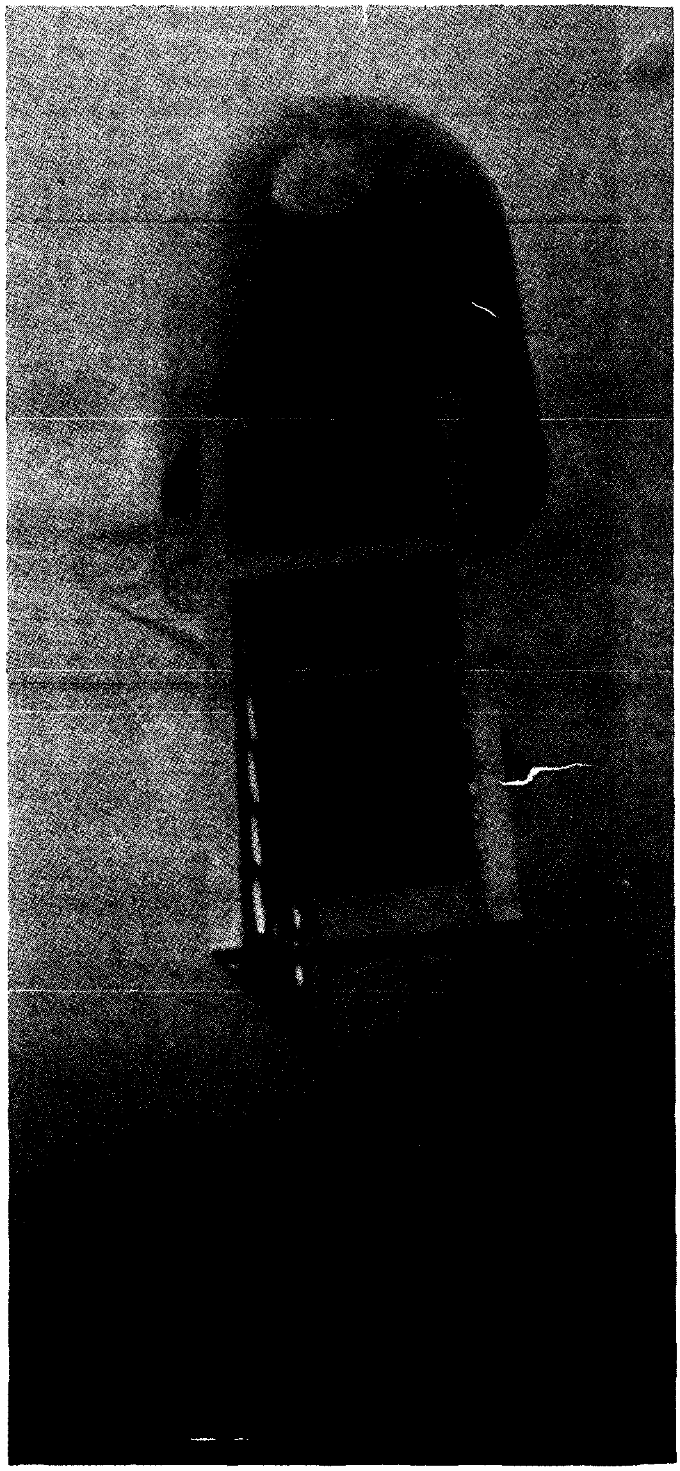
The system, developed by Wayne Tausig, mechanical engineer in the Ocean Engineering Department at the Laboratory, calls for a single unit which houses a reel of 7/16" steel cable, primary and secondary waterbrakes, and a buoyant float. The unit is called the Submarine Rescue Cable Reel.

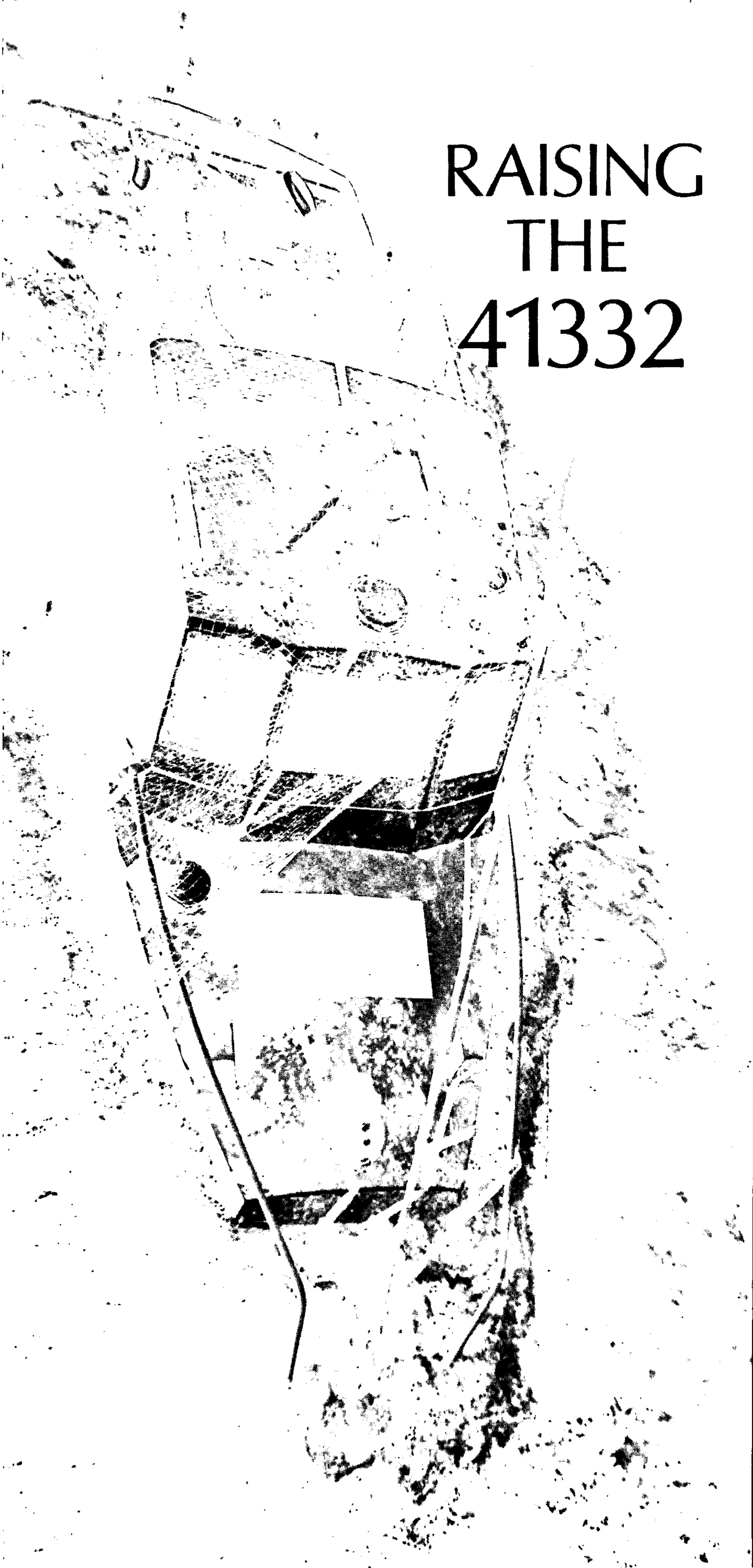
During rescue operations, the unit, the DSV and the rescue chamber are delivered to the site of the distressed submarine. The DSV, clutching brackets on the unit with its manipulators, takes it under water and attaches its cable to the hatch of the stricken submarine. Then the manipulator lets go of the unit and pulls the release pin on the unit frame. Simultaneously, ballast within the unit drops to the seafloor, the cable begins to unwind, and the unit starts to surface.

The distinctive feature about the unit is the waterbrake. Actually, there are two: the first designed to synchronize the reel payout rate with the surface rate of the unit, thus preventing cable pile-up on the distressed submarine; and the second designed to slow up the cable payout as the unit approaches the surface.

The Submarine Rescue Cable Reel weighs only 5-10 pounds in water and ascends at a rate of 92 feet per minute. Triggered by a depth-activated clutch, the second waterbrake becomes engaged at 100 feet below the surface. Once the unit has surfaced, the cable is detached from the unit and fastened to a reel on the Submarine Rescue Chamber by divers. By rewinding the cable on its reel, the chamber then pulls itself down to the hatch of the stricken submarine to effect a rescue.

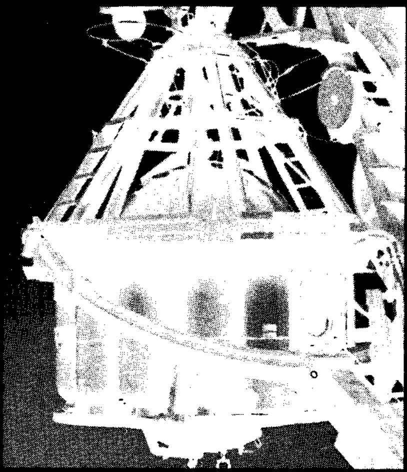
The Submarine Rescue Cable Reel is a valuable new addition to the Navy's rescue capability for distressed submarines. Additionally, the design of the rescue reel provides a means of delivering heavy lift lines from the ocean bottom to the surface for any kind of recovery operation. It can be used to recover objects from the ocean floor or for deep ocean salvage operations.





RAISING THE 41332

The primary purpose of the DDS Mk 2 Mod 1 is to transport a team of divers (repeatedly as necessary) from the ocean surface to depth, maintain them at the work site, transport them to the surface, and decompress them to atmospheric pressure. Saturation dives may be conducted in which divers are maintained at depth pressure in the Deck Decompression Chamber (DDC) and/or in the Personnel Transfer Capsule (PTC). The PTC (below) transported divers to fifty fathoms during the salvage of the Coast Guard boat 41332.



Using the Deep Dive System Mk 2 Mod 1 from the Twin-Hulled USS Pigeon, Divers Descend to More Than 300 Feet Near the Mouth of the Columbia River to Salvage the Coast Guard Boat 41332

CWO2 J.J. Fenwick, USN
Deep Submergence Officer, USS Pigeon

In April 1979, *USS Pigeon* (ASR-21) was officially tasked with the location and salvage of the CG 41332, a 41-foot Coast Guard boat which capsized and sank several months earlier at the mouth of the Columbia River near Astoria, Oregon. The location of the craft was believed to be approximately four miles southwest of the Columbia River lightship, in 312 feet of water, having been taken out to sea by the swift Columbia River current before it finally sank. Several unsuccessful attempts to salvage the 41332 were made by both military and civilian units following the accident.

To prepare for the operation, a training program was initiated immediately in San Diego for *Pigeon's* Deep Submergence personnel. All subsystems of the Deep Dive System (DDS) Mk 2 Mod 1 were checked and operated. A team of six divers was selected for the planned 250-foot saturation dives, with excursions down to depths in excess of 300 feet. A 92-percent helium/8-percent oxygen breathing gas mixture would be used. At the same time, plans for the actual salvage were formulated.

The local Coast Guard unit had a similar 41-foot craft available for inspection by the salvage team. After close inspection, it was decided to design collars to fit the forward and after towing bitts. A bridle of 1-3/8" wire was also needed. SIMA San Diego was tasked with the manufacture of both collars and bridle. Within two weeks both collars and bridle were on board, tested and ready for use.

The dive team members selected were SMC(DV) Jose A. Flores, a veteran saturation diver and experienced team leader. Assistant operator was HT2(DV) Davis S. Rolfe. The divers were Lieutenant Dave T. Otto, MMC(DV) Rick Cadwell, HT1(DV) Bruce Earnest and ET1(DV) Rusty Pavlow. In addition, divers from *USS Ortolan* (ASR-22) and Submarine Development Group One, San Diego, were offered the opportunity to participate in the salvage operation. As training progressed, plans for the divers' in-water operations were made and discussed. Actual training of the dive team and support personnel was conducted on a 41-foot boat. Continuous changes, additions and modifications resulted in a primary and two alternative recovery techniques.

In May, *Pigeon* departed San Diego straight into high winds and an angry sea, a promise of things to come. Using a towed, side-looking sonar and a special shore-based navigation system, the position of the wreck was determined. Next, a four-point moor was laid so that the ship could be positioned over the wreck, but a combination of wind, seas, currents and mud bottom caused the anchors to drag. The next attempt was only partially successful, but persistence paid off – on the third attempt, the anchors held.

The divers were pressurized to their saturation depth within the DDS Mk 2 Mod 1 on the morning of May 23. As the system's Personnel Transfer Capsule (PTC) was lowered to 285 feet, the divers suited up. The divers then left the PTC and descended the remaining 20 feet to the bottom and began an extensive and precise search of the bottom. But the search was to no avail, as it was discovered that the winds and seas had moved the ship 200 feet off target. The dive was terminated and the divers returned to the safety of the deck decompression chamber for a hot meal and rest. Not all was lost because divers Otto and Earnest brought back valuable information on bottom conditions, such as currents, surge and visibility. Safe in their chamber the divers were asleep early in anticipation of the long diving day coming.

In the middle of the night, a failure in the life support system threatened the success of the dive. The topside divers worked continuously throughout the night. Too much planning and preparation had been spent to have to quit now. Finally, after many hours, the faulty blower was replaced and a second dive was launched. This time, the side-scan sonar was attached to the PTC platform. Once on the bottom, divers Earnest and Cadwell used the sonar "fish" to make sweeps of the black, alien environment they had entered.

Contact of a large object was detected a mere 80 feet from the divers. After four hours of extensive measurements and grueling time in the water, the divers were able to convey to *Pigeon* the exact location of the sunken craft. It was decided to call it a day and return to the surface for regrouping. Tired but satisfied that everything was set for the next day, the divers hit the hay. Once again, as if on key, the life support system started acting up. Again, the topside support divers worked continuously, and, by morning, all was "go."

At 10 A.M., divers Flores, Rolfe, Cadwell and Earnest entered the PTC. On the bottom within the hour, the divers set out with their compasses and hand-held lights in the direction of the known contact. As visibility was limited to 5 to 10 feet, the search proceeded with due caution. Within minutes, debris was spotted; seconds later, the sunken boat was in sight. The PTC was a mere 30 feet away, but only the glow of its external lights could be seen. Divers Earnest and Cadwell immediately went to work as planned and rehearsed so many times before. A tag line from the PTC to the wreck was connected to speed the trips back and forth with equipment.

Slowly and carefully, all the tools and rigging equipment were lowered and carried to the wreck, which had lain undisturbed for so long. Several species of sea life swam around, ignoring the strange intruders who were disturbing their man-made home at the bottom of the ocean.

With all necessary equipment now taken to the wreck, the divers went to work, stopping only briefly for rest. Within the hour, the collars were in place and the after leg of the lift sling was connected. The divers then connected the 10-inch nylon lift line to the sling. Upon completion of this step of the operation, diver Earnest called topside and gave the Captain a progress report.

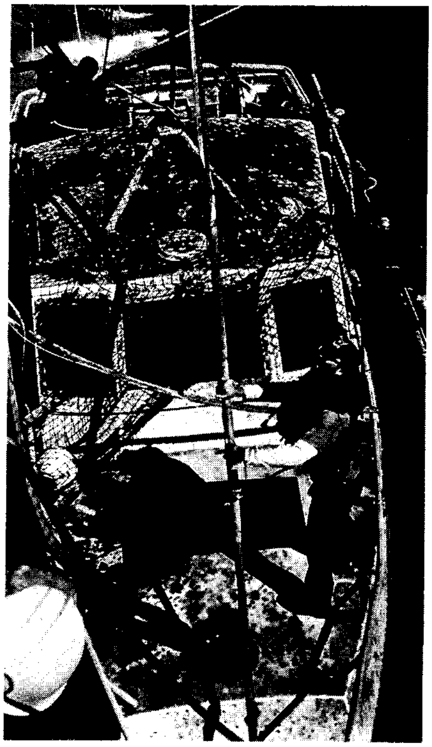
The divers then connected the forward leg of the sling and made a final inspection of their work before returning to the PTC. Diver Earnest was then recovered. Diver Cadwell remained outside acting as stand-by diver for diver Rolfe, who was sent to the wreck with an underwater T.V. camera. After making a complete survey of the work done by the divers and a close inspection of the boat, diver Rolfe returned to the PTC and divers Cadwell and Rolfe were recovered. All divers safely in the PTC, they were then brought back to the chamber thoroughly exhausted, but satisfied in knowing their work was a complete success. Once in the safety of the chamber, spirits were high, knowing the long hours of decompression were now started.

The forces of nature, however, were not ready to release their prize. Throughout the night, the wind and seas continued to build. It was therefore decided the next morning to slip the moor and move to shelter until the seas abated.

At 10:25 A.M. on May 31, the CG 41332 broke surface, marking the end of a long and grueling task and bringing a well deserved sigh of relief to a weary crew.

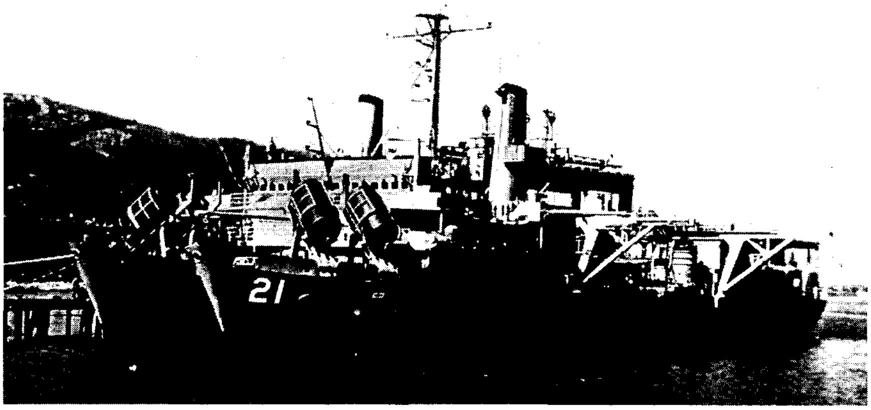
The entire diving operation was led by Commander Charles J. Duchock, Jr., Commanding Officer of *Pigeon,* and CWO2 J.J. Fenwick, the Deep Submergence Officer. The preparations and actual operations were run by master divers BMCS(MDV) J.R. Medina and ENC(MDV) C.M. Moore.

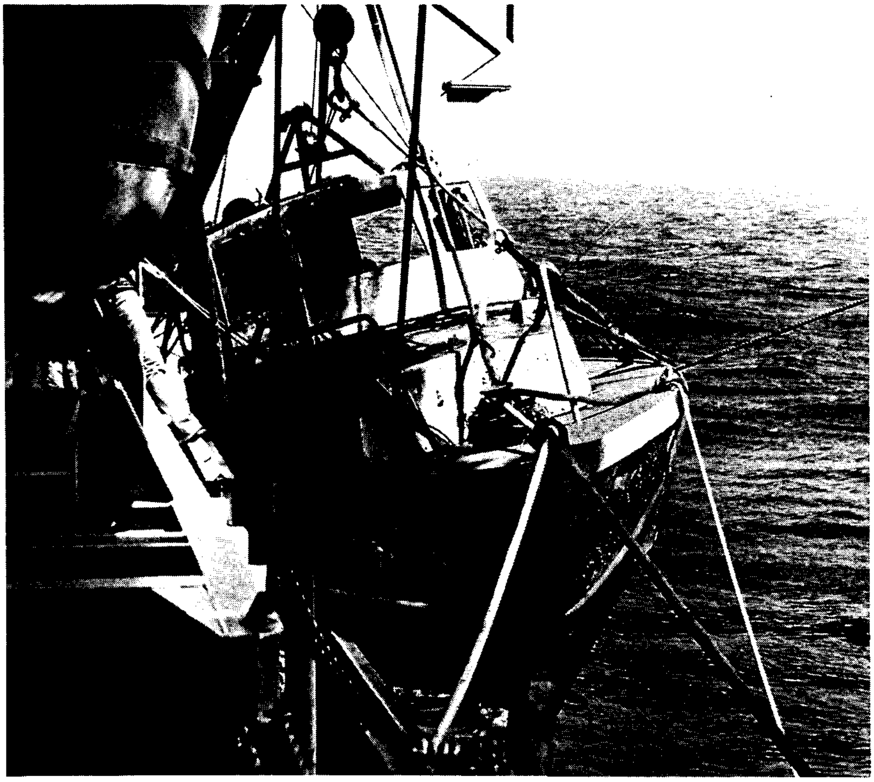
"In May, Pigeon departed San Diego straight into high winds and an angry sea, a promise of things to come."



"Slowly and carefully, all the tools and rigging equipment were lowered and carried to the wreck . . . Several species of sea life swam around, ignoring the strange intruders who were disturbing their man-made home at the bottom of the ocean."

Below: USS Pigeon *(ASR-21), with its precision deep-water mooring system, sophisticated underwater communications and television, three-dimensional sonar, and the Mk 2 Mod 1 DDS, was an ideal platform from which to conduct the deep search and salvage of CG boat 41332.* Left: *After the successful lift,* Pigeon*'s crew dewaters the craft.* Bottom: *41332 is lashed to* Pigeon *for return voyage to San Diego.*





USS Pigeon Divers Participating:

HTC(DV) M. PAXTON
GMGC(DV) G. REKOW
BMC(DV) E. EUTENEIER
ETCS(DV) M. KAUFMANN
HMC(DV) W. BOYCE
EN1(DV) D. JENNINGS
MM1(DV) F. DICKERSON
HT1(DV) F. MASON
EM1(DV) G. STANTON
HT1(DV) J. HILL
HT1(DV) D. WOODWORTH
BM2(DV) W. WRIGHT
GMG2(DV) T. HARRIS
EM3(DV) J. WILSON
HT3(DV) D. SOSNOWSKI
HM3(DV) J. ROOTS
ETSN(DV) J. STARKEY
HTFN(DV) D. ENGLE

Saturation Watch Officers:

LIEUTENANT (JG.) B. MARSH
LIEUTENANT (JG.) B. CLARK
ENSIGN J. MANUES
ENSIGN N. TIMRECK

Submarine Medical Officer:

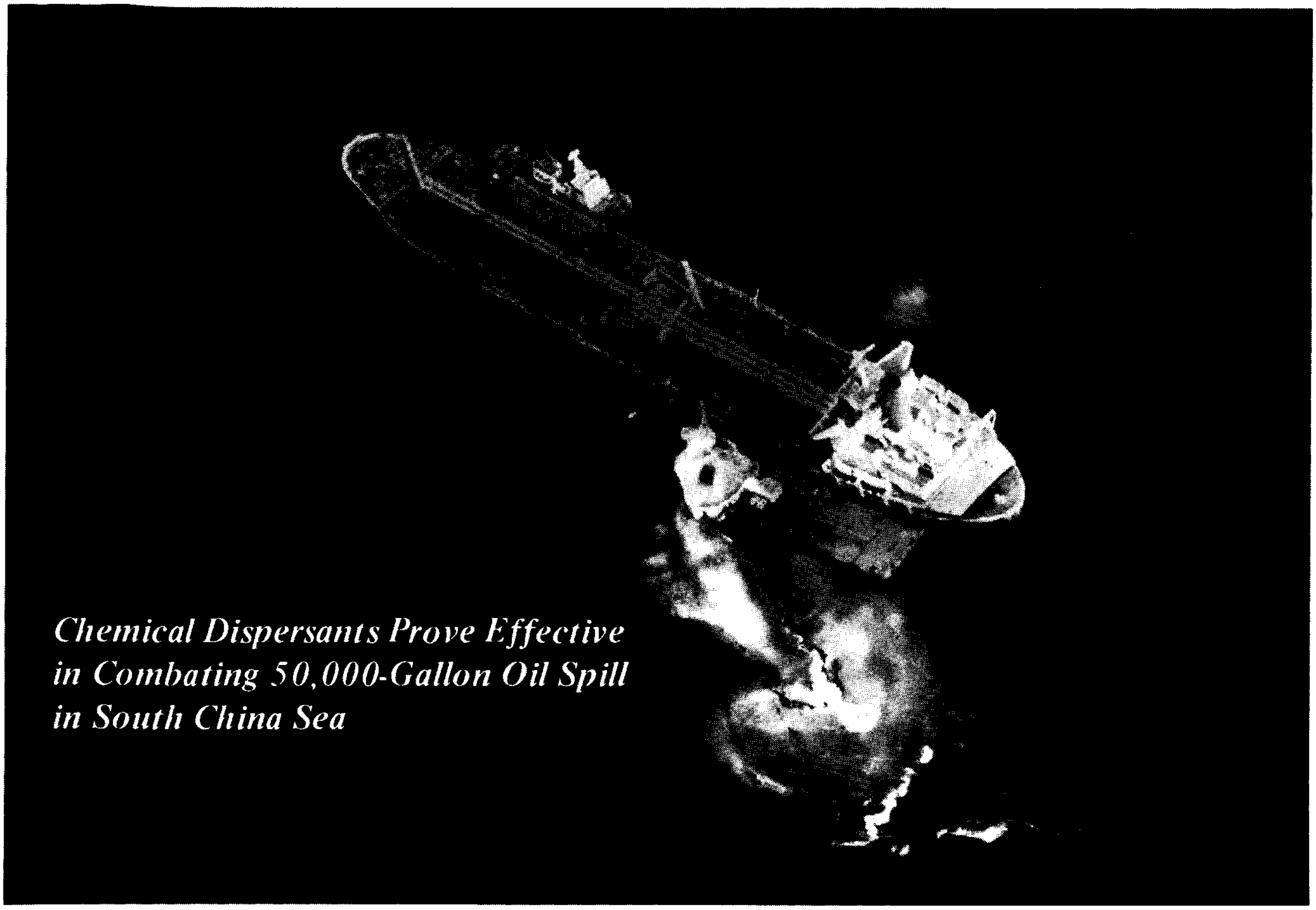
COMMANDER C.A. HARVEY

USS Ortolan Divers Participating:

HT1(DV) C. GOERLIC
EN1(DV) R. KUPKO
BM1(DV) W. DELANEY

Submarine Development Group One Divers Participating:

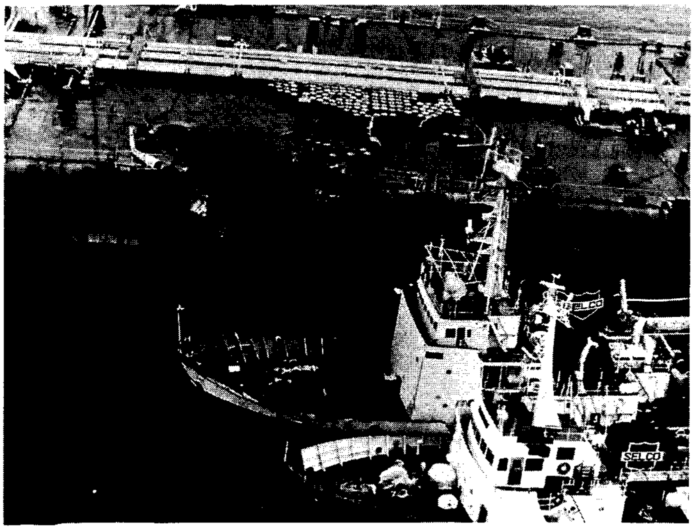
EM2(DV) S. SMITH
HT2(DV) S. BARLOW



Chemical Dispersants Prove Effective in Combating 50,000-Gallon Oil Spill in South China Sea

emergency off singapore

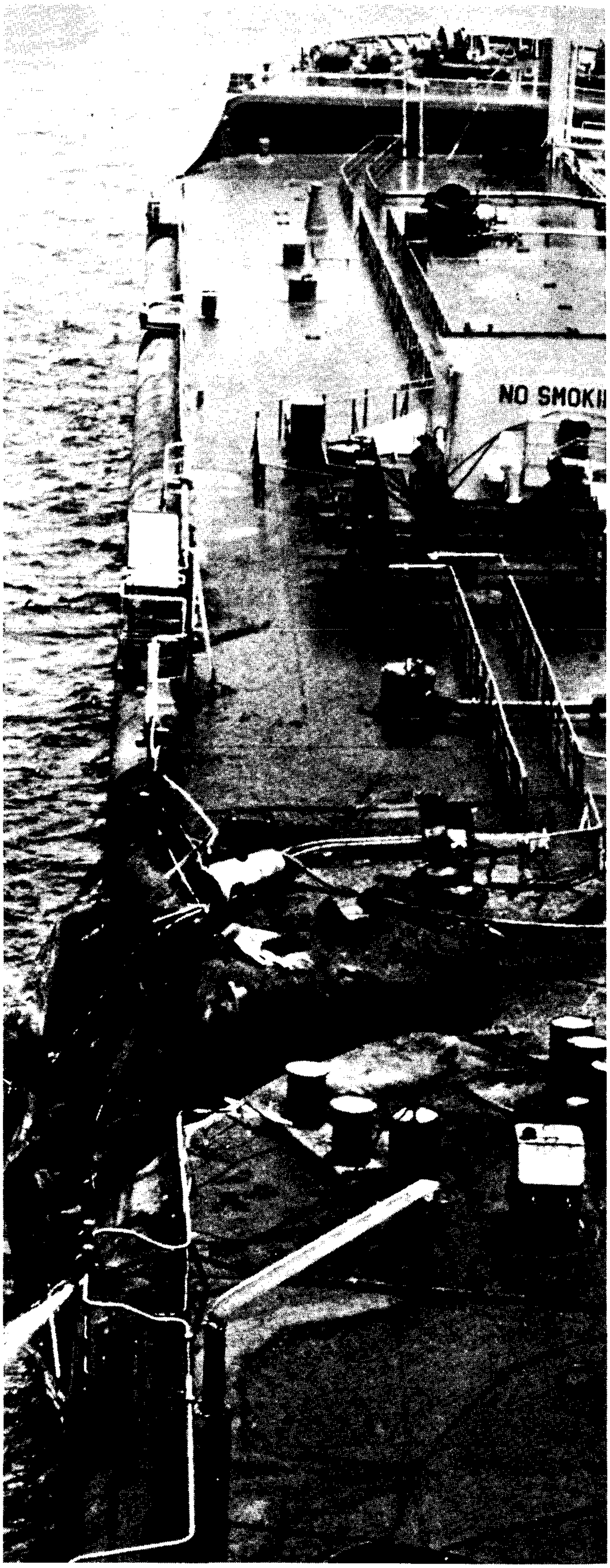
William A. Walker
Office of the Supervisor of Salvage



At 0645 on April 5, 1979, the Navy aircraft carrier *USS Ranger* (CV-61) and the 98,000-ton Taiwanese tanker *Fortune* collided in the South China Sea, approximately 40 miles east of Singapore. Both vessels sustained considerable structural damage, but *Ranger* was able to proceed under her own power to Subic Bay for repairs.

Before departing the scene, *Ranger* assigned one of her escort vessels to render emergency assistance to *Fortune*, which was dead in the water with a huge hole in the way of her number 4 and 5 port wing tanks. *Ranger* also radioed the Navy Office, Singapore, to arrange for emergency salvage tug support. The SUPSALV WESTPAC salvage contractor, Selco Pte., Ltd. (Singapore), was immediately tasked to render assistance and did so in a timely and professional manner. The subsequent salvage of *Fortune* included offloading the cargo of Kuwait crude oil and was performed by Selco for *Fortune*'s owners.

Collision with U.S. aircraft carrier Ranger *left a gash in* Fortune*'s port wing tanks. Resulting spill was quickly controlled by Navy-initiated clean-up efforts.*



From the beginning of the crisis, the Navy reasoned that abatement operations could not wait for the determination of responsibility for the collision: the spill was too close to the shores of three countries (Singapore, Malaysia, and Indonesia), there would be an enormous increase in cost to deal with the oil once ashore, and there was the unwelcomed potential for an international oil pollution incident. For these reasons, the Navy, without acknowledging responsibility for the collision, forehandedly initiated oil pollution abatement operations. Selco was tasked under Navy contract to combat the 50,000-barrel spill in accordance with local procedures and regulations. The Navy Office, Singapore, monitored the contractor's spill control effort pending the arrival of Mr. William A. Walker, pollution control operations specialist with the U.S. Navy Office of the Supervisor of Salvage.

Selco dispatched three small vessels equipped with drums of dispersant and portable dispersant spray equipment. Although the use of dispersants in U.S. waters is discouraged in favor of mechanical recovery, it is the primary spill control method in Singapore. The Selco dispersant vessels attacked the initial oil spill and remained in the area for several days to deal with the continuing discharge from the damaged tanker. The physical properties of the light crude oil and extremely warm seawater temperatures contributed to rapid dispersal of the spilled oil. In addition, the prevailing winds and seas carried the oil to the east, away from the Singapore/Malaysia/Indonesia land mass. The Navy/Selco pollution control effort was terminated on April 12, 1979.

The many valuable lessons learned from this operation will be discussed in a separate paper now in preparation by the Office of the Supervisor of Salvage.

The 57-foot fishing boat *Ruth Ellen*, which sank during a night of rough seas last November, was salvaged from the bottom of the shipping channel leading into Humboldt Bay off Eureka, California, by a Navy dive team in conjunction with the Army Corps of Engineers.

The Corps assumed responsibility for removing *Ruth Ellen* in mid-December, two weeks after the sinking, when the vessel was officially abandoned by its former owners. After the Corps requested assistance from the U.S. Navy Office of the Supervisor of Salvage (SUPSALV), a team of Navy divers from the SUPSALV West Coast Office, plus four EOD divers from the San Francisco area, arrived in Eureka to meet with Corps officials to study ways to salvage the 34-ton vessel.

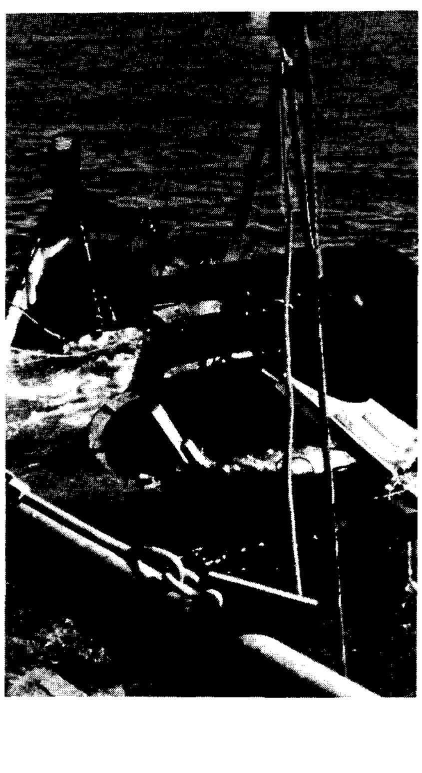
The dive team, headed by Senior Chief Boatswain's Mate H. T. Harper, proceeded to the salvage site with scuba equipment and UDATS, the Navy's underwater damage assessment television system.

Two divers, MMC(DV) Barber and FT1(DV) Taylor, descended down a buoy line which had been attached to *Ruth Ellen's* stern earlier by local divers. On the bottom, at a depth of 48 feet, the divers found the boat lying with a 20-degree list on its port side, with a 7-foot-long gash on the starboard side amidships. They also determined that the bow and stern were off the bottom sufficiently to emplace lifting slings. Divers TM1(DV) Scott and EN1(DV) Cannon confirmed this report on a follow-up dive.

On December 13, Master Diver Harper coordinated the contractual arrangements for necessary salvage equipment, including a 90-ton crane, barge, deck machinery, moorings, tugs and support people. The Navy dive team undertook responsibility for all underwater rigging and diving services.

The next five days of the salvage operation were lost to heavy weather. Winds up to 45 knots drove directly through the channel, creating 14-foot seas over the wreck site. But, by December 19, conditions improved enough to allow divers to make further assessments of damage and of the proposed lifting areas.

The salvage operation began in earnest after the Christmas holiday. On December 27, all personnel and equipment were on site, and the divers began placing lift straps in position. The aft "belly band" was led through the vessel's scupper (inboard out), down around the hull, above the shaft, around the keel, up the hull, and back in through the scupper, and both lift strap D-rings stopped off. The forward band was placed around the hull at the forward edge of the deck house, then nailed to prevent shifting. All four D-rings were married to a buoy line to maintain tension and positioning.



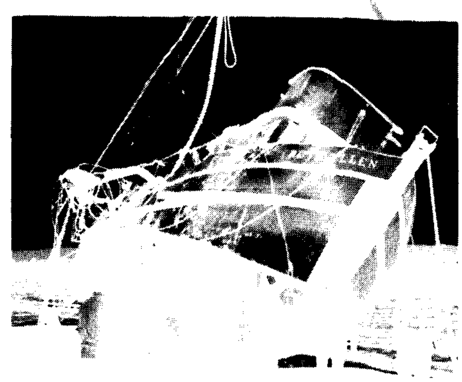
Next, the crane, which was placed in a 4-point moor above the wreck, lowered a spreader bar and balance beam into the water and the divers shackled-up the sling to the belly bands.

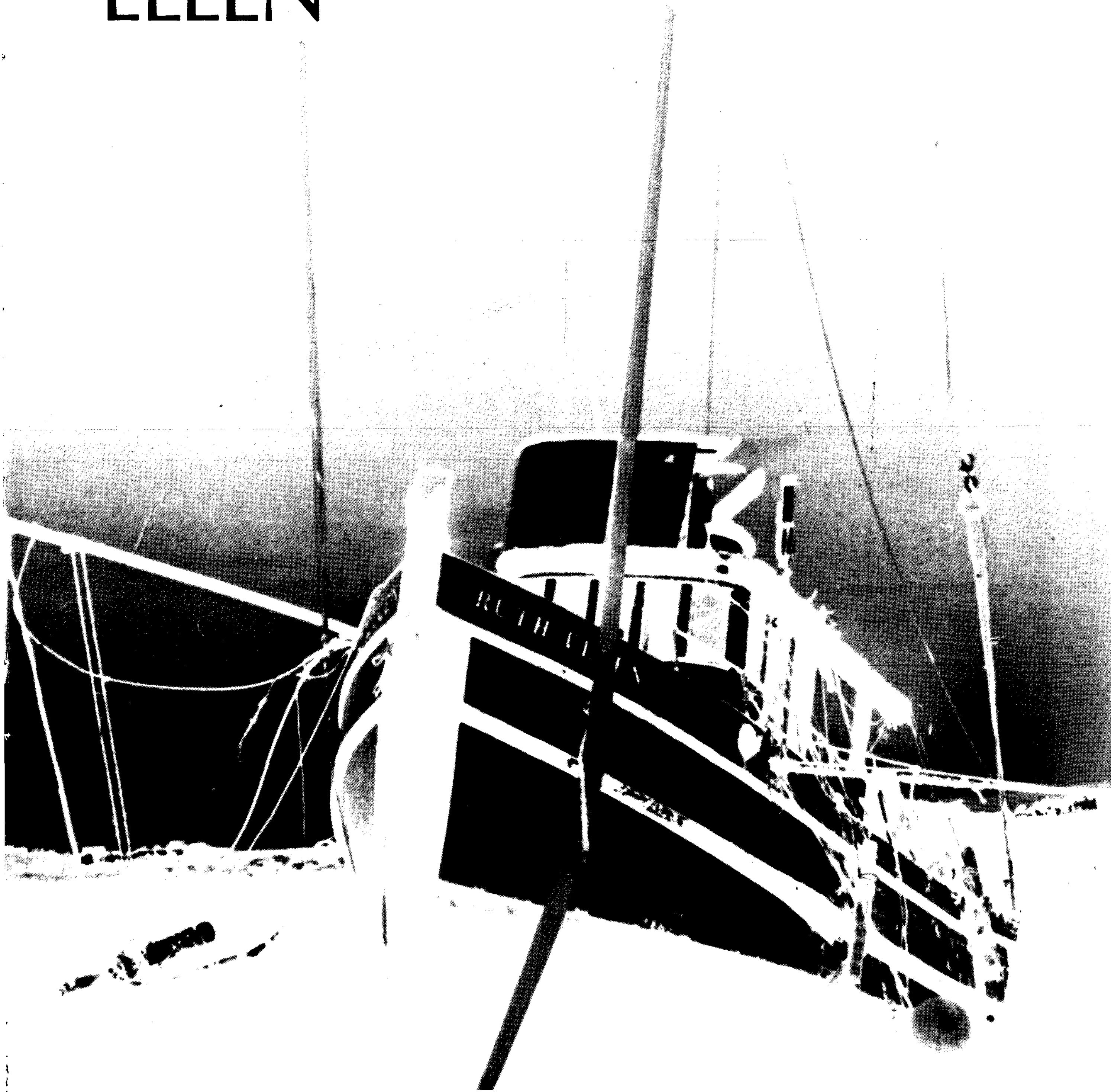
On December 29, at 10:55 A.M., after all connections were checked, the crane began lifting. Six minutes later, *Ruth Ellen* had broken the surface, and, by noon, had been transported to its designated beaching site inside Humboldt Bay.

Participating in the *Ruth Ellen* salvage were, from the SUPSALV West Coast Office: BMCS(MDV) H. T. Harper, MMC(DV) D. G. Barber, BMC(DV) A. C. Stephens, EN1(DV) R. D. Cannon, and GM2(DV) J. R. Fowler. From EOD Detachment Concord were MNCM(DV) F.C. Dull, and AO1(DV) D. D. Strohl, and from EOD Detachment Alameda, TM1(DV) D. C. Scott and FT1(DV) C. L. Taylor.

Divers rigged "belly bands" under the hull of the sunken vessel, and shackled to them a lift sling which was lowered by crane. Tension topside is reflected on the faces of Master Diver Harper (above, left) and TM1(DV) Scott (above) as the lift began, but within six minutes Ruth Ellen *was on the surface and en route to its beaching site (inset, right).*

SALVAGE OF THE RUTH ELLEN





Chief Cole in "Hot Water" Aboard Sweden's HMS Belos

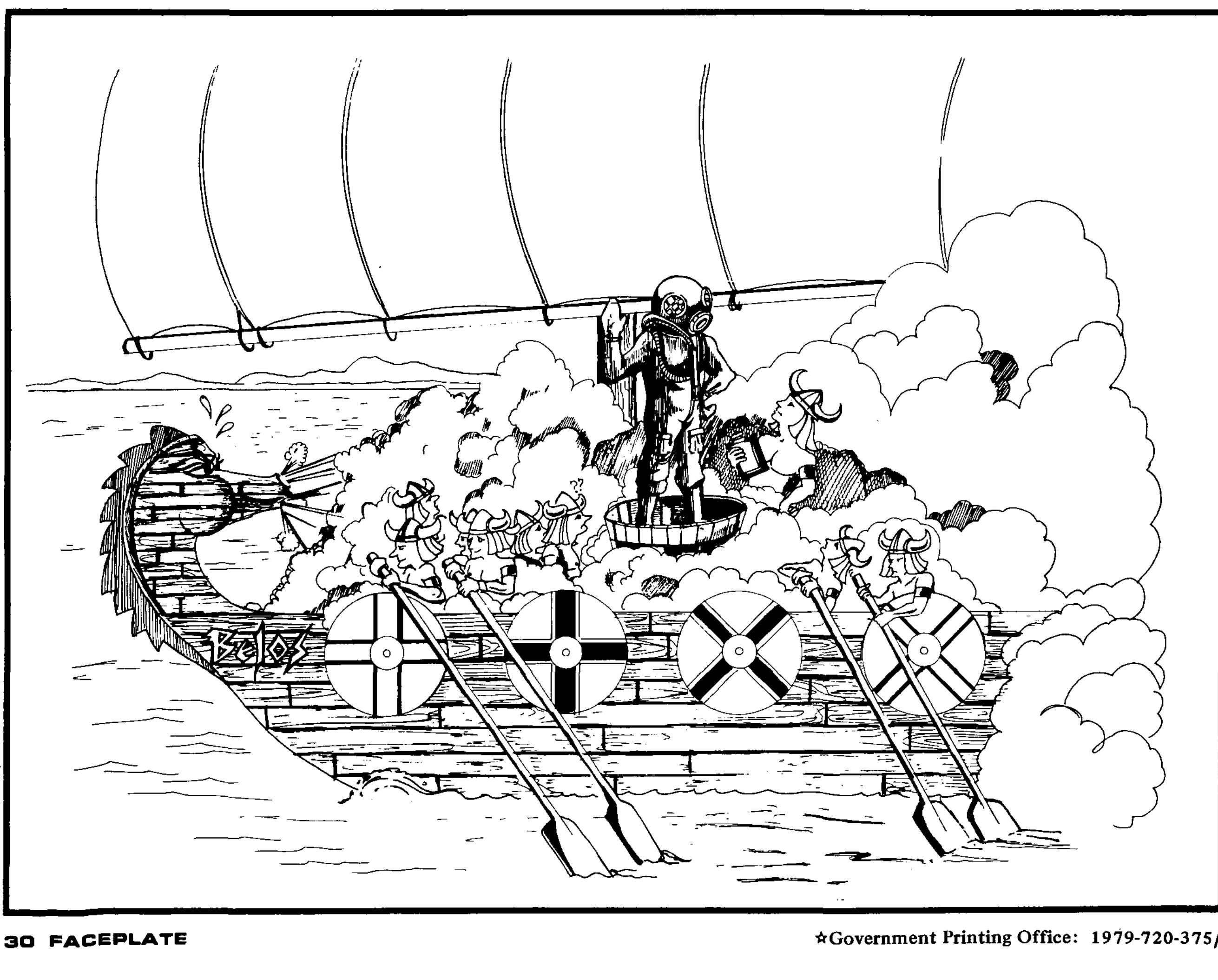
In what may be a first for the Navy's Personnel Exchange Program (PEP), a U.S. Navy chief petty officer has reenlisted aboard a foreign naval vessel. Late last year aboard the Royal Swedish Navy submarine rescue and diver training ship *HMS Belos*, homeported south of Stockholm, Sweden, Chief Electrician's Mate (DV) John Wellington Cole, USN, reenlisted in a ceremony presided over by Captain Jan Sundlof, RSN, Commanding Officer of *Belos*, and Captain Herbert E. Smetheram, USN, U.S. Naval Attache, Stockholm.

EMC Cole has served with the officers and crew of *Belos* since August 1977, doing both hard hat and free diving, training Swedish divers, and operating the decompression chamber which must be used to prevent pressure-related injuries to divers returning from extended periods at the bottom of the Baltic Sea. As is common for PEP tours, Chief Cole has also served short training tours aboard other Swedish navy units, most recently with the RSN icebreakers *Frej* and *Njord* operating in the northern Gulf of Bothnia from the Swedish port of Lulea.

After the reenlistment ceremony, Chief Cole said he counts the tour with the Royal Swedish Navy among the most challenging and interesting he has had since enlisting in 1956 from his home town of Port Huron, Michigan.

Despite some significant differences in diving equipment between the two navies, EMC Cole has mastered the Swedish techniques and says work is difficult but rewarding. He and his codivers cheerfully admit that they really appreciate one time-honored Swedish institution—the sauna (*Belos* has one onboard)—especially after a long dive in the frigid bottom waters of the Baltic.

If you have news of an unusual enlistment or reenlistment by a Navy diver, send the information and any photographs to *Faceplate*, Supervisor of Diving, NAVSEA-00C, Washington, D.C. 20362.



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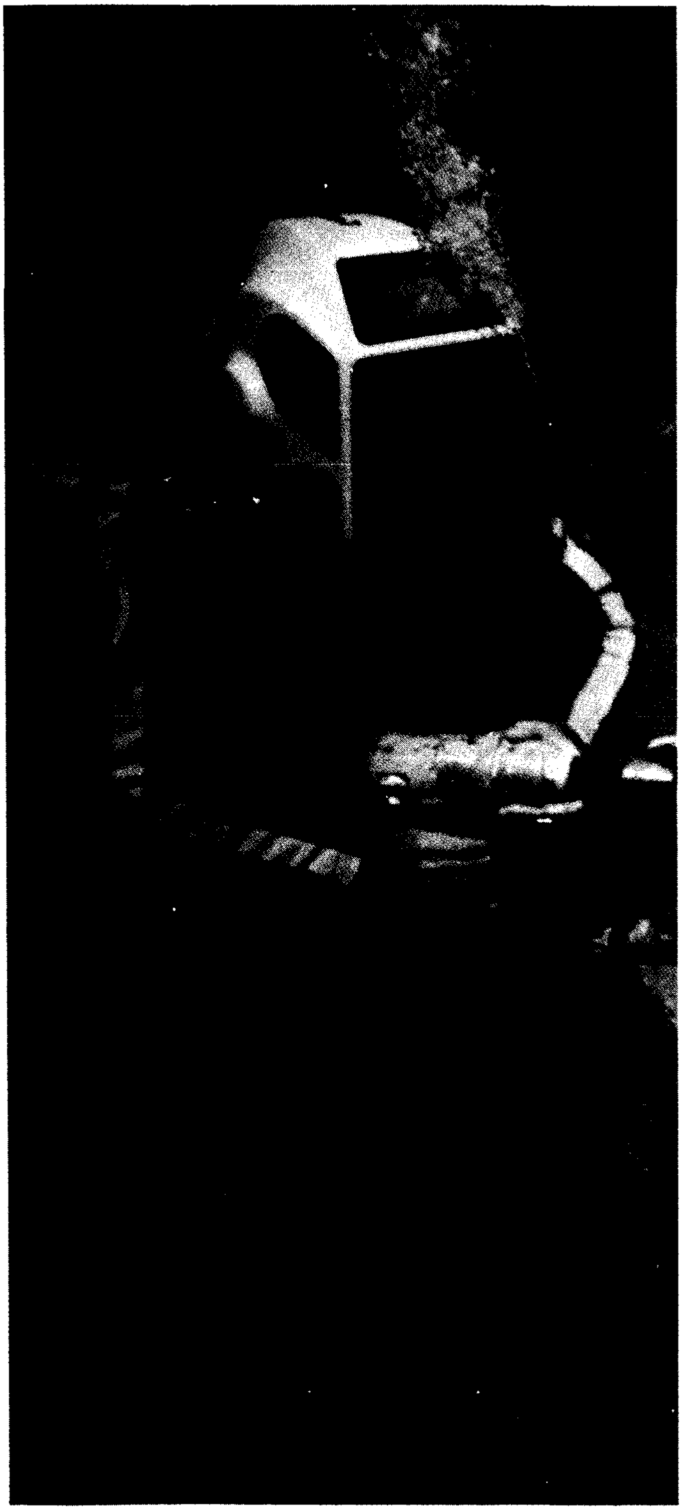
the old master

WANTED: YOUR INPUTS, YOUR QUESTIONS



Since taking over from Master Chief Tolley, writing this column has been the toughest part of the job. I hope that for future articles, I will be getting steady inputs from individuals throughout the Navy diving community. If there is an item you would like to have researched and discussed here, drop a short note or call me at Autovon 436-4351 or commercial (904) 234-4351. Just the subject of what you would like will be enough to get me going. I do not intend, nor do I feel it worthwhile, to write superfluous trivia or to be redundant in things that were written before, either here or in other publications. If I do happen to come across something of general interest, and feel that you may not have had access to it, I'll write it up in this column.

Even though we are pretty much saturation diving oriented here at NEDU, I personally cannot forget or detach myself from you in the salvage and repair side of the Community. In turn, you'll need to keep me informed about your activities, your questions, and your needs.

As you know from previous articles, we are presently working on the certification of a recompression chamber with a built-in scrubber, heat exchanger, single-valve supply and exhaust, and other updated, state-of-the-art gear. We are also building a mixed-gas, flyaway dive system. It has been and still is a hard row to hoe. I'm sure all of you out there have run the same course. Until we complete certification and all these new equipments are on the approved list, I would not recommend that you run out and buy any of these items. I want to encourage all of you who are now in the process of getting a system certified to work hard at it. The end will justify the means, and produce safer diving systems for the Navy.

I talked with the Supervisor of Diving recently and he informed me that The System Certification Procedures and Criteria Manual for Deep Submergence Systems (NAVMAT P-9290) of June 1976 will be rewritten this summer. He also indicated that I would sit on the rewrite team, so send any inputs you may have to me; all will be appreciated. This effort will produce a more useful document, and one we can more readily understand.

SUPDIVE also informed me that the Master Diver Notebook is being updated, and should be on the street shortly.

In closing, I'd like to urge you to keep up the good work in the field and keep it safe.

MMCM(MDV) A.J. PARFINSKY
Navy Experimental Diving Unit
Panama City, FL 32407

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