

Department of the Navy  
Navy Experimental Diving Unit  
Panama City, Florida 32407

NAVY EXPERIMENTAL DIVING UNIT

REPORT 1-77

PIONEERING INNER SPACE:


THE NAVY EXPERIMENTAL DIVING UNIT'S FIRST 50 YEARS

By:

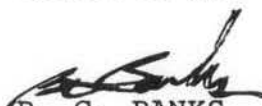
LT R. C. Carter, MSC, USN

Approved for public release; distribution unlimited.


Submitted by:

  
R. C. CARTER  
LT, MSC, USN  
Medical Department

Reviewed by:

  
B. C. BANKS  
LCDR, USN  
Executive Officer

Approved by:

  
C. A. BARTHOLOMEW  
CDR, USN  
Commanding Officer

## FOREWARD

This document is intended to present the record of progress in diving technology compiled by the U.S. Navy Experimental Diving Unit during the past 50 years.

It is not intended to be self adulatory, but rather is meant to communicate a sense of pride in a job well done, a job which has profound significance. No other diving institution can claim a more distinguished record of contribution to diving technology than that of the Navy Experimental Diving Unit.

This history was undertaken in 1977 as part of the commemoration of the golden anniversary of NEDU. The material used in the presentation is taken from interviews with numerous NEDU alumni, to whom I express my appreciation, and from the NEDU reports which give the details of most of the developments described herein. These reports are, of course, available to the public. This history is limited by their completeness, and by the accuracy of the memory of the people I interviewed. I hope that you find this history to be an enjoyable, informative chronicle.

## PIONEERING INNER SPACE:

### THE NAVY EXPERIMENTAL DIVING UNIT'S FIRST 50 YEARS

#### NOTE

The history of the Navy Experimental Diving Unit (NEDU) should be highlighted by the names of those who have been part of this exclusive organization of divers, medical men, and scientists. It would be impossible, however, to list all who have contributed so much to underwater technology. Nevertheless, they are the NEDU story.

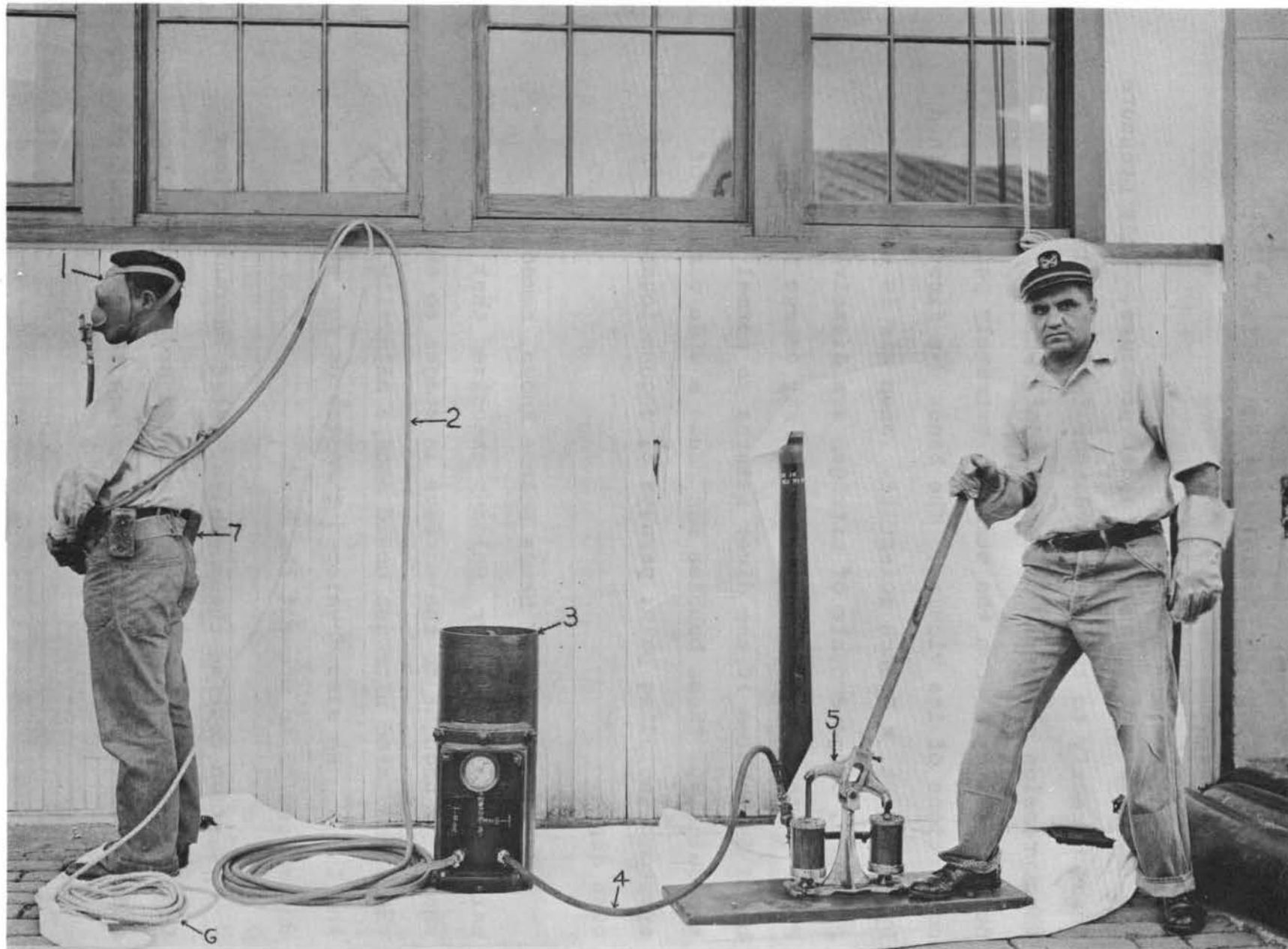
The U.S. Navy Experimental Diving Unit is observing its golden anniversary - 50 years of continuing progress in diving science and continuing dedication to its mission beneath the sea by men of courage and vision. The Unit is located in Panama City, Florida at a facility which contains the most advanced testing and diving equipment and houses the world's largest hyperbaric complex, where an ocean environment can be simulated to a maximum pressure of 1000 psi, or 2250 feet of seawater.

NEDU's mission is to support the fleet through development, test and evaluation of diving equipment and procedures. The fulfillment of this mission by NEDU has enabled operating forces to conduct diving, salvage and underwater swimming safely and effectively.

Not the least part of NEDU's mission is to maintain divers and logistic support ready at any moment to assist the fleet in rescue and salvage through the use of a dive system which can be transported by air to anywhere in the world. In addition, NEDU responds to requests for aid in military and civilian diving emergencies.

Although Navy diving operations were conducted for a long time before the inception of NEDU in 1927, divers received little formal training. During the early part of this century, a Navy diver was a Gunner's Mate whose only qualification as a diver was one 60-foot dive supported by a hand pump. All candidates for advancement to Gunner's Mate had to pass this ordeal, and little more was expected of them than an occasional dive to inspect a ship's hull or rudder.

Before 1920, most Navy diving activity was confined to a small group under the direction of Chief Warrant Officer George D. Stillson, a Gunner, at the Brooklyn Navy Yard and on the USS Walkie on Long Island Sound. Chief Warrant Officer Stillson was aware of the inefficiency and the lack of equipment in the U.S. Navy diving community and, at the same time, was familiar with the diving experience and experiments of the Europeans. He undertook a program to test the new methods of stage



Divers using a handpump and surface supported diving equipment similar to that used at the turn of the century.

decompression and time tables of ascent to the surface developed by Scottish physiologist and medical doctor John S. Haldane.

A diver must breathe gas under pressure. This pressure leads directly to the gravest danger faced by divers, decompression sickness, or the "bends", which derived its name from the strange, extremely painful contortions of its victims. The bends was first explained by Paul Bert, a French scientist. When air is under pressure, large amounts of nitrogen are dissolved in a diver's bloodstream and tissues and may emerge in the blood as bubbles if the diver returns to normal pressure too quickly. These bubbles can cause a wide variety of symptoms including pain, paralysis, unconsciousness, and even death.

When the cause of bends became known, remedies naturally followed. Dr. Haldane theorized that a diver should be brought to the surface in stages so that the accumulated nitrogen could escape naturally through the lungs. He also developed time tables for stage decompression to prevent the bends.

Besides testing these tables, Chief Warrant Officer Stillson and his group began a related program to develop standardized diving dress. By 1915, through the efforts of this small

group, an up-to-date diving manual was published and a new diving dress was adopted. This diving dress was the forerunner of the MK V Deep Sea Diving Outfit which has been the standard U.S. Navy diving dress for many years. A diving school, too, was begun at Newport, Rhode Island (this school was disbanded during World War I). Chief Warrant Officer Stillson's group more than quadrupled the maximum diving depth of U.S. Navy divers, which until this time had been limited to 60 feet.

In 1915, Stillson's group was sent to Honolulu to assist in the salvage of the F-4 submarine, which had sunk in 304 feet of water. One dive was accomplished to this depth and successful working dives were made to 204 feet during the salvage of the F-4. However, during these dives, the divers experienced severe mental impairment which prevented them from working effectively. As these problems were attributed to breathing compressed air, new breathing media were contemplated. Helium was tried, at the suggestion of a representative of the U.S. Bureau of Mines, which had huge reserves of the inert gas. The helium was combined with oxygen for use as an experimental breathing medium. It was hypothesized that this new breathing medium would shorten decompression as well as eliminate the rapture of the deep. Testing and research on helium-oxygen mixtures



progressed rapidly under the direction of another Warrant Gunner, C. L. Tibbals, who became the chief proponent of Navy diving when Chief Warrant Officer Stillson retired from the Navy following the salvage of the F-4.

The sinking of two more submarines, the S-51 in 1925 and the S-4 in 1927, with their attendant loss of life, tragically demonstrated the need for adequate procedures, trained divers, and specialized equipment for rescue operations.

The first response to this need was the establishment of the Navy Experimental Diving Unit as a permanent activity in 1927. The Experimental Diving Unit centralized all Navy diving-related research and activity in the Navy Gun Factory at Washington, D.C. Soon afterward, the Navy School of Diving was activated adjacent to NEDU under a separate command. The Navy School of Diving (NSDS) and its location were recommended by Captain Ernest King (later Fleet Admiral) so that the diving technology developed by NEDU could be rapidly incorporated into training procedures at the Navy School of Diving and Salvage. This close relationship between NSDS and NEDU continues today.





Standard Diving Dress in 1935

Submarine escape and rescue, of course, became the first objective of NEDU. CWO Tibbals was joined by LT C. B. Momsen and LCDR A. R. McCann and soon submarine escape devices, called the Momsen lung and McCann bell, became available. The Momsen lung was an air bag that provided breathing air for a submariner escaping from a sunken submarine. The McCann bell was a dry capsule which could mate with a submarine escape hatch, and then shuttle the crew to the surface.

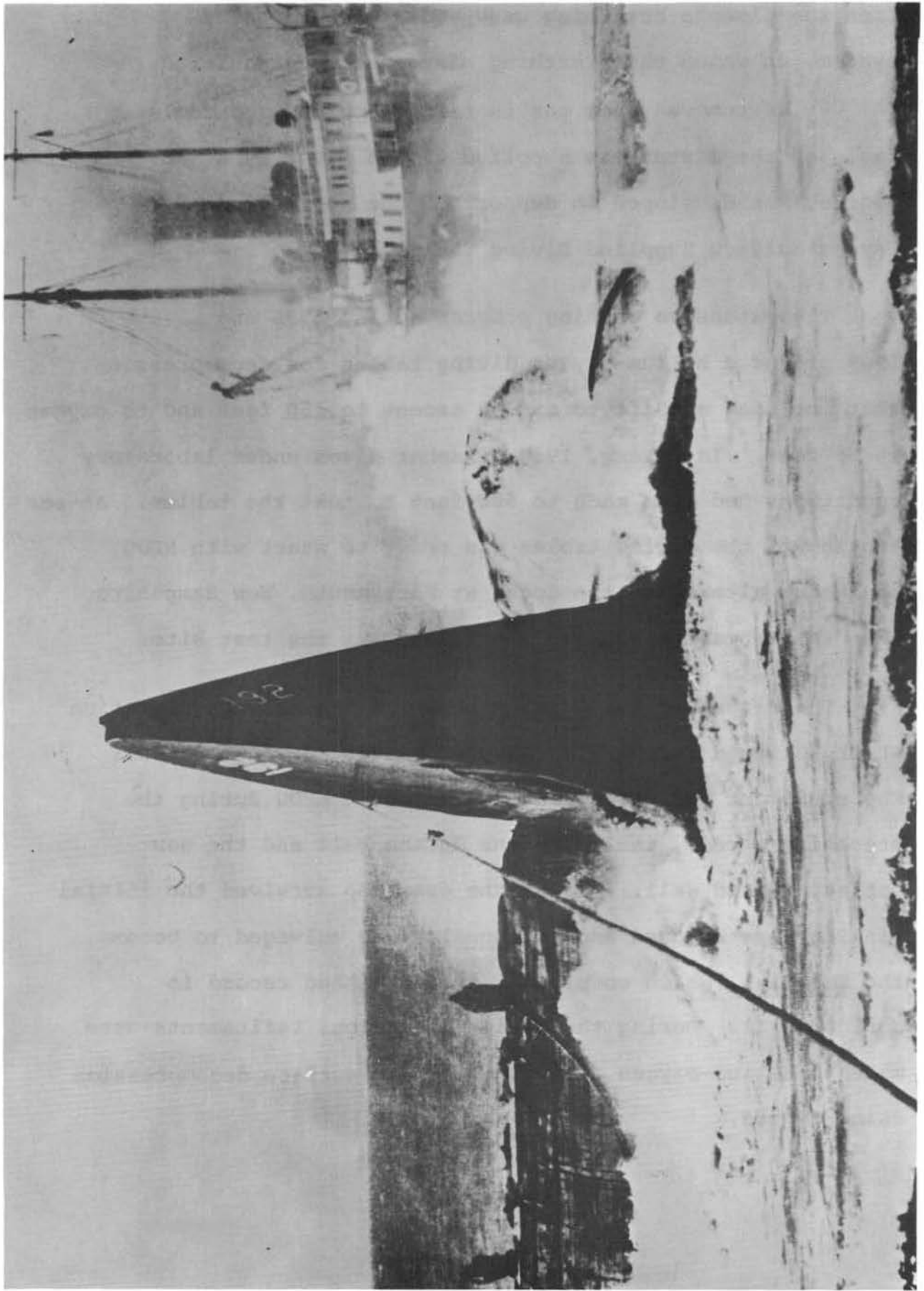
NEDU engaged in a lengthy and painstaking test program to collect data that would determine how long submarine escape by free ascent could take from various depths without causing decompression sickness. First, divers stayed at a particular depth for a short time before returning to the surface. The diver's length of stay on the bottom before his ascent to the surface was gradually extended until the diver exhibited symptoms of the bends. The depth was then increased and the entire process repeated until a table evolved which prescribes maximum bottom time for safe ascent from depths shallower than 200 feet. Somehow this table was filed in an attic at NEDU and remained out of use for five more years. When these data were finally rediscovered, they became the basis for present No-Decompression Limits (continuous ascent) Tables used by the U.S. Navy and commercial and sport divers around the world.

In the mid 1930's, three Navy doctors, C. W. Schilling, A. R. Behnke, and O. E. Van der Aue, became the first medical staff at NEDU. These men, working with divers of the Unit, demonstrated the advantages of oxygen at 40 to 60 feet in treating the bends and developed surface decompression tables using air for submarine escapees who had overstayed their no-decompression times. It was this group, too, who proved conclusively that high pressure air reduces a diver's mental and physical capabilities, compared with sea level performance. Because of this, and the (mistaken) impression that the use of helium-oxygen rather than air as the diver's breathing mixture would shorten decompression, a program of development was begun in the late 1930's on diving using helium mixed with oxygen. This program adapted the experimental helium-oxygen breathing media, developed by CWO Tibbals years earlier, to deep sea diving.

The development of the helium-oxygen surface supplied decompression table necessitated a revolution in diving equipment. The diving dress was modified to include electric heating, and more weight was added to the divers' boots. The Mark V diving rig was modified to include a venturi system for removing carbon dioxide



NEDU Crew, 9 August 1938. This is the crew which developed the Helium-Oxygen Surface-Supplied Decompression Tables. This picture includes Chief Machinist's Mate William Badders (fifth from left in front row), who was awarded a honor in 1940 for his role in the salvage and rescue of Squalus. The other Medal of Honor winners were Chief Boatswain's Mate Orson L. Crandall, Chief Metalsmith James Harper McDonald, and Torpedoman (first class) John Mihalowski.



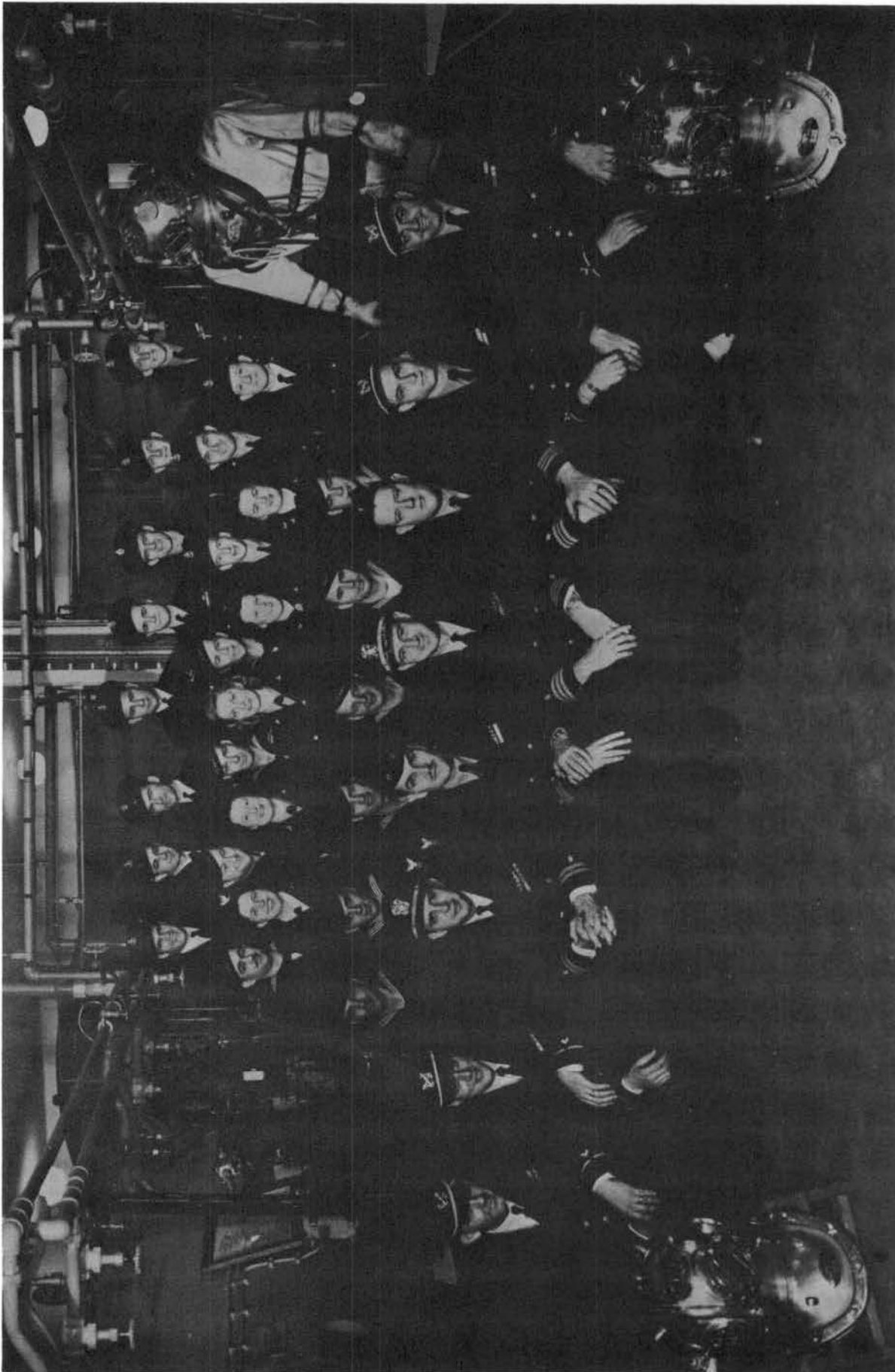
USS Squalus (SS 192 ) Broaching After A Salvage Lift.



from the diver's breathing gas. This unprecedented system, in which the breathing mixture is recirculated, the CO<sub>2</sub> is removed, new gas is mixed with the recirculated gas, and the mixture is supplied to the diver by a jet nozzle, was developed in support of the new Helium-Oxygen Surface Supplied Diving Tables.

The extensive testing program during 1938 and 1939 produced helium-oxygen diving tables for decompression that included a shift to air on ascent to 150 feet and to oxygen at 66 feet. In Spring, 1939, chamber dives under laboratory conditions had been made to 500 feet to test the tables. At-sea testing of the diving tables was ready to start with NEDU equipment already on the docks at Portsmouth, New Hampshire when the submarine Squalus sank almost at the test site.

The rescue of the Squalus crew and the salvage operation which followed is the U.S. Navy's greatest diving success. The equipment and procedures developed at NEDU during the preceding decade, including the McCann bell and the new tables, worked well. All of the crew who survived the initial sinking were rescued and the Squalus was salvaged to become the Sailfish, which compiled a distinguished record in World War II. During the diving operation, refinements were made in helium-oxygen diving, including surface decompression using oxygen.

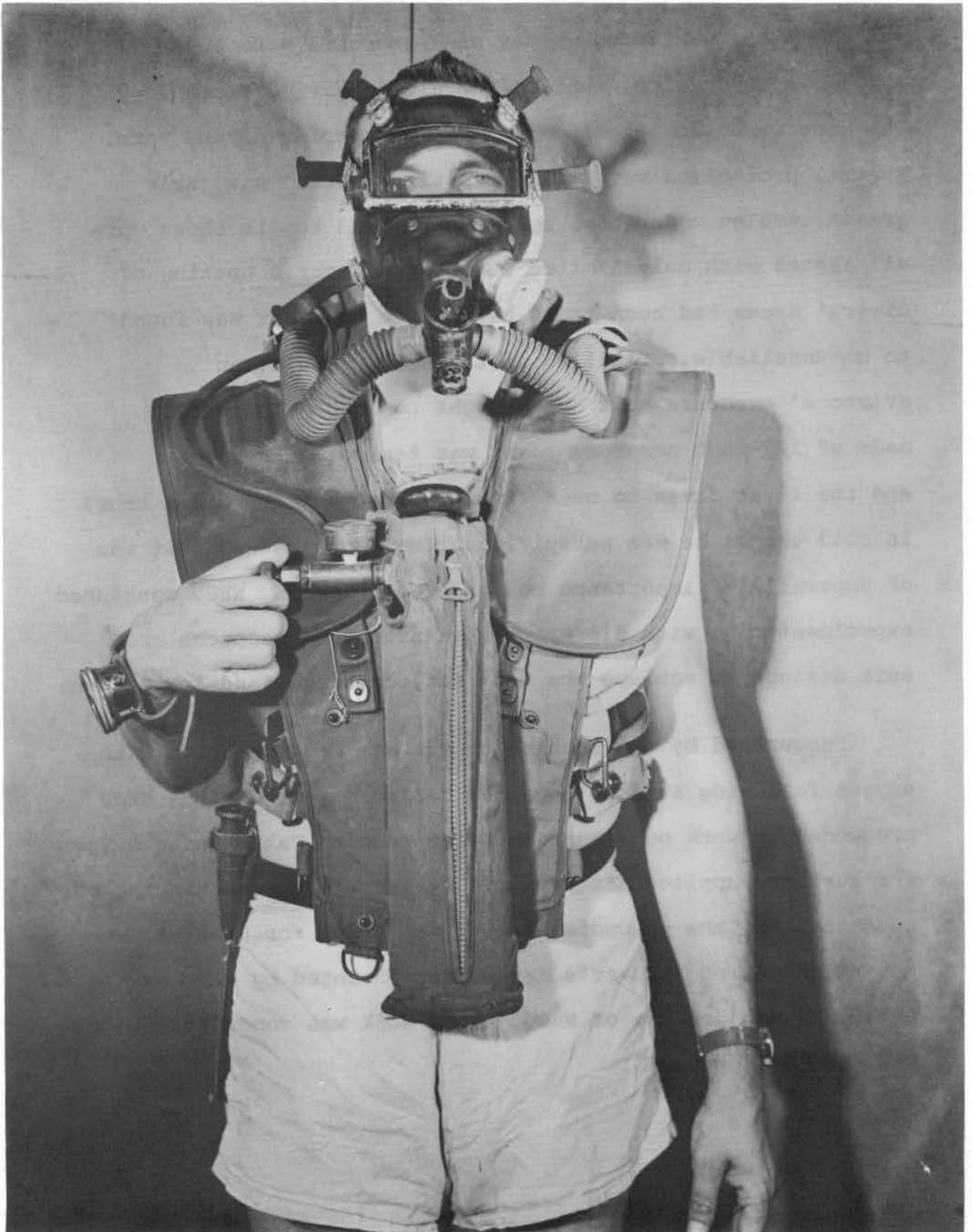


CREW OF THE NAVY EXPERIMENTAL DIVING UNIT 1944



In the late 1930's, active participation of the United States in World War II was imminent. However, no equipment was available for combat swimmers except for a closed circuit oxygen scuba (self-contained underwater breathing apparatus) invented by a young medical student, Christian Lambertsen. The Momsen lung was also adapted for scuba use. Protection from the cold was the factor which limited the use of scuba, though, as scuba divers relied on a thick coat of grease or beeswax for insulation.

Experience with oxygen scuba emphasized the importance of oxygen toxicity. This was investigated at NEDU during the war years, along with the seemingly unrelated field of aviation physiology. The advent of high performance aircraft had enabled aviators to ascend too high too fast; altitude bends made its debut. Because of NEDU's experience with the use of oxygen and the causes and treatment of bends, the testing of pilots' pressure suits and breathing apparatus became an NEDU project. NEDU work also included salvage within the United States, evaluation of captured enemy diving equipment and development of the Kapok life jacket. One of the greatest changes, however, was in personnel - women (WAVES) were assigned to NEDU.

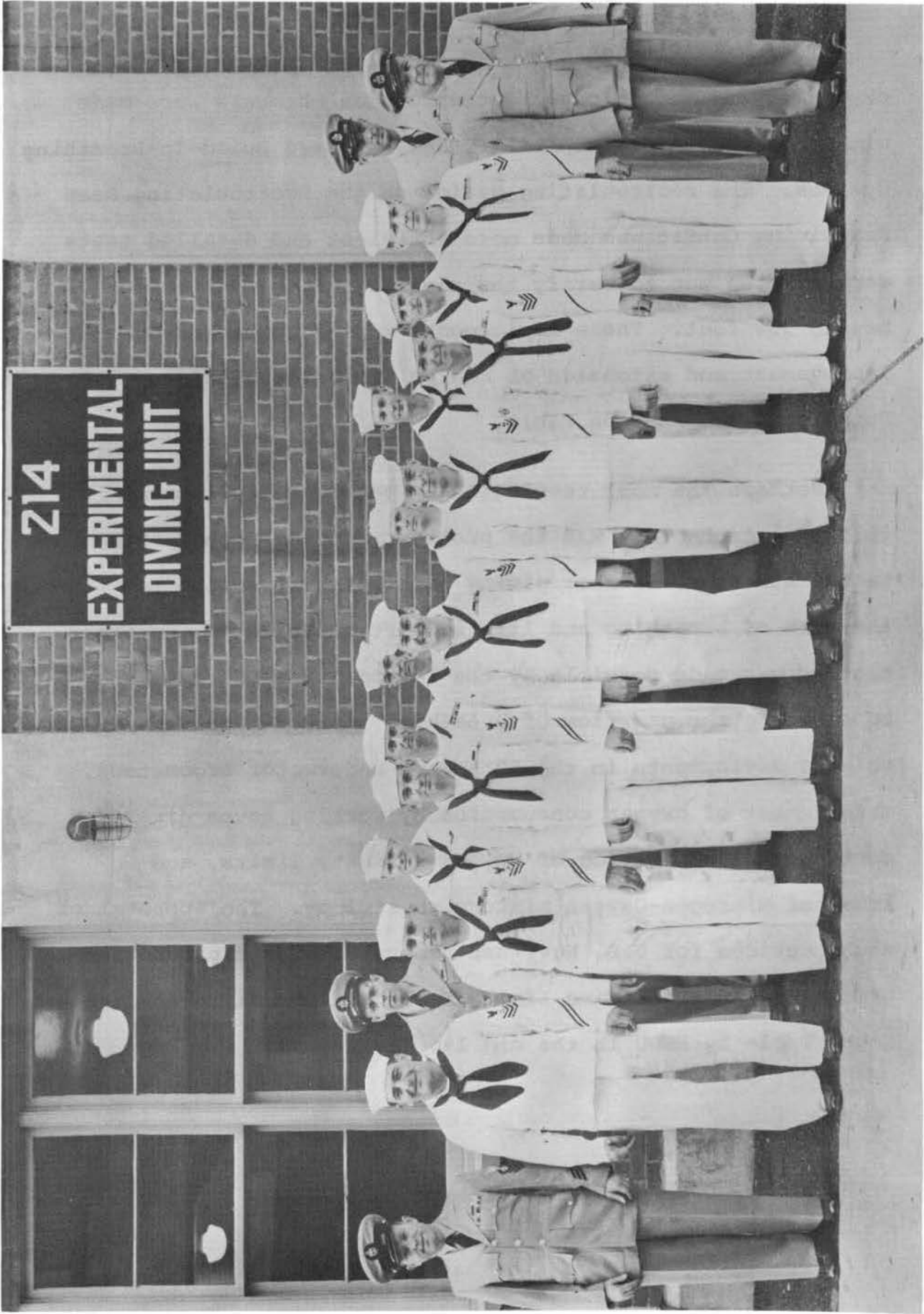


Scuba Developed By C. J. Lambertsen.

Circa 1940

When the war ended, money and personnel were again available to develop, test, and evaluate diving technology. The most immediate problem was that of keeping divers warm. Thermal protection was still primitive: bees' wax, axle grease, woolen underwear, nylon suits, and tennis shoes were all tested with only limited success. Electric heating of divers' dress had been tried before the war, but was found to be unreliable. Finally, in the early 1950's, an aviators' exposure suit was brought to NEDU. The suit, made of 1/2-inch neoprene foam, was tested in icewater and the first diver to wear it was elated - after 1 1/2 hours in cold water, he was perspiring! The neoprene wet suit was of unparalleled importance to the free swimmer. NEDU continued experimentation with different thicknesses of neoprene and suit designs to achieve the best fit, coverage, and insulation.

Encouraged by the success of surface decompression with oxygen following surface supplied helium-oxygen diving, NEDU proceeded to work on a Surface Decompression Table using Oxygen for surface supplied air diving. During the at-sea testing of these tables, the pneumofathometer, a device for precise determination of a diver's depth, was invented by Dr. O. E. Van der Aue of NEDU. This work was conducted between 1944 and 1951.

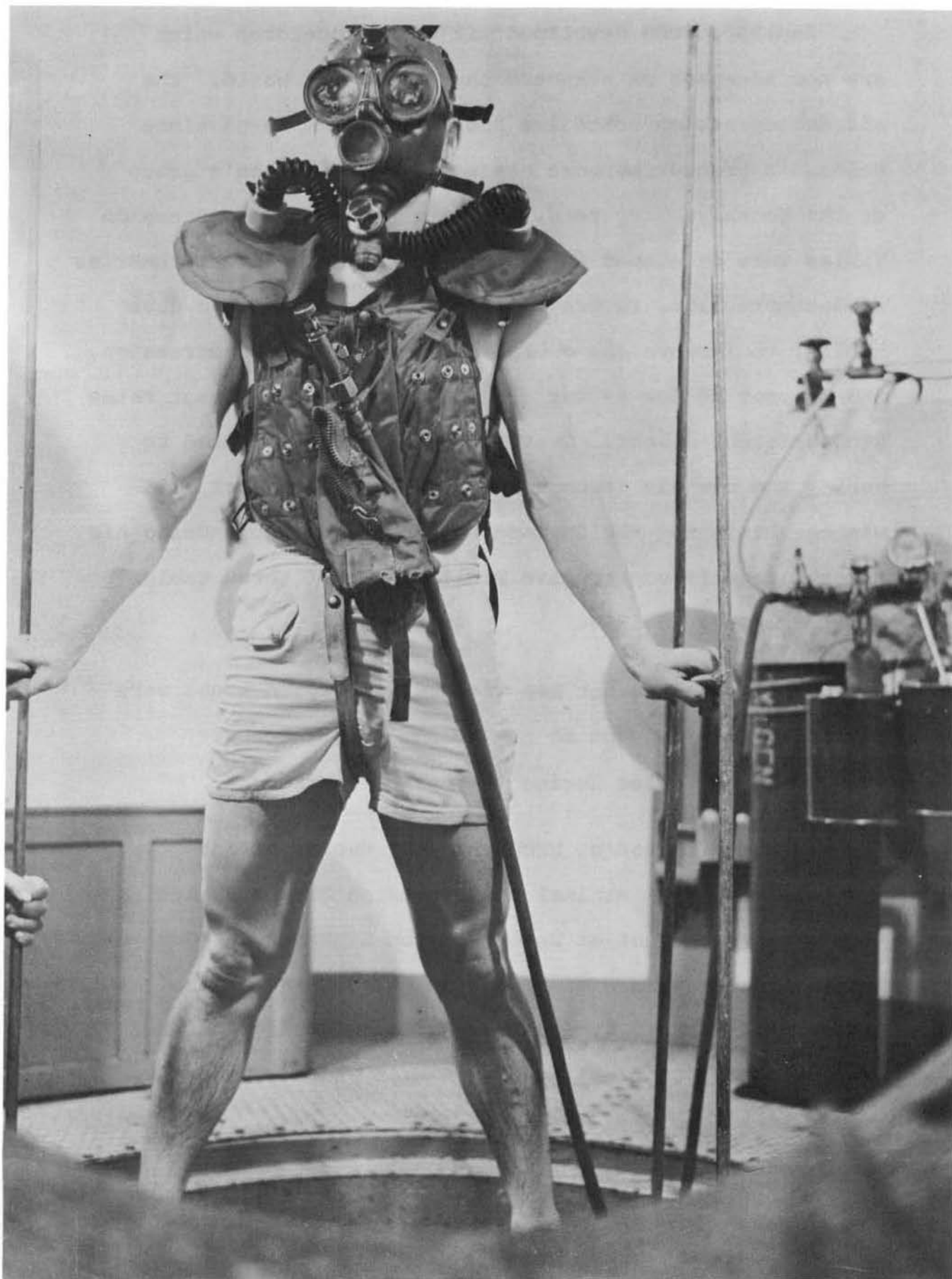


AN NEDU CREW FROM THE 1950'S

The early fifties also saw rapid advances in helium-oxygen diving technology. Recompression chambers were made with increased depth capability and improved Build-In-Breathing systems. The recirculating device on the Recirculating Deep Sea Diving Outfit was made more efficient and detailed tests were carried out to verify the adequacy of the device for diving beyond 330 feet. These developments were accompanied by improvement and extension of the Helium-Oxygen Surface Supplied Decompression Table.

Perhaps the most revolutionary post-war development in diving technology was the proliferation of scuba. NEDU tested scores of devices giving particular attention to the work of breathing and life support capability. Unmanned testing was made possible by the introduction of a machine to simulate the gas flow of breathing in 1958. Scuba-related developments in the 50's were underwater ergometers, measurement of oxygen consumption by working scuba divers, continued investigation of oxygen toxicity limits, and study of Nitrogen-Oxygen mixture physiology. The approval of scuba devices for U.S. Navy use necessitated the production of the Oxygen Depth-Time Limits Table and the Nitrogen-Oxygen Scuba Table by NEDU in the mid 1950's.





Oxygen Scuba Tested at NEDU in The 1950's.

In 1956, NEDU developed air dive procedures which are now accepted as standard throughout the world. The air decompression schedules had not been improved since Haldane's procedures were tested by CWO Stillson's group at the Brooklyn Navy Yard. New Standard Air Decompression Tables were developed in 1956 to reflect the latest theories of decompression, to provide a basis for repetitive dive tables, to improve the overall safety of air decompression, and to provide for faster (60 feet per minute) ascent rates used by scuba divers. Over 600 dives were conducted to verify the new air decompression table. This work also was the basis for the Surface Decompression Table Using Air, and the Repetitive Air Dive Tables. All of these tables were published in 1957.

Similar tables for use with helium-oxygen scuba were developed from concept to the Helium-Oxygen Scuba Decompression Tables during the next 8 years.

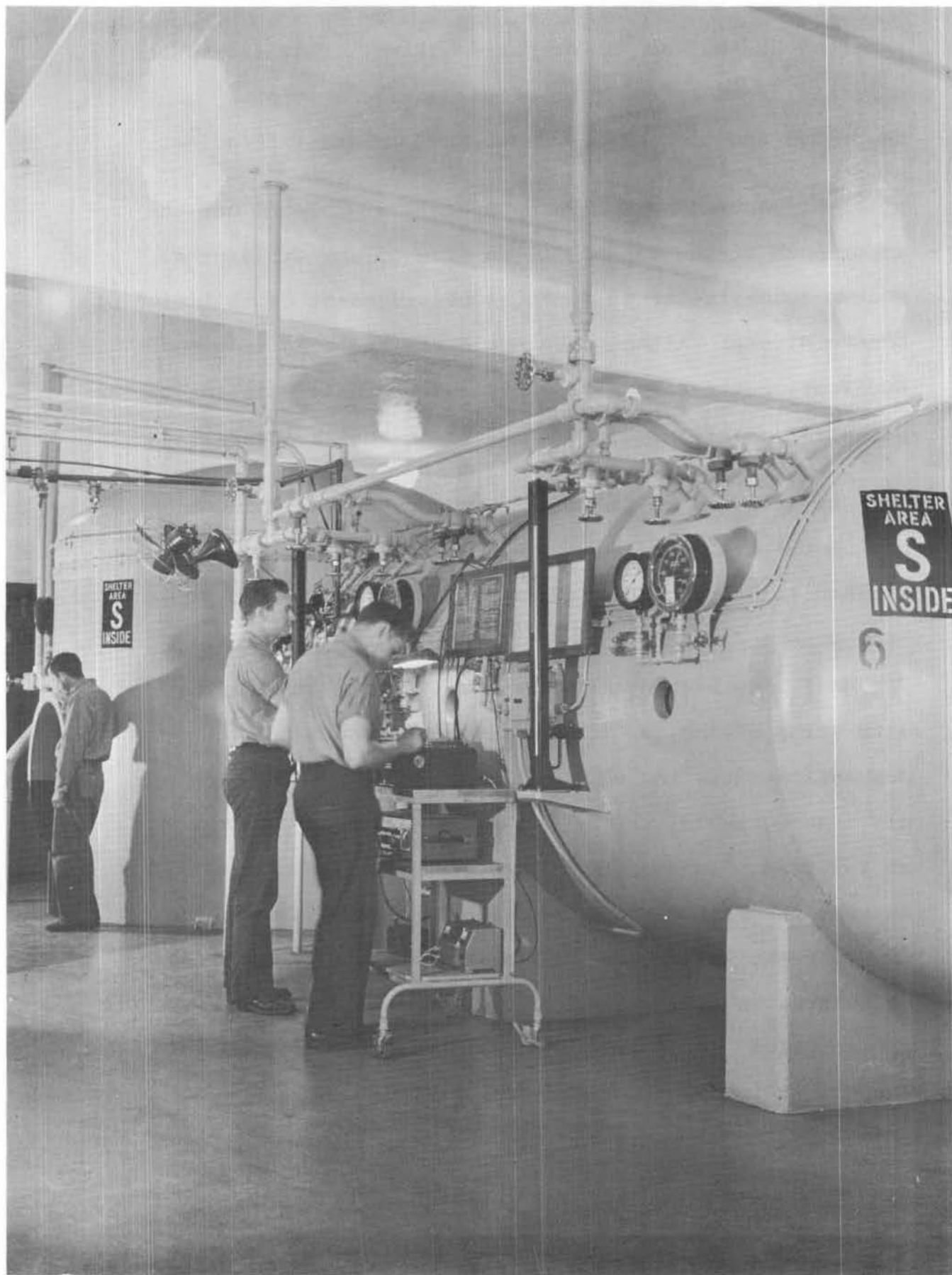
In the mid 1960's, NEDU produced two important treatment tables: Minimal Recompression Oxygen Breathing Method for Treatment of Decompression Sickness and Gas Embolism, better known as Table 5 and Table 6. These tables are in the U.S. Navy Diving Manual today and are the standards for treating divers everywhere who display



symptoms of the "bends" or gas embolism. They are the culmination of a tradition of oxygen therapy for decompression sickness begun at NEDU in the 1930's.

The sinking of the Thresher in 1962 pointed out the importance of the capability to dive to abyssal depths. Modern submarine crush depth exceeds descent capabilities of bounce divers. Although bounce dives had been made to 600 feet, saturation diving offered the only solution to the potential problem of modern submarine rescue and salvage.

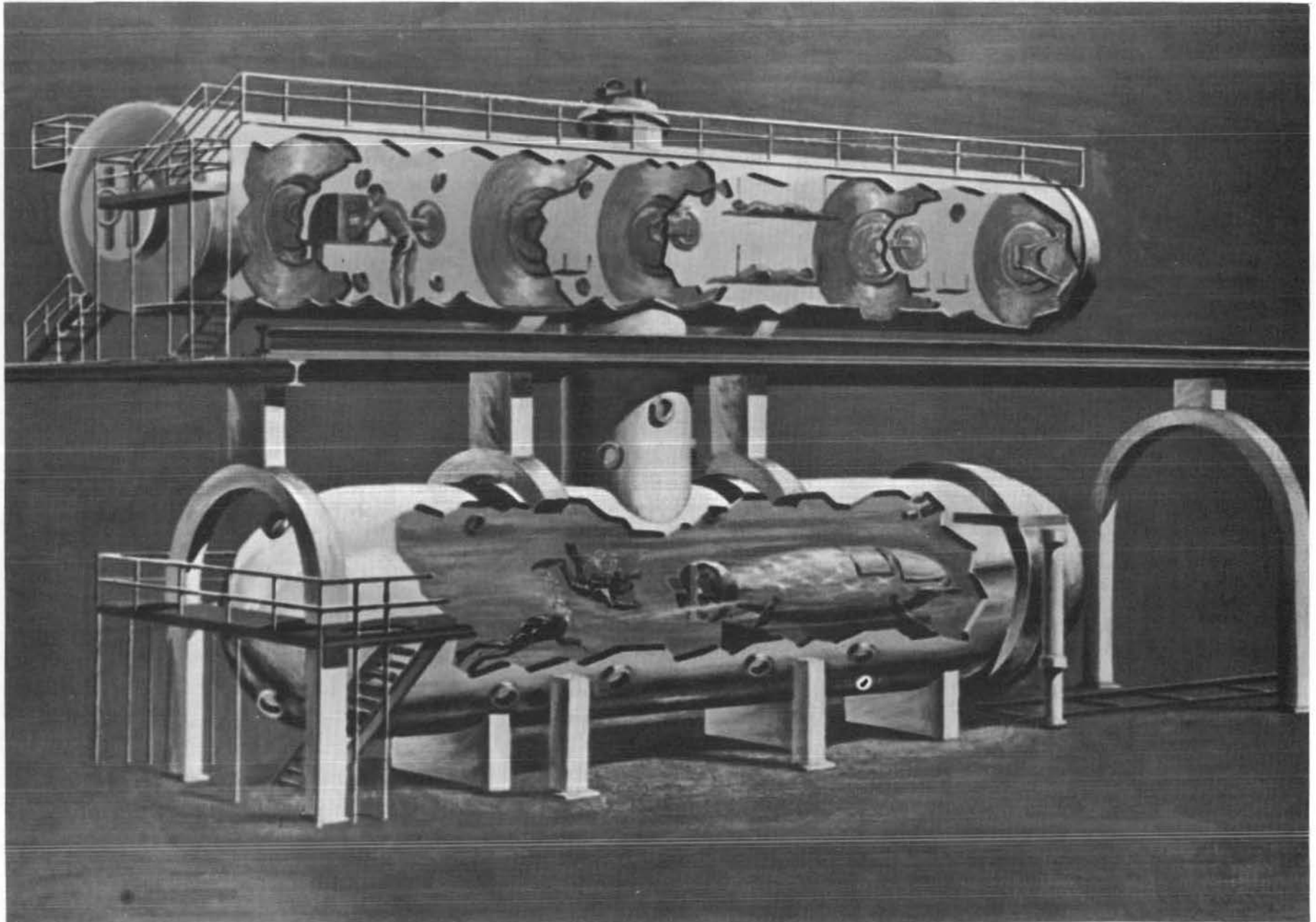
By 1969, three Sealabs, which proved the concept of man-in-the-sea using saturation diving techniques, had been trained and supported by NEDU, and saturation decompression tables were developed for the MK 1 Deep Dive System. The MK 1 Deep Dive System was a major step forward in saturation diving, as it was the most advanced and sophisticated in the world. Completely portable and air transportable, the MK 1 could operate for 14 days at 850 feet. In conjunction with Duke University, two saturation dives were conducted, one to 1000 feet and one to 600 feet, to disclose and evaluate the medical effects of saturation diving. Other developments included cryogenic gas supplies, methods of heating divers' suits, and life support equipment for saturation diving.



NEDU Diving Facility in The Washington Navy Yard.

From these beginnings, saturation diving progressed steadily at NEDU. Unlimited Duration Excursion Tables, which enhanced the vertical mobility of saturation divers, were devised and tested in the early 1970's. With these tables, a diver can safely make excursions from his support facility either up or down to accomplish work at various depths.

International cooperation has been a keynote of the NEDU story during the last decade. In 1968 representatives of the United States and Royal Navies met to revitalize their information exchange program to prevent duplication of effort and to expedite development of diving technology. An important part of this program is the exchange of officers between NEDU and the Admiralty Experimental Diving Unit (AEDU) in Portsmouth, England. In 1971, a joint NEDU-AEDU saturation dive to 1000 feet was conducted at AEDU. This dive demonstrated the feasibility of using electronically controlled closed circuit breathing apparatus for diving at 1000 feet in cold water. NEDU has also been an instrument for U.S.-Canadian information exchange on diving matters. Cooperative projects have included manned testing of Canadian diving equipment by Canadian divers at NEDU and recertification of the Canadian Submersible Diver Lockout (SDL-1) minisubmarine in the NEDU hyperbaric facility.



World's Largest Hyperbaric Facility, Operated by NEDU at Panama City, Florida.

The early 1970's were highlighted by a number of other tests and accomplishments, including the first all-Navy 1000-foot dive. On this dive, results of a respiratory heat-loss study proved conclusively that heat loss through a diver's respiratory tract can be significant enough to cause great danger even when the skin is warm. In 1973, NEDU divers using the facilities of Taylor Diving and Salvage Company in New Orleans, accomplished a 1600-foot saturation dive, demonstrating that a man could stay and work in water at extreme depths for long periods of time without adverse effects.

By the mid 1970's, NEDU had outgrown its quarters in the Washington Navy Yard and in 1975 moved to the world's largest hyperbaric complex, located at Panama City, Florida. Since then, Panama City has become a center of diving excellence due to the combined efforts of the Navy Experimental Diving Unit and the Naval Coastal Systems Laboratory. They will be joined in 1979 by the Navy School of Diving and Salvage. Accomplishments of this research, development, test and evaluation team have included development of the MK 12 Surface Supported Diving System which is slated to replace the Deep Sea Diving Outfit MK V, a Navy standard for half a century; development of the Closed Circuit Saturation Diving System MK 14; evaluation of the Large Object Salvage System; and evaluation of the Swimmer Life Support System MK 1 closed circuit scuba.

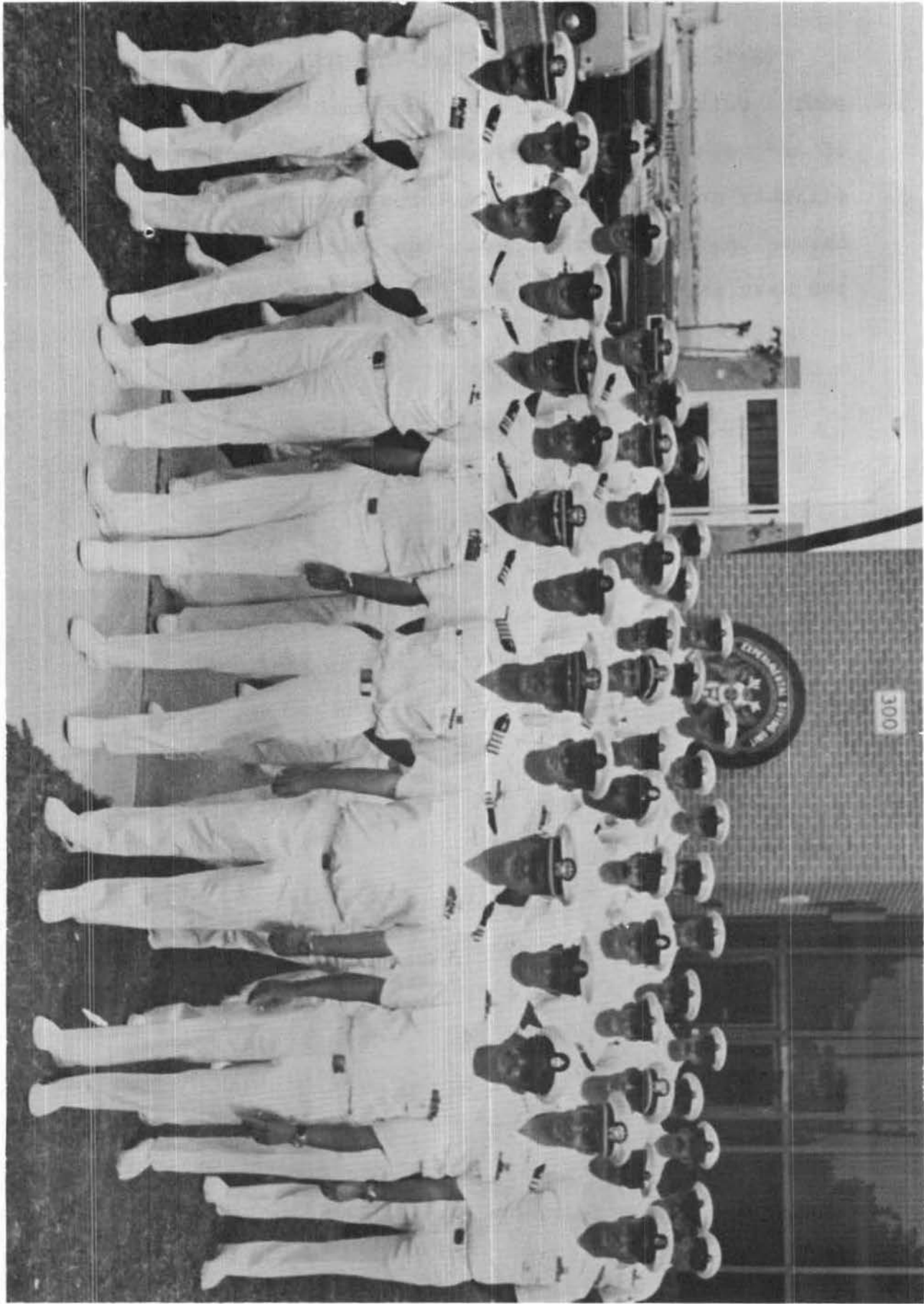




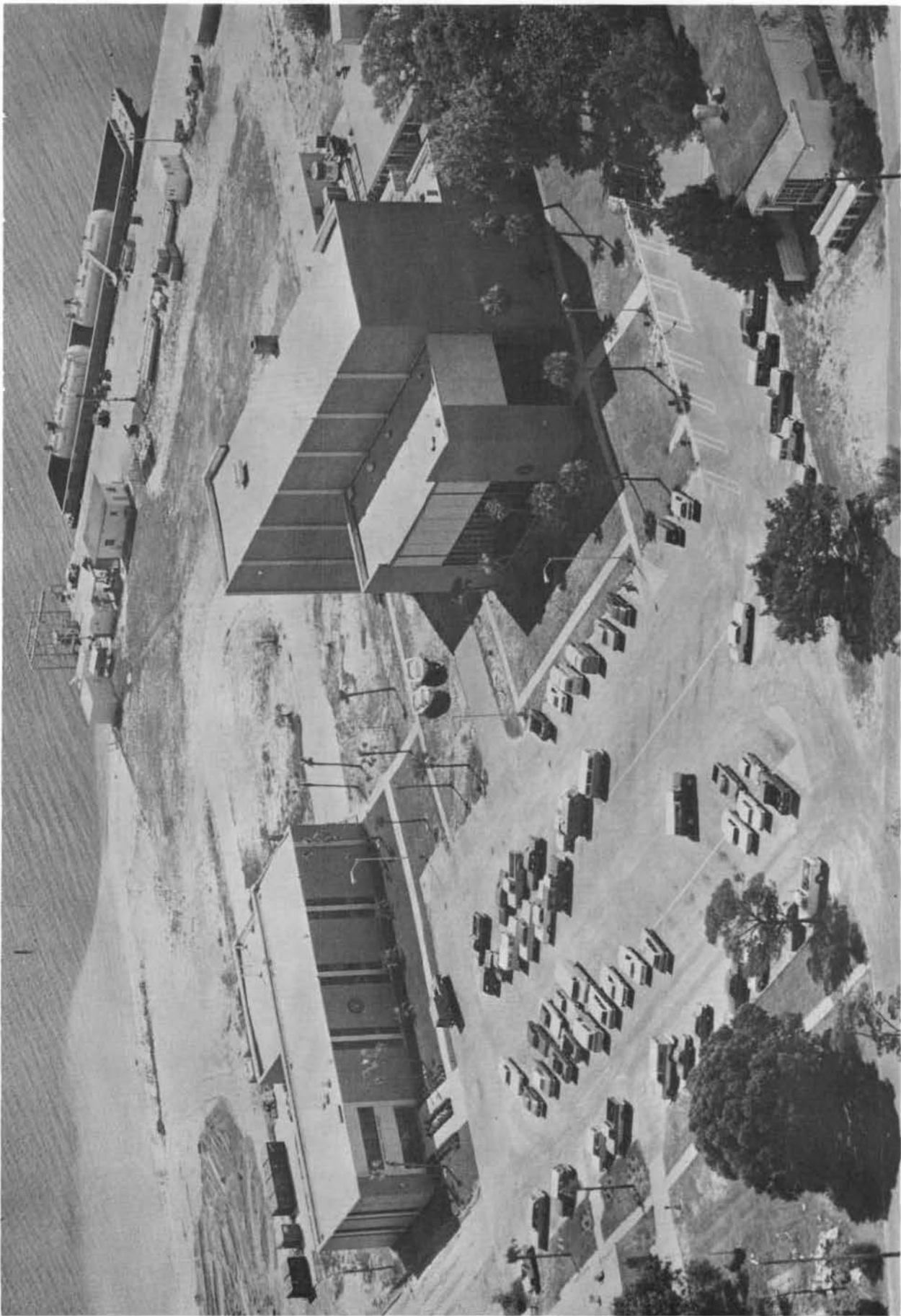
Surface Supplied Diving System MK 12  
(left) which will replace the Standard  
Deep Sea Diving Dress MK V (right)

The men who have served at the U.S. Navy Experimental Diving Unit can look with pride on their record of 50 years of progress in diving technology. Their work has benefitted military and civilian divers throughout the world; We salute them during this year, the golden anniversary of the Navy Experimental Diving Unit.





NEDU "GOLDEN ANNIVERSARY" CREW 1977



NEDU BUILDING COMPLEX IN PANAMA CITY

APPENDIX A

COMMANDING OFFICERS AND OFFICERS IN CHARGE  
OF THE NAVY EXPERIMENTAL DIVING UNIT

C. A. BARTHOLOMEW (CO)

J. M. RINGELBERG (CO)

COLIN M. JONES (CO)

J. J. COLEMAN

E. B. MITCHELL

W. LEIBOLD

C. HEDGEPEETH

M. NICHOLSON

G. MAHONEY

M. DES GRANGE

K. WILSON

G. MOLUMPHY

O. O'DANIELS

W. NEW

J. BUIE

C. B. MOMSEN

C. TIBBALS