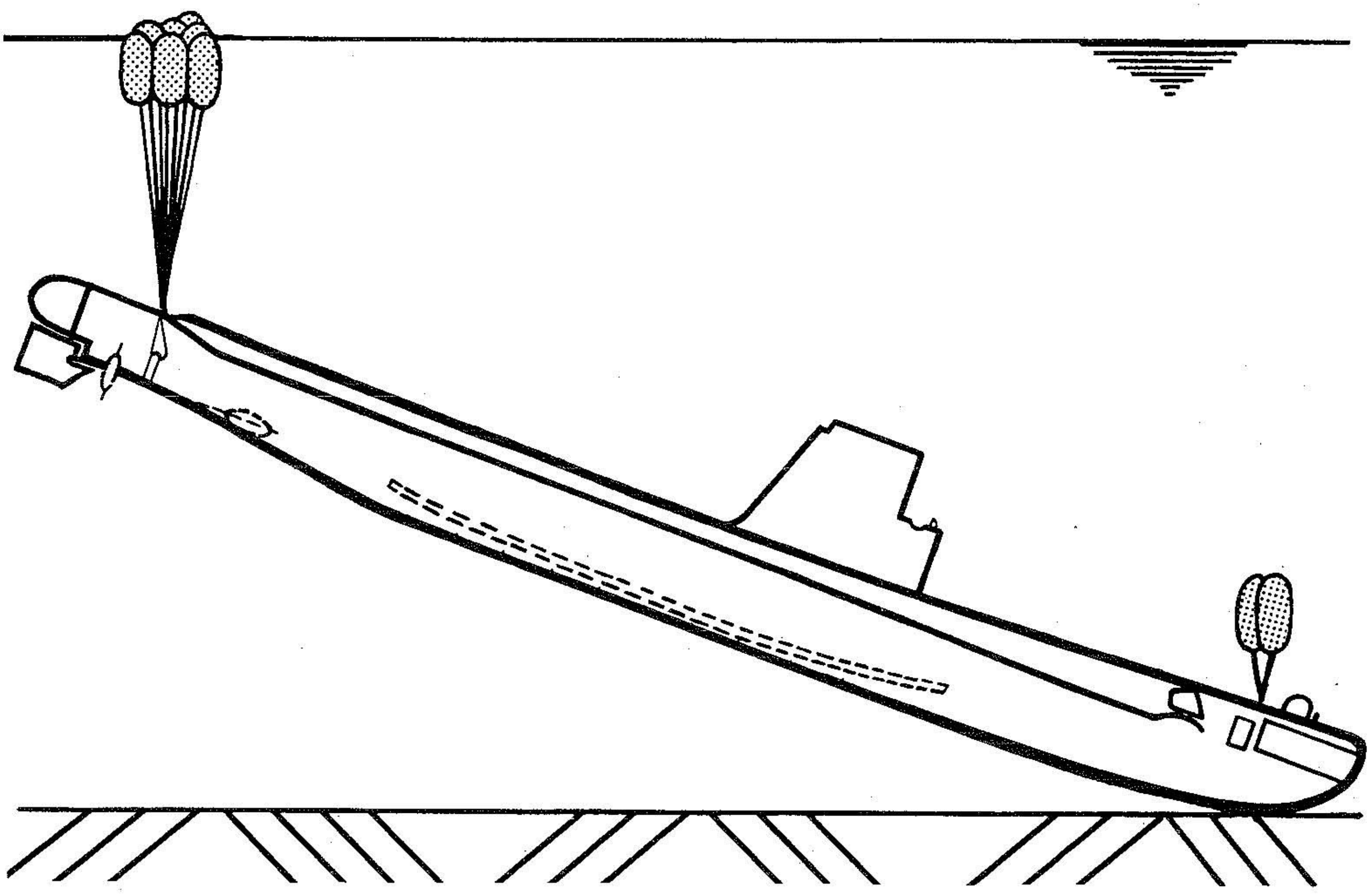
EX-USS BLUEGILL (SS-242)
SALVAGE OPERATIONS
SUPSALV REPORT 84-06



DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND
WASHINGTON, D.C.
1984

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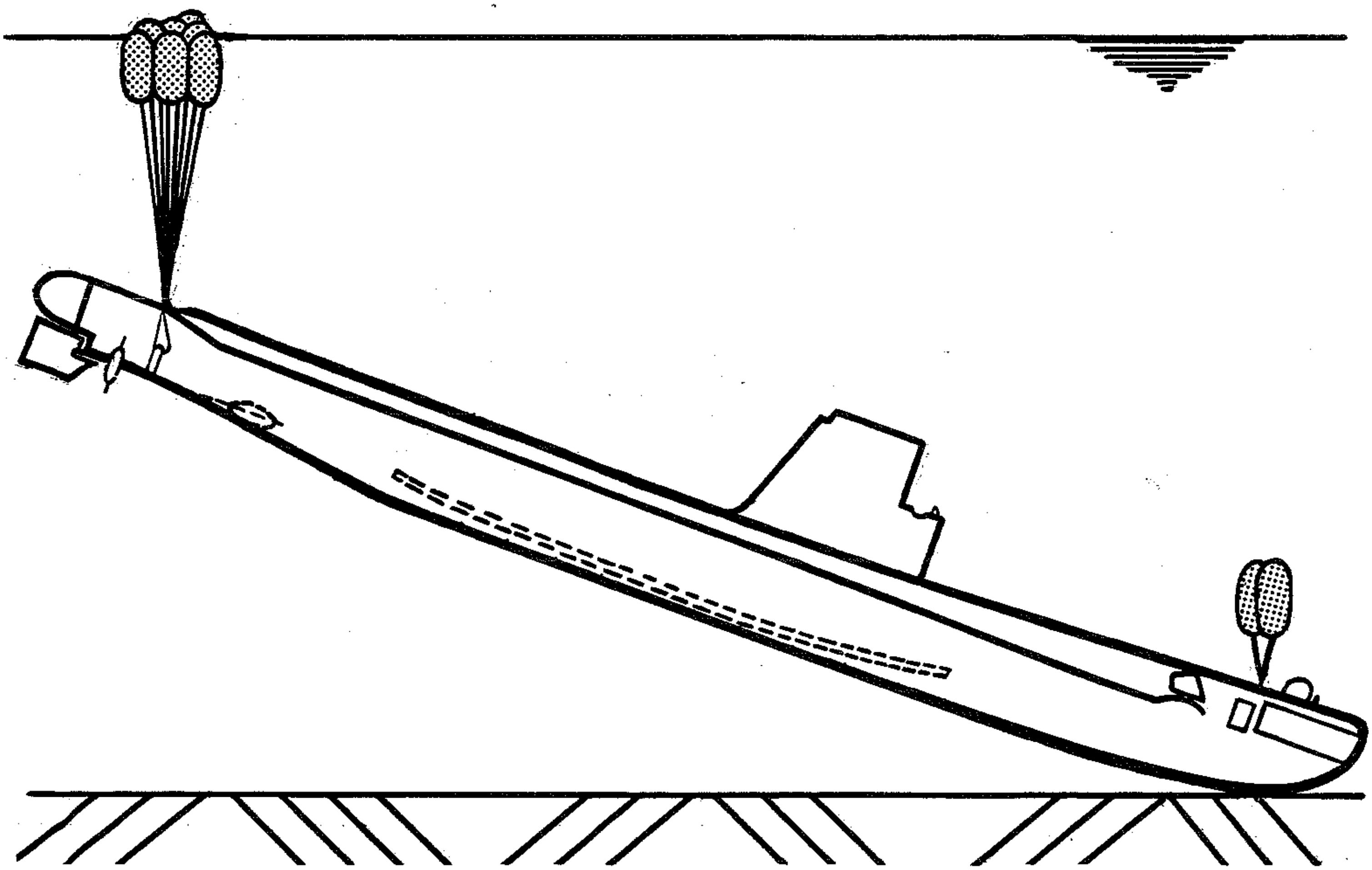

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Foreword

This report is an account of one of the most sophisticated salvage operations undertaken by the U.S. Navy in recent years.

Submarine salvage is fortunately a rare occurrence but that means techniques are rarely tested.

The salvage of the EX-USS BLUEGILL was the first submarine ever salvaged by the technique explained in this report. The men who accomplished this operation used new equipment and ideas.

Contributing to the complexity of this salvage operation was the large number of commands involved and the choice of employing a highly technical method rather than brute force. The enormous success of the operation was due to the coordination and blending into one unit of all those commands involved and the ever increasing technical knowledge of today's salvor which permitted the use of a highly technical approach. This report is dedicated to the salvors who chose not to be timid, who had the confidence to try a new direction, and who developed an up-dated method of submarine salvage.

C. S. Maclin, Capt., USN
Supervisor of Salvage, U.S. Navy

EX-USS BLUEGILL (SS-242)
SALVAGE OPERATIONS

FALL 1983

by

Cdr. Gary J. Tettelbach, USN

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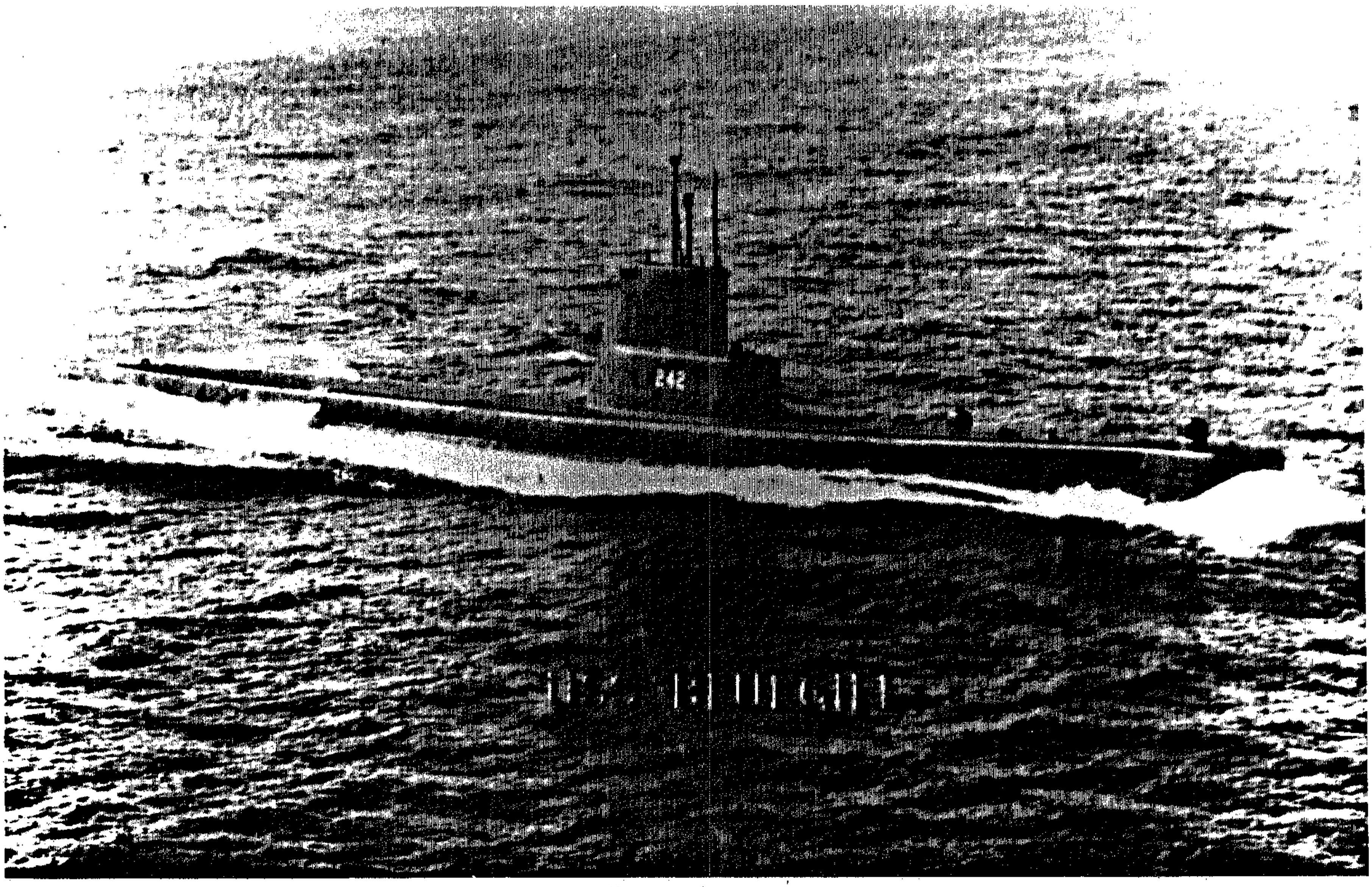


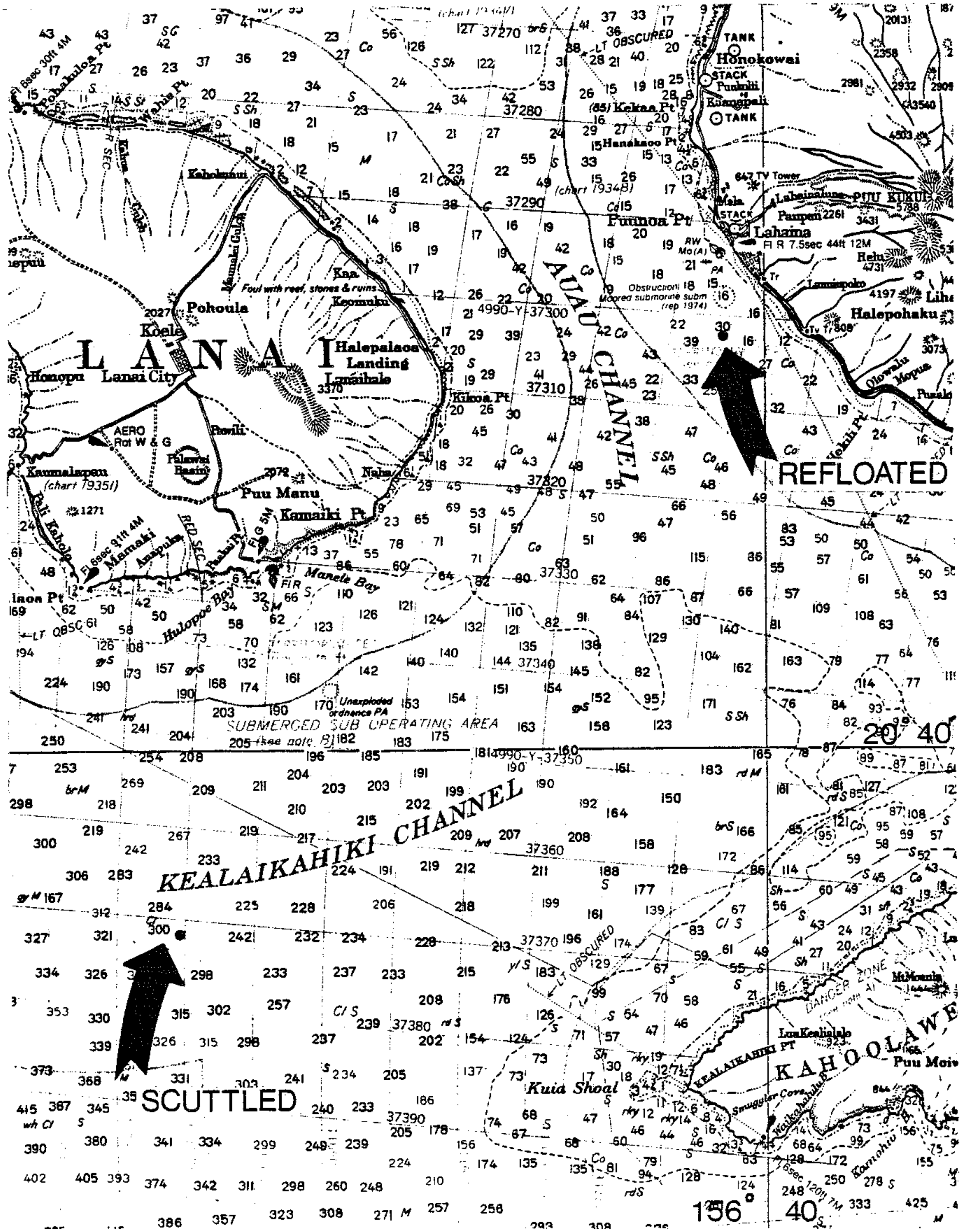
USS BLUEGILL (SS-242)

1. Abstract

The sunken submarine hull ex-BLUEGILL was used as a training platform for U.S. Navy divers. No longer required for the purposes it had served since being moored on the bottom of the Auau Channel near Maui, Hawaii, the submarine was scheduled for removal in accordance with the Navy's commitment to the State of Hawaii. The hull was lying in 135 feet of water.

Removal of the submarine was conducted as a training exercise, PACSUBSALVEX-83, during the fall of 1983 by fleet units based in Pearl Harbor. The hull was refloated after 34 days of on site preparations employing a plan of induced internal buoyancy and external salvage pontoon lift assistance. Subsequent to refloating, the ex-BLUEGILL was towed out to sea and scuttled in 1,200 feet of water 12NM south of Lanai, Hawaii.

The operation proved to be complex and difficult. It was regarded as a very successful training exercise for salvage officers and divers contributing a significant amount of experience to benefit all Naval salvage commands.


REFLOATED
SCUTTLED
LANAI
AUAU CHANNEL
KEALAIKAHIKI CHANNEL
KAHOOLAWE
Lanai City
Koele
Pohoula
Halepalaoa Landing
Lanaihale
Kikoa Pt
Puu Manu
Kamaiki Pt
Manele Bay
Hulopoe Bay
Kahokunui
Keomuku
Foul with reef, stones & ruins
Honokowai
Kekaa Pt
Puunoa Pt
Lahaina
Halepohaku
Obstruction: Moored submarine subm (rep 1974)
SUBMERGED SUB OPERATING AREA
Unexploded ordnance PA
Kuia Shoal
Smuggler Cove
Kealaikahiki Pt
Puu Moiwi
LT OBSCURED
4990-Y-37300
156° 40'
20° 40'

2. Summary

The submarine ex-USS BLUEGILL was sunk offshore Maui, Hawaii in the Auau Channel in December of 1970 and used as an exercise target for various underwater operations including the training of submarine rescue units and divers for the various commands of the Pacific Fleet.

At her sunken position; latitude 20 degrees, 51 minutes, 13.3 seconds North, longitude 156 degrees, 40 minutes, 58.7 seconds West, the submarine rested in approximately 135 feet of water.

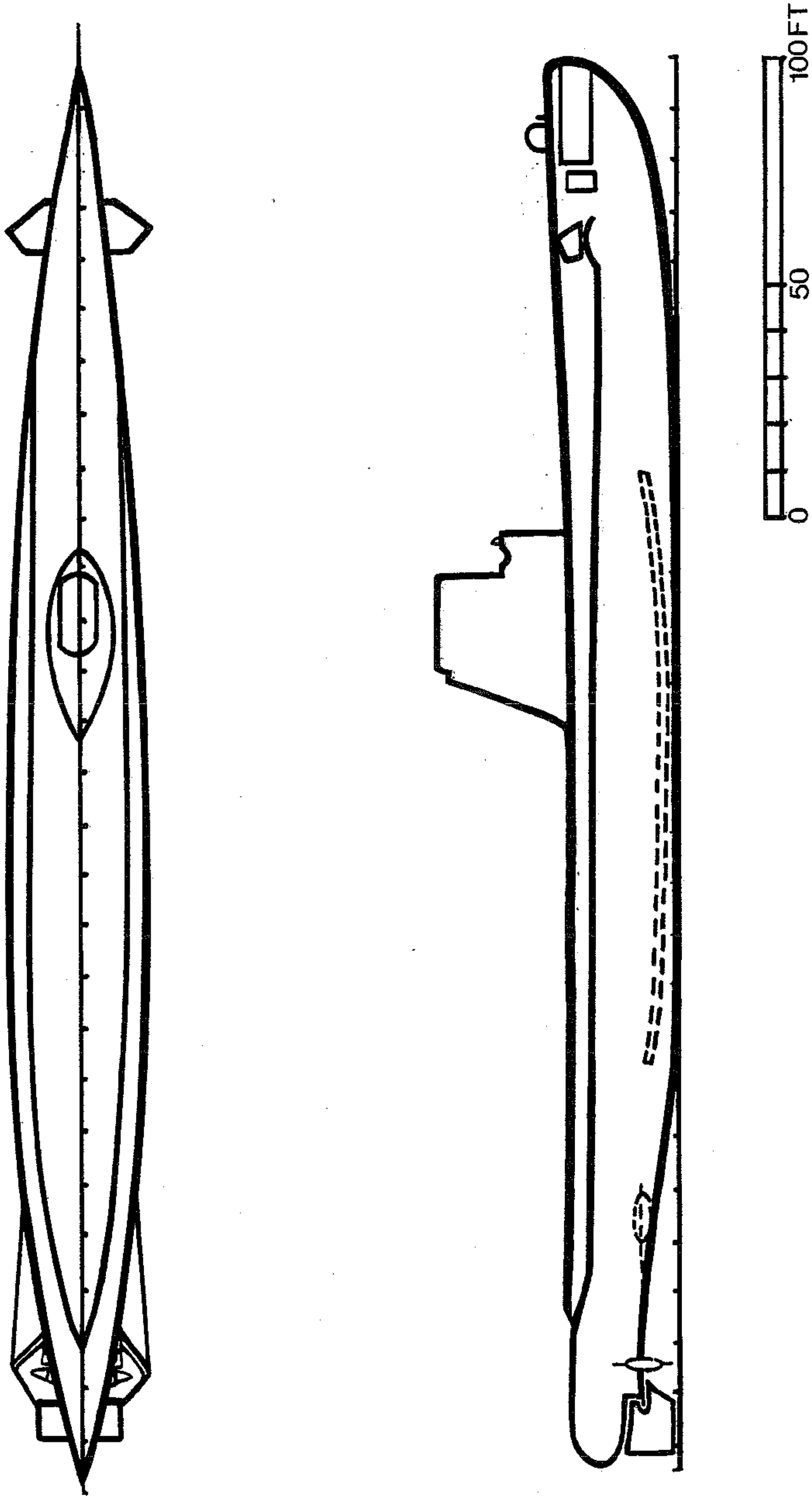
The Navy had an agreement with the State of Hawaii to remove the submarine once it was no longer required as a training platform. Refloating the submarine was undertaken as a sunken submarine salvage exercise, PACSUBSALVEX-83, by units of Service Squadron Five under the direct control of Task Group 33.5 during the fall of 1983.

The submarine had been commissioned in 1943 and its principal characteristics were:

Displacement	1,526 long tons
Length	311 feet 9 inches
Beam	27 feet 3 inches
Draft	17 feet
Class	GATO
Hull No.	242

On-site salvage operations commenced on 3 October 1983 and ended with the re-sinking of the submarine in deep waters on 6 November 1983, a total operational time of 34 days. Refloating was accomplished by induced internal buoyancy employing the assistance of 8.4 ton salvage pontoons for lift and control.

The primary units of the salvage force were the USS BRUNSWICK (ATS 3) and the USS BEAUFORT (ATS 2).



BLUEGILL

Several candidate refloating methodologies were considered and an initial salvage plan was conceived which called for dewatering the submarine with air while leaving the sunken submarine slightly negative. The controlling final lift force was to be provided by the two super tugs (ATS) in simultaneous bowlifts at the bow and stern of the submarine. During mobilization for the salvage exercise, heavy emphasis was placed on assembling the heavy bowlift gear for both BRUNSWICK and BEAUFORT. Other equipment, salvage hose, air compressors, air manifolds, and several 8.4 ton salvage pontoons were staged on a barge (YC-1485).

On 3 October 1983, the operation officially commenced when the USS BRUNSWICK departed Pearl Harbor for the salvage site. USS BEAUFORT, with YC 1485 in tow, departed on 6 October 1983, after completing preparations on the barge.

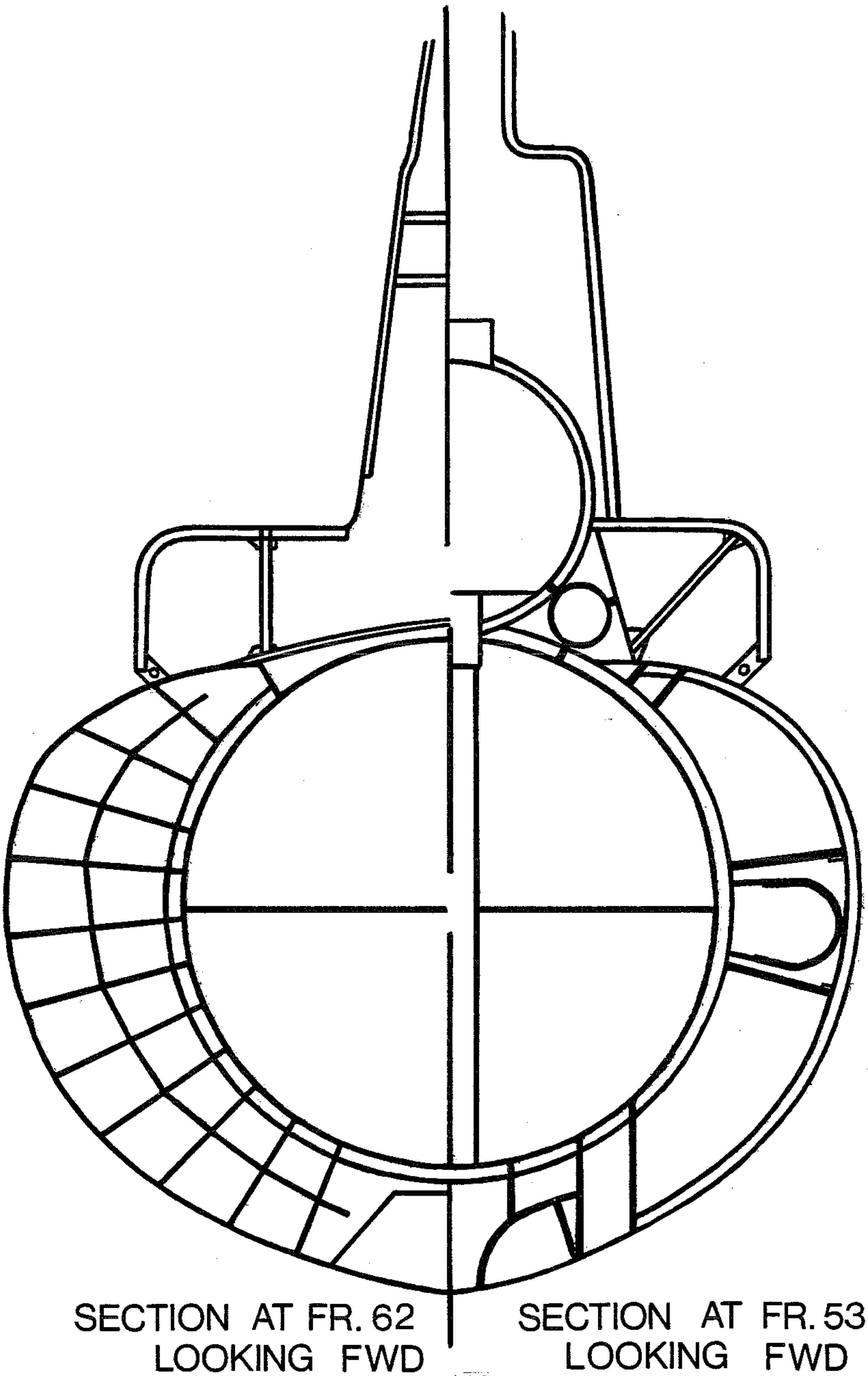
The first phase of the operation consisted of rigging and laying a total of eleven mooring legs and conducting an inspection of the submarine. Diving operations started aboard BRUNSWICK as soon as mooring was completed on 5 October. BEAUFORT started diving operations 9 October after moving into the moor.

A comprehensive diving survey had not been completed prior to the mobilization of the salvage task force. The Salvage Officer directed hull tests with air and the details of the salvage survey after arrival on site for operations.

An internal survey by divers was considered but not undertaken because it would have been too laborious and time consuming. The more positive approach of using compressed air introduced into the hull was employed to answer the primary questions relating to the condition of the hulk:

- What was the condition of the low salvage fitting piping?
- Did free communication exist between compartments in the pressure hull?
- What areas required patching to reestablish air tight integrity needed to retain the proposed induced buoyancy?

The low salvage piping was checked by hooking each fitting to a pneumofathometer and reading the depth. A comparison with the depth expected from the salvage piping plans revealed all piping intact. By putting air into the aft



SECTION AT FR. 62 LOOKING FWD

SECTION AT FR. 53 LOOKING FWD

battery space, and seeing air escape from both the forward and aft torpedeo room hatches, free communication between all compartments was verified. Air leaks were found by simply observing where bubbles escaped.

The next phase consisted of diver preparation of the submarine, mainly closing main access hatches, attaching salvage air hoses, and tying into the 10 psi blow piping to gain access to ballast tanks.

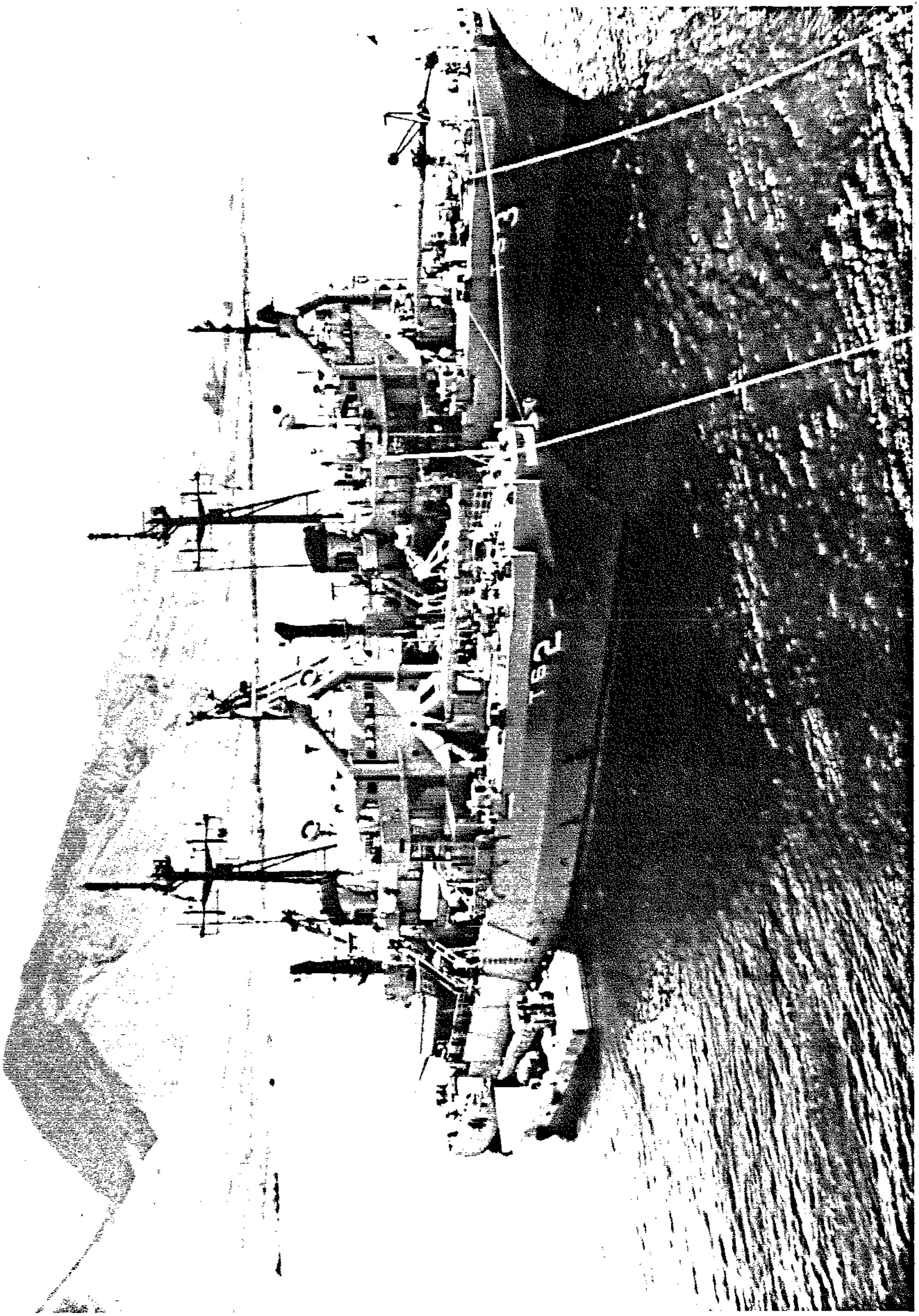
Diving operations progressed to secure the airtight integrity of the submarine until weather deteriorated severely. Between 13 and 19 October, Hurricane Raymond interrupted operations, threatening the salvage site with 125 knot winds. Both ships were ordered back to Pearl Harbor until the hurricane had passed.

Upon return to the site, diving operations continued in preparation for raising the submarine. The hurricane had left the air hoses attached to the submarine in complete disarray. It was a prolonged project to disentangle and reorganize the air lines.

Efforts to quantify the exact weight and locate the centers of gravity in the hull could only define a range of values. Given the relatively small ATS bow lift capacity, it was judged unfeasible to pursue this approach. The salvage plan was modified to raise the submarine on dewatered ballast tanks with nine inflatable salvage pontoons assisting, a safer and more feasible method of recovery.

The new salvage plan called first for dewatering of the pressure hull. Then the ballast tanks would be dewatered using the 10 psi blow system and the pontoons inflated in a carefully chosen order. This order would increase the submarine's buoyancy in small increments to avoid uncontrolled ascent. The ascent was planned in three stages: the first stage was to use control pontoons to raise the stern to 50' below the surface with the bow on the bottom; the second stage was to raise the bow to the surface with the stern still at 50'; the final stage was to raise the stern to the surface.

On 30 October 1983, a first attempt to raise the submarine failed due to a high rate of pressure hull backflooding and a very conservative deballasting plan. This first attempt provided valuable information and the lessons learned were utilized to formulate a much improved concept for a second attempt.



SHIPS MOORED OVER SUBMARINE

On 5 November, after lengthy diving work to complete preparations, the revised deballasting plan was implemented. The submarine surfaced at 1900 hours to the relief and cheer of the salvors. The remainder of the night was spent stabilizing the submarine, replacing ruptured salvage hoses and moving BRUNSWICK with barge and submarine alongside to shallower water.

On the morning of 6 November, the 10 psi blow line to No. 7 main ballast tank failed, causing the submarine to take a down angle putting the stern awash with three feet of water over the deck. After quick repairs were made by divers, the submarine was restabilized and preparations for tow were completed. At 1305 BEAUFORT took the submarine in tow alongside the barge for the 23 mile journey to the scuttling site.

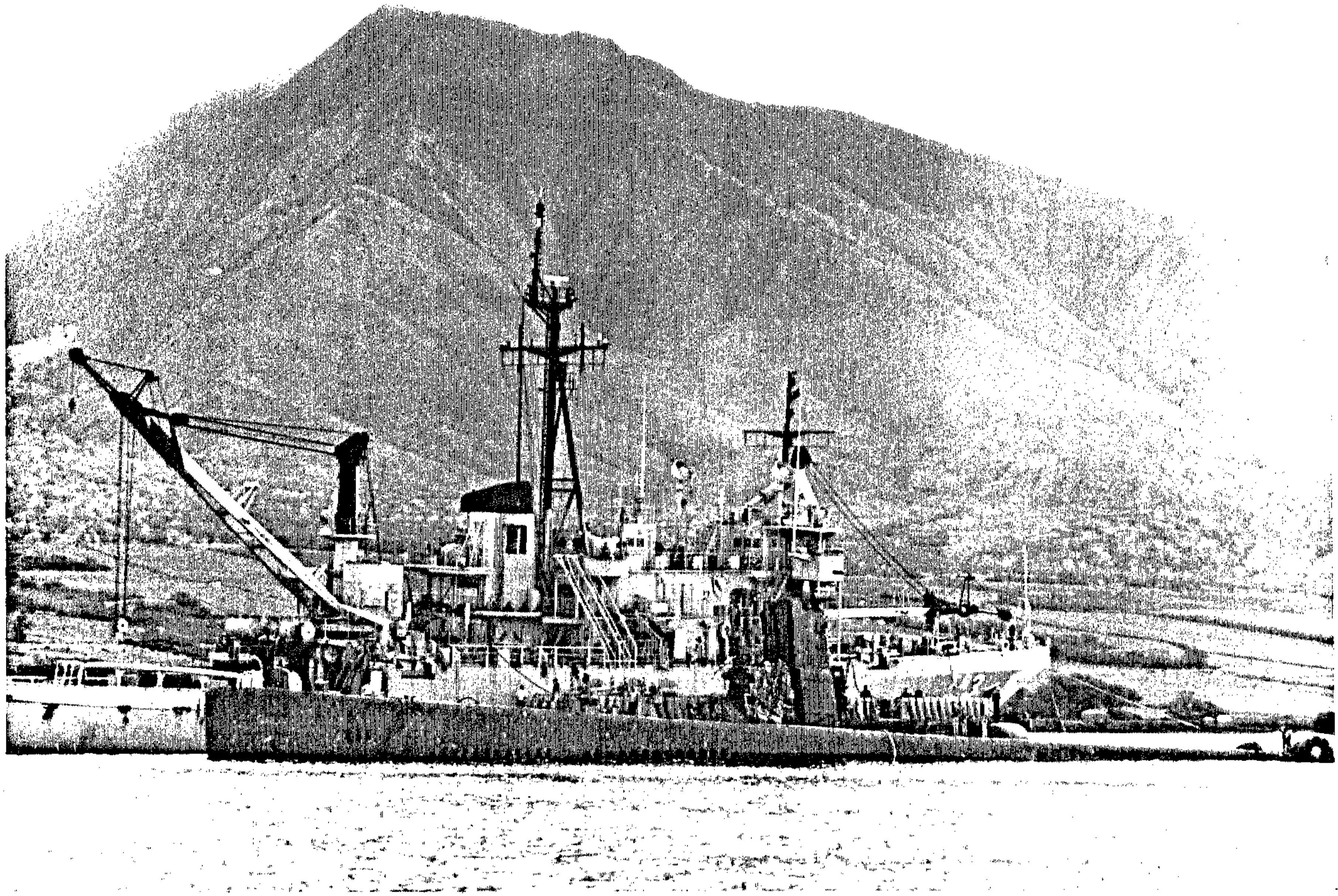
At about 1800 the submarine was sunk in 1200 feet of water 12 miles southwest of the island of Lanai.

Demobilization commenced immediately with BRUNSWICK recovering two mooring legs and returning to Pearl Harbor with the barge in tow on 8 November.

Although the operation was officially terminated on 6 November, demobilization continued onboard BRUNSWICK and the barge, with Mobile Diving and Salvage Unit ONE personnel until November 18.

Many problems were confronted and overcome in the course of PACSUBSALVEX-83. As expected, the extensive amount of diving required to implement the salvage plan presented difficulties in coordination, safety, and quality control. Since precise details of the submarine's construction were not available for advance consideration, much information had to be assembled on site and calculations based on the best estimates or conservative assumptions.

This operation reiterated the accepted premise that every salvage job is unique, being replete with unknowns which can influence the operation and implementation of the plan at any time until the final goal is achieved and all forces secured. Salvage officers must recognize important differences between information developed and initial assumptions and be prepared to modify the salvage concepts appropriately throughout the job. Safety and quality control can never be overemphasized in salvage operations of this magnitude of size, location and depth.



EX-USS BLUEGILL (SS-242) ALONGSIDE USS BRUNSWICK (ATS-3)

3. The Salvage Operation Narrative

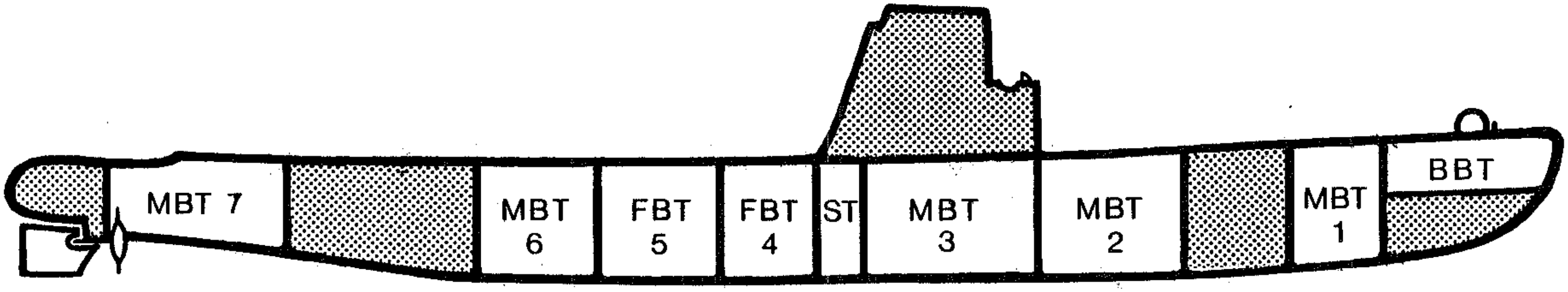
Prior to getting underway to conduct the salvage operation on ex-BLUEGILL, extensive preparations were required. The most significant of these are presented below.

3.1 Planning Phase

5 September - 2 October 1983

During the mobilization phase, early planning and equipment assembly was undertaken. Consideration of the dewatering aspects of the plan, and the mooring requirements, guided the detailed planning required and the configuration of the systems needed to implement the salvage plan. Special adapters were manufactured by Shore Intermediate Maintenance Activity (SIMA), Pearl Harbor, to mate ATS salvage hose, which is metric, to National Pipe Thread (NPT) (1¼") submarine salvage fittings. Three salvage compressors, salvage hoses, and a manifold were procured from the ESSM Base in Stockton, California. These items were essential as they are not part of the ATS's allowance.

COMSERVRON FIVE installed a micro-computer in USS BRUNSWICK (ATS-3) for the duration of the operation; essential buoyancy and stability information on ex-BLUEGILL was obtained from Philadelphia Naval Shipyard and Naval Sea Systems Command. A stability and buoyancy data base was developed and entered into the micro-computer, facilitating rapid reference to the available information. An engineering support team consisting of two Engineering Duty Officers and a COMSERVRON FIVE Special Projects Officer performed the stability and buoyancy calculations for raising the submarine. The automated data base provided numerous alternative dewatering and ballast tank blow plans to be examined in a relatively short time, allowing the On-Scene Commander and Salvage Master to make more informed decisions.



NO SCALE

GENERAL LONGITUDINAL DISTRIBUTION OF
BALLAST TANKS FOR DEWATERING

A & C TANKS ARE STARBOARD SIDE

B & D TANKS ARE PORT SIDE

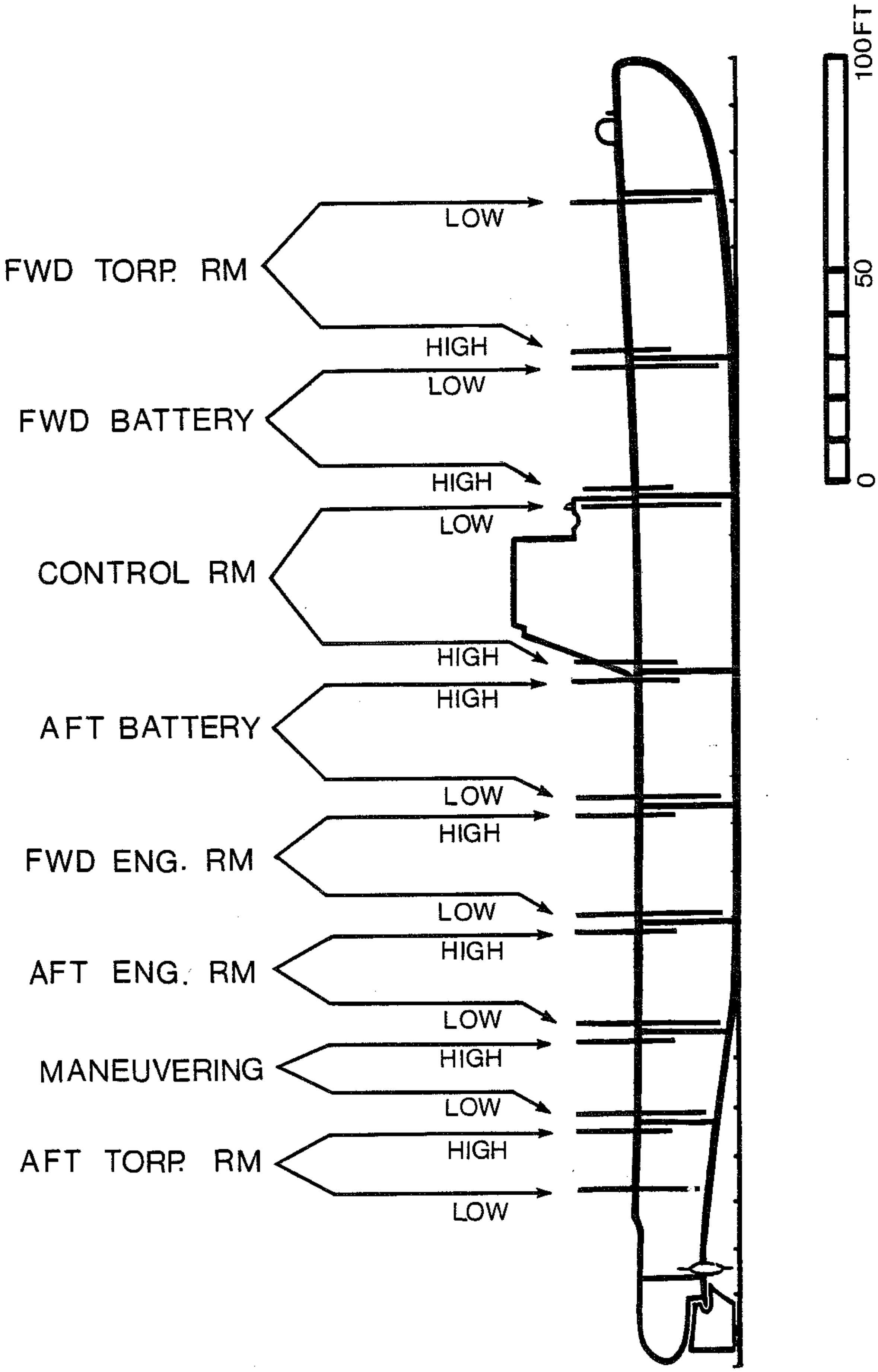
Lift Plans

To calculate the force required to raise the submarine, added weight and added buoyancy methods were used. Assuming the pressure hull could be completely dewatered, added weight method calculations indicated that ex-BLUEGILL would remain 147 long tons negative. Comparatively, the added buoyancy method indicated that 179 tons of residual weight would remain. This discrepancy of 32 tons could not be resolved and was assumed to result from the inability to quantify the effects of water remaining in internal "pockets" (fuel and hydraulic lines, machinery, etc.) and the buoyant contribution of the superstructure. To employ the more conservative estimate, work proceeded using the added buoyancy method as the basis for calculations.

The buoyancy required was to be primarily gained from ex-BLUEGILL's own ballast tanks. A utility program for the micro-computer was written to predict the submarine's behavior during candidate dewatering sequences. This program was initially run assuming the pressure hull to be 100% dewatered. It was later adjusted to account for approximately 93.5 tons of residual seawater distributed within the pressure hull according to the known or estimated locations of the salvage fittings.

Given the discrepancies in weight estimates, it was decided to refloat the submarine by first raising the stern to a depth of 50 feet by use of 7 pontoons rigged aft on 50' pennants to halt the stern's ascent 50 feet below the surface and dewatering selected ballast tanks.

The bow would then be raised from the bottom to the surface in one step, using 2 pontoons rigged forward and forward ballast tanks blown dry as necessary. The remaining ballast tanks aft would then be blown to raise the stern and gain maximum reserve buoyancy. This procedure was thought to minimize any breakout force, avoid "fluttering", and restrict transverse stability problems associated with raising the submarine on an even keel while minimizing free surface effects by limiting the trim angle to less than 11 degrees.



SUBMARINE SALVAGE FITTINGS

A dewatering sequence was developed to limit the possibility of uncontrolled ascent by adding buoyancy in small increments. Inflating the pontoons or blowing the safety tank after a given main ballast tank was blown dry and then reflooding/deflating before blowing the next main ballast tank afforded this control. Although recognized as tedious and time consuming, the plan incorporated a cautious approach for maximum control of the submarine. Computer assisted calculations predicted that the stern would lift after blowing main ballast tank (MBT) 2 A, B, fuel ballast tank (FBT) 4 A, B, MBT 6 A, B, the safety tank and three pontoons aft. The calculations indicated that the bow would surface after blowing the bow buoyancy tank.

(Following an unsuccessful raising attempt, a modified dewatering plan was drafted. Although similar to the previous plan, the pontoons were not to be inflated until after FBT 4 A, B and MBT 2 A, B were blown dry and the pressure hull would be maintained at ambient pressure until the stern began to move. Calculations allowing for backflooding at 30 tons per hour predicted that the stern would lift after blowing FBT 4 A, B, safety tank, MBT 2 B and MBT 6 A, B and two pontoons aft, and that the bow would surface after blowing the bow buoyancy tank.)

A Mini-Ranger positioning system was procured from NUWES, Det Hawaii, for use in precision mooring over the submarine. NAVOCEANWESTCEN, Pearl Harbor, Hawaii, provided a weather facsimile machine and an ocean current meter was provided by NAVOCEANO, Bay St. Louis, Mississippi. Additionally, an 1800 designated officer was assigned for the first two weeks of the operation to train USS BRUNSWICK (ATS 3) personnel in the use of this equipment.

3.2 On Site Survey Phase

Monday, 3 October

USS BRUNSWICK (ATS 3) assumed command of Task Unit 33.5.5, was underway from Pearl Harbor at approximately 0800 and proceeded directly to the ex-BLUEGILL salvage site at

Lahaina Roads off Lahaina, Maui, Hawaii. BRUNSWICK arrived and anchored in the vicinity of ex-BLUEGILL at approximately 1700. At that time, ship's force personnel began rigging mooring legs Nos. 1 and 2.

Tuesday, 4 October

Positioning of mooring legs Nos. 1 and 2 was accomplished utilizing the Mini-Ranger. The crown buoys on these legs were noted to be submerged. Three sets of scuba dives were made to buoy off the bow and stern of the submarine and to place a crown buoy with a radar reflector to the amidships position of the submarine.

Calculations performed indicated that mooring system improvements could be made by installing wedges in LWT and STATO anchors to obtain a 35 degree fluke angle (optimal for sand) and using two shots of chain.

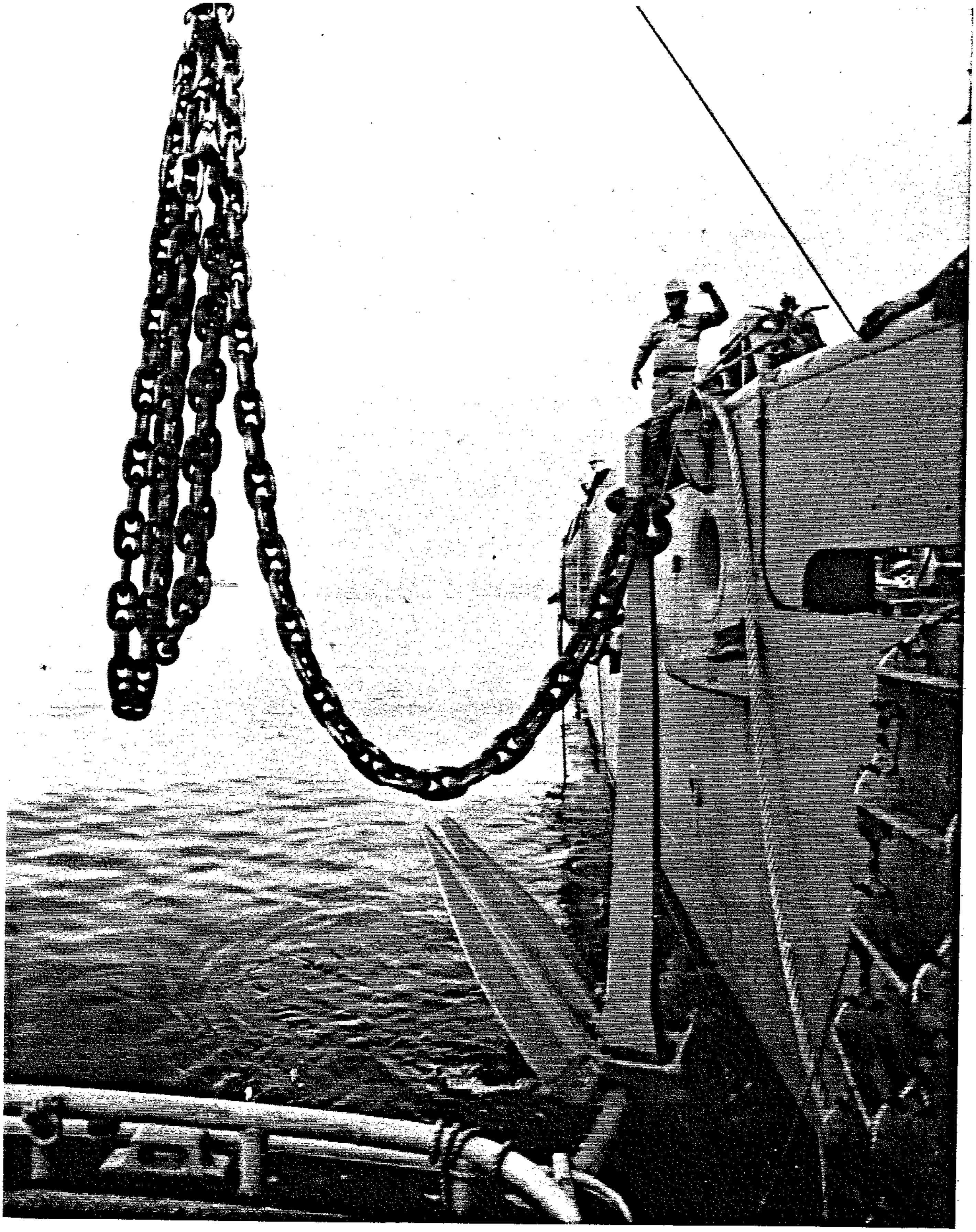
Wednesday, 5 October

The laying of mooring legs Nos. 3, 4, and 5 was accomplished with the use of the Mini-Ranger for precision navigation. The submerged crown buoys on legs Nos. 1 and 2 were located and marked with surface crown buoys by scuba divers. Three more sets of scuba dives were made by underwater photographers, salvage engineers, and ship's force divers to obtain photographic documentation and continue survey work on the submarine.

During these survey dives, checks were made of the vent valves, conning tower material, and hatches. Attempts were made to locate the salvage fittings on the submarine.

Thursday, 6 October

BRUNSWICK completed rigging of a 6,000 pound STATO anchor to the bullrope and layed this anchor while moving into a six point moor over the submarine. This provided BRUNSWICK a convenient means to move toward shallow water without use of



LWT ANCHOR BEING RIGGED FOR LEG OF MOOR

main engines. In the event the submarine were to be lifted by heavy bowlift, or became perilously afloat with air hose under the ship, this method of movement towards shore would be essential. Data obtained from the ocean current meter was used to enter the moor during the slack current.

Marker buoys were positioned on the submarine during one of the six sets of scuba dives completed on this day.

Friday, October 7

BEAUFORT, with the barge YC 1485 in tow, arrived on the scene in the late evening of 6 October 1983. The YC was positioned alongside BRUNSWICK using an LCM-8 while BEAUFORT anchored in the vicinity of the moor. BEAUFORT rigged and layed legs Nos. 6 and 7 of the moor. BRUNSWICK divers rigged the dive station for MK12 diving using the FADDS system. Four sets of MK12 dives were completed to: verify the aft torpedo room hatch was secure; enter the conning tower hatch; attempt to open the hatch between the conning tower and the control room. The hatch between the conning tower and the control room was undogged but divers were unable to open it. This presented a significant obstacle since free communication between the conning tower and the control room was essential for transverse stability.

It was determined that the ex-BLUEGILL appeared to be lying on a heading of 000 degrees true vice 330 degrees true as previously believed.

Saturday, 8 October

BEAUFORT completed rigging and laying legs Nos. 8 and 9 of the moor. After rigging and laying the 6,000 pound STATO anchor to the bullrope (leg No. 11), BEAUFORT maneuvered alongside the YC and BRUNSWICK to complete the mooring phase of the operation. Four 400-foot lengths of ESSM salvage hose were rigged for ESSM salvage compressors and satisfactorily pressure tested to 110 psi.

Three sets of MK12 dives and three sets of scuba dives were completed to conduct a bottom survey of fuel ballast tank (FBT) and main ballast tank (MBT) flood ports. The MBT

USS BEAUFORT (ATS-2) ENTERING THE MOOR
ESSM AIR COMPRESSORS IN FOREGROUND

7-POINT MOOR OVER SUBMARINE

flood ports were accessible on the port side; the flood ports on the FBT were not accessible from either side; the MBT flood ports were not accessible on the starboard side except for #7. A chain fall was used unsuccessfully in an attempt to open the control room hatch.

Sunday, 9 October 1983

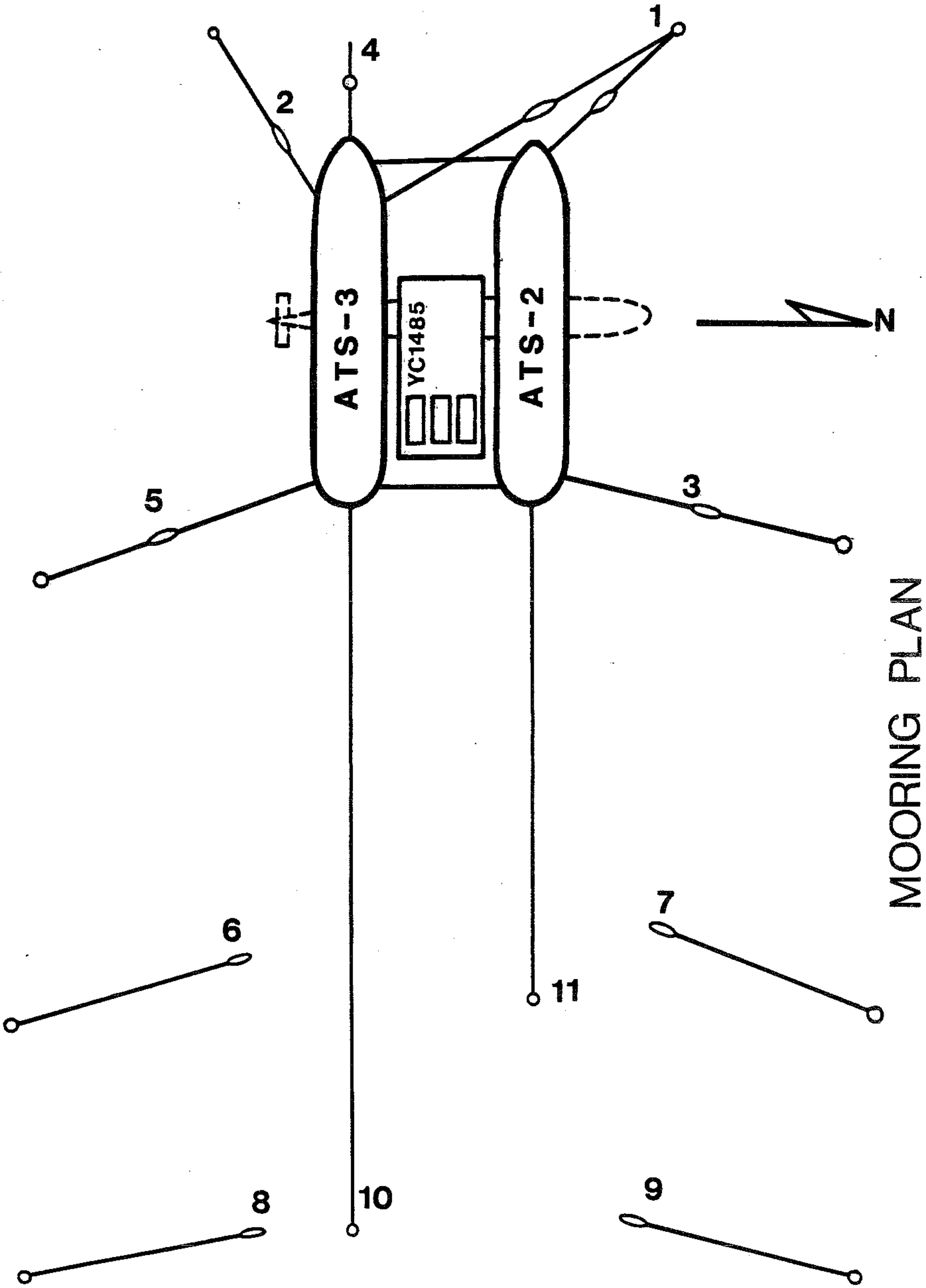
The deadlight on the hatch between the conning tower and control room was broken to assure free communication and proper dewatering of the conning tower. The ESSM hose rigged to the high and low salvage fittings of the submarine proved to be too flexible and susceptible to kinking. As the hose collapsed under hydrostatic pressure and burst when kinked, it was put aside for use on the 8.4 ton pontoons.

A special metric-to-National-Pipe-Thread (NPT) adapter was manufactured for this salvage operation which made the ATS hose usable.

In a dive on the forward portion of the submarine, marker lines were positioned on bulkheads so the salvage fittings could be located. Attempts to vent the aft torpedo and maneuvering compartments to read the pneumofathometer were unsuccessful. It was decided to wait until first light for the next attempt.

Monday, 10 October

Divers from all participating commands completed air line connections to all high and low salvage fittings with the exception of the aft battery and torpedo rooms. All compartment salvage fittings were positively labelled. A test blow of the high and low salvage fittings on the aft torpedo room and maneuvering room indicated probable free communication through the ventilation system. Test blows of forward and aft enginerooms tended to confirm this problem. The aft torpedo room hatch and aft battery hatch were found to have significant leaks and require additional securing.



MOORING PLAN
ATS-3
ATS-2
YC1485
N
1
2
3
4
5
6
7
8
9
10
11

Tuesday, 11 October

A detailed search was conducted for main ballast tank (MBT) salvage blow connections and none were found. Marker lines were rigged on the submarine to assist divers in locating MBT's. The leaks in aft torpedo room hatch were stopped by installing a new gasket. The conning tower hatch was noticed leaking and the leak was corrected. The aft battery compartment hatch continued to leak significantly. A test blow to the aft battery room high salvage fitting resulted in air pressure to all high fittings in all other compartments. This confirmed free communication between all submarine compartments, and was believed to be occurring through the ventilation system.

Wednesday, 12 October

A series of survey dives was conducted to determine the best method for connecting into the main ballast tanks. It became apparent that main ballast tank salvage fittings had never existed. Four 1¼ inch pipe risers were discovered coming from 2A, 2B, 6C, and 6D MBT's. These were in an advanced state of corrosion. It was generally agreed that these were installed to allow for a controlled sinking when the submarine was placed on the bottom. Because of their deteriorated, useless condition, they were were broken off and the holes patched. A decision was made to connect to the hull's blow system using Jubilee patches. The hatch to the aft battery room was opened, greased, a gasket installed, and secured.

3.3 Preparatory Phase

Thursday, 13 October

The forward escape trunk hatch was secured with strongbacks and wire straps. Other efforts to satisfactorily patch and repair leaky hatches continued to progress slowly. A custom fabricated pipe (Jubilee) patch was designed to tap into the 10 psi blow system of all main ballast tanks and fuel ballast tanks between the check valve and riser. Nine 8.4 ton salvage pontoons were uncrated and successfully pressure and leak tested. Calculations were made to reconsider the "added-buoyancy" and "added-weight" discrepancy and confirmed that the best estimate for residual weight to lift was 178 tons. A check of the possible ballast tank combinations to enhance stability (transverse and longitudinal) while raising the submarine determined an optimal combination whose buoyancy contribution was close to 178 tons (bow buoyancy, 4AB, #7). Hose was rigged to main ballast tanks 2B and 6D flood ports in order to test the tanks for leaks. Divers verified that the bow buoyancy vent was open.

Friday, 14 October

All units present at the submarine salvage site secured all diving operations as Hurricane Raymond approached. BEAUFORT, with barge YC 1485 in tow, returned to Pearl Harbor. BRUNSWICK remained in the moor preparing for departure during the night.

All salvage hoses connected to the submarine's salvage fittings were tied off to a crown buoy and dropped to the sea floor.

Saturday, 15 October

At 0800 BRUNSWICK returned to Pearl Harbor. Both BRUNSWICK and BEAUFORT remained in Pearl Harbor the 15th and 16th of October.

Sunday, 16 October

BRUNSWICK was scheduled to return to the salvage site at approximately 1400 on Monday; BEAUFORT, with the YC in tow, was expected to arrive at a later time.

8.4 TON SALVAGE PONTOON

Monday, 17 October

BRUNSWICK and BEAUFORT departed Pearl Harbor and sailed back to the salvage site. Upon arrival, BRUNSWICK repositioned in the four-point moor despite experiencing high, gusting winds and opposing currents which made mooring extremely difficult. BEAUFORT anchored in the vicinity of salvage site with the YC alongside.

Tuesday, 18 October

The YC was positioned alongside BRUNSWICK using workboats. BEAUFORT entered the moor alongside BRUNSWICK and the YC. The winds and currents continued to make mooring difficult with 25-knot winds and a good sea coming out of the north (from the beam). Preparations commenced to rig dive stations onboard both ships.

Wednesday, 19 October

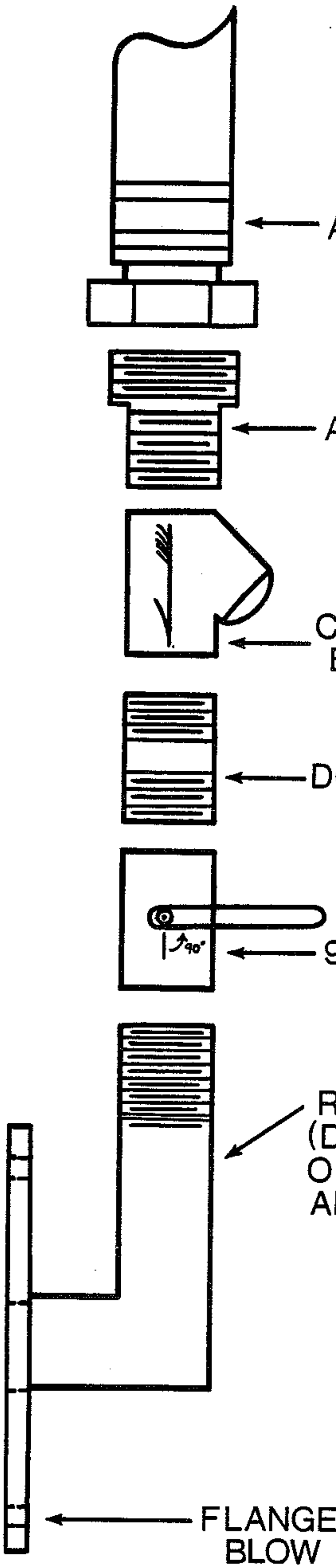
With BEAUFORT repositioned in the moor, diving efforts resumed to find places to install Jubilee patches but finding the proper locations proved to be more time consuming than originally estimated.

Thursday, 20 October

Night shift dives were commenced with the addition of divers from USS RECLAIMER (ARS 42) and MDSU-1. The difficulties of finding the proper locations to install the Jubilee patches and an increased knowledge of the 10 psi blow system gained from these efforts led to a new method. By removing the check valve from the system and replacing it with a flanged hose connection, air could be pumped to the tanks. This method was easier to install and achieved greater control of where the air went.

The new concept required the removal of the check valve in the 10 psi line to each tank. This valve was brought to the surface and used as a template to manufacture the flange

BALLAST TANK ADAPTER SETUP



with air hose connection. The result was a better airtight fitting, greater air flow, and positive segregation of tanks.

Friday, 21 October

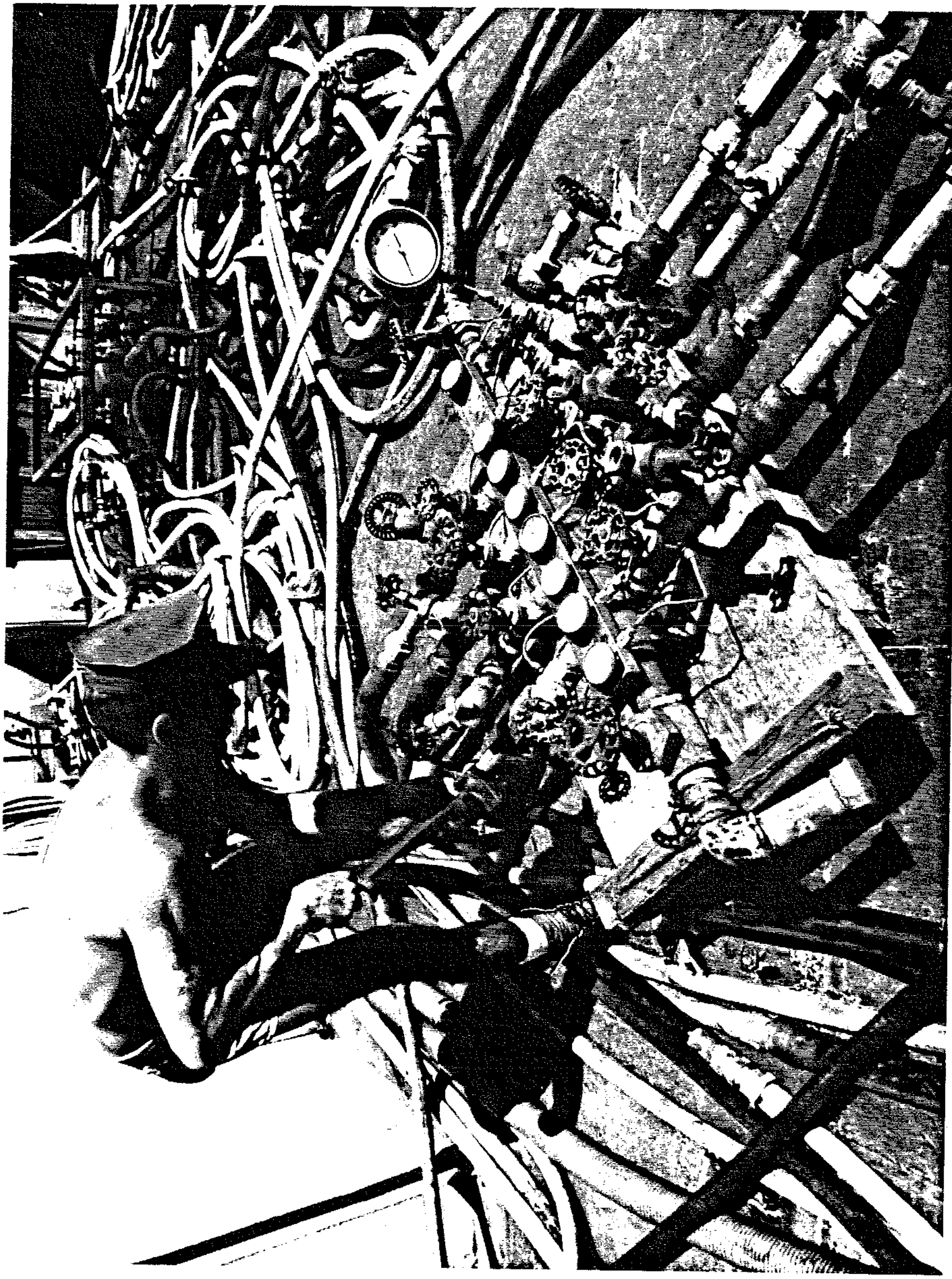
The check valves from Nos. 2C, D and 6A, B, D main ballast tanks were removed. The special flanges for blowing 2A, B, C, D and 6D were installed. The 1¼ inch pipe risers used for controlled sinking were capped. It was discovered that the piping on No. 2 MBT was 2.5" in diameter vice 3" in diameter as on No. 6 MBT's, so other flanges were manufactured by ships force hull technicians.

Saturday, 22 October 1983

Check valve 6C was removed from the 10 psi blow system. The flange blow connections on 6A, B, and C main ballast tanks were installed. No. 1 MBT check valve was removed and the flange blow connection installed. No. 7 MBT check valve was partially removed. No. 4 A, B fuel ballast tank 10 psi blow line check valves were identified and marked for removal.

The dewatering plan was started by pressurizing the pressure hull to 60 psi through all eight high salvage connections and taking suction on the aft torpedo low salvage connection with a 3-inch pump. This action worked with an estimated result of 2.3 tons per hour.

As the dewatering continued, a manifold was made to hook the other low salvage connections to the pump. At 1830, dewatering was stopped to hook up the remaining lows to the pump but the manifold would not discharge. The manifold was disconnected to determine the problem. Each of the lows was connected to the pump to check in turn. When only the after torpedo and forward battery compartments were found to discharge water, the forward battery compartment was reconnected and dewatering continued at a rate of approximately 2.5 tons per hour.



SALVAGE AIR MANIFOLD

Sunday, 23 October 1983

The bow buoyancy tank (BBT) hose connection fitting was installed. The latching device hole on the conning tower hatch was leaking and plugged with a DC plug and aircraft tiedown straps. 2D and 6C main ballast tanks required refitting and modification to allow for lack of clearance for salvage hose. The removal of the check valve on No. 7 MBT continued to progress slowly because of obstructions. The obstructions were partially removed using underwater hydraulic tools.

The dewatering plan started 22 October 1983, secured because of leaks in the aft torpedo room hatch, recommenced. It was decided to increase pressure to 70 psi at the manifold and hook each low fitting to the pump individually. While this effort was in progress, other low fittings began to discharge. A hookup was made to the manifold and pump with successful results until 1445, when the pump ceased operating. At 2120, with the pump repaired, dewatering continued at a rate of about 13 tons per hour. Within minutes the motor end of the pump seized up and a call was made to rig another pump from BEAUFORT. Pumping resumed to assist the dewatering with air during the night.

Monday, 24 October

Dewatering continued until 0700 when the flow stopped for an unknown reason. Also, a slick of oil, allegedly leaking from the submarine, was observed. With this, all pumping and blowing was secured.

A survey dive revealed no oil leaks emanating from the submarine. Pumping commenced at 1400 but pump problems developed with eventual loss of suction. When the aft battery room low hose connection was removed, a large amount of air was released indicating a dewatered condition in the compartment.

Using underwater cutting equipment, divers cleared interferences away from No. 7 main ballast tank. A specially manufactured Jubilee patch was installed on the 7-inch vent pipe of the safety tank to allow for salvage hose hookup. This was necessary because it was not connected to the 10 psi system. A satisfactory test blow of 2A, 2B, 2C, 2D, 6A, 6B, 6C and 6D MBT's was completed. Dewatering continued.

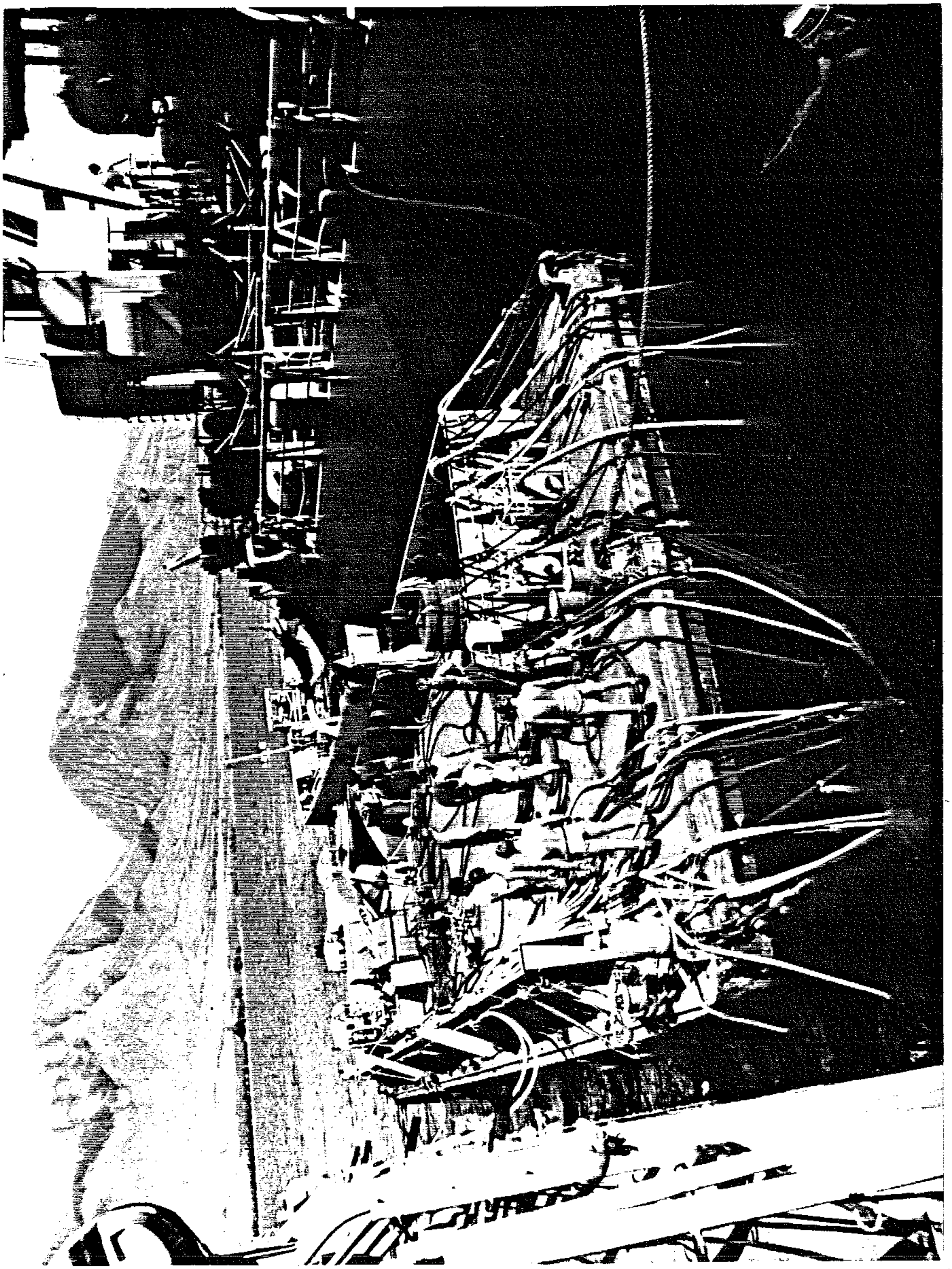
Because of the overwhelming problems of using the 3-inch pump to take suction on the low salvage connection hoses, the decision was made to disconnect all low salvage hoses. The main function of the pump was to overcome the friction of the water coming up the hose to the barge. Now a diver would have to go down and check each low salvage fitting and cycle the valve on the deck of the submarine to determine if that compartment was dewatering or dry.

Tuesday, 25 October 1983

A satisfactory test blow of the buoyancy bow tank was completed with 15 psi overbottom pressure at 5.2 tons per minute. The check valves were removed and blow fittings installed on 4A and 4B fuel ballast tanks and No. 7 main ballast tank. The salvage blow fitting installed to No. 1 MBT was found to be incorrectly positioned. The fitting was placed on the flange so that air was blown into the 10 psi blow system instead of the ballast tank. Divers put strain relief lines on all high salvage fittings to prepare for the barge being moved to its position for the raising. A salvage meeting was held to develop details of the blowing plan. The forward battery, aft battery, and maneuvering rooms were dewatered as evidenced by air escaping from low salvage fittings.

Wednesday, 26 October 1983

A satisfactory test blow on Nos. 1 and 7 main ballast tanks was conducted. The following compartments were verified as dewatered by air venting from low salvage fittings: forward torpedo room, forward battery room, maneuvering room, aft



BARGE YC 1485

battery room, aft engineroom, and aft torpedo room. Two 8.4 ton salvage pontoons were rigged on the forward capstan drive shaft. This attachment was judged too weak to support the pontoon lift and rerigging was directed.

The arrangement of hose on the YC and in the water was believed to be causing kinks in the salvage hose. With a combination of divers and shipboard working parties, rearrangement and organization of salvage hose on the YC and in the water commenced.

In preparation for the raising attempt, a detailed plan for ballast tank and pontoon was defined.

The forward battery compartment low salvage fitting valve remote operator broke forcing the divers to go under the deck grating to make their checks.

In the confusion of the process to direct air to the submarine, #7 MBT was blown completely dry. Fortunately, the added buoyancy was not sufficient to cause the submarine to move.

Thursday, 27 October 1983

The forward two salvage pontoons were rerigged to a stronger structural member. Rigging salvage pontoons aft continued with slow progress attributed to the sophisticated rigging and complex topside/diver interphasing required. The YC was shifted aft to facilitate rearranging the air hose on deck necessary due to excessive fouling of the more than two miles of hose. This hose operation was further complicated by kinks in the hoses at various depths.

A satisfactory test blow on the safety tank was completed. Nos. 4A and 4B fuel ballast tanks could not be tested satisfactorily after three attempts. At 1300 both FADDS LP compressors failed, preventing MK12 DDS operations from BRUNSWICK. Divers were divided into shifts to work from BEAUFORT's diving station. This minimized effects of the FADDS loss.

Friday, October 28

An inspection dive revealed the status of the salvage fittings' valves (open or shut) remained unclear. The obvious disadvantage of frequently needing to send divers down to check a low salvage fitting lay in using up the limited number of divers available because of decompression limits.

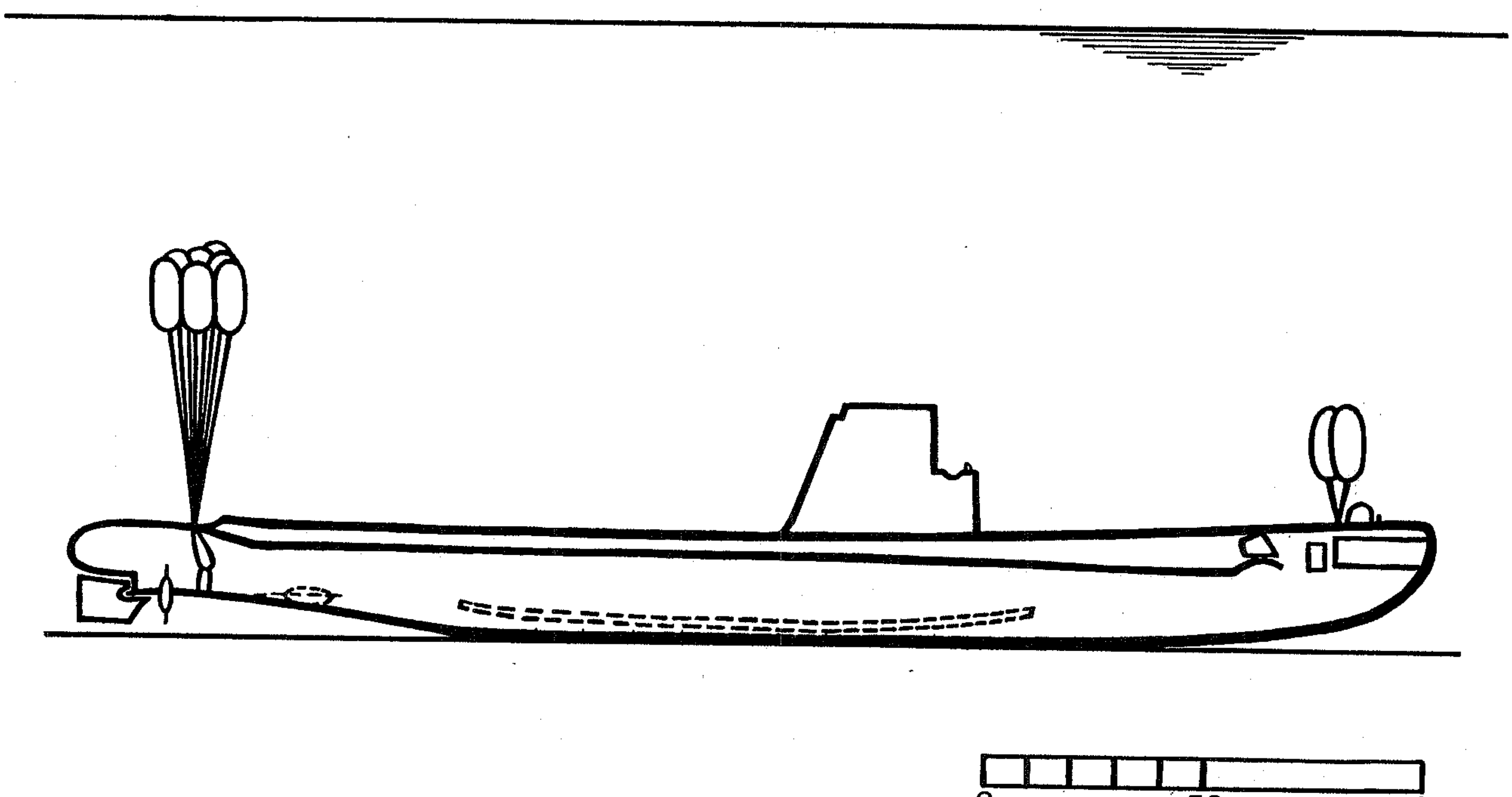
A safety meeting was held to review precautionary measures and emphasize proper supervisory control of the dewatering process. Four salvage pontoons were rigged aft and the hose rearrangement and kink removal process was approximately 50 percent complete. ATS hose was replaced with noncollapsible hose on the high salvage fittings to the control room and aft engineroom to facilitate venting at a later date. All high salvage fittings were open with air coming out of all low fittings excepting the control room and forward engineroom, which still contained water.

Saturday, 29 October

The rearrangement of salvage hose on the barge continued and was 80 percent completed. Three more salvage pontoons were installed aft, bringing the total to seven.

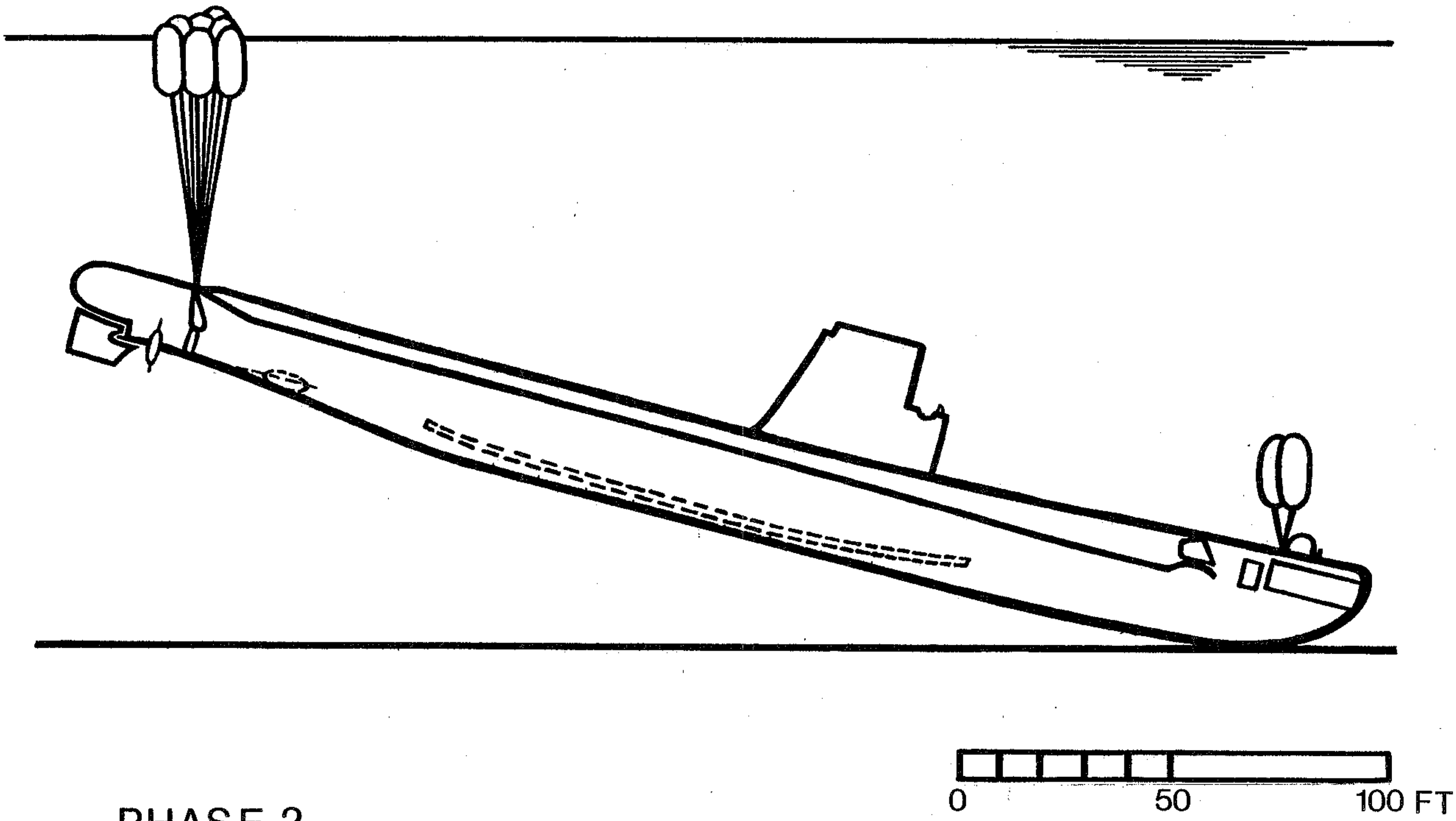
Air tests were performed on fuel ballast tank No. 4 by "timed venting", eight minutes of air blown down the hose at 75 psi revealed a scant return after a five-minute waiting period. The special fitting for No. 4A FBT was put on the wrong flange so air was being blown into the 10 psi blow system instead of the ballast tank. A hole was found on the 4B FBT vent pipe that required patching. In-line check valves were installed on Nos. 2 A, B, C, D, and No. 1 main ballast tank fittings. This was done to prevent the loss of buoyancy if a hose ruptured during the raising.

The forward pontoons were not yet rigged properly. Hose rearrangement was finished. A section of noncollapsible hose was inadvertently stepped on, ruptured, and was replaced. Station assignments for personnel to board the submarine when it appeared on the surface were organized and alternate actions, if the submarine proved not to be stable, were outlined.



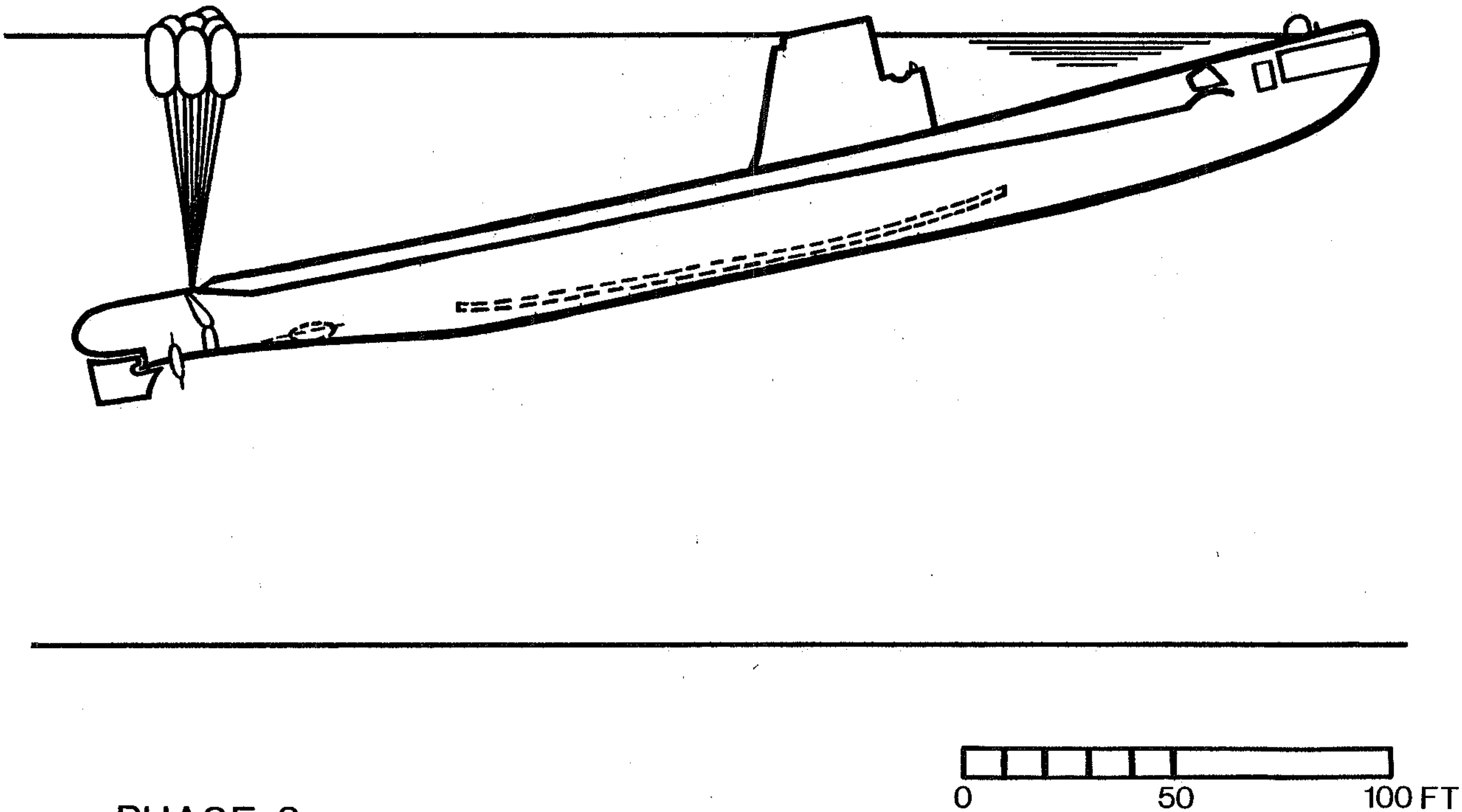
PHASE 1

ON THE BOTTOM



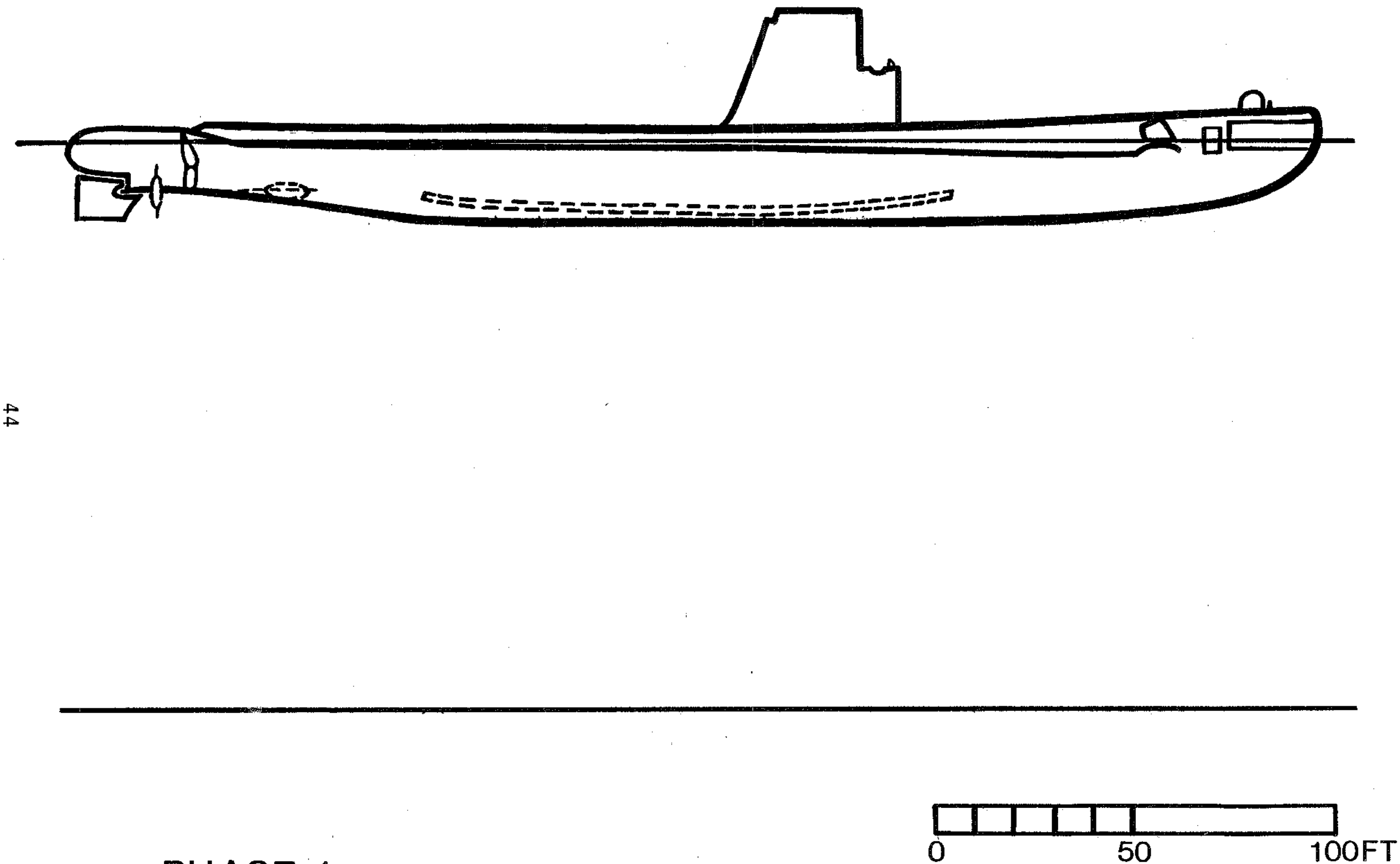
PHASE 2

STERN UP



PHASE 3

BOW UP



PHASE 4

ON THE SURFACE

Sunday, 30 October 1983

The first dive of the day to check low salvage fittings became confused and a second dive was made to verify the condition of compartments and valve positions.

Completed blowing all eight interior compartments at 1208 and commenced venting submarine to one atmosphere (ATM) immediately. At 1214 all air leaks stopped. At 1400 internal pressure was at 19 psig. A diver check confirmed no detectable leaks. At 1800 internal pressure was eight psig. Venting continued. The pressure hull was venting much more rapidly than expected.

4A and 4B fuel ballast tanks still did not test satisfactorily.

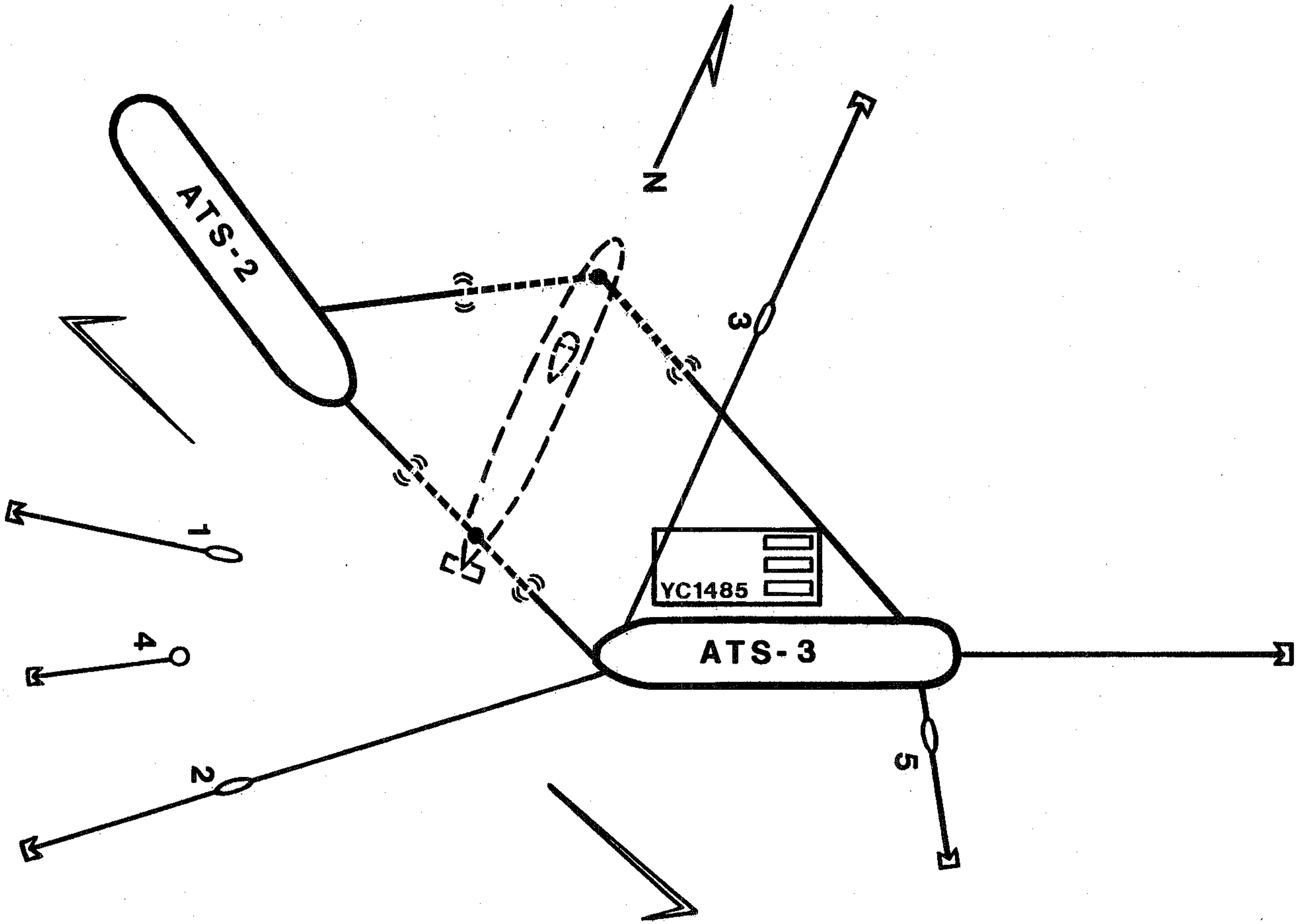
A reinspection of the trailing edge of the struts and the stern pontoon attachments generated some concern that the sharp trailing edge would cut the pontoon attachment wires under excessive strain. A split pipe was attached to the trailing edge to alleviate this problem.

Monday, 31 October 1983

The in-line patch on 4B fuel ballast tanks was reinforced with an epoxy-like sealant and an additional wrap of rubber sheet to stop leaks. This treatment proved to be satisfactory.

In the course of the process of straightening out hoses and installing check valves to MBT's, the hose from 4A fuel ballast tank was moved to a low salvage fitting and a check valve installed to the fitting. After some effort, both problems were resolved and the tank tested satisfactorily.

An inspection dive revealed potential problems. The salvage pontoons were deflated and lying across the deck of the submarine. Chafing of the rubber pontoons could cause failure. Additionally, there was an increased risk of fouling the rigging wires of the salvage pontoons on air hoses, deck fittings, and themselves each time they were inflated and deflated in accordance with the blow plan. Therefore, crown buoys were rigged fore and aft to suspend the salvage pontoons above the deck when they were deflated.



MOORING PLAN

Wire straps were rigged on bow and stern to the towing padeyes through the bullnose and stern chock respectively. These were to be used to attach control lines to the submarine during raising and for surface maneuvering.

A satisfactory test blow of 4A and 4B FBT and 6A, 6B, 6C and 6D main ballast tanks was conducted. In-line check valves were installed on No. 7, 6A, 6B, 6C, 6D MBT's and 4A and 4B FBT's.

Tuesday, 1 November 1983

At approximately 2230, water discharging from aft torpedo room high salvage fitting was noted. It was suspected that significant flooding of the pressure hull occurred since venting to one atmosphere.

BEAUFORT tripped out of the moor and repositioned off the port side of the submarine in a two-point moor. BRUNSWICK repositioned off the starboard side of the submarine in four-point moor with the YC alongside. While repositioning, numerous hoses became fouled in the sail area of the submarine. It was necessary to clear these hoses during daylight hours.

The pressure hull was repressurized and dewatering restarted.

3.4 Blowing to the Surface

Wednesday, 2 November 1983

The bow and stern control lines to the submarine were rigged to both ships. Pneumofathometer hoses were rigged on the bow and stern of the submarine. All salvage hoses were unfouled and rearranged on the barge. The dewatering phase was completed for a second time and the submarine blow plan initiated at 1800.

USS BEAUFORT REPOSITIONED FOR RAISING (FOREGROUND BUBBLES ARE FROM SUBMARINE)

After blowing Numbers 4A, 4B, Safety, 2A, 2B, 6C, 6D, 6A, 6B and seven pontoons aft, about 40 minutes at 65 psi, blowing operations were terminated. The safety tank and No. 7 main ballast tank appeared to be problematic. Flooding of the pressure hull exceeded the rate of blowing the ballast tanks. The major part of flooding was aft thus inhibiting the lift of the stern.

Thursday, 3 November 1983

After several hours of attempting to lift the submarine, the attempt was aborted at approximately 0200. It was believed that back flooding of internal compartments at a rate of 30 tons per hour combined with a greater than expected time to blow ballast tanks were the main problems in the unsuccessful blow. This was determined when the aft torpedo room high fitting began discharging water.

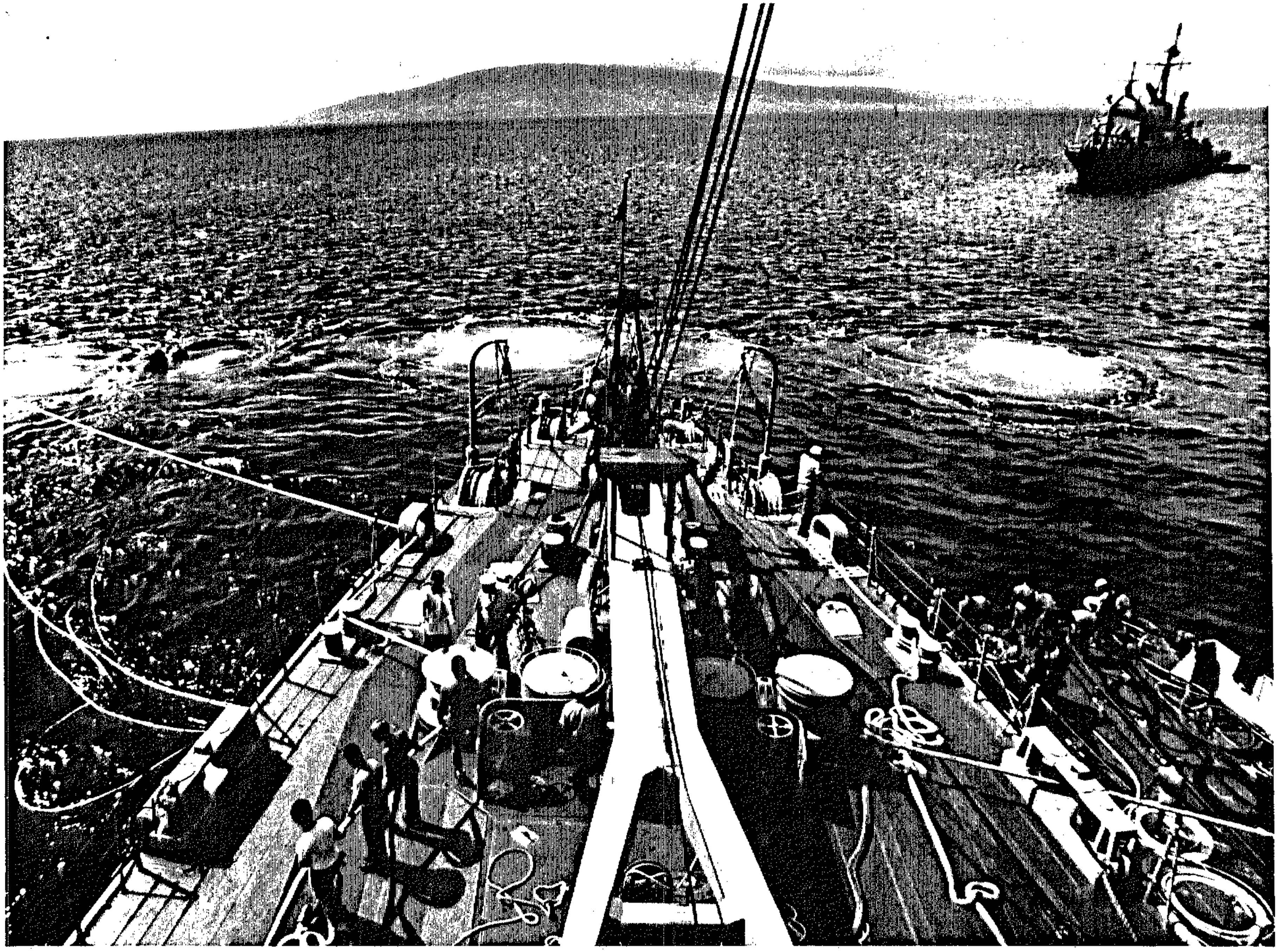
BEAUFORT repositioned over the submarine to facilitate MK12 diving operations to vent tanks and install stop values where they were omitted.

Friday, 4 November 1983

The air manifold was modified to accept and distribute the supply from all three salvage compressors, and BRUNSWICK's salvage air in an emergency, to the 31 hoses attached to the submarine. A large air leak from the radar mast of submarine sail area was found and a patch was made and installed. All the ballast tanks were vented by removing the plugs on installed check valves. Dewatering of all compartments was restarted and continued. The safety tank, 6A, 6B, 2C, 2D and 7 MBT could not be successfully test blown. The causes of the problem could not be identified.

Saturday, 5 November

All main ballast tanks, fuel ballast tanks, bow buoyancy tanks and the safety tank were successfully test blown. All other preparations were completed. BEAUFORT again repositioned off the port side of the submarine and connected control lines to the bow and stern of the submarine. All dewatering was completed.



MOORING POSITIONS FOR RAISING (BUBBLES SHOW LOCATION OF SUBMARINE)

The blow sequence was commenced at approximately 1451. At approximately 1800, 5 November 1983, the aft pontoons surfaced, placing the stern of the submarine 50 feet below the surface. At 1856 commenced blow to raise the bow of the submarine to the surface after starting to vent internal compartments at 1855. At 1907, ex-BLUEGILL was on the surface. At 2315 the submarine was alongside YC 1485 using two inflated salvage pontoons for fenders.

The stern lifted off the bottom when 4A, 4B, Safety, 2A, 2B, 6A, 6B, were blown and the stern pontoons inflated. The submarine surfaced with a minor list of approximately two degrees to starboard and a trim of six degrees down by the stern. As the submarine was positioned by steadying lines from the YC, several ESSM hoses to the ballast tanks ruptured and were replaced with the stronger ATS hose. The list, at its most severe point, was approximately 18 degrees to starboard. This, coupled with the ruptured hoses, led to the decision to move the BRUNSWICK with the YC and submarine to shallow water so that if the ex-BLUEGILL could not be maintained on the surface, it could be placed on the bottom at a depth where it would be easier for divers to work.

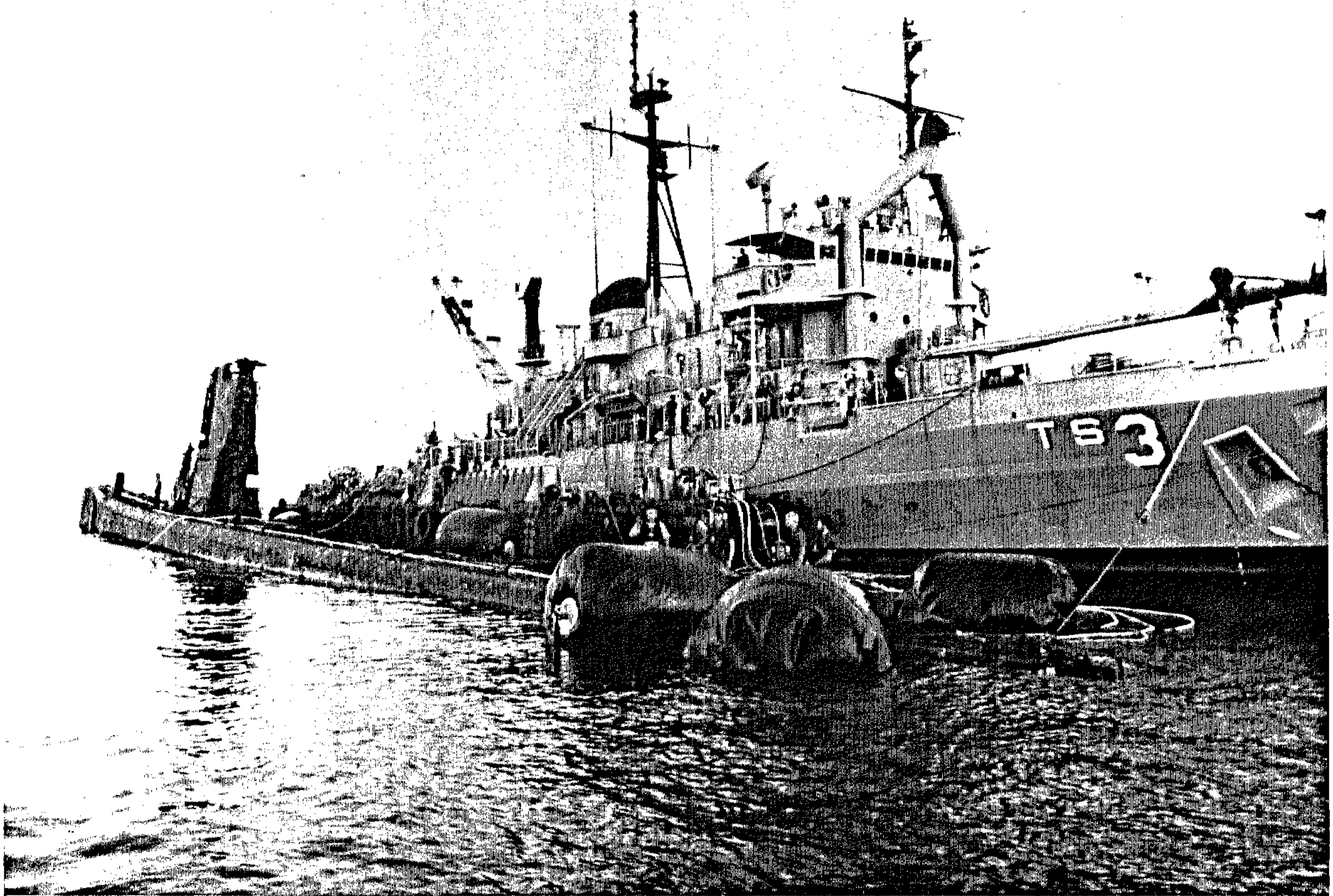
3.5 Tow Out

Sunday, 6 November

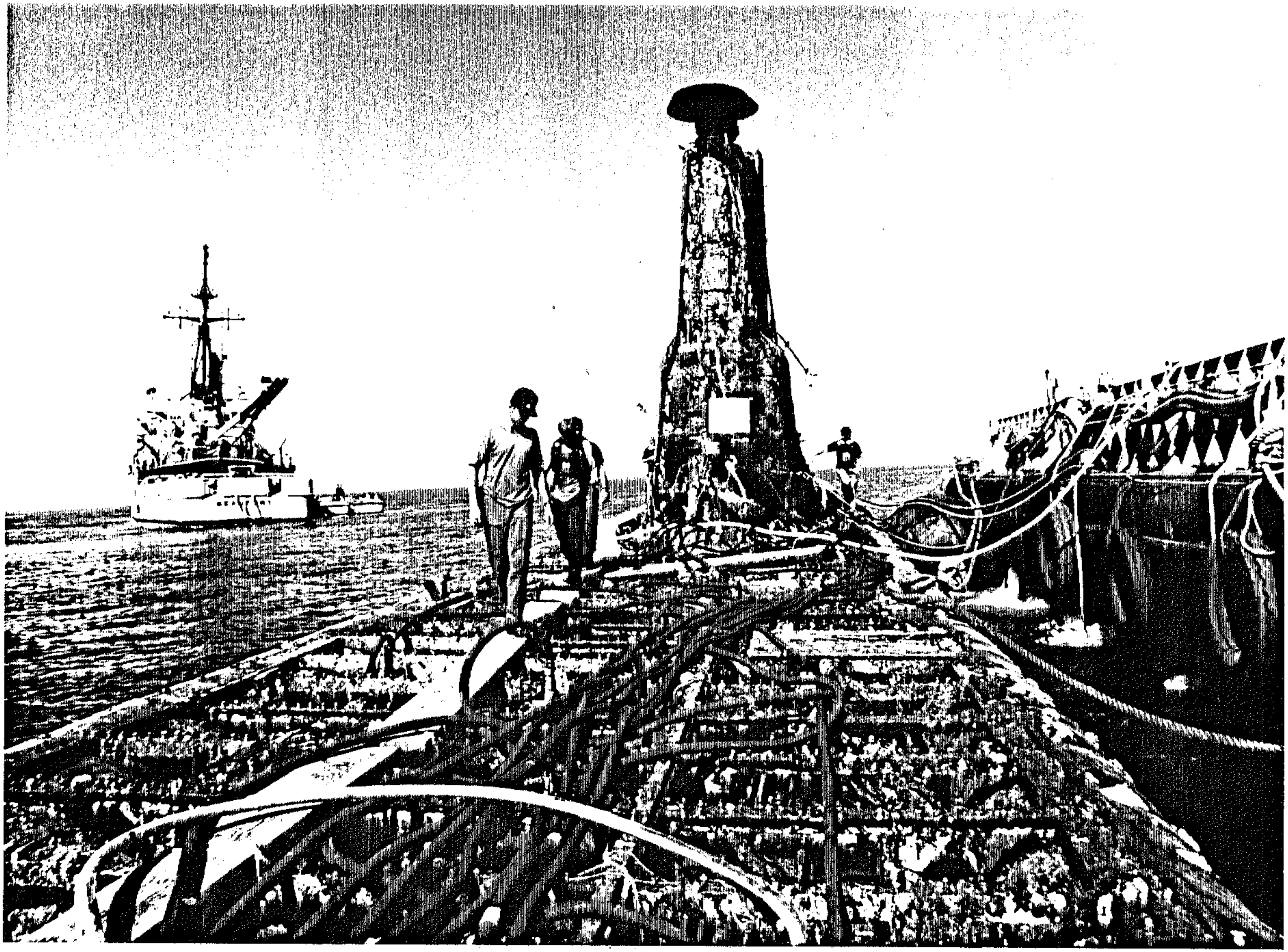
At 0400 on Sunday, 6 November BRUNSWICK with YC and ex-BLUEGILL alongside completed the move to shallow water.

At approximately 0730, the submarine started sinking by the stern due to a rupture in the 10 psi vent to No. 7 main ballast tank. The stern was 10 feet below the surface before a soft patch was placed on the vent line and the trim corrected. The submarine was stabilized at approximately 0900. After rigging the submarine and YC for tow, BEAUFORT got underway for the disposal site at 1235. BRUNSWICK commenced recovery of two legs of the moor.

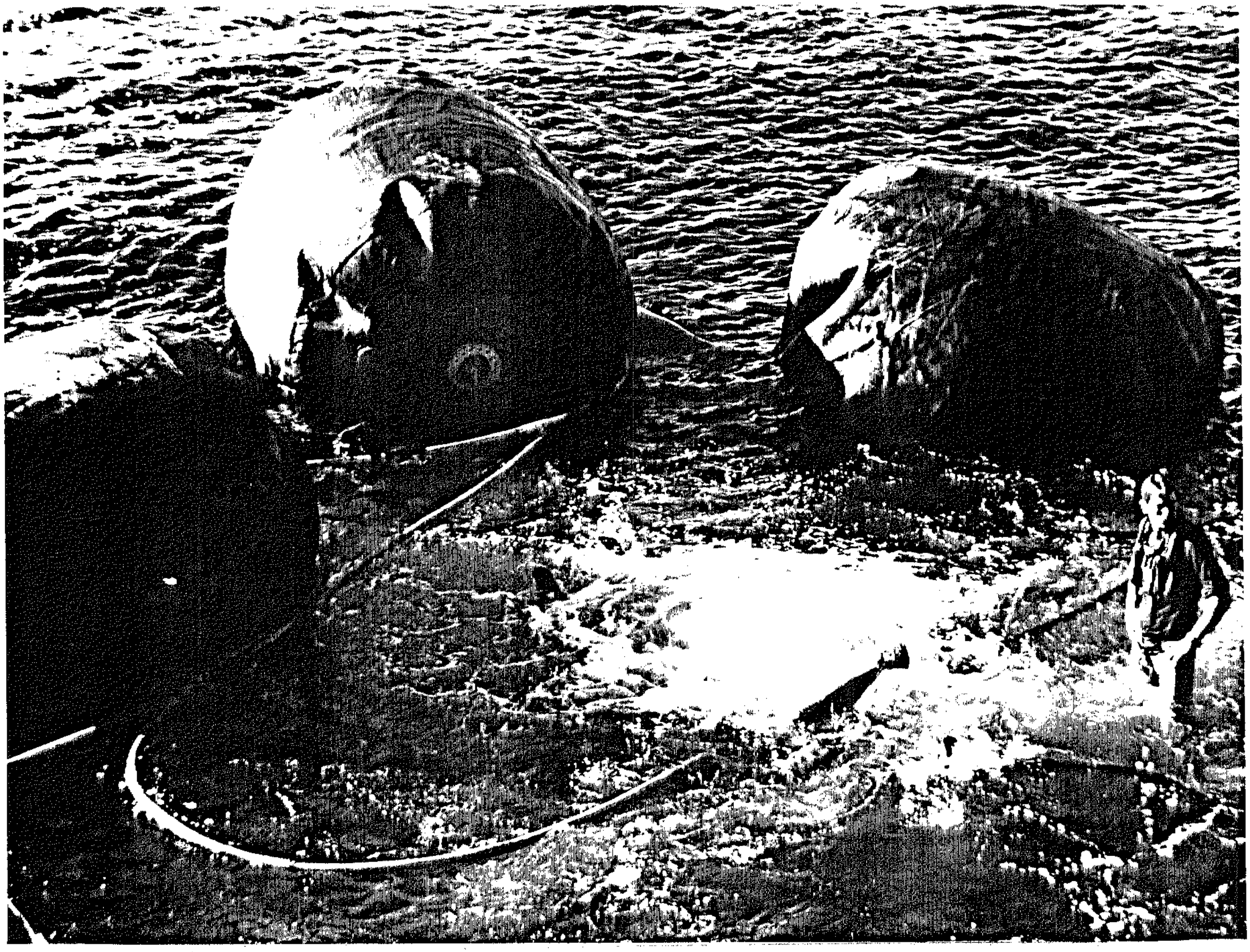
The YC-1485 was towed on a separate tow line and secured to the submarine until its tow line chafed against the submarine and parted. The tow continued on the submarine tow line with the YC-1485 made fast alongside the submarine.



EX-USS BLUEGILL ALONGSIDE YC-1485 AND USS BRUNSWICK



EX-USS BLUEGILL ON THE SURFACE



STERN SINKING ON THE MORNING OF 6 NOVEMBER 1983

At 1700 BEAUFORT came dead in the water to trip out the submarine, and disconnect all air hoses. The seas were sufficiently rough for the YC to "climb" on top of the submarine whose decks were awash. In rapidly deteriorating sea and weather conditions, the submarine riding party evacuated the ex-BLUEGILL.

3.6 Sinking

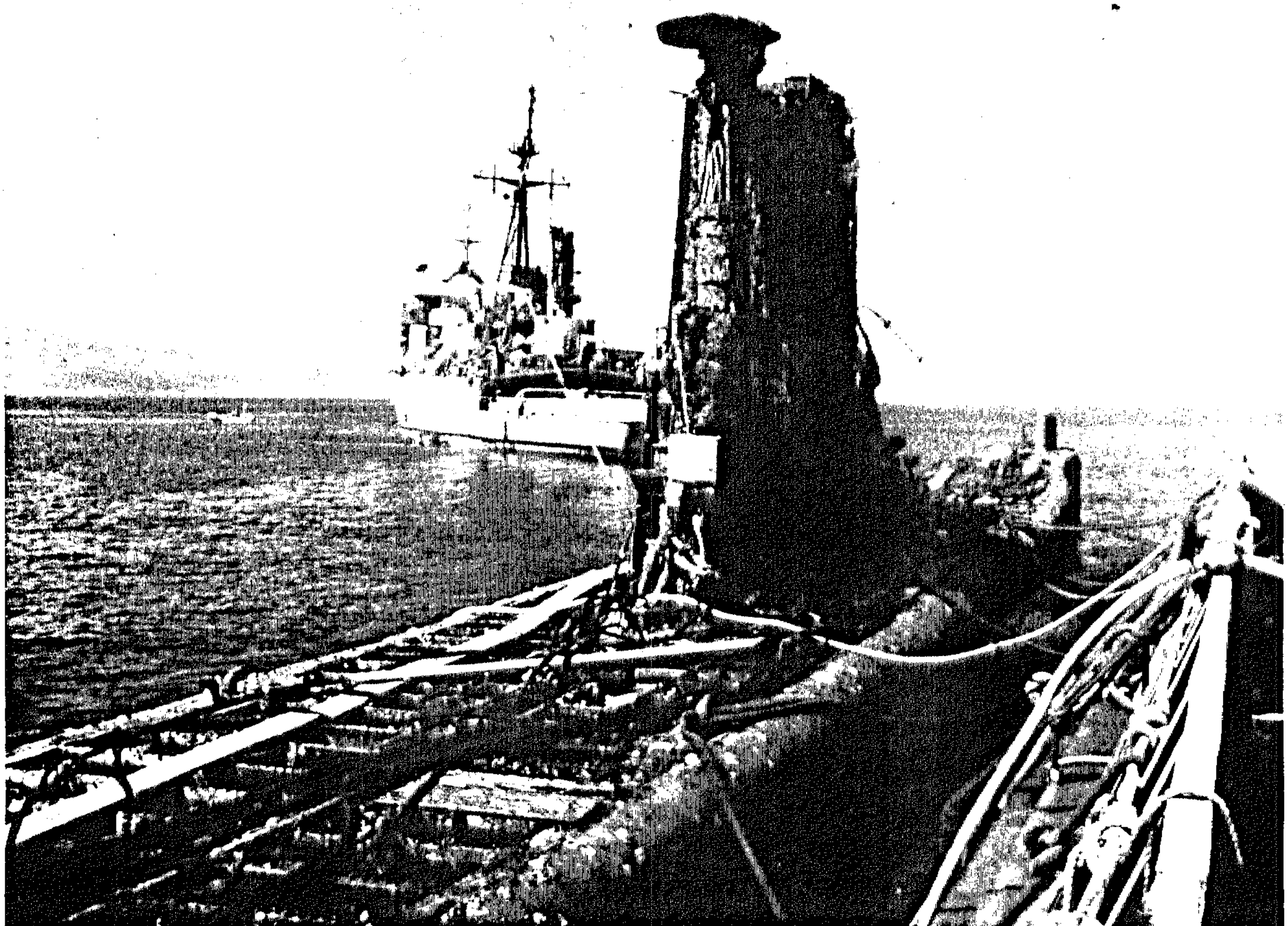
Sunday, 6 November

At approximately 1800, the ex-BLUEGILL was sunk by the BEAUFORT at 20 degrees 35.5 North/156 degrees 55.5 West in 1,200 feet of water.

BRUNSWICK recovered two mooring legs and got underway for Pearl Harbor.

Monday, 7 November 1983

BRUNSWICK arrived in Pearl Harbor in the early morning. BEAUFORT remained in the vicinity of Lahaina, Maui, the Hawaiian Islands, to recover the remaining legs of moor. BEAUFORT placed the majority of the moor rigging onboard the YC 1485 and returned to Pearl Harbor with the barge in tow on 8 November 1983.



EX-USS BLUEGILL AND YC-1485 UNDER TOW BY USS BEAUFORT

4. Engineering Data & Calculations

A wide variety of data and supporting engineering calculations were developed prior to, and during, the salvage operations.

Many questions relating to the general subject of submarine stability were addressed in the engineering process. Their resolution was essential to the analysis of situation and development of the plan. The reader is directed to the discussion of submarine stability in "Principles of Naval Architecture" published by the Society of Naval Architects and Marine Engineers (SNAME).

The primary data and most significant engineering calculations are presented in this section. Some documents have been formatted for ease of understanding, others have been duplicated for easier readability; in each instance it is hoped that the data and applicable calculations will assist the overall understanding of the salvage operations.

The following general subjects are presented:

- Theoretical Calculation of the Buoyancy Required to Surface the Submarine (Buoyancy Added Method)
- Submarine Baseline Data
- Buoyancy Calculations for Refloating the Submarine
- Dewatering Calculations of the Pressure Hull
- Transverse Stability Data
- Calculations of the Free Surface Corrections
- Longitudinal Stability Data
- Final Dewatering Plan

- Mooring Plan
- Submarine Salvage Fittings
- Ballast Tank Adapter System
- Pneumofathometer Readings Used to Verify the Low Salvage Piping Conditions
- Salvage Pontoon Arrangement
- Rigging Details of the 8.4 Buoyancy Pontoons
- Mooring Plan for the Submarine on the Surface
- Ground Reaction Calculations
- Compartment Salvage Deck Plate Markings

More extensive details pertaining to the submarine's principal characteristics, configuration, and compartment nomeclature are included in the Appendix section of this report for reference by the reader considering the engineering aspects of the operation.

4.1 Theoretical Calculation of the Buoyancy Required to Surface the Submarine (Buoyancy Added Method)

Light Ship $\Delta = 1512.9$

Specific gravity of light ship material = .8

(from NAVSEA 55W4 estimate)

Total weight of hull submerged

$W = 1512.9\ (.8) = 1210.32$ tons

When pressure hull dewatered buoyancy of

$B = 1031.51$ tons

$W - B =$ 178.91 tons of lift needed to bring to surface

4.2 Submarine Baseline Data

Light Ship Δ = 1512.9

KG = 11.32'

LCG = 155.06'

LBP = 306'6"

NO.	SPACE	WEIGHT OF WATER WHEN FLOODED	VCG	LCG
1	FTR	129.54	13.70	53.00
2	OFF QTR	121.48	13.60	86.50
3*	CONTROL	124.49	12.00	114.80
4	CREW QTR	184.68	13.60	151.20
5	FER	133.14	12.74	186.80
6	AER	120.63	12.74	213.40
7	MANEUV	96.77	13.60	236.50
8	ATR	98.71	14.92	264.00
9*	CONN	21.97	24.50	114.00
	TOTALS	1,031.41	13.57	156.73

* #3 and #9 were made common by salvors breaking the deadlight between compartments

TANKS INTERNAL TO PRESSURE HULL

TANK	WEIGHT OF WATER WHEN FLOODED	VCG	LCG
FWT #2	3.77	8.21	72.50
CFO #1	1.31	5.42	197.20
SAN #2	3.62	8.05	171.70
CFO #2	2.47	5.42	223.90
AFT BFW	2.31	6.00	155.50
FWT #1	3.77	8.21	72.50
FWT #5	3.61	5.05	184.30
RLO #2	3.51	8.23	171.70
FWT #3	4.06	8.29	127.90
NLO #2	8.20	5.72	211.70
SAN #3	0.80	8.41	247.60
NLO #1	1.95	6.34	184.30
FWT #4	4.06	8.29	127.90
FWD BFW	2.31	6.00	87.00
SAN #1	1.12	6.40	70.20
MMLO SUMP 1	0.77	4.76	234.60
TOTALS	47.64		
	KG/KB	6.94 FT ABL	155.31 FT aft FP

TANKS EXTERNAL TO PRESSURE HULL

TANK	WEIGHT OF WATER WHEN FLOODED	VCG	LCG
AFT TRIM	20.29	14.48	287.20
RLO #1/HO	1.95	2.06	192.50
AUX #2	22.23	11.31	147.50
AFT WRT	5.11	9.64	268.40
AUX #1	17.00	2.73	147.50
MELO SUMP 3	1.80	2.17	220.00
EXP	11.29	8.67	210.00
FWD TRIM	25.43	9.66	33.80
COLL	11.29	8.67	210.00
AUX #3	22.23	11.31	147.50
NFO #7	56.11	8.97	232.60
MELO SUMP 1	1.95	2.06	192.50
NFO #6A/B	36.58	9.27	217.10
NEGATIVE	7.57	2.95	110.90
MELO SUMP 4	1.80	2.17	220.00
FWD WRT	5.03	5.41	49.10
NFO #2	49.58	8.66	92.50
NFO #1	42.92	8.43	79.10
TOTALS	340.16		
	KG/KB	8.92 FT ABL	157.19 FT aft FP

MAIN/FUEL BALLAST TANKS

TANK	WEIGHT OF WATER WHEN FLOODED	VCG	LCG
BOW BUOY	46.69	20.00	10.00
MBT #1	44.72	6.70	60.70
MBT #2A/B	59.18	9.80	105.70
MBT #2C/D	62.37	9.30	119.90
FBT #3A/B	74.06	9.00	132.40
FBT #4A/B	94.00	9.00	160.00
FBT #5A/B	75.46	9.00	173.70
MBT #6A/B	64.34	9.30	186.10
MBT #6C/D	66.81	9.10	200.00
MBT #7	43.11	8.90	255.40
SAFETY	23.20	9.50	140.50
TOTALS	653.94		
	KG/KB	9.78 FT ABL	144.47 FT aft FP

4.3 Buoyancy Calculations for Refloating the Submarine

FLOATING CALCULATIONS

MIDSHIPS = 153.50' AFT FP (See "Displacement and Other Curves")

I. LIGHT SHIP 1,512.9 LT

LEAD BALLAST 112.9 LT x $\frac{708-64 \quad (LB/FT^3)}{708 \quad (LB/FT^3)}$ = 102.69 LT

STEEL 1,400.0 LT x $\frac{490-64}{490}$ = 1,217.14 LT

KG_{LS} = 11.32' ABOVE B.L. SUBMERGED LIGHT SHIP DISPL = 1,319.93 LT

LCG_{LS} = 1.56' AFT MIDSHIPS

155.06 AFT F.P. GM = 1.14 ft.

II. TANKS WHICH WILL REMAIN FLOODED UPON SURFACING:

385.9 LT (SEE BASELINE DATA)

FIGURE REVISED

III. FLOTATION DUE TO DRY PRESSURE HULL

100% 1,031.3 LT

85% 877 LT

IV. SUBMERGED LIGHT SHIP 1,320 LT

PRESSURE HULL FLOTATION 877 LT

443 LT LIFT REQUIRED

At first glance there may appear to be a discrepancy in the calculations to determine the amount of buoyancy needed to bring the submarine to the surface. This is an indication of the difficulty in obtaining data on a vessel of this age.

When a data baseline was established, then a range of buoyancy was needed depending on the amount of residual water left in the pressure hull after dewatering was investigated. Two methods were also used to check the buoyancy needed to surface. The first was to take the submerged displacement and add weight. The second was to take the light ship displacement and add buoyancy. The results of all these calculations showed that the light ship displacement and adding buoyancy was a more accurate method.

After investigating various amounts of residual water conditions for stability and weight, the final plan for the dewatering sequence was made assuming a 100% dewatered pressure hull. This was done to avoid any surprise lift offs, knowing that stability and other conditions were satisfactory.

The choice of ballast tanks to be used in the dewatering plan was a careful selection to give maximum control. The plan increased buoyancy in small increments of less than 10 tons and increased the moments about the forward perpendicular (FP) and after perpendicular (AP) in increments of around 200 foot tons. This was accomplished with only the 8.4 ton pontoons and the safety tank available for dewatering and flooding back again.

DEWATERING OF PRESSURE HULL

$$W = 1891\, d^2 \sqrt{\frac{\Delta P \rho}{K}}$$

$$W = 1891 (1.05)^2 \sqrt{\frac{25(64)}{34.1}}$$

W = 6.36 TONS/HR

WITH 8 HOSES
50.88 TONS/HR

W = RATE OF DEWATERING

d = 1.05" INTERNAL DIAMETER OF PIPE

ΔP = 25 PSI MAX ALLOWABLE PRESSURE DIFFERENTIAL

ρ = 64 LBS/FT³ (DENSITY OF SEA WATER)

K = EMPERICAL FRICTION FACTOR: 12.6 – INTERNAL SALVAGE PIPING + 21.5 – 300' OF 1¼" HOSE
⇒ 34.1

DEWATERING PRESSURE HULL WITH LOW DISCONNECTED

$W = 1891\, d^2 \sqrt{\frac{\Delta P \Delta}{K}}$

W = RATE (LBS/HR)

d = PIPE DIAMETER = 1.05

$W = 1891\,(1.05)^2 \sqrt{\frac{(5)(64)}{12.6}}$

ΔP = FORCING PSI = 5

K = 12.6

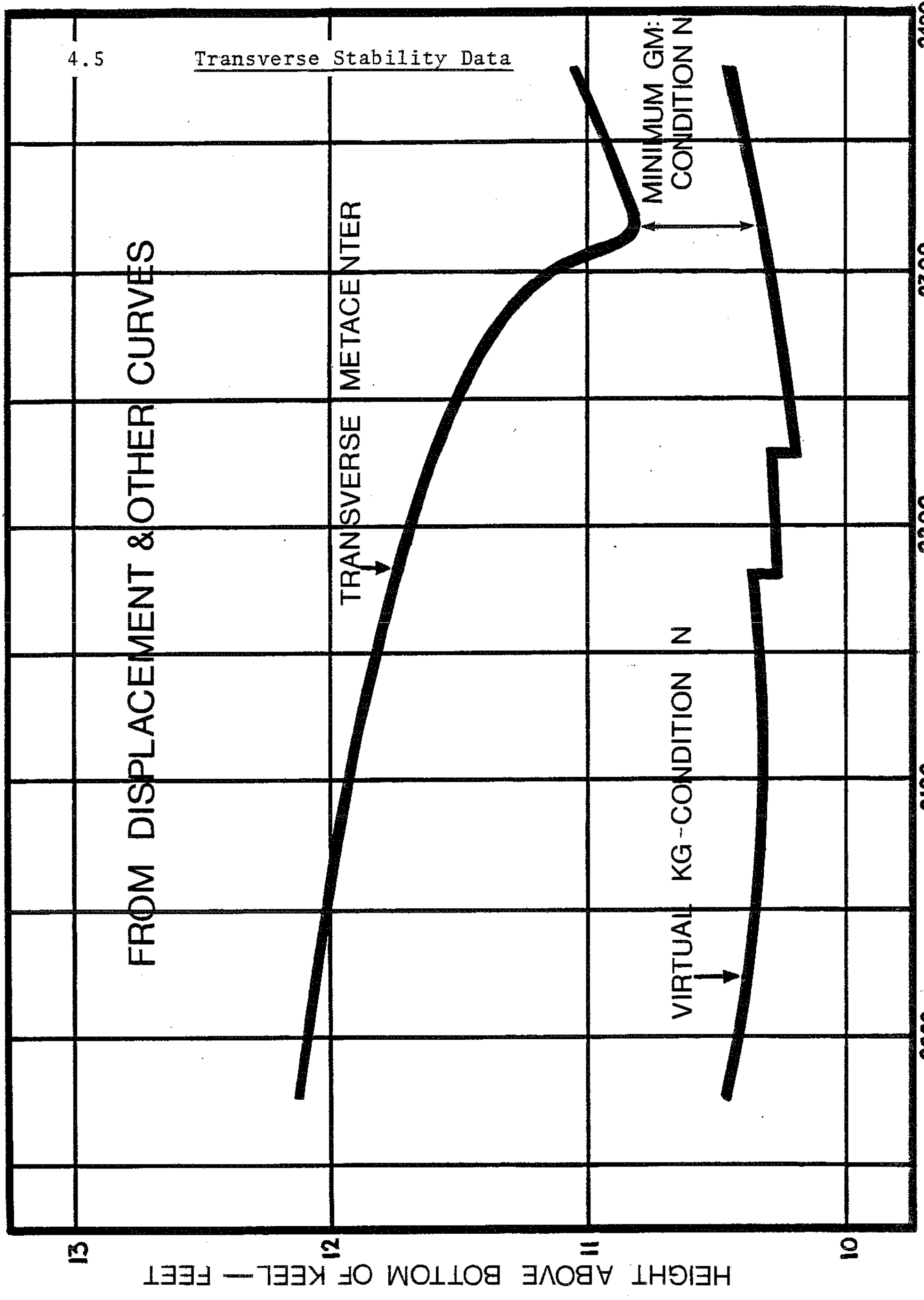
W = 10,506.5 LBS/HR = 4.69 TONS/HR PER HOSE

FOR 8 HOSES ⇒ 37.52 TONS/HR

IF ΔP = 10 PSI, W = 6.63 TONS/HR PER HOSE

FOR 8 HOSES ⇒ 53.07 TONS/HR

4.5 Transverse Stability Data



4.6 Calculations of the Free Surface Corrections

DECREASE IN KG DUE TO PARTIAL DEWATERING OF PRESSURE HULL

DEWATER %	WEIGHT	WATER DEPTH	WATER CG (ABOVE PRESSURE HULL DECK)	D	GG1
100	0	0.0'	0.0'	7.82	0'
95	52	1.54'	.77'	7.05	.28'
90	103	2.50'	1.25'	6.57	.51'
85	155	3.3'	1.65'	6.17	.72'

$$GG_1 = \frac{(W)(D)}{\Delta}$$

KG_{LS} = 11.32' ABOVE B.L. (LS = Light Ship)

PRESSURE HULL APPROX. 3.5' ABOVE B.L.

$$D = 11.32 - (CG + 3.5)$$

Δ_{LS} = 1,320 SUBMERGED

FREE SURFACE EFFECT DUE TO INCOMPLETE PRESSURE HULL DEWATERING

DEWATER %	TONS REMOVED	WATERPLANE BEAM (B)	RISE IN CG FROM FREE SURFACE (GG')
100	1,031	0	0'
95	979.5	9.2'	0.25'
90	928	11.7'	0.51'
85	876	13.1'	0.71'

GG^1 = rise in VCG due to free surface

PRESSURE HULL LENGTH = 176'

V = DISPLACED VOL = 1,320 (35) = 46,200 ft.^{3}

$$GG' = \frac{LB^3}{12\ V} = \frac{176\ B^3}{12\ (46,200)} = 0.00031746\ B^3$$

NEW KG DUE TO INCOMPLETE PRESSURE HULL DEWATERING

DEWATER %	KG_{LS}	GG_1	GG'	KG_{MOD}
100	11.32	0.0'	0.0'	11.32'
95	11.32	-0.28'	0.25'	11.29'
90	11.32	-0.51'	0.51'	11.32'
55	11.32	-0.72'	0.71'	11.31'

GG_1 = reduction VCG due to dewatering

NOTE: THIS INDICATES THAT VIRTUAL RISE IN VCG DUE TO FREE SURFACE IN PARTIALLY DEWATERED PRESSURE HULL IS OFFSET NEARLY IDENTICALLY BY DECREASE IN VCG DUE TO ADDED WEIGHT OF WATER LOW IN THE COMPARTMENT.

4.7 Longitudinal Stability Data

LONGITUDINAL STABILITY

VIRTUAL RISE IN LCG DUE TO FREE SURFACE:

ASSUME: • PRESSURE HULL IS 90% DEWATERED

• NO OBSTRUCTION TO WP AREA OF INTERNAL PRESSURE HULL

• VOL OF PRESS HULL =

1031 X 35 (FLOODABLE VOLUME)

.2 X 1512 X 35 (LIGHT SHIP STRUCTURE)

282 X 35 (BUOY NEEDED TO LIFT IF 90% DEWATERED)

56,539 FT³

GG' = VIRTUAL RISE DUE TO FREE SURFACE

$$= \frac{I}{V} = \frac{LB^3}{12V} = \frac{LB^3}{12}\left(\frac{1}{V}\right) = \left[\left(\frac{LB^3}{12}\right)_1 + \left(\frac{LB^3}{12}\right)_2 + \cdots\right]\left(\frac{1}{V}\right)$$

FOR PRESSURE HULL COMPARTMENTS:

L = WATER PLANE AREA WIDTH = 11.7' FOR 90% DEWATER *

B = COMPARTMENT LENGTH

* FROM PAGE 8 OF PREVIOUS CALCULATIONS ON TRANSVERSE STABILITY

COMPARTMENT	B	$LB^3/12$
FTR	39	57836
OFF QTR	27	19191
CONTROL	28	21403
CREW QTR	44	83054
	27	19191
AER	26	17137
MANEUV	20	7800
ATR	36	45490
TOTAL		271102

$$GG' = \frac{271102}{56539} = 4.8'$$

4.8 Final Dewatering Plan

The buoyancy data, presented space by space, utilizes the following abbreviations and notations:

B Total:	Total Buoyancy, Long Tons
B Net:	Net Buoyancy, Long Tons
BG:	Vertical separations of centers of buoyancy and gravity, FT, (negative when CG is above CB)
LBG:	Longitudinal Separation of centers of buoyancy and gravity, FT, (positive when LCB is aft of LCG)

Longitudinal moment conditions may be developed by the volume multiplied by the appropriate lever arm.

Each line of this printout indicates ex-BLUEGILL's condition after the tank or pontoon at the left is blown or flooded (-).
Program execution began at a baseline assuming the pressure hull to be 100% evacuated except for internal tanks. (Residual water accounts for the 93.5 tons of loose seawater presumed to remain in the pressure hull at the time of the actual stern lift off.) It must be remembered that after the submarine is surfaced, values for BG, and LBG, have little relevance and that the pontoons no longer contributed to buoyancy as a function of its original complete displacement.

The first phase was to bring the stern up to 50 feet; the following tanks were dewatered in the following sequence of operations.

Dewatering Operations --- Stern Up

FINAL DEWATERING PLAN

(STERN UP TO 50 FT.)

EVACUATION SEQUENCE	B TOTAL	B NET	BG	LBG
PRESS HULL	1,333.99	-178.91	1.74	1.29
FBT #4A/B	1,427.99	-84.91	1.48	1.53
SAFETY	1,451.19	-61.71	1.43	1.27
PONT AFT	1,459.19	-53.71	1.42	1.98
PONT AFT	1,467.19	-45.71	1.41	2.67
PONT AFT	1,475.19	-37.71	1.39	3.36
PONT AFT	1,483.19	-29.71	1.38	4.04
PONT AFT	1,491.19	-21.71	1.37	4.71
PONT AFT	1,499.19	-13.71	1.36	5.38
PONT AFT	1,507.19	-5.71	1.35	6.04
-7 PONT AFT	1,451.19	-61.71	1.43	1.27

-SAFETY	1,427.99	-84.91	1.48	1.53
MBT #2A/B	1,487.17	-25.73	1.36	-0.49
PONT AFT	1,495.17	-17.73	1.35	0.20
PONT AFT	1,503.17	-9.73	1.34	0.89
PONT AFT	1,511.17	-1.73	1.33	1.57
PONT AFT	1,519.17	6.27	1.32	2.24
PONT AFT	1,527.17	14.27	1.31	2.91
PONT AFT	1,535.17	22.27	1.30	3.57
PONT AFT	1,543.17	30.27	1.28	4.22
-3 PONT AFT	1,519.17	6.27	1.32	2.24
SAFETY	1,542.37	29.47	1.27	1.99
PONT AFT	1,550.37	37.47	1.26	2.65
PONT AFT	1,558.37	45.47	1.25	3.30
PONT AFT	1,566.37	53.47	1.24	3.94
-PONT AFT	1,558.37	45.47	1.25	3.30
-PONT AFT	1,550.37	37.47	1.26	2.65
-PONT AFT	1,542.37	29.47	1.27	1.99
-PONT AFT	1,534.37	21.14	1.28	1.32
-PONT AFT	1,526.37	13.47	1.29	0.65
-PONT AFT	1.518.37	5.47	1.30	-0.03
-PONT AFT	1,510.37	-2.53	1.31	-0.71
-SAFETY	1,487.17	-25.73	1.36	-0.49
MBT #6A/B	1,551.51	38.61	1.22	0.81
PONT AFT	1,559.51	46.61	1.21	1.47
PONT AFT	1,567.51	54.61	1.20	2.13
PONT AFT	1,575.51	62.61	1.19	2.77
PONT AFT	1,583.51	70.61	1.18	3.41
PONT AFT	1,591.51	78.61	1.17	4.05
PONT AFT	1,599.51	86.61	1.16	4.67
PONT AFT	1,607.51	94.61	1.15	5.29

(ACTUAL STERN LIFT OFF POINT)

-3 PONT AFT	1,583.51	70.61	1.18	3.41
SAFETY	1,606.71	93.81	1.14	3.15
PONT AFT	1,614.71	101.81	1.13	3.78
PONT AFT	1,622.71	109.81	1.12	4.40
PONT AFT	1,630.71	117.81	1.11	5.01
-3 PONT AFT	1,606.71	93.81	1.14	3.15
-PONT AFT	1,598.71	85.81	1.15	2.52
-PONT AFT	1,590.71	77.81	1.16	1.88
-PONT AFT	1,582.71	69.81	1.17	1.24
-PONT AFT	1,574.71	61.81	1.18	0.59
-SAFETY	1,551.51	38.61	1.22	0.81
MBT #6C/D	1,618.32	105.42	1.08	2.63
PONT AFT	1,626.32	113.42	1.07	3.26
PONT AFT	1,634.32	121.42	1.06	3.88
PONT AFT	1,642.32	129.42	1.05	4.49
PONT AFT	1,650.32	137.42	1.05	5.09
PONT AFT	1,658.32	145.42	1.04	5.69
PONT AFT	1,666.32	153.42	1.03	6.29
PONT AFT	1,674.32	161.42	1.02	6.88
-3 PONT AFT	1,650.32	137.42	1.05	5.09
SAFETY	1,673.52	160.62	1.01	4.82
PONT AFT	1,681.52	168.62	1.00	5.41
PONT AFT	1,689.52	176.62	0.99	6.00
PONT AFT	1,697.52	184.62	0.98	6.58
-3 PONT AFT	1,673.52	160.62	1.01	4.82
-PONT AFT	1,665.52	152.62	1.01	4.22
-PONT AFT	1,657.52	144.62	1.02	3.62
-PONT AFT	1,649.52	136.62	1.03	3.01
-PONT AFT	1,641.52	128.62	1.04	2.39

-SAFETY	1,618.32	105.42	1.08	2.63
MBT #7	1,661.43	148.53	0.99	5.17
PONT AFT	1,669.43	156.53	0.98	5.77
PONT AFT	1,677.43	164.53	0.97	6.36
PONT AFT	1,685.43	172.53	0.97	6.94
PONT AFT	1,693.43	180.53	0.96	7.52
PONT AFT	1,701.43	188.53	0.95	8.09
PONT AFT	1,709.43	196.53	0.94	8.66
PONT AFT	1,717.43	204.53	0.93	9.22

DEWATERING OPERATION --- BOW UP

(SAFETY BLOWN)

EVAC SEQ	B TOTAL	B NET	BG	LBG
PRESS HULL	1,333.99	-178.91	1.74	1.29
PONT AFT	1,341.99	-170.91	1.73	2.05
PONT AFT	1,349.99	-162.91	1.72	2.81
PONT AFT	1,357.99	-154.91	1.70	3.55
PONT AFT	1,365.99	-146.91	1.69	4.29
PONT AFT	1,373.99	-138.91	1.68	5.02
PONT AFT	1,381.99	-130.91	1.66	5.74
PONT AFT	1,389.99	-122.91	1.65	6.45
PONT FWD	1,397.99	-114.91	1.67	5.73
PONT FWD	1,405.99	-106.91	1.69	5.02
-2 PONT FWD	1,389.99	-122.91	1.65	6.45
BOW BUOY	1,436.68	-76.22	1.88	1.53
PONT FWD	1,444.68	-68.22	1.90	0.86
PONT FWD	1,452.68	-60.22	1.92	0.19
-2 PONT FWD	1,436.68	-76.22	1.88	1.53
MBT #1	1,481.40	-31.50	1.68	-1.37
PONT FWD	1,489.40	-23.50	1.70	-2.00
PONT FWD	1,497.40	-15.50	1.72	-2.63
-2 PONT FWD	1,481.40	-31.50	1.68	-1.37
MBT #2C/D	1,543.77	30.87	1.53	-2.73
PONT FWD	1,551.77	38.87	1.55	-3.33
PONT FWD	1,559.77	46.87	1.57	-3.93

4.9 Mooring Plan

Mooring calculations and the design of the mooring system were based on data from the U.S. Navy SUBMARINE SALVAGE MANUAL; for purpose of ready reference and review of the calculations, the Mooring Section (Chapter 3) should be consulted.

The mooring legs as rigged can be referenced in the drawings of this section.

The legs were generally rigged as follows:

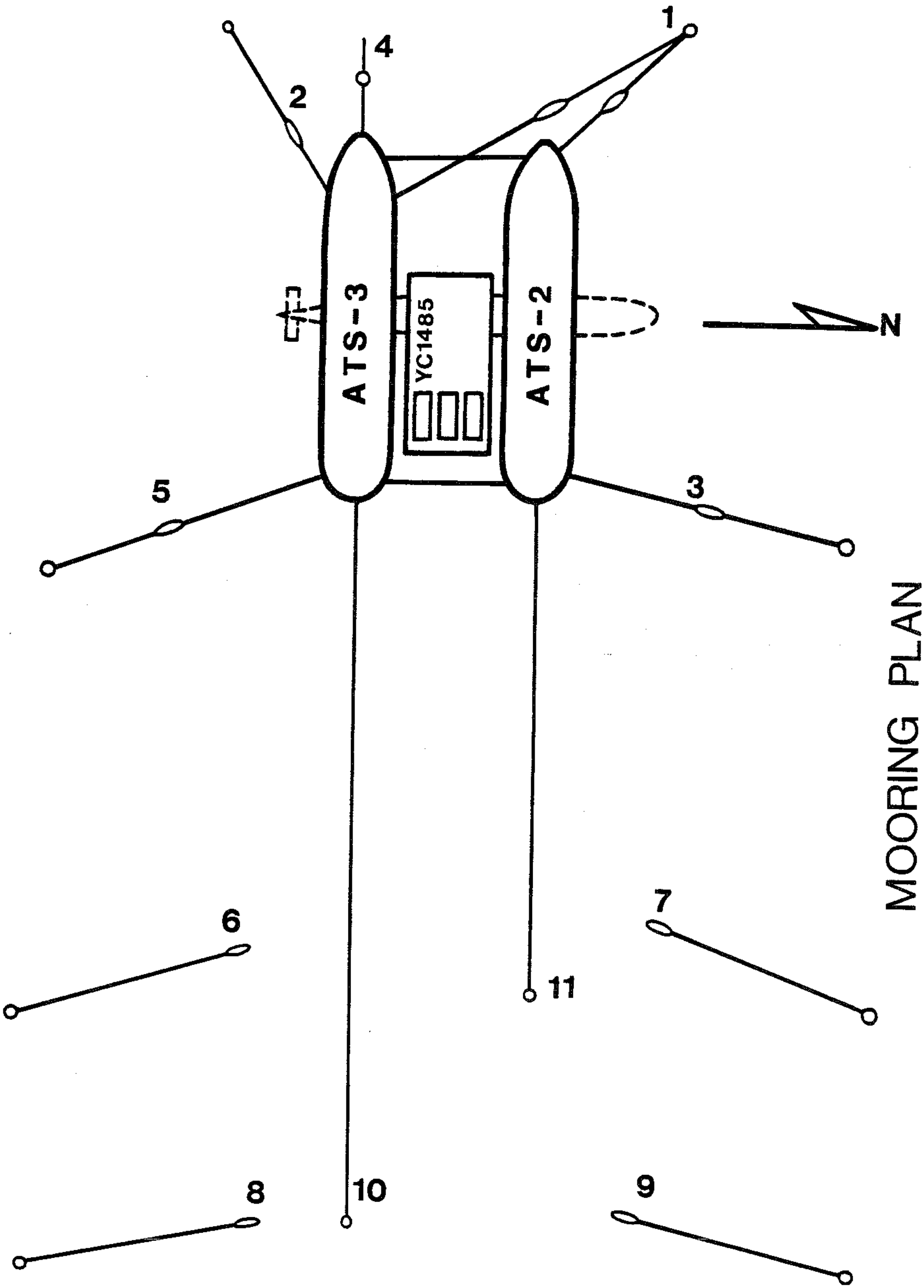
> One 6,000 lb. LWT anchor, with 35 degree wedges for maximum holding power in sand, attached to 2 shots of 2 1/4" die-lock chain, 1,200' of 1 5/8" wire, which was then attached to the ATS spud buoy.

This arrangement was similar in legs numbers 1 through 5, with the exception of leg No. 4 which had a 42 inch spherical buoy instead of a spud buoy on the end of the leg and an 8,000 pound EELS anchor instead of an LWT anchor. Each leg provided approximately 50 tons of holding power.

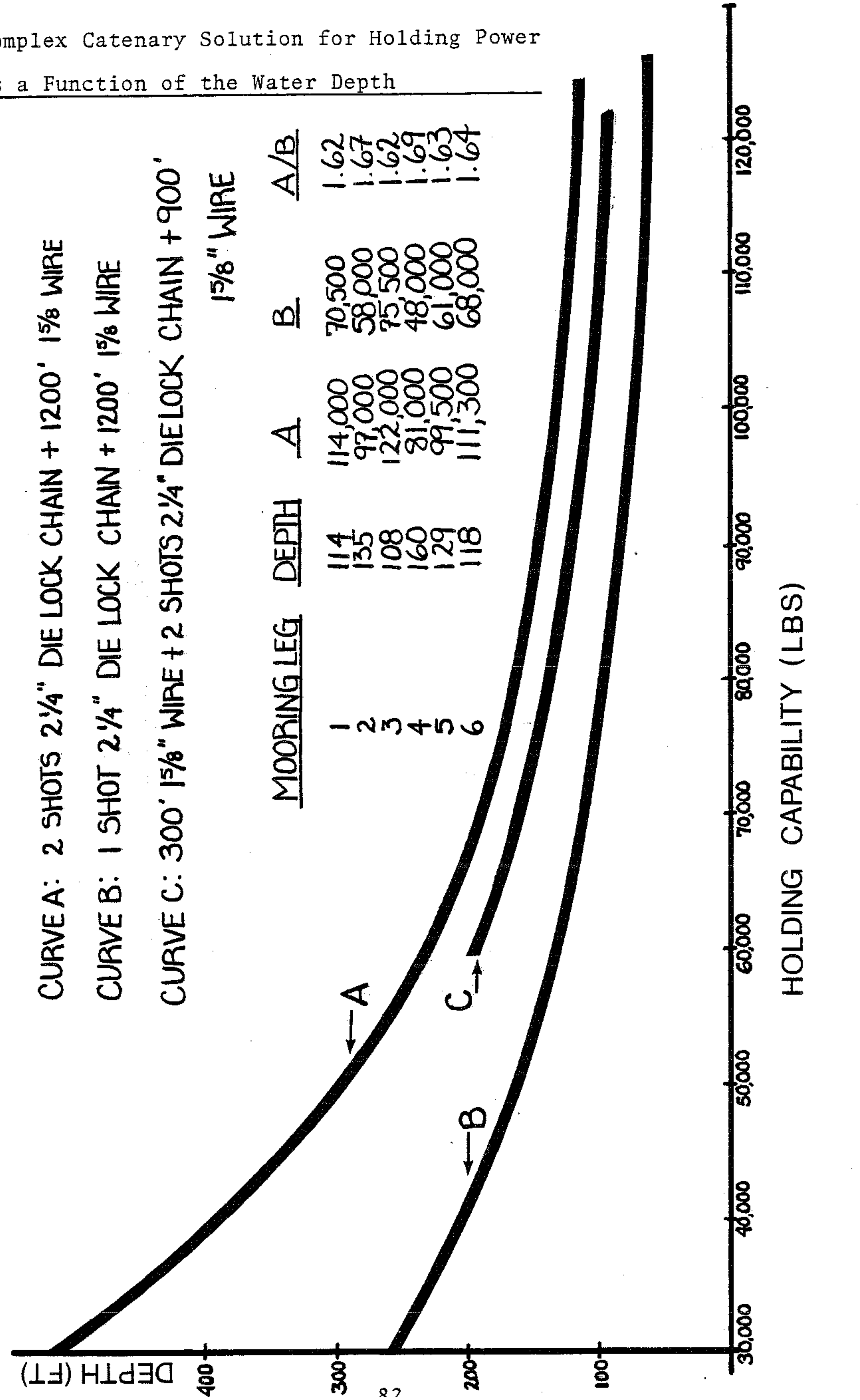
The moor was calculated to hold the ships in a maximum 2.0 knot current and a 35 knot wind. Maximum recorded current during the salvage operation was 1.2 knots from 120 degrees T to 300 degrees T. Maximum recorded wind for a brief period was 27 knots with daily average of about 5-8 knots variable.

A 7" 2-in-1 braided nylon line was used to connect legs 2, 3 and 4 to their respective spuds. Legs 1 and 5 were the down current legs. For these legs, a stronger line was desired. An 11" line was used on leg #1 and 15" on leg #5. Nine inch line would have been sufficient but was not available. Legs #6 and #7 were rigged with a 6,000 lb. STATO anchor connected to each ship's 3,000' 2 1/4 towing wire. This arrangement allowed for improved flexibility in repositioning in the moor.

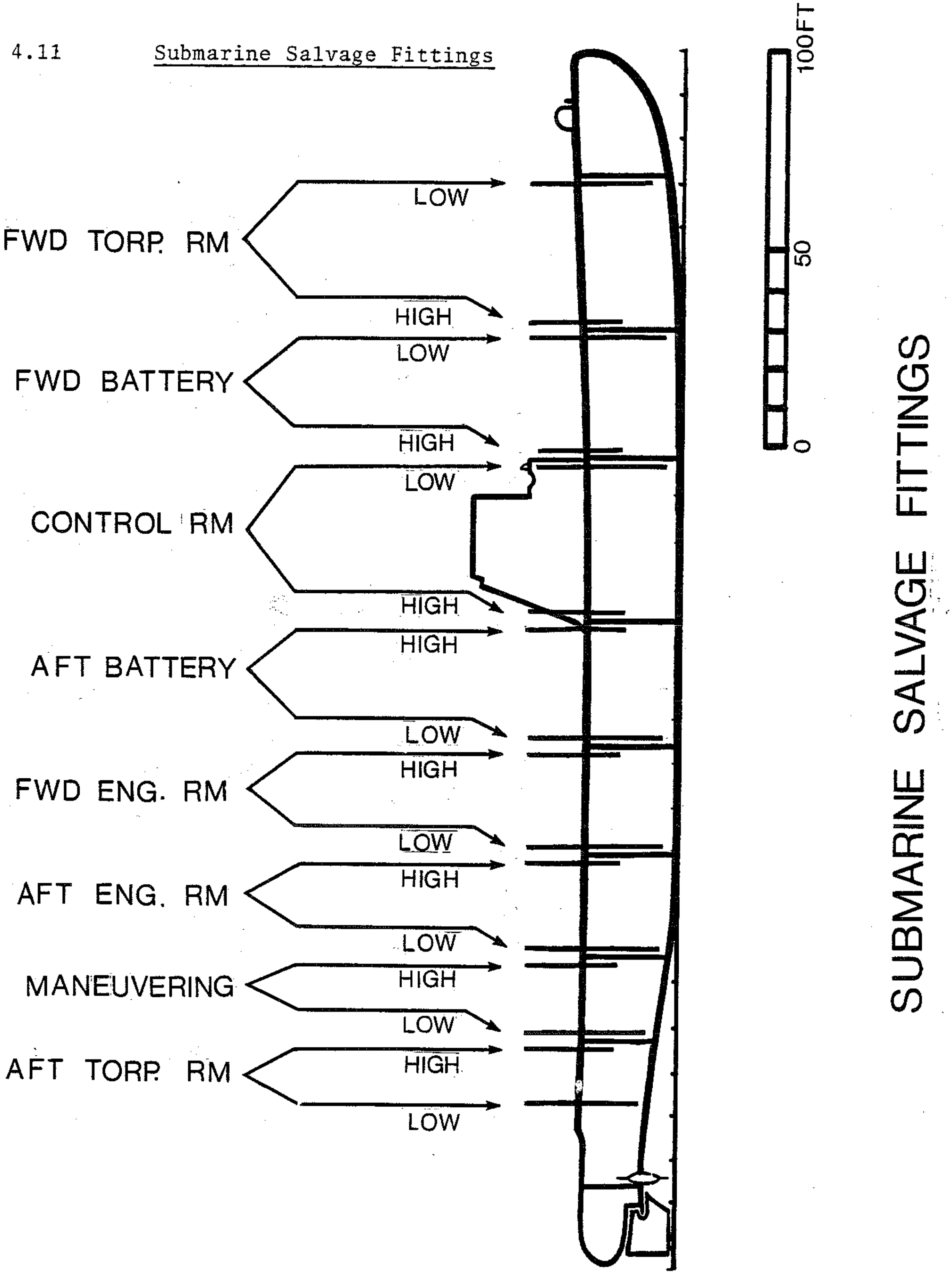
An additional four legs were laid (legs 6-9) but were not used. In the original plan these legs were to be used to shift the operation into shallow water when using the heavy bow lift.


MOORING PLAN
ATS-3
ATS-2
YC1485
N
1
2
3
4
5
6
7
8
9
10
11

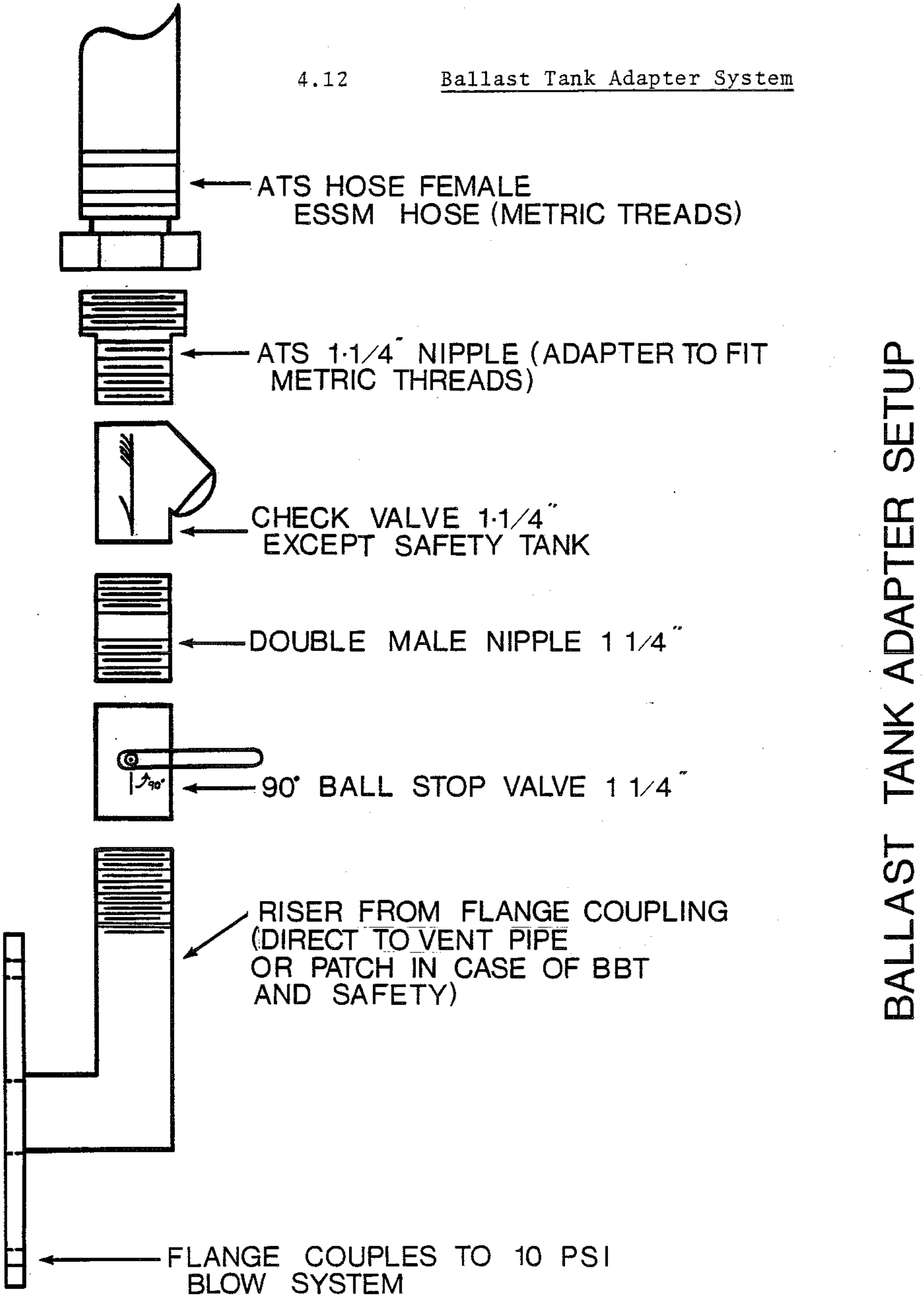
4.10 Complex Catenary Solution for Holding Power as a Function of the Water Depth



4.11 Submarine Salvage Fittings



4.12 Ballast Tank Adapter System



4.13 Pneumofathometer Readings Used to Verify the Low Salvage Piping Conditions

Submarine rests in 132' water

Top of wood deck 108'

Top of pressure hull 113'

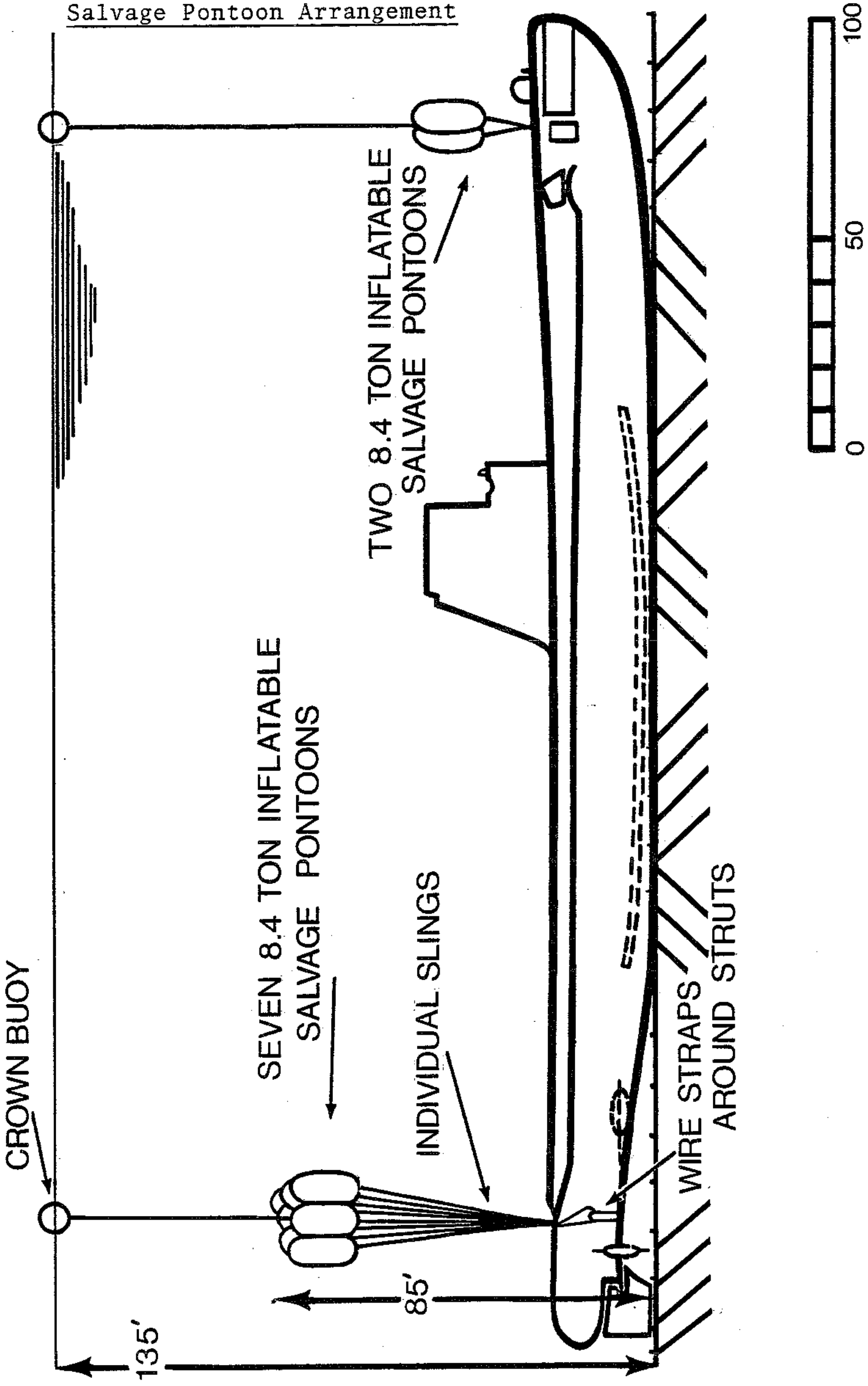
Bottom of pressure hull 129'

Depth of low salvage fitting:

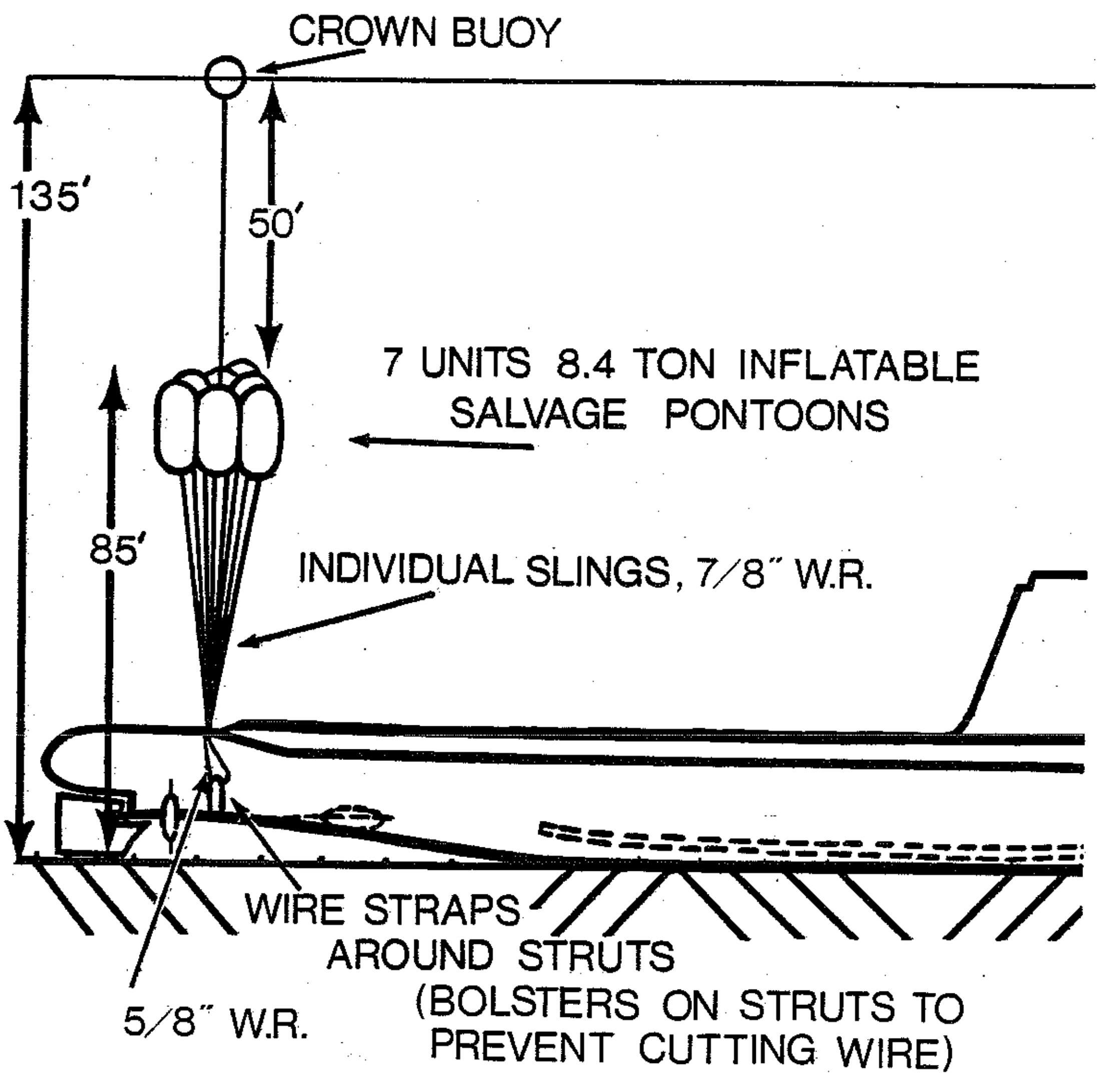
	CALCULATED	READ (*)
Fwd Torpedo	125'	123'
Fwd Battery	121'	126'
Control	128'	130'
Aft Battery	121'	129'
Fwd Engine	128'	129'
Aft Engine	128'	129'
Maneuvering	127'	130'
Aft Torpedo	120'	122'

(*) Actual Readings 10/19, 10/22

4.14 Salvage Pontoon Arrangement

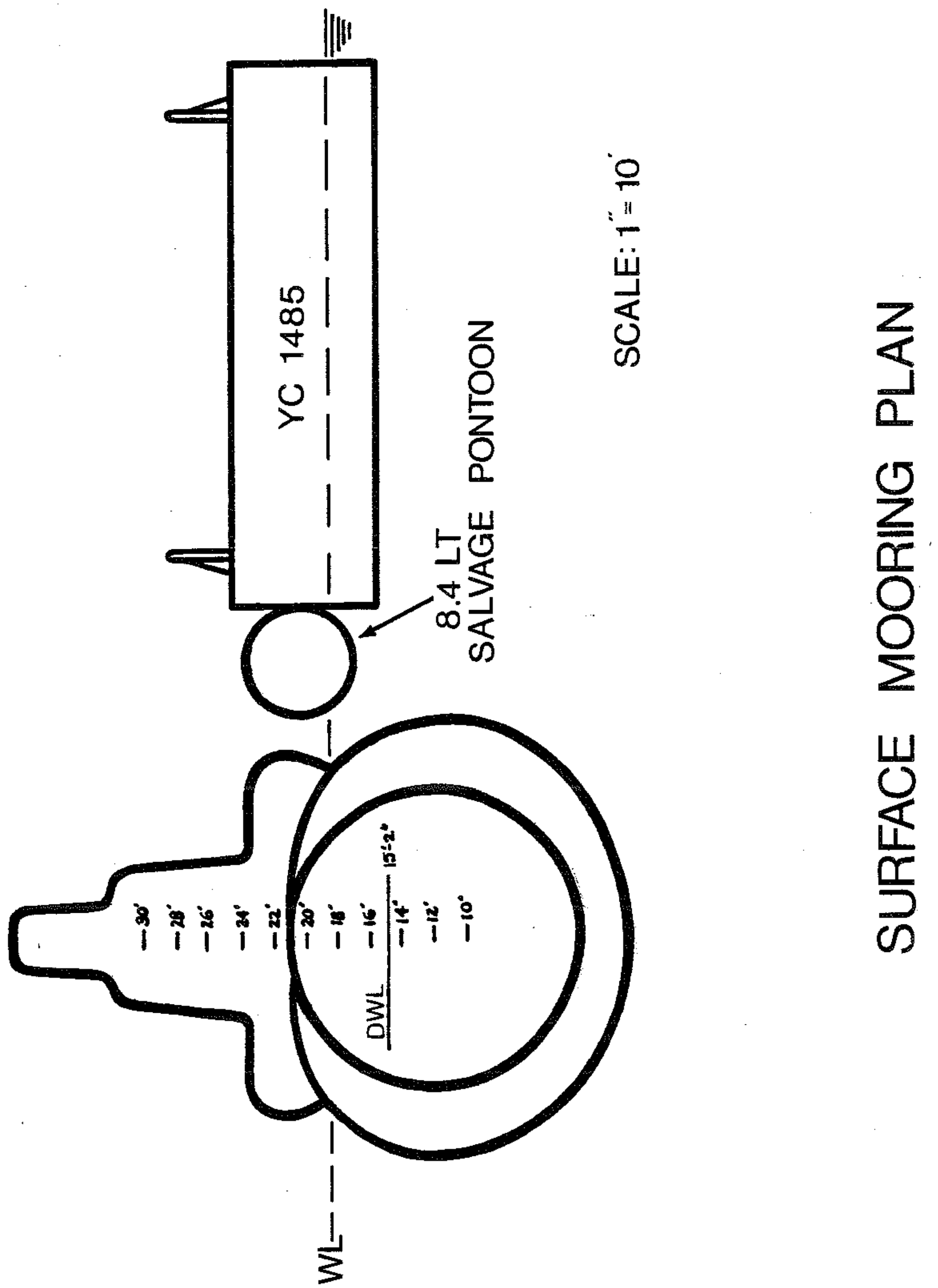


4.15 Rigging Details of the 8.4 Buoyancy Pontoons



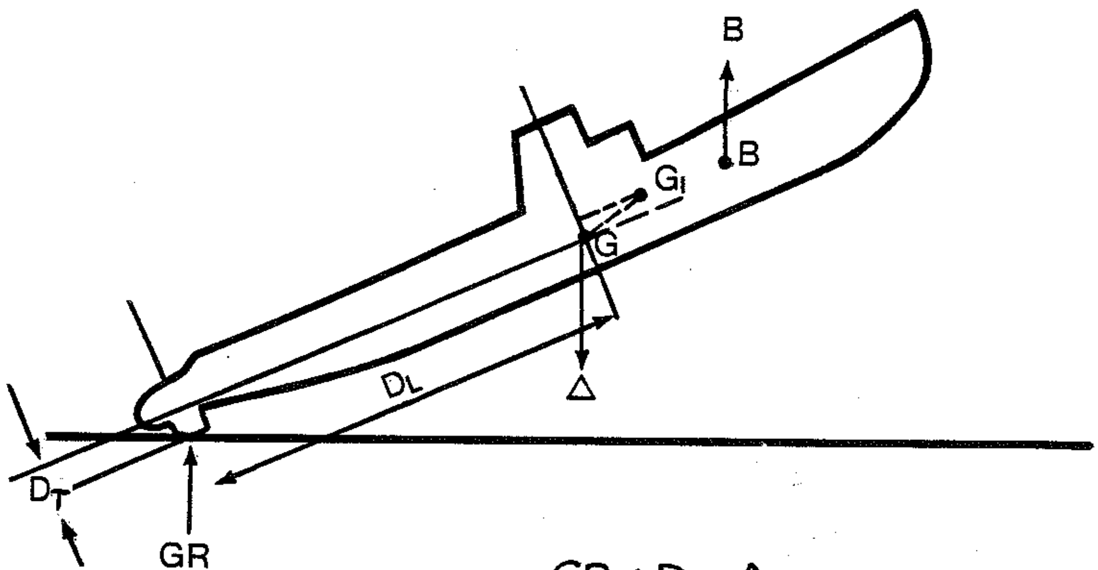
SALVAGE PONTOONS
RIGGING DETAIL ASTERN

4.16 Mooring Plan for the Submarine on the Surface



4.17 Ground Reaction Calculations

WEIGHT SHIFT DUE TO GROUND REACTION



$$GR + B = \Delta$$

$$GG_1 = \frac{WD}{\Delta} \qquad W = GR;\ GR = \Delta - B$$

$$GG_L = \frac{(GR)D_L}{\Delta}$$

$$GG_T = \left(\frac{GR\ D_T}{\Delta}\right)$$

ASSUME: Δ = 1320 LT

VCG = 11.32' ABOVE B_L

LCG = 155.01 AFT FP

4.18 Lateral Resistance of the Submarine in Mooring Conditions

ASSUME = 2 KT CURRENT

$\mathbb{R}$ = REYNOLDS NUMBER

$$\mathbb{R} = \frac{VL}{\nu} = \frac{(2)(1.67)(27.3)}{.9245\,(10^{-5})} = 9.88 \times 10^{6}$$

L = BEAM = 27.3 FT

ν = .9245 x (10^{-5}) = KINEMATIC VISCOSITY

$\rho \approx 1.98$ = DENSITY

$C_F = .003$ FRICTION DRAG COEFFICIENT FROM BLASIUS CURVE (REF. PNA)

$$R_F = \tfrac{1}{2}\rho V^2 A C_F = \tfrac{1}{2}(1.98)[(2)(1.67)]^2[(307)(\pi)(27.3)](.003)$$

$R_F = 872.4$ LBS.

$C_D = 1.2$ FORM DRAG COEFFICIENT (ASSUME CIRCULAR CYLINDER MOVING PERPENDICULAR TO ITS LONGTITUDINAL AXIS)

R_D = DRAG

$$R_D = \tfrac{1}{2}\rho V^2 A C_D = \tfrac{1}{2}(1.98)[(2)(1.67)]^2[(307)(27.3)](1.2)$$

$R_D = 111{,}073.5$ LBS.

$R_D = 49.6$ TONS

LENGTH = 307

BEAM = 27.3

TOTAL RESISTANCE $\Rightarrow$ 50 TONS

MOORING

ATS   LOA = 282.7   DRAFT = 15.1

CURRENT RESISTANCE $= \frac{1}{2} \rho V^2 A C_d$

ρ = 1.99 SLUGS / FT^3 = DENSITY OF WATER

$R = \frac{1}{2}(1.99)(2.51)^2(282.7)(15.1)(2)$

R_c = 26.8 TONS

V = 1.5 KTS = CURRENT VELOCITY
2.51 FT/SEC

A = LOA x DRAFT

C_d = 2   DRAG COEFFICIENT

TON = 2000 LBS

WIND RESISTANCE $(R_N) = \frac{1}{2} \rho V^2 A C_d$

ρ = 0.00227 SLUGS / FT^3 = DENSITY OF AIR

$R_W = \frac{1}{2}(.00227)(58.45)^2(7{,}050)(2)$

R_W = 27.3 TONS

FOR 18 KTS R_W = 7.22

V = 35 KTS = WIND VELOCITY
58.33 FT/SEC

A ≈ 7,050 FT^2

C_d = 2 = DRAG COEFFICIENT

SPHERICAL BUOY FLOTATION

LARGE BUOY $R = \frac{3.5}{2} = 1.75$ FT (RADIUS)

$V = \frac{4}{3}\pi R^3 = 1.33(3.14)(1.75)^3$

$= 22.39\ FT^3$

MAX LIFT = 1432..96 LBS

= 1430 LBS

WEIGHT		BUOYANCY	
BUOY	250 LBS.	BUOY	1430 LBS
HARDWARE	25		
1 5/8" WIRE(LBS/FT)	4.44		

TOTAL $275 + 4.44(x) = WT$

(SW SUPP .13 (WT))

$\therefore\ 1430 = (275 + 4.44x)\ .87$

$1430 = (275).87 + .87(4.44)x$

$1430 = 239.25 + 3.86x$

$\frac{1430 - 239.25}{3.86} = x$

X = **308.5 FT 1 5/8" WIRE**

SMALL BUOY

$$V = \frac{4}{3}\pi R^3 = 8.18\ FT^3$$

$$= 520\ LBS\ LIFT$$

WEIGHT		BUOYANCY	
BUOY	130	FLOAT	520 LBS
HARDWARE	10		
1 5/8" WIRE LBS/FT	2.89 X		
	140 + 2.89X		

(SW SUPP .13 WT)

$$\therefore\ 520 = .87(140 \cdot 2.89X)$$

$$520 = 121.8 \cdot 2.52(X)$$

$$\frac{520 - 121.8}{2.52} = X = \boxed{158.01\ FT}$$

5. Lessons Learned

The many problems encountered and solved offered much valuable information to U.S. Navy salvors. It is the specific intention of this section to "pass on" the lessons learned, to benefit future operations and provide opportunity to upgrade existing equipment, systems, and technical methods utilized for conventional submarine salvage.

While there are many points to be made, the following are considered primary in terms of importance and as guidelines for needed changes.

5.1 Salvage Methods

1. The original salvage plan called for introducing sufficient buoyancy to leave the submarine slightly negative. The balance of the required lifting force was to be provided by the bow lift systems of two ATS class salvage ships.

On closer examination of this plan, several problems became apparent. A lack of reliable information on the submarine made it impossible to calculate the exact tonnage to be lifted and the positions of the vertical, longitudinal and transverse centers of gravity. Most critical were the position of the center of gravity on the longitudinal axis and the "in water" weight. Preliminary calculations indicated that the inability to quantify these values precisely coupled with the relatively small lifting capacity of the ATS ships did not allow a sufficient margin for error.

Early in the operation it was also observed that the persistent daily surface swell at the site could cause dangerous dynamic loading conditions if the bow lift approach was used.

Other alternate plans were discussed. A plan to raise the submarine in place in a single operation appeared most efficient in comparison to the other two-phased approaches where a lift would still have to be completed after raising off the bottom and once the submarine was taken to shallower water.

2. The original dewatering plan called for salvage hose to be placed on all low salvage fittings to allow on-scene personnel to observe the flow rate while dewatering. It was exceedingly difficult to pump water from the interior compartments using these fittings, a fact which can be directly attributed to the low over-bottom pressure used. A higher over-bottom pressure would have been senseless since it would have caused the outer hatches to lift and allow inside air pressure to escape. Initially, a 3-inch pump was rigged on the discharge side to increase output capacity. This proved to be too difficult logistically. All low fitting hoses were removed. Consequently divers monitored the flow of water out of the low fittings continuously. Once each space was empty, the fittings were closed. Free communication between the spaces caused certain spaces to reflood once empty. It was, therefore, necessary to cycle all low fittings perodically to verify dewatering process.

3. As the salvage operation progressed, the barge became a nerve center for the control of the dewatering sequence and lift sequences. The complexity of the various test sequences, compressor operation, and blow sequences required centralized control. This centralized control is essential to a time-critical operation. Positive control by the On-Scene Commander on all air manifolds is paramount.

4. Once the blow sequence was started, only personnel with an intimate knowledge of the entire raising sequence operated the salvage air manifolds. In this case, the operators were the Salvage Master and the NAVSEA Engineer, who had direct communications with the On-Scene Commander during the entire lift sequence until the submarine was stable and in shallow water. It is felt that their knowledge of the manifold operation and the submarine's buoyancy and stability during the actual lift were crucial to the success.

5. To assist the compressors during the blow sequence, BRUNSWICK's onboard high pressure and medium pressure air compressors were tied into the blow manifold on the YC for use as a possible backup. This prudent connection gave the On-Scene Commander access to additional salvage air on the morning of 6 November 1983, when ex-BLUEGILL, while on the surface alongside the YC, was down by the stern. Without this option, the submarine may have sunk in 60 feet of water. (Once ex-BLUEGILL was secured alongside the YC over the original site, BRUNSWICK repositioned in shallow water for towing preparations.) The three salvage compressors may not have been enough.

6. Prior to the commencement of the final lift of the submarine, a boarding party consisting of a diving officer and four divers who had working experience of all the fittings were briefed and standing by in a rubber boat to board the surfaced submarine. The quick actions of this team in boarding the surfaced submarine and identifying and quickly replacing ruptured salvage hoses contributed directly to the successful stabilization of the submarine once on the surface. Once again, there was a direct communications link (using walkie-talkies) between the boarding diving officer, the Salvage Master and the On-Scene Commander, which proved invaluable to the operation.

7. A micro-computer was used throughout the salvage operation for naval architectural and salvage computations on ex-BLUEGILL. If personnel are properly trained in the use of the micro-computer and naval architecture, it can greatly assist the On-Scene Commander and his staff in performing extensive calculations that would otherwise require many manhours. Lieutenant Neil Hanson, USN, Staff, Commander Service Squadron FIVE Representative, successfully inter-phased the salvage plan with the computer. The net result was a comprehensive step-by-step plan which provided real time data and proved itself very useful during the execution of the lift.

5.2 Diving Operations

1. Throughout the 34-day salvage operation, numerous divers from many naval commands assisted. This allowed diving operations to be conducted around the clock for three weeks. Maximum use of all available area divers is strongly encouraged in similar evolutions. The training and experience gained will reap benefits for the Navy for years to come.

2. MDSU-ONE procured and provided one helmet-mounted UDATS and one large fixed-color UDATS. The color UDATS was strategically placed and used as a monitor. Until it became inoperative, the helmut-mounted unit was used mainly for topside personnel to view diver operations. The helmet-mounted UDATS was used by BRUNSWICK divers for three weeks. It was removed when it restricted divers from working below the topside framework of the submarine.

The UDATS, if used properly, can be an important survey tool. The temptation to direct divers when they are actually working on the bottom should be avoided, if possible. It only tends to confuse the diver and limit work accomplishment. A UDATS survey and an in-water diver survey can be an effective combination.

3. The MDSU-ONE FADDS was used as BRUNSWICK's primary surface-supplied diving source. Upon departing Pearl Harbor, BRUNSWICK did not have a certified diving system. This necessitated the use of a portable diving system. The FADDS worked extremely well, but after a long period of operation, extensive PMS was necessary. FADDS personnel were not equipped with adequate supplies to PMS FADDS component parts. BRUNSWICK lost the use of the FADDS on 27 October when both LP Air Compressors became inoperative. Repair would have required Re-entry Control (REC) and new parts not provided for in the Fly Away System.

5.3 Equipment

1. Large quantities of the salvage gear used during PACSUBSALVEX-83 were maintained by numerous local Naval activities. Those pieces of salvage gear specifically set aside for use by squadron ships but not actually part of shipboard inventory should be maintained by Mobile Diving and Salvage Unit ONE (MDSU-1) under the guidance of COMSERVRON FIVE. If this were to become a reality, MDSU-1 would require additional personnel manning to support this requirement. Equipment such as heavy bow lift gear, various anchors, Fly Away Deep Diving Systems (FADDS), etc., should be maintained by one command.

2. Tractor-size tires, procured through local means, were used as fenders between the two ships and the YC. These proved to be invaluable. Occasional surging swell conditions could have caused substantial damage to all vessels. A local business provided these tires at no cost as long as transportation to the salvage site was arranged for by ship's force.

3. Once ex-BLUEGILL was on the surface, two 8.4 ton inflatable salvage pontoons were used as fenders when the submarine was brought alongside the YC. These pontoons were more than adequate and actually prevented further damage to the already deteriorated submarine and the YC.

4. While rigging the seven 8.4 ton pontoons aft, it was necessary to use the shaft support struts as attachment points. These struts had sharp leading edges. It became apparent that once the pontoons were filled and tension was taken, the straps supporting the pontoons would chafe on the struts. Split pipes were cut and placed between the struts and the wire straps. By increasing the radius of the turn around the strut, a potential hazard was alleviated and prevented damage to the wire strap during the lift sequence.

5. All anchors used for the moor were rigged with wedges to maintain fluke angle at 35 degrees. This provided for maximum holding power in sand. The moor was stable with no problems encountered throughout the salvage operation.

6. A problem associated with the ATS-1 class ships designed and built in England is the use of metric fittings on many installed systems. The ATS is equipped with metric salvage air manifolds and metric salvage hose. The ex-BLUEGILL, designed and built in the United States, uses American standard fittings. If an actual submarine salvage were conducted using an ATS, this difference would severely hinder a speedy salvage attempt. Consideration should be given to convert ATS salvage manifolds and salvage hose to American Standard fittings or special adapters should be manufactured to be included in the onboard salvage inventory.

7. There were three types of salvage hose used. ATS hose was supplied by both ships. This hose was used extensively on all high fittings and most of the ballast tanks. The hose provided by the ESSM pool in Stockton, California was completely inadequate. The hose was severely deteriorated and in unsatisfactory condition. Both types of hoses were collapsible under the pressure experienced. It became necessary to procure a non-collapsible hose to vent the submarine to one atmosphere. This hose was obtained with the help of COMSERVRON FIVE. In the future, the salvage hose inventory in the ESSM pool should include a significant quantity of non-collapsible hose specifically designed for submarine salvage.

8. In general, all ESSM pool equipment needs to be maintained at a higher state of readiness. The three salvage compressors required considerable maintenance prior to use.

Considerable problems were experienced with dirty fuel tanks with all three compressors. Fuel filters had to be purchased on the local market. The ESSM sixteen-station manifold had to be adapted to meet the needs of salvage operations. Ship's force personnel modified the manifold to include eight more stations. Procurement of parts through local commercial means was required. In an isolated salvage operation, logistical support would be difficult.

6. Appendix

Documents used, and generated, in the salvage of the submarine are presented in this section in support of the developed analysis of the salvage, and as a reference for utilization in future salvage operations.

The materials presented are:

Section No.	Title
6.	APPENDIX
6.1	Organization and Personnel
6.2	Statistical Diving Data
6.3	General Information, SS 337 - 342 Class Submarines
6.3.1	General Information
6.3.2	SSK type II Conversion Displacement and Other Curves
6.3.3	SS 242 Moment Diagram
6.3.4	Piping Systems
6.3.5	Watertight Doors
6.3.6	Main Ballast Tanks
6.3.7	Compartments
6.4	PACSUBSALVEX-83 Background Information
6.4.1	Situations
6.4.2	History of the ex-USS "BLUEGILL" Up to 1959

6.1 Organization and Personnel

TASK ORGANIZATION

o CTF 33 OSE	COMSERVGRU ONE CAPT. M. H. MUNSEY
o CTG 33.5 OCE and OTC	COMSERVRON FIVE CDR A. G. CAMPBELL
o CTU 33.5.5 On-Scene Commander	CO, USS BRUNSWICK (ATS-3) LCDR J. P. SPEER
o CTE 33.5.5.1 Salvage Element	CO, USS BRUNSWICK (ATS-3) LCDR J. P. SPEER
Salvage Master	CO, USS RECLAIMER (ARS-42) LCDR J. M. EVANS
Salvage Engineer	COMNAVSEASYCOM (OOC) LCDR G.J. TETTELBACH
Diving Officers	USS BRUNSWICK (ATS-3) LT G. A. MAYNARD USS BEAUFORT (ATS-2) LT R. S. DAVIS
Diving Safety Officer	USS BRUNSWICK (ATS-3) LCDR R. A. REISH
PAO/Photo Manager	COMTHIRDFLT LT G. T. BROWN
Moor Manager	USS BRUNSWICK (ATS-3) CW04 W. L. WILCOX
o CTE 33.5.5.2 Logistics Element	CO, MOBDIVSALU ONE LCDR J. E. PECK
o CTE 33.5.5.3 Rescue/Tow/Logistics Element	CO, USS BEAUFORT (ATS-2) LCDR A. M. NIBBS, JR.

ON-SCENE ORGANIZATION

ON-SCENE COMMANDER

LCDR J. P. SPEER
Commanding Officer, USS BRUNSWICK (ATS-3)

SALVAGE MASTER

LCDR J. M. EVANS
Commanding Officer, USS RECLAIMER (ARS-42)

LOGISTIC SUPPORT

LCDR A. M. NIBBS
Commanding Officer, USS BEAUFORT (ATS-2)

NAVAL SEA SYSTEMS COMMAND, WASHINGTON, DC

LCDR G. J. TETTELBACH

USS BRUNSWICK (ATS-3)

LCDR J. P. SPEER
Commanding Officer, USS BRUNSWICK (ATS-3)

LCDR R. A. REISH
Executive Officer, USS BRUNSWICK (ATS-3)

CWO4 W. L. WILCOX
First Lieutenant, USS BRUNSWICK (ATS-3)

ENCM(MDV/SW) W. H. LOUDERMILK
Master Diver, USS BRUNSWICK (ATS-3)

USS BEAUFORT (ATS-2)

LCDR A. M. NIBBS
Commanding Officer, USS BEAUFORT (ATS-2)

LCDR J. GRIPP
Executive Officer, USS BEAUFORT (ATS-2)

LT R. S. DAVIS
Diving/Salvage Officer

HTCM(MDV) J. A. ORTIZ
Master Diver, USS BEAUFORT (ATS-2)

COMSERVRON FIVE

LT N. E. HANSEN

SUPSHIP, PORTSMOUTH, VA

LT J. R. WILKINS

PUGET SOUND NAVAL SHIPYARD, BREMERTON, WA

LCDR J. W. BLOOMER

COMNAVLOGPAC

MMCM(MDV) SCOTT BRADBURY

MOBILE DIVING AND SALVAGE UNIT ONE

ETCS(DV) D. L. VESTER

NAVAL SUBMARINE TRAINING CENTER, PACIFIC, PEARL HARBOR, HI

HTCM(DV) C. H. BOSER
BMCM(DV) K. W. WELTEKE

NAVAL OCEAN SYSTEMS CENTER, HAWAII LABORATORY

LT M. V. LINDSTROM

USS RECLAIMER (ARS-42)

LT G. A. BLACK
BMCM(MDV) D. H. McKENZIE

PACFLT AUDIO-VISUAL COMMAND, NAS NORTH ISLAND, CA

PH1 R. H. TURNER, II
PH2(DV) D. A. COTELLESA

PUBLIC AFFAIRS OFFICER

LT G. T. BROWN
Assistant Public Affairs Officer, Staff
Commander, THIRD FLEET

NAVWESTOCEANCEN, PEARL HARBOR, HI

ENS D. P. MULLEN

6.2 Statistical Diving Data

Diving logs were used to record total number of dives, bottom time, and the resulting decompression time.

The following data is indicative of the scope of the work completed in refloating the submarine:

Total Number of Dives	386
Man Dives	757
Total Bottom Time (TBT)	10,076 Minutes (167.9 Hours)
Total Decompression Time (TDT)	7,106 Minutes (118.4 Hours)
SCUBA	179
MK 12	207
Average Depth	111.5 feet
Surface Decompression on Oxygen	11

All diving evolutions were conducted by the USS BRUNSWICK (ATS-3), USS BEAUFORT (ATS-2), and TEMADD diving personnel from:

USS RECLAIMER (ARS-42)

Mobile Diving and Salvage Unit ONE

Naval Submarine Training Center Pacific,
Pearl Harbor, HI

COMSERVRON FIVE

COMNAVSEASYSCOM, Wash., DC

SUPSHIP, Portsmouth, VA

NAVSHIPYD, Puget Sound, WA

NAVDIVSALVTRACEN, Panama City, FL

NAVOCEANSYSCEN, Hawaii Lab, Kaneohe Bay, HI

Submarine Base, Pearl Harbor, HI

FLTAVCOMPAC, San Diego, CA

The total number of divers taking part was approximately 80.

Eight actual treatments for decompression sickness were conducted.

6.3 General Information, SS 337 - 342 Class Submarines

The ex-USS BLUEGILL SS 242 is similar in configuration and outfit to the class SS 337 - 342. Unfortunately, the general information desired for the SS 242 class was not available at the time of the salvage planning and operational phases. The general class information for SS 337 - 342 class was utilized with good results. Minor differences exist from the information presented and that encountered in the ex-USS BLUEGILL.

6.3.1 General Information

NOTE: THE DESIGNER'S WATER LINE IS PARALLEL TO THE BASE LINE. IT IS LOCATED 15'-0" ABOVE THE BASE LINE AND CORRESPONDS ONLY APPROXIMATELY WITH THE DESIGNED NORMAL LOAD AND DRAFT.

The forward perpendicular is 2'-2" forward of the intersection of the designer's water line with the stem. The aft perpendicular is tangent to the stern profile, at the intersection with the after end of the designer's water line. The mid-perpendicular is located half way between the end perpendiculars. The section at the mid-perpendicular is the midship section.

The molded base line is 1" above the bottom of the keel.

The datum line from which drafts are measured is at the bottom of the keel.

The actual mean draft in surface normal condition, diving trim, is 15'-3", and the trim is 7-3/4" by the stern.

THERE ARE NO PROJECTIONS BELOW THE BOTTOM OF THE KEEL (on SS337-341).
"QC" DOME - FRAME 34, STARBOARD SIDE - PROJECTS 2'-2-3/8" BELOW KEEL (on SS342).

General Data

Length overall	311'-9"
Length between perpendiculars	307'-0"
Extension of vessel beyond F.P.	4'-9"
Extension of vessel beyond A.P.	None
Length of designer's water line	304'-10"
Breadth, molded, maximum at D.W.L.	26'-0-1/2"
Breadth, extreme	27'-4"
Depth, molded, amidships (B.L. to main deck amidships)	23'-0-3/8"
Midship section is	12" Aft of Fr.69
Freeboard at bow is	12'-4"
Freeboard at stern (at frame 135, 4'-6" forward of A.P.) is	3'-11"
Depth of inner bottom molded at frame 69	3'-9"
Frame spacing (except from frame 35 to frame 62, and frame 69 to 105, where the spacing is 30")	24"
Number of frames	139

Displacement standard as designed	1523 tons
Displacement surface normal condition, diving trim	1820 tons
Mean draft in surface normal condition, diving trim	15'-3"
Bottom of keel to molded base line	1"
Capacity of normal fuel oil tanks (including clean oil tanks 95% full) . .	56,993 gals.
Capacity of reserve fuel oil tanks (rated capacity)	62,743 gals.
Total capacity of fuel oil tanks	119,736 gals.
Capacity of normal lubricating oil tanks (normal 95%; sumps 75% including motor and reduction gear lube oil sumps 75%) .	5,276 gals.
Capacity of reserve lubricating oil tank (95%)	1,201 gals.
Total capacity of lubricating oil tanks . .	6,477 gals.
Capacity of potable water tanks	3,906 gals.
Capacity of battery water tanks	1,208 gals.
Inclination of shafts (down and aft) . . .	0.2712"/ft.
Divergence of shafts, each shaft 0.324 (outboard and aft)	0.648"/ft.
Area of rudder	100 sq.ft.
Capacity of main ballast, fuel ballast and safety tanks - sea water - corrected for lead ballast and residual water	606 tons
Capacity of variable ballast tanks including W.R.T. tanks and negative tank - sea water	123.45 tons

<u>Heights above Normal Water Line</u>

(Drafts 14'-11-1/8" forward; 15'-6-7/8" aft)

Axis of 5" gun - forward	13'-5-3/4"
Axis of 5" gun - aft	12'-0-3/4"
Highest point of fixed portion of vessel (top of SJ Radar antenna)	34'-0"
Center of anchor light forward	19'-8-1/2"
Center of masthead light	28'-3-7/8"
Center of searchlight	22'-5-7/8"
Center of sidelights	16'-6-5/8"
Center of stern light, anchor light combination	8'-11-5/8"
Control room platform deck	3'-7-1/2" below
Conning tower platform	5'-11-5/8"
Axis 20 mm. gun aft	18'-7-5/8"
Axis 40 mm. gun forward	17'-9"
Bridge platform	14'-4-3/4"

Calculated Data at Normal Mean Draft - 15'-3" Water Line

Tons per inch immersion	12.6 tons
Area of water plane	5,245 sq.ft.
C.G. of water plane	5.85' Aft of Fr.69
Moment to change trim 1"	220 ft.tons
C.B. above bottom of keel	9.08'
C.B. aft of frame 69	1.23'
Transverse metacenter above C.B.	3.24'
Transverse metacentric height	1.56'
Longitudinal metacenter above C.B.	371'
Longitudinal metacentric height	369'
Area of midship section	341 sq.ft.
Wetted surface	12,395 sq.ft.
Ratio, length between perpendiculars to beam molded	11.29
Block coefficient (to 15'-2-1/2" W.L.)	.508
Prismatic coefficient (to 15'-2-1/2" W.L.) . . .	.619
Midship section coefficient (to 15'-2-1/2" W.L.)	.821
Water plane coefficient (at 15'-2-1/2" Mean Draft)	.686

Main Ballast Tanks (Vent Pipes Included)

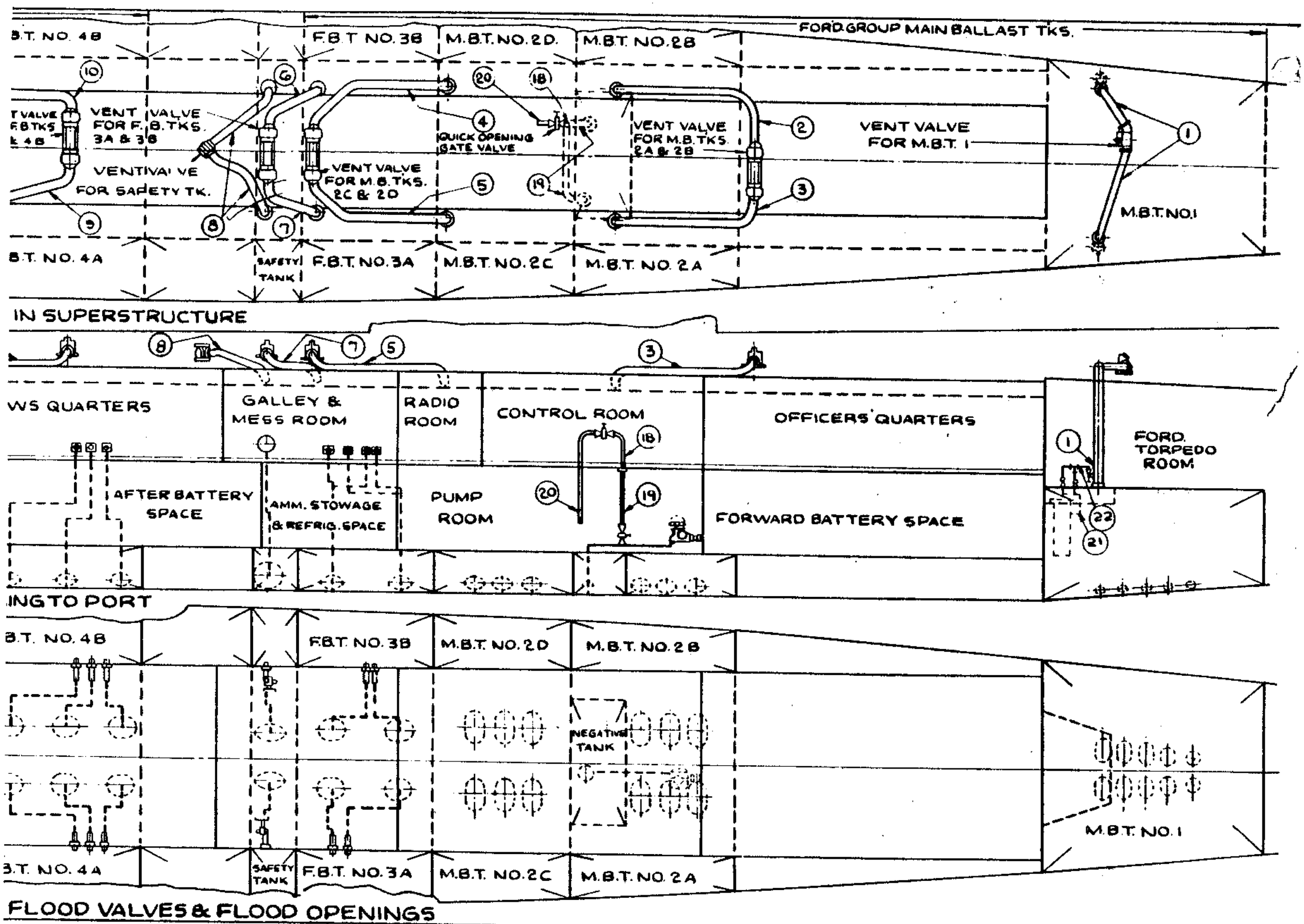
Name	Location	Cu.Ft.	Gallons	Tons Oil	Tons F.W.	Tons S.W.
1	Fr. 25-35	1,721			47.81	49.17
2A & 2B	Fr. 46-52	2,058			57.17	58.80
2C & 2D	Fr. 52-57	2,310			64.17	66.00
3A & 3B*	Fr. 57-62	2,634			73.17	75.26
4A & 4B*	Fr. 69-75	3,298			91.61	94.23
5A & 5B*	Fr. 75-80	2,668			74.11	76.23
6A & 6B	Fr. 80-85	2,371			65.86	67.74
6C & 6D	Fr. 85-91	2,585			71.81	73.86
7	Fr.107-117	1,368			38.00	39.09
Safety	Fr. 62-64	813			22.58	23.23
TOTAL		21,826			606.29	623.61

* Fitted for use as reserve fuel oil tanks.

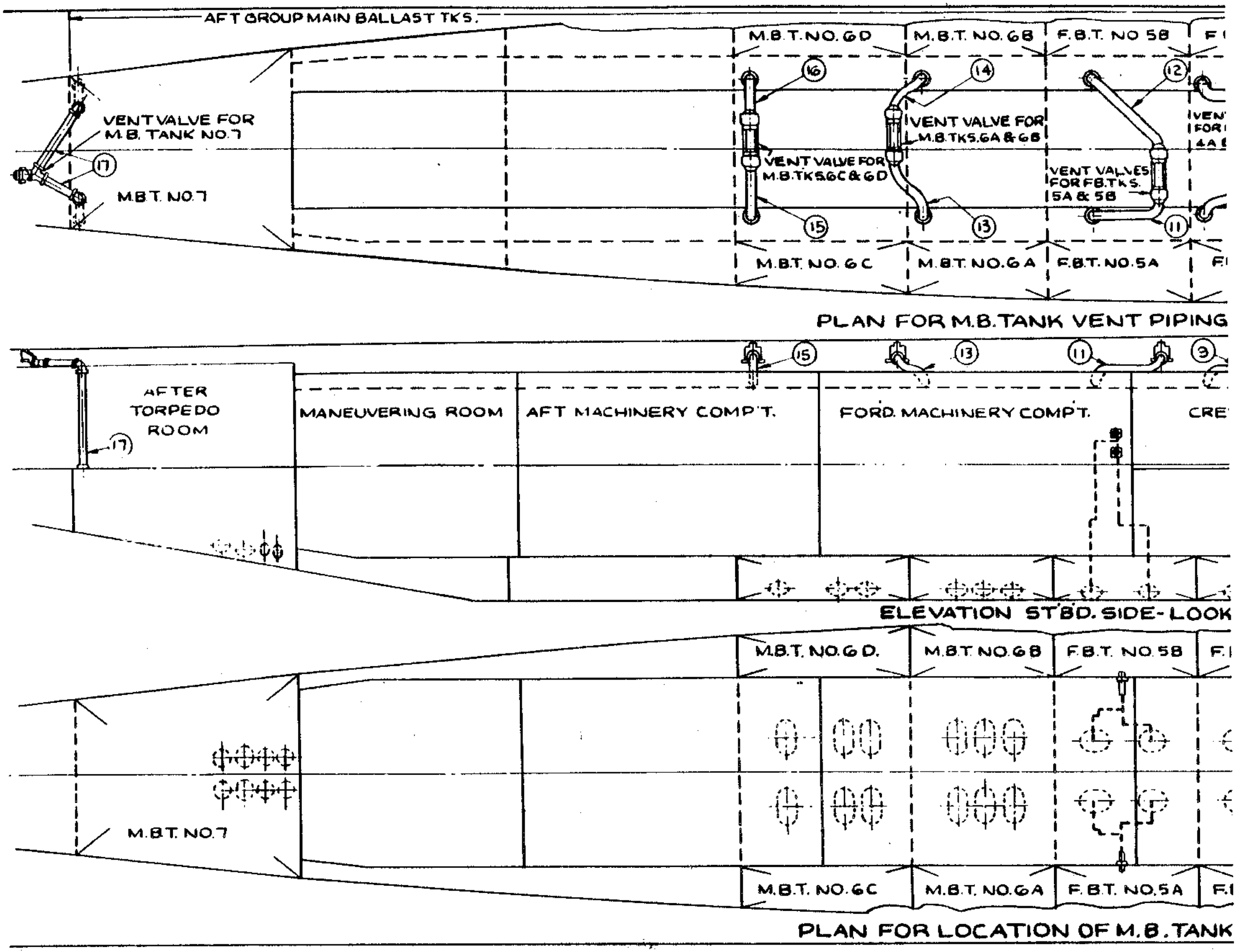
NOTE: No deductions have been made for residual water or for lead ballast stowed in any of the main ballast tanks.

Variable Ballast Tanks

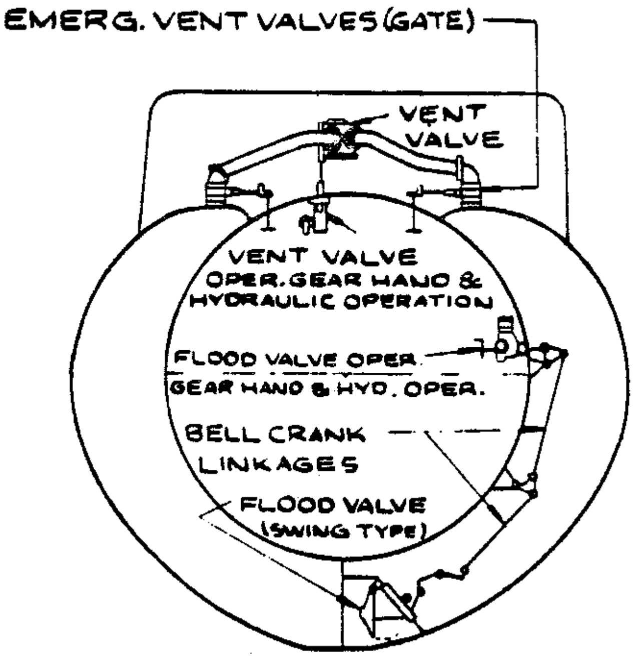
Name	Location	Cu.Ft.	Gallons	Tons Oil	Tons F.W.	Tons S.W.
Aux. #1	Fr. 64-69	1,077	8,057		29.92	30.77
Aux. #2	Fr. 64-69	1,077	8,057		29.92	30.77
Negative	Fr. 50-52	407	3,045		11.31	11.63
Ford.Trim	Fr. 13-23	851	6,366		23.64	24.31
Ford.W.R.T.	Fr. 23-25	173	1,294		4.81	4.94
Aft Trim	Fr.125-130	699	5,229		19.42	19.97
Aft W.R.T.	Fr.117-119	177	1,324		4.92	5.06
TOTAL		4,461	33,372		123.94	127.45



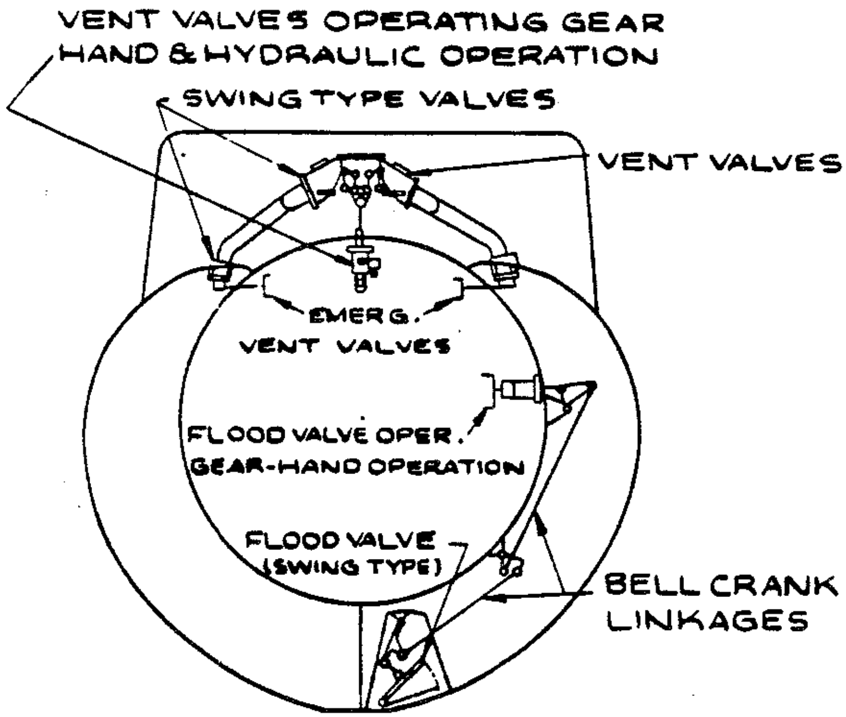
MAIN BALLAST TANK FLOODING & VENTING SYSTEM (2 OF 2)



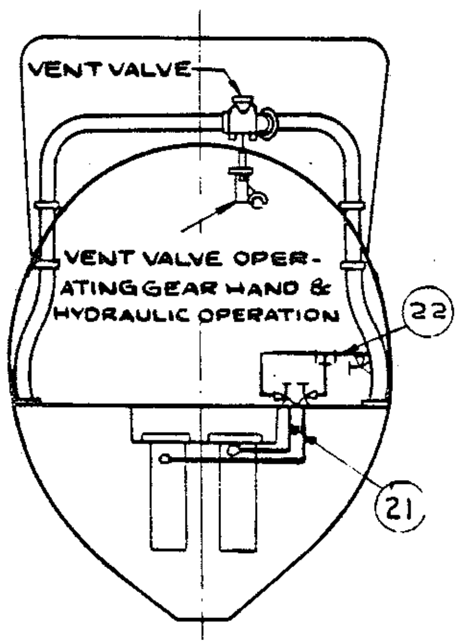
MAIN BALLAST TANK FLOODING & VENTING SYSTEM (1 OF 2)



SECTION SHOWING SAFETY TANK FLOOD & VENT VALVES



TYPICAL SECTION SHOWING VENT VALVES OF FOR'D. & AFT GROUPS & FLOOD VALVES IN F.B. TANKS NO'S. 3, 4, & 5.



TYPICAL SECTION SHOWING VENT VALVE FOR M.B. TANKS NO. 1 & 7

NOTE:-
M.B. TANKS NO'S 1, 2A, 2B, 2C, 2D, 6A, 6B, 6C, 6D & 7 HAVE FLOODING OPENINGS ONLY (NO FLOODVALVES)

PIPE LIST		
MARK	SIZE O.D.	SERVICE
1	10.75"	VENT FROM M.B. TANK #1
2	10.75"	VENT FROM M.B. TANK #2A
3	10.75"	VENT FROM M.B. TANK #2B
4	10.75"	VENT FROM M.B. TANK #2C
5	10.75"	VENT FROM M.B. TANK #2D
6	10.75"	VENT FROM F.B. TANK #3A
7	10.75"	VENT FROM F.B. TANK #3B
8	7.625"	VENT FROM SAFETY TANK
9	12.75"	VENT FROM F.B. TANK #4A
10	12.75"	VENT FROM F.B. TANK #4B
11	10.75"	VENT FROM F.B. TANK #5A
12	10.75"	VENT FROM F.B. TANK #5B
13	10.75"	VENT FROM M.B. TANK #6A
14	10.75"	VENT FROM M.B. TANK #6B
15	10.75"	VENT FROM M.B. TANK #6C
16	10.75"	VENT FROM M.B. TANK #6D
17	8.625"	VENT FROM M.B. TANK #7
18	4.00"	NEGATIVE TANK VENT
19	3.50"	NEGATIVE TANK VENT
20	4.00"	DRAIN TO BILGE NEG. TANK VENT
21	1.05"	VENT. UNDER WATER SOUND TRUNK
22	1.315"	VENT. UNDER WATER SOUND TRUNK

Fuel Oil Tanks

Name	Location	Cu.Ft.	Gallons	Tons Oil	Tons F.W.	Tons S.W.
Normal #1	Fr. 35-41	1,524	11,401	35.41	42.36	43.54
Normal #2	Fr. 41-46	1,754	13,122	40.75	48.72	50.11
Normal #6	Fr. 93-99	2,032	15,201	47.21	56.44	58.06
Normal #7	Fr. 99-107	1,344	10,054	31.22	37.33	38.40
Collecting	Fr. 91-93	400	2,993	9.30	11.11	11.43
Expansion	Fr. 91-93	400	2,993	9.30	11.11	11.43
Clean Oil #1 (95%)	Fr. 86-88 (Internal)	82	611	1.90	2.28	2.34
Clean Oil #2 (95%)	Fr. 97-99 (Internal)	83	618	1.92	2.31	2.37
TOTAL	(Normal)	7,619	56,993	177.01	211.66	217.68

Reserve Fuel Oil Tanks (Rated Capacities)

Name	Location	Cu.Ft.	Gallons	Tons Oil	Tons F.W.	Tons S.W.
3A & 3B	Fr. 57-62	2,566	19,196	59.62	71.27	73.31
4A & 4B	Fr. 69-75	3,220	24,089	74.81	89.44	92.00
5A & 5B	Fr. 75-80	2,601	19,458	60.43	72.25	74.31
		8,387	62,743	194.86	232.96	239.62
TOTAL (Maximum) (at 7.13 lbs./gal.)		16,006	119,736	371.87	444.62	457.30

Lubricating Oil Tanks

Name	Location		Cu.Ft.	Gallons	Tons Oil	Tons F.W.
#1	Fr. 79-84	95%	195	1,457	4.99	5.42
#2	Fr. 90-95	95%	124	924	3.17	3.44
#3	Fr.107-109	95%	139	1,037	3.55	3.86
Main Eng.Sump #1	Fr. 80-85	75%	51	382	1.31	1.42
Main Eng.Sump #2	Fr. 80-85	75%	51	382	1.31	1.42
Main Eng.Sump #3	Fr. 91-96	75%	51	382	1.31	1.42
Main Eng.Sump #4	Fr. 91-96	75%	51	382	1.31	1.42
Motor & Red.Gear L.O.Sump (Port)	Fr.103-105	75%	22	165	0.57	0.61
Motor & Red.Gear L.O.Sump (Stbd.)	Fr.103-105	75%	22	165	0.57	0.61
TOTAL (Normal)			706	5,276	18.09	19.62
Reserve	Fr. 76-77	95%	161	1,201	4.11	4.47
TOTAL (Reserve)			161	1,201	4.11	4.47
TOTAL (Maximum) (at 7.67 lbs./gal.)			867	6,477	22.20	24.09

Sanitary Tanks

Name	Location	Cu.Ft.	Gallons	F.W. Tons	S.W. Tons
#1	Fr. 34-35	58	434	1.62	1.66
#2	Fr. 76-77½	90	673	2.51	2.57
TOTAL		148	1,107	4.13	4.23

Battery Fresh Water Tanks

Location	Cu.Ft.	Gallons	F.W. Tons
Fr. 37-41 Stbd.	20.32	152	0.56
Fr. 42-46 Stbd.	19.12	143	0.53
Fr. 37-41 Port	20.32	152	0.56
Fr. 42-46 Port	20.99	157	0.58
Fr. 65-70 Stbd.	20.32	152	0.56
Fr. 71-75 Stbd.	20.99	157	0.58
Fr. 65-70 Port	20.32	152	0.56
Fr. 71-75 Port	19.12	143	0.53
TOTAL	161.50	1,208	4.46

Ship's Fresh Water Tanks

Name	Location	Cu.Ft.	Gallons	F.W. Tons
#1 Starboard	Fr. 35-36	131	980	3.65
#2 Port	Fr. 35-36	131	980	3.65
#3 Starboard	Fr. 57-59	130	973	3.63
#4 Port	Fr. 57-59	130	973	3.63
Emer.Fwd.Torp.Room	Fr. 29-30P	8	60	0.22
Emer.Fwd.Torp.Room	Fr. 30-31P	8	60	0.22
Emer.Aft Torp.Room	Fr.109-113	17	130	0.47
Emer.Control Room	Fr. 48P	2.4	18	0.07
Emer.Man.Room	Fr. 99P	1.1	8	0.03
TOTAL		558.5	4,182	15.57

Miscellaneous Tanks

Name	Location	Cu.Ft.	Gals.
Hydraulic System Supply & Vent Tank	Control Room Frs. 47-48P	7.09	53
Reserve Hydraulic Oil Tanks	Frs. 22-25P 3 tanks	16.04	126
5" Magazine Stowage	Frs. 58½-60½		
Magazine Empty		215	1,608
Magazine with 90 cartridges (tank stowed)		99	741
Normal Storeroom (SS337-339) Alternate stowage for 54 5" shells in tanks	Frs. 61½-64	145	1,085
Magazine with 54 cartridges (tank stowed)		76	569
Normal Storeroom (SS340-342) Alternate stowage for 24 rounds of 5" ammunition over 20 cases of 40 mm. ammunition	Frs. 61½-64	145	1,085
Magazine with 5" & 40 mm. ammunition stowed		76	569
Pyrotechnic Locker (empty)	Frs. 55½-57½S	38	284
Small Arms Magazine	Frs. 61-64P		
Magazine Empty		166	1,242
Magazine with Ammunition stowed		88	658
Torpedo Alcohol	Frs. 22-23S	6	45
Torpedo Oil	Frs. 23-24S	6	45
Tectyl	Frs. 24-25S	6	45
	Man.Room - three 5-Gallon Cans		15
Mineral Oil	Ford. Torp. Room		10
	Aft Torp. Room		5
Compressor Oil	Pump Room-3 tanks		30
Vapor Compressor L.O. Tank (1)	Ford. Eng. Room		10
Cleaning Fluid	Man.Room - one 4-Gallon Can		4

Name	Location	Cu.Ft.	Gals.
Hydraulic System Vent Tank	Ford. Torp. Room Aft Torp. Room		2 2
Hydraulic System Air Tank	Radio Room	5	
Condensate Tank	Aft Eng. Room Crew's Quarters		10 25
Hydraulic System Leakage Tank	Control Room (SS337-340) Control Room (SS341-342) Conning Tower (SS340-342)		2 5 2

6.3.2 SSK Type II Conversion Displacement and Other Curves

Key to curve data:

1. Area of Midship Section

   1 ton = 1 sq. ft.

2. Moment to Alter Trim One Inch

   1 ton = 1 ft. ton

   A. Addition to Displ. for 1 ft. Trim by Stern

   50 tons = 1 ton (1 inch = 1 ton)

   B. Addition to Displ. for 1 ft. Trim by Bow

   50 tons = 1 ton (1 inch = 1 ton)

3. Center of Buoyancy For'd Midship

   50 tons = 1 ft. (1 inch = 1 ft)

4. Displacement in Fresh Water at

   36 cu. ft. per ton

   A. Displacement in Salt Water at

   35 cu.ft. per ton

5. CG Water Planes For'd Midship

50 tons = 1 ft. (1 inch = 1 ft.)

A. CG Water Planes Aft Midship

50 tons = 1 ft. (1 inch = 1 ft.)

6. Center of Buoyancy above Bottom of Keel

Referred to Displacement Curve (S.W.)

7. Areas of Water Planes

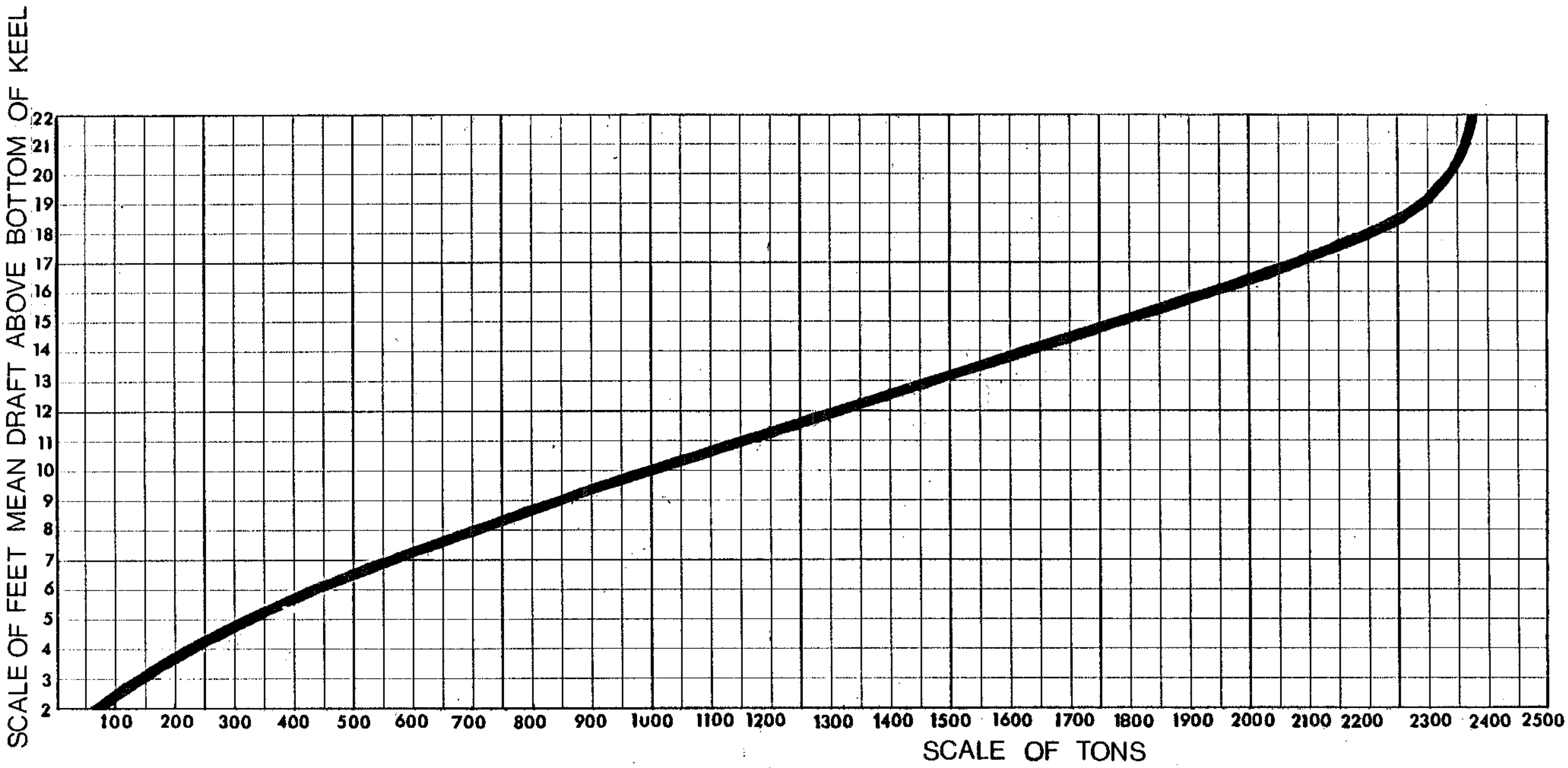
1 ton = 10 sq. ft.

8. Tons Per Inch Immersion

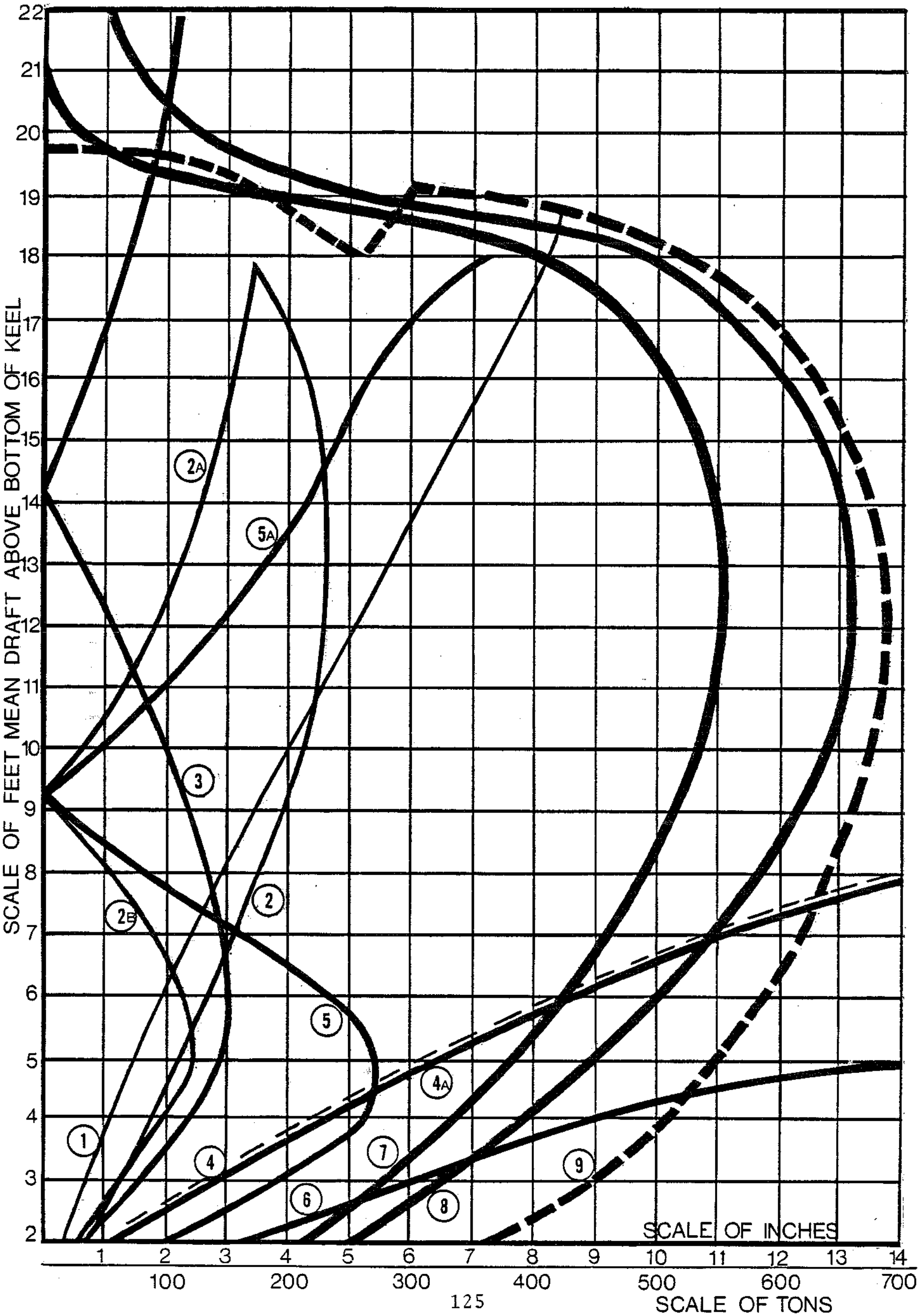
50 tons = 1 ton (1 inch = 1 ton)

9. Midship Section with Plating

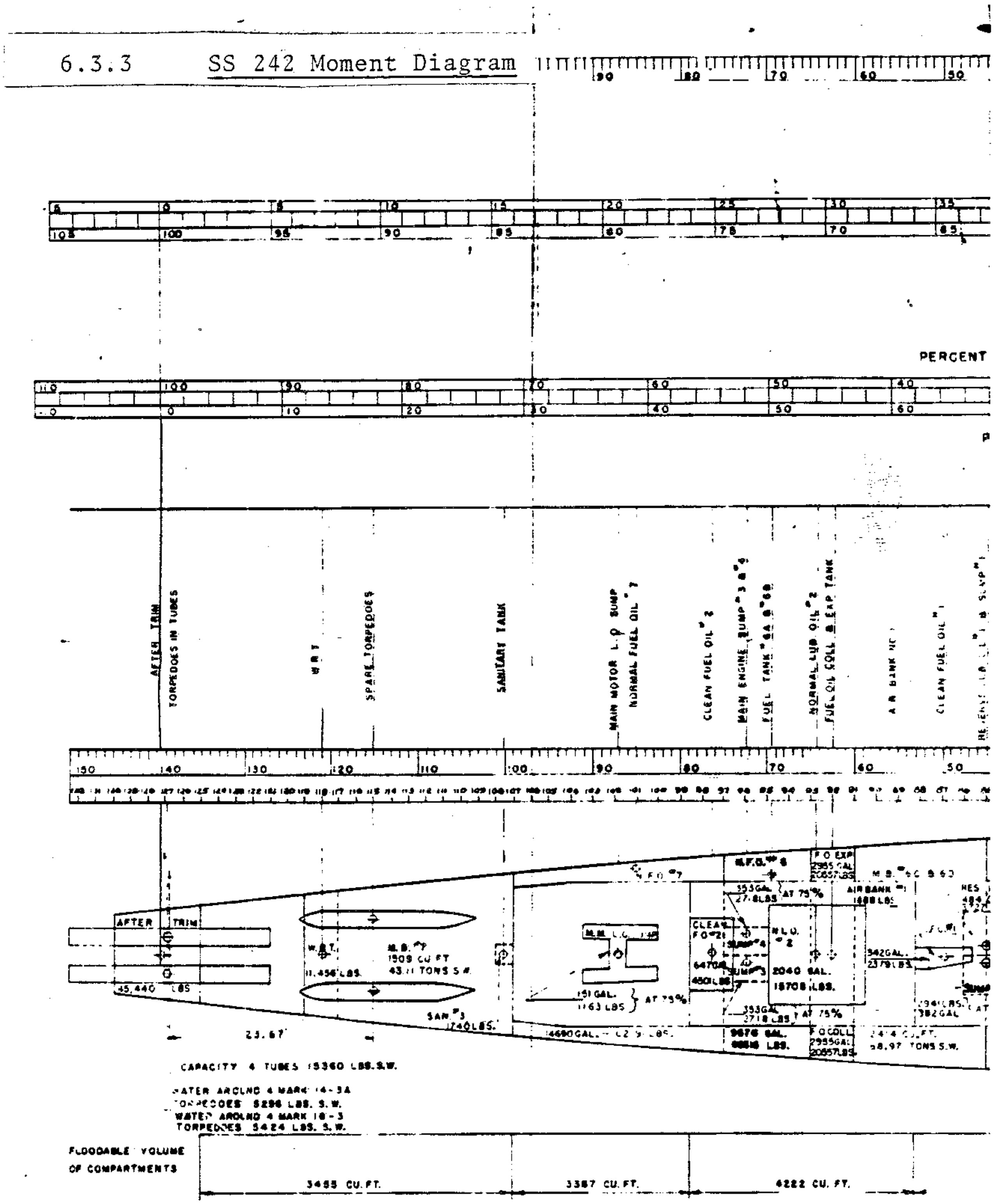
(1 inch - 1 ft.)



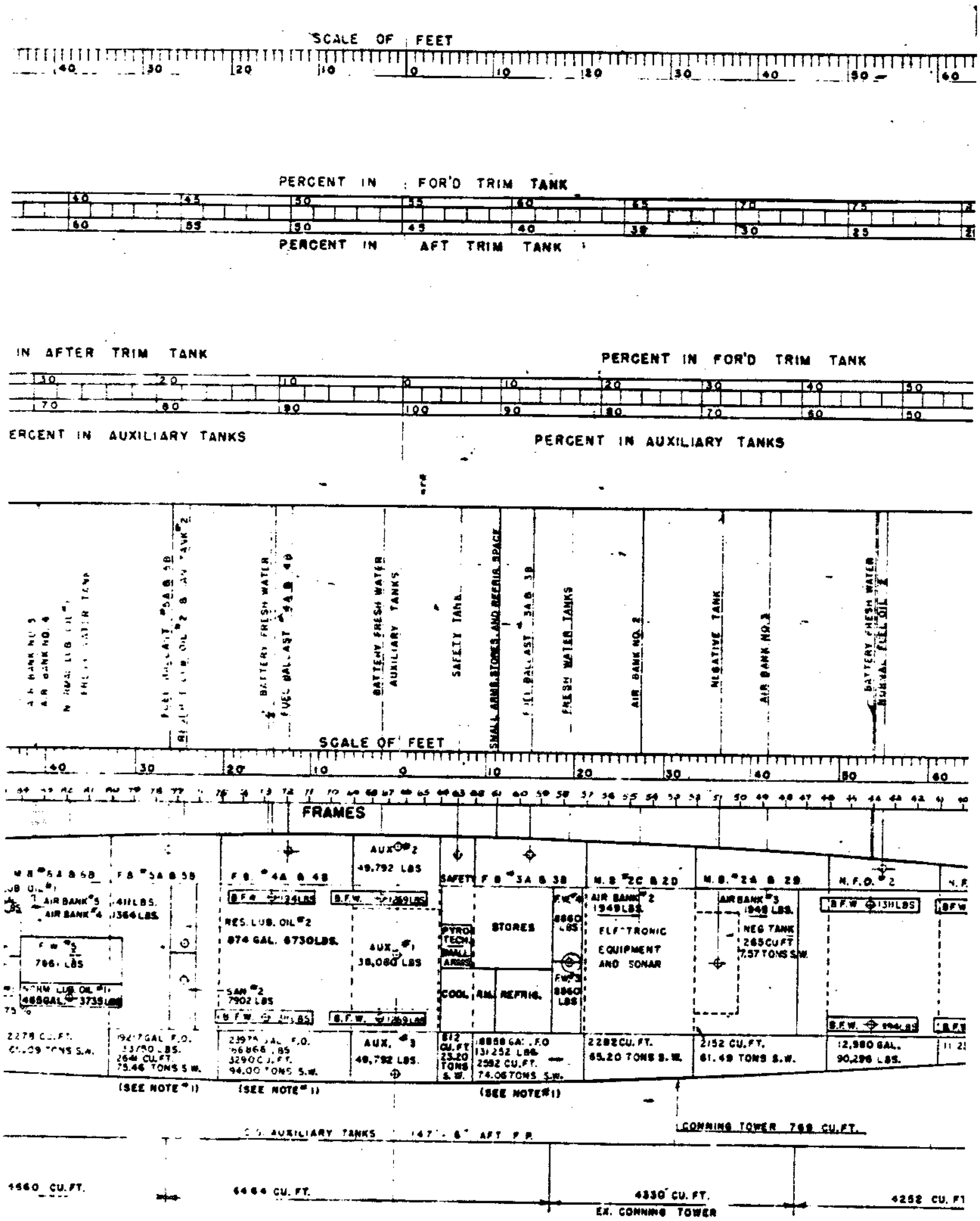
SSK TYPE II CONVERSION DISPLACEMENT CURVE


SCALE OF FEET MEAN DRAFT ABOVE BOTTOM OF KEEL
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
2A
5A
3
2
2B
5
4A
1
4
7
9
6
8
SCALE OF INCHES
1 2 3 4 5 6 7 8 9 10 11 12 13 14
100 200 300 400 500 600 700
SCALE OF TONS

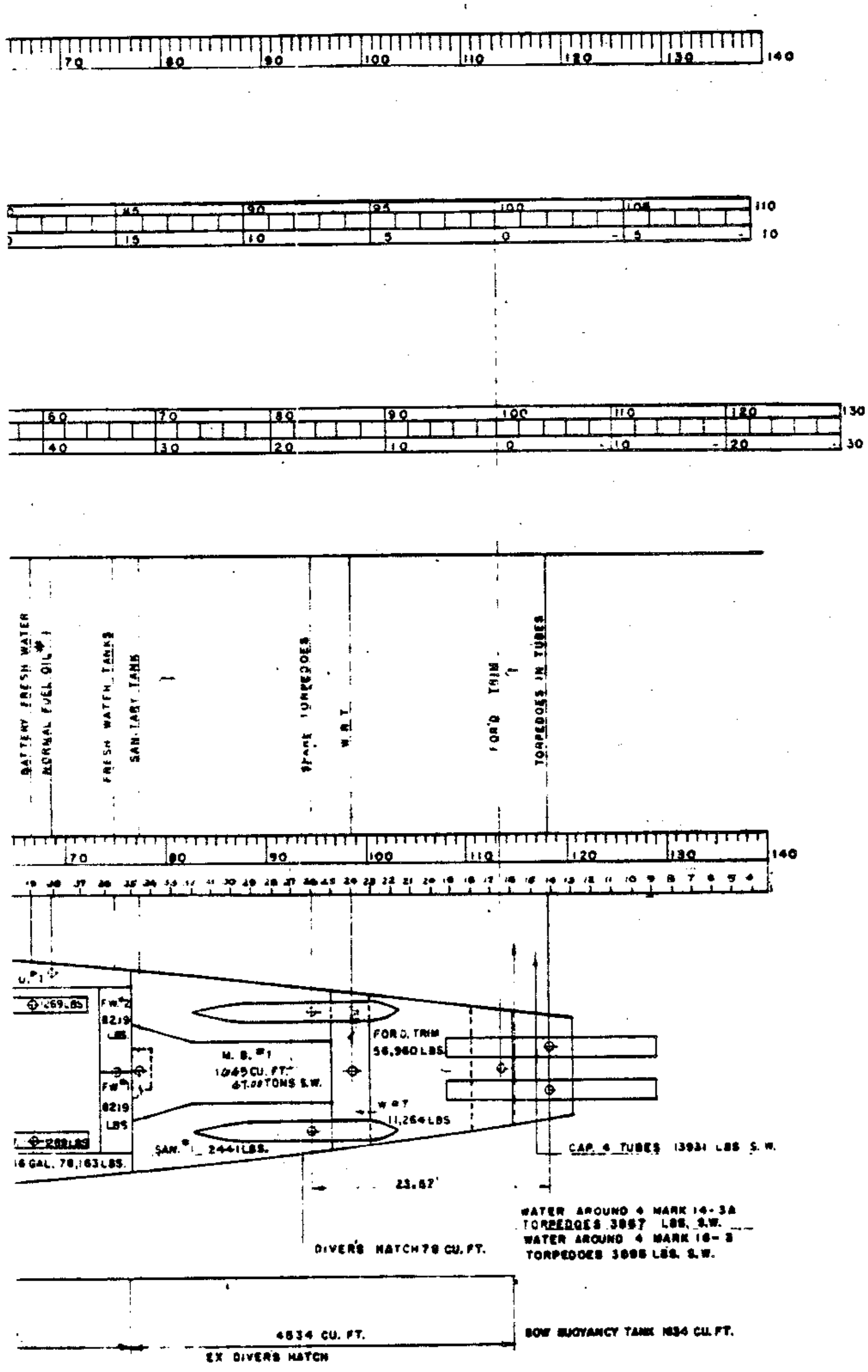
6.3.3 SS 242 Moment Diagram



SS 242
MOMENT DIAGRAM (1 OF 3)



SS 242
MOMENT DIAGRAM (2 OF 3)



SS 242
MOMENT DIAGRAM (3 OF 3)

6.3.4 Piping Systems

PIPING SYSTEMS:

Abbreviations

W.S.	- Water pressure test for strength
W.T.	- Water pressure test for tightness
W.S.&T.	- Water pressure test for strength and tightness
A.S.	- Air pressure test for strength
A.T.	- Air pressure test for tightness
A.S.&T.	- Air pressure test for strength and tightness
O.S.	- Oil pressure test for strength
O.T.	- Oil pressure test for tightness
F.O.T.	- Fuel oil test for tightness
L.O.T.	- Lubricating oil test for tightness
O.S.&T.	- Oil pressure test for strength and tightness

1. Air Piping

High Pressure (3,000 lb. system) - W.S.&T. 4,500 lbs./sq.in.; A.T. 3,000 lbs./sq.in.; drop test.

Main Ballast Blow (600 lb. system) (Regulator Valves at Inner Shell Closed) - W.S.&T. 1,000 lbs./sq.in.; A.T. 200 lbs./sq.in.

Torpedo Impulse (600 lb. system) - W.S.&T. 900 lbs./sq.in.; A.T. 600 lbs./sq.in.

Air Service (225 lb. system) - W.S.&T. 350 lbs./sq.in.

Low Pressure (10 lb. system) - Outside Pressure Hull and Inside to Gate Valve - W.S.&T. 300 lbs./sq.in.

Low Pressure (10 lb. system) - Gate Valve to Compressor - A.S.&T. 15 lbs./ sq.in.

Salvage for Compartments - W.S.&T. 300 lbs./sq.in.

Salvage for Ballast Tanks - W.S.&T. 15 lbs./sq.in.

Whistle System up to and including Operating Valve - W.S.&T. 350 lbs./sq.in.

Engine Air Starting to Reducers - W.S.&T. 5,000 lbs./sq.in.; A.S.&T. 3,000 lbs./sq.in. for pipe from air starting manifold to reducing valve, and reducing valve.

Engine Low Pressure Service - W.S.&T. 750 lbs./sq.in.

Auxiliary Engine Shutdown and Emergency Shutdown for Main and Auxiliary Engines - W.S.&T. 350 lbs./sq.in.

Exhaust Valve Operating Service - W.S.&T. 350 lbs./sq.in.

2. Engine Exhaust Piping

Trunk 300 lbs./sq.in.; Internal Exhaust Elbow 300 lbs./sq.in.; External Exhaust Elbow Jacket 25 lbs./sq.in.

Between Engine and Inside Exhaust Valve - W.S.&T. 25 lbs./sq.in. on Gas Space.

Outside Pressure Hull - W.S.&T. 25 lbs./sq.in. beyond outside valve.

3. Fuel Oil Piping

Filling and Transfer	W.S.&T. 300 lbs./sq.in.
Filling and Transfer	O.T. leak test
Water Compensating	W.S.&T. 300 lbs./sq.in.
Engine System-complete system	W.S.&T. 50 lbs./sq.in.
Engine System-after isolating F.O. Transfer and Purifier Pump	W.S.&T. 150 lbs./sq.in.
Engine System-Hand Pump Suction Drain Lines and Vents . .	Operating test only

4. Hydraulic Piping

Power Mains and Branches . .	O.S.&T. 1200 lbs./sq.in.
Replenishing and Venting Lines	O.S.&T. 150 lbs./sq.in.
Accumulator (air side only).	A.S.&T. 3000 lbs./sq.in.
Oil Circulating Tank, Pump Suction and Return	O.S.&T. 60 lbs./sq.in.
Periscope & Radar Mast Supply	O.S.&T. 1200 lbs./sq.in.
Periscope & Radar Mast Return	O.S.&T. 300 lbs./sq.in.

5. Diving Gear Piping

Bow Ram	O.S.&T. 1200 lbs./sq.in.
Stern Ram	O.S.&T. 1350 lbs./sq.in.
Change Valve	O.S.&T. 1350 lbs./sq.in.
Emergency Control Valve . .	O.S.&T. 1350 lbs./sq.in.

Hand and Emergency Lines - Bow	O.S.&T.	1200 lbs./sq.in.
Hand and Emergency Lines - Stern	O.S.&T.	1350 lbs./sq.in.
Telemotor System	O.S.&T.	900 lbs./sq.in.
Replenishing and Venting Lines	O.S.&T.	150 lbs./sq.in.

6. Lubricating Oil Piping

Filling and Transfer	W.S.&T.	15 lbs./sq.in.
Engine System	O.S.&T.	150 lbs./sq.in.
Motor & Reduction Gear . . .	O.S.&T.	150 lbs./sq.in.

Piping in tanks hydrostatically with tanks. All drain and vent lines to have operating test only.

7. Oxygen Piping

Distribution System	A.S.&T.	300 lbs./sq.in.

8. Refrigerant Piping

System to be evacuated by means of a vacuum pump to approximately 29" of vacuum. Sufficient "Freon-12" refrigerant is then to be introduced to create a pressure of approximately 10 lbs./sq.in. and system is then tested with a leak detector torch. Following this test a sufficient amount of oil pumped nitrogen is to be introduced to raise the system pressure to 225 lbs./sq.in. and again system is tested for leaks with the leak detector torch. Evacuation and testing to be from compressor discharge through condensers, evaporators and coils back to compressor suction.

9. Steering Gear Piping

Rams and Main Cutout Manifold	O.S.&T.	3000 lbs./sq.in.
Change Valve	O.S.&T.	2250 lbs./sq.in.
Emergency Valve	O.S.&T.	1200 lbs./sq.in.
Control Manifold and Cylinder	O.S.&T.	750 lbs./sq.in.
Hydraulic and Hand Power System excluding Pump and Telemotor System	O.S.&T.	2250 lbs./sq.in.
Emergency Lines	O.S.&T.	1200 lbs./sq.in.
Telemotor System	O.S.&T.	750 lbs./sq.in.
Replenishing and Venting Lines	O.S.&T.	60 lbs./sq.in.

10. <u>Ventilation Piping (Engine Air and Ship's Supply)</u>

All Pressure Proof Piping .	W.S.&T.	200 lbs./sq.in.
Outboard Valves held by their own Operating Gear (Internal)	A.T.	16 lbs./sq.in.

11. <u>Water Piping</u>

Trimming System	W.S.&T.	300 lbs./sq.in.
Magazine Sprinkler Supply .	W.S.&T.	300 lbs./sq.in.
Drainage System	W.S.&T.	300 lbs./sq.in.
Bilge Suctions	W.S.&T.	30 lbs./sq.in.
Main and Auxiliary Engine Circulating Water-Salt (inside Pressure Hull) .	W.S.&T.	300 lbs./sq.in.
Main and Auxiliary Engine Circulating Water-Salt (outside Pressure Hull) .	System to have Operating Test only.	
Main and Auxiliary Engine Circulating Water-Fresh .	W.S.&T.	50 lbs./sq/in.
Motor Room Service Circulating Water	W.S.&T.	300 lbs./sq.in.
H.P. Compressor Circulating Water (from Stop Valves at Compressor to Hull) .	W.S.&T.	300 lbs./sq.in.
H.P. Compressor Circulating Water (from Compressor To Stop Valves)	W.S.&T.	225 lbs./sq.in.
Refrigeration Circulating Water (Suction Side of Pump)	W.S.&T.	300 lbs./sq.in.
Refrigeration Circulating Water (Discharge Side of Pump)	W.S.&T.	335 lbs./sq.in.

12. <u>Distilling System</u>

Salt Water Piping from Sea Suction to Shut-off Valves at Feed Pump Suction and Feed Pump By-pass and Overboard Discharge from Overflow Tank to Shell Connection	W.S.&T.	300 lbs./sq.in.
Salt Water Piping from Feed Pump Discharge through Regulating Valve	W.S.&T.	345 lbs./sq.in.

Salt Water Piping beyond Regulating Valve to Stills	W.S.&T.	50 lbs./sq.in.
Fresh Water Piping	W.S.&T.	50 lbs./sq.in.
Air Piping on H.P. Side of Reducing Valves	W.S.&T.	350 lbs./sq.in.
Distillate Tank Blow . . .	W.S.&T.	15 lbs./sq.in.
Overflow Tank Blow	W.S.&T.	60 lbs./sq.in.

(d) WEIGHT HANDLING APPLIANCES

Derrick - Torpedo . .	Proof 6400 lbs.;	Strength 4800 lbs.
Davit - Hatch	Proof 2000 lbs.;	Strength 1500 lbs.
Storage Battery Handling Gear . . .	Proof 3600 lbs.;	Strength 2700 lbs.
Engine Lifting Gear .	Proof 5200, 7200, 9600, 15,400 and 30,000 lbs.	

Proof test consisted of hoisting and suspending for ten minutes twice the working load. Strength test consisted of operating the appliance with 1-1/2 times the working load.

(e) COMPARTMENTS

Individual Compartments . . . . A.T. 15 lbs./sq.in.

Hull was tested by submergence to depth of 400 feet from surface to the axis of the vessel (about 412 feet to bottom of keel).

Main compartment divisional bulkheads are designed for a pressure of 200 lbs./sq.in. but are not tested at that pressure.

(f) TANKS

Main Ballast Tanks

M.B.T. #1 M.B.T. #2A & 2B M.B.T. #2C & 2D M.B.T. #6A & 6B M.B.T. #6C & 6D M.B.T. #7	A.S.&T. 15 lbs./sq.in.
Safety Tank	W.S.&T. 462 ft. head to keel
Variable Ballast Tanks	W.S.&T. 462 ft. head to keel

Fuel Ballast Tanks

F.B.T. #3A & 3B F.B.T. #4A & 4B F.B.T. #5A & 5B	W.S.&T. 102 ft. head to keel F.O.T. 60 ft. head to keel (individually)

Fuel Oil Tanks

Normal F.O. #1 Normal F.O. #2 Normal F.O. #6 Normal F.O. #7 Collecting Tank Expansion Tank	W.S.&T. 102 ft. head to keel F.O.T. 60 ft. head to keel
Clean F.O. #1 Clean F.O. #2	W.S.&T. 60 ft. head to keel F.O.T. 60 ft. head to keel

Lubricating Oil Tanks - Main

Normal Lub. Oil Tank #1 Main Engine Sump #1 Main Engine Sump #2 Main Engine Sump #3 Main Engine Sump #4	W.S.&T. 35 ft. head to keel F.O.T. 30 ft. head to keel
Motor & Reduction Gear Lub. Oil Sump #1 Motor & Reduction Gear Lub. Oil Sump #2	W.S.&T. 462 ft. head to keel F.O.T. 30 ft. head to keel (together)
Reserve Lub. Oil Tank Normal Lub. Oil Tank #2	W.S.&T. 35 ft. head to keel F.O.T. 30 ft. head to keel
Normal Lub. Oil Tank #3	W.S.&T. 462 ft. head to keel F.O.T. 30 ft. head to keel

Miscellaneous Tanks

Sanitary Tanks	W.S.&T. 462 ft. head to keel
Fresh Water, Potable Fresh Water, Battery	A.S.&T. 18 lbs./sq.in.

(g) MISCELLANEOUS

Covers, Hatch, W.T.	W.S.	300 lbs./sq.in.
Doors, W.T.	W.S.&T.	200 lbs./sq.in.
Water Closets, Waste Receivers	W.S.	198 lbs./sq.in.
Water Jackets, H.P. Air Compressor	W.S.	300 lbs./sq.in.
Torpedo Tubes (before installation)	W.S.	300 lbs./sq.in.
Torpedo Tubes (after installation)	W.S.	178 lbs./sq.in.
Signal Ejector (assembled with blank flange on muzzle end and with piping attached) . .	A.S.&T.	300 lbs./sq.in. (Muzzle door to be tested at deep submergence.)
Valves - Ventilation - Hull and Outboard	W.S.&T.	300 lbs./sq.in.
Valves - Safety and Variable Ballast Tanks	W.S.	300 lbs./sq.in.
Type Test - Engine Room Blanking Off Flanges - to	W.S.	400 lbs./sq.in. hydrostatic

SECTION G-1

INNER SHELL PLATING

Portable Plates

Location		Clear Opening	Type	Access to
Fr. 43-44	Stbd.	17" x 26¾"	Bolted	Wardroom Country
Fr. 56-58	Stbd.	33½" x 40½"	Bolted	Radio Room
Fr. 69½-70½	Amid.	32¼" x 26¾"	Bolted	Crew's Quarters
Fr. 85-87	do	7'-4" x 5'-0"	Riveted	Ford. Engine Room
Fr. 96-98	do	7'-4" x 5'-0"	Riveted	After Engine Room
Fr. 103-106	Amid.	4'-0" x 5'-5"	Riveted	Maneuvering Room

The bolted plates are set up in canvas soaked in Formula 64 and coated with Formula 65 before installation. The main deck over the above openings is provided with bolted portable sections to give adequate access to the inner shell portable plates.

Reference Plans:

Bu. Ships No.	E.B.Co.No.	
SS337-S1601-234205	2421-130	Compartment & Access
SS338-S1601-234226	2421-131	
SS339-S1601-234247	2421-132	
SS340-S1601-234268	2421-133	
SS341-S1601-234289	2421-134	
SS342-S1601-234310	2421-135	

SECTION H-2

BILGE KEELS

The bilge keels are of 17.85 pound plate. They are 15" deep and designed to follow the stream lines of the vessel as far as practicable from frame 41 to frame 99.

Reference Plans:

Bu. Ships No.	E.B.Co.No.	
SS337-S0700-234208	2425-25	Docking Plan
SS338-S0700-234229	2425-26	Docking Plan
SS339-S0700-234250	2425-27	Docking Plan
SS340-S0700-234271	2425-28	Docking Plan
SS341-S0700-234292	2425-29	Docking Plan
SS342-S0700-234313	2425-30	Docking Plan
531764	2432-36	Bilge Keel and Stringers

6.3.5 Watertight Doors

WATERTIGHT DOORS

Location	Size	No. of Dogs	With or Without Deadlight	Access to
Forward Escape Trunk	30" Dia.	4	Without	Main Deck
Gun Access Trunk	30" Dia.	4	Without	Main Deck
Bhd. Fr. 35	20" x 38"	8	With	Ford. Torp. Room Wardroom Country
Bhd. Fr. 47	20" x 38"	8	With	Wardroom Country Control Room
Bhd. Fr. 58	20" x 38"	8	With	Control Room Galley
Bhd. Fr. 77	20" x 38"	8	With	Crew's Quarters Ford. Engine Room
Bhd. Fr. 88	20" x 38"	8	With	Ford. Engine Room Aft Engine Room
Bhd. Fr. 99	20" x 38"	8	With	Aft Engine Room Maneuvering Room
Bhd. Fr. 107	20" x 38"	8	With	Maneuvering Room Aft Torpedo Room

The watertight doors are of built-up welded construction and tested to 200 lbs./sq.in. hydraulic pressure on the 20" x 38" doors, and 300 lbs./sq.in. external pressure on the 30" diameter doors.

All doors are operated by a pair of crank handles located on each side of the door. The doors are further provided with an interlocking device which prevents the operation of the crank handles to lock the door until the door is closed, thereby insuring a position of the locking dogs which will not interfere with the closing of the door at any time.

The bulkhead doors are held open by spring loaded latches on the adjacent structure. The door for the forward escape trunk can be closed from inside the vessel by means of extension shafts through the pressure hull. A pin in the quadrant of the operating arm for this inboard closing device, is used to hold the door in the open position. The bulkhead doors and gun access trunk door may be held in the closed position without the operation of the locking mechanism by a single dog mounted in the door with an operating handle on each side.

Information concerning the location, size, and type of watertight door may be ascertained from the finished plan "Compartment & Access", furnished the vessels by the Supervisor of Shipbuilding.

Reference Plans:

Bu. Ships No.	E.B.Co.No.	
SS337-S1601-234205	2421-130	Compartment & Access
SS338-S1601-234226	-131	Compartment & Access
SS339-S1601-234247	-132	Compartment & Access
SS340-S1601-234268	-133	Compartment & Access
SS341-S1601-234289	-134	Compartment & Access
SS342-S1601-234310	-135	Compartment & Access
532238	2454-10	W.T. Door - 20" x 38" - Interior - General Arrgt.
SS337-S1602-235203	2454-58	W.T. Door - 30" Dia. - Exterior - General Arrangement
532281	2454-43	W.T. Door - Ford. Escape Trunk - Inboard Closing Device - Arrangement

HATCHES

Location	Pressure (Lbs./sq.in.) Above	Pressure (Lbs./sq.in.) Below	Hatch Opening Size	Hatch Opening Shape	Construction of Cover	Material
Escape Trunk Upper	300	30	25"	Circ.	Dished	Steel
Escape Trunk Lower	300	--	21" x 27"	Oval	Dished	Steel
Torpedo Loading Forward	300	30	25"	Circ.	Dished	Steel
Gun Access Lower	300	--	21" x 27"	Oval	Dished	Steel
Conning Tower Upper	300	30	25"	Circ.	Dished	Steel
Conning Tower Lower	300	--	21" x 27"	Oval	Dished	Steel
Crew's Quarters	300	30	25"	Circ.	Dished	Steel
Aft Engine Room	300	30	25"	Circ.	Dished	Steel
Torpedo Loading Aft	300	30	25"	Circ.	Dished	Steel
Torpedo Room Aft	300	30	25"	Circ.	Dished	Steel

Location	No. of Dogs	With Latch to Hold CLOSED	With Latch to Hold OPEN	With Lanyard for Closing from Below	With Deadlight
Escape Trunk Upper	3	No	No	No	No
Escape Trunk Upper	2	No	Yes	Yes	Yes
Torpedo Loading Forward	3	No	No	No	No
Gun Access Lower	2	No	Yes	Yes	No
Conning Tower Upper	3	Yes	Yes	Yes	No
Conning Tower Lower	2	No	Yes	Yes	No
Crew's Quarters	3	Yes	No	Yes	No
Aft Engine Room	3	No	No	No	No
Torpedo Loading Aft	3	No	No	No	No
Torpedo Room Aft	3	No	No	No	No

The circular hatches are each equipped with two operating wheels one on each side of the hatch and, with the exception of the torpedo loading hatches, are spring balanced.

The conning tower upper hatch is equipped with a double purpose latch which holds the cover at the open position and also holds it closed without locking the dogs. When the hatch is open, the latch is released by a lanyard. When the hatch is closed, the latch is released from above by a foot lever. The foregoing applies also to the crew's quarters hatch with one exception: there is no catch for holding the cover open.

The oval hatches are spring balanced and equipped with two hand-operated dogs.

The crew's quarters, forward engine room and aft torpedo room hatch trunks are also provided with blanking-off plates bolted to the bottom of the trunk and fitted with boiler type manholes.

Information concerning the location, size and type of hatches may be ascertained from the finished plan "Compartment and Access" furnished the vessel by the Supervisor of Shipbuilding.

Reference Plans:

Bu. Ships No.	E.B.Co.No.	
SS337-S1601-234205	2421-130	Compartment & Access
SS338-S1601-234226	-131	
SS339-S1601-234247	-132	
SS340-S1601-234268	-133	
SS341-S1601-234289	-134	
SS342-S1601-234310	-135	
SS330-S1602-234169	2454-54	Hatch Cover - 25" D. Dished Plate - General Arrgt.
532265	-37	Hatch Cover - 21" x 27" Oval with Deadlight - General Arrgt.
SS330-S1602-235171	-56	Hatch Cover - 25" D. Dished Plate - Release Type - General Arrgt.

6.3.6 Main Ballast Tanks

Water ballast tanks are divided into two groups: Main Ballast and Variable Ballast. The main ballast group consists of eighteen tanks, which are further divided into seven groups which may be termed the operating grouping, as it is based upon the use of the tanks and the flooding and venting arrangement provided for the handling of the water ballast.

Bow Buoyancy

Main Ballast Tanks (Nos. 1, 2A, 2B, 2C, 2D)

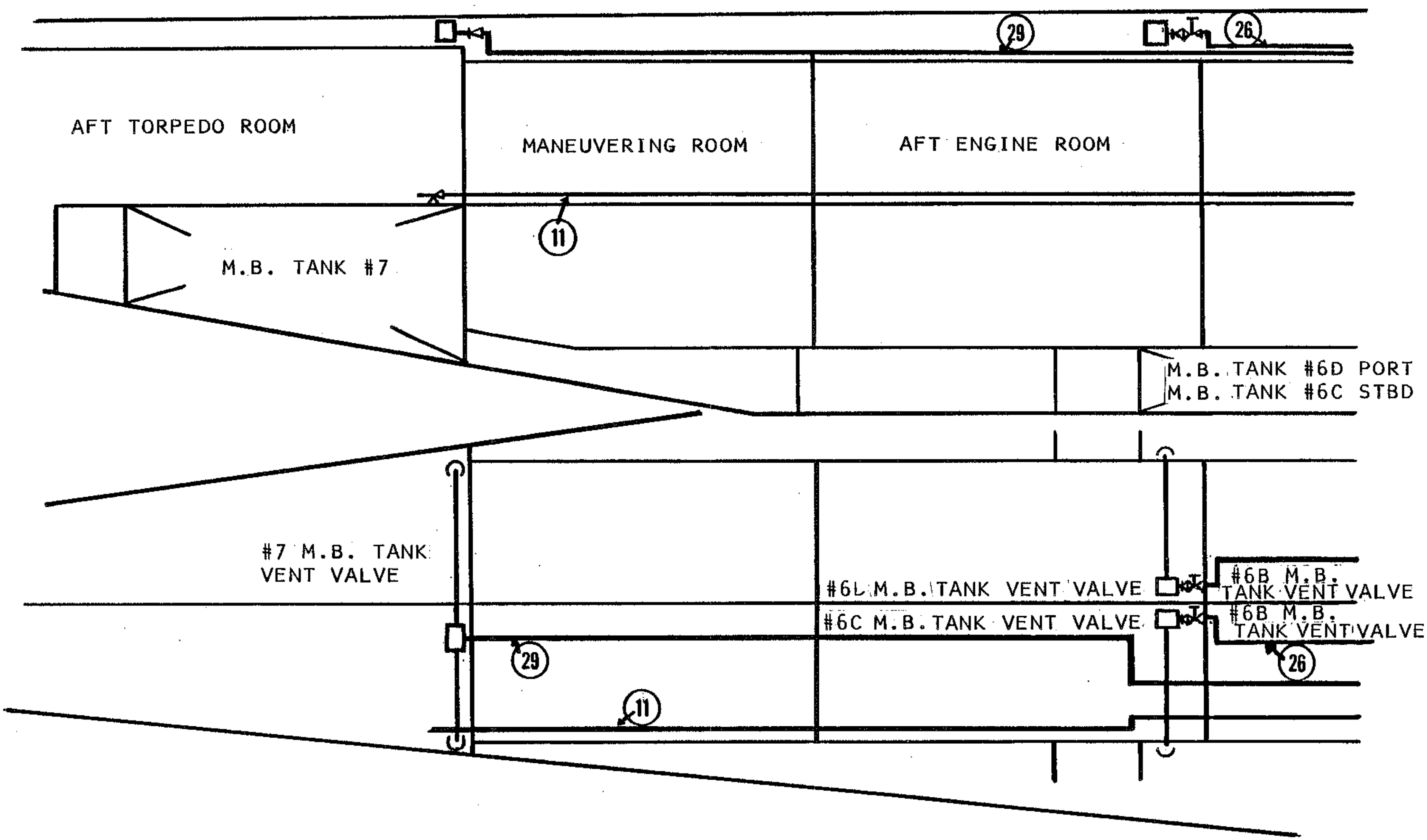
Safety Tank

Fuel Ballast Tanks (Nos. 3A, 3B, 5A, 5B)

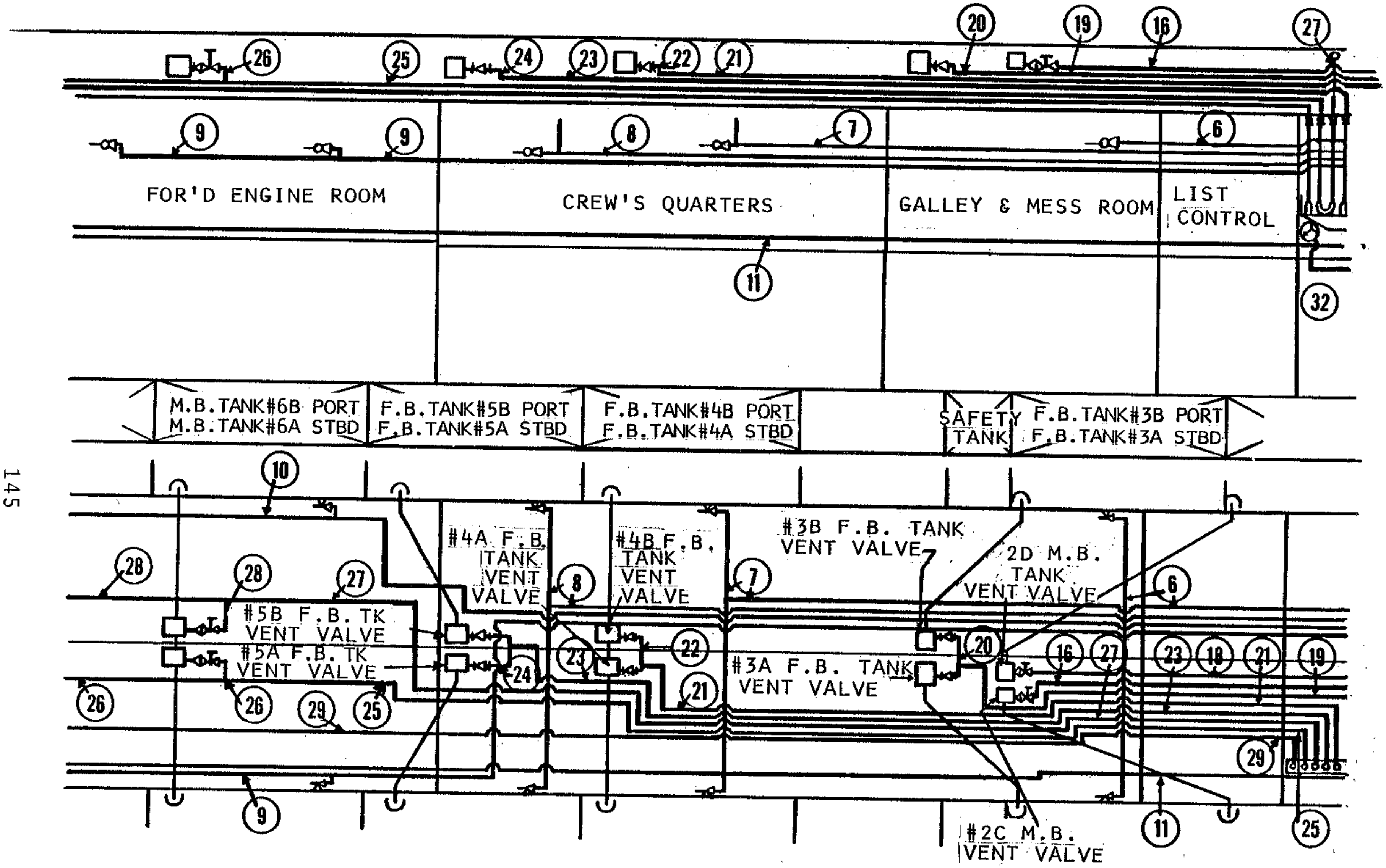
Fuel Ballast Tanks (Nos. 4A, 4B)

Main Ballast Tanks (Nos. 6A, 6B, 6C, 6D)

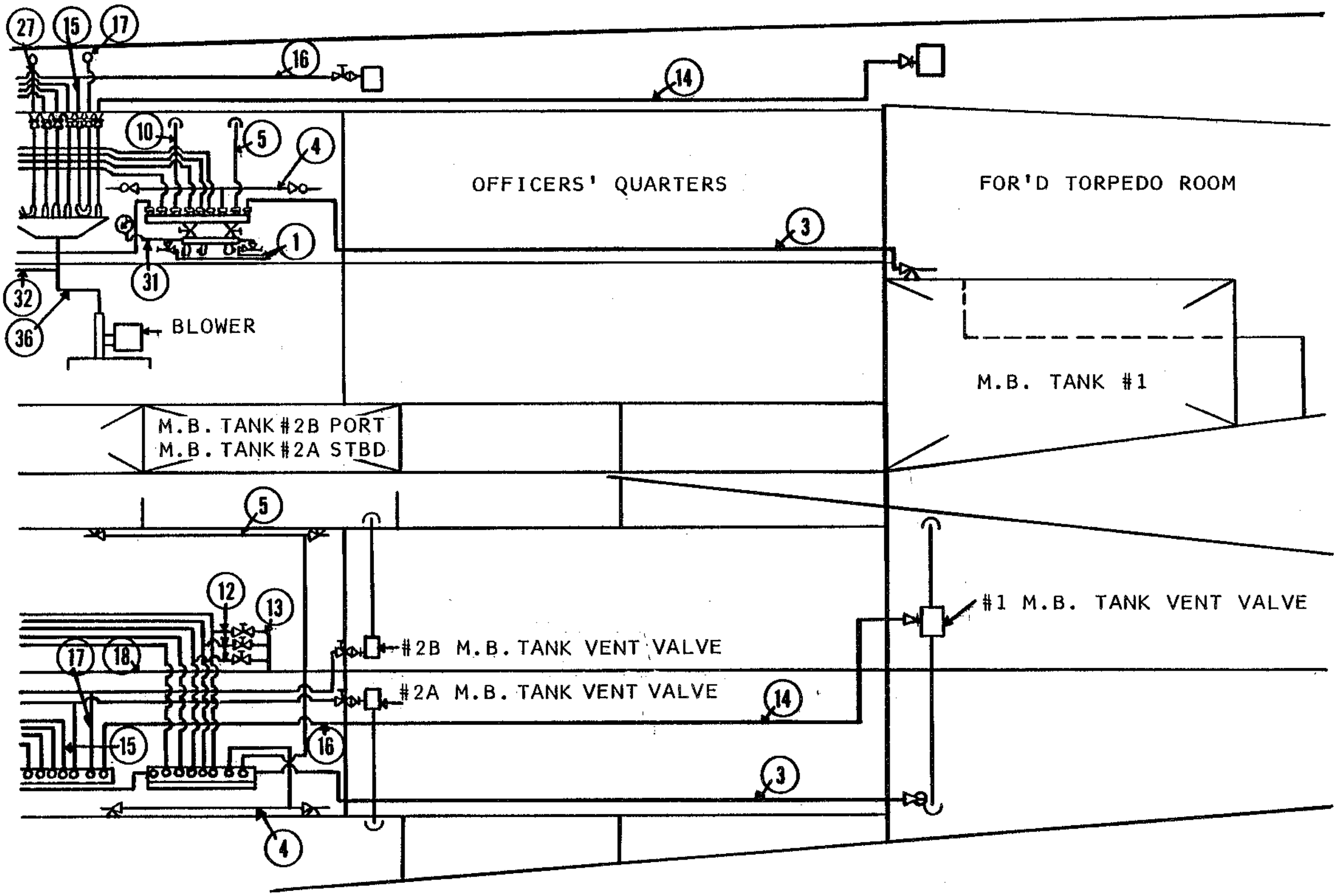
Main Ballast Tank (No. 7)



MAIN BALLAST TANK
BLOWING SYSTEM (1OF3)



MAIN BALLAST TANK BLOWING SYSTEM (2OF3)



MAIN BALLAST TANK BLOWING SYSTEM (3OF3)

SYMBOLS

CHECK VALVE

REGULATOR VALVE

ANGLE STOP VALVE

MANIFOLD

RELIEF VALVE - SET AT 750#

SENTINEL VALVE - SET AT 610#

GAUGE & COCK

LEVER OPERATED VALVE

GATE VALVE

PIPE LIST		
MARK	SIZE O.D.	SERVICE
1	1.315"	H.P. AIR TO 600# MANIFOLD IN CONTROL ROOM
3	1.66 "	600# BLOW - M.B. TANK # 1
4	1.66 "	600# BLOW - M.B. TANKS # 2A-2C
5	1.66 "	600# BLOW - M.B. TANKS # 2B-2D
6	1.66 "	600# BLOW - F.B. TANKS # 3A-3B
7	1.66 "	600# BLOW - F.B. TANKS # 4A-4B
8	1.66 "	600# BLOW - F.B. TANKS # 5A-5B
9	1.66 "	600# BLOW - M.B. TANKS # 6A-6C
10	1.66 "	600# BLOW - M.B. TANKS # 6B-6D
11	1.66 "	600# BLOW - M.B. TANK # 7
12	.840"	BLEEDER - 600# F.B.T. BLOW LINES
13	.840"	DRAIN - 600# F.B.T. BLOW LINES
14	4.00 "	10# BLOW - M.B. TANK # 1
15	3.50 "	10# BLOW - M.B. TANKS # 2A-2C
16	2.375"	10# BLOW - M.B. TANKS # 2A-2C
17	3.50 "	10# BLOW - M.B. TANKS # 2B-2D
18	2.375"	10# BLOW - M.B. TANKS # 2B-2D
19	3.50 "	10# BLOW - F.B. TANKS # 3A-3B
20	2.875"	10# BLOW - F.B. TANKS # 3A-3B
21	3.50 "	10# BLOW - F.B. TANKS # 4A-4B
22	2.875"	10# BLOW - F.B. TANKS # 4A-4B
23	3.50 "	10# BLOW - F.B. TANKS # 5A-5B
24	2.875"	10# BLOW - F.B. TANKS # 5A-5B
25	4.00 "	10# BLOW - M.B. TANKS # 6A-6C
26	2.875"	10# BLOW - M.B. TANKS # 6A-6C
27	4.00 "	10# BLOW - M.B. TANKS # 6B-6D
28	2.875"	10# BLOW - M.B. TANKS # 6B-6D
29	4.00 "	10# BLOW - M.B. TANK # 7
30		
31	.405"	GAUGE LINE - 600# MANI. - CONTROL ROOMS
32	.375"	GAUGE LINE - 10# MANIFOLD
35		
36	8.625"	10# AIR FROM BLOWER

GENERAL NOTES

1. RESERVE FUEL OIL CAPACITIES ARE RATED CAPACITIES FOR BOTH SIDES. THESE INCLUDE THE VENTS AND ALLOW FOR A WATER SEAL BELOW THE LOWEST POINT OF THE COMPENSATING WATER PIPE.

2. MAN BALLAST AND SAFETY TANK CAPACITIES INCLUDE VENT PIPING.

3. CAPACITIES SHOWN ARE AS FOLLOWS:

COMPENSATING TANKS - 100%

NON-COMPENSATING TANKS - 95%
(LUB OIL STORAGE)

SUMPS - 75%

DEDUCT FROM TANK CAPACITIES FOR LEAD BALLAST													
M.B. 2A&2B		M.B. 2C&2D		F.B. 3A&3B		MB1		F.B. 5A&5B		M.B. 6A&6B		M.B. 6C&6D	
CU.FT	TONS S.W.	CU.FT	TON S.W.	CU.FT	TONS S.W.	CU.FT	TONS S.W.	CU.FT	TONS S.W.	CU.FT	TONS S.W.	CU.FT	TONS S.W.
80.81	2.31	98.94	2.83			79.85	2.28			26.13	0.75	75.49	2.16

NOTE: DIVIDE CU.FT OF LEAD BY 35 TO GET TONS OF S.W. DISPLACED BY IT.

NOTE

1 GALLON F.W. = 8.33 LBS
1 GALLON S.W. = 8.56 LBS
1 GALLON F.O. = 6.96 LBS
1 GALLON L.O. = 7.70 LBS

1 TON = 2240 LBS

LBS/CU.FT	
LEAD	710
S.W	64
F.W.	68.2
F.O.	52.0
L.O.	57.5

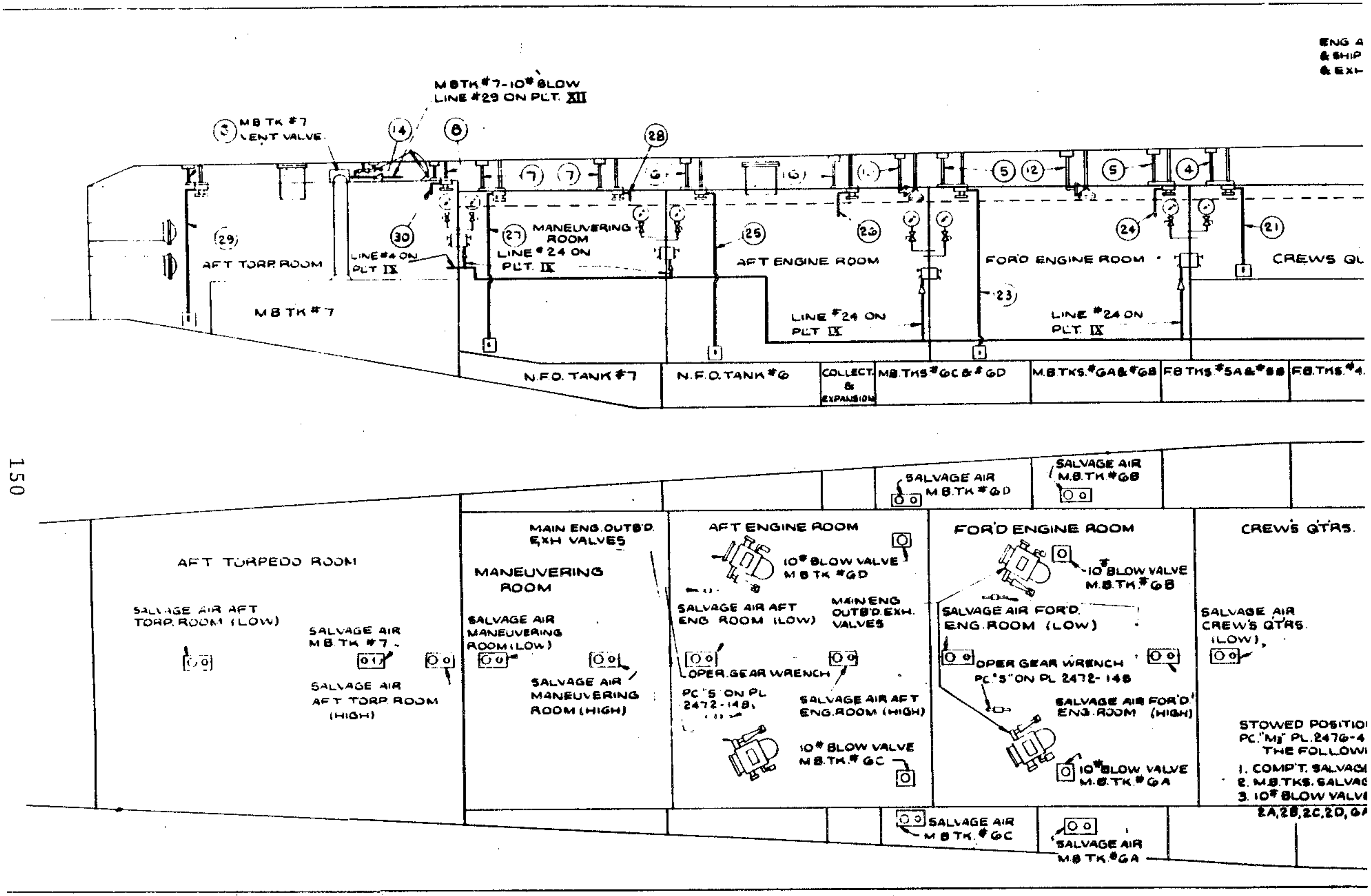
ABBREVIATIONS

S.W. - SALT WATER
M.B. - MAIN BALLAST
F.B. - FUEL BALLAST
N.F.O. - NORMAL FUEL OIL
F.W. - FRESH WATER
B.F.W. - BATTERY FRESH WATER

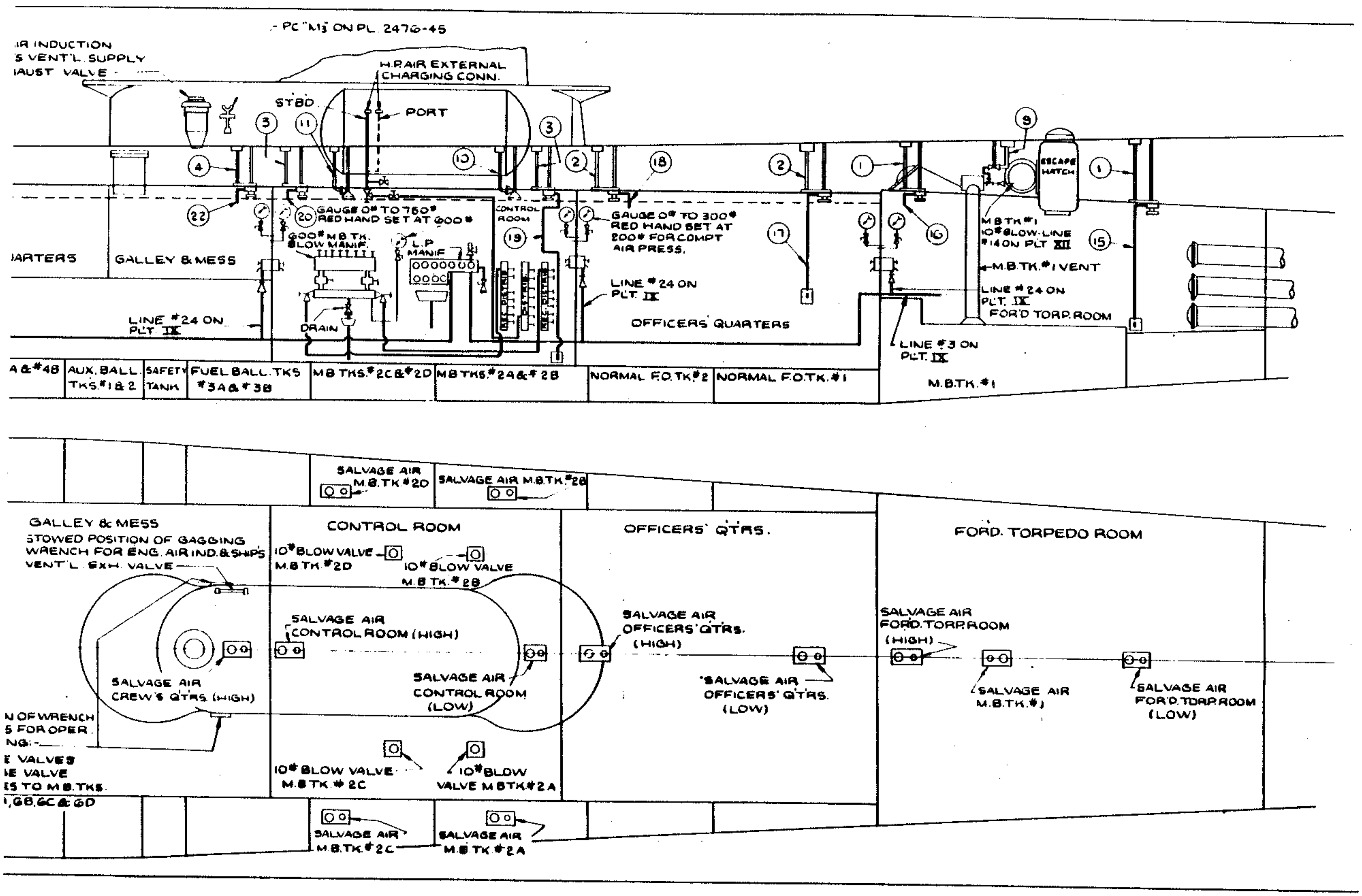
NOTE

FOR TRANSFERRING WATER BETWEEN AUXILIARY AND TRIM TANKS WITHOUT CHANGE OF WEIGHT OR MOMENT.

100 LBS. OUT AUX = 55 LBS ADDED TO F.T. AND 45 LBS ADDED TO A.T.
100 LBS OUT F.T. = 81 LBS OUT OF A.T. AND 131 LBS ADDED TO AUX.
100 LBS OUT A.T. = 123 LBS OUT OF F.T. AND 223 LBS ADDED TO AUX.



COMPARTMENT & BALLAST TANK SALVAGE SYSTEM (1 OF 2)



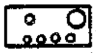
COMPARTMENT & BALLAST TANK SALVAGE SYSTEM (2 OF 2)

COMPARTMENT SALVAGE SYMBOLS


HIGH SALVAGE AIR DECK PLATE FOR OFFICERS' QUARTERS


LOW SALVAGE AIR DECK PLATE FOR OFFICERS' QUARTERS


HIGH SALVAGE AIR DECK PLATES FOR FOR'D. TORP. RM. & CONTROL RM.

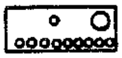

LOW SALVAGE AIR DECK PLATES FOR FOR'D. TORP. RM. & CONTROL RM.

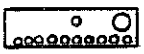

HIGH SALVAGE AIR DECK PLATE FOR CREW'S QUARTERS

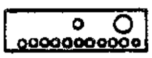

LOW SALVAGE AIR DECK PLATE FOR CREW'S QUARTERS


HIGH SALVAGE AIR DECK PLATE FOR FOR'D ENGINE ROOM

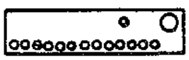

LOW SALVAGE AIR DECK PLATE FOR FOR'D. ENGINE ROOM


HIGH SALVAGE AIR DECK PLATE FOR AFT ENGINE ROOM


LOW SALVAGE AIR DECK PLATE FOR AFT ENGINE ROOM


HIGH SALVAGE AIR DECK PLATE FOR MANEUVERING ROOM


LOW SALVAGE AIR DECK PLATE FOR MANEUVERING ROOM


HIGH SALVAGE AIR DECK PLATE FOR AFT TORP. ROOM


LOW SALVAGE AIR DECK PLATE FOR AFT TORP. ROOM

TANK SALVAGE SYMBOLS


SALVAGE AIR DECK PLATE M.B.T. #2A & #2B


SALVAGE AIR DECK PLATE M.B.T. #1


SALVAGE AIR DECK PLATE M.B.T. #2C & #2D


SALVAGE AIR DECK PLATE M.B.T. #6A & #6B


SALVAGE AIR DECK PLATE M.B.T. #6C & #6D


SALVAGE AIR DECK PLATE M.B.T. #7

M.B.TKS. 10# BLOW & MISC. SALVAGE SYSTEM SYMBOLS

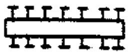
 DECK PLATE 10# BLOW M.B.T. #2A & #2B

 DECK PLATE 10# BLOW M.B.T. #2C & #2D

 DECK PLATE 10# BLOW M.B.T. #6A & #6B

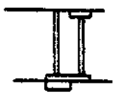
 DECK PLATE 10# BLOW M.B.T. #6C & #6D

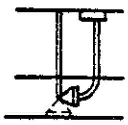
 COMP'T. AIR SUPPLY MANIFOLD

 H.P. AIR RECEIVING MANIFOLD

 L.P. AIR MANIFOLD

 600# M.B.T. BLOW MANIFOLD

 SALVAGE AIR CONNECTIONS TO COMPARTMENTS

 SALVAGE AIR CONNECTIONS M.B.TK.

 STRAINER

PIPE LIST		
MARK	SIZE O.D.	SERVICE
1	1.315"	COMP'T. SALVAGE CONN. FOR'D. TORP. ROOM
2	1.315"	COMP'T. SALVAGE CONN. OFFICERS QUARTERS
3	1.315"	COMP'T. SALVAGE CONN. CONTROL ROOM
4	1.315"	COMP'T. SALVAGE CONN. CREWS QUARTERS
5	1.315"	COMP'T. SALVAGE CONN. FOR'D. ENG. ROOM
6	1.315"	COMP'T. SALVAGE CONN. AFT ENG. ROOM
7	1.315"	COMP'T. SALVAGE CONN. MANEUV. ROOM
8	1.315"	COMP'T. SALVAGE CONN. AFT TORP. ROOM
9	1.315"	SALVAGE AIR M.B. TK.#1
10	1.315"	SALVAGE AIR M.B. TK.#2A &#2B
11	1.315"	SALVAGE AIR M.B. TK.#2C &#2D
12	1.315"	SALVAGE AIR M.B. TK.#6A &#6B
13	1.315"	SALVAGE AIR M.B. TK.#6C &#6D
14	1.315"	SALVAGE AIR M.B. TK.#7
15	1.315"	COMP'T. SALVAGE CONN.-FOR'D. TORP. ROOM
16	1.315"	COMP'T. SALVAGE CONN.-FOR'D. TORP. ROOM
17	1.315"	COMP'T. SALVAGE CONN.-OFFICERS' QUARTERS
18	1.315"	COMP'T. SALVAGE CONN.-OFFICERS' QUARTERS
19	1.315"	COMP'T. SALVAGE CONN.-CONTROL ROOM
20	1.315"	COMP'T. SALVAGE CONN.-CONTROL ROOM
21	1.315"	COMP'T. SALVAGE CONN.-CREW'S QUARTERS
22	1.315"	COMP'T. SALVAGE CONN.-CREW'S QUARTERS
23	1.315"	COMP'T. SALVAGE CONN.-FOR'D. ENG. R'M.
24	1.315"	COMP'T. SALVAGE CONN.-FOR'D ENG. R'M.
25	1.315"	COMP'T. SALVAGE CONN.-AFT ENG. RM.
26	1.315"	COMP'T. SALVAGE CONN.-AFT ENG. R'M.
27	1.315"	COMP'T. SALVAGE CONN.-MANEUV. ROOM
28	1.315"	COMP'T. SALVAGE CONN.-MANEUV. ROOM
29	1.315"	COMP'T. SALVAGE CONN.-AFT TORP. ROOM
30	1.315"	COMP'T. SALVAGE CONN.-AFT TORP. ROOM

6.3.7 Compartments

The compartments in the vessel which are provided with equipment for water and gas tightness are as follows:

Compartments	Water and Gastight With the Closing of
Forward Torpedo Room	Access to the escape trunk. Torpedo loading hatch to the main deck. Door to the Wardroom Country. Supply and exhaust ventilation bulkhead valves. Torpedo tube breech and muzzle doors.
Forward Escape Trunk	Access hatch to the forward torpedo room. Access hatch to the main deck. Door to the main deck.
Wardroom Country	Door to the forward torpedo room. Door to the control room. Supply and exhaust ventilation bulkhead valves on the forward bulkhead. Supply and exhaust ventilation bulkhead valves on the after bulkhead.
Control, Pump and Radio Room	Access hatch to the gun access trunk. Access hatch to the conning tower. Door to the wardroom country. Door to the crew's quarters. Supply and exhaust bulkhead valves on the forward bulkhead. Supply and exhaust ventilation bulkhead valves on the after bulkhead. Antenna entering tube hull valve.
Conning Tower	Access hatch to the control room. Access hatch to the bridge.
Crew's Quarters, Galley and Mess Room	Hatch to the main deck. Door to the control room. Door to the engine room. Supply and exhaust ventilation bulkhead valves on the forward bulkhead. Supply and exhaust ventilation bulkhead valves on the after bulkhead.

Ford. Engine Room	Door to crew's quarters. Door to aft engine room. Supply and exhaust ventilation bulkhead valves on forward bulkhead. Supply ventilation bulkhead valve on after bulkhead. Engine air induction hull valve. Engine inboard exhaust valves. Ship's air supply hull valve.
Aft Engine Room	Door to forward engine room. Door to maneuvering room. Hatch to main deck. Supply ventilation bulkhead valve on forward bulkhead. Supply and exhaust ventilation bulkhead valves on the after bulkhead. Engine air induction hull valve. Engine inboard exhaust valves.
Maneuvering Room	Door to aft engine room. Door to aft torpedo room. Supply and exhaust ventilation bulkhead valves on forward bulkhead. Supply and exhaust ventilation bulkhead valves on after bulkhead. Auxiliary engine air induction hull valve.
Aft Torpedo Room	Door to maneuvering room. Access hatch to the main deck. Torpedo loading hatch to the main deck. Supply and exhaust ventilation bulkhead valves on the forward bulkhead. Torpedo tube breech and muzzle doors. Signal ejector breech and muzzle doors.

COMPARTMENTS

Floodable Space

The floodable space of each compartment is figured between watertight bulkheads.

Compartment	Cu.Ft.
Forward Torpedo Room	4,481
Officers' Quarters & Forward Battery Room	4,056
Control, Radio, Pump, and Store Rooms	4,653
Conning Tower	830
Crew's Quarters, Galley and Mess, Magazine Refrigerator and After Battery Rooms	5,821
Ford. Engine Room	4,535
Aft Engine Room	4,277
Maneuvering Room	3,410
After Torpedo Room	3,455
Total Floodable Space	35,518

6.4 PACSUBSALVEX-83 Background Information

Background information was provided prior to the commencement of the salvage operation. The refloating of the BLUEGILL was specifically intended to provide two results; they were:

1. The removal of the submarine was believed to be needed for safety of local divers and because it no longer provided the necessary service required for training exercises.

2. The salvage of the BLUEGILL would provide much valued training for the US NAVY in submarine salvage operations.

Prior to the commencement of the salvage, a brief situation report, outline of salvage plans, and some of the reasons why the salvage was required, were prepared and presented to interested parties; much of the following information is based on those documents.

6.4.1. Situations

Commander Service Squadron FIVE (CTG 33.5), with assigned units and supporting elements from various MIDPAC commands, will conduct a Submarine Salvage Exercise, PACSUBSALVEX-83, utilizing the ex-BLUEGILL (AGSS-242). Ex-BLUEGILL is moored on the bottom at about 140 feet, at approximate position:

LAT 20°51'13.3"N

LONG 156°40'58.7"W

Underway operations were scheduled to commence on 3 October 1983 and continue through the final lift and re-sinking of ex-BLUEGILL.

The following statement was issued to interested parties:

"PEARL HARBOR, Hawaii (Sep. 29, 1983) -- The U.S. Navy will begin an operation to raise the ex-USS BLUEGILL from waters off Maui Monday, October 3. Presently in waters of about 140 feet, the submarine will be raised and towed to be resunk in deeper waters."

The World War II class diesel-powered submarine was sunk in Auau Channel in December, 1970 after its decommissioning. Over the years it has been used as a platform for training Navy divers, salvage and rescue specialists, and deep submergence rescue vehicle training.

The Navy no longer needs BLUEGILL for training purposes and will be moving it in accordance with a prior agreement with the State of Hawaii. The agreement signed in 1970 states that the ship will be moved when it is no longer needed for training by the Navy.

Taking part in the operation are the salvage and rescue ships USS BRUNSWICK (ATS-3) and USS BEAUFORT (ATS-2), under the direction of Commander Service Squadron FIVE. On-scene Commander is Lieutenant Commander Jim Spear, Commanding Officer of USS BRUNSWICK.

Why was the BLUEGILL originally sunk in Auau Channel?

The present site in the Auau Channel was selected because it was deep enough to provide training for Navy professional divers and was safely out of normal maritime traffic lanes.

Why does the BLUEGILL have to be moved?

Prior to the submarine being originally sunk, an agreement was signed with the State of Hawaii. Under terms of the agreement, the Navy is obligated to move the ship when it is no longer needed. Additionally, inasmuch as there have been a number of diving accidents at the present site of the ship, the Navy feels removal also would be in the public's best interest.

What kinds of accidents have occurred?

The area in which the BLUEGILL is presently located has been the scene of the greatest number of diving accidents in the state. Due to the depth of the water, the majority of the diving accidents involve decompression sickness.

Where is it going to be resunk?

The ex-BLUEGILL will be sunk in Keolaikahiki Channel, approximately 23 NM Southwest of Lahaina, Maui. Water depth there is over 2,000 feet.

How is it going to be raised?

Several methods are under consideration. All of them involve proven Navy salvage techniques. Specific details will be released as the salvage effort progresses.

Does the Navy have any plans to use the sub once it's resunk in deeper waters?

There are no present plans to use the submarine by the Navy, however, a passive acoustic marker buoy will be placed at the new site to assist in locating the submarine should it become necessary at some future time.

How many sunken subs like BLUEGILL does the Navy have?

The BLUEGILL is the last of its kind to be used in underwater training. The last submarine the Navy raised was the ex-USS HAKE in 1971 from Chesapeake Bay.

How long will the operation take?

Approximately two weeks.

Will any environmental damage occur as a result of the raising and resinking of the ex-BLUEGILL?

It is expected that no significant environmental damage will occur as a result of the salvage operation. The ship has been certified to contain no liquid contaminants (diesel fuel, oil, etc.).

Can media observe the salvage operation?

Arrangements have been made to accommodate a limited number of media embarkation requests. Embarkations aboard salvage ship will be limited to daylight hours only and on a not-to-interfere basis. COMTHIRDFLT Public Affairs Office will serve as point of contact for all embarkation requests.

6.4.2. History of the ex-USS "BLUEGILL" Up to 1959

Bluegill is a sunfish of the Mississippi basin and Great Lakes.

SS-242:	
displacement	1,526
length	311'9"
beam	27'3"
draft	17'
speed	20.3 knots
cpl.	60
a.	14"
TT.	1,021"
class	"Gato"

BLUEGILL (SS-242) was launched 8 August 1943 by Electric Boat Co., Groton, Conn.; sponsored by Mrs. W. Sterling Cole, wife of Congressman Cole of New York; commissioned 11 November 1943, Lieutenant Commander E. L. BARR, Jr., in command; and reported to the Pacific Fleet.

BLUEGILL's war operations cover the period between 1 April 1944 and 21 June 1945, during which time she completed six war patrols in an area extending from New Guinea to Formosa and through the South China and Java Seas. BLUEGILL sank ten Japanese vessels, totaling 46,212 tons, including the light cruiser, YUBARI, 27 April 1944 in 05°20' N., 132°16' E., and a submarine chaser.

During January 1945 BLUEGILL made reconnaissances in support of American reoccupation of the Phillippines. On 28 May she conducted a reconnaissance and bombardment of Pratas Island. Twelve men were landed and discovered that the island had recently been evacuated by the Japanese naval garrison. In a fitting ceremony on 29 May BLUEGILL raised the American flag on Pratas Island and proclaimed it to be "BLUEGILL Island."

BLUEGILL arrived at Pearl Harbor 21 June 1945 from her last war patrol. She continued to serve with the Pacific Fleet for training duty. On 7 July 1952 she was placed out of commission in reserve and underwent conversion to a "killer" submarine. Conversion completed, she was reclassified SSK-242 and recommissioned 2 May 1953.

On 2 November 1953 BLUEGILL was deployed to the Western Pacific where she participated in training exercises and operations with various United Nations forces. She returned to San Diego 15 May 1954 and took part in intensive anti-submarine exercises with other fleet units in the area. On 1 July 1955 BLUEGILL's home port was changed to Pearl Harbor and since that time she has conducted two cruises in the Far East and local operations in the vicinity of the Hawaiian Islands.

BLUEGILL received the Navy Unit Commendation for her first war patrol during which she sank three Japanese vessels, including the light cruiser YUBARI. In addition, she was awarded four battle stars for World War II service.