NAVSEA 0994-LP-017-5010

# THE SALVAGE OF THE LITTON LAUNCHING PLATFORM

U.S. NAVY SUPERVISOR OF SALVAGE

NAVAL SEA SYSTEMS COMMAND

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# FOREWORD

The sinking of the LITTON Launching Platform while undocking the USS SPRUANCE (DD-963) jeopardized the Ingalls Division's entire shipbuilding program. Under the direction of the U.S. Navy Supervisor of Salvage, an intense salvage operation was successfully conducted to raise the platform as expediently as possible for subsequent restoration and return to use. The structural limitations of the dock and the hydrostatics of the situation presented the salvors with a unique and formidable challenge which was ultimately to be overcome by an innovative salvage technique employing simultaneous pumping and blowing with air.

This documentation of the LITTON Launching Platform Salvage Operation provides an excellent opportunity for U.S. Navy salvors to learn from this experience. This report constitutes a valuable addition to our professional literature and is a significant contribution to the enhancement of the salvor's art.

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# THE SALVAGE OF THE
# LITTON LAUNCHING PLATFORM

## I BACKGROUND

The West Bank Facility of the Ingalls Division of Litton Industries in Pascagoula, Mississippi represents one of the most modern and efficient shipbuilding yards in the United States. Abandoning the traditional building ways or graving dock concept, Litton has designed and built a grid of rails and trolleys which allows ship construction in an assembly line fashion similar to that originally introduced by Henry Ford some seventy years ago. The basic ship assembly process may be outlined in five discrete steps: (1) transverse ship hull modules are fabricated in convenient bays (initial module size is normally limited to shipyard crane capacity), (2) modules are transported to the ship assembly area and positioned on longitudinal rails, (3) ship modules are integrated, i.e., translated longitudinally, butted and welded to make a complete hull, (4) mechanical/electrical/armament/command and control subsystems are installed--during this period the entire ship is incrementally translated transversely down the "assembly line," and (5) the ship is translated onto the launching platform and launched. See Figures 1 and 2.

Perhaps the most unique and critical major element in the West Bank Facility ship construction process outlined above is the launching platform itself. It was designed by Crandell Dry Dock Engineers of Dedham, Massachusetts, and built by Litton specifically for launching the new construction ships in the manner shown in Figure 2. Besides being the largest drydock on the entire Gulf Coast, it was also intended for use for any routine drydockings required prior to ship delivery or to customers of opportunity. Every ship in the assembly line must utilize the platform to complete--conversely loss of the platform would ultimately back up and bring the ship construction process to "all stop." The basic scantlings and characteristics of the launching platform are shown in Figure 3. The launching platform in its normal position is shown in Photograph 1. Photograph 2 shows the initial launching of the USS SPRUANCE.

## II THE CASUALTY

On the morning of 13 March 1975, USS SPRUANCE (DD 963), having just completed Builder's Trials and subsequent sonar dome grooming, was scheduled for a routine undocking. In order to reduce the block buildup, the SPRUANCE had been positioned on the after portions of the dock as shown in Figure 4, thus permitting the sonar dome to hang over and below the Pontoon Deck and the twin screws to protrude into special propeller pits built into the deck. As flooding gradually commenced, a sagging moment was apparently induced and the platform experienced severe buckling amidships. As the morning progressed and corrective action taken to ensure the SPRUANCE did not fall off the blocks, the forward starboard quadrant of portable wing walls broke loose, the combined buckling and

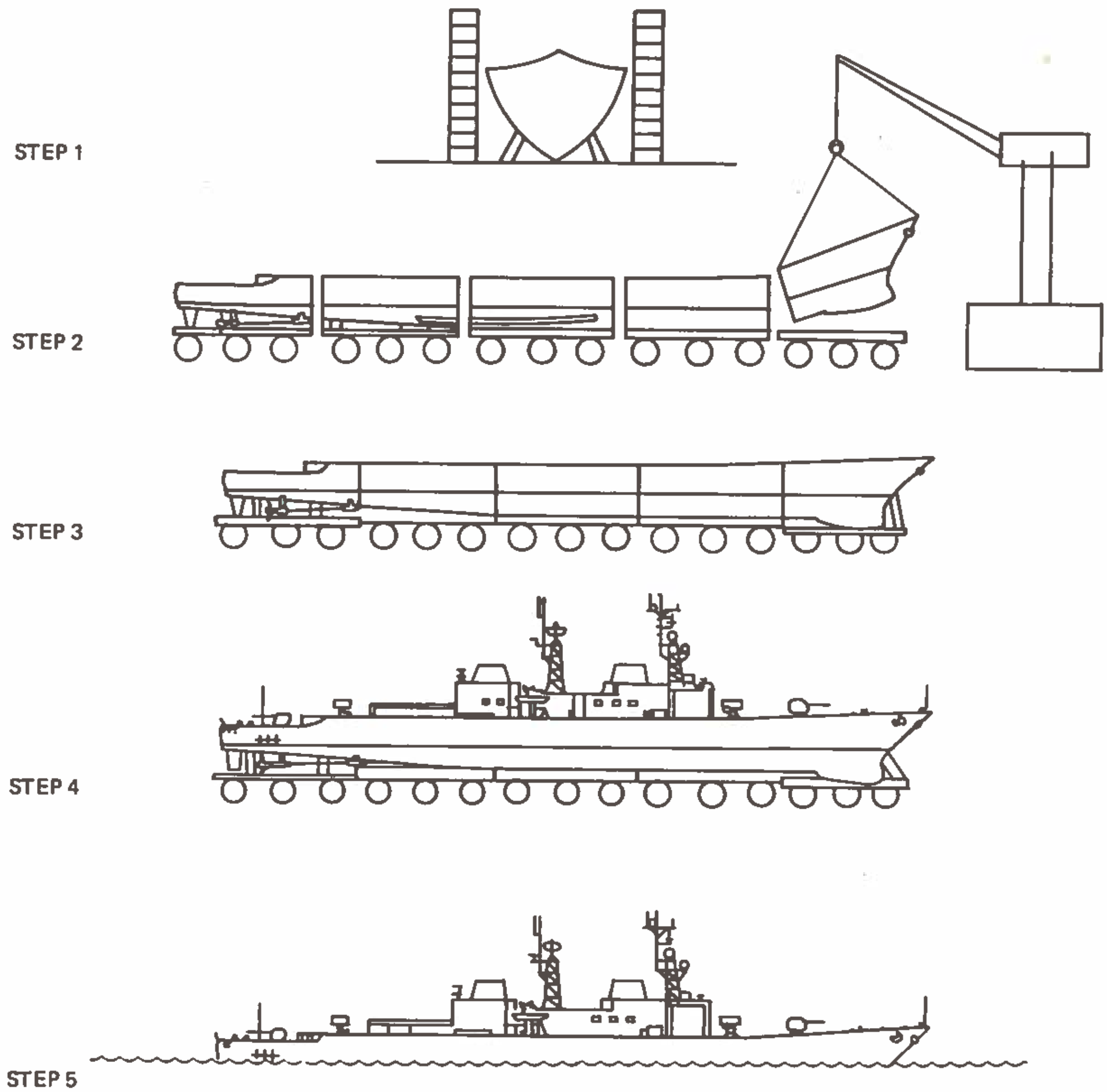



*FIGURE 1. Ship Construction and Integration Process.*

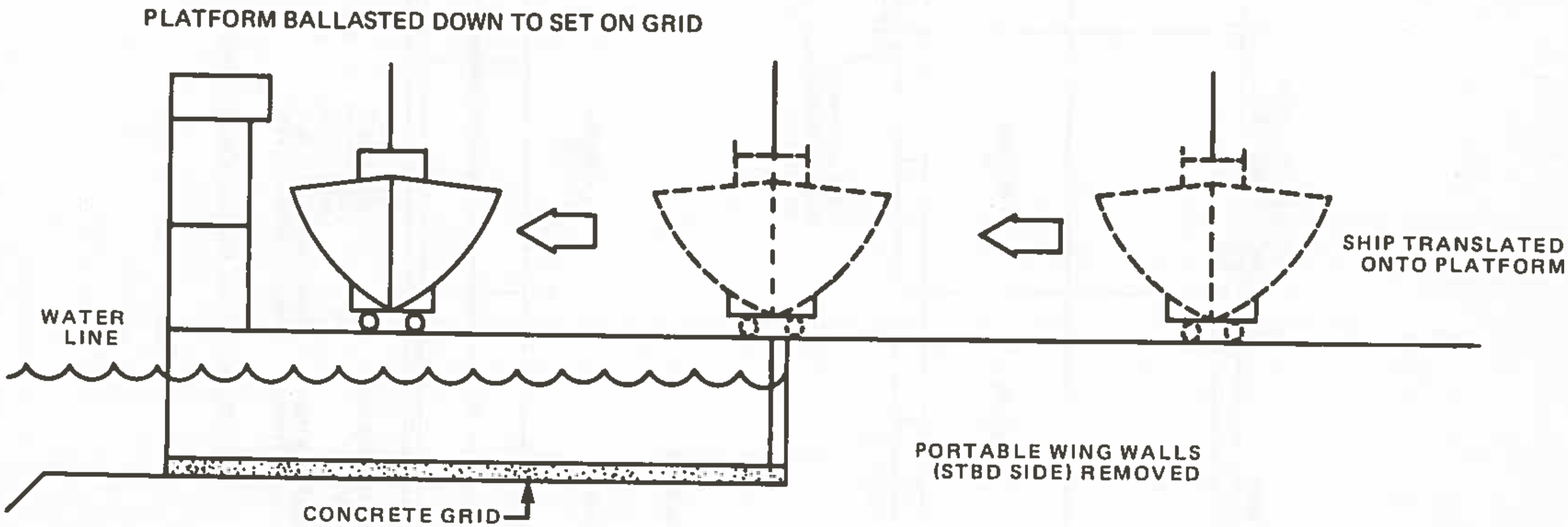
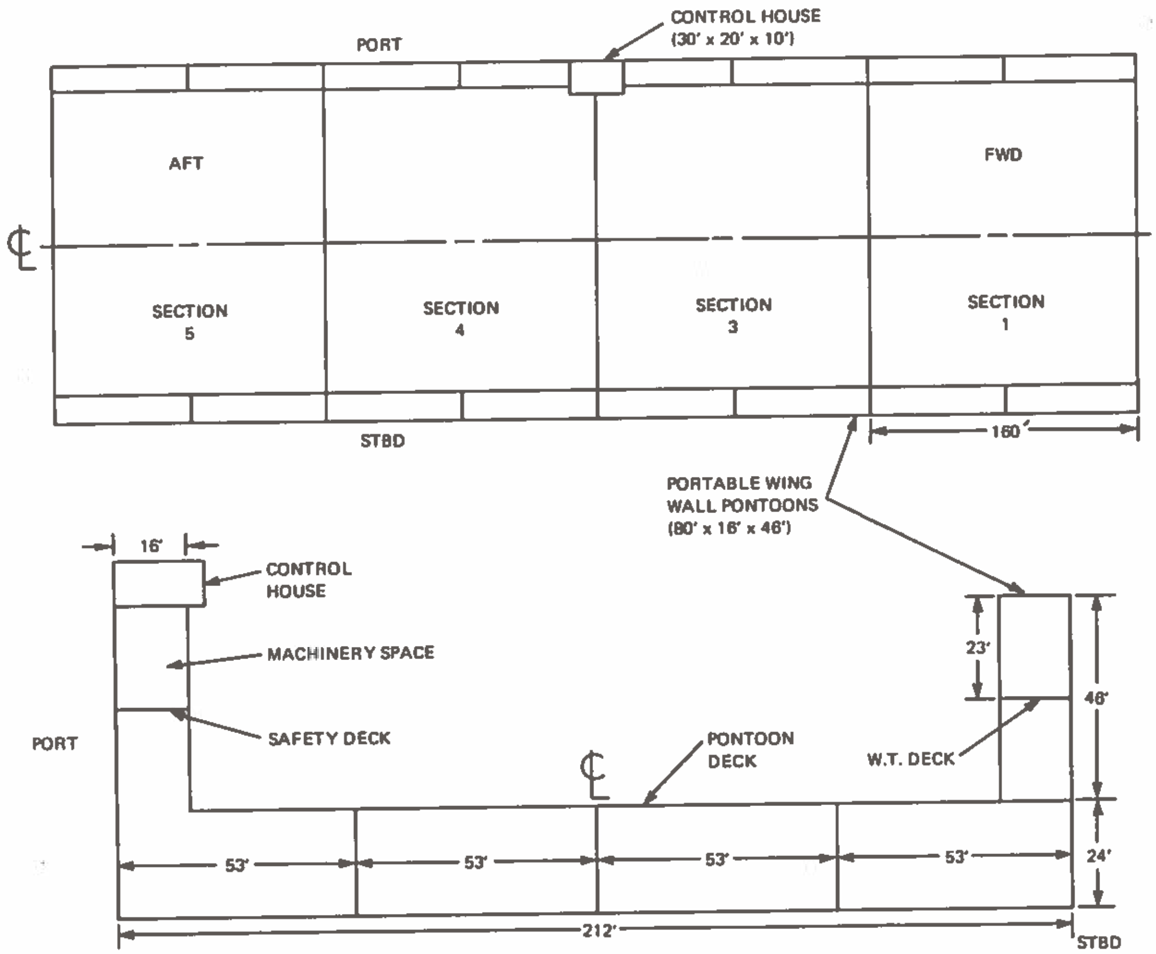



*FIGURE 2. Ship Loading onto Platform.*



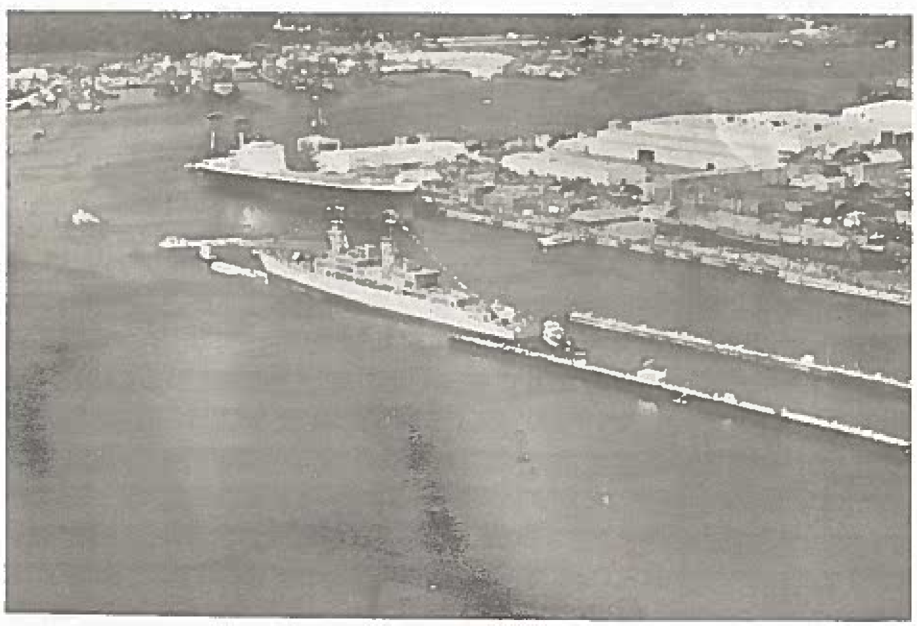

BUILT IN FOUR 160' x 212' SECTIONS
SECTIONS #2 & #6 DESIGNED
BUT NEVER BUILT
EACH SECTION COMPARTMENTED
INTO EIGHT 80' x 53' W.T. TANKS

LENGTH = 640 FT
BEAM = 212 FT
DEPTH = 24 FT
WINGWALL BEAM = 16 FT
WINGWALL HEIGHT = 46 FT

Δ = 13,600 TONS
CAP = 55,000 TONS

*FIGURE 3. General Pontoon Characteristics.*

*PHOTOGRAPH 1. Launching platform in normal position above underwater grid.*



*PHOTOGRAPH 2. Initial launching of USS SPRUANCE (DD 963).*

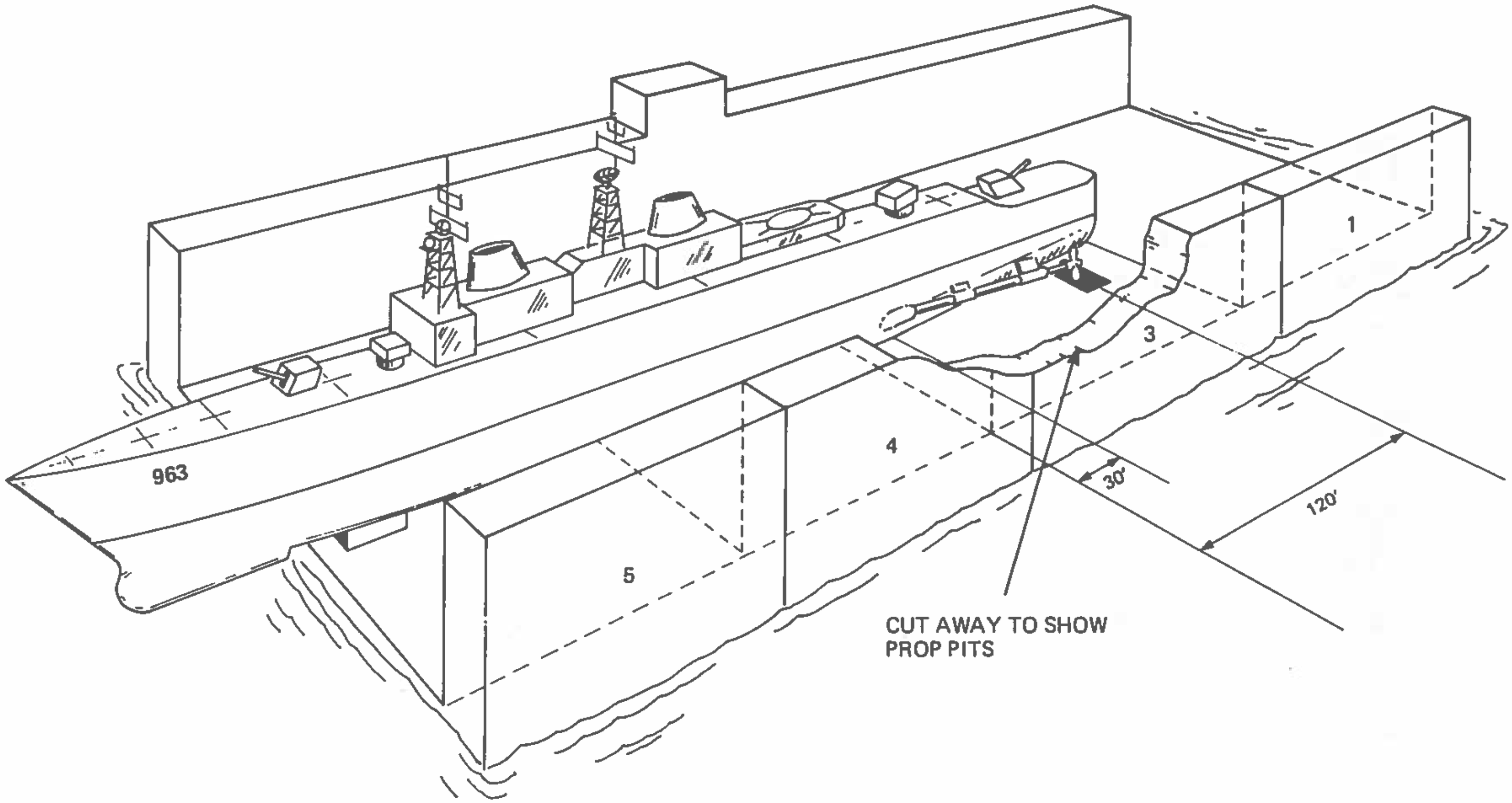
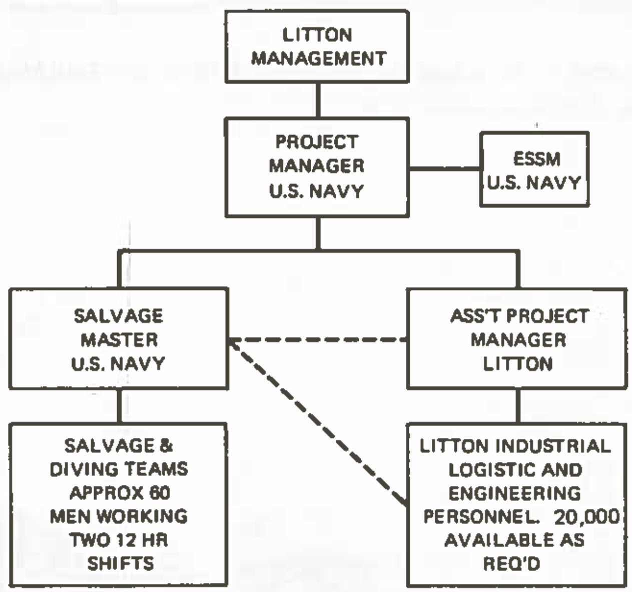



*FIGURE 4. DD 963 Positioned on Blocks.*

shearing loads broke the platform in two, and the forward half sank to the bottom in 72 feet of water. Photographs 3 and 4 show the breaking up of the platform with the SPRUANCE on blocks. Corrective action continued on the after half until the ship was successfully undocked with minimal damage. In the process, however, the second half also sank adjacent to the first.

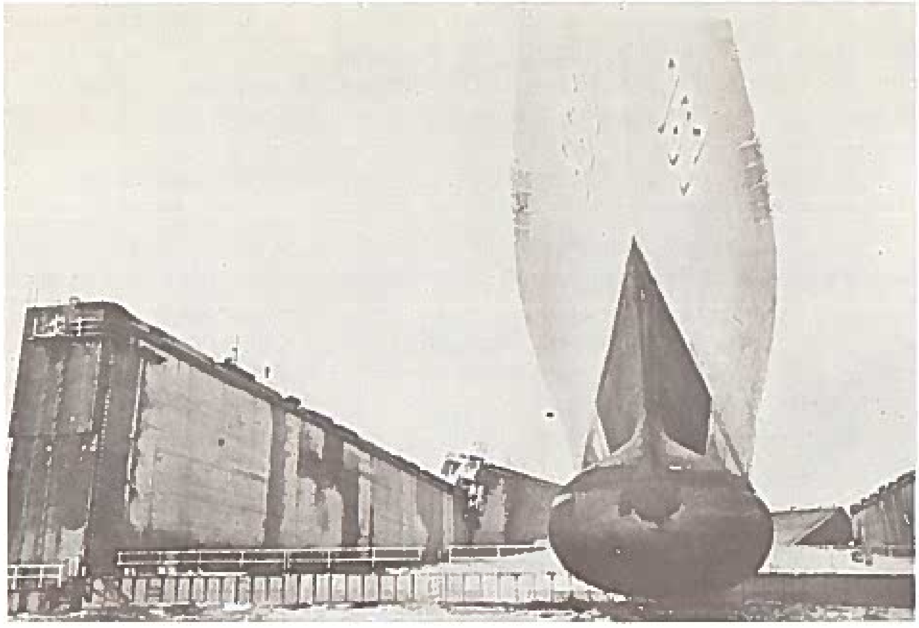
## III THE EXTENT OF DAMAGE

The need to salvage and restore the launching platform to service as expeditiously as possible was critical to the shipyard for the obvious reasons cited above. The US Navy was also most concerned, however, as Litton was under contract to deliver five LHA's and 30 DD 963's, only eight of which had progressed through the launching phase. The Supervisor of Salvage was therefore tasked by the Chief of Naval Materiel to assist Litton in their efforts to salvage the launching platform; all logistic and industrial support being provided by Litton. The Salvage/Diving Teams were also provided by Litton, but under a subcontract to Statler Marine of Mobile, Alabama. The organization of the salvage force is shown below:




A diver's survey of the wreck(s) commenced on 15 March and revealed the following:

(1) The two sections were lying in approximately the same fore and aft orientation with physical separation varying between 7 feet on the port side and 2 feet on the starboard side. Some minor involvement of plating, stiffeners, etc. existed. A simple plan-view is shown in Figure 5.



*PHOTOGRAPH 3. Dock breaking up with USS SPRUANCE on blocks. Attempting to control list and trim.*

*PHOTOGRAPH 4. Launching platform failing amidships in combined shear and compressive buckling.*

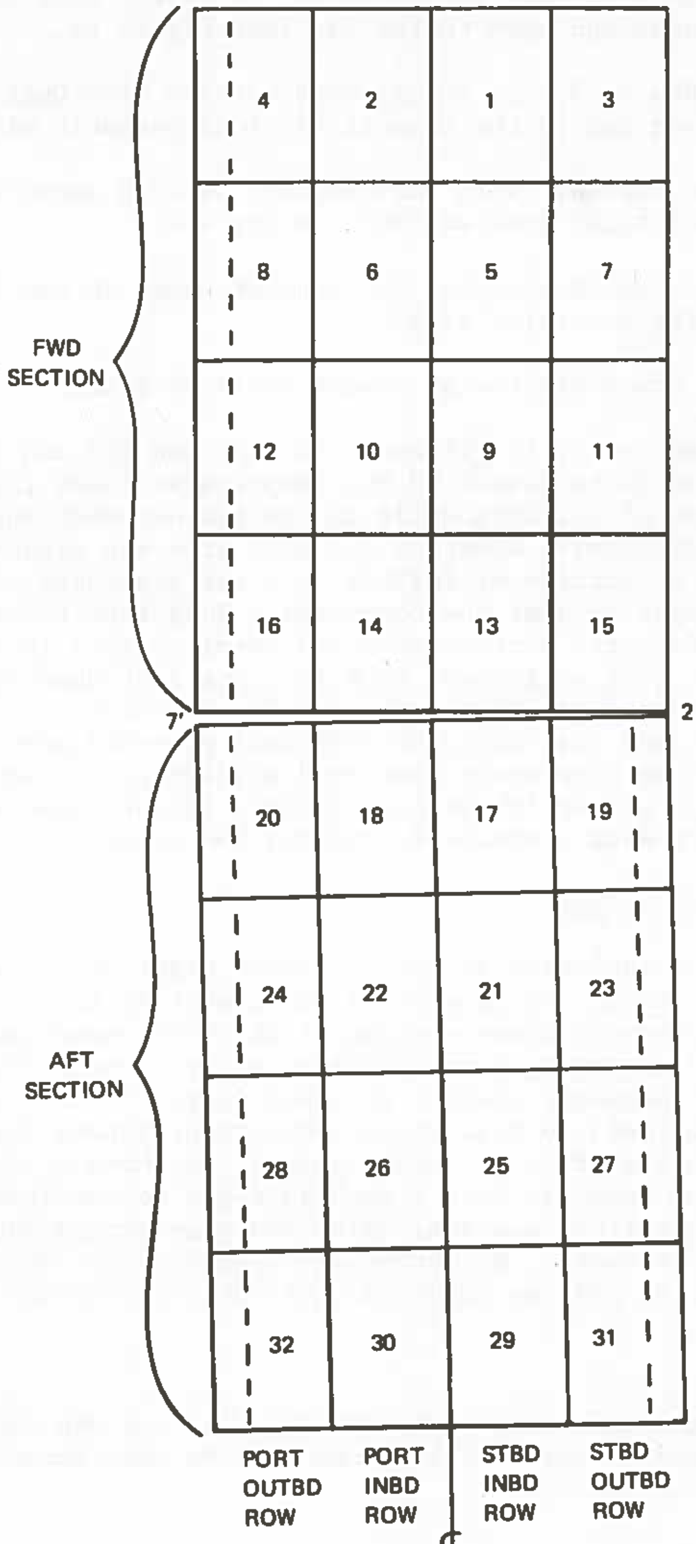



*FIGURE 5. Tank Numbering Diagram.*

(2) Both machinery spaces above the safety deck and Tank 20* were severely damaged and open to the sea (see Figure 6).

(3) Tanks 3, 7, 11, and 15 (FWD Section STBD Outboard Row) were open to the sea due to the loss of the four portable wing wall pontoons.

(4) The portable wing wall pontoon secured above Tank 19 was holed above the watertight deck and open to the sea.

(5) The SPRUANCE screws had punched holes in and immediately adjacent to the propeller pits.

(6) No other structural damage could be found.

The damage cited in (2) above to port and (3) and (4) above to starboard appeared to be caused by the compressive loads induced upon the upper portions of the wing walls as the pontoon deck sagged. Basic failure in compressive shear on the port side was clearly evidenced by the 45° axis of structural failure. On the starboard side, damage was less significant because the compressive load tore the portable wing walls loose from the pontoon deck and resulted only in minor structural damage to the wing wall above Tank 19. The four detached wing wall boxes were retrieved and set ashore for repairs within a few days. It may be further theorized that when the starboard portable wing walls broke loose and the platform completely fractured amidships, the forward half initially rotated and/or lifted a sufficient amount relative to the ship to strike the SPRUANCE propellers, causing the holes cited in (5) above.

## IV THE SALVAGE PLAN

Proper manipulation of the launching platform ballast tank venting, flooding, and deballasting systems was essential to the salvage plan. A brief description of these systems is therefore provided. Each tank had its own flooding valve, pump discharge valve, deballasting pump and air vent. Each transverse quartet of tanks (e.g., 1, 2, 3 & 4; 5, 6, 7 & 8; etc.) were designed to have these components/systems identically grouped. A typical cross-section of such a quartet is shown in Figure 7. The valve and pump group in this figure is piped to the starboard outboard tank. Adjacent (fore and aft) valve and pump groups would be piped to the other three tanks. Not shown are sluice valves which permitted cross-connecting the two outboard tanks and the two inboard tanks in each quartet.

* NOTE - The tank numbering system on the platform was somewhat unorthodox. Therefore a simple sequential system will be referenced throughout this report as shown in Figure 5.

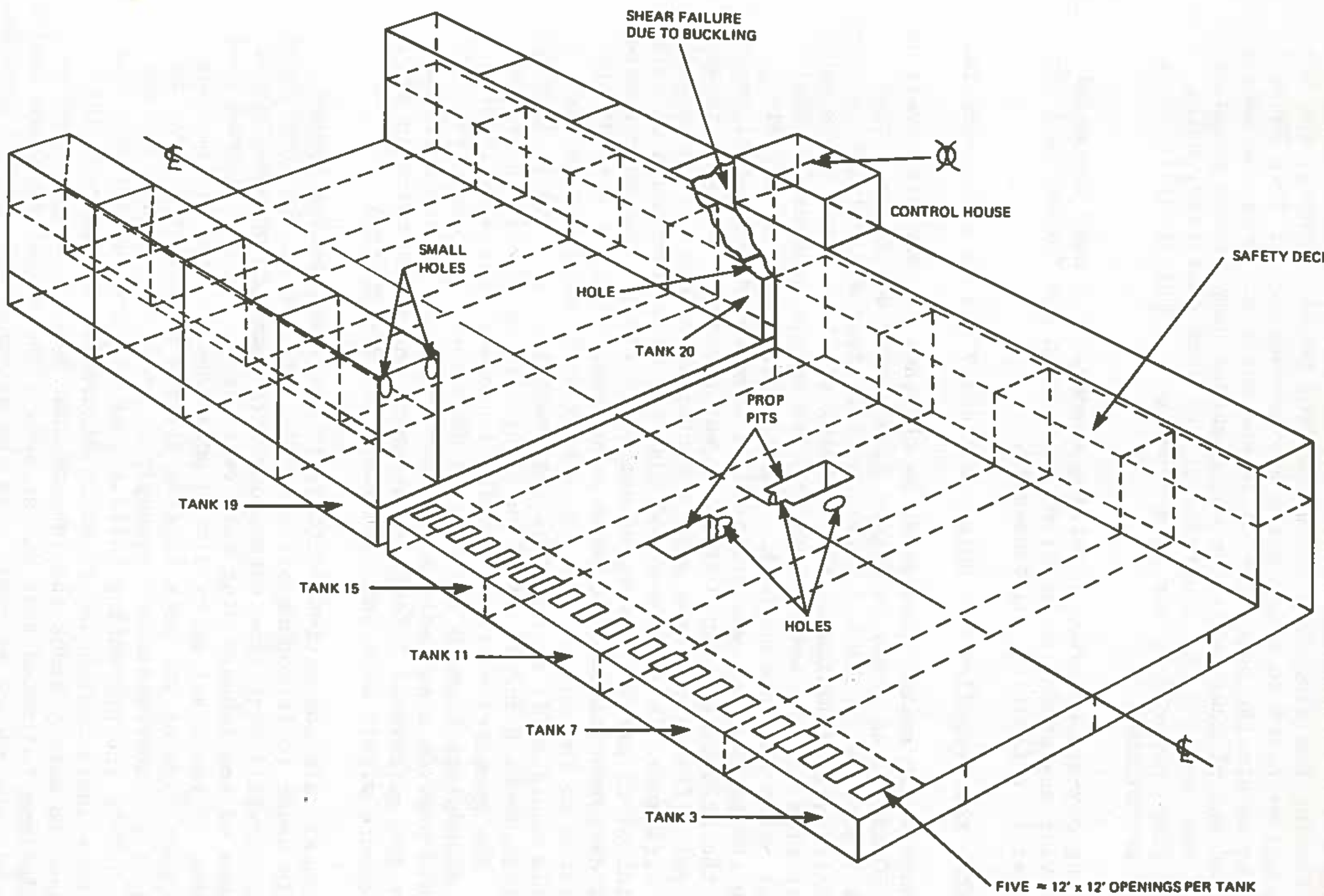



FIGURE 6. Schematic View of Underwater Damage.

A salvage plan was formulated which provided the quickest mode of refloating, blowing the air. Due to the control house overhang, the forward section was selected to raise first by introducing air into Tanks 6, 8, 10 and 12 to rotate the port side up to the surface. Once the safety deck was raised out of the water, the water-soaked pump motors would be replaced with new ones and the remainder of the dock dewatered, using the installed pumps powered by portable generators. The specific steps are described as follows:

(1) Using oxy-arc underwater cutting torches, cut away any metal joining or having any potential involvement between the forward and aft sections to permit refloating independently.

(2) Patch the propeller pit holes in Tanks 9 and 10 with concrete.

(3) Install air relief standpipes in the tank top manhole covers in Tanks 6, 8, 10 and 12 as shown in Figure 8; assembly was to be fitted with a blank flange to facilitate later shifting from a blowing to a pumping mode. Calculations indicated that blowing air into these tanks would lift the port side off the bottom when the air bubble extended approximately 5 feet below the Pontoon Deck. The limiting depth of the air bubble below the safety deck was governed by pressure differential considerations on the structure. Since the dock was generally designed to withstand a 7.5 psi differential head with a factor of safety of two on yield (or four on ultimate), it was theorized that the structure could withstand a differential of 15 psi or 34 feet of sea water (fsw). The most severe condition of differential loading would occur when the port side of the platform rotated to the point where the safety deck broke the surface. The air bubble would spill as the dock rose such that the static internal pressure within Tanks 8 and 12 would be controlled by the depth of the standpipes. The geometry of the situation indicated that a depth of 7 feet of the standpipes beneath the pontoon deck could be tolerated. This approach would provide a suitable margin for error and bottom suction (2 feet over the calculated 5 foot requirement) and still maintain the internal pressure within acceptance limits (23 + 7 = 30 fsw).

(4) Install air connection fittings to the tank venting system (outboard) in order to introduce air directly into two of the four tanks to be blown. Install vent line extensions with manually operated quick closing valves on the inboard wing wall vent lines. It was planned that manual opening of these valves by divers positioned on top of the wing wall as the port side of the dock rotated upwards would complement the air dumping of the aforementioned standpipes, thus controlling the expanding air bubble and preventing ballast tank overpressurization. The details of this installation are shown in Figure 7. It had been initially planned to merely blank the inboard vent lines. However, subsequent calculations indicated that during ascent the actual pressure inside the tanks would not reduce as rapidly as the external hydrostatic pressure due to venting limitations and the large volume of air to be relieved. If the internal air pressure were not significantly vented a maximum

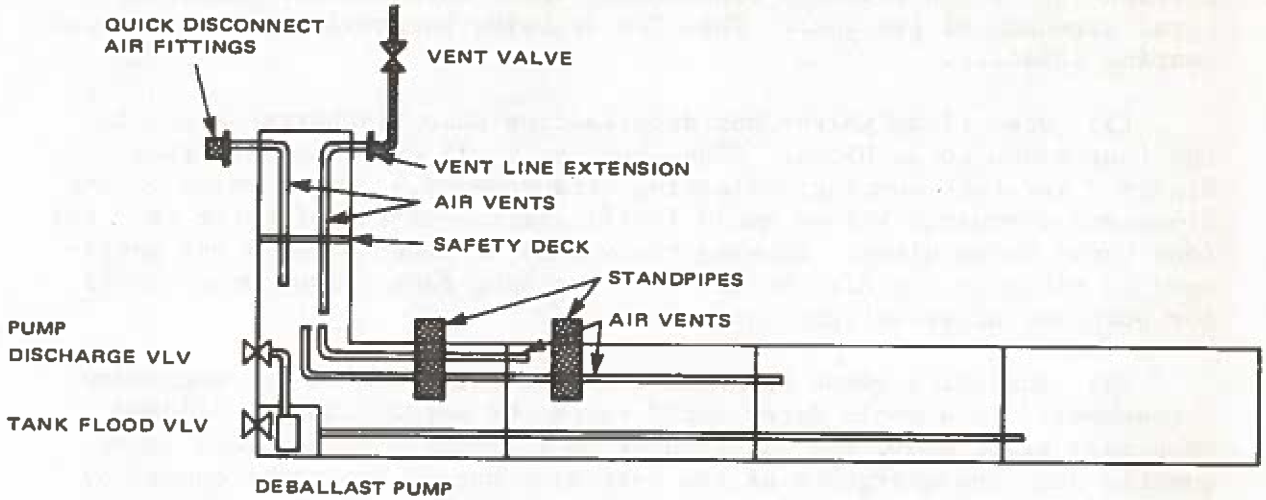



*FIGURE 7. Tank Vent, Flooding and Pumping Systems.*

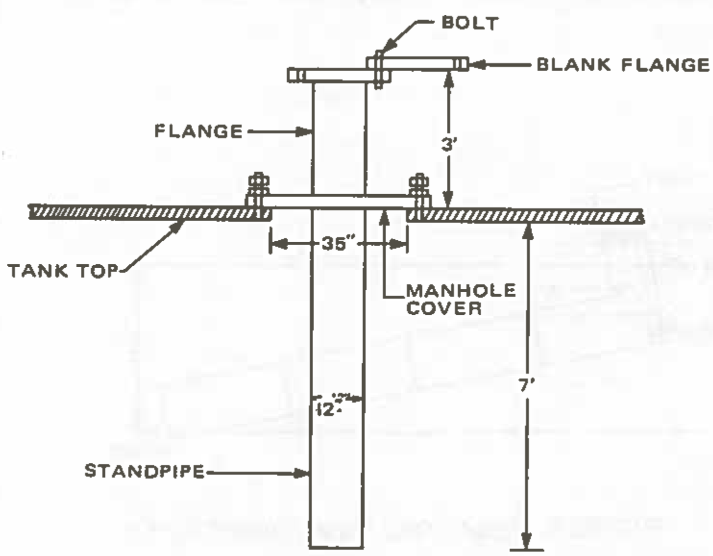



*FIGURE 8. Standpipe Assembly.*

pressure of 53 fsw could be approached, which far exceeded the structural strength of the dock. Thus the decision to provide for additional venting capacity.

(5) Open flood valves and deballasting pump discharge valves for the four tanks to be blown. Close valves in all other tanks. (See Figure 7 for tank pumping/ballasting arrangements.) The opening of the flood and discharge valves would facilitate the egress of water from the four tanks being blown. Closing the valves in Tanks 5 and 9 was necessary to minimize any air entry. The remaining tank valves were closed for purposes of watertight integrity.

(6) Install a swash bulkhead near the after end of the machinery throughway. This would deter rapid egress of water from the flooded machinery space above the safety deck as it rotated upwards and consequently damp the emergence of the port side out of the water caused by the expanding air bubble; and more importantly by serving as the basic structure, it would expedite the final fitting of the watertight bulkhead necessary to isolate the machinery throughway from the sea should the air bubble be prematurely lost and the safety deck fall beneath the water.

(7) Blow air into Tanks 8 and 12. Air will also displace water in Tanks 6 and 10 as air enters through the vent system and water exits through pump/flood systems as the bubble extends below the Pontoon Deck.

(8) As port side rotates upwards (See Figure 9), manually vent tanks via vent line extension valves (Figure 7) in order to avoid structural damage due to air bubble expansion during tank ascent as previously discussed.

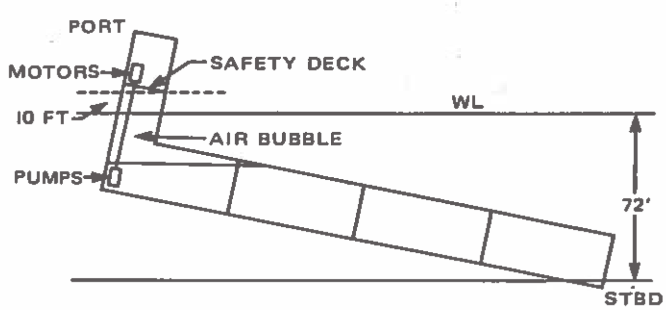



*FIGURE 9. Initial Lifting Phase, Forward Section.*

(9) With the platform now oriented as shown in Figure 9 and floating on a bubble, render the aforementioned swash bulkhead watertight and remove and replace the pump motors in the blown tanks (6, 8, 10 and 12) plus the starboard, inboard row of tanks (1, 5, 9 and 13).

(10) Close the flood valves previously opened for the four blown tanks and ensure all pump discharge valves are opened in the eight tanks with new pump motors. Install the blank flanges on the four air relief standpipes.

(11) Dewater and float the section using newly installed motors and the deballasting pumps.

The salvage plan involved two inherent items of risk, i.e., the structural adequacy of the port wing wall below the safety deck, where the maximum pressure differential would be experienced, and the assurance of maintaining the air bubble while the swash bulkhead was made watertight and the electricians were switching pump motors. As previously noted, calculations did indicate that the port side would "lift off" when the water level was blown down approximately 28 feet below the safety deck (or 5 feet below the Pontoon Deck) which was below the 15 psi design strength of the wing wall. Calculations also indicated the port wing wall would rise out of the water approximately 10 feet above the safety deck, due to the effect of the air bubble expansion as the platform rose, thus providing considerable reserve buoyancy as well as margin for error.

## V THE SALVAGE OPERATION - PHASE ONE

All preparations on the forward half of the launching platform were completed without major incident and blowing of Tanks 8 and 12 commenced on 23 March. Four 600 CFM and two 750 CFM compressors were available to feed the tanks via a gauged manifold through eight 2-inch hoses. The bubble was pushed 23 feet down the wing wall without incident, but as it spread beneath the Pontoon Deck, massive leakage developed from Tank 10 in the vicinity of the propeller pits. Blowing was secured; subsequent diver inspection revealed part of the concrete patch in the propeller pit had been blown/scoured away and an additional 18" x 6" hole approximately 12 feet forward of the pit had not been patched at all, the divers apparently having failed to locate same during the initial underwater survey. These holes were patched with external metal patches and concrete and on 25 March blowing was resumed. When the water had been blown down approximately 2 feet below the Pontoon Deck, a rupture occurred in the inboard side of the wing wall in Tank 12. Blowing was again secured; diver investigation revealed a small tear in the shell 7 feet below the safety deck where the plating had apparently been previously damaged. This tear was repaired with an external patch and internal application of "Splashzone" epoxy sealer. Blowing resumed on 26 March. By the time the water level had again been blown 2 feet below the Pontoon Deck, pierside transit readings disclosed that the wing wall had risen out of the mud over 2 feet forward and 6 inches aft. At that time, however, two ruptures occurred almost simultaneously on the outboard wing wall. Blowing was for a third time secured; diver inspection revealed a welded seam had sprung open at the corner of the wing wall in Tank 12 and a previously damaged area had ruptured in Tank 8; a more thorough internal diver inspection subsequently revealed substantial separation of the shell panels from the vertical stiffeners. These findings resulted in a lack of confidence in the ability of the upper portions of the wing wall to sustain the required internal pressure differential. The salvage plan to blow the platform to the surface with compressed air was therefore abandoned by the salvors in favor of a more conservative approach using salvage pumps.

Fortunately much of the work performed during the initial phase would also have been required during the execution of any subsequent pumping schemes, so the salvors had not lost fourteen days by the switch. Indeed the mobilization and organization of the salvage force had taken several days alone, and the more intangible gains such as the salvor's knowledge of the wreck with time and the increasing proficiency of the Diving/Salvage Teams make it difficult to predict how long the salvage operation might have taken had blowing with air been immediately discarded as the primary means of salvage. In retrospect, it is estimated that no more than five days were actually "lost." The sequence of Photographs 5 through 10 show some of the work conducted during Phase One of the salvage operation. The evidence of the rupture which led to the aborting of Phase One is shown in Photograph 11.

## VI THE SALVAGE OPERATION - PHASE TWO

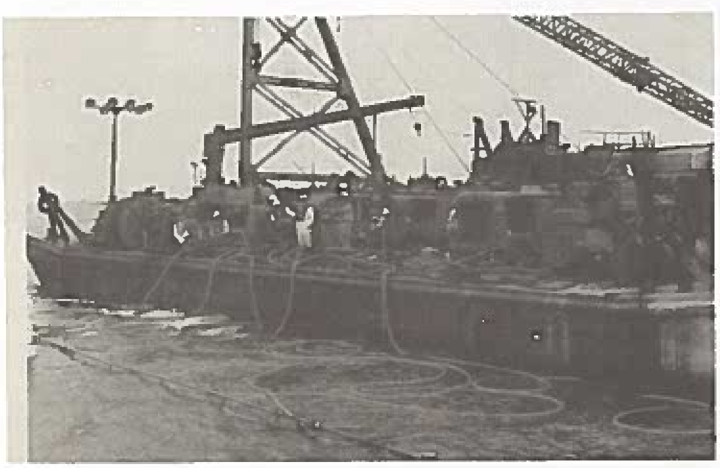
During the execution of the initial salvage plan, which relied upon the use of compressed air to blow the platform to the surface, a reasonable risk of failure was accepted in the interest of expediency, and, consequently, a fallback salvage plan based upon pumping had already been formulated. The water depth over the Pontoon Deck (approximately 48 feet) ruled out the use of conventional pumps without significant cofferdaming and/or holing of the safety decks. Consequently, a scheme based upon placing submersible pumps through the tank top access openings was adopted. Simple hydrostatics show a significant complication however, should any watertight bulkhead be open to the sea on one side and pumped (and vented to the atmosphere) on the other. The solution to this potential problem was ultimately to be solved by concurrent use of both pumps and compressed air. Photograph 12 shows the diesel generators and sub-pump controllers on the control barge.

On 27 March attention was shifted to the aft section to prepare it for pumping. Even though salving the aft section first would introduce the added complexity of dealing with the control house overhang noted previously, it was felt that section required less preparation for the first pumping attempt. Furthermore, the presence of the portable wing wall pontoons provided additional flexibility not available with the forward half. The salvage plan was therefore initially modified as follows:

(1) On an emergency basis obtain as many four-inch submersible salvage pumps as could be made available. Four-inch pumps were selected

*PHOTOGRAPH 5. Launching platform resting on the bottom in 72 ft. of water.*

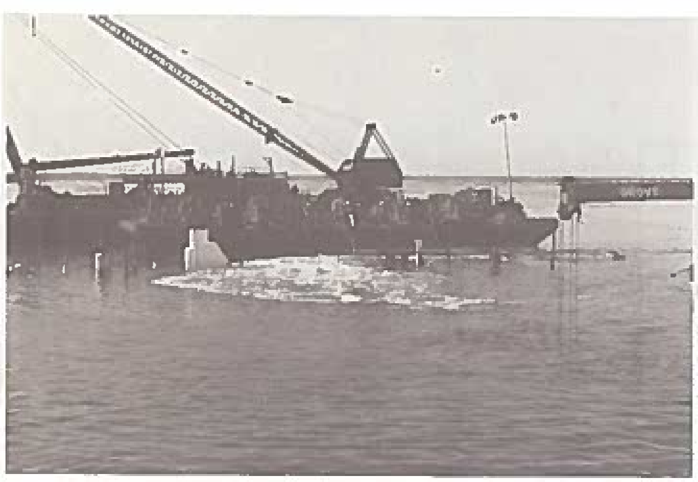
*PHOTOGRAPH 6. Salvage armada being assembled for initial blowing attempt (Phase One).*



*PHOTOGRAPH 7. Control barge outfitted with air compressors and manifolding connected to launching platform air vents.*

*PHOTOGRAPH 8. Testing of manually operated air vent dump valves.*

*PHOTOGRAPH 9. Air leakage from propeller pits.*



*PHOTOGRAPH 10. Air leakage from damaged plate on inboard wing wall.*


*PHOTOGRAPH 11. Rupture on outboard wing wall which led to abortion of Phase One plan to blow with air. (Estimating the size of a leak by the size of the bubble is difficult. This spectacular boil was caused by an 8"x1" (max) tear in a corner weld. The differential pressure across the rupture was only 15 FSW; it leaked at the rate of 1200-1800 SCFM. The air of course expanded rapidly during its free rise of 33 ft to the surface.)*

primarily because of known availability, high pumping rates, and suitable size for installing two units into each tank top access opening; 440 volt 3 phase AC power was also readily available. The successful use of the four-inch sub-pumps on the starboard side of the aft section is shown in Photograph 13.

(2) Patch Tank 20 to render it watertight for pumping. This would allow a uniform pumping scheme and minimize or eliminate any pressure differentials between adjacent tank watertight bulkheads.

(3) Patch the hole in the portable wing wall above Tank 19 and dewater the upper half using a six-inch salvage pump placed on the portable wing wall top, which was about 3 feet above the waterline.

(4) Modify the ballast tank venting system to extend one vent line per wing wall tank well above the waterline in order to ensure that if the platform rotated or settled in either direction (i.e., to port or starboard) the vents would not fall below the surface. The dissimilarity between the tank vent systems in the forward and after sections should also be noted. As originally shown in Figure 7 for the forward half, vent lines extended from beneath the safety deck on both the outboard and inboard sides of the wing wall. The inboard vent extension apparently was the result of a partial "dock-alt" because on the after half this alteration had not been accomplished. The outboard side of the portable wing walls also possessed vent lines extending from the outboard tank row (these vents are shown later in Figure 11).

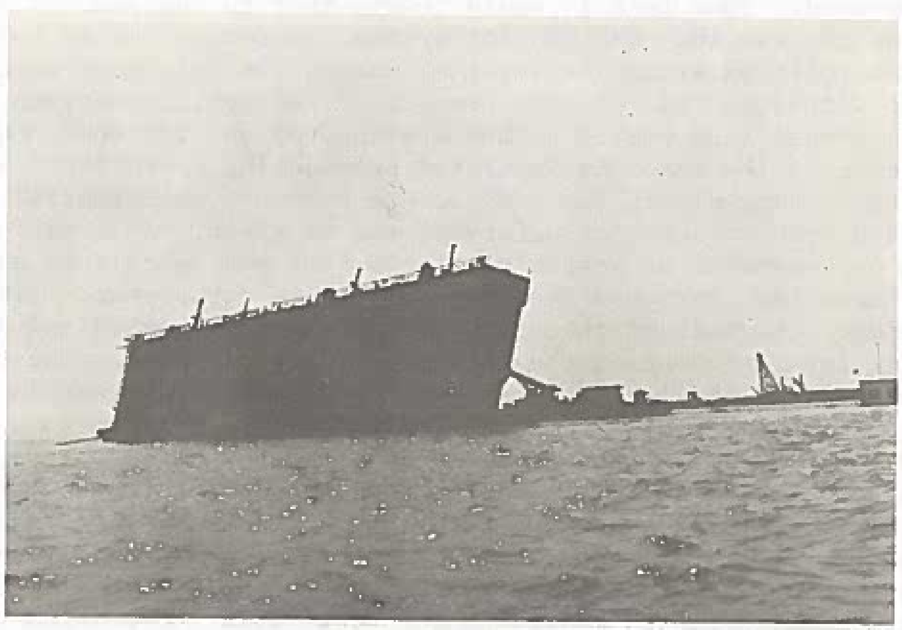
(5) Install submersible pumps (two per tank) in the starboard outboard row (Tanks 19, 23, 27, and 31) and the entire port side (Tanks 18, 20, 22, 24, 26, 28, 30, and 32) for a total of 24 pumps.

(6) Close all tank flood and pump discharge valves.

(7) Cut away sufficient structure from the forward section wing wall beneath the control house to permit a vertical rise of the after wing wall of about 10 feet before contact. An initial upward surge as the port side broke bottom suction of about 5 feet was estimated. The salvors were confident that a vertical clearance twice that distance would provide sufficient tolerance to avoid a collision between the two sections as the after half floated off. Figure 6 shows how a rectangular cut under the control house could accomplish this requirement.

(8) Pump the four starboard outboard tanks until the starboard side lifts (rotates) and the pontoon deck is awash. The decision to lift the starboard side first was not arbitrary. If the port side came up first, the forward extremity would certainly raise into the control house overhang of the forward section as tugs could not be expected to overcome the ground reaction from the starboard side settled in the mud. With the starboard side already floating, however, there would be no

*PHOTOGRAPH 12. Control barge outfitted with diesel generators and sub pump controllers for initial Phase Two dewatering attempt on starboard side of aft section.*



*PHOTOGRAPH 13. Starboard side of aft section successfully rotated using four-inch sub pumps supplemented with compressed air.*

adverse ground reaction to prevent the after half from being pulled from beneath the overhang as noted in paragraphs (7) and (10). Rotation of the port side first would have also been aggravated by the orientation of the dock in the soft mud bottom. The bottom contour beneath the platform dropped off in such a manner that the entire starboard side was cantilevered about 40 feet; the vertical distance between the mud bottom and the platform bottom varied between 4 and 10 feet along the starboard edge. The port edge was soundly buried in the mud. Thus if the platform were rotated about its starboard side, a vertical drop upwards of 10 feet could be expected. This would clearly submerge the upper wing wall deck and increase the existing hydrostatic loads on the portable pontoon walls; neither effect was desired.

(9) Pump the remaining eight tanks until the port side rotates upwards and the section is afloat.

(10) Use tugs to snake the port side from beneath the control house overhang. Photographs 14 through 19 show the dewatering and raising of the port side of the aft section. Photographs 20 through 23 show the continued raising and pulling of this section.

(11) Completely dewater the section. This step is shown in Photographs 24 and 25.

After intensive diver reinvestigation of the damage to the wing wall area of Tank 20 (see Photographs 26 and 27), the salvors begrudgingly agreed that the sustained structural damage rendered it incapable of withstanding the resulting hydrostatic forces if it were made watertight and pumped. Thus Tank 20 would remain open to the sea, as would Tanks 17 and 18, via the tank venting system. A second change to the salvage plan followed since the internal watertight bulkheads were not designed to withstand the required pressure differentials between the tanks being pumped (and vented to the atmosphere) and the ones now remaining open to the sea. As indicated previously, operational ballasting/deballasting discipline limited the pressure differential to 15 fsw, based upon a factor of safety of two on yield. As a minimum, a pressure differential of approximately 25 feet was calculated as required to float the starboard side and 48 feet to subsequently lift off the port side. The salvors therefore decided to pump compressed air into certain tanks to control the internal pressure and thus maintain the pressure differentials across any watertight bulkheads within acceptable limits. A simplified sketch depicting this principle is shown in Figure 10. Actual selection of the air pressure to be used was a compromise since the air pressure needed on the bottom became a potential hazard after the section rose and the counter hydrostatic pressure was removed. As a bonus the air pressure would also reduce the apparent pump discharge pressure and thus increase pump flow rate. The use of air necessitated modifying the vent piping to provide for blanks with air connections as shown in Figure 11.

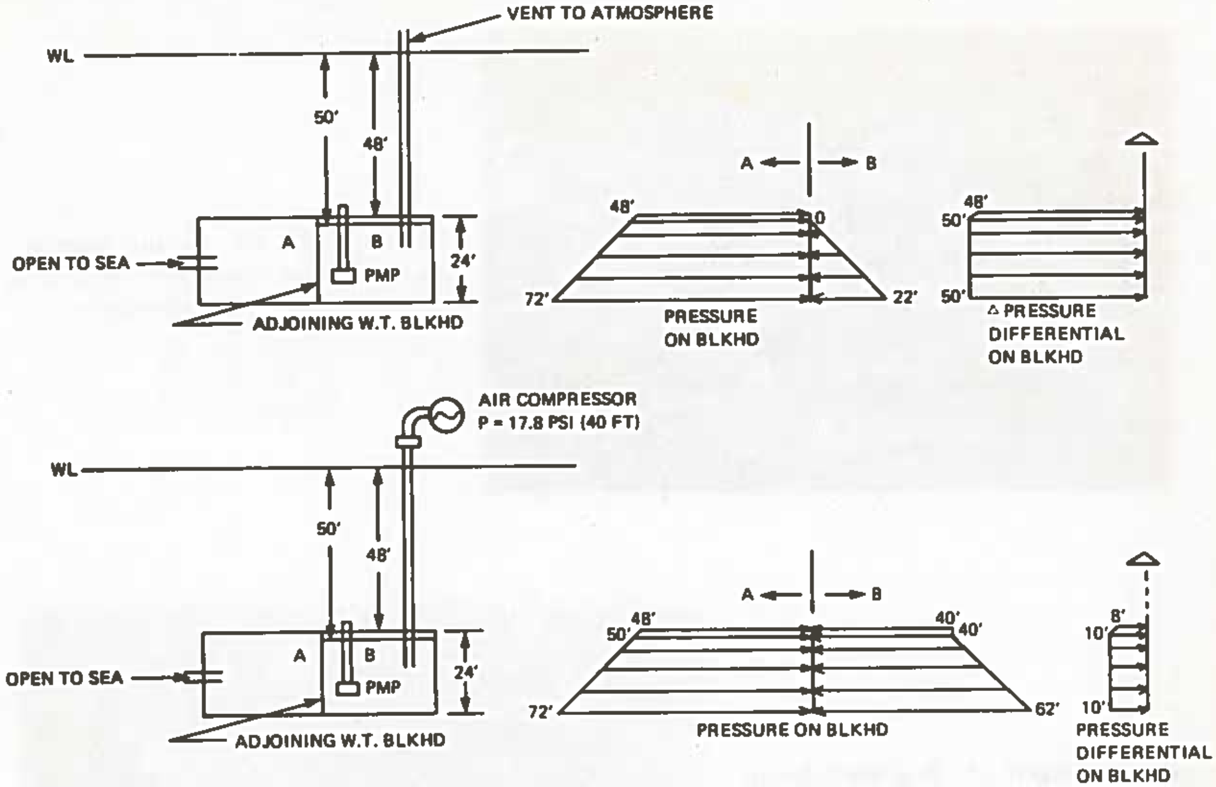



*FIGURE 10. Effect of Air Pressure on Reducing Pressure Differential Across Watertight Bulkhead.*

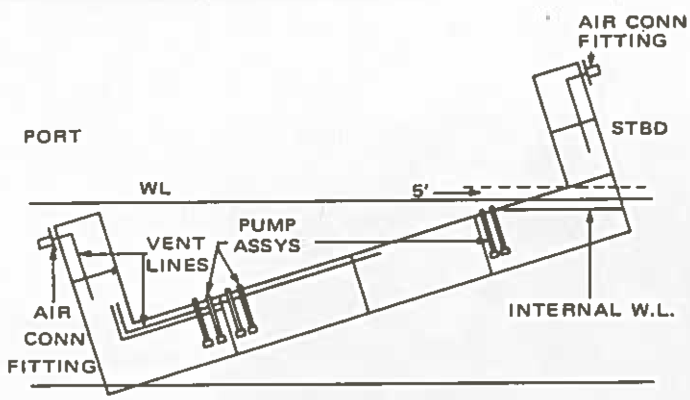
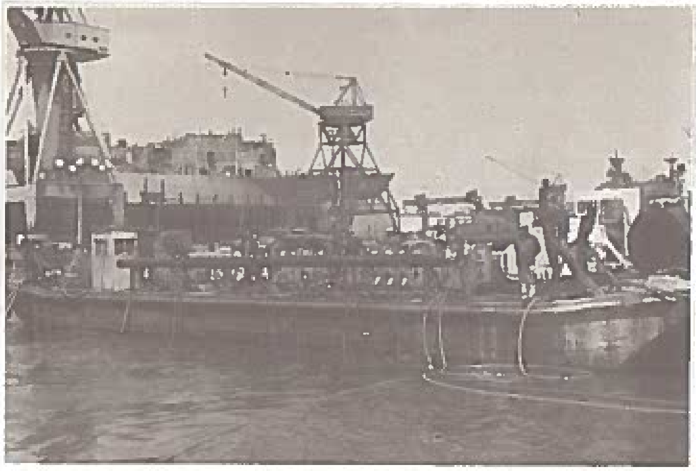



*FIGURE 11. Aft Section After First Phase of Dewatering Complete.*



*PHOTOGRAPH 14. Control barge being readied for Phase Two dewatering attempt on port side of aft section.*

*PHOTOGRAPH 15. Tugs made fast to port side capstan to snake section from beneath control house overhang of forward section.*

*PHOTOGRAPH 16. . Port side aft commencing breakout.*

*PHOTOGRAPH 17. Port side aft on the surface.*

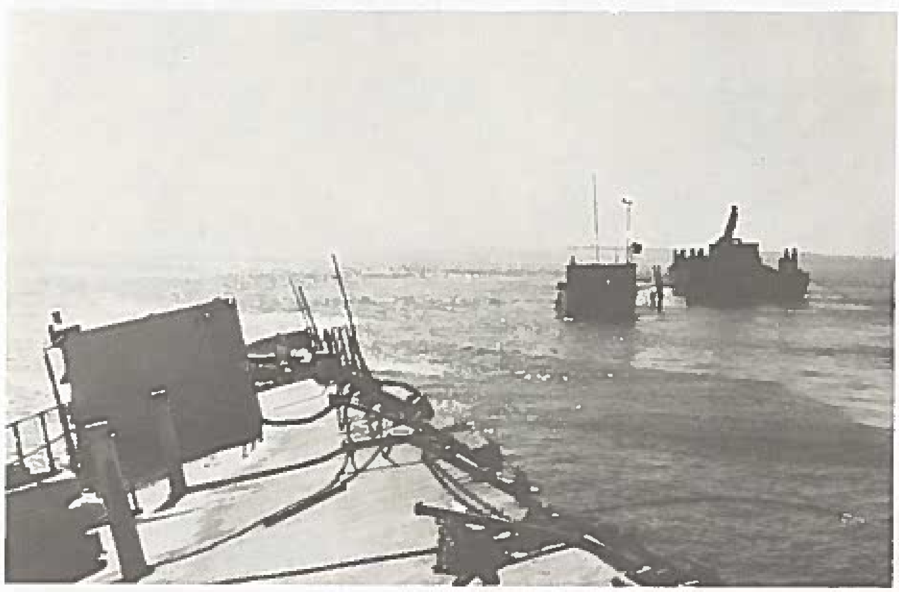
*PHOTOGRAPH 18. Port side aft continuing up.*

*PHOTOGRAPH 19. Tugs continue pulling aft as aft end of platform section continues up with forward port corner still embedded in bottom mud.*

*PHOTOGRAPH 20. Breakout of forward port corner of aft section. A trim of 20 feet was being experienced at this time.*

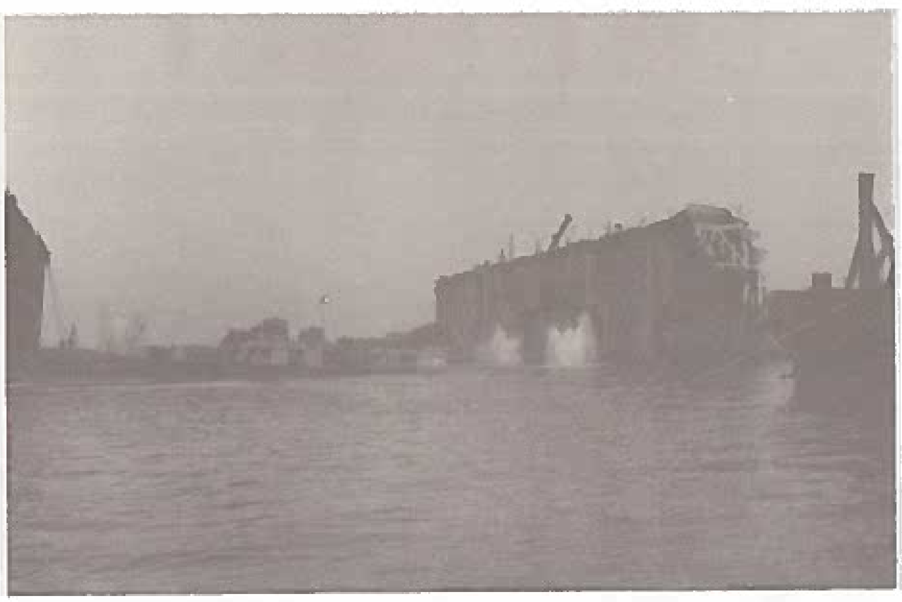
*PHOTOGRAPH 21. Aft section now completely afloat. Tugs pulling section from beneath forward section overhang.*

*PHOTOGRAPH 22. Tugs continue pulling as port side continues to rise.*

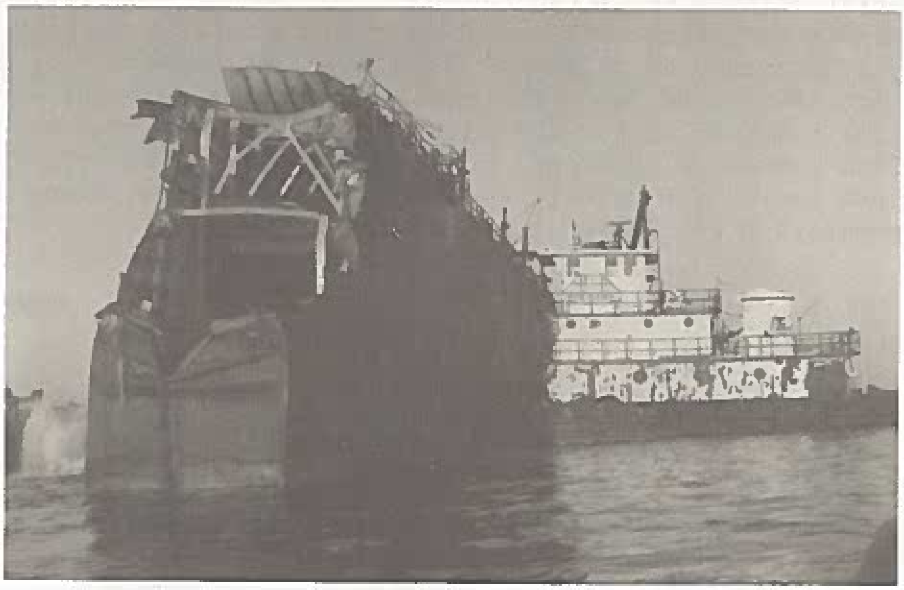


*PHOTOGRAPH 23. Aft section completely free from forward half.*

*PHOTOGRAPH 24. Four-inch sub pumps, installed in parallel, continue to dewater the aft section.*



*PHOTOGRAPH 25. Aft section dewatering continues. Entire Pontoon Deck almost awash.*



*PHOTOGRAPH 26. Damage to machinery throughway and Tank 20 (below safety deck) on aft section wing wall.*

*PHOTOGRAPH 27. Closer view shows extensive damage which precluded patching and pumping of Tank 20.*

Initial efforts by Litton to obtain sufficient submersible pumps in an acceptable time frame were unsuccessful; therefore, SUPSALV turned on the Navy's Emergency Ship Salvage Material (ESSM) system. By 31 March, twenty-five 440V 25 HP 1000 GPM four-inch submersible pumps had been received from the ESSM system and an additional six had been received by Litton from commercial sources. The typical pump installation assembly details are shown in Figure 12 (note the addition of a pneumo line to permit monitoring of the internal tank waterline).

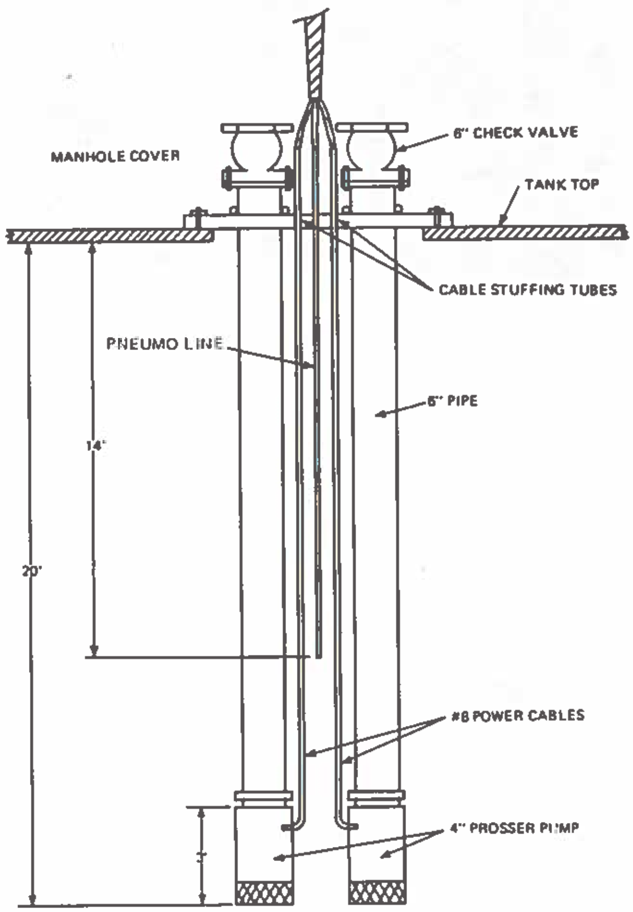



*FIGURE 12. Pump Installation Assembly.*

As installation and checkout of the sub pumps progressed, a high incidence of pump failure was experienced due primarily to water leaking through the power cable packing gland and into the pump motor. Because the electrical leads provided with the pumps had been too short to reach the two 500 KW power sources, the leads had been replaced "en toto" and the subsequent sealing had not been consistently watertight.

On 1 April pumping/blowing of the four starboard outboard tanks (19, 23, 27 and 31) commenced, and by late evening the section had been successfully rotated to the attitude shown by Figure 11. Immediate pumping of the port side had to be delayed however, due to continued electrical failure of several of the pump motors. Finally, on 2 April the motors had been replaced and those in Tanks 22, 24, 26, 28, 30, and 32 were incrementally lit off. Compressed air was also pumped into the air vents in Tank 24 to provide pressure compensation to the bulkheads bordering Tanks 17, 18 and 20 which were open to the sea. Within 2-1/2 hours the after port corner broke loose from the mud and about two hours and twenty feet of trim later the forward corner broke loose, and the section was afloat. Harbor tugs which had been continuously pulling aft exerted sufficient force to extricate the after platform sufficiently clear of the control house overhang before it rose high enough to interfere. As soon as the damaged portion of Tank 20 emerged from the water, the pumps in Tanks 18 and 20 were energized, and that evening the after half of the launching platform was safely deposited in its normal position over the launching grid on the West Bank.

## VII THE SALVAGE OPERATION - PHASE THREE

The salvage plan developed for the remaining platform section was similar in principle to the first, except that the four missing wing wall pontoons made the execution a trifle more complex. Again, the starboard side would be rotated up first with hydrostatic problems being eased by compressed air. As with the salvage of the aft section, the decision to rotate the starboard side up first was not arbitrary. The 50-foot ascent of the starboard side would be largely uncontrolled and there was no assurance against significant fore and aft trim, bulkhead or skin rupture, etc. It was much less risky to perform this dynamic evolution with the port side firmly buried in the river bottom mud. The final floating of the section could then be accomplished under much more static conditions. However, because the starboard side was totally submerged almost 50 feet beneath the surface, a means of venting air not required previously on the aft section would be necessary. Lifting of the port side should be more straightforward, as all of the port tanks were intact and capable of dewatering. The essential elements of the salvage plan were as follows:

(1) Remove sufficient tank top access covers including the previously installed standpipe assemblies to allow installation of pump assemblies in all tanks except the outboard starboard four which were

open to the sea (total of 24 pumps). The testing of the pump assembly is shown in Photograph 28.

(2) Isolate the vent lines to Tanks 1, 5, 9, and 13 from the vent system for the port side tanks. This step was mandatory in order to isolate the four starboard, inboard tanks from the port side and introduce buoyancy only to starboard under a controllable pressure.

(3) Install air connections and manually operated venting valves to both the inboard and outboard wing wall vent lines. The inboard air connections could be used to introduce compressed air during the initial starboard lift with the vent valves closed. During ascent the vent valves could be opened to dump air if required. The outboard vent valves would be open during this entire phase to bleed off any air tending to accumulate beneath the safety deck should the paragraph (2) above tank vent line isolation not be 100% complete. During the lifting of the port side these outboard vents would be closed to permit introduction of air into the port tanks.

(4) Install 16" flapper relief valves, manually operated dump valves, and air connection fittings in the manhole covers of the four starboard tanks (1, 5, 9 and 13). The flapper valves were intended to dump air during the ascent of the starboard side to prevent tank overpressurization. The successful result of the use of the flapper valves is shown in Photograph 29. The air connections provided a secondary means of introducing compressed air, and the manual dump valves were added as a precaution in the event operational problems necessitated the bleeding of air.

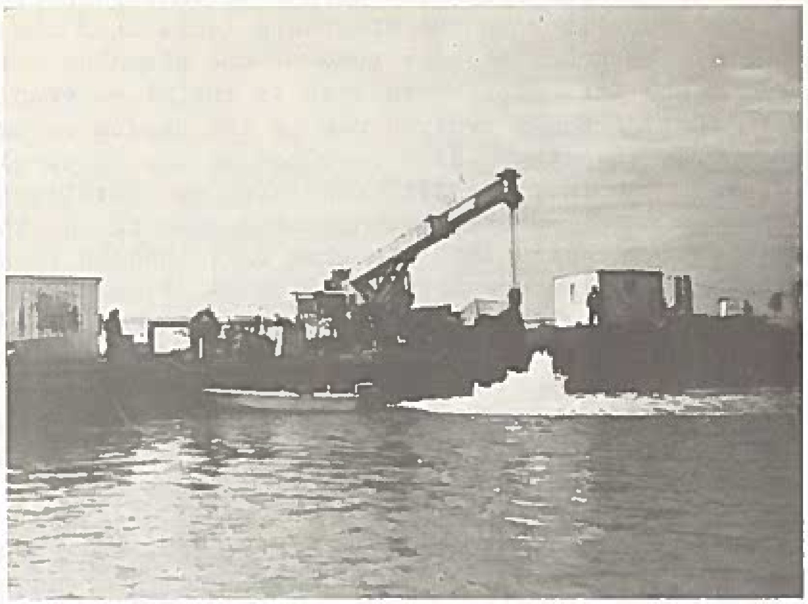
(5) Close all flood and pump discharge valves to establish and maintain the watertight boundary.

(6) Commence pumping and force feeding air in the four starboard tanks until liftoff, maintaining sufficient air pressure to maintain acceptable pressure differentials against outboard watertight bulkheads (outboard side open to the sea). Air could be introduced via either the inboard wing wall vent extensions or the tank top air connections. Calculations indicated that liftoff would occur when the water fell approximately 9 feet below the tank tops.

(7) After the section had stabilized with the starboard edge well out of the water, dewater the four outboard tanks using conventional six-inch salvage pumps transferred from the diving barge coupled, if necessary, by sluicing to the port side.

(8) Incrementally energize the eight pump assemblies to port and simultaneously commence pumping air into the outboard wing wall air connections.

(9) Float the platform.



*PHOTOGRAPH 28. Testing final pump assembly prior to installation in preparation for dewatering and blowing of the forward section (Phase Three).*

*PHOTOGRAPH 29. Starboard side of forward section commencing ascent as installed flapper valves vent air. Control barge is in background.*

The critical path for the execution of the salvage plan proved to be the isolation of the vent lines in the starboard tanks from their respective port side tanks. Sketches showing some of the plumbing details are shown in Figures 13A and 13B. The variations in installed venting models of the two inboard rows of tanks evolved due to the desire to improve tank venting efficiency when flooding, which resulted in the "dock-alt" discussed in Section VI. The initial "alt" consisted of installing vent extensions through the safety deck and connecting same to the inboard tank vents with a box structure built into the wing wall inboard bulkhead. After this alteration had been completed in Tanks 4, 8, and 12, it was found to reduce venting efficiency. Thus the alteration was undone by cutting a 7-inch circular hole in each box. Isolation of the tanks possessing the box assy consisted of installing a "Tooker" type patch inside the box (Figure 13A). Two-piece sheet metal sleeves, lined on the inside with neoprene, were installed in Tank 16 which was missing the "boxalt" but not the vent extension "alt" (Figure 13B).

Final preparations were completed on 6 April 1975, and pumping/blowing of the four inboard starboard tanks commenced. During the final planning stages it had been decided not to pump Tank 9 due to anticipated leakage through the propeller holes with consequent inability to maintain adequate compensating air pressure. This change increased the required water level for liftoff from 9 feet to 12 feet below the tank top. Just before the commencement of pumping it had also been decided to force air into the tanks via the inboard wing wall vent extensions in lieu of the tank top air connections. However, as pumping progressed it became apparent that water was not being pumped from Tank 13 at the same rate as from Tanks 1 and 5, and the air compressors could not sustain the required air pressure in Tank 13. Apparently so much air was leaking from the vent sleeves (Figure 13B) that sufficient air could not be forced into the tank. This excessive air leakage was readily confirmed by the great volumes of air vapor and froth escaping from the open outboard vent from Tank 16. The salvors then elected to switch the source of air directly to the tank, and an air line was connected to the tank top by the divers and rigged to a single 600 CFM compressor. Immediately sufficient compensating air pressure was obtained in Tank 13 (15 psi) and the water level commenced falling at an accelerated rate. At approximately 1000 hours, small bubbles were noticed rising to the surface above the submerged starboard edge. Shortly thereafter great belches of air began bursting to the surface from the three flapper valves (Tanks 1, 5 and 13), and moments later the pontoon deck broke the surface and steadied with approximately 4 feet of freeboard along the deck edge. The remainder of the evolution proceeded in a routine fashion in accordance with the salvage plan, and that evening the forward half of the launching platform was positioned in place alongside its mate over the launching grid. Photographs 29 through 46 depict the salvage operation carried out in Phase Three.

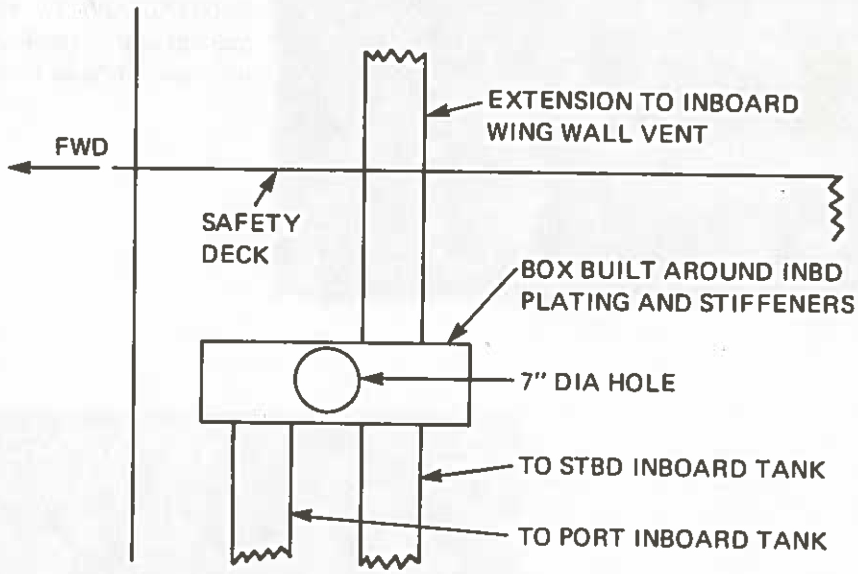



*FIGURE 13A. Inboard Tank Assemblies in Tanks 4, 8, and 12.*

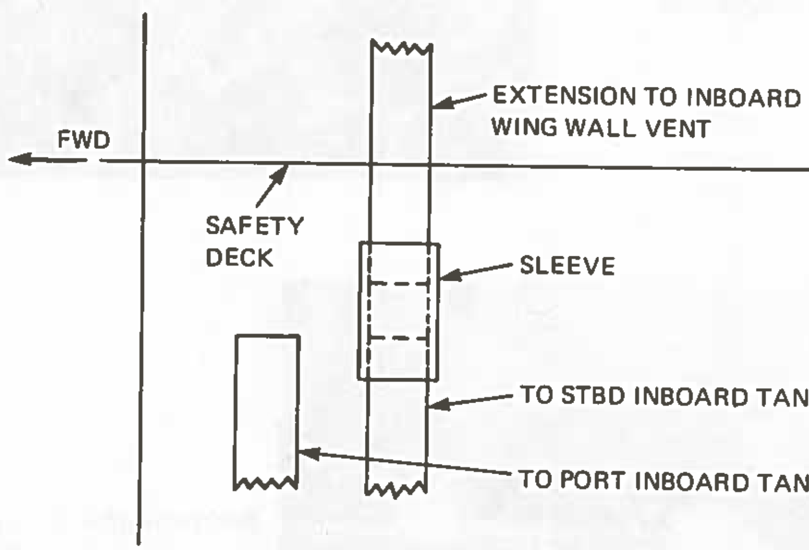
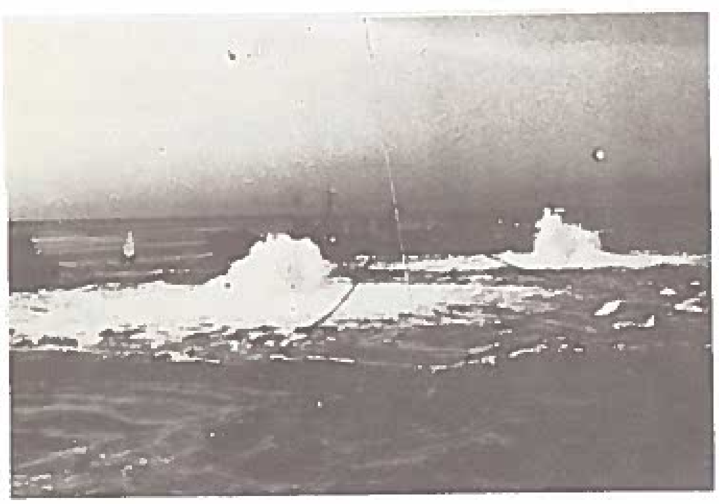



*FIGURE 13B. Inboard Tank Vent Assembly in Tank 16 with Sleeve Installed.*

*PHOTOGRAPH 30. Flapper valves continue to vent as starboard side rises from the bottom (Phase Three).*

*PHOTOGRAPH 31. Venting continues. Vertical poles were installed to provide initial indications of movement.*

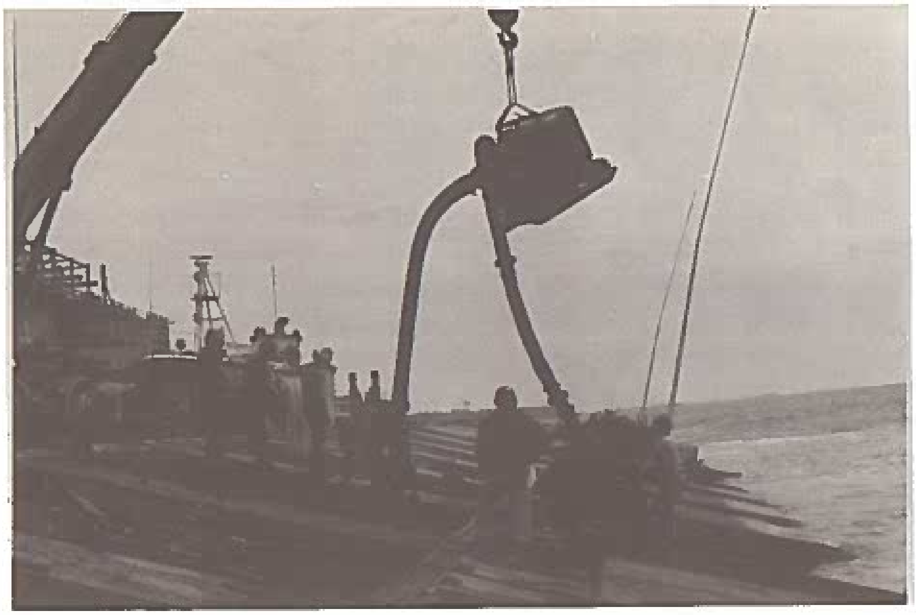


*PHOTOGRAPH 32. Ascent continues, deck edge nearing the surface.*

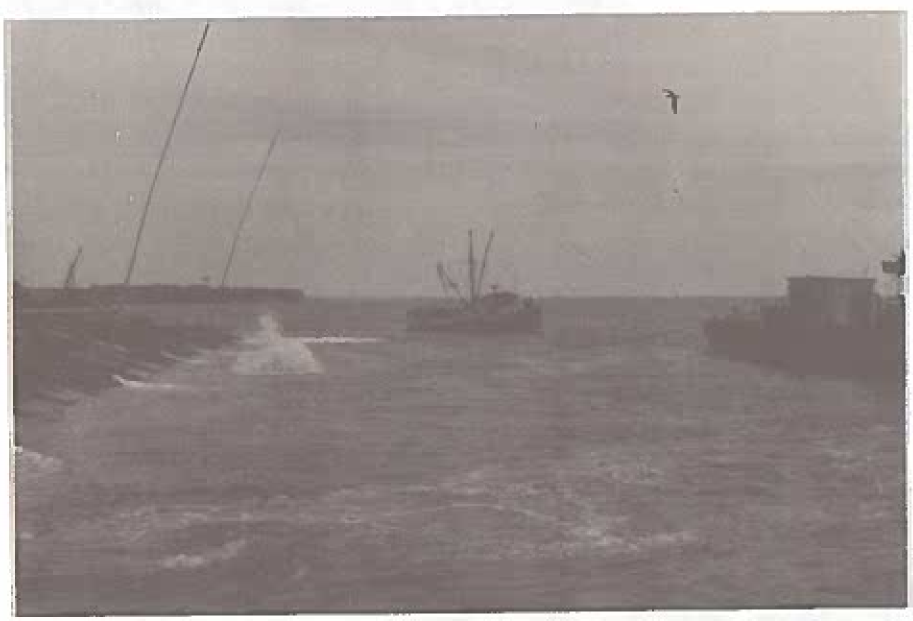
*PHOTOGRAPH 33. Pontoon Deck breaks the surface. Forty-eight foot ascent required approximately one minute.*

*PHOTOGRAPH 34. Pontoon Deck continues to rise.*

*PHOTOGRAPH 35. Pontoon Deck steadies with approximately four feet of freeboard.*



*PHOTOGRAPH 36. Conventional six-inch salvage pumps being loaded onto Pontoon Deck for dewatering of Tanks 3, 7, 11 and 15 through missing STBD wing wall openings.*



*PHOTOGRAPH 37. Dewatering of starboard side almost complete and preparations for pumping port side commencing.*

*PHOTOGRAPH 38. Preparations nearing completion for dewatering of port side of forward section (Phase Three).*

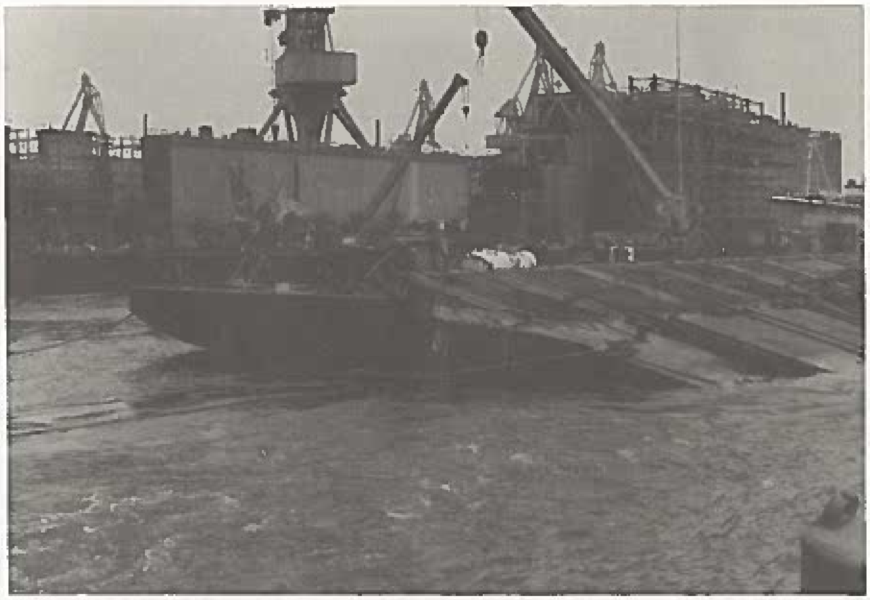
*PHOTOGRAPH 39. Dewatering and blowing of port side commences.*

*PHOTOGRAPH 40. Port side breakout occurs. Section now completely afloat.*

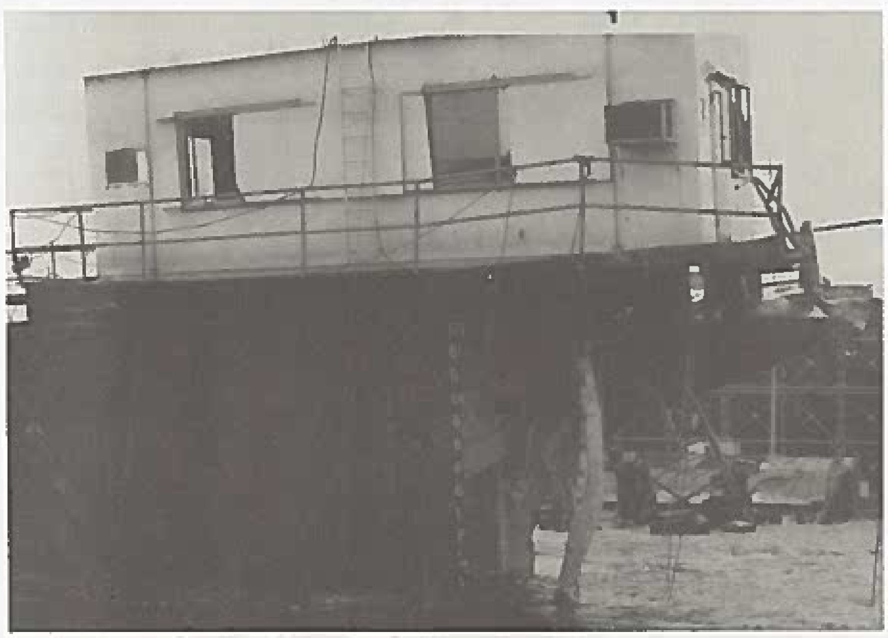
*PHOTOGRAPH 41. Port side continues up.*

*PHOTOGRAPH 42. Dewatering continues as port side rises higher out of the water.*

*PHOTOGRAPH 43. Pontoon Deck begins to level as keel blocks become visible.*



*PHOTOGRAPH 44. Repairs in progress to the after section during Phase Three.*



*PHOTOGRAPH 45. Underwater oxy-arc cutting performed by divers beneath control house to facilitate snaking of aft section from beneath.*

*PHOTOGRAPH 46. Dewatering of second half of launching platform nearing completion. Dock was moved over grid alongside aft section approximately six hours later, completing the SALVOPS.*

## VIII SUMMARY

The salvage of the Litton launching platform was accomplished in just twenty-five days, which is no small feat for a structure displaying almost 14,000 long tons and completely broken in half. Only through the dedicated efforts of the swiftly assembled team of experts, their willingness to work long, arduous hours, and their ability to work harmoniously under the most trying of conditions was the operation concluded so successfully.

The unique conditions surrounding the casualty; the fragile platform scantlings, the water depth, poor underwater visibility, the sustained damage, and the urgency to salve so the DD 963-class building program could continue with minimum disruption, presented the salvors with a most challenging and formidable task. Neither the tried and true methods of pumping nor blowing with air proved adequate. The innovative combination of the two, however, enabled the salvors to complete a most successful salvage operation.

## IX SAMPLE CALCULATIONS

I. The cross section schematic of the launching platform shown in Figure 14 is the basis for all righting moment calculations. The schematic could be considered to flip-flop dependent upon which side (i.e., PORT or STBD) of the platform section was being rotated upwards.

In all calculations the following assumptions/simplifications were made:

(1) All scantlings rounded to nearest foot.

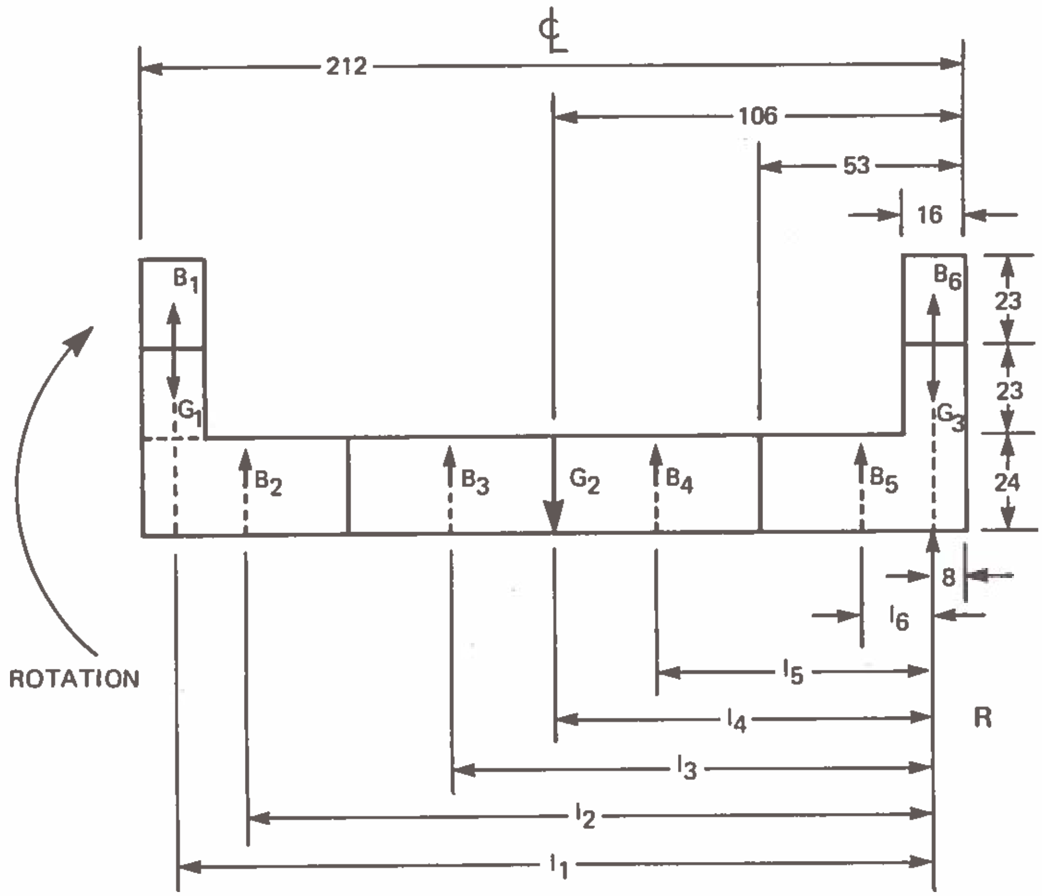
(2) Half-weight of structure excluding wing walls = 5,200 tons; half-weight of each wing wall, whether permanent (PORT) or portable (STBD), = 800 tons.

(3) Ground reaction during rotation passed through a vector R 8 feet from platform edge.

(4) Density of water = 35 $ft^3$ /ton even though upper levels were brackish.

(5) Effect of mud suction at breakout quantitatively disregarded.

II. During the first evolution of Phase One, the port side was to be rotated upwards by introducing air into Tanks 8 and 12. Once the air bubble was blown beneath the Pontoon Deck, air was assumed to displace water equally rapid in Tanks 6 and 10 through the air vent piping. No water was assumed displaced from Tanks 5 and 9. Referring to Figure 14:




$l_1$ = 196 FT.
$l_2$ = 177.5 FT.
$l_3$ = 124.5 FT.
$l_4$ = 98 FT.
$l_5$ = 71.5 FT.
$l_6$ = 18.5 FT.

$G_1$ = $G_3$ = 800 TONS
$G_2$ = 5200 TONS

ALL TANKS 80 FT DEEP

*FIGURE 14. Litton Platform Cross Section.*

For the major tanks, $TPF = \frac{53 \times 80}{35} = 121$ tons/ft; $B_2 = B_3 = TPF \times h$

For the wing walls, $B_1 = \frac{16 \times 80 \times 23}{35} = 84$ tons

$\Sigma M_R = 0$ ; h = water level below pontoon deck

$$2B_1\ell_1 - G_1\ell_1 + 2B_2\ell_2 + 2B_3\ell_3 - G_2\ell_4 = 0$$

$$(2B_1 - G_1)\ell_1 + (2)\ (121h)(\ell_2 + \ell_3) - G_2\ell_4 = 0$$

$$(1680-800)196 + 242h(177.5 + 124.5) - 5200(98) = 0$$

Divide by 1000

$$172.5 + 73h - 510 = 0$$

$$h = \frac{510 - 172.5}{73} = 4.6 \text{ ft} \approx 5 \text{ ft}$$

III. The distance that the port wing wall would rise out of the water and stabilize required a trial and error solution to determine. In order to avoid rigorous calculations, several simplifying assumptions were made:

(1) All moment arms remained constant during ascent, i.e., rotation neglected.

(2) All air in Tanks 6 and 10 escaped by venting.

(3) The air in Tanks 8 and 12 stabilized with a 7 foot bubble at inboard bulkhead.

<u>Assume</u> the final waterline will be 9 feet below the safety deck. Then, referring to Figures 14 and 15:

$$\theta = \text{angle of rotation} = \tan^{-1}\left(\frac{2 + 23 + 9}{212-8}\right) \approx 9°$$

Consider the trapezoidal air bubble beneath the Pontoon Deck as a rectangle, $B_2$, and a wedge, $B_\omega$.

$$B_\omega = \frac{1}{2}\ \frac{(53\text{SIN}9^\circ)(53)80}{35} = 502 \text{ tons}$$

$$\ell_\omega = 212 - \frac{53}{3} - 8 = 186.3 \text{ ft}$$

$\Sigma M_R = o$ ; h = waterline below safety deck

$$\text{TPF (wingwall tank)} = \frac{16 \times 80}{35} = 36.6 \text{ tons/ft; } B_1 = 84\text{-TPF h}$$

$$2B_1\ell_1 - G_1\ell_1 + 2B_2\ell_2 + 2B_\omega\ell_\omega - G_2\ell_4 = o$$

$$(2)(84 - 36.6h)196 - 800(196) + 2(121)(7)(177.5) + 2(502)(186.3) - 5200(98) = o$$

Divide by 1000

$$173 - 14.3h + 301 + 187 - 510 = o$$

$$h = \frac{15.}{14.3} = 10.6 \text{ ft}$$

A second iteration would probably result in a solution approaching 11 feet. However, considering the assumptions made and the gross nature of the salvage calculations, a general range of 8-12 feet below the safety deck was considered a satisfactory estimate. Unfortunately the above calculations were never confirmed due to the failure of the structure to contain the air bubble.

IV. Similar moments were taken about the bottom reaction points during the two pumping phases. Correlation between predicted and actual breakouts in these instances was very good.

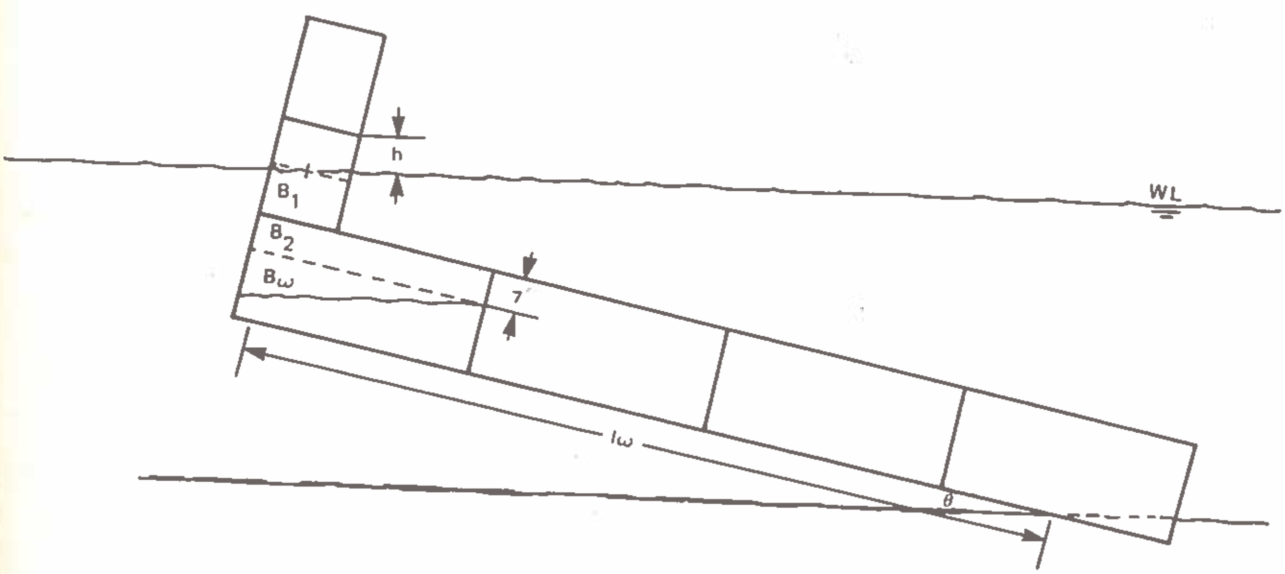



*FIGURE 15. Forward Section Floating.*