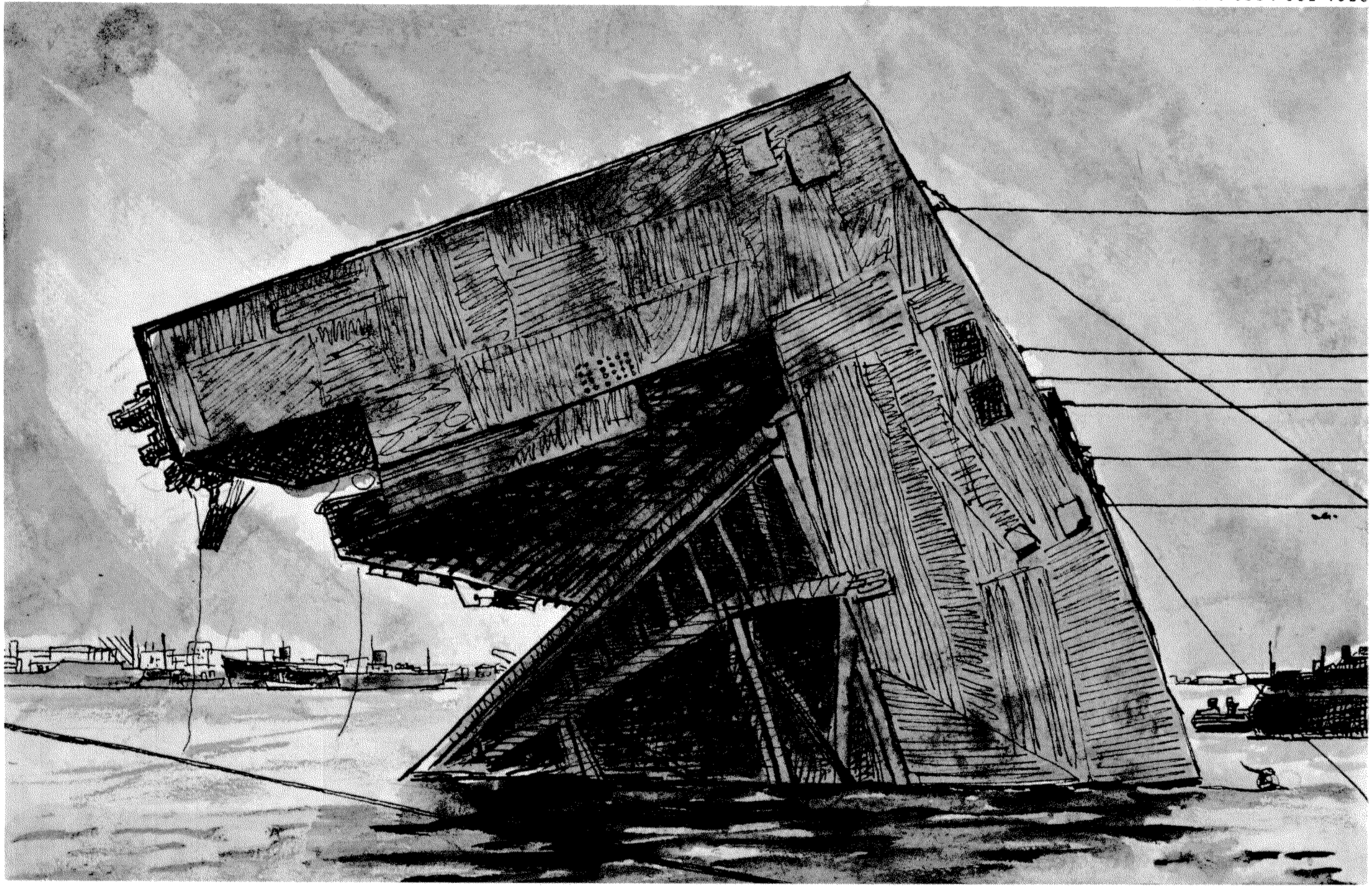
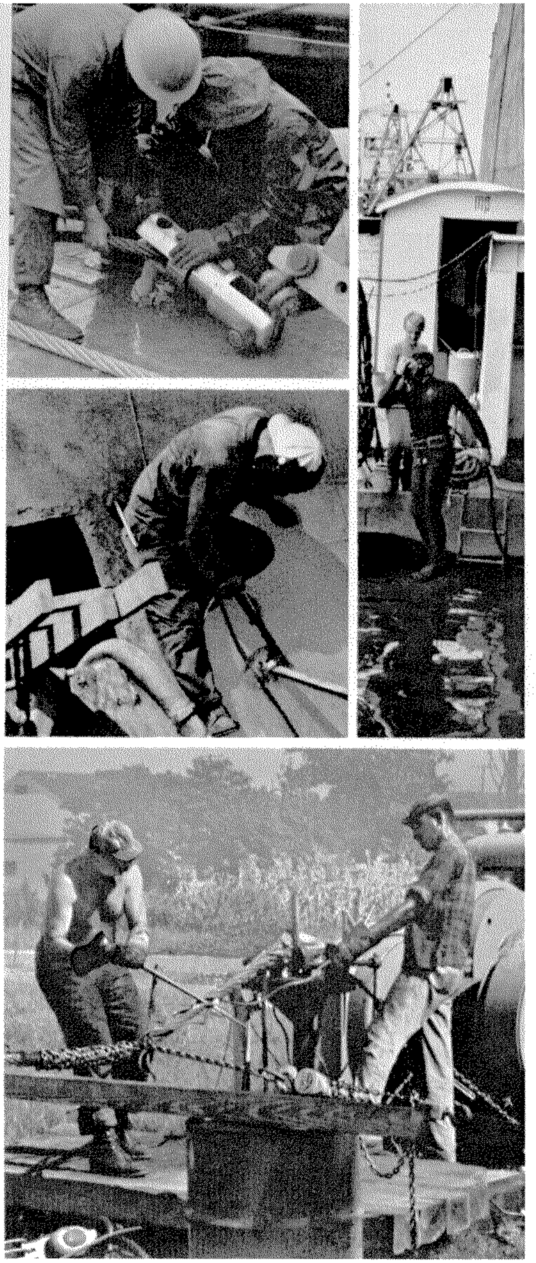
NAVSHIPS 0994-001-4010



technical report on SALVAGING OF AFDM-2

PUBLISHED BY DIRECTION OF COMMANDER, NAVAL SEA SYSTEMS COMMAND

CONTENTS

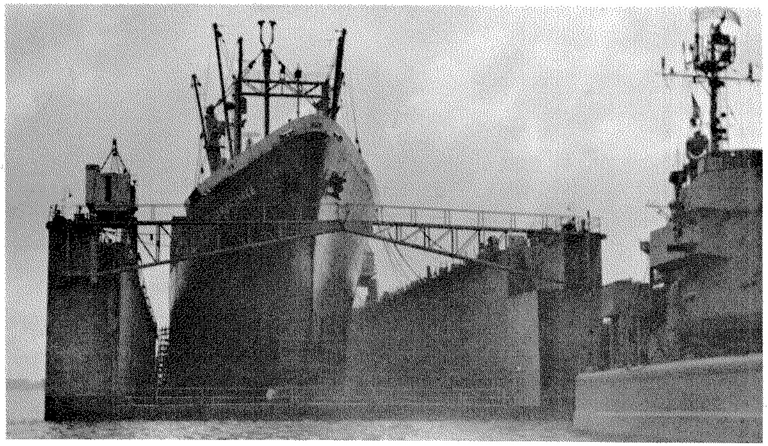


MORE THAN 100 MARINE SPECIALISTS—engineers, divers, riggers, welders, boat crews and supervisory personnel—played key roles in the Navy's biggest salvage operation since the battleships sunk at Pearl Harbor were raised in World War II.

background

THE AFTERMATH OF HURRICANE BETSY

NEWLY BUILT SS ELIZABETH LYKES shown in a Navy-leased floating drydock similar to AFDM-2 in which the freighter was docked when Hurricane Betsy struck.



SPECIFICATIONS

DESIGNATION: AFDM-2 (Auxiliary Floating Drydock Medium)

BUILT: 1942 at Mobile, Ala.

CONSTRUCTION COST: $2,760,300

STATUS: Operated by Todd Shipyards Corporation at New Orleans, La., under lease from Navy since 1942

CONSTRUCTION: All-welded steel

DESIGN: Three U-shaped sections bolted together; each end section contains four ballast compartments; center section contains eight ballast compartments

DISPLACEMENT: 6,360 tons

OVERALL LENGTH: 614 feet, including 35-foot outriggers at each end

WIDTH: 90 feet inside wingwalls; 116 feet overall

HEIGHT: 37½ feet inside; 52¾ feet overall

DRAFT: 5½ feet when empty

LIFTING CAPACITY: 15,000 tons with 12-inch freeboard; 16,000 tons with zero freeboard to pontoon deck

POWER: Equipped with electric generating plant for offshore operations; can be connected to power source on shore

On the morning of 27 August 1965, a weather reconnaissance aircraft on patrol over Caribbean waters reported the presence of a serious tropical depression. This was the first sighting of what was to develop into the most destructive storm ever to strike the Louisiana Gulf coast.

That afternoon gale warnings were issued along the Lesser Antilles as squalls built in intensity and began to move in a west-northwesterly direction. Two days later, as winds reached 80 miles per hour and the storm moved steadily toward the United States mainland, it was officially designated Hurricane Betsy.

On 8 September, the storm passed through the Florida Keys into the Gulf of Mexico on a west-northwesterly course toward the Texas coast. In mid-Gulf, however, the accelerating hurricane changed direction and in the early evening of 9 September slammed into the Louisiana coast just west of Grand Isle.

As Hurricane Betsy passed the coast and headed north, wind velocity ranged from 70 to 105 miles per hour with gusts up to 160 miles per hour, minimum barometric pressure was 28 inches, and rainfall varied from three to nearly six inches. Tides rose more than 16 feet above normal in less than one hour, and more than three million acres of low-lying coastal land were inundated. The combination of high winds and the tidal surge was so strong it stopped the flow in the lower Mississippi River.

Damage estimates in the aftermath of Hurricane Betsy approached $1 billion, and the area hardest hit was the Port of New Orleans. As the waters of the Mississippi rose to record levels, high winds ripped dozens of ships free of their moorings in the port area and set them adrift. Marine underwriters termed the storm the most costly natural disaster in history.

The biggest single Navy casualty was an auxiliary floating drydock medium—AFDM-2—which had been tied up at the Todd Shipyards Corporation's yard on the west bank of the Mississippi in the Algiers section of New Orleans. The drydock had been leased to Todd by the Navy.

The all-steel drydock is composed of three U-shaped sections bolted together. Each section consists of a rounded pontoon portion and two fixed wingwalls that rise 37 feet above the pontoon deck. The assembled dock is 544 feet long and outriggers at each end give her an overall length of 614 feet. Overall width is 116 feet and the light displacement is 6,360 long tons. Her docking capacity is rated at 15,000 long tons, with 12-inch pontoon deck freeboard, and 16,000 tons with zero freeboard.

AFDM-2 incorporates several engineering features that enhance her value. She is one of a class of floating drydocks that is designed to be self-docking. Her two L-shaped end sections can be disconnected, flooded, and moved under the center section to cradle her. When water is pumped from the end sections, they raise the center section out of water for maintenance or repairs. The two end sections similarly can be raised out of water by the center section. The self-docking feature of a drydock like AFDM-2 is of great value to the Navy in areas of the world where maintenance facilities are unavailable or inadequate.

AFDM-2, despite her size, also could be moved through the Panama Canal if necessary. A similar drydock was moved through the canal during World War II on transfer from the East Coast to the Pacific war area. To pass through the Panama Canal, that drydock was turned on her side—a technique called careening. Buoyancy chambers were added to one wingwall of the drydock to increase the buoyancy so that the drydock would float when listed 90 degrees.

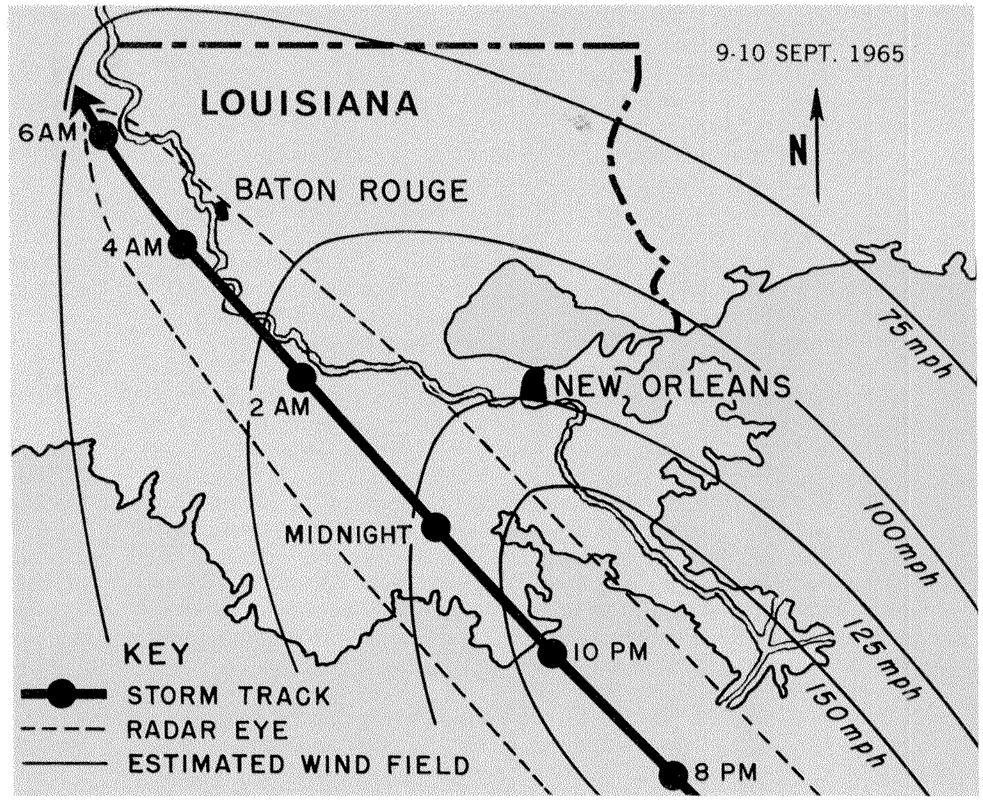
When Hurricane Betsy struck New Orleans, the SS ELIZABETH LYKES, a newly constructed ocean-going freighter, was docked in AFDM-2. During the night, several ships and craft which were moored downstream of the drydock were torn loose by the storm, and as they were driven upstream they struck AFDM-2. These collisions, combined with high water and hurricane-force winds, ripped the drydock from her specially designed mooring spuds at the Todd yard.

Still cradling the freighter, the drydock moved into the channel of the Mississippi. Carried upstream by the wind and wind-blown wave action, she apparently collided with a number of other storm-tossed ships. A succession of holes was ripped in the hull along the sidewalls, and the drydock began to ship water.

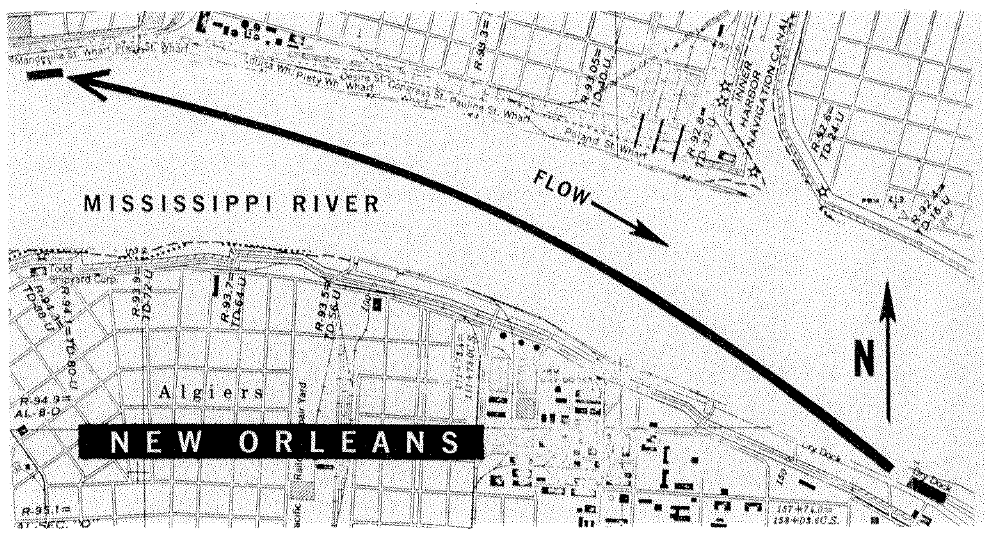
Sometime during the night, the ELIZABETH LYKES rolled off the docking blocks and floated out of the drydock. Along with a half-dozen other ships, she came to rest near the east bank of the Mississippi about 3.5 miles upstream from the Todd yard, off Dumaine Street Wharf.

The next morning, 10 September, the drydock was located off the east bank, a half-mile short of where the ELIZABETH LYKES and other damaged ships had come to rest. She was completely capsized some 300 feet off the Mandeville and Press Street Wharves, with the inshore wingwall aground in about 80 feet of water and the offshore wingwall afloat in 110 feet.

Strong winds and the tidal surge had propelled the drydock across the 1,100-foot-wide river and about three miles upstream.



HURRICANE BETSY followed northwesterly course roughly parallel to Mississippi River after striking Louisiana coast with winds up to 150 miles per hour. Port of New Orleans was hardest hit area.



DRYDOCK WAS TORN from her moorings on west bank, blown 1,100 feet across river and three miles upstream. She was found capsized about 300 feet off Mandeville and Press Street Wharves.

investigation

TO SALVAGE OR NOT TO SALVAGE?

Would it be possible to salve AFDM-2? Or would it be necessary to destroy her to remove a serious navigational hazard from one of the world's busiest waterways?

On the initial inspection, 10 September, first appearances were anything but encouraging. Only a small portion of the rounded bottom of the hull was visible; more than four-fifths of the capsized drydock was under water and the hull still was taking on water.

On 11 September, salvage experts from the Naval Ship Systems Command in Washington and the Marine Salvage Division of Merritt-Chapman & Scott Corporation in New York were flown to New Orleans. They joined Eighth Naval District salvors already on the scene.

To prevent further sinking of the drydock, ¾-inch connections with valves were fitted promptly to each of the eight compartments of the center section and compressed air was introduced. Divers were assigned to make a preliminary inspection and an Eells anchor was planted upstream for a mooring.

Reports from the divers indicated that damage to the exterior hull plating was not as extensive as had been expected. There were more than 100 holes in the hull structure, but only one major break was considered serious. This was an oval-shaped gash, 20 feet by 15 feet, at one end of the center section, about midway between the upper deck and the chine line, on the outside shell plating. In all probability, this hole shipped most of the water that capsized the drydock on her erratic journey during the hurricane.

Most of the other breaks in the sidewalls were small, apparently resulting from collisions with other ships that also broke loose during the storm. The drydock's pontoon sections appeared to be in good condition, and it was speculated—correctly—that internal structural damage, if any, was minimal.

On the basis of these findings, it appeared that salvage of AFDM-2 was technically feasible; later study showed that salvage would be economically sound.

AFDM-2 was built in 1942 for the Navy at Mobile, Alabama, at a cost of $2,760,000. Construction of a replacement at current prices, according to Navy estimates, would cost $7 million to $8 million.

A measure of the importance of the drydock is that she docked more than 2,600 vessels during her 23 years of service to the Port of New Orleans. Todd Shipyards, to which the Navy had leased the facility, held $2.7 million of insurance coverage on the drydock at the time of the storm. Thus the economic factors clearly indicated that salvage would be desirable if the engineers were able to develop a procedure to salve and repair that would cost within, or close to, the total of available insurance funds. The desirability of salvage was bolstered by the fact that the alternative—piece-by-piece removal—would be lengthy and costly.

Pending evolution and approval of the salvage plan, it was decided to move the drydock from the point where she was aground off the Mississippi's east bank to a work area off the west bank. This was necessary because the drydock was a navigational hazard, and also to provide a better location for a comprehensive examination of the condition of the dock by divers in aid of a workable salvage plan.

To prepare AFDM-2 for the move across the river, additional water was displaced from the hull with compressed air, and padeyes for tow lines were welded to the hull.

The transfer was made on 22 September when the water level of the Mississippi was comparatively low, but the current was not negligible. The size of the drydock and the fact she had to be towed in her capsized position made the move anything but routine. The wingwalls of AFDM-2 presented a large underwater surface—the equivalent of towing two BB-61 class battleships—that would be susceptible to dangerous current forces when the dock was moved into the river.

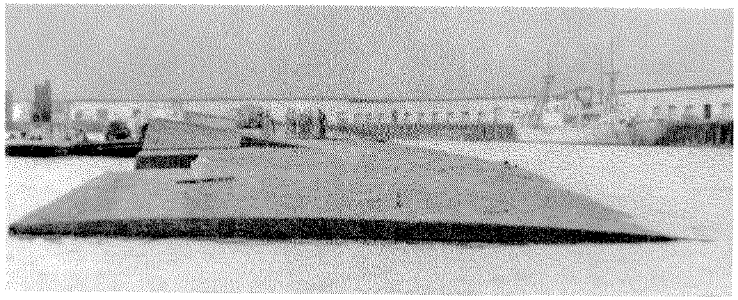
The MS CABLE, a specially-designed 3,000-shaft-horsepower salvage ship, and the USS SALINAN (ATF-16) were assigned to make the transfer. The CABLE was tied alongside AFDM-2 primarily to manipulate the Eells anchor mooring and supply compressed air; the SALINAN was to work upstream with a tow cable on the drydock to ease the strain on the Eells anchor mooring that would serve as a pendulum for the cross-river movement.

In the course of preparations and before the SALINAN was under full power, AFDM-2 broke free of the mud prematurely and the current took charge. The drydock was swept downstream approximately half a mile before the combined power of the CABLE and the SALINAN were able to halt her. Then the drydock was maneuvered upstream and cross-river toward the west bank on the Eells anchor mooring. She was moved with the assistance of the CABLE, the SALINAN and a local tug of 1,750 horsepower which had been commandeered when the drydock broke away.

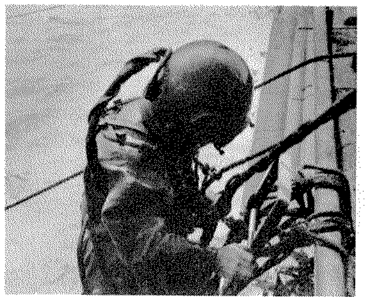
On the west bank, AFDM-2 was moored off Vallette Street in the Algiers section, almost directly across the river from where she had been found the day after Hurricane Betsy. She remained at this site for more than two months while salvors gave priority to other operations in the immediate aftermath of the storm.

A comprehensive underwater survey of the hull was made during this period under adverse conditions. The turbid water and strong current hampered the divers and they had to rely on touch alone to determine the extent and location of the damage. Nonetheless, the survey confirmed the preliminary findings and assumptions: AFDM-2 was not damaged beyond repair.

It was while the drydock was tied up off Vallette Street that engineers developed the plan for righting her. On 23 November, following approval of the plan by the Navy, Merritt-Chapman & Scott's Marine Salvage Division commenced salvage of the drydock.

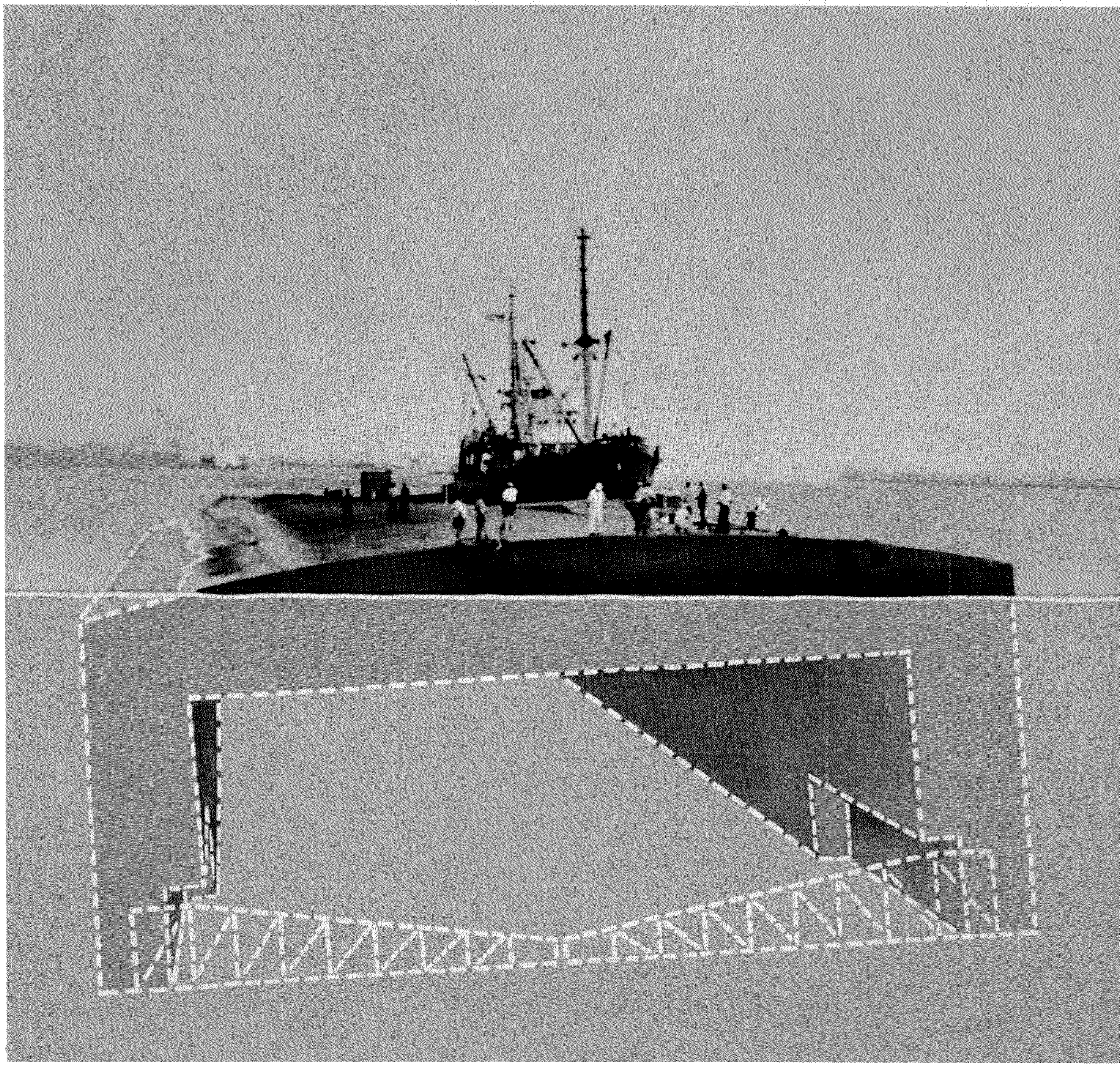


CAPSIZED DRYDOCK'S bottom pontoon sections were not seriously damaged, but more than 100 breaks were found in the wingwalls.



DIVERS' reports on extent and location of damage helped determine salvage method.

SUBMERGED SIDEWALLS are shown in artist's conception of drydock's position when she was located the morning of 10 September 1965, the day after Hurricane Betsy. AFDM-2 was found aground in about 80 feet of water, some 300 feet off the east bank of the Mississippi River. On 22 September, while deliberations continued on whether to salve or destroy her, the drydock was towed to the west bank to remove her from the river's busy main channel. Her wingwalls presented a large underwater surface that was equivalent to moving two BB-61 class battleships.



planning

METHOD IS DETERMINED

The plan for salving AFDM-2, as finally approved, called for snugging the capsized drydock against the river bottom and righting her by rolling her up and over 180 degrees toward the levee. The rolling operation—called parbuckling—was to be accomplished in 12 stages employing a combination of land-based beach gear, inflatable rubber pontoons for an external source of buoyancy, and the judicious use of water ballast and compressed air.

All of these techniques had been employed before on salvage projects, but this was to be the first time all four would be utilized in a carefully predetermined combination. This factor itself made the project unique in the long history of Naval salvage operations.

A key element of the plan called for one wingwall of the drydock to be grounded on the river bottom during the parbuckling operation. The fact that a similar dock had been careened for passage through the Panama Canal (see page 1) afforded engineers the initial assumption that AFDM-2 had the structural strength to withstand the stresses that would be imposed on the wingwall when the dock was rotated. The ability of the upper edge of the immersed wingwall to resist local failure from the ground reaction was an important consideration. Subsequent analysis of the drydock confirmed that it was structurally sound.

The salvage plan evolved from a careful, detailed study not only of the structure of AFDM-2, but of her characteristics—center of gravity, center of buoyancy, displacement, wetted surface, etc., under various conditions of ballast and angles of inclination. Constant control of the structure during the full 180 degrees of rotation was a *sine qua non* of the salvage procedure. Thus each of the 12 stages of the final plan represented an intermediate state of equilibrium as well as a procedural implementation.

Such a demanding objective in the handling of a structure of the size and weight of AFDM-2 necessitated a number of major decisions to enhance accomplishment or to reduce aspects of questionable reliability to a minimum.

One of the first decisions was whether to disconnect the two end sections of the drydock from the center section to reduce the bulk and weight of the section that would be parbuckled. The end sections, L-shaped in elevation, are bolted to the center section cantilever, which fits over the horizontal bar of the L. To remove them under water would have been difficult, time-consuming and dangerous. In view of their form, it would have been a major task to keep them parallel to the center section cantilevers while removing the 111 bolts at each of the four junctures. Accordingly, it was decided to salvage the drydock as one unit.

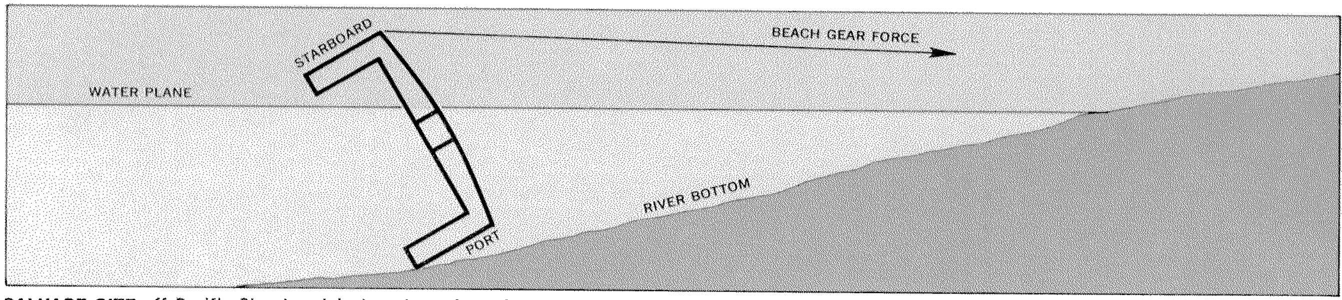
Another determination was the extent of the repairs that would have to be made before the uprighting operation could begin and whether both sidewalls must be made watertight. Most of the more than 100 breaks in the hull plating were in the sidewalls, and the position of the capsized drydock was such that the majority of them were now under water.

It was decided that only one wall — the one that would be under water during the parbuckling operation — need be watertight. The more seriously damaged wall—with the large oval-shaped break—would be placed offshore during the salvage operation and consequently most of this wall area would be above water for the duration of the parbuckling. Some repairs near and below the water-line would be necessary. Major repairs could be deferred until the drydock was righted and towed to a shipyard. Thus, the salvage contractor could concentrate his repair efforts on the wall that would be underwater during the parbuckling operation.

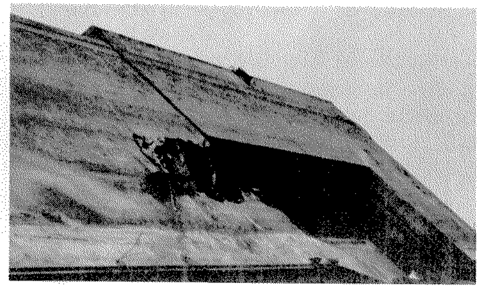
A prime decision was the amount of beach gear force that should be used to roll the drydock from her inverted position. As usually employed in salvage operations, beach gear consists of anchors planted seaward of a grounded ship to a scope of cable tensed by purchase tackle aboard the ship. In this operation, however, the pulling force would be exerted by land-based engine-powered winches acting through a nine-part purchase tackle rigged to 1⅝-inch cables attached to the drydock. Each beach gear set would theoretically afford 50 tons of force.

In the preliminary study of the interplay of the forces involved, engineers contemplated the installation of as few as ten and as many as 20 sets of beach gear; they finally employed 16 sets. These afforded a theoretical horizontal pulling force of 800 tons and, after allowances for safety, friction losses and other factors, made available an actual horizontal pulling force of approximately 680 tons. Such force in planned combination with the inflated rubber pontoons, internal ballasting and compressed air exceeded the maximum requirement at any stage by a sufficient margin for variations between assumed and actual conditions.

A number of factors influenced the final choice. They included (a) the amount of force that could be imposed on the drydock without causing failure of the structure from excessive stresses, (b) the amount of pressure that could be exerted on the shell plating without excessive



SALVAGE SITE off Pacific Street matched engineers' requirements. It enabled wingwall to be grounded at depth of about 80 feet on a firm bottom with a gradual slope toward shore. Unobstructed area behind adjacent levee afforded ample space for installation of beach gear sets.



BIGGEST BREAK was an oval-shaped gash, 20 feet by 15 feet, at the end of the center section.

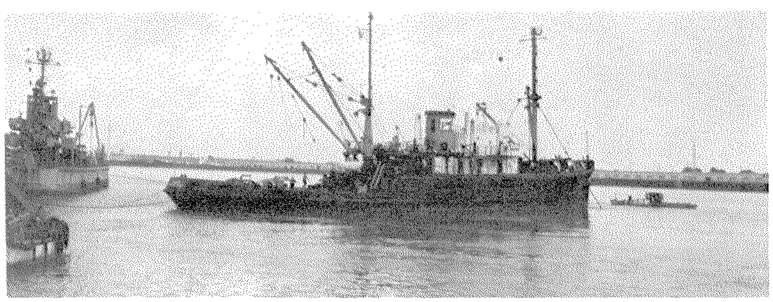
local buckling, and (c) the need of maintaining the proper relationship between the horizontal and vertical forces so that sliding to the near shore would not take place.

In keeping with the importance of control, it was essential to determine on a minute-to-minute basis whether calculated conditions were being met. So, for the first time on a large-scale salvage project, each beach gear set was equipped with a tensiometer to provide a continuous reading of the force being exerted. In this manner large deviations from the anticipated forces would signal a deviation from the conditions required by the engineering study. In addition, the tensiometers guaranteed against inadvertent overstressing and failure of one or more beach gear cables with the probable consequence of progressive failure of the other cables.

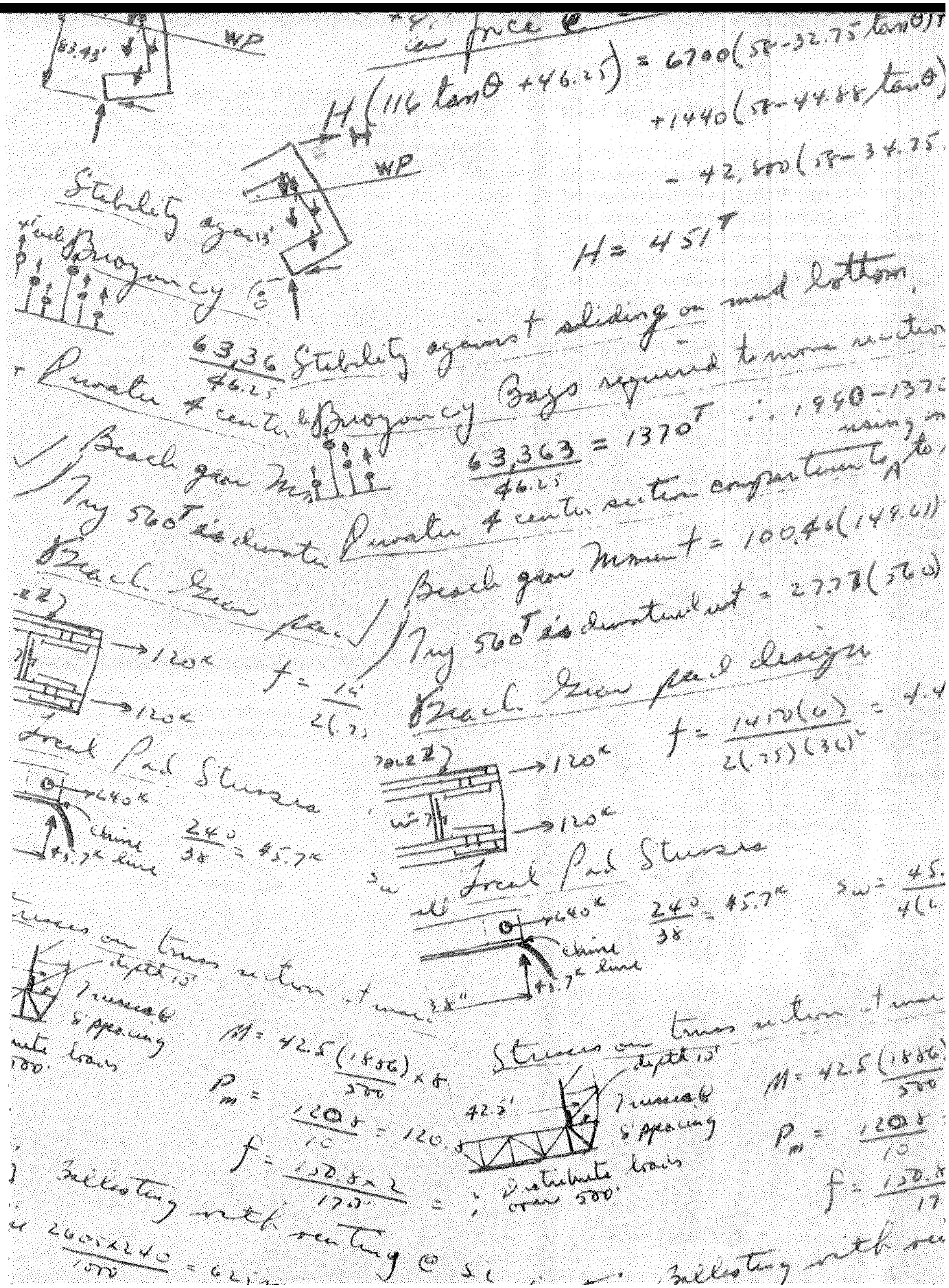
The function of the inflatable rubber pontoons warrants special note. Execution of the final stages of the plan required that the center of pressure of the ground reaction move, for Stage VI, from a point on the grounded wingwall approximately one-fourth of the depth of the wall from the chine line over to the chine line itself. An external uplifting force of 600 tons at the outer edge of the immersed wingwall was computed to bring this about. Use of barges and/or floating derricks was considered and ruled out because this would not provide the requisite measure of control and there was the attendant problem of keeping the hulls clear of the rising wingwall.

With the pontoons there was no such problem. Moreover, the final arrangement of the pontoons at three predetermined levels—so that one-third of the total lift was progressively lost with rotation—provided an added refinement toward control.

Selection of the salvage site was of prime importance. The plan called for grounding of the wingwall at a depth closely approximating 83 feet on a reasonably firm bottom with little slope—preferably none—toward shore. The location had to be out of the main current of the Mississippi River, and the land behind the adjacent levee had to afford an unobstructed, firm area. The site had to range the length of AFDM-2 and considerably beyond each end for the installation of winches and the beach gear purchases and anchors. The site off Vallette Street, where the drydock was temporarily moored after her move to the west bank on 22 September, did not meet these requirements. At an early stage, the prospect of seeking a satisfactory site upriver as much as 30 miles from New Orleans was considered. However, study of the river profiles maintained by the Corps of Engineers, U.S. Army, revealed a suitable site off Pacific Street, just 1,500 feet downstream.

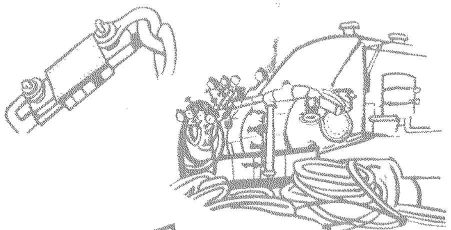


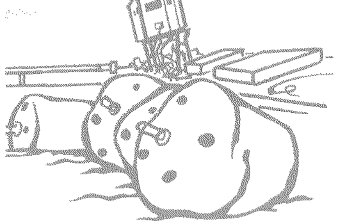
SALVAGE SHIP CURB was one of the two ARS ships used by salvage contractor. Two ARSD lift ships also were assigned to the operation.

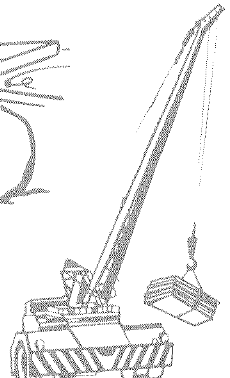


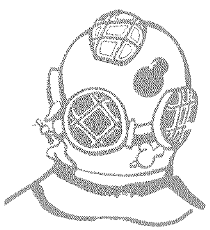
engineering
THE REFLOATING PLAN

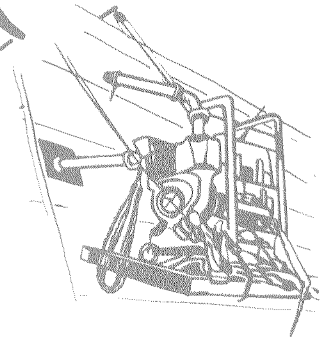
The 12 stages of the salvage plan devised by engineers to right AFDM-2 are illustrated here and on the two foldout pages opposite. Figures and captions with each drawing refer to engineering calculations made at the planning stage. Weight of ballast and pulling force is figured in short tons. Actual conditions necessary to reach each stage are detailed on pages 12 through 18. Drawings below illustrate the four basic concepts of the plan: 1. Beach Gear (external pulling force), 2. Inflatable Rubber Pontoons (external buoyancy), 3. Air Pressure (internal buoyancy) and 4. Water Ballast (internal weight force).



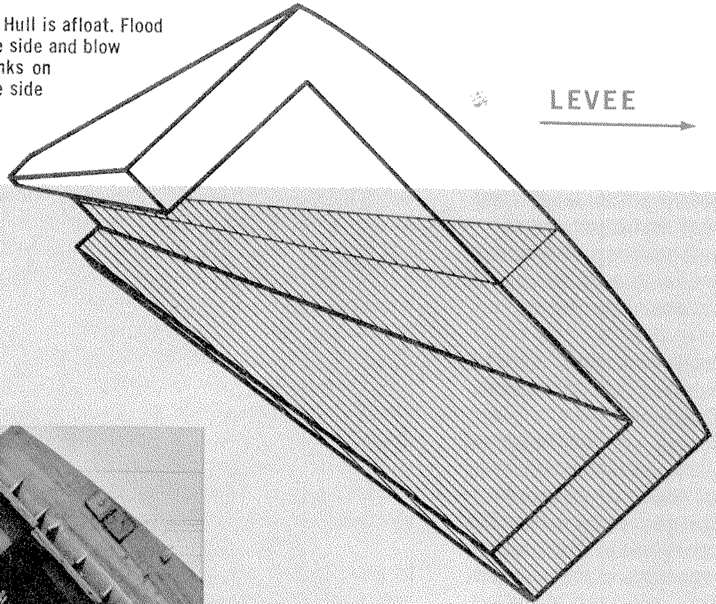


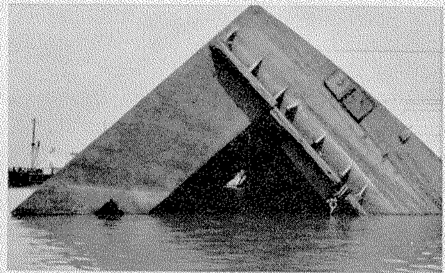




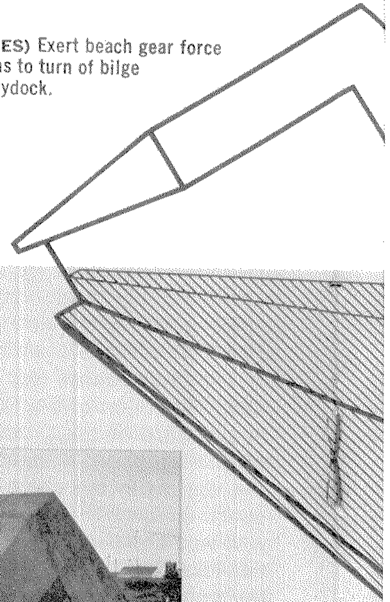


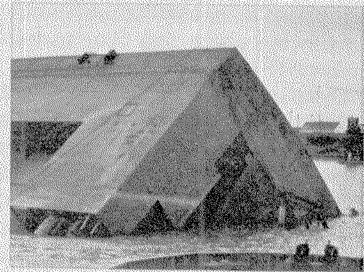
STAGE I (46½ DEGREES) Hull is afloat. Flood all ballast tanks on onshore side and blow or pump dry all ballast tanks on offshore side to ground one side of the hull on bottom.



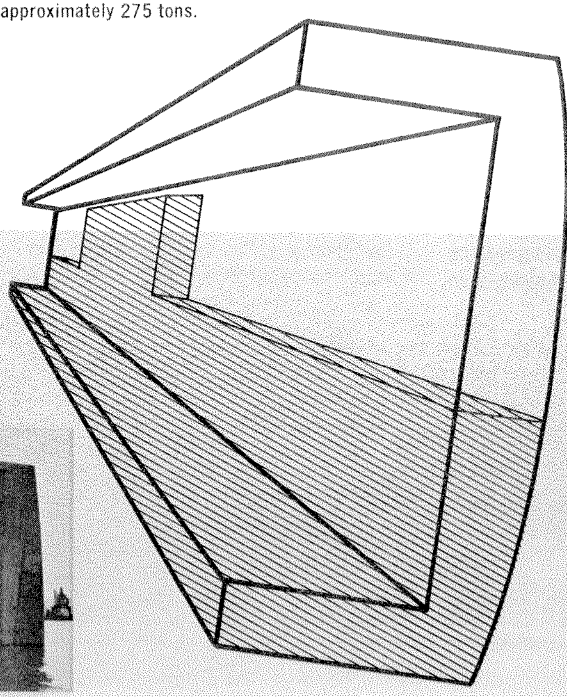


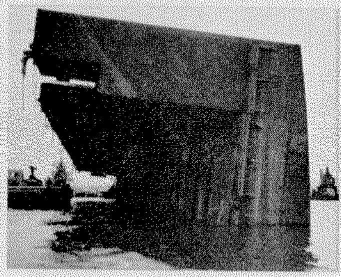
STAGE II (60 DEGREES) Exert beach gear force approximately 551 tons to turn of bilge on offshore side of drydock.



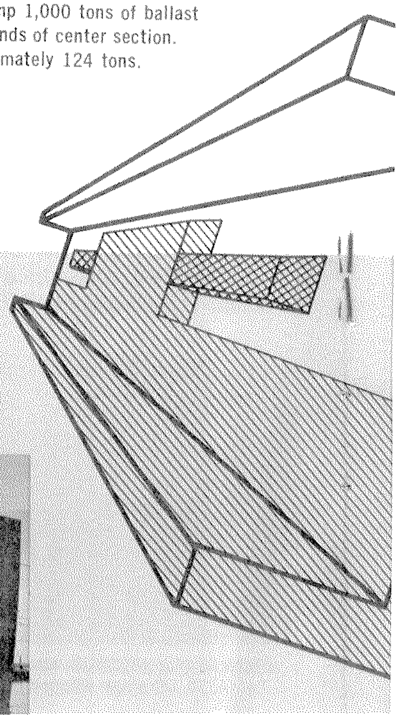


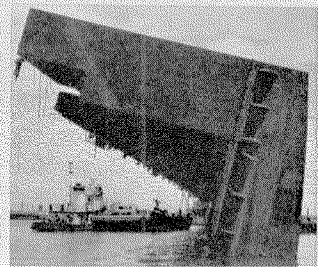
STAGE VII (100 DEGREES) Continue to rotate hull until beach gear force is reduced to approximately 275 tons.

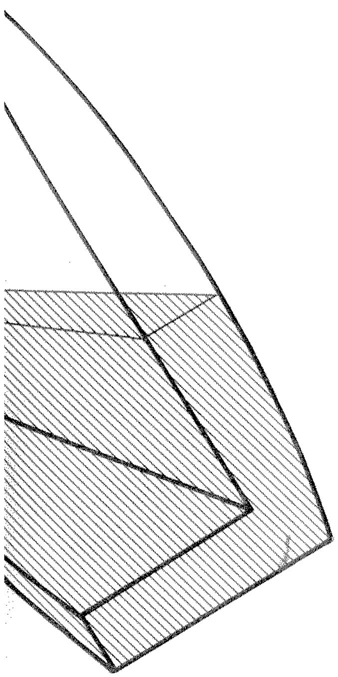




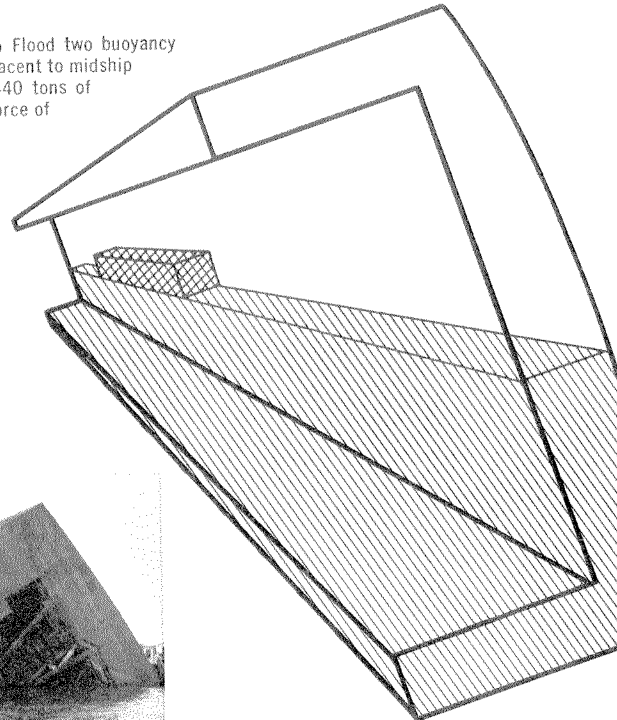
STAGE VIII (110 DEGREES) Pump 1,000 tons of ballast into two upper compartments at ends of center section. Exert beach gear force of approximately 124 tons.

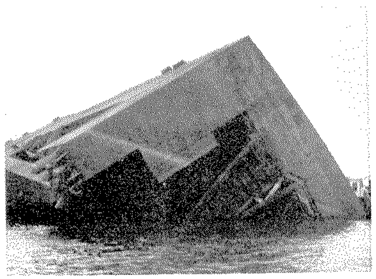




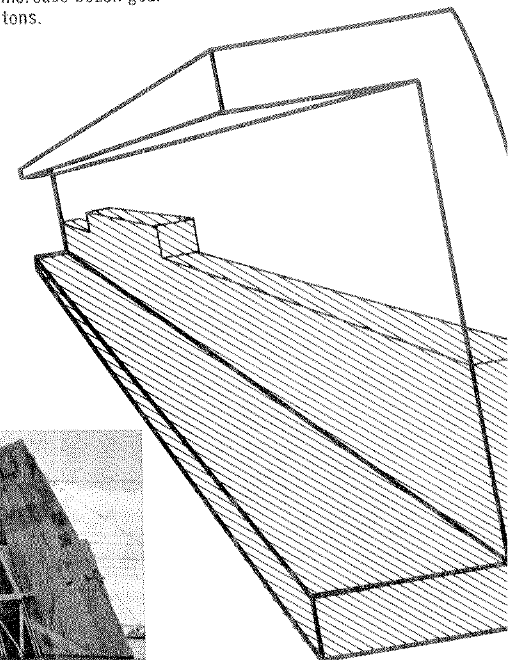


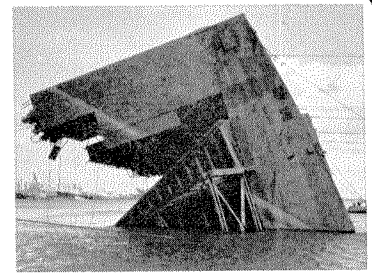
STAGE III (70 DEGREES) Flood two buoyancy chamber compartments adjacent to midship of center section with 1,440 tons of ballast. Exert beach gear force of approximately 332 tons.

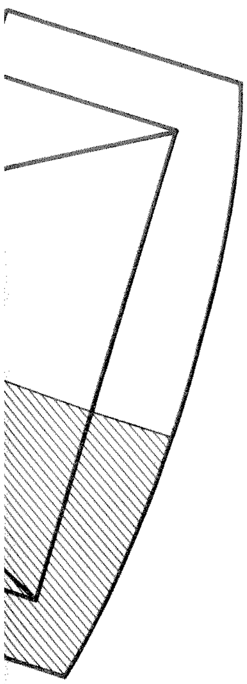




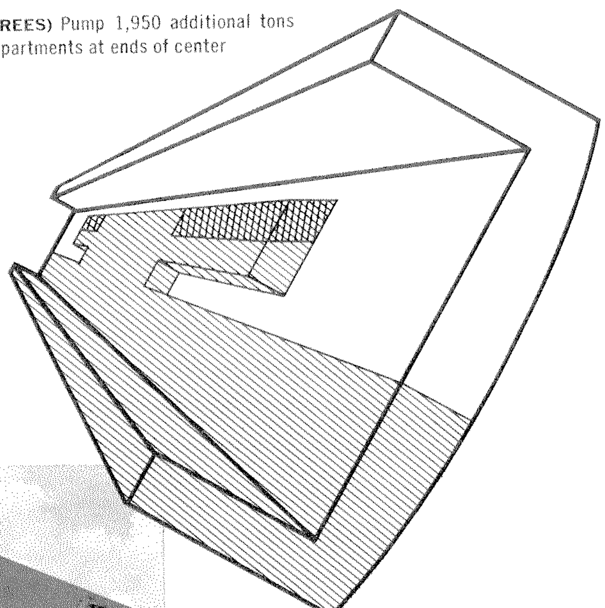
STAGE IV (80 DEGREES) Increase beach gear force to approximately 451 tons.

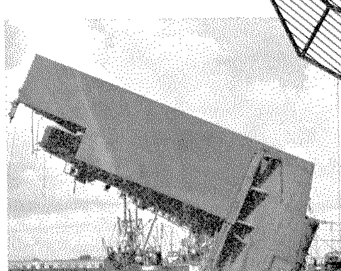




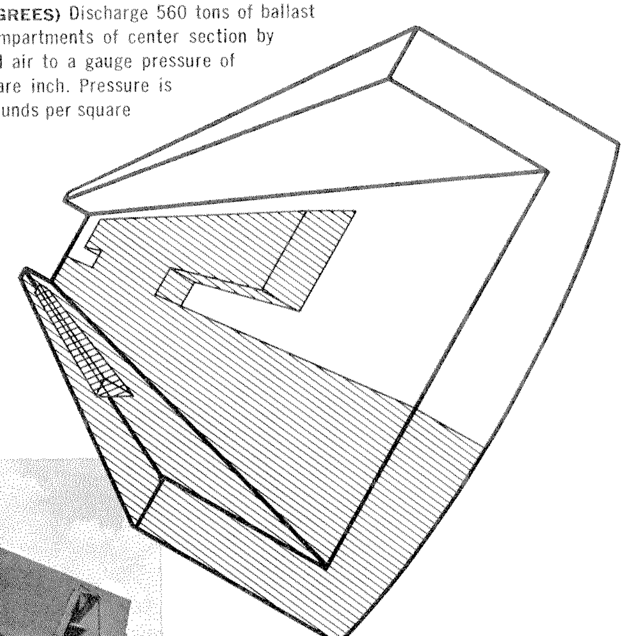


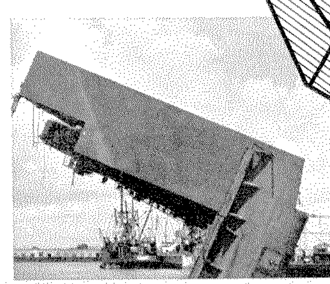
STAGE IX (120 DEGREES) Pump 1,950 additional tons of ballast into two compartments at ends of center section of drydock.



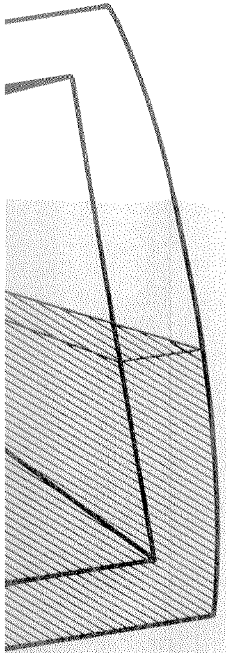


STAGE X (120 DEGREES) Discharge 560 tons of ballast from four lower compartments of center section by blowing compressed air to a gauge pressure of 25 pounds per square inch. Pressure is not to exceed 26 pounds per square inch at this stage.

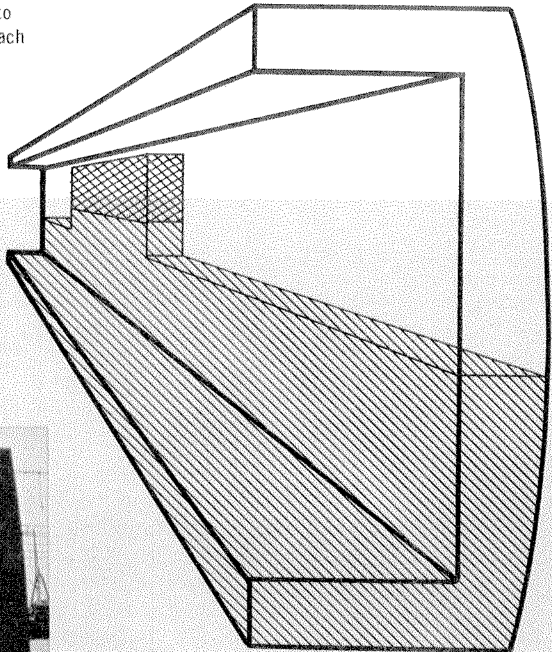


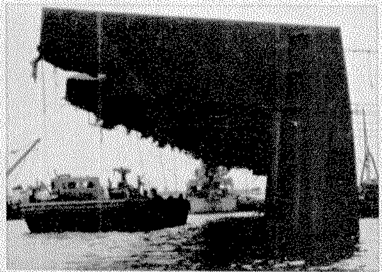


STAG
upper
discha
awash
inch,
contai

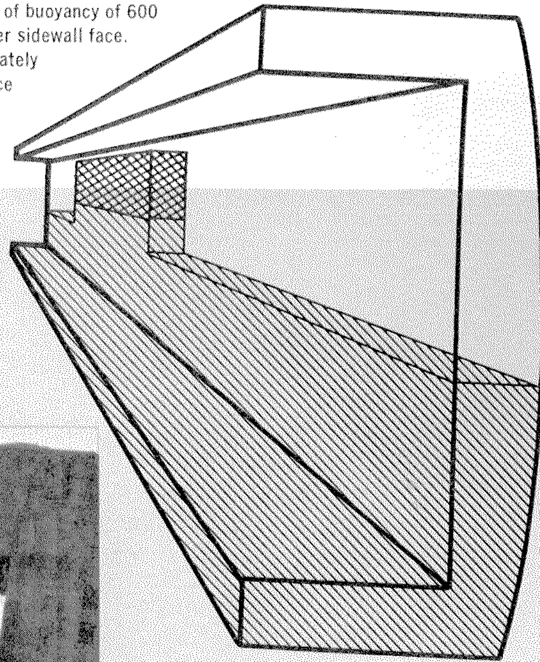


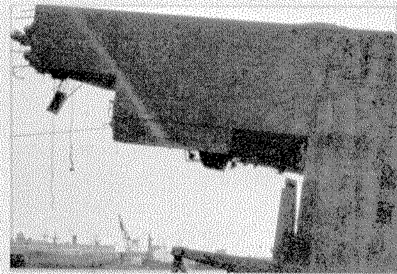
STAGE V (90 DEGREES) Pump 2,950 tons of ballast into two upper compartments adjacent to midships of center section. Increase beach gear force to approximately 500 tons.



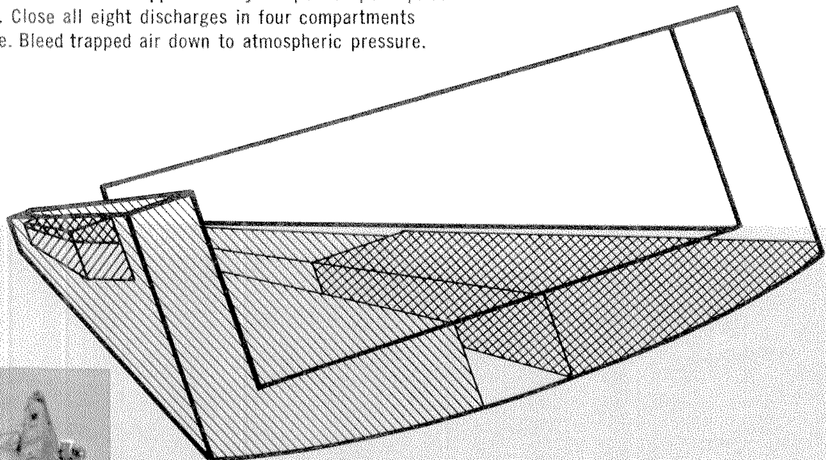


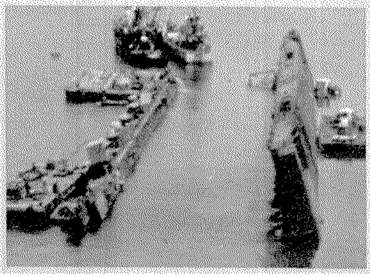
STAGE VI (90 DEGREES) Add 68 inflatable rubber pontoons to create external source of buoyancy of 600 tons at the intersection of the lower sidewall face. Exert beach gear force of approximately 558 tons. Increase beach gear force until hull begins to rotate.



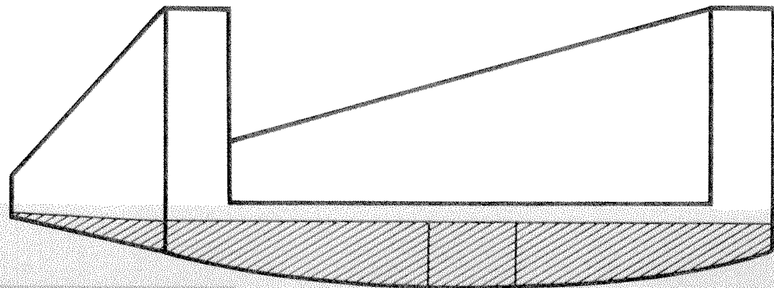


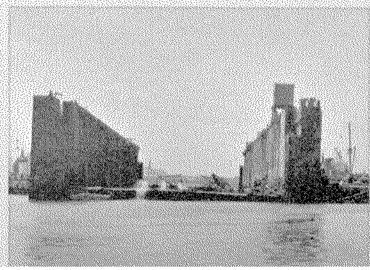
STAGE XI (160 DEGREES) Pump 2,605 tons of ballast at maximum rate of 250 gpm into four upper compartments of the two end sections. As hull rotates, air will expand and discharge approximately 1,635 tons of ballast and air pressure will reduce. With deck awash at low side, gauge pressure should be approximately six pounds per square inch, and not exceed 6½ psi. Close all eight discharges in four compartments containing air. Tow hull inshore. Bleed trapped air down to atmospheric pressure.





STAGE XII (180 DEGREES) Pump approximately 1,100 tons of ballast from between main deck and safety deck. Continue pumping ballast from all compartments on low side of hull until list is zero. Approximately 7,100 tons of ballast will be removed. Draft then will be approximately 15 feet.





preparation

FOUNDATION FOR SUCCESS

Months of preparatory work preceded implementation of the 12-stage plan to right AFDM-2. This divided itself into two main categories: (1) Making repairs to those sections of the hull that would be under water during the parbuckling operation; and (2) installing the valves, vents, padeyes, and other fittings that would be utilized during the operation.

On 27 November 1965, four days after the salvage contractor was authorized to proceed with the project, AFDM-2 was moved to the selected site off Pacific Street, three blocks downstream from Vallette Street. At Pacific Street, the drydock was moored with her inshore wingwall grounded on the river bottom in approximately 60 feet of water. The one major hole in her hull—the large oval-shaped break in the center section — was in the inshore wall at this stage.

Utilizing ¾-inch air intake fittings and valves installed in each of the drydock's 16 ballast compartments, compressed air was injected to raise the hull, one side at a time, so that repairs could be made. The hull was heeled from side to side in this manner, and work crews made necessary patches as breaks in the sidewalls of the hull appeared above the water-line. Welders, working from mobile stages and fixed platforms with leads from a 600-amp welding machine, patched the holes with box-type steel plates with little difficulty.

A quick-setting cement compound, placed by divers over small underwater breaks to seal them temporarily for the buildup of air pressure to further lift the drydock, worked very well. When the damage appeared above the surface as the hull was heeled, it was repaired with a steel plate patch.

An important segment of the advance preparations was the installation of the air and ballast intakes and vents that would be required during the parbuckling procedure. The number, size and location of the vents were considered critical. The main consideration was that the vents had to have the capacity to dispel water rapidly when air was injected into the ballast compartments. When the drydock started to rotate, the rate of expansion of the compressed air in the ballast compartments had to be equated to the rate at which water could be expelled; otherwise, excessive pressure might rupture the hull.

The valves installed on the inverted hull bottom of the center section were designed to serve as both intakes and vents for water ballast. Two eight-inch gate valves were placed in each of the eight ballast compartments of the center section of the drydock. Each was located adjacent to the longitudinal buoyancy chamber bulkhead and a transverse bulkhead.

Four three-inch globe valves were installed in each of the two center section buoyancy chambers. Each of the eight ballast compartments in the two end sections of the drydock was equipped with a single eight-inch gate valve for flooding. In addition to these fittings, which

SPECIALIZED FACILITIES AND PERSONNEL

Salvaging of AFDM-2 called for the assembling of specialized facilities and marine personnel, including the following:

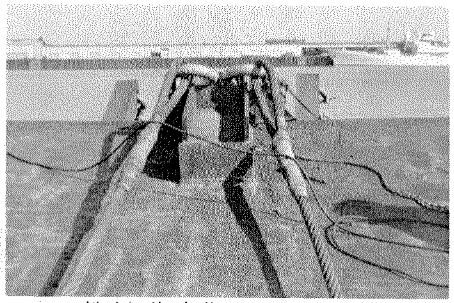
Salvage Ships (ARS): Two specially designed salvage ships of 1,202 gross tons each, MS CABLE and MS CURB. One of the two always was at the salvage site. Constructed in 1943 and owned by the Navy, the 213-foot-long ships were manned and operated under bareboat charter by the salvage contractor. Equipment on board each included a complete salvage work shop, a machine shop, diving locker, automatic towing engine, pumps, compressors and eight four-ton Eells anchors.

Lift Ships (ARSD): Two decommissioned Navy lift ships, SALVAGER and WINDLASS. On special assignment to the salvage contractor, their principal job was to moor AFDM-2 at the salvage site.

Special Barges: Three 500-ton-capacity work barges, each 110 feet long and 32 feet wide, on loan to the Navy from the U.S. Army Transportation Services. One barge carried four diesel-driven 600-cfm air compressors and a 900-amp welding machine with leads capable of reaching all the drydock's above-water sections. Another barge carried a five-ton materials handling crane; the third carried supplies, pumps and auxiliary equipment.

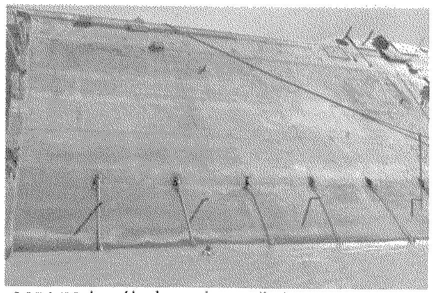
Divers: Six divers and tenders supplied by Dick Evans, Inc., a subsidiary of J. Ray McDermott & Company, Inc.

BOX-TYPE steel plates were welded over major breaks in wingwalls.



PADS welded to the hull accommodated two-inch cables used as tow lines during moves.

VALVES served as intakes and vents for ballast. Each center section compartment had at least two valves.



CABLES to attach pontoons (bottom of photo) were installed when wingwall was above water.

were called for in the engineering analysis, a number of other valves were installed by the salvage contractor to facilitate repair operations.

With the valves installed on the pontoon bottom of AFDM-2, plans called for the drydock to be moved out into deeper water so that the offshore wall could be raised completely out of the water for final repair work, for the welding of padeyes to which rubber pontoons would later be attached and for the installation of the venting arrangements through the security deck. By accomplishing this work above water, it would be possible to avoid the time and expense of divers. In addition, it afforded an opportunity to closely examine the wall that would be required to carry heavy ground reaction as well as compressed air.

But before this operation could be completed, the forces of nature intruded. In the pre-dawn of 16 February 1966, the drydock was jarred from her moorings by what is believed to have been a combination of high water created by upstream floods and a surge of debris. She broke free and was carried across the river.

Bringing the drydock back across the river to the Pacific Street salvage site was a major task (see pages 20-21 for complete details) and by the time this was done—on 13 March—the Mississippi was approaching its yearly high-level mark. The salvage contractor already had determined, prior to the breaking away of AFDM-2, that as soon as the preparatory work on the offshore wingwall had been completed the obstacles created by the spring floods would make it mandatory to suspend salvage operations until after the river crest had passed. Accordingly, salvage work was halted immediately after the return of the drydock, and the breakaway incident did not significantly influence the overall time span required to complete the project.

During the suspension period, the inshore wall was grounded and the drydock was held in position by the lift ships and beach gear. Because of fluctuations in the height of the river, the beach gear cables had to be tightened or slackened as required to maintain a predetermined strain on the beach gear sets. A salvage crew kept a round-the-clock watch on the moorings, beach cables, the condition of the drydock and her position. Concurrently, the beach gear sets were thoroughly inspected and substandard components were removed and replaced.

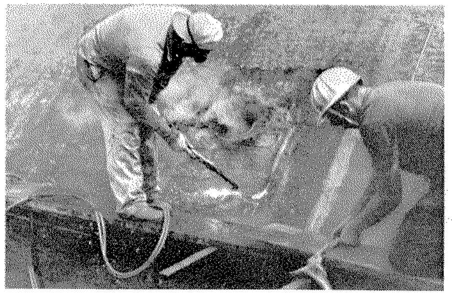
When salvage work resumed three months later on 15 June, the first step was to complete the operations interrupted on 16 February. Crews completed repairs of holes and breaks in the offshore wall after it had been raised out of the water. Sixty-eight pads for the pontoon pendants were welded to the hull at each frame and about 11 feet from the weather deck on the outer face of the offshore wall. Chains and cables secured to the pads were carried around the top of the wall and lashed to the inside face of the sidewall. When the time came to install and inflate the pontoons during the late stages of the salvage job, it would be a relatively simple matter for divers to attach them to the cables.

Air intake valves were installed in the top of the offshore wingwall. In the later stages of the salvage operation, plans called for these valves to introduce enough compressed air into the wingwall to displace 560 tons of water. The feasibility of using the volume between the weather deck and security deck had been discounted early in the engineers' study of the drydock configuration because of the large number of openings in the weather deck. As a result, this space was free flooded during the entire operation. Access to the wingwall below this space for the compressed air was achieved by passing an eight-inch pipe through an existing 12-inch vent in the top of the wall. Installation of the pipe and associated ¾-inch valves in each of the four center section compartments was accomplished by divers.

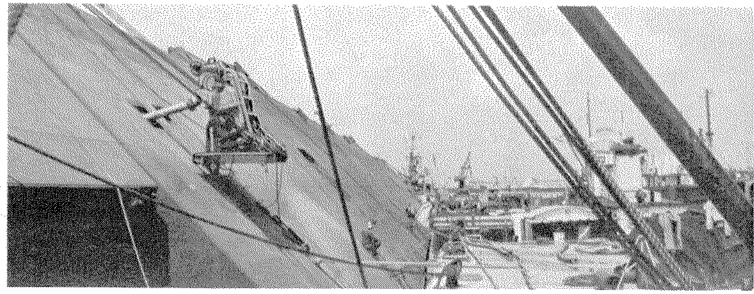
When all these preparations had been completed, the drydock was end-for-ended. Thus the watertight offshore wall became the inshore wall and the one major break would be on the offshore side and above water for the duration of the parbuckling operation.

With the dock sidewalls oriented for the salvage operation, the offshore wall was fitted with pads for the beach gear cables. Five double pads and six single pads were welded to the wall at the chine line in way of a bulkhead or truss frame.

While all the preparatory work on the drydock was proceeding, another crew was readying the area behind the levee for the salvage operation. Winches and deadmen had to be located so that each beach gear set would pull in a direction normal to the longitudinal axis of the dock. This was important to insure that the full capacity of each beach gear set could be applied during the parbuckling operation. The beach gear purchases were rove off, the tensiometer system was installed and the 1⅝-inch beach cables were strung to the drydock. In addition, a control and communications center was established; the inflatable pontoons were inspected and fitted with slings, and crews were instructed and drilled in the 12-stage plan.



WELDERS used oxy-acetylene torches to gain access to compartments containing excess mud.



PUMP on platform welded to wingwall was utilized to dewater offshore wall so that inshore side could be grounded on the river bottom.

WATER JET turned mud into slurry that was later pumped from drydock.

CHERRY PICKER-TYPE CRANE, mounted on work barge tied alongside capsized drydock, positioned scaffold that served as platform for welders who worked on steeply sloped wingwall. To raise damaged sections out of water, compressed air was injected to heel hull from side to side. Leads from a 600-amp welding machine mounted on another work barge were long enough to service all above-water portions of the drydock. Workers reached the hull by walking over six 8 x 35-foot barges that were strung end-to-end to connect the drydock and levee.

operations

TWELVE STAGES TO SUCCESS

By mid-July 1966, the salvage contractor was ready to put into effect the 12-stage operation that was to rotate the hull 180 degrees from her inverted position.

The first step was to ground the inshore wingwall (called the B wall) in approximately 83 feet of water. In this position, the B wall of the drydock would serve as the axis of rotation for the first ten stages of the operation.

To put the inverted corner of the B wall on the bottom of the river, water ballast was added to compartments on that side of the hull for a total of 18,900 tons, while the compartments in the offshore (A wall) side were emptied with compressed air and/or pumped dry. According to plan, the combination of ballasting and deballasting should have brought the hull to the $46\frac{1}{2}$-degree position, which had been designated as Stage I.

However, dense mud had permeated all sections of the hull, especially the offshore wall that had received most of the damage on the night of Hurricane Betsy. As a result, before the drydock could be brought to the Stage I position it was necessary to remove approximately 2,000 tons of mud and water from the pontoon ballast compartments on the offshore side. This was done by jetting with water to turn the compacted mud into a pumpable slurry.

On 31 July, eight days after the operation began, the drydock had been rotated to 45 degrees from the inverted position, $1\frac{1}{2}$ degrees short of the engineering calculations, but well within acceptable limits.

With the hull in the Stage I position, the force of 16 sets of land-based beach gear was now applied. Engineering calculations indicated that a total force of 551 tons, applied to the chine line on the offshore side, would bring the drydock to Stage II (60 degrees).

When the calculated force failed to accomplish this goal, the beach gear pull was increased gradually until it approached available capacity. Still the drydock failed to assume the 60-degree position. Conditions on the river bottom were surveyed to make sure they were the same as had been assumed, and divers were sent down to re-check the quantity of water trapped within the hull.

Once again the Mississippi's tightly compacted mud proved to be the culprit. The divers' assessment that only a negligible amount of mud remained in the hull had been made under highly adverse conditions. As a matter of fact, mud was clinging to horizontal stiffeners in both the pontoon and A wall machinery space areas to a thickness of about one foot. The weight and location of this mud was the upsetting factor.

All computations had been made on the assumption that only small quantities of mud or water remained within this area. Such assumption was unrealistic but necessary because it was impossible at the time to assess with any degree of accuracy the quantity and location of silt and mud that had collected in the drydock over the years as well as during the time it was capsized. Since even slight changes in the

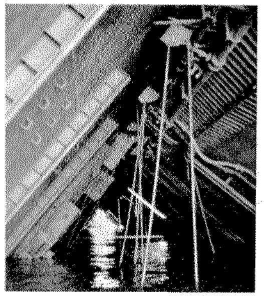
LAND-BASED BEACH GEAR SPREADS LOAD

The 16 sets of land-based beach gear played a vital role in the salvage operation, particularly in the early stages. As the salvage contractor worked to overcome the weight of approximately 2,000 tons of mud and water trapped in ballast compartments, the beach gear exerted more than 650 tons of horizontal pull on the hull.

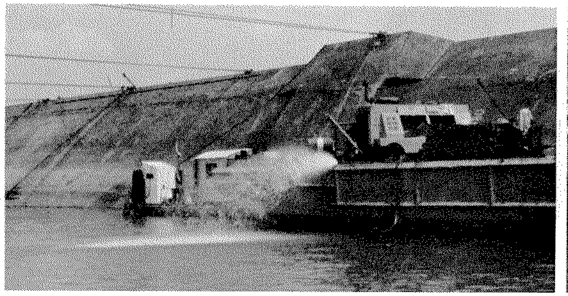
The beach gear sets were powered by gasoline or diesel-fueled winches which were located several hundred feet behind the levee at the Pacific Street salvage site. Each beach gear set was rated at 50 tons maximum capacity, and actual operational capacity through a nine-part purchase tackle was 42.5 tons.

The standing blocks of the beach gear tackles were fastened to deadmen planted behind the levee in excavations that measured 10 feet long, four feet wide, six feet deep. Each deadman consisted of four 12x12-inch timbers, ten feet long, that were tied together by a wire-cable bridle. Six-foot-long 6x6-inch timbers lined the face of each excavation to give additional support when the beach gear was stressed. When all the timbers were in place, the excavation was backfilled by the same tractor-mounted backhoe that had dug it.

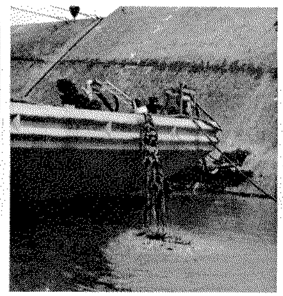
The distance from the winches to the capsized drydock exceeded 1,000 feet. The $1\frac{5}{8}$-inch beach gear cables were attached to five double pads and six single pads that had been welded to the offshore wingwall (A wall) of the hull at the chine line.



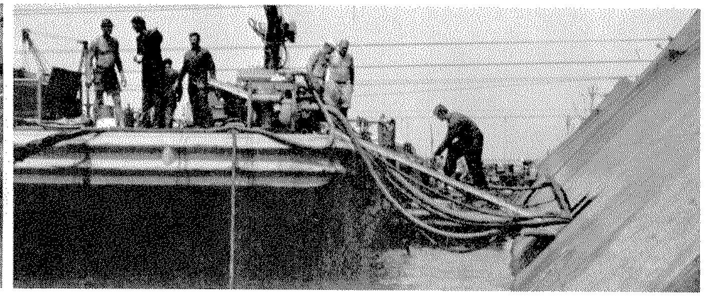
VIEW THROUGH WELL of drydock at an early stage.



DEWATERING PUMPS, mounted on work barges, removed ballast as beach gear continued to exert pull.



MUD, turned to slurry, was pumped from center section.



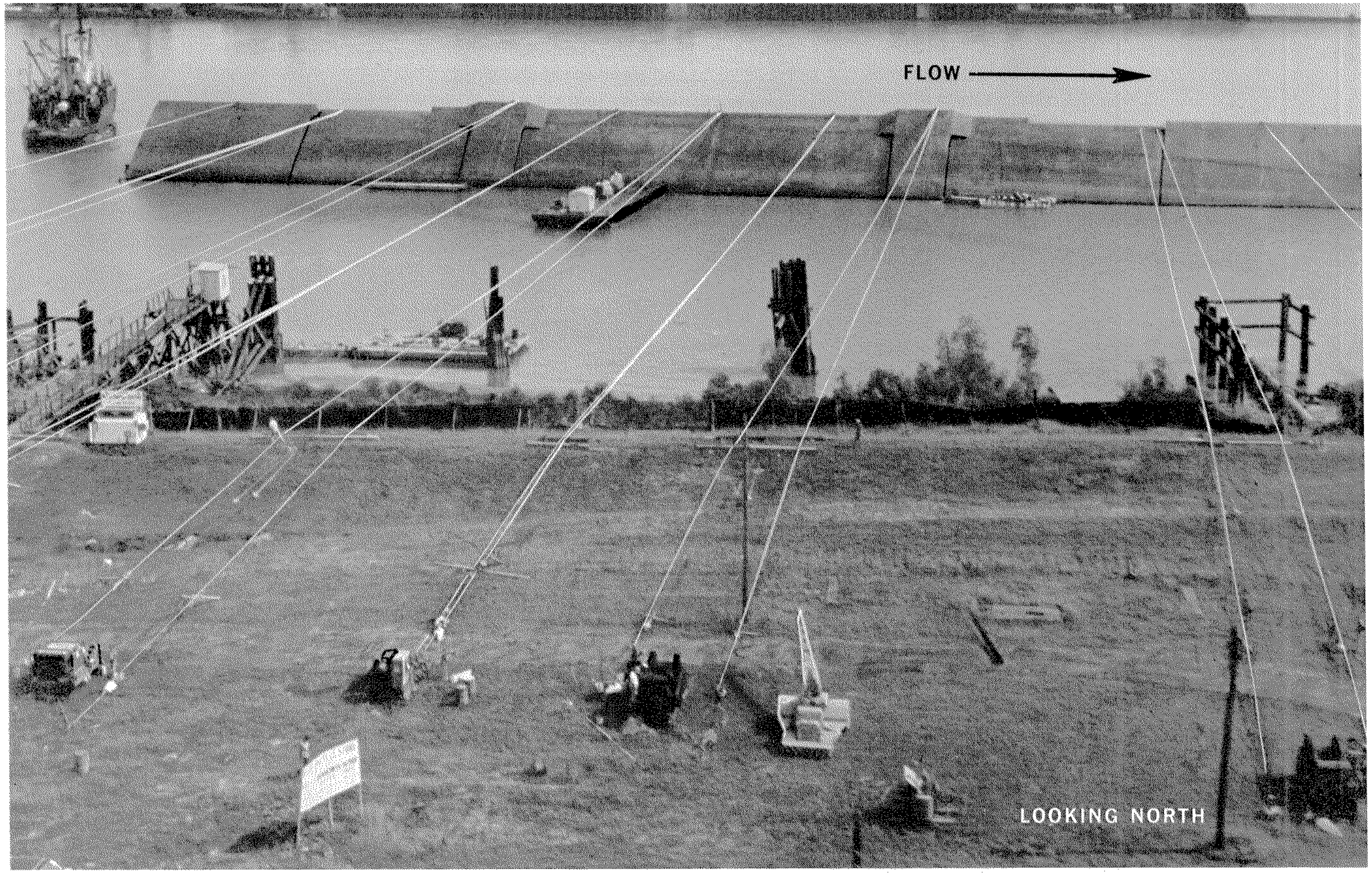
BALLAST was added to inshore compartments of center section. Before drydock would assume Stage I position, 2,000 tons of mud and water had to be removed.

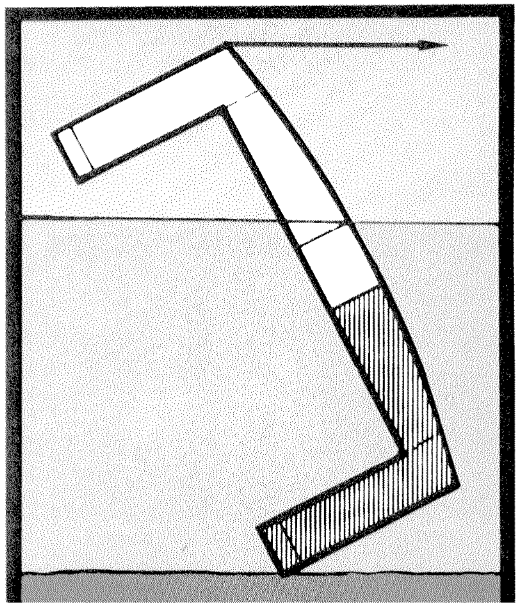
LAND-BASED beach gear sets were powered by engine-driven winches located behind Pacific Street levee (top).

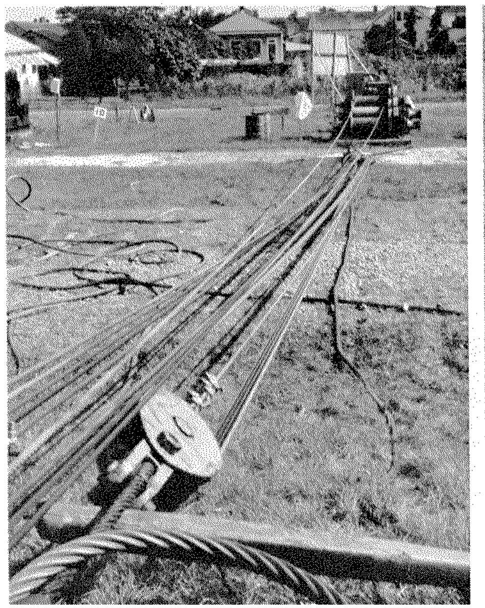
EACH SET of beach gear delivered up to 42.5 tons of pull through nine-part purchase tackle (bottom, center).

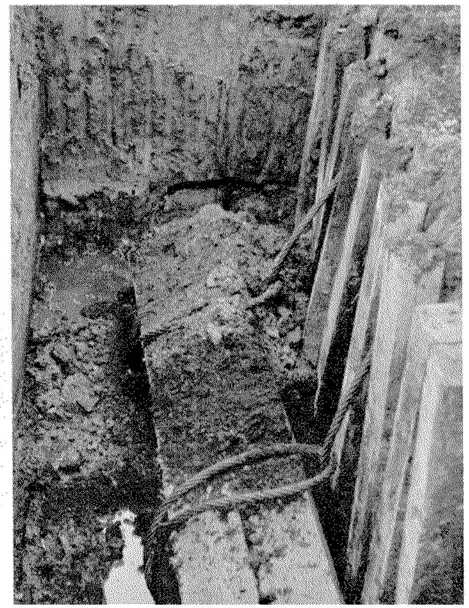
STANDING BLOCKS were secured to timber deadmen—four 12 x 12 timbers, 10 feet long—buried behind levee in six-foot-deep excavations (bottom, right).

ARROW on drawing (bottom, left) indicates direction of beach gear as the drydock was rotated to 60 degrees from the inverted position. Before reaching Stage II, 2,000 tons of mud had to be pumped from offshore compartments.









center of gravity would affect the amount of beach gear force required, it was decided to base the calculations only on known factors with full recognition that any sizeable accumulation of mud had to be removed.

In eight days, from 1 August to 8 August, an additional 2,000 tons of mud and water were pumped from AFDM-2. For the first six days, when the jets and pumps were concentrated in the pontoon compartments, the hull rotated only four degrees, despite the fact that an average beach gear force of more than 650 tons was being exerted.

On 6 August, the salvage contractor began to remove mud from the A wall machinery area, and in less than two days the hull reached the Stage II position. Computed beach gear force to hold the drydock in equilibrium at 60 degrees from the inverted position was 550 tons. The actual beach gear force was 590 tons, and the angle of the drydock was 59½ degrees.

The key to reaching Stages III and IV was the addition of water ballast to the center section of the hull. On the day Stage II was reached, 1,440 tons of ballast were added over a four-hour period to two buoyancy chamber compartments adjacent to the midships transverse bulkhead. Approximately 26 hours after the ballast was placed, Stage III (70 degrees) was reached. Beach gear force during this period ranged from 530 to 630 tons.

On 10 August, an additional 2,500 tons of water ballast was added to the two midships pontoon compartments, and with a beach gear force of 600 tons the drydock rolled steadily to 80½ degrees from the inverted position. This was half a degree more than had been calculated for Stage IV.

The next six days were a second critical period for the project's salvage engineers. Gradual increase of the beach gear force to 650 tons caused only 3½ degrees of rotation, 6½ degrees shy of the 90-degree position called for at Stage V. A careful check of computations and conditions narrowed the cause of the deviation from anticipated results to the slope of the river bottom underlying the B wall.

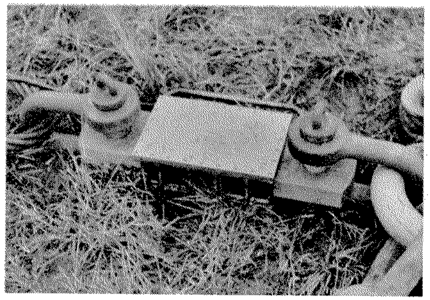
The parbuckling plan contemplated a bearing area with very little or no slope, and leveling of the known slope of the river bottom at the salvage site had been considered before the attempt to raise the drydock got under way. It was decided, however, to defer dredging on the reasonable chance that the scrubbing action of the river current under the B wall would wash out enough mud to reduce the slope significantly and/or the weight of the structure would compact the

TENSIOMETERS INSURE PIN-POINT CONTROL

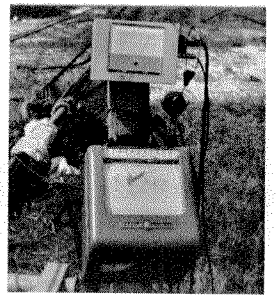
It was considered essential right from the start to continuously monitor the beach gear force being exerted on the capsized drydock so as to avoid local distortion from asymmetrical loading and to insure against failure of one of the cables from overload with progressive failure of the remainder. It also was important to maintain the proper relation between the beach gear force and the reactions at the point of rotation in avoidance of inshore slippage.

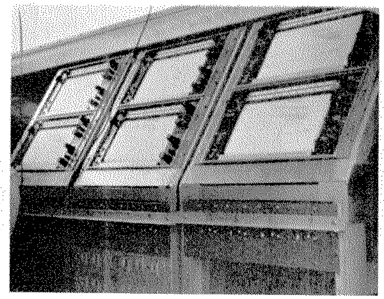
Since suitable devices were not commercially available, the problem was turned over to research specialists at the Navy's David Taylor Model Basin, Carderock, Maryland. Adapting tensiometers placed between the deadman and the standing blocks of each beach gear tackle, they devised a carefully calibrated system, comprising a direct-reading dial at each winch for guidance of the operator, and a master remote control by stylus recorders housed in a communications center. These gave the project engineer a continuous overview of the beach gear complex and a permanent record of the operation. The arrangement, in conjunction with an electronic inclinometer and voice communication by telephone and radio, comprised an effective system of pin-point control and coordination.

Working from the communications center located on the levee, an engineer directed by telephone the desired stressing of the beach gear cables in symmetrical order. Numbers 1 and 16 were stressed first, then numbers 2 and 15, and so on. Each beach gear set was stressed to within five tons of its counterpart on the other end of the drydock, and when all were so tensed the operation was repeated as necessary to achieve the planned effect. Engineers estimated that the tensiometers were accurate to within 10 percent, which provided a higher degree of control than had ever been available on a large-scale salvage operation.


TENSIOMETER was placed between the deadman and standing blocks of each beach gear set.


CONTROL CENTER housed stylus recorders that indicated beach gear force. From this central location engineers were able to control rate of pull.


WINCH operators checked direct reading dials.


STYLUS RECORDERS provided minute-by-minute record of the operations.

DREDGING was necessary to level the river bottom before AFDM-2 could be brought to the 90-degree position (Stage V). After the hydraulic dredge had dug a 10-foot-deep trench along 360 feet of the inshore chine line (shaded area), the drydock moved easily into the trench and rotated past the 90-degree mark.

COMBINATION of beach gear force, inflatable rubber pontoons and water ballast brought the drydock quickly to the Stage VII position (100 degrees) as the dredge (far right) moved out. As the hull rotated, beach gear force was reduced gradually to 250 tons.

LOOKING SOUTHWEST

bottom. If so, dredging would not be necessary, with a saving of approximately $50,000 in the overall cost of the salvage operation. A second reason was the probability that mud or silt would backfill any dredged trench in the interim to the Stage V position (90 degrees)

The hoped-for scouring action or compaction did not occur. In a final effort to avoid the expense of dredging, it was decided to advance the timing of several procedures originally planned for later stages of the operation; to do so would not ultimately affect the operation.

The first step was to build up the ballast in the midships compartment to 2,500 tons, 450 tons less than the total called for at Stage V. The additional weight might cause compaction of the river bottom. It was also determined to increase the beach gear force up to 650 tons, 200 tons higher than had been contemplated at this stage, and to attach and inflate the rubber pontoons initially planned at Stage VI. The 68 pontoons, attached in three levels at the B wall weather deck, would exert an external lifting force of approximately 600 tons and create a righting moment.

On 11 August, the first ten pontoons were attached and inflated by divers and an additional 800 tons of water ballast was added to the midships compartments. The next day, 15 more pontoons and 500 tons of ballast were placed. This produced a one degree rotation of the drydock. In the following two days, another 31 pontoons were attached, but the hull did not move nearer to Stage V. Dredging had to be undertaken.

On 15 August, permission to employ an hydraulic dredge was requested and received from the Corps of Engineers. The river bottom survey had indicated that dredging would not be as extensive as originally contemplated. The position of AFDM-2 was such that the downstream third of the B wingwall rested in soft mud and only about 360 feet had to be trenched, starting from the upriver end of the drydock.

In two days, the dredge dug a trench 15 feet wide and 10 feet deep —two-thirds of the length of the drydock along the chine line. During this period, no heaving was done on the beach gear, and cables were slacked off as necessary to allow the dredge to pass. After completing the trench, the dredge retraced her path with her suction line down to remove any backfill. While the dredging was under way, the final 12 pontoons were attached to the hull.

The dredge pulled away from the salvage site early on the morning of 17 August and the beach gears sets were promptly stressed. The drydock responded to a force of only 445 tons, and by noon of that day

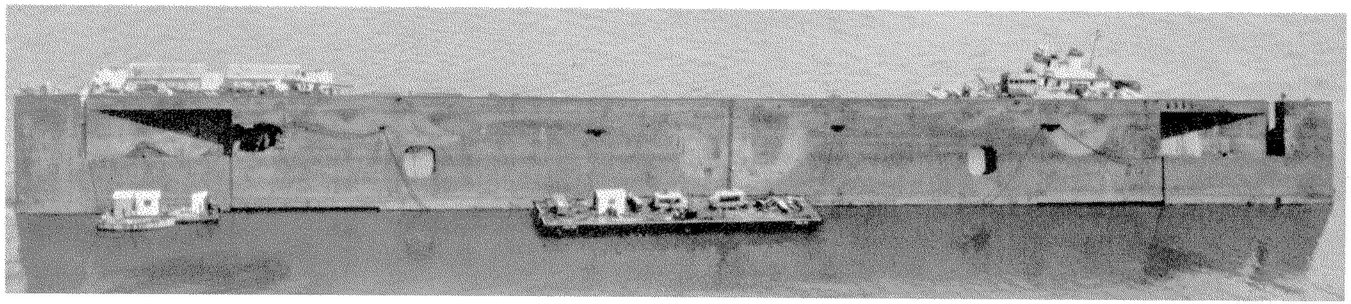
PONTOONS PROVIDED EXTERNAL BUOYANCY

In the critical stages of the operation after the drydock had been rotated to 90 degrees from the inverted position, 68 inflatable rubber pontoons (Sealdbins) provided an important external source of buoyancy. The pontoons, which were attached to cables secured to the inboard face of the inshore wall, were not an innovation in salvage work, but they had never before been used in this quantity or fashion. Total lifting capacity when inflated was 600 tons.

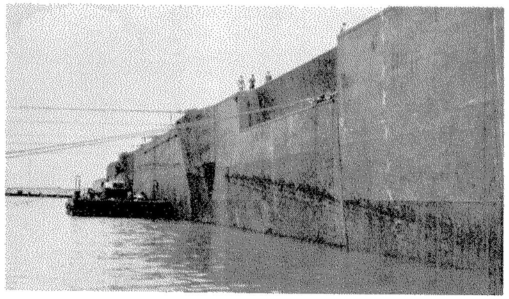
Each pontoon was eight feet high and seven feet in diameter. They were made of ¾-inch-thick rubber and lined with fabric to make them stronger. The pontoons were not actually sealed; a nine-inch-diameter opening at the bottom provided an access for air and venting. The United States Rubber Company manufactured the pontoons to specifications of the salvage contractor with respect to fittings for attaching them to the drydock.

The pontoons were lowered into the water in the collapsed condition by a cherry picker-type crane mounted on one of the work barges. An air hose from a compressor was lashed to the pontoon and after the diver had attached a pontoon to its cable he signalled topside to place air. When air bubbles started to escape from the bottom of the pontoon, it was considered fully inflated. The air hose then was recovered and lashed to the next pontoon.

To provide control over the rate of rotation of the hull, the inflated pontoons were arrayed in tiers at three different levels so that one-third of the total lifting capacity would be dissipated as each row broke the surface. The timing of this was regulated by the length of the sling and the schedule was so phased with the expansion of the compressed air in the drydock's ballast tanks that rotation of the hull was momentarily halted until the evacuation of water ballast again created the imbalance for further rotation. Thus an unwelcome blowout from excessive air pressure was avoided.



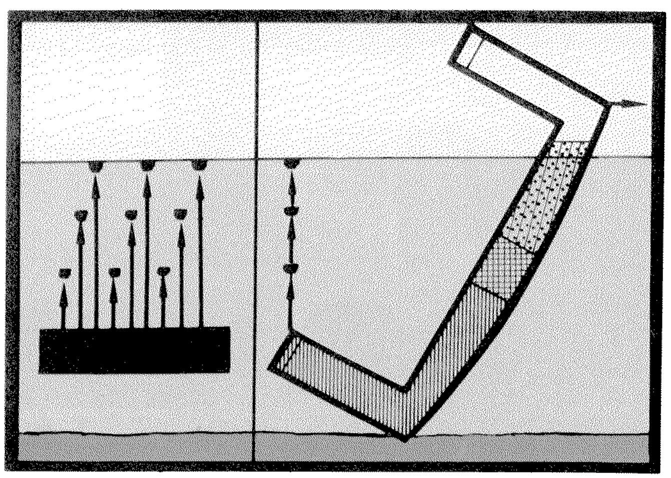
MOST SERIOUSLY DAMAGED WINGWALL, with oval-shaped hole (left), is shown at Stage XI. Salvage plan called for this wall to be placed offshore during the parbuckling operation so that the hole would be above water while the drydock was being rolled.

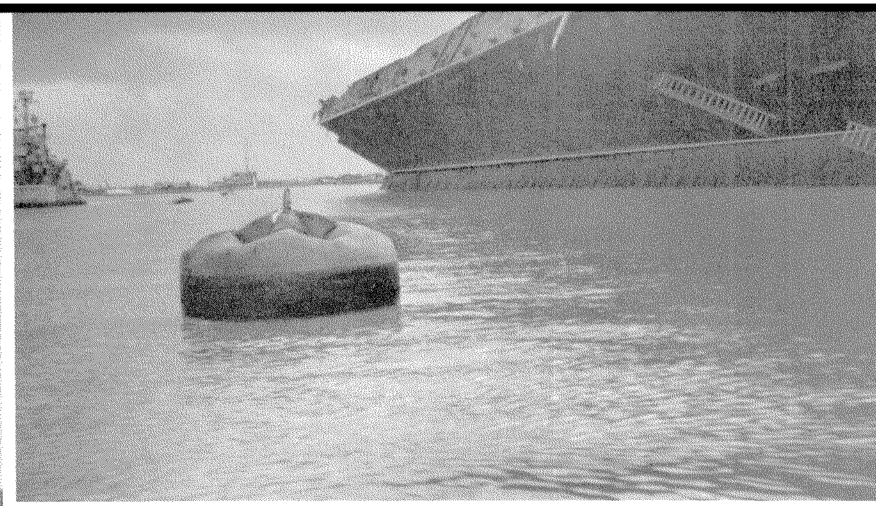


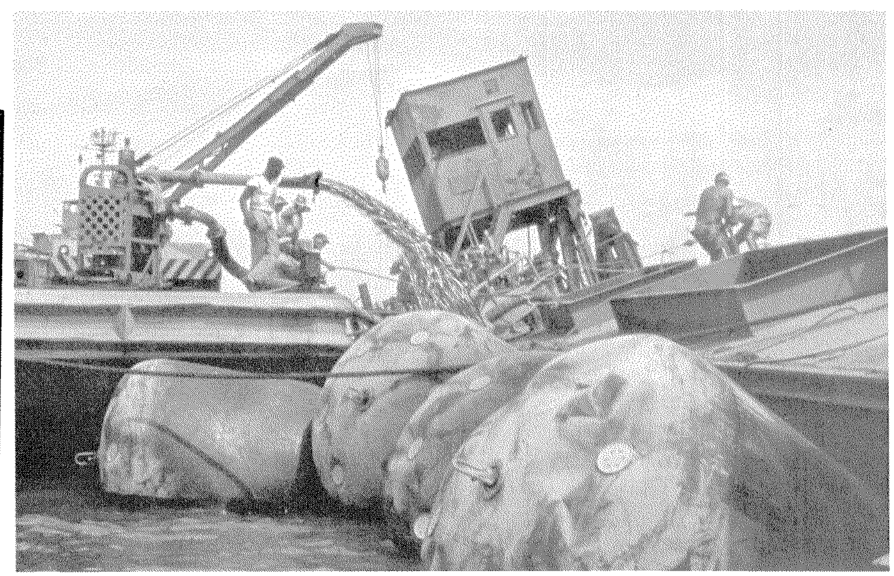
COMPRESSED AIR delivered at 60-psi gauge pressure was placed in B wall to displace 560 tons of water.

INFLATABLE PONTOONS, eight feet high and seven feet in diameter, were lowered one at a time by crane (right) after operation reached Stage IV. Underwater, the rubber pontoons were attached to preplaced pendants by divers, who then inflated them with air hoses from a barge-mounted compressor. A key element of the salvage plan, the pontoons provided 600 tons of external buoyancy force. In photo at far right, top, the first row of pontoons is shown after it broke the surface, dissipating 200 tons of lifting force. Center, all three rows are on the surface; bottom, a closeup of surfaced pontoon. Long-submerged B wall rose 12 hours after the first pontoons broke water.

BUOYANCY EFFECT of the rubber pontoons is shown in drawing that depicts AFDM-2 in Stage X position (120 degrees). Pontoons were arranged in three levels to help control final ascent of drydock.







had rotated through the critical Stage V position, passed Stage VI and reached Stage VII (100 degrees). In this period, the beach gear force required to effect rotation gradually lessened, as anticipated. At Stage VII, only 250 tons of beach gear force pulled on the drydock, compared to the 275 tons computed.

The next day, as the beach gear force was increased gradually to 315 tons, the drydock assumed an angle of 109 degrees from the inverted position, one degree less than the Stage VIII position called for. The beach gear pull was considerably more than twice the 124 tons that had been calculated for Stage VIII and investigation revealed that the amount of water ballast in the center section compartments was about 150 tons shy of the 3,950 tons calculated. This deviation was not serious because there was more than enough beach gear capacity to overcome the shortage of ballast.

On 19 August, approximately 2,100 more tons of water ballast were placed in the center section compartments on the A wall side to bring the total up to the 5,900 tons calculated for Stage IX. The drydock rotated to an angle of 118 degrees from the inverted position, two degrees less than the calculated angle for Stage IX. Beach gear pull at this stage was 150 tons, exactly the force that had been anticipated.

The salvage operation now entered the third and last critical period from the engineering standpoint. Compressed air was to replace beach gear as the prime force that eventually would rotate the drydock toward the 180-degree position. The amount of air and the pressure built up in the hull compartments were of extreme importance. Care had to be taken to assure that the drydock did not rise to the surface prematurely. If that were to happen, excessive air pressure would almost certainly rupture the hull or cause serious internal damage.

Design studies called for back pressure readings of 25 psi, but specified they were not to exceed 26 psi. When the hull rotated to the point where only the low side of the weather deck of the wingwall was awash (about 160 degrees), the construction of the security deck imposed a precautionary limit of 6 psi and not more than 6½ psi.

The arrangement of the 68 pontoons connected to the top of the B wall provided a measure of control over the rate of rotation of the hull. The securing cables varied in length for a three-tiered array of inflated pontoons so that one-third of the uplifting force would be dissipated as each level broke surface, slowing the rate of rotation to keep pace with the expansion of the air bubble and expulsion of water ballast from the drydock. When the first tier of pontoons broke surface, the uplifting effect was reduced by 200 tons. This effect was repeated when the second and third tiers broke surface.

While adding approximately 2,000 tons of water ballast to the two end sections on the A wall side, the salvage contractor began introducing enough compressed air to displace 560 tons of ballast from the four center section compartments of the B wall.

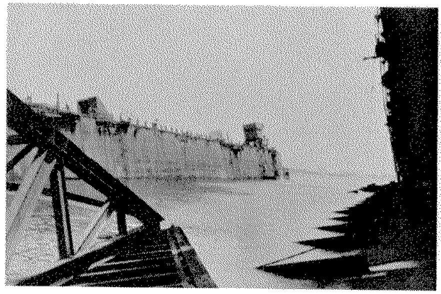
Ballasting was completed by 11 p.m., 20 August, and air placement was continued at a carefully controlled rate. Beach gear force dropped progressively from 130 tons to zero, but the drydock at first did not rotate according to plan because the B wall had wedged itself against a mound of material formed during the dredging operation. At 5:30 a.m., 21 August, this resistance was overcome by the righting forces exerted on the drydock, and AFDM-2 started its slow, controlled rise to the surface.

Eight minutes later, the third tier of pontoons and the long-submerged B wall broke surface. A loud, booming noise during this period of rotation was attributed to a large number of gratings that fell to their normal position through the force of gravity.

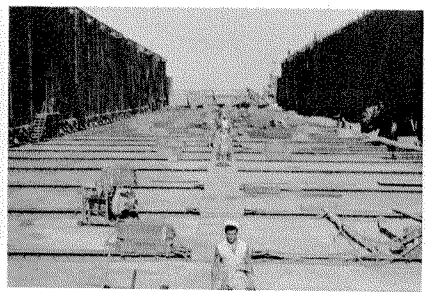
The drydock now was at Stage XI. The last major obstacle to the success of the salvage operation was past. Actual conditions and those anticipated by the engineering calculations were extremely close. The hull was 161 degrees from the inverted position versus the calculated angle of 160 degrees. Air pressure in the B wall compartments was to be 6 psi; actually it was 7 psi. Ballast in the A wall compartments was to be 2,605 tons; actual water ballast was approximately 2,000 tons, but an additional 600 tons of mud in the compartments made up the difference. The chine line on the B wall was to be 42.5 feet below the surface of the river; it stabilized at 41.5 feet.

With the hull in the 161-degree position, all ballast vents were closed and the compartments under air pressure were bled down to atmospheric condition. From 21 August through 25 August, two six-inch pumps and three four-inch pumps were used to dewater all drydock compartments. Slowly, the drydock assumed an upright position with a draft of six feet.

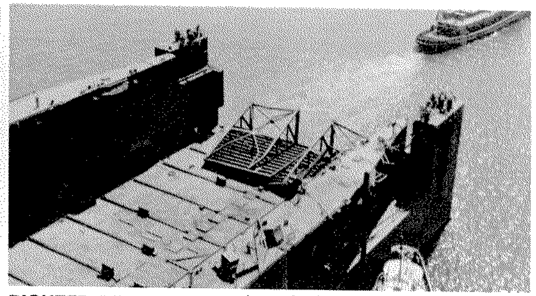
On 25 August, 1966, the salvage ship CABLE and two tugs turned AFDM-2 end-for-end off Pacific Street and then towed her two miles downstream to Todd Shipyards' Algiers yard from which it had broken loose during Hurricane Betsy 11½ months before.



RISING B WALL shown above surface as drydock rotated to 161 degrees from inverted position.



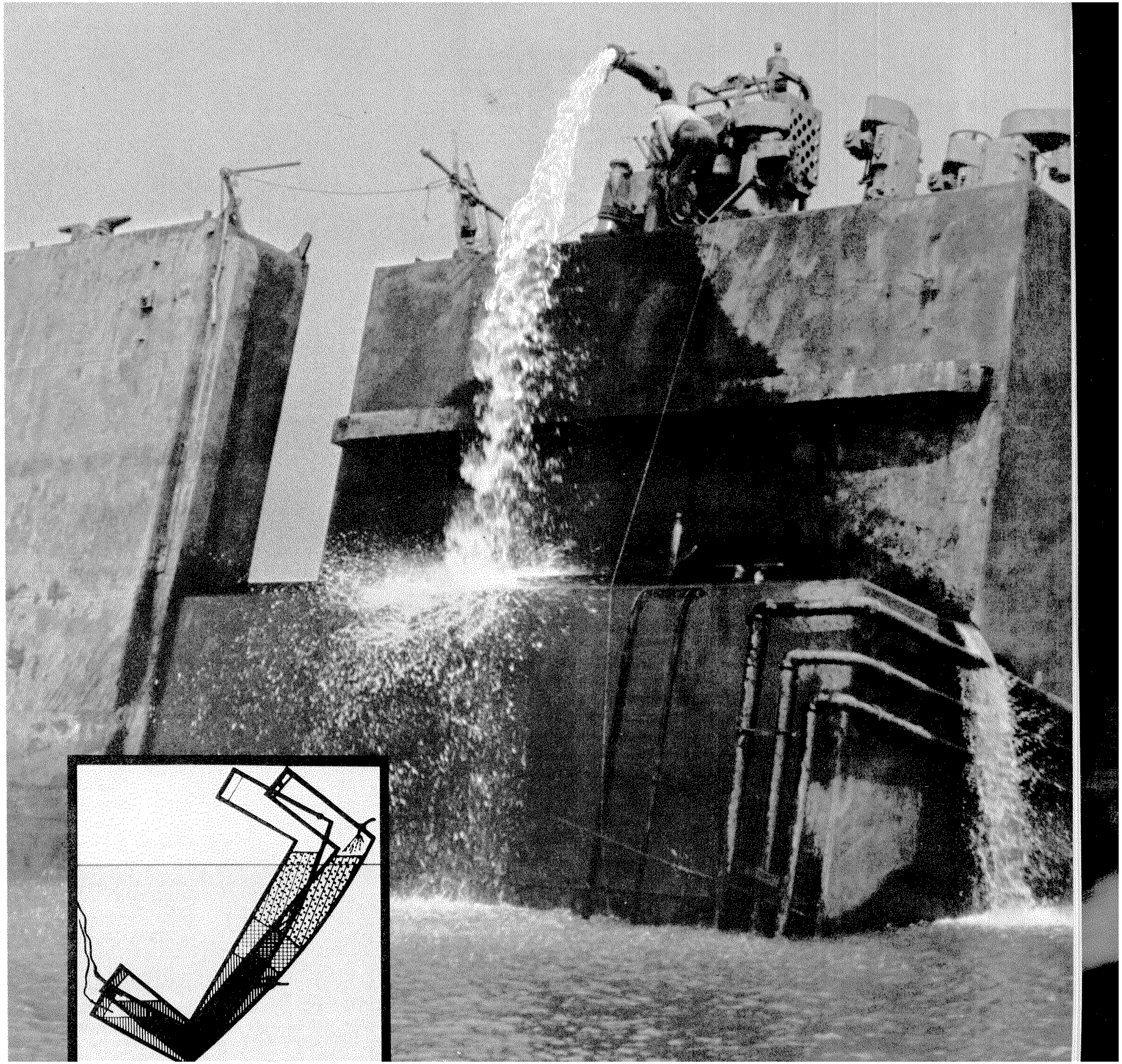
COMPLETELY DEWATERED, AFDM-2 assumed upright position with draft of six feet.



RIGHTED DRYDOCK was cleared of equipment and debris, turned end-for-end off salvage site, then towed to shipyard.

WITH BOTH WALLS of drydock above water, ballast vents were closed and compartments under air were bled down to atmospheric pressure. Then all compartments on both sides of the drydock were dewatered by four-inch and six-inch pumps. In less than four days the drydock reached the 180-degree position.

COMBINATION of compressed air and ballast rotates hull in final stages of salvage operation. Drawing shows water venting as air is pumped into ballast compartments of center section to displace 560 tons of water. Ballast was added to end-section areas at the same time.



problems

NATURE TAKES A HAND AGAIN

Unanticipated problems are to be expected on any large-scale marine salvage operation, especially one as extensive as the AFDM-2 project. The most serious occurred on 16 February 1966 during efforts to reposition the drydock in deeper water so that final repairs and preparations could be made on the offshore wall.

Shortly before dawn, at approximately 5 a.m., the surge of high-velocity water caused by upstream floods ripped the drydock from her moorings and — for the second time in five months — carried her to the east bank of the Mississippi River.

At the Pacific Street salvage site, the drydock had been held by two 1⅝-inch cables to shore and by tow cables from the lift ships SALVAGER and WINDLASS. The lift ships were moored off opposite ends of the drydock; each was held fast by one 6,000-pound anchor and two 10,000-pound lightweight (LWT) anchors. To assist in the repositioning, a tug pulled on a line attached to the offshore side of the drydock.

Flood conditions upstream raised the water level quickly. The river crested at 5.5 feet above normal and was clogged with uprooted trees, timber and other debris. Apparently, submerged debris severed the 1⅛-inch cable holding SALVAGER's 6,000-pound anchor and, with her other two anchors dragging, the lift ship began to swing out into the river channel. The cable holding the WINDLASS' 6,000-pound anchor also snapped, but her two 10,000-pound anchors held fast.

As a result, the SALVAGER, WINDLASS and AFDM-2 all drifted across the river. They came to rest off the east bank near Congress Street Wharf, approximately 1,400 feet across the river and 500 feet downstream of Pacific Street, with the drydock herself parallel to the wharf.

Immediate measures were taken to secure AFDM-2 to prevent her from becoming a navigational hazard. Two beach gear sets moored the drydock to the wharf. In addition, the two-inch towing line of the salvage ship CURB was made fast to the upriver end of the drydock and the CURB herself was tied to the wharf with a nine-inch nylon. To relieve the wharf bollards, two pusher tugs were positioned at the downriver end of the drydock.

As soon as AFDM-2 was moored to Congress Street Wharf and an examination disclosed no serious new damage, arrangements were initiated to return the drydock to the Pacific Street salvage site. The drydock occupied more than 600 feet of important wharfage on the east bank, the main pier space of the Port of New Orleans, and there also was some question as to the ability of Congress Street Wharf to long withstand the thrust of the river in flood stage. On the other hand, it was recognized that a river crossing under present conditions would be much more formidable than it had been the previous September when the salvage ship CABLE, the USS SALINAN and a local tug had accomplished the first such move. As a result, the return of the drydock to the west bank was deferred until a special plan was devised to insure constant control of the drydock throughout the transfer.

TONS OF DEBRIS, carried by high velocity flood waters, apparently snapped anchor cable of lift ship holding AFDM-2. Drydock was swept to opposite bank of Mississippi River.

The basic idea was to swing the drydock across the river in pendulum fashion. The pivot was formed upstream of the drydock by planting two ten-ton and two five-ton anchors in mid-river, with one two-inch wire cable leading from each anchor toward the drydock forming the arm. In addition, lines from two sets of beach gear based on the west bank were attached to the drydock to help control the swing of the pendulum.

Three weeks were required to develop the plan, have it approved and prepare for its implementation. Studies of the river level and the current velocities at various points along the projected return route were made to fully assess the forces to be encountered. Stresses on the anchor lines and the horsepower requirements for the tugs that would push or pull the drydock were determined as well as the best manner of tying AFDM-2 to the two-inch anchor cables. The plan called for the cables to be brought aboard the bow of the SALVAGER and attached to her hoisting winches. The SALVAGER, in turn, was to be connected to the drydock by a rendering 2½-inch chain bridle.

In all the plan called for approximately 100 men and 12 ships — the salvage ship CURB, the lift ships SALVAGER and WINDLASS, and nine local tugs — to handle the assignment. The combined horsepower of the nine tugs and the CURB aggregated 15,850.

A Sunday — 13 March — was chosen to make the move because Sunday river traffic normally is light. An 8,000-foot stretch of the river channel was closed to traffic for eight hours (10 a.m. to 6 p.m.) during the transfer. However, the weather on 13 March was rainy and foggy, and poor visibility posed an additional problem.

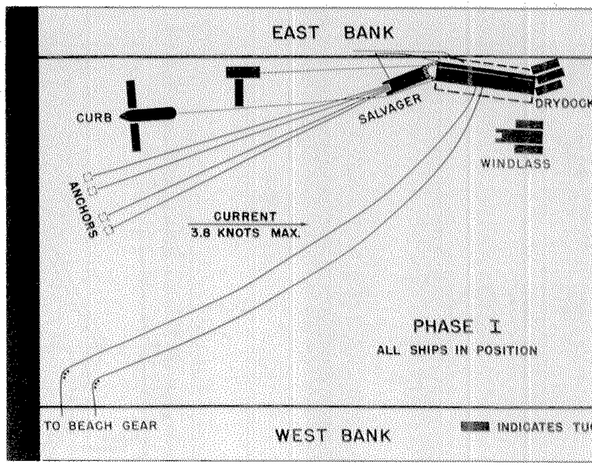
When the operation began, barge-mounted compressors were used to dewater ballast compartments on the grounded side of the drydock and the structure was raised off the river bottom. Moorings to Congress Street Wharf were cut and, as tugs inched the drydock into the channel, AFDM-2 began to swing on the anchors.

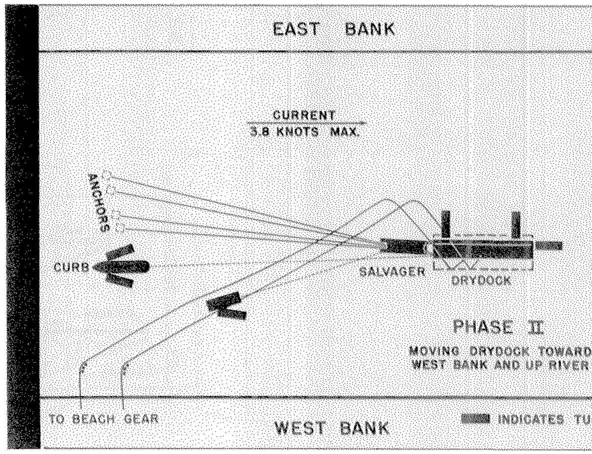
The CURB and a 2,400-horsepower tug were positioned upstream of the drydock, with tow lines to the offshore and inshore sides, respectively. Their function was to assist in working the drydock upstream and to help maintain its longitudinal axis position in direct line with the anchors. Other tugs were positioned at the downstream end for similar purposes.

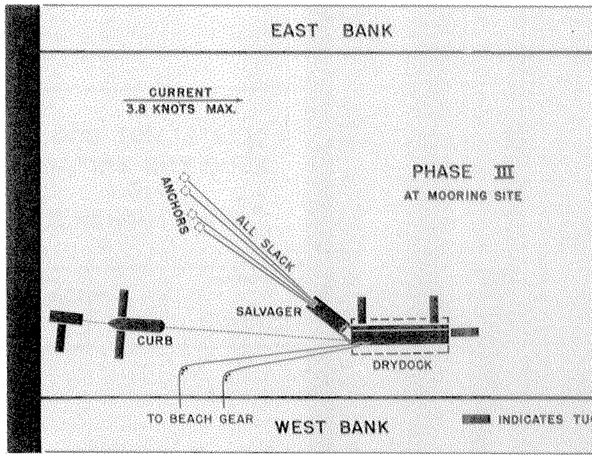
Halfway across the river, as the drydock swung out into the strong current, slippage of the anchor moorings negated the intent to move the drydock upstream by means of the winch power of the SALVAGER and an alternate plan was put into operation. All nine tugs were repositioned and their combined horsepower, plus the 3,000-shaft horsepower of the CURB, were utilized to push and pull the drydock the remaining distance to the west bank. At 6:18 p.m., only 18 minutes behind schedule, the river was reopened to traffic.

At the Pacific Street salvage site, the drydock was made fast with 13 sets of beach gear, all of which later were used in the righting operation. A lift ship was positioned fore and aft of the drydock, and ballast was taken on to ground the hull securely on the river bottom.

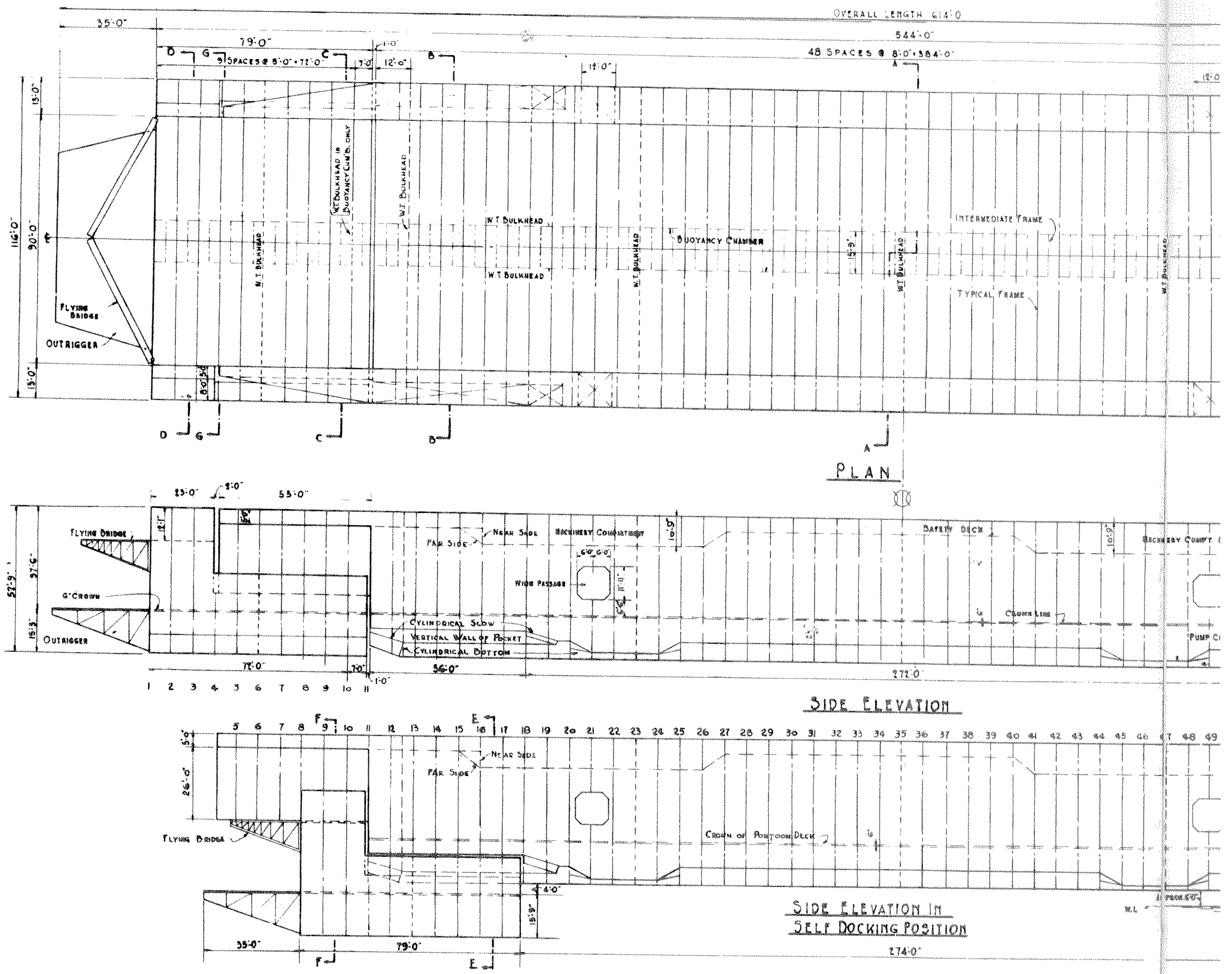
RETURNING DRYDOCK to salvage site on west bank required the services of three Navy ships—salvage ship CURB and lift ships SALVAGER and WINDLASS—and nine tugs. Plan called for AFDM-2 to swing pendulum fashion on four lines fastened to anchors dropped in mid-river as ships pulled and pushed her across. Anchors slipped, however, and move was completed under alternative plan.

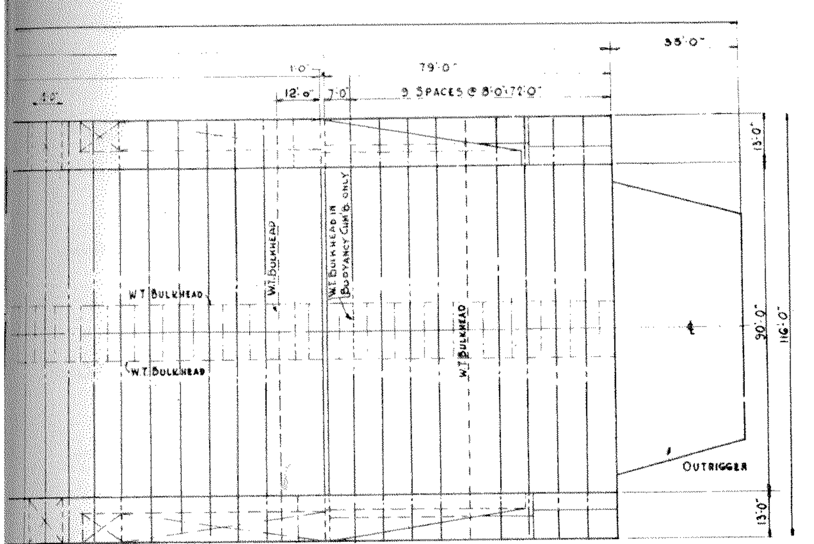


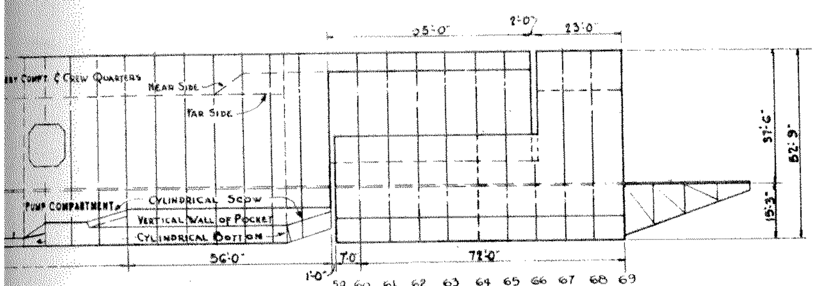


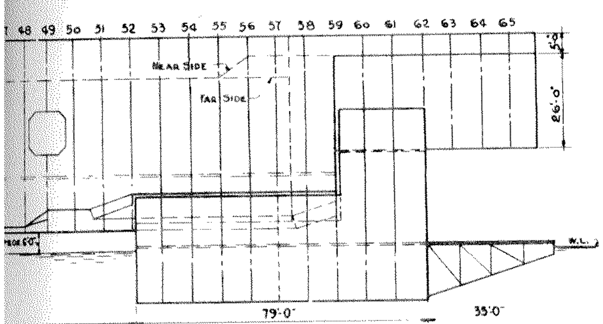


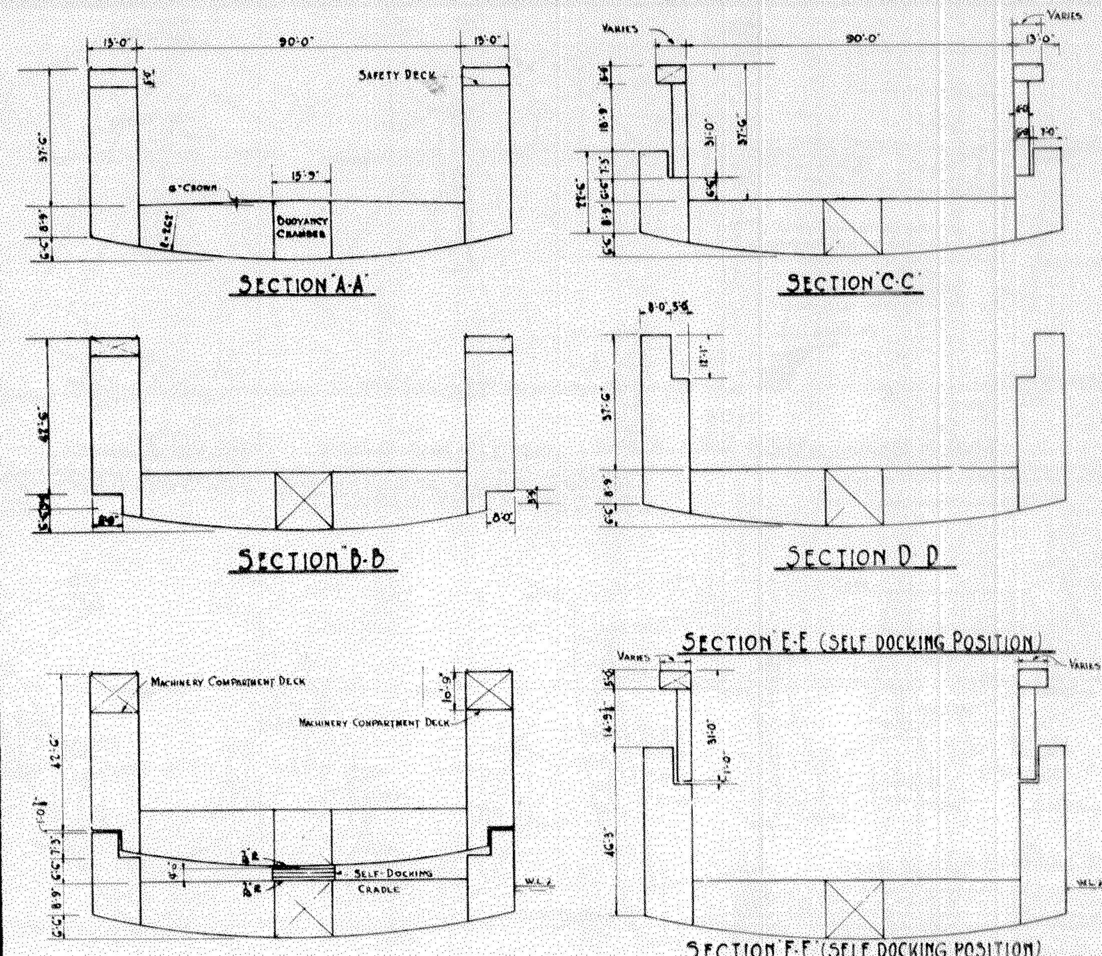
engineering data and drawings





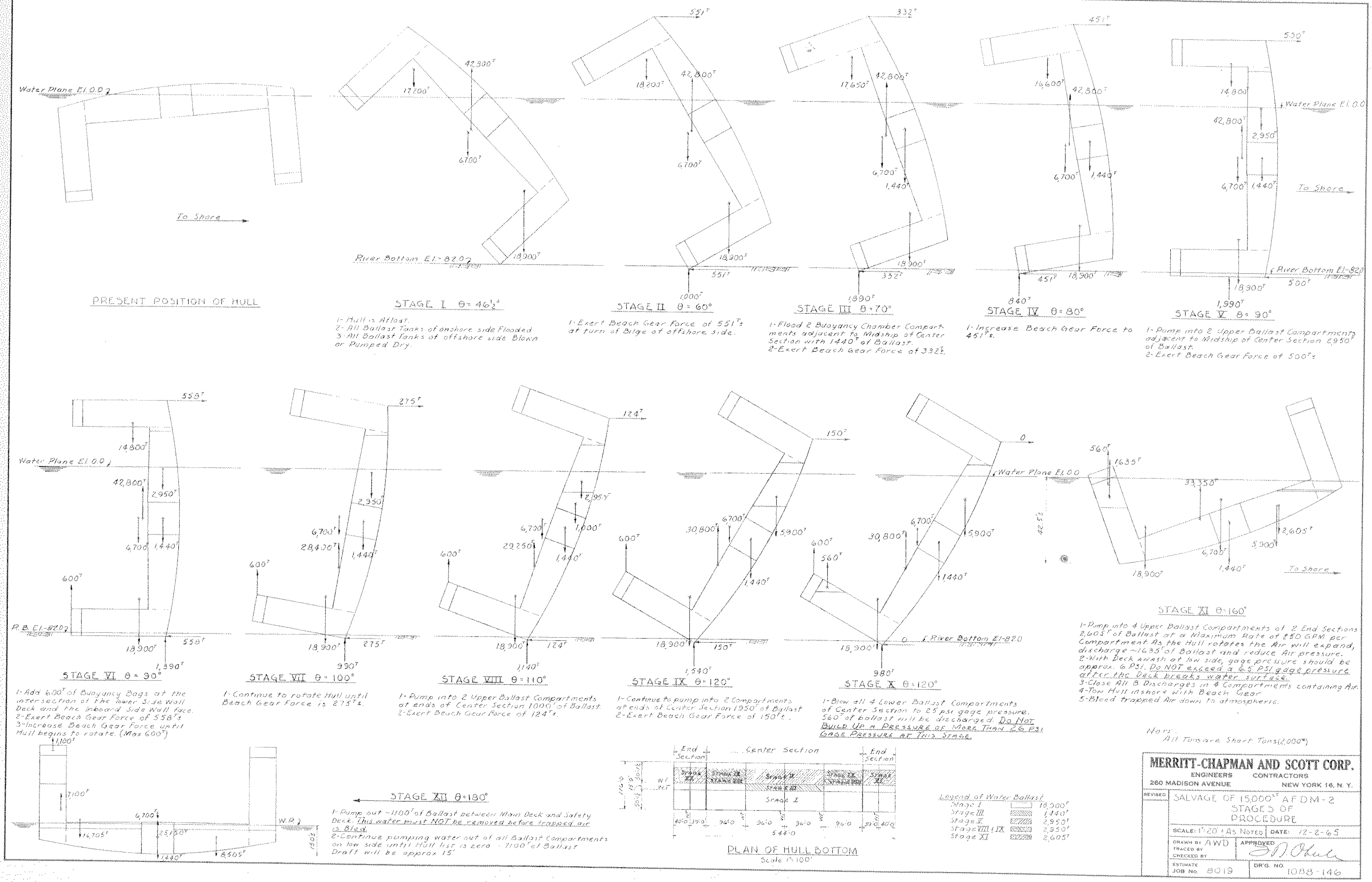




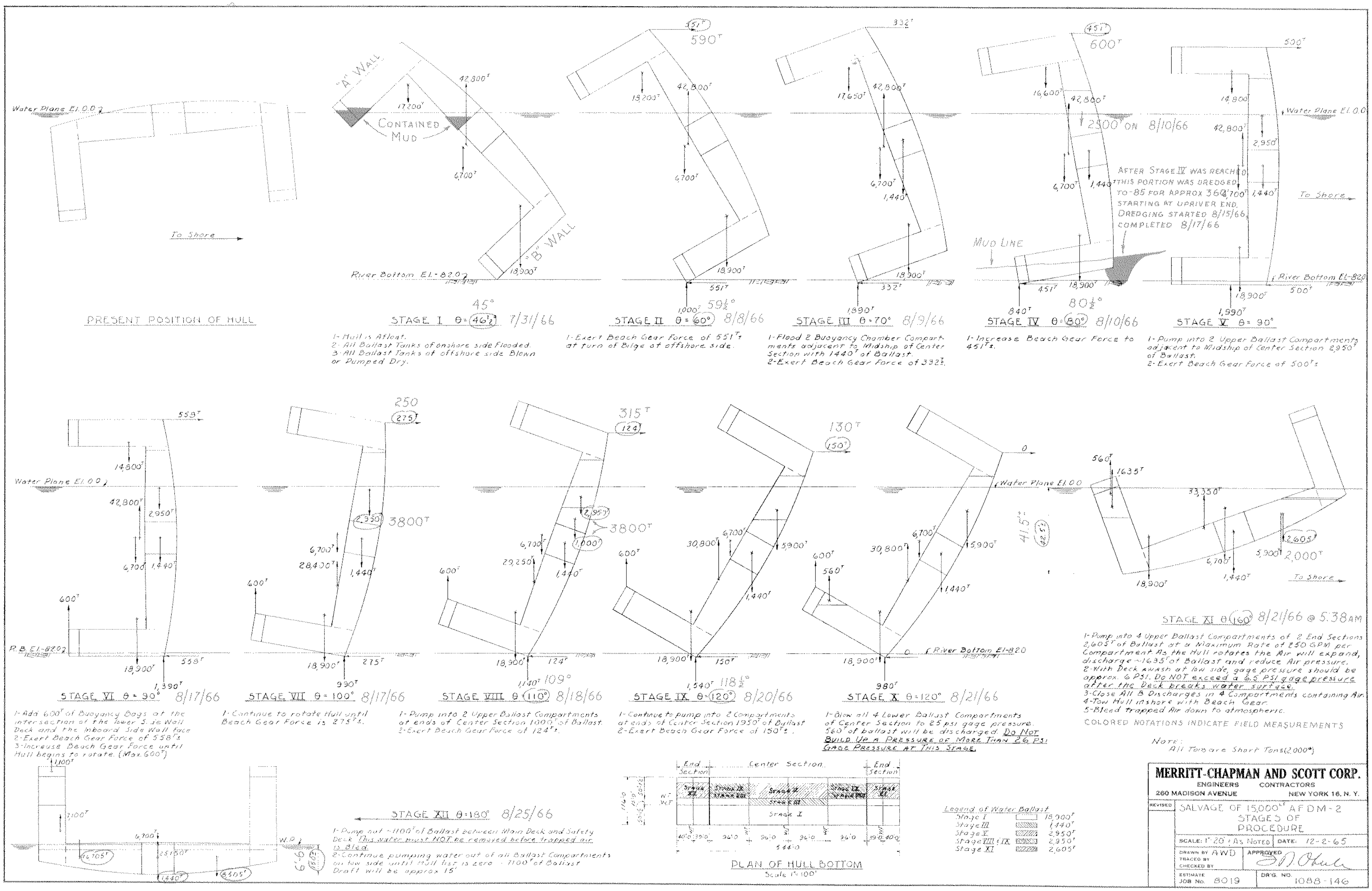


15,000 TON STEEL
FLOATING DRY DOCK
MILITARY
GENERAL PLAN

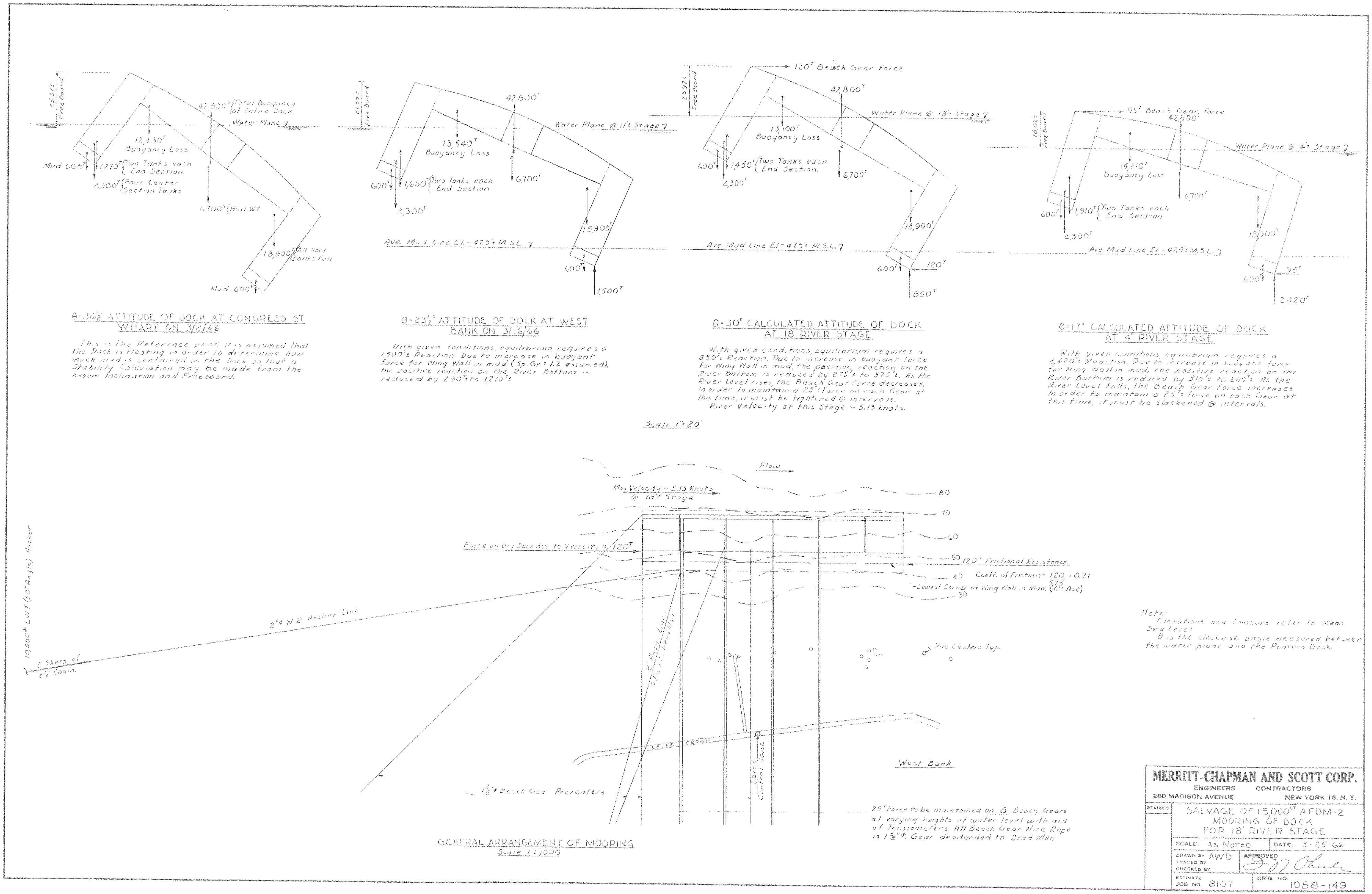
DRAWING NO. DC-110-1
DATE: JUNE 1941



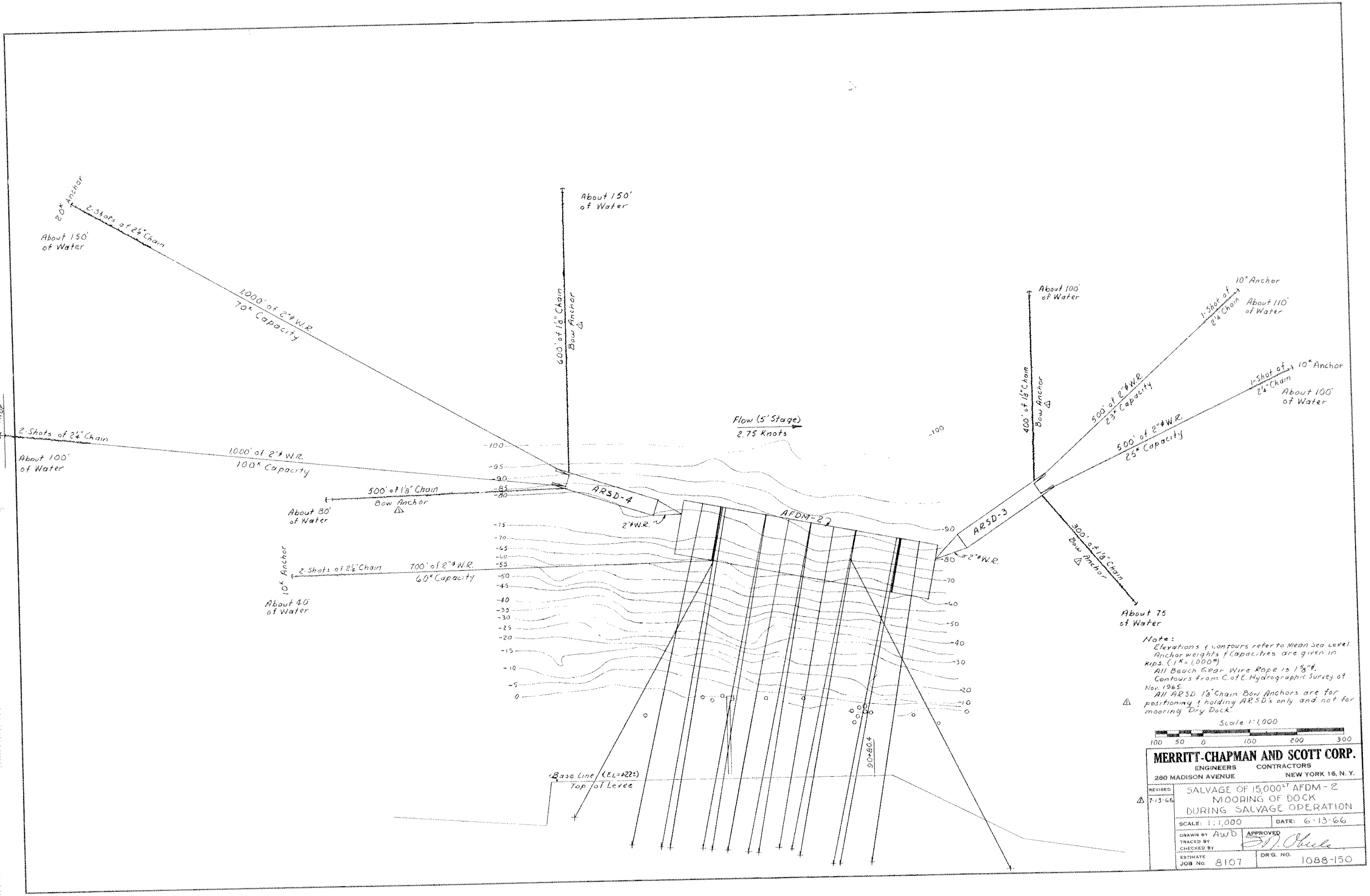
THE 12-STAGE SALVAGE PLAN — AS CALCULATED



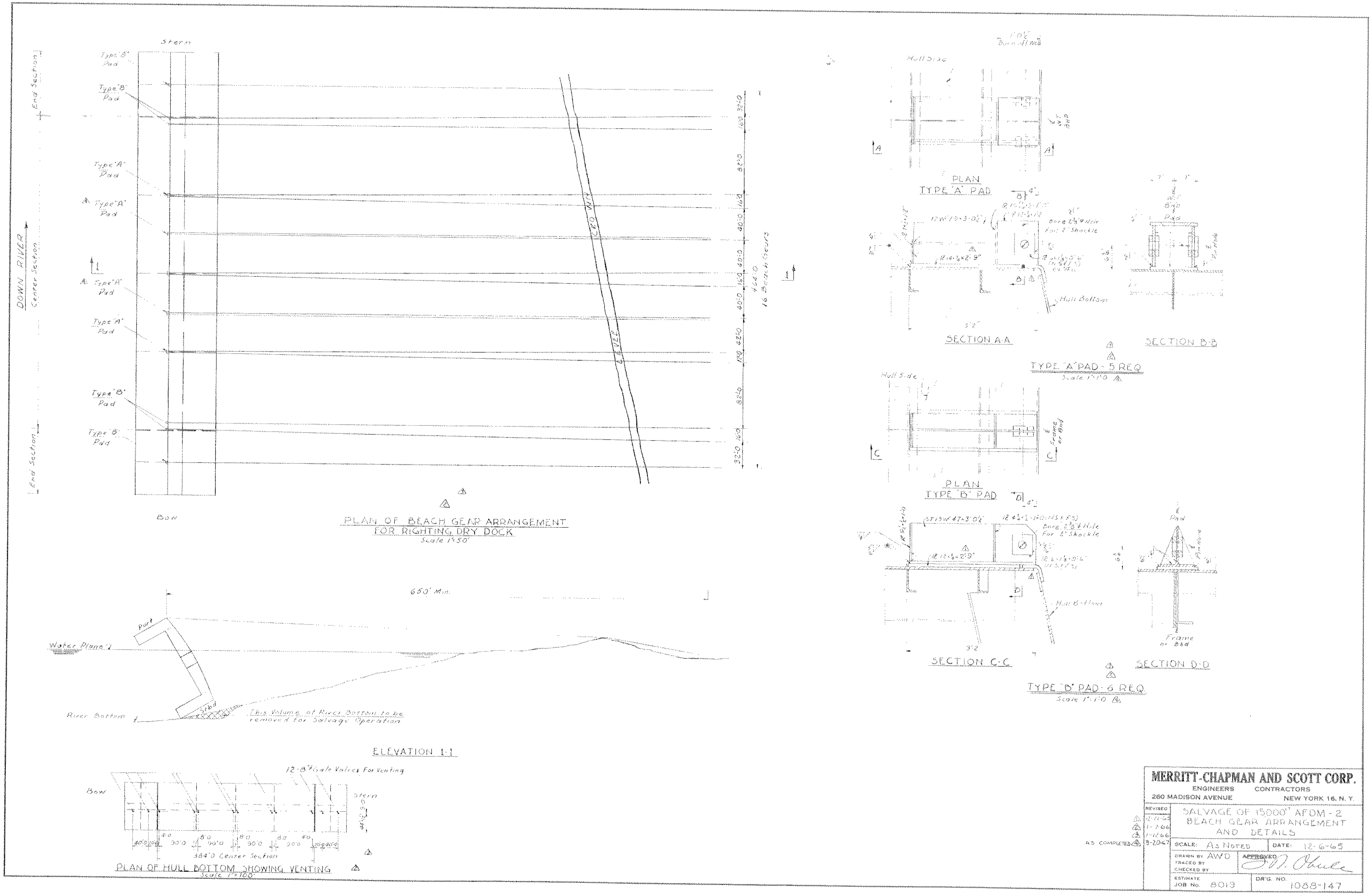
THE 12-STAGE SALVAGE PLAN — AS EXECUTED



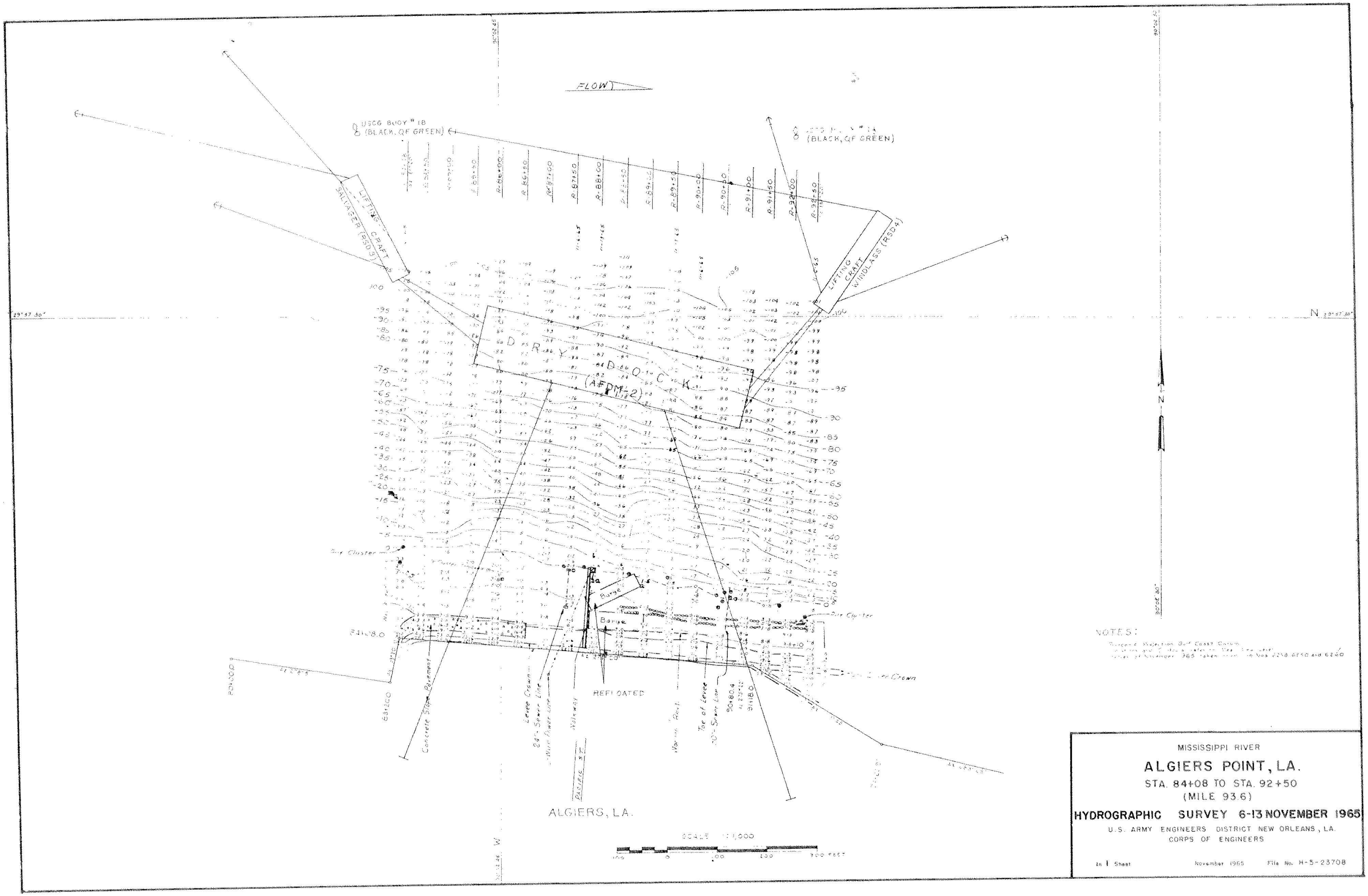
MOORING ARRANGEMENT DURING HIGH WATER STAGE



MOORING ARRANGEMENT DURING SALVAGE

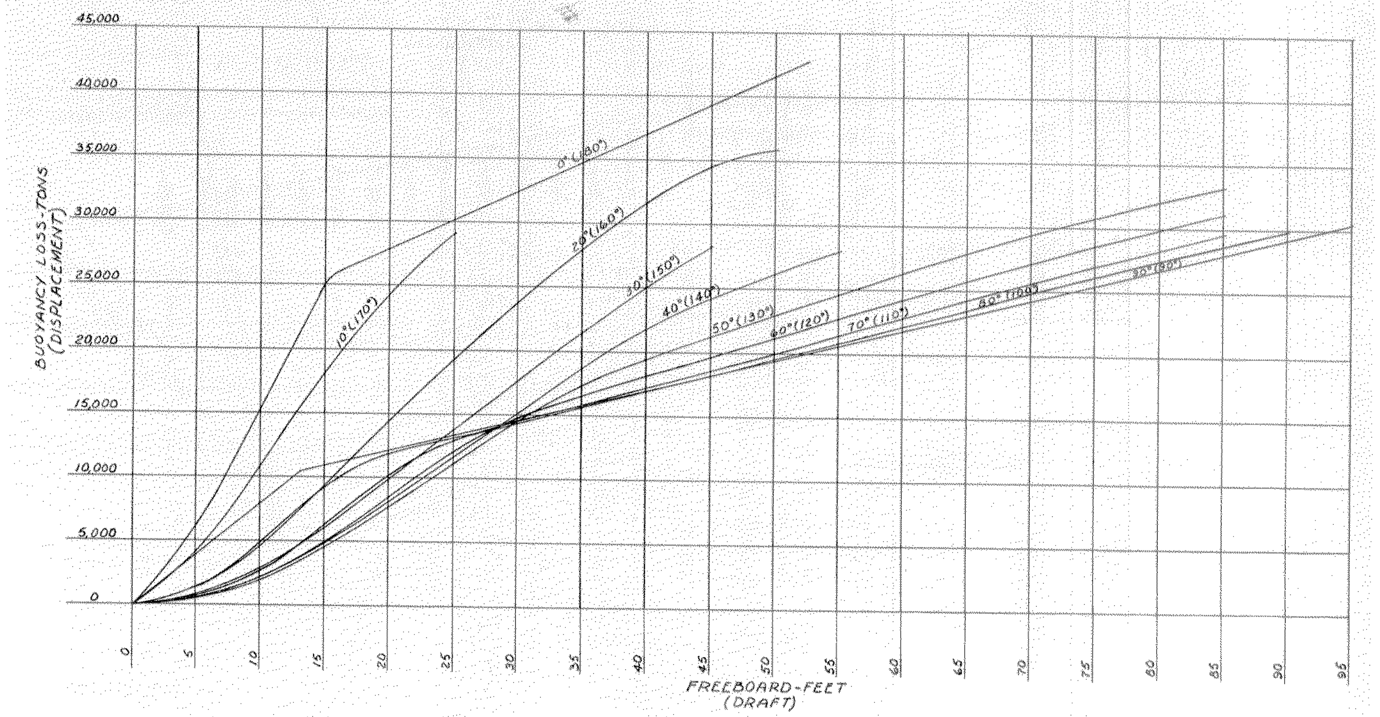


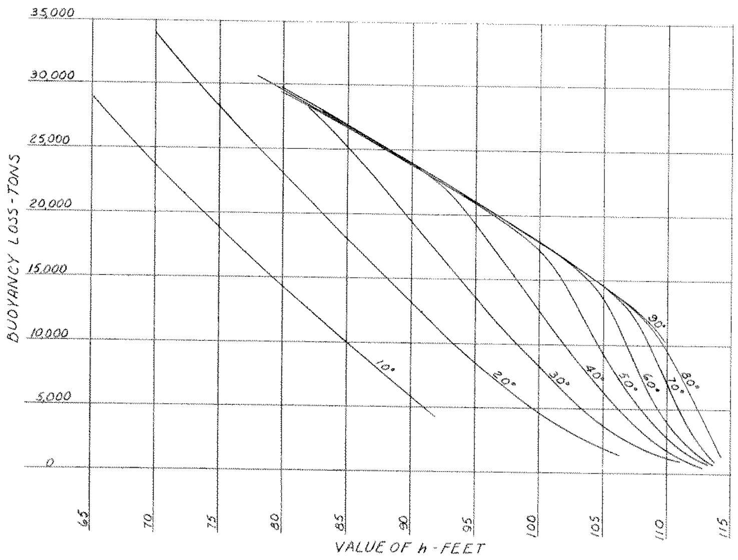
BEACH GEAR ARRANGEMENT DURING PARBUCKLING

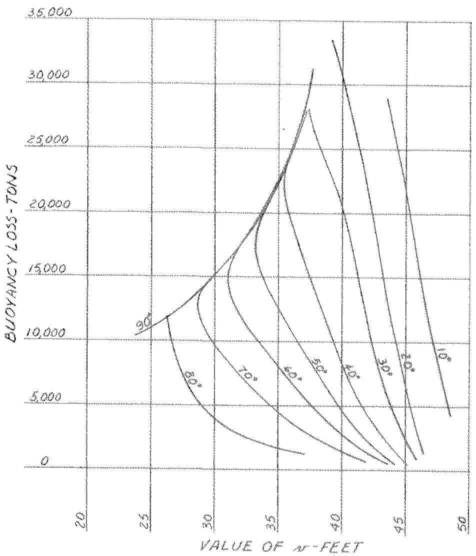


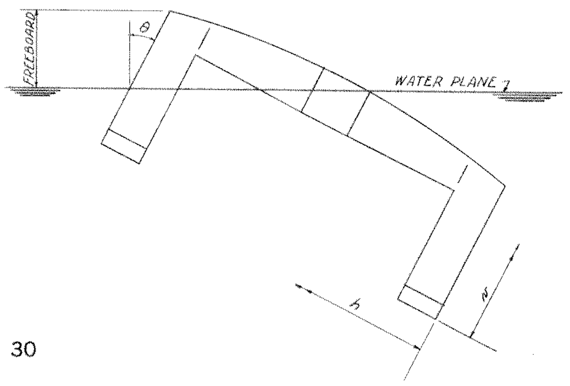
HYDROGRAPHIC SURVEY OF SALVAGE SITE

CURVES TO DETERMINE STATIC STABILITY AT VARIOUS SALVAGE STAGES









THE FINALE: Nearly one year after AFDM-2 was torn from her moorings during Hurricane Betsy, she was returned to Todd Shipyards' Algiers yard for extensive repair and refurbishment. Navy-owned salvage ship CABLE (foreground) and two tugs towed the huge drydock two miles from salvage site to yard.

SALVAGING OF AFDM-2

Performed for the United States Navy, owner of AFDM-2, by the Marine Salvage Division of Merritt-Chapman & Scott Corporation, salvage contractor (NObs-3688), under the direction of the following:

UNITED STATES NAVY

CAPTAIN W. F. SEARLE, JR., USN
Supervisor of Salvage, USN

CAPTAIN H. A. GERDES, USN
Industrial Manager/Supervisor of Shipbuilding, USN
Eighth Naval District

LIEUTENANT W. N. KLORIG
LIEUTENANT W. H. SMITH
Resident Salvage Officers

MERRITT-CHAPMAN & SCOTT CORPORATION
MARINE SALVAGE DIVISION

FRANCIS N. OBERLE
Vice President

ROBERT K. THURMAN
Project Manager

ANDREW W. D'ANGELO
Project Engineer

HENRY C. HALBOTH, JR.
NELSON R. HILLER
Salvage Masters

THIS TECHNICAL REPORT
CREATED AND PRODUCED BY
J. Edward Klein Associates, Inc.

WRITTEN BY
Frank W. Corrigan

DESIGN AND ILLUSTRATIONS
Rudolf F. Schaefer

PHOTOGRAPHY
Stephen S. Roszel, Jr.

DEPARTMENT OF THE NAVY
SHIP SYSTEMS COMMAND