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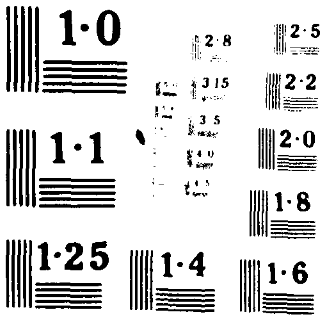
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REPORT ON RESULTS OF THE CONVENTIONAL BREAKBULK SHIP PRETEST OF THE JOINT LOGISTICS-OVER-THE SHORE (LOTS) TEST AND EVALUATION PROGRAM

29 October 1976

Prepared under
Contract Number MDA-903-75-C-0016
For the Office of the Secretary of Defense,
Deputy Director, Defense Research and Engineering,
(Test and Evaluation)
Washington, D.C. 20310

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The primary objective of the Conventional Breakbulk Ship Pretest was to determine the capability of the Services to use such a vessel for deploying selected heavy, outsized LOTS equipment to a site where fixed port facilities do not exist. This test, conducted during April 1976, was the first of five planned preliminary tests, the others employing a heavy-lift breakbulk ship, containership, LASH and SEABEE. (cont. on back)

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20. Abstract

The principal test items were the Army's two newly acquired container handling cranes (140-ton and 300-ton capacities), and Army LCM8 landing craft and Navy 3 X 15 floating causeway. The cranes were disassembled so that the weight of each major component was less than 60 long tons, the maximum capacity of heavy-lift booms on the majority of cargo ships. The causeway weight exceeded this capacity by only 0.3 long tons. The risk of making that lift would normally be acceptable under emergency conditions.

All major test objectives were successfully achieved. One difficulty, a sling design problem that prevented the outloading of the P&H 9125 crane, was considered solvable (and has since been accomplished in another pretest). The P&H 9125 was landed by LCU (the boom sections were loaded aboard ship), fully assembled on the beach, and used to assist in the assembly of the larger crane.

Both cranes suffered minor boom damage primarily from swaying into hatch coamings during discharge. Training deficiencies were noted as well as the effects of off-shore sandbars and currents on the abilit, of boat crews to land equipment on the beach.

Data collected during the pretest were analyzed in detail for use in planning for subsequent tests, for documentation of causes behind operational difficulties, and for evaluation of stresses in the ship's gear while hoisting heavy lifts in a seaway.

The conclusion reached is that LOTS equipment can be deployed by conventional breakbulk ships with heavy-lift boom capacities of 60 or more long tons and discharged into LCM8 landing craft in a calm to moderate sea for movement to shore. The containership cranes can be landed with minimum beach preparation, reassembled on the beach, and positioned for subsequent container operations.

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I. INTRODUCTION

BACKGROUND

One of the major conclusions of an analysis on the feasibility and definition of a Joint Logistics-Over-The-Shore (LOTS) operational test[1/] was that a series of preliminary tests were required relating to the deployment of LOTS major end items on typical merchant vessels. The types of vessels recommended for pretesting included a conventional breakbulk ship, a Lighter-Aboard-Ship (LASH) vessel, Sea-Barge (SEABEE), a non-self-sustaining container-ship, and a heavy-lift breakbulk ship. The objectives and results of pretests for each type vessel are addressed in separate reports.

The objectives of the conventional breakbulk ship pretest were: to determine the capabilities to use a typical commercial breakbulk ship to deploy selected heavy and outsized, mission-essential LOTS system equipment to an operational site where fixed facilities are not available; to resolve potential technical problems in disassembly for deployment, loading/unloading, and reassembly of the larger test items; and to refine main test planning.

This pretest involved the in-port loading by contract stevedores of LOTS system equipment aboard a commercial breakbulk ship, the movement of the ship to an off-shore anchorage for the unloading of the ship by Army and Navy stevedores, and the movement ashore by landing craft. The pretest design called for the loading of the Army's tactically disassembled P&H 9125 truck-mounted crane (140-ton capacity), a 3 X 15 causeway section, a LACV-30 (Lighter, Air Cushion Vehicle), an LCM8, a frontloader, and a sideloader. A primary objective of the test was the disassembly, loading/unloading, movement ashore, and reassembly of the Army's P&H 6250 model truck-mounted crane (300-ton capacity).

[1/] Operations Research, Inc., Feasibility and Definition of a Joint Logistics-Over-The-Shore (LOTS) Operational Test, ORI Technical Report No. 913, 30 April 1975.

Some of the above recommended test items were eliminated from the pretest loading plan. The frontloader and the sideloader on hand for test and evaluation were not the items selected for ultimate use in the terminal service company (container) table of organization and equipment (TO&E).[2/] The TO&E versions had been placed on order but were not received in time for the conventional breakbulk ship pretest. Both the TO&E sideloader and frontloader are larger than the original developmental test items identified in the LOTS Pretest Design.[3/] Both require disassembly for lifting by booms of a typical conventional breakbulk ship (60-long ton capacity or better). Additionally, movement of these items to shore by LCM8 and reassembly on the beach is required to validate the capability to deploy them. (The 70-ton sideloader was successfully [illegible] a LASH vessel, discharged off-shore into an LCM8, and lightered to shore during the LASH ship pretest 23-27 August 1976.)

An additional item not included in this pretest was the LACV-30. Two pre-production models were scheduled for delivery but only one was received by the Army before the test. Certain of its trials have to be completed before it can be tested in a LOTS environment. To date some of those trials are still in process.

The ship selected for the test was an AMERICAN CHALLENGER-class vessel (MARAD designation C-4-S-57a, abbreviated C457). This ship was acceptable as being representative of the majority of U.S. merchant marine vessels. Its jumbo boom capacity is 70 long tons and serves two holds instead of one. It is one of the most available type commercial breakbulk ships for sealift deployment since all eleven ships of the class are under charter to the Military Sealift Command (MSC). All of the lifts except the Navy's causeway section are within the boom capacity of the majority of U.S. merchant breakbulk ships, that is, 60 long tons. The causeway section weighs 60.3 long tons and under emergency conditions the .3-ton excess would normally be an acceptable risk.[4/]

Initially, the master of the SS PIONEER COMMANDER was consulted regarding ship capabilities and operational techniques to be employed. Before the test could be executed, the PIONEER COMMANDER was committed to another voyage and was replaced by the SS AMERICAN COURIER, a sister ship.

One question received considerable attention in the process of load planning and led to conferences with ship owners and engineers of U.S. Lines. This related to the capacity of the ship's boom to accommodate the heavy lifts

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2/ The original test sideloader and frontloader were intended to move only 20-foot containers. The new TO&E items, weighing approximately 70 (short) tons, will be able to handle 20 to 40-foot containers.

3/ Operations Research, Inc., Design of Preliminary Field Tests for the Joint Logistics-Over-The-Shore (LOTS) Test and Evaluation Program, ORI Technical Report No. 993, 6 January 1976.

4/ For further discussion on the causeway load and discharge operation see the paragraphs under Loading and Unloading.

planned even though the lifts were well within the design limits of the boom.[5/] Since ship motion increases the forces on the boom structure, the question was raised whether or not the boom could withstand these forces (specifically in a sea state three) while handling the heaviest of the test lifts. U.S. Lines authorities had no initial qualms about their ships being capable of handling the proposed lifts under the prescribed conditions. Nevertheless, they did make the necessary calculations to validate their judgments that the lifts could be safely made.

Two technical problems surfaced concerning the deployment of the 6250 crane. First, would the carrier fit in the well of the LCM8 and, second, would the LCM8 with the carrier be seaworthy during the ship-to-shore movement. A third problem evolved later concerning the placement of the 6250 crane upper into an LCM8 and their safe movement ashore. All of these problems were meticulously examined to minimize the possibility of personnel injury or equipment damage.

The Joint Test Directorate tasked the study of the fit of the carrier in the LCM8 to the J.J.Henry Co., Inc. As a result of this tasking a design for a ramp was provided and fabrication was ordered by the Joint Test Directorate. (See Figure 1, the LCM8 with ramp and 6250 crane carrier.) The second problem, seaworthiness of the LCM8 with the carrier, was partially confirmed when the carrier was backed into the LCM8 without the specially fabricated ramp and test runs were made on the James River. These runs resulted in no ventilation of the LCM8's propeller nor was the craft excessively down in the bow. However, the LCM8 did have a noticeable starboard list because the carrier was not centered longitudinally. Also the LCM8 did ride with its main deck parallel with the water when it normally rides with its bow quite high.

The third problem, off-loading the 6250 upper onto a trailer in an LCM8, was less apparent at the time of the Pretest Design than it was after the 6250 crane had been disassembled. Two factors altered the Pretest Design, which suggested leaving the upper mobile-loaded for the duration of the loading and off-loading phases. First, the 24th Transportation Battalion determined that it could save approximately 5-7 days reassembly time if the gantry were left on and the cables and drums were not removed. This meant that the upper section had a weight of approximately 54 long tons. This is some nine tons more than indicated in the Pretest Design, but still left it within a 60-long ton boom capacity. Second, a different trailer from that suggested in the Pretest Design was used. The upper was placed on a trailer new to the Army inventory, the M747. The trailer weighs approximately 14 long tons and is 42 feet 11 inches long. It is 5 inches longer than the hatch through which it had to go to be stowed. This meant that the new semi-trailer had to be lowered with a pronounced tilt in order to clear the hatch. Thus, the trailer and the crane upper had to become two separate lifts instead of one. In turn, this meant that the upper had to be loaded either onto the trailer on the main deck and then the two lowered over the side, or onto the trailer already loaded in the LCM8. Consolidating the two lifts

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[5/] The Stülken Boom (70-long ton capacity) when originally installed was tested to lift 140 long tons. It is tested annually pursuant to American Bureau of Shipping Regulations to accommodate 77 long tons in a dynamic mode (i.e., with the boom moving the load). The ship was designed to be capable of unloading 70 long tons in a seaway. The maximum lift in the present test was 60.3 long tons.

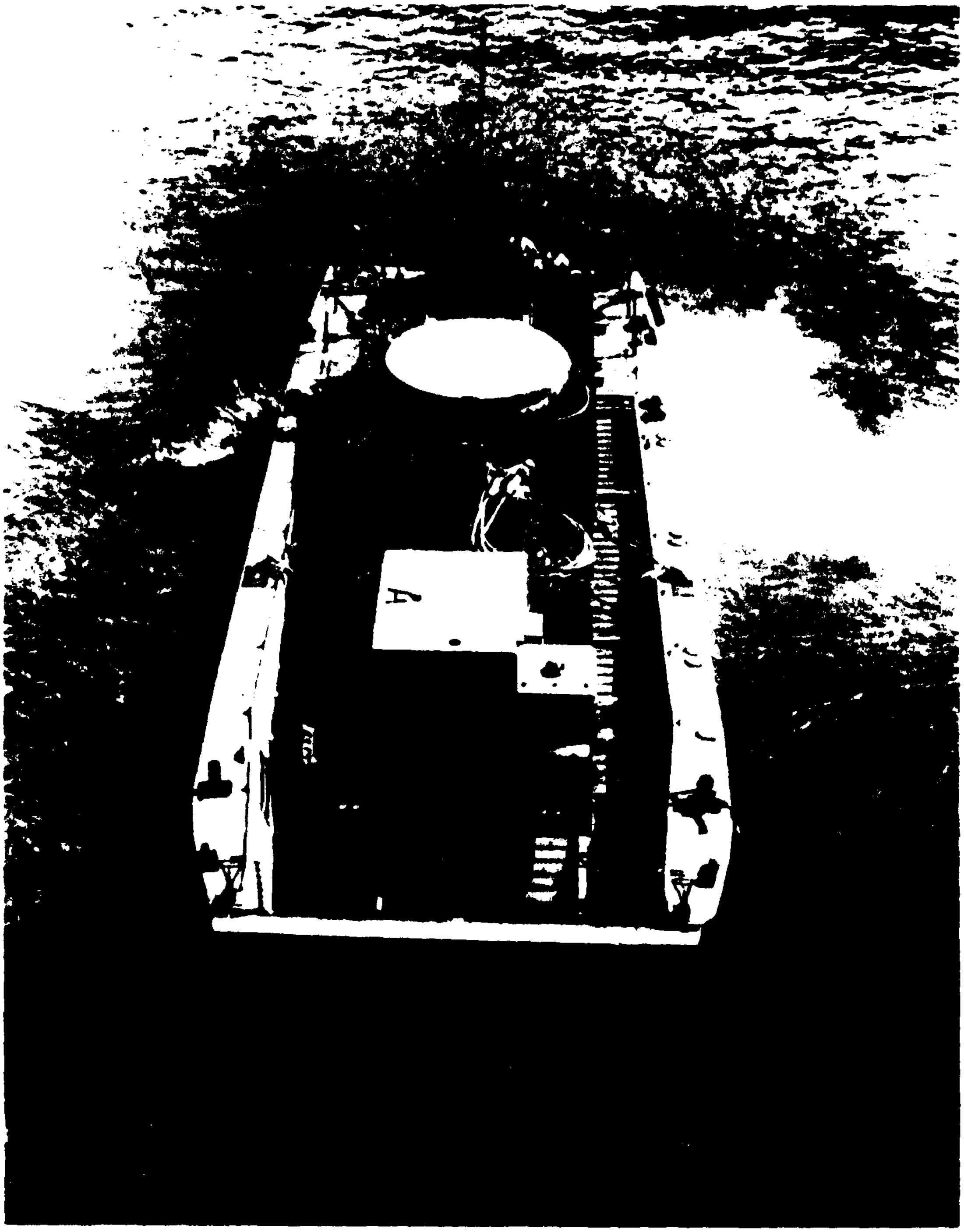

FIGURE 1. P&H 6250 CRANE CARRIER LOADED ON AN LCM8 WITH WELL DECK RAMPS

on the main deck was preferred and this procedure had the concurrence of the master of the PIONEER COMMANDER. It apparently had not been discussed with the master and first mate of the AMERICAN COURIER. This oversight resulted in a subsequent problem discussed below.

The ship's part in the exercise began April 19 with the embarkation of 16 mobile-loaded trailers together with the upper and its trailer. Commercial stevedores were used for loading in port at Pier 4, Naval Supply Center, Norfolk, Virginia. Loading was completed April 20 and the ship set sail for the beach off Ft. Story, Virginia, early in the morning of April 21. LOTS personnel boarded the ship at approximately 0600. The ship was off-loaded and set sail 2200 April 22. The crane reassembly was completed April 26.

PRETEST RATIONALE

The capability to use commercial ships to deploy LOTS system equipment to a site where adequate fixed facilities are not available is an important consideration for all of the Services. The equipment selected for deployment testing posed challenging loading/unloading, handling, and movement problems markedly different from those of other military cargo handling and transport equipment. Because these items were new, equipment such as the P&H 6250 crane had never been transported by military stevedores and terminal personnel in an operational environment. To reduce ship charter time only those beach and lighterage items of central interest were included in the pretest.

Operations in a seaway complicate unloading and, as the severity of sea conditions increases, the capability to off-load decreases. Because of the weight and size of the selected LOTS equipment, boom capacity and hatch square sizes of available breakbulk ships are marginal for handling and stowage and necessitated check tests to verify the practicability of this deployment means.

Finally, a key question to be resolved was— could the LOTS equipment be lightered from the ship to shore using only lighterage deployable by the conventional breakbulk ship. While lighterage could be loaded using port facilities and deck stowed, the question was whether the ship could unload the lighterage in a ready-to-use condition. If that could be done, then the test would have established that a conventional breakbulk ship could be used to embark and discharge its own heavy LOTS equipment and also provide a limited capability for the handling and throughput of containers. This verification of equipment deployment capability would eliminate total reliance on a limited number of specialized ships as the only means available to deploy a LOTS system capability.

MEASUREMENTS MADE

A basic reason for the pretests was to find whether or not certain difficult tasks, particularly heavy lifts, could be accomplished operationally. Thus, measuring such factors as clearances was considered more important than measuring times. Time required for various operations was recorded, but these readings are considered significant chiefly as guidance for main test planning and as an indicator of troop learning.

Records were made of the sea state during off-loading and of the pitch and heave motions of an empty, instrumented LCM8. The latter was intended to simulate the motion of an LCM8 being loaded. For some of the off-loading lifts a load-cell was used in an effort to record any extra force that might occur as a result of ship or lighter motion.

The decision to measure the sea state, the motion, and the load was made with two foreseen difficulties in mind:

- That the chances of encountering a substantial sea are small at the time of year of the test. (In fact, the predominant movement of air during the year is off-shore for the East Coast of the U.S.)

- That there probably would be an inadequate basis for interpreting test measurements at this time. (There is, as yet, no known theoretical analysis that indicates to what degree specific conditions such as pendulation, impacts on lighters, etc., slow up or stop off-loading operations as the sea state increases.)

It was decided before the test to accept these limitations. In fact, the primary basis for the decision was to have a record of the sea state in the event that the sea state might cause a judgment that it was not safe to off-load test items into the LCM8s. It was also decided not to instrument for ship motion since ship motion would likely be small while the expense of measuring it would be considerable.

PRETEST REPORTING

Data were collected by military personnel during the pretest and a detailed report has been published for the LOTS Joint Test Directorate (JTD). The report provides general background, preparations, and a chronological sequence of events,[5/] and does not present an analysis of test results. This ORI technical report (prepared under contract for DDR&E) analyzes the data and pretest results. These data will be used, as appropriate, in the LOTS main test design. It should be noted that this report was based not only on the data published for the JTD but also on data collected by ORI observers during the pretest. In some cases, the latter data provided greater detail required for certain analyses and in other cases it was used to correct or fill gaps in the JTD data base.

[5/] Appendix C of this (ORI) report contains a listing of references used; the pretest data report is cited as Reference 3.

II. OBSERVATIONS AND RESULTS OF MEASUREMENTS

GENERAL

Loading operations were conducted pierside in fair weather conditions. Numerous observers consisting of data collectors, Army and Navy stevedores, photographers, Naval Supply Center (NSC) personnel, JTD members, and several other miscellaneous groups crowded the loading area. Some observers justifiably had requirements to be close to the working area, while others should have been kept from the hatch area and observed the exercise from the ship's bridge. Visitor control was not originally considered a major problem but interest in the pretest was higher than had been anticipated, resulting in congestion in the work areas.

At the anchorage weather conditions were, for the most part, excellent. Wind conditions from time to time did cause some wave activity, but the significant waves (i.e., the highest 1/3 measured) did not exceed 3½ feet in height at any time. During the 40-hour period the ship was at anchor, the off-shore currents caused a shifting of the ship's position of approximately 1,000 yards. This did not endanger the ship but it did point out reasons for some of the difficulties with the current experienced in the surf zone (discussed later).

Troop experience varied considerably between Army and Navy units. Both observed the contract stevedores during the load-out phase and then during the unloading phase alternated their personnel in operating the ship's 70-ton boom and handling tag lines. Although it was not intended to compare the two units with each other, Navy personnel clearly were more familiar with what had to be done and were more aggressive in their hatch square operations. Near the end of the off-loading, however, Army stevedores appeared to gain confidence and to operate more effectively as their experience increased. Both units needed the training on commercial equipment, an understandable limitation in view of the high charter costs and restrictive commercial stevedore contractual requirements.

Army lighterage had considerable difficulty at low tide crossing a sandbar which slowed beach operations. Ship unloading was not affected since considerable time was required in handling the large, outsized LOTS equipment. Ship off-loading was delayed by the slow response of lighterage to report to ship unloading stations between lifts. Once a lighter has cast off, another lighter should be close by and ready to moor when signaled by the hatch foreman or officer-in-charge of unloading. This was not always the case as lighters sometimes had to move into position from stations approximately one-half mile away. Initially, mooring times were slow because a mooring line was not available to assist or hold lighterage in position. This item should have been provided by stevedore crews before the first lift went over the side. Some landing craft also lacked lines and fenders. As with the stevedore crews, performance of the lighterage crews improved with experience.

The only Navy lighterage used in the unloading was a causeway ferry and two warping tugs (converted LCM6's). There were no problems in the employment of the causeway ferry and it expeditiously landed four trailer loads.

As previously mentioned, it was originally planned to use the PIONEER COMMANDER but later she was replaced by the AMERICAN COURIER. Both ships' masters agreed to the test loads and did not appear concerned about their ships' capabilities. Both captains had considerable experience, especially with Victory ships. There was no discourse with the ship's crew other than the captain of the PIONEER COMMANDER. With the AMERICAN COURIER the ship's chief officer ("first mate") was personally involved with all the large and outsized lifts, even when commercial stevedores were loading the ship. Operating procedures previously negotiated with the PIONEER COMMANDER did not receive the same concurrence from the AMERICAN COURIER's first mate. In part, this might be attributable to the background of the first mate who was a younger individual, not as experienced or comfortable in handling the outsized test loads.[1/] This emphasizes the need to fully coordinate operating procedures whenever personnel/ship changes may be involved.

LOADING

Observations

Thirty lifts were made or attempted in loading the various elements of one 6250 crane and a 9125 crane, an LCM8, and a causeway section aboard the ship. The ship's 70-ton boom was used for all cargo lifts and loading/unloading dunnage, tools, and gear. The 10-ton or 15-ton booms were used to close the hatches and assist in some of the clean-up work.

No emphasis on speed or urgency was intended in the test. Loading was accomplished by the contract stevedores in a deliberate manner, perhaps sometimes slowed also by the number of observers in the vicinity of the hatches. Nevertheless, loading could have progressed more expeditiously.

1/ Based on comments made by the ship's master.

Certainly loading of the trailers could have been expedited by the use of the smaller booms that have a faster working speed than the 70-ton boom. Further, hatches could have been opened at more opportune times than was accomplished. Booms other than the one required to load the hatch could have been used more often to open/close hatches and load dunnage, tools, etc.

Two items were noted as damaged during loading. The first, the 6250 crane upper, received minor damage when the shoring upon which it was placed collapsed. The damage was repaired while the crane was being assembled on the beach. The second item known to have been lightly damaged during loading was the 9125 crane cab. This damage occurred during the attempts to lift the crane.

On the first attempt to hoist the crane, the cab was pointed aft of the carrier. As the crane was lifted off the boat deck, it tilted sharply to the right, slightly denting the right side of the upper from one leg of the sling. The slings were unhooked, the LCU moved away from the ship, and the crane was started up. The crane cab position was reversed so that the boom base then pointed forward. On the second attempt the crane again tilted but this time to the left. Both attempts having failed, the crane was administratively introduced onto the beach by LCU.

The difficulty initially appears to be the result of a combination of factors. According to interviews with crane personnel, it was believed than when the crane was first hoisted with that particular sling, several conditions apparently were different from previous lifts made by P&H. When tested, the crane had no fuel in it. When embarked, it had a nearly full load of 225 gallons of fuel in its tank which is located on the left side of the crane upper, adding approximately 1,350 pounds to that side. Second, a small generator was also added to the crane, also on the left side. Third, the sling used had as an integral part a strongback shaped like an inverted "T." Such an arrangement is much more sensitive to imbalance than an ordinary sling having four parts that come together in an apex. Subsequent to the test a new sling was designed. It performed adequately in a pretest of a different ship. Thus, there is good reason to consider that the test lift would have been successful except for the sling, and that the test on the overall was basically successful.

With the C457 type ship the heavy-lift boom services holds 3 and 4. To do this a change-over is required. The normal procedure, no matter which direction the boom is traveling, is rather tricky. The boom, with the hook removed but block intact, relies on momentum and gravity to swing past a dead center position between the kingposts. Once changed over, the hook is re-attached and loading/unloading continues. The procedure was always accomplished by ship's company and took between 15 and 25 minutes.

Hatch opening and closing times varied. The hatch covers are divided into halves and there are three hatch covers for each level of the three levels of holds 3 and 4. The covers work on rollers and are activated by a line rigged to the ship's winches. To get both sections of a hatch cover open and permit access to the next lower level required 3 to 4 minutes on the average. Closing times were considerably longer, 7 to 8 minutes on the average. The rigging for closing is somewhat more involved and the hatch covers bind from time to time.

Measurements

In addition to the observations already discussed, specific measurements of hatch sizes (to establish clearances), dunnage requirements and the like were made for the record and are shown in the data report (see Appendix C, Reference 3). Times for each lift, and for closing or opening hatches, boom changeovers and the like were also recorded, as well as delays. An analysis of the time data is shown in Section III of this report.

OFF-LOADING

Observations

The off-loading operation began 21 April off Green Beach, Ft. Story. Weather conditions were excellent. The ship arrived at approximately 0540 and anchored approximately one mile off-shore. Army and Navy stevedores boarded shortly thereafter, followed by various observers.

Neither Army nor Navy personnel at that point had had much opportunity to use the booms, although some practice in closing and opening hatches was accomplished after in-port loading had ceased the first day. The ship's scheduled port arrival, a weekend holiday (Easter), and union regulations virtually eliminated planned practice periods. In effect, these limitations helped lend some realism to the test since in an overseas LOTS operation no practice periods with unfamiliar gear would be possible.

The ship's chief officer was most concerned with the progress of the exercise and frequently stepped in to assist, correct, and advise military personnel on ship off-loading procedures. Ship's company assisted in the installation of powered tag lines[2/] and passing the 70-ton boom between holds. Beyond these appropriate functions nothing else was done to interfere with the military use of ship's equipment.

The status of personnel training and lack of practice were apparent. Off-loading progressed slowly and cautiously. Under the first mate's watchful supervision the first lift, an LCM8 controlled by powered tag lines, was unloaded in approximately 2½ hours. Once the landing craft was at the ship's rail, it could well have been manned and then lowered over the side as is usual in Navy amphibious operations. As it was, delays were experienced in manning the craft. Shackles were used instead of a hook to rig the sling to the boom block. This also caused considerable delay in off-loading the LCM8. Both delays may be attributable to the inexperience of personnel. The craft was unloaded without serious incident and, as the unloading of other equipment progressed (particularly on the second day), handling and deck organization significantly improved.

A key objective of the breakbulk ship pretest was to determine whether the large components of the 6250 crane could be unloaded in a seaway. Two critical unloading steps were involved: the placement of the carrier inside an LCM8,

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2/ Powered tag lines consist of nothing more than employing the lines off snatch blocks or smaller booms as a means to steady the load. The winch is powered, blocks are rigged as necessary, and pendulation can thus be controlled. Rigging does take time, however.

the well of which is normally only about an inch longer than the load; and the placement of the 50-long ton crane upper section on a large trailer specially shored to seat the crane upper.

The first step, off-loading the carrier, required that ramps for the port and starboard sides of the LCM8 well deck be off-loaded. These were the second and third lifts. The first ramp went over very slowly. Lifting points had to be relocated twice to find the proper balance. The second ramp was loaded in about half the time and the LCM8 was ready to receive the carrier by 1100 hours.

By 1125 hours the carrier had been rigged and an initial attempt at hoisting the carrier was made, but some rerigging was necessary. It was 1146 hours before the boom was again ready and the power tag lines were hooked up. The carrier was rigged with its front end canted lower than the rear end in order that the carrier would be on a plane approximately parallel to that of the ramp. Its hoisting weight was 45 short tons. It was the fourth heaviest item in the test. Approximately 30 minutes later the carrier had been lowered into the LCM8. No major problems were encountered, although some non-structural elements on the carrier were slightly damaged. The carrier was then tied down and the landing craft proceeded toward the beach. The total time to off-load the LCM8, ramps, and carrier with a relatively inexperienced unit was 5½ hours. While the carrier was being discharged, the sea state was relatively calm.

The second major event was the off-loading of the 6250 crane upper section. The trailer used, an M747, exceeded the length of the hatch opening by five inches. As a result, the trailer had to be tilted when lowered or lifted. Initially the plan had been that the trailer would be lifted out of the hold and temporarily deposited on deck. Then the sling would be changed to level the draft and the upper would be retrieved from the hold and loaded on the trailer. Both would be lowered over the side as a single lift into an LCM8. This procedure had to be modified because the weight of both items (approximately 67 long/75 short tons) on the hatch square and time required to tie down and block the trailer on deck caused concern. It was then decided to first deposit the trailer on deck, readjust the front two legs of the sling, and then lower the trailer into the LCM8 without the crane upper section. Subsequently, the upper would be retrieved from the hold and lowered onto the trailer in the LCM8.

The original plan to temporarily deposit the trailer on deck had the concurrence of the master of the PIONEER COMMANDER, but it was discouraged by the AMERICAN COURIER's chief officer. The trailer was being lowered onto the closed hatch squares, when the chief officer decided it would be too difficult to lower and secure. Instead, the hardest possible way to off-load the trailer and the crane upper section was used. The trailer was lowered into the LCM8 at approximately a 35 degree angle, without incident in a fairly calm sea state. Since the trailer was removed from the hold with a tilt angle more than adequate for the clearance, the sling legs could have been adjusted (shortened) so that the trailer would have been lowered at a less severe angle.

The crane upper was also off-loaded in a fairly calm sea state. While being brought out of the hold, it developed a considerable amount of pendulation and banged into the ship several times. One error continuously made in manually handling tag lines was that all of the lines went out of the hold to persons stationed on deck. As a result, the lower the draft was in a hold, the longer the tag lines and the less control there was on pendulation. In this case, because of the criticality of the crane to a LOTS operation, powered tag lines rigged down into the hold should have been used even though it would have been slower. They were rigged for use while the upper was going over the side. This resulted in smooth, controlled off-loading. The upper was lowered to within a few inches of the desired position and with a little maneuvering was placed exactly in position. Together the upper and the trailer required almost two hours to off-load.

The largest and heaviest lift, the 3 X 15 causeway section, was to have been done using a load cell for measuring dynamic effects in a seaway. Because the slings were so long, it was decided to eliminate the load cell. This decision later proved to be a wise one as the block with the sling attached and the block at the boom tip were almost two-blocked at the extreme outreach of the boom just before rotating and lowering the causeway.

During the unloading the causeway section knocked over a short container stanchion located alongside the hold. The causeway started to drag somewhat across the hatch square and caught a container adapter fitting projecting above the stanchion and hatch. The fitting should have been removed from the stanchion. The impact broke the stanchion loose from its welded spot on deck. Besides the scrape marks on the hatch square and the broken stanchion, a tag line also bent outboard a section of the ship's skin along the gunwale.

Powered tag lines were used to steady the causeway. As the causeway was swung over the side of the ship and at the maximum outreach of that particular lift, the lightly loaded ship acquired a maximum list of 4.5 degrees to starboard and rolled to a maximum of 5.5 degrees. Unloading the causeway required well over an hour.

The sling used had four legs, each approximately 40 feet long, attached to the causeway about a third of the way in from each end. With shorter legs the lift could have been accomplished easier. Normally causeway sections are lifted with a 100-ton floating crane that doesn't have the topping up and space limitations of a ship's boom. According to the commanding officer of the unit which has causeway sections, shorter sling legs would pose no problems. A shorter sling, in turn, might well permit the stacking of causeway sections to increase the ship's deployment capability of these items.

Measurements Taken During Off-Loading

Data on Sea State and Motion of LCM8. The following is an excerpt from the summary of the data report on the test (Appendix C, reference 3).

> ... Table 1 below contains representative data on sea state recorded during the pretest by the instrumented wave riding buoy and platform motion instruments. This table shows wave heights in feet from peak (PK) to trough (TR), lighter (LCM8) roll and pitch in degrees, and lighter (LCM8) heave in feet....

TABLE 1

SEA STATE DATA*

Time 0746-0756, 21 April 1976, Army LOTS, Ft. Story						
	Average		Average Upper One-Third		Extreme	
	Peak	Trough	Peak	Trough	Peak	Trough
Wave	0.58	-0.62	0.89	-1.01	1.24	-1.64
Roll	0.77	-0.72	1.17	-1.22	1.60	-2.15
Pitch	0.63	-0.55	1.00	-0.87	1.48	-1.46
Heave	0.47	-0.45	0.74	-0.72	1.00	-1.19
Time 1152-1202, 21 April 1976, Army LOTS, Ft. Story						
	Average		Average Upper One-Third		Extreme	
	Peak	Trough	Peak	Trough	Peak	Trough
Wave	1.04	-0.91	1.83	-1.65	3.45	-2.82
Roll	1.29	-1.25	1.53	-1.56	1.72	-1.81
Pitch	1.13	-0.92	1.76	-1.42	2.67	-2.12
Heave	0.67	-0.70	1.02	-1.06	1.56	-1.66
Time 1159-1209, 22 April 1976, Army LOTS, Ft. Story						
	Average		Average Upper One-Third		Extreme	
	Peak	Trough	Peak	Trough	Peak	Trough
Wave	0.87	-0.81	1.46	-1.30	2.40	-1.97
Roll	3.42	-3.87	5.48	-6.17	9.03	-10.10
Pitch	1.06	-0.79	1.76	-1.38	1.74	-2.67
Heave	0.70	-0.63	1.11	-0.99	1.74	-1.77

* Wave and heave data are given in feet and roll and pitch data are given in degrees.

As will be seen from the table, the seas were moderate. The largest "significant" size waves (i.e., the upper third of the wave sizes recorded) were less than [illegible] feet.

Note that the measurements were taken by accelerometers aboard a free-floating spherical buoy that was tended by a landing craft. The waves measured, then, were typical of those affecting the ship and lighter but were not (and in principle cannot ever be[3/]) the same as those at the ship.

The motions of the LCM8 with the measuring equipment aboard are also shown in the table. Here a closer control of the location of the measuring boat, so it could more accurately reflect the effect of the ship in terms of a lee, would have been desirable. The instrumented LCM8 had more difficulty than seemed necessary in keeping station. At times it was estimated to be as much as 500 feet away from the ship. However, in one instance, when the measurement boat made a closer approach, the coxswain was warned by a cargo officer to move away so as not to make waves.

Further comments on the sea state and lighter motion data will be found in Section III.

<u>Load-Cell Data</u>. For some of the lifts a load-measuring cell was used to measure the dynamic forces of the lift. It was located between the blocks of the heavy-lift tackle and the hook. It measured the small deflections of a heavy spring-like element in the apparatus as loads were applied. The readings, calibrated in terms of the force being applied at the hook, were recorded on a strip chart. The chart was capable of being run at various constant speeds, and time ticks were recorded on the strip. Excerpts from the chart recordings are shown as Figure 2.

One reason for making the load-cell measurements was to find whether variations in the force, caused by motion of the ship and lighter in a seaway, would be within the nominal capacity of the ship's gear. The record showed that the largest recorded instantaneous peak force was 66 long tons. This is clearly well within the 70-long ton nominal capacity of the gear. It occurred during the lift of the LCM8, which, according to available information, weighs 61 long tons. Further comments on interpretation of the load-cell data will be found in Section III.

<u>Time Measurements</u>. As was the case for ship loading, the time for loading each lift was recorded. Additional total times for loading dunnage, opening hatches, rigging booms, etc., were noted including explanations of delays. The times were generally recorded to the nearest minute. Analyses of the time data will be found in Section III.

3/ The reason for this is that any one "wave" is made up of many components, each of which is travelling at a different speed. This means that the wave is different at different places where it might be measured. Since the measuring device cannot be in the same place as the ship, it cannot measure the same wave as the one acting on the ship.

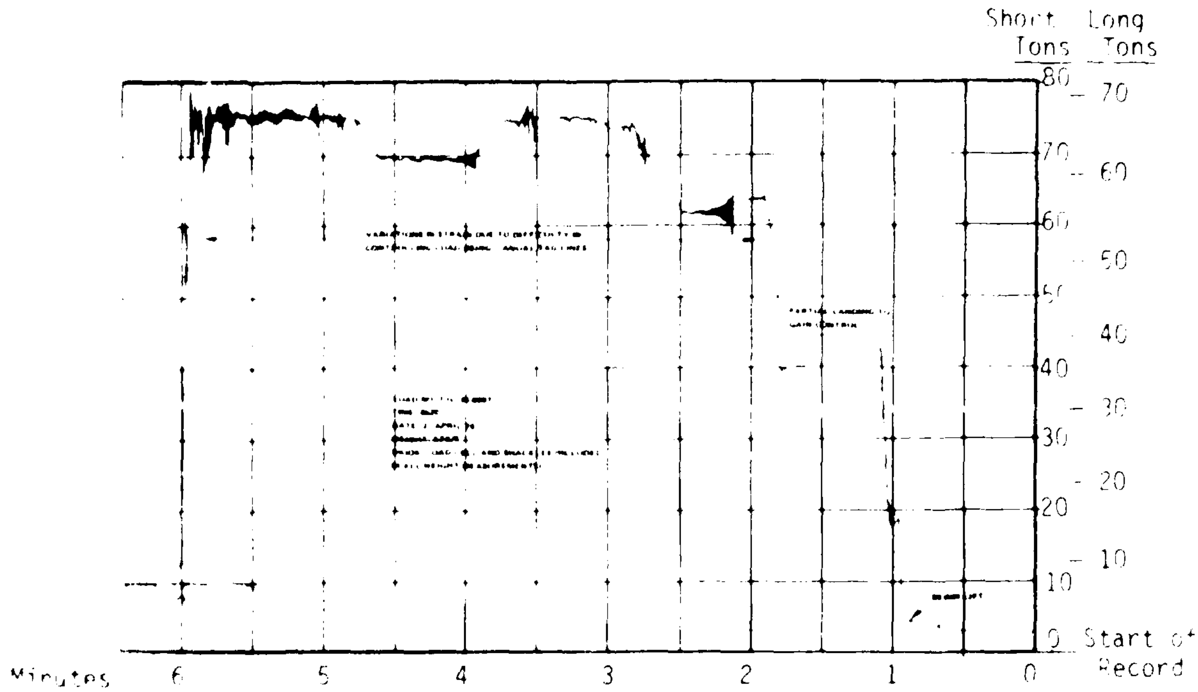

FIGURE 2. EXCERPT FROM LOAD CELL RECORD DURING INITIAL LIFT OF LCM8
(Reproduced from Data Report, Reference 3, Appendix C)

LIGHTERAGE AND BEACH OPERATIONS

Since this test was intended to verify capabilities to deploy equipment used in a LOTS operation, no other type cargo was included in the exercise. With few exceptions no loads were lifted from landing craft at the beach. Cargo off-loaded from the ship was either lighterage (i.e., the LCM8 and the causeway) or was on wheels. The wheeled cargo was either mobile-loaded (including the 6250 crane upper, booms, and counterweights) or had its own wheels (the carrier for the 6250). Both mobile-loaded and wheeled vehicles were rolled off the lighters at the shoreline.

The near shore depth profile (a slope of approximately 2 percent) and the presence of off-shore sandbars limited the "window" of working time to about one and a half hours each side of high tide. (This is discussed in detail below.) For a throughput operation such as the LOTS main test, limiting beach operations to a fraction of the total working day would result in unacceptably low numbers of containers crossing the beach. For the throughput part of the main test a change in beach site to one with a steeper gradient, such as sites northwest of the one used in this test, presumably would result in a larger part of the working time being productive.

Problem Areas

Three problems had to be overcome when LCM8's were used to lighter the heavier wheeled cargo such as the 6250 crane carrier and separately loaded crane upper:

- About 100 feet off shore a sandbar obstructed passage of the LCM8 even at times near high tide.
- The loose soft beach sand caused wheels to sink, requiring a timber "roadway" for the vehicles.
- Steep sections of the beach near the water's edge had to be bulldozed flat before placing the timbers. This permitted driving the cranes ashore avoiding abrupt changes in slope.

Sandbar Problem

In a wartime emergency off-shore sandbars could possibly be breached by periodically clearing channels with explosives. In peacetime the use of explosives, which would kill fish, is not acceptable from the environmental point of view. In any event, the possibilities for deepening approaches to the shoreline for landing craft by blasting or dredging have not been sufficiently explored. (For example, one of the unknowns is how quickly the cleared channel would be filled in by shifting sands.) An assessment is necessary if valid conclusions as to feasibility of these methods and impact on operations can be drawn.

An LCM8 loaded to its designed draft draws 4 feet 6 inches; therefore, the sandbar must have had somewhat less water over it. On one occasion after the highest tide had passed, even an empty LCM8 had difficulty in crossing the sandbar while retracting. An empty LCM8 has approximately 1.4 feet less draft than one with a 60-ton load. Only one LCM8 with intermediate or light loads successfully negotiated the sandbar without assistance. An LCU, administratively introduced with the tactically disassembled 9125 crane, also was grounded on the sandbar until assisted by a bulldozer.

The causeway ferry did not ground out on the sandbar. It was loaded to a lesser fraction of its full capacity (4-foot maximum draft). In any event, the causeway draws six inches less water when fully loaded than the LCM8. Note that a causeway ferry has an inherent potential for dealing with a sandbar reasonably close to the shore, if one or more sections at the front are left unloaded. Each empty section, about 92 feet long, draws only one foot of water. Such sections joined end to end thereby form a causeway for driving a mobile load ashore when the loaded sections are aground on a sandbar.

The tide tables for 23 and 24 April show a difference between high and low tides of 2.3 to 2.5 feet at Cape Henry. This is somewhat less than the year-round mean difference of 2.8 feet. The tables also mention the "one-quarter, one-tenth" rule. This says that one-tenth of the tidal rise or fall occurs during the one-quarter of the tidal cycle time closest to high or low water. For the problem at hand, this means that the time from high tide until the tide has receded 10 percent is one-quarter of the 6½ hour cycle or just over 1½ hours. If the work "window" is arbitrarily defined as the time the tide is between 90 and 100 percent high, this window is about three hours long and occurs every 12½ hours. (See Figure 3.) For Cape Henry on the test dates the window would be with tides between about 2.2 and 2.4 feet above mean low water. The window for the heaviest, most critical loads may well have been shorter—perhaps as short as 3/4 of an hour.

In assessing the boat operation of crossing the sandbar, it was difficult to judge whether the LCM8s would have fared better if the operators had been more proficient. It was clear from the maneuvering close to the ship that more practice in a seaway was indicated.

The survey used by the planners of the beach operation had been made two weeks before. It is reproduced as Figure 4. It does not show pronounced deeper-water areas inshore from the sandbar. Such areas were there and made bulldozer operations difficult. One bulldozer "drowned-out" in attempting to assist an LCM8 grounded at approximately the middle of the surveyed area.4/

4/ It has been noted that the Army tractors operating in the beach area were not equipped with fording gear. These vehicles are often called upon to assist landing craft and sometimes other vehicles through the surf but they cannot operate in water deep enough to accomplish such tasks if an occasional small wave is able to drown them out. This type of activity in the surf had apparently not been envisioned previously so fording equipment was not provided as part of the TO&E. Navy and Marine Crops dozers are equipped with fording gear specifically for this purpose.

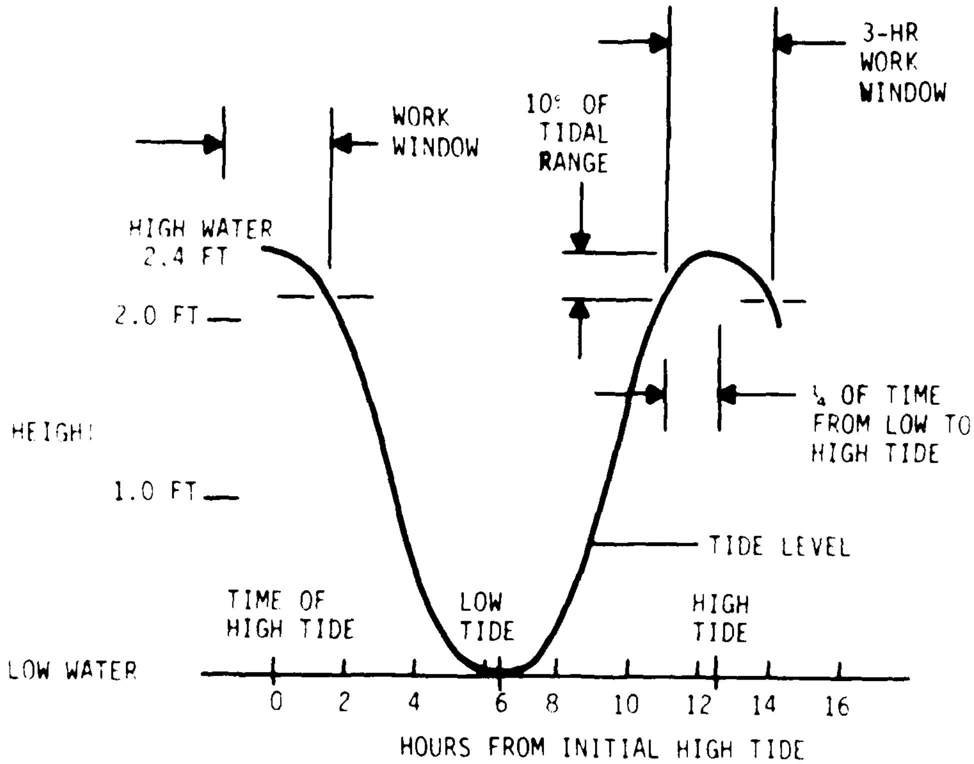

FIGURE 3. APPROXIMATE TIDAL LEVELS AT CAPE HENRY ON APRIL 23 and 24, 1976 (Showing the three-hour work window during which tides are between 90 and 100 percent of full.)

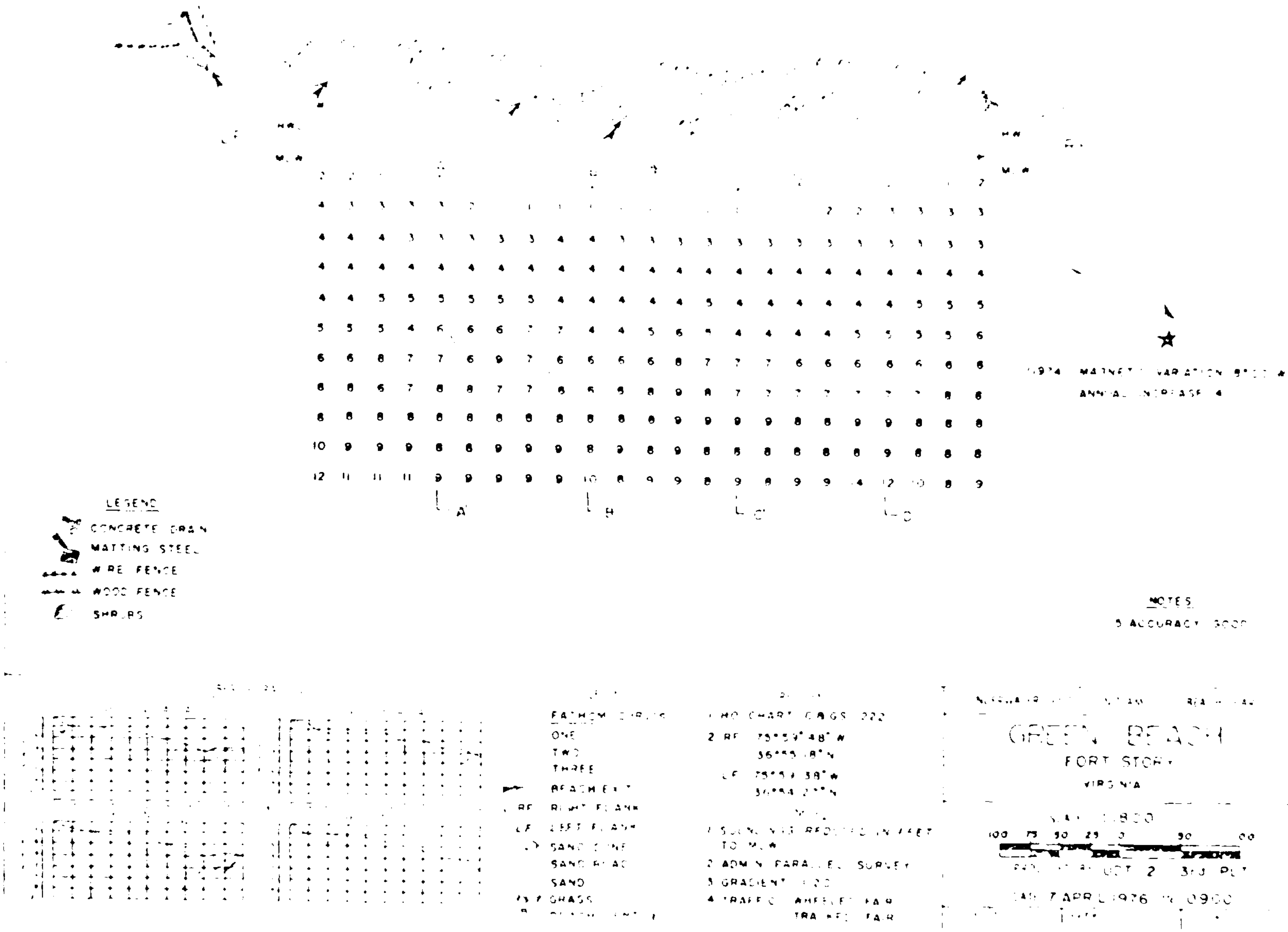

FIGURE 4. SURVEY MADE TWO WEEKS BEFORE PRETEST

These holes were estimated to be five feet deep. Changes to the near-shore beach bottom typically occur from winter to summer and as a result of storms. How much change occurred during the two weeks between the survey and the test is not known, but it seems clear that the sandbar was more pronounced than the survey indicated.

Two conclusions seem warranted on the basis of the test. One is that, in addition to the planning survey about two weeks before, a second survey should be conducted immediately before beginning over-the-beach operations. Any channels or favorable beach approaches should be clearly marked. The second conclusion is that other beaches at Ft. Story more suitable for landing craft should be surveyed for selection. In particular, areas toward the bay side of Cape Henry appear from nautical charts to have steeper near-shore gradients.

Effect of Sand on Beach Operations

The two problems with sand mentioned above— the loose texture and the abrupt changes in slope— had been foreseen and were resolved with straightforward solutions. "Mud shoes," railroad ties and rails assembled together in sections, were used to prevent vehicles from sinking. These were positioned using rough-terrain forklifts. To provide smooth changes in slopes, bulldozers leveled the sand before placement of these track sections. Wave action continuously erodes sand ramps. Therefore, the forklift trucks had to quickly place the cross-tie assemblies onto the smoothed sand roadway. If the surf had been heavier,this problem could have been more severe.

CRANE DISASSEMBLY AND FIELD REASSEMBLY

300-Ton Crane Disassembly

The Army's P&H 6250 model crane was disassembled into pieces light and small enough to be transported by LCM8. This is commonly known as an administrative configuration because it is similar to the manner in which the crane was shipped by the manufacturer. Using a crew which had never attempted a disassembly before,[5/] 274 man-hours were required to reconfigure the 300-ton crane into its administratively disassembled form. Besides disassembly the crew at the same time mobile-loaded components on trailers. This total time could be equated to approximately 3½ to 4 8-hour days for a 10-man crew under non-contingency conditions. The figure is tempered by the fact that it represents the summation of productive time increments and excludes administrative delay times. In reality, disassembly was accomplished over a nine-day period. On the other hand, observers and participants in the exercise did believe that the disassembly could be completed with fewer man-hours once the crew had been trained and had all its proper tools and manuals on hand. The order and approximate times (in hours) for the disassembly of the crane and loading of trailers are contained in Table 2.

5/ A factory representative was available in an advisory/instructor capacity. Many of the crew had participated, however, in the crane's assembly when it arrived from the factory.

TABLE 2

300-TON CRANE DISASSEMBLY AND MOBILE-LOADING TIMES*

Major Component	Approximate Time (In Hours)
Boom sections	8.50
Counterweights	2.50
Mast	2.33
Operation module, framework, carrier bolts	6.50
Upper	2.25
Outriggers (unitized removal)	2.50
Other mobile loading requirements	7.50
TOTAL	32.08

* Reference 3 listed in Appendix C provides detailed information on each event. The figures represent the summations of productive time increments and exclude administrative delay times.

140-Ton Crane Disassembly

The Army's P&H 9125 model crane (140-ton lifting capacity) was disassembled to its tactical configuration. That is, its disassembly consisted of removal of its two counterweights, outriggers, and all boom sections except its boom base. In this mode the crane does not need the assistance of another crane to be disassembled (or reassembled) and it can be lightered in an LCM8. The disassembly took place over a four-day period and, like the 300-ton crane, its reassembly was partially constrained by the lack of appropriate tools and technical manuals. The disassembled components of the 140-ton crane required eight trailers. The crane's disassembly required about 92 man-hours. The time for disassembly by major components is contained in Table 3.

TABLE 3

140-TON CRANE DISASSEMBLY AND MOBILE-LOADING TIMES*

Major Component	Approximate Time (In Hours)
Boom sections	4.67
Counterweights	3.83
Outriggers. lower gantry	.50
Other mobile-loading requirements (i.e., lashing)	3.75
TOTAL	12.75

* Reference 3 listed in Appendix C provides detailed information on each event.

Reassembly Preparations

To accomplish the reassembly of the Army's P&H 6250 model crane on the beach, an Army P&H 9125 model crane was required. Therefore, the 9125 had to be reassembled first. Both cranes had to be on the timber mats or "mud shoes" to prevent their bogging down in the soft sand. As discussed under loading operations, the 9125 arrived "administratively" on an LCU. Boom sections and counterweights for both cranes had been loaded on the ship on separate trailers. Both cranes had to wait for their components to be landed before reassembly could begin. Ship unloading began April 21 and the assembly of the 140-ton crane began about 1400 on April 22. The crew responsible for reassembly worked 12-hour days once reassembly operations began.

140-Ton Crane Reassembly

To assemble the 9125 a rough terrain forklift was used to align boom sections and a tractor and dozer were used to position trailer-loaded components near the crane. No major delays were encountered in the reassembly operation, completed at 1623 on April 23. Nine military personnel composed the crew.

The reassembly required a total of 13 hours and included the installation of the outrigger floats, counterweights, 50 feet of boom sections and the boom tip, and the reeving of the lifting blocks. A total of 118 man-hours was required.

300-Ton Crane Reassembly

Reassembly of the 300-ton crane commenced at 0815 on April 24. Equipment used consisted of the 140-ton crane, a rough terrain forklift, a tractor, a bulldozer, and, of course, the timber mats. Three delays were experienced in the operation: two torque wrenches were broken (considered an inconvenience and minor delay); a hydraulic fluid leak had to be located and repaired (4½ hour delay); and rain and wind conditions halted operations (15 minute delay).

The reassembly required a total of 20 hours and 10 minutes (calculated as a summation of productive time increments) and was completed on the beach at Ft. Story at 1530 on April 26. A total of 181 man-hours were required. The operations included reassembly of the outriggers, counterweights, mast, two 30-foot boom sections, the boom base and tip, and the operator's module.

Crane Damage

Some damage was sustained by the 6250 booms, apparently during unloading from the ship. The damage was judged to be important enough to prevent near-limit loads from being lifted by the crane but would not have prevented containers from being handled at reaches somewhat short of the maximum. It was estimated that in a military emergency the crane would have been used without making repairs. The damage consisted of dents in the tubular struts in seven places and some bending of struts. The worst dent was about 3/8 of an inch deep. The worst bend was a deflection from straightness of about ½ inch in eight feet.

III. ANALYSIS

GENERAL

It should be reemphasized that the equipment selected for pretest loading posed particularly difficult and unique problems for loading and, especially, off-loading. The pretest approach, to conserve funds and other test resources, was directed toward the most difficult potential problems in deployment rather than considering more typical loads, such as dozers, trucks, pallets, etc. In effect, this approach gave the hardest of problems to personnel whose previous experience with handling the LOTS equipment was limited. When the brief pretest was over, the test participants were just beginning to approach their normal operating pace in the opinion of experienced observers.

The approaches to solving loading and off-loading problems were essentially sound. Those areas of particular difficulty and unique to LOTS deployment had been thought through and, to the extent feasible, check tested before the actual pretest. Test participants initially reflected some training deficiencies but, in light of major test objectives, the pretest was successful.

The training deficiencies alluded to did not seriously interfere with the accomplishment of the pretest. In the main test where timing and execution will be paramount, such deficiencies as landing craft lacking essential equipment or careless handling of equipment, would detract and overall proficiency must be improved. In this regard both Services showed the need for improvement. It should also be noted that enlisted personnel performed their duties cheerfully and willingly over prolonged periods of time.

In the instance when there was a failure to load the 140-ton crane the value for a pretest was proven. In the sense that a basic purpose of the test was to establish or to disavow certain borderline capabilities, the failure shows that the selected lifts did, in fact, pose substantial problems.

Check tests and detailed rehearsals are essential for as many aspects of an important test as possible, but there is no substitution for a test that experiences the actual conditions in which a system is expected to operate.

EQUIPMENT ANALYSES

Crane Disassembly and Field Reassembly

In view of the failure to load the Army's P&H 9125 model crane, steps have subsequently been taken to correct the cause of failure. A new lift sling was designed and tested on a later LASH ship pretest but, in addition, the 9125 was also test loaded during the heavy-lift breakbulk ship pretest in a configuration suitable for deployment by a conventional breakbulk ship. Thus, the 140-ton crane deployment objective has now been completed.

In commercial use the upper section of the Army's P&H 6250 model crane is rarely removed once the purchased crane has been delivered to the user. As a routine procedure such separation does not appear to be advisable, particularly because of the wear and potential damage to the mounting ring. Nevertheless, the capability to administratively disassemble the 300-ton crane has been demonstrated and this capability should be recognized as a potential means for broadening the deployment capabilities of the Army's terminal service company (container).

The reassembly of the cranes in the field presented no major problems. The soft sand made the task more difficult than if done on a hardstand but did not hinder the work unduly. The reassembly was accomplished in a beach environment using only personnel, tools, and equipment organic to the unit. All crane components, less the tactically disassembled 140-ton crane itself, and the tools to make the cranes operational were discharged from the ship as part of the exercise in the same manner they would have been in a contingency operation. The new sling for the Army's 9125 crane now makes it possible for all terminal service company (container) cranes to be embarked aboard a breakbulk ship having a 60-long ton (or greater) capacity boom and lightered to shore in LCM8s.

In terms of deployment capabilities the ocean-going breakbulk ship assets constitute approximately 63 percent of the U.S. dry cargo fleet.[1/] Prior to the pretest only 2.5 percent of the merchant dry cargo fleet was considered capable of deploying the container company. These ships consisted of five heavy-lift ships,[2/] a roll-on/roll-off vessel, and three SEABEES. This pretest has demonstrated that approximately 45 percent of the dry cargo fleet[3/] can be used for deployment of LOTS system elements...provided that the 300-ton crane is administratively disassembled and the 140-ton crane is reduced to its tactically disassembled configuration.

1/ See Reference 2 listed in Appendix C.

2/ Three of these ships have 150- or 160-long ton boom capacity but limited stowage capabilities and, therefore, are limited in their deployment potential.

3/ Includes the ships cited above plus all breakbulk and partial containerships with boom capacities of 60 long tons or greater. The advance results of the LASH Pretest do indicate that 20 more ships also could be added to the list, changing the percentage from 45 to 51. The LASH results are the subject of of a separate report.

Planning factors relating to LOTS system deployment and earliest establishment in a bare beach environment must take into consideration the sequence and timing for ship off-loading and crane reassembly, since the latter is a time-consuming operation. The 140-ton crane and its components must be among the first items unloaded so that the crane's reassembly may commence as early as possible. While it is being reassembled (approximately 13 hours), the 300-ton crane and its components can be off-loaded so that its reassembly (approximately 20 hours) can begin when the 140-ton crane is operational.

Concurrent with crane reassembly, site preparations can be underway (such as soil stabilization, a suitable platform for the beach crane, the preparation of a marshalling site, and continuation of ship-to-shore operations). Based upon the conventional breakbulk ship pretest and crane reassembly operations (one crew working 12 hours per day), it is estimated that container throughput operations could begin as early as three days after the breakbulk ship commenced unloading. This estimate does not include delays due to weather conditions and assumes that all resources and equipment needed for beach preparations are available during the three-day period of crane reassembly.[4/]

Although the exercise involved a considerable amount of learning experience, this consideration must be offset by the fact that the infrequency of crane disassembly and the frequency of Service personnel rotations make it highly unlikely that a fully trained crane crew for this type of reassembly will be available at any given time. Thus, the exercise times noted above may well be operationally realistic. Obviously, the data gained from only one exercise has only limited reliability, but the above derived estimates are considered adequate guides for potential future operations of this nature. The circumstances behind this test, however, should also be considered. Specifically, a test date had been established and activities were planned well ahead of time; a manufacturer's representative was available prior to the test to assist in the planning and training; and there was more than ample time to prepare for the load-out. Further, there were no other movement requirements within the terminal battalion competing for trailers. It might be possible that in a contingency some boom sections or counterweights would not have been mobile-loaded. In such an instance loading, handling, and reassembly would have been considerably more difficult and reassembly a good deal slower.

Having learned the lessons discussed above, standard operating procedures should be published by the operating units, commands, and agencies concerned regarding deployment. These SOPs should contain provisions for equipment disassembly/reassembly procedures, requirements for movement to port-of-embarkation, scheduling, ship loading requirements, and such other resources and priorities as may be necessary. Training and drills will especially be required since there is very little flexibility possible in the preparation,

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4/ Beach preparation and subsequent maintenance is a continuing activity, but preparations sufficient to allow for receipt of containers should be timed to coincide with crane reassembly. Beach preparations will be contingent upon the condition of the site upon arrival, resources flown in ahead of time, and the initiation time of beach site preparations. These are generally intangible factors and beyond the scope of this report.

loading/unloading, and return to operating status of container handling equipment. This is true particularly for cranes but also applies to some degree to other items such as the frontloaders, sideloaders, lighterage, and the LACV-30.

LACV-30 and Frontloader

Since the LACV-30 and the frontloader were not available for this pretest the capabilities/limitations for deployment of these items still remains unverified. If not pretested earlier, both of these items should be loaded and unloaded from a ship (or ships) during the main test to verify the unit's capability to deploy them. If a heavy-lift breakbulk ship is used in lieu of a conventional one, both vehicles should be configured and loaded as if they were being embarked on a breakbulk ship with a 60-long ton boom.

6250 Crane Carrier-LCM8 Ramp

Because of the restricted internal clearance in the LCM8, a well deck ramp is a prerequisite for deployment in any situation that requires an LCM8 to lighter the crane carrier. The ramp was developed as a result of preliminary deployment check tests and subsequently was constructed under the auspices of the JTD. While the carrier can be driven into the LCM8 without the ramp and the craft could be used for lighterage under fair weather conditions, lowering the carrier into the LCM8 with a ship's boom might seriously damage either the carrier or the LCM8. Fore and aft clearances in the well are so small (approximately an inch) that in sea state three conditions, unloading very likely would be impossible. A set of such ramps should be made part of the TO&E of the terminal service company (container).

Conventional Breakbulk Ship

Although the C457 type breakbulk ship is somewhat more capable than the majority of conventional breakbulk ships (those having 60-long ton booms), it adequately served pretest purposes. The fact that two holds could be used for the heavy lifts instead of one also helped expand the scope of the pretest. The additional boom capacity (70 long tons versus 60), merely provided an extra safety margin. As previously noted only one of the lifts equalled or exceeded 60 long tons, namely the 3 X 15 causeway, which would have exceeded a 60-ton boom capacity by 0.3 of a ton. Under wartime emergency conditions this overload probably would have been acceptable since booms normally are tested to a 10 percent overload.

One noticeable disadvantage of this ship is its narrow hatch squares. With the wider hatch squares of other conventional ships it is unlikely that boom sections would have been damaged as much. In this pretest the Army's 300-ton crane capabilities were reduced because of damage, primarily as a result of pendulation and banging against hatch coamings. However, narrow hatches in no way eliminate this conventional breakbulk ship as a LOTS system deployment vessel. Much of the damage could have been avoided had better use been made of taglines, properly rigged and controlled, in handling the heavy lifts.

ANALYSIS OF SPECIFIC MEASUREMENTS MADE

Load Cell Data

Magnitude of Force. As mentioned in Section II, the load cell measurement provided assurance that the forces on the lift gear were within the capacity of the 70-ton boom on the ship tested. Using that data the analysis is concerned with whether or not the loads could be handled by ships with 60-long ton booms. The question is especially important because 85 percent of the breakbulk ships of the merchant fleet (about 162 ships) have 60-ton or heavier booms. From a LOTS operational view point, to be able to deploy and off-load a 6250 crane, an LCM8, and a 3 X 15 causeway on vessels with 60-ton booms is an important capability. (Note, that in deployment planning the quantities of equipment any one ship could embark depends upon the specific ship design involved. The designs vary widely with respect to space suitable for these items of equipment.)

In analyzing load cell data for maximum force readings the highest spike recorded was during the off-loading of the LCM8. After deducting tare weight, the peak force was 66 long tons, 10 percent over an assumed static weight of 61 long tons for this LCM8. The difference of five tons is seen as the result of dynamic forces. There is no way of separating the possible components of the measured force[5] to pinpoint the causes of this transient peak. However, it seems safe to assume that at least a large part is associated with the motion of the ship in the seaway.

If it is assumed that the weight could be reduced to 60 long tons by cutting down the amount of fuel, the question is: can a 60-ton boom lift in an open sea environment (no worse than was encountered in the test) a 60-ton load considering that some load cell readings would be 10 percent above the actual dead weight? It was clear that the master of the AMERICAN COURIER was willing to handle any load that came within the capacity of his gear, even in an offshore environment. He assumed, in effect, that the design of the gear included some allowance for the effects of a seaway. Thus, without benefit of the load cell measurement he presumably would have been willing to lift a 60-ton load with a heavy-lift boom having a nominal capacity of 60 tons.

Based upon available information the pretest peak force measurement does not appear to invalidate the above interpretation. Periodic static tests of ship's gear apply 110 percent of the rated capacity. Also, the design of the ship's gear is based upon predicted failure not below 500 percent of the design load (i.e., a factor of safety of 5 to 1). This factor of safety is intended to take into account variations in force such as the load cell in fact measured. It also includes allowances for various impact forces and jerks, normal wear and tear, and reasonable deterioration (none of which are quantitatively specified). Had the record been made in a higher sea state with considerably higher fluctuations, the recorded results probably would have endorsed the master's judgment not to make the lift.

5/ The components include: forces associated with normal acceleration of the load; tagline forces; accelerations caused by impacts of the load; jerks caused by line slack being taken up; forces induced by roll, heave, and pitch of the ship; buoyant forces (discussed later); and possibly others.

Variability of Force

Figure 5 reproduces a part of the load cell record made during the final half of the lift of the LCM8. Note that in these records later times are to the left of earlier times. The figure reproduces the actual record trace. The scales indicating times are shown in a different way than in the data report for clarity in the following analysis.

The right-hand side of the graphic record shows the forces on the load cell from just before the time the LCM8 was lowered over the side to the time it was first in the water. For this right-hand part the recording paper ran slower than during the later left-hand part. As has already been discussed, there are small peaks and valleys in much of the record that can be attributed to the motion of the ship. The deep valley at the time marked 40 seconds is the consequence of the load being rested momentarily on the deck. The load cell measurement did not reach zero during this period since there was still some tension on the line.

When the LCM8 reached the water the load cell measurements went to near zero as the buoyancy of the water supported the craft. The powered taglines may also have contributed to the support since at this state of the unloading they were necessarily nearly vertical.

The next part of the record, the left portion of the figure is of special interest because the variability in force was so large. At this point the load cell chart speed was increased making the details of the force fluctuations clearly visible. The basic reason for these larger forces was that the lift gear was deliberately given greater strain in order to keep the LCM8 under control.[6] The craft was waiting for a crew transfer but it had begun to swing out away from the ship. As already noted, the taglines at this point were nearly vertical and could not apply enough horizontal force to adequately control the craft. The mate ordered a greater strain (i.e., shortening the lift line and lowering the LCM8) resulting in intermittenly higher recordings in the load cell.

As will be seen in the record, the forces measured by the load cell ranged from essentially zero to a peak of about 30-45 [illegible] ton. The transitions between high and low loads take several seconds, so that the interpretation can be made that generally there were no jerks on the gear.

It is clear that the basic mechanism causing the fluctuations was wave action. The period between the force peaks averages approximately eight seconds. This corresponds to wave lengths of some 330 feet, or 4½ times the length of the LCM8. Figure 6 illustrates how the recorded forces were probably generated. The upper part of the figure shows the craft on the crest of a shallow wave. Buoyancy furnishes a preponderance of the support for the craft and in this situation the load cell registers near zero. In the lower part of the sketch

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[6] This was not discussed in detail in the data report but verified by the Army officer in charge of the unloading troops.

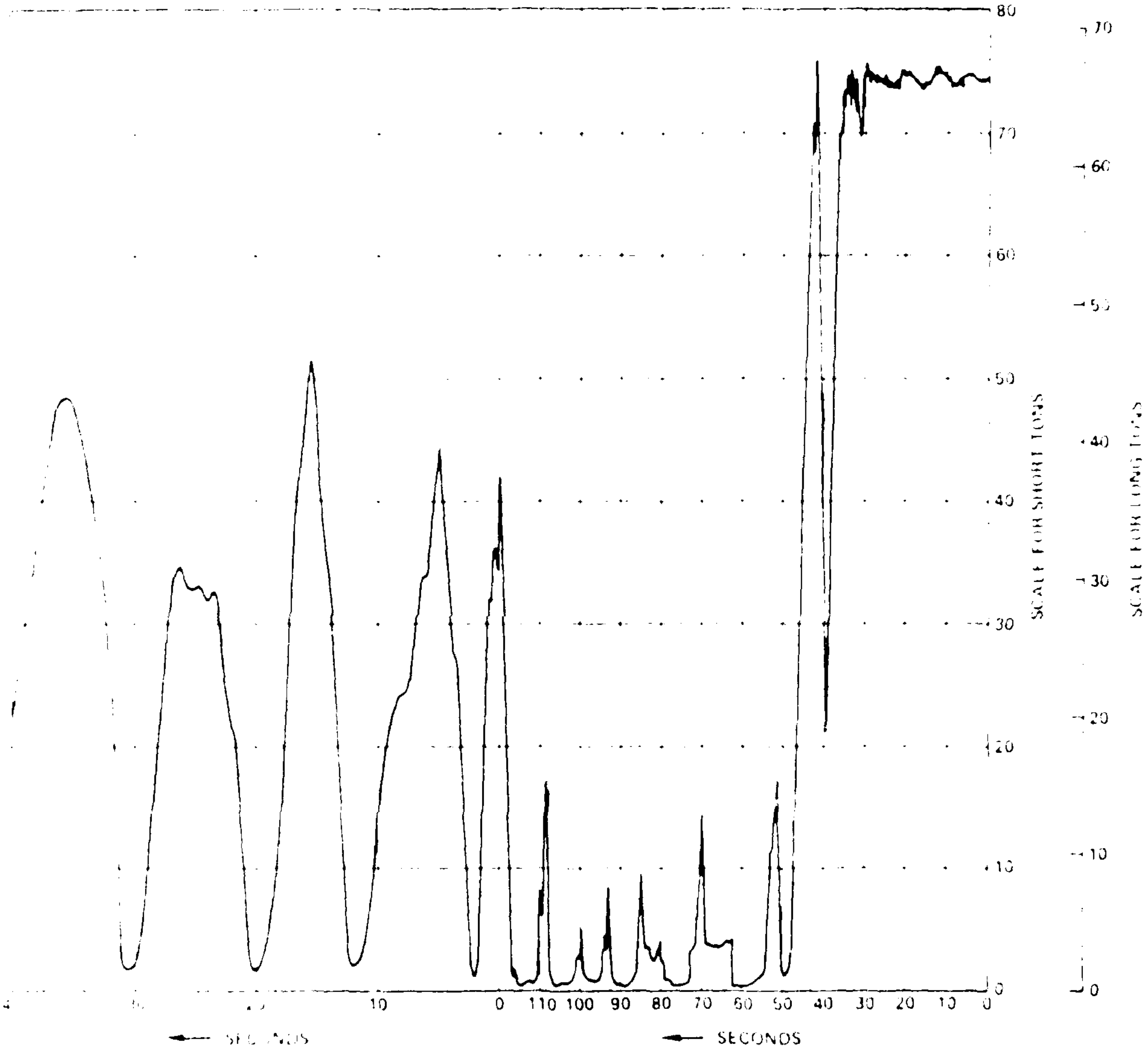
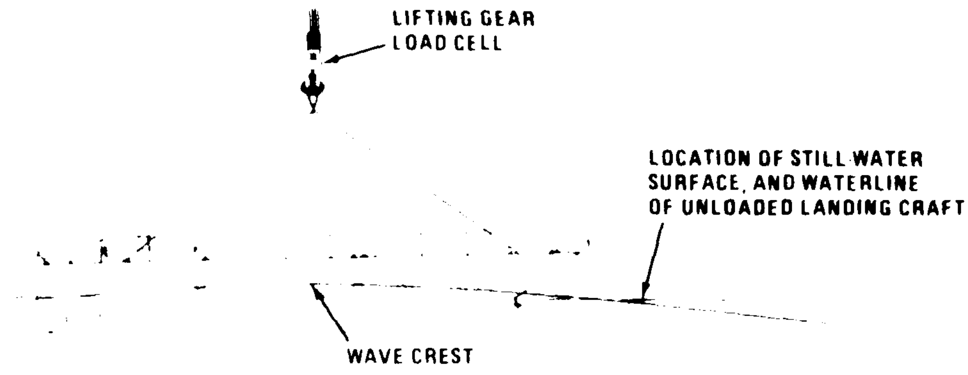
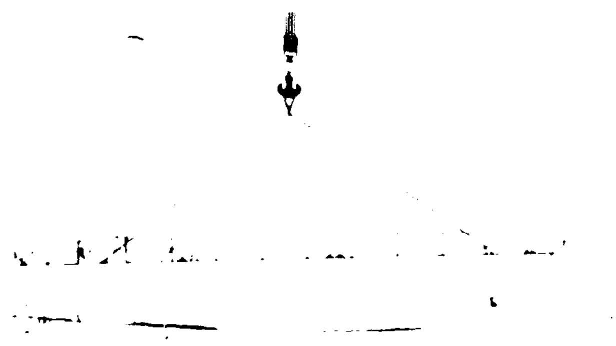


FIGURE 5. LOAD CELL RECORD DURING TIME LCM8 WAS BEING LOWERED INTO WATER
(Reproduced from original record.)



(a) LCM-8 Supported by buoyancy on crest of shallow wave. Lift gear nearly slack.



(b) LCM-8 In trough of wave. Lift gear supports nearly whole weight.

FIGURE 6. SKETCHES EXPLAINING POSSIBLE CAUSE OF WIDE FLUCTUATIONS IN LOAD CELL READINGS DURING FINAL PHASES OF LIFTING LCM8 OFF SHIP

the wave has moved on and the craft is now in a trough. As the craft started down into the trough, the heavy-lift gear began to support it. In the lower sketch, nearly the whole weight of the craft is on the lift gear. The load cell at this point of the cycle shows peak readings noted above.

The above interpretation of the load cell data is supported by records of motion of the instrumented LCM8. During the nearest corresponding period of time, vertical oscillations of the instrumented LCM8 averaged 1.4 feet. This corresponds to a calculated "average" draft of an LCM8 in still water of 1.6 feet, obtained by dividing its displacement by the estimated waterplane area.

Analyses of Time Data

Subdivisions of Recorded Shipboard Time. The time data for loading and unloading was analyzed initially by dividing the recorded times into four categories as follows:

- Lift Working Time. Defined as time during which lifts were being prepared, made, or tied down.[7] Almost two-thirds of the total recorded time was in this category.

- Ship Working Time. Time required for opening and closing hatches, relocating the heavy-lift boom from one hold to the other, and the like.

- Unavoidable Delays. Arbitrarily considered to include lunch breaks and replacement of failed dunnage.[8]

- Avoidable Delays. Defined as delays that, given proper forethought, need not have occurred. Note that simple mistakes made by stevedores or others were considered part of the normal course of an operation and were generally included as part of lift working time.

By separating the time into these categories certain times might have been distributed another way. For example, there were recurrent circumstances where judgment was necessary to interpret the data. In one instance when lifts overlapped some of the stevedores were able to start preparing for the next lift. In the analysis these overlaps were arbitrarily allocated to one lift or the other or occasionally split between them. (Using a continuous-log analysis of the data ensured that the sum of the times for the four categories would be equal to the available elapsed time.[9]) A second example is incomplete

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7/ When the tie-down procedure kept the stevedores from working on the next lift, the tie-down was included in the Lift Working category and was counted as part of the time for the particular numbered lift.

8/ On one occasion when the ship's crew relocated the heavy-lift boom during a lunch break, the unavoidable delay was correspondingly reduced for analysis purposes.

9/ The continuous-log used is shown in Appendix B. Allocations to specific lifts shown there can be compared with the raw data in the data report, cited as Reference 3 in Appendix C.

records between lifts. Back-up data usually cleared up what had happened. Unrecorded periods of one to five minutes between lifts had to be arbitrarily assigned to one lift or the other. Usually the next lift was selected on the assumption that some or most of this brief unlabelled time was used by the stevedores simply in moving to the next load.

The total elapsed time for both loading and off-loading phases during which records were kept (the working hours over the four days) was 2,667 minutes, or approximately 44½ hours. The division of time into the four categories is shown graphically as Figure 7 and is tabulated in more detail in Table 4. Note that in the table most of the avoidable delays occurred on the second day of loading. This was the result of (a) the faulty sling design for the P&H 9125 crane, and (b) an administrative problem involving an LCM8 crew not being ready to board the craft. The unavoidable delay total of 3½ hours included lunch breaks during each of the four days.

Analyses of Times for Lifts. The time under the category "Lift Working Time" was subdivided into the times for each of the various lifts. Table 5 shows the basic data on the individual lifts, including measurement tons and long tons for each, and the time it took to move each lift onto and off the ship.

Five of the lifts made and shown in the list were out-of-the-ordinary: loads 1 and 2, the LCM8 and the 6250 crane carrier; load 6, the causeway; and loads 14a and 14b, the 6250 crane upper and M747 trailer for the crane upper. The average time for loading these five lifts aboard the ship was 42 minutes. The average time for the remaining 24 lifts was 15.3 minutes. The latter compare with the 15 minute planning factor for heavy lifts found in Army Field Manual 55-17[10]. On this basis the 24 lifts, mostly mobile-loaded trailers, may be considered with some confidence as being conducted at a typical or standard pace.

Ship off-loading cycles took almost twice as long per successful lift as the loading cycles. Among the more important reasons noted were: unloading in an open seaway requires more tagline rigging, the motion of the load requires more care and slower lifts, and unloading was done by Service crews less experienced than the contract stevedores who had done the loading.

Test results were plotted in a number of ways in an effort to determine relationships among the variables. Three trends were found and are shown as Figures 8, 9, and 10. The figures relate off-loading time (the variable most important to LOTS test planning) for each lift: to loading time, to long tons per lift, and to measurement tons per lift. Other plots showed no clear relationships, as for example ones between loading time and lift size measured in long tons or in measurement tons.

The first of the three plots, Figure 8, shows a rough relationship between unloading time (vertical scale) and loading time (horizontal scale).

10/ U.S. Army, Terminal Operations Specialist Handbook, Field Manual 55-17, November 1975.

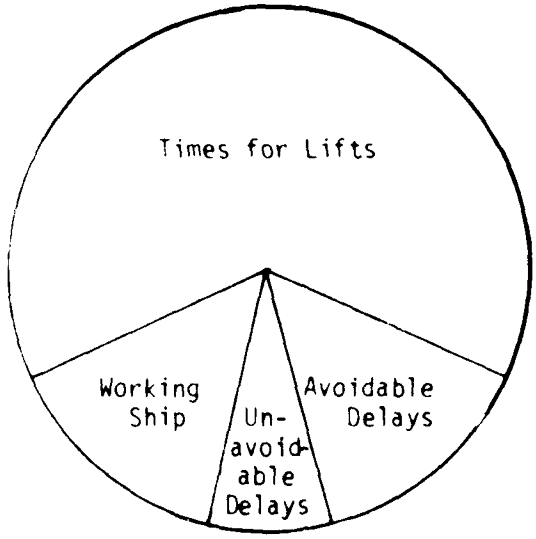

FIGURE 7. DIVISION OF RECORDED SHIP-TEST TIME INTO CATEGORIES

TABLE 4

BREAKDOWN OF RECORDED WORKING TIME DURING SHIP USE IN PRETEST
(Time shown in minutes)

Category	Day	Lifts	Working Ship	Unavoidable Delay	Avoidable Delay	Totals
Loading	1	349	143	73	25	590
	2	228	112	30	280	650
Subtotal		577	255	103	305	1240 (=20.7 Hrs)
Unloading	3	531	68	53	47	699
	4	582	53	53	40	728
Subtotal		1113	121	106	87	1427 (=23.8 Hrs)
Overall Totals		1690 (63.4%)	376 (14.1%)	209 (7.8%)	392 (14.7%)	2667 (=44.5 Hrs)

TABLE 5

DATA ON LIFTS—SIZES AND TIMES

Lift Number	Load	Measurement Tons	[illegible]	Times (Minutes)	
				[illegible]	[illegible]
1	LCMB	[illegible]	[illegible]	[illegible]	31
2	P&H 6250 carrier	[illegible]	45	[illegible]	[illegible]
3	P&H 9125 crane (not lifted onto ship)				
4	P&H 6250 40-foot boom base	106	4	1	
5	P&H 6250 45-foot mast	[illegible]	3	[illegible]	[illegible]
6	Causeway (3 x 15)	[illegible]	[illegible]	[illegible]	[illegible]
7	P&H 9125 counterweight, 20 tons, on 172A1 trailer	[illegible]	25	[illegible]	[illegible]
8	P&H 9125 10-foot boom and 10-ton counterweight on M127 trailer	65	16	[illegible]	[illegible]
9	P&H 9125 20-foot boom on M127 trailer	65	8	[illegible]	No data
10	P&H 9125 30-foot boom on M127 trailer	68	9	[illegible]	[illegible]
11	P&H 9125 25-foot boom tip on M127 trailer	65	8	10	10
12	P&H 9125 20-foot boom on M127 trailer	65	8	15	14
13	P&H 9125 outrigger floats on M127 trailer	52	9	[illegible]	[illegible]
14a	P&H 6250 upper	[illegible]	[illegible]	50	60
14b	M747 trailer for 14a	115	14	52	[illegible]
15	P&H 6250 counterweight, 15.5 tons, on M172A1 trailer	50	21	16	[illegible]
16	P&H 6250 counterweight, 15.5 tons, on M172A1 trailer	50	21	19	[illegible]
17	P&H 6250 counterweight, 15.5 tons, on M172A1 trailer	50	21	20	[illegible]
18	P&H 6250 10-foot and 20-foot booms on M127 trailer	96	6	15	[illegible]
19	P&H 6250 30-foot boom on M127 trailer	[illegible]	8	[illegible]	[illegible]
20	P&H 6250 30-foot boom on M127 trailer	96	8	16	[illegible]
21	P&H 6250 25-foot boom tip on M127 trailer	100	10	14	
22	P&H 6250 outrigger beams and malkiel float beams on M127	[illegible]	[illegible]	13	[illegible]
23	P&H 6250 malkiel float beams on M127 trailer	59	[illegible]	14	[illegible]
24	P&H 6250 outrigger beams with malkiel float pads on M127	[illegible]	13	[illegible]	[illegible]
25	P&H 6250 malkiel float pads on M127 trailer	[illegible]	[illegible]	13	[illegible]
26	P&H 6250 module and walkway platform on M127 trailer	[illegible]	9	[illegible]	[illegible]
27	P&H 6250 module support framework on M127 trailer	81	[illegible]	20	[illegible]
-	Ramp (LCMB/P&H 6250 carrier)			[illegible]	69
-	Ramp (LCMB/P&H 6250 carrier)			14	[illegible]

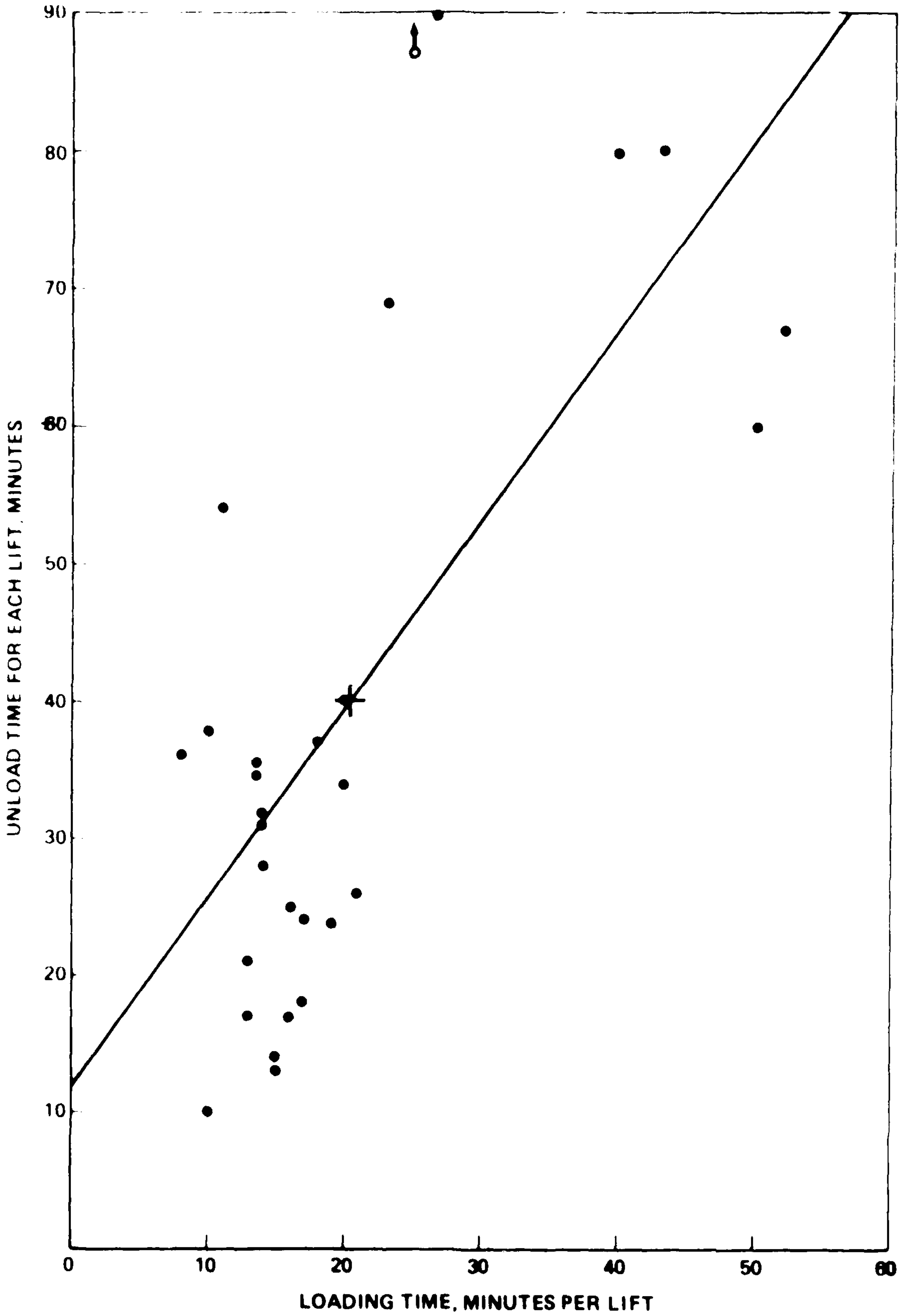

FIGURE 8. OFF-LOADING TIME VS. LOADING TIME FOR SEPARATE LIFTS

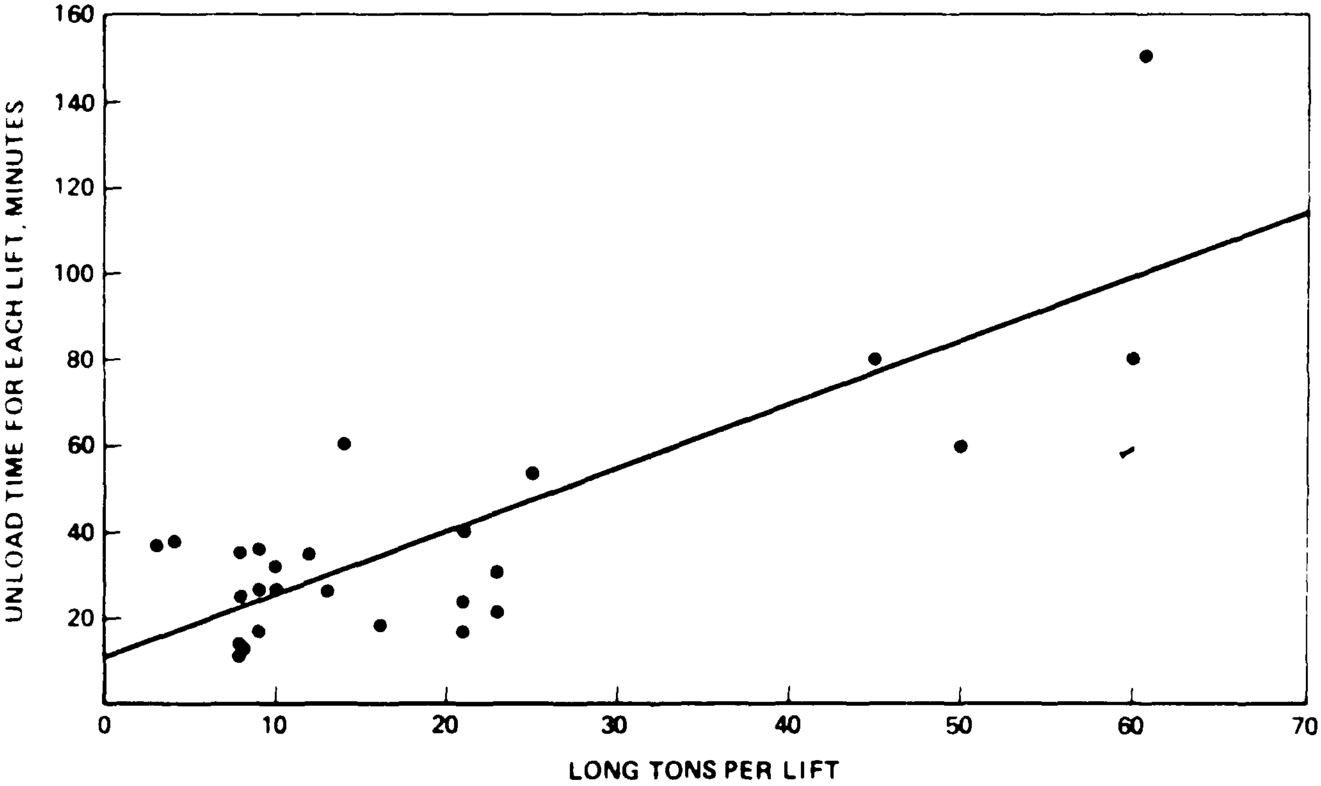

FIGURE 9. RELATION BETWEEN UNLOADING TIME AND LONG TONS
(Chart is for 26 lifts)

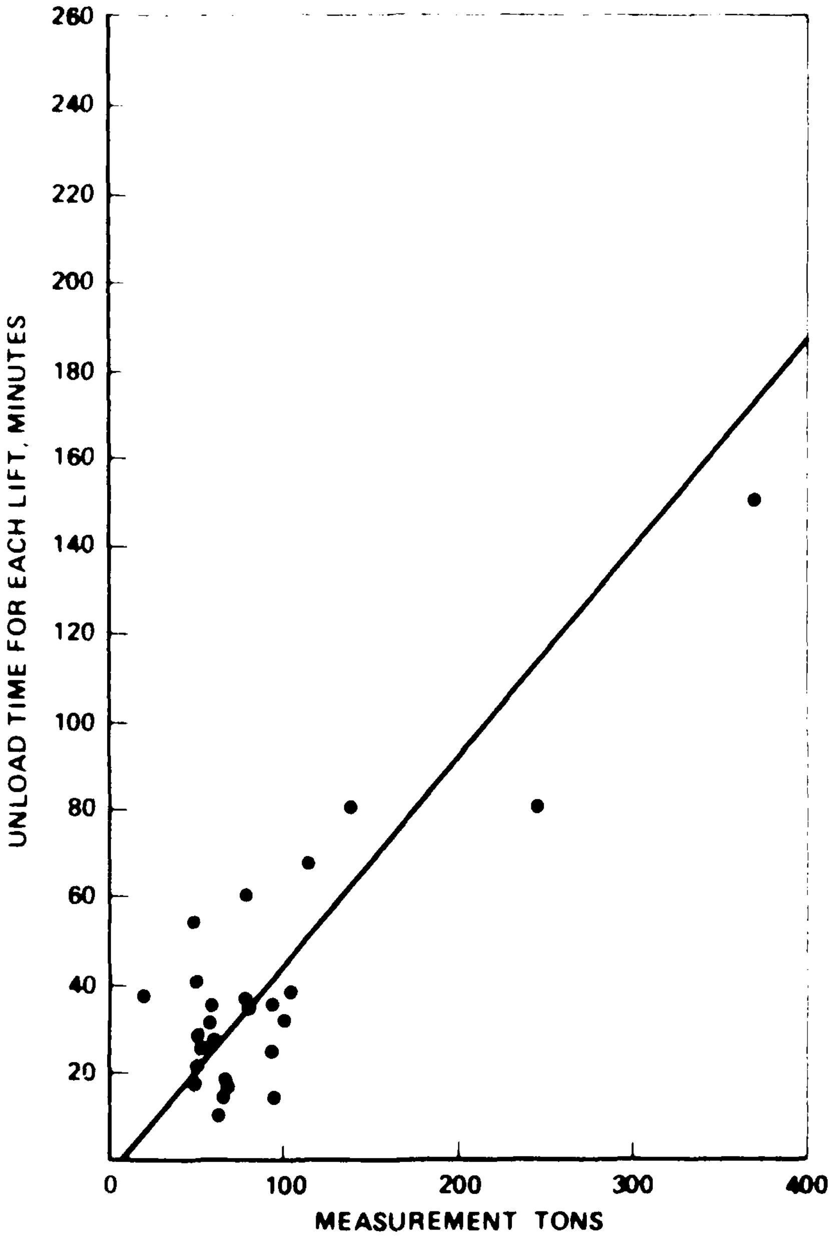

FIGURE 10. RELATION BETWEEN UNLOADING TIME AND MEASUREMENT TONS
(Chart is for 26 lifts)

The average unloading cycle was 40 minutes and for loading cycles it was 20 minutes.[11/] Thus, it might be expected that a straight line through the zeros of the scales with a 2 to 1 slope would fit the data. As can be seen in Figure 8, there is a substantial scatter in the plotted points and using a least-squares fit line through the data, the slope is much less than 2 to 1. The line does not go through the origin. The relationship between off-loading time and the loading time is not a clear cut one.[12/]

The second plot, Figure 9, shows the relationship between unloading time and the long tons for each lift. The scatter in this instance is less than that for the first plot and at least roughly[13/] indicates that the heavier the lift the longer it takes to unload.

The third plot, Figure 10, shows quantitatively the intuitively expected result, that the larger the lift the longer it takes to unload. The figure shows the relationship between unloading times and measurement tons. Here the correlation is good and the graph shows less scatter than the previous charts.[14/] The graph can be translated into the following rule of thumb: for every 100 measurement tons of a lift allow about 45 minutes for unloading. These results are applicable to individual lifts only and are not readily applicable as general military planning factors because the test ship was not fully loaded with typical LOTS cargo. The test load consisted of selected items many of which had, in fact, been chosen because they were especially difficult to handle.

FUTURE DATA AND DATA ANALYSES

The basic purpose of the series of protests was to assess capabilities for future tests and future emergency operations. The analyses already discussed cover applications of test data as originally planned except for sea state and platform motion. As anticipated,these data require a long term collection effort. This section discusses intended future use of the data collected in the pretest and suggest additional collection efforts in future tests.

Analysis of Data on Waves and Motions of Lighters

As noted in Section I of this report it was foreseen during planning of the pretest that there would be difficulties with direct use of wave and lighter motion data. This was because (a) the pretest had to be conducted in whatever

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11/ The loading and unloading operations each took two days. Surprisingly, the elapsed lift-working time for the unloading phase was twice as long as the loading phase. The loading in-port had shorter working days, more time spent working the ship, and substantially more time in the avoidable delay category.

12/ Statistically, for this plot the correlation coefficient, r^2, has a value of 0.32. Perfect correlation, where all the points fall exactly on a straight line, would yield an r^2 value of 1.00. No correlation, that is, the points falling in no pattern at all, the r^2 value is 0.

13/ Correlation coefficient = 0.66.

14/ Correlation coefficient = 0.72.

sea state might occur, and (b) there was as yet no practical and theoretical basis for precisely stating at what point sea roughness dictates cessation of operations, or to what degree operations are degraded as sea roughness increases. However, there is a reasonable capability for prediction of ship or lighter motions in a given spectrum of wave energies. What is lacking is organized knowledge of how, in a practical way, these motions hinder the unloading process.

The sea state that occurred in the pretest was rough enough to help in developing the needed theoretical-practical framework. The next few paragraphs outline the potential contributions of the present test results toward increasing our understanding of sea state effects on unloading. A good start has already been made in this area (see the theoretical analyses of the 1972 test data, References 4 and 5 listed in Appendix C).

The present test results can be considered as one documented point in a series of future test points to determine when a sea state begins to seriously slow down or actually prevent off-loading operations. The fact that specific heavy loads were safely off-loaded from the conventional breakbulk ship into landing craft in a measured sea state (ranging from 1 to 3½ feet and with a specific range of periods) constitutes an initial multi-dimensional data point. Besides wave characteristics other dimensions included the sizes and weights of the loads, lighter characteristics and factors such as hook speed.

For an example of the way such an analysis might proceed, consider the dimension of cargo weight and size as it affects off-loading in a seaway. As shown at Normandy, small loads can be transferred from breakbulk ships to small lighters even in substantial seas. Presumably larger and heavier lifts can be unloaded into larger landing craft in lesser seas. At what point the operation must be halted, and for what type, size, and weight of load, is now a judgmental decision. To quantify the results of tests for future planning purposes an understanding is needed of how the seaway affects the operation. The mechanisms may be: load pendulation with consequent impacts against the ship or lighter; impacts of the lighter against the ship; the parting of lines caused by ship or lighter oscillation; or combinations of these and other factors. All of them, and in fact more, are considered by the experienced man in charge of the unloading operation. What is needed is a quantification of these practical and theoretical effects that together determine the impact of the sea state on the operation.

Some future tests may occur in periods of calmer seas and would not add to our current knowledge. However, one or more future test events can be expected to occur in rougher seas. Then the capability to load specific cargos in these seas will be established, or the reason the operation was slowed or had to be stopped will be demonstrated and documented.

There is some risk that, when a fuller understanding of the mechanisms involved has become clear, the documentation or the test procedures used for the present test will in fact prove deficient to some degree. Efforts were made to collect appropriate data in the light of present knowledge and to preserve it. Examples of potential procedural difficulties have already been discussed earlier in the report. For example, the fact that the instrumented LCM8 was not adjacent to the ones being loaded may cause some analysis problems. Also a spectrum of wave energies (basically a statistical distribution of the frequency of wave heights at different wave lengths during a given elapsed time) will be required in order to predict lighter and ship motions. These data are obtainable from the tape records made of sea state during the test, but were not available in time for this report.

Tests to Show Effects of Ship's Lee

The analysis of the pretest experience indicates that one kind of data should be collected in a future test. It is the effect of the ship's lee upon lighter motion. The instrumented lighter could be placed in various locations relative to the ship and relative to the wind and wave direction. Hopefully such a series of test runs would provide the beginning of a quantitative evaluation of where it is best to position a lighter for ship unloading operations.

CONCLUSIONS AND RECOMMENDATIONS

A. FINDINGS

1. The major objectives of the pretest were attained.[1/] In particular, the Army's 300-ton crane was successfully landed and reassembled for use. This conclusion is tempered only by the fact that off-loading operations were conducted in a relatively calm sea.

2. The relatively narrow hatch openings of the C4S7 type breakbulk ship did not restrict loading but did require more careful tagline handling than was evidenced in this pretest.

3. Boom sections for the 300-ton crane suffered damage during the operation. The damage was such that lifts near maximum rated capacities of the crane would have been questionable.

4. Skill levels in stevedoring and seamanship indicated a need for more training in an open-sea environment, particularly for Army personnel.

5. The off-shore sandbars and the gentle beach gradient at Green Beach posed more severe difficulties than had been anticipated and caused extensive delays in the landing of equipment.

1/ The Army was unable to deploy its 140-ton crane in a tactical configuration due to a faulty sling design. In a later pretest, however, a redesigned sling was successfully used and the crane was moved ashore by LCM8. Thus, all of the major objectives of the breakbulk ship pretest may be considered to have now been fully met.

6. In a LOTS operation the Army dozers will need to work in the surf to assist landing craft, to prepare approaches, and to support salvage operations.

7. Beach preparations for the landing and assembly of the 140-ton and 300-ton capacity cranes on the beach were highly successful.

8. The specially designed ramps made feasible the loading of the carrier of the 300-ton capacity crane and movement ashore in an LCM8.

9. The reassembly of the Army's 140-ton capacity crane from a tactically disassembled configuration in a beach environment can be accomplished within about one day with a nine-man crew.

10. The reassembly of the Army's 300-ton crane from an administratively disassembled configuration is feasible in a beach environment and can be accomplished within about two days with a nine-man crew assisted by a 140-ton crane.

11. The data on sea state and on motion of an instrumented LCM8 were recorded satisfactorily and permitted documenting off-loading capabilities for the particular sea state encountered.

12. The load cell measuring the lift forces showed maximum forces on the order of 10 percent above the static load. This variability is interpreted as being caused by the sea state. While the load cell data showed forces larger than the nominal 60-ton boom capacity on the majority of breakbulk ships, this nominal capacity includes sufficient allowance for overloads at least in a seaway no worse than that encountered in the test.

13. Uncontrolled observers constituted a hazard to themselves and operating personnel both ashore and on the ship.

RECOMMENDATIONS

1. Training opportunities should be sought for boat handlers and cargo handlers in an open sea environment before the main test in 1977.

2. A means for providing better protection of crane boom sections should be developed. Boom repair capabilities and requirements for the unit should be studied.

3. Beach operations:

   a. Consideration should be given to relocation of the main test beach site to an area with more favorable approaches and gradients.

b. A planning survey of the near-shore bottom should be conducted about two weeks before a test. Another survey should be made within 24 hours of the test.

c. For LOTS operations the Army should consider procuring and equipping dozers with fording gear for use on the beach and in the surf zone.

4. The special LCM8-crane carrier ramps should be included along with the 300-ton crane in the unit table of equipment.

5. In future tests data on sea state and lighter motions should be collected to build a data bank that establishes the effects of sea states on off-loading operations in a seaway.

6. In future tests using a separate landing craft instrumented to record platform motion:

   a. The instrumented LCM8 should be positioned so that its motion is more nearly representive of the lighter being loaded, and

   b. A series of trial measurements should be made to explore the attenuation of lighter motion that may be expected in the lee of the ship.

7. Load cell, sea state, and platform motion data should be collected during operations in the sea states rougher than has been encountered to date.

Observers should be restricted to specified areas of the ship and beach and such restrictions should be made known upon their arrival at or near the exercise area.

APPENDIX A

PICTORIAL SUMMARY OF CONVENTIONAL BREAKBULK SHIP PRETEST

FIGURE A.1. AMERICAN COURIER. The SS AMERICAN COURIER, a C4S7 conventional breakbulk ship under charter to Military Sealift Command, was used April 19-22 for the first LOTS pretest. Holds 4 and 3 (located just forward of the superstructure, respectively) are serviced by the ship's 70-ton boom (seen here off-loading an LCM8). The off-loading was conducted off Ft. Story, Virginia.

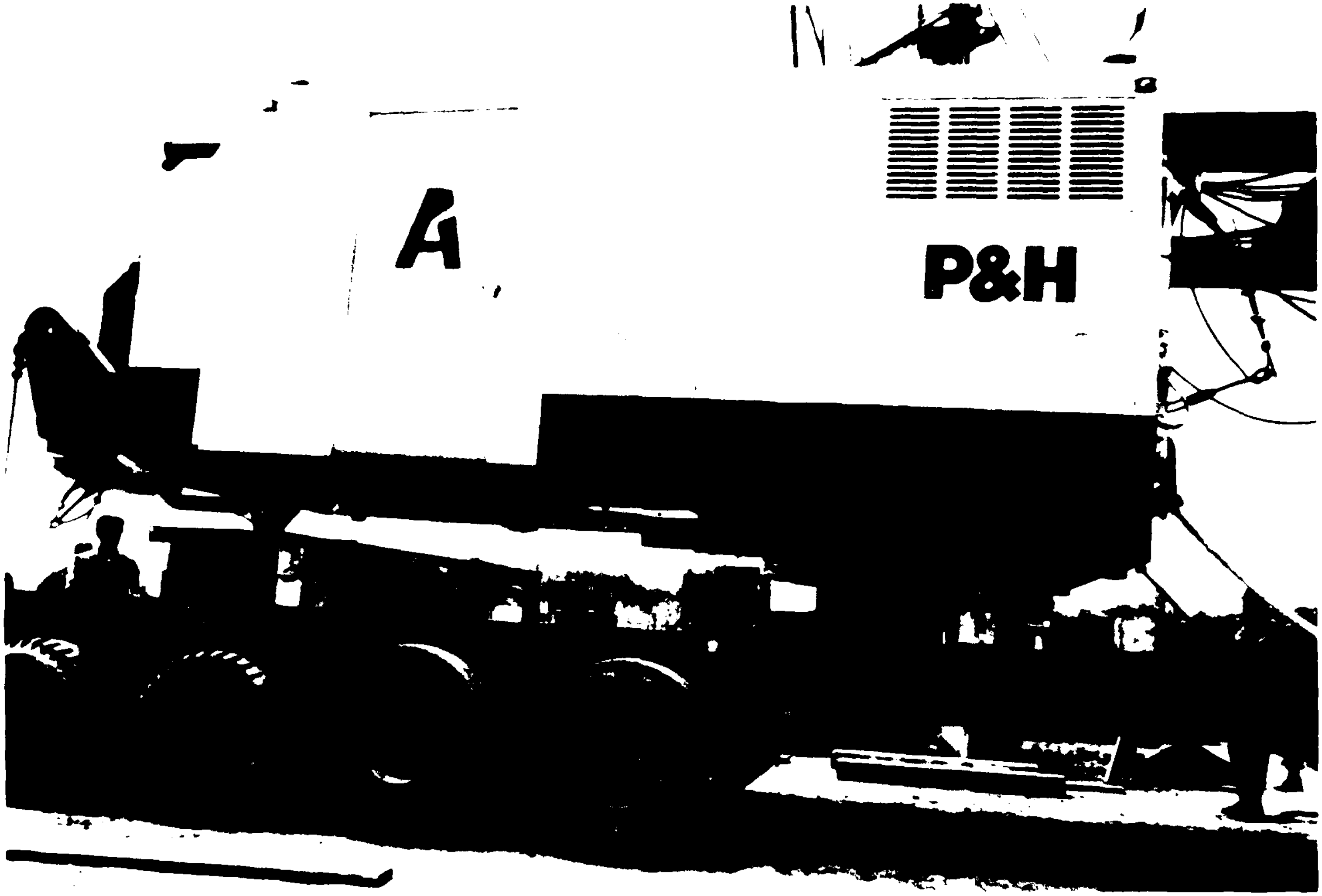

FIGURE A.2. MOBILE LOADING THE UPPER. The 52-short ton upper section of a P&H 6250 model crane (300-ton lifting capacity) is lowered onto blocks on an M747 semi-trailer. Mobile-loading the crane upper helped protect the underside of the upper until it could be reassembled on its carrier. The gantry, drums, and cable were left on the upper to expedite reassembly.

FIGURE A.3. LCM8 RAMP APPROACH. In preparing for the pretest various preliminary trials were made to insure the test could be conducted smoothly. In the above photo the upper, mobile loaded on an M747 trailer, is backed onto the LCM8. Because of the concentration of weight on the LCM8 ramp and low vehicle clearance, approaches to the well of the LCM8 had to be made reasonably level and the weight distributed.

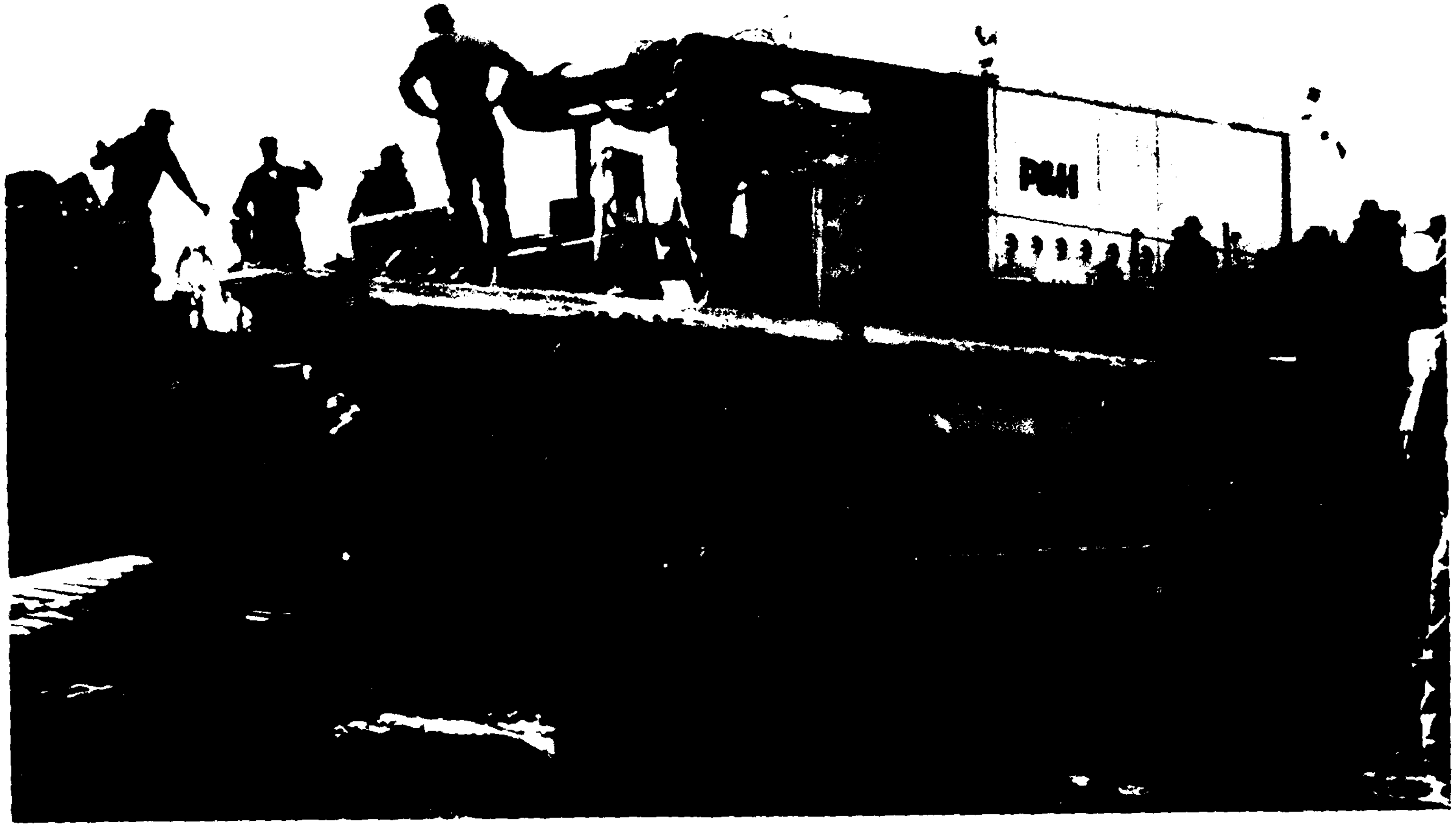

FIGURE A.4. LOADING THE LCM8. Once the P&H 6250 model crane upper was mobile-loaded on the M747 trailer, they were both backed onto an LCM8. The well of the LCM8 was first strengthenend by adding steel to the deck as tire trackage. The trailer with upper was loaded without difficulty.

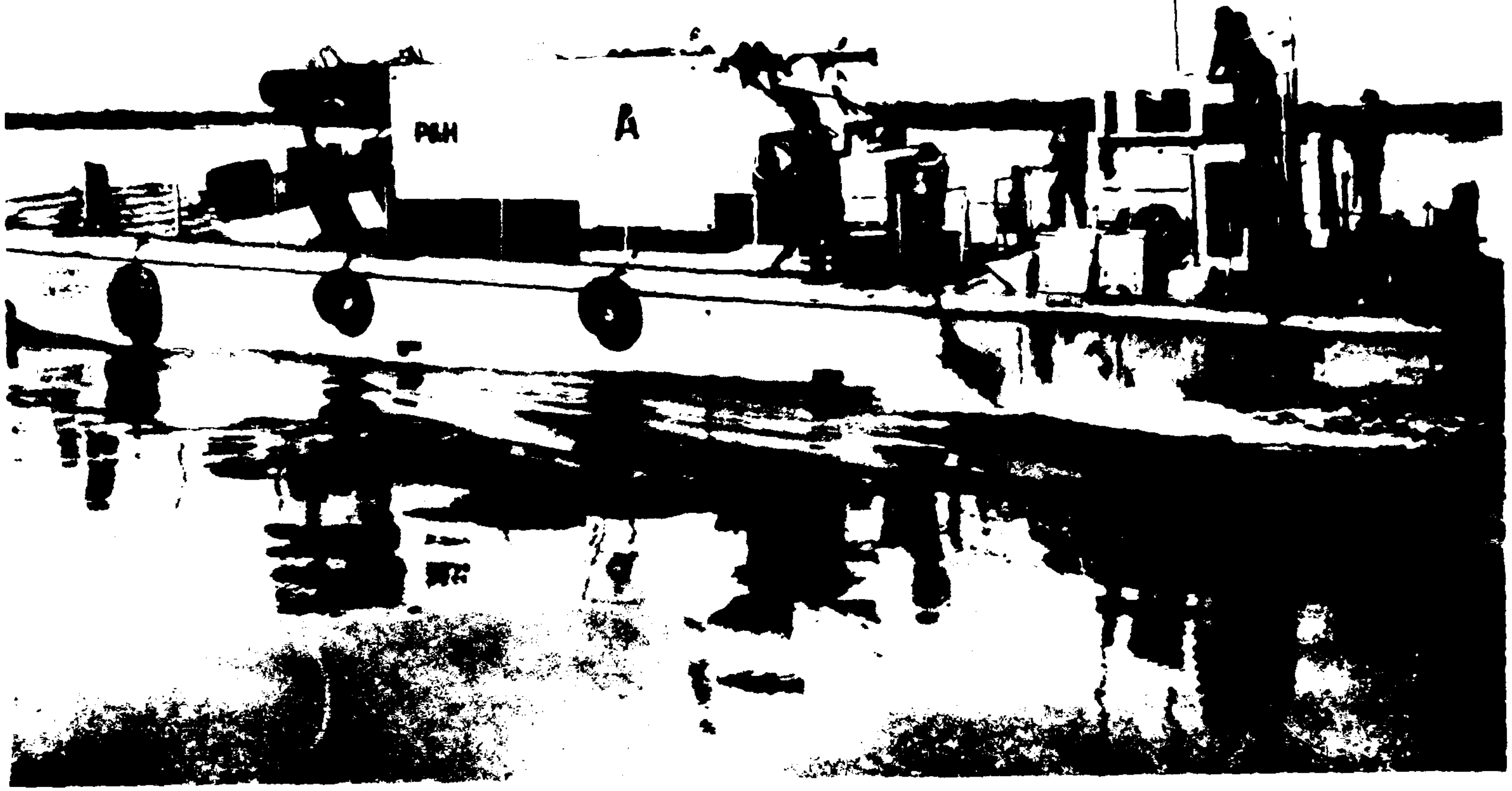

FIGURE A.5. HEAVIEST LCM8 LOAD. One of the preliminary trials for the Conventional Breakbulk Ship Pretest was to test the seaworthiness of the most heavily loaded LCM8. The above test was made in the James River with a 64-long ton load consisting of the 300-ton crane upper and an M747 trailer. Although heavily loaded the test was a success as later evidenced in an open seaway.

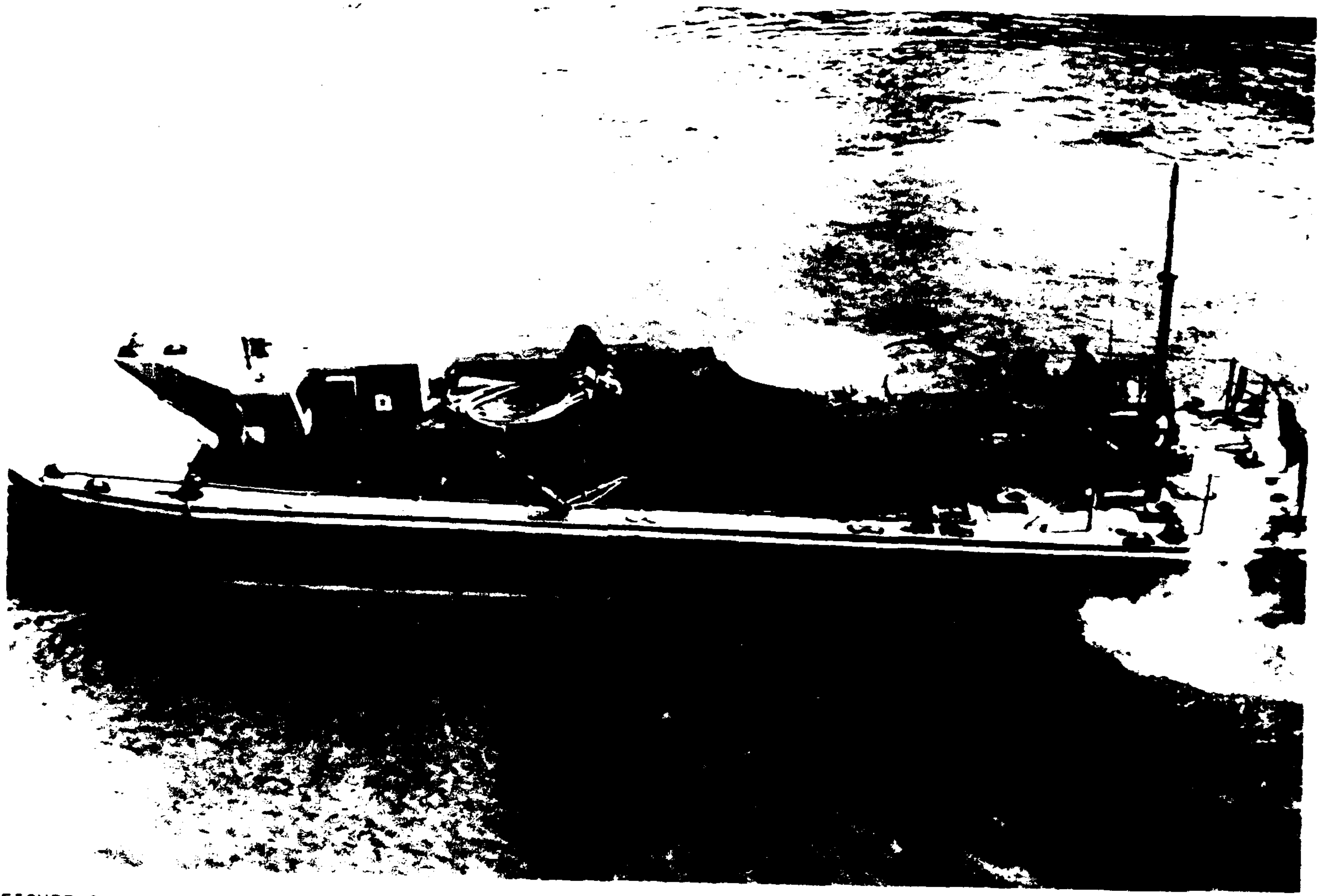

FIGURE A.6. CARRIER LOADED IN LCM8. In order to deploy and off-load a 300-ton crane it was necessary to have a lighter that could carry it ashore. The LCM8 has the capability to carry the weight but there was less than an inch clearance between the LCM8 well and the carrier, too little to normally off-load the carrier from the ship without incurring damage. Above the carrier is shown riding on specially designed ramps that permit loading it on a slant in the well of the LCM8. This added about 4 feet of clearance and made the LCM8 ride in the water more safely.

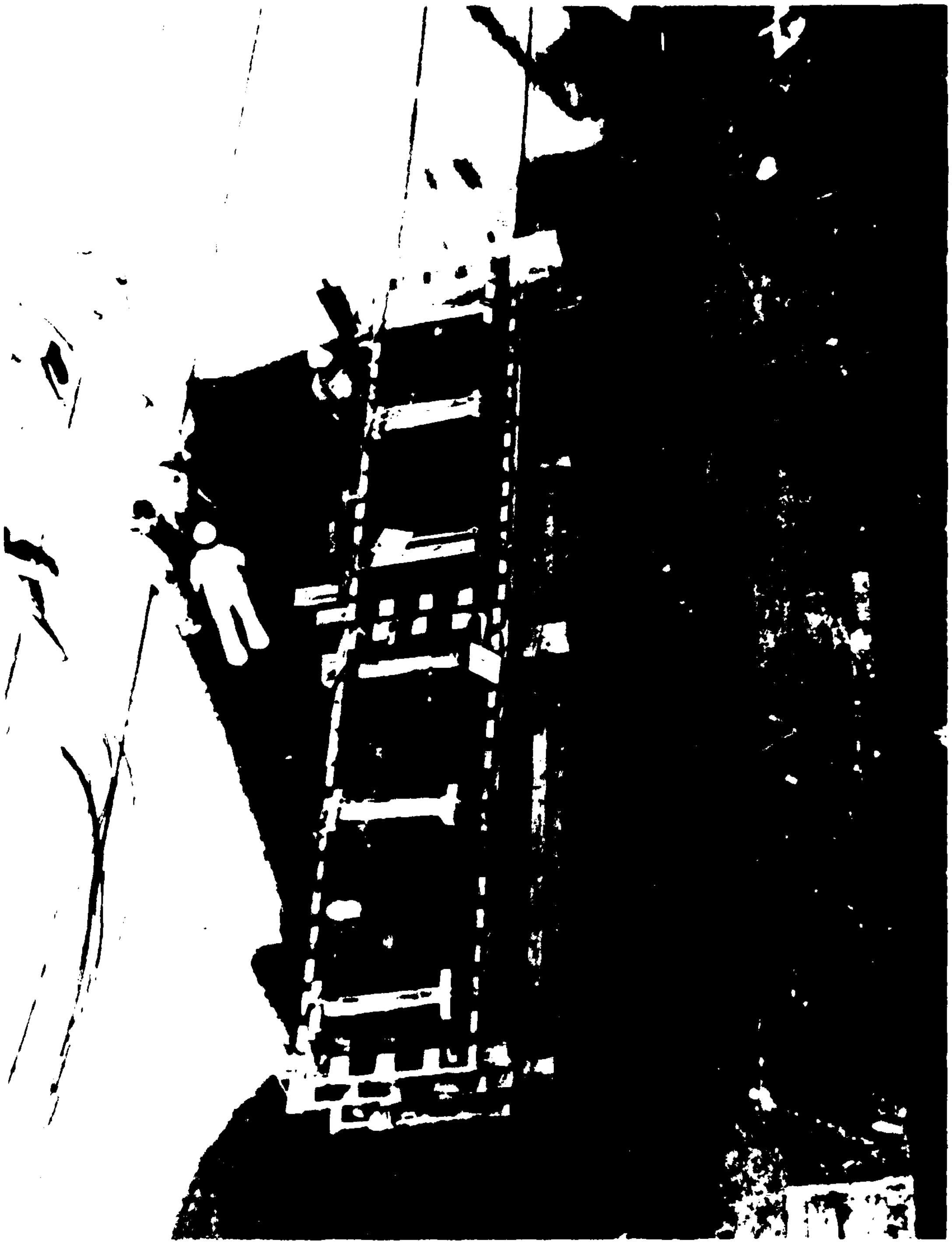

FIGURE A.?. MALKIEL FLOATS READY. Other crane equipment mobile-loaded included the Malkiel floats on an M127 trailer. The mobile loads were positioned alongside the ship just before being embarked.

FIGURE A.8. OUTRIGGER BEAMS LOADED. Outrigger beams mobile-loaded on an M127 trailer are being loaded aboard the AMERICAN COURIER's Hold No. 4. Contract stevedores were used to load the ship. Army and Navy stevedores were used to discharge it while at anchorage off Ft. Story, Virginia.

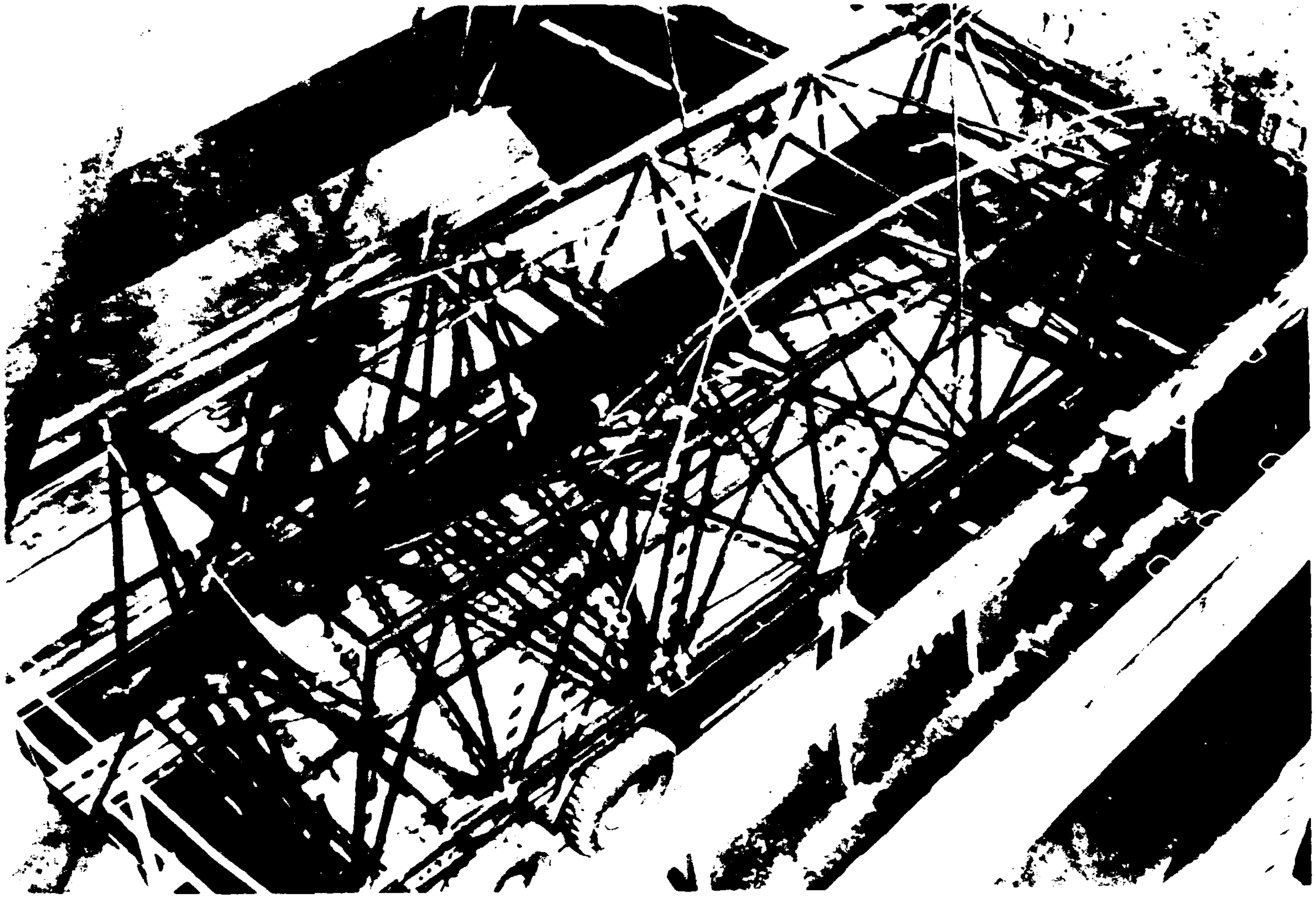

FIGURE A.9. CLOSE FIT. Mobile-loaded 10- and 20-foot boom sections for the 300-ton crane are lowered into midships No. 4 hold. The hatch squares through which vehicles had to be lowered were 16 feet x 42.5 feet and required careful handling to prevent loads from banging into the coaming.

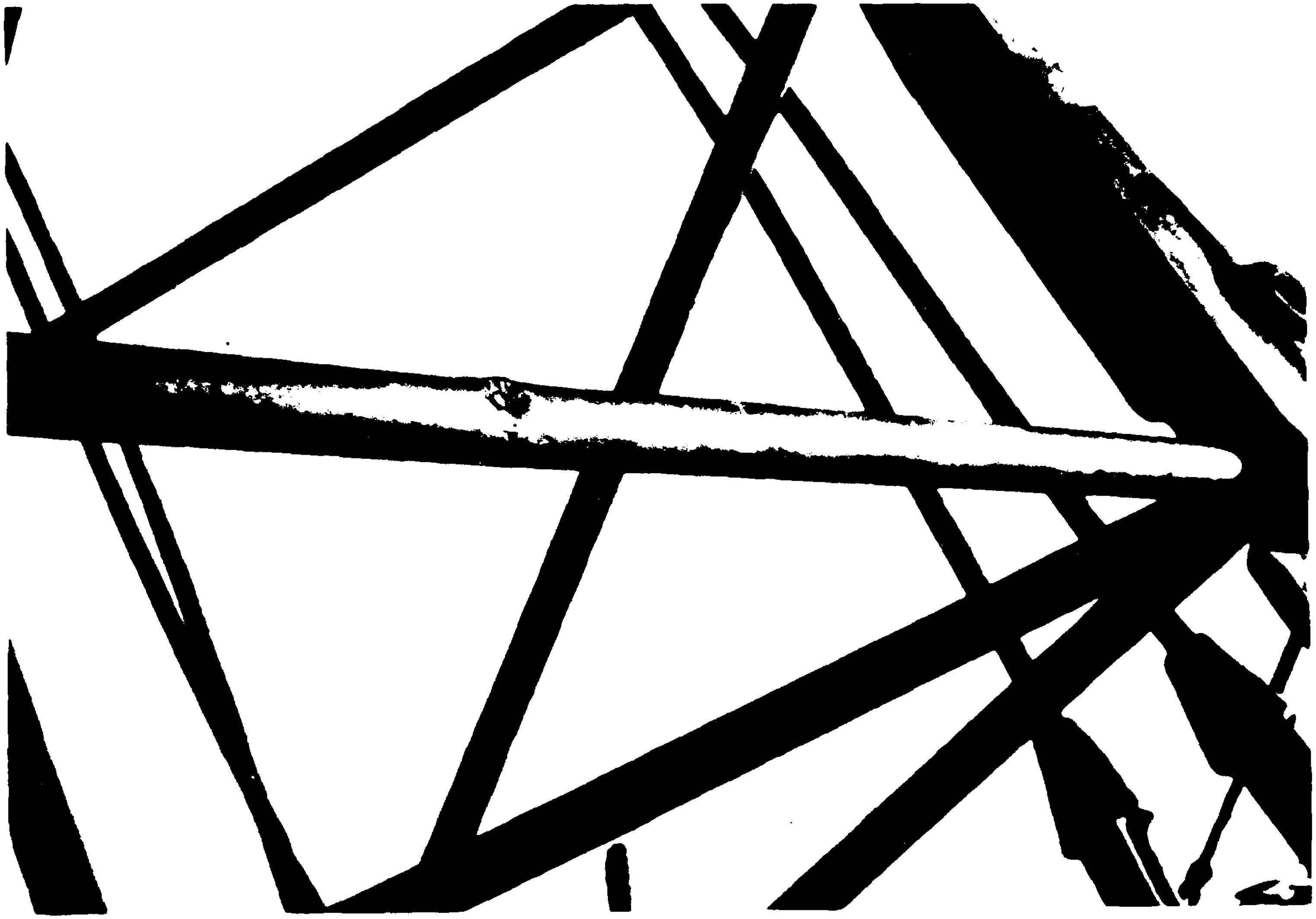

FIGURE A.10. BOOM DAMAGE. At some unknown point during the exercise several of the struts on the 300-ton crane's boom were damaged. Although the dent shown above appears minor, it seriously impaired the crane's capability to handle heavy lifts. The dent had to be cut out and a new piece welded in place.

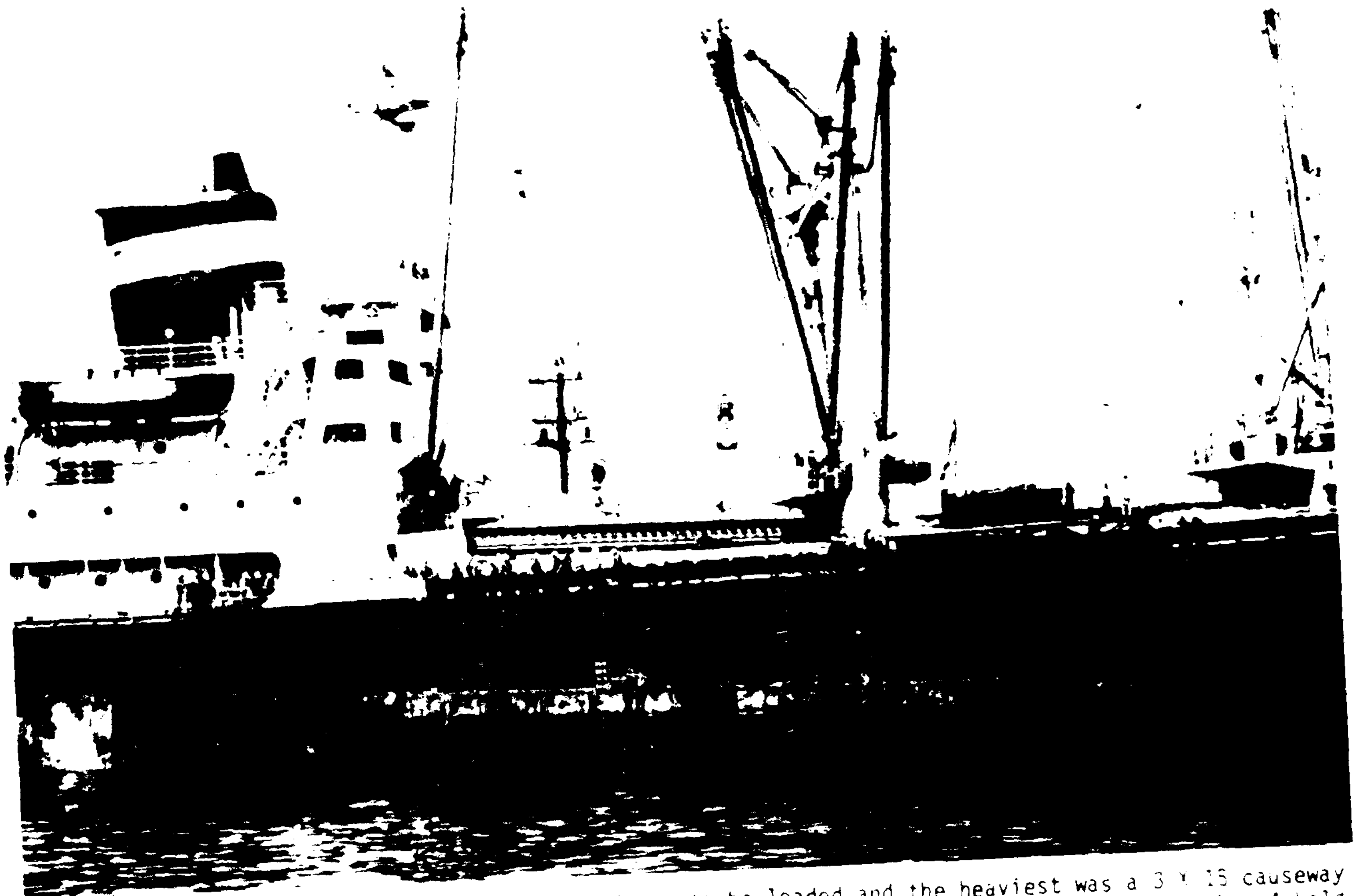

FIGURE A.11. HEAVIEST LIFT. One of the last items to be loaded and the heaviest was a 3 X 15 causeway section. It was almost 92 feet long and weighed 60.3 long tons. It was stowed on deck over No. 4 hold. It's long sling legs did complicate the topping operations of the boom but otherwise there were no difficulties loading the causeway.

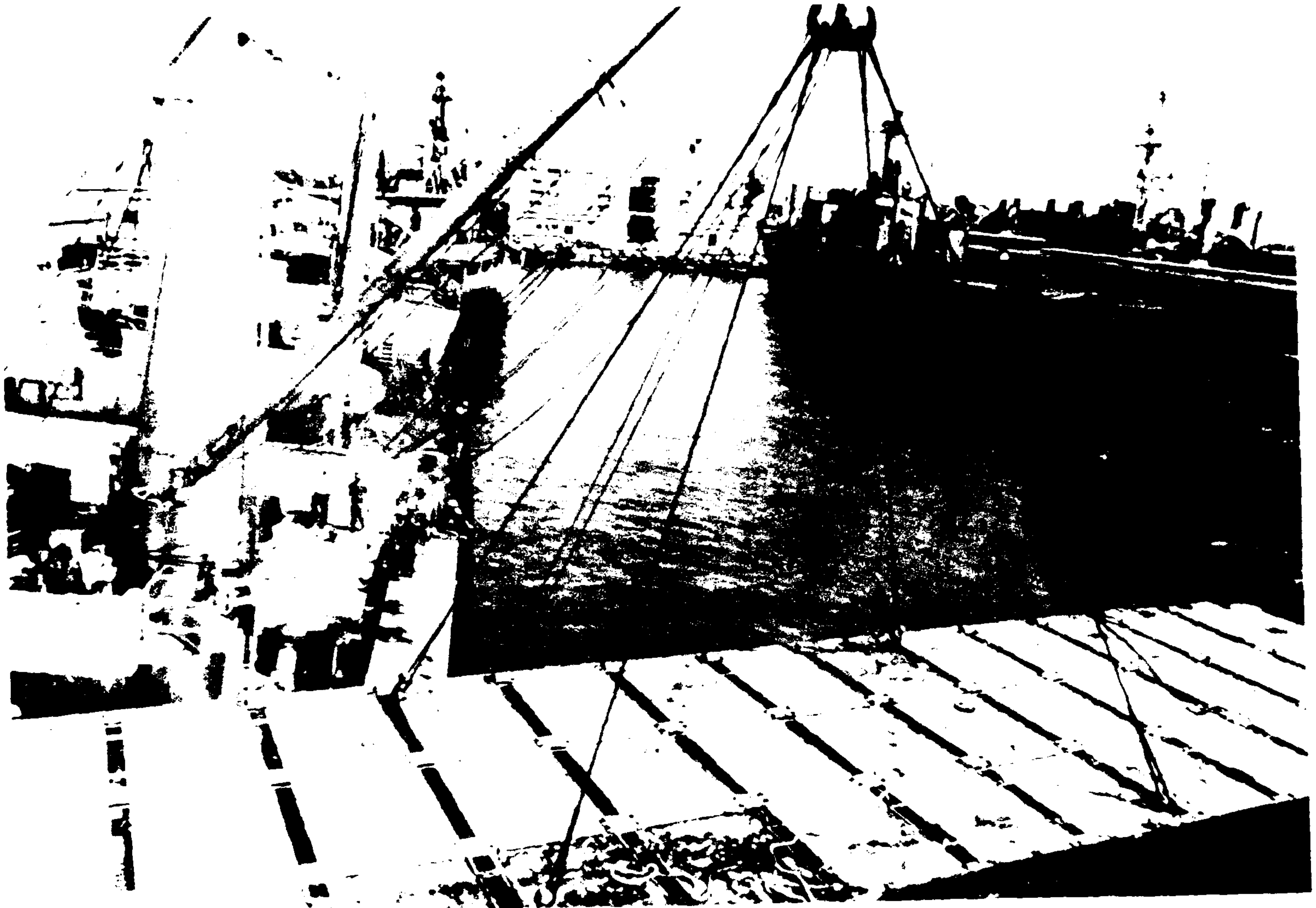

FIGURE A.12. CAUSEWAY ROTATES. Once the causeway had been hoisted above the main deck, it was partially rotated and stowed athwartship. The causeway had approximately a 4-foot overhang to starboard and a 12-foot overhang to port.

FIGURE A.13. SLING FAILURE. The most surprising failure during the pretest was the sling of the 140-ton crane. The crane, being lifted for the first time above, tilted sharply to the right. In the process the right forward sling leg dented the side of the crane upper, which was considered minor damage. The lift was temporarily abandoned.

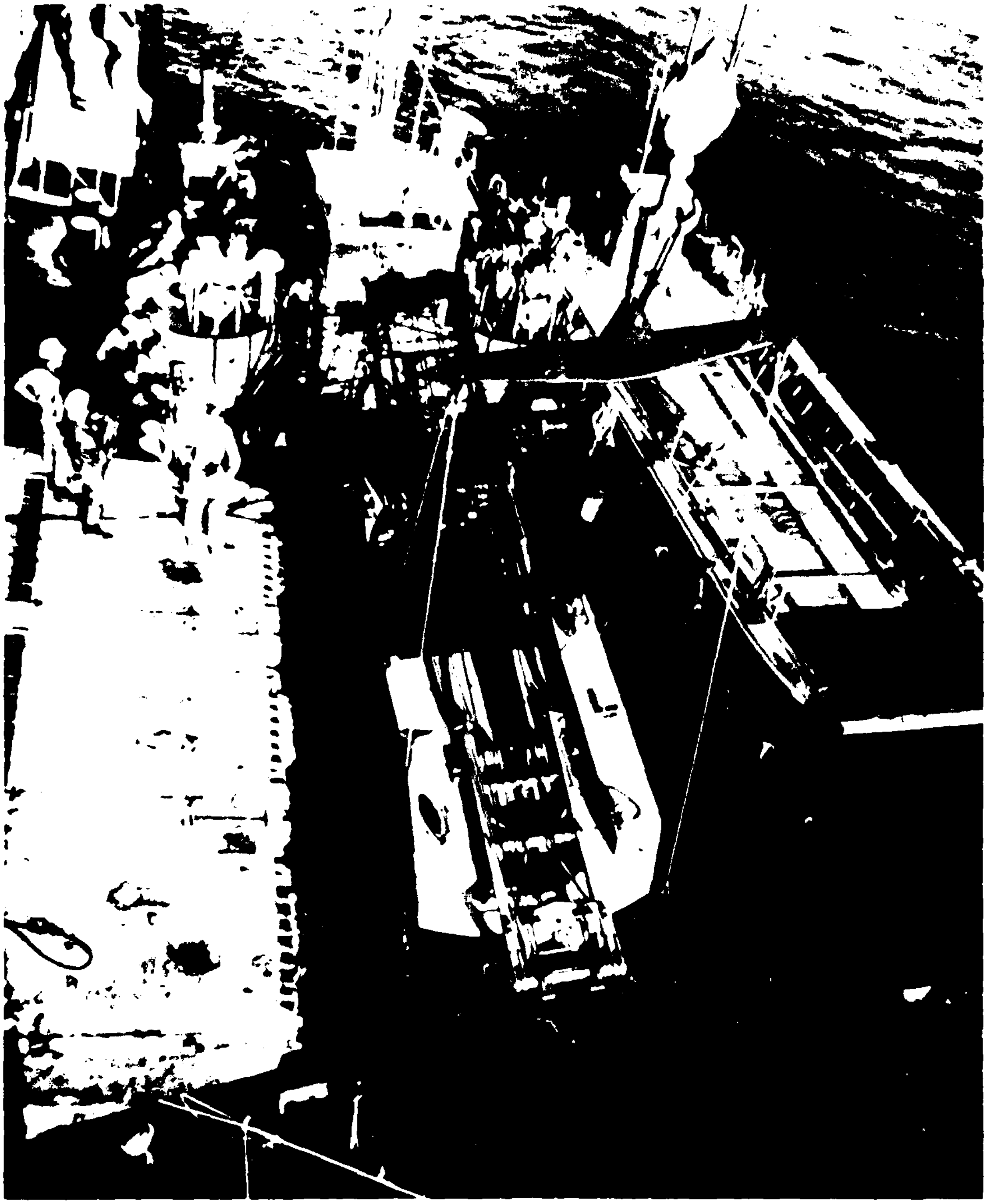

FIGURE A.14. SECOND FAILURE. The crane's upper was rotated after the first failure so that the boom base was pointed forward. It had been hoped that this would bring the crane's center of gravity back into alignment with the sling. On the second attempt the crane tilted, this time to the left. The crane was left in the LC[illegible] and proceeded administratively to the test site.

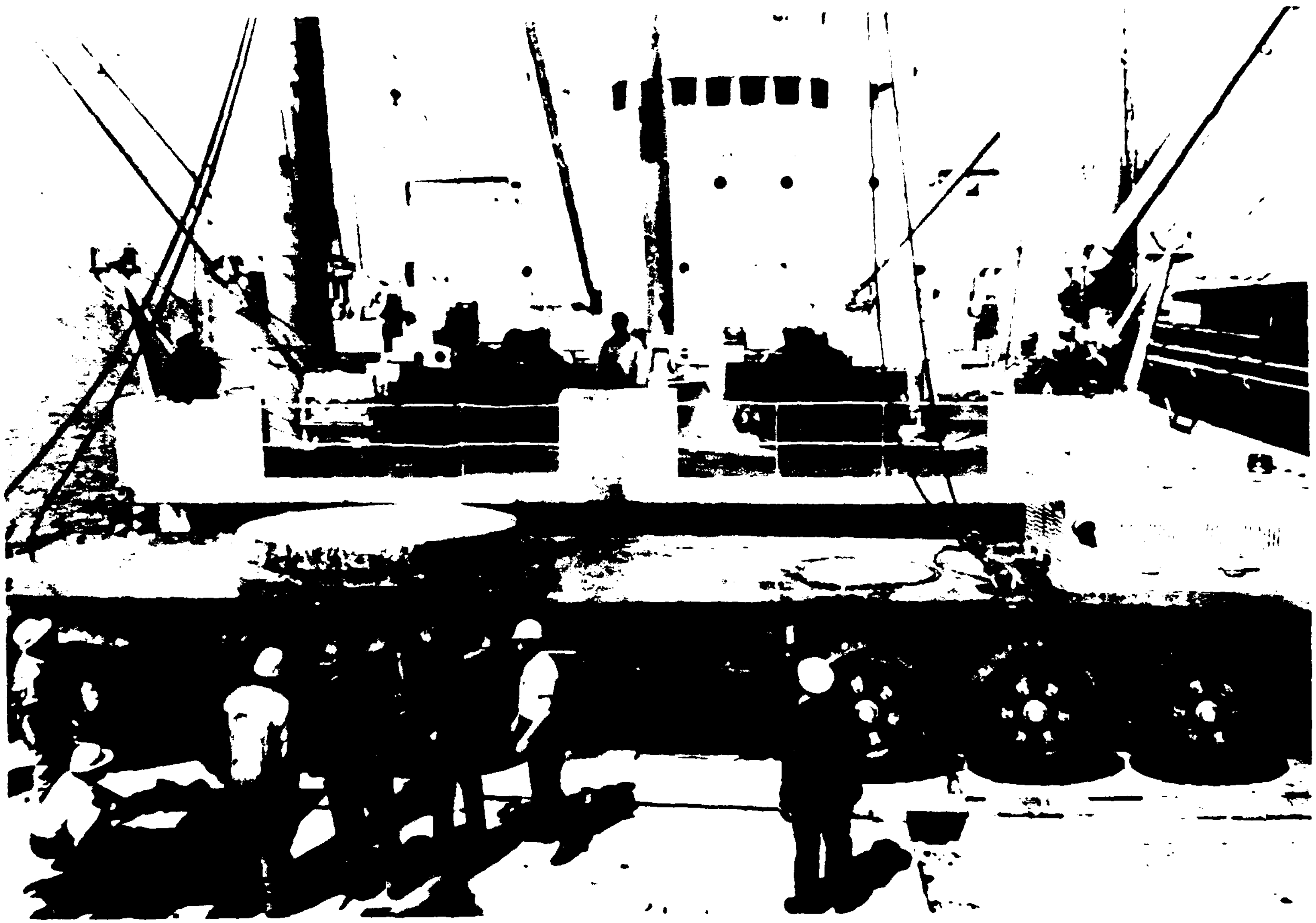

FIGURE A.15. CARRIER STOWED ON-DECK. The carrier for the Army's P&H 6250 model crane (300-ton capacity) was stowed over Hold No. 3. The carrier in its lifting condition shown above weighed 45 long tons.

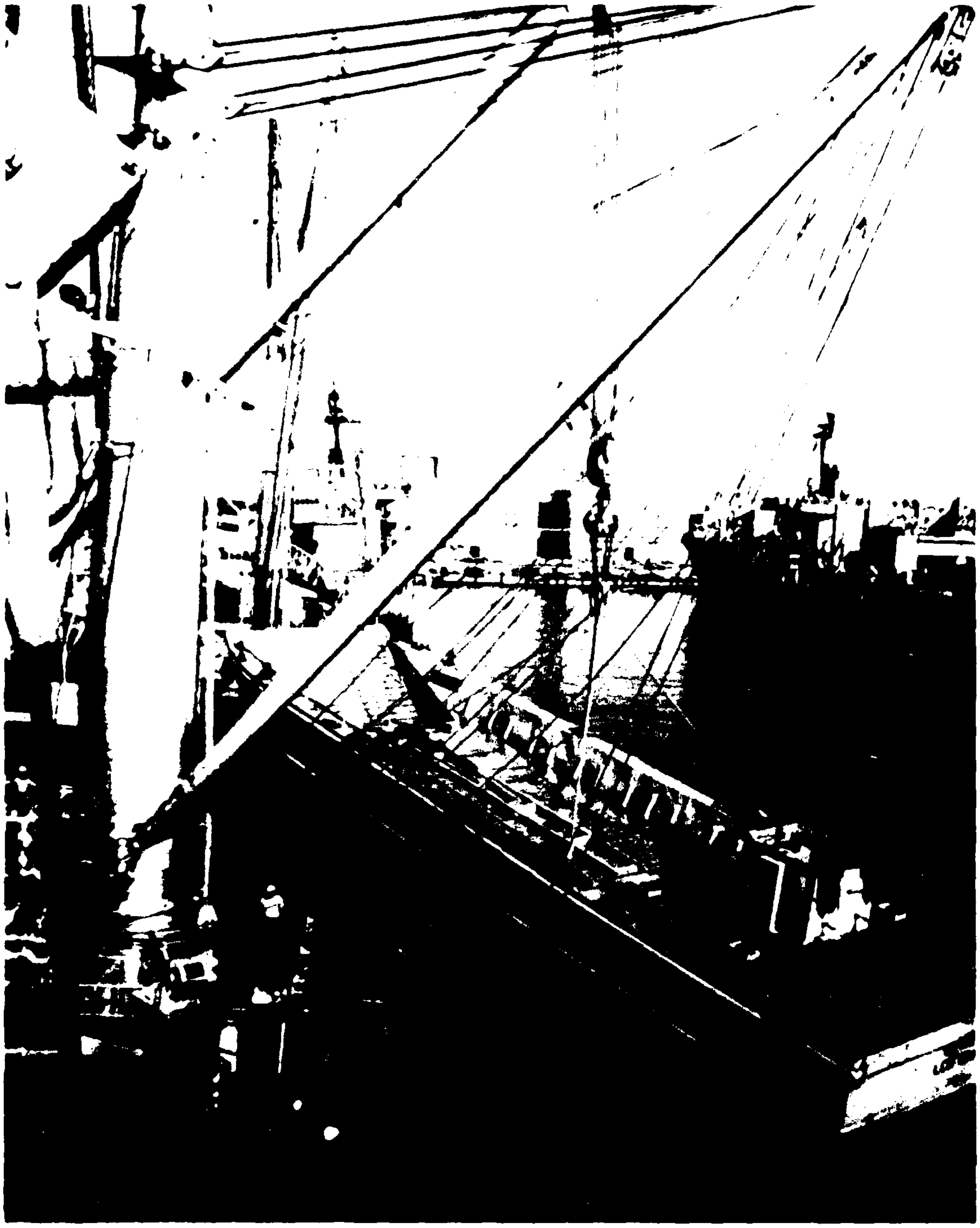

FIGURE A.16. LCM8 LOADED. An LCM8 was loaded to verify the breakbulk ship's capabilities for embarking container compatible lighterage and lighterage capable of transporting container support equipment. At approximately 60 long tons the LCM8 was the second heaviest lift made.

FIGURE A.17. OFF-LOADING BEGINS. Once at anchorage the first item to be off-loaded was the LCM8. Because it was the first item, military stevedores proceeded very cautiously. The ship's cargo handling gear had no difficulties. The load cell attached to the heavy-lift boom block indicated forces of about 66 long tons. This included weights of the LCM8 (estimated at about 58 long tons), the boom's hook, the load cell itself, the sling, and inertial forces.

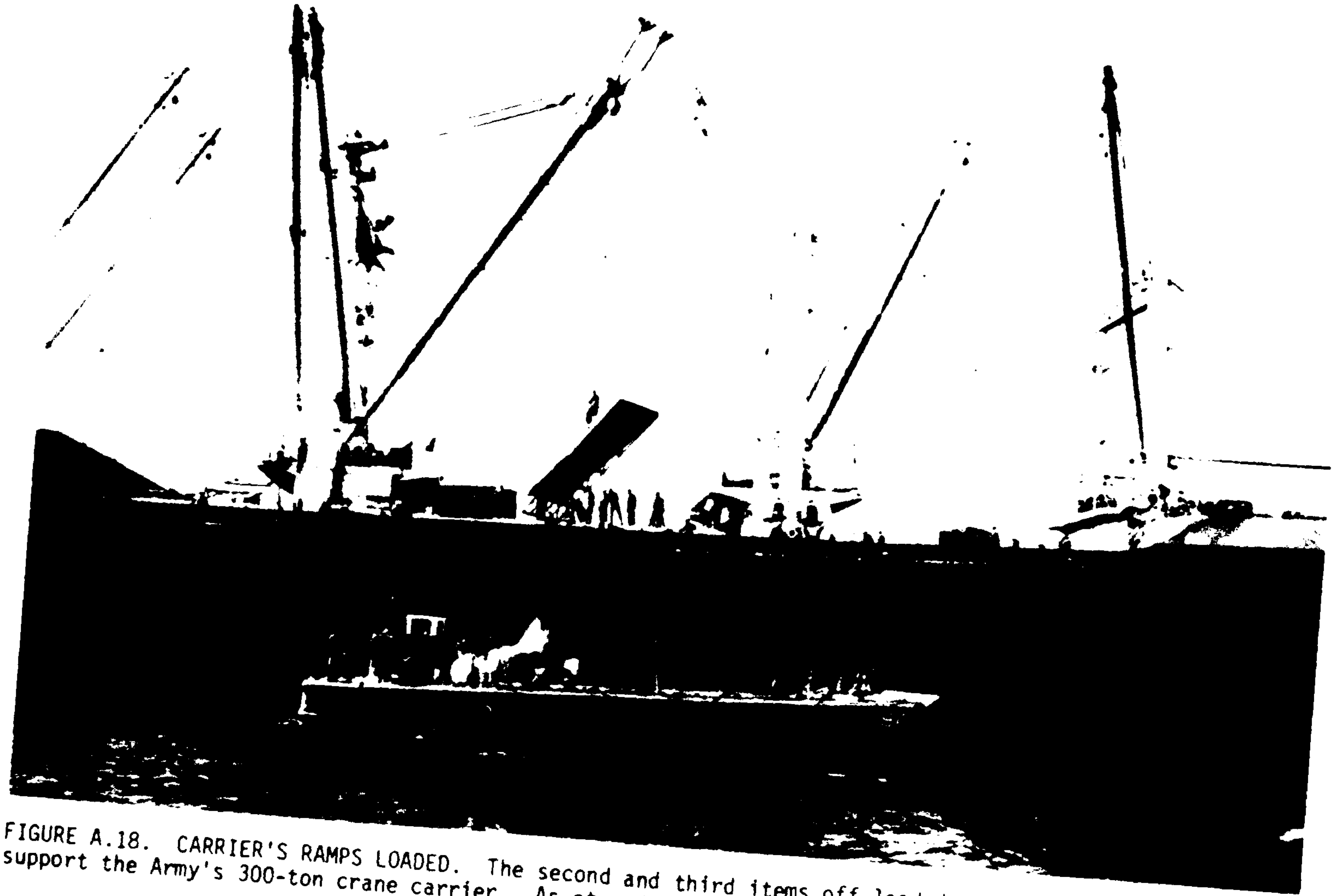

FIGURE A.18. CARRIER'S RAMPS LOADED. The second and third items off-loaded were the two ramps used to support the Army's 300-ton crane carrier. As stevedore experience increased, the speed of unloading increased.

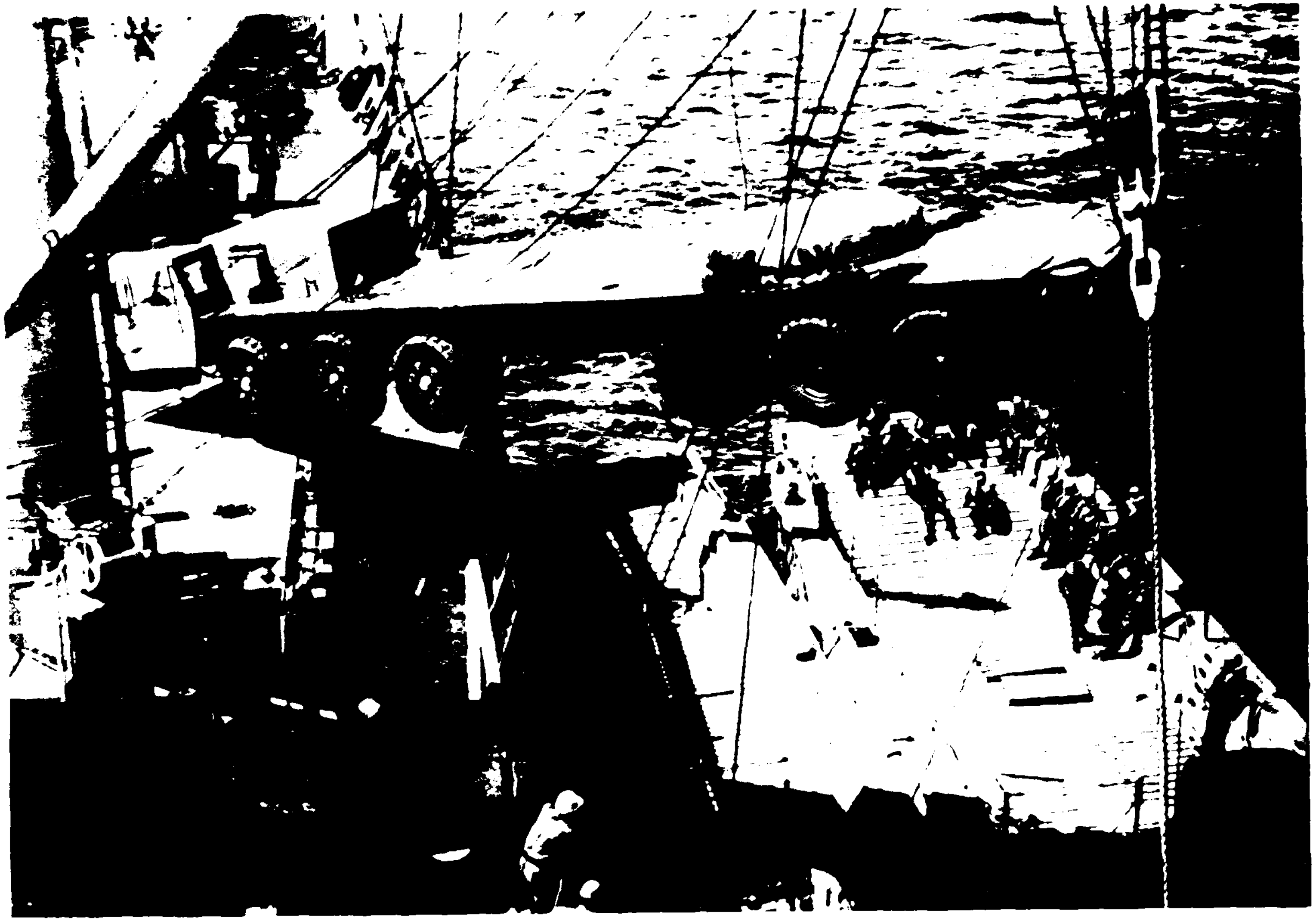

FIGURE A.19. CARRIER OFF-LOADED. For the first time the Army's P&H 6250 model crane carrier is off-loaded (above). Its ramps were first positioned inside the LCM8. A second LCM8 was positioned alongside the first so that tag line handlers, LCM8 crew, and others could be out of the way when the outsized vehicle was lowered over the side.

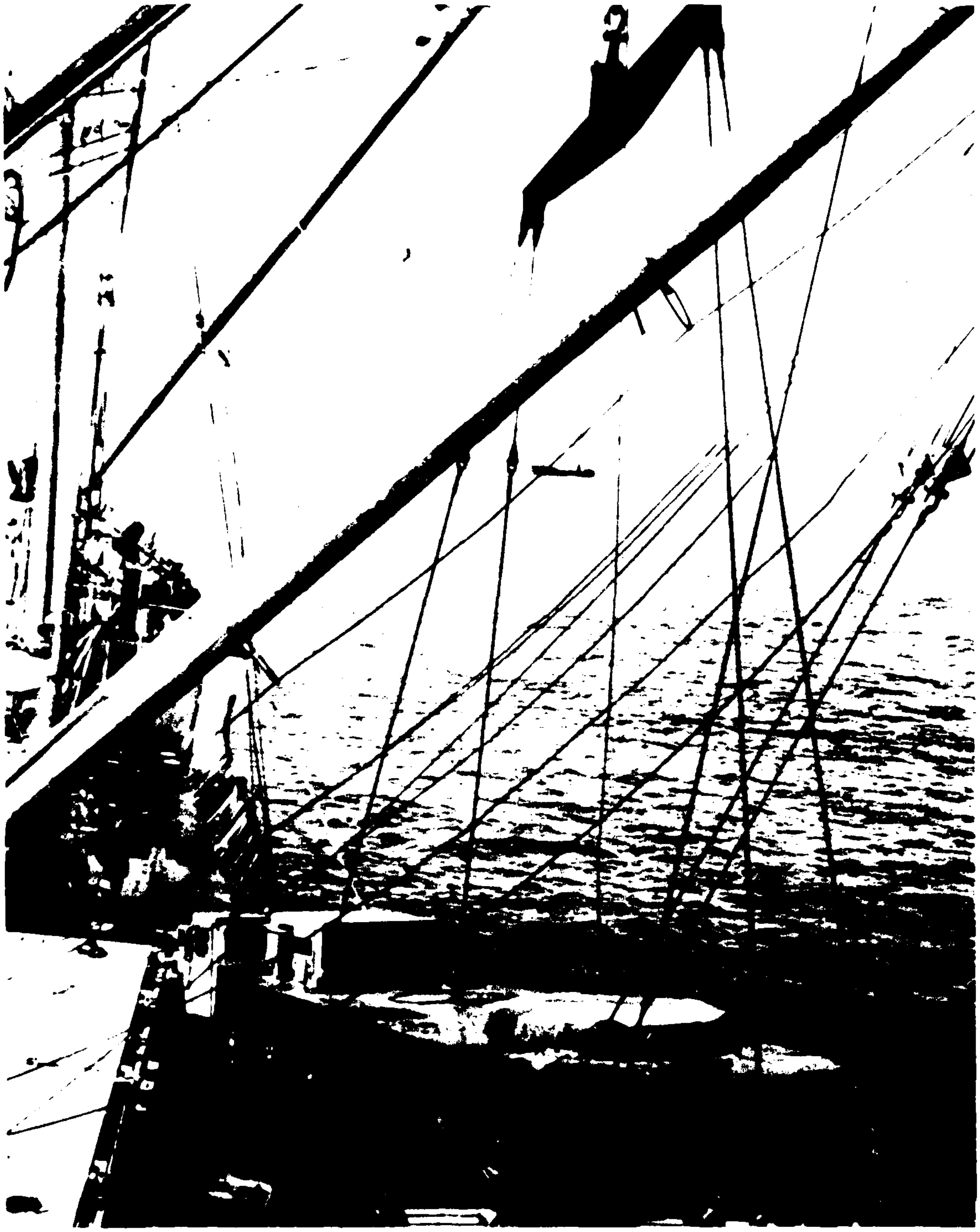

FIGURE A.20. SPECIAL SLING. Because the carrier rested in the LCM8 in a position where the front end was almost 4 feet lower than the rear (to increase the LCM8 well deck stowage area), a special sling was used. The front legs were longer than the rear ones so that the carrier itself was lowered with a forward slant.

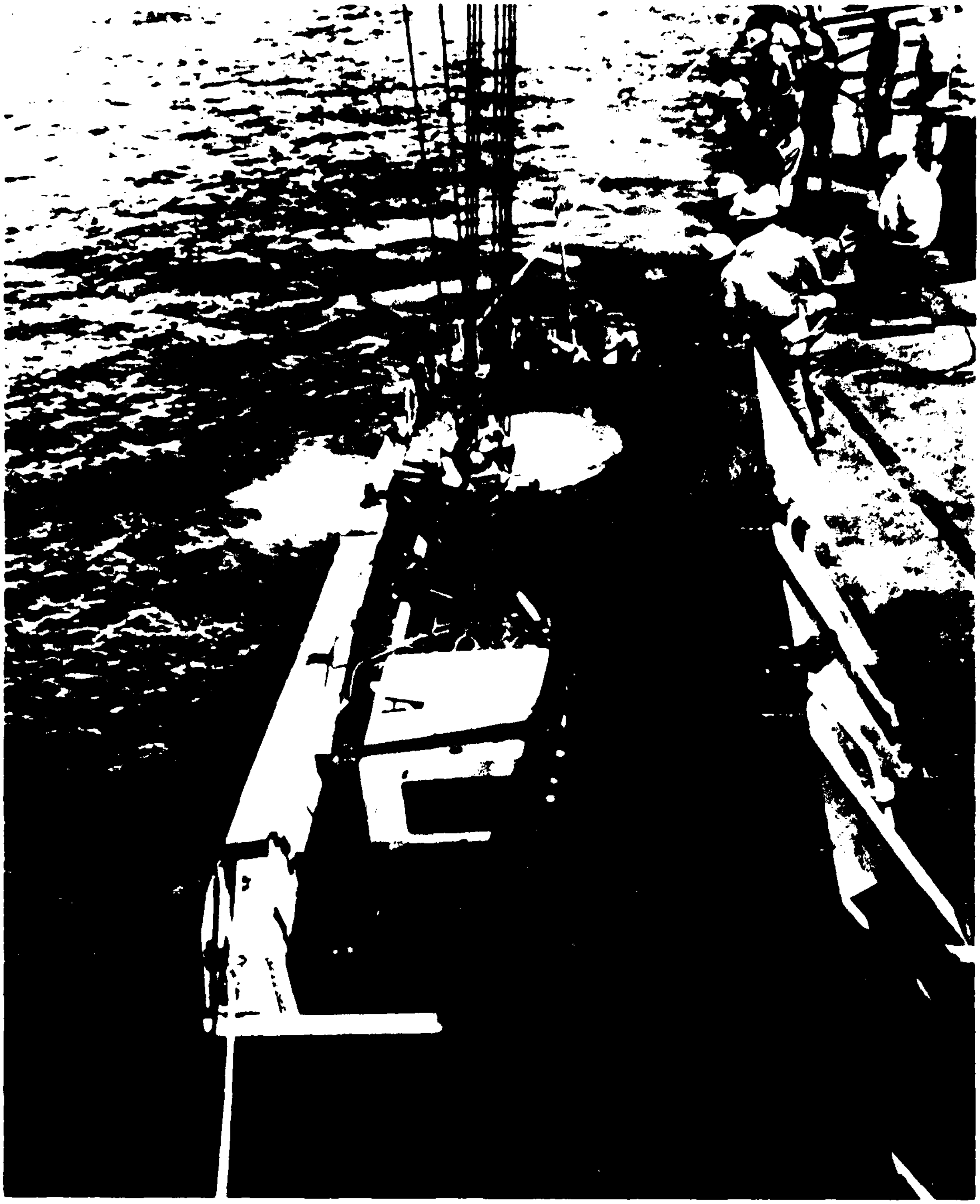

FIGURE A-21. SAFELY LOADED. The 300-ton crane carrier was cautiously lowered over the side without difficulty. Once in the well, it was quickly shackled aft and on each side and the wheels were chocked. Above, shackle pins are removed so the hook can be freed.

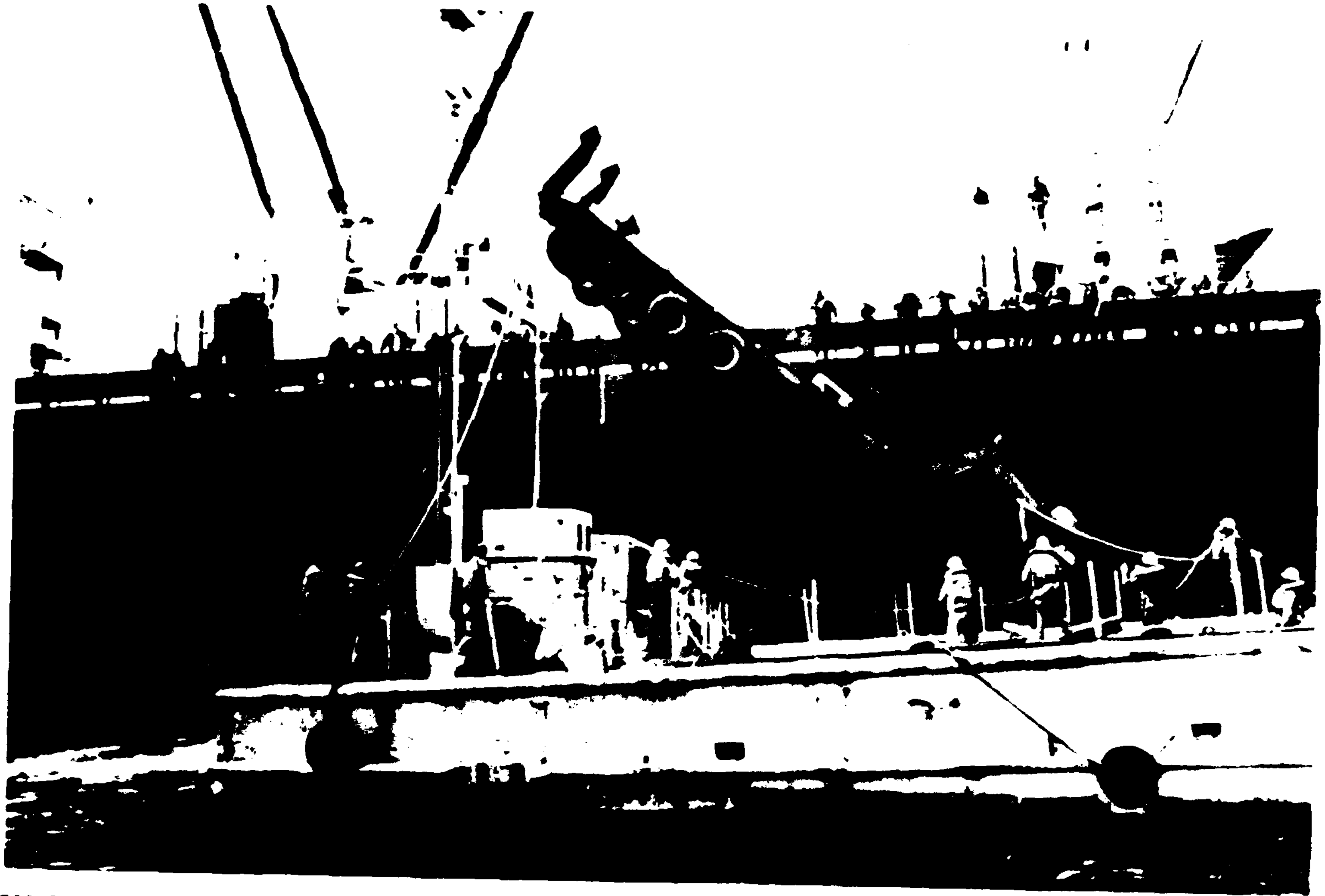

FIGURE A.22. PRECARIOUS LIFT. The M747, designated to transport the 300-ton crane upper, is lowered into an LCM8 at a severe angle. The trailer had to be lowered and raised at an angle to clear the hatch square, which it easily did. However, the AMERICAN COURIER would not permit setting the trailer down on deck to readjust the sling legs before lowering the trailer over the side. The trailer did incur minor damage to its landing legs as a result of being lowered at this angle. Otherwise, it was safely loaded.

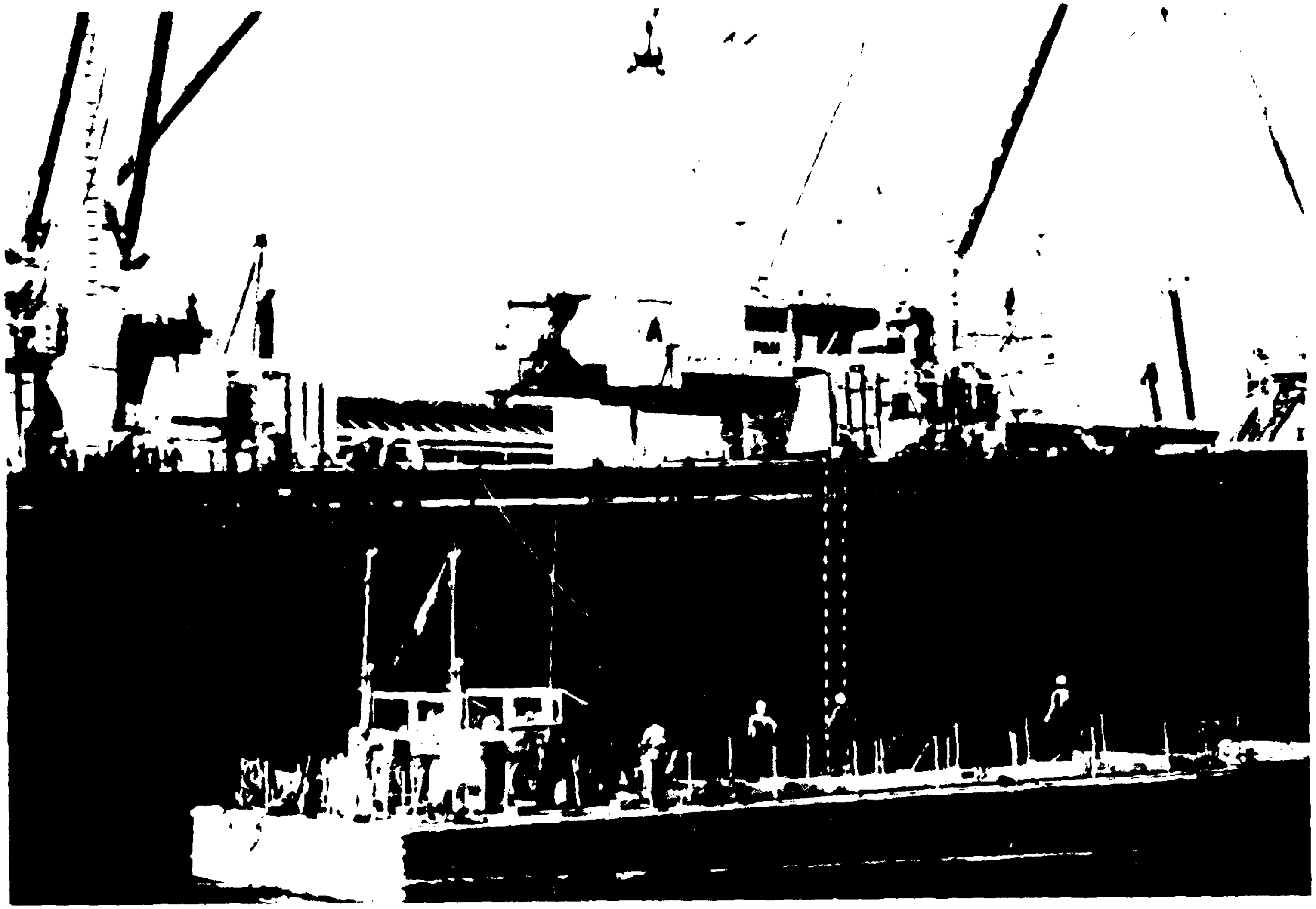

FIGURE A.23. CRITICAL LIFT. One of the most critical lifts was the upper section of the Army's P&H 6250 model crane. The underside of the upper could have been seriously damaged without careful handling. The upper had to be positioned exactly on dunnage on the M747 trailer. In very calm water this was successfully accomplished in about 45 minutes.

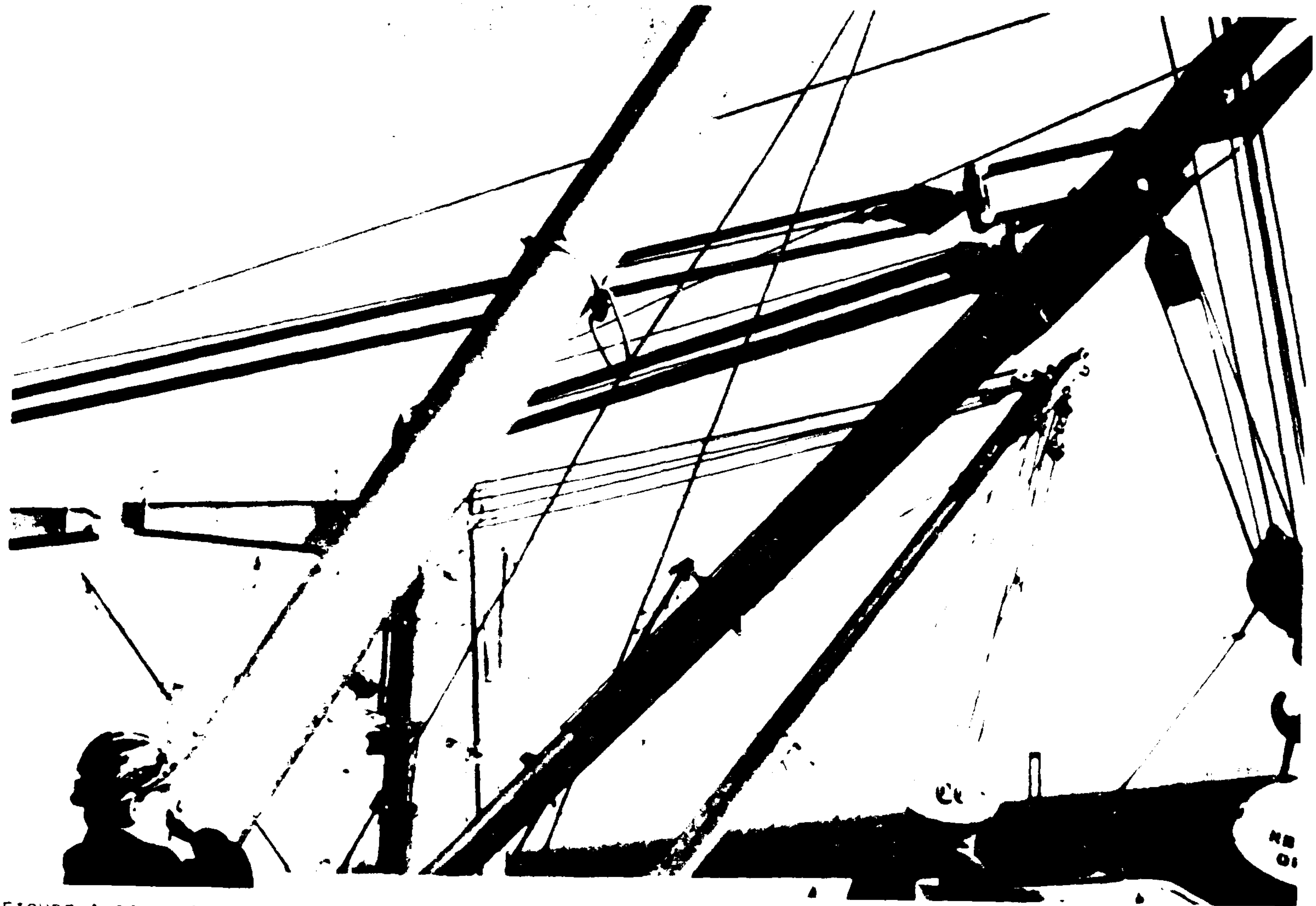

FIGURE A.24. CAUSEWAY CAUSES LIST, BLOCK NEARLY TOPPED. The very lengthy sling legs and the length of the 3 X 15 causeway made for very slow ship unloading when the causeway was discharged. The ship listed about 5 degrees to the starboard (exaggerated in the photo above) as the causeway was rotated so that it was parallel to the ship. A powered tag line was used to help the causeway clear the side of the ship. Because the sling legs were very long, the block was nearly topped.

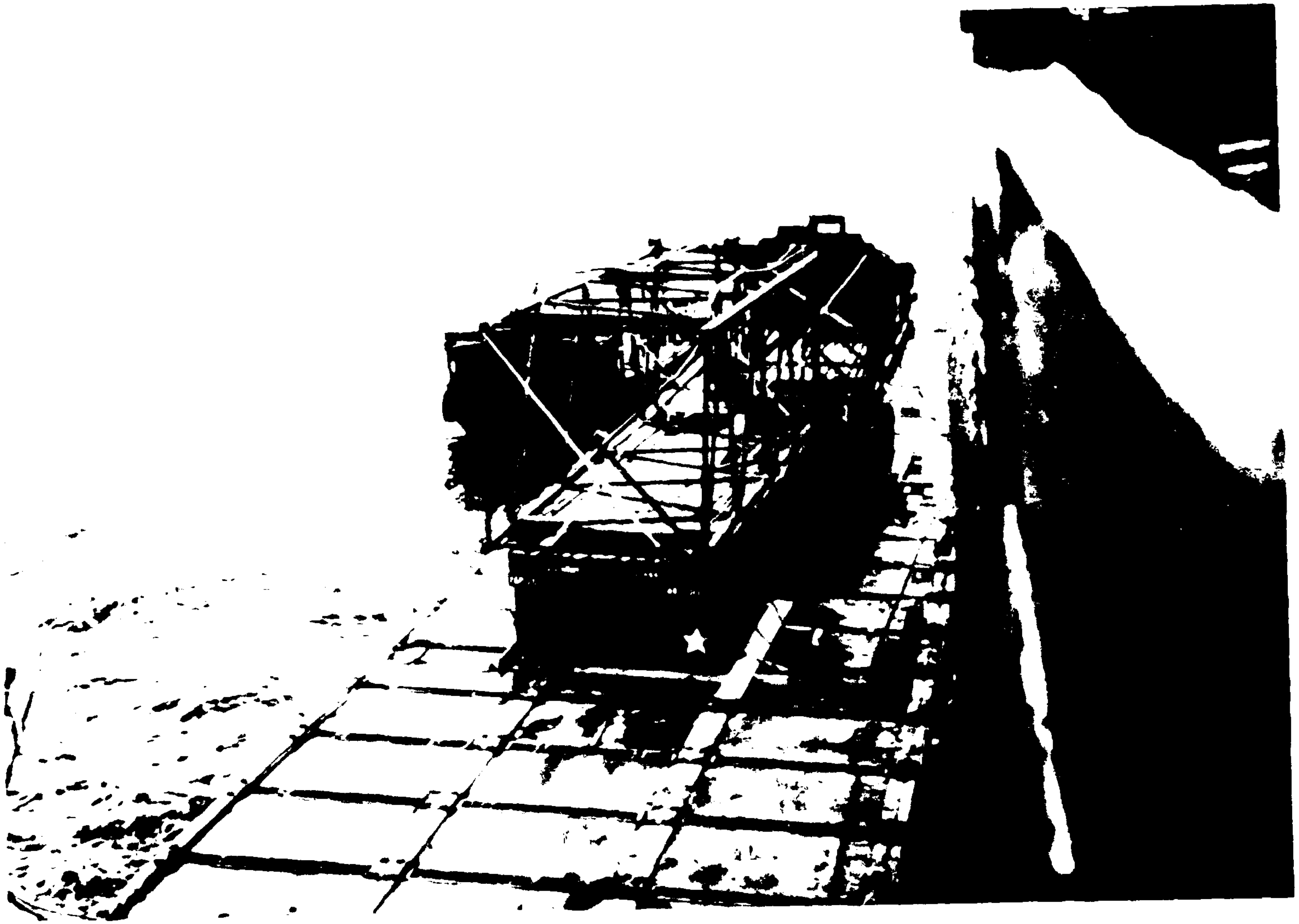

FIGURE A.25. CAUSEWAY FERRY LOADED. One of the methods used to assist in discharging the ship was the causeway ferry. Four trailers with boom tips and counterweights were successfully loaded and ferried ashore. The causeway had the least difficulty clearing a sandbar off Green Beach.

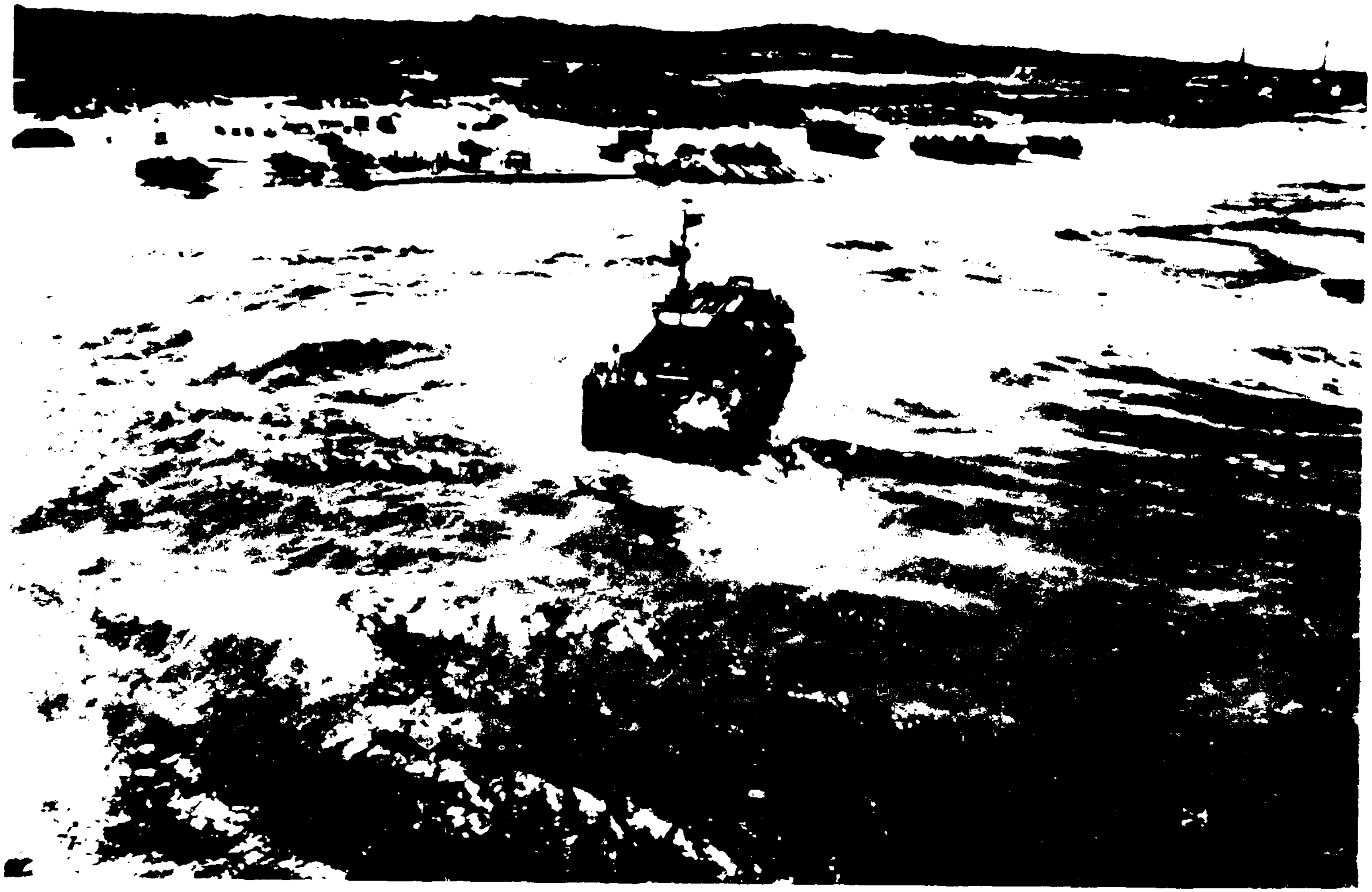

FIGURE A.26. LCU ENROUTE TO GREEN BEACH. An Army LCU with the 140-ton crane attempts to land at Green Beach, Ft. Story. A large sandbar, located approximately where the LCU is above, plagued beaching operations for both LCUs and LCM8s.

[illegible] BEACH REA[illegible]. To facilitate off-loading of landing craft with [illegible] crane components [illegible] unloading [illegible] approaches. Trackage was subsequently [illegible] the shoreside approaches.

FIGURE A.28. CARRIER LANDED. Once the landing craft was beached a small ramp was built up and special trackage was laid out to the LCM8 and over its ramp. The 300-ton crane carrier (weighing 100,800 pounds) was then driven off quickly and easily.

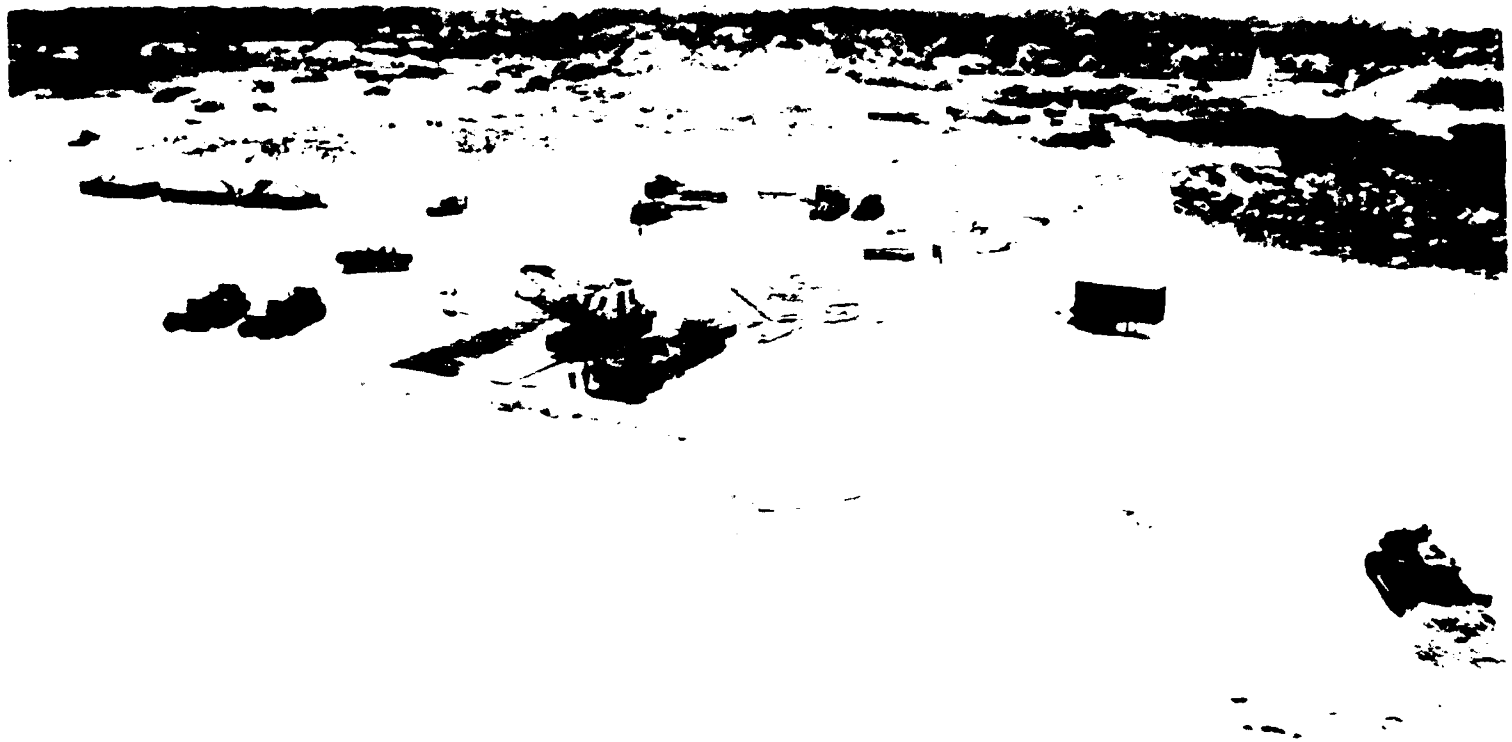

FIGURE A.29. ASSEMBLY SITE READIED. As the cranes and their components were landed, they were positioned for assembly. Above, the 140-ton crane awaits its boom sections and counterweights. The trackage to the left of the 140-ton crane was laid for the M747 trailer with the 300-ton crane upper. Once ashore and with the assembled 140-ton crane the upper was then lifted off the trailer and placed on the carrier to the right of the 140-ton crane.

FIGURE A.30. BOOM TIP ADDED. A heavy-lift forklift is used to help assemble the 140-ton crane's boom tip. Once this step was completed, the crane's counterweight could be added.

FIGURE A.31. COUNTERWEIGHT ASSEMBLED. With the use of its gantry the crane is able to assemble its 62,000-pound counterweight.

FIGURE A.32. BOOM SECTIONS ADDED. Once the counterweight was attached to the crane, additional boom sections had to be added before the 140-ton crane was ready to assist in the assembly of the 300-ton crane. Assembly of the 140-ton crane required 13 hours.

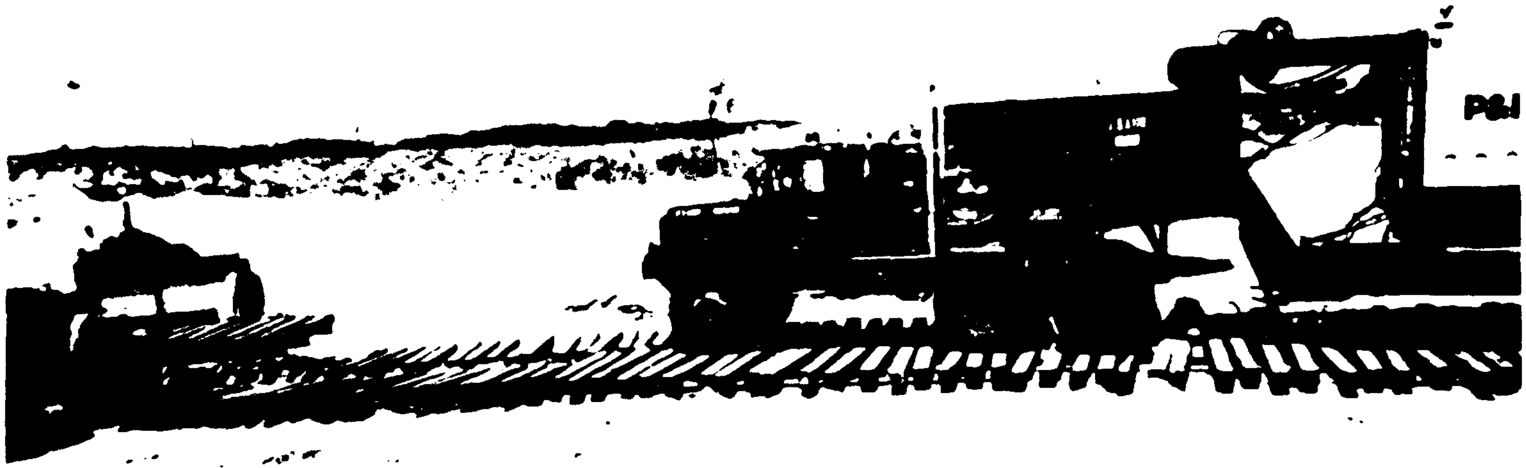

FIGURE A.33. UPPER ARRIVES. With the arrival of the 300-ton crane upper and the 140-ton crane's boom sections, assembly of the big crane was ready to begin. The photo above illustrates the use of the Army's special trackage used to handle very heavy vehicles. The above tractor and trailer with the crane upper section weighed approximately 160,000 pounds.

FIGURE A.34. 6250 ASSEMBLY BEGINS. Once the 300-ton crane upper was in position, assembly began. The 140-ton crane had little difficulty on the beach hoisting the upper.

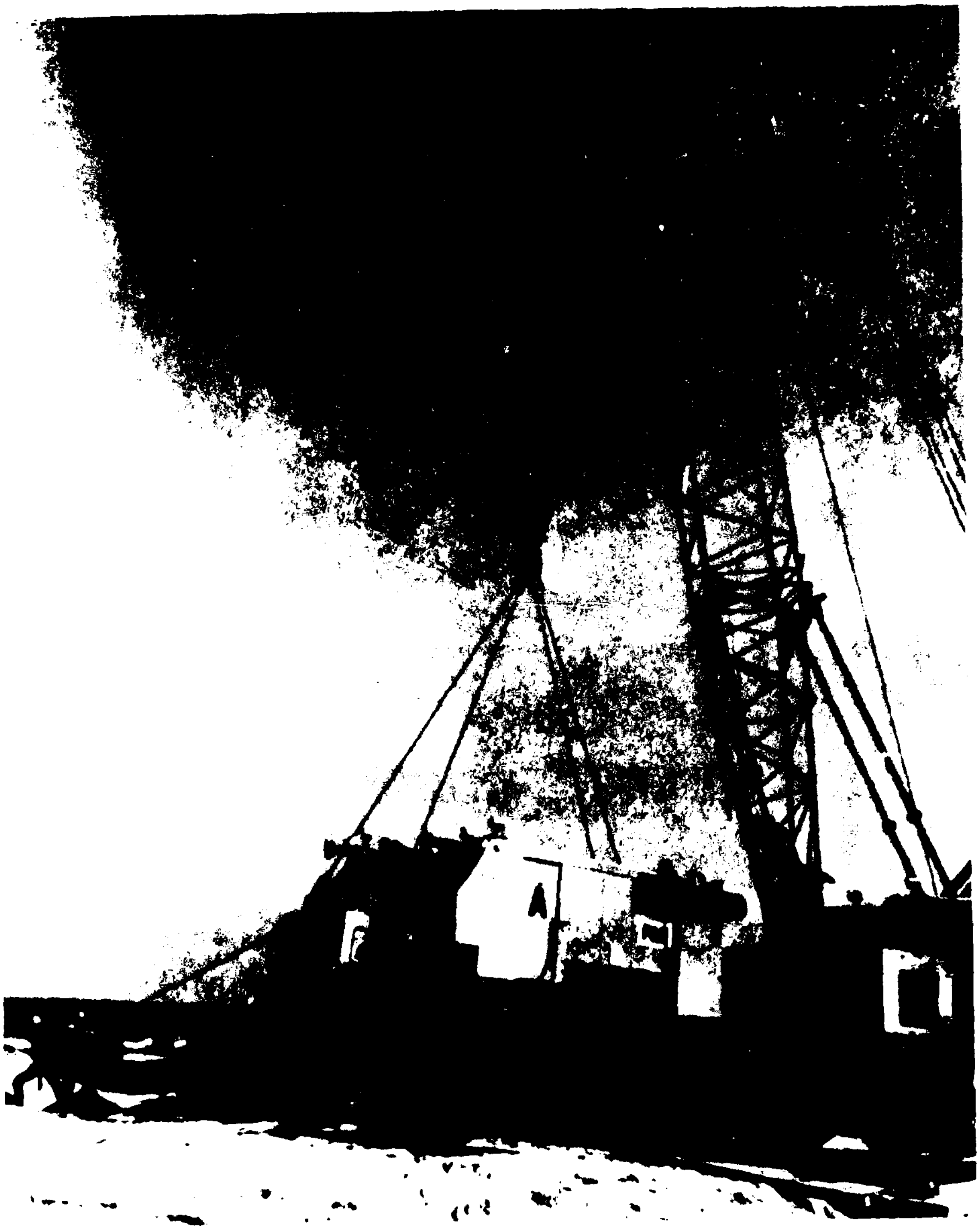

FIGURE A-[illegible]. [illegible] IS LOWERED ONTO THE CARRIER. The most complex part of the assembly of the [illegible]-ton crane was fitting the upper precisely onto the ring on the carrier.

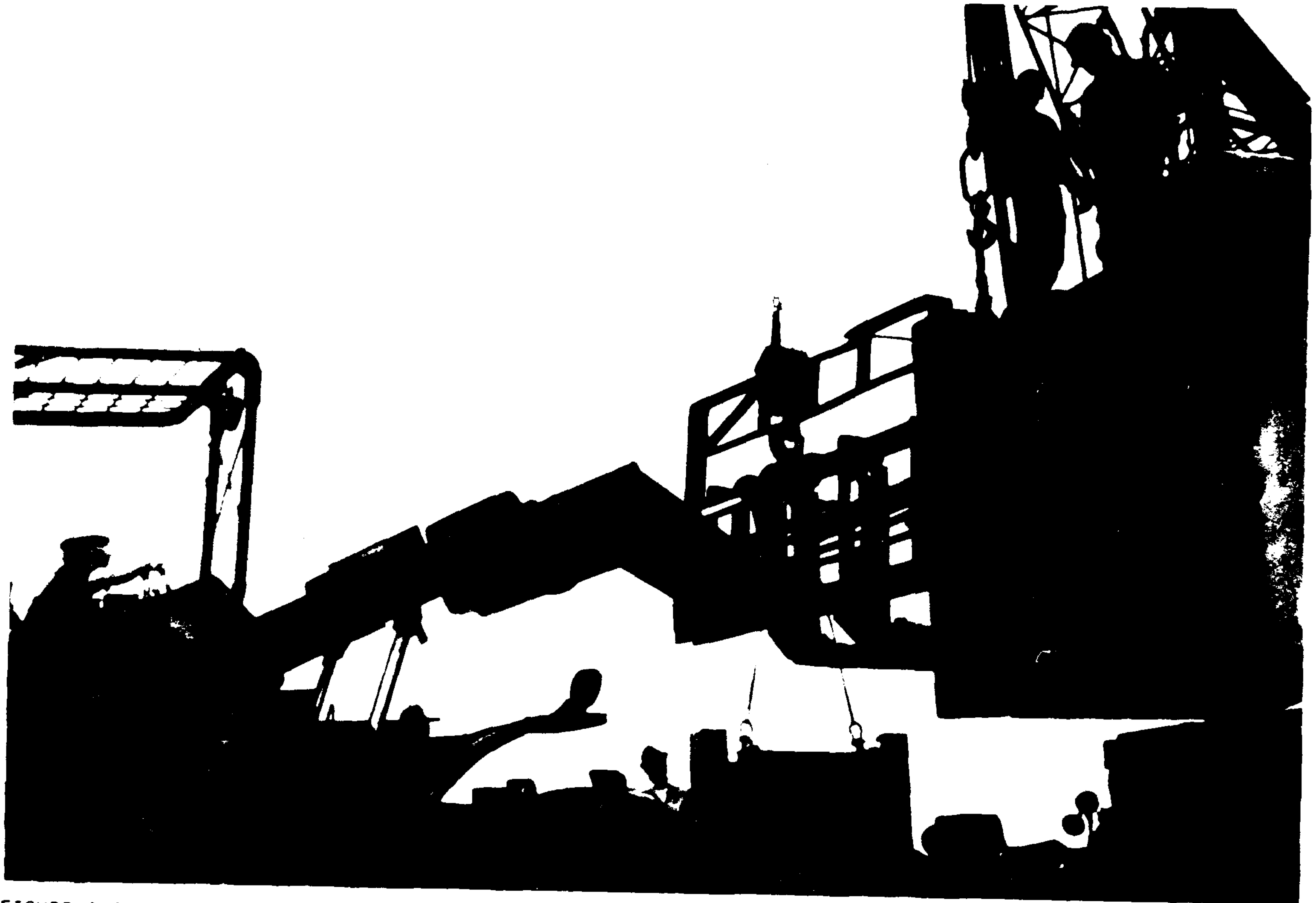

FIGURE A.36. COUNTERWEIGHTS ASSEMBLED. Using the 300-ton crane's gantry for lifting and with the help of a 6,000-pound forklift for fine positioning, the first of three counterweights (approximately 31,000 pounds) is assembled. The 140-ton crane has the second counterweight ready to be positioned behind the 300-ton crane for assembly.

FIGURE A.37. BOOM SECTIONS ASSEMBLED. With the counterweights in place, the 140-ton crane was used to help assemble the boom for the 300-ton crane. Assembly of the 300-ton crane required a total of 20 hours and 10 minutes. This included assembly of the outriggers, counterweights, mast, two 30-foot boom sections, the boom base and tip, and the operator's module.

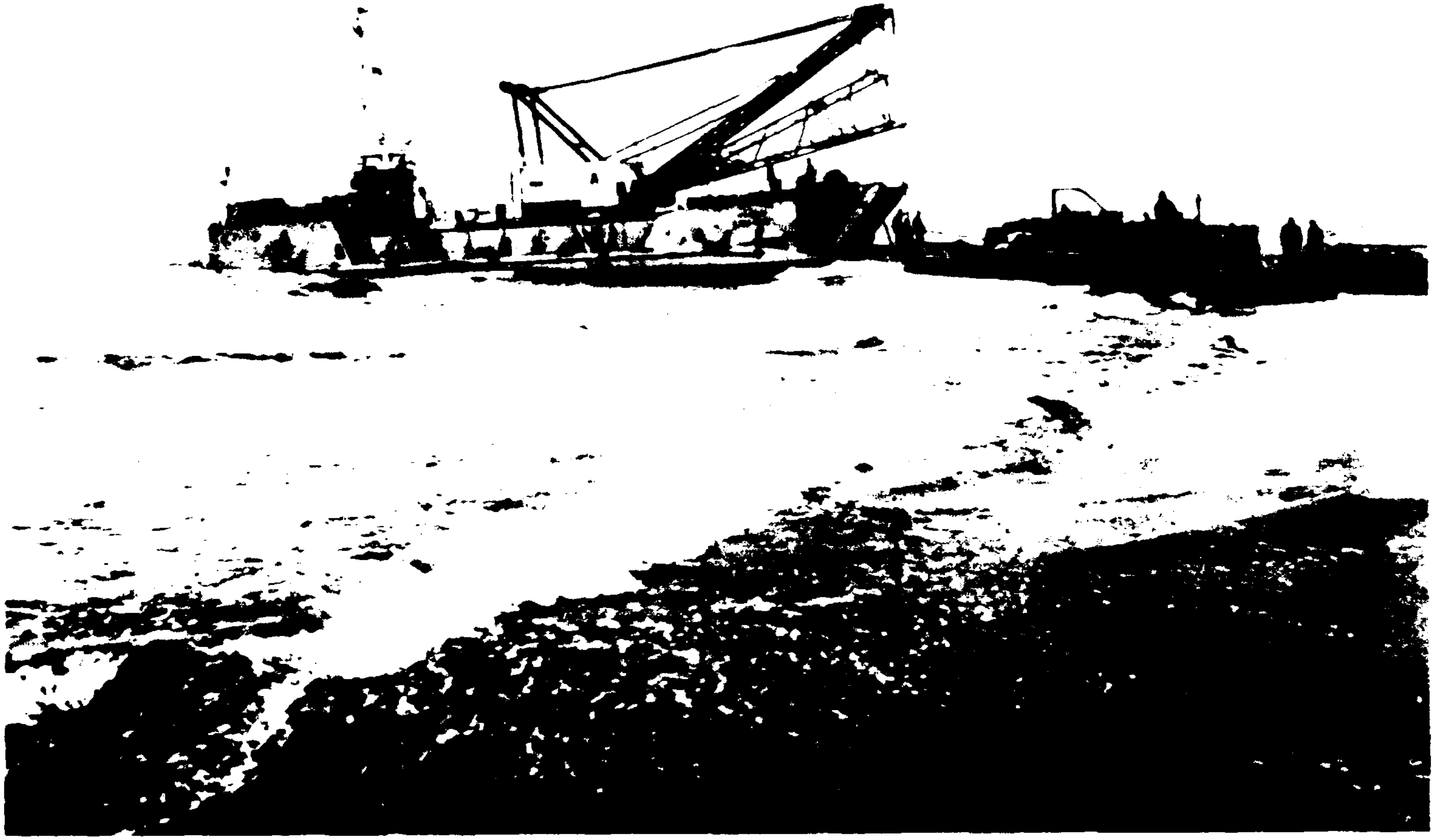

FIGURE A.38. RETROGRADE. Upon assembly of the cranes, the pretest was terminated and equipment retrograded. Above, a sand ramp was constructed, trackage laid, and the 300-ton crane (tactically disassembled but with counterweighting still on) was backloaded aboard an LCU.

APPENDIX B

TIME ALLOCATIONS

TABLE B.[illegible]

[illegible]

AD-A149 209 REPORT ON RESULTS OF THE CONVENTIONAL BREAKBULK SHIP PRETEST OF THE JOINT..(U) ORI INC ROCKVILLE MD H CASEY ET AL. 29 OCT 76 ORI-TR-1037 MDA903-75-C-0016

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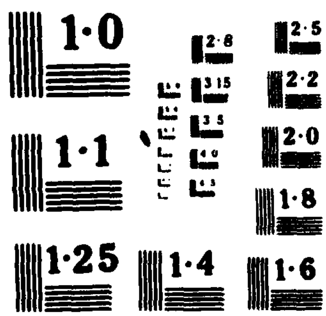
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2·2
1·1
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TABLE B.2

INTERPRETED LOG SHOWING ALLOCATION OF TIME INTO TIMES FOR NUMBERED LIFTS AND TIMES FOR WORKING SHIP AND DELAYS

Loading Ship, 20 April 1976

Time Interval	Elapsed Time Minutes	Load	Load Designation Number	Time Used in Working Lifts	Time Used in Working Ship	Unavoidable Delay	Avoidable Delay
[illegible]	[illegible]	Trailer	12	15			
[illegible]	[illegible]	Trailer	13	17			
[illegible]	[illegible]	Trailer	10	13			
[illegible]	[illegible]	Trailer	11	10			
[illegible]	[illegible]				82 Closing Hatch and Dunnage		
[illegible]	43	Carrier	2	43			
[illegible]	[illegible]	Ramp	Ramp #1	23			
[illegible]	[illegible]	Ramp	Ramp #2	14			
[illegible]	63						53 Problem with LCMB sling pins
[illegible]	[illegible]				30		
[illegible]	[illegible]					30 Noon Break	
[illegible]	[illegible]	Causeway	6	40			
[illegible]	[illegible]						77 1st Unsuccessfull attempt to lift 9125
[illegible]	[illegible]	LCMB	1	25			
[illegible]	140						140 2nd Unsuccessfull attempt to lift 9125
[illegible]	[illegible]	Mast	5	18			
[illegible]	[illegible]	Boom	4	10			
TOTAL	650			228	112	30	280

TABLE B.3

INTERPRETED LOG SHOWING ALLOCATION OF TIME INTO TIMES FOR NUMBERED LIFTS AND TIMES FOR WORKING SHIP AND DELAYS

Unloading Ship, 21 April 1976

Time Interval	Elapsed Time Minutes	Load	Load Designation Number	Time Used in Working Lifts	Time Used in Working Ship	Unavoidable Delay	Avoidable Delay
[illegible]	145	LCM8	1	145			
[illegible]	69	Ramp	Ramp	69			
[illegible]	28	Ramp	Ramp	28			
[illegible]	[illegible]	Carrier	6250 Carrier 2	80			
[illegible]	53					53 Lunch	
[illegible]	25				25 Swung Boom		30 Avoidable delay in unloading loads 4&5
[illegible]	30						
[illegible]	20		4&5 Unlashing of Both	20			
[illegible]	28	Boom	4 About boom base	28			
[illegible]	10	Mast	Mast 5				
[illegible]	17						17 Waiting for LCM8
[illegible]	[illegible]	Mast	Mast 5	10+27=37			
[illegible]	[illegible]	Causeway	Causeway 6	80			
[illegible]	43				43 Opening hatch & reattaching boom		
[illegible]	54	Trailer	7	54			
TOTAL	699			531	68	53	47

TABLE B.4

INTERPRETED LOG SHOWING ALLOCATION OF TIME INTO TIMES FOR NUMBERED LIFTS AND TIMES FOR WORKING SHIP AND DELAYS

Unloading Ship, 22 April 1976

Time Interval	Elapsed Time Minutes	Load	Load Designation Number	Time Used in Working Lifts	Time Used in Working Ship	Unavoidable Delay	Avoidable Delay
No Data		Trailer	9	No Data			
[illegible]	[illegible]	Trailer	[illegible]	[illegible]*			
[illegible]	[illegible]				[illegible] Swinging Boom		
[illegible]	[illegible]	Trailer	11	[illegible]			
[illegible]	[illegible]	Trailer	[illegible]	17			
[illegible]	[illegible]	Trailer	13	27			
[illegible]	[illegible]	Trailer	12	14			
[illegible]							[illegible]
[illegible]	[illegible]	Trailer	[illegible]	17			
[illegible]	[illegible]	Trailer	19	35			
[illegible]	52	Trailer	14b Trailer 6250 Upper				
[illegible]	[illegible]						10 Problem with mate's views on life
[illegible]	[illegible]		14b	67 (total)			
[illegible]	[illegible]	Upper	14a				
[illegible]	53					53 Lunch	
[illegible]	[illegible]	Upper	14a	60 (total)			
[illegible]	[illegible]	Trailer	21	32			
[illegible]	[illegible]	Trailer	20	25			
[illegible]	[illegible]				31 Swinging Boom		
[illegible]	[illegible]	Trailer	16 Container and Trailer				
[illegible]	40	Trailer	17	40			
[illegible]	[illegible]	Trailer	23	31			
[illegible]-1654	26	Trailer	24	26			
1654-[illegible]	21	Trailer	22	21			
[illegible]	35	Trailer	25	35			
[illegible]-1824	34	Trailer	27	34			
1824-1829	5				5 Transferring Dunnage		
1829-1[illegible]42	13	Trailer	18	13			
1842-1918	36	Trailer	26	36			
TOTALS	728			582	53	53	40

* Time from ORI observers notes.

APPENDIX C

REFERENCES

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2. Operations Research, Inc., Design of Preliminary Field Tests for the Joint Logistics-Over-The-Shore (LOTS) Test and Evaluation Program, ORI Technical Report No. 993, 6 January 1976.

3. BDM Corporation, Volumes I and II, Joint Logistics-Over-The-Shore (LOTS) Pretest Report Conventional Breakbulk Ship, BDM Technical Report No. BDM/N-76-122-TR, 19 July 1976. (Note: contains listing of data collected but no analysis.)

4. Davis, D.A. and Zwibel, H.S., The Motion of Floating Advanced Base Components in Shoal Water--A Comparison Between Theory and Field Test Data, Technical Note N-1371, U.S. Naval Civil Engineering Laboratory, January 1975 (sponsored by Naval Facilities Engineering Command).

5. Davis, D.A. and Traffalis, J.J., OSDOC II Crane Platform Productivity as a Function of Sea State, U.S. Civil Engineering Laborary Special Report, September 1973.

6. U.S. Army, Terminal Operations Specialist Handbook, Field Manual 55-17, November 1975.