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High Sea State Container Transfer System (HISEACOTS) Concept Evaluation Program (CEP) Technical Test Report

by
Brian David

Report Date
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A full-scale HISEACOTS platform and gantry crane (minus traversing rails and arresting gates) was fabricated and tested in a 5-week Concept Evaluation Program (CEP) user test at the James River Ready Reserve Fleet, located near Fort Eustis, Virginia, 25 March through 26 April 1991. Although not a complete system for testing, the platform and gantry crane represent the major components of the total system and as such provide invaluable information on the feasibility of the concept. The HISEACOTS was moored next to the Temporary Auxiliary Crane Ship (T-ACS 1) *Keystone State* for the duration of the test. the Army's Lighter Air Cushion Vehicle-30 (LACV-30) successfully flew onto the platform 57 times. A loaded (15 ton), 20-foot container successfully transferred to the LACV-30 17 times. The shortest total lighterage cycle time recorded during the test was 12 minutes. This technical report summarizes the results of that test.

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PREFACE

The High Sea State Container Transfer System (HISEACOTS), developed by the US Army Belvoir Research, Development and Engineering Center (BRDEC), enables in-stream container cargo transfer from crane ships to Army lighterage in high sea state conditions.

Mission Area Analysis identifies the need for an expanded cargo offload capability in high sea state/swell conditions to improve productivity and efficiency. Recent Logistics-Over-The-Shore (LOTS) operations reveal severe deficiencies during in-stream offloading/ backloading of cargo in Sea States 2 (3.5 foot waves) and above. Operations are practically non-existent in Sea States 3 (more than 3.5 foot waves) because lighters and cargo experience severe relative motion and pendulation. Also of concern is the potential for damage when attempting to moor next to the crane ship.

A full-scale HISEACOTS platform and gantry crane (minus traversing rails and arresting gates) was fabricated and tested in a 5-week Concept Evaluation Program (CEP) user test at the James River Ready Reserve Fleet, located near Fort Eustis, Virginia, 25 March through 26 April 1991. Although not a complete system for testing, the platform and gantry crane represent the major components of the total system and as such provide invaluable information on the feasibility of the concept. The HISEACOTS was moored next to the Temporary Auxiliary Crane Ship (T-ACS 1) *Keystone State* for the duration of the test. The Army's Lighter Air Cushion Vehicle-30 (LACV-30) successfully flew onto the platform 57 times. A loaded (15 ton), 20-foot container successfully transferred to the LACV-30 17 times. The shortest total lighterage cycle time recorded during the test was 12 minutes. This technical report summarizes the results of that test.

Referenced photographs and figures will be found in chronological order in Appendix A. Appendix B contains a detailed summary of test runs.

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Section I

BACKGROUND

Logistics-over-the-shore (LOTS) involves the in-stream discharge of military equipment and supplies from offshore strategic sealift vessels and their transport ashore aboard lighterage. Strategic sealift is required for 95 percent of our force deployment and resupply. Offloading containers and heavy outsized equipment in high sea states or large ground swell is severely limited by the extreme movement of the lighterage relative to that of the crane ship and by the pendulation motion of the cargo.

Current LOTS offloading operations virtually cease in Sea State 3 or above. (Sea State 3 is characterized by a wave height of 3.5 to 5 feet from crest to trough). According to a Naval Coastal Systems Center study, Sea State 3 and higher may occur 75 percent of the time in strategically located LOTS sites worldwide. A lack of synergism best describes the weak link in the LOTS high sea state/cargo offload operation. Individually, each of the Army's lighterage and sealift cranes operates and maintains adequate headway in Sea States 3 to 4. However, the system fails when it is required to interface. Figure 1 in Appendix A shows offload productivity decreasing sharply for sea states greater than 1 during a Joint Service LOTS exercise in October 1984. A Monte-Carlo simulation of the productivity of cargo offload operations shows that significant improvement (up to 125 percent increase in tons of cargo offloaded per day) would be realized with a Sea State 3 capability system.

The HISEACOTS project began in 1987 as a Small Business Innovation Research (SBIR) program with Band, Lavis and Associates, Inc. of Annapolis, Maryland. The current HISEACOTS configuration is designed to improve the interface between the T-ACS crane ships and the LACV-30 lighters, both being primary assets of cargo offload operations (Figure 2). [NOTE: The HISEACOTS is adaptable to any air cushion lighter and potentially to a significant portion of the Army's displacement watercraft.] The HISEACOTS development strategy aims to field a near-term system that will increase container offload capability in Sea States 3 or 4 but avoid modifications to the container ship, the T-ACS, or the LACV-30.

The prototype gantry crane was built and successfully demonstrated in Phase II of the SBIR program at Fort Belvoir in April 1990 (Figure 3). Phase III of the SBIR program consists of ship-side gantry crane and platform tests (which this report documents) and of full-scale technology demonstrations of the complete system in the DOD Joint Service LOTS (J-LOTS III) exercise at Fort Story, Virginia, in September 1991.

The HISEACOTS consists of a platform formed by assembling the 8 x 40 x 4.5-foot square end and 8 x 20 x 4.5-foot raked end modular pontoons currently being added to the Army inventory (Figure 4). This platform securely moors alongside the T-ACS and provides a stable landing for the LACV-30 during offload operations. The inverted raked end modules form ramps that allow the LACV-30 to fly on one end and fly off the other. The platform is fitted with batterboards and arresting gates to safely guide and align the LACV-30 during high sea state operations. It is outfitted with a specially designed, traversing gantry crane that accepts the transfer of a container from the T-ACS crane and then spots and lowers the container onto the deck of the LACV-30, eliminating problems associated with pendulation or relative motion. The HISEACOTS, as tested and documented in this report, is shown in Figure 5. Its main characteristics are in Table 1 below.

Table 1. HISEACOTS Characteristics

Overall Length	160 feet
Entrance Ramp Beam	88 feet
Exit Ramp Beam	72 feet
Middlebody Beam	56 feet
Fly-Through Width	40 feet
Overall Height	41 feet (Gantry: 36.4 feet)
Entrance Freeboard	22 inches
Exit Freeboard	34 inches
Weight (Light)	513.4 short tons
- Gantry Crane	13.4 short tons
- Platform	500 short tons
Full Load Weight	593 short tons (w/LACV-30 + one 22-short ton container)
Gantry Crane Design Capacity	25-short ton container
Pendulation Limits	+/- 15 foot lateral displacement
Heave Limits	+/- 5 foot vertical displacement

Section II

HISEACOTS ASSEMBLY

The Army Landing Craft Utility, LCU-2000 (*Buena Vista*) delivered the HISEACOTS gantry crane to Fort Eustis, Virginia, on 31 March 1991 (Figure 6) following upload at Fort Belvoir, Virginia, using the Connecticut National Guard CH-54B Skycrane (Figure 7). We removed the gantry crane's engine/hydraulic power unit (HPU) and spare for the helicopter lift. Table 2 below lists the "as lifted" weight of the gantry crane. The helicopter loaded the crane's spar unit separately. Ten days earlier, the engine/HPU, cover plates, batterboard tie-down pipe, wear boards, 1/2-inch diameter chain, tools, and miscellaneous items travelled to Fort Eustis in a 20-foot ISO container on a 40-foot-bed truck along with the fender frames, 4-foot diameter x 12 foot long fenders, HISEACOTS sling and 20-foot spreader frame, and gantry tie-down frames (Figure 8). Table 3 on page 4 lists the weights of various components.

Table 2. HISEACOTS Gantry Crane Weight "As Lifted"

Component	Weight (pounds)
Leg	3,200
Leg	3,200
Middlebody (Including Hoses)	7,320
PA Bar	4,250
Bearing Caps	700
Top Grating	240
Access Ladder	20
U-Bolt Fittings	120
Top Rail	100
Control Deck and Braces	975
Cab	400
HPU Cover	400
Fuel Tank	190
Main Ladder	100
Top Slings (4 each, 45 foot)	540
Foot Slings (4 each, 9 foot)	110
Total	21,865 pounds

HPU - hydraulic power unit
PA - pendulation attenuator

Table 3. HISEA[illegible] Miscellaneous Components Weight

Component	Quantity	Weight (pounds)
Spar	1	3,500
HPU	1	1,500
Cover Plates, Rectangular	16	335
Cover Plates, Triangular	2	375
Fender and Frame Assembly	2	3,470
Batterboard Tie-Down Pipe (each 8- foot section weighs 225 pounds)	2	1,150
Gantry Tie-Down Frame	4	700
Approach Batterboard Tube	12	100
Wear Board	26	40
1/2-inch dia. Chain	300 feet	3 lb/foot

The HISEACOTS setup at Fort Eustis' 3rd Port Hardstand Area used the 100-ton capacity barge crane to lift, assemble, and stage its components and modules, assembling 60-foot (long) ramp sections first. The barge crane used chain and wire rope slings and the 50,000-pound (lift capacity) Rough Terrain Container Handler (RTCH) to invert the 20-foot, raked-end modules before connecting them to 40 foot square end-modules (Figures 9 and 10). Then, they were end-connected by an 18,000-pound (lift capacity) forklift (Figure 11). Side connectors on the 20-foot, raked-end modules were removed, inverted, and reinstalled to provide a side-to-side connection capability (Figure 12). The inverted 20-foot, raked-end modules end-connected to 40-foot, square-end modules with special Grade 8 bolt/shear plate assemblies (Figure 13). Completed 60-foot ramp sections were hoisted into the water for assembly using chain slings and the barge crane (Figure 14). Single inverted 20-foot, raked-end modules also were hoisted into the water by two-legged chain slings (Figure 15). Once in the water, a 60-foot ramp section end-connected to a 40-foot, square-end module, and subsequently to another 60-foot ramp section to form a 160 foot long string. The 160-foot string side-connected to either another 160-foot string or to a staggered 40-foot, square-end module to form the basic platform.

Two 4-foot-diameter x 12-foot-long Seaward marine fenders attached to two steel tubular fender frames and side-connected to two 20-foot, raked-end modules (one inverted), using the RTCH (Figures 16 and 17). In turn, those 20-foot, raked-end fender modules side-connected to the starboard side of the platform.

Rectangular and triangular 3/8-inch-thick steel cover plates span gaps in the platform. These gaps result from staggering some modules to compensate for the worst-case, platform-bending load. The cover plates prevent LACV-30 air cushion losses when hovering on the platform. The cover plates secure to the platform with turnbuckles that clamp to the module's connectors (Figures 18 and 19).

Six urethane water bladders (each having a material weight of 33 ounces per square yard and a capacity of 2,300 gallons) stack upon each other (1 x 2 x 3 configuration) both port and starboard of the entrance ramp. These bladders serve as the approach batterboard and as ballast (120,000 pounds each side). A steel tie-down pipe, chained to the platform, secures the stack of water bladders (Figures 20 and 21). Two inch wide polyester webbing straps (10,000-pound tensile strength) secure the bladders to each other and to the tie-down pipe. Specially manufactured, high strength connectors (10,000-pound tensile) attach the webbing to the bladders and the tie-down pipe (Figures 22, 23, and 24). Ultra high molecular weight wear boards, attached to the inboard side of the approach batterboards, prevent the LACV-30's hull or skirt hardware from abrading or puncturing the water bladders. We pumped water into the bladders through detachable butterfly valves using a 250-gallon per minute (gpm) water pump (Figures 25 and 26).

The large crane hoisted the HISEACOTS gantry crane from the deck of the LCU-2000 and set it on four steel I-beam tie-down frames that secured to the platform (Figures 27, 28, and 29). The gantry crane was bolted to the tie-down frames and guyed to the deck. Then, the barge crane reattached the spar to the gantry crane and reinstalled the engine/HPU by spotting the load.

Finally, 20-foot, raked-end modules, turned on their sides and placed on dunnage along the edge of the platform, acted as the middlebody batterboards. These modules were chained to the deck of the platform to prevent accidental movement and tipping from an LACV-30 impact load (Figure 30). LACV-30 low pressure fenders were attached to the exit batterboards to protect against any propeller strikes when leaving the platform (Figure 31). The joints between the platform modules over the fly-through area were sealed with a commercial high density spray-on foam.

Tables 4, 5, 6, and 7 give the HISEACOTS assembly summary, crew size, manhours, and shore-side pre-assembly times, respectively.

Table 4. HISEACOTS Assembly Summary

Week	Dates	Comments	BLA*	BRDEC*	BD Crane Crew*	BD Crane	Causeway Crew*	Warping Tug	Tug	Forklift	Total Manhours*
1	3/25/91 to 3/29/91	Includes unpacking and setup. 5-BLA, 2-BRDEC, 7-BD, 10-Causeway, 1-Forklift	206	80	175	25	120	4	—	2	583
2	4/1/91 to 4/5/91	5-BLA, 2-BRDEC, 7-BD 6-Causeway, 1-Forklift	188	80	175	25	64	8	—	8	515
3	4/8/91	Towing and Mooring 4-BLA, 2-BRDEC	48	24	—	—	—	6	8	—	72
4	4/9/91	Completion 4-BLA, 2-BRDEC	32	16	—	—	—	—	—	—	48
		TOTAL									1,218
		TOTAL without Towing and Mooring									1,146

** Represents manhours. All others are equipment hours.*

BLA Band, Lavis & Associates, Inc.
BRDEC Belvoir Research, Development & Engineering Center
BD Barge Derrick Crane
F/L Forklift

Table 5. HISEACOTS Crew Size

	Estimate					Actual					Optimum				
	BLA	BRDEC	BD	Cause	F/L	BLA	BRDEC	BD	Cause	F/L	BLA	BRDEC	BD	Cause	F/L
3/25/91	4	2	5	4	1	5	2	7	10	—	5	2	7	6	1
3/26/91	4	2	5	4	1	5	2	7	10	—	5	2	7	6	1
3/27/91	4	2	5	4	1	5	2	—	—	—	5	2	7	6	1
3/28/91	4	2	5	4	1	5	2	7	10	—	5	2	7	6	1
3/29/91	4	2	5	4	1	4	1	7	10	1	5	2	7	6	—
4/1/91	4	2	5	4	—	4	2	7	8	—	5	2	7	6	—
4/2/91	4	2	5	4	—	5	2	7	8	—	5	2	7	6	—
4/3/91	4	2	5	4	—	5	2	7	8	1	—	—	—	—	—
4/4/91	4	2	5	4	—	5	2	7	6	—	—	—	—	—	—
4/5/91	—	—	—	—	—	4	2	7	6	—	—	—	—	—	—
4/9/91	—	—	—	—	—	4	2	—	—	—	—	—	—	—	—
Man Days	36	18	45	36	9	51	21	31.5	38	1	35	14	49	42	4
Total Man Days			140					142.5					144		
Average/Day			16					13					21		
Days			9					11					7		

BLA Band, Lavis & Associates, Inc.
BRDEC Belvoir Research, Development & Engineering Center
BD Barge Derrick Crane
F/L Forklift

Table 6. HISEACOTS Manhours

Week	Date	ESTIMATED BLA	ESTIMATED BRDEC	ESTIMATED BD	ESTIMATED Cause	ESTIMATED F/L	ACTUAL BLA	ACTUAL BRDEC	ACTUAL BD	ACTUAL Cause	ACTUAL F/L
1	3/25/91	32	13	40	32	8	50	20	56	80	—
	3/26/91	32	16	40	32	8	40	16	28	35	—
	3/27/91	32	16	40	32	8	40	16	—	—	—
	3/28/91	32	16	40	32	8	40	16	28	20	—
	3/29/91	32	16	40	32	8	32	16	28	20	2
2	4/1/91	32	16	40	32	—	32	16	28	32	—
	4/2/91	32	16	40	32	—	40	16	28	32	—
	4/3/91	32	16	40	32	—	40	16	28	32	8
	4/4/91	32	16	40	32	—	40	16	21	14	—
	4/5/91	—	—	—	—	—	32	16	14	14	—
3	4/9/91	—	—	—	—	—	32	16	—	—	—
	Subtotal	288	144	360	288	40	418	180	259	279	10
	Total	1,120					1,146				

OPTIMUM BLA	OPTIMUM BRDEC	OPTIMUM BD	OPTIMUM Cause	OPTIMUM F/L
40	16	56	48	8
40	16	56	48	8
40	16	56	48	8
40	16	56	48	8
40	16	56	48	—
40	16	56	48	—
40	16	56	48	—
280	112	392	336	32
Total 1,152				

① Set-up and Staging
② Shore-Side Pre-Assembly
③ Basic Platform
④ Gantry
⑤ Batterboards
⑥ Gantry and Batterboards

Table 7. HISEACOTS Shore-Side Pre-Assembly

	Estimated (hours)	Estimated (manhours)	Actual (hours)	Actual (manhours)
Invert 20 raked-ends	7.5	120	8	96
Roll 11 raked-ends on side	2	32	—	—
Assemble fender modules	1	16	4	28*
Assemble 60-foot modules	9.5	152	8	46
Assemble 2-inverteds to 2-standard raked-ends	2.5	40	1	5
Total	**22.5**	**386**	**21.6**	**175**

**Two hours with seven, and three hours with four.*

Section III

CONTAINER TRANSFER OPERATIONS

An Army 65-foot Small Tug (ST) and a Side Loadable Warping Tug (SLWT), shown in Figures 32 and 33, towed the HISEACOTS to the *Keystone State* T-ACS ship on 8 April 1991. The ST had a very difficult time maneuvering the HISEACOTS into position next to the T-ACS ship due to the strong tide and swift current. The SLWT was not used to help; and the T-ACS fender was slightly damaged during the initial mooring operation. It is unclear why the SLWT did not help with the mooring. The ST moored the HISEACOTS aft of Station 140 on the *Keystone State*, using three-strand, 2 1/2 inch wide nylon line (156,000-pound breaking strength). The mooring lines were attached to both the T-ACS lighterage mooring bitts and two double bitts on deck. The T-ACS crane tensioned the two mooring spring lines on deck, thereby keeping the HISEACOTS fenders snug against the ship (Figure 34). Periodic adjustments to these mooring lines took up the slack as they stretched. It was difficult to handle and attach the mooring lines to the ship's lighterage bitts because of the:

- absence of people on the T-ACS;
- weight of the three-strand line; and
- tendency of the three-strand line to kink.

Two 5-ton truck tires were secured to the aft starboard 20-foot, raked-end module that was exposed to the side of the T-ACS ship. This module's ISO corner hit the side of the T-ACS ship several times during the initial mooring operation.

Container transfer operations began on 9 April. The platform's freeboard measured 22 inches at the entrance ramp and 34 inches at the exit ramp. Orientation of the Maritime Administration (MARAD) crane operators was done on-site before the first container transfer. From the T-ACS crane cab, visibility of the HISEACOTS slings and the markings painted on the gantry crane's pendulation attenuator (PA) bar was fair. When the crane was fully extended, the view from the cab was partially blocked by the lower T-ACS crane boom cross member.

Two, loaded (15 tons each), 20 foot long containers were used throughout the transfer operations, with unequal distribution of weight in one so it did not hang level when lifted. The weight of each container was measured using a Bendix 25-ton strain gage and digital strain indicator.

The LACV-30s began fly-on operations on 10 April 1991 (Figures 35 and 36). Appendix B contains a summary of the test runs recorded from 8-19 April. Twenty-three LACV-30 operators were trained during the tests. The average approach and moor time recorded was 45 seconds. Several aborted landings were recorded and attributed to low approach speed. The close proximity of the T-ACS stern anchor chain may have slowed forward speed on several of these aborted attempts (Figure 37). The T-ACS normally is anchored at the bow of the ship during offload operations. The best approach speeds clocked between 4 to 6 knots. Several LACV-30s got stuck on the entrance ramp but eventually powered onto the platform. Backing off the entrance ramp was no problem. There were no reports of any lighter hitting its landing pad against the entrance ramp. They could not reverse on the platform, however, because of the non-skid surfacing on the raked-end modules being used as middlebody batterboards and the tight fly-through width (Figures 38 and 39).

The water-filled approach batterboards provided the LACV-30s excellent protection and orientation as they flew onto the platform. However, the exposed fill valves on the inboard bags were pulled out several times during this maneuver until, eventually, they were capped with PVC pipe plugs. The ultra high molecular weight wear boards worked well to protect the water-filled bags from the lighters' hull and skirt hardware.

The two, 20-foot, raked-end middlebody batterboards farthest astern, both port and starboard, were canted outboard to prevent the lighters' high pressure fenders from snagging their corner ISO fitting when flying onto the ramp. Several platform cover plates were slightly damaged by the landing pads but remained usable throughout the tests.

The T-ACS crane operator had little difficulty slewing the 15-ton container against the gantry crane PA bar. Two orange marks, painted on the PA bar, spot the slings in the correct position before engaging the spar (Figures 40, 41, and 42). MARAD tagline men controlled the container as it lifted from the T-ACS to the HISEACOTS. [NOTE: The *Keystone State* cranes, produced by General Electric, have a 5-second time delay between each movement. The crane operator waits 5 seconds after slewing before booming up, etc.] The crane operator had no difficulty lowering the container sling onto the spar's outrigger arms (Figure 43). Once the sling was secured, the LACV-30 flew under the container for loading (Figure 44). When it was positioned under the gantry crane, the HISEACOTS operator lowered the outrigger arms and spotted the container on the deck (Figure 45). There were several incidents where it became difficult to unlock the container spreader frame from the container. This may be caused by excessive wear on the LACV-30's urethane landing pads, which would render the container sling too short. Putting dunnage under the container until the spreader frame unlocked from the container's ISO corners solved the problem. The average time to load a container onto the spar from the T-ACS ship and spot the container on deck was 6.5 minutes. To complete the crane cycle, the HISEACOTS operator raised the outrigger arms to their full up position. The T-ACS crane operator then hoisted up the container sling until its swages where free and clear of the outrigger arms (Figure 46). The HISEACOTS operator, using the PA bar, pushed the sling away from the spar as the T-ACS crane operator simultaneously slew back to the ship to retrieve another container (Figure 47).

The LACV-30 crew began container tie-down once the spreader frame was unlocked. On the average, tie-down took 6.5 minutes. Most of that time involved adjusting chain tensions to accommodate container placement at different deck locations.

The fully loaded LACV-30 had no difficulty flying off the exit ramp (Figures 48, 49, and 50). There were no reports of their landing pads hitting. The two forward 20-foot, raked-end batterboards nearest the gantry crane also were canted to avoid snagging the LACV-30's high pressure fenders on exit. The average cast-off and clear time was 37 seconds.

Night operations were performed on 17 April (Figure 51). The T-ACS crane and deck lights illuminated the side of the ship. The HISEACOTS gantry crane floodlights lighted the platform deck area. Green chemical lights were attached to the top surface of all the approach and middlebody batterboards and to the ship's anchor chain (Figure 52). LACV-30 operators preferred green lights over red because they are brighter. There did not appear to be any appreciable degradation in the lighterage cycle times when operating at night. One high pressure fender caught the corner of one batterboard and was damaged.

Backloading the containers from the LACV-30 was done almost exclusively without the HISEACOTS gantry crane, but one backload operation using the gantry crane went smoothly. The spreader frame hanging from the spar had to be rotated slightly with tag lines in order to mate up with the ISO container corners. Backloading without the gantry proved to be time consuming and slightly hazardous. This can be attributed to:

- the T-ACS crane operator not being able to see the LACV-30 deck or the container;
- the need for a signalman to coordinate the movement of the crane; and
- container pendulations occurring near the LACV-30 cab when lifting a container off the deck.

The HISEACOTS can be used safely to backload containers; however, they must be placed within reaching distance of the spreader frame when it is hanging from the gantry crane's spar. This may not always be possible when backloading containers onto the LACV-30 at the beach.

The 65-foot ST and the SLWT towed the HISEACOTS back to Fort Eustis' 3rd Port on 19 April. They experienced no difficulties casting off and clearing the T-ACS ship. Estimated tow speed back to the port was 4 knots.

Section IV

HISEACOTS DISASSEMBLY

The HISEACOTS was disassembled at the 3rd port next to the barge crane. The gantry crane, 60 foot long ramp sections, fender sections, cover plates, gantry tie-down frames, approach batterboards with wear boards, and the approach tie-down pipe were stowed on a 110 x 33 foot cargo barge (Figures 53, 54, and 55). These components were stored on the cargo barge to facilitate assembly of the HISEACOTS for testing in the September 1991 Joint Logistics Over-the-Shore (J-LOTS III) exercise at Fort Story, Virginia.

Disassembly of the platform was relatively easy, although several module connectors were very difficult to unlock. Cuts were made in the approach batterboard water bladders to allow them to drain completely before being lifted from the platform.

Disassembly of the HISEACOTS took approximately 5 calendar days and required a total of 375 manhours (crane crew - 150 hours, causeway crew - 25 hours, Belvoir/contractor crew - 200 hours) along with 25 crane hours.

Section V

CONCLUSIONS AND RECOMMENDATIONS

The complete setup, assembly, test, and disassembly took 25 calendar days. The assembly and disassembly required 1,593 manhours, 22 hours of time for the warping tug, 12 hours for the 65 foot long ST, and 75 hours of the barge crane's time. With some design improvements, assembly time could be reduced to five 10-hour shifts with a crew of 21 (including crane crew) and a dedicated crane. Recommended design changes include:

- Utilizing a special cast connecting pin to allow conventional "guillotine" connection of the inverted 20-foot, raked-end modules to the 40-foot, square-end modules (as opposed to the bolt-on ISO connection); and

- Fabricating the approach batterboard water bladders as a unitized structure to eliminate time-consuming field assembly.

The average lighterage cycle time recorded in calm water was 14.3 minutes. This represents a 34 percent reduction from the average J-LOTS II lighterage cycle times recorded in 1984. Figure 56 gives a comparative breakdown of the lighterage cycle times recorded during the HISEACOTS tests in April 1991 and during J-LOTS II in 1984. The difference can mainly be attributed to the reduction in the approach and moor and cast-off and clear times made possible by the platform. However, pre-loading containers was not tested due to the lack of arresting gates for the LACV-30. It is very likely that pre-loading the gantry crane spar will substantially reduce the total lighterage cycle time. Reductions in container tie-down times will also be possible when the traversing system is installed. At that time, the gantry crane will be able to spot the containers in the same location on the LACV-30s, thus requiring only one chain length adjustment. High sea states were not encountered during the tests. Therefore, the use of the PA bar to mitigate heave and pendulation motion was not demonstrated. The J-LOTS III exercise scheduled for September 1991 is to be held off the beach of Fort Story, Virginia. The chances of encountering Sea State 3 conditions during the HISEACOTS test are good.

We performed an analysis using these cycle times to look at the performance of the LACV-30 with and without the HISEACOTS in calm water. Table 8 gives a comparison of the LACV-30 cycle times and productivity at various offshore distances. Figure 57 plots the various productivities versus stand-off distances. It is important to note that the ship's loading time recorded with the HISEACOTS gantry crane averaged approximately 6.5 minutes per container. This time did not include: the time to attach the spreader frame to the container; slewing across the deck of the crane ship; or disengaging from the gantry crane and returning for another container, as did the J-LOTS II ship's loading time. In an effort to make a fair comparison between the two cycle times, an extra 2.5 minutes were added to the HISEACOTS gantry crane load cycle. This was deemed a reasonable time for attaching the container spreader frame, slewing across the crane ship deck, and disengaging and returning to the containership. This adjusted time was used for the productivity analysis.

Table 8. Estimated Calm Water Performance of Army Lighters

	Components of Container Operations	LACV-30 w/no Improvements with HISEACOTS	LACV-30 w/no Improvements with HISEACOTS	LACV-30 w/no Improvements with HISEACOTS Preload	LACV-30 w/no Improvements without HISEACOTS
1	Approach and moor ship facility (min)	0.7	0.7	0.7	6
2	Cargo capacity (# containers)	2	1	2	2
3	Crane cycle time per container (min)	9	9	5.15	9
4	Total loading time (min)	18	9	10.3	18
5	Tiedown time for last container (min)	4	4	4	4
6	Cast-off and clear from ship (min)	0.7	0.7	0.7	4
7	Inbound speed (knots)	19.1	19.1	19.1	19.1
8	Transition inbound (min)	4.5	4.5	4.5	4.5
9	Approach and moor at shore facility (min)	0	0	0	0
10	Off-loading time per container (min)	3	3	3	3
11	Total off-load time (min)	6	3	6	6
12	Cast-off and clear from beach time (min)	2	2	2	2
13	Transition outbound (min)	4.5	4.5	4.5	4.5
14	Return speed (knots)	47.8	47.8	47.8	47.8
15	Cycle time less transit time (min)	31.4	19.4	23.7	40
	Number of Containers transferred in a 10-hour shift				
1	with a stand-off distance of 1 nm	26	18	32	22
2	with a stand-off distance of 2 nm	24	16	28	20
4	with a stand-off distance of 4 nm	20	13	22	18
6	with a stand-off distance of 6 nm	16	10	20	14
8	with a stand-off distance of 8 nm	14	9	16	14
10	with a stand-off distance of 10 nm	14	8	14	12
12	with a stand-off distance of 12 nm	12	7	14	10
14	with a stand-off distance of 14 nm	10	6	12	10
16	with a stand-off distance of 16 nm	10	6	10	10
18	with a stand-off distance of 18 nm	10	5	10	8
20	with a stand off distance of 20 nm	8	5	8	8

It would be reasonable to say that the reduction in the total ship cycle time while utilizing the HISEACOTS in calm water can be attributed to the ability of the LACV-30 to quickly and safely approach/moor and cast-off/clear the ship. However, this statement may be too simplistic and slightly misleading.

There are several author-noted real benefits to be gained from using the gantry crane, even in calm water conditions.

1. The gantry crane is able to precisely spot and lower a container onto the deck of an LACV-30 without damaging the deck, railings, or cab. Loading a container onto the LACV-30 that is sitting on the platform, without the gantry crane, is still a difficult and, at times, hazardous operation. Crane operator-induced cargo pendulations and the inability of the crane operator to see the deck of the LACV-30 are major sources of these safety hazards.

2. The gantry crane eliminates the need for tag line duties on the deck of the LACV-30. This reduces the fatigue factor if the LACV-30 crew is used instead of the ship's boat jumpers. The gantry crane is able to spot a container in the same location on the deck of the LACV-30, thus eliminating the need to adjust the chain tensioners for each container load.

3. Finally, the gantry crane and soon-to-be-tested arresting gates will allow for parallel operations when loading a container. A container can be preloaded onto the gantry crane when there is no LACV-30 on the platform, or the container can be loaded simultaneously while the LACV-30 is approaching or flying onto the platform. The arresting gates will ensure that the LACV-30 cannot fly straight through the platform and hit a container hanging from the spar. This should also help in reducing the total ship cycle time. Figure 57 shows that preloading or simultaneous loading is indeed the most productive method of cargo transfer. It may be helpful to point out that it is easy to forget the true function of the gantry crane: high sea state container transfer operations. However, it does appear that the gantry crane does offer some benefits in cargo offload operations even in calm water conditions.

It is recommended that the complete HISEACOTS system, including the arresting gates and traversing capability, be demonstrated and tested during the September 1991 J-LOTS III exercise; specifically,

- HISEACOTS ability to preload containers.

- Container operations with and without the gantry crane in various sea states.

Appendix A

FIGURES AND PHOTOGRAPHS

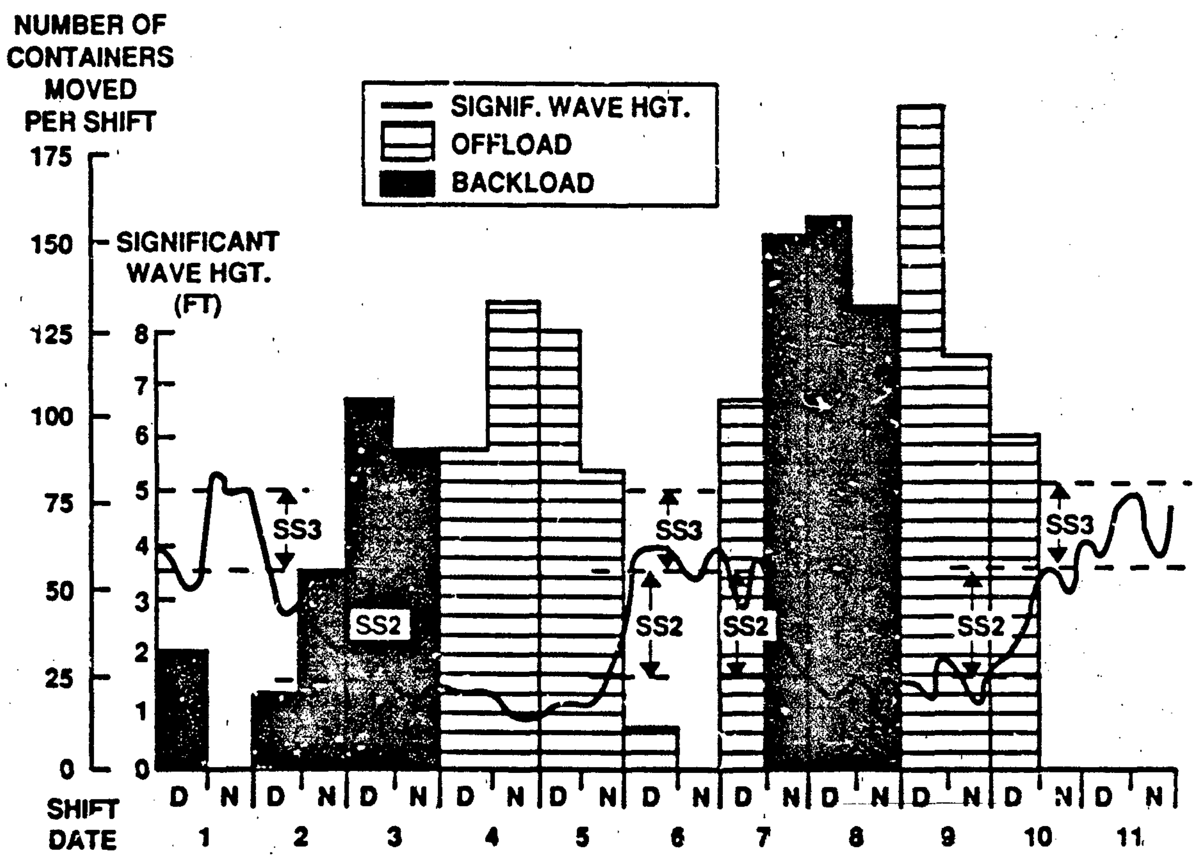


Figure 1

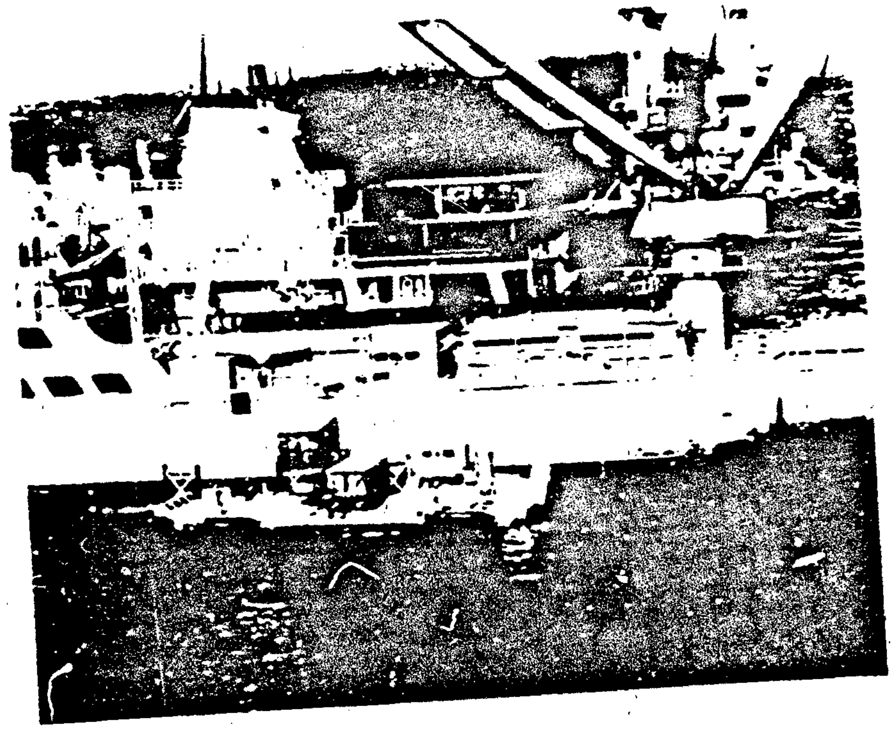
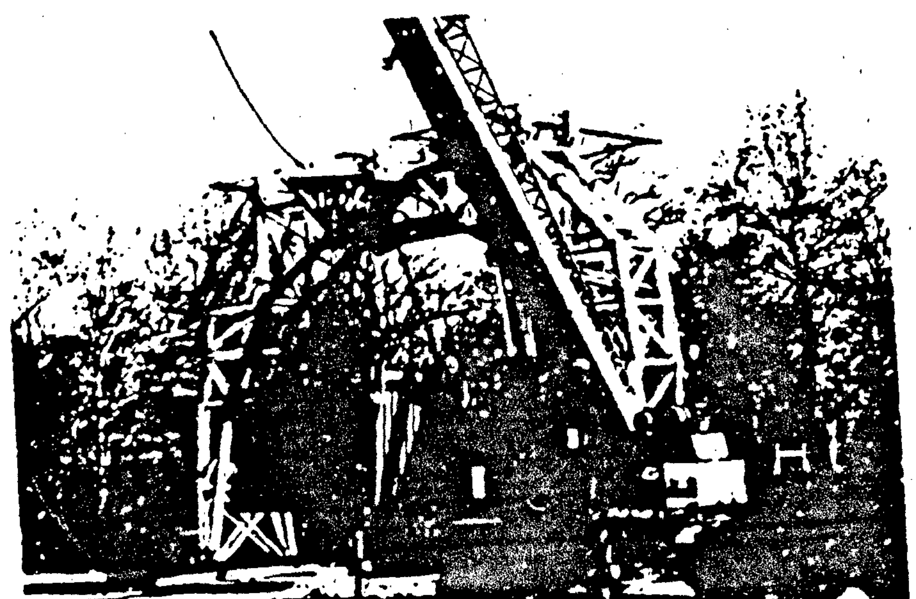


Figure 2



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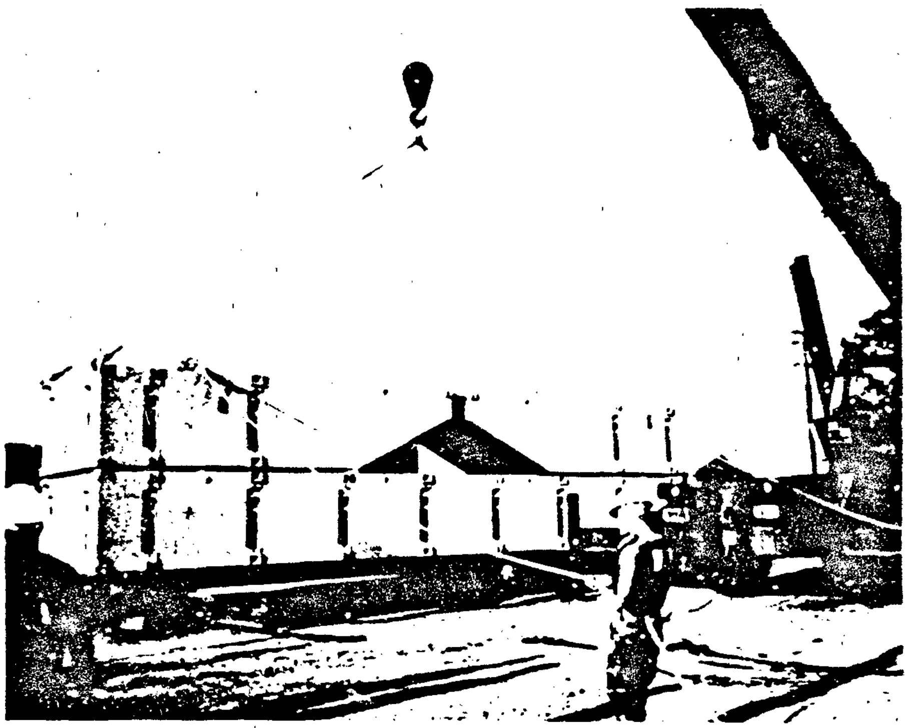

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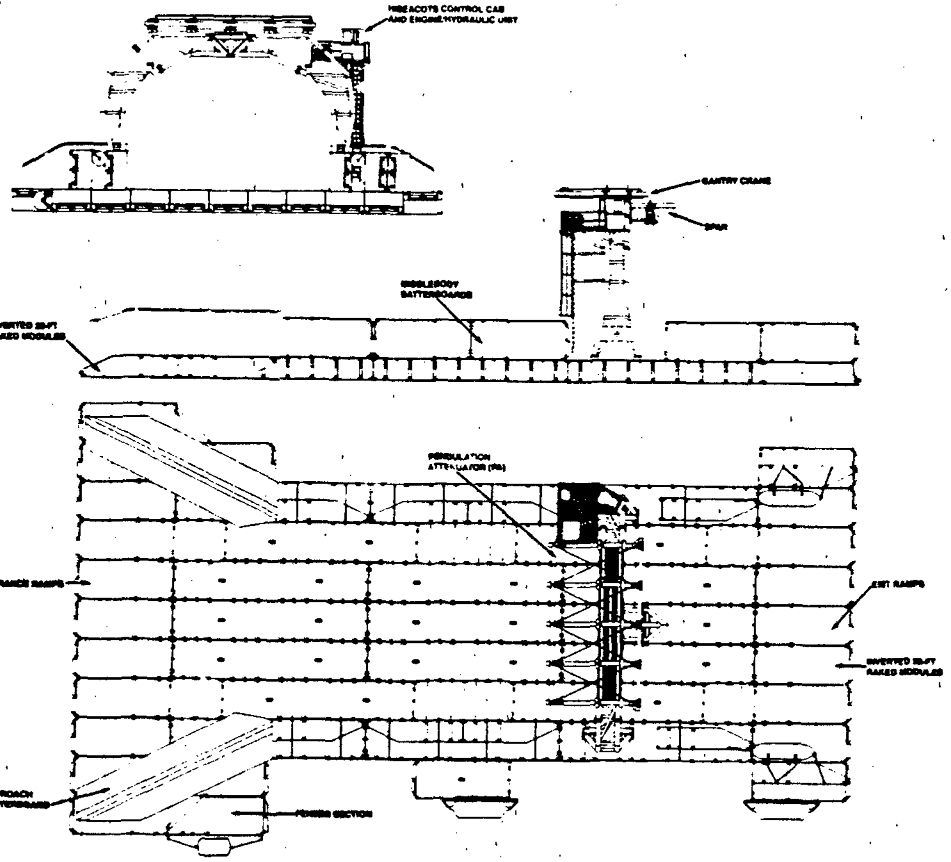
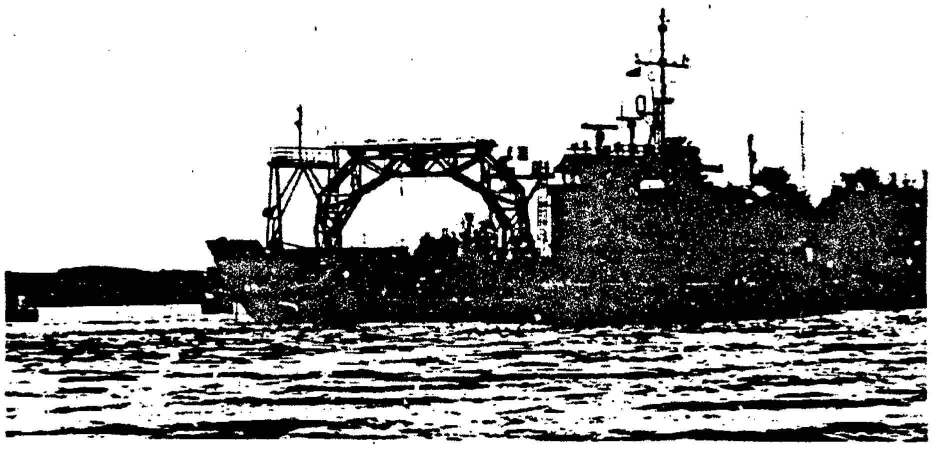

HISEACOTS CONTROL CAB
AND ENGINE/HYDRAULIC UNIT
GANTRY CRANE
PENDULATION
ATTENUATOR (PA)
ENTRANCE RAMPS
EXIT RAMPS

Figure 5



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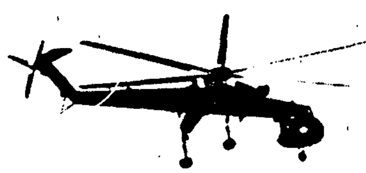

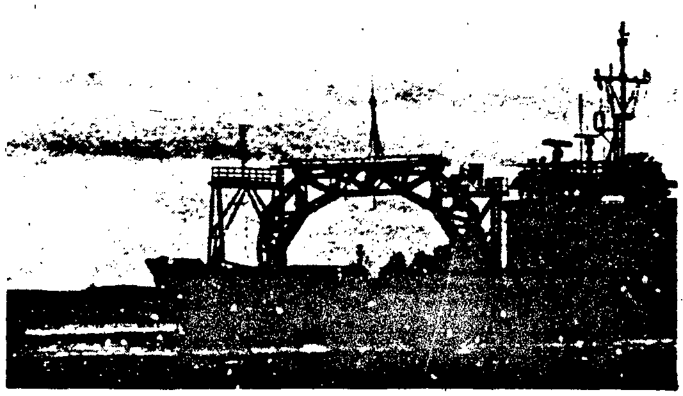

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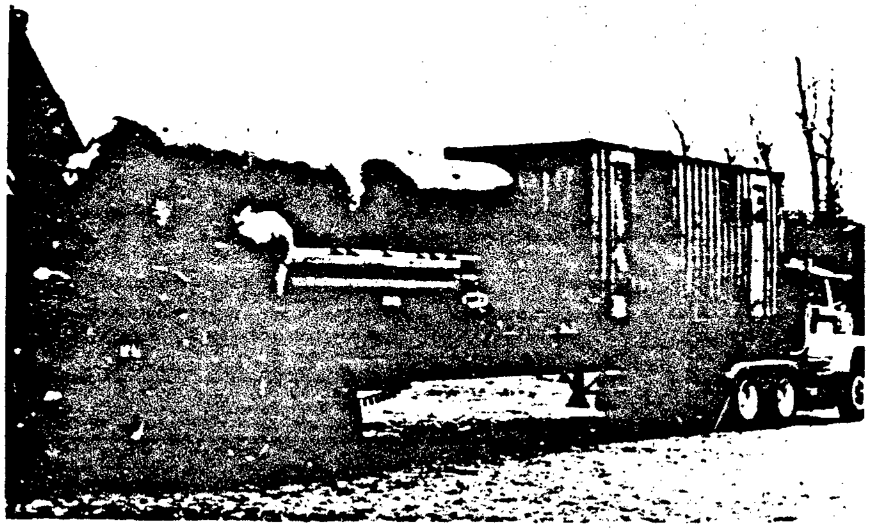
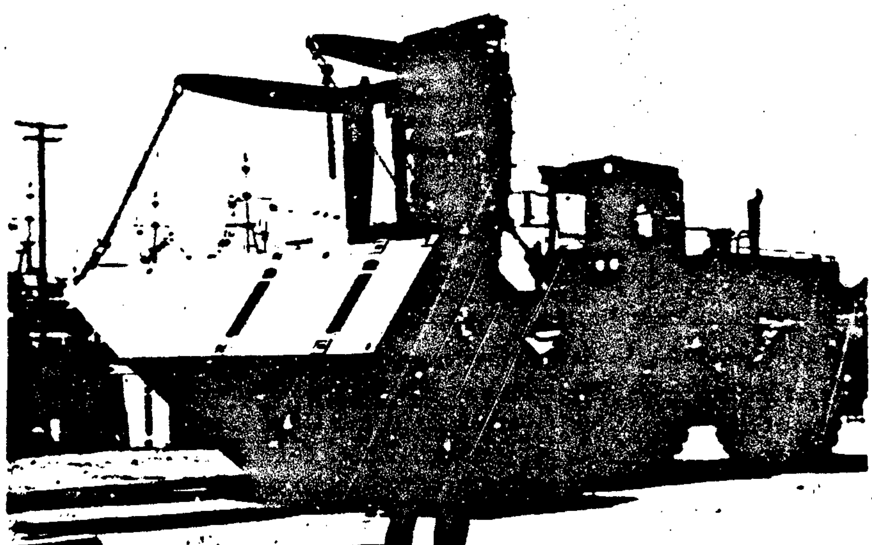


Figure 8



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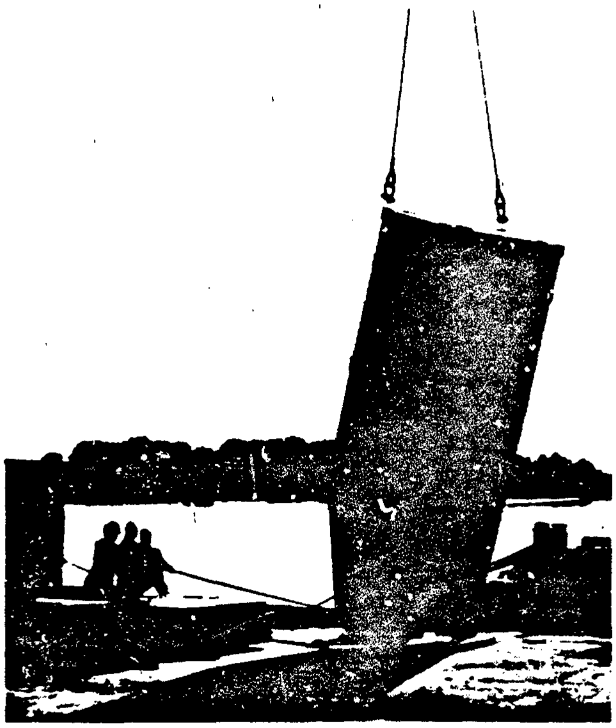

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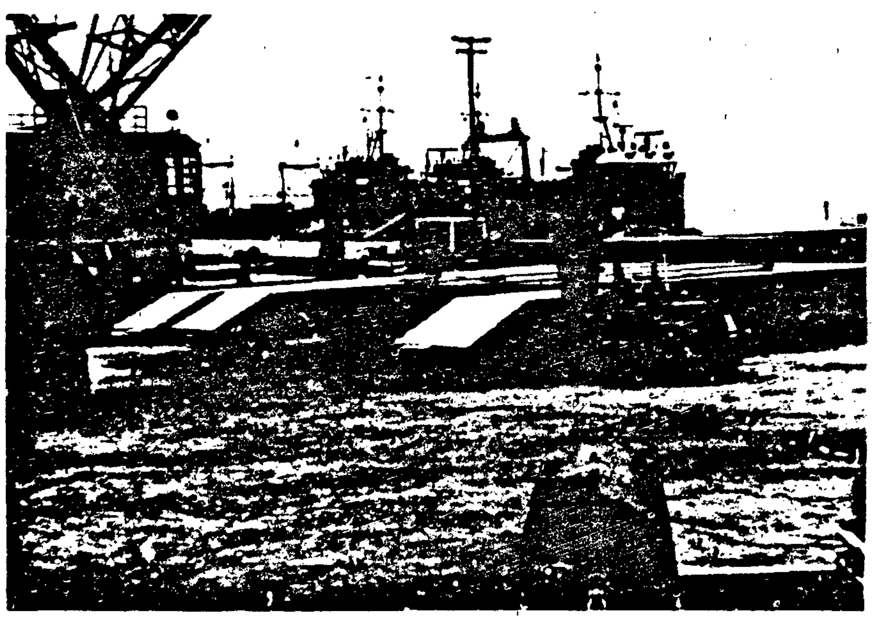

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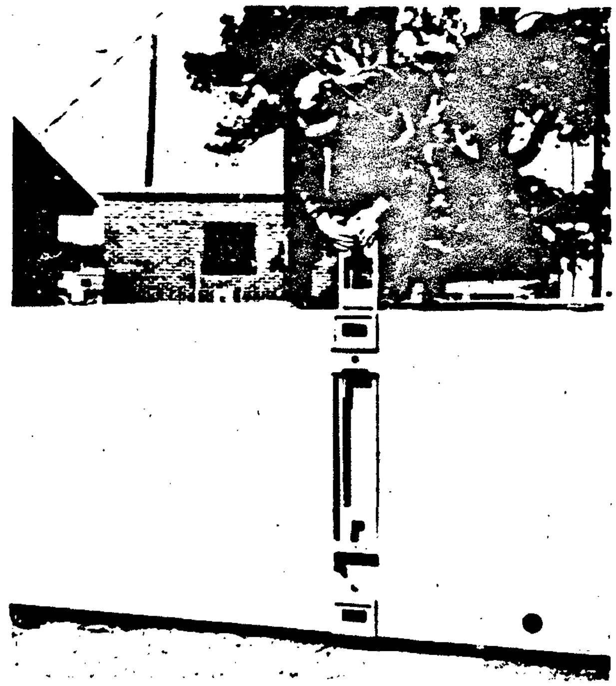

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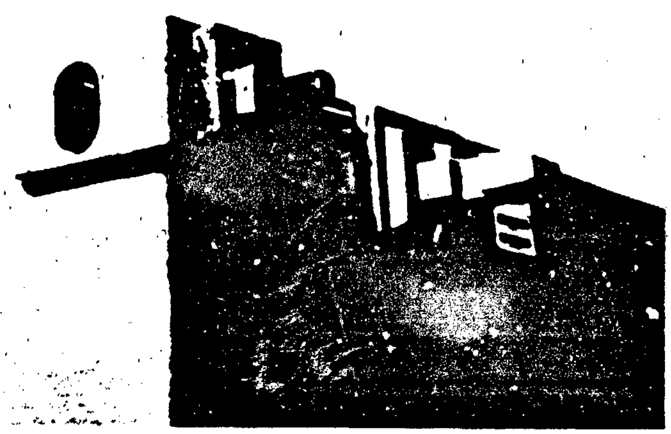

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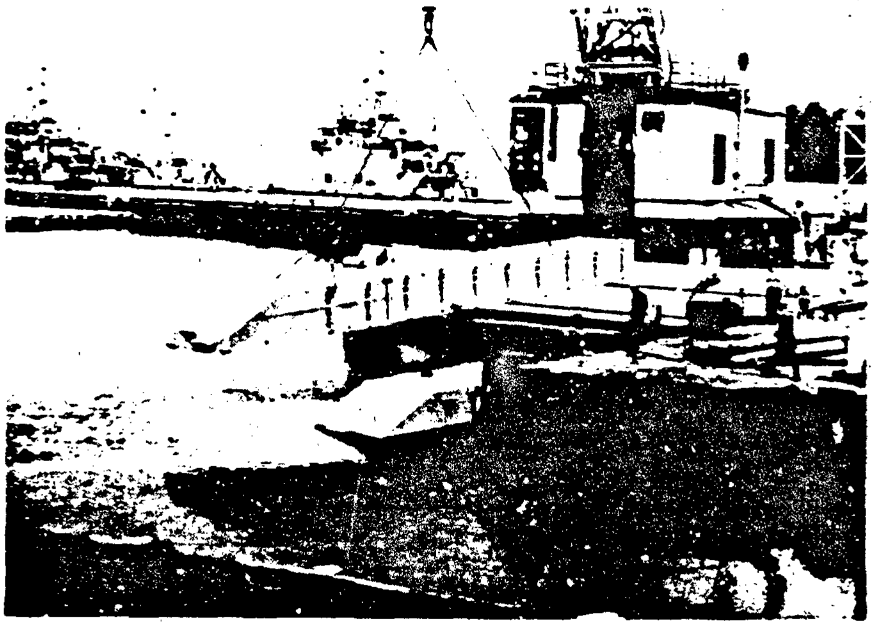

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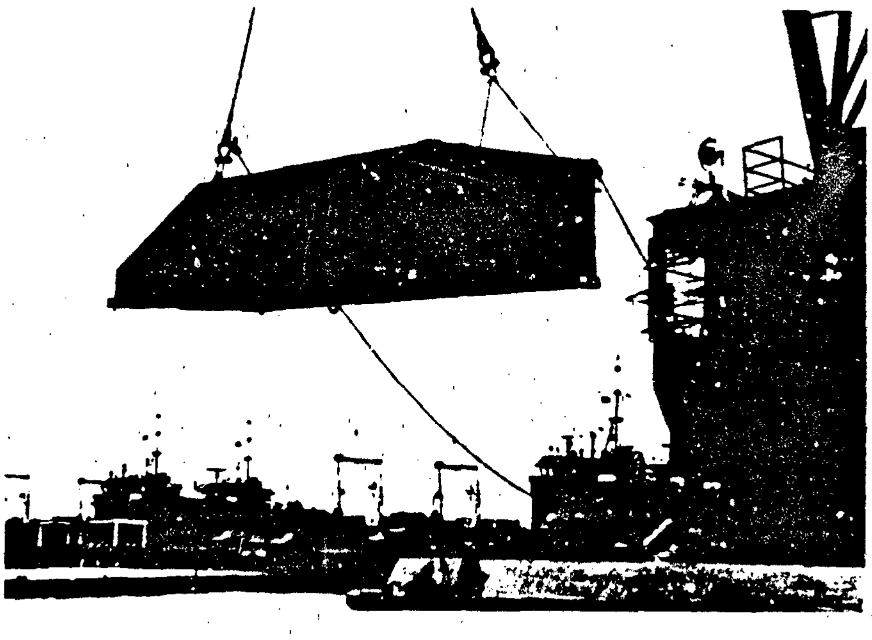

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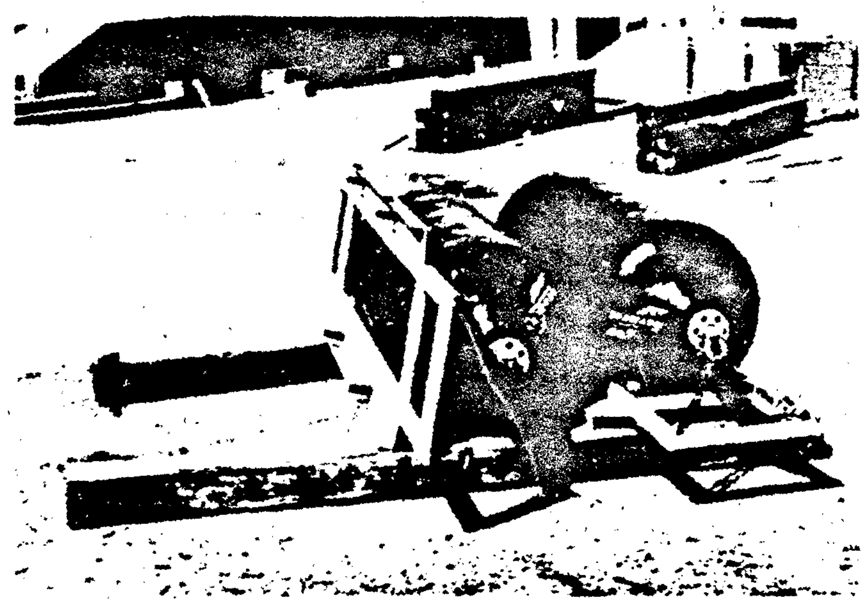

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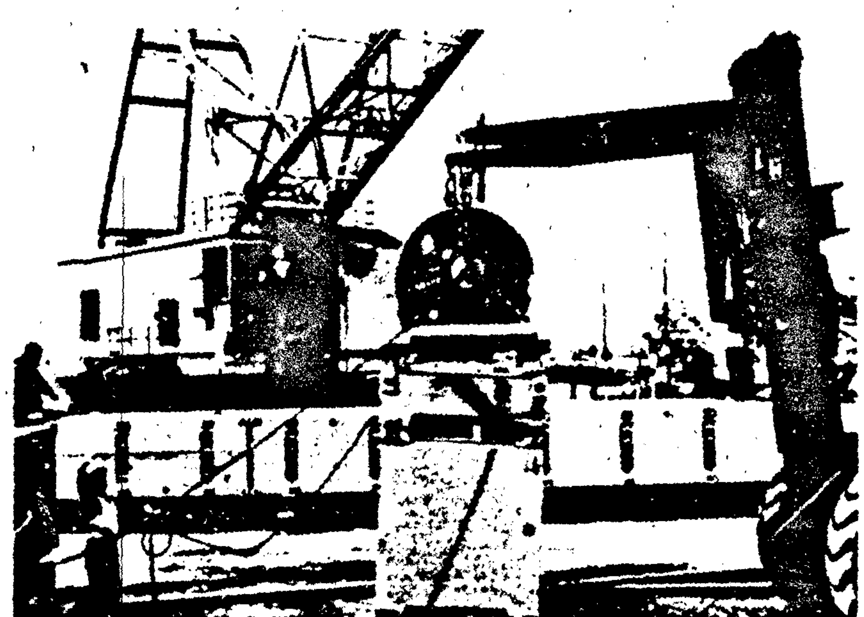

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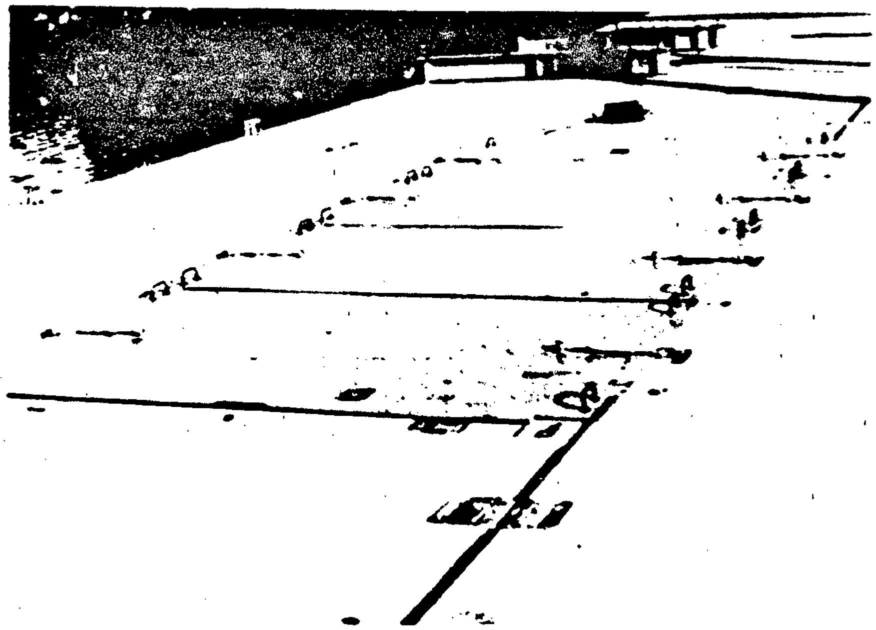

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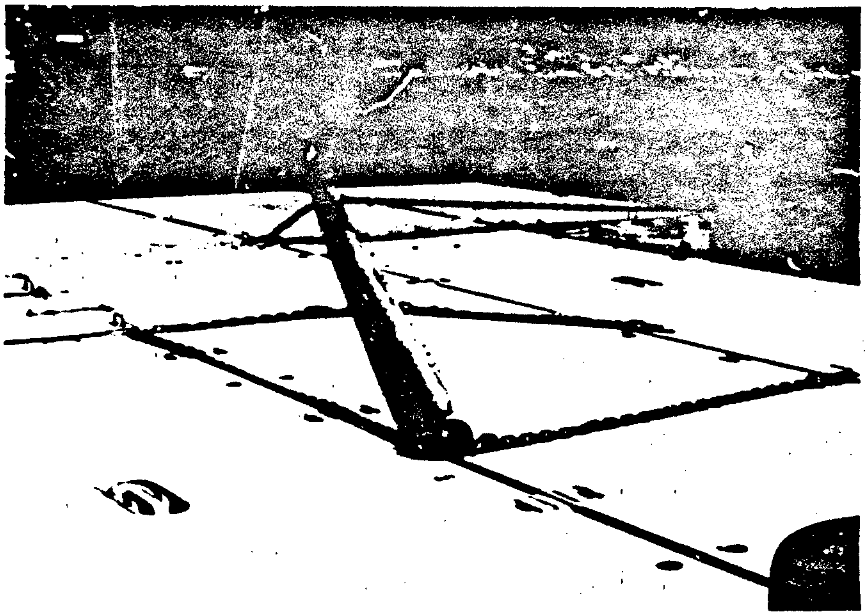

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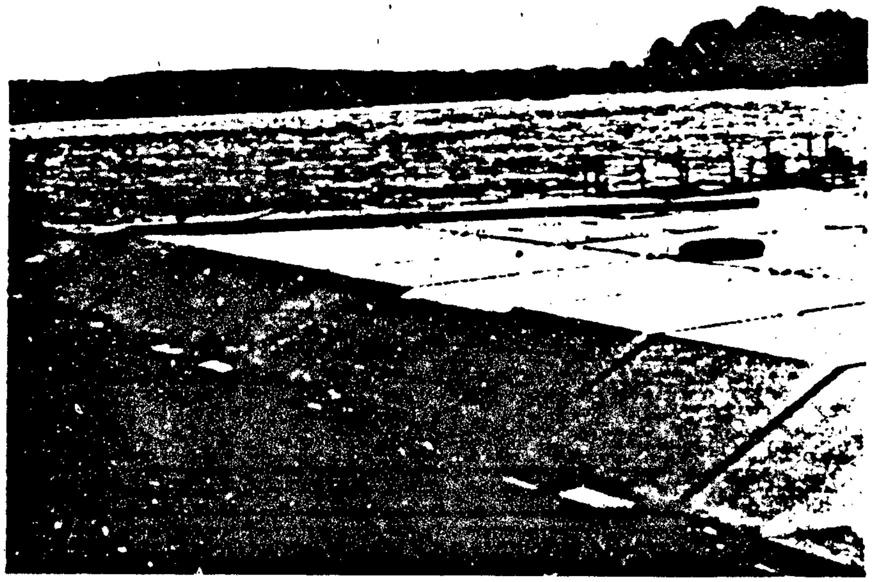

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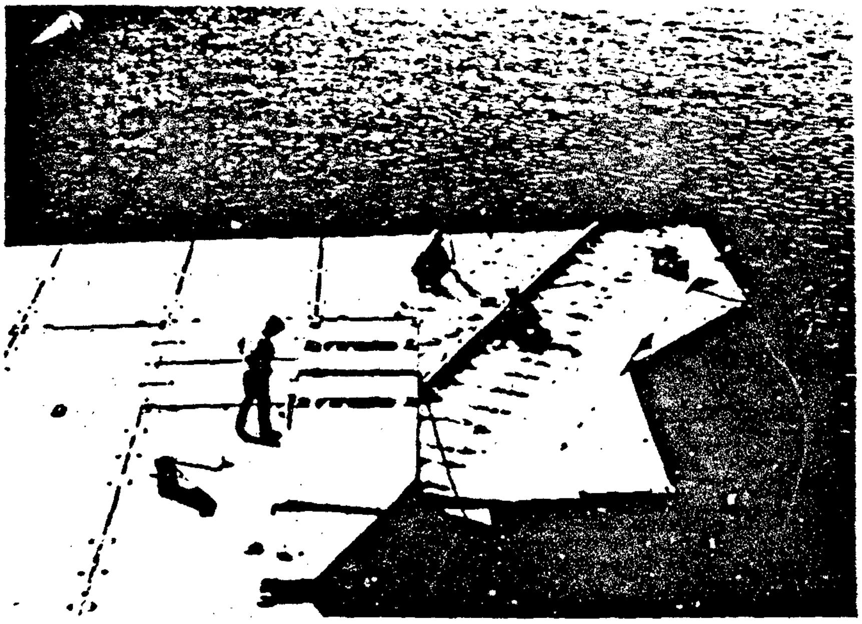

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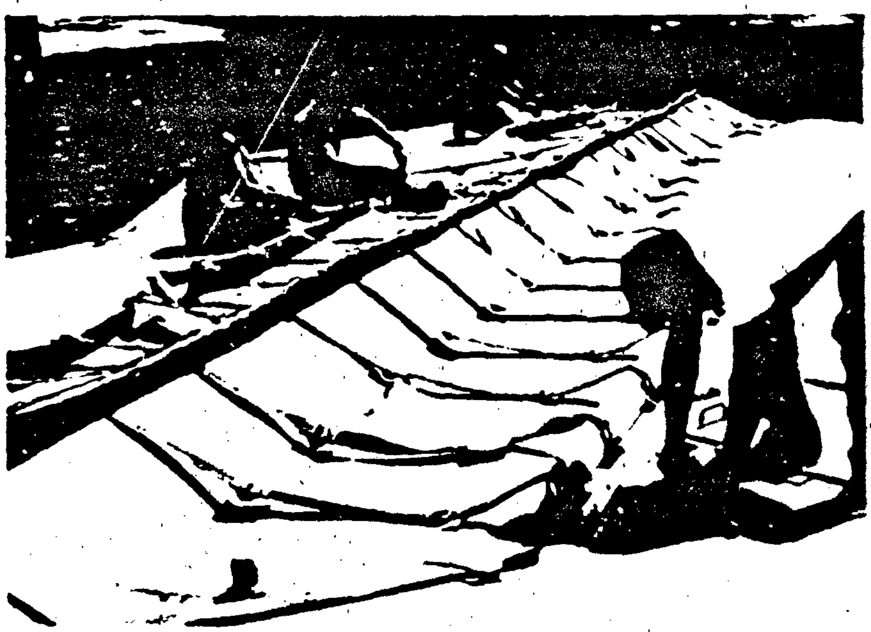

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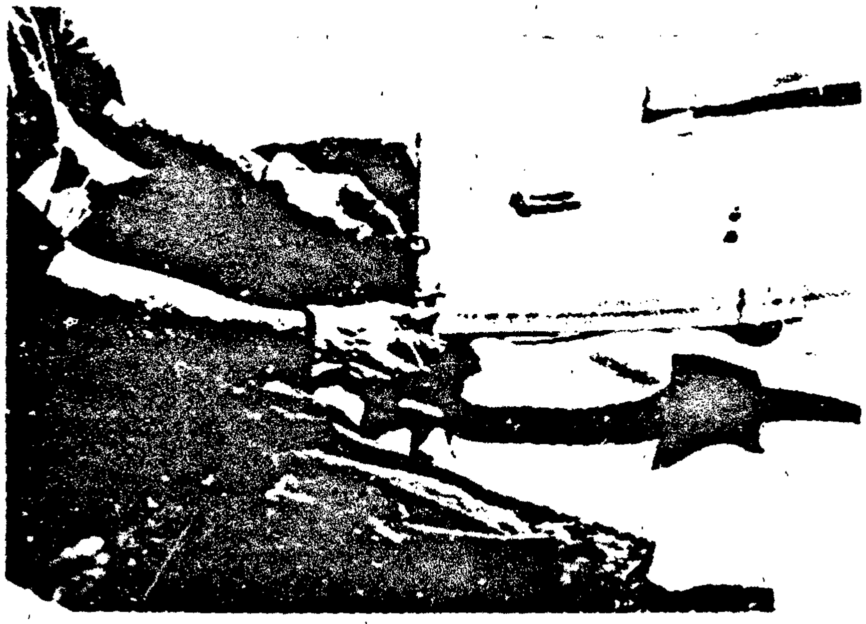

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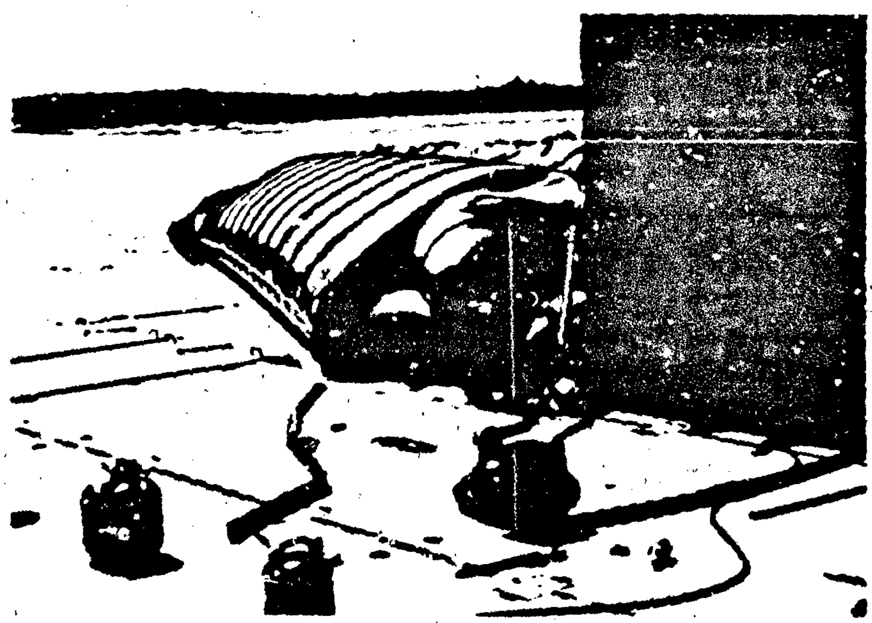

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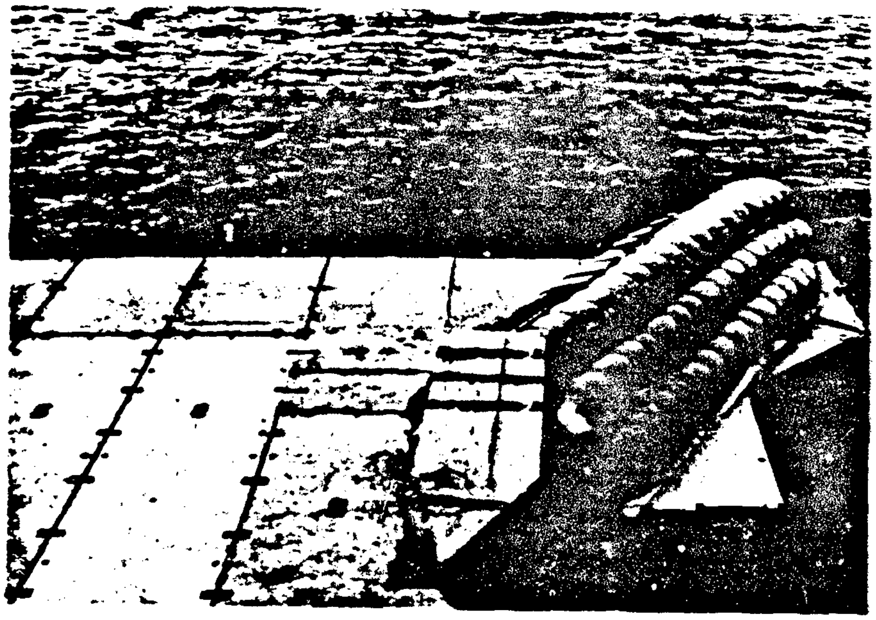

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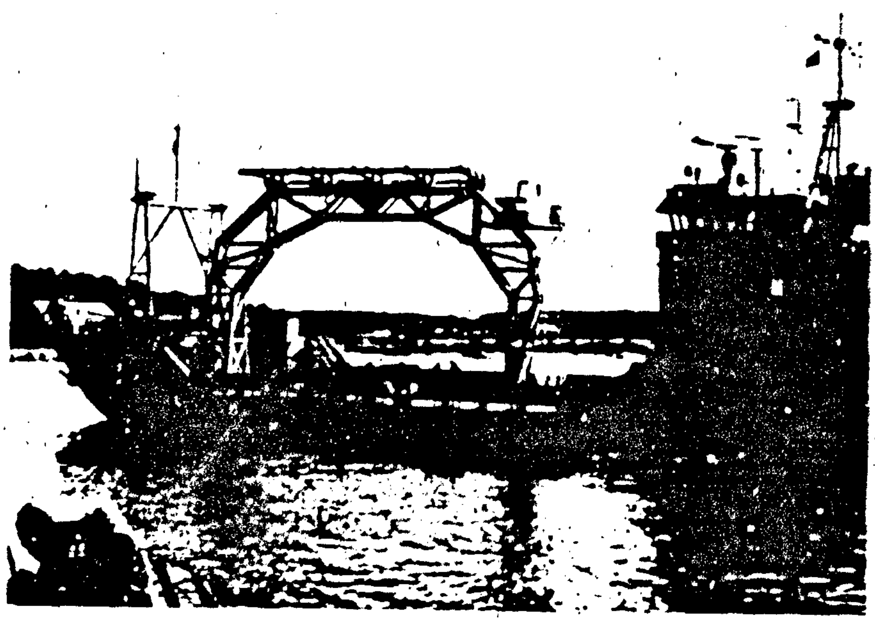

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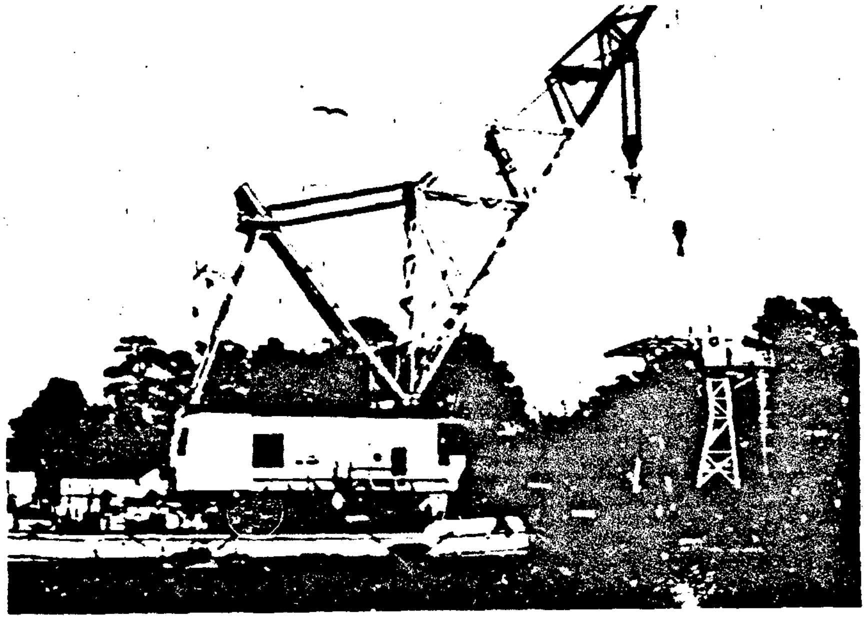

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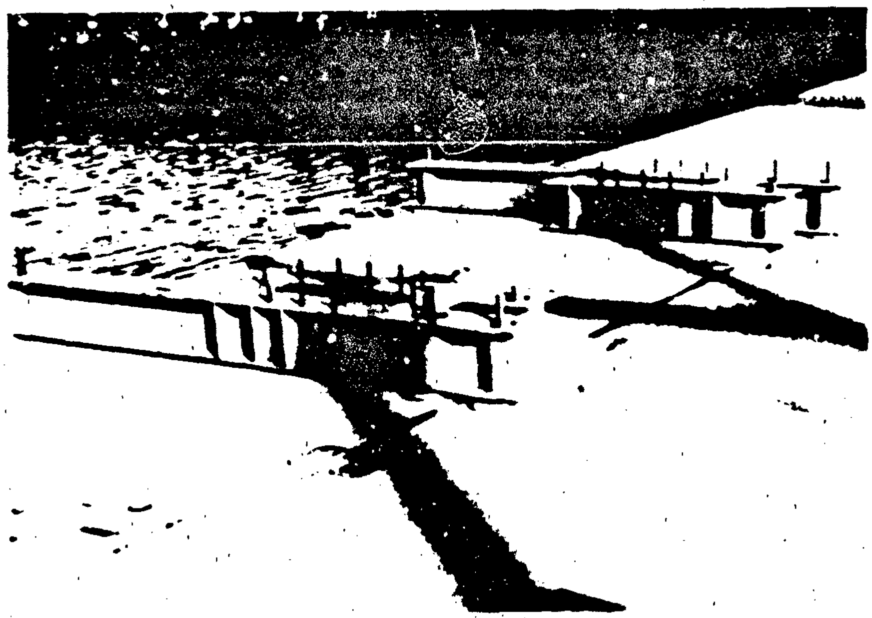

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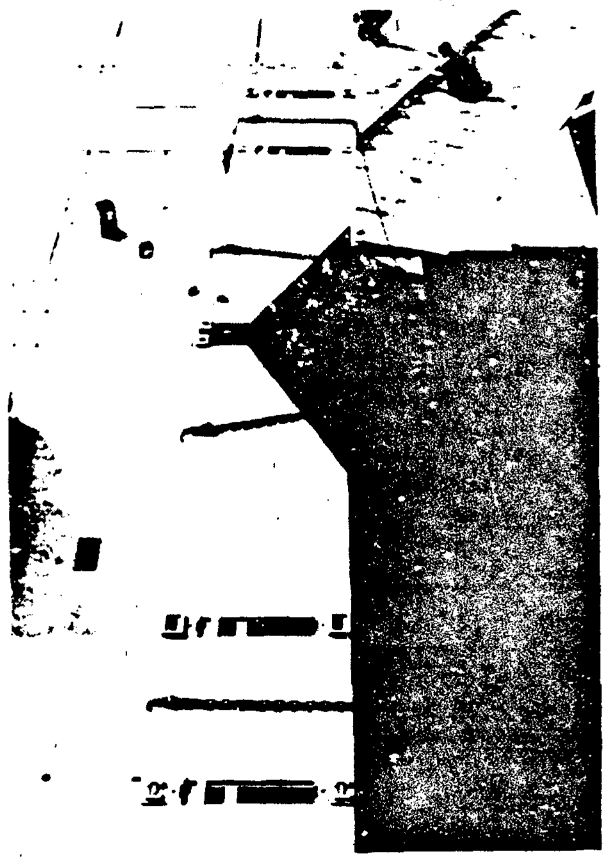

Figure 30

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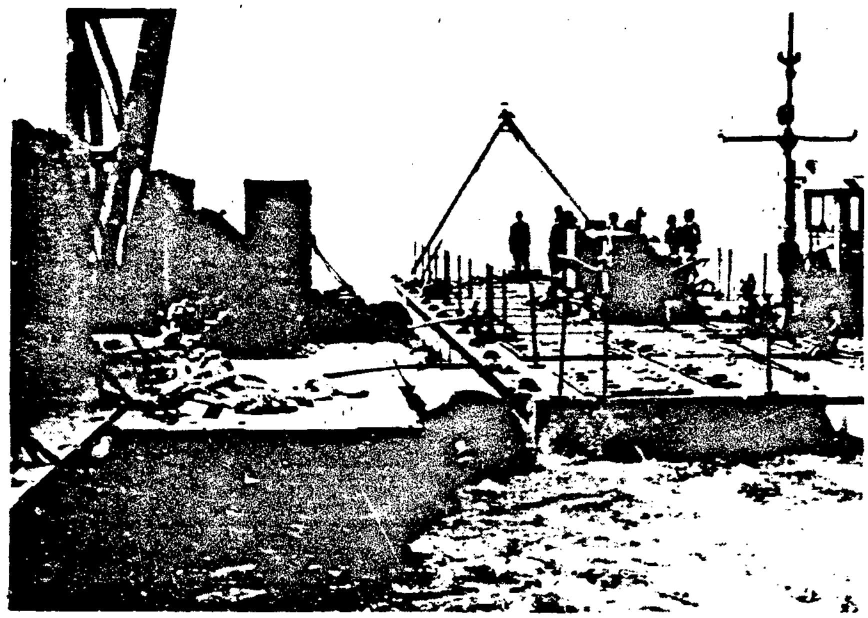

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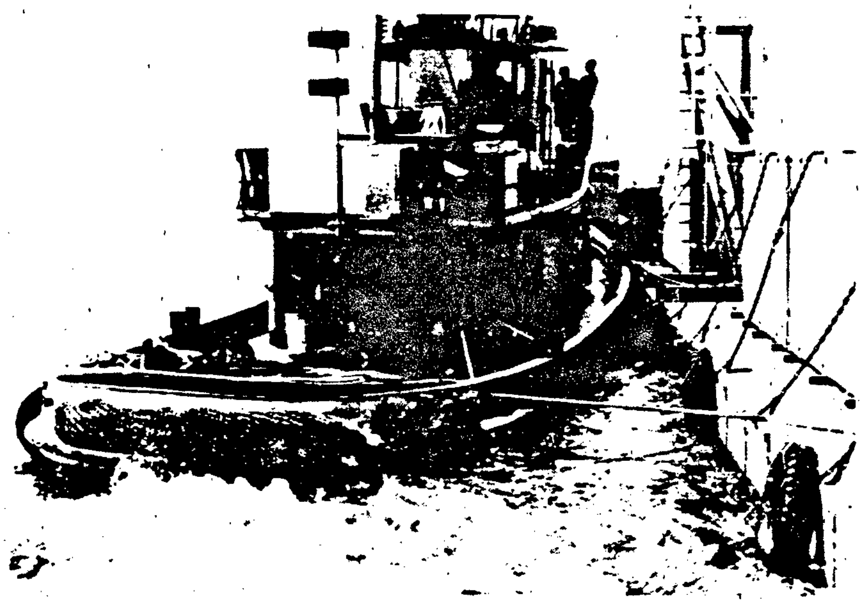

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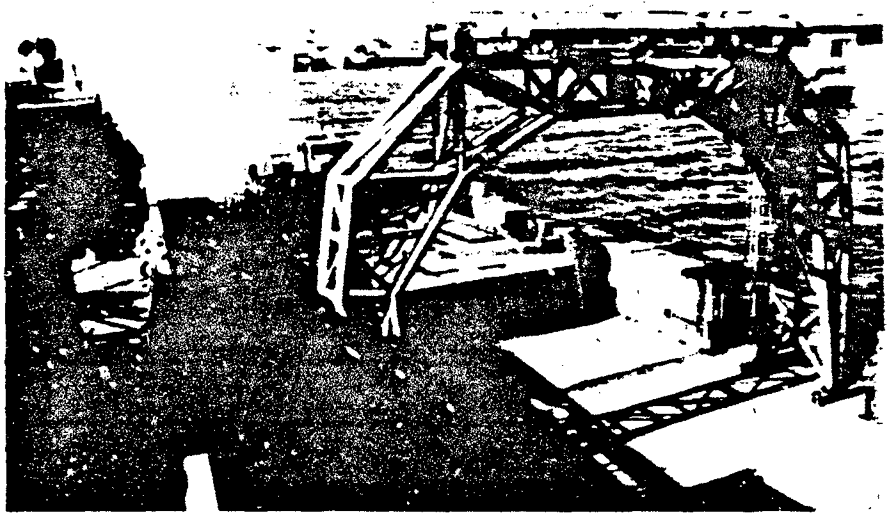

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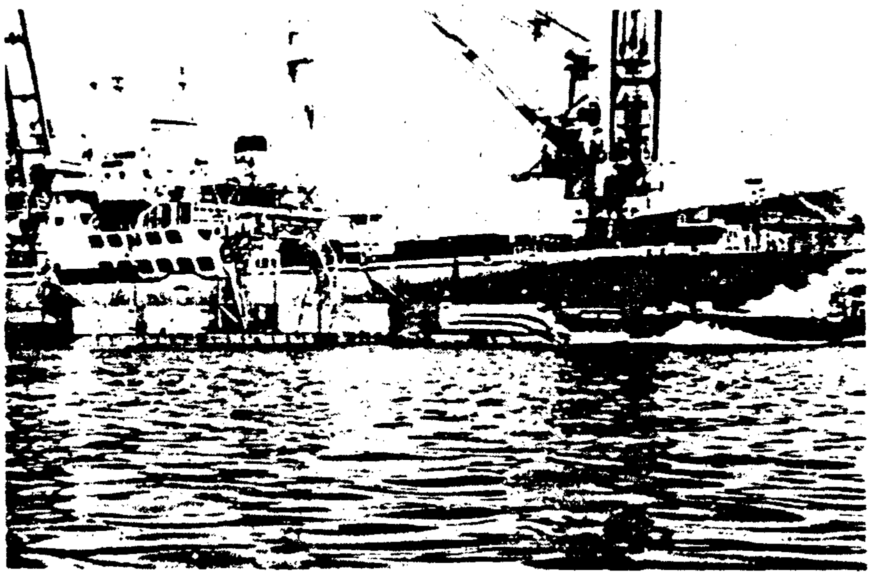

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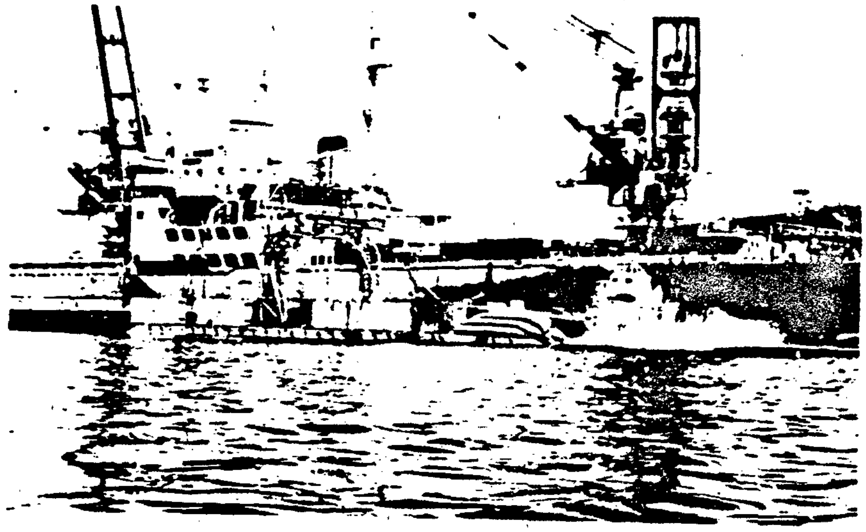

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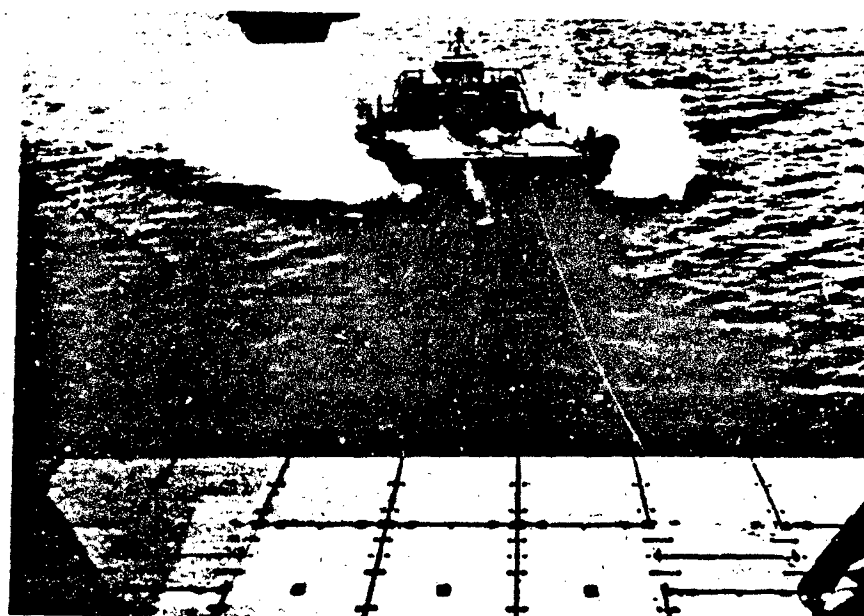

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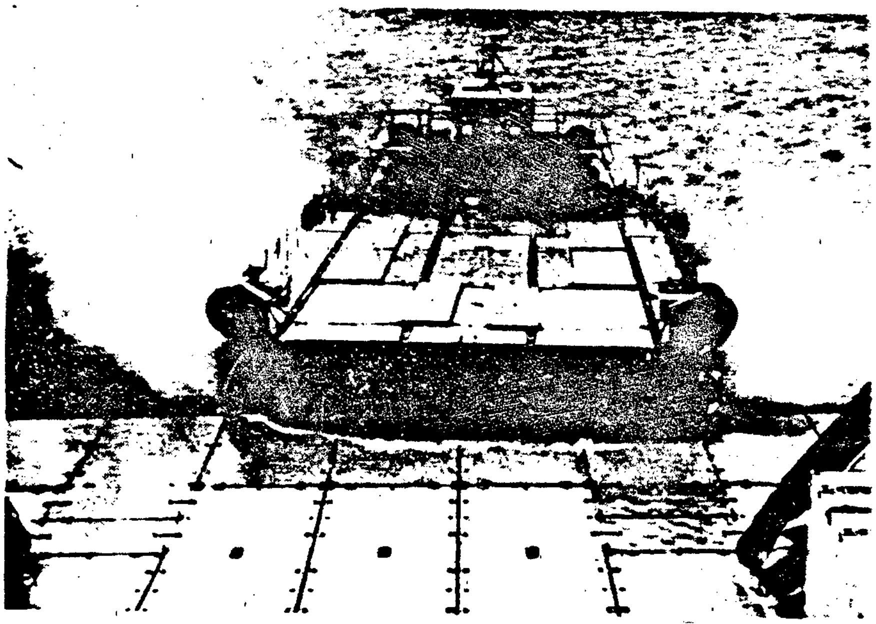

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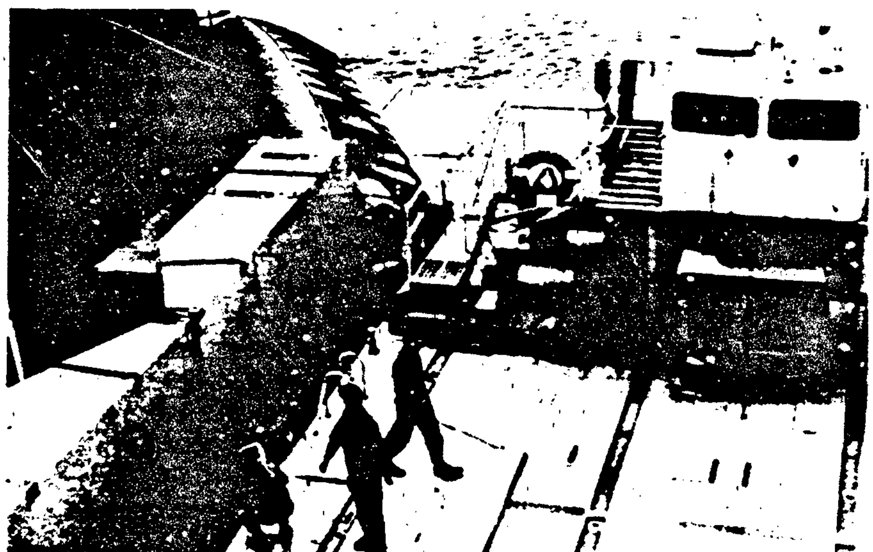

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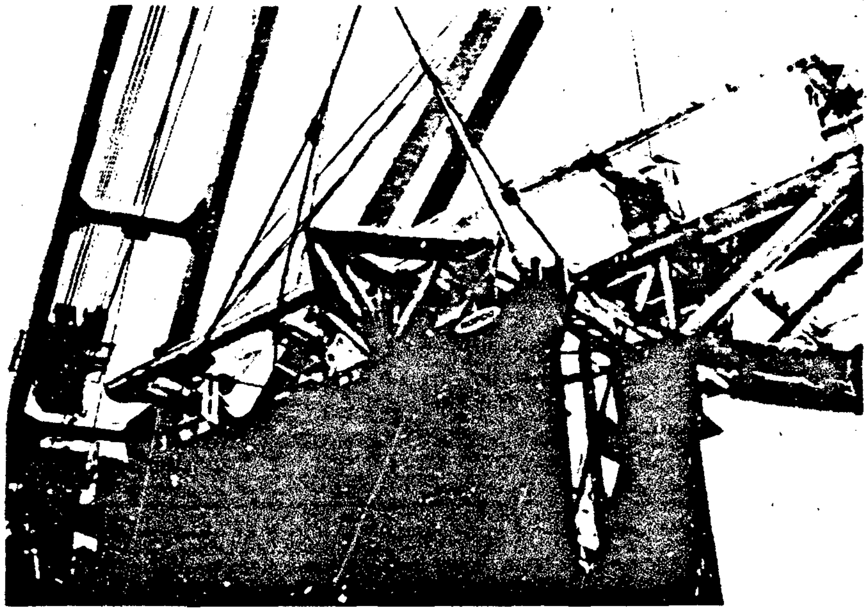

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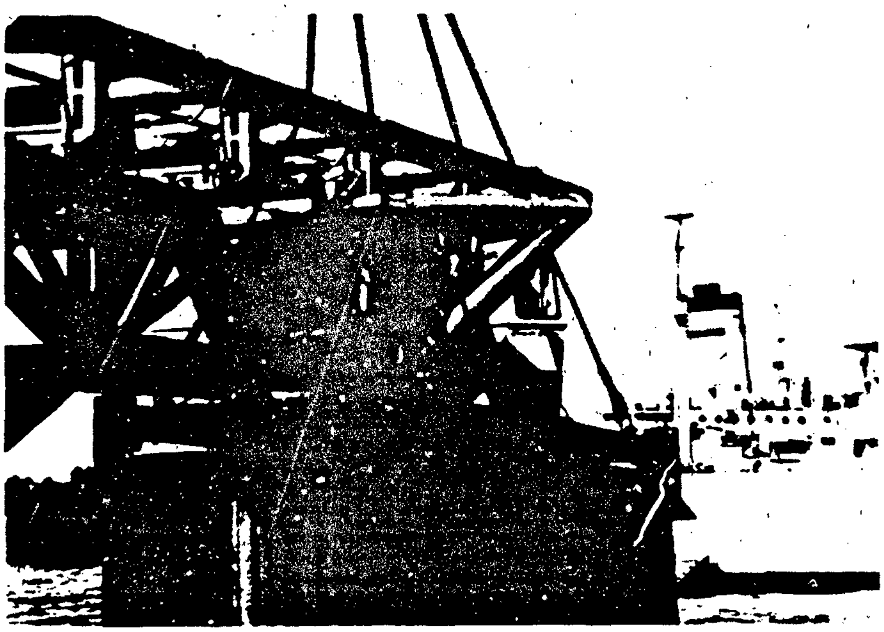

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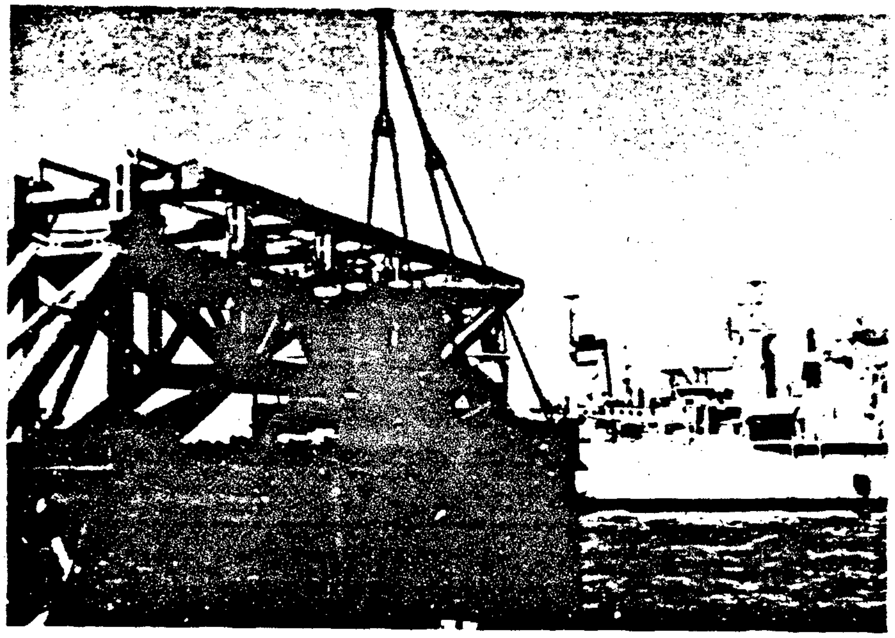

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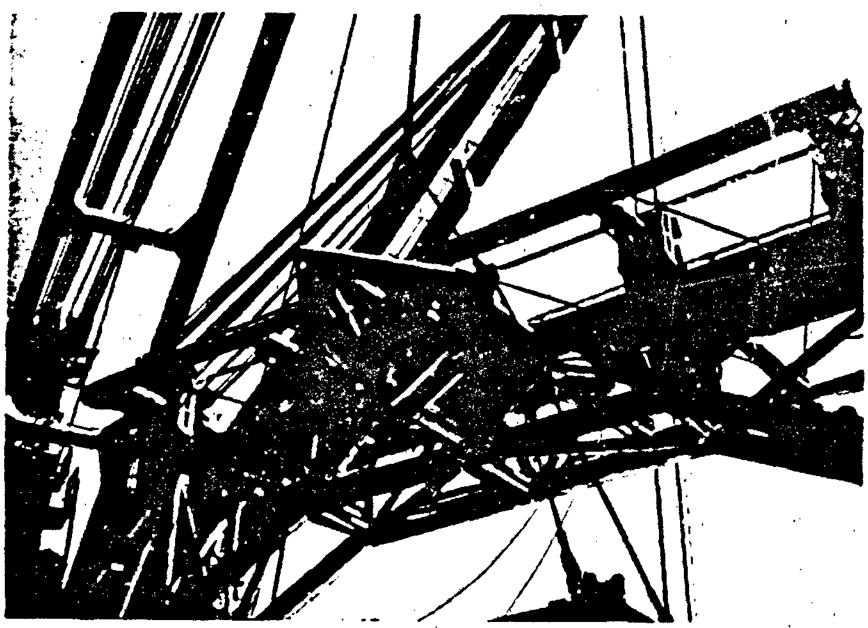

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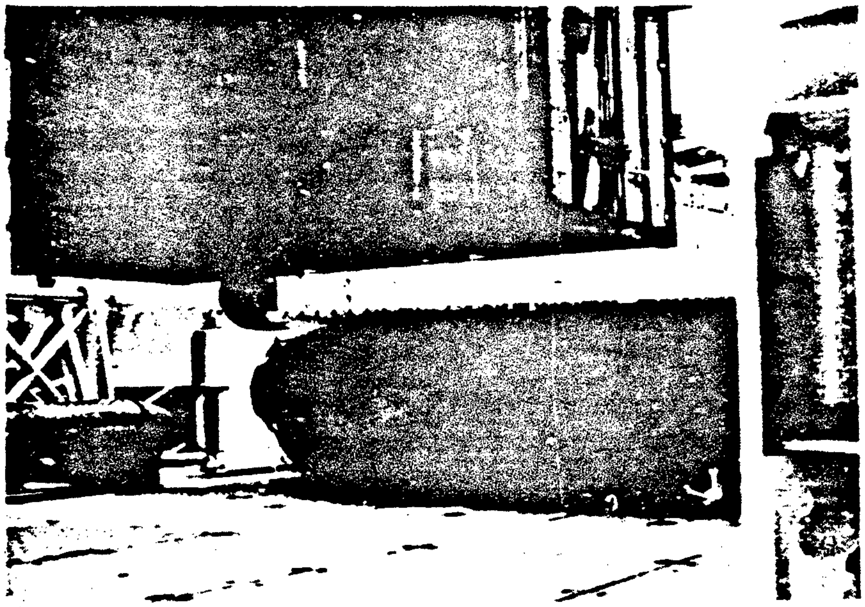

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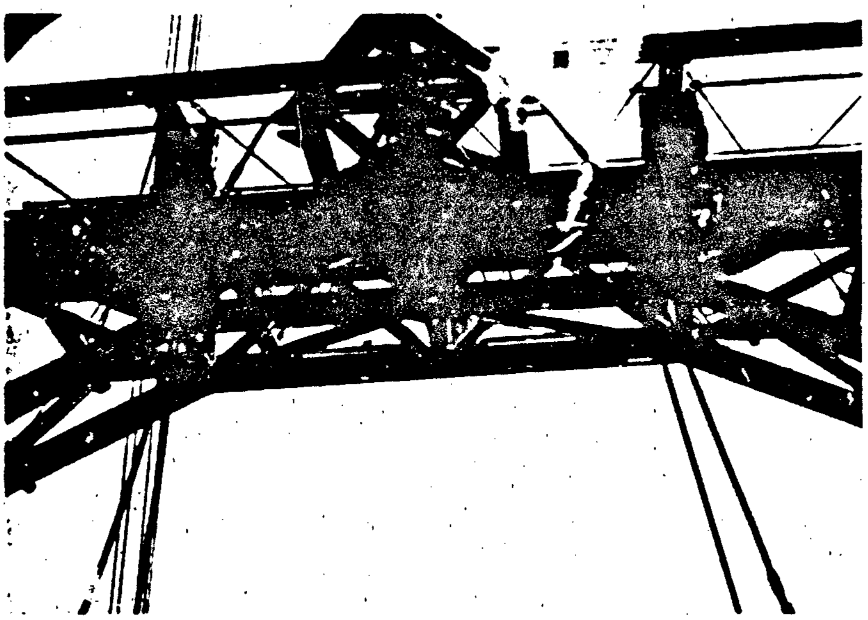

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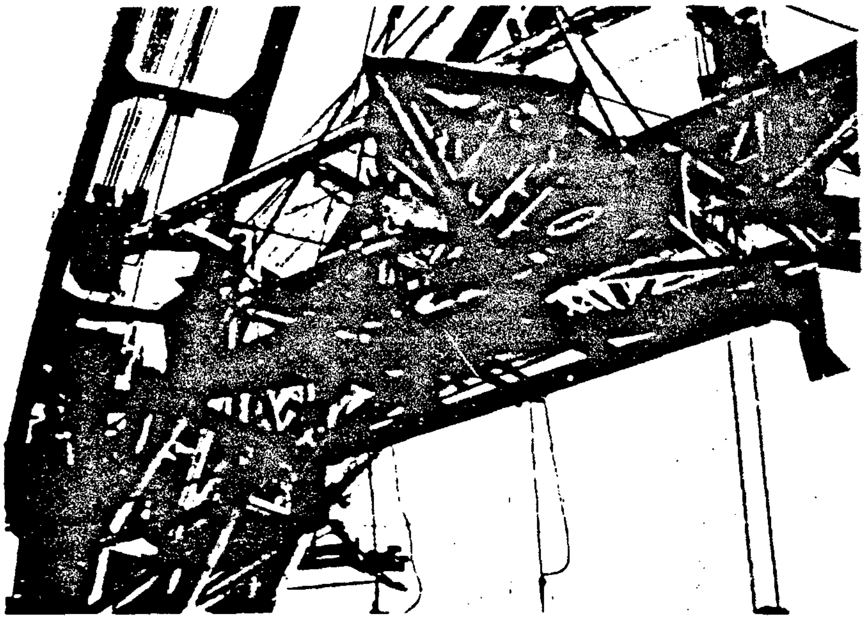

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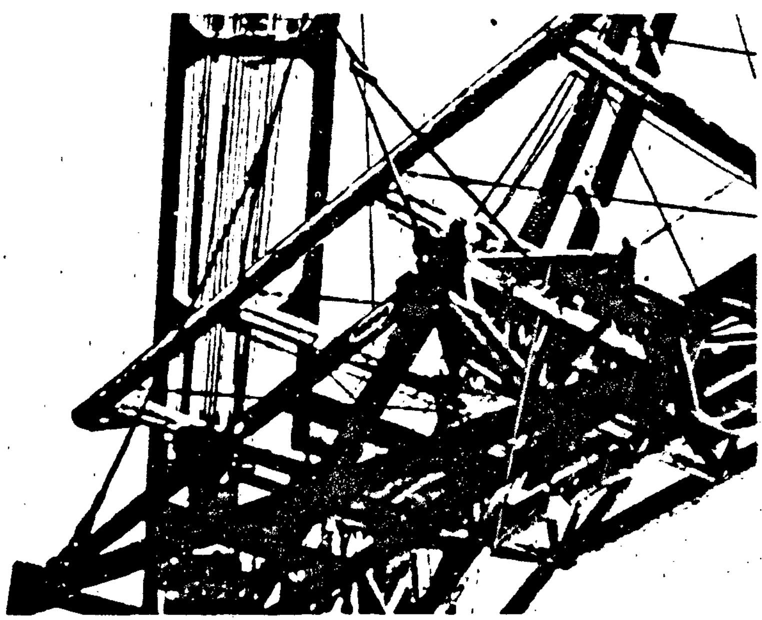

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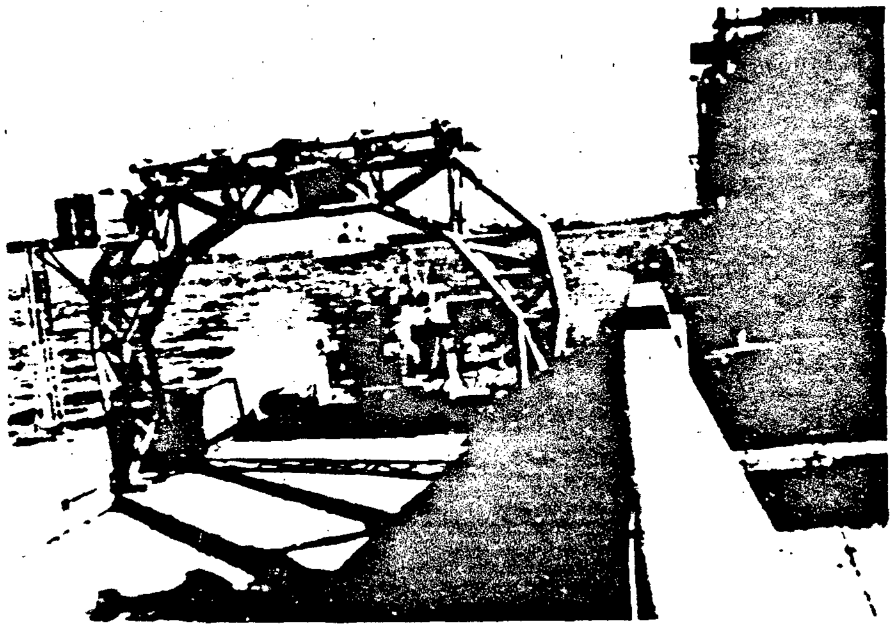
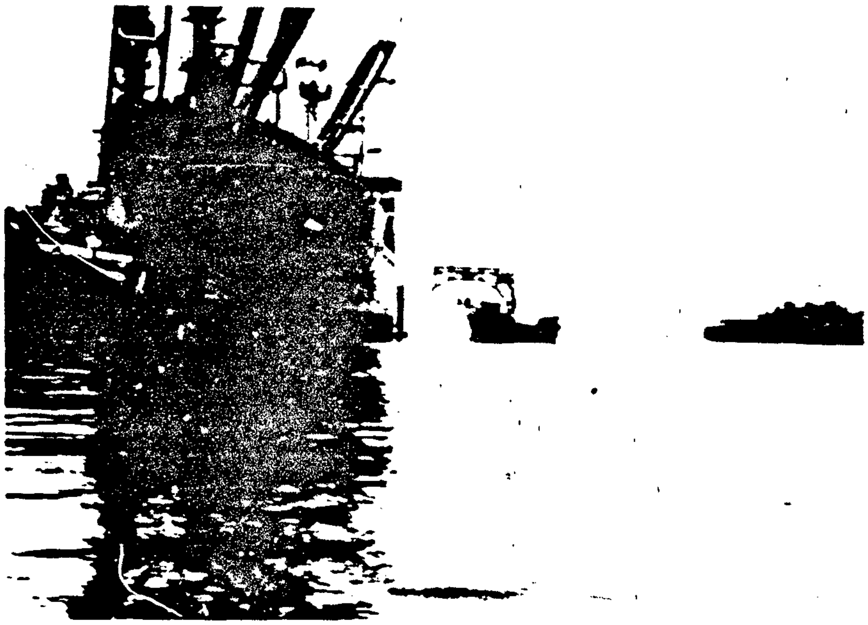


Figure 48

Figure 49



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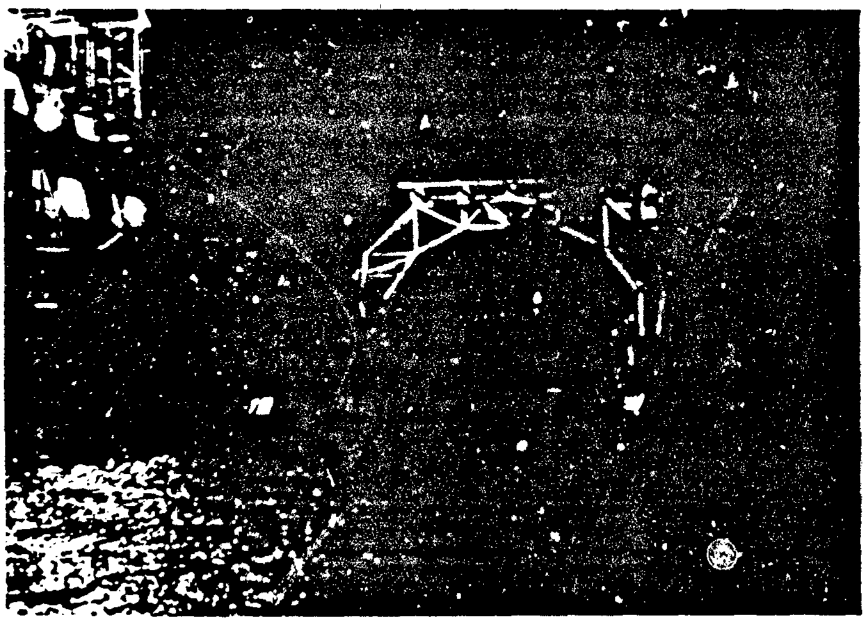

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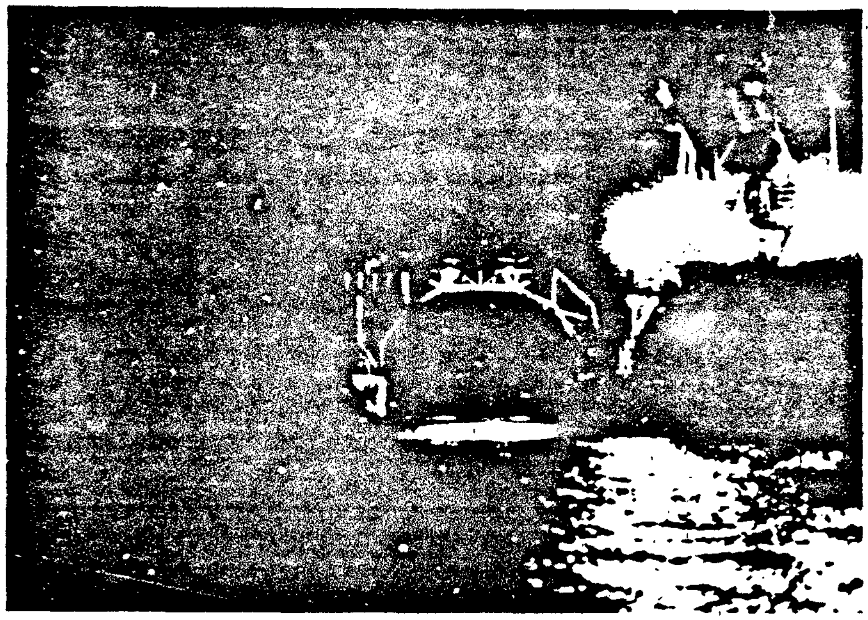

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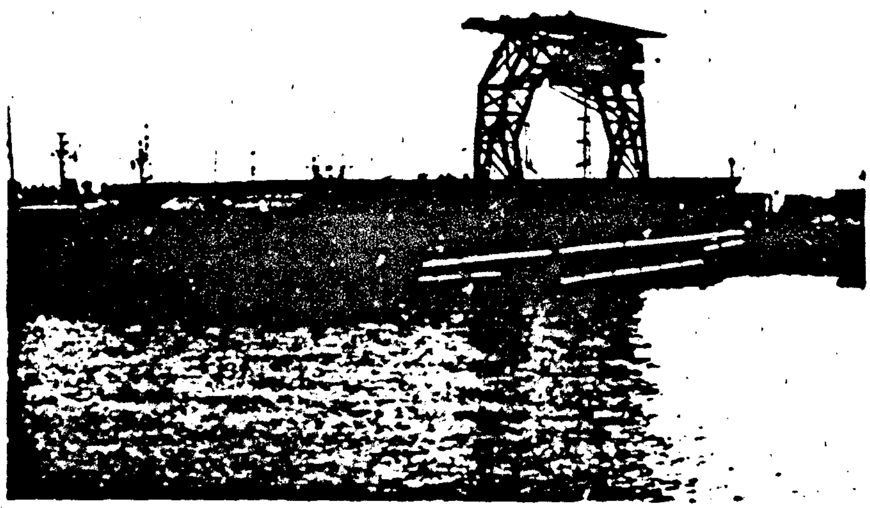

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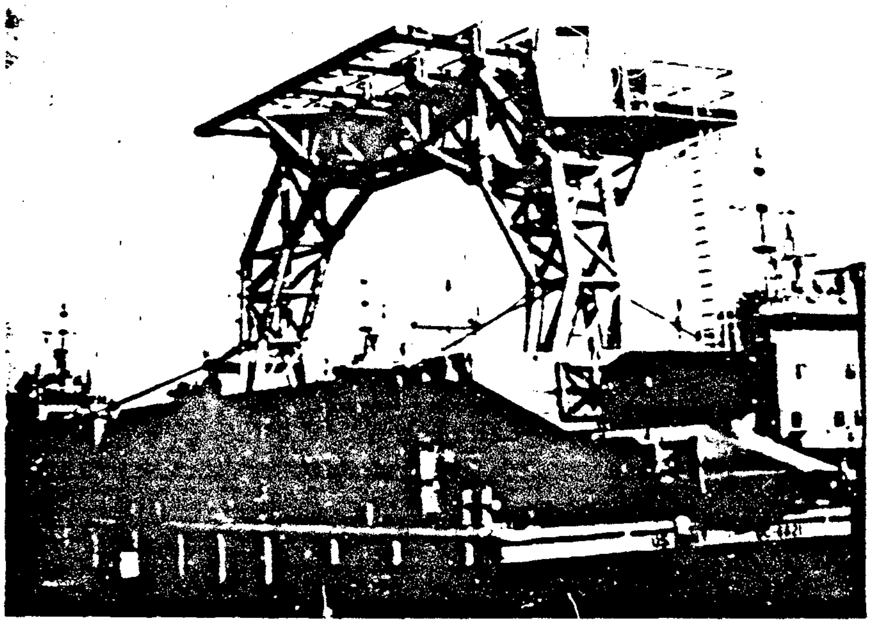
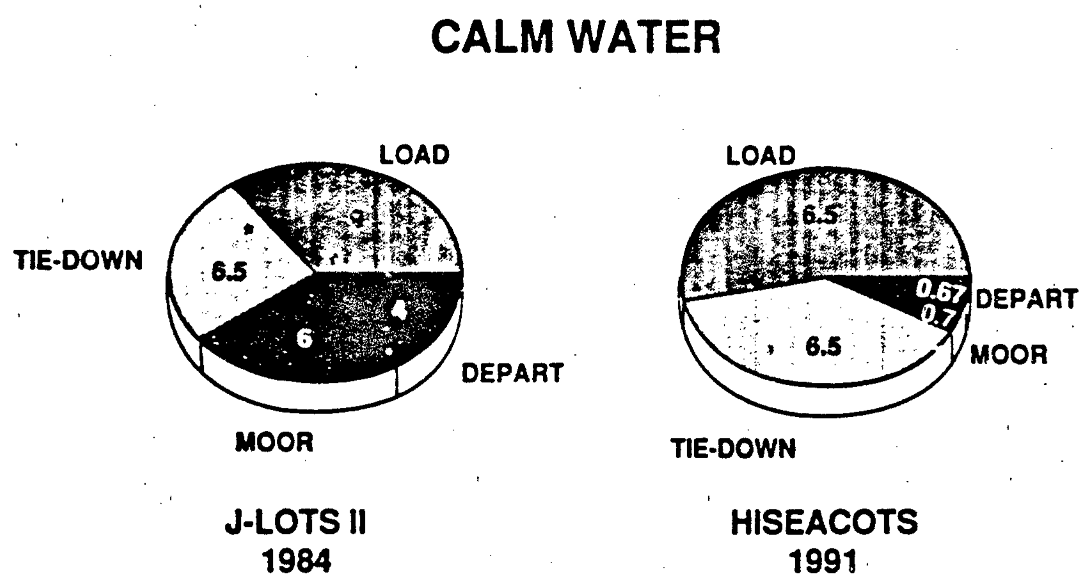


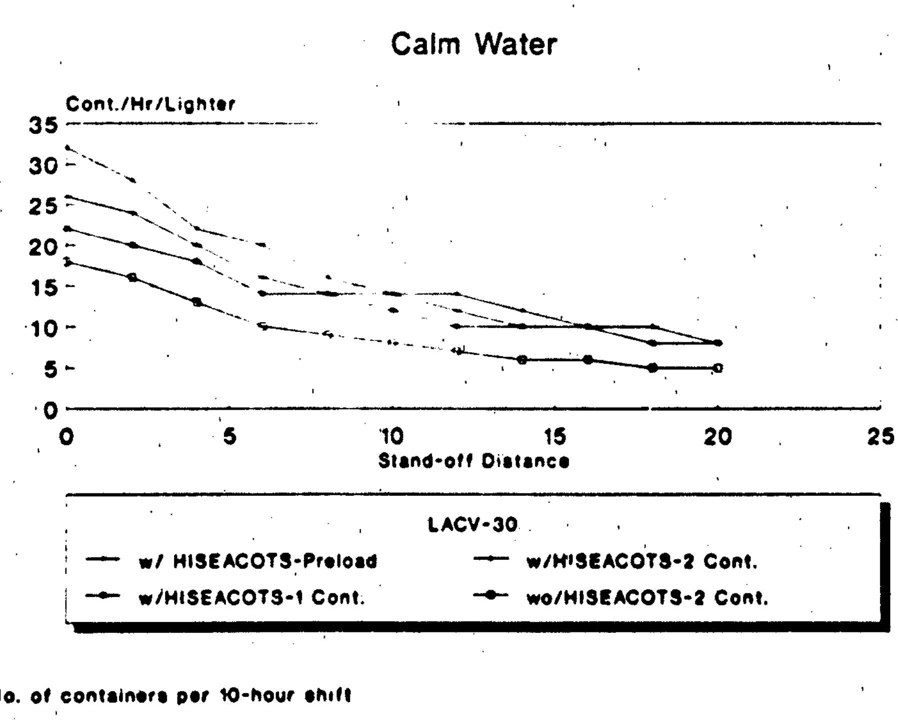
Figure 54

Figure 55



* NOT RECORDED SEPARATELY

Figure 56. Shipside Cycle Times Comparison (min)



No. of containers per 10-hour shift

Figure 57. Army Lighterage Productivity

Appendix B

SUMMARY OF HISEACOTS TEST RUNS

Summary of HISEACOTS Test Runs – April 8, 1991 through April 19, 1991 (1 of 6)

Run	Date	Time	Wind Speed (kts)	Wind Direction (Note 1) (deg)	Sea State	Sea Direction (Note 1) (deg)	Craft	Payload When Flying-On (tons)	Container Weight Loaded (tons)	Approach Speed (kts)	Time to Land (Note 2) (min)	Time to Load Spar (Note 3) (min)	Time to Load LACV-30 (Note 4) (min)	Time to Tie-Down (min)	Time to Depart (Notes) (min)	Comments
1	4/10/91	0930	10-13	285	0-1	285	22	0	---	3-4	1.72*	---	---	---	---	Fly through only. Operator managed to work craft on the platform. *This time is too long because this attempt was the first and the craft struggled onto the platform.
2	4/10/91	1000	10-13	285	0-1	285	03	0	---	2-3	---	---	---	---	---	Aborted. Operator did not increase power when he hit the ramp
3	4/10/91	1020	10-13	285	0-1	285	22	0	---	3-4	1.23*	---	---	---	---	Fly through. LACV-30 stayed on hover after it went onto the platform; therefore, making this time longer.
4	4/10/91	1040	10-13	285	0-1	285	22	0	---	2	2.5*	---	---	---	---	Aborted. LACV-30 hit batterboards, batterboards moved further outboard. *This includes first and second attempts to fly-on the platform (Runs 4 and 4a).
4a	4/10/91	1042	10-13	285	0-1	285	22	0	---	3	0.8	---	---	---	1.0	*Fly through. The LACV-30 backed down ramp and made it on second approach.
5	4/10/91	1110	10-11	280	0-1	280	03	0	---	4	2.25*	---	---	---	---	Aborted. *Time represents the first and second attempts (Runs 5 and 5a). Operator did not increase power when they hit the ramp
5a	4/10/91	1112	10-11	280	0-1	280	03	0	---	3-4	0.8	---	---	---	---	Fly through.
6	4/10/91	1325	8-12	280	0-1	280	03	0	15	4-5	1.13	5.5	2.7*	7	0.5	Fly through with crane. Time to land includes excess hovering when operators were feeling-out platform. The time to load of 2.7 minutes includes time to jockey the LACV-30 into the proper location.

NOTES:

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4. From the Initial Outrigger Actuation to Clearing Sling and Spreader from Spar

Summary of HISEACOTS Test Runs – April 8, 1991 through April 19, 1991 (2 of 6)

Run	Date	Time	Wind Speed (kts)	Wind Direction (Note 1) (deg)	Sea State	Sea Direction (Note 1) (deg)	Craft	Payload When Flying-On (tons)	Container Weight Loaded (tons)	Approach Speed (kts)	Time to Land (Note 2) (min)	Time to Load Spar (Note 3) (min)	Time to Load LACV-30 (Note 4) (min)	Time to Tie-Down (min)	Time to Depart (Notes) (min)	Comments
6a	4/10/91	1350	8-12	280	0-1	280	03	- - -	- - -	3-4	0.8*	- - -	- - -	- - -	- - -	Backload. *Estimated.
7	4/11/91	0830	15-20	0	2 (Low)	300	None	- - -	- - -	- - -	- - -	6	- - -	- - -	- - -	HISEACOTS crane only. New T ACS crane operator needs practice run.
8	4/11/91	0918	15-20	0	2 (Low)	320	22	0	- - -	3	1.45*	- - -	- - -	- - -	- - -	Fly through. *Represent more than just time to land.
9	4/11/91	0946	15	0	1 (High)	340	11	0	- - -	5	- - -	- - -	- - -	- - -	- - -	Aborted. Did not increase power when he hit the ramp.
10	4/11/91	0953	15	0	1 (High)	350	11	0	4	5	0.8	6	0.7	7-8	0.6	Fly through with crane.
11	4/11/91	1020	15	350	1	350	22	0	15	4	0.8*	4.5	0.5+	7	0.5^2	+30 seconds to land container on the deck, estimate approximately 7 minutes to tie-down. (2) Estimated. *Estimated, total time to come onto the platform and position under HISEACOTS crane was 1.5 min.
12	4/11/91	1110	10-15	350	1	350	22	15		5-6				- - -	- - -	Backload. Aborted. LACV-30 hit high pressure fender on starboard side. Brought the craft to a dead stop and had to abort.
13	4/11/91	1112	10	350	1	350	22	15	- - -	8-9	0.5-0.7	- - -	- - -	- - -	- - -	Backload.
14	4/11/91	1125	8-10	350	1 (Low)	350	11	4	- - -	6-7	0.7-0.75	- - -	- - -	- - -	0.22	Backload.
15	4/11/91	1320	8-10	350	0-1	350	None	0	4	- - -	- - -	7-8	- - -	- - -	- - -	HISEACOTS crane only. New operator on HISEACOTS crane.
16	4/11/91	1359	8-10	350	0-1	350	18	0	4	4	1	5	0.6	4	0.6	Nice run. Fly through with crane.
17	4/11/91	1425	8	350	0 (Med)	350	18	4	- - -	5-6	0.75	- - -	- - -	- - -	0.9	Backload
18	4/11/91	1445	4	350	0	350	11	0	- - -	6-8	0.6	- - -	- - -	- - -	0.9	Backload.
19	4/11/91	1455	2	350	0	- - -	11	0	- - -	8-10	0.5	- - -	- - -	- - -	0.33	Fly through.

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4. From the Initial Outrigger Actuation to Clearing Sling and Spreader from Spar

Summary of HISEACOTS Test Runs – April 8, 1991 through April 19, 1991 (3 of 6)

Run	Date	Time	Wind Speed (kts)	Wind Direction (Note 1) (deg)	Sea State	Sea Direction (Note 1) (deg)	Craft	Payload When Flying-On (tons)	Container Weight Loaded (tons)	Approach Speed (kts)	Time to Land (Note 2) (min)	Time to Load Spar (Note 3) (min)	Time to Load LACV-30 (Note 4) (min)	Time to Tie-Down (min)	Time to Depart (Notes) (min)	Comments
20	4/12/91	0910	5-6	270	0-1	0	09	0	...	2	1.2	...	...	...	0.7	Fly through
21	4/12/91	0920	5-6	270	0-1	0	09	0	...	2	0.68	...	...	...	0.8	Fly through
22	4/12/91	0945	5-6	270	0-1	0	09	0	4	2-3	0.78	5.5	0.6	6.5	0.7	Fly through with crane.
23	4/12/91	1020	5-6	270	0-1	0	09	0	...	2-3	0.78	...	...	...	0.7	Fly through
24	4/12/91	1040	5-6	270	0-1	0	09	4	...	2-3	...	...	...	...	...	Aborted. Hit starboard batterboard.
25	4/12/91	1050	5-6	270	0-1	0	09	4	...	4-5	0.5	...	...	...	0.65	Fly through with container. Operator flew too far forward to off-load container.
26	4/12/91	1100	5-6	270	0-1	0	09	4	...	4-5	0.42	...	...	...	0.6	Backload.
27	4/12/91	1115	5-6	270	0-1	0	09	0	4	4-5	0.5	5	0.68	7	0.5	Fly through with container. Sling slipped off starboard spar.
28	4/12/91	1310	2-3	270	0	0	09	4	...	2-3	0.55	...	...	...	0.6	Backload.
29	4/12/91	1320	2-3	270	0	...	09	0	15	1-2	0.6	5.5	0.6	8	0.55	Fly through with container transfer.
30	4/12/91	1340	0	...	0	...	22	0	...	1-2	0.65	...	...	...	0.6	Fly through
31	4/12/91	1410	0	...	0	...	09	45	...	3-4	0.65	...	...	...	0.5	Back load.
32	4/12/91	1430	0	...	0	...	22	0	...	2	1	...	...	...	0.4	Fly through.
33	4/15/91	1005	3-4	150	0	...	03	0	...	4	0.53	...	...	...	0.3	Fly through.
34	4/15/91	1010	3-4	150	0	...	18	0	...	5	0.65	...	...	...	0.4	Fly through.
35	4/15/91	1013	3-4	150	0	...	03	0	?	4-5	0.55	5.82	0.8	7	0.45	Fly through with container transfer.
36	4/15/91	1025	3-4	150	0	...	18	0	?	5	0.7	3.95	0.75	6.2	0.52	Fly through with container transfer.
37	4/15-91	1048	3-4	150	0	...	03	4 or 15	...	6	0.53	...	...	...	0.46	Backload.
38	4/15/91	1103	3-4	150	0	...	18	4 or 15	...	6	1.1	...	...	...	0.52	Backload.

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4. From the Initial Outrigger Actuation to Clearing Sling and Spreader from Spar

Summary of HISEACOTS Test Runs – April 8, 1991 through April 19, 1991 (4 of 6)

Run	Date	Time	Wind Speed (kts)	Wind Direction (Note 1) (deg)	Sea State	Sea Direction (Note 1) (deg)	Craft	Payload When Flying-On (tons)	Container Weight Loaded (tons)	Approach Speed (kts)	Time to Land (Note 2) (min)	Time to Load Spar (Note 3) (min)	Time to Load LACV-30 (Note 4) (min)	Time to Tie-Down (min)	Time to Depart (Notes) (min)	Comments
39	4/15/91	1113	3-4	150	0	...	03	0	...	7	0.75	...	...	..	0.67	Fly through
40	4/15/91	1313	7	250	0	...	03	0	4 or 15	6	0.7	4.5	0.67	4.5	0.47	Fly through with container transfer
41	4/15/91	1330	7	250	0	...	03	4 or 15	...	6	0.5	...	...	...	0.66	Backload
41a							26									Fly through
41b							26									Fly through with container transfer
41c							26								-	Backload
42	4/16/91	1310	8-10	170	1 (Low)	170	18	0	...	5	0.67	...	...	...	0.55	Fly through
43	4/16/91	1400	8-10	170	0-1	170	11	0	4	5	0.5	4.5	0.6	7	0.53	Fly through with container transfer.
44	4/16/91	1410	8-10	170	1 (Low)	170	11	15	...	4-5	...	...	...	...	...	Backload Aborted. Came in crooked. Operator backed off on power and contact from batter-boards used up momentum.
45	4/16/91	1415	8-10	170	1 (Low)	170	11	15	...	7-8	0.42	...	...	...	0.33	Backload.
46	4/17/91	0845	3-4	200	0	...	26	0	...	3-4	0.70	...	...	...	0.51	Fly through.
47	4/17/91	0851	3-4	200	0	...	26	0	...	6	0.68*	9.83*	4.39*	5.9	1	Fly through with container transfer. Time to land is longer than usual, the LACV-30 came in crooked and was banged around by batterboards which slowed the LACV-30 down. New crane operator. These times represent the worst case. Also had trouble with sling being too short.
48	4/17/91	0924	3-4	200	0	...	26	15	...	4-5	...	...	...	...	...	Backload Aborted. Came in crooked, backed off on power when it hit ramp and the contact from batterboards used up the momentum.

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Summary of HISEACOTS Test Runs – April 8, 1991 through April 19, 1991 (5 of 6)

Run	Date	Time	Wind Speed (kts)	Wind Direction (Note 1) (deg)	Sea State	Sea Direction (Note 1) (deg)	Craft	Payload When Flying-On (tons)	Container Weight Loaded (tons)	Approach Speed (kts)	Time to Land (Note 2) (min)	Time to Load Spar (Note 3) (min)	Time to Load LACV-30 (Note 4) (min)	Time to Tie-Down (min)	Time to Depart (Notes) (min)	Comments
49	4/17/91	0930	3-4	200	0	. . .	26	15	. . .	8	. . .	. . .	. . .	. . .	. . .	Backload. Aborted. The chain from stern of the T-ACS ship is getting in the way of the mouth of the HISEACOTS platform making it hard to the operators to come in straight. The LACV-30 hits the non skid on the batterboards and uses up all their momentum. Off-loaded this container with LACV-30 3/4 on platform. The LACV-30 operator tend to back-off on power when he comes in crooked.
50	4/17/91	0950	6-8	180	1 (Low)	180	26	0	15	5	0.58	5.17	0.83	5.75	0.72	Fly through with container transfer.
51	4/17/91	1015	6-8	180	1 (Low)	180	26	15	. . .	8-9	0.32	. . .	. . .	. . .	0.75	Backload. Used HISEACOTS crane for backload. It went well and was surprisingly easy to line up spreader and container.
52	4/17/91	1045	8	170	1 (Low)	170	26	0	4	5	0.53	5.5	1.25	6	0.67	Fly through with container transfer. Neat and clean.
53	4/17/91	1103	6-8	170	0-1	170	26	4	. . .	6	0.35	. . .	. . .	. . .	0.75	Backload.
54	4/17/91	2000	8-10	170	0-1	170	11	0	. . .	4-5	0.5	. . .	. . .	. . .	0.7	Fly through. Night operations.
55	4/17/91	2030	8-10	170	0-1	170	11	0	15	4-5	1.3	4.3	1	9.3*	0.7	Fly through with container transfer. The slings were too short and the sling got caught on the spare. Night operations. No noticeable difference between day and night operations.
56	4/17/91	2110	8-10	170	0-1	170	11	15	. . .	3-4	0.5	. . .	. . .	. . .	0.8	*Backload night operations. Ripped out plug on water batterboards.*
57	4/17/91	2115	8-10	170	0-1	170	22	0	. . .	5	0.5	. . .	. . .	. . .	0.75	Fly through. Night operations. Hit batterboard and tore off skin of high pressure batterboard

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Summary of HISEACOTS Test Runs – April 8, 1991 through April 19, 1991 (6 of 6)

Run	Date	Time	Wind Speed (kts)	Wind Direction (Note 1) (deg)	Sea State	Sea Direction (Note 1) (deg)	Craft	Payload When Flying-On (tons)	Container Weight Loaded (tons)	Approach Speed (kts)	Time to Land (Note 2) (min)	Time to Load Spar (Note 3) (min)	Time to Load LACV-30 (Note 4) (min)	Time to Tie-Down (min)	Time to Depart (Notes) (min)	Comments
58	4/17/91	2141	10-12	170	1	170	22	0	15	5	0.67	4.67	12	9	1	Fly through with container transfer night operations.
59	4/17/91	2155	10-12	170	1	170	22	15	---	5-6	0.48	---	---	---	0.9	Backload. Night operations.
60	4/18/91	1000	6-8	300	1 (Low)	300	26	0	---	3-4	0.55	---	---	---	0.8	Fly through.
61	4/18/91	1010	6-8	300	1 (Low)	300	03	0	---	3	0.6	---	---	---	0.8	Fly through.
62	4/18/91	1020	6-8	300	1 (Low)	300	26	0	15	3-4	0.5	5	0.55	5	0.75	Fly through with container transfer.
63	4/18/91	1045	6-8	300	1 (Low)	300	26	15	---	3-4	0.7	---	---	---	0.85	Backload.
64	4/18/91	1110	6-8	300	1 (Low)	300	03	0	---	3	0.5	---	---	---	0.65	Fly through.
65	4/18/91	1120	6-8	300	1 (Low)	300	26	0	---	3-4	0.5	---	---	---	0.65	Fly through.

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