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Naval Sea Systems Command
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DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND
1333 ISAAC HULL AVE SE
WASHINGTON NAVY YARD DC 20376-0001

IN REPLY TO:

5720
00D3J/2008F010081F

DEC 17 2008

This is our final response to your December 20, 2007 Freedom of Information Act (FOIA) request for electronic copies (in any available format such as pdf) of the following Salvage Reports:

Title	Date	Pages	Electronic File Available
USS Frank Knox (DDR-742) Stranding Salvage	25 Oct 1968	99	Y
► Suez Canal Salvage Operations in 1974	1974	313	Y
EX-TORTUGA (LSD 26) Salvage Report	14 Sep 1989	155	Y
USCGC Mesquite Salvage Operation Dec 89 – July 90	19 July 1991	169	Y
Commercial Aircraft Salvage Operations	1 Apr 1992	74	Y
US Navy Salvage Report Operations Desert Shield/Desert Storm Vol 1	July 1992	162	Y
US Navy Salvage Report Operations Desert Shield/Desert Storm Vol II	July 1992	76	Y

We conducted a search and found documents responsive to your request. By electronic mail (email) on November 10, 2008, we explained that as an "other" category requester, you are entitled to the first 2 hours of search and the first 100 pages of duplication at no cost to you. We also informed you that fees in excess of what you are entitled to as an "other" category requester were determined to be $186.20. By November 11, 2008 email, you forwarded a request for a total fee waiver. Due to the holiday, we received your request for the fee waiver on November 12, 2008.

Fee waivers are considered on a case by case basis. Fee waivers are typically granted to the extent that the release of the records will benefit the public. In fact, the Freedom of Information Act states that fees should be waived or reduced "if disclosure of the information is in the public interest because it is likely to contribute significantly to public understanding of the operations or activities of the government and is not primarily in the commercial interest of the requester."

You contend that information will reach the public through posting on a website www.GovernmentAttic.org which advertises it *"provides electronic copies of hundreds of interesting Federal Government documents obtained under the Freedom of Information Act. Fascinating historical documents, reports on items in the news, oddities and fun stuff and government bloopers."*

After carefully considering your fee waiver request under FOIA, 5 U.S.C. 552, as amended, and Secretary of the Navy Instruction 5720.42E, I determined your waiver should be granted in this instance.

The seven US Navy Salvage reports were prepared by the Supervisor of Salvage and Diving, USN to provide future salvage officers and engineers with a perspective of the evolving capability of deep ocean recovery. They are cleared for public release and have always been available in hard copy upon request. The reports are enclosed in electronic format.

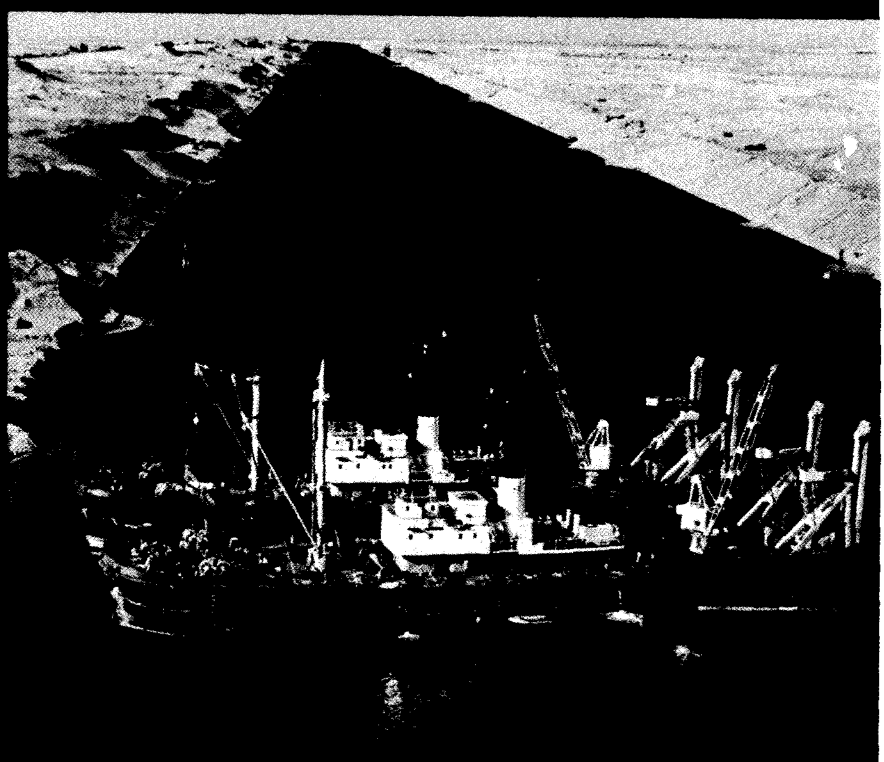
If you have any questions on the processing of your request, please contact me at (202)781-2433, or Ms. Roberta Petrillo at (202)781-3038 citing our case number 2008F010081. You may contact us by electronic mail at navseafoia@navy.mil

Sincerely,

Stephanie L Carr

STEPHANIE L. CARR
Head, Freedom of Information
and Privacy Act Program Office
By Direction of the Commander

SUEZ CANAL SALVAGE OPERATIONS IN 1974



SUPERVISOR OF SALVAGE
NAVAL SEA SYSTEMS COMMAND
DEPARTMENT OF THE NAVY
Washington, D.C. 20362

SUPERVISOR OF SALVAGE
UNITED STATES NAVY

FOREWORD

On 5 June 1975 the Suez Canal will again be open to the ships of the world for the first time since its closure during the 1967 Six-Day War, when ten ships were scuttled by Egyptian forces to close this important waterway to ocean going shipping. From 11 April to 20 December 1974, U.S. forces, in cooperation with British, French, and Egyptian forces, conducted concurrent operations to clear the Canal of wrecks, mines, and ordnance.

The 1974 Suez Canal salvage operations are classic with respect to the equipment and techniques used to remove the sunken ships from the shallow waters of the Canal. In addition to the obvious historical value of documenting the successful removal of the sunken ships, it is important to describe in some technical detail the application of salvage equipment and techniques to the Suez Canal problem as an aid to future salvors.

The Suez Canal salvage operations were conducted under the direction of Captain J. H. Boyd, USN, Supervisor of Salvage, U.S. Navy, using the resources of the Murphy Pacific Marine Salvage Company. For his outstanding leadership and management of this difficult and highly sensitive effort of national significance, Captain Boyd was awarded the Distinguished Service Medal.

Prepared by Booz, Allen & Hamilton Inc., and Sea Salvage, Inc., under the direction of Captain Boyd, this report should prove valuable to salvors throughout the world who are faced with the task of removing sunken ships from shallow waters.

R. C. Gooding
Vice Admiral, USN
Commander Naval Sea Systems Command

ABSTRACT

The Suez Canal was closed in 1967 by the Egyptian government. The ships that were used to block the Canal remained there until 1974 when an international operation was mounted to clear the Canal, and transform it back into a major world trade route. A major component of this total project was an operation to remove 10 large wrecks from the Canal. The Supervisor of Salvage, U. S. Navy, using the resources of the salvage contractor, Murphy Pacific Marine Salvage Company, completed this operation in a 7-month period in 1974. This report describes what happened.

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I. INTRODUCTION

I. INTRODUCTION

The first known canal in the Suez area dates back to the 14th century B. C. From this time throughout most of antiquity, a canal was open from the Nile River to the Red Sea. The first canal was closed by the Caliph Mansur during the eighth century to prevent supplies from reaching his enemies in Egypt. It remained closed until the 19th century, when the idea of a canal crossing directly from the Mediterranean Sea to the Red Sea appeared increasingly attractive.

In 1854, the Frenchman Ferdinand de Lesseps, sometime consul at Alexandria and Cairo, retired from the diplomatic service. Shortly thereafter he received a 99-year concession from his friend, Said Pasha, the Khedive of Egypt, to build and operate a canal. De Lesseps organized the Suez Canal Company and began construction of the new canal with $40 million in capital stock supplied by French and Ottoman interests. The Suez Canal was opened in 1869 by Khedive Ismail in the presence of Empress Eugénie of France and Emperor Franz Joseph.

In 1875, Britain, realizing the importance of the Canal to her own interests as a maritime and naval power, took advantage of the bankruptcy of Egypt's Khedive Ismail to become the largest shareholder. From this time until the nationalization by Egypt in 1956, the Anglo-French Suez Canal Company managed the Canal.

The effect of the Canal on world trade was tremendous. Its opening in 1869 coincided with the growing importance of steam as the principal method of maritime propulsion. From the time of its opening, shipowners began shifting their growing fleets of steamships away from the lengthy route around the Cape of Good Hope to the short, direct route through the Canal. The Suez Canal became so important to the international shipping industry that for nearly a century few ships were built that exceeded the Canal's draft limits.

In 1956, during the crisis that followed the nationalization of the Suez Canal Company, the Canal was blocked and closed. After the crisis was settled, the Canal was reopened in 1957 under the newly formed Suez Canal Authority (SCA) and at that time recovered its commercial importance. The SCA proved adept at managing canal operations, and revenue from the Canal increased significantly.

Approximately 21,250 ship transits had been made through the Canal in 1966, accounting for 242 million tons of cargo and 40 percent of Europe's oil imports. With the closure of the Canal during the Six-Day War in 1967, trade routes were lengthened considerably. The cost to world trade was determined by a recent United Nations study to be $1.7 billion annually in lost trade and increased shipping costs. The loss to the Egyptian economy from tolls alone was $250 million annually.

A side effect of the closure of the Canal was to encourage the development of supertankers and very large crude carriers (VLCC). With the short route between Europe and the Middle East blocked, the necessity to make the long voyage around Africa made very large tankers economical. As a result, over 40 percent of the world's tankers in 1974 displaced more than 200,000 tons and drew over 60 feet. All these tankers are too large for the Canal at its present size.

Reopening the Canal became possible following the return of both Canal banks to Egyptian control after the 1973 Yom Kippur War and the achievement of an agreement in early 1974 between Egypt and Israel for military disengagement and separation of forces. An ambitious plan to reopen and revitalize the Canal was effected immediately. This report deals with one portion of that plan, the removal of 10 wrecks that blocked the Canal.

1. INVOLVEMENT OF THE U.S. NAVY IN THE CLEARANCE

Initially, the Suez Canal Authority intended to undertake the clearance of the Canal as a purely commercial venture. Negotiations that almost produced a completed contractual arrangement were carried out with a consortium of a West German salvage company and a Yugoslav firm, and later with Murphy Pacific Marine Salvage Company. Before contractual arrangements were completed, the governments of the United States and the Arab Republic of Egypt entered into an agreement whereby the United States would assist in clearing mines and unexploded ordnance from the Canal. This clearance agreement, included as Appendix A, was a direct result of the negotiations for the cessation of hostilities between Israel and the Arab states.

In April 1974, the Government of Egypt requested U.S. assistance in funding the salvage operations as well as the clearance of ordnance. A bilateral agreement was concluded between the two governments for U.S. assistance in the removal of the wrecks from the Canal whereby the U.S. Navy would be designated as principal salvage agent and would use its own contractual resources.

The U.S. Navy, specifically the Supervisor of Salvage, was experienced in administrating contract salvage operations and had available a standing contract with Murphy Pacific Marine Salvage Company. The salvage agreement, included in Appendix B, was the basic operating instrument under which the 10 designated wrecks were removed from the Canal, using these resources.

2. OVERVIEW OF THE TOTAL CANAL OPERATION

Operations to reopen the Suez Canal required both the removal of shipwrecks from its navigation channels, sweeping of potential mines, and the removal of unexploded ordnance from its fairways, banks, and anchorages so that it could be dredged to navigational depths.

From 11 April to 20 December 1974, U.S. forces in cooperation with British, French, and Egyptian forces conducted concurrent operations to clear the Canal of wrecks, mines, and ordnance. Following these operations, a multimillion dollar dredging contract was awarded to a Japanese firm and dredging operations commenced in late December. The operations between April and December were conducted under the command of Commander Task Force Sixty-Five (CTF 65), Rear Admiral Brian McCauley, USN, and consisted of four elements:

- Minesweeping operations
- Land ordnance clearance operations
- Underwater ordnance clearance operations
- Salvage operations.

A brief overview of the above Canal operations is presented in the following sections.

(1) Minesweeping Operations (code name NIMBUS STAR)

Operations to sweep the Suez Canal and its approaches of influence mines and other ordnance commenced on 11 April. By 22 April, the buildup of U.S. forces was completed with the arrival of USS IWO JIMA (LPH-2) in Port Said with RH 53D minesweeping helicopters and CH 46F helicopters aboard for search and rescue (SAR) and logistic support. Sweeping commenced simultaneously in Lake Timsah going north and in Port Said going south. By 29 April, sweeping from Port Said to Ismailia was completed. Shortly afterward, sweeping commenced in the southern half of the Canal, with helicopters operating from landing sites at Deversoir in the north and at Adabijah, the Egyptian naval base, in the south. Upon completion on 30 May, more than 7,616 linear miles of sweep track had been flown.

(2) Land Ordnance Clearance Operations (code name NIMBUS MOON Land)

Training of Egyptian Army forces commenced on 29 April, using U.S. Army personnel assembled from 29 U.S. posts and airlifted to Egypt with necessary support equipment. A three-phased pyramid training program was instituted. In the first phase, 63 U.S. Army technicians trained 173 Egyptian Army officers in U.S. minefield clearance and disposal procedures. These officers returned to their units and during the second phase, with assistance from U.S. advisors, trained an additional 1500 Egyptians. Clearance operations executed in the third phase resulted in the clearance of the Canal banks for 250 meters on each side, encompassing a total area of more than 30 square miles.

The operation was completed on 3 July by the Egyptian Army, which reported that 686,000 anti-tank and anti-personnel land mines had been removed and that 13,567 unexploded ordnance items were recovered and destroyed.

(3) Underwater Ordnance Clearance Operations (code name NIMBUS MOON Water)

The task of advising and assisting the Egyptian Government in clearing unexploded ordnance from the Suez Canal, its anchorages, approaches, and contiguous waters was carried out as a joint effort by the United States, Great Britain, France, and Egypt. Forces available consisted of three Royal Navy minehunters with a Fleet clearance diving team, a French Navy diving team with two support ships, Egyptian explosive ordnance disposal (EOD) diving teams, and the U.S. Water Clearance Group.

Each area of the Canal was searched at least twice by separate groups. Most areas were searched using either Royal Navy minehunting sonar or U.S. Navy side-scanning sonar, aided by magnetometers and precision navigation equipment. This method was effective in locating ordnance below the 8-meter curve; the Canal slopes above 8 meters were searched by divers. Visual inspection of suspected ordnance contacts, identification, and destruction of ordnance items were carried out by Royal Navy and French Navy clearance diving teams, as well as by Egyptian Navy forces trained earlier by U.S. EOD specialists. U.S. Navy EOD divers acted primarily in an advisory capacity to the Egyptians.

The Great Bitter Lake presented special problems. A highly saline bottom layer made sonar search ineffective. The ganged magnetometer search was effective, resulting in the location of all ferrous objects (potentially as many as 10,000) that would have to be classified by diver inspection to determine which objectives were unexploded ordnance. Scuba-diving was made hazardous by the presence of hydrogen sulphide and the heavy bottom layer, which required divers to wear substantial quantities of extra weight. Use of surface-supplied diving was considered but would have lengthened the operation with a probable low return in clearance effectiveness. After experiments to mechanically disperse the layer proved unsuccessful, diving operations were called off. The SCA chose to use a net drag sweep through the area to clear it for dredging.

During the operations by the clearance forces from 11 April to 20 December, approximately 7,500 unexploded ordnance items were found in the Canal proper. An additional 1,000 items were found in harbor basins and anchorages outside the Canal. The search also located approximately 700 major nonordnance items, such as tanks, trucks, pontoon sections, boats, and barges, which were removed later by the SCA.

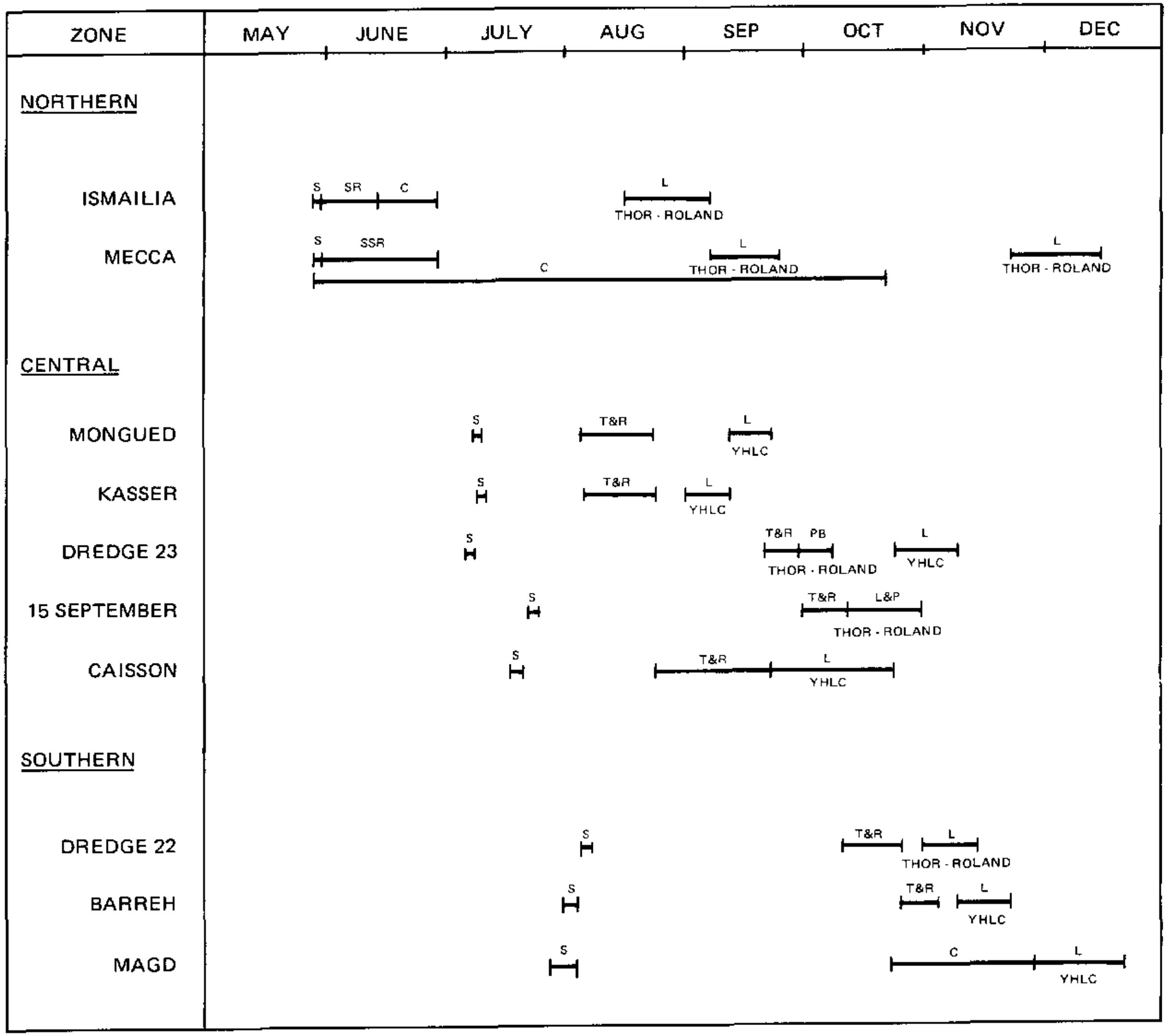
(4) Salvage Operations (code name NIMROD SPAR)

Ten wrecks were removed from blocking the Canal during the period 29 May to 20 December 1974. These wrecks were removed by the Murphy Pacific Marine Salvage Company, acting under the direction of the U. S. Navy Supervisor of Salvage, Captain J. Huntly Boyd, U. S. Navy, designated Commander Task Group 65. 7. All but one removal were accomplished by lifting the wrecks either intact or in sections, and then transporting them to one of the designated dump areas at Port Said, the Great Bitter Lake, or the Gulf of Suez. The dredge 15 SEPTEMBER, the one wreck that was not dumped, was refloated and delivered to the SCA for refurbishment. Four wrecks (tug MONGUED, dredge KASSER, DREDGE 23, and the Concrete Caisson) were removed using the heavy-lift craft CRANDALL and CRILLEY. Five others (cargo ship ISMAILIA, passenger cargo ship MECCA, tanker MAGD, DREDGE 22, and tug BARREH) were removed using the heavy-lift cranes THOR and ROLAND.

The schedule for the salvage operations as planned is shown in Figure I-1. Necessary adjustments to the salvage plan, discussed in the description of the individual operations, resulted in a somewhat modified schedule, as shown in Figure I-2, which depicts the salvage events as they occurred. The employment of the heavy-lift cranes ROLAND and THOR and the heavy-lift craft CRANDALL and CRILLEY in accomplishing these events is shown in Figure I-3.

Salvage operations were conducted concurrently with, but relatively independently of, other clearance operations in the Canal. The EOD forces, however, provided assistance in checking and removing unexploded ordnance as necessary from the wrecks both before and during salvage evolutions. Salvage forces provided assistance to and coordinated with other elements of the clearance group wherever it was indicated.

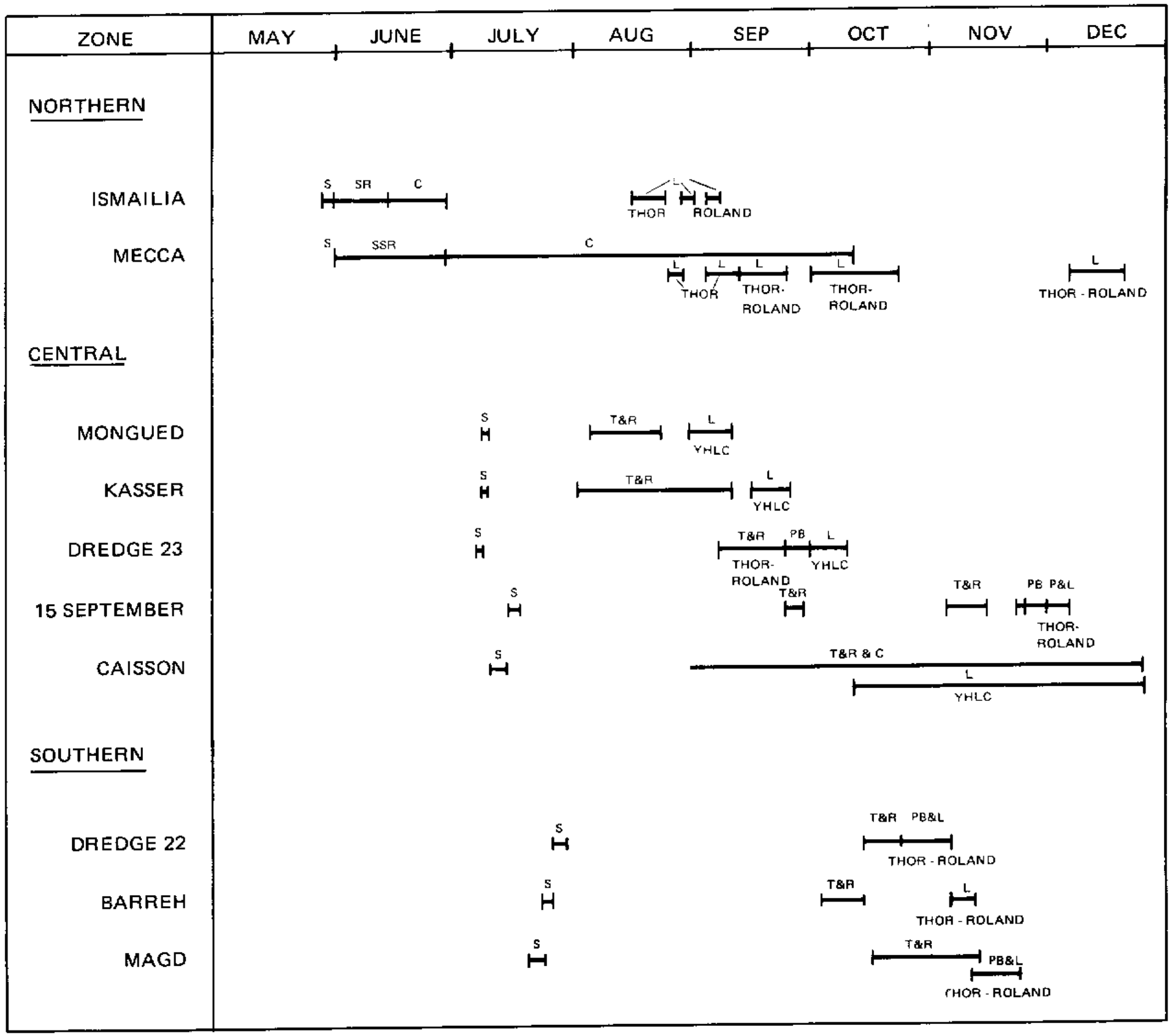
SCHEDULE, 25 AUGUST 1974



S	SURVEY
SR	SILT REMOVAL
SSR	SUPERSTRUCTURE REMOVAL
C	CUT
L	LIFT
T&R	TRIM & RIG
PB	PARBUCKLE
P	PUMP
YHLC	HEAVY-LIFT CRAFT
THOR AND ROLAND	HEAVY-LIFT CRANES

FIGURE I-1
Schedule, 25 August 1974

SALVAGE EVENTS



S	SURVEY
SR	SILT REMOVAL
SSR	SUPERSTRUCTURE REMOVAL
C	CUT
L	LIFT
T&R	TRIM & RIG
PB	PARBUCKLE
P	PUMP
YHLC	HEAVY-LIFT CRAFT

FIGURE I-2
Salvage Events Showing
Actual Sequence

EMPLOYMENT OF
HEAVY-LIFT CRAFT CRANDALL AND CRILLEY
HEAVY-LIFT CRANES THOR AND ROLAND

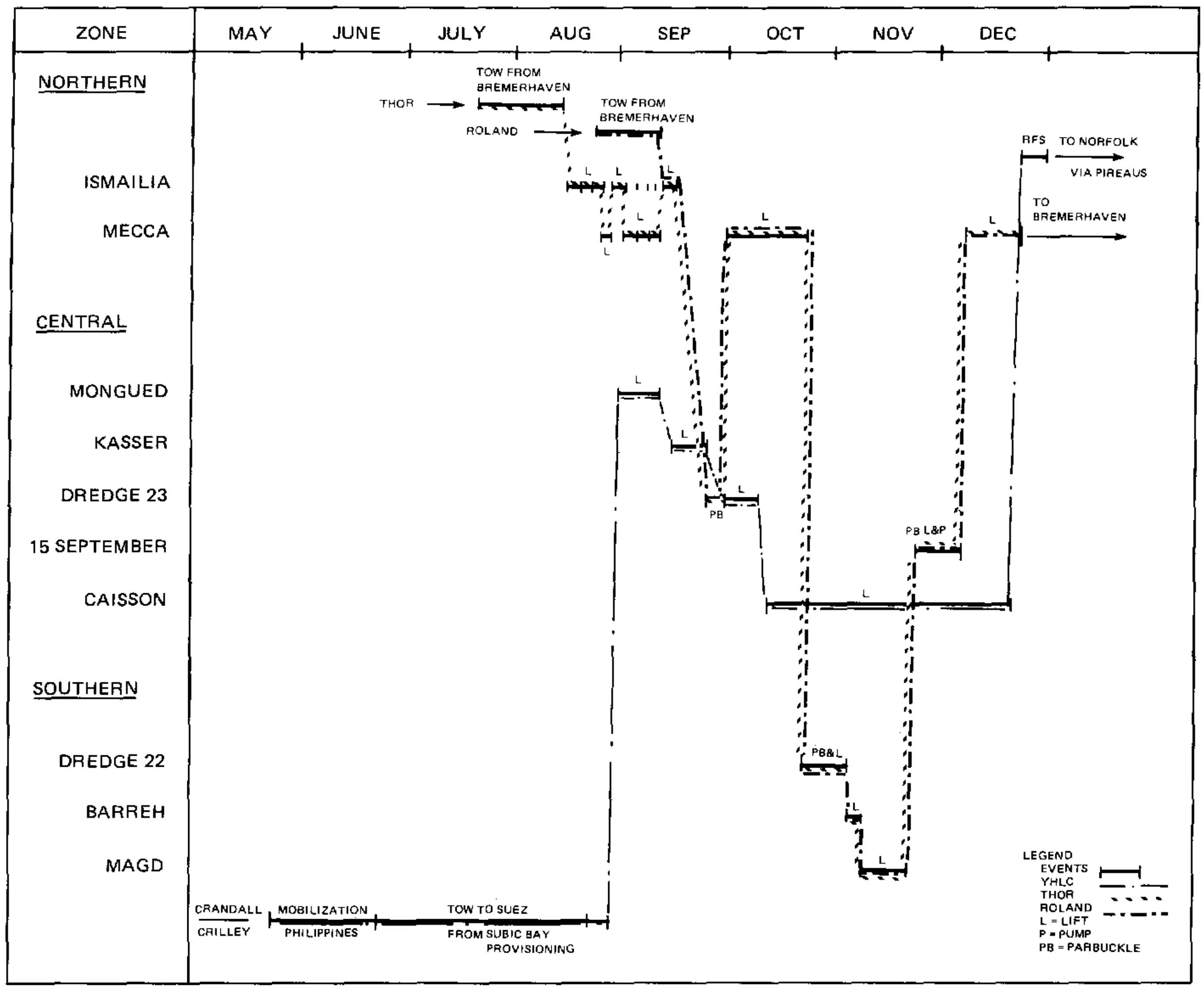


FIGURE I-3
Employment of Heavy-Lift Craft
CRANDALL and CRILLEY
and Heavy-Lift Cranes THOR and ROLAND

A summary of the salvage operations is presented in Table I-1. A detailed description of these operations is presented in Chapters IV through VII.

3. ORGANIZATION OF THE REPORT

The remainder of this report is organized into seven additional chapters, which contain detailed material in the following subject areas.

- Chapter II gives a brief description of the 10 wrecks to be cleared from the Canal.
- Chapter III describes the organization and facilities for clearance, equipment used, logistics support, and the working environment to point out the flexibility of the U. S. Navy's salvage organization in undertaking and accomplishing a task of this magnitude.
- Chapter IV discusses the salvage survey schedule, the actual survey operations, and the results.
- Chapter V describes in detail the salvage operations and plans involving the wrecks ISMAILIA and MECCA, located in the Northern Zone of the Canal. The sectioning and lifting of these wrecks are discussed in detail. Since the sectioning operations conducted on MECCA were complex and involved difficult lifting arrangements, this wreck merited complete documentation. However, the removal of ISMAILIA was straightforward and is treated in less detail.
- Chapter VI presents a description of the salvage operations of the five wrecks (DREDGE 23, tug MONGUED, dredge KASSER, the Concrete Caisson, and dredge 15 SEPTEMBER) located in the Central Zone of the Canal.
- Chapter VII discusses the salvage operations of the three wrecks (tanker MAGD, tug BARREH, and DREDGE 22) located in the Southern Zone of the Canal.
- Chapter VIII summarizes the lessons learned in the salvage operations.

Table I-1
Summary of Salvage Operations

Wreck	Started	Completed	Method of Removal	Dump Area
NORTHERN ZONE				
ISMAILIA	29 May	10 Oct.	Cut into five pieces; lifted with THOR and ROLAND.	Dry dump, Port Said
MECCA	29 May	18 Dec.	Cut into 10 sections; lifted with THOR and ROLAND.	7 dry dump, 3 wet dump, Port Said
CENTRAL ZONE				
DREDGE 23	6 Sept.	9 Oct.	Parbuckled with THOR and ROLAND; lifted with CRANDALL and CRILLEY.	Wet dump, Great Bitter Lake
MONGUED	5 Aug.	11 Sept.	Lifted with CRANDALL and CRILLEY.	Wet dump, Great Bitter Lake
KASSER	2 Aug.	25 Sept.	Lifted with CRANDALL and CRILLEY.	Wet dump, Great Bitter Lake
Concrete Caisson	30 Aug.	19 Dec.	Cut into two sections, one lightened, lifted with CRANDALL and CRILLEY.	Wet dump, Great Bitter Lake
15 SEPTEMBER	25 Sept.	6 Dec.	Parbuckled and lifted with THOR and ROLAND; patched, pumped, and refloated.	SCA Yard, Ismailia
SOUTHERN ZONE				
MAGD	17 Oct.	22 Nov.	Cut into two sections, each parbuckled, and lifted with THOR and ROLAND.	Wet dump, Gulf of Suez
DREDGE 22	15 Oct.	4 Nov.	Parbuckled and lifted with THOR and ROLAND.	Wet dump, Gulf of Suez
BARREH	6 Oct.	8 Nov.	Lifted with THOR and ROLAND.	Wet dump, Gulf of Suez

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Throughout the main body of the report, the salvage operations are described according to the geographical zone in which the operation was conducted, taking into account the interplay of resources within each zone. The employment of the heavy-lift cranes THOR and ROLAND is described in detail in Chapter V. Employment of the heavy-lift craft CRANDALL and CRILLEY is detailed fully in Chapter VI on the clearance of MONGUED, KASSER, and DREDGE 23. The use of CRANDALL and CRILLEY for side and gantry lifts on the Concrete Caisson, which was a difficult and challenging operation, is also described in Chapter VII.

Representative evolutions are presented fully either in the main body of the report or in the appendices to enable current and future salvors to gain insight into the technical complexities of a large salvage operation. The appendices include details of the sectioning of ISMAILIA, parbuckling DREDGE 23, and explosive cutting of MECCA ISMAILIA, and the Concrete Caisson. The appendices also include additional information that is pertinent to the main report and helpful to the reader.

II. THE TEN WRECKS IN THE CANAL

II. THE TEN WRECKS IN THE CANAL

The Suez Canal was effectively blocked by 10 wrecks in three principal areas: the Northern Zone, just south of Port Said (two wrecks); the Central Zone, north and south of Ismailia (five wrecks); and the Southern Zone, north of Port Taufiq (three wrecks). The locations of these wrecks are illustrated in Figure II-1 and their final dumping locations are shown in Figure II-2. Appendix C is a chronology of the events that occurred between the situations shown in Figures II-1 and II-2.

1. NORTHERN ZONE WRECKS: ISMAILIA AND MECCA

The small cargo ship ISMAILIA and the larger passenger cargo ship MECCA were sunk close to each other in the Canal, approximately 6 to 7 kilometers south of the northern entrance to the Canal at Port Said.

ISMAILIA, a small, 345-foot long, 1400-ton displacement, steam-powered, shelter deck, three-hold cargo ship of European origin, was in the process of being dismantled in 1967 at the shipyard in Port Fuad. The superstructure, shelter deck, and main engines had been removed. When hostilities commenced in June 1967, ISMAILIA was towed to a position in the Canal about 6 kilometers south of Port Said and sunk by explosive charges. ISMAILIA settled in an upright position across the channel in 44 feet of water.

MECCA, a 438-foot long, 7300-ton steam-powered passenger cargo ship, was built in England during 1929-34. MECCA was owned by the United Arab Maritime Company and had been converted from a passenger ship to a passenger cargo ship especially designed to carry pilgrims to Mecca. At the outbreak of the 1967 war, MECCA had been involved in a collision and was undergoing repair in the SCA shipyard at Port Fuad. From there, it was towed to a point in the Canal about 7 kilometers south and positioned across the Canal, bow to the west bank. Explosive charges were detonated. MECCA rolled over to starboard and sank, blocking the Canal to all but small ships and craft. Figure II-3 is a photograph of MECCA shortly after sinking.

FIGURE II-1
Locations of Wrecks in Suez Canal

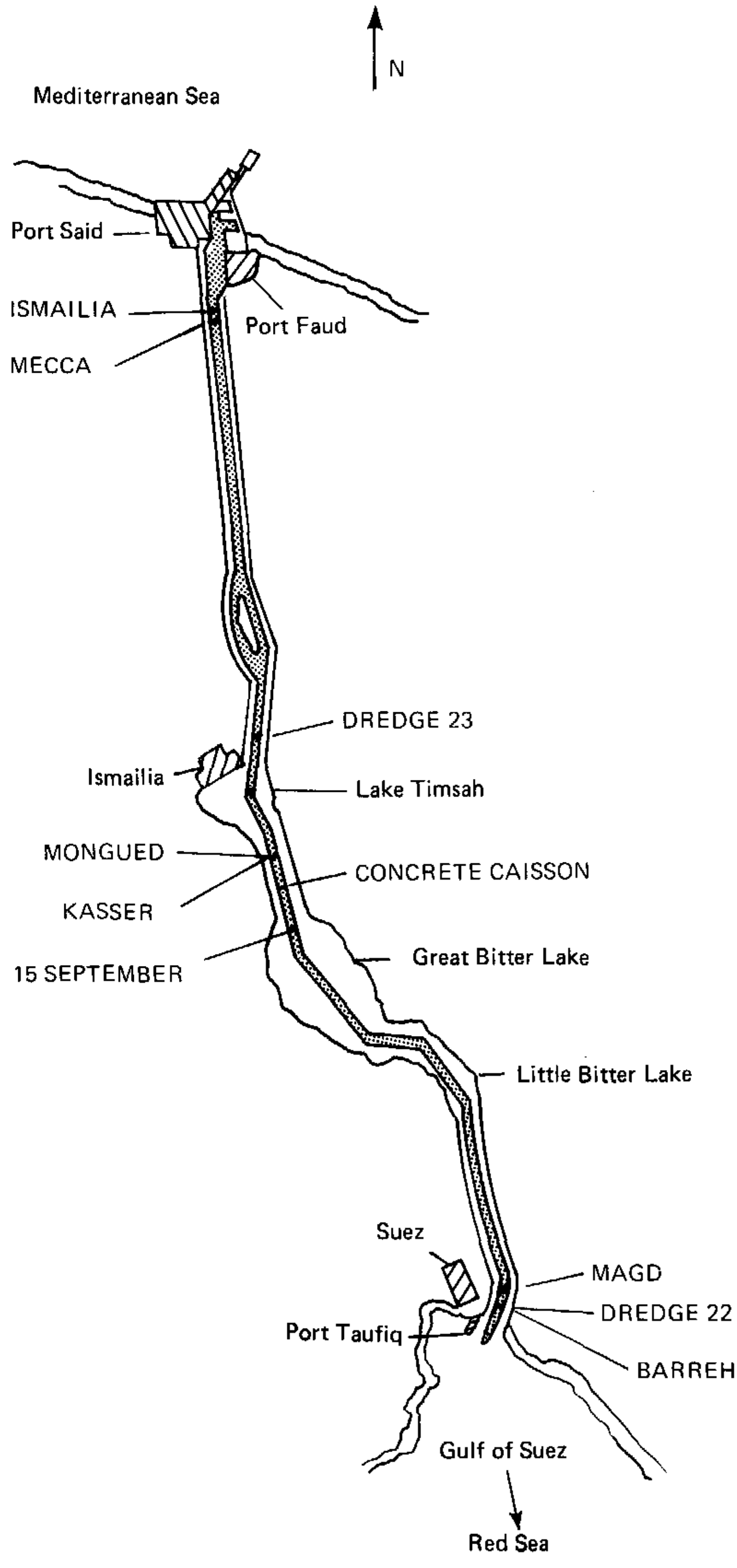


FIGURE II-2
Wreck Dumping Areas

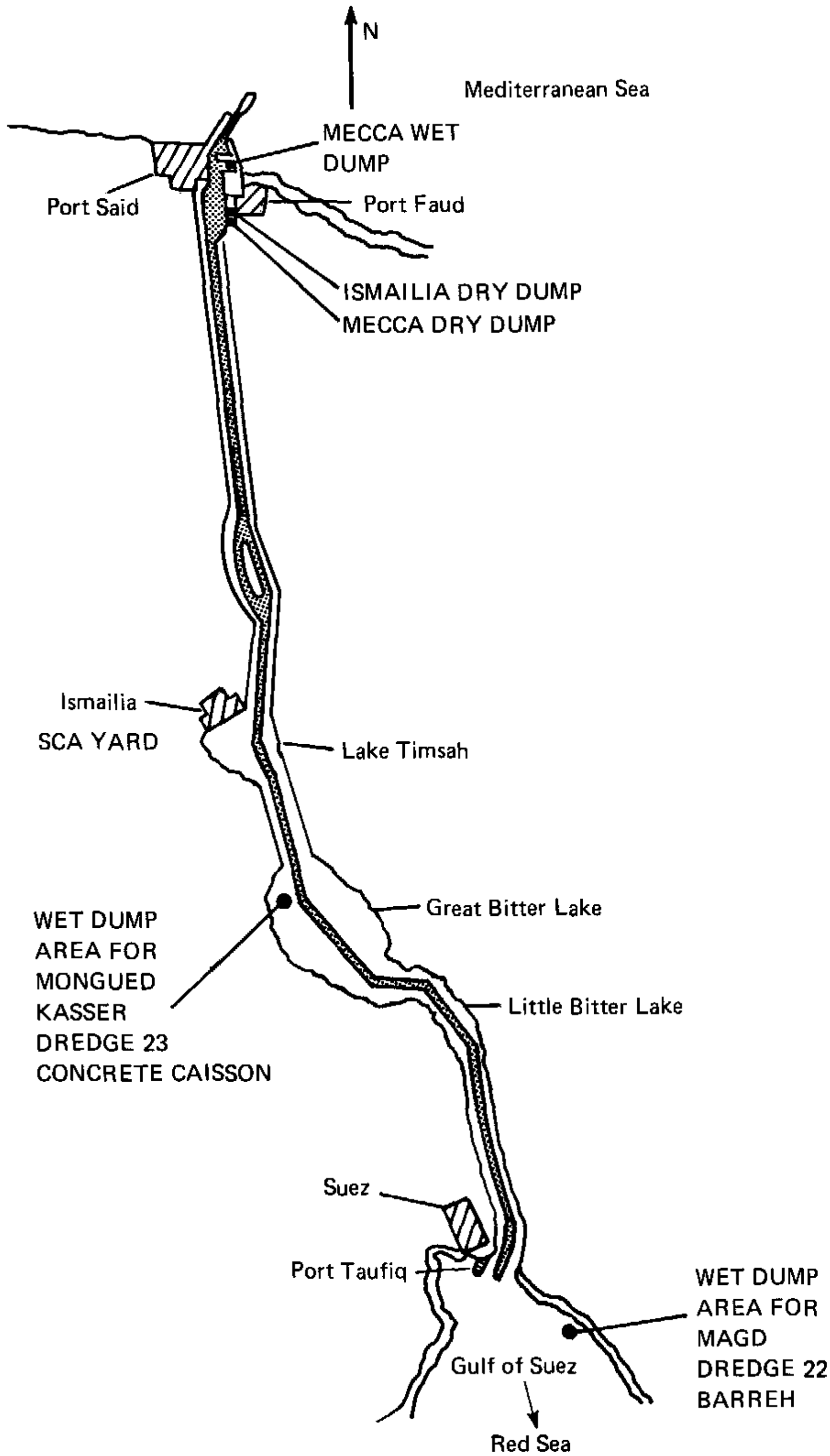


FIGURE II-3
MECCA Shortly After Sinking in 1967

2. CENTRAL ZONE WRECKS: DREDGE 23, MONGUED, KASSER, CONCRETE CAISSON, AND 15 SEPTEMBER

Five wrecks blocked the Canal at four points in the Central Zone:

- DREDGE 23 was sunk across the channel 5 kilometers north of the entrance to Lake Timsah

- MONGUED and KASSER formed a combined block of the Canal south of the city of Ismailia in the lower reaches of Lake Timsah

- The Concrete Caisson was sunk athwart the Canal effectively blocking it at Tuson Control Station between Lake Timsah and the Great Bitter Lake

- 15 SEPTEMBER was sunk along the axis of the Canal just inside the entrance to the Great Bitter Lake.

DREDGE 23, a 191-foot long, 1600-ton, 850-liter capacity conveyor belt bucket dredge, built by the French in 1926, previously had been sunk to block the Canal during the 1956 war. It was salvaged in 1957 and subsequently returned to dredging operations. The dredge was sunk a second time in June 1967 by two scuttling charges detonated in the engine room. These charges opened two holes, each about 2 feet in diameter, located on the port and starboard sides 40 feet forward of the stern. As the wreck sank, it settled on the western slope across the Canal on its starboard side with a list of 130 degrees. A photograph of DREDGE 23 prior to sinking is shown in Figure II-4. The conveyor structure is shown at the midships of the dredge.

KASSER, a small 125-foot long, 1200-ton, 3.8 cubic meter dipper dredge in service at Ismailia in 1967, was towed to the Canal channel just south of Lake Timsah and scuttled at the outbreak of the 1967 war. The main hull valves were blasted. Afterward, the hull burned and the dredge sank, coming to rest at a 45-degree port list supported by the spuds, rock crusher, and shovel. A 1967 photograph of KASSER is shown in Figure II-5; two spuds, gantry, ladder, and bucket are shown at the bow. The stern spud and rock crusher are shown at the left.

FIGURE II-4
DREDGE 23 Prior to Sinking in 1967

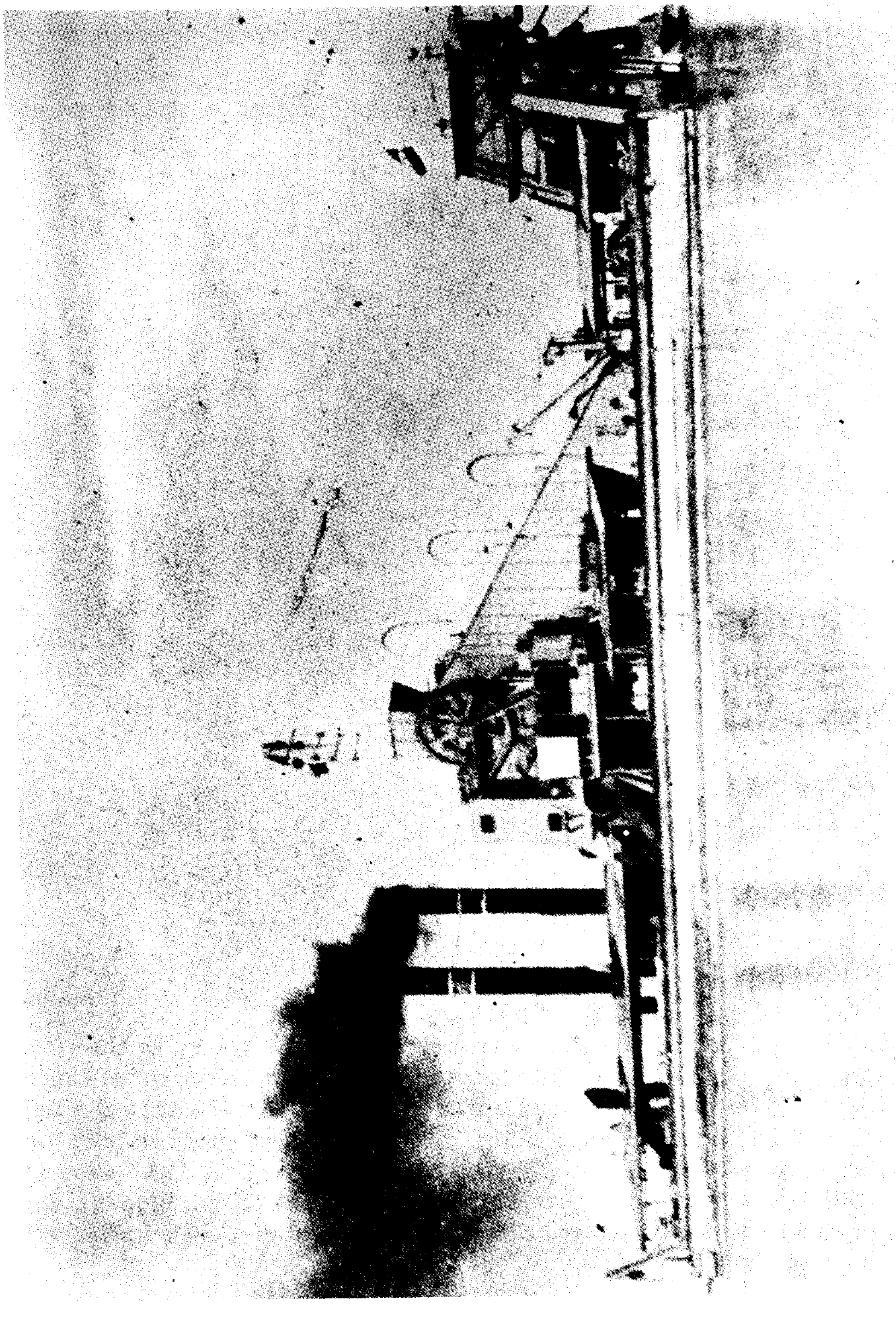


FIGURE II-5
KASSER Prior to Sinking in 1967,
SCA Headquarters Ismailia at Right

MONGUED, a 165-foot long, 1200-ton tug, was in the process of being dismantled by the SCA prior to the 1967 war. The engines had been removed and some of the main deck had been cut away. At the outbreak of hostilities, MONGUED was towed into position 100 feet west of KASSER and scuttled by blasting three holes in the port side aft (the largest was 3 by 4 feet). MONGUED sank with a slight starboard list.

The Concrete Caisson, a 203-foot long, 3800-ton multicompartmented barge, was designed to be towed to areas within the Canal, ballasted down, and used as a movable pier. It was under construction at the time of sinking; the top, which was to be used as a roadway, had not been installed. In June 1967, the Concrete Caisson was towed from Ismailia, positioned across the Canal near the Tuson Control Station, and sunk by explosive destruction of the ballasting sea connections. As it sank, the Concrete Caisson rolled over on its side, bottom toward the south.

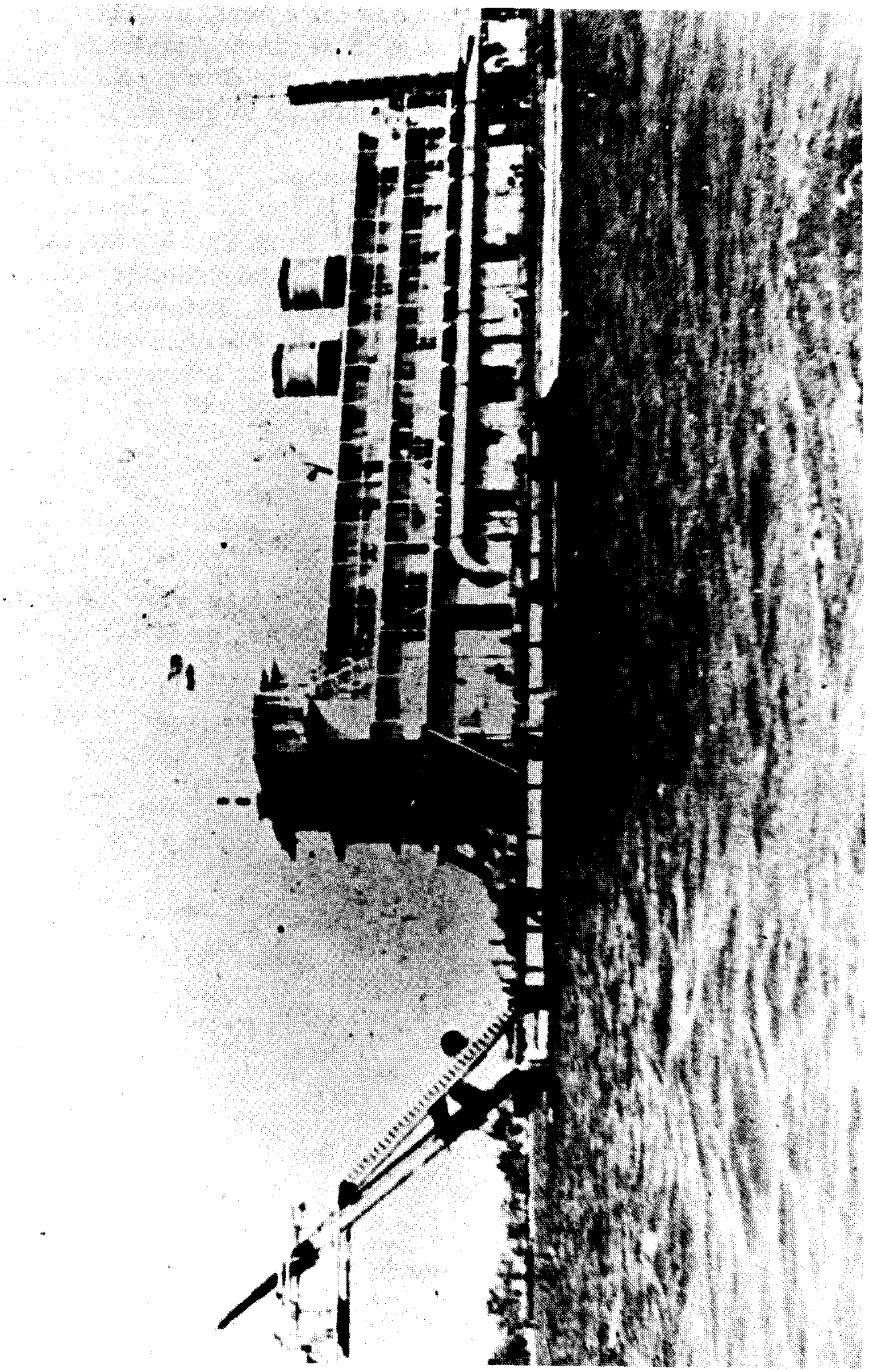
15 SEPTEMBER, a 200-foot long, 2000-ton, 30-inch suction cutter dredge, the only wreck of value to the Suez Canal Authority, had been operating in the Great Bitter Lake area until it was scuttled, just south of Deversoir station at the northern entrance to the lake, by opening the main suction valve after removing an inspection plate on the main pump. As it sank, 15 SEPTEMBER rolled over and came to rest on its port side with the hull relatively undamaged. A photograph of 15 SEPTEMBER taken prior to sinking is presented in Figure II-6.

3. SOUTHERN ZONE WRECKS: MAGD, DREDGE 22, AND BARREH

Tanker MAGD blocked the Canal about 3 kilometers north of the southern entrance at Port Taufiq. DREDGE 22 and the tug BARREH formed a combined block about 1 kilometer south of MAGD. While much of the earlier background of the wrecks is obscure, limited information is available concerning the circumstances of their background and employment as block ships.

MAGD, a 358-foot long, 2400-ton engines aft tanker, had been undergoing stripping (much of the main deck had been removed) at Port Taufiq prior to sinking. In June 1967, it was towed north from Port Taufiq and scuttled by detonating explosive charges in all 15 main cargo tanks. As a result of extensive holing, MAGD sank, coming to rest on its port side in 73 feet of water.

FIGURE II-6
Dredge 15 SEPTEMBER Prior
to Sinking in 1967



DREDGE 22, a 175-foot long, 1200-ton, 550-liter conveyor belt bucket dredge, was scuttled across the Canal immediately to the south of tug BARREH. The dredge was in service with the SCA dredging division at the time of sinking. It was towed into position and scuttled by blowing nine underwater holes in her hull.

BARREH, a 165-foot long tug displacing 1200 tons, was to have been scuttled by explosive charges. After towing the tug to the designated block site 2 kilometers north of Port Taufiq, the stern was positioned on the west bank of the Canal and explosive charges were rigged in the machinery spaces. BARREH, however, took on water through hull openings and sank before the charges could be detonated. After sinking, the tug remained upright with stern rested firmly on the west banks visible at low tide with the tip of the stack watching.

*   *   *   *   *

Further details on the individual wrecks were determined during the Salvage Survey, reported in Chapter IV.

III. ORGANIZATION AND FACILITIES FOR CLEARANCE

III. ORGANIZATION AND FACILITIES FOR CLEARANCE

Early in 1974, the Murphy Pacific Marine Salvage Company competed for and was offered a commercial contract by the Suez Canal Authority (SCA) for the removal of the 10 wrecks blocking the Canal. In the meantime, before the contract was signed, the Government of Egypt requested the U. S. Government to fund the wreck removal operation.

Detailed discussions between the Departments of State and Defense explored all possible mechanisms for the execution and funding of this task. It was concluded and agreed that the Department of State could provide policy guidance and funding to the Department of Defense who would execute the task. The U. S. Navy was designated as the executive agent to perform the task, using the commercial salvage contracts of the Supervisor of Salvage, USN.

The Supervisor of Salvage (SUPSALV) was assigned to direct operations by the Chief of Naval Operations. SUPSALV reported to the Chief of Naval Material (CNM) for technical and fiscal matters and, as CTG 65.7, to Commander Task Force Sixty-Five (CTF 65) for coordination. SUPSALV was directed to coordinate closely with the U. S. Ambassador to Egypt for interface with the Government of Egypt and the Suez Canal Authority. The actual salvage work was performed by the Murphy Pacific Marine Salvage Company under the direction of SUPSALV using an existing Navy contract.

Table III-1 shows the responsibilities and functions of the U. S. Government agencies and the principal contractor. Figure III-1 illustrates the organization for the operation.

1. PERSONNEL, FACILITIES, AND EQUIPMENT

This section describes the personnel, facilities, and equipment used in the operation to clear the Canal of the 10 wrecks.

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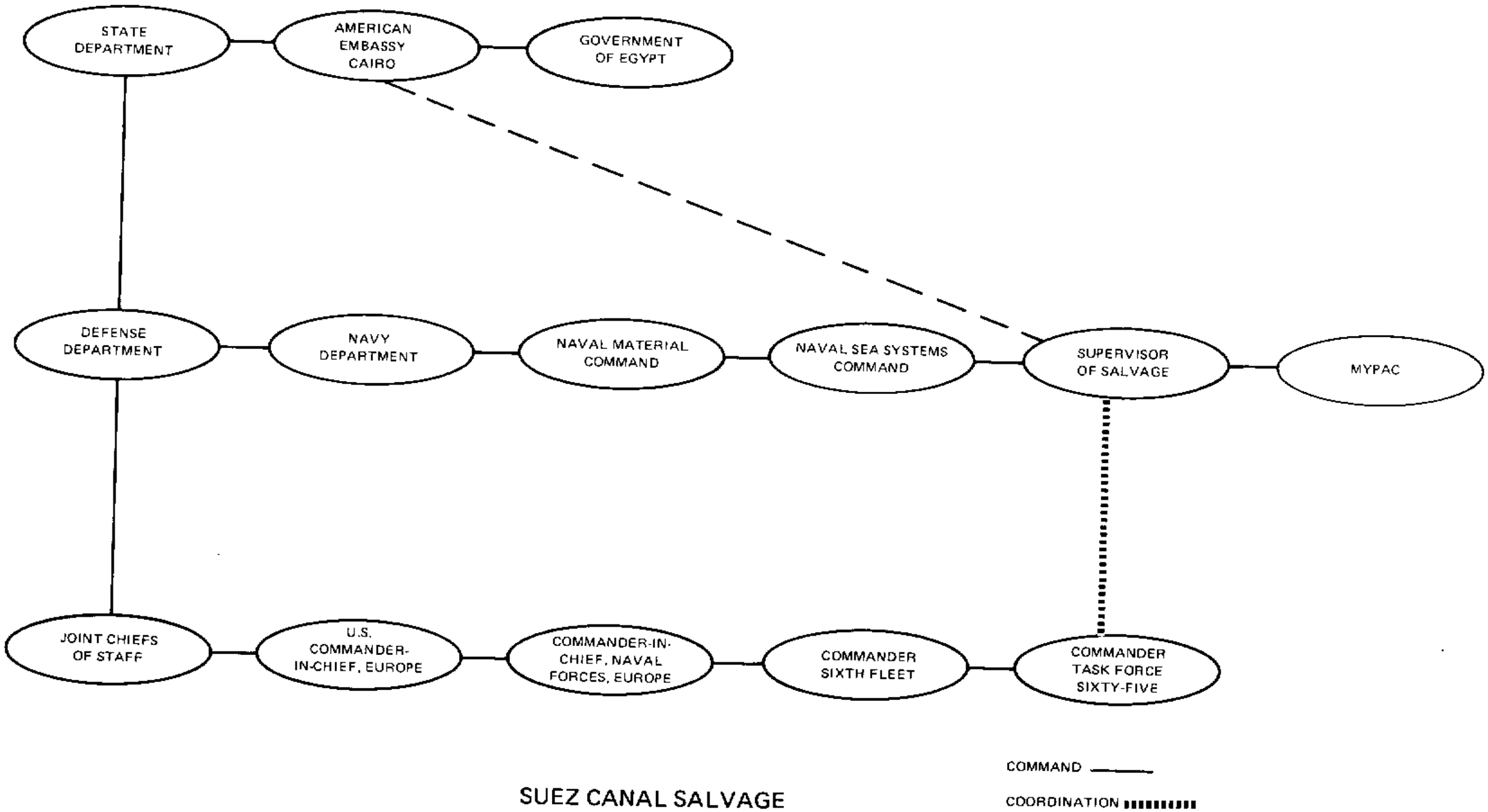
Table III-1
Responsibilities and Functions of U. S. Government Agencies and the Principal Salvage Contractor

Organization	Responsibility/Function
Department of State	General policy guidance/funding Obtain agreements between the Egyptian and U. S. governments relative to salvage and support Establish relationships between SUPSALV and AMEMB Cairo
Department of Defense	Responsible for salvage Task Joint Chiefs of Staff for salvage
Joint Chiefs of Staff	Task CNO for salvage
Chief of Naval Operations	Task CNM to carry out SALVOPS
Chief of Naval Material	Task SUPSALV to direct SALVOPS Exercise technical and fiscal management
Supervisor of Salvage	Task the contractor Arrange funding plan Arrange related services Supervise salvors
Murphy Pacific Marine Salvage Company	Mobilize salvage forces Execute SALVOPS

FIGURE III-1
Suez Canal Salvage
Organizational Relationships



SUEZ CANAL SALVAGE
ORGANIZATIONAL RELATIONSHIPS

(1) Personnel

The Supervisor of Salvage, accompanied by a small staff, coordinated the operations. Operations of the prime contractor, Murphy Pacific Marine Salvage Company, and its subcontractor personnel were directed by the Murphy Pacific project manager, Captain Joseph F. Madeo, Jr., assisted by several senior salvage masters who were placed in charge of individual clearance operations.

The German-manned cranes THOR and ROLAND and the lift craft CRANDALL and CRILLEY were manned by their own crews. Other salvors were organized into teams and employed as necessary to meet the salvage schedule. Various teams were constituted to carry out specialized operations, such as cutting, trimming, and rigging, and were modified as the salvage evolution changed. The composition of a typical trim and rig team and an underwater cutting team are shown in Appendix D.

When the operation began, the salvage work force consisted of 30 men. By the end of the first month, the force had grown to 40, increasing to 60 at the end of the second month, and peaking at over 200 in September, October, and November. In mid-November, progressive reductions began as elements of the salvage work were completed.

Principal Navy and contractor personnel are listed in Appendix E.

(2) Facilities and Equipment

The principal salvage tools were the Navy-owned heavy-lift craft CRANDALL and CRILLEY and the heavy-lift cranes THOR and ROLAND. These craft and cranes were assisted by the German tug BUGSIER 26, the Philippine tug MARINER, and various SCA tugs and cranes. Features and operational methods of CRANDALL and CRILLEY are detailed in Appendix F. Characteristics of ROLAND and THOR are presented in Appendix G.

Other salvage equipment, such as pumps, compressors, welding machines, and diving systems, were provided by the prime and subcontractors, backed up by a U. S. Navy Emergency

Ship Salvage Material (ESSM) Base. Inventory of this base, including the salvage material used in outfitting a typical work barge, is presented in Appendix H.

2. LOGISTICS SUPPORT

The SCA agreed to provide berthing, messing, land transportation, water craft, local labor, limited industrial support, and related services for the salvage forces. Medical, supply, communications, and air transportation services, provided in part by CTF 65, were supplemented by the salvage contractor, Murphy Pacific Marine Salvage Company, and by SUPSALV, using the resources of his office in Washington and the numerous ESSM pools and bases.

(1) Bases of Operation

SUPSALV initially established his headquarters in Port Said in the SCA building in the port area, shown in Figure III-2. As the operation expanded southward, SUPSALV transferred his headquarters to Ismailia, locating in an SCA building in the boatyard area. SUPSALV area headquarters remained here for the duration of the operation. Throughout, the Murphy Pacific Marine Salvage Company project manager was collocated with SUPSALV. Task Force headquarters were located in the SCA buildings in Ismailia shown in Figure III-3. Salvage operating forces were stationed in Port Said, Ismailia, and Suez/Port Taufiq for most of the operation. The numbers at a given location varied with the level of activity. SUPSALV and Murphy Pacific management offices were located in the two cities away from the central headquarters. Contractor and Navy liaison offices were maintained in Cairo.

(2) Berthing and Messing Facilities

The SCA provided berthing and messing facilities for both the salvage forces as well as other U.S. forces living ashore in Port Said, Ismailia, and Suez/Port Taufiq. In the beginning, these cities, normally populated by more than 700,000 people, were still largely evacuated as they had been during the past 7 years. These cities were severely damaged by enemy action,

FIGURE III-2
SCA Regional Headquarters
(Port Said in Background)

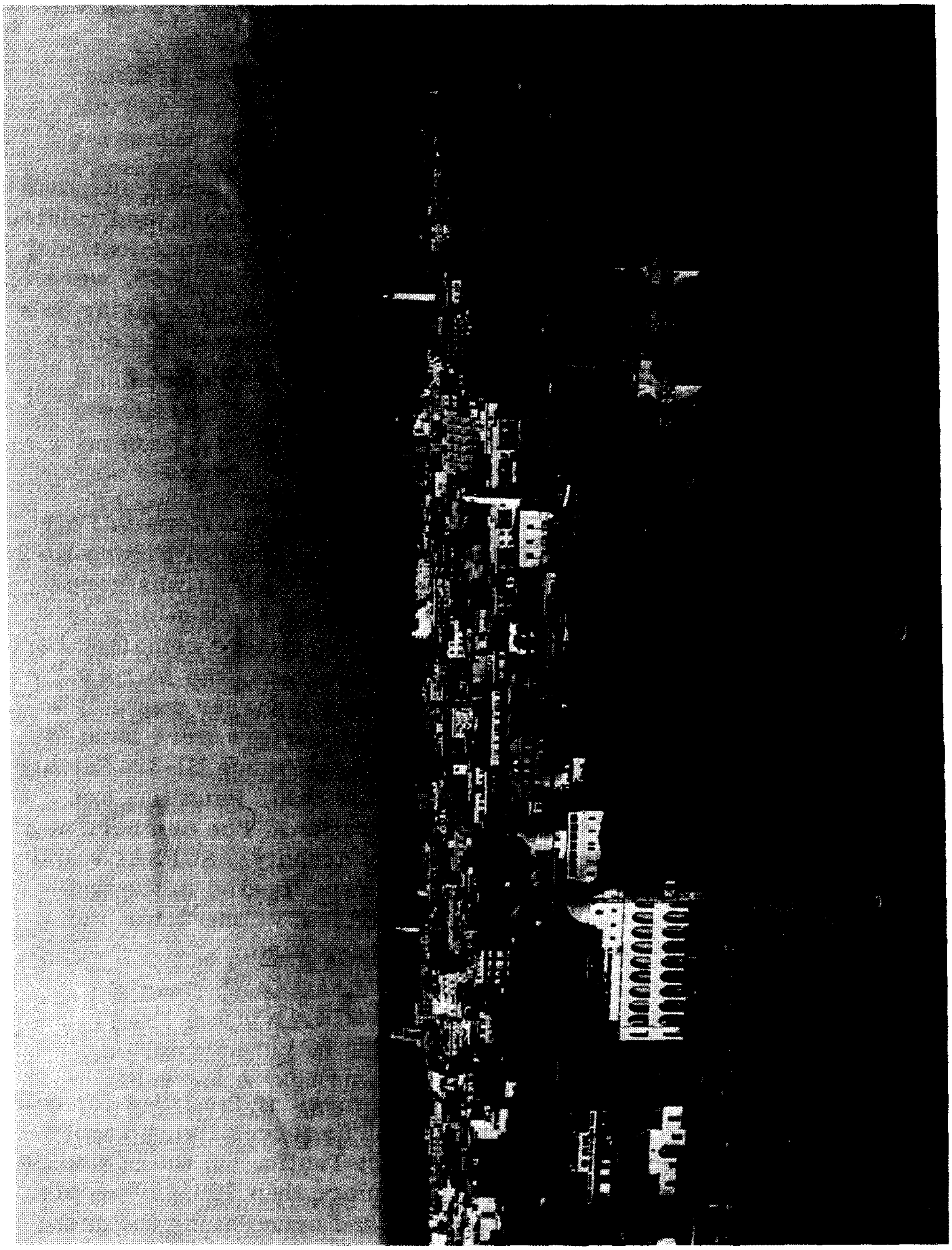


FIGURE III-3
SCA Headquarters on Banks
of Lake Timsah at Ismailia

and Port Taufiq was devastated during two wars. A section of the city along the Canal bank showing typical damage is presented in Figure III-4. Under these conditions and with limited resources to obtain U. S. standards of messing and berthing, the SCA performed ably. As the operation progressed, additional efforts by Murphy Pacific contributed significantly to the improvement of living conditions.

The crews of the craft CRANDALL and CRILLEY and the cranes THOR and ROLAND lived aboard these craft under reasonably good conditions.

1. Port Said Facilities

Berthing and messing for salvage forces were furnished by the SCA under contract with one of the best available local hotels a few blocks from the Mediterranean beaches. The contract was administered by the SCA and was monitored by an SCA liaison man. Although the Navy and Murphy Pacific could exercise no direct control over the hotel operation, they were successful in influencing considerable improvement in sanitation and food quality as the operation progressed. The quality and quantity of the local water supply was limited because the water purification plant had been nearly destroyed. Port Said's electrical power plant and local telephone service had been partially restored.

2. Ismailia Facilities

The SCA provided berthing in an apartment building near the Arab section of the city and established messing in an SCA villa in the old French section. Meals were catered by one of the best caterers in the Middle East and were adequate. Although living conditions were better here than at other locations on the Canal, they were still substandard. Success in improving cleanliness in the berthing areas varied with the effectiveness of the Murphy Pacific hotel managers. Efforts to improve food quality met with limited success, drinking water was usually safe, and electrical power and local telephone service were in

FIGURE III-4
Southern Entrance to Canal Showing
Characteristic Port Taufiq Devastation

the process of being restored. Warehouse space in Ismailia was provided by the SCA.

3. Suez/Port Taufiq Facilities

Initially, during the period of the salvage survey, salvage personnel were billeted in a recently reopened Suez City hotel. Messing was provided in the same hotel for other U.S. forces in the area and was marginal. Sanitation and food quality were poor. C-rations were used liberally. Major improvement was not possible because of a lack of resources.

When salvage forces returned to commence salvage operations in the Southern Zone, greatly improved messing and berthing arrangements were made using an SCA apartment building in Port Taufiq with a catered mess on the premises. The assignment of an American hotel manager by Murphy Pacific had a significant effect improving living conditions in Port Taufiq.

4. Cairo Facilities

Before commencement of salvage operations, a SUPSALV representative was stationed in Cairo to:

- Assist in communications
- Effect liaison with the U.S. Embassy and SCA
- Expedite country clearance for personnel and material, and arrange for local logistic support.

When operations were well underway, the SUPSALV Cairo office was disestablished. However, Murphy Pacific Marine Salvage Company maintained a Cairo office throughout the operation.

The Navy Medical Research Unit in Cairo provided assistance in the administration of the excess Egyptian currency account, and the Navy detachment at the Embassy assisted in liaison with the SCA.

(3) Airborne Cargo and Personnel Support

Both military aircraft and commercial airlines were employed for logistic support. Commercial flights and large military aircraft used Cairo International Airport. Cargo arriving by air in Cairo was transshipped by truck to the Canal. A schedule of C-130 cargo flights between Naples and Ismailia was established. Cargo arriving at Ismailia was further distributed by truck or helicopter. Daily round trips by helicopter were made from Ismailia to Port Said and Port Taufiq. The C-130 schedule to Ismailia was interrupted during July and August by the outbreak of hostilities on Cyprus.

Movement of personnel into and out of Cairo was effected primarily by commercial airlines. Extensive use was made of excess Egyptian currency to purchase airline tickets.

(4) Ground Transportation

Ground transportation was furnished by the SCA. Key managers were assigned late model sedans driven by competent drivers. Heavy-duty trucks, buses, and jeeps assigned were in general poorly maintained and required frequent repair. A daily shuttle bus service was maintained between Cairo and Ismailia by both the SCA and Murphy Pacific for personnel and light freight.

(5) Communications

Both land-line and telecommunications were used for command and control as well as for coordination and logistic support functions.

CTF 65 flagships, successively USS INCHON, USS BARNSTABLE COUNTY, USS BOULDER, and USS ESCAPE provided access to the Worldwide Defense Communications System through the terminal at the Naval Communications Station, Greece. Reliability was generally good.

Communications ashore were handled by a U.S. Army unit from the 7th Signal Brigade, deployed from Germany. Flight control and air navigation systems for U.S. aircraft at Ismailia were provided by U.S. Air Force units.

Telephone communications using the Worldwide Automatic Voice Network (AUTOVON) were established between Ismailia and the Embassy in Cairo to points in Europe and the United States through Camp Darby, Italy. AUTOVON communications were improved during the operation when circuits were upgraded from two to four wires and termination shifted to Naples. However, complete lapses in service were not uncommon.

The communication center in Ismailia linked Ismailia with Port Said, Port Taufiq, and Greece by teletype. Local telephone service was either nonexistent or marginal. Murphy Pacific maintained communications with the United States and Europe using commercial teletype services from Cairo.

(6) Medical Support

The CTF 65 forces were accompanied by Navy corpsmen who were qualified for independent duty. These corpsmen provided immediate on-scene medical services. A dispensary, manned by one physician and two corpsmen, was maintained at Ismailia as a sick-call station and pharmacy. MYPAC provided medical technicians for their afloat operations.

Arrangements were made to use the Polish-staffed United Nations Emergency Force (UNEF) hospital at Ismailia. This full-service hospital was equipped with excellent surgical capabilities and was capable of handling any emergency.

MEDEVAC services were available during daylight hours when normal salvage operations were in progress. Night flights were prohibited since the Canal was designated a free-fire area at night.

3. SALVAGE ENVIRONMENT

While some general statements can be made regarding the environment, the conditions of tide, current, underwater visibility, bottom composition, and other factors varied in the three zones of operation. Environmental conditions and their effects on the operation will be discussed as they applied to the operation as a whole and to each zone in particular.

(1) General

The surface and above water conditions were consistent throughout the area of operations and presented no special problems for salvage. Summer temperatures were high, ranging from the lower 70's to 100 degrees F. The high temperatures were offset by a low (10 to 15 percent) relative humidity and a prevailing breeze. Winter temperatures ranged from the lower 50's to lower 70's. Morning fog was common and sometimes hindered movement of the salvage craft. Strong winds and sandstorms encountered during late October and November occasionally delayed salvage evolutions.

The natural flow of water through the Canal is a function of the difference in the level between the Red Sea and Mediterranean, the prevailing winds and the high salinity of the Canal waters originating in the Great Bitter Lake. During the greater part of the year, from October until June, the level of the Red Sea is higher than that of the Mediterranean, causing the surface current to flow northward. During the remainder of the year the relative heights of the natural sea levels are reversed and the surface current flows southward. Highly saline bottom water flows northward from the Great Bitter Lake at all times and also flows southward to the Red Sea from July until December.

Conditions of tide and current encountered during salvage operations varied greatly and were frequently unpredictable. Some changes in current conditions could be attributed to the 10 wrecks that blocked the Canal and the changes in flow patterns that their removal caused. The major perturbation to flow was caused by the earthen causeway erected by the Israeli Army in 1973, across the Canal at Deversoir Station, as shown in Figure III-5. This causeway effectively blocked the flow of water during the early stages. North of Deversoir, the observed current and tidal range was small; south of Deversoir, relatively unpredictable currents up to 4 knots and a tidal range of 6 feet were encountered. As the causeway was opened natural patterns of flow were reestablished.

FIGURE III-5
Earthen Causeway Blocking Canal
at Deversoir Station

There was no harmful marine life encountered; although sharks have reportedly entered the southern end of the Canal from the Red Sea, none were sighted. Small marine growth abounded.

(2) Northern Zone

The Canal in the Northern Zone is bounded by Lake Manzala on the west and salt marshes on the east. The Canal bottom is comprised of clay and silt, deposited by the eastern branches of the Nile via the Mediterranean. Silt deposits reached 7 to 10 feet in depth in the vicinity of MECCA and ISMAILIA and heavy silting was found in these wrecks. Currents were generally light except around the ends of the wrecks where flow was restricted. Underwater visibility was poor primarily because of the heavy silt content of the water. Typical Canal east bank terrain between Port Said and Ismailia is shown at Al Firdan swing bridge in Figure III-6. Opening of the pontoon bridges which crossed the Canal at six locations required coordination with the SCA for movement of salvage craft. A typical pontoon bridge is shown at Al Qantara Signal Station, Figure III-7.

(3) Central Zone

The Central Zone of the Canal was bounded by a small agricultural area to the west and the Sinai desert to the east. The bottom changed from silt and fine sand in the northern section of the zone to hard-packed fine and coarse sand south of Al Qantara. This type of bottom continued throughout the zone to Kabrit at the northern end of Little Bitter Lake, except for the lakes, and a unique condition at the Concrete Caisson site where the fine sand was very fluid and hindered rigging the caisson for lift with the heavy-lift craft. Underwater visibility was good and currents were negligible.

In Lake Timsah the bottom and contiguous sections of the Canal were covered with soft mud to 7-foot depths. This mud was a product of agricultural drainage, sewage disposal, and industrial waste from the city of Ismailia. There was heavy silting from this mud in MONGUED and KASSER. The soft mud

FIGURE III-6
Al Firdan Bridge South of Port Said
(terrain in background
is typical for area)

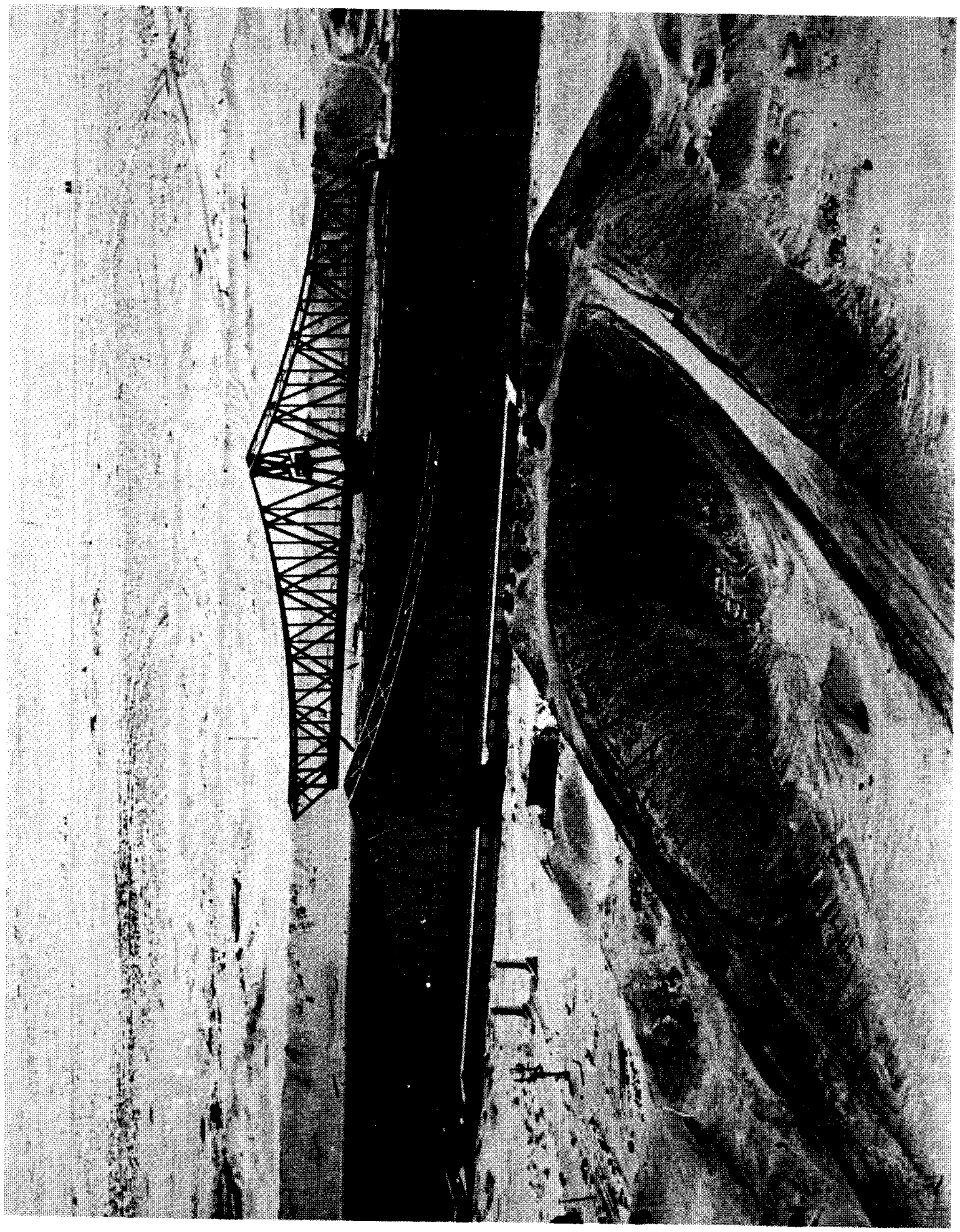
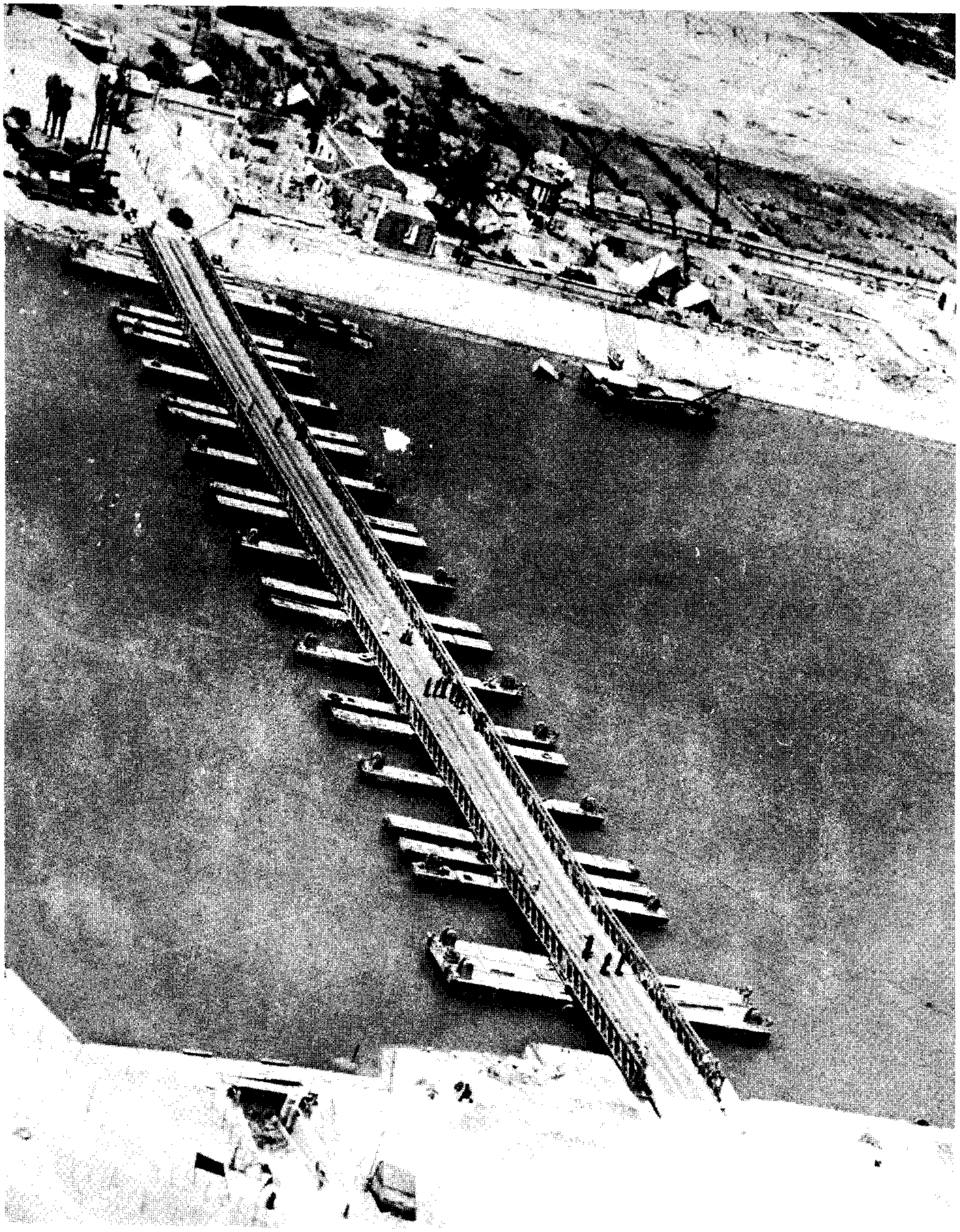


FIGURE III-7
Typical Pontoon Bridge Across Canal
(demolished Al Qantara signal
station in background)



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obscured underwater visibility and impeded lift rigging. A photograph of the Canal at the southern end of Lake Timsah at the KASSER/MONGUED site is shown in Figure III-8.

The Great Bitter Lake lies over a salt deposit which causes the water in the lake to be extremely high in salinity. The high salinity had no impact on salvage operations. The bottom of the Great Bitter Lake, particularly in the northern end at the wet dump area, was relatively firm and facilitated successive lifting of the wrecks.

(4) Southern Zone

The Canal bottom in the Southern Zone was relatively hard, being comprised of silt with frequent rock and soft sandstone outcroppings. Swift tidal currents hindered diving operations throughout the zone and contributed to heavy silting of the wrecks of MAGD and BARREH. Underwater visibility was better in the Southern Zone than in other areas of the Canal. A typical section of the Canal is shown in Figure III-9 and a representative tide table is included as Appendix I.

FIGURE III-8
Suez Canal at Southern End of Lake Timsah
(sunken dredge KASSER in foreground)

FIGURE III-9
Typical Section of Canal at Southern End

IV. SALVAGE SURVEY

IV. SALVAGE SURVEY

Planning for the clearance of the Suez Canal by the U. S. Navy began in April 1974, when the Government of the United States agreed to undertake wreck removal operations. The first step was a comprehensive survey to determine the condition of each wreck. Ideally, such a survey should have been carried out well before commencement of the salvage operations in order to facilitate proper planning, but the urgency of the clearance prevented this.

The U. S. Navy's principal salvage contractor, Murphy Pacific Marine Salvage Company (MPMS) had previously gained some knowledge of the wrecks, independently of the U. S. Navy, during the first few months of 1974. When the Suez Canal Authority was soliciting proposals from commercial salvage firms to clear the Canal, MPMS and other international salvage operators, submitted proposals. MPMS offered to survey the Canal gratis in order to provide the SCA with a realistic, detailed proposal. The SCA refused this offer maintaining that no other prospective bidder had been afforded a similar opportunity and stated that the Canal survey performed in 1967 by the SCA was adequate. The 1967 SCA survey, however, gave little more than the principal dimensions of the wrecks, their location and attitude, and the depth of the water around each wreck.

The information obtained from the 1967 SCA survey, together with discussions that MPMS had held with SCA staff early in 1974, were the only sources of data available to the Navy when it began to plan the clearance of the Canal in April 1974.

1. SALVAGE SURVEY SCHEDULE AND PROCEDURES

The Supervisor of Salvage (SUPSALV), with a small staff and contractor personnel, arrived in Suez late in May 1974 to begin the Canal clearance. Since there was a desire to begin operations quickly, a survey of MECCA and ISMAILIA, the two wrecks in the Northern Zone, was conducted as soon as both wrecks had been checked for unexploded ordnance. A survey of the other eight wrecks in the Central and Southern Zones was undertaken later after similar checks for ordnance had been conducted. Table IV-1 presents the survey schedule, as accomplished.

The survey team consisted of a SUPSALV representative, a salvage master, an assistant salvage master, a diving supervisor, four divers, four tenders, a medical technician, and an equipment operator. The team operated from the 25-ton SCA crane barge BAYOUMI, which was particularly suited for survey work because of its ability to lay its own moors over the wrecks. It was self-propelled with one Voith-Schneider propulsion unit, which gave a dynamic positioning capability allowing it to move about over the wrecks. BAYOUMI was outfitted as a diving platform with the installation of two diving air compressors and filters, a jetting pump, and a double-lock decompression chamber. Throughout most of the survey it was accompanied by the small 1600-horsepower tug CHADID and a motor launch.

Table IV-1
Survey Schedule

Canal Zone*	Distance from Port Said (km)	Wreck	Survey Dates
Northern	7.2	MECCA	28-29 May
	6.4	ISMAILIA	28-29 May
Central	72.0	DREDGE 23	5- 6 July
	81.5	KASSER	7- 8 July
	81.5	MONGUED	8- 9 July
	87.0	Concrete Caisson	9-13 July
	98.2	15 SEPTEMBER	14-18 July
Southern	156.9	MAGD	19-24 July
	158.0	DREDGE 22	25-29 July
	158.0	BARREH	27-29 July

* See map, Figure II-1.

2. SALVAGE SURVEY RESULTS

It was necessary to check all 10 wrecks for unexploded ordnance before beginning the surveys. U.S. Navy explosive ordnance disposal divers checked BARREH, MAGD, DREDGE 22, KASSER, MONGUED, 15 SEPTEMBER, and the Concrete Caisson. Royal Navy clearance divers checked ISMAILIA, MECCA, and DREDGE 23. With the exception of gelignite charges (of the type used in fishing) around tug MONGUED in the Central Zone, and three pieces of military ordnance near DREDGE 22 in the Southern Zone, no other ordnance was found at that time.

The requirements for each survey were unique for each individual wreck; the thoroughness with which each wreck was surveyed was governed by the priority of removal of the wreck and the desirability of refloating as a means of clearance. Of the eight wrecks surveyed, a fine grain survey was conducted on the dredge 15 SEPTEMBER and the Concrete Caisson near ISMAILIA, and on the tanker MAGD near Port Taufiq. Refloating of 15 SEPTEMBER intact for repair and future use was desired by the Egyptians. The other two were being examined to determine if this method of removal was preferable to cutting in place and lifting the sections. The surveys of the two wrecks in the Northern Zone, MECCA and ISMAILIA, were less detailed because the primary concern was a determination of their silt content and confirmation that both wrecks could be sectioned for lifting by a heavy lift crane. Of particular interest in each survey were the wrecks' attitude, general condition, grounded hull support, silting, and hull damage. Table IV-2 summarizes the results of the surveys on each wreck, and additional details are presented in the following sections.

(1) ISMAILIA Survey

ISMAILIA, one of the two wrecks located in the Northern Zone of the Canal, was a cargo ship displacing about 1,400 tons. The 1967 SCA survey reported that ISMAILIA was resting on its starboard side; it was, in fact, found upright. The bow of the wreck pointed toward the west bank of the Canal, as shown in Figure IV-1. The depth of water was 52 feet, and there was less than 20 feet of water over the main deck.

The survey revealed that the superstructure and propulsion machinery, except for the boiler, had been removed. The

Table IV-2
Summary of Salvage Survey Results

Wreck	Attitude	Hull Condition	Hull Support	Quantity of Silt	Projected Method of Removal
ISMAILIA	Upright	Superstructure, machinery, and shelter deck removed	Supported mid one-third of its length; ends cantilevered	Extensive (estimated weight 2,257 tons)	Section and lift with cranes
MECCA	75-degree starboard list	Port side essentially intact; starboard side not determined because it was buried in mud	Supported by mud more than 80 percent of its length	Interior cluttered with debris	Section and lift with cranes
DREDGE 23	130-degree starboard list	Extensive shelter deck carried away; three holes in hull	Supported at the ends by silt and sand; resting on starboard deck edge and dredging structure	Machinery spaces silted to 2 feet	Parbuckle side lift by YHLCs
KASSER	45-degree port list	Generally sound except for two scuttling holes	Rested on turn of bilge at bow and stern and on starboard spud	Extensive	Side lift heavy-lift craft
MONGUED	12-degree starboard list	Much of overhead deck cut away; engines removed; holes in machinery spaces	Supported on mud	Extensive	Side lift by YHLCs craft after removal of stack and other projections
Concrete Caisson	On starboard side	Essentially intact except for three cracks (hairline to 2 inches), two scuttling holes, and a damaged area in the bottom	Supported by Canal bottom. Heavy scouring at western end.	Extensive, 3 to 6 feet along starboard side	Section along crack amidships and lift

Table IV-2 (Continued)

Wreck	Attitude	Hull Condition	Hull Support	Quantity of Silt	Projected Method of Removal
15 SEPTEMBER	On port side	Wooden superstructure carried away; plating split on a riveted seam; hull dished on starboard side but wreck suitable for further use	Supported by Canal bottom	Mud 2 to 4 feet deep in pump room and machinery spaces; 6 inches of silt in port bow storage space	Refloat by parbuckling, patching, lifting, and pumping
MAGD	On port side	Cargo tank tops buckled, plating and rivets missing; damage in tankage widespread	Supported by Canal bottom over half its length	Silted 2 to 4 feet in starboard and center tanks and 4 to 6 feet in port tanks; mud 3 to 10 feet in engine room	Section and lift
DREDGE 22	22 degrees past horizontal on starboard side	Damage from scuttling charges and rust; shelter deck and sections of main deck missing	Supported by hard sandstone bottom	Mud 3 to 6 inches in pockets between main deck and longitudinal bulkheads	Parbuckle and lift
BARREH	10-degree port list	Hull sound; stack and superstructure gone; eight portholes broken, open, or missing	Supported generally on hard sandstone bottom, except bow on soft sand	Silt to 4 feet in engine room, 3 feet in boatswain locker and compartment aft of engine room; also in boiler rooms and crew's quarters	Lift

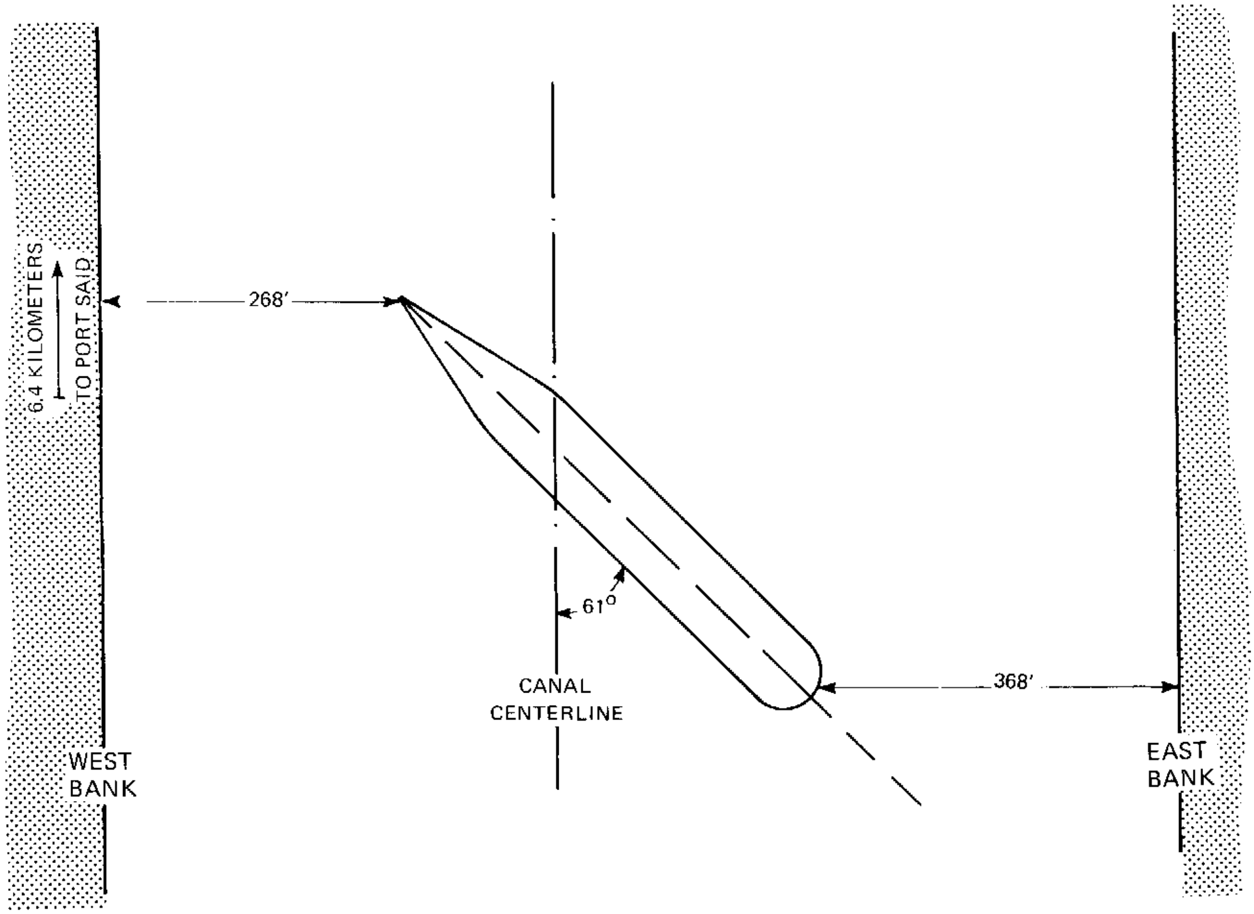
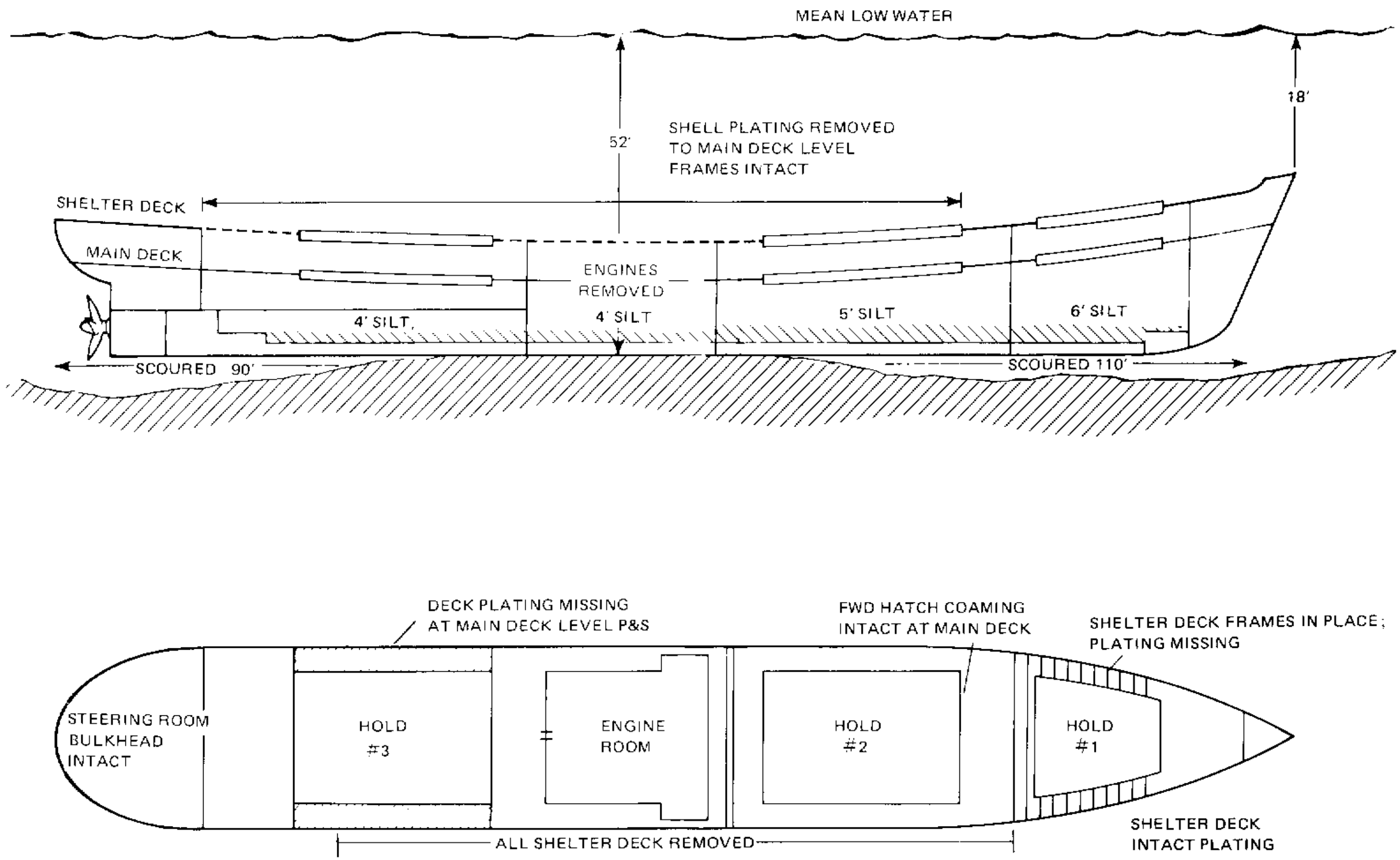


FIGURE IV-1
Location of ISMAILIA in Canal

shelter deck had been removed from a point 60 feet foward of the stern to the after end of number 1 hold. The shelter deck plating forward of the forward bulkhead of number 1 hold was intact. Shell plating had been removed from the shelter deck to the main deck from the forward edge of number two hatch to the forward bulkhead of the steering flat; frames were intact. The propeller and shafting were in place. No hull damage was discovered apart from the missing structure indicated on Figure IV-2. ISMAILIA was grounded over the mid one-third of its length, with the ends cantilevered.

There was considerable silting within the wreck. The silt, estimated to have a total weight of 2,257 tons, was



PRINCIPAL DIMENSIONS

Length	345'
Beam	44'
Depth	27'
Displ.	1400 tons

CONDITION OF ISMAILIA AT SURVEY

FIGURE IV-2
Condition of ISMAILIA at Survey

concentrated on the port side. Figure IV-2 illustrates the degree of silting found, and Table IV-3 presents further details.

Table IV-3
Silting in ISMAILIA

Location	Depth (feet)	Tonnage (tons)
Number 1 Hold	6	291
Number 2 Hold	5	907
Number 3 Hold	4	618
Engine Room	$4\frac{1}{4}$	441

Before the survey began, it was decided that the hull was likely to be too frail to permit refloating without inordinate expense. Primarily, the aim of the survey was to confirm the feasibility of sectioning the wreck, and then lifting the sections with a heavy-lift crane. Despite the discovery of large quantities of silt in the wreck, the survey confirmed that sectioning and lifting was the most desirable method of removal.

(2) MECCA Survey

MECCA, the other wreck in the Northern Zone, was a passenger/cargo ship reportedly displacing about 4,600 tons. This estimate was raised to 6,500 to 7,300 tons after inspection. MECCA was resting on its starboard side with a 75-degree list at an angle of 75 degrees on the Canal centerline, as shown in Figure IV-3. The bow of the wreck was only 26 feet from the west bank in 13 feet of water, with a significant portion of the bow and superstructure out of the water. The stern rested in 65 feet of water about 180 feet from the east bank.

Since the ship was known to be riveted construction and was over 40 years old, refloating it as a method of removal

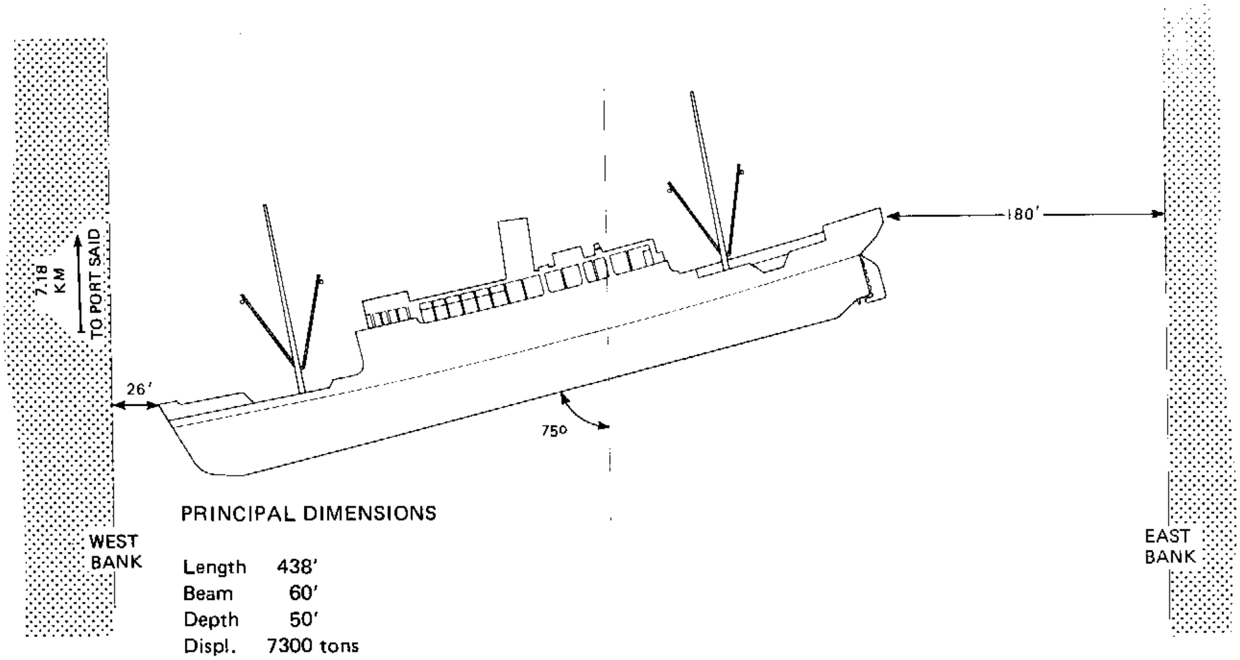


FIGURE IV-3
Location of MECCA in Canal

was not considered. Hence, there was no need for a detailed survey. As with ISMAILIA, the objective of the survey was to confirm the feasiblity of sectioning the wreck and lifting the sections with a heavy-lift crane. No attempt was made to survey inaccessible portions of the hull.

Currents, often exceeding 2 knots, hindered diving operations around the ends of the ship. The hull of MECCA was found to be essentially intact and supported by mud over more than 80 percent of its length. Since the starboard side was buried in the mud, there was no evidence of the collision damage under repair at the time of sinking or of the damage which caused the sinking. The ship had been outfitted to carry pilgrims to Mecca; thus, living accommodations were cramped, which resulted in the interior being cluttered with debris.

(3) DREDGE 23 Survey

DREDGE 23, the northernmost of the five wrecks in the Central Zone of the Canal, was a conveyor belt bucket dredge with a displacement of about 1,600 tons. The wreck lay on its starboard side at 80 degrees to the Canal centerline with a 130-degree list. It was supported by the starboard deck edge and the dredging gantry, with 1 foot of water over the stern and 17 feet over the bow. Figure IV-4 illustrates the location of DREDGE 23 in the Canal.

The hull of the dredge had deteriorated. The wooden shelter deck above the main deck had been carried away, leaving only a few pipe stanchions for roof support. The dredge buckets were still attached to the ladder but had slipped off their tracks. The boom protruded about 15 feet beyond the bow, hanging 8 feet below the hull but clear of the bottom. The hull was supported at the ends and the Canal bottom had scoured to a maximum depth of about 9 feet in the center one-third. The dredge was silted in the machinery spaces to a maximum depth of approximately 2 feet. Figures IV-5 and IV-6 illustrate the condition of DREDGE 23 at survey.

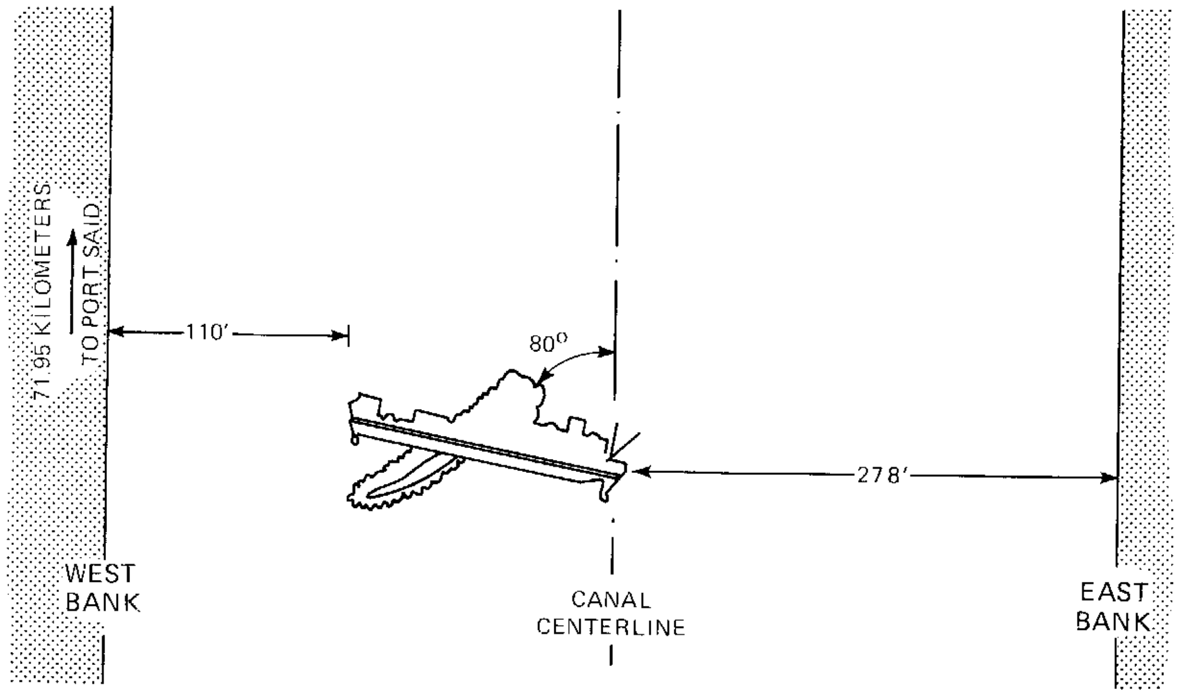


FIGURE IV-4
Location of DREDGE 23 in Canal

There were two holes in the engine room apparently created by scuttling charges. These holes were approximately 2 feet wide and were located port and starboard about 20 feet forward of the stern at the turn of the bilge. A third hole, 1-1/2 by 2 feet, was located on the port side 40 feet forward of the stern.

It was ascertained that the wreck could be removed by parbuckling with heavy cranes and lifting with liftcraft. Rigging would be facilitated by scouring of the Canal bottom amidships.

(4) KASSER Survey

The dipper dredge KASSER displaced 1,200 tons. The 1967 SCA survey reported its attitude as upright; however, it actually lay at a 45-degree port list, 50 degrees to the Canal centerline, as shown in Figure IV-7. The hull rested on the turn of the bilge at the bow and stern and on the starboard spud; the port spud was even with the bottom but apparently carried no load. Neither spud penetrated the bottom. The Canal bottom was scoured to a depth of 1 to 3 feet over the mid 60 percent of the length of the hull. There were 17 feet of water over the starboard quarter and 26 feet over the starboard bow. All three spuds were visible above the surface. A photograph of the dredge KASSER at the beginning of the survey is shown in Figure IV-8.

The dredge was reportedly burned and then sunk by blowing main hull valves with explosives. It was generally sound except for two scuttling holes at the turn of the bilge, as shown in Figure IV-9. The hole on the starboard side was 4 feet in diameter and extended 3 feet under the dredge bottom. The port hole was 18 inches in diameter. The port fuel oil tank was blown in toward the engine room, but the starboard tank appeared intact. The rock crusher was secured to the stern A-frame and was clear of the bottom. Figure IV-9 also illustrates how the bucket boom and its supporting A-frame had fallen forward so that the bucket rested on the canal bottom.

Silt and debris had filled the engine room skylight trunk. Silt was 8 to 10 feet above the port turn of the bilge tapering to 18 inches amidships. Debris and silt were level with the windows in the deckhouse at the bow tapering to zero amidships.

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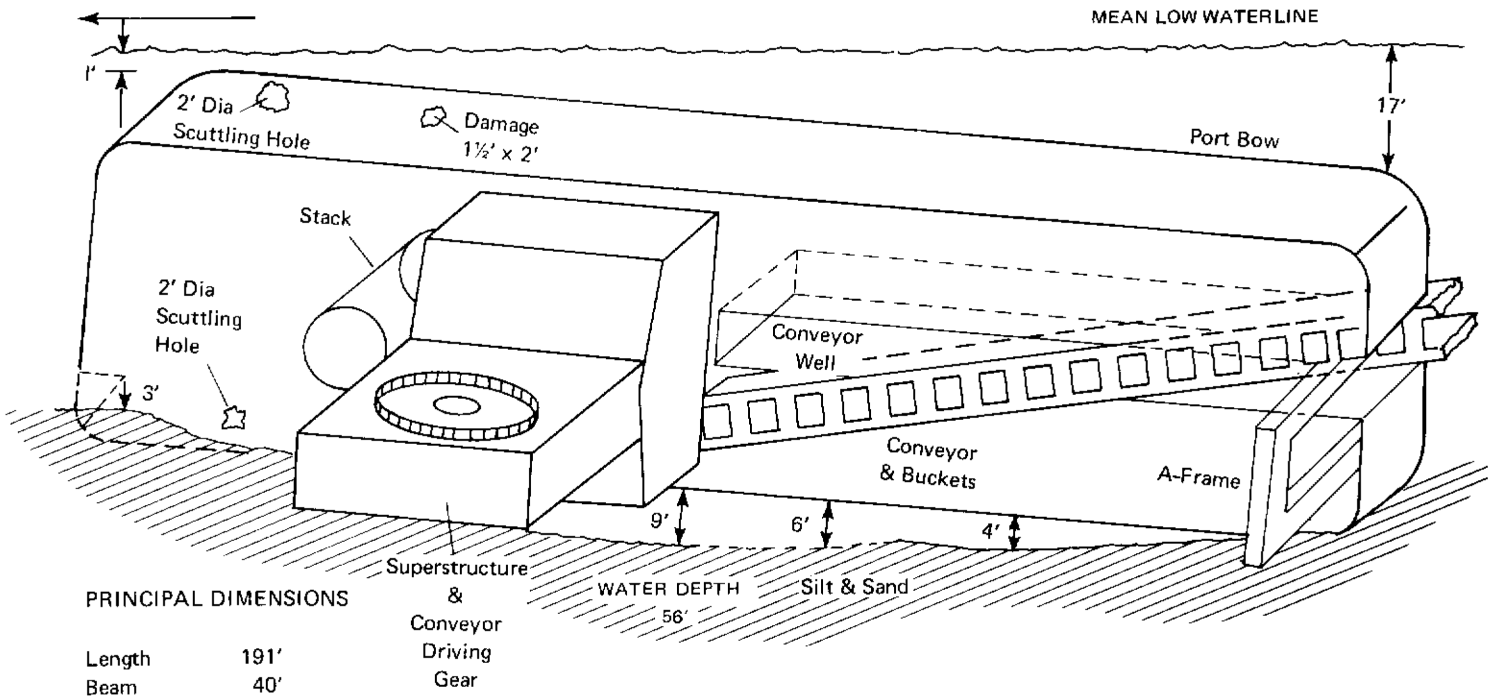


PRINCIPAL DIMENSIONS

Length	191'
Beam	40'
Depth	11'
Displ.	1600 tons

CONDITION OF DREDGE 23 AT SURVEY

FIGURE IV-5
Condition of DREDGE 23 at Survey

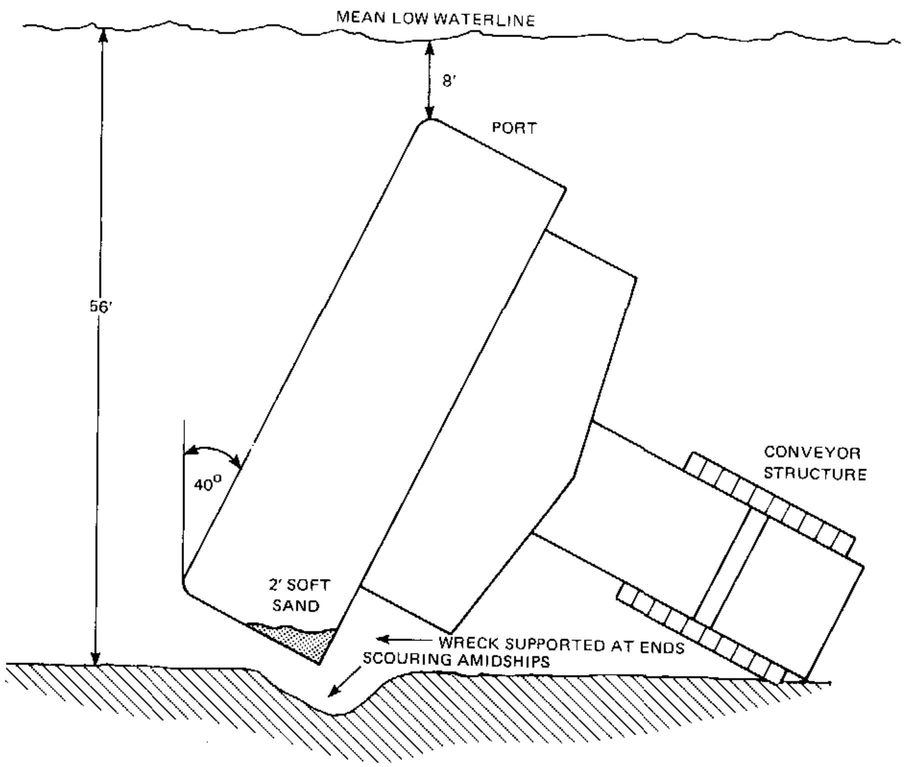


FIGURE IV-6
Midship Section of DREDGE 23 at Survey

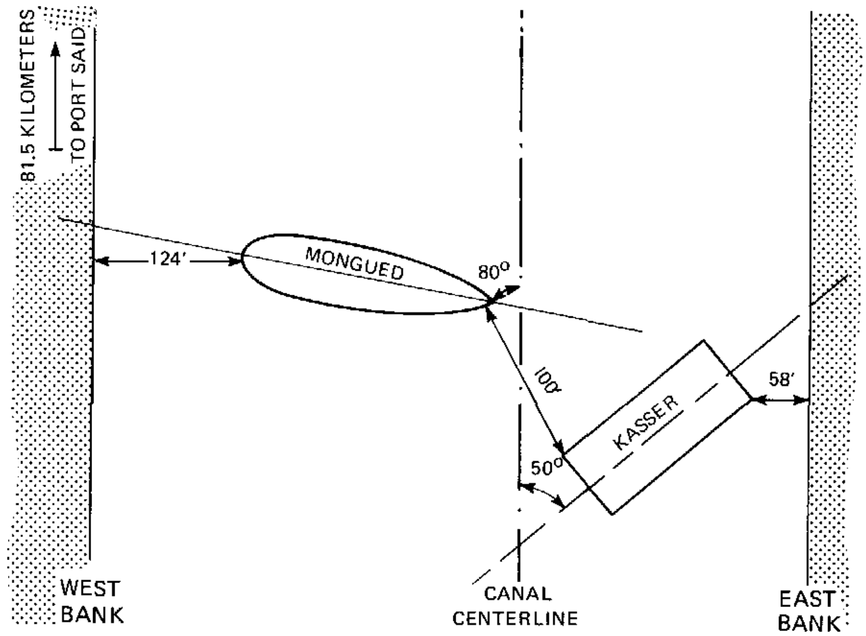
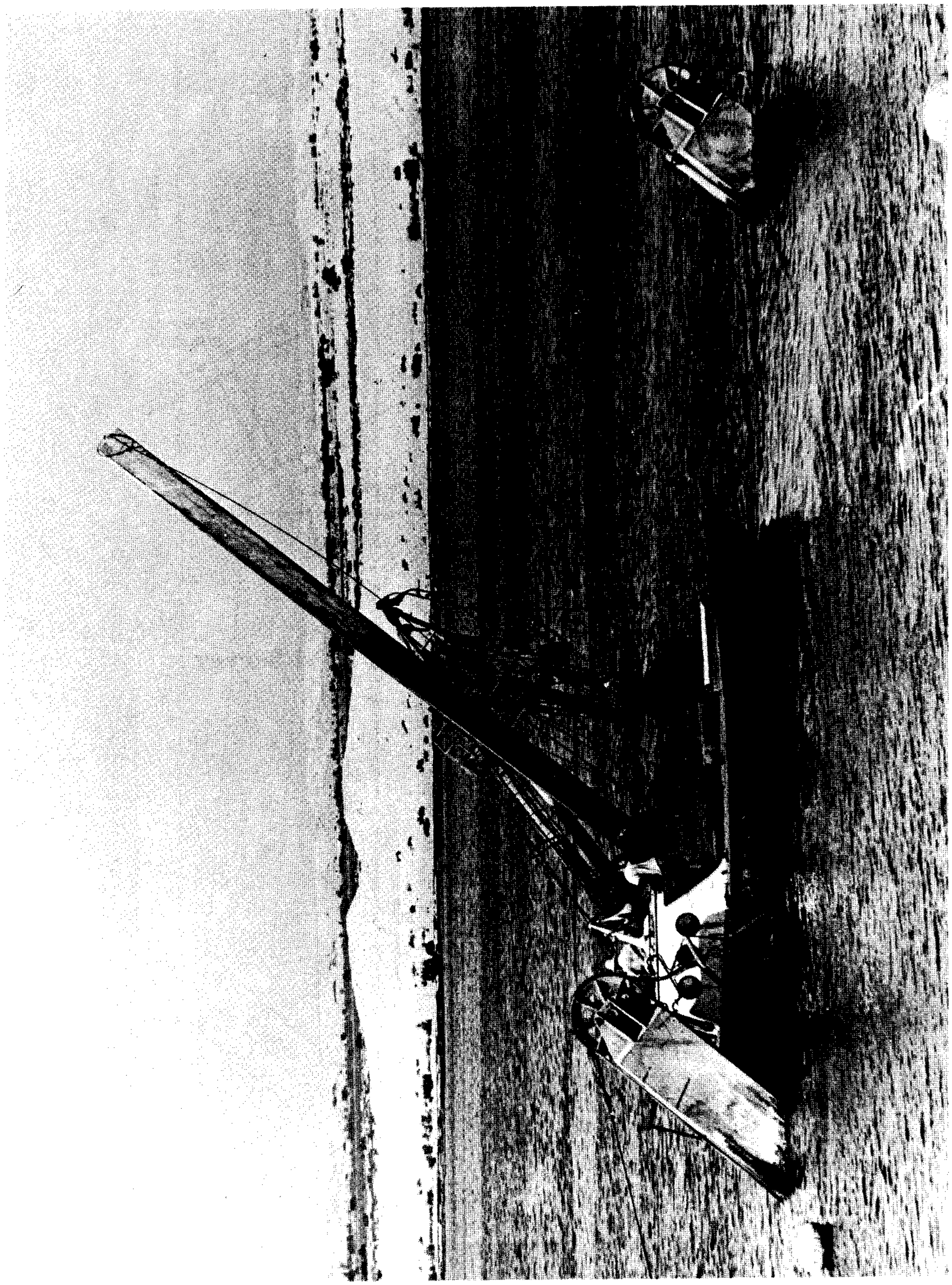
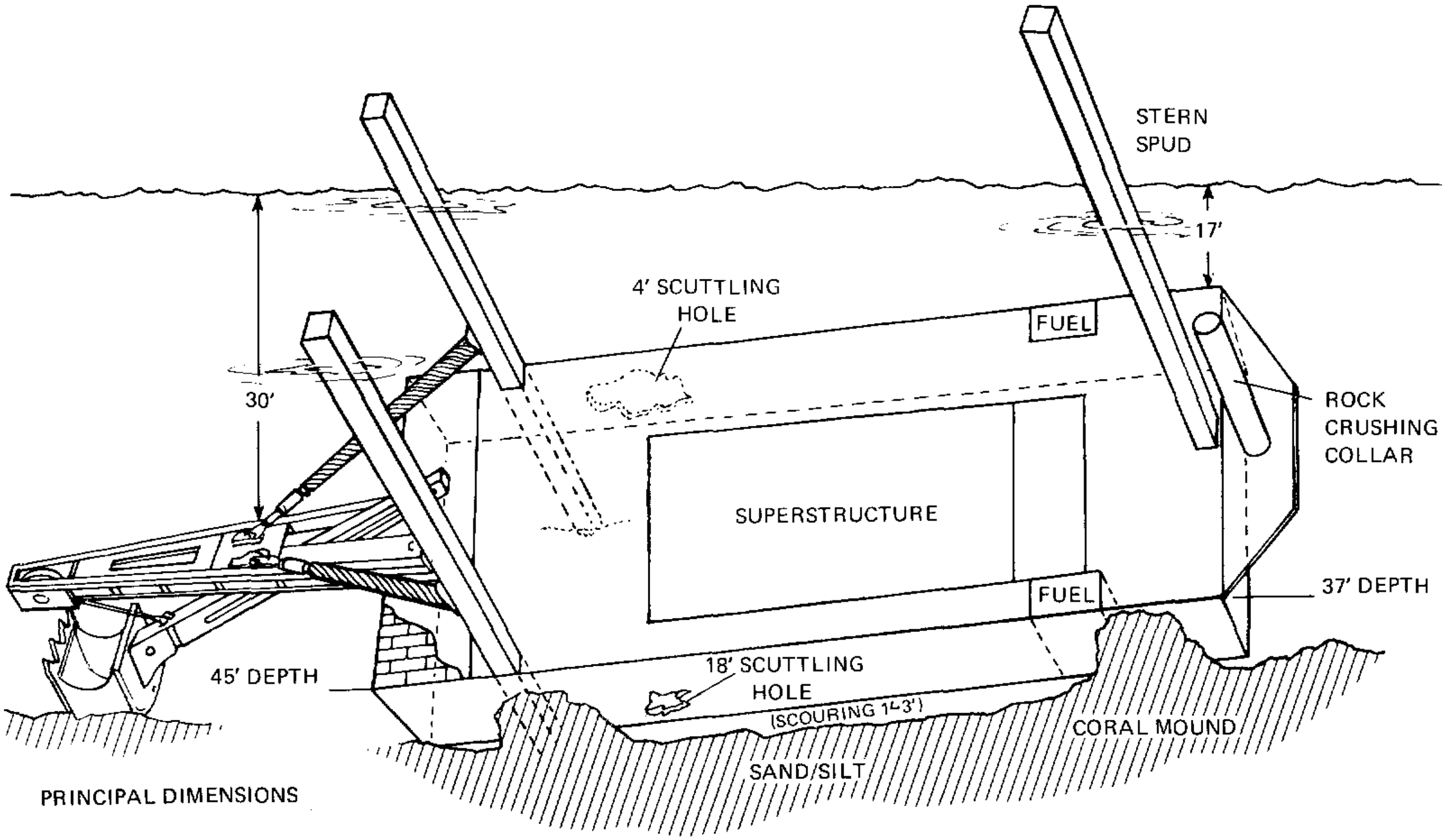


FIGURE IV-7
Location of Dredge KASSER and Tug MONGUED in Canal

FIGURE IV-8
Dredge KASSER
at Beginning of Survey





PRINCIPAL DIMENSIONS

Length	125'
Beam	44'
Depth	10'
Displ.	1200 Tons

CONDITION OF DREDGE KASSER
AT SURVEY

FIGURE IV-9
Condition of Dredge KASSER at Survey

Figure IV-10 indicates KASSER's attitude and support, together with the quantities of silt found during the survey.

The survey determined that the wreck could be side-lifted by two lift craft. Passing of lift wires would not be difficult. Stern lifting was not feasible as the deadweight of the wreck, including the silt deposits, exceeded the combined stern-lift capacity of the two lift craft.

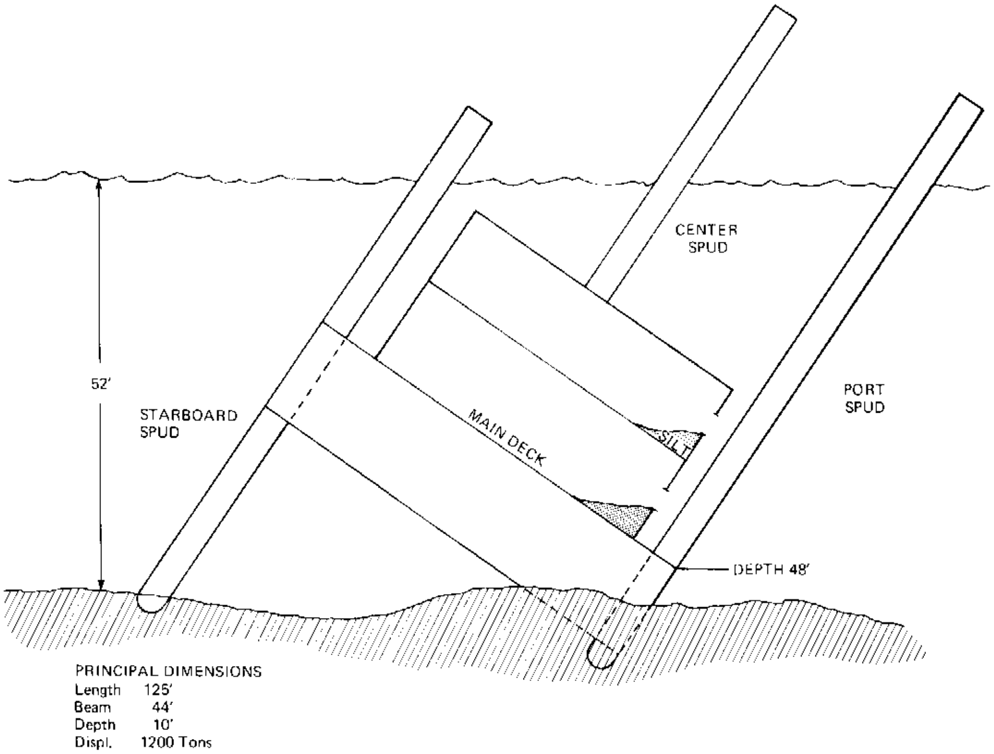


FIGURE IV-10
Condition of Dredge KASSER,
at Survey, Front View

(5) Tug MONGUED Survey

The tug MONGUED, with a displacement of 1,200 tons, lay almost due west of the dredge KASSER, as shown in Figure IV-7. MONGUED had a 12-degree starboard list. It lay at an angle of 80 degrees with the Canal's centerline, and its stern was about 100 feet from the west bank of the Canal. The Canal bottom was scoured from the bow 30 feet aft, and the after end of the skeg was buried in 4 feet of mud. Figure IV-11 shows the Canal bottom scoured around the wreck, as well as the depth of water in which MONGUED lay.

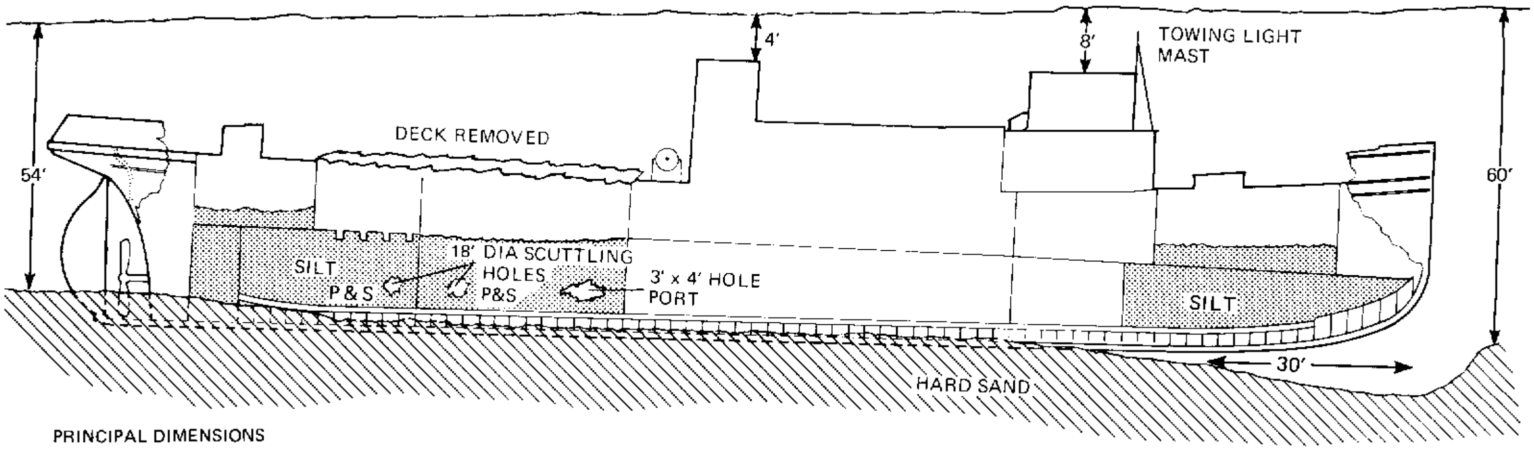
Hull damage was concentrated in the machinery spaces. The engines had been removed, but two 10-foot propellers were in place. There was a 3- by 4-foot hold in the forward port side 2 feet above the turn of the bilge. Two holes 18 inches in diameter were located port and starboard in the engine room and in the space immediately aft. The overhead deck of the engine room was rolled back to the port and starboard gunwales, which left the area over the engine room open. The overhead deck aft of the engine room appeared to have been deliberately cut away. Figure IV-11 illustrates the hull damage and silting on the tug MONGUED.

The survey showed that the wreck was suited to removal by heavy-lift craft after removal of the stack and other projections.

(6) Concrete Caisson Survey

The Concrete Caisson, with a displacement of 3,800 tons, lay in an average depth of 55 feet nearly normal to the Canal centerline as shown in Figure IV-12. It lay on its starboard side, the end nearest the west bank having been designated the bow. There were 17 feet of water over the starboard bow and 10 feet over the starboard quarter. The hull was supported by the Canal bottom, as shown in Figure IV-13. The forward 2 feet of the starboard side lay below the mud line. There was heavy scouring at the western end.

The Concrete Caisson was essentially intact; however, there were two scuttling holes along the starboard turn of the bilge, both indicated on Figure IV-13. The first hole was 35 feet from the bow and extended 2 feet up the port side and 5 feet inboard along the bottom; the hole was about 5 feet wide. The second hole, 2 by 4 feet, was 150 feet abaft the bow. In addition, a 2- by 4-foot damaged area was found on the bottom 13 feet from the starboard turn of the bilge; rebar within the hole was exposed. There was a major crack running through



PRINCIPAL DIMENSIONS

Length	165'
Beam	32'
Depth	15'
Displ.	1200 Tons

CONDITION OF TUG MONGUED AT SURVEY

FIGURE IV-11
Condition of Tug MONGUED at Survey

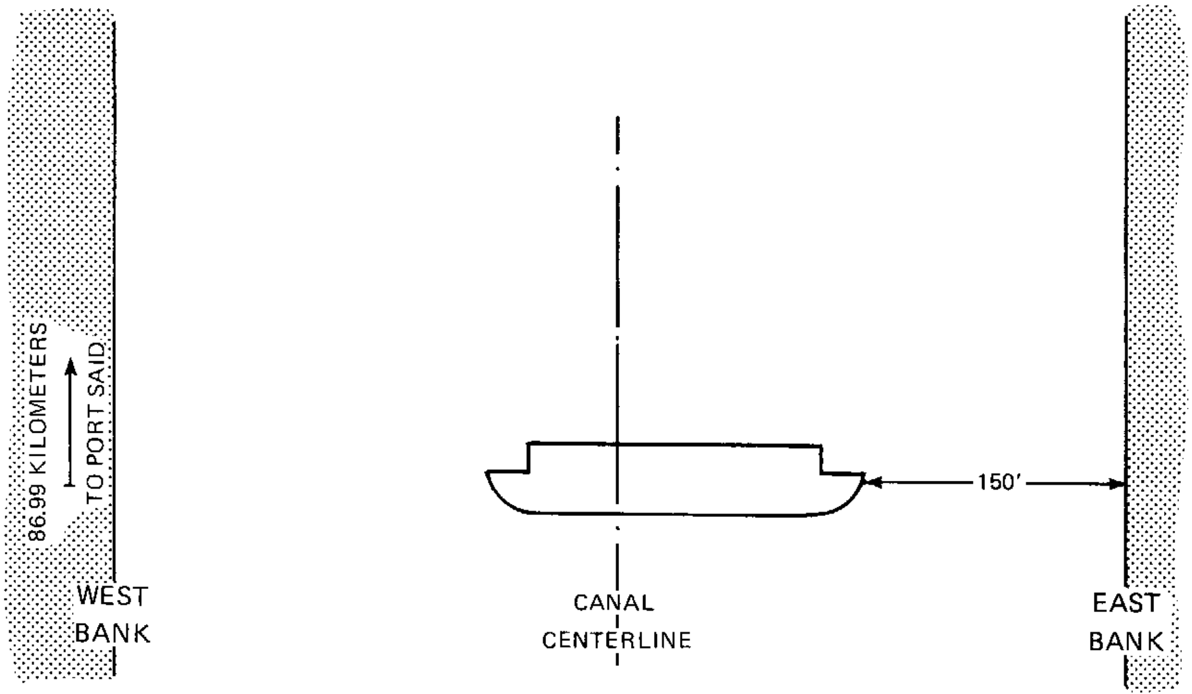


FIGURE IV-12
Location of Concrete Caisson in Canal

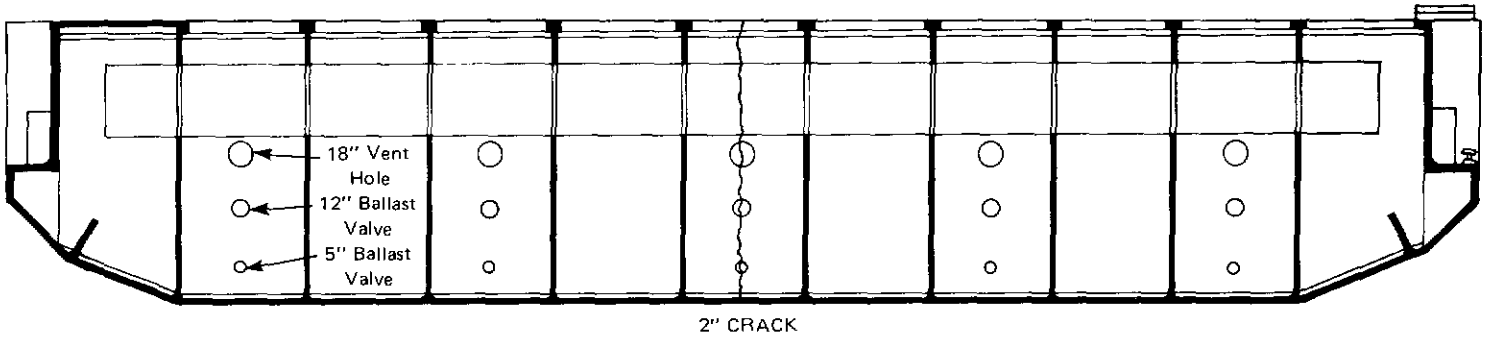
the port side and bottom of the hull approximately amidships. The crack varied in width from 2 inches to a hairline at the starboard turn of the bilge. Two hairline cracks, one 15 feet forward, the other 2 feet aft, paralleled the large crack, as shown in Figure IV-13. Silting was severe along the longitudinal bulkheads, varying between 3 and 6 feet along the starboard side.

The difficulty of inverting the caisson and floating it on an air bubble made that method of removal impractical. Based on the position of the crack amidships in the hull, it was decided to cut the caisson into at least two sections for heavy lift.

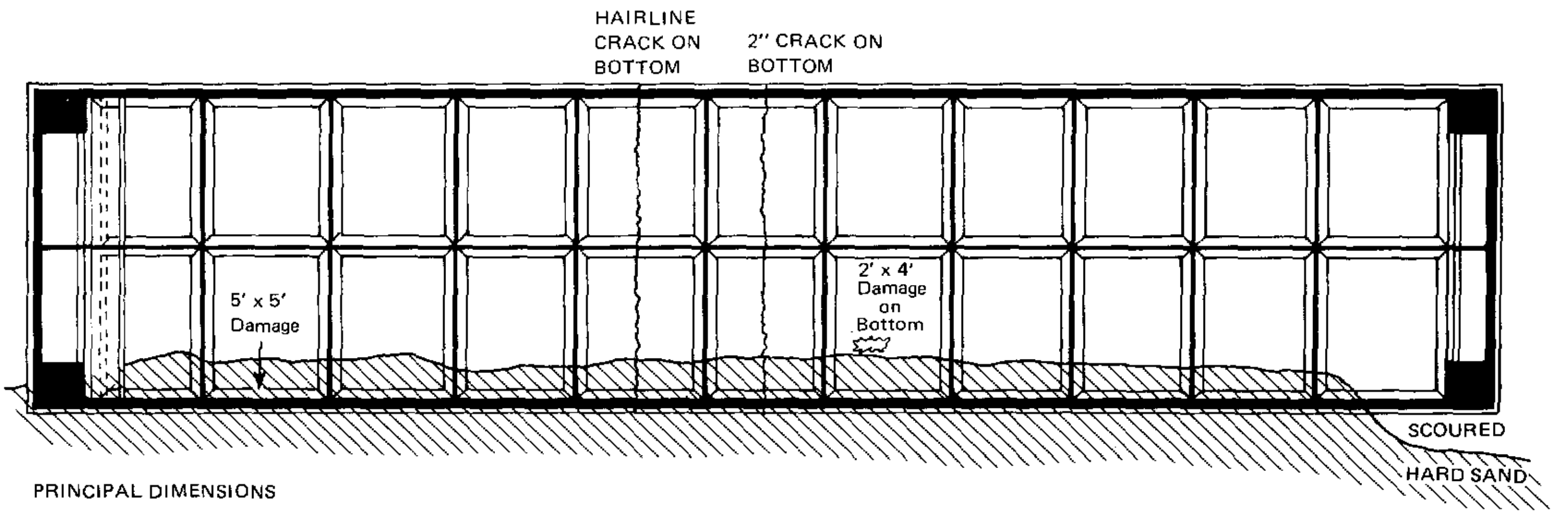
(7) <u>15 SEPTEMBER Survey</u>

The suction cutter dredge 15 SEPTEMBER, the southernmost wreck in the Central Zone, was sunk south of Deversoir Station at the entrance to the Great Bitter Lake. The dredge displaced 2,000 tons and lay on its port side nearly parallel to

FIGURE IV-13
Condition of Concrete Caisson at Survey



SIDE ELEVATION



PRINCIPAL DIMENSIONS

Length	203'
Beam	44'
Depth	40'
Displ.	3800 tons

CONDITION OF CONCRETE CAISSON AT SURVEY

and 12 feet east of the Canal axis in an average water depth of 52 feet as shown in Figure IV-14. The hull was supported by the Canal bottom along its entire length.

The centerline spud (a walking spud) and the starboard quarter spud each 90 feet long and the spud supports appeared undamaged. The centerline spud extended 6 feet below the bottom gate and lay horizontal 34 feet below the surface. The starboard spud extended 70 feet below the bottom gate and lay horizontal 22 feet below the surface. The dredge ladder was secure in its trunnions, and the ladder topping lift was still reeved with the hauling part still on the winch. The gantry was in place with four backstays intact. Both ladder and gantry were clear of the bottom. The sea chest on the starboard side appeared intact, and the main sea suction valves appeared to be open. Starboard storage and ballast tanks contained air pockets varying from 3 to 5 feet deep. Residual oil was found in seven of the nine wing tanks.

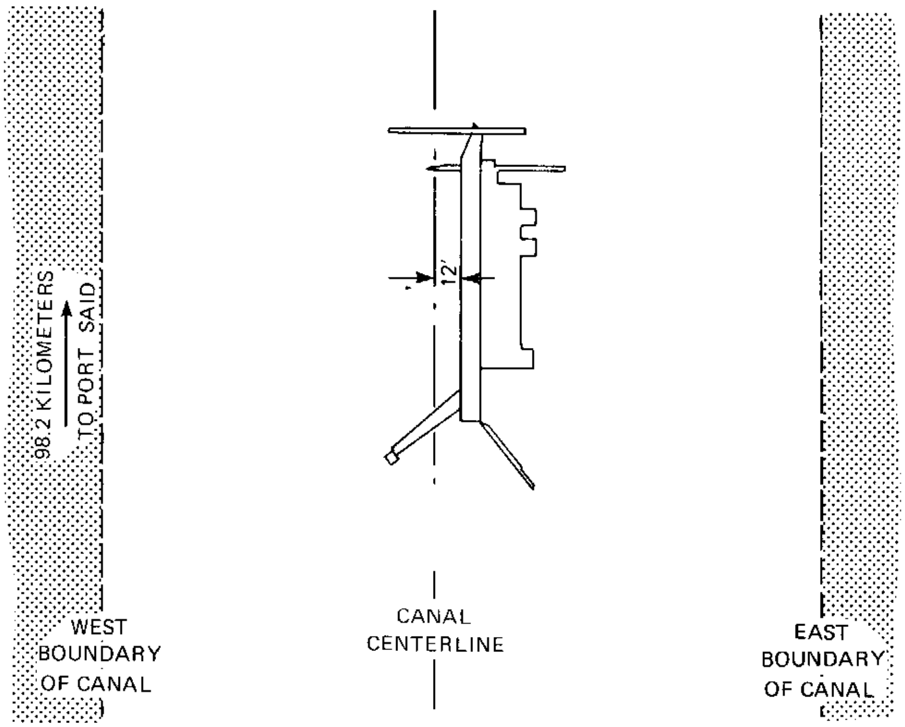


FIGURE IV-14
Location of Dredge 15 SEPTEMBER in Canal

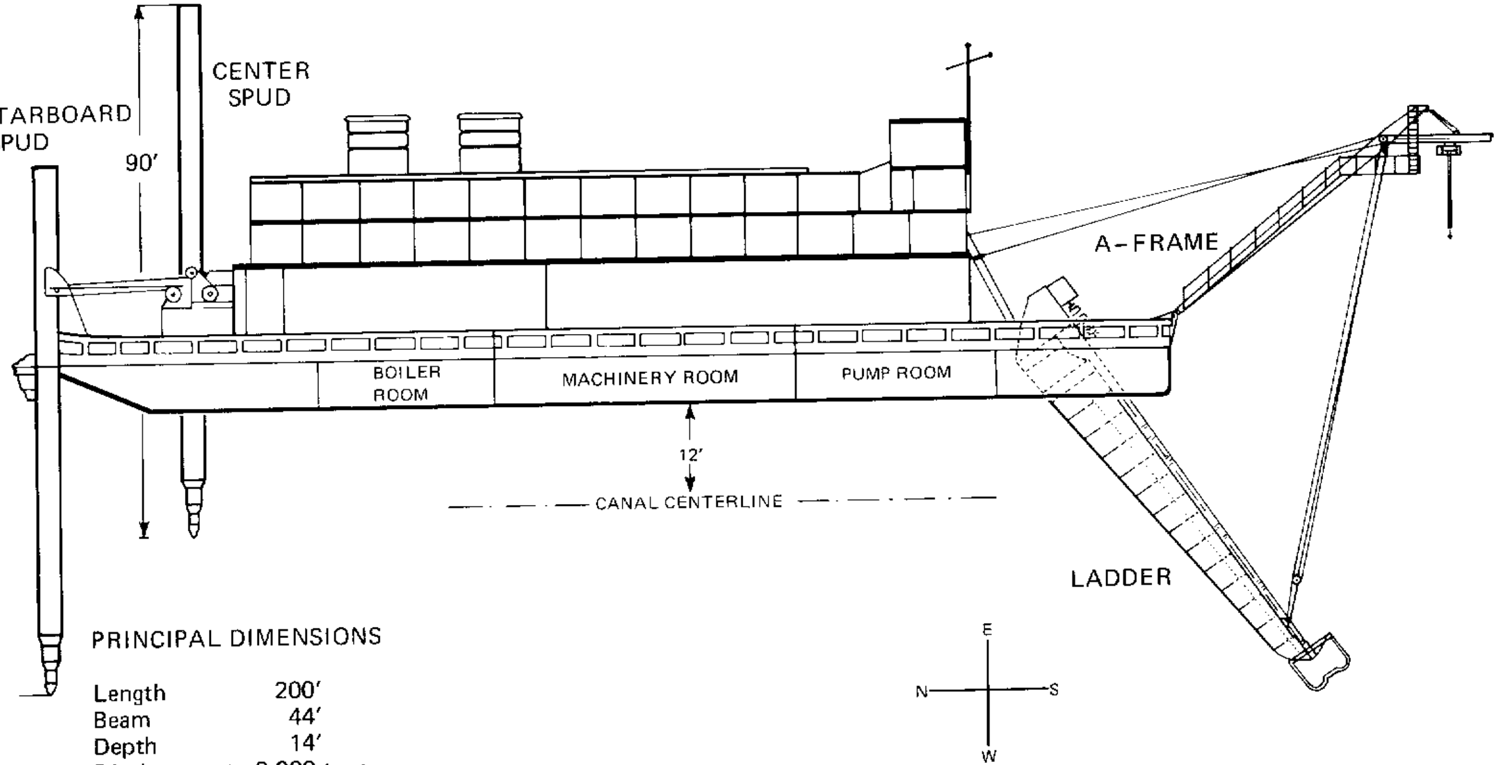
The hull plating appeared to be in sound condition and the hull suitable for further use. Some of the wooden superstructure had carried away, leaving only the steel framing. The hull was dished on the starboard side 60 feet aft of the bow and 3 feet from the turn of the bilge to a depth of 8 inches over an area of 2 square feet. Plating in the way of the dishing had been split along a riveted seam. There was no damage to the bottom of the dredge. That reported sinking was caused by removal of an inspection plate on the main dredge suction line could not be verified. Soft mud varying between 1 and 2 feet in depth covered the main deck edge on the port side. There was silting 2- to 4-feet deep in the pump room and machinery spaces and 6 inches deep in the port bow storage space. The sketch of the dredge 15 SEPTEMBER in Figure IV-15 shows an inboard profile and its location in the Canal.

Since the SCA requested that the dredge 15 SEPTEMBER be returned to service, refloating would be necessary. The survey confirmed the feasibility of refloating by parbuckling, patching, lifting, and pumping.

(8) MAGD Survey

The tanker MAGD, the northernmost of the three wrecks in the Southern Zone, displaced 2,400 tons. The SCA survey reported that it rested on its starboard side, bow toward the southeast at an angle of 12 degrees with the Canal centerline at an average depth of 52 feet. As shown in Figure IV-16, it was actually found lying on its port side, bow toward the west bank, at an angle of 30 degrees with the Canal centerline in 63 feet of water. There were 14 feet of water over the wreck, and it had settled to about 10 feet below the Canal bottom. The hull was supported for about half its length, the Canal bottom having been scoured away for 85 feet at the bow and 90 feet at the stern. Tidal currents in the Southern Zone were exceptionally strong, frequently exceeding 3-1/2 knots, and limited diving operations to 3 to 5 hours per working day.

The hull was in generally poor condition; cargo tank tops were buckled, and plating and rivets were missing. Some plating appeared to have been scarfed out. The superstructure was intact, but damage in the tankage, summarized in Table IV-4, was widespread. The wreck was silted to a depth of 2 to 4 feet



PRINCIPAL DIMENSIONS

Length	200′
Beam	44′
Depth	14′
Displacement	2,000 tons

DREDGE 15 SEPTEMBER
RESTING ON PORT SIDE

FIGURE IV-15
Condition of Dredge 15 SEPTEMBER at Survey

Table IV-4
Summary of Damage to Tankage in MAGD

Space	Damage	Location	Upper Deck Plate
Tank No. 1			
Port			Sections removed
Center			Lifted from deck frames
Starboard	4' scuttle hole	Above turn of bilge	Blown loose
Tank No. 2	2' scuttle hole	Bottom	Sections missing
Port	1' x 2' scuttle hole	Bottom next to No. 3 port	
Center	1' x 2' scuttle hole	Bottom next to No. 3 center	Loose and lifted
Starboard	3' hole blown in	10' turn of bilge	Blown loose
Tank No. 3			
Port	1' x 2' scuttle hole	Bottom next to No. 2 port	75% removed
Center	1' x 2' scuttle hole	Bottom next to No. 2 center	25% removed
Starboard	3' scuttle hole	Aft bulkheat at bilge turn	75% removed
Starboard	18" scuttle hole	Bottom	
Tank No. 4			
Port	14" diam. pipe hole	Bottom	75% removed
Center			25% removed
Starboard			75% removed
Tank No. 5			
Port	2' scuttle hole	Bottom	Sections missing
Starboard			Appeared intact
			Loose and raised from deck frames
Aft starboard Cross bunker	2-1/2' scuttle hole	Bilge turn	Intact
Engine room			
Forward cross Bunker			Gaps in plates
Forecastle			

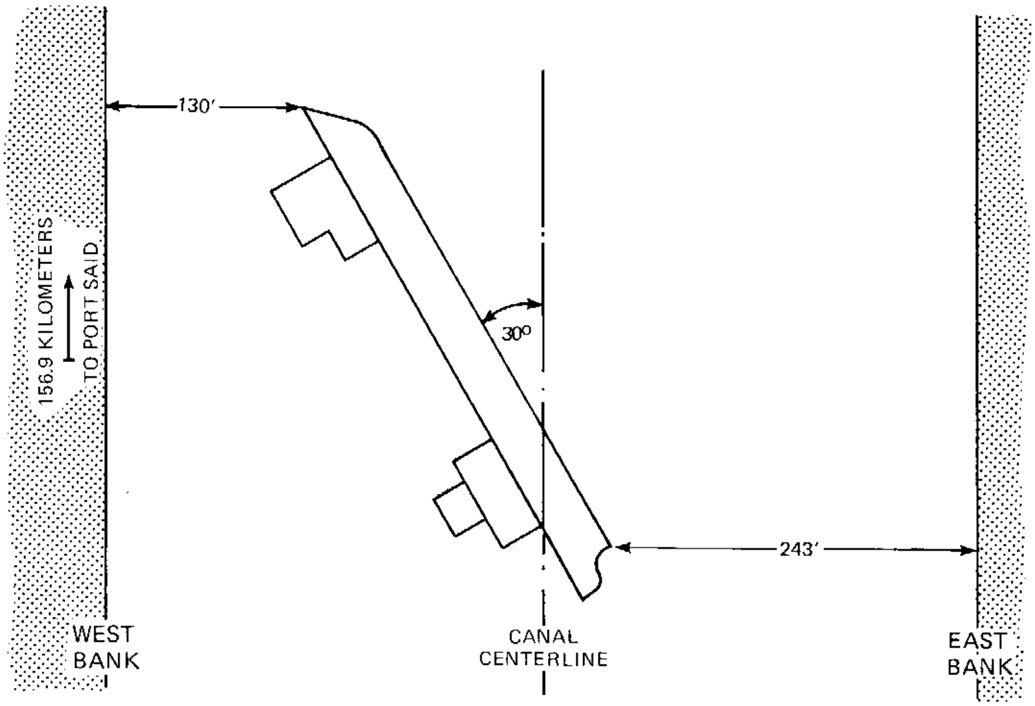


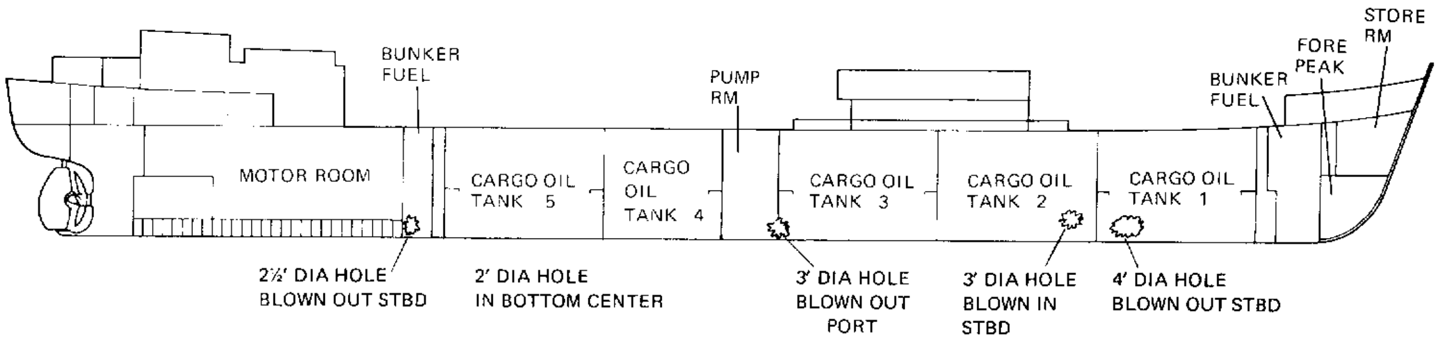
FIGURE IV-16
Location of Tanker MAGD in Canal

in the starboard and center tanks and 4 to 6 feet in the port tanks. Mud was pocketed throughout the entire room with depths varying between 3 to 10 feet. The sketch of MAGD in Figure IV-17 indicates the plating removed and the damage found during the survey.

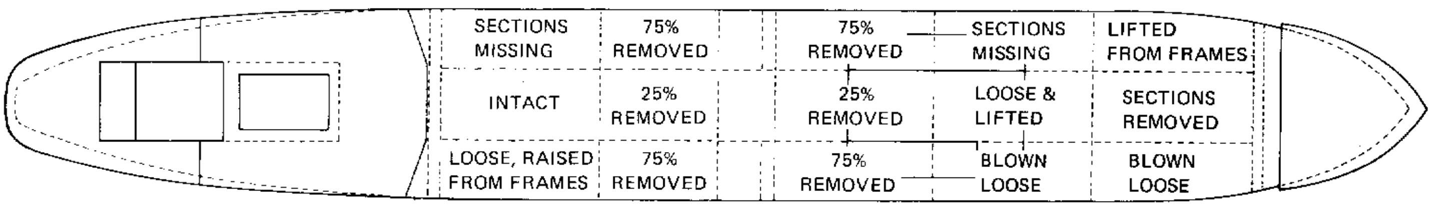
The survey indicated that the wreck could be sectioned forward of the engine room and the sections lifted independently.

(9) DREDGE 22 Survey

The bucket DREDGE 22 displaced 1,200 tons. It lay southeast of the tug BARREH, as shown in Figure IV-18, resting on its starboard side at about 22 degrees past the horizontal. (The 1967 survey had described it as upright.) Its bow was 144 feet from the east Canal bank and its stern about 250 feet from the west bank. It lay normal to the Canal centerline in an average depth of 52 feet of water. The hull was supported by a hard



HULL DAMAGE



MAIN DECK PLATING CONDITION

PRINCIPAL DIMENSIONS

Length	358'
Beam	48'
Depth	27'
Displ.	2400 Tons

CONDITION OF TANKER MAGD AT SURVEY

FIGURE IV-17
Condition of Tanker MAGD at Survey

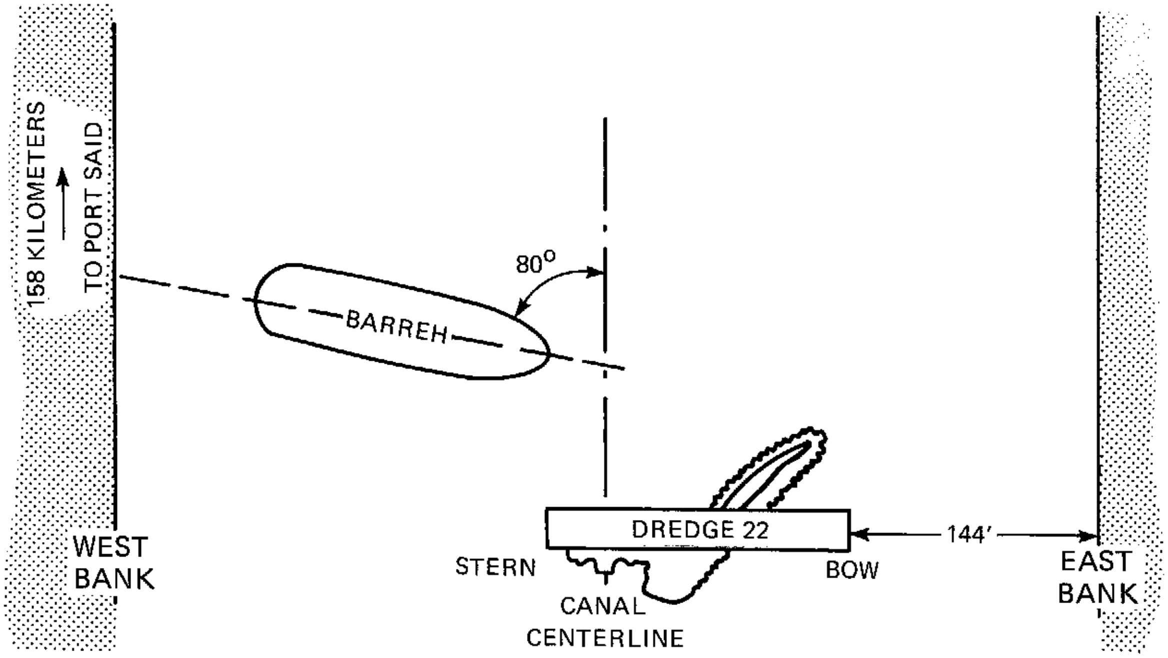


FIGURE IV-18
Location of DREDGE 22 and Tug BARREH in Canal

sandstone bottom with scouring of the Canal bottom, as shown in Figure IV-19.

The hull was in a generally deteriorated condition as a result of damage from scuttling charges and rusting. The bucket conveyor system had dropped below the hull at an angle of about 40 degrees with the ladder 24 feet below the surface and clear of the Canal bottom. Two holes, approximately 6 by 7 feet, were located in the port turn of the bilge. Three holes, 4 by 6 feet, 2 by 3 feet, and 3 by 4 feet, were located in the port turn of the bilge. One hole, 6 by 6 feet, was blown through the bottom amidships. There were three other minor dents or holes. All damage was apparently caused by scuttling action. The shelter deck of the dredge had carried away, leaving only steel framing. Sections of the main deck had been blown open and rusted through. Mud was found 3 to 6 feet deep in pockets between the main deck and longitudinal bulkheads. The sketch of the DREDGE 22 in Figure IV-19 indicates the support of the hull and the damage found in the wreck.

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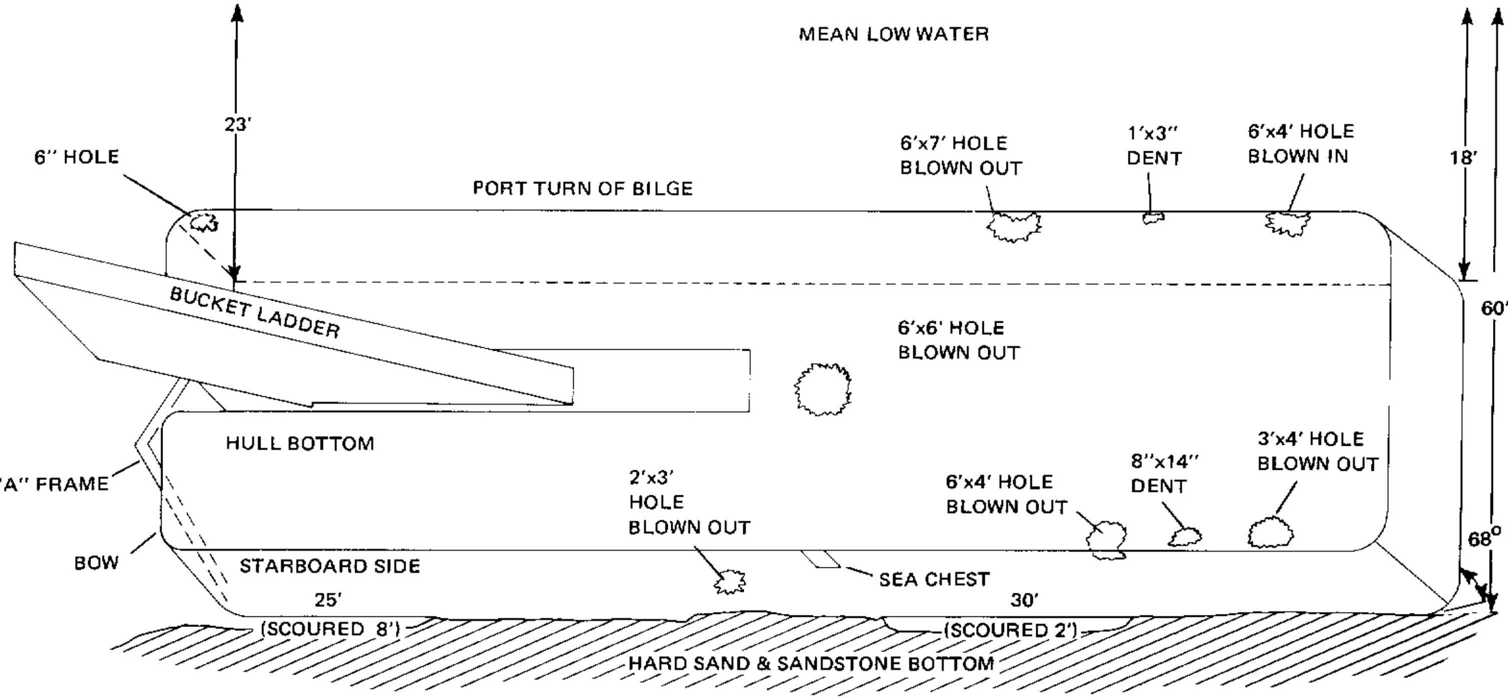


PRINCIPAL DIMENSION

Length	175'
Beam	41'
Depth	13'
Displ.	1500 tons

CONDITION OF DREDGE 22 AT SURVEY

FIGURE IV-19
Condition of DREDGE 22 at Survey

Prior to the survey, the plan had been to clear the DREDGE 22 and the tug BARREH with the heavy-lift craft as the craft moved north. However, the complications presented by the attitude of the DREDGE 22 (which would require parbuckling), the swift current, and the limited space in which to maneuver made it more feasible to bypass these wrecks.

(10) BARREH Survey

The tug BARREH displaced 1,200 tons. It was found with its stern 100 feet from the west bank and with a 10-degree port list. It was at an 80-degree angle to the Canal centerline, as shown in Figure IV-18. The hull was generally supported by a hard sandstone bottom with the exception of the bow, which rested on soft sand. The bow was submerged in 60 feet of water, and the Canal bottom under the hull had been scoured to a depth of 18 inches, as shown in Figure IV-20.

Although the hull was sound, the stack and superstructure above the 01 level had fallen to port and the wheelhouse lay on the Canal bottom. Eight portholes, four on each side, were broken, open, or missing. The hull was silted to a depth of 4 feet in the engine room and 3 feet in the boatswain locker and the compartment aft of the engine room. Figure IV-20 illustrates the hull ground support, silting, and damage found during the survey.

The results of the survey showed that BARREH could be lifted by heavy-lift cranes.

* * * * *

The surveys were completed on schedule. Salvage operations were begun on each wreck as soon as practicable after its survey was completed and the best method of removal was determined. The operations are described in Chapters V, VI, and VII.

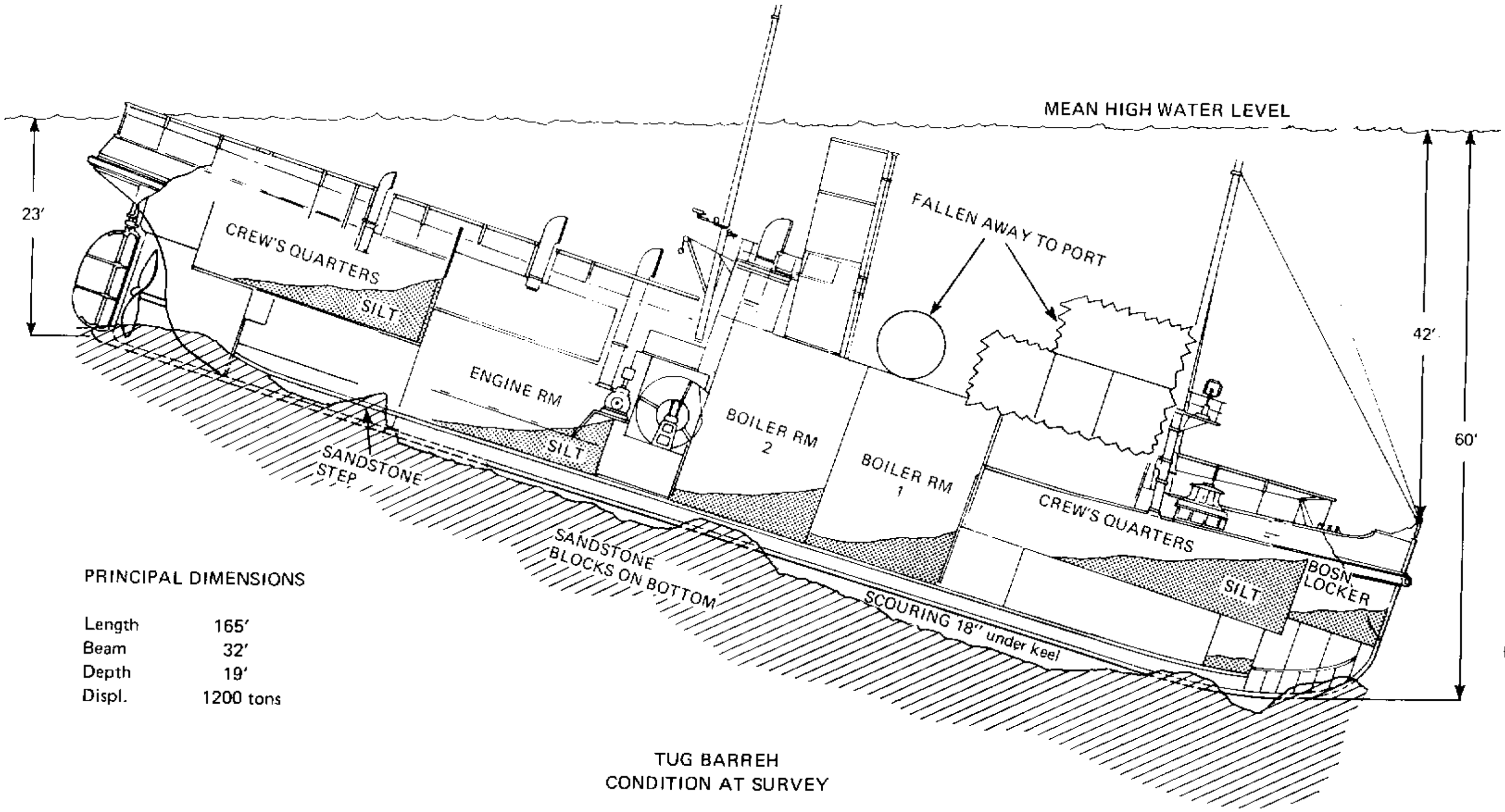


FIGURE IV-20
Condition of Tug BARREH at Survey

V. SALVAGE OPERATIONS IN THE NORTHERN ZONE

V. SALVAGE OPERATIONS IN THE NORTHERN ZONE

MECCA and ISMAILIA were the two wrecks in the Northern Zone of the Suez Canal. The sectioning of these wrecks was given top priority so that the heavy-lift cranes THOR and ROLAND could be fully utilized when they arrived in the Canal. Clearance of MECCA and ISMAILIA would also facilitate access to the Central and Southern Zones. Moreover, it was prudent to initiate the removal of MECCA without delay because it was the largest and most difficult wreck to clear and would, therefore, probably take the longest time to remove of all 10 wrecks. Table V-1 gives the principal dimensions of the two wrecks in the Northern Zone.

Table V-1
Principal Dimensions of Wrecks
in the Northern Zone

Wreck	Length (feet)	Beam (feet)	Depth (feet)	Lift Weight (tons)
MECCA	438	80	32.75	6,733
ISMAILIA	345	44	27.00	1,474

1. SALVAGE PLANS FOR ISMAILIA AND MECCA

The evaluation of the two wrecks by the Suez Canal Authority showed that they were of such an age and condition that return to service was not desired. Clearance plans were then directed toward the quickest, most effective method of removal. The two wrecks could be removed in one of four ways:

Refloating each wreck, towing to a disposal area for grounding and/or sinking

- Lifting each wreck clear of the Canal bottom with heavy-lift ships, towing to a disposal area, and dumping

- Cutting each wreck into sections, lifting the sections clear of the water, towing to a disposal area, and dumping

- Cutting each wreck into sections, lifting sections off the bottom and towing the partially submerged sections to a disposal area, and dumping the sections.

ISMAILIA was planned to be removed by the third option because sectioning plans could be prepared without performing a detailed survey of the wreck. The first option, refloating the wrecks, would require cofferdamming, patching, and pumping hulls of doubtful structural integrity. An operation of this sort would not only be time-consuming, but it also was unlikely to be successful. Although the second option, lifting the wrecks using the heavy-lift craft CRILLEY and CRANDALL, was technically feasible, this option was rejected because the lift craft would not be available in the Northern Zone until near the end of the salvage operation, and this delay was unacceptable. The fourth option, towing sections of the wrecks that were partially submerged to the disposal area, was rejected for ISMAILIA because of the desire to dry dump.

MECCA was planned to be removed by either the third or fourth option for many of the same reasons just described for ISMAILIA. The first and second options were rejected for MECCA as being technically risky. Because MECCA was a larger vessel than ISMAILIA and had to be removed from the Canal as quickly as possible to permit access to the Central and Southern Zones, the fourth option (cutting into sections, towing sections partially submerged to disposal areas, and dumping) was kept open because fewer cuts, and consequently less time and expense, would be required to effect its removal.

Two heavy-lift cranes especially designed for salvage, THOR and ROLAND, each capable of lifting 500 tons, were ordered from northern Germany. THOR was ordered initially and ROLAND about 1 August when its need was justified. The plan was to cut each wreck into sections of approximately 400 tons each, use either THOR or ROLAND to lift the sections, and tow the sections (clear of the water if possible, otherwise partially submerged) to the disposal site.

The original concept was to wet-dump the two wrecks, since wet dumping was simpler and would have allowed sectioning into somewhat larger pieces. The Suez Canal Authority requested, however, that dry dumping be done to facilitate scrapping of the wrecks, and plans were changed accordingly. After the decision was made to section ISMAILIA and MECCA, detailed planning for the operation began. A brief salvage survey of each wreck was conducted to determine its attitude, the extent of damage, and silting. The following subsections summarize the results of the salvage survey and the plans that were developed for oil and silt removal, sectioning, cutting, and lifting.

(1) Survey Results

Because the decision had been made initially to section and lift the two wrecks rather than to refloat them, a finely detailed salvage survey was not necessary. Accordingly, a salvage survey was conducted at the end of May to verify the feasibility of sectioning and lifting the wrecks, and to define the general conditions of the wrecks and their surroundings.

ISMAILIA was found to be upright rather than lying on its starboard side, as described in the 1967 SCA survey. The hull was submerged in 52 feet of water and was lying at a 60-degree angle to the Canal centerline, its bow toward the west bank and about 82 meters from the revetment (the facing sustaining the Canal sidewall). Approximately 17 feet of water covered the main deck. The ship was clear of the Canal bottom at the bow and stern and was supported by the bottom, under the mid one-third of its length. The superstructure had been demolished completely, and the shelter deck, much of the main deck, and the side plating down to the main deck had been removed. Although most of the propulsion and other machinery had been removed, the boilers, propeller, and shaft remained in place and all frames were intact. The hull contained considerable silt.

MECCA rested on its starboard side at a 75-degree list and at a 75-degree angle to the Canal centerline. The bow was in 13 feet of water 26 feet from the west bank; thus, much of the bow and superstructure were above water. The stern was in 65 feet of water about 180 feet from the east bank. The hull was found to be intact and supported by mud more than 80 percent of its length. The starboard side could not be surveyed because it was buried in the mud. Considerable debris was found inside the hull.

The surveys of ISMAILIA and MECCA are described in more detail in Chapter IV.

(2) Oil Removal Plan

The amount of oil onboard ISMAILIA could not be determined because information on the arrangement of the tankage could not be obtained. However, since the ship had been undergoing scrapping before it was sunk, the quantity was estimated to be small. As a result, it was decided to section the ship assuming no oil was present, revising that approach if significant quantities of oil were released during cutting operations.

A substantial quantity of oil was found on the surface of MECCA's compartments, which impeded diving operations and increased the risk of fire ignited by above-water cutting operations. The survey indicated that the ship's tankage contained oil equivalent to Bunker C, but determination of the precise location and arrangement of the tanks at the beginning of the operation was hindered by a lack of ship's plans. About a week later on 7 June, however, a set of general arrangement plans for MECCA was located in England and hand-carried to Suez. These plans indicated two groups of tanks, a group in the after part of the ship and the principal tankage near the midship section, as shown in Figures V-1 and V-2. It was planned to remove oil from the tanks by a hot-tap method, which permits penetration of an oil tank from outside for removal of the oil without spillage. The sequence of oil removal would be constrained by the progression of cutting work. Men and equipment would be diverted to oil removal operations as necessary to clear a way for cutting.

(3) Silt Removal Plan

Both wrecks contained a considerable quantity of silt and other debris that had to be removed to reduce the lift weight of the sections. It was determined that silt could be removed by airlift.

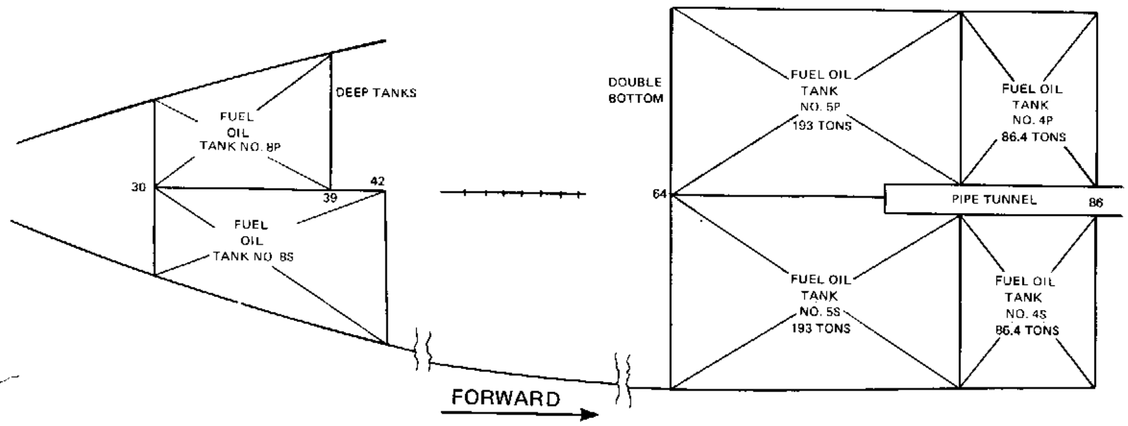


FIGURE V-1
MECCA Tankage Plans: Deep Tanks and Double Bottom Tanks

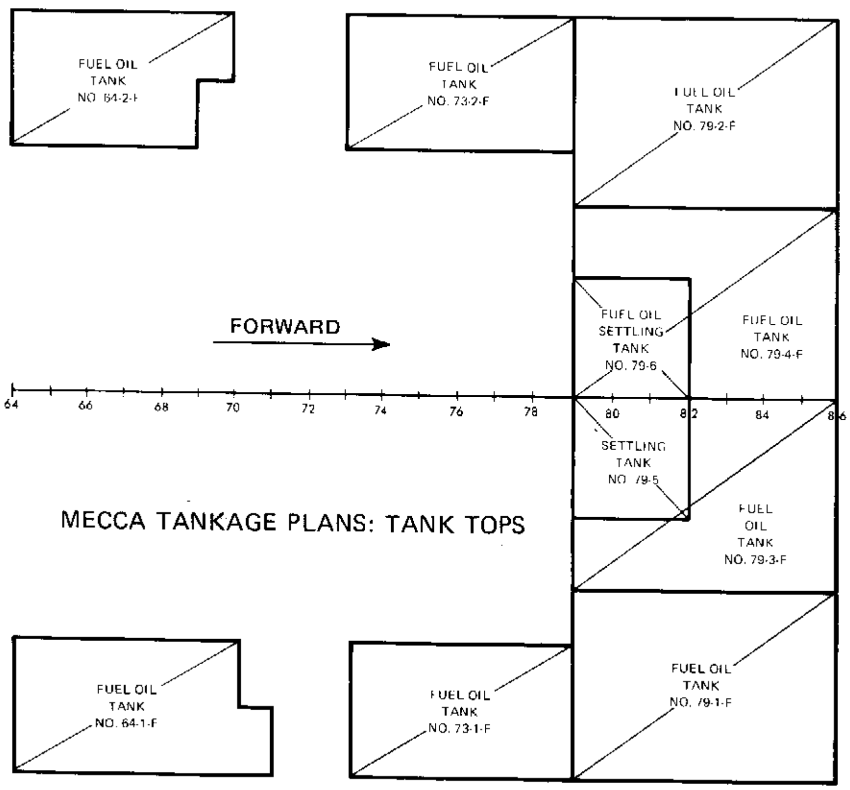


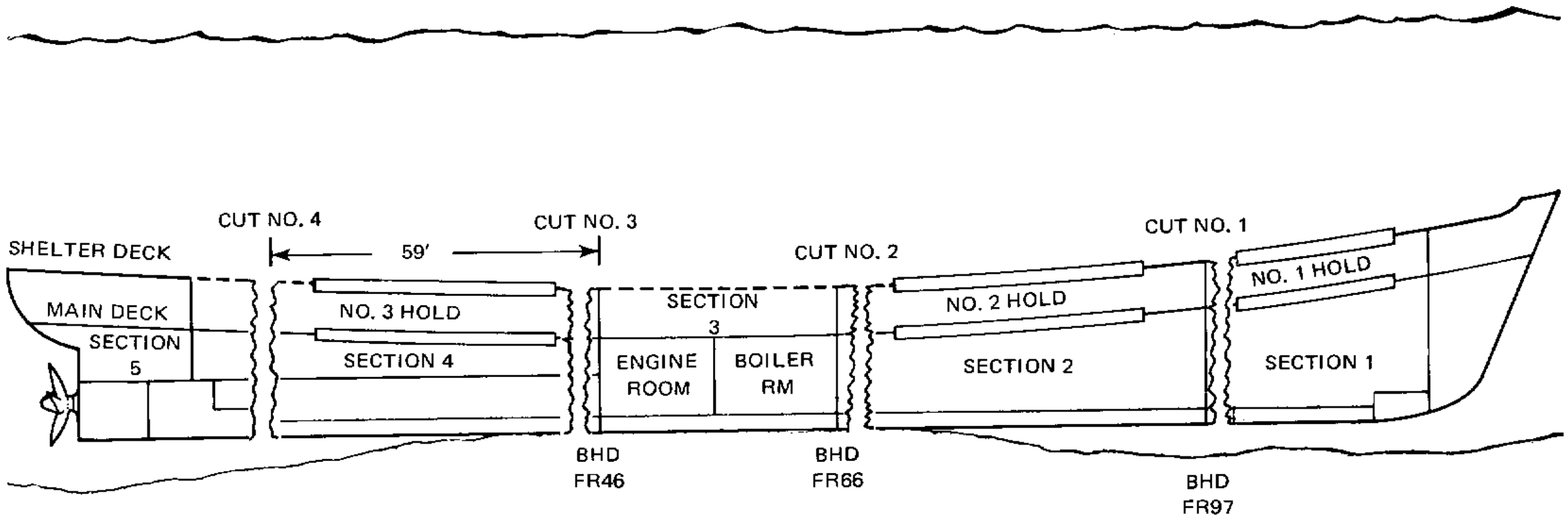
FIGURE V-2
MECCA Tankage Plans: Tank Tops

(4) <u>Sectioning Plan</u>

The governing factor in determining the number and size of cuts was the available lift capacity. Sections were limited to a maximum of 500 tons for each heavy-lift crane to stay within the hook capacity of a single crane. In the early stages of the operation, an 80-ton-capacity crane belonging to the SCA was available to lift superstructure sections. The SCA requested that, where possible, the sections be placed on the Canal bank between kilometers 2.5 and 3.3, measured from Port Said, to facilitate scrapping. Since the cutting plan called for sectioning into pieces that could be lifted by the cranes and since the area designated for such was suitable for dry dumping, it was planned to lift the wreck onto the dry bank wherever possible.

Prior to its sinking, ISMAILIA was being scrapped. Consequently, the superstructure decks, much of the shelter deck, and all the machinery had been removed. The principal parts of the wreck requiring cutting included the main deck, sides, tank top, bottom, propeller shaft, and two longitudinal hatch stiffeners. Two sectioning plans, the first involving two sections and the second involving five sections, were considered. If the wreck were cut into two pieces, the sections could be moved with a heavy-lift crane, using both the deck lifting gear and the main boom, in a 1,000-ton capacity mode, and deposited in a wet-dump area. Using the heavy-lift cranes in this mode was somewhat restrictive in that positioning was critical and the wreckage could not be lifted clear of the water for dry dumping. However, the hull could be cut relatively easily into five sections of manageable size (about 300 tons each) for lifting by a heavy-lift crane and depositing in a dry-dump area. This plan for sectioning ISMAILIA is illustrated in Figure V-3. Further, the relatively simple cutting of ISMAILIA would have the important advantage of serving as a training ground for divers who were known to have little experience in this work.

Since MECCA was a larger ship than ISMAILIA, preparation of its sectioning plan was proportionally more difficult. In planning the layout and position of cuts in areas where there was little interference, advantage could be taken of structural discontinuities, such as hatch openings. Cuts could then be routed around bulkheads and other areas of concentrated structural strength. In way of machinery spaces, advantageous cuts were



PRINCIPAL DIMENSIONS

Length	345'
Beam	44'
Depth	27'
Displ	1400 tons

SECTIONING PLAN FOR ISMAILIA

FIGURE V-3
Sectioning Plan for ISMAILIA

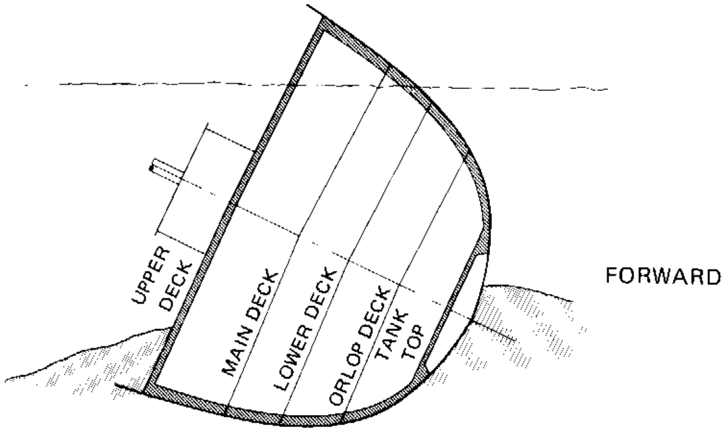
more difficult to plan and had to be routed clear of machinery and the heavy structure supporting it. A major consideration in positioning the cuts involved whether all the superstructure should be removed by separate cuts or the vertical cuts should be carried through to the promenade deck and the whole sections lifted intact. If the wreck were divided into 14 sections, lifting an entire section was within the capacity of the available lifting equipment. Minimizing the number of cuts was desirable to reduce the complexity of the operation. Elimination of a horizontal cut at the upper-deck level would remove the need to cut heavy transverse frames. Further, this cut would be complicated by the fact that these decks had been used as passenger quarters and thus were compartmented into numerous staterooms, heads, and other small spaces. The lightly structured joiner bulkheads would be easily damaged by explosive cutting, and much time could be lost while the continuity of cuts was verified by divers.

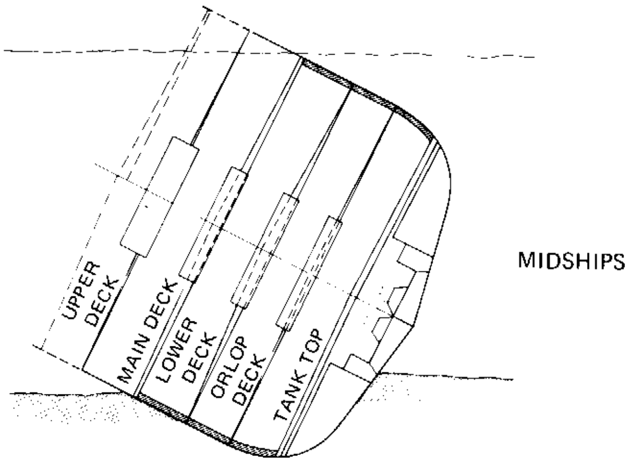
The final plan was to cut the main hull of MECCA into 14 sections to be moved with the heavy-lift crane, and to cut the lightly structured superstructure above the promenade deck into 10 major sections of no more than 70 tons each. These sections could then be moved by the 80-ton SCA crane. Typical sections in way of the cuts are illustrated in Figure V-4. Figures V-5 and V-6 illustrate the sectioning plan for MECCA. Following convention, the 13 cuts in the main hull are numbered from the bow aft; frames are numbered in the commercial fashion, from the stern forward.

(5) Cutting Plan

Explosive, oxyarc, and flame cutting were to be used to section the wrecks. The majority of the underwater cutting would be accomplished by explosives, and abovewater cutting would be completed with torches. Locally fabricated, diver-placed charges of plastic C-4 explosive packed into 2-inch angle iron sections (angle charges) or 2-1/2-inch fire hose (hose charges) at 2 to 5 pounds per linear foot and electrically detonated, would be used to accomplish the majority of underwater cutting. In order that divers would not be disoriented when returning to the scene of the shot, charges were to be sized to sever the member being cut with minimum deformation of the structure. The weight of the charges would be increased

FIGURE V-4
Typical Cut Sections of MECCA





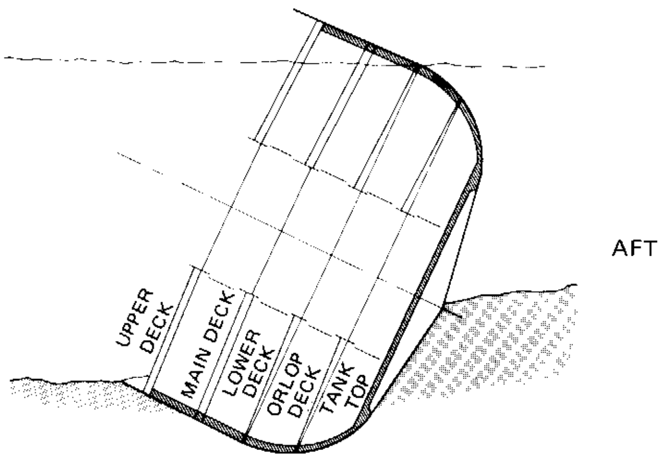
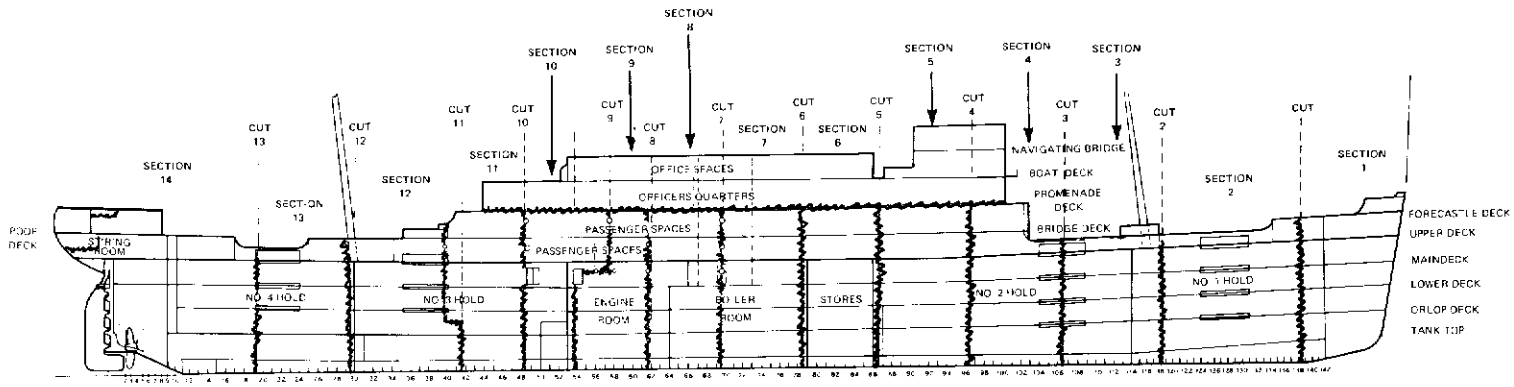


FIGURE V-5
Sectioning Plan for MECCA

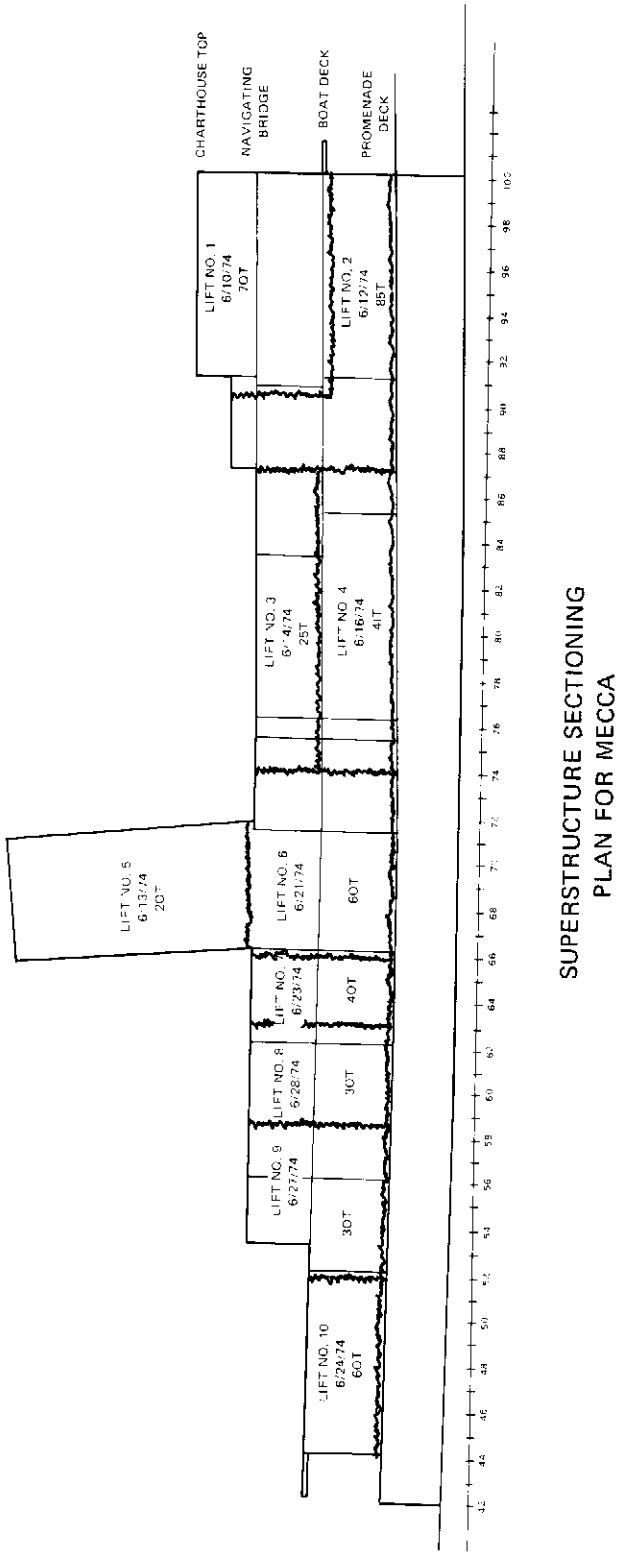


PRINCIPAL DIMENSIONS

LOA	438′
LBP	415′
B	80′
Depth	32.75′
Displ. (F.L.)	1200 Tons

SECTIONING PLAN FOR MECCA

FIGURE V-6
Superstructure Sectioning
Plan for MECCA



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as necessary to cut heavy structural members and the propeller shaft. To determine the effects of explosive shock on the Canal banks and to prevent damage from excessively large charges, seismographic instruments would be used to measure bank loadings.

Cutting would be accomplished by using many short cuts rather than a few long cuts to avoid weakening contiguous structures and to reduce the possibility of diver disorientation. Cuts would be lengthened as the operation progressed and the divers gained experience. Figure V-7 is a typical charge used for hull cutting.

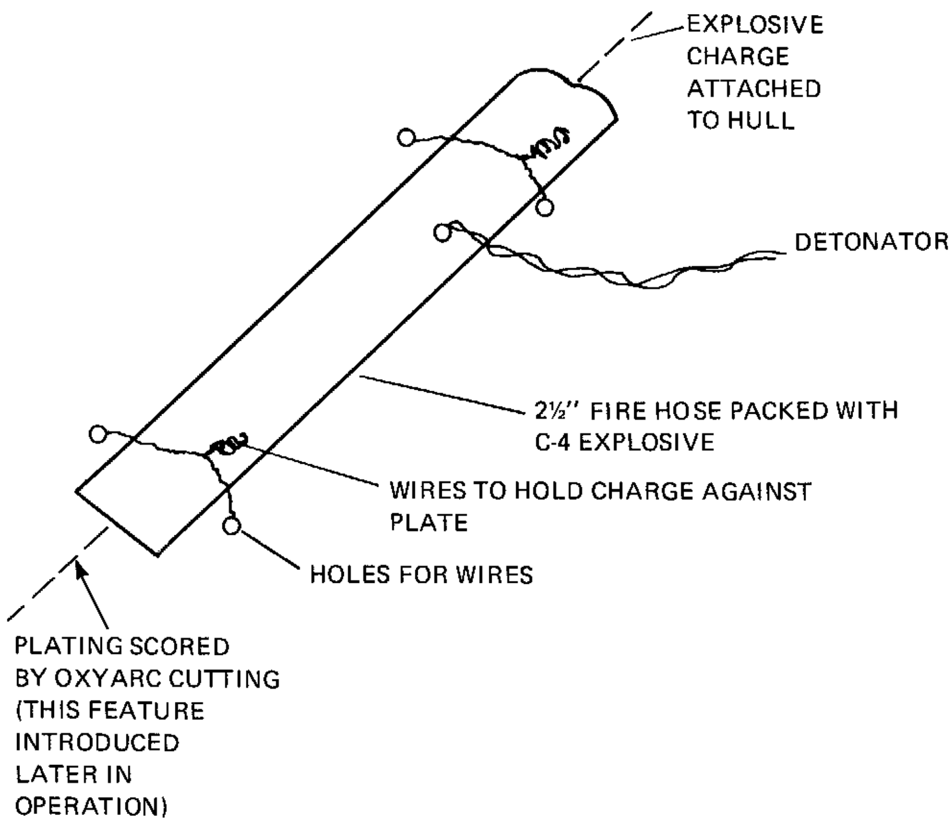


FIGURE V-7
Typical Charge for Shearing Plate

Oxyarc cutting would be used for such secondary cutting efforts as:

- Cutting access openings
- Cutting areas with easy access
- Cutting near the surface
- Cutting holes to tie explosive charges in position.

Oxyarc equipment was available in sufficient quantity to employ a maximum of eight burners at a time.

ISMAILIA was to be used for training in explosive cutting since it was a relatively simple wreck and afforded easy access for perfecting this technique. Each of the four circumferential cuts was estimated to require 2 to 3 days. Thus, the entire cutting operation could take about 10 days. Based on four hull cuts averaging 500 feet each and 2 pounds of explosive per foot, the total compound C-4 required was expected to be 4,000 pounds for the basic hull. After cutting, the sections would be buoyed off and left to await arrival of the 500-ton crane.

Since a large portion of MECCA's side and superstructure was out of the water, burners working topside with oxyacetylene torches would be used to remove this portion of the wreck. Underwater cutting would be carried out using the techniques developed and refined on ISMAILIA, using both oxyarc and explosive cutting. It was planned that the divers would enter the hull through access holes cut in the side, clear away a strip along the overhead and bulkheads down to the deck, then place and detonate the charges. Cutting would begin on the promenade deck and proceed downward to the bottom.

Good salvage practice dictates the development of alternate plans. This was particularly necessary for MECCA because the possibility of major unknowns, such as extensive silting in the hull and the presence of cement, insulation, piping, wireways, and other interference, might make cutting from the inside impractical. An alternate plan envisioned tunneling under the wreck to provide working space for divers to cut or place charges from the outside.

(6) Lifting Plan

Before scrapping operations had begun on ISMAILIA, its lift weight would have been between 1,600 to 1,700 tons. As a wreck in the Canal, with its machinery and superstructure removed, its lift weight was estimated to be somewhat less. Arrival of the heavy-lift crane THOR, which would make the principal lifts, was planned for the mid-August, by which time a substantial backlog of lift work would have accumulated from sectioning operations to keep the heavy-lift crane fully employed. As described in Appendix G, THOR was a shearleg type A-frame derrick with an additional two sixfold deck purchases. It had a fixed outreach of 36 feet beyond the pontoon and was capable of lifting 500 tons from the main hook and an additional 500 tons using the gin tackle.

The lifting plan basically consisted of 2-3/8-inch dielock chains to be rigged through strong points, such as hawses, or through cutouts in the hull. The chains would be connected with detachable links to 2-7/8-inch wire slings rigged to the double lift hooks on the heavy-lift crane. Lift holes would be cut in the side shell.

Detailed weight data were not available for MECCA; therefore, initially, a lift weight was figured at 4,600 tons, using data provided by the SCA. Adding this figure to MECCA's registered deadweight of 4,668 tons resulted in a displacement of 9,268 tons. Combining this displacement with the principal dimensions of MECCA yielded a block coefficient of 0.566, which indicated a much finer ship than MECCA was known to be. An approximation of MECCA's block coefficient and displacement, using its known speed-length ratio, gave a more reasonable full-load displacement of 12,026 tons and lift weight of about 7,300 tons. Initially, lifting all 14 main hull sections was planned for single heavy-lift crane lifts. Two lifts would be required for each: the first lift would invert the section and move it a short distance from the hull. The crane would then be repositioned parallel to the wreck and the section lifted again and transported to the dumping area. Holes for rigging the lift would be cut in the bottom. The SCA 80-ton crane would be used to remove superstructure sections. These plans were modified as the operation progressed.

2. SALVAGE OPERATIONS ON ISMAILIA

Actual salvage operations in the Suez Canal began with the initiation of the survey on 29 May and the commencement of silt removal 3 June 1974, with the first cutting operation 14 June.

(1) Oil Removal Operations

Because ISMAILIA was being scrapped before it was sunk, it had been concluded that the ship contained little or no oil. On this assumption, no oil removal operations were planned. During the salvage operation, salvors were alerted for signs of oil leaks, but there were none.

(2) Superstructure Removal Operations

During scrapping, ISMAILIA's superstructure had been removed, which left only the hull proper to be sectioned.

(3) Silt Removal Operations

Silt had to be removed from ISMAILIA's hull prior to commencing cutting operations to permit access in way of the double bottoms and to lighten the wreck for lifting. The weight of silt in the hull was originally estimated to be 1,700 tons. Calculations later placed the total at 2,257 tons. On 3 June, the SCA barge outfitted for diving was moored over the wreck and silt removal operations were begun.

As the magnitude of the silt problem became more apparent, horizontal cuts at the tank tops were considered so that the silt could be washed over the side through them. Such cuts would have been difficult because of the numerous transverse frames in way of the proposed cuts. They proved unnecessary, however, because conventional airlifting alone successfully removed the top layers. Hard-packed lower layers had to be broken up with a high-pressure jet pump (500 GPM at 300 psi) prior to airlifting, but once broken up were airlifted from the wreck without difficulty.

During the 11-day period of silt removal operations, 4 to 6 feet of silt were removed from the engine room, three cargo holds, and the shaft alley. Contrary to expectations, the double bottoms contained no silt. Silt removal was time-consuming but did not present any significant technical problems. Early operations were plagued by clogging of the airlift inlet with loose debris. This problem was eliminated by rigging a wire across the inlet. Table V-2 summarizes the total silt removal and the diver bottom time expended during the operation.

Table V-2
Summary of Silt Removal Operations in ISMAILIA

Location	Silt Removal (tons)	Diver Time (hours)
Number 1 hold	291	13
Number 2 hold	907	40
Number 3 hold	618	28
Engine and boiler rooms	441	10
Total	2, 257	91

(4) Cutting Operations

After a final airlift sweep was made of ISMAILIA on 14 June to remove residual silt in the engine room and number 1 hold, cutting operations on the hull began. (A significant portion of shell and deck plating had been removed, which facilitated operations to section the hull proper.) Initially, work proceeded slower than had been anticipated while the divers developed experience with placing explosive charges; it could have been hastened by using more oxyarc cutting. The use of explosives was stressed, however, because ISMAILIA was used for training in developing explosive expertise for use on more difficult work where explosive cutting could be mandatory.

As operations progressed, explosive-cutting techniques improved noticeably as the divers gained experience and confidence. During early cuts charges of about 100 pounds were fired in increments using delayed detonation. However, the seismographic instruments that were recording the shock loadings on the Canal banks during these explosive-cutting operations indicated that charges of several hundred pounds could be detonated without bank damage; hence, delayed detonation was discontinued.

Work in making the four cuts progressed satisfactorily in the usual sequence of tank top, bottom, sides, and main deck and was completed by the end of the first month of salvage operations on 28 June. Details of a typical cut, cut number 2, are presented in Appendix J.

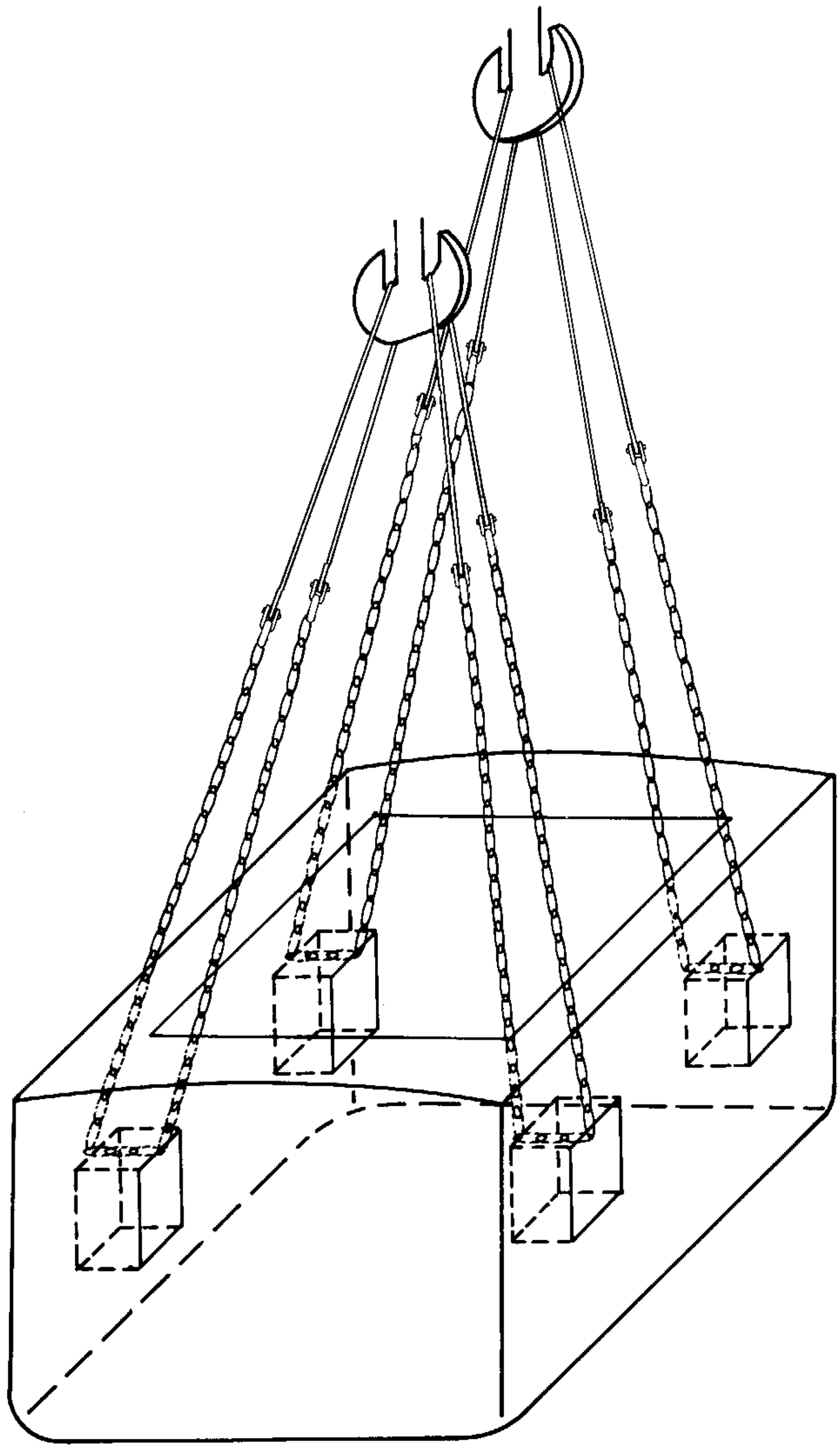
After 14 days and an expenditure of 2,438 pounds of explosive, ISMAILIA had been cut into five sections. With the completion of cutting, operations on ISMAILIA were suspended on 28 June to await the arrival of the heavy-lift cranes.

(5) Lifting Operations

With the first heavy-lift crane (THOR) due to arrive on 14 August, salvage operations on ISMAILIA resumed on 13 August, when work was undertaken to make the connecting points for the lifts. Each section was made ready by burning two lift holes in each side, port and starboard, typically 10 feet down from the main deck. Lifting then began with the bow section and was completed with section 3, the midship section.

The first lift, the bow section, commenced on 15 August as messenger wires were passed through the hawse pipes and the after lifting windows. Divers from the heavy-lift crane THOR shackled the messenger into 2-3/8-inch lifting chains and reeved them through the hull openings. The 2-7/8-inch wire lifting slings were then connected to the chain with a detachable link. The lift arrangement is illustrated in Figure V-8. Upon the first lift attempt, it was found that the after lifting slings had ripped the skin of the ship in way of the lifting windows and that the two sections were still connected. Divers cut the connecting sections and rerigged the after sling, running the lift

FIGURE V-8
Typical Lift Arrangements on ISMAILIA



wire under the hull rather than through the hull. On 21 August a successful lift was achieved, and the section was moved to a dump area. Figure V-9 shows the bow section of ISMAILIA being lifted, and Figure V-10 illustrates it in the dump area.

The stern section was then rigged with a 2-3/8-inch chain passed under the counter with a 1-inch messenger wire (based on the experience with the bow section, the original plan to make a forward connection through lifting windows was abandoned in favor of slings rigged under the hull). After rigging was completed, the section was hoisted clear and moved to the dump site on 23 August. The first lift had required 7 days to rig, lift and dump the bow section, whereas the second lift required only 2 days for the same sequence.

At this time the cranes concentrated on MECCA, using ISMAILIA lifts for crane employment if delays should develop in MECCA.

The third lift, section 2, presented few problems. It was rigged with one shot of 2-3/8-inch chain under the section at each end connected to 20-foot long 2-1/4-inch lift slings. Two days later on 28 August, it was lifted and transported to the dump site. The absence of delays in this third lift confirmed the improvement in cutting techniques.

Later on 30 October, ROLAND (the sister crane to THOR having arrived from Germany in the meantime) was shifted from the MECCA to ISMAILIA to lift the remaining two sections. Section 4, the fourth lift, was moved to the dump area uneventfully on 5 October. The last section of ISMAILIA to be moved was unbalanced. It had been rigged for a uniformly distributed load, but the boilers and an accumulation of mud located around the boilers at the forward end of the section caused an excessive load on one hook. The slings were repositioned on 10 October after an abortive first lift attempt. A second attempt, made the same day, was successful. The section was lifted and moved to the dump area, where fire hoses were used to wash out about 80 tons of silt to lighten the section sufficiently to permit it to be lifted to the Canal bank. All five ISMAILIA sections, as deposited in the dump area, are shown in Figure V-11.

FIGURE V-9
Lift of ISMAILIA Bow Section

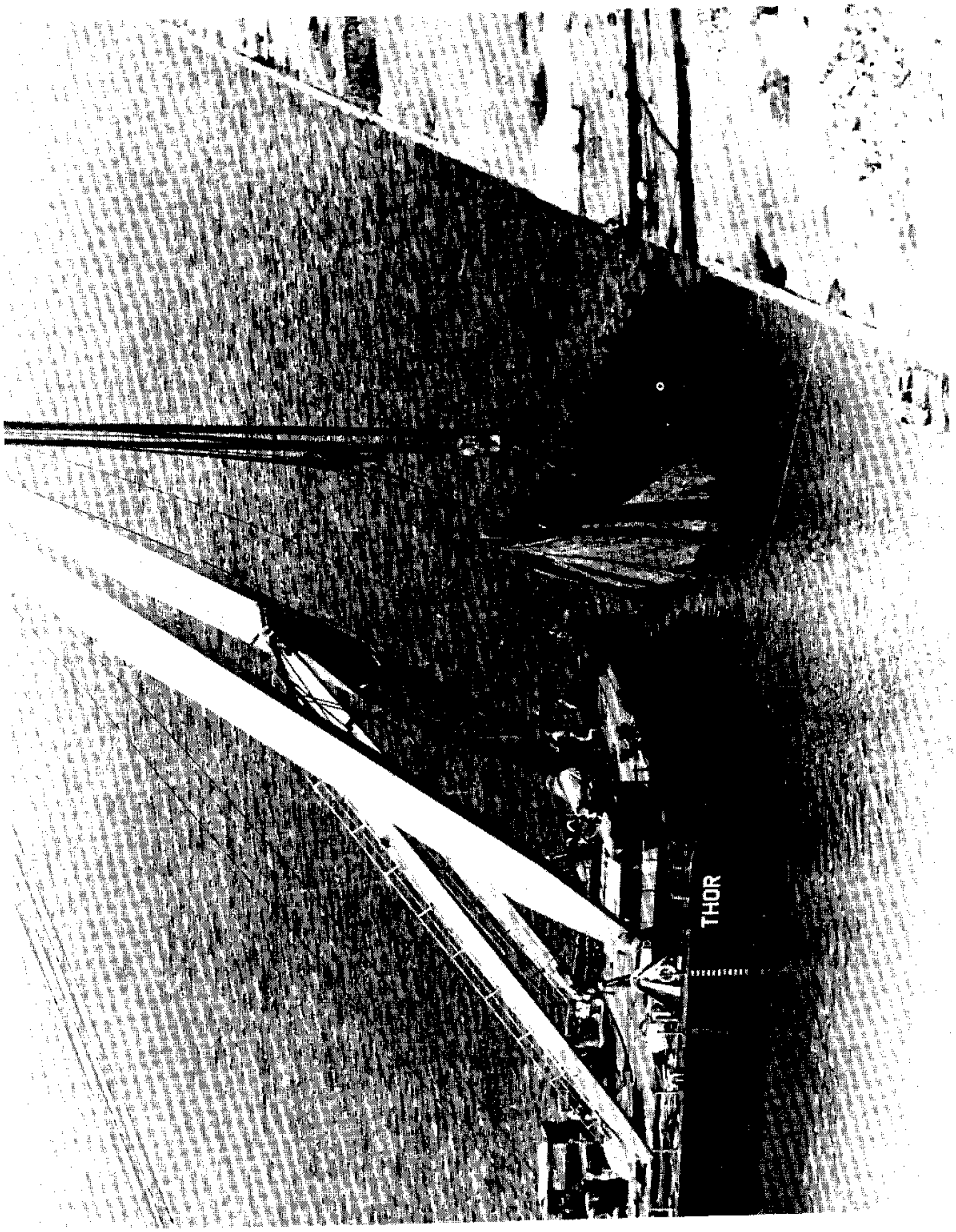


FIGURE V-10
ISMAILIA Bow Section in Dump Area

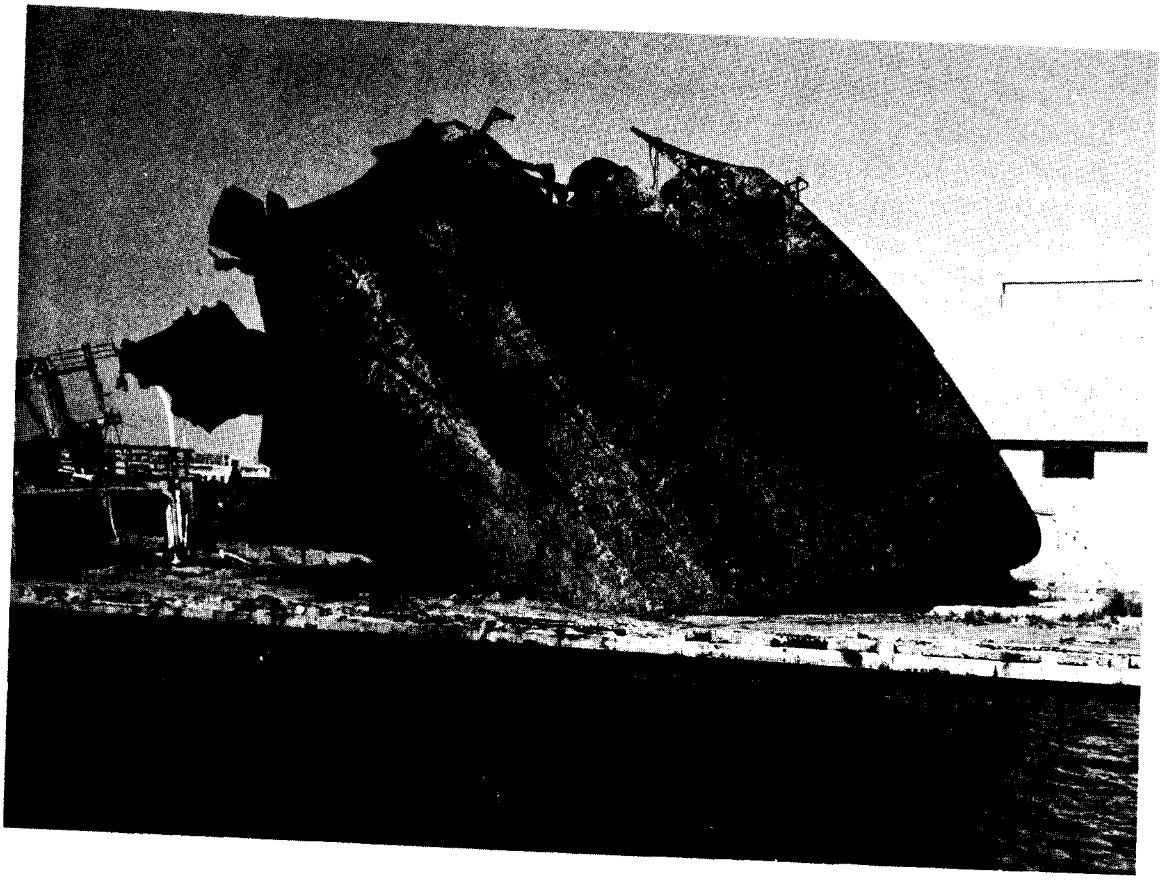


FIGURE V-11
ISMAILIA Sections in Dump Area
Near Port Said

3. SALVAGE OPERATIONS ON MECCA

Salvage operations on MECCA commenced on 29 May 1974 as soon as practicable after the first contingent of salvage personnel had arrived in the area and outfitted Suez Canal Authority barges as work platforms. To improve access to the wreck, the SCA had installed a foot bridge from the Canal bank to the bow of MECCA and walkways with lifelines around the waterline of the wreck. Figure V-12 shows MECCA at commencement of salvage operations.

Initially, three operations were carried out concurrently on the wreck:

- A diving survey, followed immediately by underwater oxyarc cutting
- Oil removal operations to remove surface oil and then to remove oil from the tanks
- Nonexplosive cutting on the exposed superstructure to section it into pieces suitable for lift by the SCA 80-ton crane.

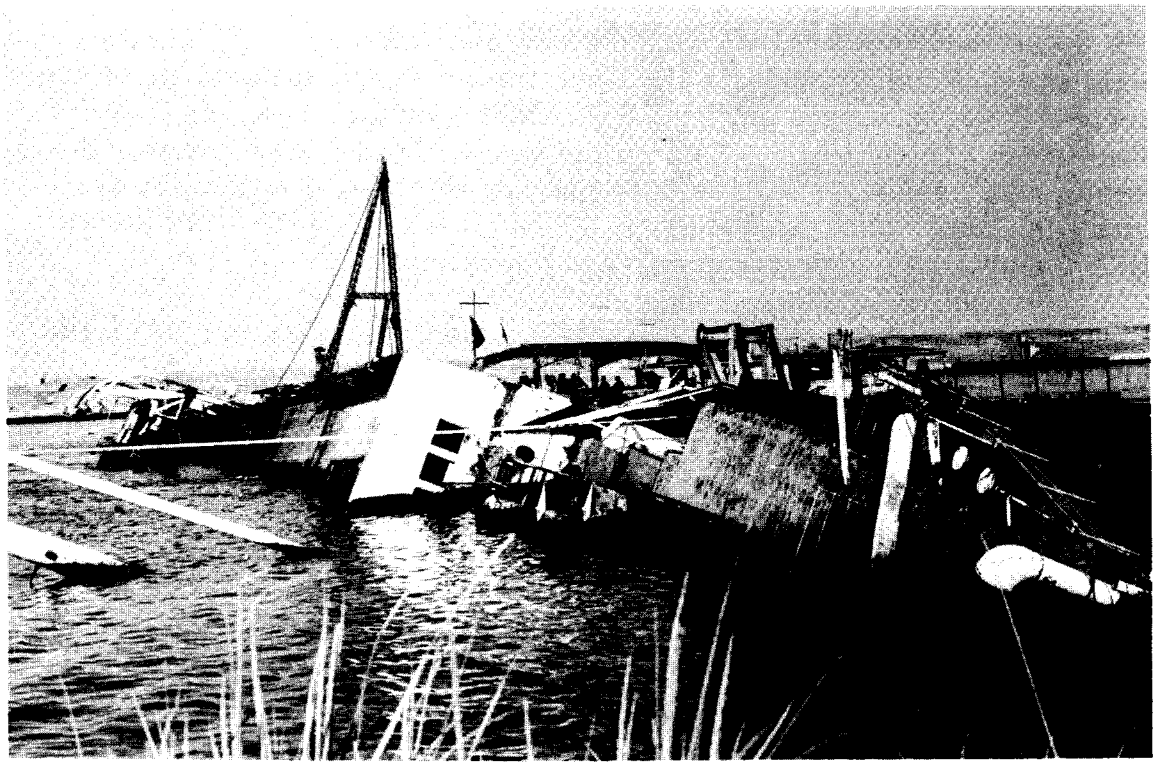
(1) Oil Removal Operations

Oil removal operations began on 2 June, shortly after completion of the MECCA salvage survey on 29 May. The operation began using Suez Canal Authority pumps, but these proved unsatisfactory. Pumps were flown in from the United States. An oil barge was provided by the SCA. Oil was removed simultaneously from the midship and after tankage areas with the major effort in the midship tanks.

The surface oil was essentially removed without difficulty in 1 day. However, seepage continued to reappear during the remainder of the salvage operation and required intermittent collection as significant amounts accumulated. In the interim, spray and air curtains were rigged to minimize interference with divers.

It was planned to remove the oil from MECCA by the hot-tap method, which permits penetration of an oil tank from the

FIGURE V-12
MECCA at Commencement
of Salvage Operations



outside for removal of the oil without spillage. Accordingly, the first two hot-tap flanges were put in place in the midship tanks during the first week of salvage operations. Pumps and fittings arrived from the United States a week later, and pumping operations commenced shortly thereafter. Figures V-13 and V-14 show a hot-tap flange in place and an oil removal pump in operation.

Less than 50,000 gallons of oil were found and removed from the midship tanks. A negligible quantity was found in the after group of tanks. During removal operations the SCA installed a boom around MECCA to protect against accidental spills.

(2) Superstructure Removal Operations

Nonexplosive cutting on MECCA's superstructure began immediately after completion of the salvage survey. As shown in Figure V-15, SCA burners worked topside with oxyacetylene burning equipment while divers worked underwater with oxyarc equipment. Detonation of an underwater cutting charge is shown in Figure V-16.

A week later, the first explosive cuts were made on MECCA's superstructure using C-4 plastic explosive obtained from the Egyptian Army. These charges successfully separated the pilot house and officers' quarters from the remainder of the superstructure. When the 80-ton SCA crane arrived 2 days later, three superstructure sections were ready for lift. Cutting and lifting the superstructure sections proceeded routinely. At this stage of the operation, there was an increasing reliance upon explosive cutting rather than oxyarc methods. The fifth superstructure lift was particularly difficult because of secondary expensive damage to joiner and light structure that inhibited diver access to all areas requiring cutting. Thus, emphasis was shifted to using more oxyarc and less explosive cutting in areas of light construction. A typical cut made early in the operation is shown in Figure V-17. Figures V-18 and V-19 show typical superstructure sections being lifted and towed to the dump area.

The cutting and removal of all sections of the superstructure was completed within a month of commencement of salvage

FIGURE V-13
Oil Removal Pumping
Amidships in MECCA

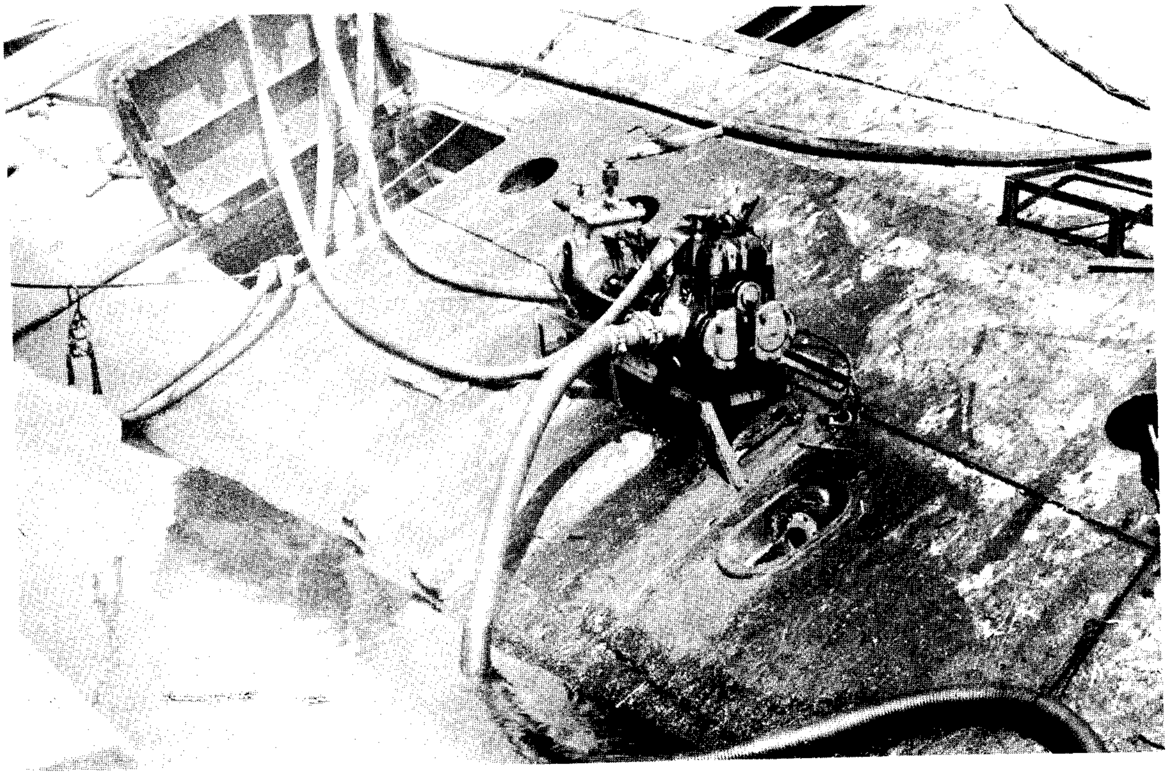


FIGURE V-14
Hot-Tap Spool in Way
of Midship Tanks on MEC A

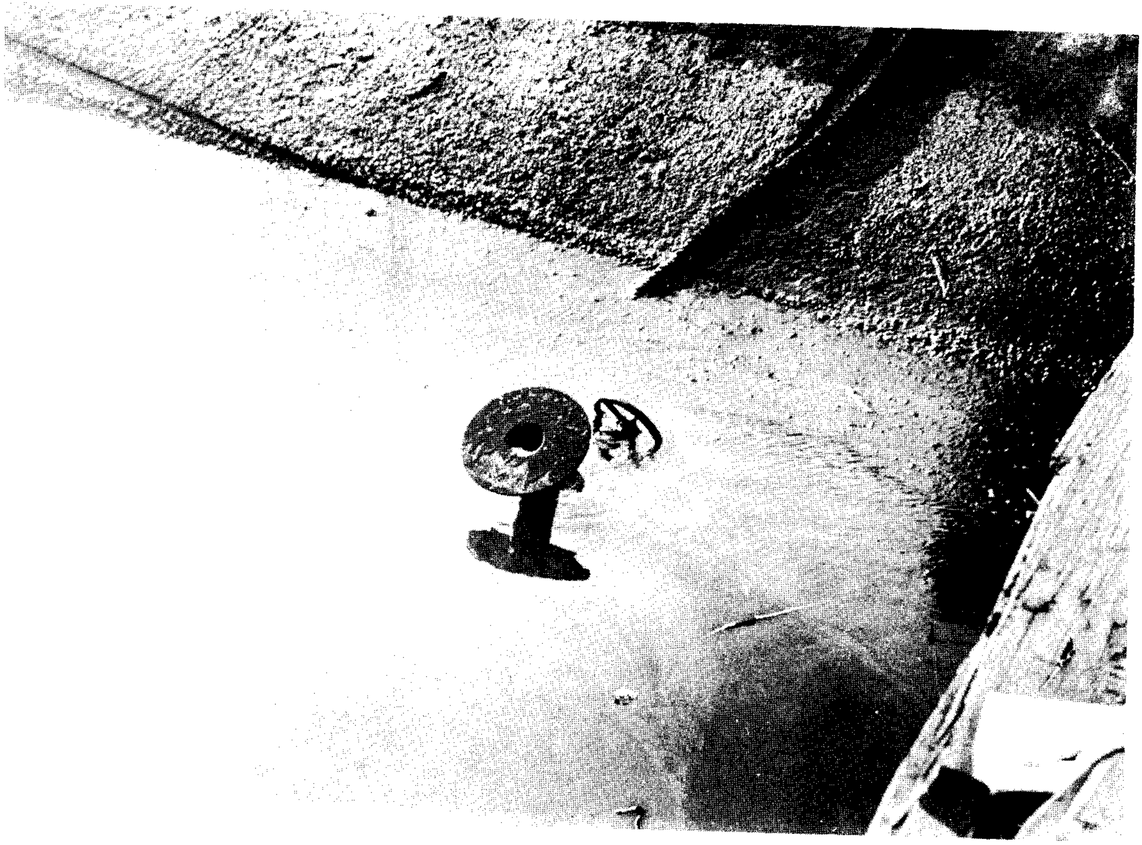


FIGURE V-15
Above-Water Cutting Operations
on MECCA by SCA Burners

FIGURE V-16
Detonation of Underwater Explosive
Cut on MECCA's Superstructure

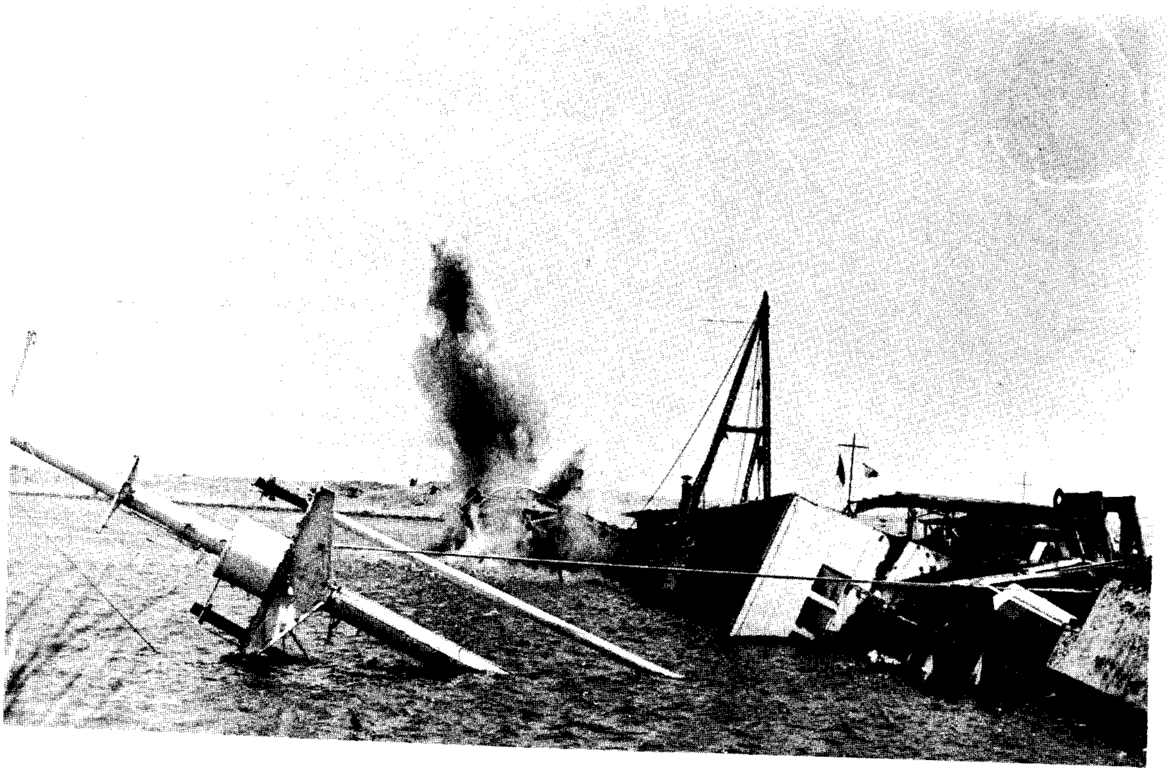


FIGURE V-17
Typical Cut Made Early
in MECCA Operation

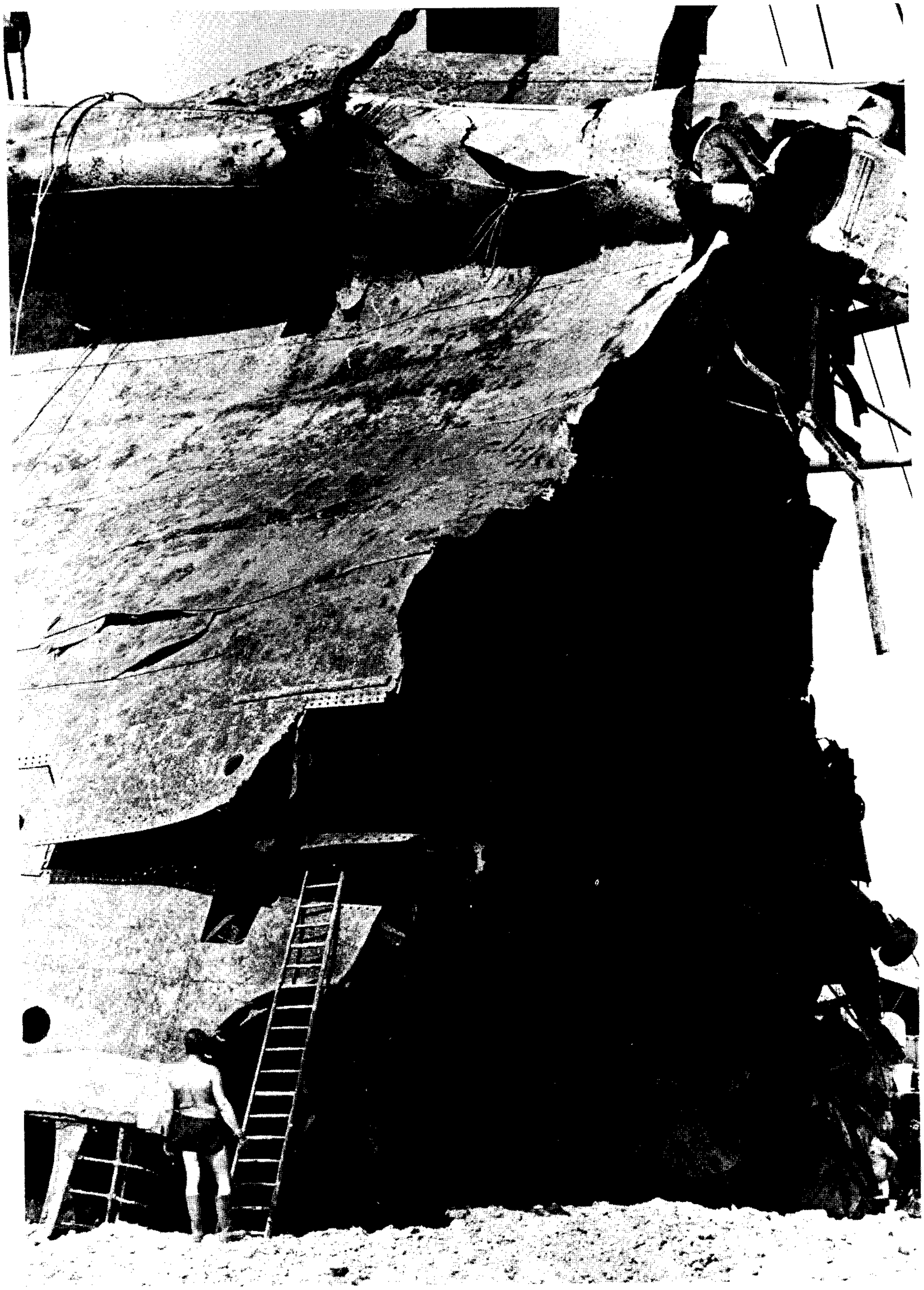


FIGURE V-18
A Section of MECCA's Superstructure Suspended
Over Barge by SCA 80-Ton Crane
Under Tow to Dump Area

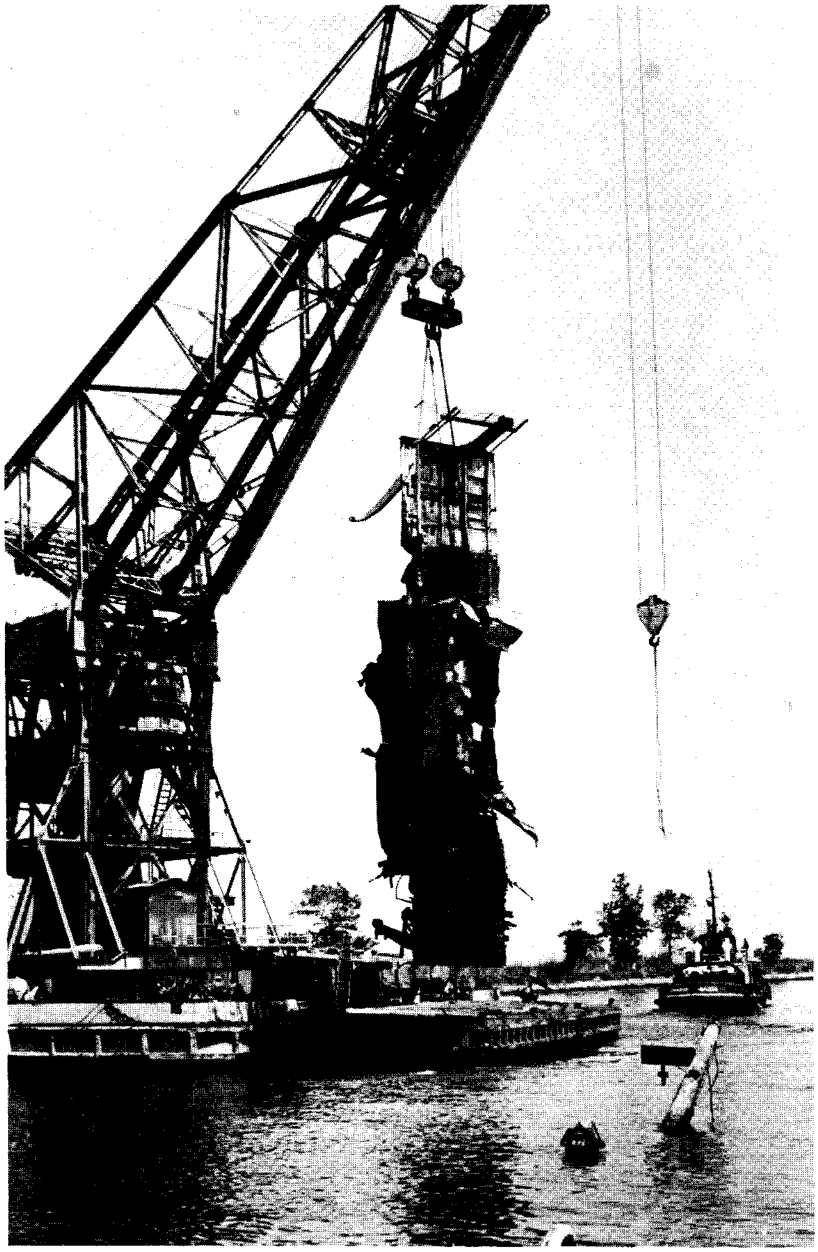
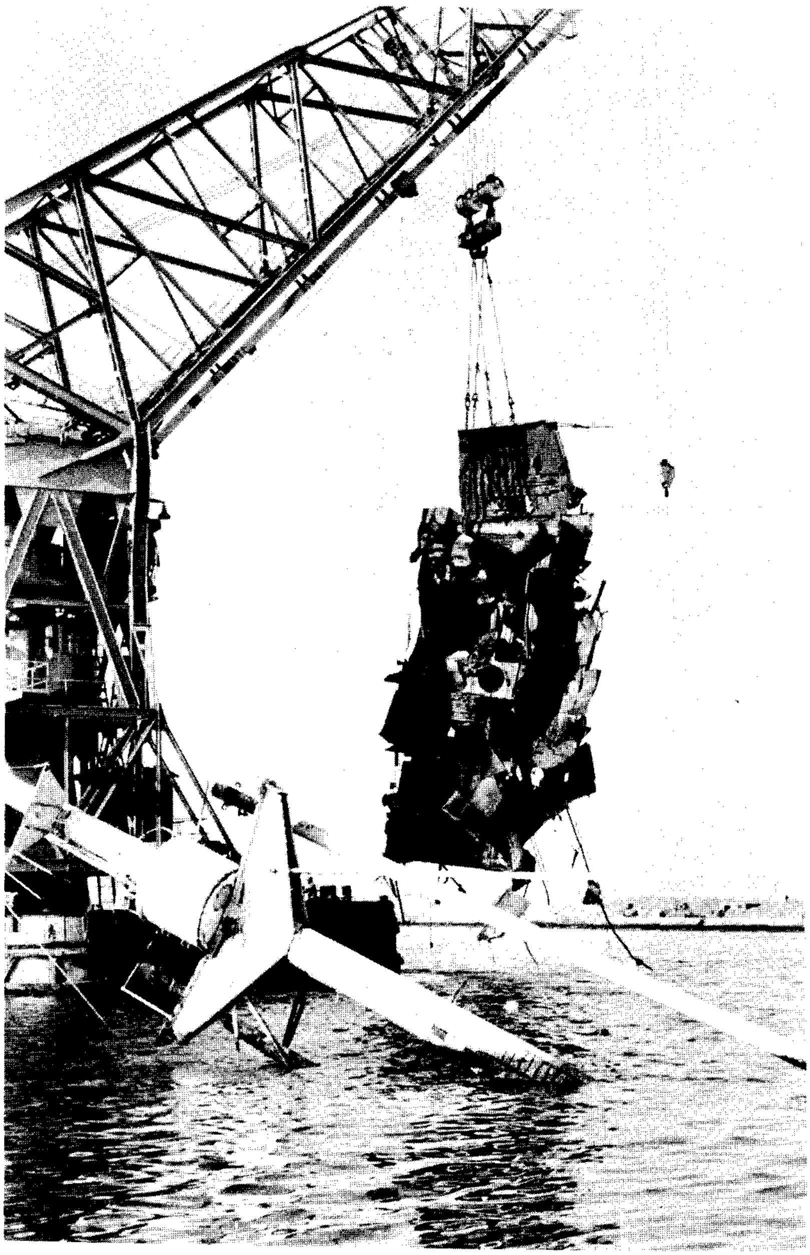


FIGURE V-19
A Section of MECCA's Superstructure
in Way of Engine Room Uptakes



operations on MECCA (28 June). A summary of lifting operations on MECCA superstructure is shown in Table V-3.

Table V-3
Summary of Lifting Operations
on MECCA Superstructure

Section*	Date (1974)	Lift Weight (tons)
1	10 June	70
2	12 June	85
3	14 June	25
4	16 June	41
5	13 June	20
6	21 June	60
7	23 June	40
8	28 June	30
9	27 June	30
10	24 June	60

* Although 15 lifts were planned, lifting operations on MECCA were completed with 10 major lifts.

(3) Silt Removal Operations

Silt removal was undertaken concurrently with cutting operations in early June in order to provide access to the cuts. On occasion, silt removal was also necessary in the dump area; this is described under Lifting Operations, Subsection (5).

(4) Cutting Operations

Explosive cutting of the hull began on 27 June. Seismographic instruments installed for measurement of shock loadings on the Canal banks indicated that loadings were within acceptable limits and that bank damage was unlikely to occur.

The first portion of the MECCA hull removed was a 16-foot section of the stern, which was removed to increase the width available for the passage of USS BARNSTABLE COUNTY, en route from Port Said to Ismailia to act as task force flagship.

The first major cut was completed in 7 days using a combination of oxyarc and explosive techniques. Although it was a relatively short cut, it was at the bottom of a learning curve, and its quick completion augered well for future cuts.

Silt and debris in the space blocked access to the starboard side of the hull that would eventually necessitate changing the basic plan of divers cutting from inside the wreck. Although silt and debris were evacuated by airlift, the remaining silt, debris and wreckage from cutting charges made it difficult for divers to gain access to the structure or to determine which structure must be cut. The debris problem was particularly severe on MECCA which had once been converted to carry refrigerated cargo and thus had heavy insulation in her holds. MECCA had subsequently been converted to a pilgrim ship and had a large number of bunks installed.

After a month of cutting, work was delayed because of a shortage of oxyarc-burning rods. A limited quantity of rods was provided from Navy sources in the Mediterranean to allow operations to continue, but the basic problem was not solved for several days.

Two decisions affecting the cutting operations were made at this time. The first decision was to order the second heavy-lift crane ROLAND from Germany. It arrived in the Canal on 15 September. The principal effect of this additional asset on MECCA operations was to permit consideration of eliminating three cuts—5, 7, and 9—so that the two sections on either side of these cuts could be lifted as nominal 900-ton lifts by two cranes. The elimination of these cuts would save considerable time in the overall operation (a disadvantage was that wet dumping would be required). The second decision was to employ a second cutting team, which would start forward and work aft. By the beginning of the third month of salvage operations, significant experience and some definitive techniques for cutting had been developed.

- Access holes were cut through the port side to each deck.

- Decks were cut by oxyarc from the underside using the transverse frames as guides. No great effort was expended to ensure the hull was cut through.

- Holes were cut in the starboard shell to guide explosive placement on the outside.

- Inner bottom, vertical keel, and bottom longitudinals were oxyarc cut.

- Lapped seams in the bottom were cut by oxyarc through all but one plate thickness.

- Guide holes for placement of explosives were cut in the bottom.

- In cuts 10 through 13, the shafts were explosively cut after completion of oxyarc cutting.

- The bottom was cut explosively from outside using the guide holes to assist in charge placement.

- The starboard half of the decks was cut with intermittent line charges spaced about 5 feet apart to ensure that decks were completely opened up.

- The starboard side was cut from the outside. In explosive cutting the starboard side, it was often necessary to use hogging lines to hog charges into close contact with the hull.

- The port and starboard sides of the decks were cut with intermittent line charges.

In addition to generally easier access, shooting from the outside presented other advantages. For example,

- Larger charges could be used without disrupting other work.

- Shooting against the support of the frames increased the tendency of the charge to cut the plate, rather than to merely distort it.

- There was less interference from mud, debris, and wreckage than was experienced when cutting from inside.

Authorities in explosive technology (from the Naval Undersea Center at China Lake) visited the site and confirmed that the method developed of scoring plating with rod and then opening with pounding charges was the best possible way of cutting the hull. They emphasized that charges must be placed tightly against the hull and made many additional suggestions of great value on use of explosives. The authorities recommended that linear-shaped charges not be used for cutting the hull because of the difficulty of assuring evacuation of all water from the cavity which was necessary to ensure effectiveness of the charges. The technique that developed and the factors that influenced explosive cutting are detailed in Appendix K.

When lifting operations commenced on MECCA toward the end of the third month of salvage operations, explosive cutting was discontinued while the heavy-lift cranes worked alongside. To ensure that heavy-lift cranes were fully utilized and that there was no interference between lifting and cutting operations, the cutting crew was divided into two shifts. A day crew carried out oxyarc cutting and a night crew, explosive cutting. Two-shift work continued for approximately 5 days until a reasonable backlog had been accumulated. Cutting then proceeded routinely as divers worked to maintain a backlog.

(5) Lifting Operations

The heavy-lift phase of MECCA's removal using THOR, and later THOR and ROLAND together, began with the arrival of THOR at the MECCA site late in the third month of salvage operations (14 August). Planning and preparation for the lift proceeded systematically. When lifting holes had been cut, chains were rigged through the holes, and the lifting tackle was attached as shown in Figure V-20. During the first lift attempt made on 26 August, section 14 was rotated into an inverted position but did not clear the bottom with a 500-ton lift.

On the following day, after burning away interlocking stiffeners and removing as much silt as possible, slings were re-rigged and the section was lifted free. The weight of the section was still too great for THOR to lift clear of the water. It was therefore taken partially submerged with a draft of about 7 meters to the dump area and was deposited temporarily in the water approximately 50 meters from the dry-dump area.

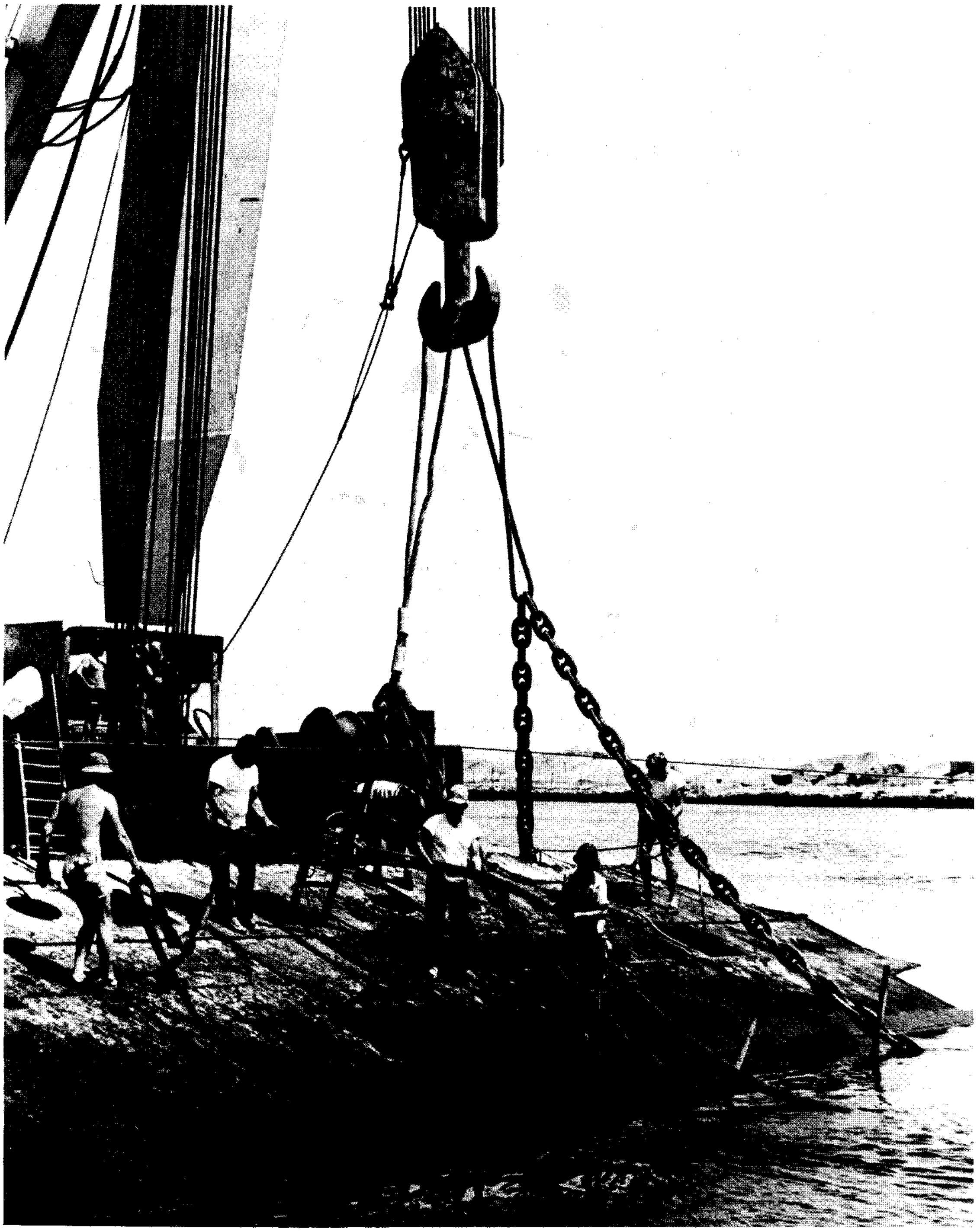
Concurrently with lifting operations on section 14, preparations were made for lifting of sections 12 and 13. When section 13 was lifted on 1 September, the shell plating tore longitudinally along the sides, leaving the bottom, double bottom, and orlop deck on the Canal bottom. In addition, the piece that was lifted sagged and buckled with only the main deck retaining any structural integrity. The lifted piece, estimated at 200 tons of a planned 311-ton lift, was dry dumped. The remainder was left on the bottom for future removal.

There were three major contributing factors to the structural failure of section 13. First, the quantity of explosives used inside the wreck during the first cuts had apparently destroyed the structural integrity more than had been anticipated. Second, the lateral strength of this section was low because there was no transverse bulkhead, and considerable deck strength was lost because of hatch openings. Third, section 13 was also weakened by scuttling charge damage.

Section 12 was lifted smoothly and cleanly. THOR was shifted to the bow of MECCA and lifted section 1. When section 1 was lifted, it separated longitudinally into halves. The upper half was dry dumped and THOR returned to complete the lift of section 1. The failure of this section was determined to be caused by collision damage suffered by MECCA prior to scuttling.

After completion of the lift of section 1, THOR returned to section 11 and after additional silt had been removed, lifted it and placed it in the water adjacent to the dry-dump area.

FIGURE V-20
Typical Rigging for Lift
of MECCA Hull Section



The second heavy-lift crane ROLAND arrived in the area in mid-September. Meanwhile, preparations were made to lift section 2, but considerable difficulty was encountered rigging slings. In order to utilize the heavy-lift cranes while these problems were being resolved, THOR and ROLAND were used to lift three temporarily wet-dumped pieces to the dry-dump area on the Canal bank. Figure V-21 shows section 14, the stern section of MECCA being lifted from wet storage to the dry-dump area. Figure V-22 shows this section on the bank.

When section 11 (another section without an included transverse bulkhead) was lifted, it collapsed and was unable to clear the seawall. It was redeposited on the Canal bottom and THOR and ROLAND temporarily left for Central Zone operations.

THOR and ROLAND returned to MECCA at the end of September and began rigging for the lift of the first double section, sections 9 and 10. The success of this endeavor was of critical importance. If it proved impractical to make the double lifts, which required very careful crane coordination, it would be necessary to make the omitted difficult cuts 5, 7, and 9. An early decision was needed to plan for these cuts if required. While ROLAND was rigging for this lift (shown in Figure V-23), THOR lifted section 2 (shown in Figure V-24) and moved it to the dump area. On 2 October, the first two-crane double lift was made. Some slight problems with tearing in way of lifting slings were experienced, but the section was lifted clear of the bottom and the remainder of the wreck. A lift weight of 800 tons was recorded with the upper deck wash.

THOR and ROLAND moved section 9/10 to the wet-dump area. THOR returned to MECCA to lift section 3, while ROLAND worked ISMAILIA until the next dual lift, section 7/8 of MECCA, was ready for lifting. Figure V-25 shows THOR lifting section 3 to the Canal bank, while ROLAND lifts section 4 of ISMAILIA. THOR returned to MECCA and began rigging for the lift of section 7/8. THOR was joined by ROLAND and a double crane lift was attempted. After several unsuccessful efforts to free the section, plans were made to lift section 5/6 first and save section 7/8 until last.

FIGURE V-21
Lift of MECCA Stern Section

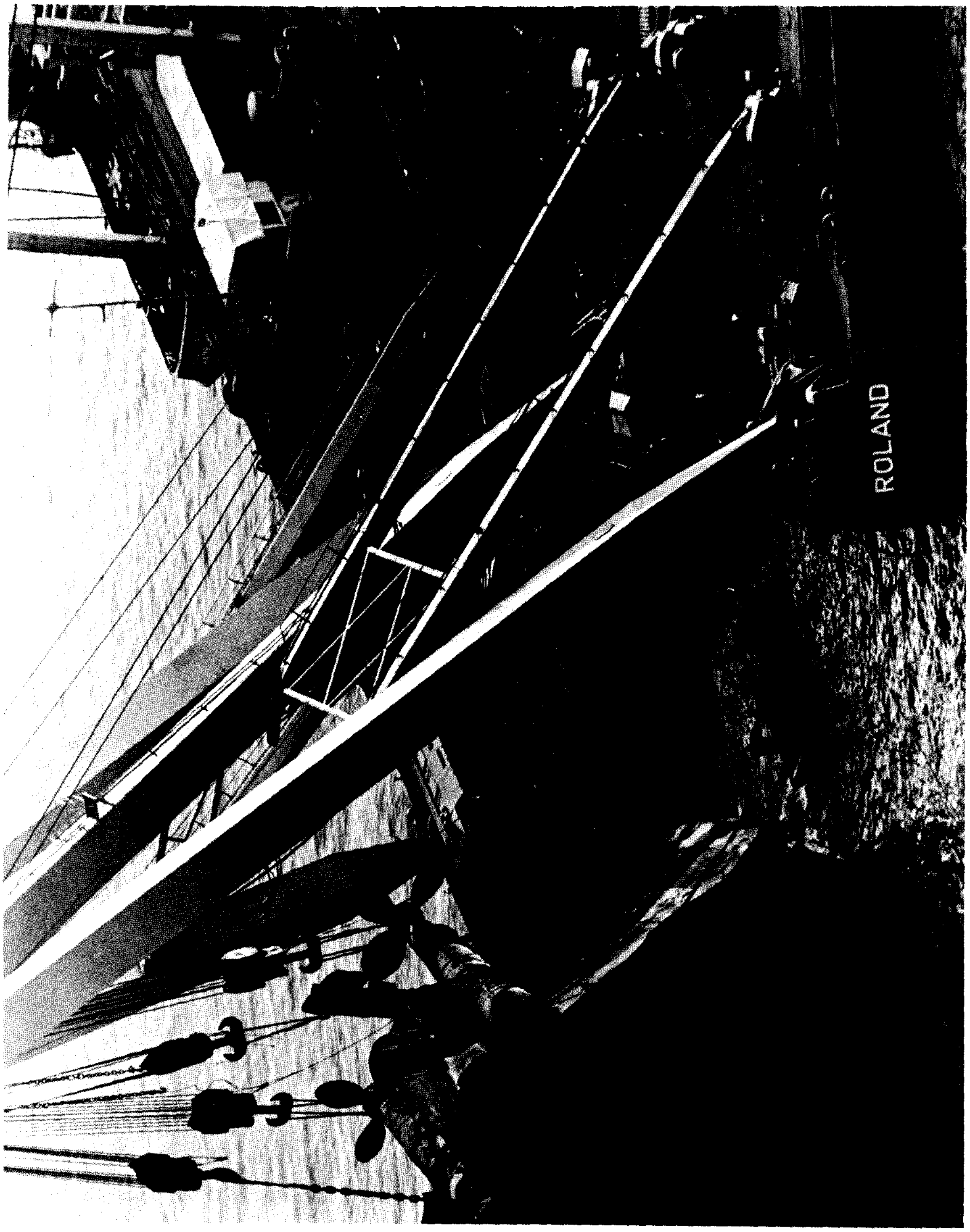


FIGURE V-22
Stern Section of MECCA
in Dry-Dump Area

FIGURE V-23
ROLAND Rigging for Lift
of Sections 9 and 10,
THOR Rigged for Lift of Section 2

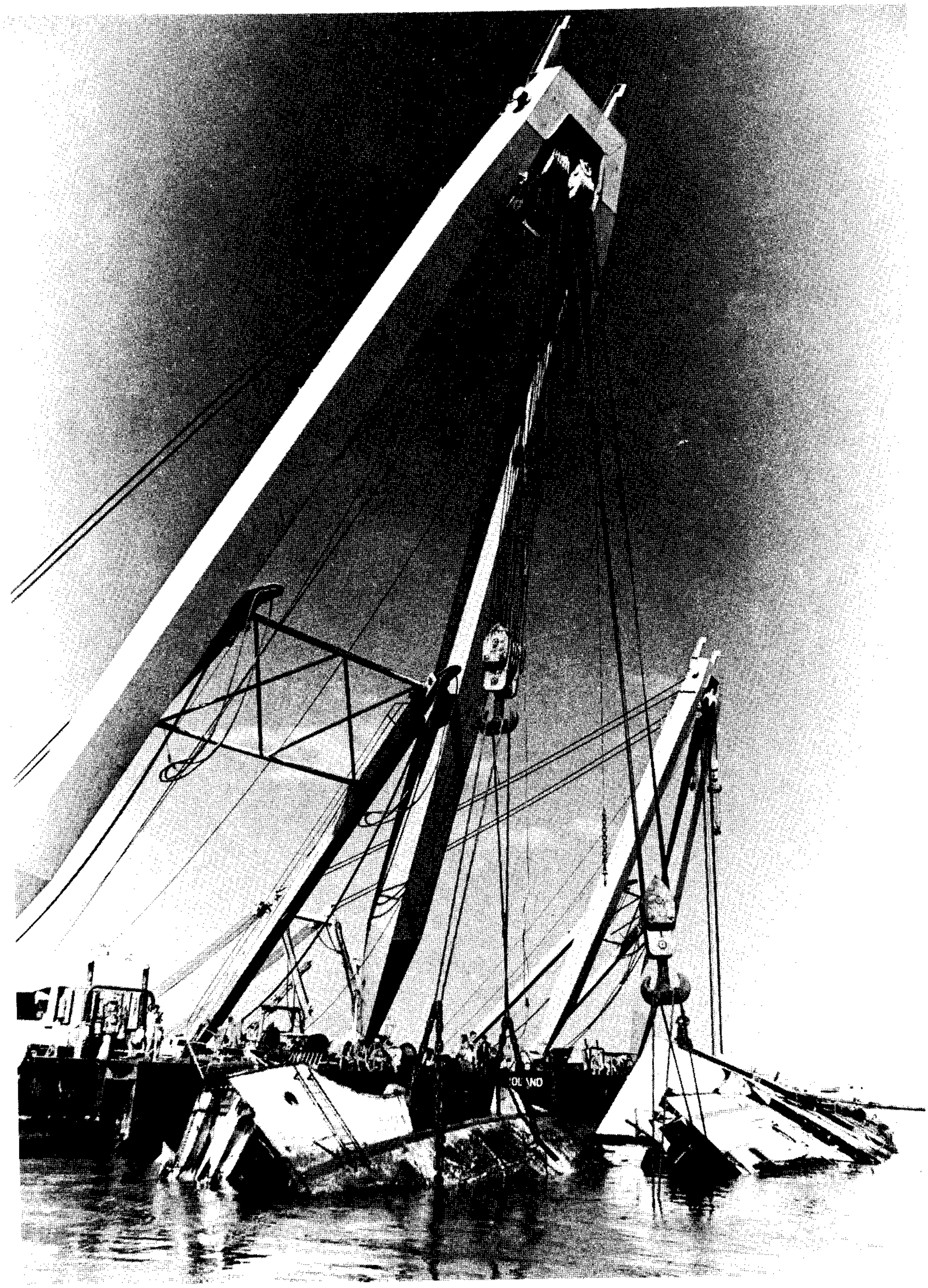


FIGURE V-24
THOR Lifting Section 2 of MECCA

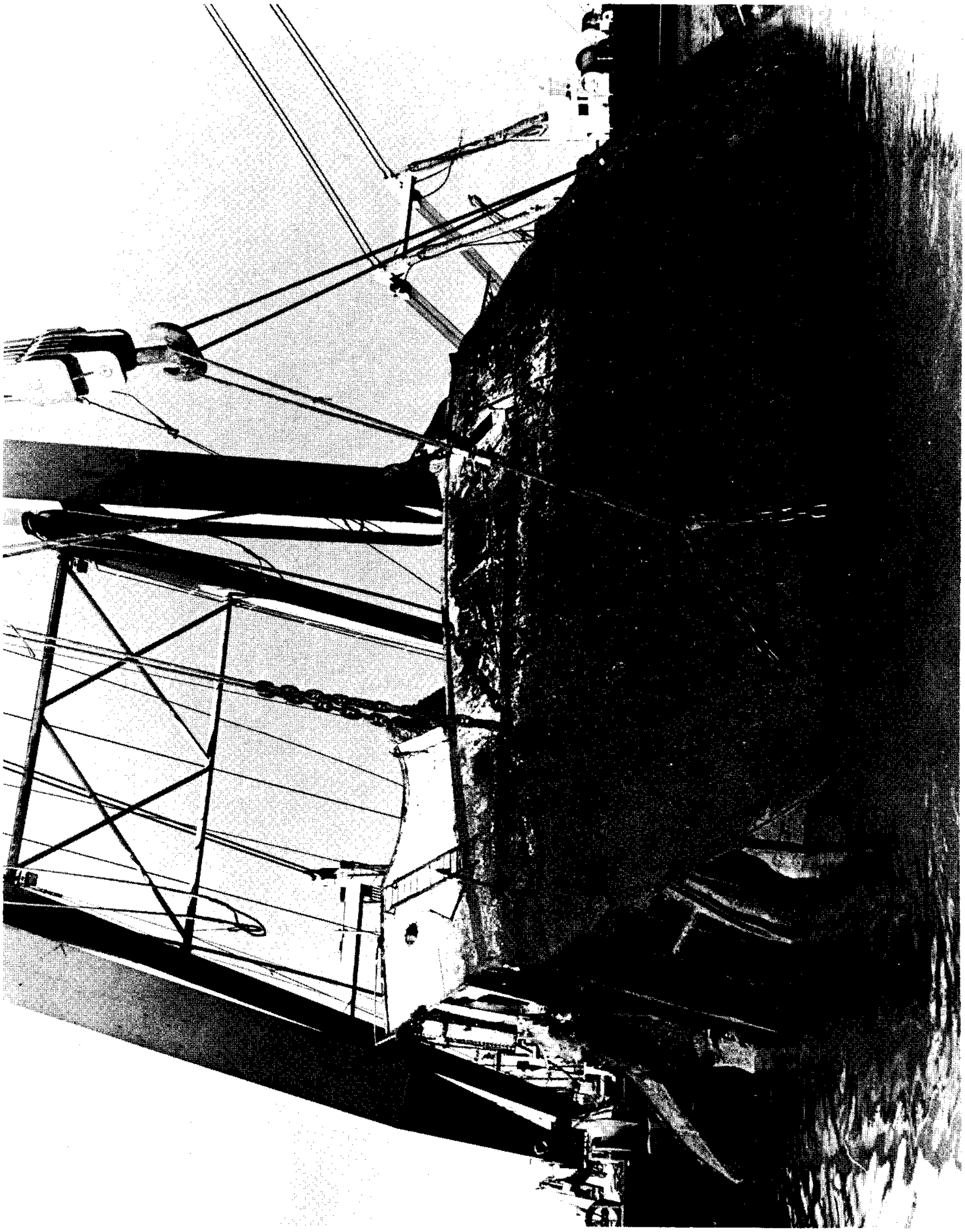


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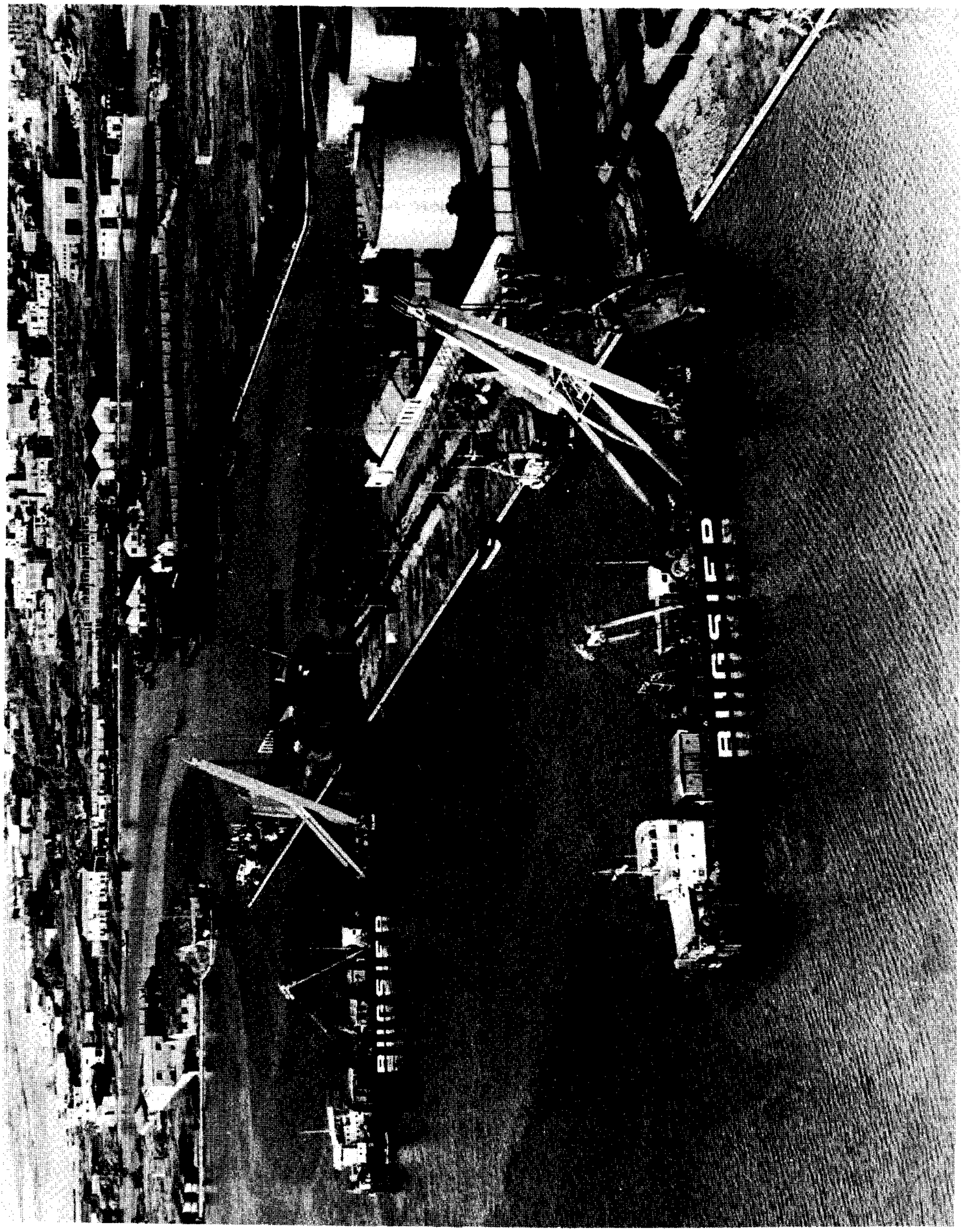
FIGURE V-25
Section 4 of ISMAILIA
and Section 3 of MECCA



While THOR was carrying out preliminary rigging of section 5/6, ROLAND re-rigged and lifted the collapsed section 11 to dry dump. The lift of section 5/6 and its removal to the wet-dump area was made without incident. THOR and ROLAND returned to section 7/8, the last remaining section of MECCA. The section was lifted in the water. As the topmost deck began to break the surface, one of ROLAND's chain slings completely pulled through the ship's structure. When the increased load came on the other sling, it parted. THOR set its side of the piece down with no damage. Inspection of section 7/8 showed that all connections had suffered such damage that they had to be redone. It was also apparent after these unsuccessful lift attempts that the section should be lightened. Mud removal on this section had been comprehensive so lightening had to be accomplished with the removal of additional structure. THOR and ROLAND were dispatched to other operations while the weight of section 7/8 was being reduced. Scrap in the area and small sections of MECCA were removed using a 25-ton SCA crane.

The object of the weight removal was to reduce the weight of section 7/8 by not less than 100 tons by removing the two upper decks. The removal proceeded with deliberation but was delayed by mechanical difficulties with the 25-ton crane, a shortage of barges to remove scrap, and a shortage of oxygen for oxyarc cutting. By late November, 195 tons were eventually removed. Table V-4 is a summary of the lifting operations on MECCA.

After completing the refloating of the dredge 15 SEPTEMBER in the Central Zone, THOR and ROLAND returned to the Northern Zone to lift the remaining section of MECCA before departing for Bremerhaven. Lifting operations commenced on 10 December. A lift attempt on this section the next day resulted in raising it about 5 feet before one of THOR's chain slings again pulled through the shell and caused failure of the remaining sling. The decision to rerig both slings underneath the hull was implemented, and section 7/8 was lifted and transported to the wet-dump area in the outer basin of Port Said harbor on 18 December. The work on MECCA was completed. THOR and ROLAND and the tug BUGSIER 26 were then released.

Table V-4
Summary of Lifting Operations on MECCA

Crane Days	Section	Date Completed	Weight (Approx. tons)	Crane	Dump Area
3	1	10 Sep	350	THOR	Dry
8	2	1 Oct	450	THOR	Dry
1	3	4 Oct	450	THOR	Dry
5	4	11 Oct	350	ROLAND/THOR	Dry
5	5/6	14 Oct	900	ROLAND/THOR	Wet
13	7/8	18 Dec	1,150	ROLAND/THOR	Wet
6	9/10	3 Oct	800	ROLAND/THOR	Wet
8	11	16 Oct	500	THOR	Dry
7	12	7 Oct	460	ROLAND/THOR	Dry
3	13	1 Sep	175	THOR	Dry
9	14	24 Sep	550	ROLAND/THOR	Dry

4. SUMMARY

Removal operations on both wrecks in the Northern Zone were similar in that sectioning with oxyarc and explosive cutting and lifting with heavy-lift equipment were used to remove the sections. ISMAILIA, a smaller and less complicated wreck than MECCA, was used to develop techniques for sectioning.

Experience was gained and cutting techniques were developed as the operation progressed. The principles involved are reiterated here for emphasis.

> Cutlines should be laid out as simply as possible and should avoid heavy structure whenever possible.

- Cuts should be made near to traverse frames or other stiffening structure. If explosive cuts are made away from such structure, the plating will tend to deflect or deform plastically without shearing.

- Since there was no easy source of tailor-made precision shaped charges, locally fabricated shaped charges were not practical for use in this crude underwater work since difficulty in totally evacuating the cavity makes their efficient use extremely questionable.

- To cut efficiently, charges must be in close contact with the plating to be cut.

- The most efficient cutting operation occurs when the plating is first scored with oxyarc, then explosively cut.

- Charges should be kept as small as possible to prevent excessive loss of structural integrity, minimize secondary damage, and reduce diver disorientation when returning to the scene.

- Increasing charge size is no substitute for care in the placement of charges and is likely to be counterproductive.

When expensive assets such as the heavy-lift cranes THOR and ROLAND are used, they must be kept fully employed in productive work. Effort expended to ensure that sections are well separated and that weights are well within the lift capacity with an adequate margin for unknowns is time well spent and results in a more efficient operation, with a minimum of lost time.

VI. SALVAGE OPERATIONS IN THE CENTRAL ZONE

VI. SALVAGE OPERATIONS IN THE CENTRAL ZONE

Five wrecks blocked the Central Zone of the Canal: DREDGE 23, the dredge KASSER, the tug MONGUED, the Concrete Caisson, and the dredge 15 SEPTEMBER. DREDGE 23 was sunk across the Canal 5 kilometers north of the city of Ismailia. The tug MONGUED and the dredge KASSER were sunk as a combined block in the southern exit from Lake Timsah, 5.5 kilometers south of Ismailia. The Concrete Caisson, one of the more formidable blocks, was sunk across the Canal at Tuson Control Station, 11 kilometers south of Ismailia. The fifth wreck, the dredge 15 SEPTEMBER, was sunk near the centerline of the channel just inside the northern boundary of the Great Bitter Lake. The location of each wreck is shown in Figure II-1. Table VI-1 summarizes the principal characteristics of the wrecks.

Table VI-1
Characteristics of the Wrecks Located in the Central Zone

Wreck	Length (feet)	Beam (feet)	Depth (feet)	Lift Weight (tons)
DREDGE 23	191	40	11	1,600
KASSER	125	44	10	1,200
MONGUED	165	32	15	1,200
Concrete Caisson	203	44	40	3,800
15 SEPTEMBER	200	44	14	2,000

Survey operations on the wrecks in the Central Zone began on 5 July 1974 and continued through 18 July. Detailed survey results are presented in Chapter IV. Table VI-2, extracted from Table IV-2, summarizes the survey results for the five wrecks in the Central Zone.

Table VI-2
Summary of Salvage Survey Results for Wrecks Located in the Central Zone

MECCA	Attitude	Hull Condition	Hull Support	Quantity of Silt	Projected Method of Removal
DREDGE 23	130-degree starboard list	Extensive shelter deck carried away; three holes in hull	Supported at the ends by silt and sand; resting on starboard deck edge and dredging structure	Machinery spaces silted to 2 feet	Parbuckle side lift by YHLCs
KASSER	45-degree port list	Generally sound except for two scuttling holes	Rested on turn of bilge at bow and stern and on starboard spud	Extensive	Side lift heavy-lift craft
MONGUED	12-degree starboard list	Much of overhead deck cut away; engines removed; holes in machinery spaces	Supported on mud	Extensive	Side lift by YHLCs craft after removal of stack and other projections
Concrete Caisson	On starboard side	Essentially intact except for three cracks (hairline to 2 inches), two scuttling holes, and a damaged area in the bottom	Supported by Canal bottom. Heavy scouring at western end.	Extensive, 3 to 6 feet along starboard side	Section along crack amidships and lift
15 SEPTEMBER	On port side	Wooden superstructure carried away; plating split on a riveted seam; hull dished on starboard side but wreck was suitable for further use	Supported by Canal bottom	Mud 2 to 4 feet deep in pump room and machinery spaces; 6 inches of silt in port bow storage space	Refloat by parbuckling, patching, lifting, and pumping

The salvage of the wrecks in the Central Zone comprised three basic categories of operations. DREDGE 23, KASSER, and MONGUED were planned to be removed by a classic side-lift salvage operation using the heavy-lift craft, CRILLEY and CRANDALL. The displacement of the Concrete Caisson approached the capacity of the heavy-lift craft and the hull was cracked amidships. Consequently, the removal of that wreck required a more complicated operation, first sectioning the hull into two nearly equal parts along the crack and then lifting to a dump area. The dredge 15 SEPTEMBER was to be returned to service and thus required a combination of lifting, patching, and pumping to effect its salvage. Because of their similarity, the side-lift operations on DREDGE 23, KASSER, and MONGUED were undertaken simultaneously and are described together. The salvage operations on the Concrete Caisson and 15 SEPTEMBER were accomplished at different times and are each described separately. Section 1 summarizes the salvage plans; Section 2 describes the salvage operations on DREDGE 23, KASSER, and MONGUED; and Sections 3 and 4 describe the salvage operations on the 15 SEPTEMBER and Concrete Caisson, respectively.

1. SALVAGE PLANS

The lift weights of DREDGE 23, KASSER, and MONGUED were each under 1,600 tons and therefore easily within the side-lift capability of the heavy-lift craft, CRILLEY and CRANDALL. The results of the survey in the Southern Zone indicated that the heavy-lift craft could not be immediately used in that area as originally planned. Therefore, it was decided to employ them first in the Central Zone to lift MONGUED, KASSER, and DREDGE 23, in that sequence. They would then be used to lift the Concrete Caisson after it had been cut into two sections by the trim and rig team. The dredge 15 SEPTEMBER required more sophisticated planning to refloat it for subsequent refurbishment.

Two of the five wrecks, DREDGE 23 and 15 SEPTEMBER, required parbuckling before lifting. It was planned to use the heavy-lift cranes THOR and ROLAND to parbuckle DREDGE 23 as soon as the cranes could be freed temporarily from lifting operations on MECCA and ISMAILIA in the Northern Zone. Parbuckling 15 SEPTEMBER would be undertaken later concurrently with the lifting operations. The plan was to raise the dredge until the main deck was above the surface of the water, thereby stabilizing it for patching and pumping; it was anticipated that both cranes would be required for this operation.

The Concrete Caisson would be lifted without righting. KASSER would be righted by removal of the supporting spud. Removal operations on MONGUED, KASSER, DREDGE 23, and the Concrete Caisson were planned sequentially for full utilization of the heavy-lift craft. THOR and ROLAND would be used in the Southern Zone after finishing in the Northern Zone and would return to the Central Zone at the conclusion of the salvage operations to raise 15 SEPTEMBER as one of the final phases.

2. SALVAGE OPERATIONS ON DREDGE 23, KASSER, AND MONGUED

Following the survey, trim and rig operations were commenced to prepare the three wrecks for side-lift.

(1) Trim and Rig Operations (2 August to 10 September)

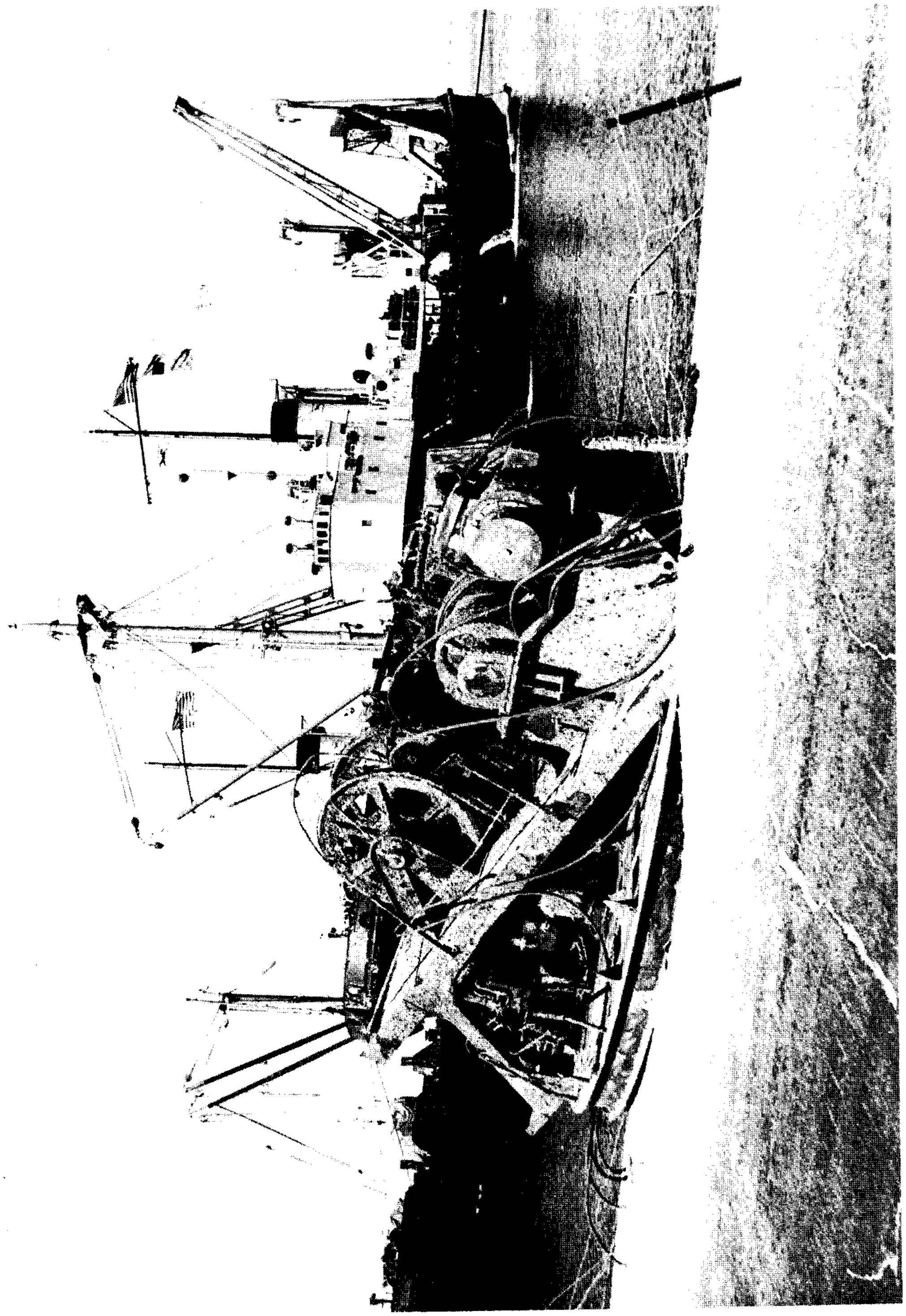
The purpose of the trim and rig operations was to remove any structure from the wreck that was likely to interfere with passage of messengers or lift wires or to create difficulties during lifting, and to rig messengers that could expedite passage of lift wires. Completion of preparations for lift prior to the arrival of CRILLEY and CRANDALL would minimize the time these craft would be dedicated to each lift.

Trim and rig operations in the Central Zone began on 2 August with the trim and rig team operating from the SCA 25-ton crane barge BAYOUMI at the KASSER/MONGUED site.

Ten messengers were passed under KASSER in 2 days, two of them requiring jetting. Following this, the upper gate for the starboard spud was opened with an explosive charge allowing the dredge to right itself from its 45-degree list. Other preparations on KASSER included removal of the spuds, dipper bucket, bucket arm, ladder, and turntable. A total of 100 tons of structure was removed. Figure VI-1 shows the turntable machinery after lift to the Canal bank.

The trim and rig team moved to MONGUED and by 8 August, had completed the trimming of the jagged metal from the scuttling holes on the port side. On 12 August after all

FIGURE VI-1
KASSER's Turntable Machinery
After Lift to Canal Bank
(CRANDALL and CRILLEY in Background)



damaged metal that could interfere with the lift wires had been cut away and after a tripod on top of the pilot house had been burned off, the wreck was clear for a navigational draft of 15 feet to simplify maneuvering of the YHLC in the KASSER/ MONGUED area.

While the trimming operations were taking place, a second team began sweeping lift-wire messengers into position beneath MONGUED. Initial efforts using locally procured 5/8-inch wire were plagued with wire breakages. This problem was remedied with the use of stronger 5/8-inch wire from the United States. These operations continued until 13 August when all 12 messengers were in place, some having required extensive jetting and tunneling by divers.

On 21 August, silt removal operations were begun on both KASSER and MONGUED. Although mud depths up to 8 feet were found in the machinery spaces of KASSER, the average throughout the ship was 1 foot or less. Two diving teams were employed on each wreck using 4- and 6-inch airlifts. Silt removal was completed on MONGUED on 22 August and on KASSER on 24 August.

During 6 to 10 September, the trim and rig team, operating from a diving barge and supported by the SCA 80-ton crane and two scrap barges, worked on DREDGE 23. Dredge buckets, seven sets of five each, were removed by scarfing the connection plates with oxyarc cuts and shearing with explosive charges. When all 10 connection plates had been cut, the buckets were lifted clear. The ladder was cut into three sections and removed by the same procedure. When the kingpost, two deck winches, fenders, and fender brackets had been removed and lifted to the Canal bank, trimming operations were completed.

Nine 5/8-inch messenger wires were rigged under the hull without difficulty. These were used to pull eight 1-inch messengers, which, in turn, would be used to pull the 3-inch heavy-lift wires. In addition, four messengers were rigged for pulling the 2-7/8-inch parbuckling wires. Because the weight of the craft plus silt was within the capacity of the heavy-lift crane, only the small amount of silt in the engine room was removed to provide an extra margin.

(2) Lifting Operations on MONGUED (27 August to 12 September)

It was decided to lift MONGUED first since it was narrower than KASSER and would provide more margin for the first passage around the Concrete Caisson of the first wreck in transit to the dumping ground in the Great Bitter Lake.

Upon arriving at the MONGUED wreck site on 27 August, the heavy-lift craft crews exercised at ballasting and deballasting operations. After satisfactory completion of this exercise on 30 August, the heavy-lift craft were moored over MONGUED, CRILLEY to the north and CRANDALL to the south, bows to the west bank. During the initial lift period, the moor effectively blocked the Canal to ships and larger service craft traffic.

Rigging the heavy 1-inch messengers and the 3-inch heavy-lift wires was accomplished from the lift craft positioned alongside. Using the already rigged 5/8-inch wire messengers, pulling of the heavier 1-inch messengers commenced on 30 August. The hauling parts of the messengers were fairlead to the lift craft deck winches. Pulling of the 1-inch messenger wires was completed without incident on 1 September. Pulling of the 3-inch heavy-lift wires was then begun. Since most deck crew members were relatively inexperienced, the rigging of the heavy-lift wires was done with extra care. Five heavy-lift wires were pulled the first day, particular emphasis being placed on safety. At the outset, 12 messengers were rigged in anticipation of passing 12 pairs of lift wires. The forward wire, number 12, was abandoned when it would not remain in position because of the curvature of the keel at the stem.

Passing the 3-inch lift wire at the stern was found to be impossible because the messenger had been passed between the rudder post and the rudder. As a result, there was insufficient clearance for the 3-inch lift wire, and it was omitted. Number 7 wire in the midship area became fouled in the damaged area of MONGUED and could not be rigged. Number 8 wire, which was in way of the engine room, could not be rigged initially because of fouling but was subsequently pulled under after the first lift.

By 3 September, 17 wires had been passed, and MONGUED was ready for the first lift. The decision was made to lift the wreck clear of the bottom and to rig the other three wires to achieve a total of 10 pairs of lift wires for subsequent lifts. By the end of the day on 4 September, the lift craft had been ballasted down, the lift wires had been tensioned further and pinned down, and the lift craft deballasted 50 percent in order to stretch the wires in preparation for the second lift, which was planned for the following morning. During this operation, an 18-inch lift was obtained and an additional heavy-lift wire was passed. Wire pair number 7 was still fouled and was eliminated, leaving nine pairs of wires for future use with a calculated load of about 75 to 100 tons per wire at maximum lift, which was an acceptable figure. Figure VI-2 shows the lift craft crew pinning down for lift, and Appendix F describes how CRANDALL and CRILLEY were rigged and operated.

Figure VI-3 illustrates the arrangement of the craft and soundings in the area. At 0800 on 5 September, the lift craft were deballasted raising them to a draft of 4 meters. The wreck was raised 5.5 feet to a keel depth of 16 meters. At 0930, using tugs SHAHM, MARINER, LULU, and SHABAR, the nest was pivoted 45 degrees around a shallow spot and moved a distance of 20 meters, where it grounded. Inspection by divers revealed that MONGUED had been lifted out of a 4-foot-deep hole. Ballasting of the lift craft commenced at 1130. At 1300, with the wreck resting solidly on the bottom, the lift wires were tightened and pinned for a new lift.

At 0600 on 6 September, deballasting of the lift ships was commenced. By 0800, the craft were deballasted and floating at a draft of 4.2 meters; the wreck was suspended between them at a keel depth of 13.7 meters. At 0900, after working clear of a shallow spot, the nest got underway for Lake Timsah to a new grounding area selected 3.35 kilometers south of Ismailia just west of the main channel. The two lift craft were towed stern first by SHAHM. MONGUED, suspended between the lift craft, was towed bow first at a slight upward angle. MARINER's tow wire was rigged to the bow of the lift craft to maintain position control of the nest. Figure VI-4 illustrates the towing arrangement. The tug SHABAR was used alongside as directed. At 1100, MONGUED grounded and was dragged into bottom at the designated grounding area. Inspection by divers revealed that

FIGURE VI-2
Lift Craft Crew Pinning Down for Lift

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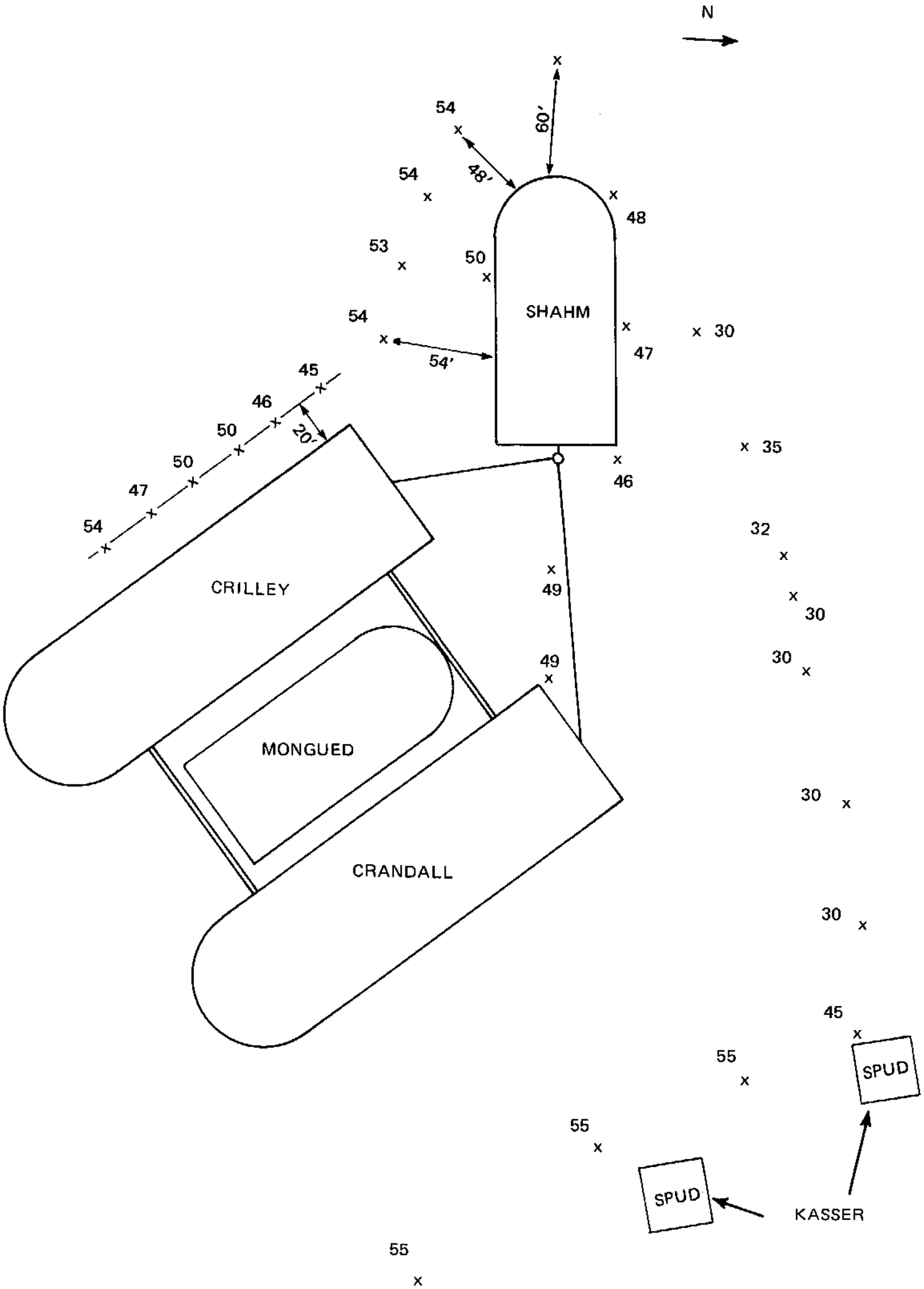
FIGURE VI-3
Arrangement of Craft After
First Lift of MONGUED
(showing soundings in feet)



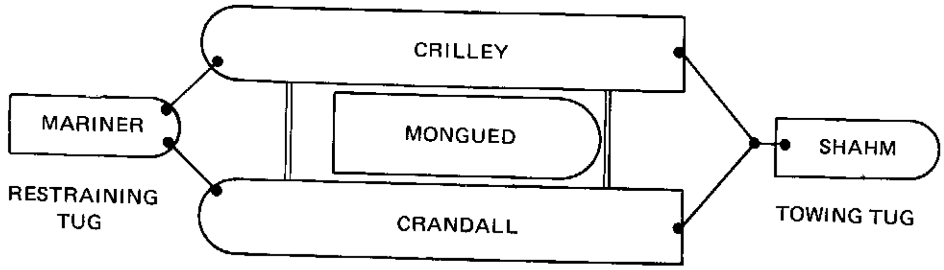


FIGURE VI-4
MONGUED in Transit to Lake Timsah

the wreck was imbedded in the bottom about 0.8 meters. Figure VI-5 illustrates MONGUED after grounding.

After the wreck grounded on this plateau, the lift craft were ballasted down. As the lift craft were ballasted, the wreck sank into the mud to such an extent that it was considered to be unfruitful to try another lift to decrease the draft of the

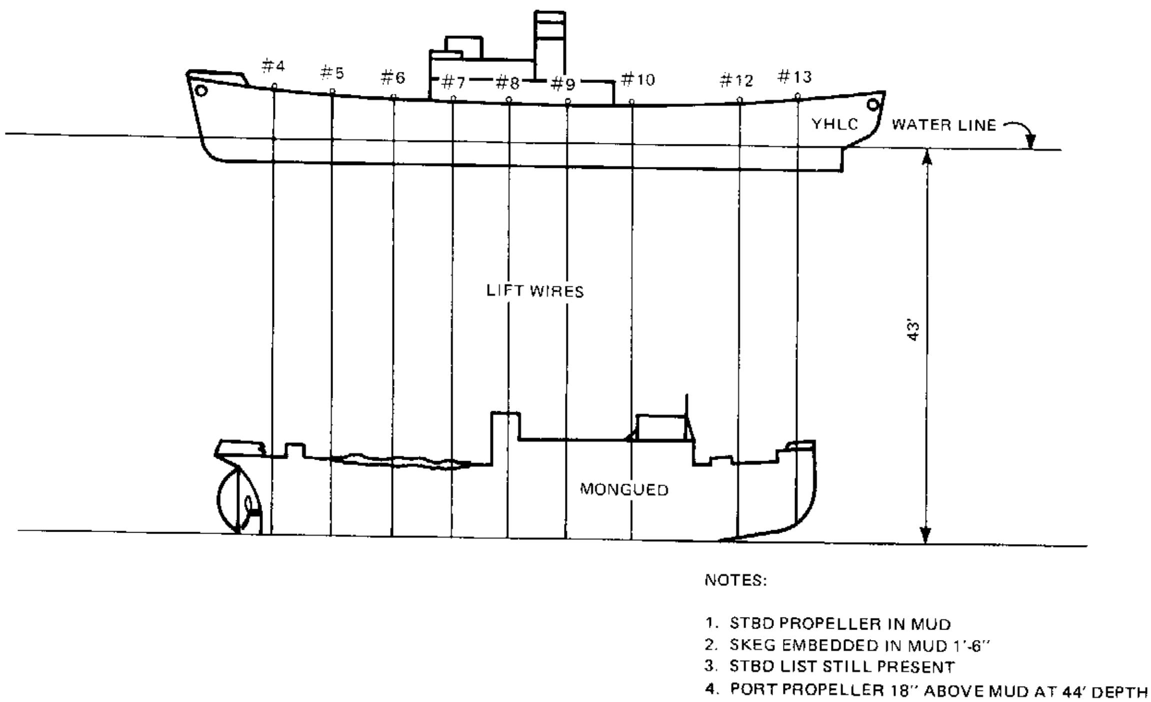


FIGURE VI-5
MONGUED After Grounding in Lake Timsah

wreck at this site. Therefore, the wreck was relifted to its former keel depth of 14 meters by deballasting the lift craft while a sounding survey was conducted in Lake Timsah for an area with suitable depth and firmness of bottom. None was found; a diver survey indicated that the general silt deposit was 5 to 7 feet deep throughout the lake.

To reach the designated pumping area in the Great Bitter Lake, the wreck would have to clear the Deversoir Causeway. The controlling depth of the Deversoir Causeway was reported to be 14.0 meters equaling MONGUED's keel depth and providing insufficient margin for error.

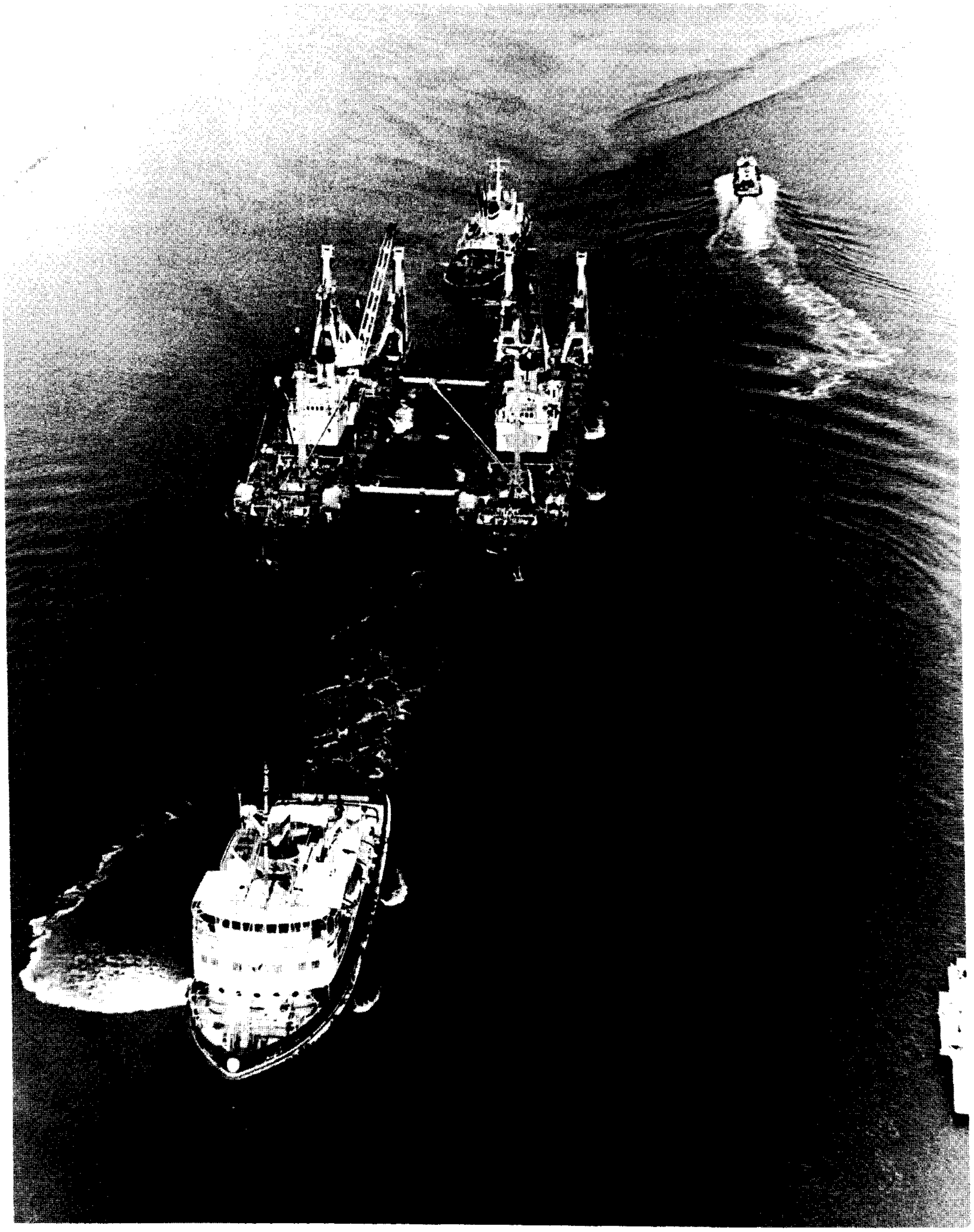
In the absence of a suitable alternative beaching area, it was decided to make another lift in the present location in the expectation that an additional 2-foot rise could be obtained that would permit clearing the causeway. Consequently, on 7 September, the lift craft were again ballasted, allowing the wreck to sink 5 to 6 feet into the bottom. When the lift craft were pinned and deballasted, the wreck was raised more than 7 feet, a net gain of about 2 feet, which was enough to clear the Deversoir Causeway with a maximum draft of 13.4 meters.

On the morning of 8 September, the tug MONGUED, slung between the heavy-lift craft at a keel depth of 13.4 meters, was towed from a point 3 kilometers south of Ismailia to the dumping area. With precise tug control, the craft and the wreck negotiated the restricted channel between the Concrete Caisson and the west bank without difficulty. (There were approximately 50 meters of navigational clearance for the 37-meter-wide nest.)

Figure VI-6 shows the wreck slung between CRILLEY and CRANDALL under tow to the Great Bitter Lake. For the final leg of the tow, the lift craft had been turned around and were towed bow first by SHAHM and restrained by MARINER.

Early on the morning of 8 September, a recheck of the depth over the Deversoir Causeway showed rocks at 13.0 meters instead of the then expected clear depth of 14.0 meters. The nest was anchored at a point 3 kilometers north of the causeway to await further clearance of the causeway by the SCA Dredging Division, which was engaged in an around-the-clock effort to remove the remaining obstructions. On 9 September, the

FIGURE VI-6
Tug MONGUED Slung Between
CRANDALL and CRILLEY
Under Tow to Great Bitter Lake



Deversoir Causeway was cleared to a depth of 14.0 meters at the center and 13.6 meters at the sides. On 10 September, after a navigable passage over the causeway had been confirmed by a diver survey, CRILLEY and CRANDALL, MONGUED, and the attending tugs got underway at 1100 and cleared the causeway at 1300. Figure VI-7 shows the nest approaching the causeway.

At 1500, the wreck and support craft turned from the Canal proper into a channel especially swept to allow access to the dumping area in the Great Bitter Lake. At 1600, the wreck grounded on a mud bank 3,800 meters from the ship channel. The stern became embedded in the mud with the bow 3 feet off the bottom.

In the early morning of 11 September, an additional lift was made and successfully raised the wreck to a keel depth of 11.6 meters. As the wreck was pulled into the dump area, the keel was raised to a depth of 10.2 meters aft and 9.5 meters forward, with about 5 feet of the pilot house exposed. Figures VI-8 and VI-9 illustrate MONGUED grounded in the dumping area in Great Bitter Lake prior to the last lift.

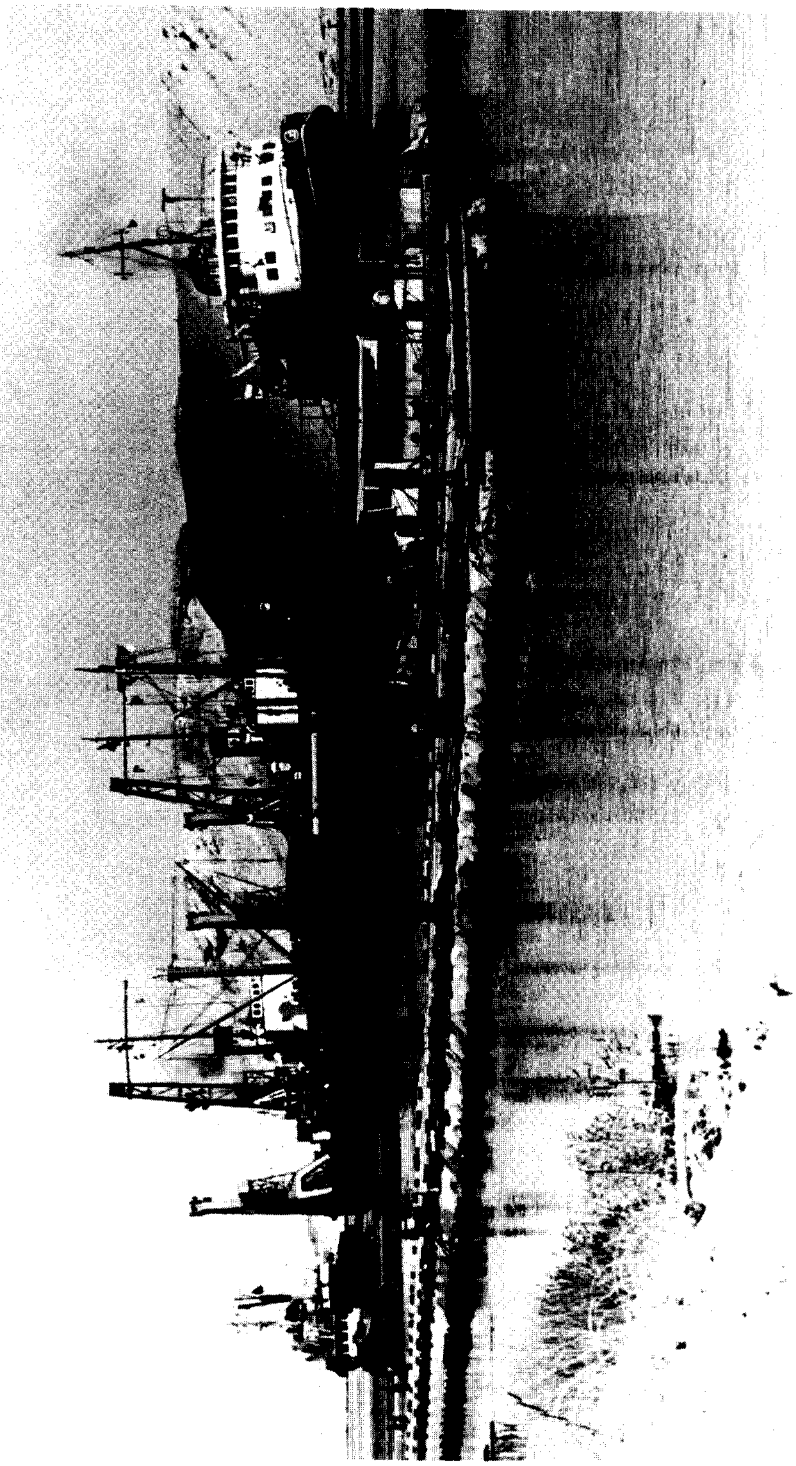
The operation was thus completed, and the lift craft were unrigged on 12 September to begin transit northward to commence lifting operations on KASSER.

(3) Lifting Operations on KASSER (14 September to 25 September

After MONGUED was dumped, CRILLEY and CRANDALL were moved to KASSER to commence removal of that wreck. On 14 September, CRILLEY and CRANDALL were moored over KASSER bow to stern using anchors from both craft supplemented by mooring lines run to the Canal bank and to one another. After the moor had been made, spreaders were rigged between the craft, and work was commenced to recover the lift wire messengers and to pull the 3-inch wires under the wreck. Figure VI-10 shows CRILLEY and CRANDALL ballasted down over KASSER with spreaders rigged.

After 2 days of effort, the wires from lift positions 5 through 12 were rigged. The wires in lift position 11 were fouled

FIGURE VI-7
MONGUED Nest Approaching
Deversoir Causeway



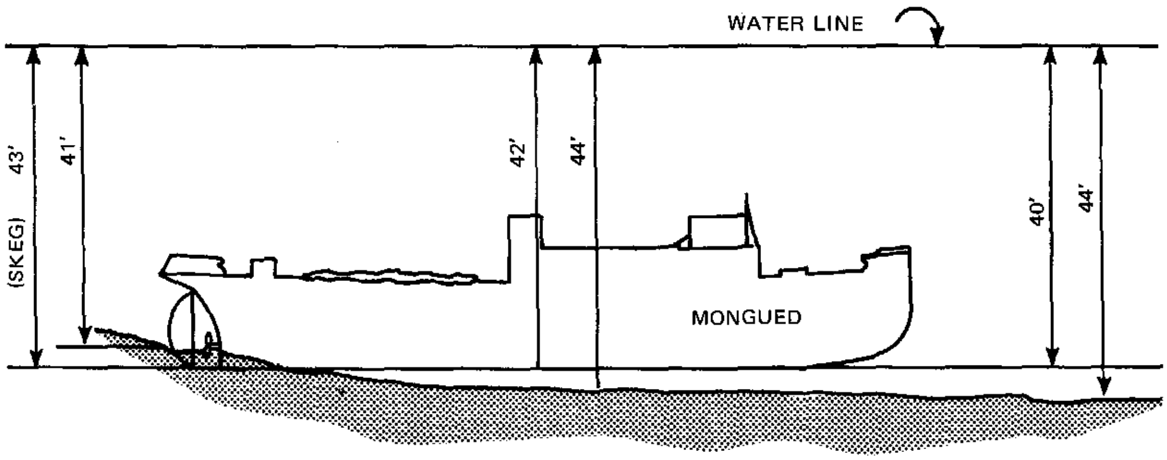


FIGURE VI-8
MONGUED Grounded in Great Bitter Lake
Prior to Last Lift

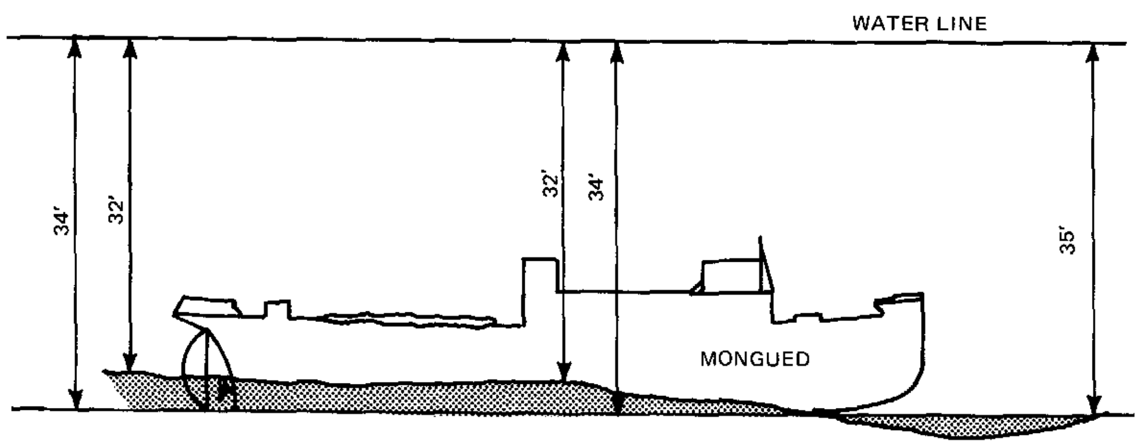
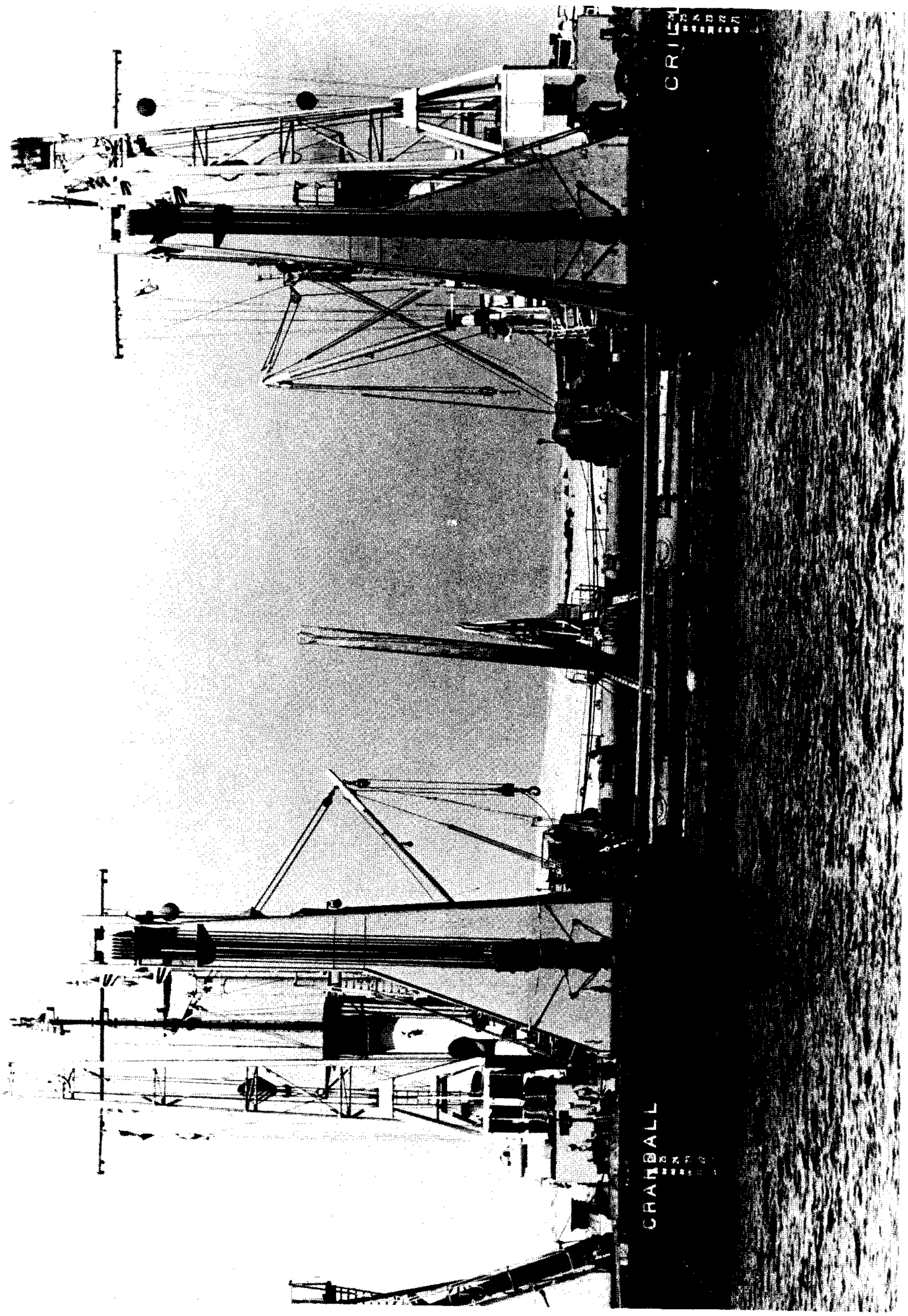


FIGURE VI-9
MONGUED at Dumping Ground
in Great Bitter Lake

FIGURE VI-10
CRILLEY and CRANDALL
in Position for Lifting KASSER



in the spud well; they were cleared by relocating them to lift position 13. An additional wire was passed at lift position 4 after being fairlead to lift position 5. Figure VI-11 illustrates the lift wire placement.

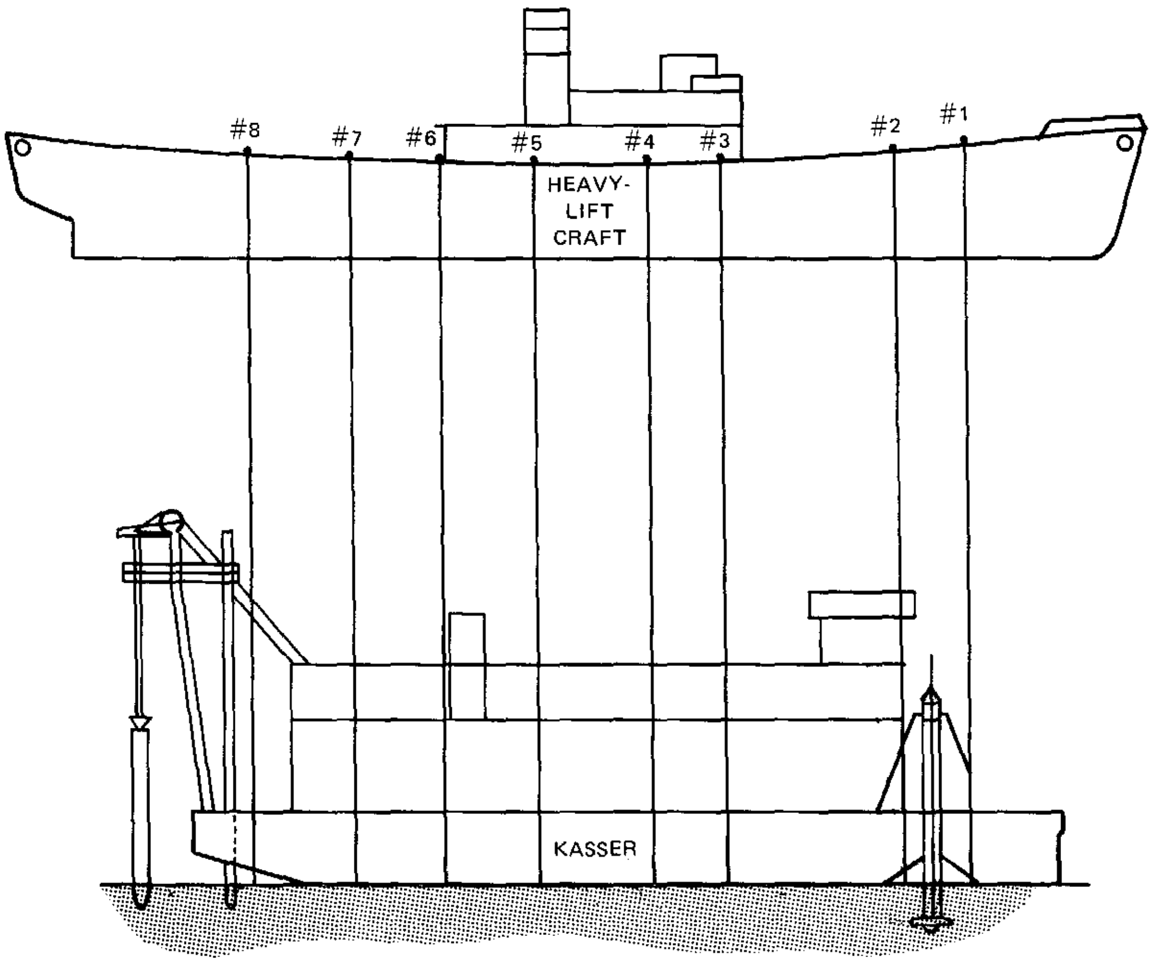
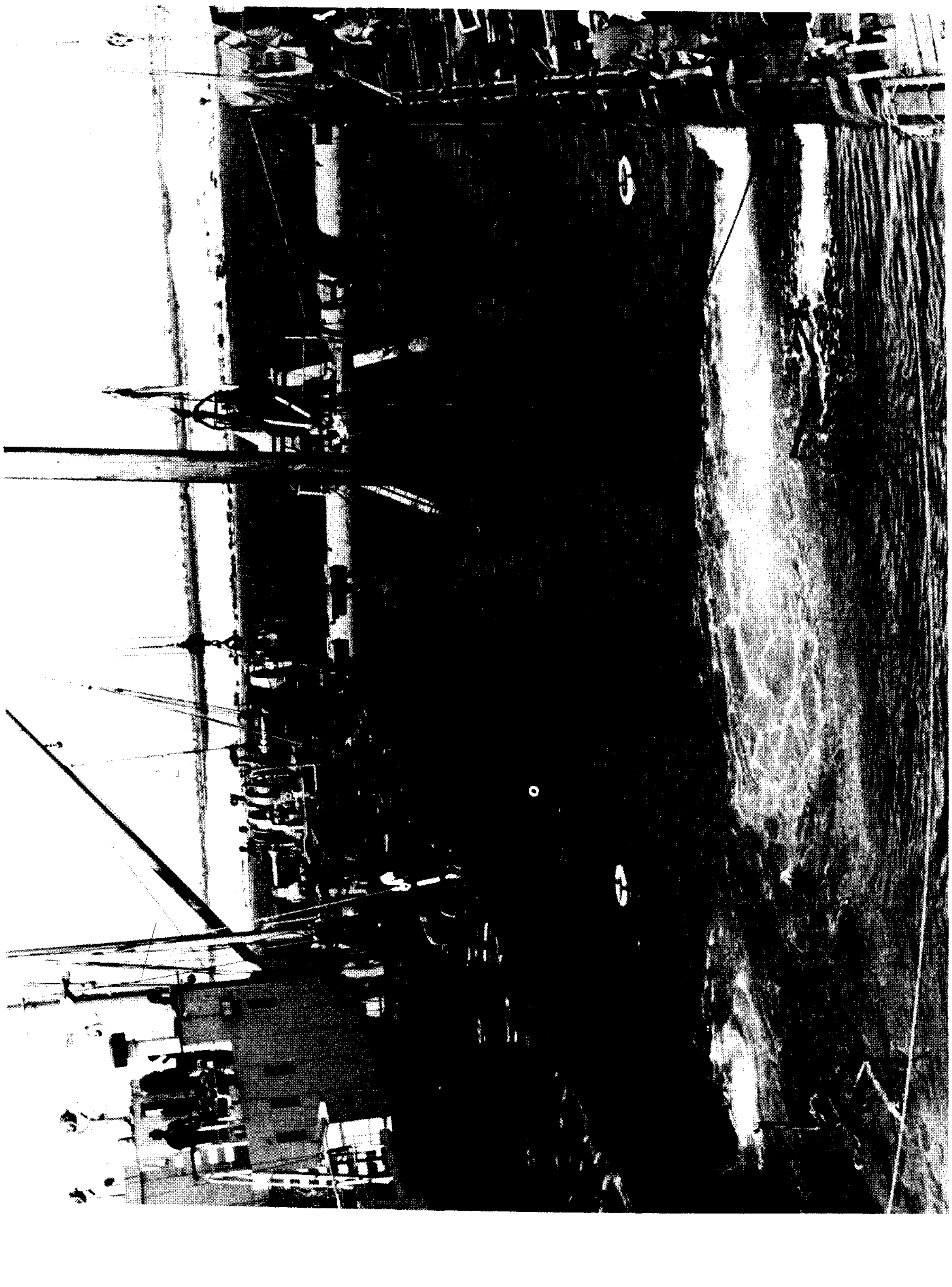


FIGURE VI-11
Arrangement of Lift Wires on KASSER

By 22 September, all 17 lift wires were in place. The lift craft was ballasted down, the wires were pinned, and the craft were deballasted to obtain a lift of 7 feet, as shown in Figure VI-12. With an 8-inch line to CRILLEY and CRANDALL, the tug SHAHM managed to pull the nest approximately 50 yards northward to Lake Timsah before grounding.

The lift of KASSER was an interesting case of good fortune and opportunism resulting in a maximum draft reduction greater

FIGURE VI-12
CRILLEY and CRANDALL
Deballasting to Lift KASSER



than the capability of the lift craft. Originally, the drafts of KASSER were 61 feet forward and 43.5 feet aft, as shown in Figure VI-13(a). The first lift of 7 feet, shown in Figure VI-13(b), was made on 22 September and the whole nest moved about 50 yards northward before grounding. As it turned out, the small grounded area caused the wreck to trim by the stern for a total change of 10 feet in trim. As shown in Figure VI-13(c), the net rise was 7 feet but the maximum and therefore controlling draft was reduced by 12 feet. The second lift raised KASSER another 7 feet to a maximum draft of 42 feet, sufficient to permit passage over the Deversoir Causeway, as illustrated in Figure VI-13(d). Thus, a planned third lift in Lake Timsah was eliminated. Figure VI-14 shows dredge KASSER suspended between CRANDALL and CRILLEY under tow to Great Bitter Lake.

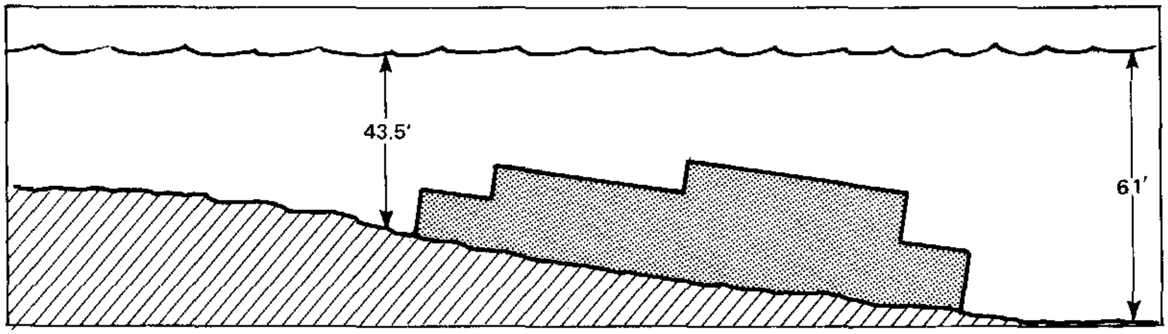
KASSER was towed south grounding in the Great Bitter Lake on 24 September. On 25 September, a third lift, again with some trim improvement, raised KASSER to a draft of 32 feet fore and aft, permitting movement into the designated dump area where the wreck was deposited approximately 200 yards from MONGUED.

(4) Parbuckling and Lifting Operations on DREDGE 23

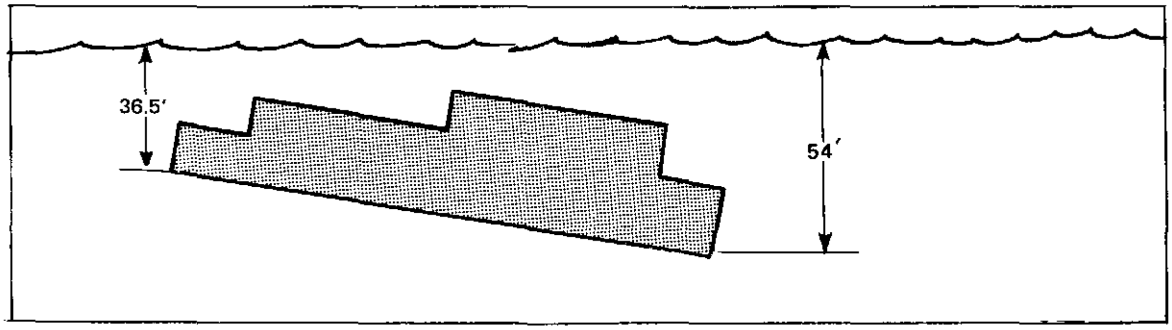
The first task in the removal of DREDGE 23 was to parbuckle it to an upright position. This operation began on 23 September when THOR and ROLAND arrived at the wreck site. Appendix L contains a detailed analysis of the righting of DREDGE 23.

After the fendering of the deck edge had been removed, both cranes moored side by side to the south of the wreck, two 2-7/8-inch parbuckling wires from each crane were run across the deck of the wreck, under the starboard side, across the bottom around the port turn of the bilge and attached to the port deck edge with a parbuckling anchor, which was a specially fabricated steel angle section for attaching the parbuckling wires to the deck edge. By 26 September, additional fenders had been removed, the parbuckling anchors had been set, and the parbuckling wires rigged under the hull and fastened to the anchors. The lift commenced at 1800; at 1830, THOR had registered a pull force of 150 tons. Just as the wreck commenced rotating, a wire parted on ROLAND's port gear, and the wreck was set back down on the

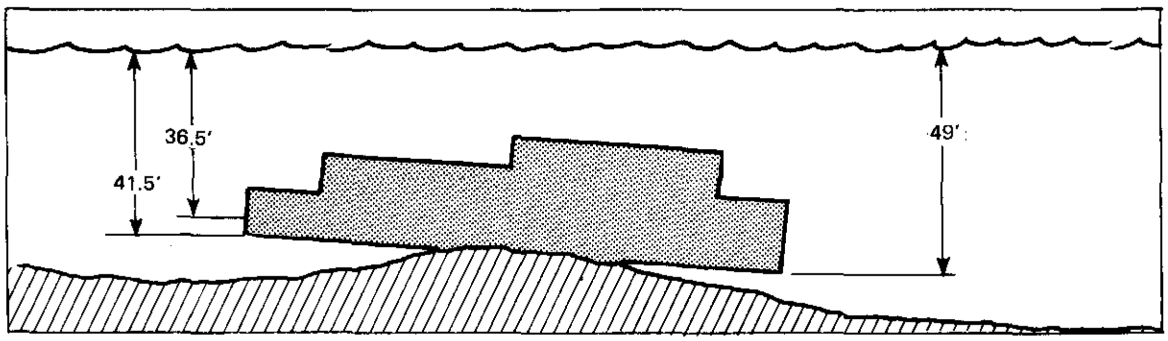
FIGURE VI-13
Lifting Sequence of KASSER



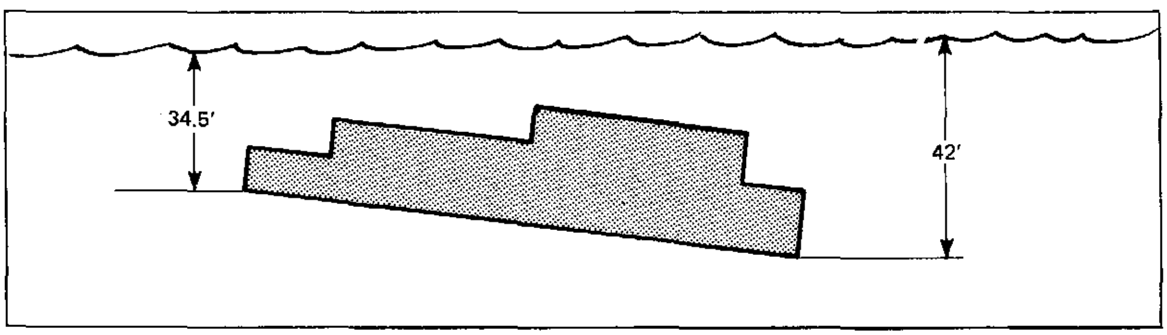
a. ORIGINAL POSITION



b. AFTER FIRST LIFT OF 7 FEET

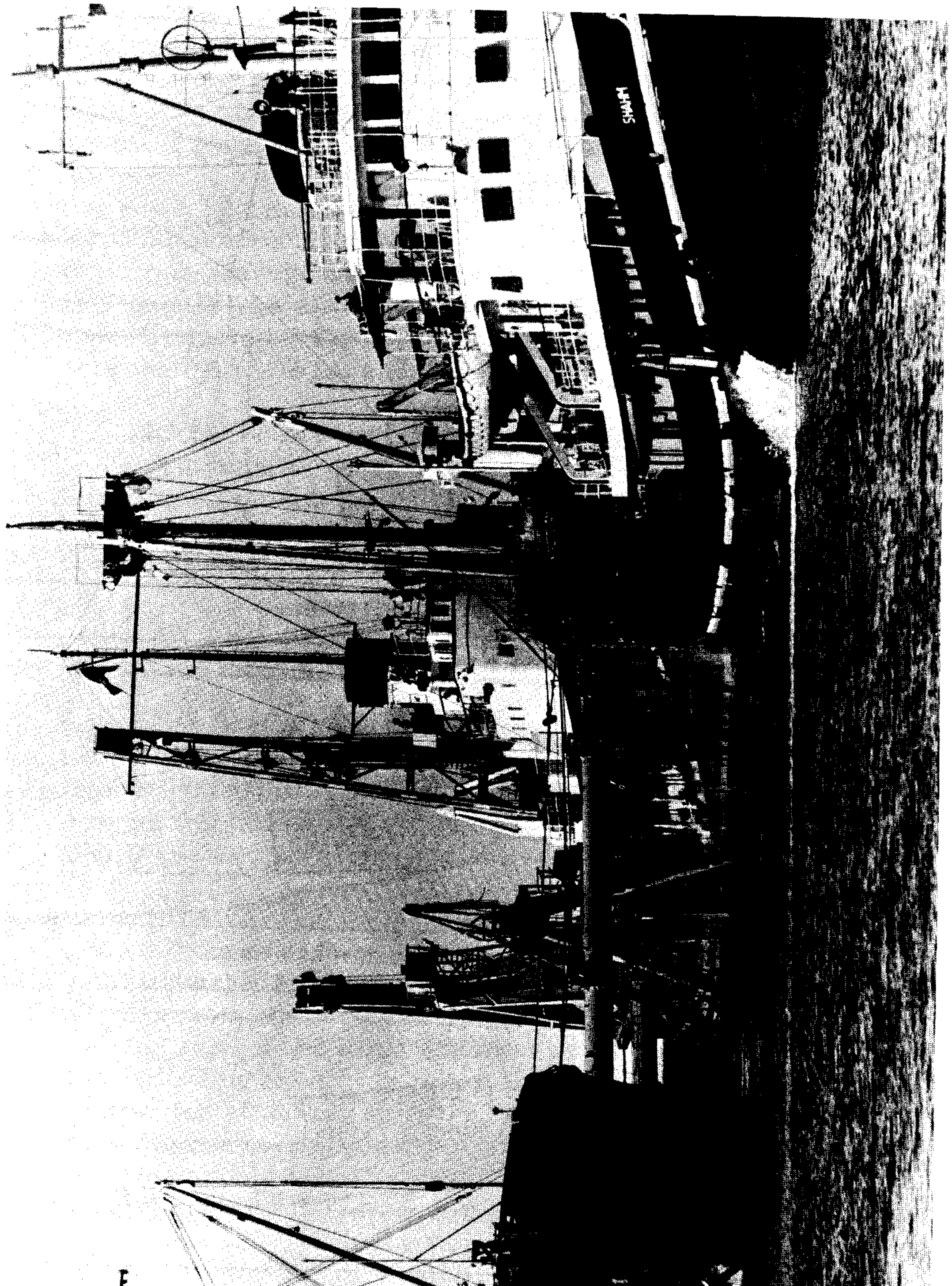


c. TRIMMING OF KASSER AFTER FIRST GROUNDING



d. ATTITUDE OF KASSER AFTER SECOND LIFT

FIGURE VI-14
Dredge KASSER Suspended
Between CRANDALL and CRILLEY
Under Tow to Great Bitter Lake



bottom. ROLAND was rerigged, and on 27 September at 1300 the parbuckling effort began again. It failed shortly thereafter when ROLAND's parbuckling wires began tearing the hull of the dredge under a 150-ton load. The dredge had been parbuckled to about 100 degrees but was subsequently set back on the bottom. Diver inspection revealed that the port wire was still holding on the fendering strip and the starboard wire had cut the hull deeply. In addition, the parbuckling wires from THOR had bent the starboard pontoon up against the port bow pontoon causing buckling and cracking in the bent area. Thus, the decision was made to employ ROLAND in a direct lift of the dredge gantry to obtain sufficient righting moment and to avoid the hull structural deficiencies which had been encountered. Because of the width of the cranes, it was not possible for ROLAND to plumb the dredge gantry while operating alongside THOR.

On 28 September, ROLAND was unrigged and moved to the north side of the dredge to permit rigging a single parbuckling wire from ROLAND for a direct lift on the gantry. THOR remained in its previous position. Although the long lever arm afforded by the gantry made it a desirable lift point, the initial decision to parbuckle using wires around the hull was made on the basis of doubt that the gantry would support a parbuckling load. On 29 September, after connecting ROLAND's parbuckling wire directly to the dredge gantry, parbuckling commenced at 1000 and was completed shortly thereafter. With the wreck in an upright position, THOR and ROLAND removed the parbuckling straps and returned to Port Said on 30 September to continue work on the wrecks in the Northern Zone.

CRANDALL and CRILLEY were moved to the DREDGE 23 site. After departure of THOR and ROLAND, the craft moved alongside the dredge athwart the Canal with the bows of the lift craft to the stern of the dredge. Figure VI-15 shows CRILLEY and CRANDALL moored over DREDGE 23 in the process of rigging heavy-lift wires. Passing and rigging lift wires continued until 5 October when the first lift was made by CRILLEY and CRANDALL. Figure VI-16 shows DREDGE 23 suspended between the lift craft ready for tow. After the dredge was lifted, the nest proceeded southward toward Lake Timsah. Figure VI-17 shows the nest proceeding south with SHAHM towing, MARINER restraining, and small SCA tugs assisting as necessary. After grounding lightly several times, the wreck grounded hard on an

FIGURE VI-15
CRILLEY and CRANDALL Rigging
Heavy-Lift Wires Under DREDGE 23

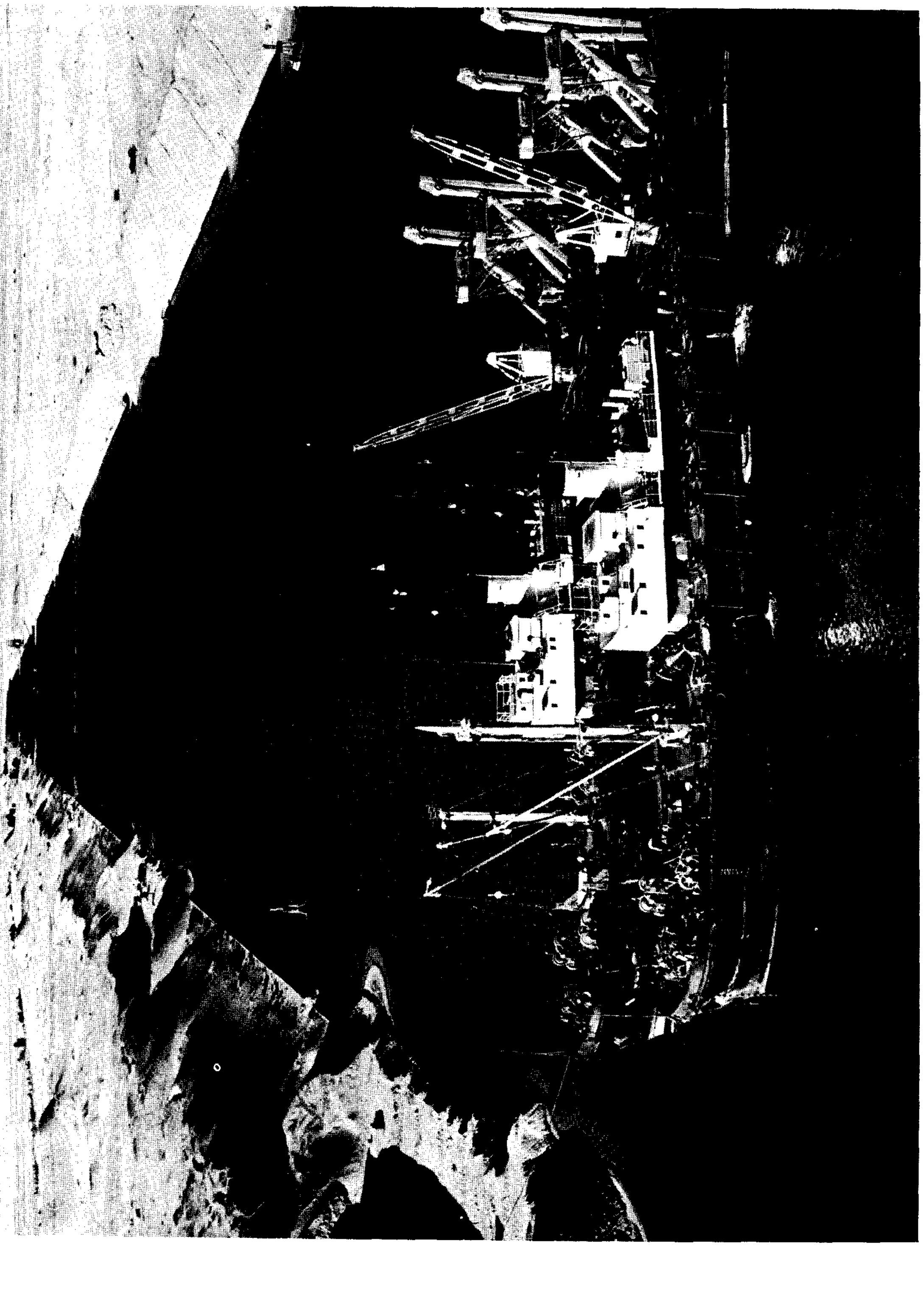


FIGURE VI-16
DREDGE 23 Slung Between CRILLEY and CRANDALL
Ready for Tow to Great Bitter Lake

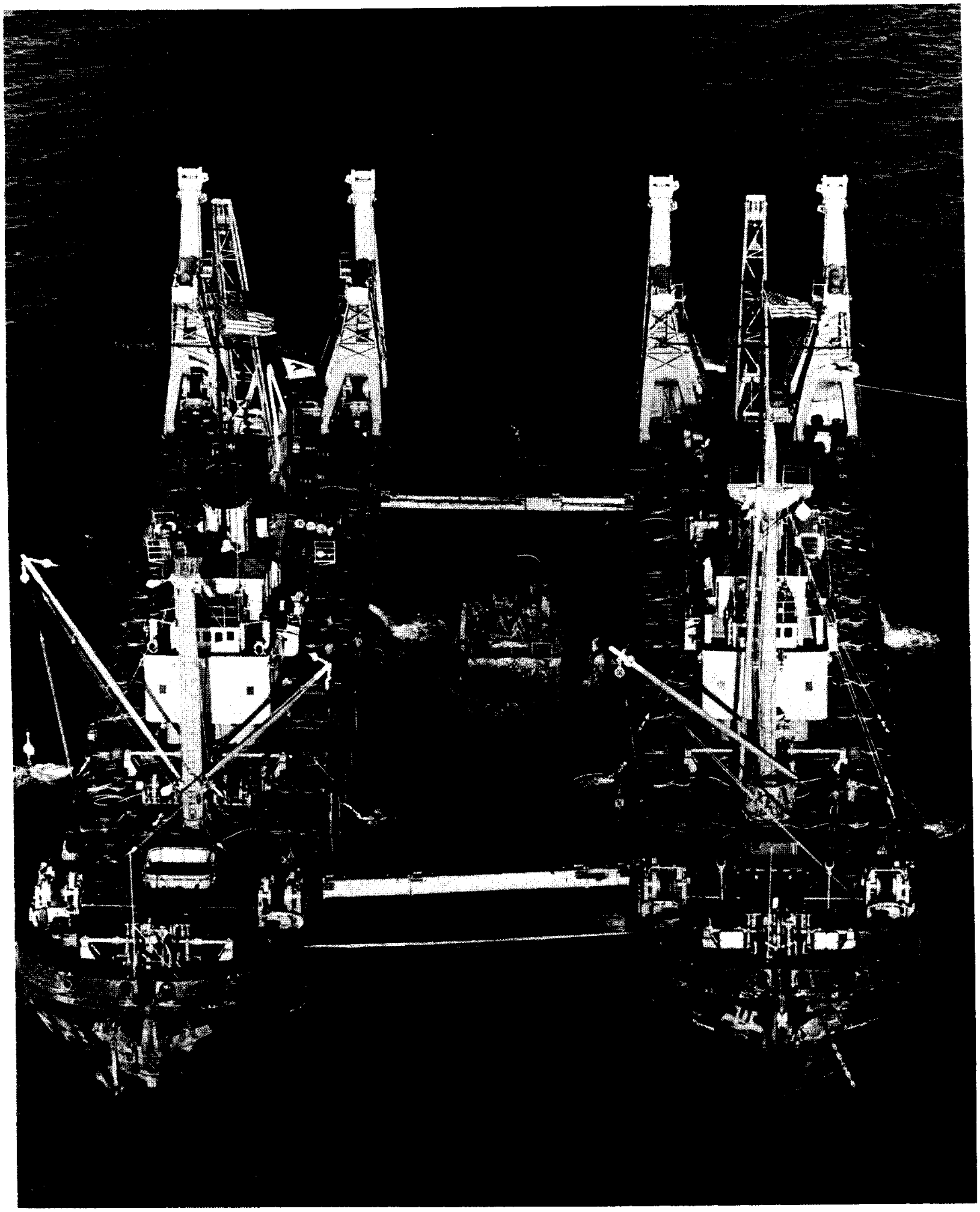


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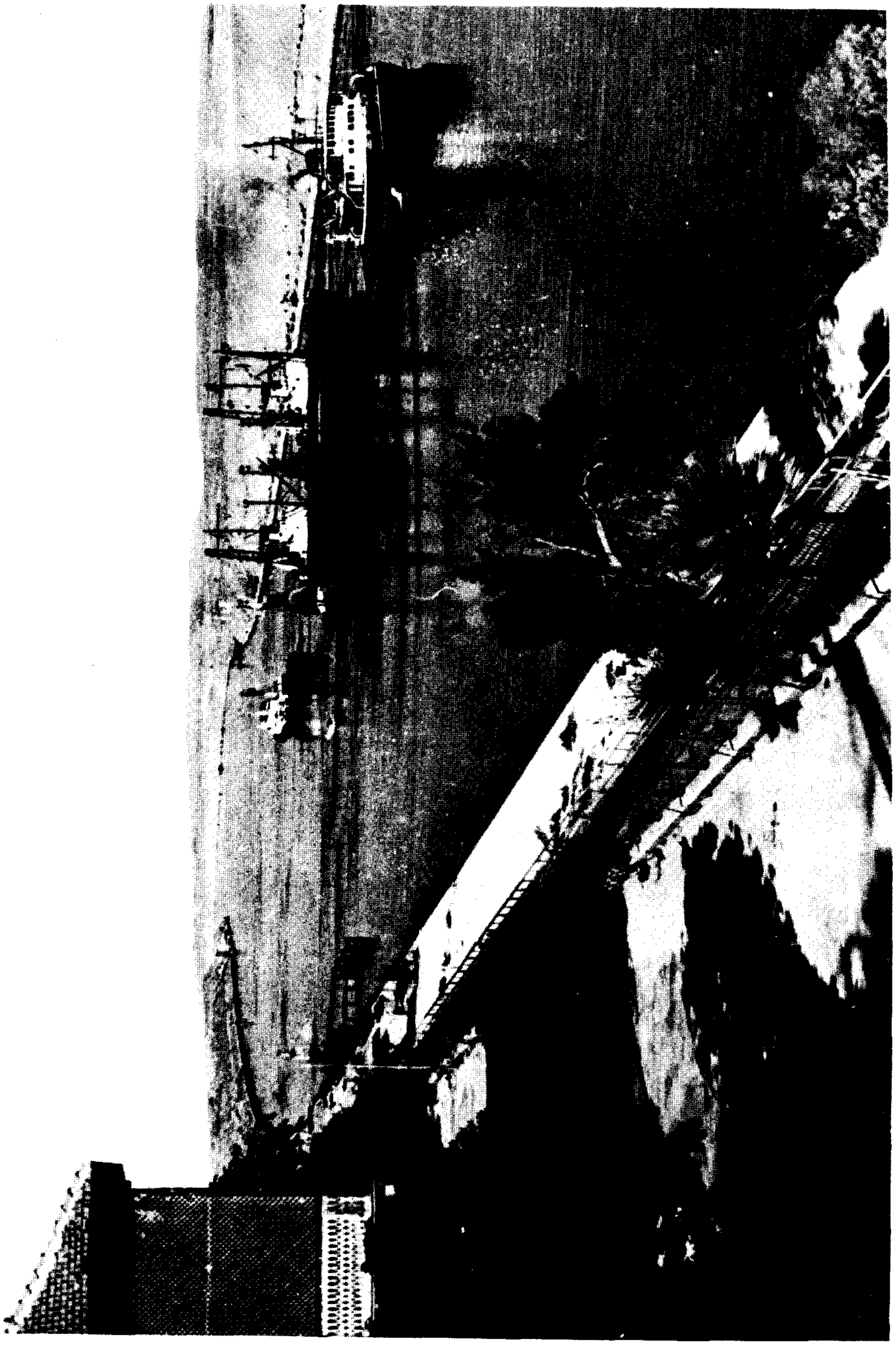
FIGURE VI-17
DREDGE 23 Approaching Lake Timsah
en Route to Great Bitter Lake



obstruction 2.4 kilometers south of its original position. A second lift to a maximum draft of 43 feet was made on 7 October. The wreck and the lift craft then continued southward, clearing the Concrete Caisson and Deversoir Causeway, and entering the Great Bitter Lake on 8 October. On 9 October, the final lift of DREDGE 23 was made, and the wreck was deposited in the designated dump area between MONGUED and KASSER, as shown in Figure VI-18.

* * * * *

With the dumping of DREDGE 23, the straightforward heavy-lift operations in the Central Zone were complete, and attention could be directed to the more complex problems offered by the Concrete Caisson and the dredge 15 SEPTEMBER.

3. SALVAGE OPERATIONS ON DREDGE 15 SEPTEMBER

Refloating of Dredge 15 SEPTEMBER had been determined to be feasible during the salvage survey. The lift cranes THOR and ROLAND would be employed to accomplish this by parbuckling the dredge into an upright position and lifting it until the main deck was clear of the water. Then positive buoyancy would be restored by pumping the interior of the hull until the dredge was afloat.

Prior to the arrival of the two cranes, preparatory work by the trim and rig team was required to rig parbuckling and lifting messenger wires and to patch openings in the hull for pumping.

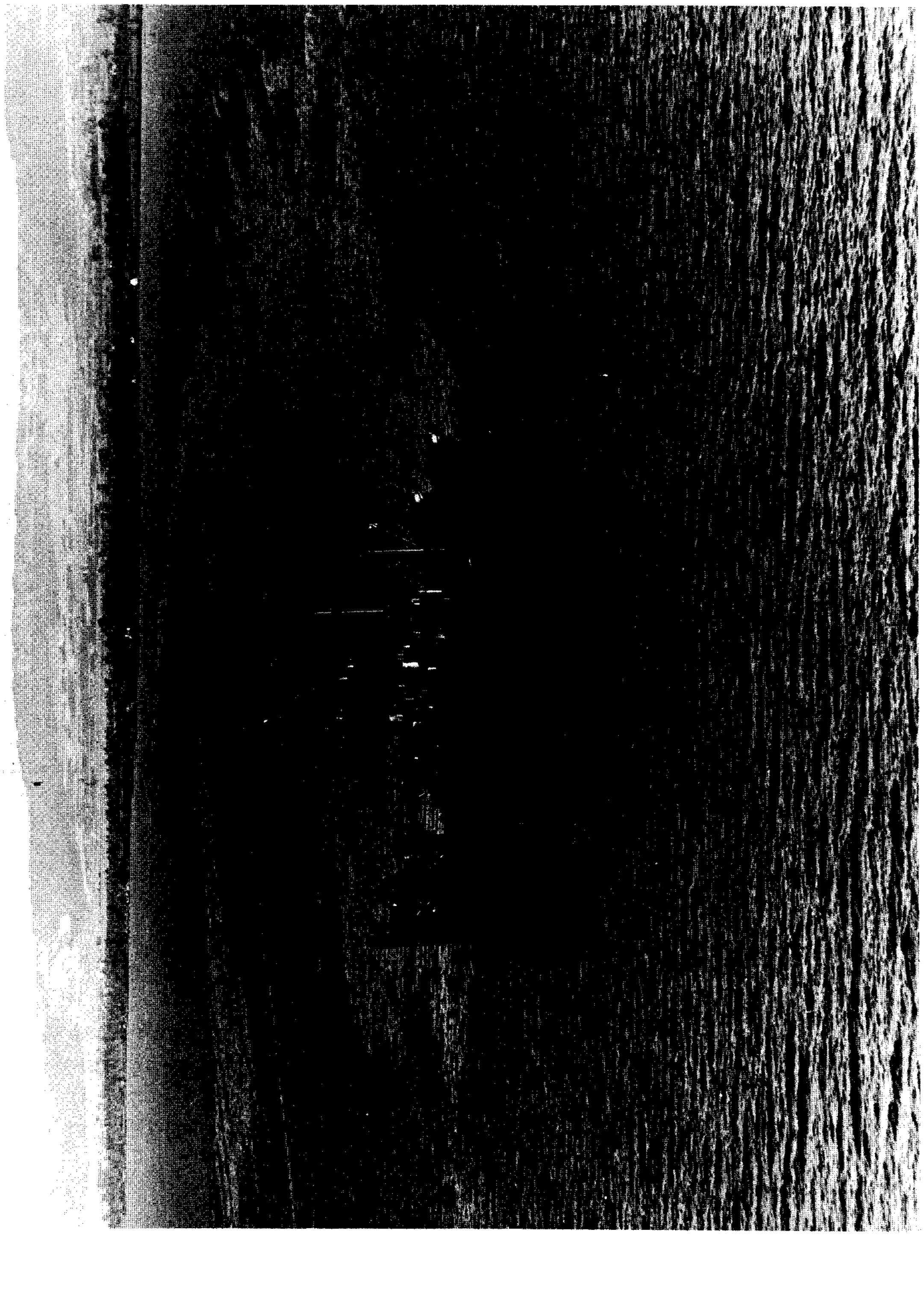
(1) Trim and Rig Operations

On 25 September, the trim and rig team arrived at the site of 15 SEPTEMBER, accompanied by the SCA 80-ton crane and a diving barge, to commence preparing the dredge for parbuckling and lifting. Total preparation involved the following procedures:

- Removal of fendering strips obstructing parbuckling wires and hooks

- Removal of accumulated silt

FIGURE VI-18
DREDGE 23 Suspended Between Heavy-Lift Craft
In the Dumping Ground at Great Bitter Lake
Between KASSER (foreground) and MONGUED (background)



- Repositioning of the dredge ladder and gantry
- Removal of spuds
- Patching numerous hull openings
- Rigging parbuckling and lift wires.

Shortly after arrival, divers commenced work burning the fendering strips at the top and bottom on both the port and starboard sides to facilitate parbuckling rigging. A second diving team inspected the side of the dredge that rested on the Canal's bottom and determined that rigging wires under the hull was feasible by jetting and lancing even though there was no clearance between the dredge hull and the bottom. Trimming of the fenders continued until 29 September, when the trim and rig team was required in the Southern Zone.

After completion of the work on BARREH and DREDGE 22 in the Southern Zone, the trim and rig team returned to the Central Zone on 5 November and resumed work on the dredge 15 SEPTEMBER. Divers continued oxyarc-cutting of the fenders and commenced silt removal operations in the forward machinery room, boiler room, and forward storage spaces. Approximately 170 tons were removed from the forward machinery room and 205 tons from the engine room, boiler room, and forward storage spaces. Silt removal operations employing airlifts were completed on 13 November.

After removal of the fenders on 6 November, the divers began working on the dredge ladder and gantry. Efforts to adjust the positions of both the ladder and gantry were necessary since the ladder in the lowered position would offer resistance to rolling the dredge upright and the gantry in the raised position would likely foul the parbucking wires as the dredge was rotated. To alleviate interference, both the ladder and gantry were to be brought as nearly as possible into a horizontal position. The plan was to raise the ladder using the installed rigging to the gantry. Afterward, the gantry was to be lowered by cutting the back stays and pulling it into a horizontal position. To accomplish this, the installed 1-1/4-inch wire rigging was cleaned of marine growth by shocking it with a small primacord explosive charge, then checked for clearance for pulling the ladder into place, and finally shackled to a hauling wire fairlead to the surface and attached to a small SCA tug.

On 9 November, the tug attempted to pull the ladder into position but was unsuccessful. The following day, the fairlead was changed to a more advantageous position. The 100-ton SCA crane was brought to the site and shackled into the hauling wire of the existing gantry tackle for lifting the ladder. After pulling for 1-1/2 hours on the afternoon of 12 November, the ladder was pulled within 2 feet of the desired position. A new eye was rigged in the hauling wire and the ladder was positioned early on 13 November. The ladder was then secured with 1-1/2-inch wire straps to prevent it from falling when the dredge was righted. The next day, after cutting the back stay wires from the gantry, a 5/8-inch wire was fairlead to the SCA tug, which pulled the gantry down.

On 9 November, while other work was progressing, one diving team commenced work on the spuds, which also had to be removed to permit parbuckling. Both the walking and the stern spuds were wrapped with primacord and detonated to remove sea growth prior to cutting. The simultaneous effort to sever the installed hoisting and lowering wires with primacord was unsuccessful; they were subsequently burned in two with oxyarc.

The walking spud was burned in half and lifted to a scrap barge. On 11 November, an attempt to remove the stern spud by using the 100-ton SCA crane was made, but the effort was abandoned after it was discovered that the spud was bound in its collar. This spud was then burned off 4 feet below the spud gate, lifted from the water, and placed on a scrap barge.

On 15 November, the trim and rig team left the site of 15 SEPTEMBER to work for 8 days on the Concrete Caisson. When the team returned on 22 November, divers commenced patching operations by closing sea valves where possible and measuring, fabricating, and installing patches on the sea suctions and damaged area. The port and starboard sea suction valves in the boiler room were closed. Patches were fabricated and installed, as indicated in Table VI-3. Patching operations were completed before the arrival of THOR and ROLAND on 24 November.

Table VI-3
Description of Patches on 15 SEPTEMBER

Location	Size (inches)	Type	Type of Fastener
Forward sea suction strainer	19 x 19 x 1/4 thick	Steel	1-1/2 in. J-bolts
Hull crack in forward end deck house	28 x 5 x 3/4 thick	Plywood	2-1/2 in. J-bolts
Aft sea suction strainer	52 x 40 x 1/4 thick	Steel	2-1/2 in. J-bolts
Various overboard discharges	2-3/4 diameter	Plywood	Explosive studs
Blast hole starboard side engine room	96 x 56 x 3/16 thick	Steel and mattresses	Strongback with 2-3/4 in. bolts

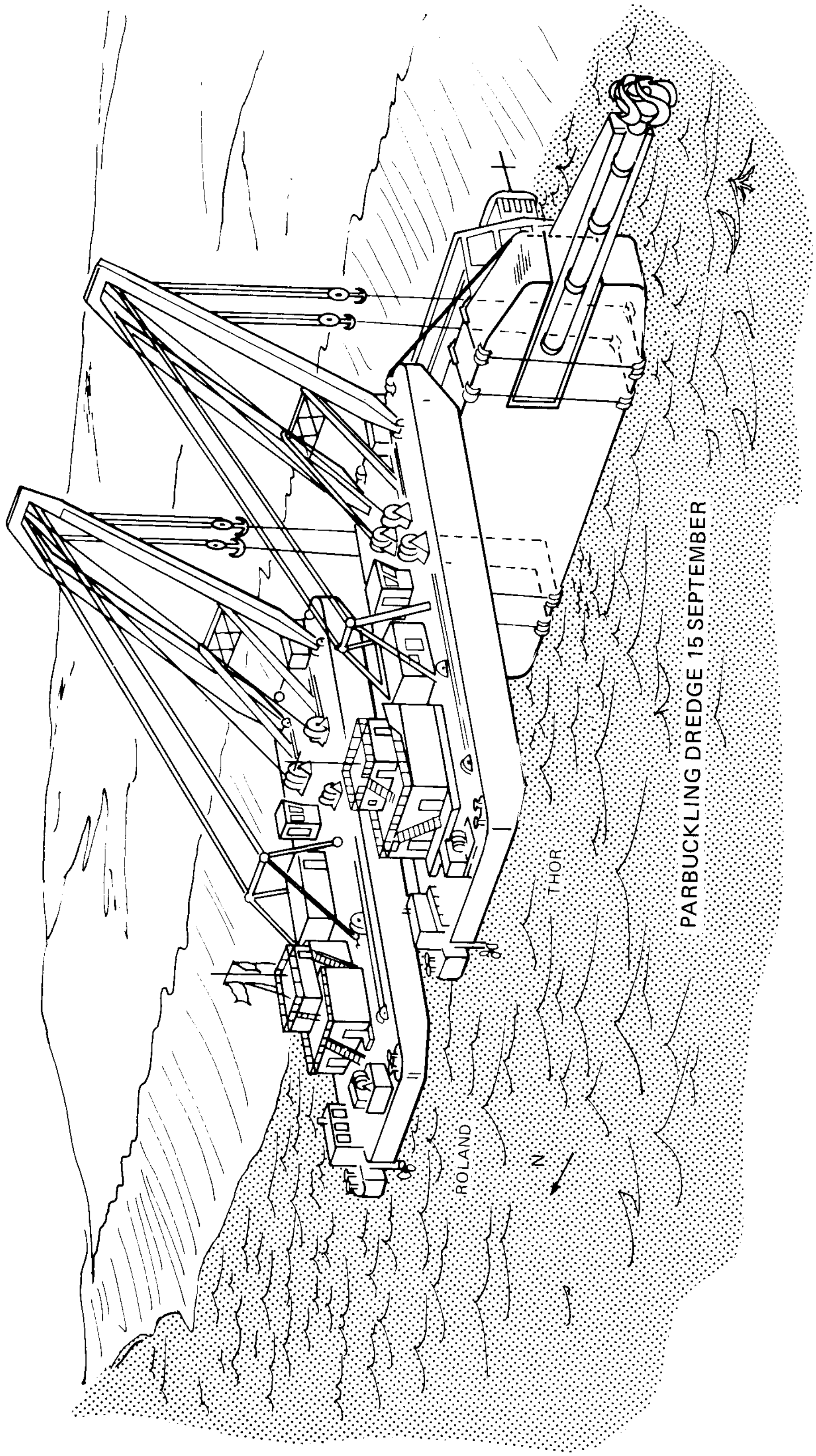
(2) Parbuckling Dredge 15 SEPTEMBER

On 24 November, after completion of operations in the Southern Zone, THOR and ROLAND returned to the Central Zone to begin salvage operations on 15 SEPTEMBER.

Upon arrival, the two cranes were moored perpendicular to the dredge and to the west of it, THOR to the south, ROLAND to the north, as shown in Figure VI-19.

On 25 November, the trim and rig team working with the crane crews commenced recovering messenger wires that had been rigged previously. One messenger, which was out of position, was repositioned by jetting under a new messenger. When all messengers were positioned, work commenced to rig the 3-inch parbuckling wires. Although some difficulty was experienced in positioning the after wire of ROLAND, all four 3-inch wires were rigged into position on 26 November.

FIGURE VI-19
Parbuckling Dredge 15 SEPTEMBER



After burning the handrails on the port side clear of the wires, the divers, with crane assistance, rigged the parbuckling anchors to the starboard deck edge, and the chafing plates to the turn of the bilge port and starboard for all four wires. Diver inspection revealed that THOR's port wire was not on the chafing plate and that ROLAND's starboard chafing plate at the port turn of the bilge of the dredge had slipped out of position. These chafing plates were repositioned on 29 November.

The next day, after running messengers for ultimate lift wires, the parbuckling of 15 SEPTEMBER commenced shortly after noon and was completed 27 minutes later. Two legs of ground tackle prepositioned off the stern of the cranes to provide additional horizontal force for parbuckling could have been rigged quickly in the event of need. The lifting force of the cranes proved to be sufficient. The parbuckling force of 950 tons, however, caused minor damage to the hull of the dredge. THOR's starboard wire cut into the deck and port side of the gunwale the width of the wire to a 3-foot depth. The wire was found later to have slipped off the chafing plate.

(3) Refloating Operations

After parbuckling was completed, four additional lift wires and chafing plates were rigged. Lifting operations commenced shortly after noon on 2 December. After application of 1600 tons of lift force, using THOR's and ROLAND's main hooks and gin tackle, the dredge was lifted off the bottom. As the hull was lifted and additional structure was raised above the surface, the required lifting force increased. With the 01 deck out of the water, the lifting force reached 1900 tons. Figures VI-20 through VI-23 are photographs of Dredge 15 SEPTEMBER at progressive stages in the lifting operation.

Lightening the wreck for further lifting was necessary. All remaining silt and debris were removed by washing out each deck as it became awash. Drain holes were burned when natural drainage did not exist. Removal efforts continued throughout the following day until all accessible silt and debris had been cleared. With application of maximum load on THOR and 10-percent overload on ROLAND, the dredge 15 SEPTEMBER was raised until the main deck was 5 feet out of the water forward and 5 feet beneath the surface aft. By then it was evident that the wreck

FIGURE VI-20
Dredge 15 SEPTEMBER Breaking the Surface

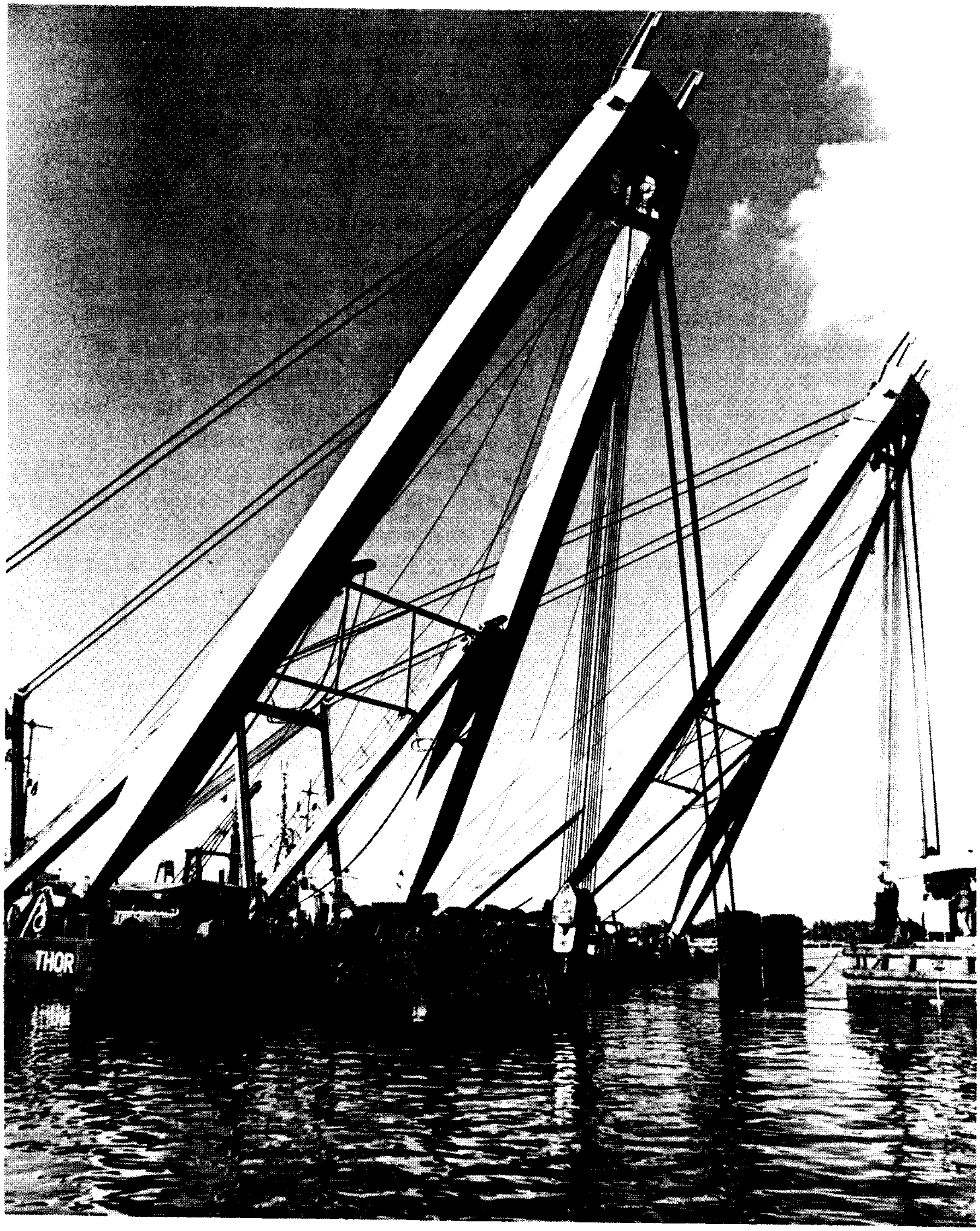


FIGURE VI-21
Dredge 15 SEPTEMBER With 03 Level
Above the Surface

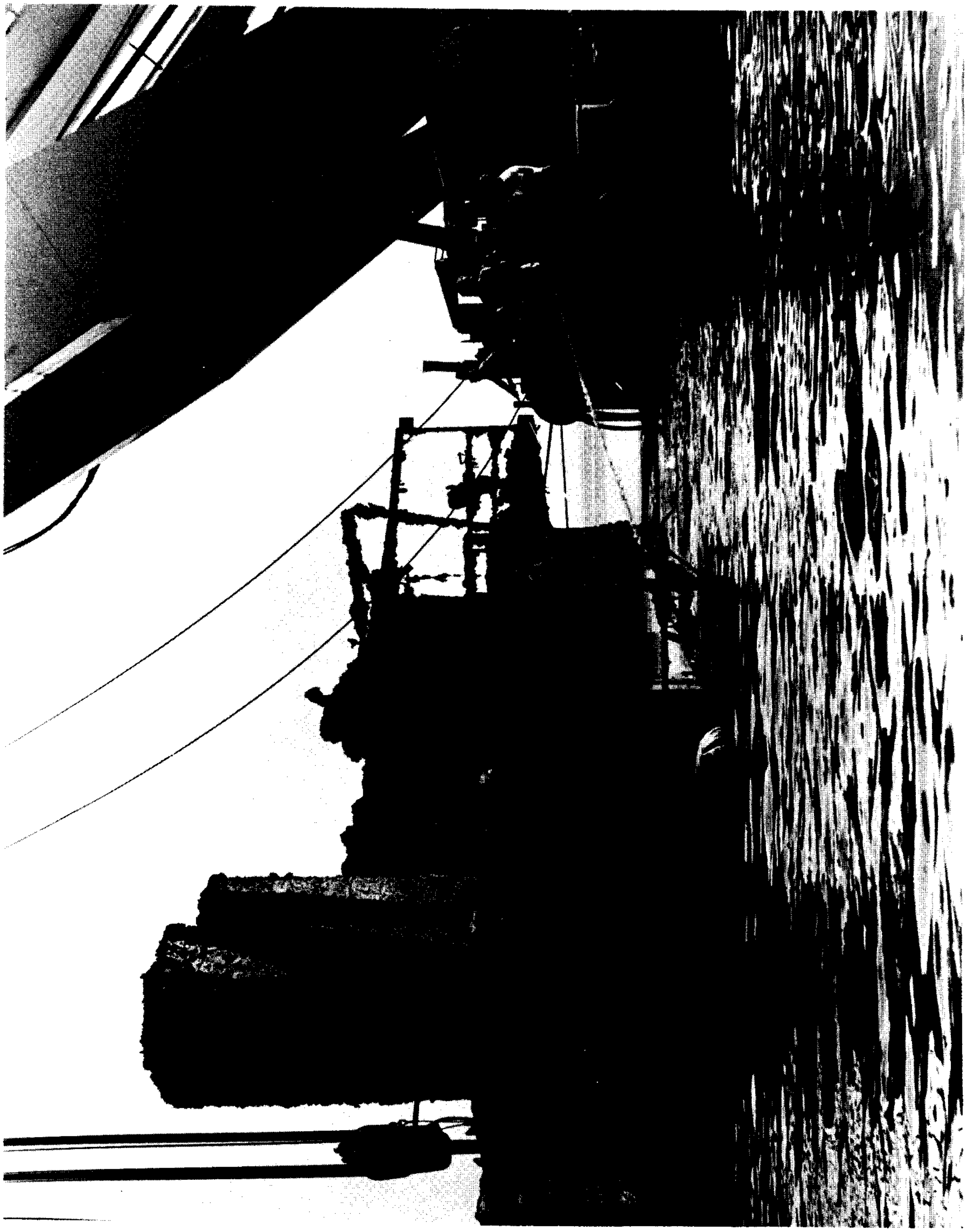


FIGURE VI-22
Dredge 15 SEPTEMBER With 02 Level
Above the Surface

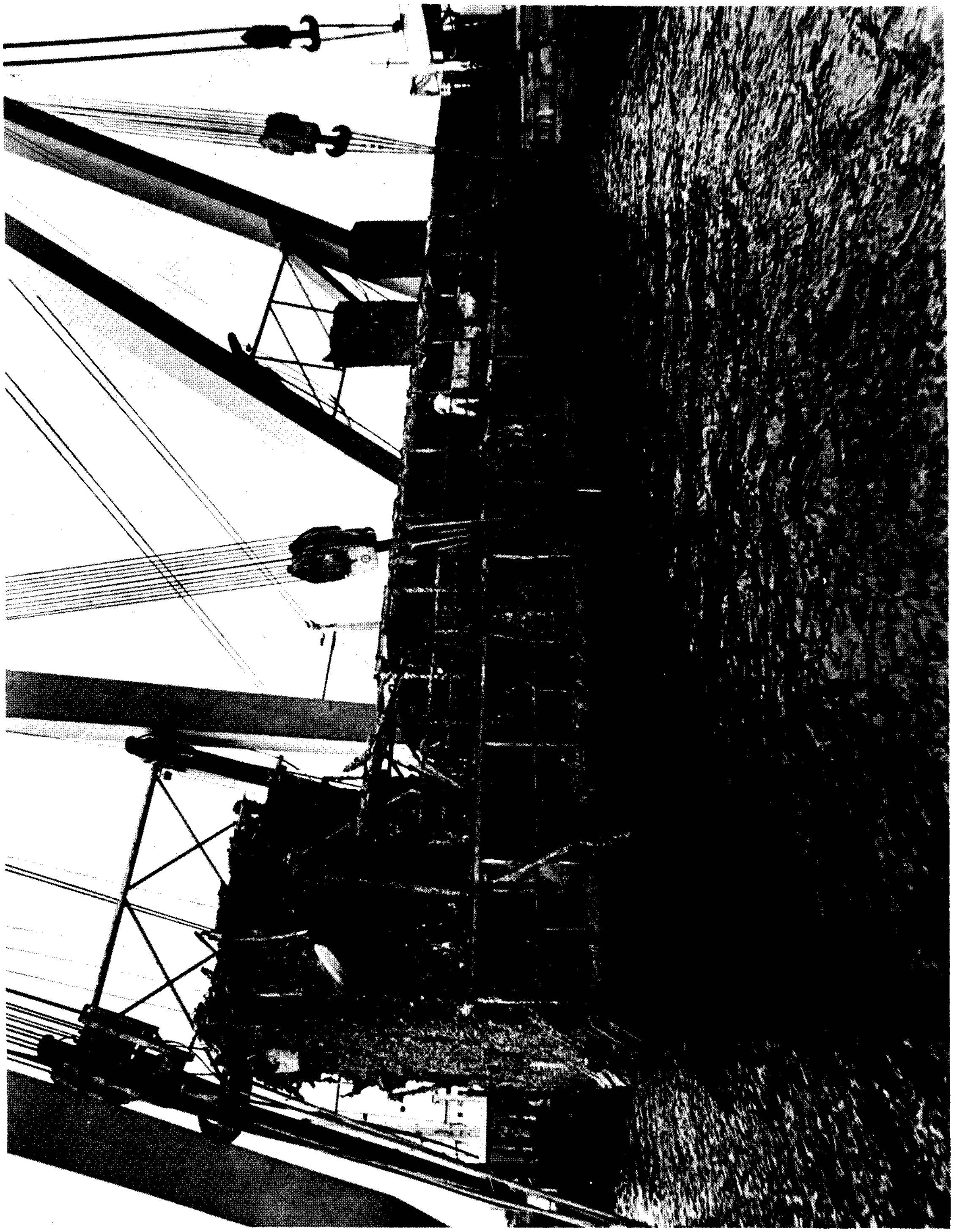


FIGURE VI-23
Dredge 15 SEPTEMBER
Suspended by ROLAND and THOR
Prior to Final Refloating

was heavier than had been estimated and that additional buoyancy would be required to surface the remainder of the main deck so that the hull could be pumped out.

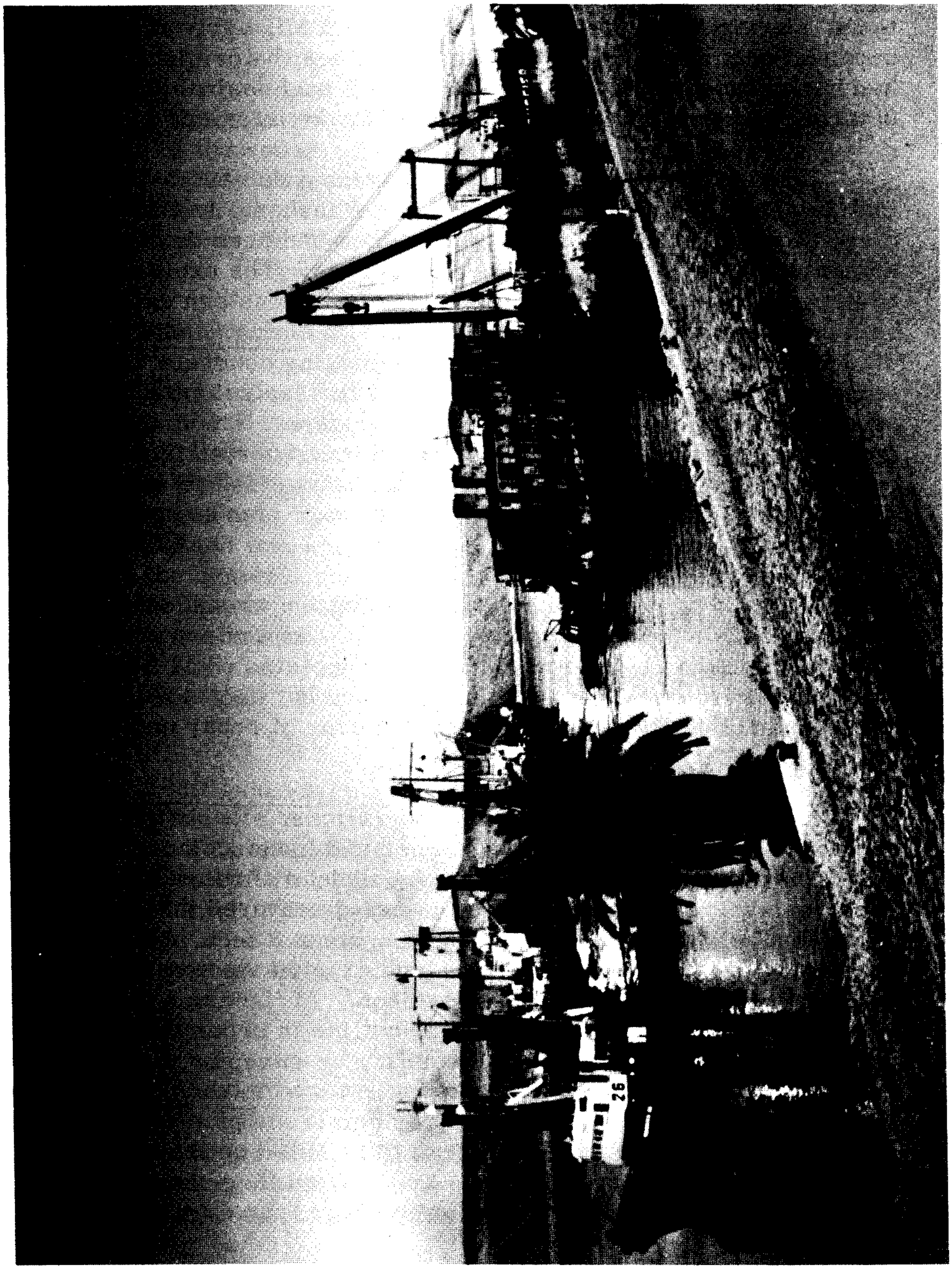
The after ballast tanks of the dredge were patched and blown in an effort to generate additional buoyancy. Numerous leaks, however, detracted from the full effectiveness of this measure. Pumping was then undertaken using the casing of the main deck house as a cofferdam. The pumps employed included one 6-inch, nine 3-inch, and several small submersibles. Care was taken during the dewatering to prevent shifting the center of gravity of the suspended wreck toward the already overloaded ROLAND. As more of the main deck lifted, pumping was concentrated aft in order to trim the wreck and lighten the load on ROLAND. With the dredge still suspended by THOR and ROLAND, pumping operations continued throughout the night until 15 SEPTEMBER floated on the morning of 5 December. Choppy waters in the Great Bitter Lake and 20- to 25-knot winds prevented release of the dredge by the cranes until the following day. After the cranes were unrigged, THOR was shifted to lift the dredge ladder, which had fallen during refloating, into a horizontal position.

In late afternoon, 15 SEPTEMBER was taken under tow by the tug BUGSIER 26, with ROLAND trailing astern holding the 200-ton ladder off the Canal bottom. After an uneventful 22-kilometer tow up the Canal, 15 SEPTEMBER was delivered to the SCA yard in Ismailia at dusk on 6 December. The dredge is shown in Figure VI-24 under tow just south of Tuson Station, passing the two heavy-lift craft as they were lifting the eastern half of the Concrete Caisson.

4. SALVAGE OPERATIONS ON THE CONCRETE CAISSON

The initial salvage plan for the Concrete Caisson called for it to be sectioned into two parts, each of nominally equal weight, by a combination of oxyarc and explosive cutting. The heavy-lift craft would then lift each section in successive lifts to achieve a draft which would permit transit over the remains of the Deversoir Causeway to the dumping area in the Great Bitter Lake. Sectioning and rigging for lift would be accomplished by the trim and rig team prior to the arrival of the heavy-lift craft, CRANDALL and CRILLEY.

FIGURE VI-24
Refloated Dredge 15 SEPTEMBER
Under Tow to Ismailia From Great Bitter Lake
(ROLAND, at right, is supporting the ladder)



(1) Trimming and Rigging of the Concrete Caisson

Operations commenced on 30 August when the trim and rig team, supported by the crane barge BAYOUMI, arrived and began a second survey of the caisson. Since the original survey had been conducted 48 days previously, it was desirable to determine if any changes had occurred in the interim.

This second survey revealed additional damage. The original 2-inch wide crack had opened up to 8 inches. In addition, there was evidence that explosive charges had been detonated alongside the hull since the previous survey. The explosives had created two 12-foot diameter holes in the eastern end with both concrete and reinforcing bar (rebar) missing, and a 5-foot diameter hole in the western end with missing concrete and some cut rebar. It was considered that the explosions probably resulted from fishing by indigenous fishermen. The forces from the explosions, coupled with the forces exerted from the cantilevered western end, caused the crack amidships to open. The additional damage reaffirmed the salvage plan of sectioning and lifting.

Prior to commencement of trimming the wreck, the rigging of eleven 5/8-inch messenger wires under the western end of the caisson began on 1 September and was completed on 11 September. The wires were usually sawed into position but occasionally had to be jetted under because of the protrusions of rebar underneath the caisson.

In preparation for sectioning operations, silt obstructing the crack line in the mid-section upper and lower compartments was removed to expose the sides and bulkhead of the caisson. Upon removal of silt in this area, it was discovered that the centerline bulkhead had been crushed in about 3 feet. This failure further weakened the structure and created a potential hazard to divers working underneath the caisson. At the same time, a wire was rigged under the hull at the cutline in order that the completeness of the cut could be verified by sweeping the wire through the cut. The effort to place this wire by tunneling under the wreck was handicapped not only by numerous pieces of concrete that fell into the tunnel and had to be lifted out by hand as the tunneling progressed, but also by the fluid flow characteristics of the fine granular sand that composed the Canal's bottom.

The sand flowed laterally into the tunnel and tended to close it. On 16 September, after a week of effort, the wire was passed and stopped off on the wreck. Cutting operations began on the same day.

The procedure for cutting consisted of shattering the concrete with explosive charges and finishing the cut by oxyarc-cutting of the rebar. Although cutting the rebar was not difficult, it did require considerable time because of the large quantity present. Appendix K includes a dicussion of the use of explosives on the Concrete Caisson.

(2) Silt Removal

Silt removal commenced in the 10 compartments in the western end of the caisson using a 10-inch airlift. Access holes for the airlift were cut through the centerline bulkhead using the 3-pound C-4 explosive charges to clear the concrete from the access opening. Removal of the silt from the top of the centerline bulkhead was accomplished first. An access hole was then cut in the centerline bulkhead and the silt removed from the lower compartment. Silt removal operations were completed in the western end of the caisson on 10 October. Silt in the eastern end was removed several weeks later just prior to lift of that section.

(3) Additional Rigging Operations

On 6 October the firm decision was made to remove the western end of the caisson using the heavy-lift craft CRANDALL and CRILLEY. To make possible the use of these craft, six additional wire messengers were rigged under the wreck: two under the eastern end of the section and four under the western end.

(4) Lifting of Western Section

On 11 October, CRANDALL and CRILLEY moved into position alongside the western end of the caisson: CRANDALL to the north, CRILLEY to the south, bows toward the west.

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The 16 messenger wires that had been rigged previously were taken aboard, and pulling of the heavy-lift wires commenced. A total of 20 wires were to be used.

By 16 October, the 3-inch heavy-lift wires had been pulled under the wreck with some difficulty. The following morning the lift craft rigged 45-foot spreaders between the craft and ballasted down to both check the vertical clearance over the wreck and to commence pinning down. On the morning of 17 October, the western extremity of the caisson dropped 7 feet into a 72-foot deep depression, which had been growing about 1 foot per day. The side lift had been premised on lifting the western end 7 feet off the bottom when it was at a maximum depth of 65 feet followed by a second lift on the side of the scoured out depression around the western end. The increase of the maximum draft now precluded this plan. A section of the western end is shown in Figure VI-25. Dredging a slope to permit the caisson section to be lifted out of the hole in sequential lifts was not practical since no dredges were available. On 19 October, CRANDALL and CRILLEY unrigged, leaving the messengers in place, and proceeded to other operations while the western end was lightened.

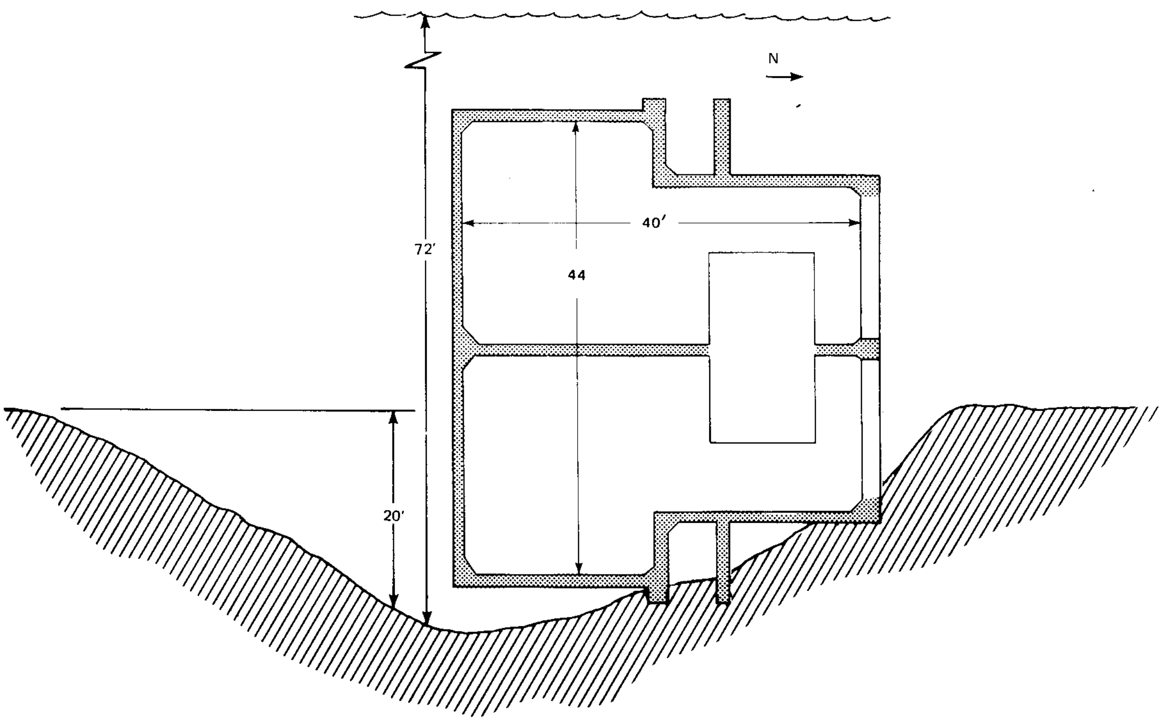


FIGURE VI-25
Western End Section of Concrete Caisson
Showing Bottom Topography

The section was estimated to weigh 1500 tons (wet) excluding any entrained silt. The goal was to lighten it enough for lift by the YHLC stern gantries (1200 tons total lift capacity).

(5) Lightening of Western Section

After abandoning the plan to lift the western end by side lift with CRANDALL and CRILLEY, the trim and rig team returned to complete the sectioning operation necessary to any future salvage operation. This cut was completed after a 2-day effort expended mostly in cutting the rebar on the upper side that held the two halves together.

Lightening of the western end of the caisson called for removal of the upper compartments after cutting them into five sections of 100 to 200 tons each, as shown in Figure VI-26. These pieces would be within the 300-ton dynamic lift capacity of the outward gantry hooks of a single YHLC. The stern gantries of the lift craft would be used to lift the individual sections.

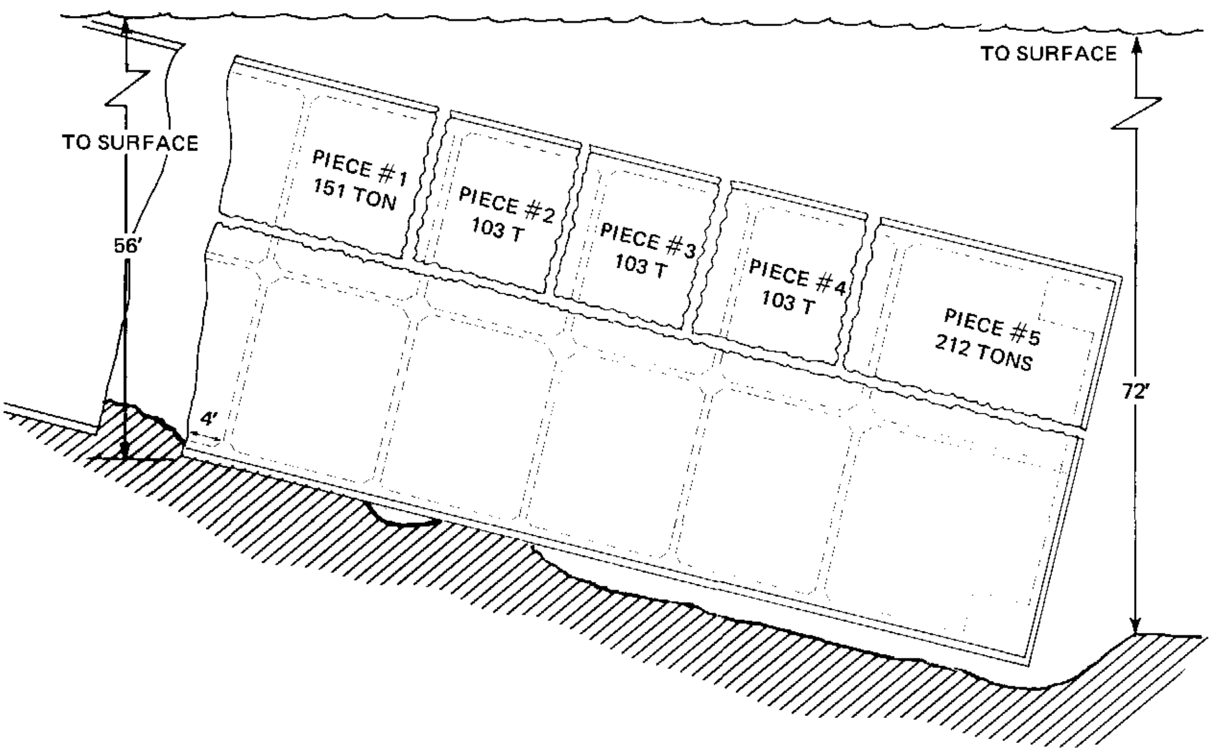


FIGURE VI-26
Caisson Bottom Section Showing Cuts

The sections would then be transported to the wet dump area, suspended from the lift craft. After lightening, the weight of the western section would be within the 1200-ton stern lift capacity of the heavy-lift craft operating together. With the stern dynamic lift, the caisson section could be lifted out of the depression.

The plan for sectioning the five sections called for placing all sectioning explosive charges from the outside. Hence, the divers would not have to enter the hull and encounter the risks presented by the badly cracked concrete structure. Explosive cutting on the first section began on 24 October, using linear-shaped charges containing 1 pound of C-4 per foot on flat surfaces; hose charges were used around structural shapes. The cut sequence involved cutting the transverse bulkhead horizontally, vertically up the bottom around the turn of the bilge, and horizontally across the side. Most of the rebar survived the explosive cutting and was cut with oxyarc procedures. This first cut (toward the eastern end of the section) was completed and the piece lifted with the stern gantry on 31 October.

The SCA crane barge assisted in the rigging of the sections for lifting. The lifts employed two chain slings led under the upper side of the caisson section through two openings cut in the section by explosive charges, as shown in Figure VI-27, and secured to the lift craft's starboard gantry hook. The after ends were secured in a similar manner to the port gantry hook. The first section was removed by CRANDALL on 30 October and dumped in the Great Bitter Lake.

Upon lifting, the stern gantry rigging was two-blocked. The lift craft was ballasted so that it was trimmed 2 feet by the bow and towed to the dumping ground in the Great Bitter Lake, where the section was placed on the bottom and unrigged by divers. The second section was cut, lifted, and deposited in the dump area by CRILLEY on 4 November. The third and fourth sections of 100 tons each were lifted together to space the lift points further apart and thus reduce lateral loading on the stern gantry. They were removed as a single piece on 7 November by CRANDALL. The fifth section was completed by CRILLEY on 11 November. CRANDALL is shown lifting a caisson section with stern gantries in Figure VI-28.

FIGURE VI-27
Lift Arrangements for Removal
of Caisson Sections

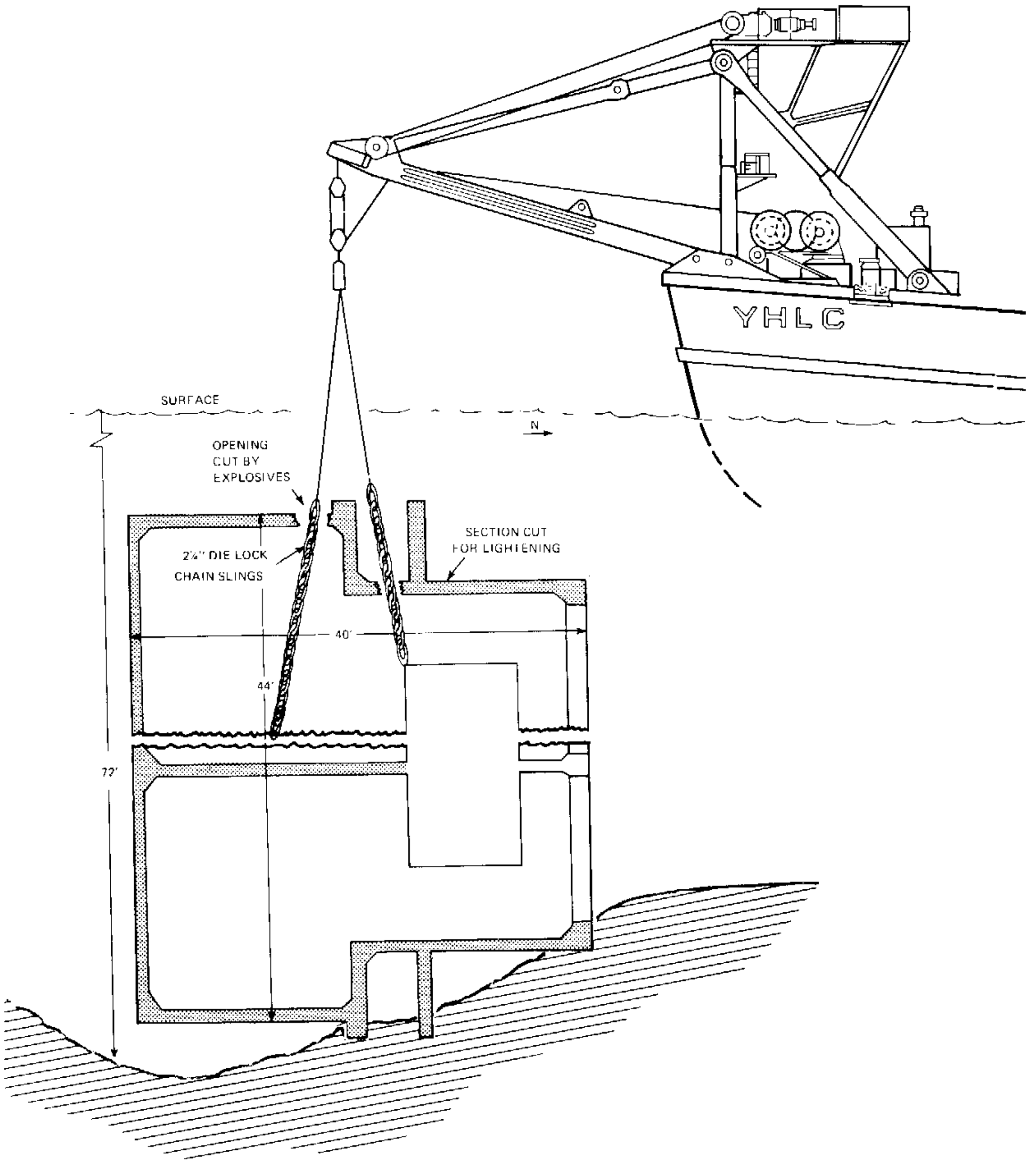
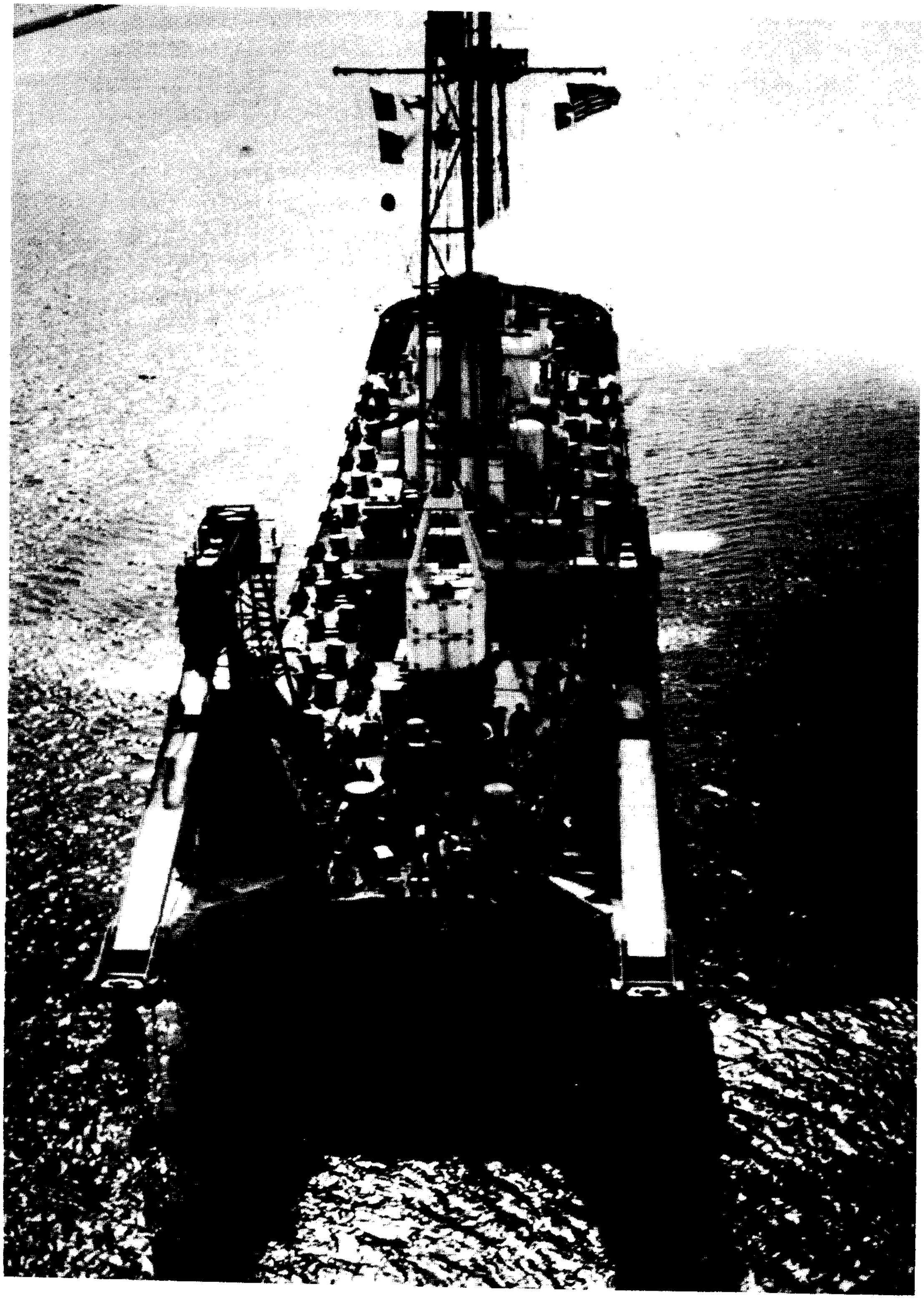


FIGURE VI-28
CRANDALL Using Stern Lift Gantry
to Lighten Concrete Caisson



Removal of these sections, totaling about 550 tons, required cutting 514 linear feet of reinforced concrete. During this sectioning operation, 500 pounds of C-4 explosive, 258 pounds of burning rod, and 185 hours of diving time were used during an 18-day period.

(6) First Lifting Operations on the Western Section of the Caisson

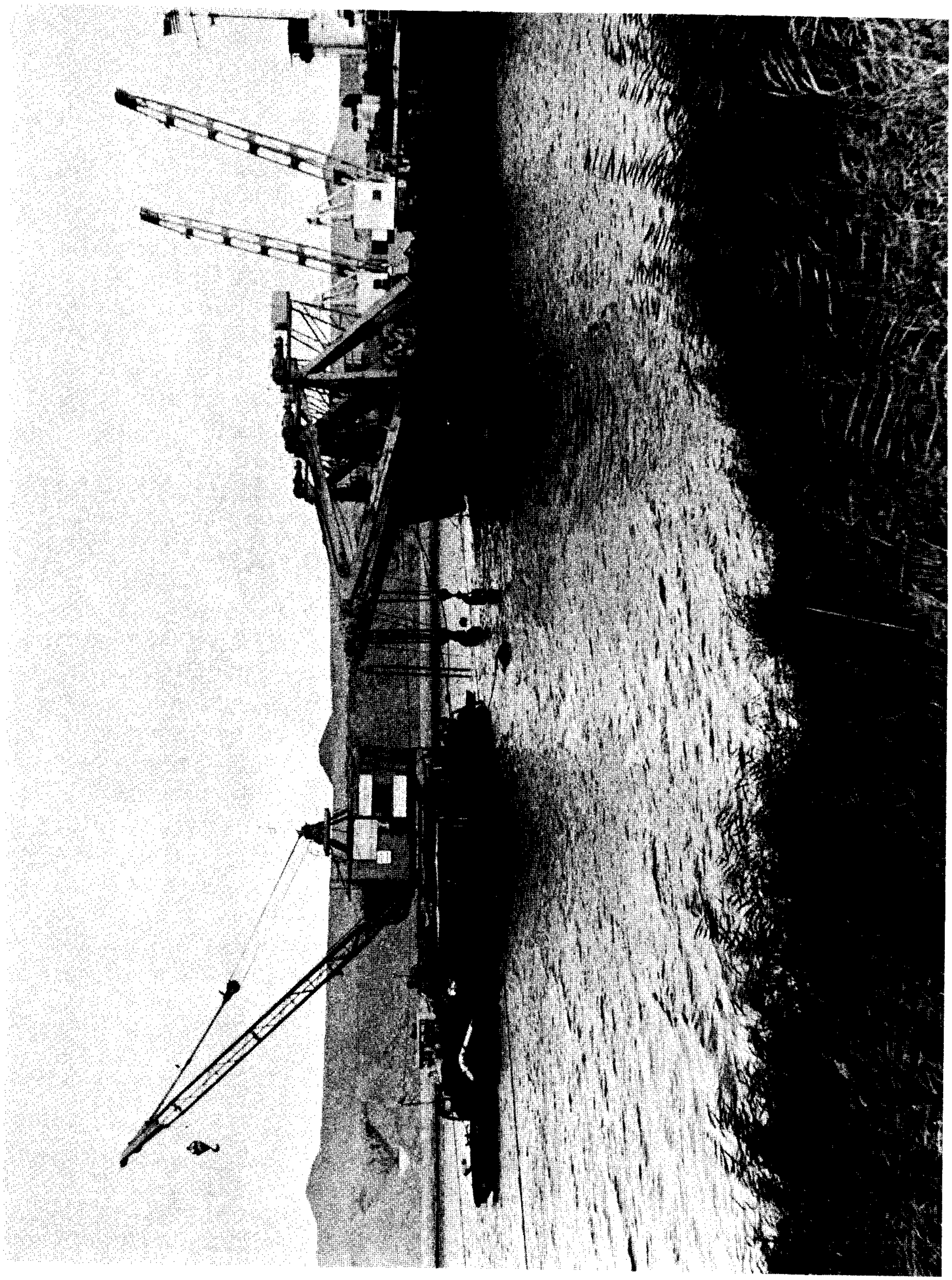
The lower portion of the western end had been lightened to an estimated 900 tons and could be stern lifted by the two lift craft, operating together. The section was in poor structural condition, but it was determined that it would be sound enough for lifting. On 12 November, CRANDALL and CRILLEY moored stern to the western section of the caisson, bows to the south. Bower anchors, quarter lines to prepositioned anchors, and lines to bollards on the Canal bank were used for the moor. A photograph of the craft positioned and being rigged for this lift is shown in Figure VI-29.

The lift positions on the 92-foot effective length of the section were to be spaced 32 feet apart to correspond with the spacing on the gantry hooks. With the two lift craft married together during lifting, there was an 8-foot overhang of the caisson section at each end and a 1-foot spacing between lift craft.

Rather than employing chains as had been done with the smaller sections, advantage would be taken of the nine 1-inch messengers that had been rigged for the earlier side lift attempt. Using the messengers, four 3-inch wires were run from the deck tackle down under the caisson up over the gantry hook roller, back down under the caisson, and up to the deck tackle. A total of four such bights, one on each lift hook, would be employed to lift the section. Rigging, which proceeded slowly as each wire was fought under the wreck, was completed on 17 November.

To preclude the possibility of a disastrous unintentional grounding while en route to the dump area, it was planned to complete the operation with a side lift. (Grounding at the Deversoir Causeway with a 92-foot-wide obstruction was a distinct possibility.) To facilitate this, the caisson section would be lifted from the depression, transported a short distance, and

FIGURE VI-29
Rigging CRANDALL and CRILLEY for Stern Gantry Lift of Western End of Caisson



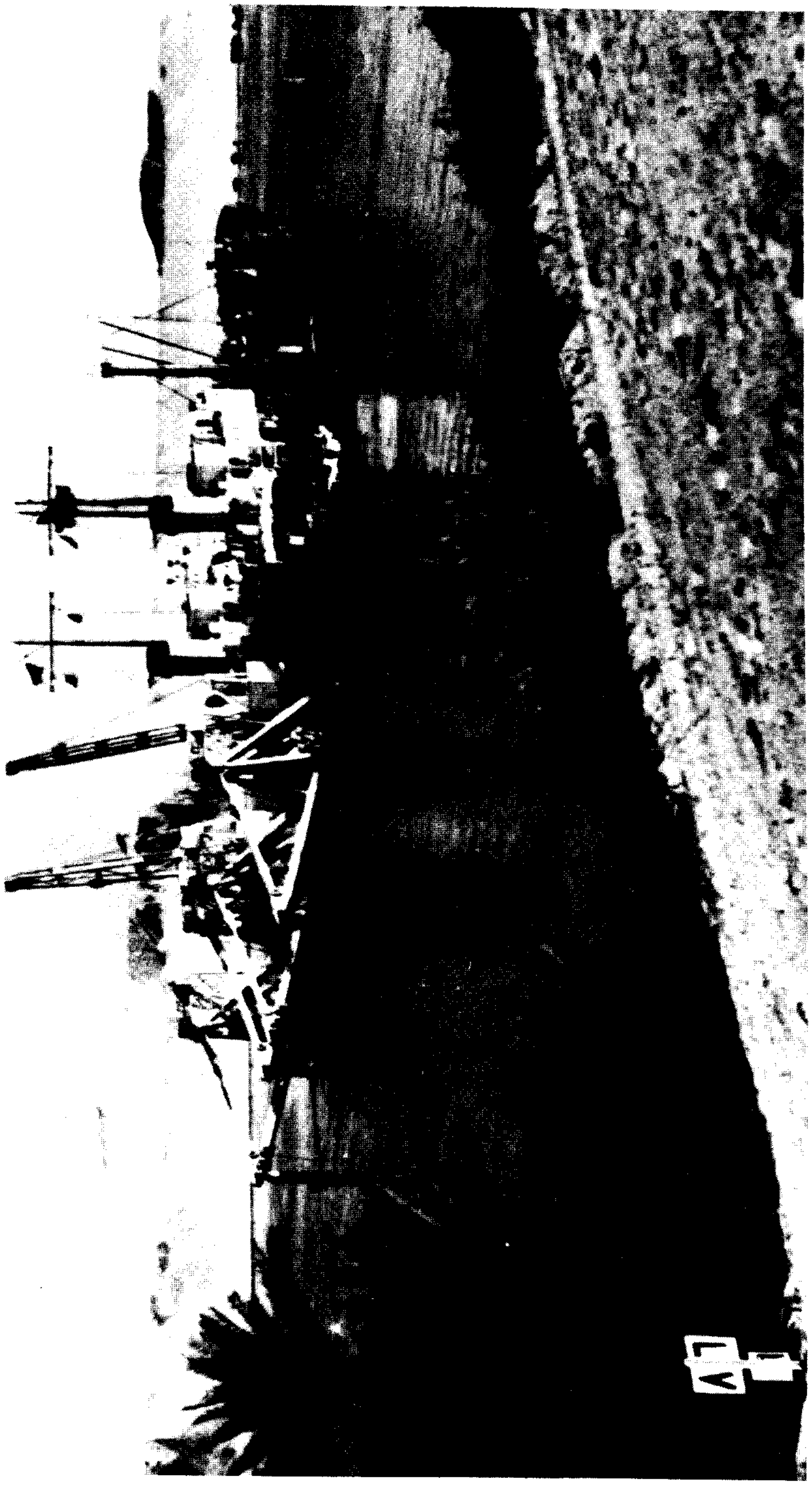
held clear of the bottom while additional lift wires were rigged. The section would then be set down and rigged for a side lift. The side lift would have a significantly larger margin of available capacity and would hold the section much more securely during the transit to the dump site. Additionally, of course, the cross-section of the wreck at maximum depth would only be about 25 feet vice 92 feet.

The first lift attempt made on the morning of 21 November was unsuccessful because the east end of the section would not lift free. Divers cleared the rubble and a second lift attempt was made on 23 November. In the second attempt, the caisson section was lifted from the depression and moved about 20 meters southward, where it was lowered to the Canal's bottom in 51 feet of water at dusk. When the section was lifted on the morning of 24 November, two strands of one wire parted. The section was replaced on the bottom where it was and stern lift operations on the western half of the caisson terminated rather than rerig the failed stern lift wire to move the section only a few hundred meters further south. CRANDALL and CRILLEY are shown lifting the western section in Figure VI-30. The caisson had been positively separated and was in a depth where a side lift was feasible. CRANDALL and CRILLEY moved to the eastern half of the caisson.

(7) Lifting Operations on the Eastern Section of the Caisson

When the stern lift operations had been completed, CRANDALL and CRILLEY began rigging for side lift of the eastern section on 26 November. Eighteen wires were passed and the first lift was made on 30 November. The lift was successful but some wires appeared to have suffered damage from the sharp concrete corners. To preclude catastrophic failure, the caisson was set down. Approximately 150 tons of mud were removed from the caisson to reduce the weight of the lift. To reduce wire loading and to make it more equitable, two additional pairs of wire were passed, and the position and lead of one pair of wires was improved. A second lift was made on 5 December. The section was twisted to take advantage of a natural rise of the bottom and regrounded. A third lift was made on the morning of 8 December and the wreck maneuvered toward Deversoir Causeway with a 46-foot draft. The caisson section grounded in the Causeway.

FIGURE VI-30
CRANDALL and CRILLEY Lifting
Western Section of Caisson
From Depression in Canal Bottom



Careful examination of the bottom at Deversoir showed that some additional difficulty could be expected in passing the Causeway. There was a ridge approximately 50 feet wide and 45 feet deep, with rocks as shallow as 42 feet. Large rocks were removed by divers and a crane and high spots were lowered by divers to achieve a 47-foot clearance. The lift craft were ballasted, the caisson was set on the bottom (the southern end was in 47 feet, the northern end in 52 feet), wires were rendered, and a lift was made. The caisson section now drew a maximum of 45 feet. On 10 December, Deversoir was crossed without difficulty. The section grounded only 1 kilometer from the dumping ground in the Great Bitter Lake and had to be lifted once more before being deposited in the dump area.

(8) Final Lifting Operations on the Western Section of the Caisson

Because of the delay that was experienced with lifting the eastern section of the caisson and because of the availability of the heavy-lift crane THOR (which had just completed the 15 SEPTEMBER), it was deemed expeditious to employ THOR using both crane and gin tackles to lift the western section since its total weight (950 tons) was within the crane's total capacity.

THOR was unable to lift the section, however, because of caisson weight distribution problems. During the attempted lift the crane tackle was overloaded, but the gin tackle carried little load. Since it would be necessary to devote considerable time to prepare and balance the caisson sections for a type of lift that might not be successful, the continued use of THOR was not attractive. This attractiveness was further diminished by the fact that CRANDALL and CRILLEY were capable of handling the job easily, and by the possibility of damaging THOR, which was a valuable asset needed for a two-crane lift of the last remaining piece of MECCA in the Northern Zone. Hence, a decision was made to employ CRANDALL and CRILLEY to remove the last section of the caisson and to release THOR to assist in the final work on MECCA. Consequently, work began on rigging messengers for employment of CRANDALL and CRILLEY when they returned from dumping the eastern section.

CRANDALL and CRILLEY returned to the western section on 14 December and began work passing six pairs of heavy-lift wires. Rigging and first lift on 18 December proceeded without difficulty. A second lift was made on top of the ridge at Deversoir the morning of 19 December and a third lift just short of the dump area that afternoon. Salvage operations in the Central Zone terminated when the western half of the caisson was dumped at 1730 local time on 19 December. The removal of all wrecks from the Northern and Southern Zones having been completed earlier, dumping of the western section of the caisson marked completeion of ship salvage and clearance operations in the Suez Canal.

5. SUMMARY

Salvage operations in the Central Zone were conducted much as they had been planned. Successive lifting of MONGUED, KASSER and DREDGE 23 with the heavy-lift craft and depositing them in the dumping ground in the Great Bitter Lake was accomplished in classic fashion. Righting, lifting, patching, and pumping evolutions to refloat dredge 15 SEPTEMBER were carried out rapidly and effectively. The minor rigging problems that were experienced in the process of removal of these wrecks were typical and not unexpected.

The Concrete Caisson, however, presented difficult problems, particularly in the western section. One setback was the settling of this section into the bottom as the result of disturbances caused by explosive cutting, tunneling, and other forces, coupled with the sudden shift into a deeper hole which prevented lifting with the heavy-lift craft. The resultant requirement to commit additional time and assets to lighten it for lift caused momentary concern as to meeting the overall completion date. Judicious use of available resources was successful, however, in overcoming this setback and meeting the scheduled completion date for the operation.

VII. SALVAGE OPERATIONS IN THE SOUTHERN ZONE

VII. SALVAGE OPERATIONS IN THE SOUTHERN ZONE

Three wrecks blocked the Canal in the Southern Zone. The tug BARREH and DREDGE 22 were sunk as a combined block athwart the Canal just 2 kilometers north of the city of Port Taufiq at the southern entrance to the Canal. The tanker MAGD was sunk 30 degrees from the Canal axis about 1 kilometer north of BARREH and DREDGE 22. The location of each wreck is shown in Figure II-1. The principal dimensions of the wrecks are shown in Table II-1.

Table VII-1
Principal Dimensions of Wrecks in the Southern Zone

Wreck	Length (feet)	Beam (feet)	Depth (feet)	Lift Weight (tons)
MAGD	358	48	27	3,000
BARREH	165	32	19	1,200
DREDGE 22	175	41	13	1,200

Survey operations of the Southern Zone wrecks began on 19 July and continued through 29 July. Detailed survey results are presented in Chapter IV. Table VII-2 (extracted from Table IV-2) summarizes the survey results on the three Southern Zone wrecks. Salvage operations in the Southern Zone began on 6 October when the trim and rig team commenced work readying tug BARREH for lifting. They were completed 48 days later on 22 November when the bow section of MAGD was deposited in the wet dump area in Suez Bay, as indicated in Figure VII-18.

Table VII-2
Summary of Salvage Survey Results in the Southern Zone

Wreck	Attitude	Hull Damage	Hull Support
MAGD	On port side	Extensive; cargo tank tops buckled plating and rivets missing; damage in tankage widespread	Supported by Canal bottom over half its length
DREDGE 22	22 degrees past horizontal on starboard side	Extensive; damage from scuttling charges and rust; shelter deck and sections of main deck missing	Supported by hard sandstone bottom
BARREH	10-degree port list. Stern awash at low tide.	Hull sound; stack and superstructure gone, eight portholes broken open or missing	Supported generally on hard sandstone bottom except bow on soft sand

1. SALVAGE PLANS

Salvage plans for removal of MAGD, DREDGE 22, and BARREH underwent several revisions because of the following four factors:

> During the salvage survey, it was discovered that DREDGE 22 was on its side rather than in an upright position, as reported previously by the SCA survey. The significance of this was that the heavy-lift cranes THOR and ROLAND would be required to parbuckle the dredge and thus could lift it as well shortly thereafter. The delay which would be incurred by removing the cranes after parbuckling and then re-rigging the wreck for the employment of heavy-lift craft for lifting would thereby be avoided.

- It was decided not to use CRANDALL and CRILLEY shortly after their arrival in the Southern Zone for the following reasons:

  - The requirement to parbuckle DREDGE 22

  - The proximity of DREDGE 22 to BARREH which would seriously interfere with the positioning of the lift craft

  - The swift tidal current would create a problem in mooring CRANDALL and CRILLEY normal to the current for side lift operation

  - The heavy-lift cranes would be easier to moor since they normally operate parallel to the current.

- After sectioning MAGD it was easier to parbuckle its stern section, rather than trim its superstructure to permit lifting on its side by YHLC. This was another factor for using cranes rather than lift craft.

- Continued difficulty had been experienced with the Concrete Caisson. This required the employment of the lift craft on the Caisson in the Central Zone for longer than expected and precluded their availability for use in the Southern Zone.

After the plan to use CRANDALL and CRILLEY immediately upon their arrival in the Southern Zone was abandoned, subsequent plans for the Southern Zone evolved in which emphasis was shifted from the lift craft to the cranes as the primary operational tool in the Southern Zone. The major changes to the salvage plans for the Southern Zone are detailed as follows:

- 30 August Plan: ROLAND and THOR to parbuckle and lift DREDGE 22. Using stern gantries, CRANDALL and CRILLEY to lift BARREH's bow to permit pumping and refloating of the tug. Following this, they would lift MAGD after it was cut into three sections and the superstructure trimmed. Refloating of BARREH was considered as an expeditious means of removal. Refurbishment was not desired.

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- 15 September Plan: This plan was basically the same as the 30 August Plan except that THOR would lift the bow and refloat BARREH because interference by DREDGE 22 prevented use of CRANDALL and CRILLEY; removal of DREDGE 22 was scheduled for later accomplishment.

- 15 October Plan: Essentially the same as the 15 September Plan except that MAGD would be cut into two sections instead of three to reduce the tedious underwater work involved in making a second cut. Also, the bow section would be parbuckled by THOR and ROLAND to eliminate the work involved in the underwater trimming of the superstructure required before lift by CRANDALL and CRILLEY. THOR and ROLAND would lift BARREH instead of refloating because this would be more expeditious and would not involve working in the hull in proximity to suspected and unexploded scuttling charges.

- 5 November Plan: Basically the same as the 15 October Plan except that THOR and ROLAND would parbuckle and lift both the bow and stern section of MAGD. This revision was caused by CRANDALL and CRILLEY not being able to finish work on the Concrete Caisson in time to commence work in the Southern Zone and THOR and ROLAND, operating in the Southern Zone, could save a significant amount of time by lifting the bow of MAGD shortly after parbuckling. Furthermore, considerable underwater work required in trimming the superstructure of MAGD could be avoided by parbuckling the stern section and lifting it shortly thereafter. All sections would be lifted high enough to clear the bottom of the channel, transported to, and set down in the dump area.

Oil removal plans were not developed since two of the wrecks would be lifted intact and a third would be sectioned in an area where no oil was present and the ends lifted intact.

2. SALVAGE OPERATIONS ON DREDGE 22 AND BARREH

Salvage operations in the Southern Zone were conducted using basically the same techniques on all three wrecks:

- Righting the wreck if necessary, using ROLAND and THOR
- Sectioning the wreck if too heavy for lift by cranes
- Lifting as a whole or in sections.

Because of their similarity and the fact that they were undertaken consecutively, the lift operations on DREDGE 22 and BARREH are described together. MAGD, a somewhat more complex operation, is presented separately.

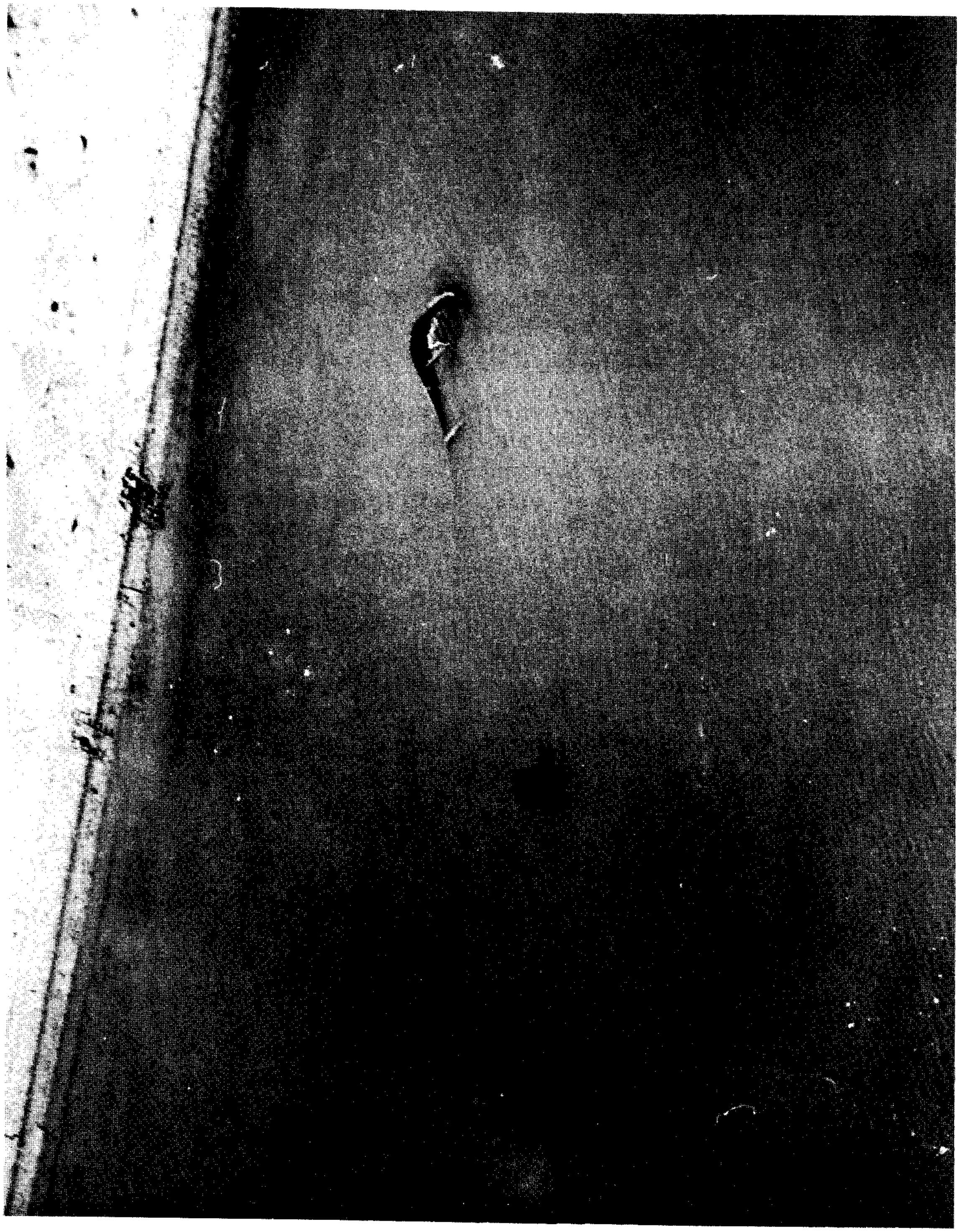
(1) Trim Operations

Trimming was necessary on DREDGE 22 and BARREH to remove structure and fittings, which would interfere with lift wires. The trim and rig team first trimmed the wreck as necessary, then passed wires and rigged the wrecks for lift as much as possible so that the lift operation could begin as soon as possible after arrival of the lift crane.

Trim operations began on BARREH on 6 October, when the trim and rig team, the SCA crane, and the diving barge arrived. These craft were moored together in a four-point moor over the wrecks. BARREH, resting on the inclined Canal bank, was securely moored to the west bank of the Canal to prevent it from slipping into deeper water during salvage operations. Figure VII-1 shows BARREH prior to the commencement of operations. Trimming operations began with removing of the stacks and continued with the clearing of loose wreckage on the deck of the tug, cutting and removing the anchor chains, and finally rigging and lifting the upper bridge structure.

On 15 October, the trim and rig team completed work on BARREH and moved to DREDGE 22. Removal of the wooden and metal fendering in way of the parbuckling and lift wires was undertaken concurrently with removal of the dredge ladder and buckets and the rigging of the parbuckling and lift wires. Removal of the dredge ladder and buckets, the most difficult and time-consuming part of the trimming operation was completed on 22 October. Removal of the dredge's fenders in way of the parbuckle and lift wires was completed by 22 October

FIGURE VII-1
BARREH at Commencement
of Salvage Operations



using oxyarc-cutting with occasional assistance from explosive charges.

(2) Rigging the Parbuckling and Lift Wires

At the time of rigging the messenger wires, it was desired to keep open the options of using either ROLAND and THOR or CRILLEY and CRANDALL to lift BARREH. The use of CRILLEY and CRANDALL required the greatest number of lift wire messengers. Thus a total of eight messenger wires were passed under the wreck by 13 October. Jetting of parbuckling wire messengers followed and was completed by 19 October. Rigging of the parbuckling and lift wires on DREDGE 22 was accomplished as a part of the lifting operations and is described below under that heading.

(3) Silt Removal

Since the amount of silt in DREDGE 22 was insignificant, silt removal operations were not undertaken. Silt in BARREH, however, was of concern because it added appreciably to the lifting force required to remove the wreck. Table VII-3 indicates the location and quantity of silt in BARREH.

Silt removal operations on BARREH commenced in the after berthing compartment, moved progressively to the forward berthing compartment, thence to the engine room, and completed in the forward boiler room on 13 October. During these operations, it was frequently necessary to use a high-pressure water jet to break up the packed silt prior to removal. The after boiler room was not evacuated because it was suspected that undetonated scuttling charges were present.

(4) Righting Operations

DREDGE 22 (unlike BARREH) required righting before lifting. ROLAND and THOR moored over DREDGE 22 and righted the dredge expeditiously and without incident. This work was carried out between 23 and 27 October. The positions of the cranes and the rigging for parbuckling are shown in

Table VII-3
Location and Quantity of Silt in BARREH

Compartment	Silt Depth (feet)	Volume (cubic feet)	Weight in Air (tons)
Forward berthing compartment	6.5	7,488	459
Boiler room	5.5	4,857	298
Engine room	5.5	2,587	159
Aft berthing compartment	5.5	4,083	251

Figure VII-2. DREDGE 22 as parbuckled between the two lift cranes is shown in Figure VII-3.

(5) DREDGE 22 Lift Operations

After DREDGE 22 was righted, it was discovered that the 3/8-inch thick by 4-foot long steel bolster at the turn of the bilge had crushed into the hull approximately 4 feet. The possibility of a more severe recurrence of this during application of the heavier lifting loads was cause for concern, especially in view of the poor condition of the hull of DREDGE 22. Precautions were taken to distribute the lifting loads over a wider area by constructing larger bolsters of 3/8-inch plate stiffened with five sections of railroad rails welded to the plate, as shown in Figure VII-4. Two of these bolsters, each 4 meters long, were to be fitted on each side at the stern and two others, each 6 meters long, were to be fitted on each side at the bow.

It would have been preferable to lift DREDGE 22 with ROLAND and THOR on the same side. However, because of the need to shift the lift points to avoid the area damaged by

FIGURE VII-2
Parbuckling Arrangement, DREDGE 22

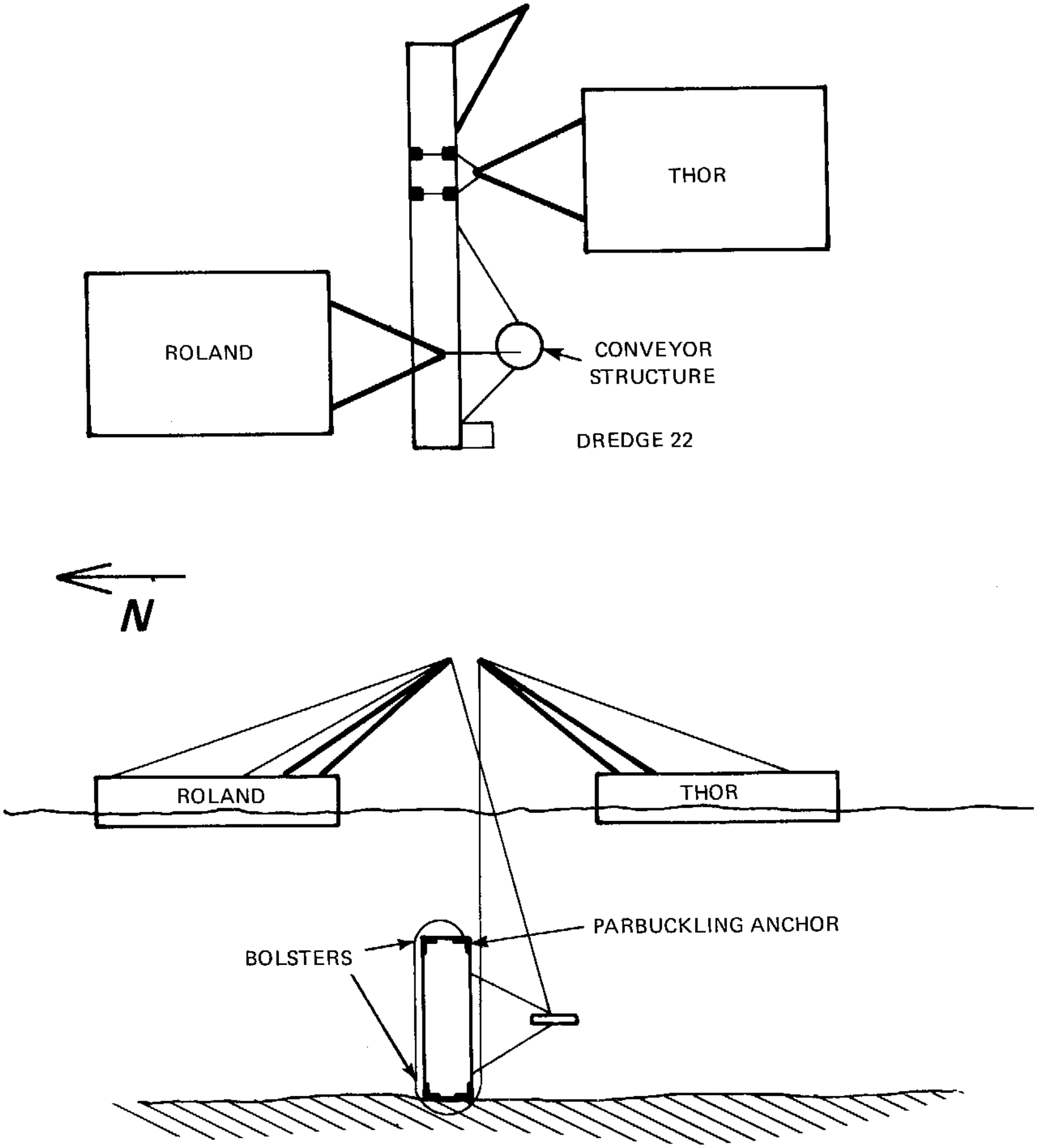
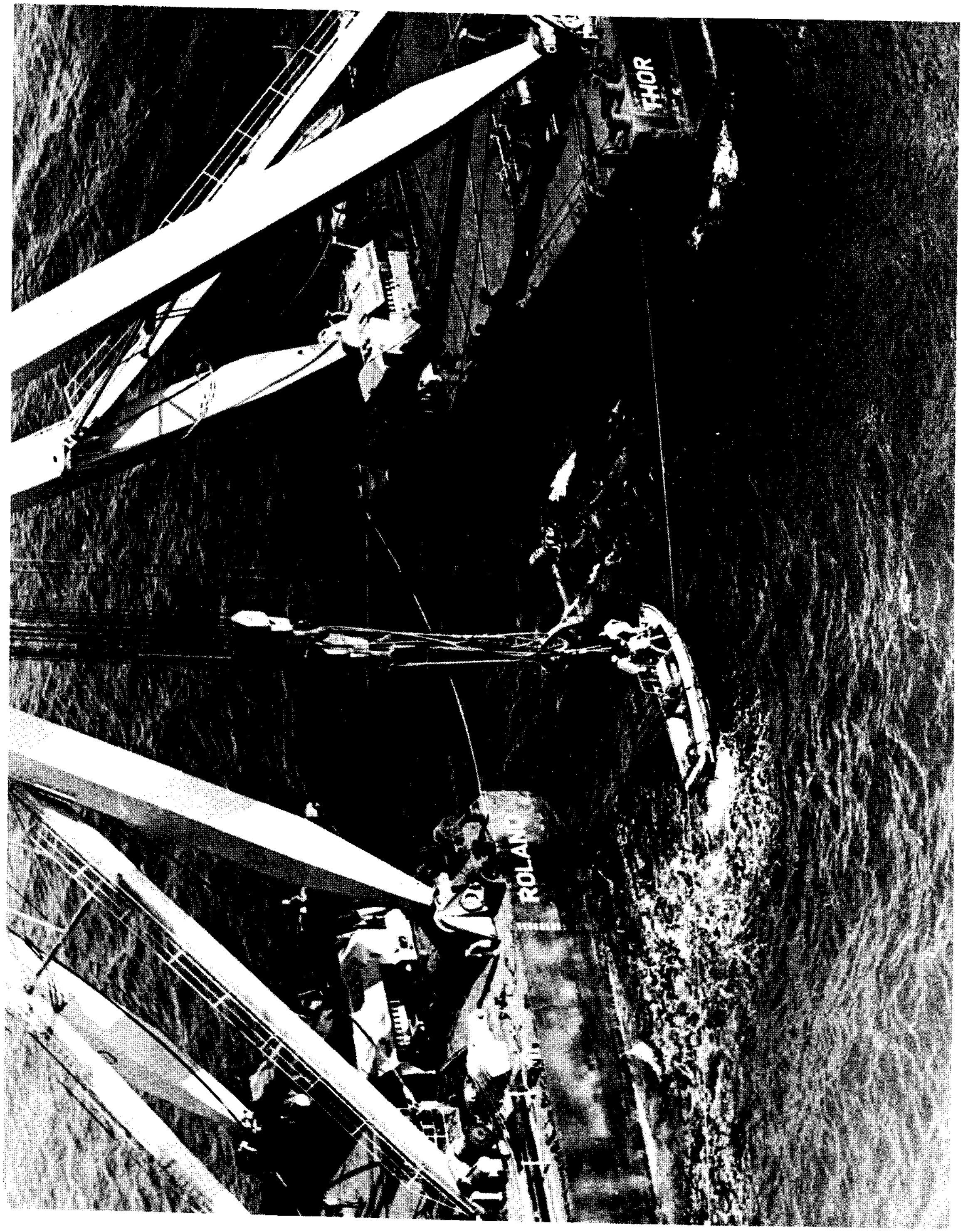


FIGURE VII-3
DREDGE 22 Parbuckled Upright
Between ROLAND and THOR



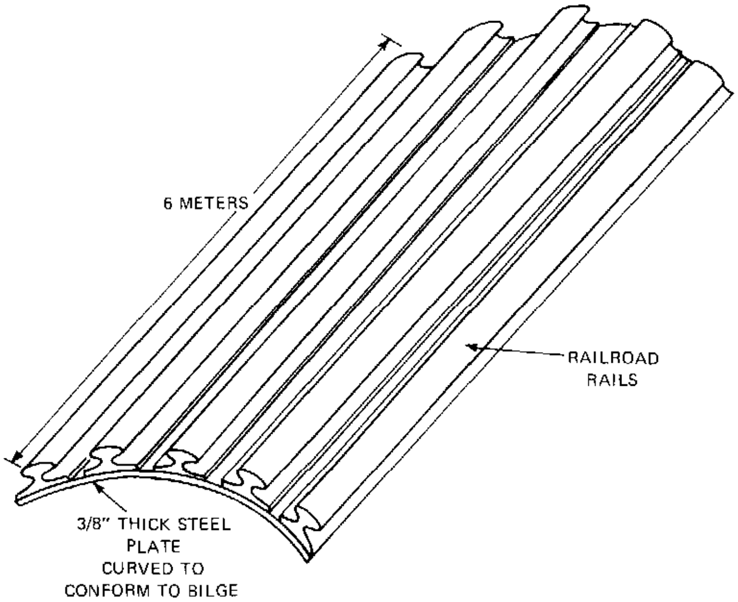


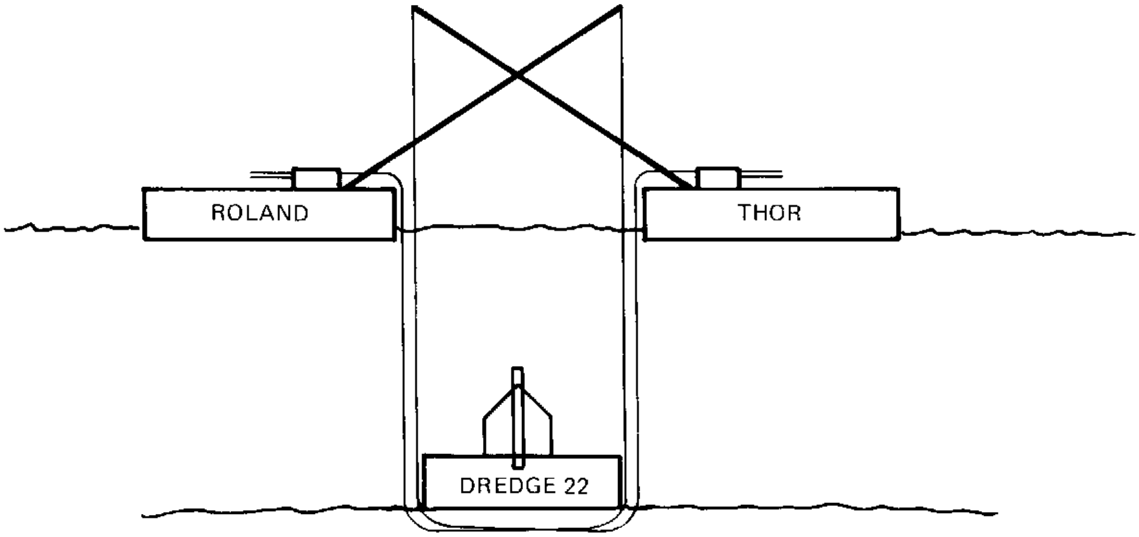
FIGURE VII-4
Parbuckling and Heavy-Lift Chafing Plates

the parbuckling forces, it was necessary to move THOR to the opposite side of the dredge.

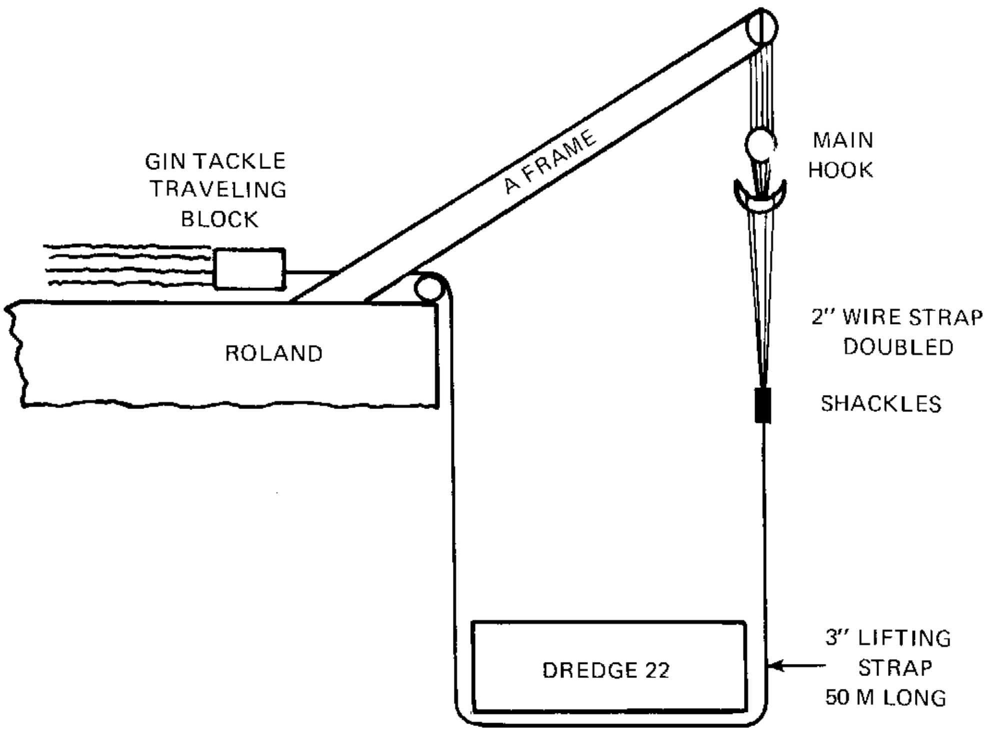
With the cranes in the lifting position, lift wires were positioned. Two wires used the previous parbuckling wires, but two had to be repositioned, one requiring 4 days of effort by divers to tunnel through the hard sandstone under the wreck. Bolsters at the turn of the bilge in way of the lift wires, four on each side of the hull, were jetted into position and placed with some difficulty by the crews of ROLAND and THOR. Employing the main hooks and gin tackle of both cranes for lifting DREDGE 22, as shown in Figure VII-5, lifting commenced on the ebb tide on the morning of 4 November and proceeded smoothly until the dredge was lifted to the water's edge, transported to and deposited in the wet-dump area south of the southern entrance to the Canal.

Operations in the Southern Zone were constantly handicapped by the swift tidal currents which restricted diving to periods of slack water, about 3 to 4 hours per day. Operations were also hampered once by a severe sandstorm that occurred in the middle of the day.

FIGURE VII-5
Lift Arrangement for DREDGE 22



LIFT ARRANGEMENT



SINGLE HOOK ARRANGEMENT

(6) <u>BARREH Lift Operations</u>

After DREDGE 22 was deposited in the wet-dump area south of Suez on 5 November, ROLAND and THOR returned to the BARREH site and moored alongside each other north of and over the tug. Rigging of lift wires commenced shortly thereafter and was completed on 7 November. Each crane was made up in the 1000-ton lift mode with the main hooks of each lifting on the starboard (far) side of the wreck and the gin tackle to the near side, as shown in Figure VII-6. This 2000-ton lift capacity proved adequate for the 1200-ton predicted lift weight of BARREH. As the wreck was lifted on the afternoon of 7 November, a lift wire that was out of position was shifted into place. The wreck was lifted clear of the bottom, moved to the center of the Canal, and set down. Figure VII-7 shows BARREH being lifted by THOR and ROLAND.

On the early morning slack tide of 8 November BARREH was raised, transported 16 kilometers to the wet-dump area without incident, and placed on the bottom. During the lift and transit, ROLAND carried 800 tons and THOR carried 600 tons. Both cranes were unrigged and returned to the MAGD salvage site the following morning.

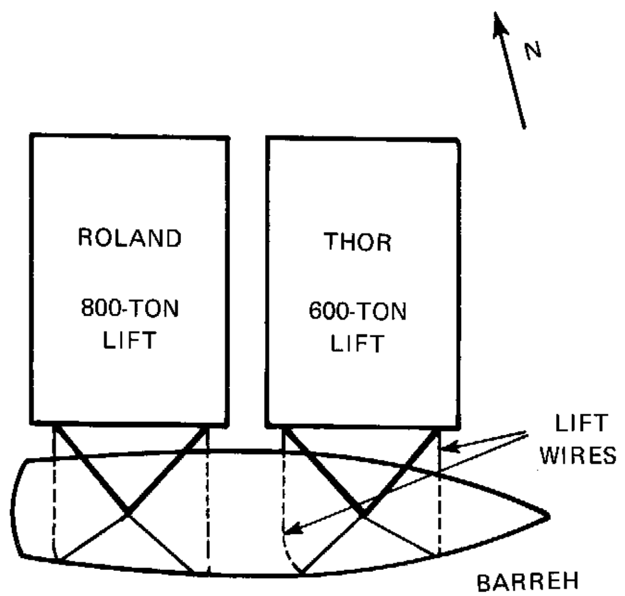
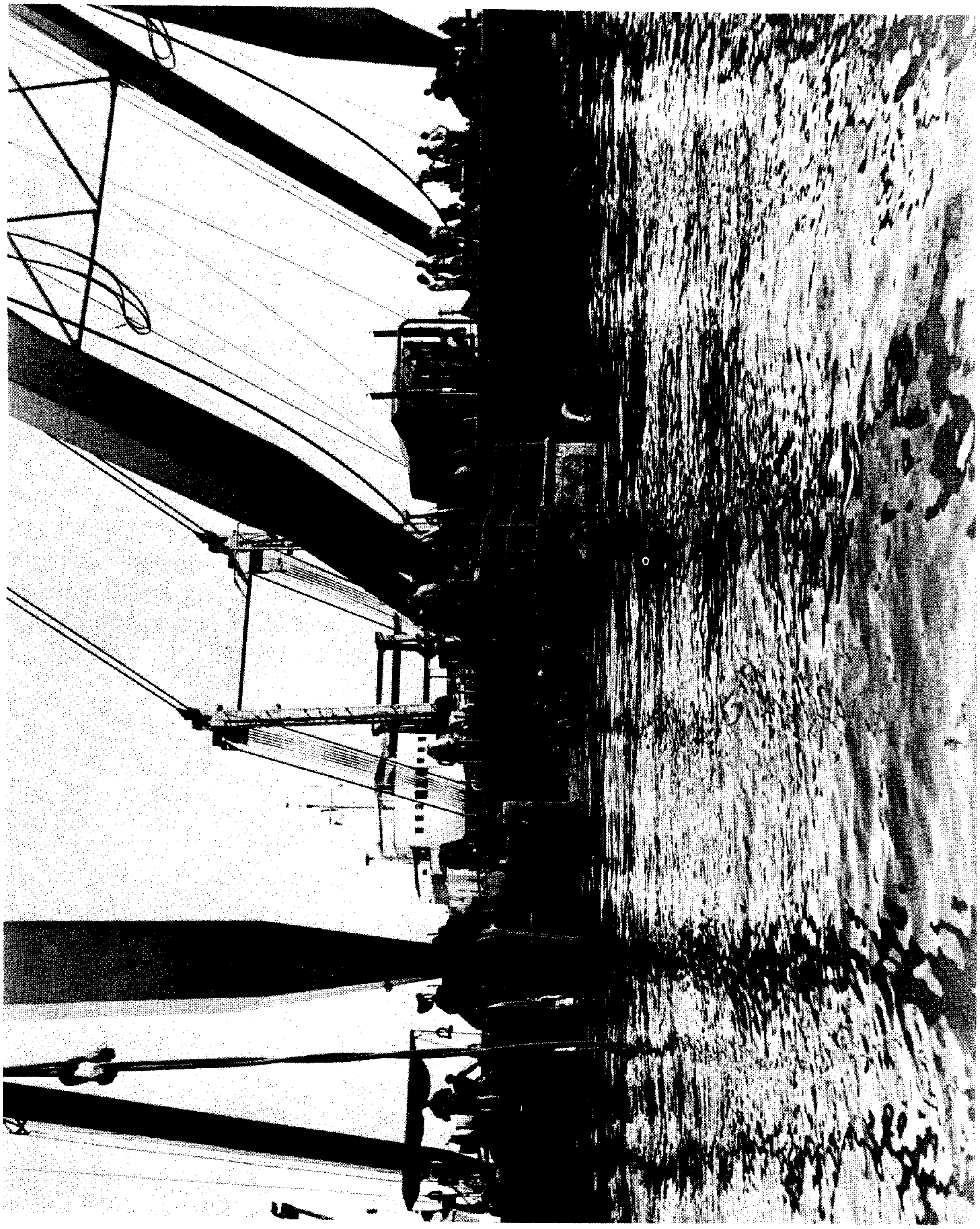


FIGURE VII-6
Lift Arrangement for BARREH

FIGURE VII-7
BARREH Lifted by ROLAND and THOR



3. SALVAGE OPERATIONS ON MAGD

MAGD salvage operations commenced on 17 October and consisted of the following evolutions:

- Fabricating and placing cofferdams for diver access to the interior of the hull under all conditions of tide and current
- Removing silt from within the hull
- Sectioning the hull into two sections
- Rigging the parbuckling and lifting messengers
- Parbuckling bow and stern sections
- Lifting bow and stern sections
- Transporting sections to disposal area
- Cleaning up the salvage site.

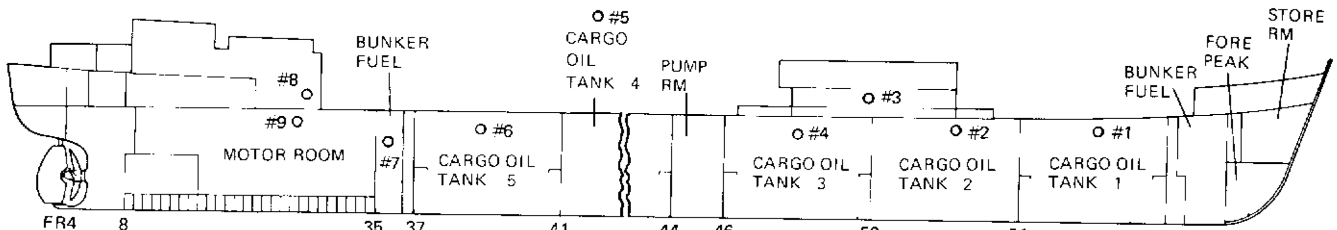
Oil removal operations were not contemplated since the two sections were to be lifted intact and the area in way of the cut contained no oil.

(1) Trim and Rig Operations

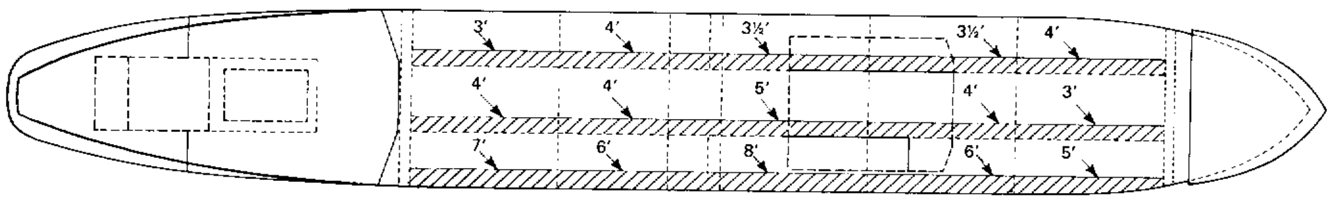
The restrictions on diving created by the swift tidal currents, coupled with the requirement for extensive diving operations in severing the hull and removing large quantities of silt from tanks and machinery spaces, led to the decision to use cofferdams to permit diver access to the interior of the hull in order that the cutting and silt removal operation could be conducted from inside. Accordingly, the placement of cofferdams took first priority upon commencement of operations.

On 17 October, divers working in slack water burned cofferdam openings #3 and #5 in the amidships superstructure, as shown in Figure VII-8. Burning operations continued on 18 October with the cutting of cofferdam holes #4, #6, #7, #8,

FIGURE VII-8
MAGD Cofferdam Locations and Silting Conditions



MAGD COFFERDAM LOCATIONS



PRINCIPAL DIMENSIONS

Length	358'
Beam	48'
Depth	27'
Displ.	2400 Tons

NOTE: AS VIEWED FROM BOTTOM. SHIP WAS LYING ON STARBOARD SIDE.

MAGD SILTING CONDITIONS

and #9, again shown in Figure VII-8. Using the SCA 80-ton crane, placement of the first two cofferdams in the engine room at #9 and #5 was accomplished on 20 and 21 October. Cofferdam openings #1 and #2 were completed later.

The procedure for setting the cofferdam consisted of cutting access openings for the cofferdam on the high (starboard) side of the wreck and an additional opening alongside for the airlift. Following this, an area was cleared by airlift for an access opening for further lowering the cofferdam into the center tank. The cofferdam lowered only as far as the center tank was fitted with a window so that the diver had access to the starboard as well as the center tank. Figure VII-9 shows a typical cofferdam installation.

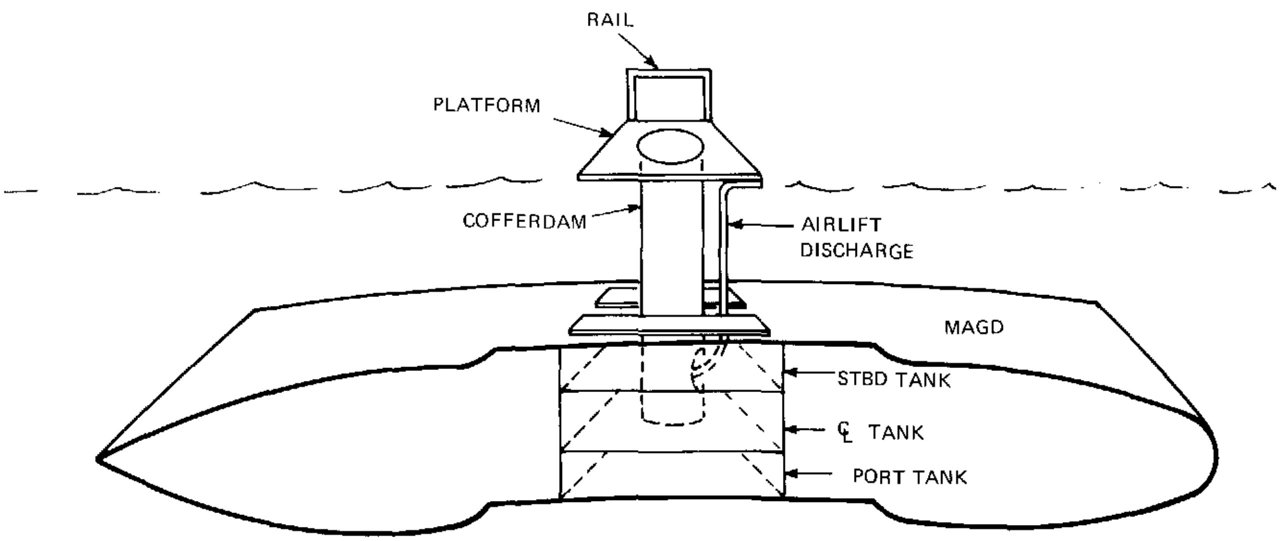


FIGURE VII-9
Cofferdam and Airlift Installation in MAGD

(2) Silt Removal

After setting two cofferdams in place, work commenced to airlift the silt from the engine room and the number 4 tanks. Inspection showed about 5 feet of silt in the engine room and in number 4 cargo tanks. The location and quantity of silt in the wreck are illustrated in Figure VII-8. Results of the MAGD silt calculations are shown in Table VII-4.

Table VII-4
Location and Quantity of Silt in MAGD

Compartment	Silt Depth (feet)*	Volume (cubic feet)	Dry Weight (tons)
No. 1 oil tanks	12.0	9,329	572
No. 2 oil tanks	14.0	11,469	704
No. 3 oil tanks	16.5	14,144	868
No. 4 oil tanks	14.0	14,469	888
No. 5 oil tanks	14.0	14,469	883
Bunker	10.0	1,348	83
Engine room	5.0	1,070	66

* Silt depth shown is the cumulative amount found at the various levels in a major grouping.

After completion of silt removal in the engine room, and tank number 4, cofferdams were moved forward progressively as the removal work proceeded. As a general practice, divers started removing silt in the starboard tank and moved down through the center to the port tank. In way of the planned cut at frame 43, however, the divers cleared the port or bottom area first to facilitate an early start of cutting there. Silt removal operations were completed on 12 November in a routine manner.

(3) Rigging Stern Section

Rigging of 1-inch messenger wires under the stern of MAGD commenced on 28 October while sectioning and silt removal operations were in progress. Six wires were passed by 6 November. The two remaining messenger wires were run on 11 November after completing the sectioning operation (which caused the two halves of the hull to tilt toward her ends), thereby facilitating the work under the mid-length of the hull.

(4) Sectioning Operations

After the cofferdam had been placed and the silt in way of the cut at frame 43 had been removed, cutting operations commenced. Oxyarc torches were used exclusively with the exception of the use of heavy-duty primacord to clear the cutline of scale and marine growth along the starboard or upside. The location of the cut is shown in Figure VII-10.

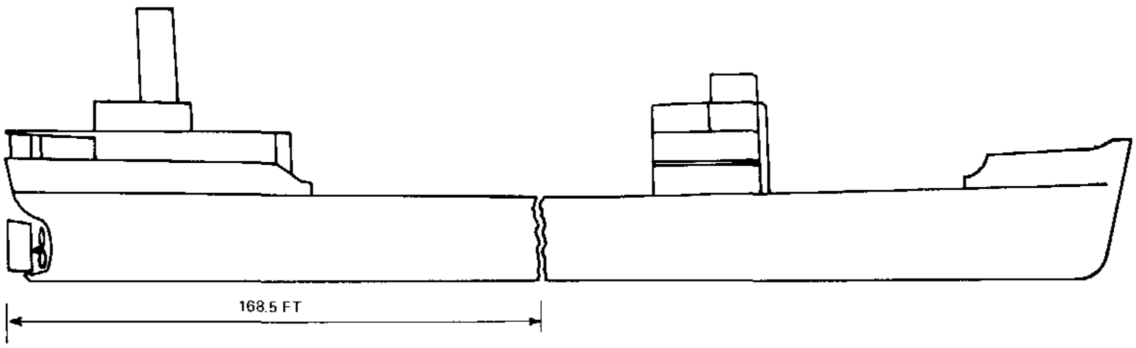


FIGURE VII-10
Location of Hull Cut on Tanker MAGD

Sectioning of the hull commenced on 25 October when divers began cutting the port or downward side of the wreck from the inside. The cut progressed to the port bilge area on 26 October, across the bottom of the ship on 28 October to the starboard bilge area on 30 October, and slightly around the starboard turn of the bilge on 1 November. The main deck cut was completed on 31 October. The starboard side remained intact until 7 November to permit running parbuckling and lifting wire messengers. When this side was cut, the stern section slid away from the bow section about 15 feet, the forward end of the stern lifted off the bottom about 6 feet, and rolled 12 degrees toward the upright. Figure VII-11 illustrates the progress of the cuts.

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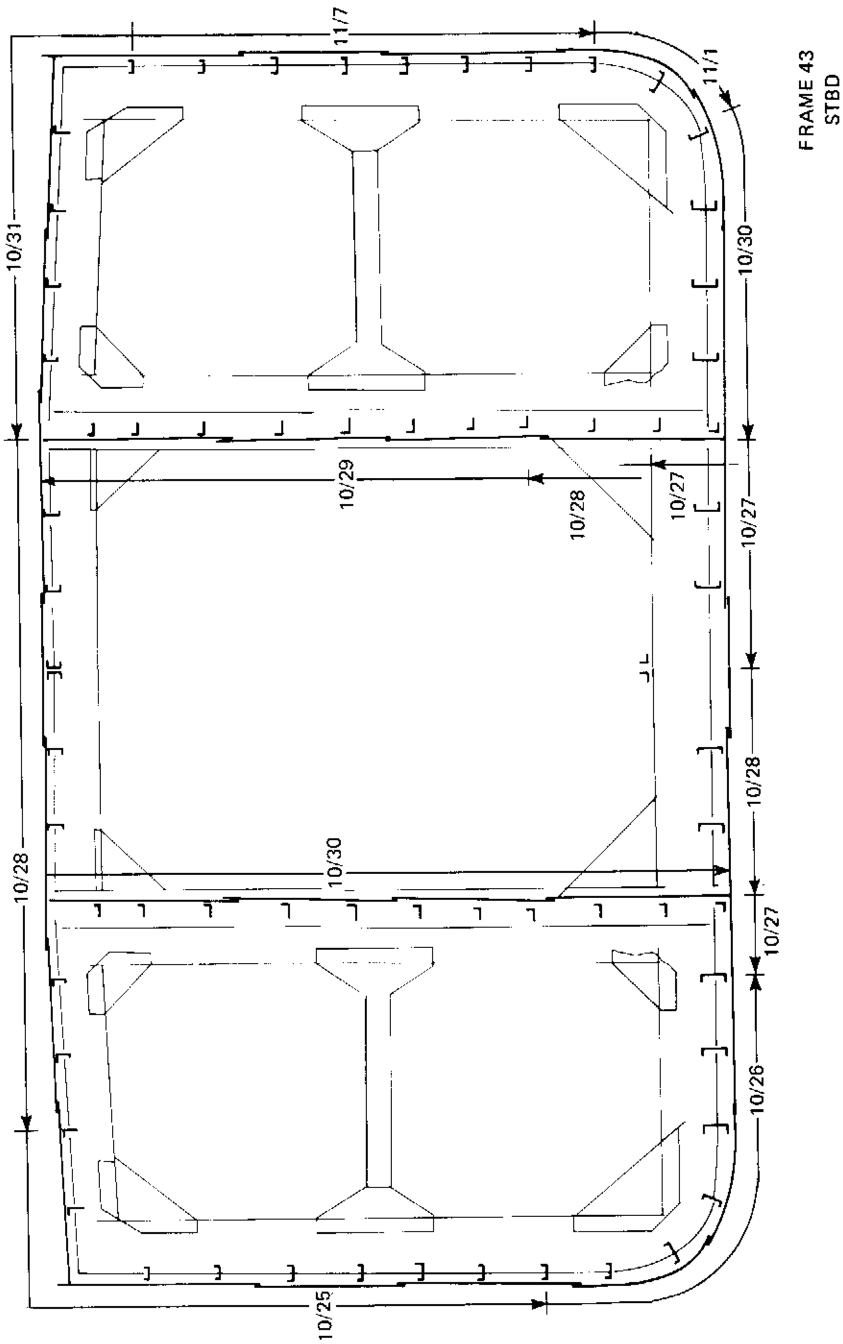
FIGURE VII-11
MAGD Sectioning, Size,
and Date of Cut



MAGD
SECTIONING
SIZE AND DATE OF CUT

(5) Parbuckling Operations on Stern Section

After depositing BARREH in the dump area, ROLAND and THOR returned to the MAGD wreck site at mid-day on 9 November and moored over MAGD in preparation for parbuckling the stern section, which then lay with a 78-degree port list. THOR maneuvered into position over the forward end of the stern section. Figure VII-12 shows their relative positions.

The cranes were rigged as follows: THOR was rigged to use deck tackle only, two 3-inch straps were rigged over the bow rollers down across the deck of MAGD under the port side around the keel and up across the starboard side to parbuckling hooks rigged on the starboard deck edge; ROLAND was rigged with one parbuckling wire from her port hook run in the same fashion as THOR's, as shown in Figure VII-13. Parbuckling was completed after 27 minutes of pulling effort on the afternoon of 10 November. In this evolution, THOR exerted a force of 350 tons and ROLAND, 160 tons. Upon completion, the stern section of MAGD was sitting upright with about 15 feet of stack watching.

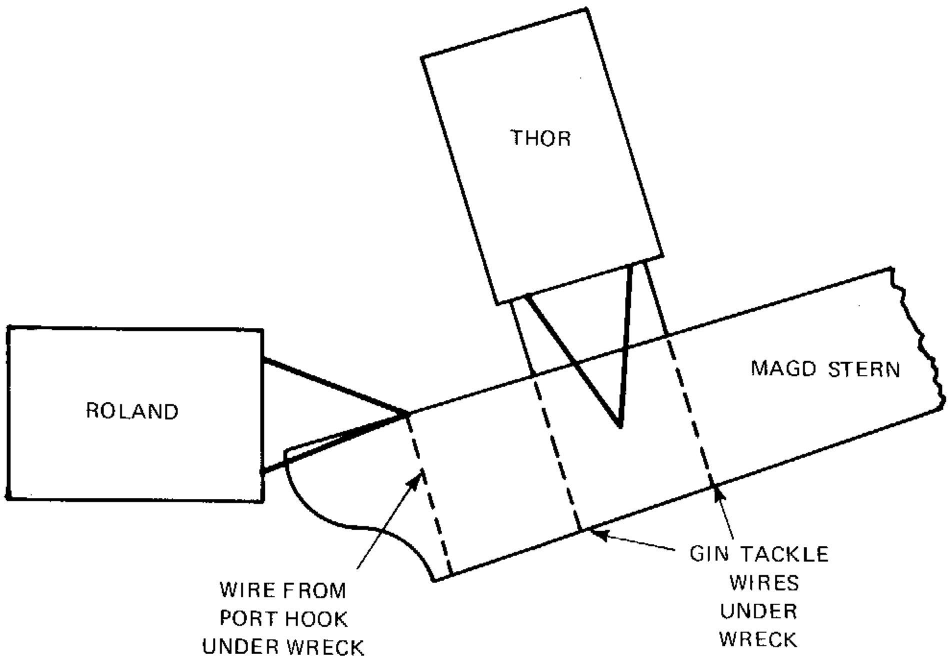


FIGURE VII-12
Arrangement of Heavy-Lift Cranes
for Parbuckling MAGD Stern

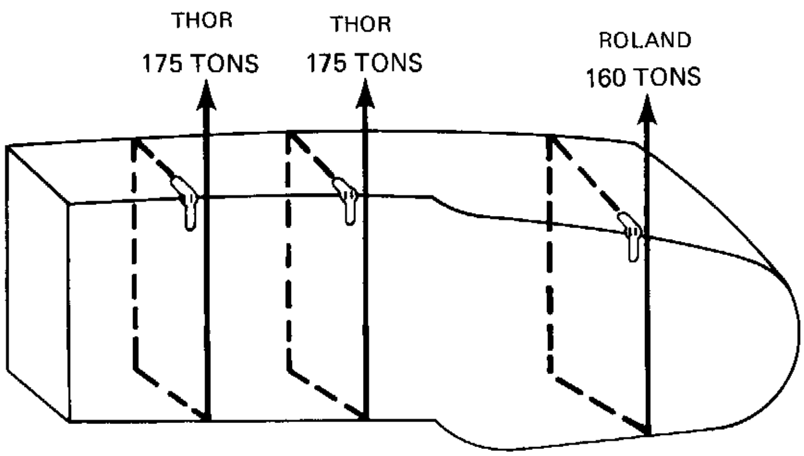


FIGURE VII-13
Arrangement of Parbuckling Wires
on MAGD Stern Section

(6) Lifting Operations on Stern Section

On 11 November, ROLAND and THOR commenced rigging for lift operations on the stern section. ROLAND shifted around parallel to THOR on the west side of the wreck.

Lift wires from THOR and ROLAND were rigged by noon of 12 November. (The rigging of the port lift wire from ROLAND was facilitated when THOR picked up the forward edge of the stern to provide clearance.) Each craft, rigged to lift 1000 tons using the main hooks and deck tackle working together as previously described, commenced lifting and shortly thereafter during the afternoon slack tide lifted the wreck. The lift weight was 1200 tons: 650 tons lifted by ROLAND and 550 tons by THOR.

Shortly afterwards, while under tow to the dump site, the stern section grounded unexpectedly near Port Taufiq. As a result, the outboard starboard wire of ROLAND parted at the shackle connecting the wires to the gantry hook and at the running block of the deck purchase gear, leaving the wire under the wreck. The second wire from ROLAND parted at the shackle to the hook and was pulled from under the wreck as ROLAND separated from THOR and lurched forward. THOR remained secured to the wreck. Both purchase wires on ROLAND's deck gear were crushed when the lift wire parted. A day was spent in re-rigging lifting tackle and re-running the deck purchase wires. One heavy-lift wire was re-rigged and an additional heavy-lift wire was re-run, using a spare messenger which was still rigged to the stern of MAGD.

Again, difficulty was experienced in pulling the heavy-lift wire. As before, THOR lifted the forward end of the section to permit ROLAND to complete rigging. With both wires rigged in the early afternoon of 14 November, the section was lifted and towed to the dump area. The lifting arrangement for MAGD stern is shown in Figures VII-14 and VII-15. ROLAND and THOR were towed stern first by the tugs BUGSIER 26 and KADER. A sketch of the towing arrangement is shown in Figure VII-16.

At the end of the day, the cranes had passed landfall and set the wreck down for the night. The next morning, ROLAND and THOR commenced picking up the wreck but experienced problems. In setting down, the wreck had rolled slightly toward the cranes and on lifting, the deck edge impinged on ROLAND and tended to crush the lift wire. The second lift attempt brought the section up satisfactorily and it was towed to the wet-dump site and placed on the bottom south of DREDGE 22. The funnel and the top deck were above water.

(7) Parbuckling Operations on Bow Section

After depositing the MAGD stern, ROLAND and THOR returned to the MAGD bow on 16 November to commence parbuckling efforts. It had been decided that to conserve time the bow would be parbuckled rather than the superstructure trimmed in order to facilitate access for the lift operation. Further, it had been determined that the bow section would be lifted by the cranes since the heavy-lift craft were employed in lightening the western section of the Concrete Caisson for a planned side lift of that structure. This decision was influenced by the fact that once the cranes were used to parbuckle, they could make use of parbuckling wires as lift wires. The cranes positioned themselves at the ends of the bow section with THOR to the north and ROLAND to the south. Divers completed rigging parbuckling wires and parbuckling deck edge anchors on 17 November (THOR was rigged with two wires, ROLAND with one).

FIGURE VII-14
Lift Arrangement for MAGD Stern Section

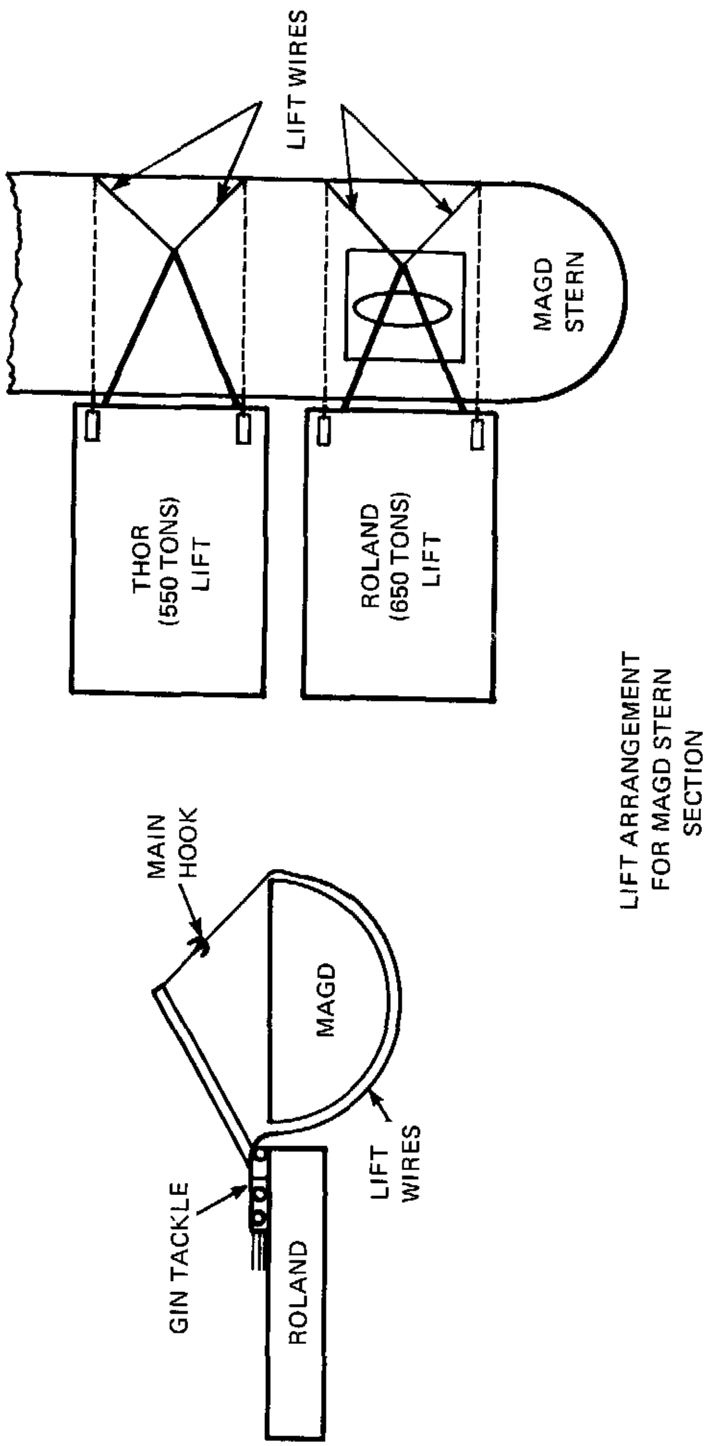
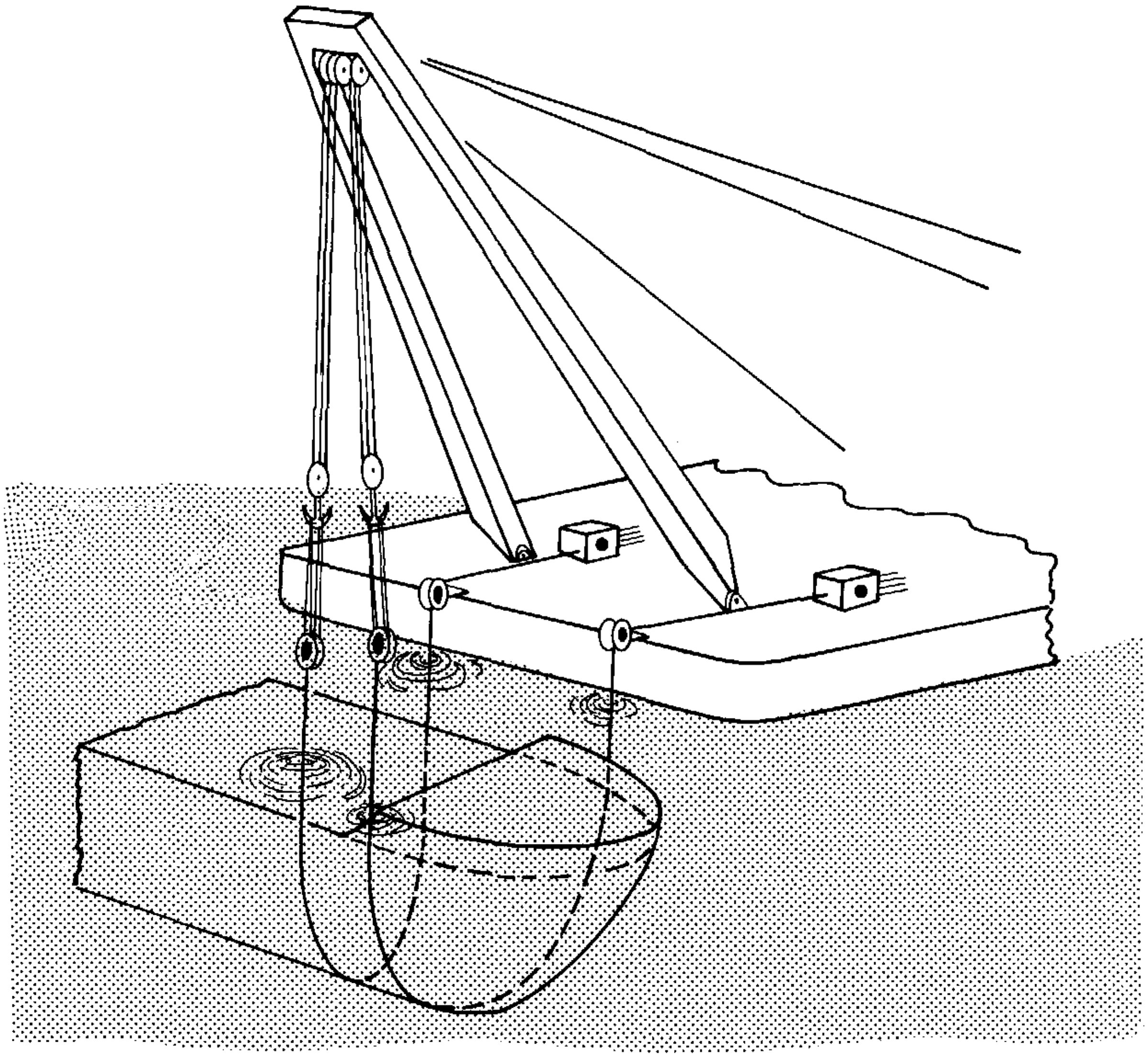


FIGURE VII-15
1000-Ton Lift Using Gin Tackle
and Main Hooks to Lift MAGD Stern



Early in the morning of 18 November, parbuckling commenced. ROLAND, exerting a force of 80 to 120 tons, appeared to be pulling the wire through the hull. After rotating the bow 20 degrees, the parbuckling effort was suspended until the situation could be assessed. After inspecting the section, divers reported that the forward parbuckling wire on the wreck from THOR had been improperly placed in a weak area away from its prescribed position. The wire was actually bearing against the forecastle deck and had cut this deck completely and all but 10 feet of the main deck. The longitudinal bulkhead dividing the forward ballast tanks was ripped 15 feet down from the main deck and the side was cut down to the heavy strength members near the keel. The cut down the side crossed the transverse bulkhead. This bulkhead, the side plating, and stiffeners provided sufficient strength to hold the section together. A sketch of the damage is shown in Figure VII-17.

On 20 November after re-rigging the parbuckling wires around the damaged area, the parbuckling effort commenced. With the application of a force of 150 tons by ROLAND and 320 tons by THOR, the bow section was righted smartly, overtaking the parbuckling rigging.

(8) Lifting Operations on Bow Section

One parbuckling wire from ROLAND was used as a lift wire. The other had to be moved to provide proper spacing between the wires. Both of THOR's parbuckling wires had dug into the hull about 15 feet and had to be relocated. Lifting preparations were interrupted on 20 November to permit the passage of four Mecca-bound pilgrim ships. These were the first ships to transit the Canal since 1967. After passage of the convoy, ROLAND and THOR positioned themselves in the lift position to the west of the MAGD bow section. On the following morning, after the remaining lift wires were passed, lifting forces of 600 tons from THOR and 500 tons from ROLAND were applied and the section was lifted uneventfully.

After the nest got underway, with the cranes being towed stern first to the dump area by BUGSIER 26 and MARINER, it was discovered that the anchor from MAGD was dragging the bottom. Motion was halted, and the anchor was buoyed and

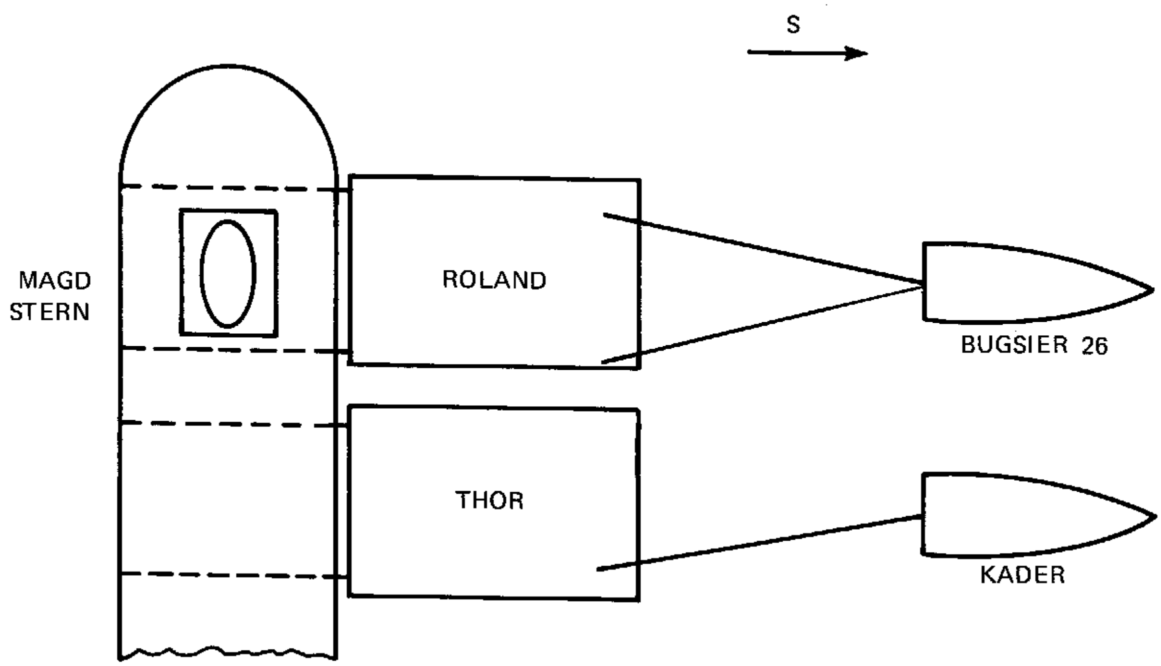


FIGURE VII-16
MAGD Stern Section Under Tow to Dump Area

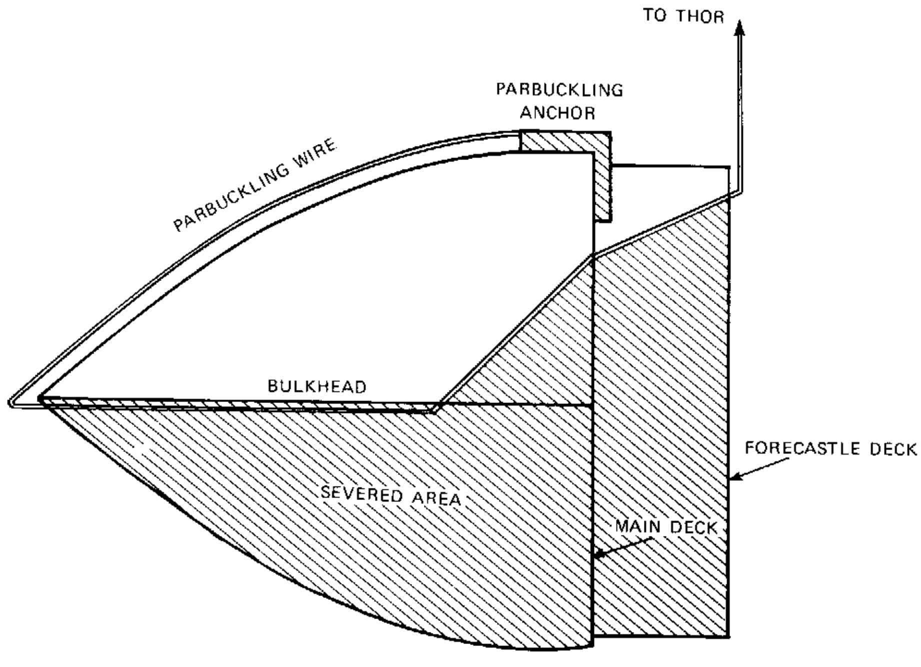


FIGURE VII-17
Damage to MAGD Bow Section During First
Parbuckling Attempt

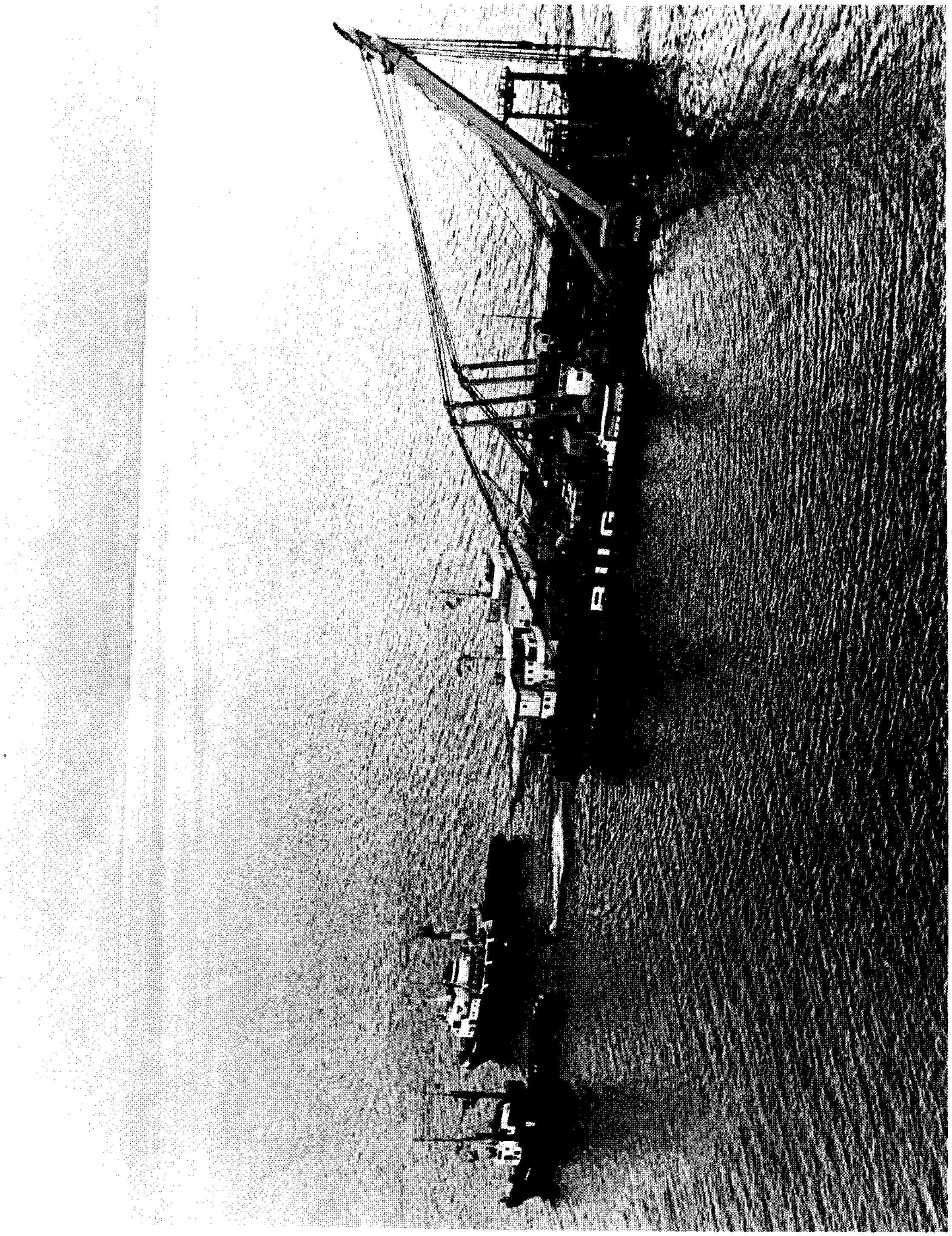
removed. The wreck was placed back on the bottom late in the afternoon to await a daylight transit to the dump site the following morning. Transit to the dump area resumed on the high tide of the morning of 22 November and was completed without incident. Figure VII-18 shows the bow section of MAGD en route to the wet dump. The wreck was placed on the bottom early on 23 November, after waiting overnight en route.

4. SUMMARY

Although the strong currents played an important part in all decisions in this section of the Canal, salvage operations in the Southern Zone were among the simplest in the entire operation and were classic examples of the use of lift equipment for righting and removing wrecks. The problems encountered of passing wires under wrecks, cutting of the hull by wires, and wires placed out of position were typical problems encountered in heavy-lift operations.

Sectioning and lifting operations were simple, with no unnecessary sophistication. The salient feature of the Southern Zone was the continuing flexibility of the salvage plan, which was modified several times to adapt to changing conditions. The ability to adapt the salvage plan as necessary was a major factor in the expeditious completion of the operation.

FIGURE VII-18
MAGD Bow Section en Route
to Wet Dump



VIII. LESSONS LEARNED

VIII. LESSONS LEARNED

The preceding chapters have described in detail the salvage schedule, plans, operations, and procedures used by the U. S. Navy in clearing the 10 wrecks from the Suez Canal. This chapter summarizes some of the experience gained and lessons learned during the salvage operations.

1. DIVING DEPTHS

Diving depths were underestimated and consequently diver cost increased. The predicted depths were based upon charts and verbal information and not upon the results of a site survey. In significant salvage operations like this, diving depths should be verified if possible (it was impossible in Suez) prior to planning and costing the operation.

2. PERSONNEL TURNOVER

Although not anticipated, there was a high turnover of personnel in all categories, such as divers, tenders, office help, seamen, and explosive technicians. This was sometimes attributed to medical causes but was usually due to the trying living environment. In future operations of long duration conducted under similar conditions with a large portion of the work force specially recruited for the job, a high turnover of personnel should be taken into account in the planning of the operation.

3. FLEXIBILITY IN USE OF ASSETS

As discussed in previous chapters, an onsite salvage survey prior to commencing operations should be conducted if possible. As the operation progressed, the lack of a survey in Suez resulted in several surprises, such as the attitude of the wrecks, diving depths, silt content, and current velocity. If it is not possible to survey the site, sufficient flexibility in the use of major assets must be made available in planning to accommodate unexpected conditions. The discussion of operations in the Southern Zone describes how this was done in this salvage operation.

4. DEPENDENCE ON INDIGENOUS SUPPORT

Too much reliance was placed on indigenous support in the following areas: messing, berthing, consumables, and floating equipment. While the SCA supported the operation to the limit of its resources, the support requirements and standards were underestimated. This was further aggravated as the SCA developed competing requirements of its own for use of its resources in other phases of readying the canal for opening. Greater self-support should be emphasized in large operations conducted under conditions such as those found in Suez.

5. EMPLOYMENT OF HEAVY-LIFT CRAFT, CRILLEY AND CRANDALL

Full capabilities of the heavy-lift craft were demonstrated during operations in the Canal. Several problems were encountered in their use because of the lack of inclined planes to permit successive lifts and the lack of adequate dredges to create such planes. Surprisingly, it was also difficult to determine depths of the various portions of the vessels while being lifted without the use of diver-mounted pneumofathometer. Further, it was not always possible to obtain the weight under lift accurately. Both were important and steps should be taken in future operations to provide this information.

6. EMPLOYMENT OF SHEER LEG CRANES, THOR AND ROLAND

Without depreciating the sheer leg cranes, there are certain restraints in their use. The restraints stem from their limited outreach and inability to move the sections under lift independently of the pontoon. The restrictions apply to their use singly, side by side, and in tandem. There is a further restriction on the lengths and weight relationships of the section to be lifted. When obtaining maximum lift with a two-crane side-by-side lift, the length of the wreck is of critical importance. In attempting to lift a shorter and heavier section, if an attempt is made to get around the side lift length problem by making a face-to-face lift, then mutual interference created by outreach becomes a problem.

7. RIGGING OF CRANE LIFTS

Much difficulty was encountered from lifts failing because of failure of the lifting points and the resultant requirement to rig slings under the hull. This was attributable in part to the poor material condition of the wrecks and the lack of structural plans to permit intelligent design of lifting points. Consequently, under such conditions in the future, the additional time required to rig slings under the hull should be seriously considered since it might provide an overall saving. Rigging the wreck for lift should be done to the greatest extent possible prior to the arrival of the cranes to reduce crane standby time. In addition, some crane time was lost earlier in the operation because of incomplete hull cuts. Although this was overcome as cutting experience was gained, it does indicate the need for verification of the completeness of early cuts. These evolutions should be included as part of the crane planning to ensure minimum crane employment in rigging and standby while the rigging takes place.

There was also a certain amount of improperly done pre-rigging for lifts. Messengers were occasionally out of place, which was attributed to a certain degree of diver inexperience.

8. EXPLOSIVE CUTTING TECHNIQUES

The lessons learned in explosive techniques are documented in Chapter V and Appendix K. Of particular importance was the development of the technique of scoring plating to be cut with oxyarc and severing it with relatively light explosive charges. The technique of explosive cutting of wrecks underwater must be carefully engineered for each job. The capability for fabricating precisely tailored shaped charges was not available in Egypt. Consideration should be given to bringing such a capability to the site in future operation.

9. SAFETY

Safety was emphasized throughout the course of the operation at all levels of supervision. The fact that there were no fatalities

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and few serious injuries in such an inherently dangerous situation reaffirmed the value of attention to safety both in the planning and execution of salvage operations.

* * * * *

While this operation was conducted efficiently and completed with dispatch, there are always areas that could be improved if this particular operation were to be repeated. Although future operations will always be somewhat different, the basic lessons learned and observations made that are described in this chapter have potential future benefit.

APPENDIX A

SUEZ CANAL CLEARANCE AGREEMENT

APPENDIX A

SUEZ CANAL CLEARANCE AGREEMENT

EMBASSY OF THE
UNITED STATES OF AMERICA

NO. 78

Cairo, April 13, 1974

Excellency:

I have the honor to refer to the recent discussions between our governments regarding the proposed assistance by the United States in the clearance of mines and unexploded ordnance from the Suez Canal, and to propose that such assistance be governed by the following agreement.

1. The Government of the United States will, subject to the availability of funds, and otherwise in accordance with the laws of the United States, assist in the clearance of the Suez Canal as follows:

a. A special United States force (hereinafter referred to as the "Force") established for those purposes shall, in cooperation with the appropriate authorities of the Arab Republic of Egypt, and, as may be agreed, the Armed Forces of the United Kingdom, carry out minesweeping operations in the Suez Canal.

b. The Force shall also provide training and advisory assistance to personnel of the Arab Republic of Egypt with a view to enabling the latter to carry out detection and disposal of unexploded ordnance situated in or adjacent to the Suez Canal, but the Force shall not itself carry out such operations.

c. The provisions of this agreement governing the presence of the Force in the Arab Republic of Egypt shall be applicable until the termination of the activities of the Force referred to in subparagraphs A and B above and consequent departure of the Force.

2. The Government of the Arab Republic of Egypt will provide such assistance as may be necessary for safety of the Force and its members in carrying out the activities referred to in paragraph 1.

3. The Government of the United States will make every effort to ensure that the activities of the Force referred to in paragraph 1 are carried out in such a manner as to render the Suez Canal and its environs safe for further clearance activities and subsequent operations; however, the Government of the United States cannot guarantee that all hazardous objects will be located and removed or rendered harmless.

4. The Government of the Arab Republic of Egypt waives any and all claims against the Government of the United States, and agrees to indemnify and hold harmless the Government of the United States against any and all claims by others, whether governments or private parties, arising out of any acts or omissions of the Government of the United States, the Force, or its members in the conduct of the activities referred to in paragraph 1.

5. In accordance with such procedures as may be established under paragraph 9 hereof:

a. Vessels and aircraft assigned to or supporting the Force may freely enter and depart territorial waters, ports, and airfields of the Arab Republic of Egypt, without payment of fees or charges.

b. Members of the Force will be allowed freedom of movement within the Arab Republic of Egypt, other than areas the Government of the Arab Republic of Egypt may designate as restricted areas, and freedom of entry to and egress from the Arab Republic of Egypt.

6. Members of the Force will respect the laws, customs, and traditions of the Arab Republic of Egypt, and will abstain from activities inconsistent with the spirit of this agreement. The Government of the United States shall take necessary measures to that end.

7. Members of the Force shall be immune from the criminal, civil, and administrative jurisdiction of the Arab Republic of Egypt unless, in a particular case, the Government of the United States elects in writing to waive such immunity. The Force and its members, and property belonging to either, shall be exempt from all forms of taxation, customs, and other regulations, except as may be agreed pursuant to paragraph 9.

8. The term "Members of the Force" means members of the Armed Forces of the United States and persons serving with or employed by the said Armed Forces, including contractor personnel, while in the Arab Republic of Egypt in connection with the activities referred to in paragraph 1 above. All members of the Force shall be furnished with appropriate identification, which will be produced, upon demand, to the appropriate authorities of the Arab Republic of Egypt.

9. Supplementary arrangements between the appropriate authorities of the two governments may be entered into as required to carry out the purpose of this Agreement.

If the foregoing is acceptable to the Government of the Arab Republic of Egypt, I have the honor to propose that this Note and your Note in reply confirming acceptance will constitute an Agreement between our respective governments.

Accept, Excellency, the assurance of my highest considerations.

Hon. Hermann Eilts
U. S. Ambassador to Egypt

Cairo, 25 April 1974

Mr. Ambassador,

I have the honor to acknowledge receipt of your Excellency's letter dated 13th of April 1974 regarding the proposed assistance by the United States Government in the clearance of mines and unexploded ordnance from the Suez Canal.

The Government of the Arab Republic of Egypt, whilst welcoming the assistance proposed by the United States, noted with appreciation that members of the Force will respect the laws, customs, and traditions of the Arab Republic of Egypt, that they will abstain from activities inconsistent with the spirit of these arrangements, and that the Government of the United States shall take necessary measures to that end.

The Government of the Arab Republic of Egypt wishes, furthermore, to signify its understanding as to some of the points raised in the aforementioned letter:

1. Desirous to ensure the safety of the American force and its members while carrying out their activities in Egypt, the Government of the Arab Republic of Egypt shall spare no effort, as far as possible, in providing assistance for the safety of the force in conformity with the regulations issued by the Egyptian authorities.

2. The Governments of the Arab Republic of Egypt and of the United States of America waive any and all claims against each other for damage to property, or for death or injury to any member of either party in the course of his activities in the clearance of the Suez Canal, or by any other act or omission for which either of the parties is legally responsible. Claims (other than contractual claims and those waived by the Arab Republic of Egypt) arising out of acts or omissions of a member of the Force of the United States Government done in the performance of his official duty, or out of any other act, omission or occurrence for which the force of the United States Government is legally responsible, will be dealt with by the Egyptian Government and in all cases settled at the cost of the Arab Republic of Egypt. Claims in respect of acts or omissions of a member of the Force of the United States Government arising otherwise than out of or in the course of his duty in Egypt may at the discretion of the United States service authorities be dealt with and settled by such authorities.

3. The Government of the Arab Republic of Egypt, while recognizing the freedom of entry and departure as referred to in subparagraphs "A" and "B" of paragraph 5 of the above mentioned letter, wishes to stress the following:

a. Prior authorization is necessary for entry of aircraft and vessels assigned to or supporting the Force to the port airfields of Egypt and to Egyptian territorial waters and for the departure of such aircraft from Egyptian airfields. Reasonable notification shall be given prior to departure of vessels supporting the Force from ports and Egyptian territorial waters.

b. Freedom of entry and departure is recognized to the members of the Force, in accordance with arrangements to be agreed upon with the Egyptian competent authorities.

4. The Government of the Arab Republic of Egypt agreed to grant immunity from criminal jurisdiction to the members of the Force as provided for in your letter. However, the Government of the Arab Republic of Egypt reserves its position to undertake the following:

a. On the event of violation of Egyptian laws or regulations by a member of the Force, Egyptian authorities may take him into custody without subjecting him to ordinary routine arrest. In such a case, Egyptian authorities shall deliver the offender immediately to the nearest authority representing the Force.

b. When a member of the Force is taken into custody, Egyptian authorities may undertake a preliminary interrogation in the presence of a representative of the United States Government.

c. While handing over the offender, Egyptian authorities shall inform the command of the Force of the charge sustained against him together with a copy of the preliminary interrogation.

d. The command of the Force shall carry out a detailed investigation with the offender and shall deliver a copy of the inquest to the Egyptian competent authorities.

e. The command of the Force and the Egyptian authorities shall assist each other in carrying out all necessary investigation concerning offenses committed by a member of the Force, including producing witnesses, collecting and presenting evidence, seizing, and handing over items connected with the offense.

5. Members of the Force shall not be subject to the civil jurisdiction of Egyptian courts in matters related to the carrying out of their official activities.

6. Members of the Force may wear the uniform and insignias of the United States Armed Forces when within the operation zones. Outside these areas, they will wear civilian clothes.

7. All members of the Force shall be furnished with appropriate identification cards issued by Egyptian competent authorities. Such cards shall be produced upon demand, to the authorities of the Arab Republic of Egypt.

8. The term "Members of the Force" as defined in paragraph 8 of your letter does not include Egyptian individuals serving with or employed by the Force.

If the above points are acceptable, your letter of April 13 and this letter constitute an agreement between our two governments for the execution of activities related to United States assistance in the clearance of mines and assistance in clearance of unexploded ordnance in the Suez Canal area.

Accept, Mr. Ambassador, the assurance of my highest consideration.

Ismail Fahmy
Minister of Foreign Affairs

APPENDIX B

SUEZ CANAL SALVAGE AGREEMENT

APPENDIX B

SUEZ CANAL SALVAGE AGREEMENT

Cairo, June 11, 1974

Dear Ambassador,

I have the honour to acknowledge receipt of your letter of today's date which reads as follows:

"I have the honour to refer to the recent discussions between our governments regarding the proposed assistance by the United States in the salvage and/or removal from the Suez Canal of sunken vessels and certain other hazards to navigation, and to propose that such assistance be governed by the following provisions:

1. The Government of the United States will, subject to the availability of funds, and otherwise in accordance with the laws of the United States, effect the removal from the Suez Canal of those vessels and other objects designated in Annex A hereto, and of such other objects and hazards to navigation in the Canal as may hereafter be mutually agreed which the Government of the Arab Republic of Egypt cannot remove without assistance. Except with respect to any vessel as to which it is jointly determined that salvage is possible, all vessels and other objects removed from the Canal shall be moved to agreed dumping areas designated by the Government of the Arab Republic of Egypt within its territory.

2. The Government of the Arab Republic of Egypt shall provide all necessary assistance as far as possible to enable the Government of the United States to carry out the operation efficiently. In particular, the Government of the Arab Republic of Egypt shall provide a navigable access to the site of each object to be removed; provide all available information as to the location, character and condition, and other characteristics of the areas of the canal in which the operations are to be conducted; provide for the payment of such local costs as may be agreed; and provide for the security as far as possible of the personnel and equipment engaged in the operation.

3. The United States Navy shall, under the general policy guidance and responsibility of the Embassy, carry out the operations

referred to in paragraph 1 above, and may, after due consultation, make use of such contractors, other than Egyptian nationals, as it deems necessary and advisable in carrying out the work. The Suez Canal Authority, and such other authorities or agencies as the Government of the Arab Republic of Egypt may designate, shall be responsible for carrying out the obligations of the Government of the Arab Republic of Egypt under paragraph 2 above.

4. The arrangement presently in force with respect to the assistance of the Government of the United States in the clearance of mines and unexploded ordnance from the Suez Canal shall also be applicable, mulatis mutandis, to the operations contemplated by the present arrangement. In particular, but with limiting the generality of the foregoing, the provisions of the arrangement concerning liability for claims shall apply in full to the operations referred to in paragraph 1 above. Members of the Armed Forces of the United States and persons serving with or employed by the said Armed Forces, including contractors and contractor personnel, other than Egyptian nationals, while in the Arab Republic of Egypt in connection with the operations referred to in paragraph 1 above, shall be covered in all respects by the provisions applicable to the "members of the force" under that arrangement.

If the foregoing is acceptable to the Government of the Arab Republic of Egypt, I would appreciate your written concurrence therein.

Accept, Excellency, the assurance of my highest consideration."

In reply, I have the honour to inform you that the foregoing assistance is acceptable to the Government of the Arab Republic of Egypt who therefore concur that your letter and present reply shall constitute an agreement between the two governments which shall enter into force on today's date.

I avail myself of this opportunity to renew to you, Mr. Ambassador, the assurance of my highest consideration.

Ismail Fahmy
Minister of Foreign Affairs

APPENDIX C

CHRONOLOGY OF SALVAGE EVENTS

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CHRONOLOGY OF SALVAGE EVENTS

May 27*	Twenty-nine contractor personnel and two C-141 loads of salvage equipment arrived in Cairo from the United States. Personnel arrived at Port Said later in the day.
May 28	Two C-141 loads of salvage equipment arrived at Port Said from Cairo. SUPSALV, MYPAC project manager, and five key SCA personnel connected with salvage operations made Canal-length helo inspection. Two SCA barges were outfitted as work/diving barges.
May 29	Work/diving barges moved to MECCA. First diver entered water at 1100 to commence survey. Began cutting superstructure into 80-ton SCA crane-size sections. Divers working underwater with oxyarc burning rigs; SCA mechanics working above water with oxyacetylene rigs. Completed outfitting of second work/diving barge.
May 30	Continued survey work and nonexplosive cutting of MECCA superstructure. Commenced removal of surface oil from MECCA compartments.
May 31	Completed divers' survey of M/V ISMAILIA.
June 1	Continued nonexplosive cutting of MECCA superstructure. Removed all oil on surface of partially flooded compartments. SUPSALV briefed COMSIXTHFLT staff on salvage operation.
June 2	Fitted two hot tap flanges in position in way of fuel tanks most likely to contain oil.
June 3	Senior salvage master for MECCA and ISMAILIA departed for Hamburg to familiarize himself with equipment and key personnel of heavy cranes. Continued nonexplosive cutting and preparation for oil removal in MECCA.
June 4	Continued nonexplosive cutting of MECCA superstructure. Oil removal slowed by lack of proper oil pumps.
June 5	Commenced mud removal on ISMAILIA using airlift.
June 6	Completed removal of mud from engine room and one large hold in ISMAILIA. Outfitting additional work/diving boats. Recompression chamber arrived.

*All dates 1974.

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June 7	Continued nonexplosive cutting of MECCA superstructure. Moved a much improved work/diving barge over ISMAILIA.
June 8	Made three initial explosive cuts on MECCA superstructure using C-4 explosive borrowed from Egyptian Army. 80-ton SCA crane arrived in Port Said from Alexandria. Began using two airlifts on MECCA to improve mud removal rate.
June 9	Installed seismic instrumentation to monitor effects of explosives on canal banks.
June 10	SCA 80-ton crane arrived. Made first 41-ton lift of MECCA superstructure. Oil removal equipment arrived from the United States.
June 11	Deposited MECCA superstructure wreckage on dry bank 5 kilometers to north. Continued airlift of mud from MECCA. Completed oil removal from first tank in MECCA; 10,000 gallons were removed from a 50,000-gallon tank.
June 12	Mud removal continues on ISMAILIA. Made second lift consisting of 85 tons of MECCA superstructure and placed wreckage in disposal area. Received two 600-CFM air compressors from Emergency Ship Salvage Material (ESSM) assets.
June 13	Made third lift of MECCA superstructure, the 25-ton stack. Received shipment of C-4 explosive. Pumped two oil tanks free of oil and found one additional double bottom tank to be empty. Four tanks of 12 tanks free of oil. Completed mud removal on ISMAILIA. Received additional divers' air compressors.
June 14	Discovered more mud in shaft tunnel of ISMAILIA; continued removal. Authorized contractor to proceed with wreck removal for DREDGE 23, dredge KASSER, Concrete Caisson, dredge 15 SEPTEMBER, MAGD, and BARREH.
June 15	Fired first explosive charges on ISMAILIA. Tried unsuccessfully to cut through inner bottom with 1.7 pounds per foot shaped charge. Made successful shot with flexible hose charges. Completed lift of 29-ton deck house structure of MECCA.
June 16	Completed fifth lift of MECCA superstructure. Continued explosive cutting of ISMAILIA bow sections.
June 17	Continued oxyarc cutting of lighter MECCA superstructure. Commenced working on removal of a 15-foot section from the stern that can be lifted by SCA 80-ton crane to increase channel width for smaller craft and boats that currently transit the canal. Received shipment of 7,000 pounds of C-4 explosive.
June 18	Completed first circumferential cut of ISMAILIA with severance of forward 20 percent of ship. Commenced cutting stern section of MECCA to allow passage of USS BARNSTABLE COUNTY en route to ISMAILIA.

June 19	Continued work on second circumferential cut on ISMAILIA; severed shaft with a shearing charge. Continued work on removal of MECCA superstructure and on removal of stern section.
June 20	Continued explosive cutting on ISMAILIA. Continued to cut MECCA superstructure and stern section. Made decision to include two lower superstructure decks--bridge and promenade in main hull cuts on MECCA. Released seismographic technicians after readings showed bank loadings to be within acceptable limits.
June 21	Completed second cut on ISMAILIA. Completed removal of MECCA stern. Removed 60-ton fourth section of superstructure from MECCA. Secured diving operations while treating diver for suspected decompression sickness.
June 22	Continued cutting superstructure of MECCA. No work accomplished on ISMAILIA, while continuing to treat diver for decompression sickness.
June 23	Removed 30-ton section of superstructure from MECCA. No work accomplished on ISMAILIA because of diver under treatment in recompression chamber.
June 24	Removed sixth section of MECCA superstructure. Resumed cutting ISMAILIA after completion of diver treatment.
June 25	Made arrangements for SCA oil boom to be placed on southern side of MECCA to guard against accidental oil spill. Removed one section of superstructure and foremast. Last sections of superstructure were removed with ease by right combination of oxyarc and explosive cutting.
June 26	Mainmast and part of one superstructure section of MECCA removed by SCA crane.
June 27	Last superstructure section removed from MECCA. Began underwater cutting. Rearranged salvage support barges to better support the major effort of cutting hull into liftable slices. Divers cut into after tanks and verified that they contained no oil.
June 28-29	Continued cutting of MECCA and began setting up logistic arrangements for survey team.
June 30	Problems that had appeared in cutting MECCA matured to the point where early resolution was mandatory. Problems were basically associated with techniques being employed in explosive cutting. Continued cutting operations while attempting to resolve problems. Continued preparations for survey operations.
July 1	Continued working on cut 13 on MECCA and preparation for survey operations with progress.

July 2	Continued cutting on stern of MECCA. Encountered compacted mud and sand on MECCA tank top and began removal with airlift.
July 3	Continued removal of mud and sand from MECCA, but made no progress in explosive cutting. Continued load out of survey barge, test ran equipment, and set up diving stations.
July 4	Stern section (section 14) of MECCA dropped to bottom, remaining attached to main hull by a small section of port shell plating. Completed load out of survey barge.
July 5	Completed severed stern section of MECCA and began work on cut 12.
July 6	Continued work on cut 12 and began work on cut 11 in MECCA. In way of cut 12, encountered heavy silting that varied in depth from 6 feet on the upper deck to 14 feet on the orlop deck. Two small explosions believed to be caused by trapped hydrogen gas occurred during cutting operations. Conducted DREDGE 23 survey.
July 7	Severed starboard shaft of MECCA on second attempt using 28 pounds of explosives. Mud removal in MECCA was hampered by large chunks of concrete clogging airlifts. Moored survey barge over dredge KASSER and commenced survey of this wreck and tug MONGUED.
July 8	Completed mud removal in way of internal cuts on cut 12 in MECCA. Retapped after port fuel oil tank and confirmed absence of oil. Installed oil boom around MECCA. Continued survey of dredge KASSER. Shifted barge into moor over tug MONGUED and commenced survey.
July 9	Continued cutting operations on MECCA. Completed survey on KASSER and MONGUED and commenced survey on Concrete Caisson at kilometer 87.
July 10	Began using technique of burning with oxyarc then separating using explosives on cuts 11 and 12. Found 1 foot of oil pressed up in the after starboard tank. Discovered unexploded ordnance on Concrete Caisson, which temporarily terminated survey.
July 11	EOD personnel checked out Concrete Caisson for unexploded ordnance. Near accident happened at MECCA site when unannounced water barge came alongside during diving operations. Water barge nosed into diving barge forcing it into the side of the wreck, narrowly avoiding cutting hoses. Continued cutting on MECCA.

July 12	Continued cutting on cuts 11 and 12 on MECCA. Determined technical expertise on explosive cutting was required to take advantage of the peculiar physical conditions of the wreck. Continued Concrete Caisson survey.
July 13	Continued work on cut 12 on MECCA. Completed Concrete Caisson survey. Moved survey barge to dredge 15 SEPTEMBER.
July 14	Continued cut 12 on MECCA. Additional oil pollution and explosive technicians, divers and tenders arrived. Commenced survey of dredge 15 SEPTEMBER.
July 15	Completed cut 12; continued work on cut 11, and commenced cutting accesses on cut 10. Began mud removal in way of cut 11. Continued very thorough survey of dredge 15 SEPTEMBER.
July 16	Continued work on cut 11. After arrival of double diaphragm pumps began hot tap operations in MECCA. Continued survey of dredge 15 SEPTEMBER.
July 17	Continued working on cut 11, oil removal operations and cutting accesses on cut 10. Completed survey of dredge 15 SEPTEMBER and began transit of survey team to tanker MAGD site.
July 18	Continued cutting on cut 11 and oil removal operations on MECCA. Survey team spent day in transit.
July 19	In MECCA continued burning in way of keel and cutting longitudinal pipes and stiffeners on cut 11. Work on access holes in cut 10 hampered by up to 9 inches of cork insulation in holds and black oil in orlop and lower decks. Removed 10,000 gallons of oil from starboard deep tank. Treated one diver for decompression sickness. Commenced survey of tanker MAGD.
July 20	Continued cutting and oil removal on MECCA and survey operation on MAGD.
July 21	Continued cutting, oil removal, and survey operations. Survey operations hampered by strong current allowing only 3 to 4 hours of diving daily.
July 22	Continued cutting, oil removal, and survey operations.
July 23	Continued cutting, oil removal, and survey operations.
July 24	Continued cutting and oil removal operations on MECCA. Cutting operations came to an abrupt halt when all available cutting rod was expended. Oil removal operations continued; minor oil spill occurred while removing oil from starboard inner bottom tank. Completed tanker MAGD survey. Sickness among divers slowed operations.

July 25	No progress in cutting since no cutting rod was yet available. Completed oil removal operation. Commenced survey of DREDGE 22 and tug BARREH. Survey operation was slowed by diver who became entangled and was unable to free himself.
July 26	No progress on MECCA because of lack of rod. Three divers were sent to augment the survey team. Continued survey on DREDGE 22 and tug BARREH. Made decision to employ additional heavy-lift crane.
July 27	Started airlifting mud from accessible areas of cut 1 on MECCA. Resumed oxyarc cutting of above-water sections to enhance diver access. Explosive consultants arrived from NUC. Continued survey operations.
July 28	Removed approximately 500 pounds of underwater cutting rods from Navy assets in the Mediterranean. Immediately began cutting on cuts 1, 8, and 10 in MECCA. Continued airlifting mud in way of cut 1. Completed DREDGE 22 survey and continued BARREH survey. NUC explosive ordnance consultants completed survey.
July 29	Continued cuts 1 and 10 and removal of selected hull plating on MECCA. VADM Murphy, COMSIXTHFLT, RADM Carroll, CTF 65, and others visited MECCA operations. Completed survey operation and reorganized survey team as trim and rig team.
July 30	Continued cuts 1 and 10 on MECCA. NUC consultants briefed SUPSALV, strongly endorsing basic approach taken by contractor but offering useful suggestions.
July 31	Continued cuts 1 and 10 on MECCA.
August 1	Continued cut 1 on MECCA; stopped work on cut 10 because of shortage of cutting rod. Trim and rig team arrived at site of dredge KASSER and prepared to start operations.
August 2	Continued explosive cutting on cut 1 on MECCA while awaiting additional cutting rod. Began passing messenger wires under dredge KASSER and removal of top hamper from tug MONGUED.
August 3	Impact of lack of rod now severe as it completely prevented cutting on cut 10. Continued explosive cutting on cut 1 and began airlifting on cut 2. Continued trim and rig work on KASSER and MONGUED.
August 4	Completed cutting on cut 1 and continued airlifting on cut 2 and tunneling under cut 10 to allow exterior placement of charges. Continued trim and rig work.

August 5	Received 500 pounds of cutting rod at MECCA site. Began cutting on cut 2 and mud removal on cut 3. Continued trim and rig work on KASSER and MONGUED.
August 6	Continued burning on cuts 2 and 10 and mud and debris removal from cut 3. Began sweeping messenger wires under tug MONGUED.
August 7	Commenced cutting accesses and removing mud on cut 3 in MECCA. Cut upper deck on cut 2; cut main deck, tank tops, and piping under orlop deck on cut 10. Completed removal of top hamper and continued messenger rigging on MONGUED.
August 8	Continued work on cuts 2 and 10 and proceeded with mud removal on cut 3. Continued to rig wires under MONGUED; rigging efforts were hampered by repeated parting of locally procured wire.
August 9	Continued cutting on cuts 2 and 10 on MECCA. Started cutting promenade and bridge deck on cut 8. Began airlifting on cut 4. Tunneled under MONGUED to pass messenger wires.
August 10	Continued cutting and airlifting on MECCA. Received additional supply of urgently required cutting rod. Navy medical officer visited and checked out sanitary conditions at wreck sites. Completed tunneling for passage of wires under MONGUED. Trim and rig team working on trimming jagged edges from scuttling damage on MONGUED.
August 11	Continued cutting on MECCA and passing messenger wires on MONGUED. Received 3000 pounds of underwater cutting rod.
August 12	Continued work on cuts 2, 3, 8, and 10 on MECCA; prepared one of two diving barges at MECCA site to move to ISMAILIA to cut holes for lifting chains. Completed rigging all but one wire on MONGUED.
August 13	Heavy-lift crane THOR arrived. Completed oxyarc cutting on cuts 2, 3, and 8. Began rigging for first lift on ISMAILIA. Completed all trim and rig work on MONGUED. Began to remove dredging rig and appendages from KASSER.
August 14	Rigged THOR for lifting and moved to ISMAILIA site. Kept tug BUGSIER 26 with crane to provide overall project support. Trim and rig team efforts slowed by shortage of necessary materials, particularly high quality wire; some airshipped support material for this team arrived. Moved diving barge from ISMAILIA back to MECCA and continued work on cuts 3 and 8 and began work on cut 4 on MECCA.
August 15	THOR moored over ISMAILIA and began rigging lift pendants. Continued cutting access holes in ISMAILIA hull. Continued burning on cuts 3 and 8 on MECCA. Continued working on dredging rigging and other appendages on KASSER.

August 16	Continued cutting lifting holes for chain straps in all sections of ISMAILIA and continued rigging first section for lift. Burned double bottom of cut 8 and main, lower, and orlop decks on cut 3 in MECCA. Continued cutting of KASSER for ladder and bucket removal.
August 17	THOR lifted bow section of ISMAILIA to surface; however, it was still connected. Diver inspection showed only cables connecting the two pieces. Cables were cut. Continued removal of appendages from KASSER. Continued to work cuts 3 and 8 in MECCA.
August 18	THOR began hoisting on ISMAILIA bow but plating tore, causing the wire to pull free. Passed lifting wires and cut drain holes to allow entrapped water to drain free. Left section hanging from crane with a 300-ton lift on the crane. Continued burning on cuts 3 and 8 on MECCA, and removing appendages from KASSER.
August 19	THOR lift of ISMAILIA bow was unsuccessful because of bottom plating which had not been cut. One explosive shot to cut the plating was fired. The attitude of the section changed, but it was still connected. Moved diving barge to ISMAILIA and began resurveying other cuts to ensure separation. On MECCA, continued work on cut 3 and commenced cutting accesses for cut 4. Jetted and ran messenger wires under KASSER. Began mud removal from MONGUED.
August 20	Diver inspection revealed that plate had not cut on ISMAILIA. Made second shot, moved crane back in position, and commenced cut. Parted one strand of hoisting wire but continued and successfully made lift. Completed accesses on cut 4 of MECCA and started work on bottom and deck. Tunneled under starboard side of cut 3 to facilitate charge placement. Trim and rig work continued on KASSER and MONGUED.
August 21	THOR moved ISMAILIA bow to dump area returned and commenced rigging to lift stern section. Cut away mooring in use on KASSER at time of sinking and continued cutting on MECCA.
August 22	Completed tunneling under cut 3 on MECCA and started oxyarc cutting on starboard shell plating. Continued rigging for second lift of ISMAILIA. Continued rigging messengers on MONGUED and KASSER.
August 23	Stern section of ISMAILIA lifted clear. Continued cut 4 on MECCA and commenced cutting lifting holes in section 14. YHLC's arrived in Suez.
August 24	Moved THOR to MECCA and began rigging to lift section 14. Reinspected cut 13 and cut one section of plating. Completed mud removal from KASSER and commenced replacing 5/8-inch wire messengers with 1-inch wire messengers.

August 25	THOR rigging stern section of MECCA for lift. Began cutting lift holes in pieces 12 and 13; continued cut 14. Continued passing messengers under KASSER.
August 26	Completed rigging and made first lift attempt on MECCA stern. Diver investigation showed section attached and fouled. Dispatched THOR to ISMAILIA while MECCA was cleared and mud removal completed. YHLC's got underway en route to ISMAILIA.
August 27	Continued cutting on cut 4 of MECCA and burning access holes in pieces 12 and 13. Inspection showed pieces 13 and 14 were cut, but wreckage was entangled. Burned and shot wreckage free. THOR began rigging for lift of section 2 of ISMAILIA.
August 28	Lifted section 2 of ISMAILIA and placed on bank. Checked and demudded piece 14 of MECCA. Rigged piece for lift.
August 29	THOR returned to MECCA, lifted stern section free and carried to dump area. Made decision to lift MONGUED first. YHLC's held ballasting drills.
August 30	THOR returned to MECCA and began rigging for lift of section 13. Completed cut 4. Trim and rig team began work on Concrete Caisson passing messengers. YHLC's moored alongside MONGUED and began rigging incidental to lift.
August 31	THOR continued rigging lift chains for piece 13 on MECCA. Divers on MECCA placed explosive charges on cuts 10 and 2.
September 1	THOR picked up piece 13. Piece fell apart and collapsed when lifted. After departure of THOR began explosive cutting on cut 10. Began pulling heavy-lift wires under MONGUED.
September 2	Continued oxyarc cutting on cuts 6 and 8, explosive cutting on cut 3,and tunneling under cut 10 on MECCA. THOR returned and began to rig and remove mud from piece 12. Completed passing lift wires under MONGUED. Continued passing messengers under the Concrete Caisson.
September 3	Split MECCA diving crew to work two shifts. Continued burning on cuts 6 and 8 and mud removal in way of cut 8. Explosively cut on cuts 2, 3, and 10 on night shift. Prepared for test lift on MONGUED.
September 4	Rigged THOR for lift of section 12 of MECCA. Made practice lift on MONGUED stretching wire. Continued mud removal on the Concrete Caisson. Completed cut 2 on MECCA.

September 5	Made first YHLC lift on MONGUED and moved wreck a short distance. Lifted piece 12 of MECCA with THOR. Completed cutting on cut 10.
September 6	THOR rigged to lift section 11 of MECCA. Continued explosive cutting on cuts 3 and 14. Lifted MONGUED and moved approximately 2 kilometers.
September 7	Continued oxyarc cutting of cuts 6 and 8 and explosive cutting of cut 4 on MECCA. Discontinued night shift. Lifted MONGUED more than 7 feet and moved toward Deversoir Causeway. Did trial explosive cutting on Concrete Caisson. Trim and rig team started work on DREDGE 23.
September 8	THOR attempted to lift section 11 of MECCA, but it was still attached to section 10. Shifted THOR to bow and lifted section 1. Section 1 separated into two halves on lifting. Moved MONGUED further toward Deversoir Causeway. Continued preparation of Concrete Caisson for lift and preparation of DREDGE 23 for parbuckling.
September 9	THOR rigged lower half of MECCA bow for lifting. Continued cutting on cuts 6, 8, and 10. CRILLEY and CRANDALL remained anchored while dredging improved available depths in Deversoir Causeway. Began removal of buckets and ladder of DREDGE 23 and did additional work to prepare KASSER for YHLC lift.
September 10	YHLC's passed over Deversoir Causeway and grounded MONGUED in dump area; lifted lower half of section 1 of MECCA.
September 11	YHLC's deposited MONGUED in final position in dump area. Unsuccessfully attempted to lift piece 11 of MECCA. Continued explosive and oxyarc cutting of Concrete Caisson and removal of buckets and ladder from DREDGE 23.
September 12	Unrigged YHLC's and airlifted mud from section 11 of MECCA.
September 13	Lifted section 11 of MECCA and deposited it in water adjacent to dry-dump area. Continued work on cut 8. Completed unrigging of YHLC's and continued cutting on Concrete Caisson.
September 14	Moved THOR along MECCA and began rigging section 2 for lift. Moved YHLC's alongside KASSER.
September 15	Heavy-lift crane ROLAND arrived at Port Said. Began passing lift wires under KASSER. Removed 20-foot ladder section from DREDGE 23.
September 16	ROLAND began rigging pieces wet dumped for dual lift to dry-dump area. Continued rigging work on MECCA and KASSER.

September 17	Continued work on cut 8 on MECCA. YHLC's completed rigging lifting on KASSER. Completed removal of ladder and all buckets from DREDGE 23.
September 18	Difficulties with rigging on section 2 caused THOR to move to dump area to work with ROLAND to make dual lifts into dry-dump area. Continued work on cut 8 of MECCA. Began passing lift wires on DREDGE 23.
September 19	Made first dual lift of MECCA section 14 but were unable to lift clear of water because of silting. Cut holes to allow washing out. Repositioned two sets of lift wires on KASSER to more favorable location.
September 20	ROLAND and THOR lifted stern section of MECCA from wet to dry dump. Completed oxyarc cutting on cut 8, continued work on cut 6. Continued rigging KASSER for lift.
September 21	ROLAND and THOR attempted to lift piece 13 of MECCA but the section collapsed, was unable to clear the seawall, and had to be returned to wet dump. Began explosive cutting on cut 8 on MECCA.
September 22	Completed explosive cutting of cut 8 on MECCA. ROLAND and THOR proceeded south to parbuckle DREDGE 23. YHLC's made first lift on KASSER; moved it approximately 50 feet and swung it 70 degrees. Completed cutting of lower side of Concrete Caisson.
September 23	Continued oxyarc cutting on cut 6 of MECCA. ROLAND and THOR being rigged for parbuckling of DREDGE 23. Rigged KASSER for second lift.
September 24	Made second lift of KASSER and proceeded into Great Bitter Lake. Continued cutting on MECCA.
September 25	Lifted KASSER again and deposited in dump area. Continued rigging for parbuckle of DREDGE 23 and cutting on MECCA.
September 26	Unrigged YHLC's from KASSER lift. Completed rigging for parbuckling of DREDGE 23. Attempted to parbuckle, but lift was aborted when lift wire parted. Continued mud removal from Concrete Caisson and cutting on MECCA.
September 27	Replaced parbuckle wire and attempted parbuckling. ROLAND's wire cheesed hull to the midpoint.
September 28	Pulled wire completely through the lower side of the Concrete Caisson. Continued airlifting mud from Concrete Caisson. Rerigged ROLAND to lift midships gantry structure of dredge.

September 29	Parbuckled DREDGE 23 into upright position. Unrigged heavy-lift crane and moved cranes back to MECCA.
September 30	ROLAND and THOR arrived at MECCA site. ROLAND began rigging for dual lift of sections 9 and 10. THOR began rigging for lift of section 2; YHLC's moved alongside DREDGE 23. Trim and rig team en route to the Suez district. Mud removal and other diving work on the Concrete Caisson delayed by unexplained explosions in the area.
October 1	Lifted section 2 of MECCA and took to dry-dump area. Began rigging lift wires under DREDGE 23. Stopped work on Concrete Caisson awaiting EOD recheck.
October 2	Completed washing mud out of section 2 of MECCA and made final lift to dry dump. THOR returned to MECCA and completed rigging for first double lift. Sections 9 and 10 were lifted clear of bottom and wreckage and set down for the night. Continued rigging lift wires under DREDGE 23. EOD divers cleared Concrete Caisson.
October 3	THOR and ROLAND took section 9/10 of MECCA to wet-dump area. Completed oxyarc cutting on cut 6 of MECCA. THOR returned to MECCA and began rigging section 3 for lift, while ROLAND began rigging for lift of one of two remaining sections of ISMAILIA. Completed rigging lift wires on DREDGE 23. Began silt removal from western end of Concrete Caisson.
October 4	THOR lifted section 3 of MECCA and moved to dry-dump area. Began washing mud out of section 3 for final lift. Explosive cutting done on cut 6 on MECCA. ROLAND continued to rig for lift of section 4 of ISMAILIA. Completed rigging for lift of DREDGE 23 by CRILLEY and CRANDALL. Continued demudding of Concrete Caisson.
October 5	THOR completed lifting section 3 of MECCA on bank and returned to MECCA to begin rigging section 7/8 for dual lift. ROLAND lifted section 4 of ISMAILIA and placed in dry dump. Made lift of DREDGE 23 with CRILLEY and CRANDALL. Dredge grounded on concrete rubble 2.4 kilometers south of original position. Continued silt removal on Concrete Caisson.
October 6	Attempted dual crane lift of section 7/8 of MECCA; section rotated but could not be lifted. THOR and ROLAND unrigged prepared to lift section 12 from wet to dry dump. Made second lift on DREDGE 23. Continued silt removal from Concrete Caisson and began work on tug BARREH.
October 7	Lifted section 12 of MECCA from wet to dry dump. Cut and section apparently interfering with lift of section 7/8 of MECCA and attempted second lift. Lift attempt was unsuccessful. Made final lift of DREDGE 23 and proceeded to dump area. Began messenger removal under Concrete Caisson.

October 8	Completed explosive cutting on cut 4 of MECCA and began rigging section 4 for lift by THOR. ROLAND began rigging for last section of ISMAILIA. Continued moving DREDGE 23 to dump area and rigging on Concrete Caisson. Moored stern of BARREH to bank to prevent slipping into deeper water during salvage operations.
October 9	Continued rigging on MECCA and ISMAILIA. Made final lift of DREDGE 23 in the Great Bitter Lake and deposited the wreck in the designated dump area. Completed passing messengers under BARREH.
October 10	THOR lifted section 4 of MECCA and moved to dry-dump area. Began rigging section 4 for two crane lift to final position. ROLAND lifted final section of ISMAILIA and took to dump area. Began washing mud from section for final lift. YHLC's moved to Concrete Caisson. Completed passing messengers under BARREH and commenced silt removal.
October 11	ROLAND lifted final piece of ISMAILIA to dry dump. ROLAND joined THOR in lifting section 4 of MECCA to dry dump. Continued mud removal on BARREH. Continued rigging CRILLEY and CRANDALL for removal of the Concrete Caisson.
October 12	ROLAND worked on rigging of section of MECCA for lift to dry dump. THOR rigged section 5/6 for dual crane lift. Continued lifting on BARREH and rigging on Concrete Caisson.
October 13	ROLAND lifted section 11 of MECCA and returned to MECCA site for rigging for lift of section 5/6. Continued silt removal on BARREH and rigging on Concrete Caisson.
October 14	THOR and ROLAND lifted section 5/6 of MECCA and moved it to the wet-dump area. Completed silt removal from BARREH and moved to DREDGE 22. Continued rigging of Concrete Caisson.
October 15	Attempted dual crane lift on section 7/8 of MECCA. One lift leg on ROLAND ripped through the shell, causing the other sling to carry away. THOR set the section back on bottom. Continued rigging of Concrete Caisson. Began removal of buckets and ladder from DREDGE 22.
October 16	SCA crane at ISMAILIA site attempted to pick up miscellaneous wreckage with little success. ROLAND en route to pick up DREDGE 23 boilers. Began cutting on the tanker MAGD. Continued mud removal from Concrete Caisson, and ladder and buckets from DREDGE 22.
October 17	Continued removal of scrap at ISMAILIA site, cutting of MAGD, bucket removal from DREDGE 22, and mud removal from Concrete Caisson.

October 18	Continued cleanup of ISMAILIA site. Established cutlines and rigging plan for reduction of MECCA section 7/8. ROLAND lifted both boilers from DREDGE 23. 80-ton SCA crane arrived at MAGD to lift sections that had been cut free.
October 19	Completed cleanup at ISMAILIA site and moved to MECCA site for cleanup. Operations on MAGD were delayed by French EOD, who exploded demolitions during period when tidal current permitted diving. Continued preparations for parbuckling DREDGE 22 and attempted to sever Concrete Caisson.
October 20	Continued removal of weight from section 7/8 and removal of debris from MECCA site. Continued removal of superstructure from MAGD and placement of diver cofferdams. Continued rigging on DREDGE 22.
October 21	Continued weight reduction on section 7/8 of MECCA and cutting and mud removal on MAGD. Completed rigging on BARREH. Continued preparations for parbuckling on DREDGE 22.
October 22	Continued weight reduction on section 7/8 of MECCA. Completed trim and rig on DREDGE 22.
October 23	MECCA team continued to make steady progress on weight reduction of section 7/8, MAGD team continued making steady progress. Revised Concrete Caisson plans to make individual lifts of five pieces.
October 24	Continued preparations on MAGD, DREDGE 22, and Concrete Caisson. Continued weight removal on MECCA.
October 25	SCA crane at MECCA site broke down stopping scrap removal operations. Continued cutting on MAGD and Concrete Caisson and rigging of DREDGE 22.
October 26	Continued cutting on MECCA, MAGD, and Concrete Caisson. ROLAND and THOR arrived for parbuckling of DREDGE 22.
October 27	Continued cutting on MECCA, MAGD, and the Concrete Caisson. ROLAND and THOR parbuckled DREDGE 22 to an upright position.
October 28	Sand and wind storm prevented lift of first section of Concrete Caisson and loss of more than half a day of cutting and rigging of MAGD.
October 29	MECCA cutting team made steady progress though no scrap removal. Began rigging heavy plates in way of lift wires on DREDGE 22 to serve as pudding.
October 30	Successfully lifted first section of Concrete Caisson. Continued rigging ROLAND and THOR for lift of DREDGE 22.

October 31	Continued cutting on MECCA but crane remained out of commission. Held cutting at 90 percent on MAGD pending completion of mud removal.
November 1	SCA crane returned to operation and began removal of MECCA scrap. Continued rigging for second section of Concrete Caisson lift. Continued rigging of load-spreading plates on DREDGE 22.
November 2	SCA crane continued scrap removal from MECCA. Completed second lift of Concrete Caisson and deposited section in Great Bitter Lake.
November 3	Began rigging for third lift on Concrete Caisson. Installed two additional cofferdams on MAGD. Continued scrap removal on MECCA and installation of bolsters on DREDGE 22.
November 4	Lifted DREDGE 22 with ROLAND and THOR and moved it to the wet-dump area. Continued rigging on Concrete Caisson and removal of mud from MAGD.
November 5	THOR and ROLAND arrived at BARREH site and began rigging lift wire. Small SCA crane became operational and began removal of pieces from section 7/8 of MECCA.
November 6	Continued rigging lift wires on BARREH, mud removal on MAGD and 15 SEPTEMBER, and weight removal from section 7/8 of MECCA.
November 7	CRANDALL removed two small pieces from the western section of the Concrete Caisson and dumped them into the Great Bitter Lake. Completed rigging lift wires on BARREH. Completed cut on MAGD.
November 8	CRILLEY removed last small section from western half of the Concrete Caisson. Continued weight removal from section 7/8 of MECCA and mud removal from 15 SEPTEMBER. THOR and ROLAND lifted BARREH and transported to the dump area.
November 9	ROLAND and THOR moved to MAGD and began rigging for parbuckling of stern section. CRILLEY and CRANDALL moved into position and began rigging for two craft stern lift of the western section of Concrete Caisson.
November 10	Stern section of MAGD was parbuckled to an upright position. Began re-rigging ROLAND and THOR for lift of MAGD stern section. Continued removal of excess weight from section 7/8 of MECCA and preparation for parbuckling of 15 SEPTEMBER.
November 11	Captain of ROLAND, who was injured when a wire parted, was evacuated first to U.N. hospital in Ismailia, then to Naples. Work continued on removal of excess weight from section 7/8 of MECCA, rigging for parbuckling and lift of 15 SEPTEMBER, and rigging for lift of western end of the Concrete Caisson.

November 12 ROLAND and THOR lifted the stern section of MAGD and moved toward the dump area. While en route to the dumping ground, MAGD grounded causing ROLAND's lifting slings to part and deck purchase to be damaged. Completed work on preparing bow section of MAGD for parbuckling.

November 13 Continued weight removal from section 7/8 of MECCA and rigging for lift of western section of Concrete Caisson. Completed work on removing spuds, raising ladder, and removing mud from 15 SEPTEMBER. Began replacement of damaged rigging on ROLAND.

November 14 Completed replacement of damaged rigging on ROLAND, lifted stern section of MAGD, and moved it clear of the Canal.

November 15 Completed passing wires under western half of Concrete Caisson and began work on rigging eastern half. ROLAND and THOR returned to MAGD and began rigging for parbuckling of the bow section.

November 16 Continued lightening of section 7/8 of MECCA, rigging of Concrete Caisson and MAGD.

November 17 Completed rigging of MAGD bow section for parbuckling.

November 18 Continued lightening of section 7/8 of MECCA and final preparations for lift of Concrete Caisson and parbuckling of MAGD.

November 19 Continued final rigging and final patching of 15 SEPTEMBER.

November 20 Successfully parbuckled bow section of MAGD, began re-rigging for lift.

November 21 Lifted bow section of MAGD and moved 2 kilometers before being forced to set down by current. Attempted lift of western section of Concrete Caisson, but eastern end was hung up and would not come loose.

November 22 Completed lightening of section 7/8 of MECCA.

November 23 Began cutting new lifting holes in MECCA. Lifted western half of Concrete Caisson, moved it approximately 20 feet from depression and set it down. Deposited bow section of MAGD in dump area and unrigged cranes.

November 24 Began rigging CRILLEY and CRANDALL for side lift of the eastern section of the Concrete Caisson. ROLAND and THOR began rigging 15 SEPTEMBER for parbuckling.

November 25	Continued work on new lifting points for section 7/8 of MECCA, rigging Concrete Caisson for lift, and rigging 15 SEPTEMBER for parbuckling.
November 26	Continued passing heavy lift wires and preparing for final lifts.
November 27	Continued rigging work. Experienced difficulty rigging chafing plates around 15 SEPTEMBER.
November 28	Continued rigging for final lifts.
November 29	Made final preparations for lifting Concrete Caisson and parbuckling 15 SEPTEMBER.
November 30	Lifted eastern half of Concrete Caisson but set it back down because of apparent damage to wires. Began airlifting mud from Concrete Caisson. Parbuckled 15 SEPTEMBER and began re-rigging for lift.
December 1	Continued re-rigging Concrete Caisson and 15 SEPTEMBER.
December 2	Completed removing mud from Concrete Caisson and rigging additional lift wires. Lifted 15 SEPTEMBER and began washing and shoveling out mud and sea growth.
December 3	Continued lifting and lightening of 15 SEPTEMBER and passing of additional lift wires under the Concrete Caisson.
December 4	Lifted 15 SEPTEMBER high enough to begin restoring buoyancy by pumping and blowing ballast tanks.
December 5	Dredge fully afloat by early morning but move delayed by high winds. Lifted Concrete Caisson section, twisted, and set down on higher ground.
December 6	Towed 15 SEPTEMBER to Ismailia and delivered to dredging department of SCA.
December 7	ROLAND returned to MECCA site and began repositioning collapsed MECCA section in dry dump.
December 8	Lifted Concrete Caisson section and proceeded south to ground in Deversoir Causeway. THOR began rigging for lift of Concrete Caisson western section.
December 9	Repositioned ROLAND over MECCA section 11 and moved it further into dry-dump area.
December 10	Commenced rigging ROLAND and THOR for lifting MECCA section 7/8. Moved eastern half of Concrete Caisson over Deversoir Causeway and grounded it unintentionally in Great Bitter Lake. THOR made unsuccessful attempt to lift 950-ton western section of Concrete Caisson.

December 11	Lifted section 7/8 of MECCA about 5 feet. THOR chain sling pulled through lift opening in hull. Commenced re-rigging to pass slings under hull. Eastern half of Concrete Caisson remained grounded in Great Bitter Lake because of high winds. Commenced rigging messengers on western section of Concrete Caisson.
December 12	Continued re-rigging MECCA section 7/8 for lift. Lifted eastern half of Concrete Caisson and moved it to grounded position within 1 kilometer of dump area. Loaded retrograde salvage material on USS BOULDER.
December 13	Dumped eastern half of Concrete Caisson in Great Bitter Lake.
December 14	Commenced rigging lift craft for lift of western section of Concrete Caisson. Completed rigging one sling under MECCA section 7/8.
December 15	Continued rigging MECCA section 7/8 and western end of Concrete Caisson for lifting.
December 16	Continued rigging.
December 17	Completed rigging both lifting slings under MECCA section 7/8 and lifted it from bottom where it was held overnight. Lifted western end of Concrete Caisson. Undesirable list of craft developed. Set Concrete Caisson back on bottom to retension wires.
December 18	Moved section 7/8 of MECCA to wet-dump area and placed it on bottom. MECCA completed. Lifted last piece of Concrete Caisson and moved it to grounding area at Deversoir Causeway, where subsequent lift was made.
December 19	Moved western section of Concrete Caisson to dump area and deposited it. Salvage operations in the Suez Canal completed.
December 20	Disbanded the Suez Canal Salvage Force.

APPENDIX D

TYPICAL MANNING REQUIREMENTS

APPENDIX D

TYPICAL MANNING REQUIREMENTS

Personnel Manning List for ISMAILIA Cutting Operations

Personnel	No. Reqd.
Salvage master - in charge	1
Assistant salvage master - part-time only	1
Diving supervisor	1
Divers	5
Tenders	3
Explosive technician	1
Explosive helper	1
Mechanic	1
Egyptian boat crew	1

Personnel Assignments for Trim and Rig Team One

Personnel	No. Reqd.
Salvage master	1
Diving supervisor	1
Divers	6
Tenders	6
Mechanic/equipment operator	1
Medical technician	1
Total contract personnel	16
Suez Canal Authority crane crew	9
Suez Canal Authority boat crew	3

APPENDIX E

PRINCIPAL U.S. GOVERNMENT AND CONTRACTOR PERSONNEL

APPENDIX E

PRINCIPAL U.S. GOVERNMENT AND CONTRACTOR PERSONNEL

State Department

Hon. Hermann Eilts—U.S. Ambassador to Egypt

U.S. Navy

Rear Admiral Brian McCauley, USN—CTF 65 (April - May 1974)

Rear Admiral K. J. Carroll, USN—CTF 65 (June - Dec. 1974)

Captain J. H. Boyd, USN—Director of Ocean Engineering and Supervisor of Salvage—CTG 65.7

Captain R. B. Moss, USNR—Deputy Supervisor of Salvage

Commander C. M. Jones, USN—Officer-in-Charge, Experimental Diving Unit

Commander J. J. Coleman, USN—Assistant for Salvage and Deep Ocean Systems, Staff of the Supervisor of Salvage

Lieutenant Commander A. K. Paszly (SC), USN—Assistant for Resources and Logistics, Staff of the Supervisor of Salvage

Lieutenant Commander R. Jones (SC), USN—Assistant for Logistics

Lieutenant R. Ostrom (SC), USN—Assistant for Logistics

James C. Bladh—Operations Specialist

B. Staub—Logistics Specialist

B. W. Sanders—Ocean Engineering/Marine Specialist

Murphy Pacific Marine Salvage Company

Warren D. Thomas — Executive Vice President
J. F. Madeo, Jr. — Suez Project Manager
R. McKenzie
R. Belsher
J. L. Bradshaw
D. Thomas
R. D. Yentes
J. Shirley
J. Kjellman
K. Brown

Buck Steber, Inc. (Divers)

A. Holgerson
J. Jones

BUGSIER 26 (German Tug)

H. Detlev
E. Wefer
H. Possel
R. Meyer

Technical Explosives, Inc.

P. Kenny

Ocean Oil International (Naval Architects)

H. Pazos

Luzan Stevedoring Corporation (LUSTEVCO) — Towing and Lift Craft from Subic Bay in the Philippines to Suez

R. Griarte

Finn Company (Certified Public Accountants)

T. Finn

Sea Salvage, Inc.

E. B. Mitchell

APPENDIX F

OPERATION OF THE HEAVY-LIFT CRAFT CRILLEY AND CRANDALL

APPENDIX F

OPERATION OF THE HEAVY-LIFT CRAFT CRILLEY AND CRANDALL

1. INTRODUCTION

The heavy-lift craft CRILLEY and CRANDALL are designed for three modes of salvage lift: stern, side, and bow. Two of these methods, stern and side, were used in the Suez Canal clearance and are described in this appendix. In the side-lift mode, the craft can be used either singly or together, but are normally used together. A straight tidal ballast lift with lift wires rigged underneath the wreck is shown in Figure F-1. Each craft has a capacity of 2400 tons, giving a total lift of 4800 tons when the craft are acting together. In a stern-lift mode, the lift is made as a combination tidal ballast lift and dynamic lift using the stern gantry and hauling tackle laid out on deck. The stern-lift capacity of each craft is 600 tons. Positioning for a double stern lift is shown in Figure F-2. A 300-ton lift can be made using the gantry tackle alone.

The heavy-lift craft must be placed in a sound moor before commencing any lift operation. The composition and arrangement of the moor is dependent upon type and attitude of the wreck and upon the conditions of tide, current, and weather at the wreck site. The primary consideration is that the moor be secure and individually tailored to the peculiar conditions of the wreck being lifted.

2. SIDE LIFT

The side lift is generally made using both craft and the wreck slung between them supported by 3-inch wires. The following steps are taken in making a side lift:

- The heavy-lift craft are positioned as dictated by the conditions found in the salvage survey and placed in a secure moor.

- Special spreaders are placed between the craft. These comprise 3-foot diameter pipe sections with flanged ends whose lengths can be varied by bolting on sections. The

FIGURE F-1
YHLC's Positioned for a Side Lift

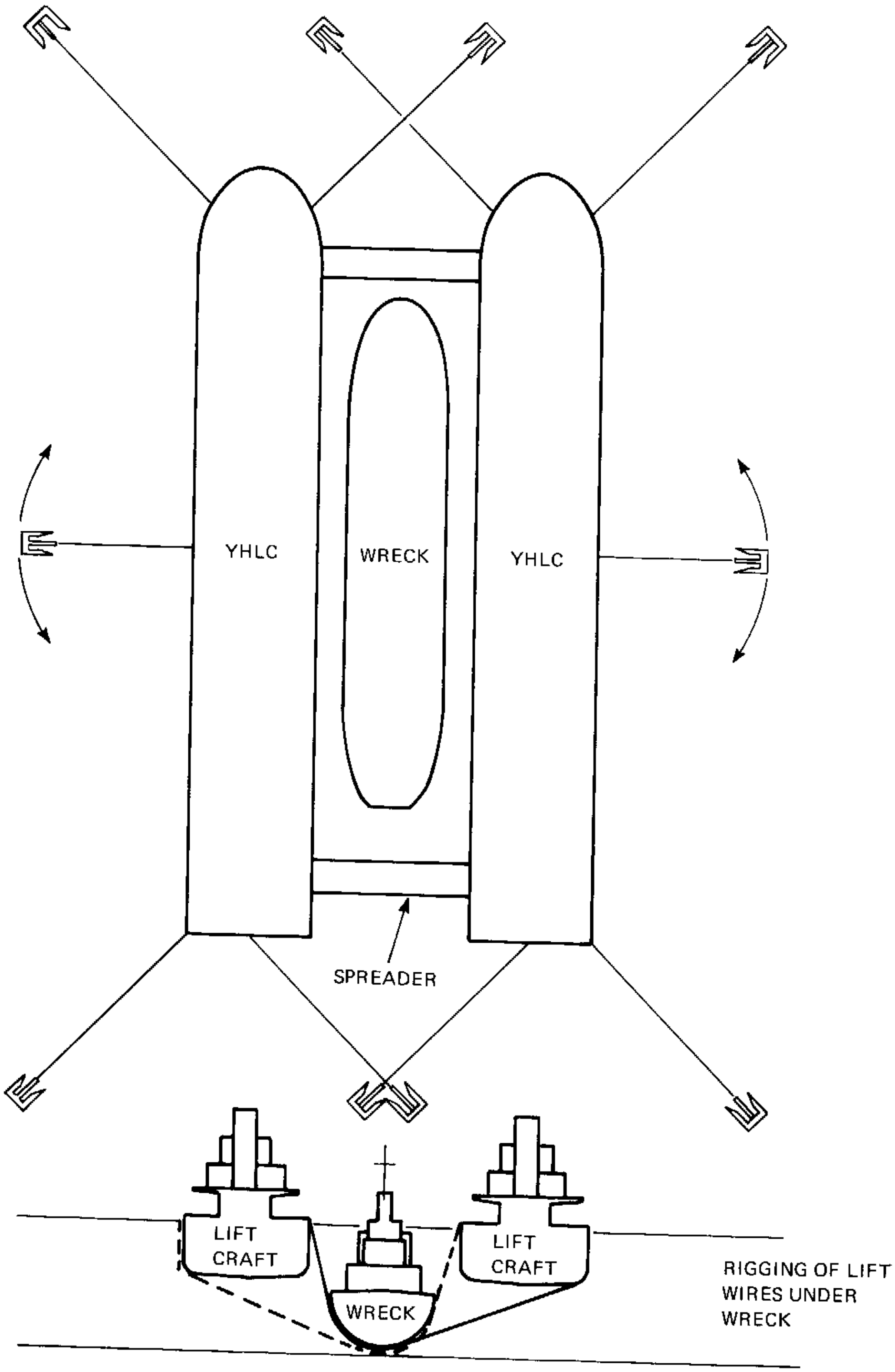
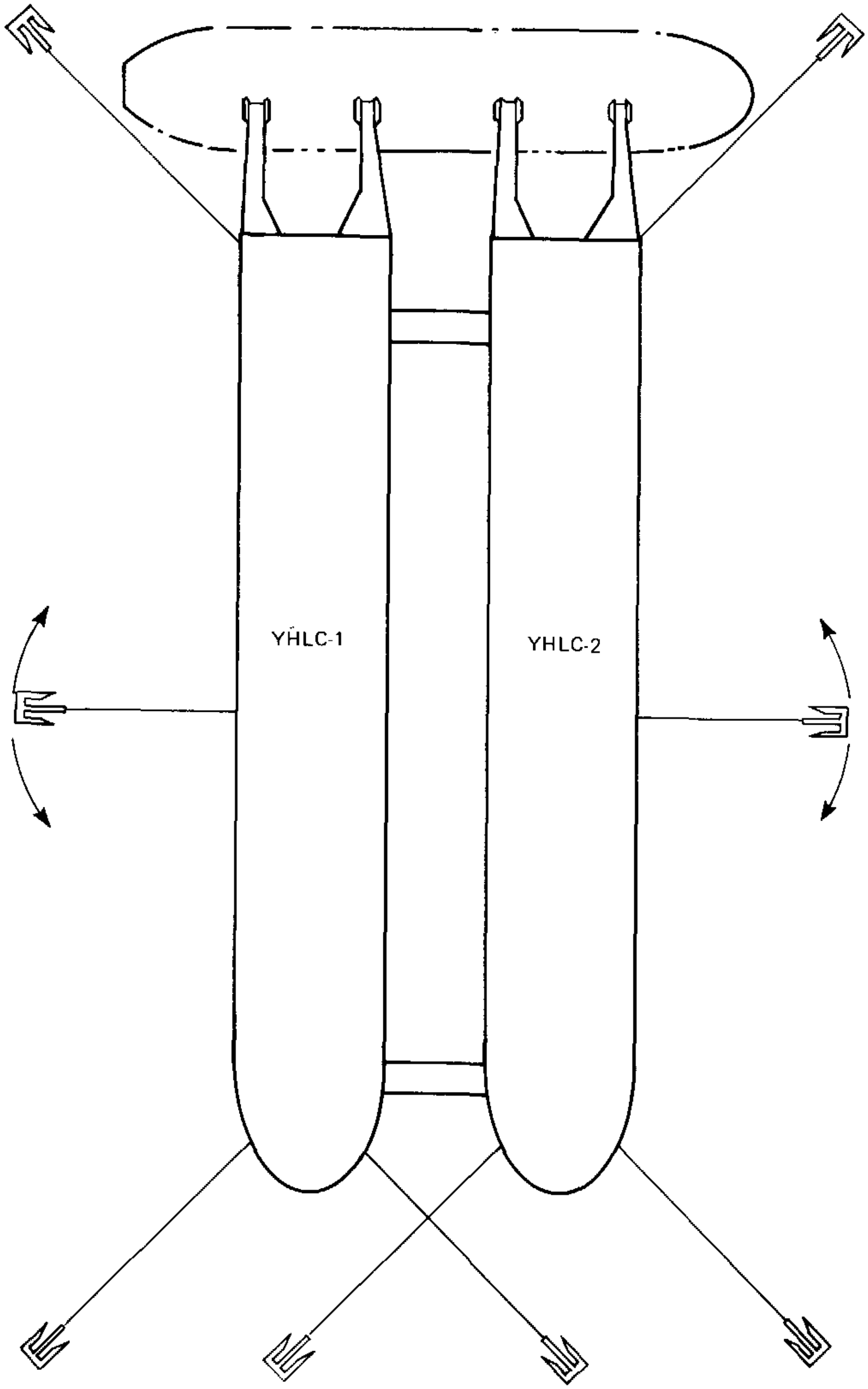


FIGURE F-2
Heavy-Lift Craft Positioned
for Double Stern Lift



purpose of the spreaders is to keep the craft apart during the lift when horizontal force components tend to cause them to move toward one another.

- Messenger wires are run beneath the wreck by any one of three basic methods: sweeping (sawing), passing with divers under ungrounded sections of wrecks, and tunneling. As was often done during the operation, messengers can be passed prior to the arrival of the lift craft. Messengers are usually 1-inch wires.

- Three-inch heavy-lift wires are passed using the messenger wires. The wires are passed from the inboard side of the first lift craft beneath the wreck and up the outboard side of the other. The wires are led through the deck edge nipper, figure eighted on the bitts, and led through the inboard nippers. When all slack has been hauled out of the wire, the deck edge nipper is set up. Figure F-3 shows the arrangement of nippers and bitts at each pinpoint (lift wire station). Figure F-4 is a closeup photograph of the inboard nipper.

- In preparation for lifting, the craft are ballasted down and all wires are again hauled to remove all slack. Inboard nipper gates are closed and set up. Figure F-5 shows the arrangement of the lift wires and bitts during lifting operations.

- During ballasting and deballasting operations, care is taken to press all tanks completely full and to utilize a stripping sequence which will minimize loss of stability. In addition to minimizing stability loss, the deballasting sequence should be chosen to minimize changes in trim so that loading of the wires occurs evenly and undue strains are not placed on any wires.

- The distance the wreck can be raised clear of the bottom can be estimated by considering the two lift craft and wreck as a single structure and considering the weight of ballast water removed as buoyancy added to the nest. This buoyancy gain, plus the use of tide, will determine the height of lift that can be obtained.

FIGURE F-3
Wires Secured for Side Lift

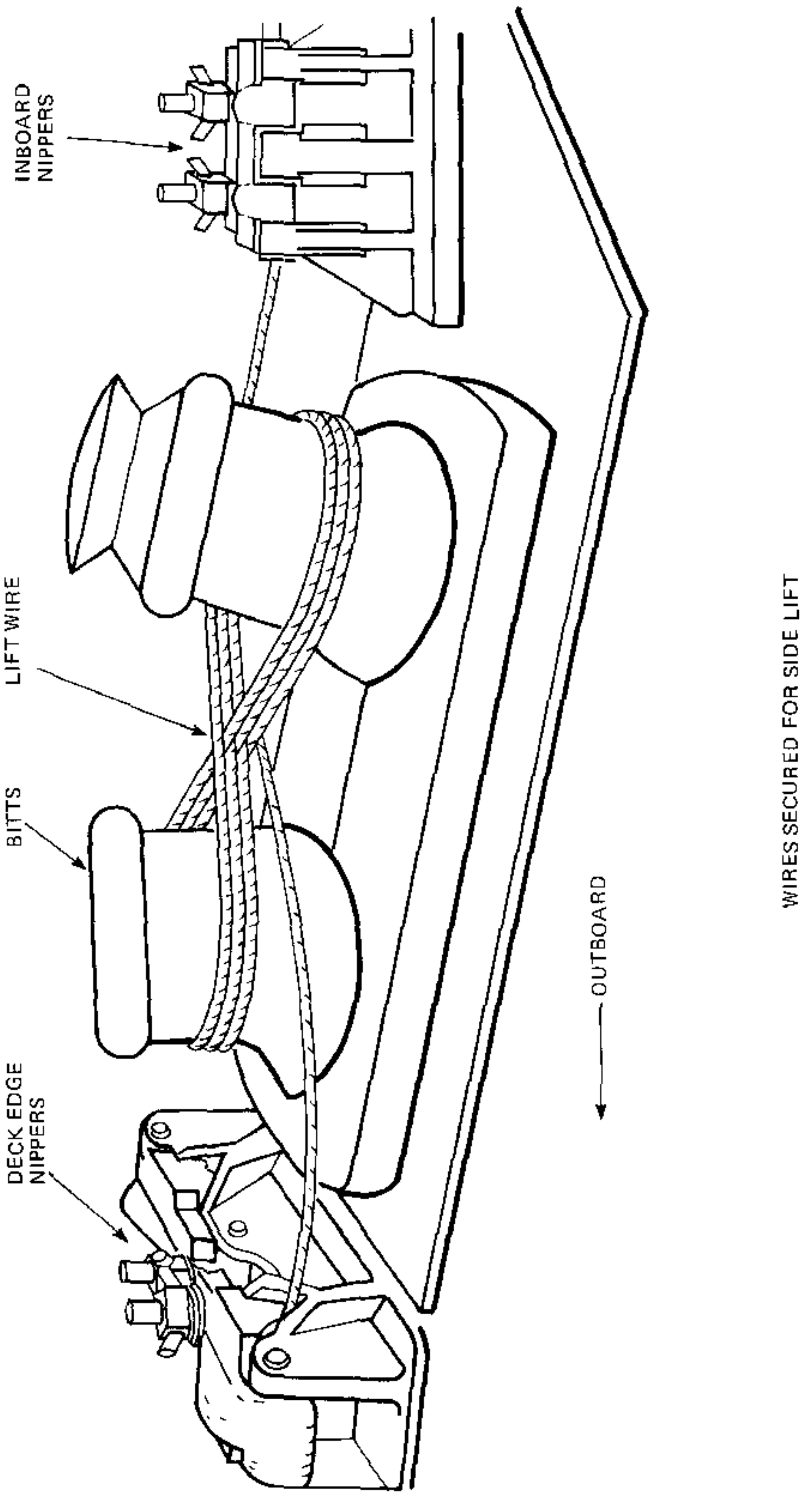


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FIGURE F-4
Inboard Nipper

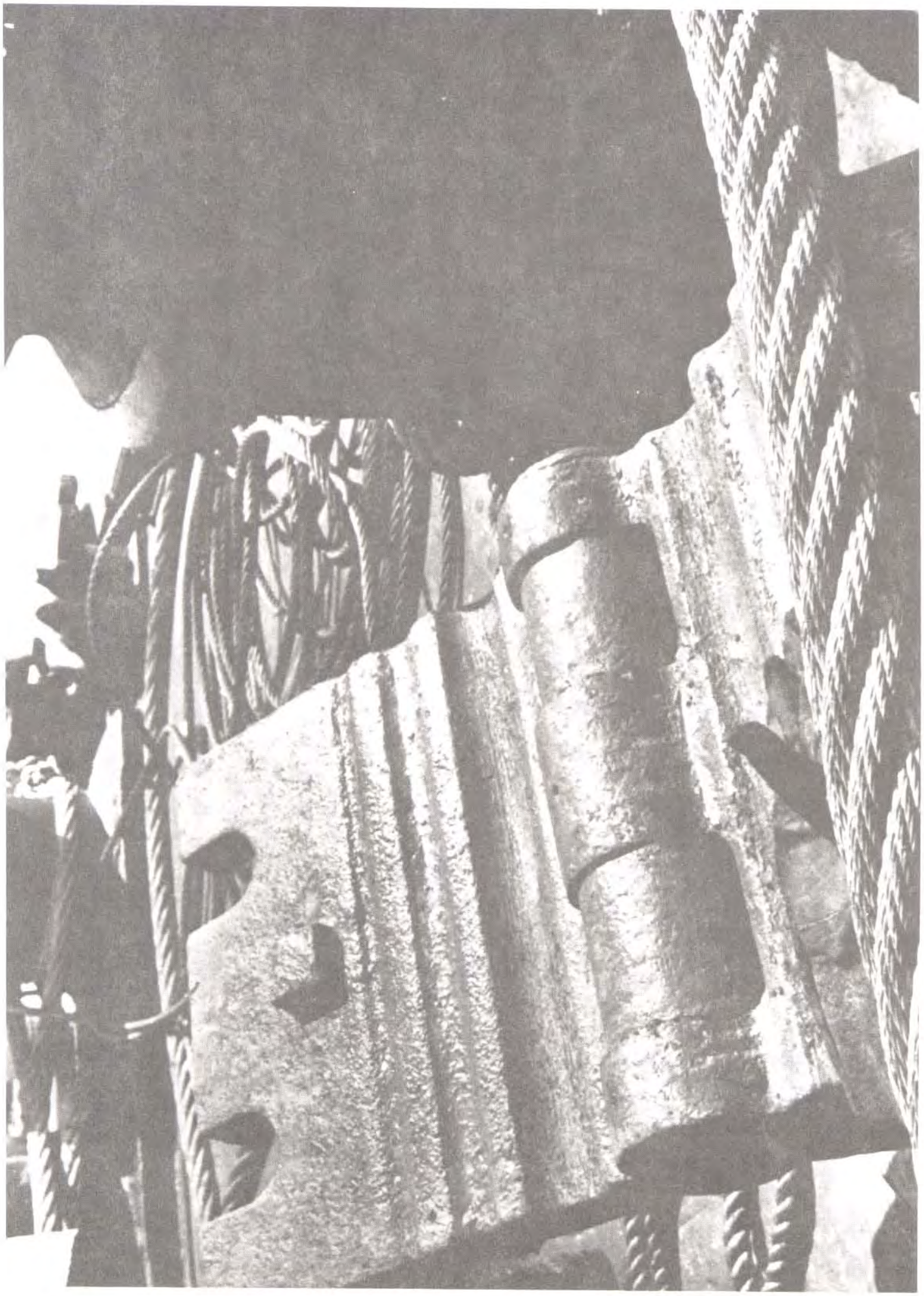
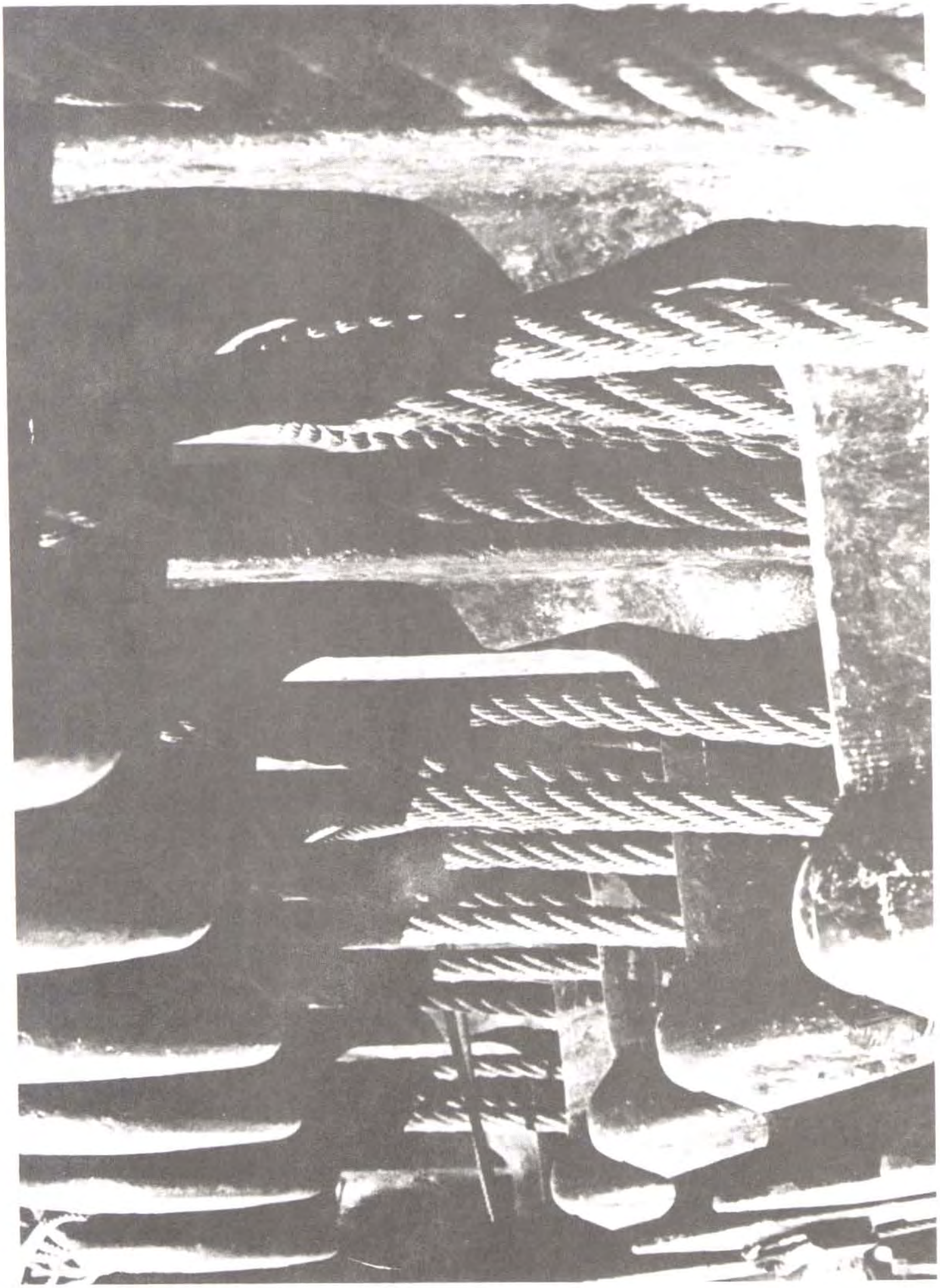


FIGURE F-5
Arrangement of Lift Wires and
Bitts During Lifting Operations



- Lift craft must be equidistant from the wreck. Otherwise, both lift craft will assume a significant list as the wreck tends to "plum" the space between its craft.

3. 300-TON STERN LIFT

The 300-ton stern lift employs the stern gantry tackle to make a combination tidal ballast and dynamic lift. As with a side lift, the first step is to place the craft in a secure moor. The composition and arrangement of this are dependent upon the attitude of the wreck and tide and current conditions at the site. For a stern lift, the craft will generally be positioned, as shown in Figure F-2, with their longitudinal axis normal to the longitudinal axis of the wreck. The 300-ton stern lift uses only the permanently rigged gantry tackle. The basic principle is that wires are passed under the wreck, made up to the hook on the gantry tackle at the end of the outreach. The lift is made by deballasting the craft and simultaneously hauling the six-fold gantry tackle using the hauling winches located near the stern of the lift craft. Rigging arrangements for the 300-ton stern lift are shown in Figure F-6.

4. 600-TON STERN LIFT

The 600-ton stern lift is somewhat more complicated than the 300-ton lift because it employs the deck tackle as well as the gantry tackle, as shown in Figure F-7. A bight of heavy-lift wire is rigged from the deck under the wreck and passed over the roller in the gantry hooks. The ends of the wire are passed around the teardrop-shaped hauling block and made up on themselves using three boulivant clamps. Rigging of the hauling blocks is shown in Figure F-8. Extra long wires are required for the method.

The deck tackle using the teardrop-shaped hauling block and the fixed standing block on the forecastle are reeved with 1-1/8-inch wire as is the gantry tackle. The tackle passes down the line of bitts used in the side lift. Figure F-9 is a plan view of the deck tackle. When ready for lifting the craft are ballasted down, the hauling blocks are supported by the crane until a light strain is taken on all tackle, and the jacking shaft between both sets of winches is engaged. To lift, the craft is deballasted and all tackle are hauled simultaneously. Using the stern lift, the object being salvaged may be lifted either to the surface or to the limit of the tackle and repositioned for another lift. Although stern lifts are generally made to take advantage of the tide because of the dynamic lift of the hauling tackle, they are particularly useful where the tidal range is small.

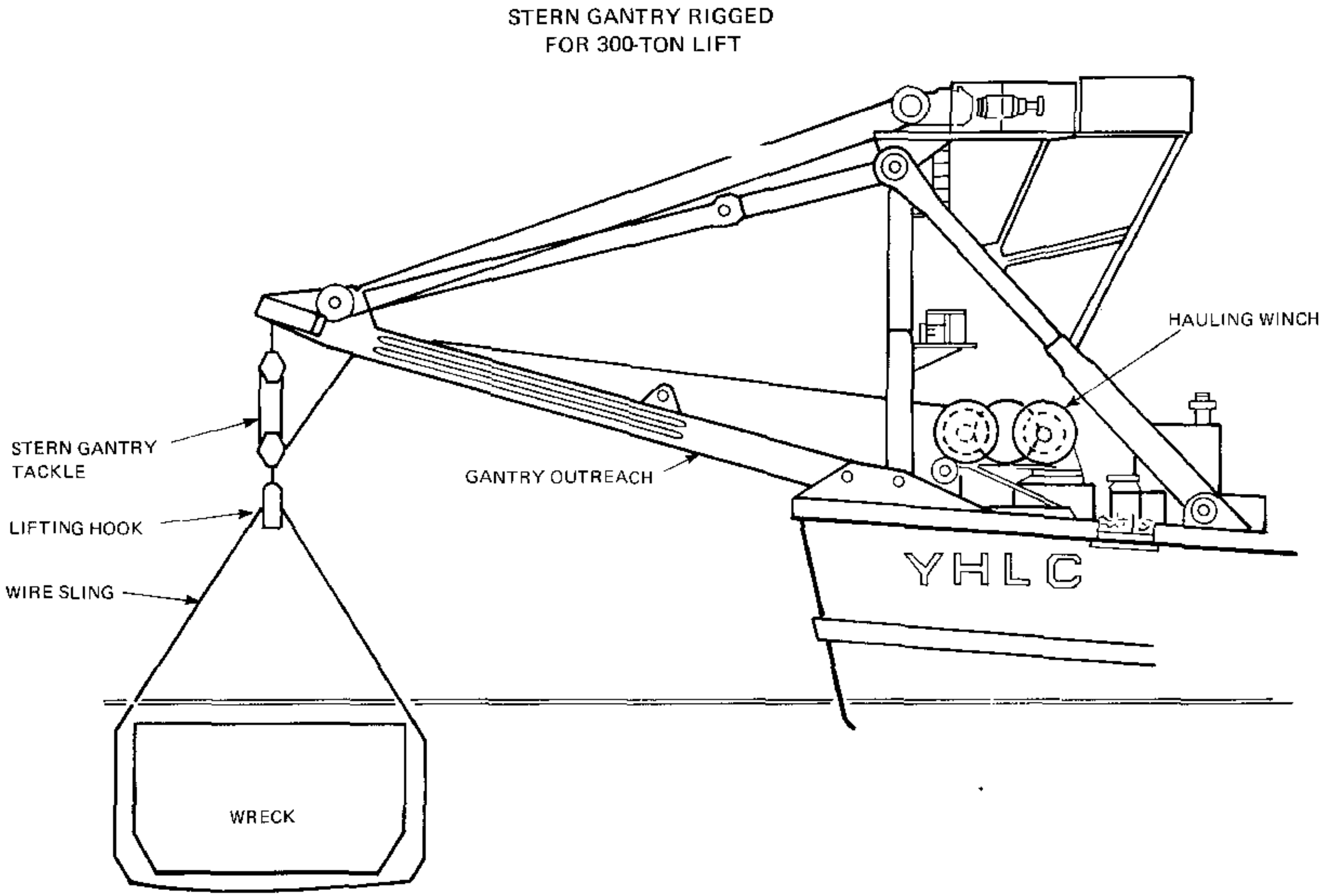


FIGURE F-6
Stern Gantry Rigged for 300-Ton Lift

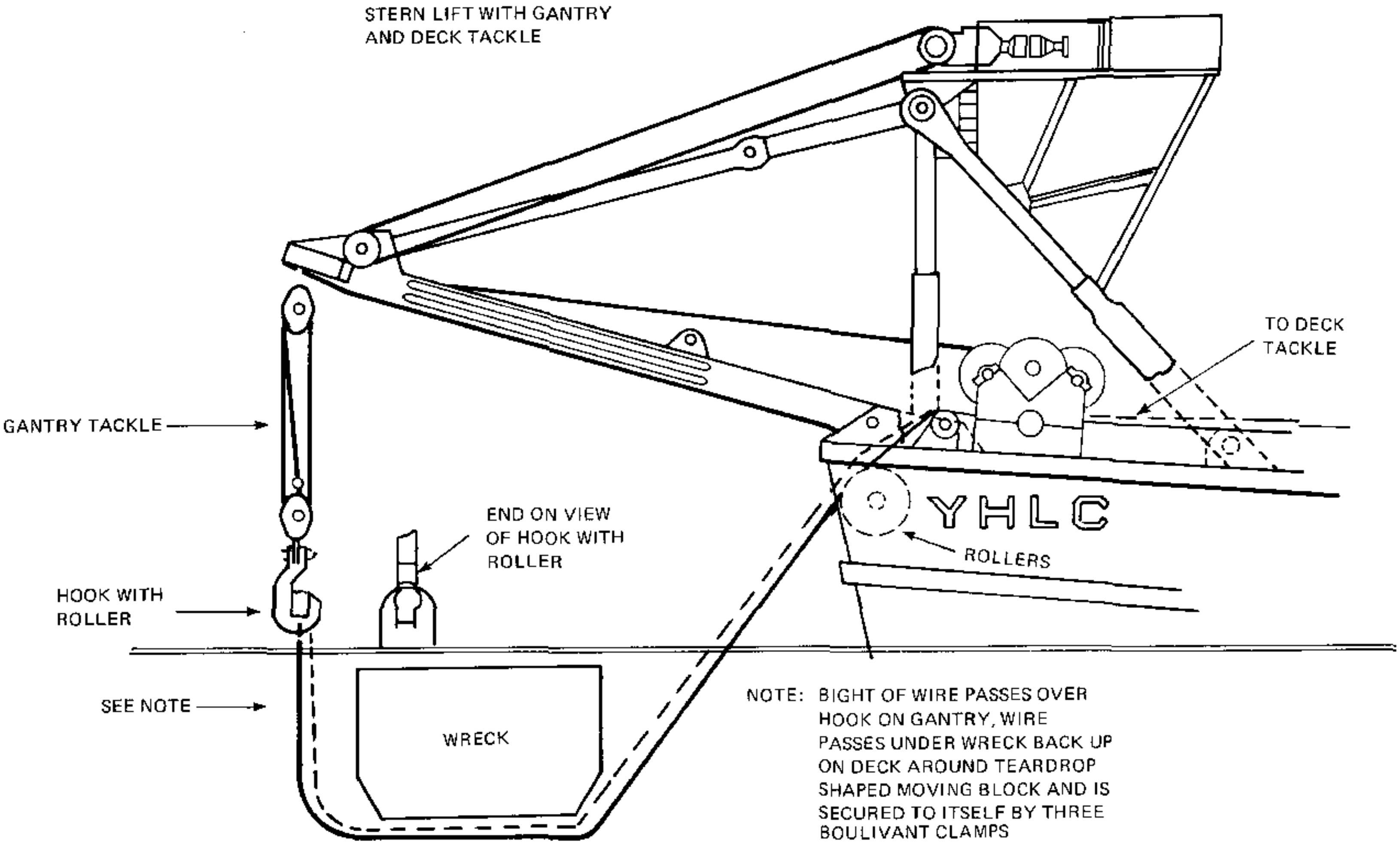
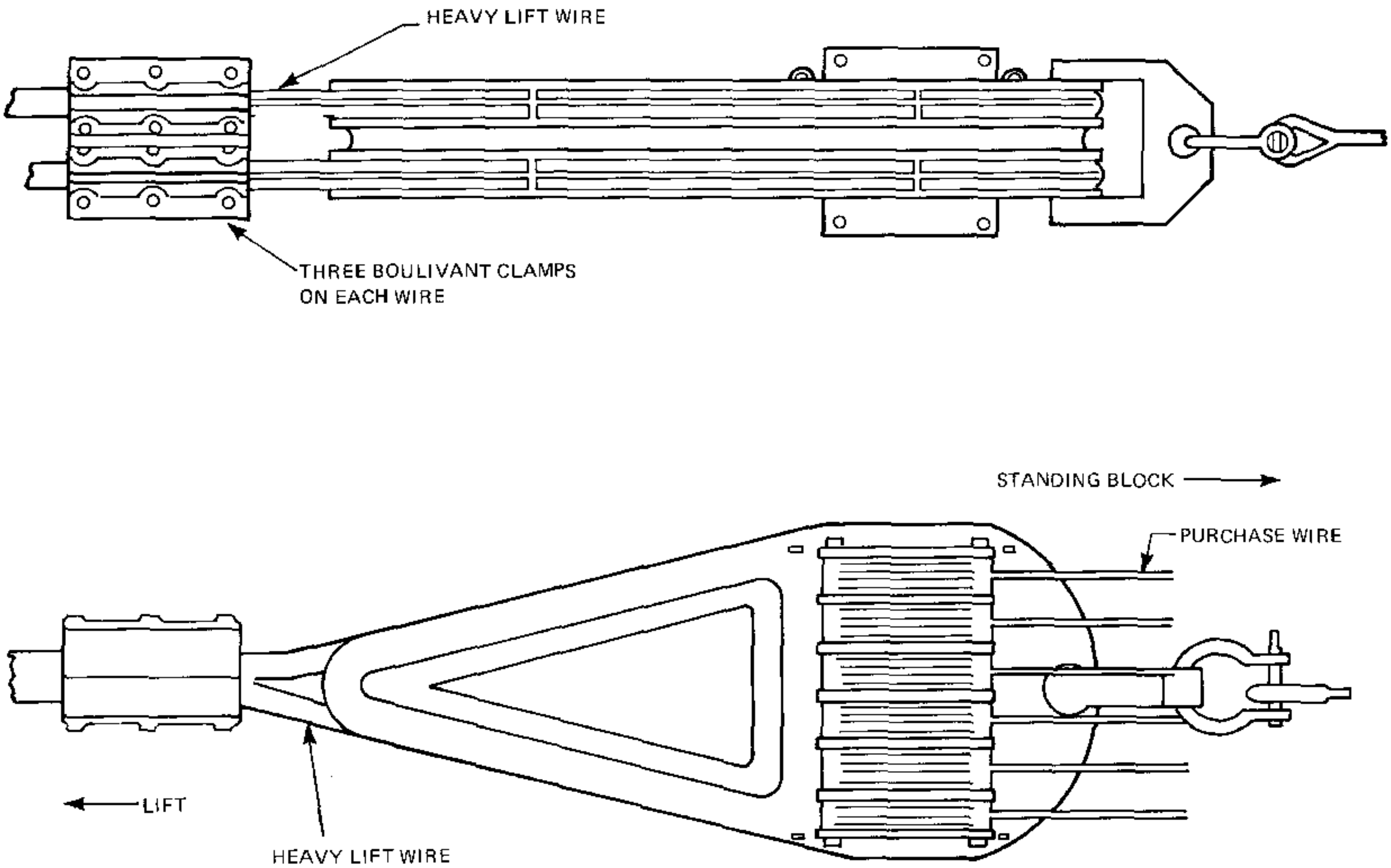


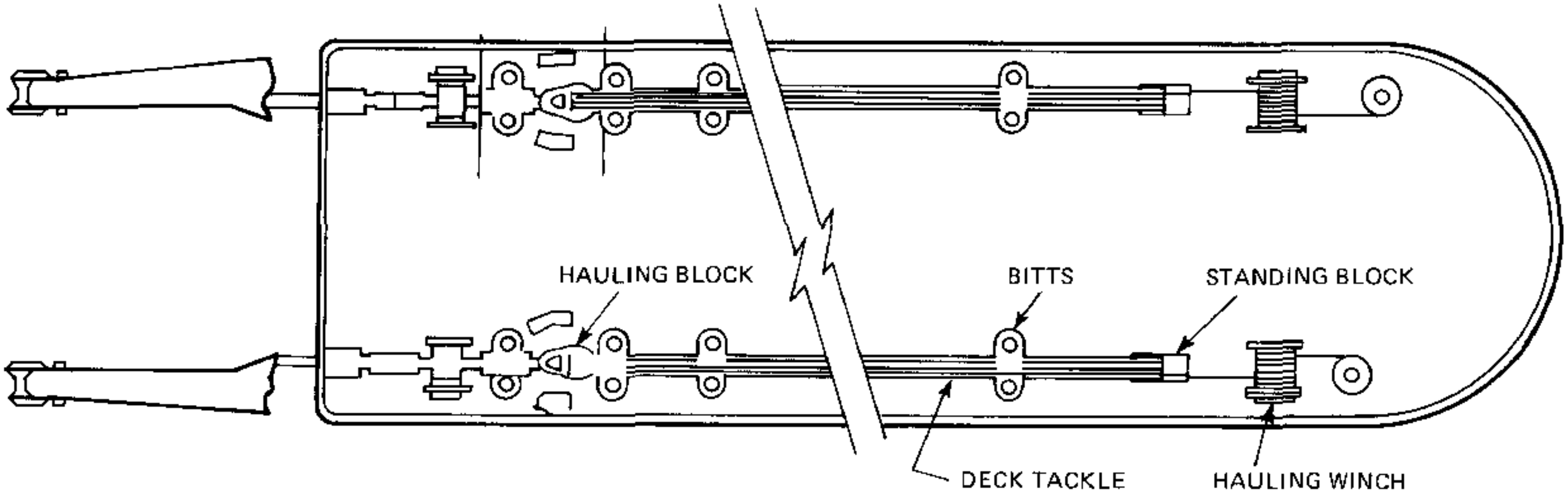
FIGURE F-7
Stern Lift With Gantry and Deck Tackle

FIGURE F-8
View of Hauling Block Prepared for 600-Ton Lift



VIEW OF HAULING BLOCK PREPARED FOR 600-TON LIFT

FIGURE F-9
View of Deck Tackle for 600-Ton
Gantry Lift



DECK TACKLE FOR STERN GANTRY LIFT

VIEW OF DECK TACKLE FOR 600-TON GANTRY LIFT

APPENDIX G

CHARACTERISTICS OF THOR AND ROLAND

APPENDIX G

CHARACTERISTICS OF THOR AND ROLAND

1. Principal dimensions

- Length: 249 feet 6 inches
- Beam: 78 by 9 inches
- Depth: 15 feet 4 inches
- Draft light: 3 feet
- GRT: 2667 tons
- Propulsion: 2 Schottel engines, 600 bhp each.

2. Lifting features

- Load, main hooks:
  - 2 hooks, 250 tons each, from A-frame jack
- Clearance, main hooks:
  - Maximum load of 500 tons can be lifted 95 feet above water with 36-foot horizontal clearance between hooks and front plate of pontoon
  - Maximum horizontal clearance is 76 feet, with 72-foot height above water, and a maximum load of 200 tons
  - Maximum height above water of 105 feet can be reached with a horizontal clearance of 12 feet and a maximum load of 500 tons
- Load, auxiliary hooks:
  - The A-frame carries a jib with two hooks of a total 300-ton lifting capacity, with horizontal clearance of 76 feet and 164-foot height above water
- Clearance, auxiliary hooks:
  - Maximum horizontal clearance of 89 feet, with a height above water of 141 feet and a maximum load of 210 tons.

3. General

The A-frame jack and the jib are able to work simultaneously in a fixed horizontal clearance of 36 feet (42 feet on ROLAND). For raising heavy objects in the open sea, the pontoon is equipped with two gin tackle, 250 tons each, at the front plate of the pontoon. This arrangement of tackle of 500 tons maximum load can work together with the A-frame jack and gives the pontoon a 1000-ton lifting capacity.

APPENDIX H

EQUIPMENT DETAILS

APPENDIX H

EQUIPMENT DETAILS

List of Major Equipment Used on ISMAILIA Cutting Operation

Item	Description	Qty.
1	Diving barge, 25 x 75 feet	1
2	600-CFM rotary air compressor	1
3	90-CFM diver's air compressor	1
4	40-CFM diver's air compressor	1
5	Double-lock decompression chamber	1
6	600-ampere direct current welder	1
7	6-inch airlifts	2
8	6-inch jetting pump with falcon nozzles	2
9	Oxyarc underwater cutting rigs	3
10	Surface-supplied diving outfits (each diver used own helmet)	3
11	Hot-tap machine (on barge but not used)	1
12	Motor launch (transportation to and from barge)	1

Equipment Available at the Special ESSM* Base, Port Said, Egypt

Location: On the southern side of the Suez Canal Authority's Cherif Basin area with good access to all utilities as well as water access to the northern end of the Canal.

Components: Conventional ESSM equipment used for commercial equipment backup.

Item	Description	Qty.
1	Portable diesel salvage air compressors, 600 CFM, 125 psi	6
2	Portable diesel salvage air compressor, 125 CFM, 125 psi	1
3	Portable diesel high-pressure jetting pumps	8
4	Portable diesel welding generators, 400 amperes	6
5	Portable diesel salvage pumps, 20-inch, 3000 GPM	4
6	Portable diesel salvage pumps, 6-inch, 1600 GPM	4
7	Portable diesel salvage pumps, 3-inch, 500 GPM	4
8	Submersible electric salvage pumps, 4-inch, 600 GPM	2
9	Special (not ESSM) Bendix diving air filter	1
10	Portable diesel A/C 30 kW generators, 9 cubic feet	2
11	Portable diesel A/C 5 kW generator	1
12	4-inch fire hose for submersible pumps	200 ft.
13	Electric extension leads for submersible pumps	100 ft.
14	Diving masks	2
15	Diving hose	300 ft.
16	Underwater welding holders	6
17	Underwater cutting holders	6
18	Underwater welding cable	1200 ft.
19	2-1/2-inch fire hose	1500 ft.
20	1-1/2-inch fire hose	1000 ft.
21	6-inch lightweight suction/discharge hose	540 ft.
22	3-inch lightweight suction/discharge hose	600 ft.

*Emergency Ship Salvage Material.

Item	Description	Qty.
23	10-inch heavy suction hose	108 ft.
24	10-inch steel discharge pipe	176 ft.
25	30-inch spherical steel buoys	24
26	6000-pound lightweight anchors	24
27	1-5/8-inch wire rope	600 ft.
28	Falcon, reverse thrust 2-1/2-inch nozzles	9
29	Rigging vices, for wire rope spliced	2

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APPENDIX I

TYPICAL TIDE TABLE FOR SOUTHERN END OF SUEZ CANAL

APPENDIX I

TYPICAL TIDE TABLE FOR SOUTHERN END OF SUEZ CANAL
(Suez, United Arab Republic, 1974)

July						August						September					
Day	Time (H.M.)	Ht. (ft.)	Day	Time (H.M.)	Ht. (ft.)	Day	Time (H.M.)	Ht. (ft.)	Day	Time (H.M.)	Ht. (ft.)	Day	Time (H.M.)	Ht. (ft.)	Day	Time (H.M.)	Ht. (ft.)
1	0333	1.4	16	0218	1.6	1	0444	1.4	16	0342	0.6	1	0502	1.3	16	0459	0.0
M	0942	4.9	TU	0804	4.6	TH	1106	4.5	F	0945	5.1	SU	1136	4.9	M	1115	6.2
	1547	1.5		1430	1.4		1652	1.6		1601	0.6		1718	1.5		1725	0.3
	2206	5.4		2038	5.2		2310	4.9		2206	5.8		2331	5.1		2329	6.4
2	0421	1.4	17	0311	1.2	2	0510	1.4	17	0430	0.2	2	0529	1.2	17	0546	0.0
TU	1035	4.9	W	0902	4.8	F	1140	4.6	SA	1038	5.5	M	1158	5.0	TU	1204	6.4
	1632	1.7		1525	1.1		1719	1.6		1651	0.3		1748	1.5		1813	0.4
	2251	5.3		2131	5.5		2338	4.9		2257	6.1		2353	5.2			
3	0501	1.5	18	0400	0.9	3	0534	1.3	18	0517	-0.1	3	0557	1.1	18	0018	6.4
W	1120	4.9	TH	0957	5.1	SA	1207	4.6	SU	1130	5.8	TU	1219	5.2	W	0633	0.1
	1710	1.8		1616	0.9		1747	1.6		1741	0.1		1820	1.5		1255	6.4
	2330	5.2		2222	5.8					2347	6.2					1902	0.6
4	0533	1.6	19	0448	0.5	4	0003	4.9	19	0605	-0.3	4	0017	5.2	19	0109	6.1
TH	1159	4.8	F	1050	5.4	SU	0558	1.3	M	1222	6.1	W	0630	1.1	TH	0721	0.3
	1744	1.9		1707	0.6		1232	4.7		1832	0.1		1245	5.3		1346	6.3
				2313	6.0		1816	1.5					1854	1.5		1954	0.9
5	0004	5.1	20	0535	0.2	5	0027	5.0	20	0037	6.2	5	0046	5.2	20	0201	5.8
F	0601	1.6	SA	1144	5.7	M	0627	1.2	TU	0653	-0.3	TH	0704	1.1	F	0811	0.7
	1232	4.8		1758	0.4		1255	4.9		1314	6.1		1316	5.3		1441	5.9
	1814	1.9					1848	1.5		1924	0.2		1931	1.5		2048	1.2

Notes: Time Meridian 30° E. 0000 is Midnight. 1200 is Noon.
Heights are reckoned from the datum of soundings on the largest scale charts of the locality.

APPENDIX I (Continued)

July						August						September					
Day	Time (H.M.)	Ht. (ft.)	Day	Time (H.M.)	Ht. (ft.)	Day	Time (H.M.)	Ht. (ft.)	Day	Time (H.M.)	Ht. (ft.)	Day	Time (H.M.)	Ht. (ft.)	Day	Time (H.M.)	Ht. (ft.)
6	0034	5.1	21	0004	6.1	6	0052	5.0	21	0129	6.0	6	0118	5.2	21	0258	5.3
SA	0629	1.6	SU	0625	0.0	TU	0700	1.1	W	0744	-0.1	F	0741	1.2	SA	0905	1.1
	1302	4.8		1238	5.9		1321	5.0		1408	6.0		1351	5.3		1540	5.6
	1846	1.8		1351	0.3		1925	1.5		2017	0.5		2012	1.6		2148	1.6
7	0102	5.0	22	0056	6.2	7	0121	5.0	22	0224	5.7	7	0156	5.0	22	0403	4.9
SU	0659	1.5	M	0716	-0.1	W	0736	1.1	TH	0837	0.2	SA	0821	1.3	SU	1006	1.6
	1331	4.9		1332	6.0		1351	5.0		1506	5.8		1434	5.2		1647	5.2
	1920	1.8		1945	0.3		2004	1.5		2115	0.8		2058	1.8		2256	1.9
8	0131	5.0	23	0150	6.0	8	0155	5.0	23	0323	5.3	8	0241	4.8	23	0518	4.5
M	0733	1.4	TU	0808	0.0	TH	0814	1.1	F	0934	0.6	SU	0909	1.5	M	1120	2.0
	1401	4.9		1429	5.9		1428	5.0		1609	5.4		1526	5.0		1757	4.9
	1959	1.8		2041	0.5		2046	1.6		2219	1.1		2153	1.9			
9	0203	5.0	24	0247	5.8	9	0233	4.8	24	0429	4.9	9	0336	4.5	24	0015	2.1
TU	0810	1.4	W	0902	0.2	F	0856	1.3	SA	1039	1.1	M	1005	1.6	TU	0638	4.4
	1435	5.0		1529	5.8		1511	4.9		1717	5.2		1630	4.9		1240	2.1
	2041	1.8		2141	0.7		2134	1.7		2332	1.5		2302	1.9		1906	4.8
10	0239	4.9	25	0347	5.4	10	0318	4.6	25	0545	4.5	10	0448	4.3	25	0131	2.1
W	0852	1.4	TH	1001	0.5	SA	0942	1.4	SU	1155	1.4	TU	1120	1.7	W	0750	4.4
	1514	4.9		1633	5.5		1602	4.8		1829	4.9		1744	4.8		1350	2.2
	2127	1.8		2247	1.0		2229	1.8								2007	4.9

APPENDIX I (Continued)

July						August						September					
Day	Time (H.M.)	Ht. (ft.)	Day	Time (H.M.)	Ht. (ft.)	Day	Time (H.M.)	Ht. (ft.)	Day	Time (H.M.)	Ht. (ft.)	Day	Time (H.M.)	Ht. (ft.)	Day	Time (H.M.)	Ht. (ft.)
11	0321	4.3	26	0453	5.1	11	0411	4.4	26	0053	1.6	11	0020	1.8	26	0229	2.0
TH	0937	1.6	F	1108	0.9	SU	1038	1.5	M	0704	4.3	W	0612	4.3	TH	0848	4.6
	1559	4.9		1741	5.3		1703	4.7		1314	1.6		1243	1.6		1441	2.1
	2218	1.9		2359	1.2		2334	1.9		1938	4.8		1857	5.0		2066	4.9
12	0408	4.6	27	0605	4.7	12	0517	4.2	27	0208	1.6	12	0132	1.5	27	0307	1.9
F	1026	1.6	SA	1221	1.1	M	1146	1.6	TU	0817	4.3	TH	0731	4.6	F	0932	4.8
	1650	4.8		1351	5.2		1811	4.7		1423	1.6		1355	1.3		1519	2.0
	2315	2.0								2040	4.8		2002	5.3		2136	5.1
13	0501	4.5	28	0116	1.3	13	0046	1.7	28	0307	1.5	13	0232	1.0	28	0338	1.8
SA	1124	1.7	SU	0720	4.5	TU	0631	4.2	W	0918	4.4	F	0837	5.0	SA	1008	5.0
	1748	4.8		1336	1.3		1302	1.5		1516	1.6		1455	1.0		1550	1.9
				1958	5.1		1918	4.9		2130	4.8		2059	5.6		2207	5.2
14	0018	2.0	29	0225	1.4	14	0153	1.4	29	0347	1.5	14	0324	0.6	29	0403	1.7
SU	0601	4.4	M	0831	4.5	W	0743	4.4	TH	1005	4.5	SA	0934	5.4	SU	1037	5.2
	1226	1.8		1442	1.4		1410	1.2		1555	1.6		1547	0.7		1619	1.8
	1847	4.9		2100	5.0		2018	5.1		2210	4.9		2150	6.0		2234	5.3
15	0120	1.8	30	0324	1.3	15	0251	1.0	30	0415	1.4	15	0413	0.3	30	0430	1.6
M	0703	4.5	TU	0934	4.5	TH	0848	4.7	F	1042	4.6	SU	1026	5.9	M	1102	5.3
	1330	1.6		1537	1.5		1508	0.9		1625	1.6		1637	0.4		1650	1.8
	1944	5.0		2152	5.0		2114	5.4		2242	4.9		2241	6.3		2257	5.5
			31	0410	1.3				31	0439	1.4						
			W	1025	4.5				SA	1112	4.7						
				1619	1.5					1650	1.6						
				2234	4.9					2308	5.0						

APPENDIX J

DETAILED DESCRIPTION OF CUT NUMBER 2 ON ISMAILIA

APPENDIX J

DETAILED DESCRIPTION OF CUT NUMBER 2 ON ISMAILIA

The body of the report has dealt with both the explosive techniques used and the problems encountered in the removal of ISMAILIA and MECCA, the two wrecks that were explosively cut. This appendix details the explosive-cutting operations on a representative cut, cut number 2 on ISMAILIA. This cut was made just forward of bulkhead 66, the forward bulkhead of the boiler room which separated that space from the number 2 cargo hold. Work on the cut began 21 June and was completed 4 days later on 25 June 1974.

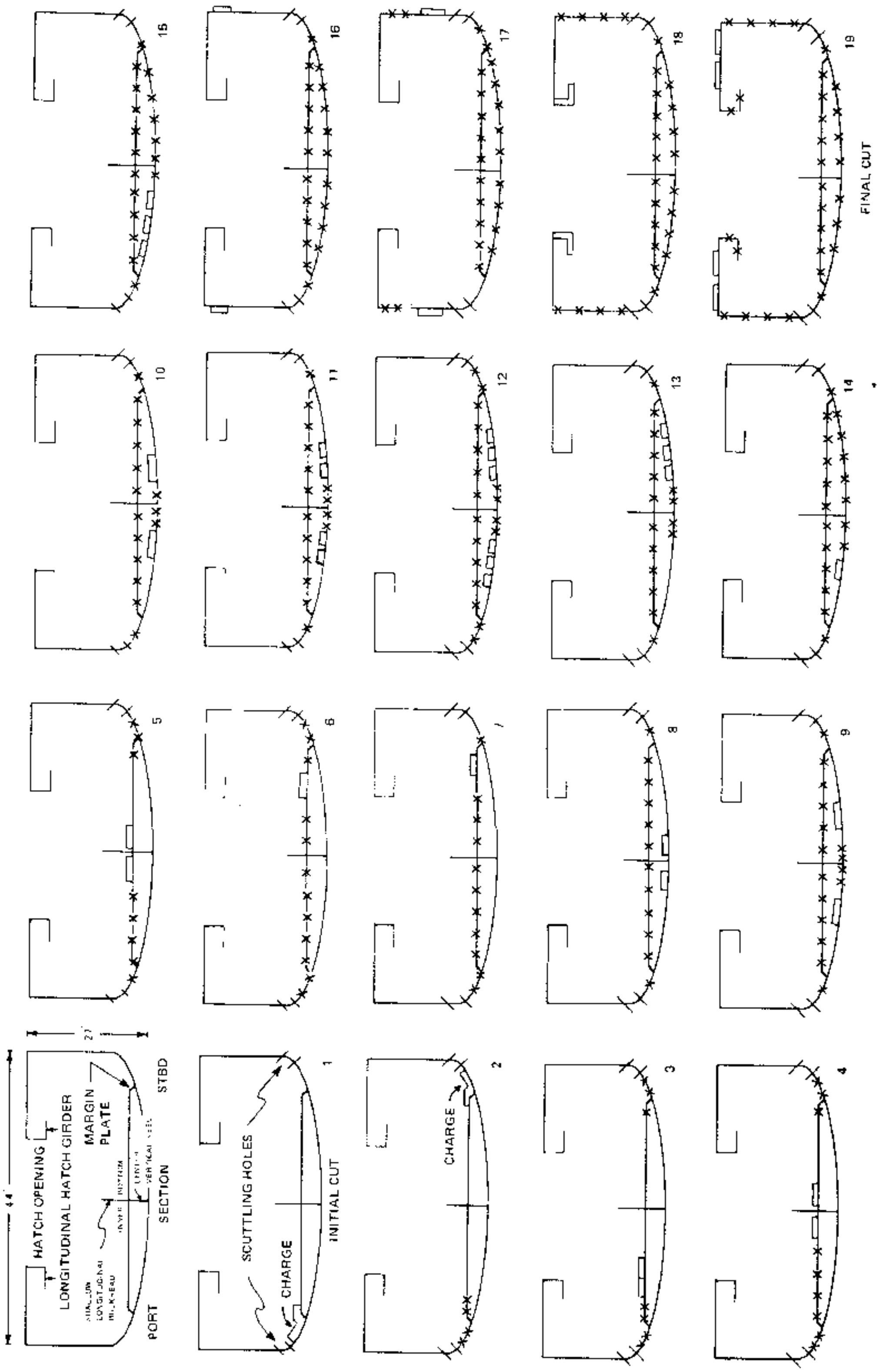
This appendix describes each explosive cut (shot) in a series of 19 shots, illustrated in Figure J-1, made using C-4 explosive. The original plans that called for cutting just abaft bulkhead 66 in the boiler room were abandoned early when the boiler room was found to be filled with debris. The cut was made between frames forward of bulkhead 66 through the cargo hold. There were two scuttling holes in way of the cut.

ISMAILIA was German built and classed by Germanischer Lloyd, the German ship construction classification society. While no detailed plans were available, scantlings were approximated from contemporary classification society rules. The amount of explosives required was determined from the scantlings.

The first cuts were made on the inner bottom to allow later cutting of the bottom from inside. The first shot was laid along the port side to cut the side, margin plate, and tank top. One 8-foot hose charge was used. The hose was 2-1/2-inch fire hose split and packed with C-4 explosive at 3 pounds per foot. The charge successfully blew the tank top margin plate and shell. The second charge was an identical shot placed on the starboard side. It cut the shell and margin plate but failed to cut the tank top.

The next shot was made along the tank top on the port side with an 8-foot angle-shaped charge. The charge was C-4 packed in 1- to 1-1/2-inch angle at 2 pounds per foot. The shot successfully blew an athwartships cut 1 foot wide. The cut was continued by hose charges placed along the tank tops from the termination of the previous cut,

FIGURE J-1
Cut Number 2 on ISMAILIA



through the centerline longitudinal bulkhead to 3 feet to port, and by other similar increments that cut the tank to the starboard margin plate.

With the inner bottom cut, cutting on the hull proper began. Cutting began along the bottom with two 4-foot hose charges packed at 2-1/2 pounds of C-4 explosive per foot placed alongside the center vertical keel. These charges cut the hull. The cut was continued with two identical charges placed outboard of the cut. The operations detailed above constituted the cutting operations on the first day.

When operations were resumed on 22 June, cutting was continued with hose charges, one placed 1 foot from the center vertical keel on the port side, the other 2 feet from the center vertical keel on the starboard side. Both charges were placed atop a floor that had been flattened when the tank tops were cut. Inspection of the cut showed that 4 feet of the starboard bottom and none of the port had been cut.

Operations on this cut were delayed while a diver was treated for suspected decompression sickness. When operations resumed on 24 June, a shot of two 4-foot hose charges was placed on the starboard side. This charge failed to cut the bottom and was the first of a series of unsuccessful attempts. The first attempt was followed by three 4-foot hose charges placed on the bottom to starboard of the center vertical keel. This charge failed to cut. In the following identical charge, one 4-foot hose charge fired properly, but the other two misfired. Another attempt at cutting the bottom occurred when four 4-foot hose charges were placed from the center vertical keel to the starboard scuttling hole. This shot fired well and severed the plate except for a few small areas that were burned.

On the following day, 25 June, the bottom port side was cut by two individual shots. The first, one 4-foot hose charge, cut outboard to port from the center vertical keel. The second, two 4-foot and one 5-foot hose charges, was laid along the tank top from the existing cut to the scuttling hole. When this hose successfully cut the bottom, a major section of the hull girder, the bottom and tank top with its associated structure had been cut. Attention was then devoted to cutting the deck and shell which, in a transversely framed ship such as ISMAILIA, was a simple structure.

To begin shell cutting, two 8-foot hose charges were laid alongside the sheer strake from the deck edge downward. Each charge cut about 10 feet of shell plating. The cuts were continued with similar charges along each side. The starboard side charge cut completely, and the port charge cut all but 6 feet of shell near the bottom. The next shot used a 6-foot hose charge to pick up the uncut section along the port side and two 3-foot hose charges on the longitudinal angle section hatch guides. The three charges cut successfully. The final shot on this cut was across the main deck. The main deck, the last remaining portion of the hull girder, was cut in one shot. This shot was comprised of five 3-foot hose charges and two 3-foot hose charges.

The following significant points should be emphasized:

- Hose charges were placed hard against the skin of the ship slightly offset from the frames. When this was not done, the force of the charge was dissipated and the charge did not cut as planned.

- Hose or angle charges rather than shaped charges were used in all cases. Hose charges lack the finesse and efficiency of shaped charges but have the advantage of being simpler to use by personnel not specifically trained in explosive technology. Because shaped charges lose efficiency when the cavity is even partially flooded and when they are not precisely placed, their use was ill suited to these salvage operations where a source of carefully fabricated shaped charges was not available.

- It was found advantageous to begin the cutting with the most complex portion of the structure and continue slowly to areas of less complex structure.

Cut number 2 on ISMAILIA was typical of explosive cuts made on ISMAILIA and MECCA in the earlier stages of the cutting operation.

APPENDIX K

EXPLOSIVE CUTTING

APPENDIX K

EXPLOSIVE CUTTING

1. INTRODUCTION

Explosive cutting was used extensively during the Suez clearance to reduce wrecks to pieces that could be removed by the available lifting equipment. This appendix discusses techniques developed and factors that influenced explosive cutting of both steel hulls and the Concrete Caisson. The experience gained in the Suez, while not making significant improvement to existing technology, provided affirmation of basic principles and was an excellent example of practical field work. The steel hulls of MECCA and ISMAILIA sectioned in the Northern Zone and the Concrete Caisson in the Central Zone will be considered separately.

2. CUTTING OF STEEL HULLS

Explosive cutting of the hulls of MECCA and ISMAILIA was carried out by divers working in limited visibility. The objective was to obtain continuous separation of the plate under explosive attack and to prevent distortion of adjacent plating which would hinder diver re-entry or contribute to diver disorientation upon return to the site.

Brief discussions now follow on the following aspects of cutting steel hulls:

- Limited visibility
- Continuous separation
- Adjacent structure distortion
- Charge fabrication
- Use of linear-lined cavity-shaped charges
- Charge immersion.

(1) Limited Visibility

Conditions of limited visibility tend to be the rule on clearance operations that usually take place in the relatively murky waters of harbors, rivers, canals, and the like. Effective charge emplacement requires that the charge be designed so that the diver can successfully place it working totally by feel without visual confirmation of his work. Accordingly, a simple technique was developed of scoring the plate to be cut with oxyarc and then placing hose charges along the score.

(2) Continuous Separation

The amount of explosive needed to achieve continuous separation can be determined by onsite testing or by reference to Table 10 of OP 2081, "Use of Explosives in Underwater Salvage." The data from OP 2081 refer to the explosive equivalent of blasting gelatin. In terms of relative strength, the strength of TNT is set at 100, blasting gelatin at 90, and C-4 at 130. In using data from Table 10, OP 2081, repeated here in Table K-1, the amount of explosive required can be reduced by a factor of 0.69, which is the factor for converting blasting gelatin to C-4. Table K-1 includes equivalent values for C-4, and Figure K-1 illustrates the amount of C-4 explosive required to cut mild steel plate.

Table K-1
Explosive Charge Requirements for Cutting Plate

Plate Thickness (in.)	Charge Blasting Gelatin	Size (lbs/ft) C-4
.25	1.5	1.04
.50	2.0	1.38
.75	2.5	1.73
1.00	3.5	2.42
1.25	4.5	3.11
1.50	6.0	4.14
1.75	7.5	5.18
2.00	10.0	6.90

When the exact scantlings of the wreck are unknown, they can be estimated from general knowledge of ship construction and trial shots made using the values from OP-2081. The amount can then be modified to suit the particular situation. The use of a light overcharge proved desirable to provide a sufficient safety factor to ensure cutting, to allow for the heavy tape wrap on the hose charge, and to ensure separation at points of plate overlap. In deck cutting, overcharge was particularly desirable to enhance cutting through undetermined quantities of concrete and deck covering.

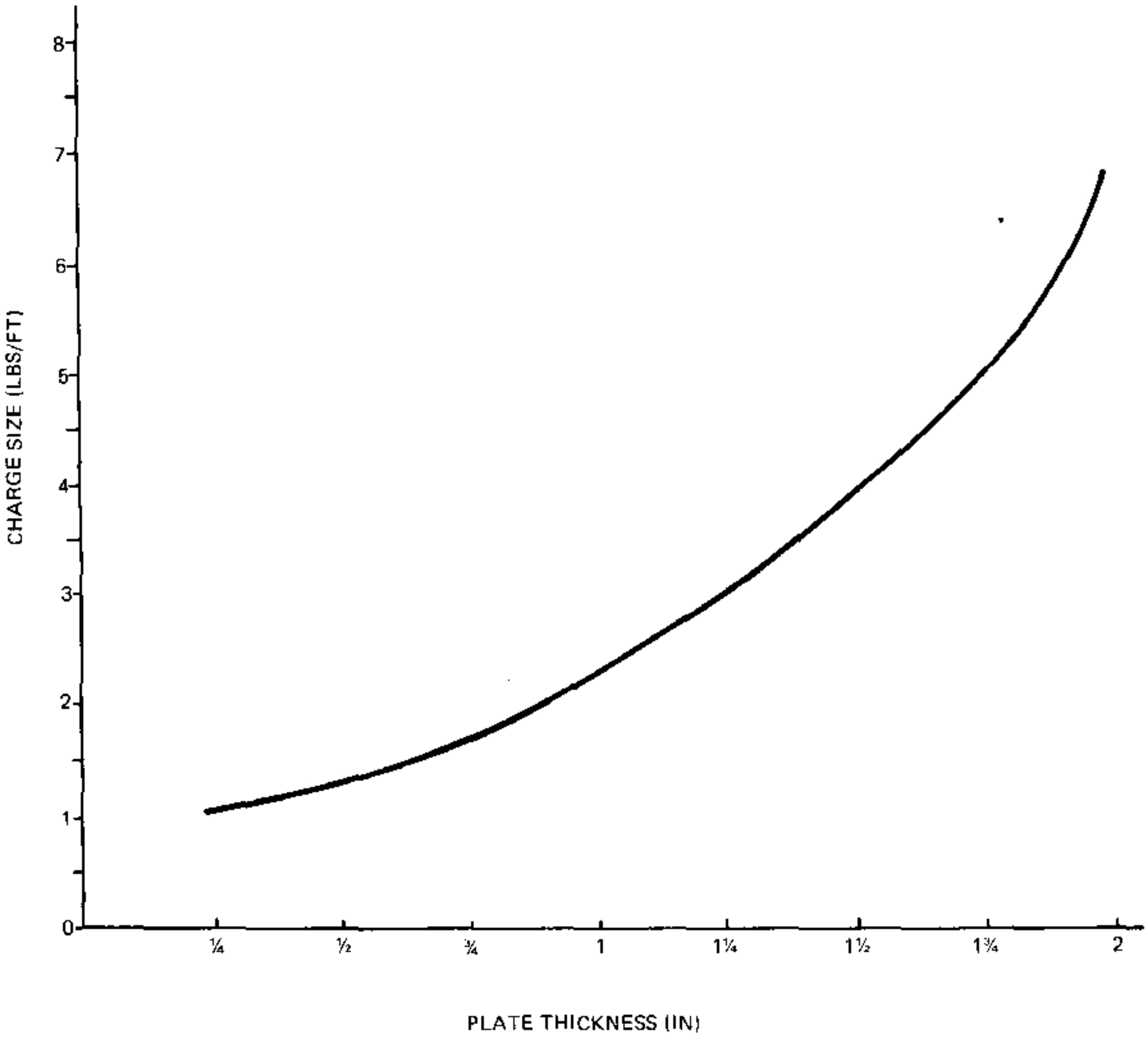


FIGURE K-1
C-4 Explosive Required to Cut Mild Steel Plate
(Hose Charges)

The ability of plate to be cut is dependent upon both the geometry of the plate and the physical properties of the steel. For a low-carbon, soft, ductile steel, typically used in ship construction, attempts at cutting unsupported spans may result in plastic deformation without tearing. This was especially true when trying to cut from the inside of a riveted structure where the rivets often pulled out effectively increasing the width of the unsupported span. If the plate is rigidly supported or backed, the charges will cut the plate more effectively. In cutting MECCA and ISMAILIA, cutlines were laid out close to frames to take advantage of the stiffening offered by the frame. In all cases it was found that if the charge was to effectively cut steel plate, an intimate contact between the hull and charges was required.

(3) Adjacent Structure Distortion

The amount of explosive that can be detonated during each shot without causing excessive damage to contiguous and secondary structure is best determined onsite for each particular condition. A major consideration is that larger charges can be used for external rather than internal shots, since venting problems are minimized for external shots.

(4) Charge Fabrication

Charges that are to be fabricated under field conditions must be simply constructed and easily fabricated. The basic charge used in the Suez clearance was a hose charge that was composed of C-4 explosive at about 3 pounds per foot, packed in 2-1/2 inch fire hose that had been split open. The charge, which had an elliptical section, was initiated from the mid-length of the outer surface. When using such charges on lapped plate construction, care was taken to ensure that the point of initiation was at least 1 foot clear of plate laps so that the full force of the charge was developed at the point of greater strength. It was appreciated that the charge design could have been improved by a double initiation scheme using two detonating cord leads to give a meeting wave reinforcement. However, this idea would have caused sufficient additional complication during fabrication to negate its potential advantages. Instead, a slightly heavier charge was used when additional cutting force was needed.

(5) Use of Linear-Lined Cavity-Shaped Charges

The use of linear-lined cavity-shaped charges for cutting both decks and hull appeared attractive as an efficient and effective cutting method. Shaped charges have some disadvantages in field fabrication and employment which affect their suitability for use in the type of effort undertaken in the Suez Canal. The shaped charge is a precision device whose successful employment is highly dependent upon liner construction and symmetry. Field fabrication is seldom successful unless excessive quantity of explosive is used. In underwater employment, the standoff volume must be gas- or air-filled and must be in intimate contact with the material being cut. These conditions were extremely difficult to obtain in the conditions found in the Suez. Neither accurate and consistent charge placement nor complete cavity evacuation could be guaranteed.

It was found that for hull cutting under suitable conditions a series of linear-lined cavity-shaped charges was suitable for use on flat or convex surfaces but did not work well on sharply convex or concave surfaces. Consideration was given to using shaped charges to cut through double hull sections, such as the shell and double bottom. Experience showed that shaped charge jets were not reliable for cutting plates separated by water, even when sophisticated liners and large charges are used. Because of the difficulties associated with their field fabrication, underwater placement, and employment, linear-lined cavity-shaped charges were not used in cutting the hulls of MECCA and ISMAILIA.

(6) Charge Immersion

The duration of immersion of the charge between placement and detonation can affect the overall efficiency of the operation. Water-soaked detonating cord is much more difficult to detonate than is dry cord. A strong potential for misfire exists if detonating cord charge leads are not sealed on the cut ends. If it was necessary to allow as much as 8 to 12 hours between charge placement and detonation, extra care was taken in sealing cut ends and a booster charge was used as charge to trunkline connections. In general, delay between placement and detonation was minimized.

3. CUTTING OF THE REINFORCED CONCRETE CAISSON

Explosive sectioning of the Concrete Caisson was facilitated by Egyptian concrete construction practices. For example:

- Use of a round pebble aggregate that shatters when subjected to shock
- Small, inadequately rodded, porous placements highly subject to cold joint formation
- Heavy rebar with cover insufficient to utilize the strength of the bars.

Demolition or sectioning of the Concrete Caisson called for shattering the concrete by shocking, then cutting the rebar with torches. Techniques for accomplishing the sectioning were somewhat similar to those employed for the steel hulls of MECCA and ISMAILIA. Since the concrete degraded rapidly under repeated shock loading, care had to be taken to limit structural degradation so that the lift of the sectioned structure was possible.

Conventional concrete demolition techniques and the formulas that appear in OP 2081 were the only guidance available. Empirically based breaching formulas for both satchel-type charges and hose charges gave explosive weights that seemed excessive. For example,

For satchel-type or hose charges, $P = 20\ TC$
where

P = weight of explosive in pounds per foot
T = thickness in feet, 14 inches
C = location factor, 2.0 for underwater shot of this type

Thus,

$$P = 20\,\frac{14}{12}\,(2.0) \text{ or } P = 46.7 \text{ pounds per foot}$$

Similar cratering charge formulas seem too light for underwater work with 14-inch concrete. For example,

$$P = R^3 KC$$

where

P = weight of explosive in pounds
R = breaching radius (distance in feet from charge site from which all concrete is removed) taken as 2 feet
K = material factor, taken as 0.7
C = location factor, taken as 2.0

gives

$$P = (2)^3 (0.7) (2) \text{ or } P = 11.2 \text{ pounds}$$

In the absence of more definitive guidance, trial-and-error methods were used to obtain the sizes and types of charges employed on the Concrete Caisson.

Linear-lined, cavity-shaped charges were employed extensively. Four-foot long hose charges packed at 3 pounds of C-4 per foot were used to cut heavy sections. Shaped charges as light as 1 pound of C-4 per foot, and hose charges approximately the same as those used on MECCA, were used for removal of lighter top structure. The use of shaped charges was more useful on the concrete than on steel under adverse field conditions because shock effect is equally as important as direct cutting. While the shaped charge remains a precision tool, the jet formation is not as critical for cutting concrete as for steel. Since jet formation is a function of exact construction and symmetry, less care need be taken so that the charges are more suited to field fabrication.

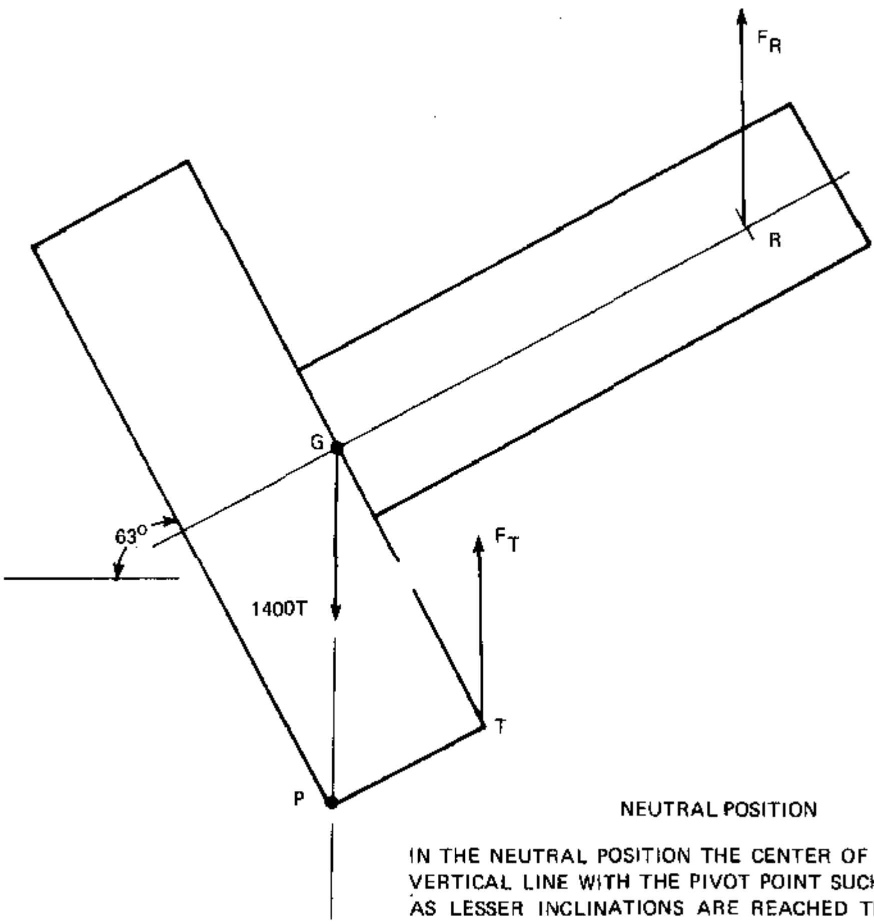
APPENDIX L

RIGHTING OF DREDGE 23

APPENDIX L

RIGHTING OF DREDGE 23

The salvage of DREDGE 23 reported in Chapter VI involved righting the wreck from its original attitude. It was lying on its starboard side with a list of about 130 degrees. The heavy-lift cranes ROLAND and THOR were to be used to right DREDGE 23. Lift would be applied from the original attitude to an angle of approximately 63 degrees where a neutral position, shown in Figure L-1, would be reached. After the neutral position was passed, the wreck would right itself. This appendix details calculations made in preparation for the final righting.



NEUTRAL POSITION

IN THE NEUTRAL POSITION THE CENTER OF GRAVITY IS IN VERTICAL LINE WITH THE PIVOT POINT SUCH THAT dw = 0. AS LESSER INCLINATIONS ARE REACHED THE CENTER OF GRAVITY MOVES TO THE LEFT TO PRODUCE A RIGHTING MOMENT.

FIGURE L-1
Neutral Position

Calculations are made at five different positions between the original position and the neutral position. A weight (W) of 1400 tons is assumed at all times. ROLAND and THOR were positioned and rigged as shown in Chapter VI. ROLAND's righting force was applied as a vertical lift on the gantry at a point 30 feet above the main deck. THOR's force is taken as acting vertically at the port deck edge until the wreck reaches a 90-degree list. At lesser inclinations, THOR's force acts vertically at the starboard deck edge.

The following symbols will be used throughout, and are illustrated in Figure L-2.

θ = angle of inclination

F_T = THOR force

F_R = ROLAND force

W = weight of wreck

d_T = moment arm for THOR force

d_R = moment arm for ROLAND force

d_w = moment arm for weight

P = pivot point

G = center of gravity

T = point through which THOR force acts

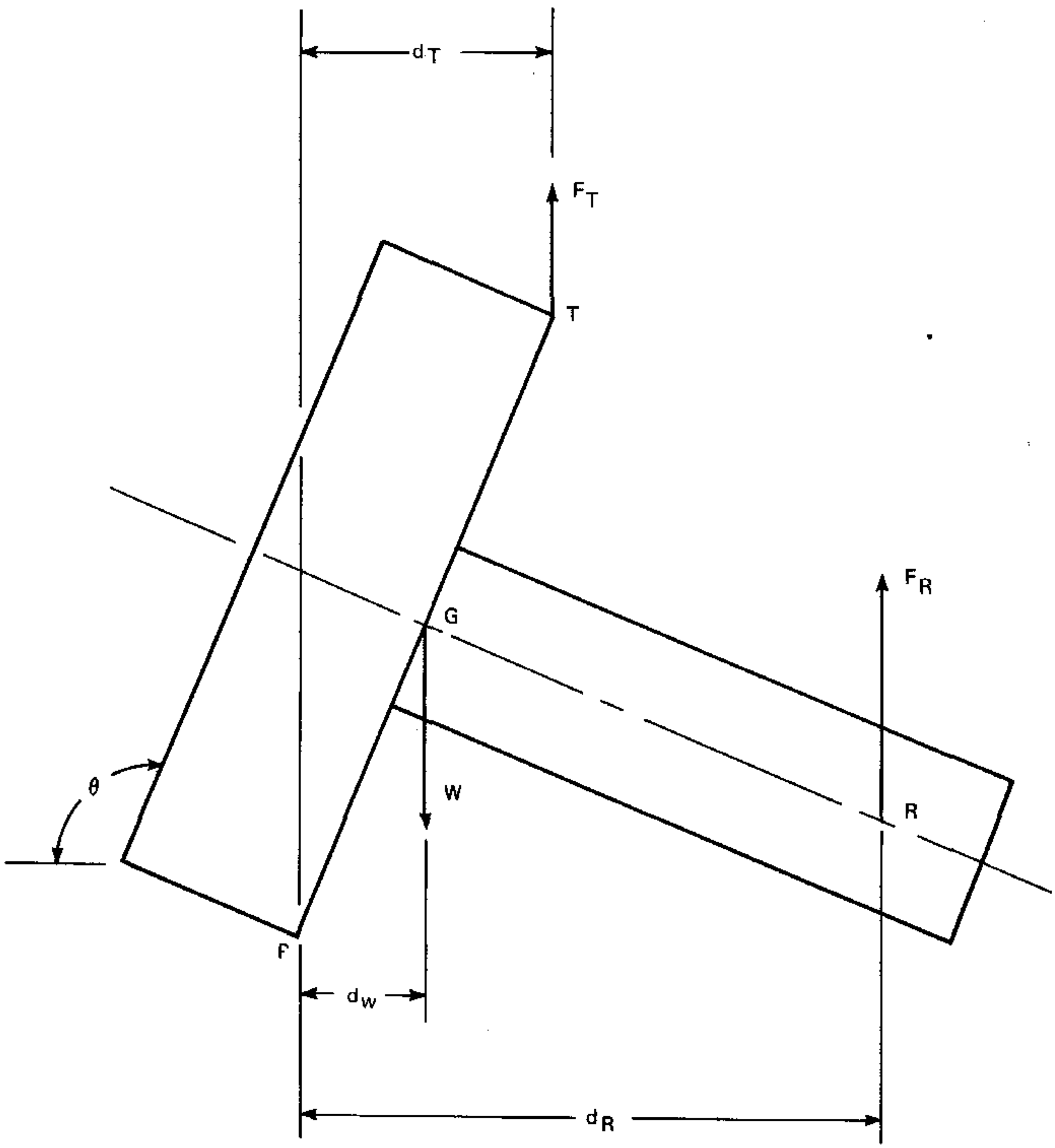
R = point through which ROLAND force acts

The forces required can be calculated by summing moments about the pivot point, P.

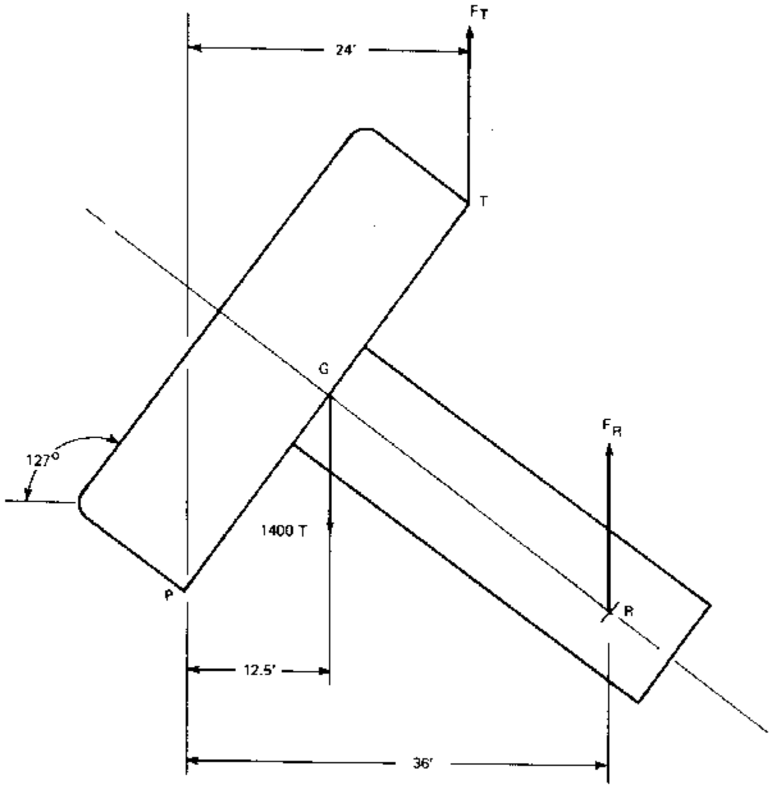
$$F_R d_R + F_T d_T = Wdw \quad (1)$$

By successively assuming F_R and F_T are not acting, the force requirement in each position for one crane acting alone can be determined. Then by allowing F_T to take values from 100 to 500 tons in 100-ton increments, corresponding values of F_R can be determined.

FIGURE L-2
Definition of Symbols



POSITION 1



For Position 1,

θ = 127 degrees

W = 1400 tons

d_T = 24 feet

d_R = 36 feet

d_w = 12.5 feet

From Equation (1),

$$F_R d_R + F_T d_T = W dw$$

If $F_R = 0$, then

$$F_T = \frac{1400 \times 12.5}{24}$$

or

$$F_T = 729.2 \text{ tons}$$

729.2 tons is in excess of THOR's lift capacity.

If $F_T = 0$, then

$$F_R = \frac{1400 \times 12.5}{36}$$

or

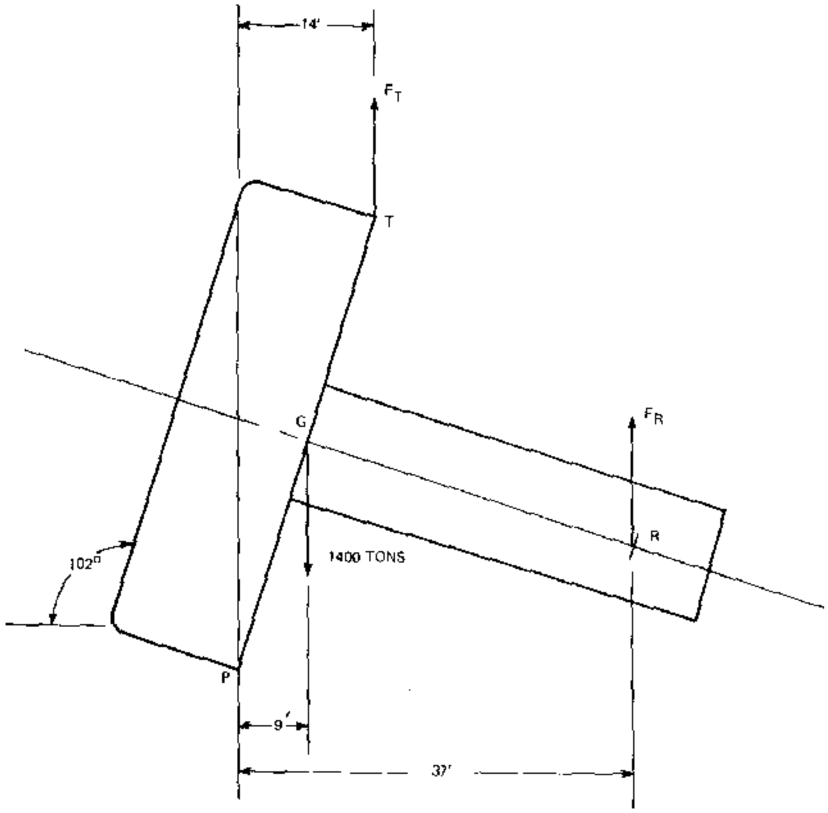
$$F_R = 486 \text{ tons}$$

486 tons is within ROLAND's lift capacity.

Using Equation (1), the following further results can be obtained:

F_T	F_R	Total
0	486	486
100	419	519
200	353	553
300	286	586
400	219	619
500	152	652
729	0	729

POSITION 2



For Position 2,

$$\theta = 102 \text{ degrees}$$

$$W = 1400 \text{ tons}$$

$$d_T = 14 \text{ feet}$$

$$d_R = 37 \text{ feet}$$

$$d_w = 9 \text{ feet}$$

From Equation (1), if $F_R = 0$, then

$$F_T = \frac{1400(9)}{14}$$

or

$$F_T = 900 \text{ tons}$$

900 tons is in excess of THOR's lift capacity.

If $F_T = 0$, then

$$F_R = \frac{1400(9)}{37}$$

or

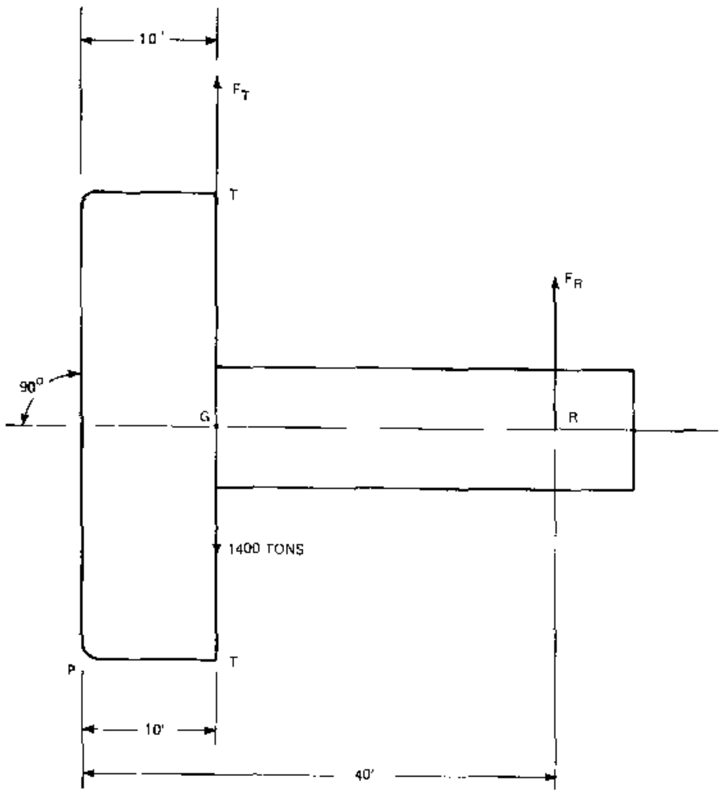
$$F_R = 340.5 \text{ tons}$$

340. 5 tons is within ROLAND's lift capacity.

Using Equation (1), the following further results can be obtained:

F_T	F_R	Total
0	341	341
100	303	403
200	265	465
300	227	527
400	189	589
500	151	651
900	0	900

POSITION 3



For Position 3,

θ = 90 degrees

W = 1400 tons

d_T = 10 feet

d_R = 40 feet

d_w = 10 feet

From Equation (1), if $F_R = 0$, then

$$F_T = \frac{1400(10)}{10}$$

or

$$F_T = 1400 \text{ tons}$$

1400 tons is far in excess of THOR's lift capacity.

While this value calculates as exactly equal to the weight of the dredge, THOR exerts no moment since the line of action of its force is through the center of gravity.

If $F_T = 0$, then

$$F_R = \frac{1400(10)}{40}$$

or

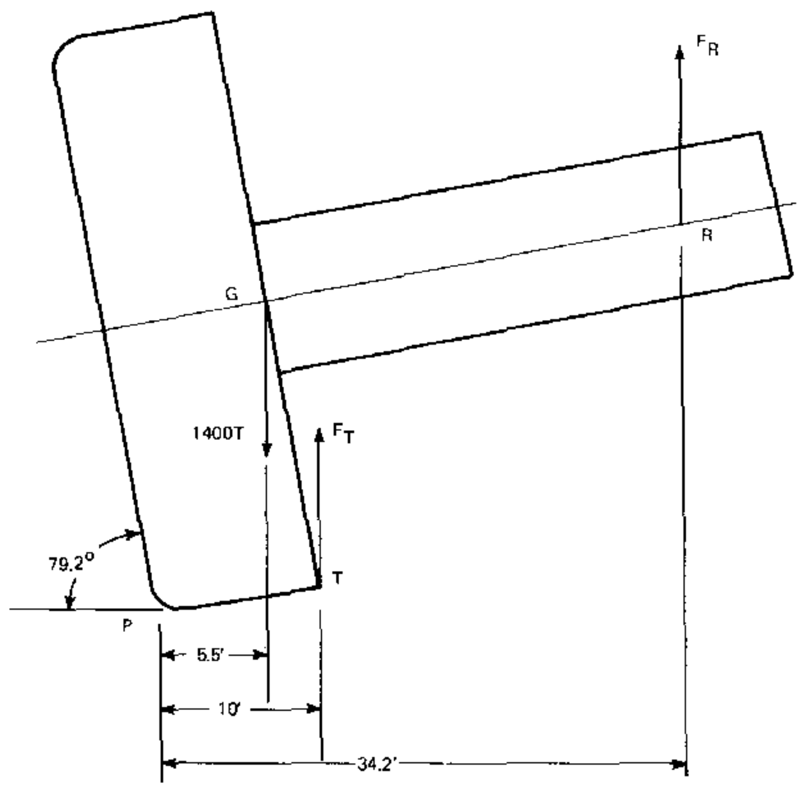
$$F_R = 350 \text{ tons}$$

350 tons is within ROLAND's lift capacity.

Using Equation (1), the following further results can be obtained:

F_T	F_R	Total
0	350	350
100	325	425
200	300	500
300	275	575
400	250	650
500	225	725
1400	0	1400

POSITION 4



For Position 4,

θ = 79.2 degrees

W = 1400 tons

d_T = 10 feet

d_R = 34.2 feet

d_w = 5.5 feet

From Equation (1), if $F_R = 0$, then

$$F_T = \frac{1400(5.5)}{10}$$

or

$$F_T = 770 \text{ tons}$$

770 tons is in excess of THOR's lift capacity.

If $F_T = 0$, then

$$F_R = \frac{1400(5.5)}{34.2}$$

or

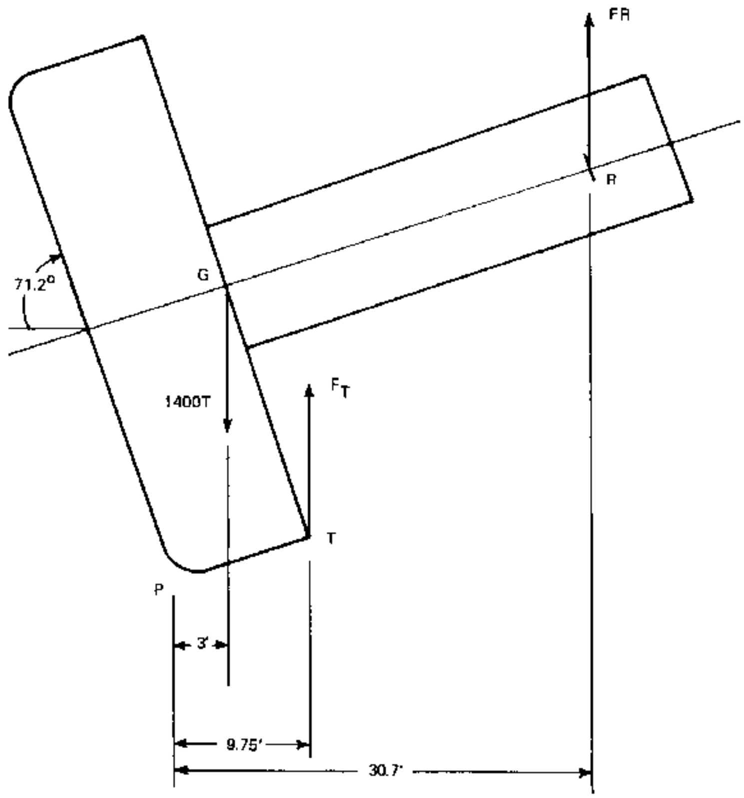
$$F_R = 225 \text{ tons}$$

225 tons is within ROLAND's lift capacity.

Using Equation (1), the following further results can be obtained:

F_T	F_R	Total
0	225	225
100	196	296
200	167	367
300	137	437
400	108	508
500	79	579
770	0	770

POSITION 5



For Position 5,

θ = 71.8 degrees

W = 1400 tons

d_T = 9.75 feet

d_R = 30.7 feet

d_w = 3 feet

From Equation (1), if $F_R = 0$, then

$$F_T = \frac{1400(3)}{9.75}$$

or

$$F_T = 430 \text{ tons}$$

430 tons is within THOR's lift capacity.

If $F_T = 0$, then

$$F_R = \frac{1400(3)}{30.7}$$

or

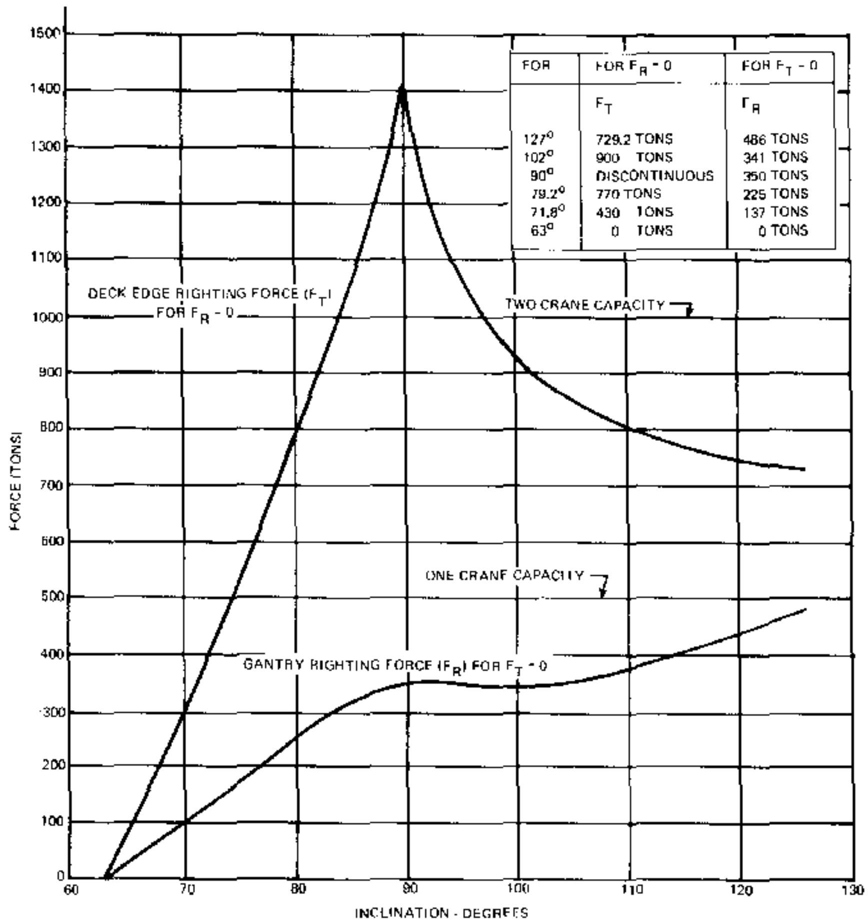
$$F_R = 137 \text{ tons}$$

137 tons is within ROLAND's lift capacity.

Using Equation (1), the following further results can be obtained:

F_T	F_R	Total
0	137.0	137.0
100	105.0	205.0
200	73.0	273.0
300	41.5	341.5
400	9.8	409.8
500	0	430.0

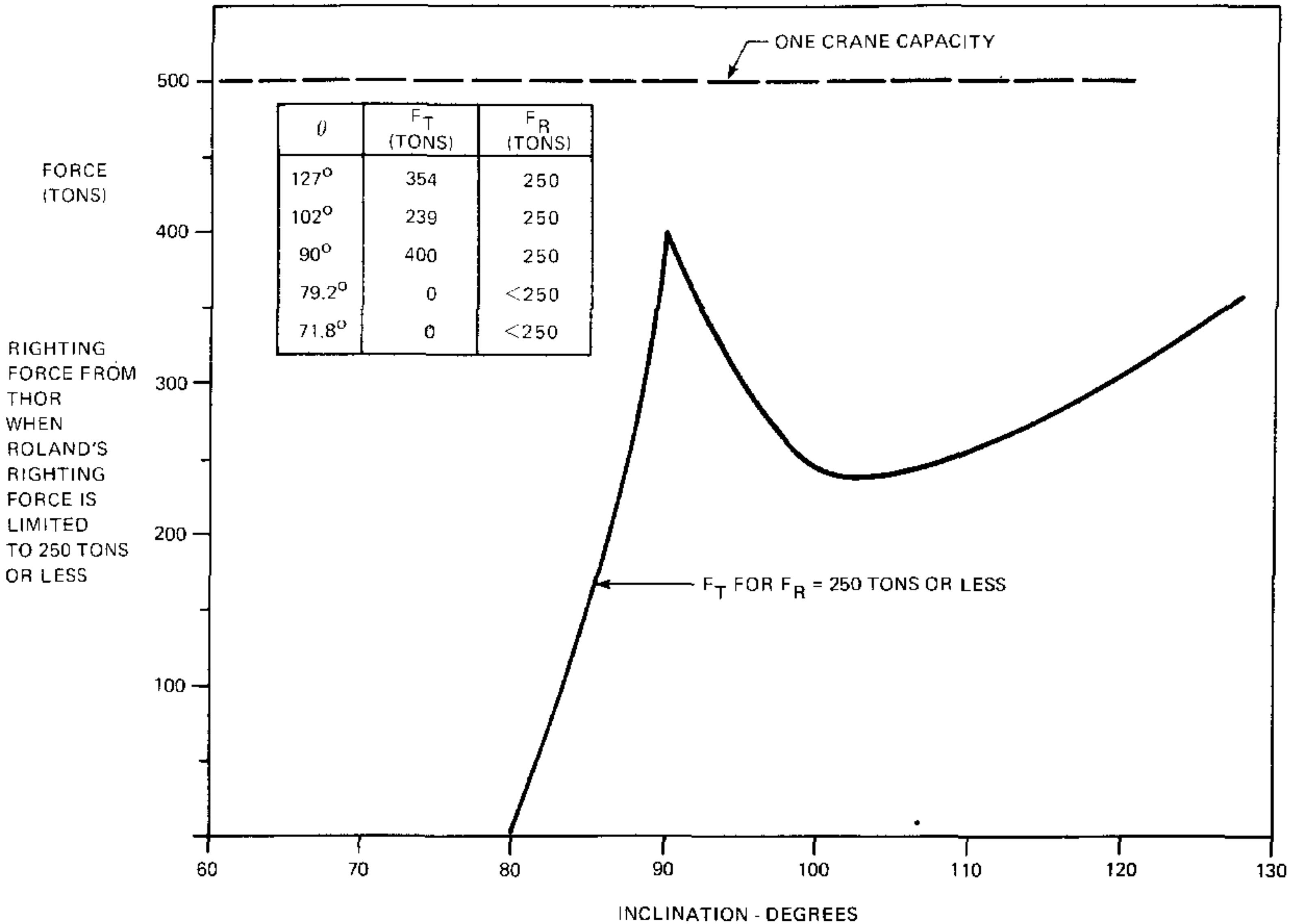
As shown in Figure L-3, the deck edge righting force (F_T) required to achieve angles of inclination of 74 to 127 degrees is in excess of the capacity of one crane and from angles of 84 to 97 degrees is in excess of the capacity of both cranes. Only by moving one crane away from the center of gravity to take advantage of the extra moment arm could the dredge be righted. Righting of the dredge using only ROLAND rigged to the gantry was theoretically possible. However, the use of two cranes provided the margin of safety required to ensure an effective operation, and reduced the possibility that the deteriorated gantry structure would not fail. In fact, it was concern over the possible failure of DREDGE 23's gantry that led to the decision to limit F_R to 250 tons or less. Figure L-4 illustrates what happens to F_T when F_R is held constant at that value. This type of calculation was used in order to develop a reasonable strategy for the use of THOR's righting force.



FOR	FOR F_R - 0	FOR F_T - 0
	F_T	F_R
127°	729.2 TONS	486 TONS
102°	900 TONS	341 TONS
90°	DISCONTINUOUS	350 TONS
79.2°	770 TONS	225 TONS
71.8°	430 TONS	137 TONS
63°	0 TONS	0 TONS

FIGURE L-3
Deck Edge and Gantry Righting Force
(F_T for F_R = 0 and F_R for F_T = 0)

APPENDIX L(15)



θ	F_T (TONS)	F_R (TONS)
127°	354	250
102°	239	250
90°	400	250
79.2°	0	<250
71.8°	0	<250

VARIATION OF F_T FOR F_R = 250 TONS OR LESS

FIGURE L-4
Variation for F_T
for F_R = 250 Tons or Less

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