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S.S. SIDNEY E. SMITH, JR.
SALVAGE OPERATION

Removal of the sunken coal freighter, SIDNEY E. SMITH
from the shipping channel of the St. Clair River

Port Huron, Michigan
June-November, 1972

Department of the Navy
Naval Sea Systems Command
Washington, D.C.

DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND
WASHINGTON, D.C. 20362

FOREWORD

Removal of the sunken freighter SIDNEY E. SMITH, JR., from the shipping channel of the St. Clair River at Port Huron, Michigan, was a remarkable salvage achievement. The SMITH capsized and sank on 5 June 1972 following a collision with another freighter in the treacherous narrows opposite Port Huron. Broken in two sections, the huge 500-foot hulk partially blocked the channel, presenting a grave navigational hazard. Removal of the wreck posed formidable salvage problems. Its vast interior spaces lay open to the river, defying conventional methods of dewatering. A strong river current battered the hulk unceasingly, precluding normal diving operations and rendering any removal effort exceptionally difficult and dangerous.

These obstacles were overcome through the combined efforts of the U.S. Army Corps of Engineers and the Office of the Supervisor of Salvage, U.S. Navy. Working closely together, these agencies mounted a major salvage operation, assembling and directing the salvage force and providing for its sustained logistics support from both Government and civilian contractor sources. These efforts culminated in the safe and successful removal of the wreck sections from the channel, the stern section on 6 August followed by the bow section on 22 September. Further salvage work was done over the next several weeks to refloat the beached sections for towing to a disposal site.

The salvage force used urethane foam to lighten each section of the wreck in mid-channel. This was only the second time that the Navy had applied the "foam-in-salvage" technique under water on a large scale. The technique is highly promising but not fully developed. The salvors learned a great deal from this application that should accelerate its further development. A unique hydraulic pulling system was designed, fabricated and installed on the Port Huron bank of the river to pull the lightened sections from the channel. This aspect of the salvage effort also merits careful study. Other innovations included the use of cofferdams which allowed divers to gain access to the submerged bow section, and the diver access tubes used in foaming the stern section.

The SMITH operation is thus highly significant because so many innovative techniques were devised and applied to overcome the obstacles confronting the salvage force. Equally important was the SMITH salvors' extensive and effective use of standard, familiar techniques. This report provides a wealth of information for the professional salvor. It explains in detail how the salvage force successfully combined proven methods and imaginative innovations to accomplish its task.

R. B. MOSS
Captain, USNR
Supervisor of Salvage, U.S. Navy

12 July 1976

ABSTRACT

This report describes the removal of the sunken freighter SIDNEY E. SMITH, JR., from the channel of the St. Clair River at Port Huron, Michigan, during June-November, 1972. The hulk, broken in two sections, presented an extreme navigational hazard. At the request of the U.S. Army Corps of Engineers, the Supervisor of Salvage, U.S. Navy, undertook the removal effort. A major salvage operation was mounted, involving the coordinated participation of Army, Navy and Coast Guard agencies and several civilian contractors. Each wreck section was removed by first lightening it with urethane foam in mid-channel and then pulling it ashore with a system of hydraulic pullers. The beached sections were then refloated for towing to a disposal site. A strong river current made salvage operations unusually difficult and dangerous. The report highlights the innovative salvage techniques applied to remove the wreck sections from the channel. Information on the circumstances of the sinking, control of shipping traffic, and defueling of the wreck is also provided.

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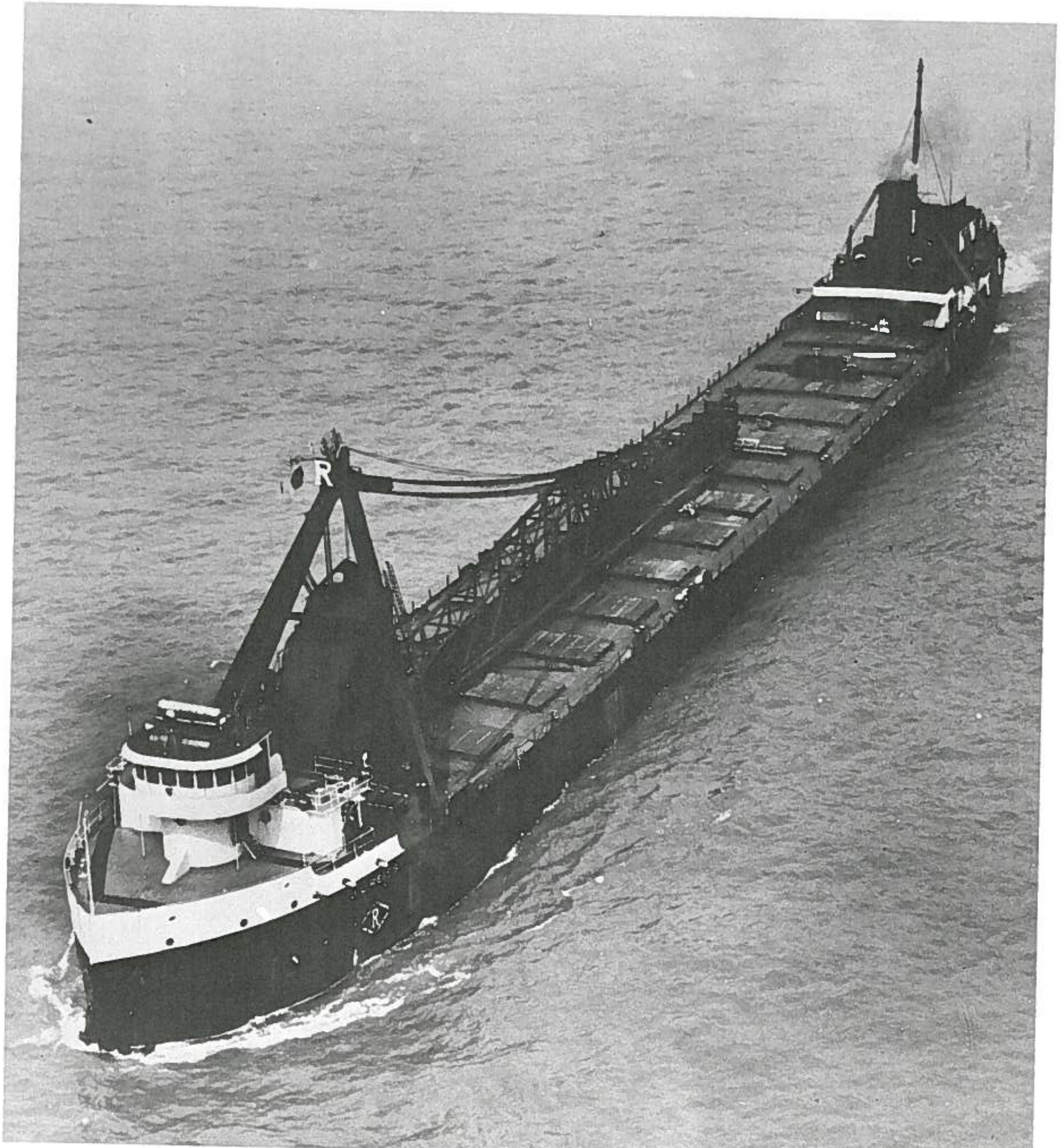


Freighter steamed the Great Lakes waterways for more than six decades before collision and sinking at Port Huron. Ship's former name, J. L. REISS, still shows here on SMITH's hull.

SIDNEY E. SMITH, JR. – VETERAN GREAT LAKES COAL FREIGHTER

CHAPTER 1
INTRODUCTION AND OVERVIEW

PURPOSE AND STRUCTURE OF THE REPORT

Purpose of the Report

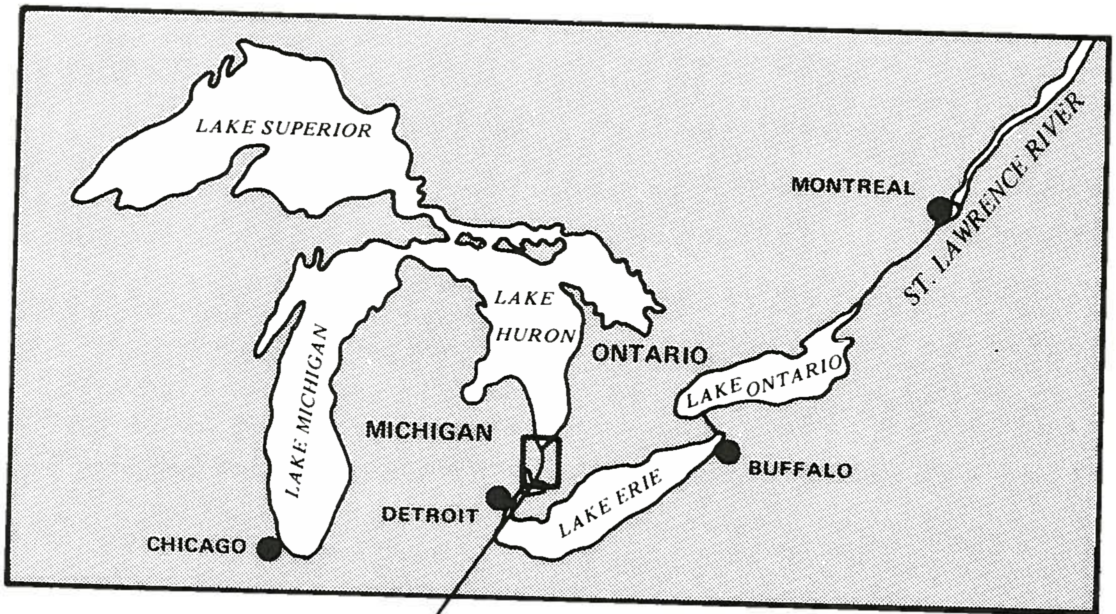
This report provides a detailed account of major salvage operations conducted at Port Huron, Michigan, to remove the sunken Great Lakes coal freighter S.S. SIDNEY E. SMITH, JR., from the channel of the St. Clair River, a vital waterway linking Lake Huron and Lake Erie. The SMITH sank and broke up in two sections on 5 June 1972 following a collision with another freighter, the S.S. PARKER EVANS. The sunken hulk, partially obstructing the narrow channel, disrupted shipping traffic and presented a grave navigational hazard.

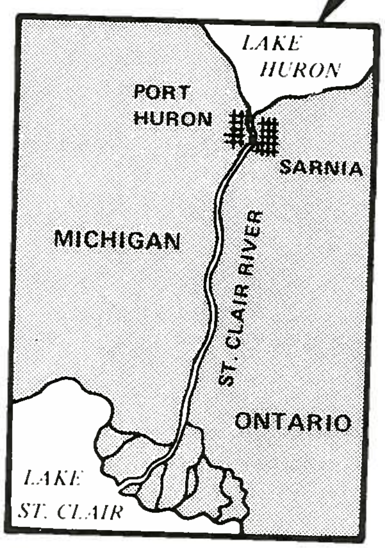
Scope of the Subject Matter

At the request of the U.S. Army Corps of Engineers, the Supervisor of Salvage, U.S. Navy, undertook the difficult and hazardous task of removing the wreck sections from the channel. The report addresses all aspects of the ensuing salvage operation. It describes the techniques used in lightening the two wreck sections in mid-channel, pulling them ashore to clear the channel, and then preparing the beached sections for towing to a remote site for final disposition. Many of these techniques were highly innovative, particularly the use of long, steel cofferdams to provide divers access to the wreck, and the design, fabrication, and installation of a hydraulic system to pull the wreck sections from the channel. The application of the "foam-in-salvage" technique to lighten the wreck sections was also an important feature of the operation.

The report is principally concerned with the main salvage operations to clear the channel and prepare the wreck for towing. These operations covered a period of 5 months beginning on 23 June and concluding on 18 November. The report also includes a short description of the removal of Bunker C fuel oil from the SMITH during the week following the sinking and a discussion of measures instituted to control shipping traffic in the wreck area. These latter two activites were conducted under the auspices of the U.S. Coast Guard and the Corps of Engineers respectively.

The report is organized in 10 chapters. The opening chapters are designed to orient the reader on the circumstances and consequences of the SMITH's collision and sinking and the





St. Clair River, with Lake St. Clair, provides only shipping link between eastern and western Great Lakes. Narrow river passage is one of the world's busiest waterways, accommodating up to 1500 ships a month.

Port Huron, at head of river, 57 miles north of Detroit, is mid-point on St. Lawrence Seaway. Two-way passage of huge Great Lakes freighters is exceptionally hazardous between Port Huron and Sarnia because of narrow, bending channel and strong river current, fed by Lake Huron.

Coal freighter, SIDNEY E. SMITH, JR., sank opposite Port Huron on 5 June 1972, precipitating major salvage operations to clear channel.

ST. CLAIR RIVER, VITAL GREAT LAKES SHIPPING ARTERY

ensuing formulation of plans to remove the wreck and mobilization of salvage resources for the operation.

The main body of the report deals with the removal of the wreck sections from the channel. Chapters 5 and 6 address the planning and conduct of stern removal operations, the first major task of the salvage force. The second major task, removal of the bow section, is covered in Chapters 7 and 8. In each case, the account highlights the innovative salvage techniques adopted during the planning and preparation stages, and then describes the application of these techniques during the actual conduct of operations.

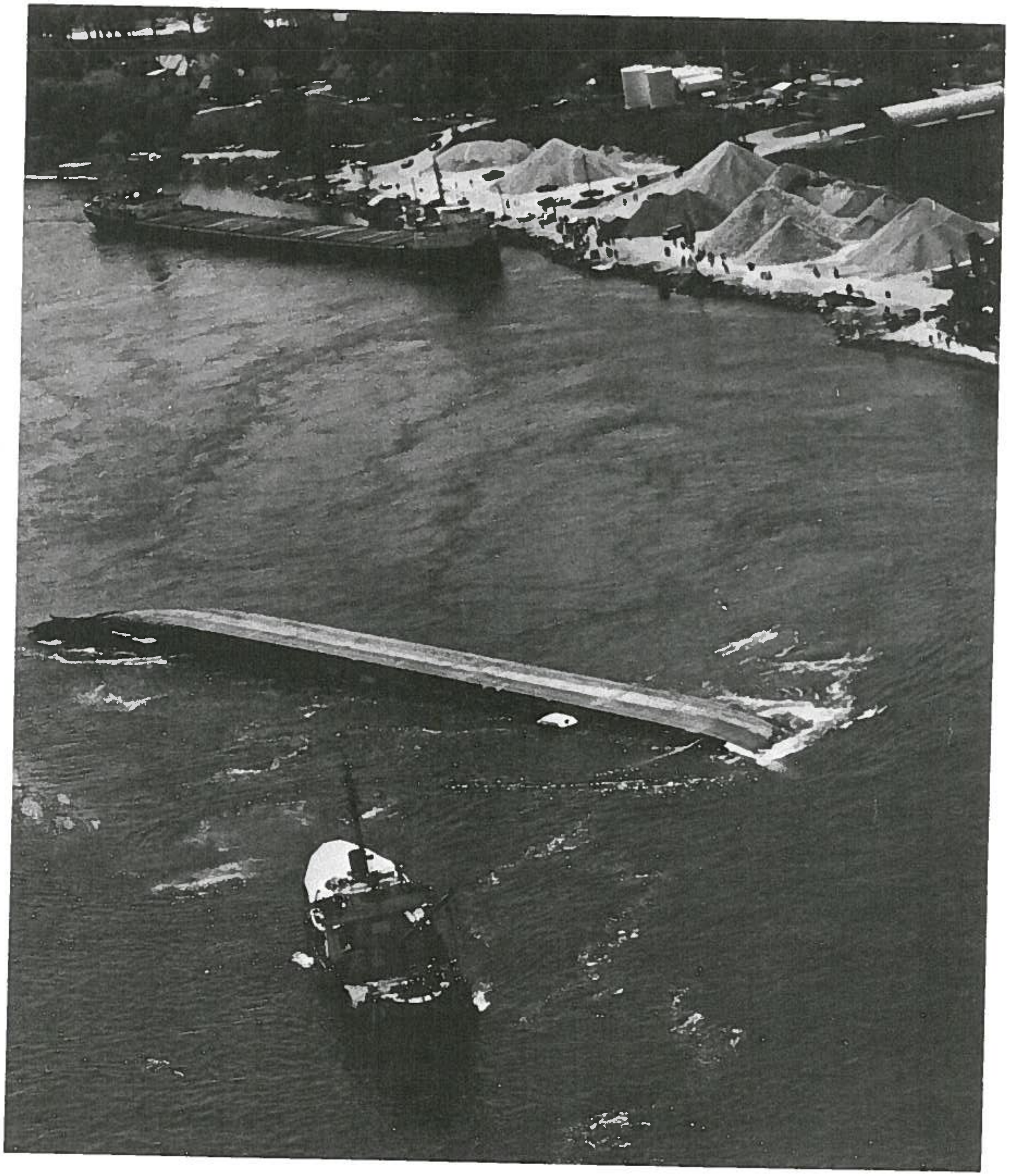
The final salvage task, that of preparing the beached sections for towing following their removal from the channel, is covered in Chapter 9. The report concludes with an evaluation of the salvage operation in Chapter 10. A series of appendices amplifies selected portions of the report. Appendix G, at the end of the report, is a foldout illustration with details of the SMITH's construction. Readers are encouraged to keep this foldout open for ready reference while reading the text.

GENERAL ORIENTATION

Sinking of the SMITH

The downbound Canadian steamer S.S. PARKER EVANS and the upbound U.S.freighter S.S. SIDNEY E. SMITH, JR., collided at the head of the busy St. Clair River at 0145 Eastern Standard Time on 5 June 1972. The PARKER EVANS sustained serious bow damage but was able to proceed to a safe mooring. The SMITH, however, overturned in mid-channel, completely blocking the downbound lane of an already narrow and treacherous thoroughfare. The hulk, bottomed on its starboard side, split in two sections within a few days. The stern section remained partially exposed but the bow section slipped completely below the surface.

The St. Clair River Channel is vital to shipping on the Great Lakes. With the SMITH obstructing half of the already narrow channel, traffic on the river was slowed and the possibility of a second collision, which could block the channel completely, was greatly increased. It was thus imperative that the SMITH be removed as soon as possible. Pending removal, Coast Guard authorities took immediate action to defuel the hulk, eliminating the serious threat of a major oil pollution incident, and instituted emergency traffic control measures in the wreck area.



Overturned SMITH lies bottomed on starboard side, morning after nighttime collision with PARKER EVANS (background). Hull, still intact, protrudes 250 feet into shipping channel. River current hammers at bow (upstream, right). SMITH broke up three days later.

CAPSIZED SIDNEY E. SMITH OBSTRUCTS RIVER CHANNEL

Resulting Salvage Operation

River clearance is a statutory responsibility of the Corps of Engineers (COE). In this instance, the Corps requested the Supervisor of Salvage (SUPSALV) to remove the sunken SMITH because the situation demanded an immediate, effective response. SUPSALV, with the Government's most extensive marine salvage capabilities at his disposal, could quickly mobilize the necessary resources for the large, complex salvage effort. COE and SUPSALV personnel worked very closely together and with U.S. Coast Guard officers, who were responsible for enforcing COE's regulations for control of shipping traffic on the river, in devising and implementing a plan for removing the SMITH from the channel.

The salvage force, as assembled, was a joint organization with participation of Army, Navy and Coast Guard agencies. A large number of civilian contractors also participated, either directly or in a supporting role. These military and civilian participants were carefully integrated into an effective organization that performed its tasks efficiently and safely despite grueling 24-hour workdays under unusually demanding environmental conditions. The stern section was pulled from mid-channel on 6 August, followed by the bow section on 22 September. The channel was opened again to its full width on 25 September. Remaining salvage work, to prepare the recovered sections for final disposal, was accomplished by 18 November.

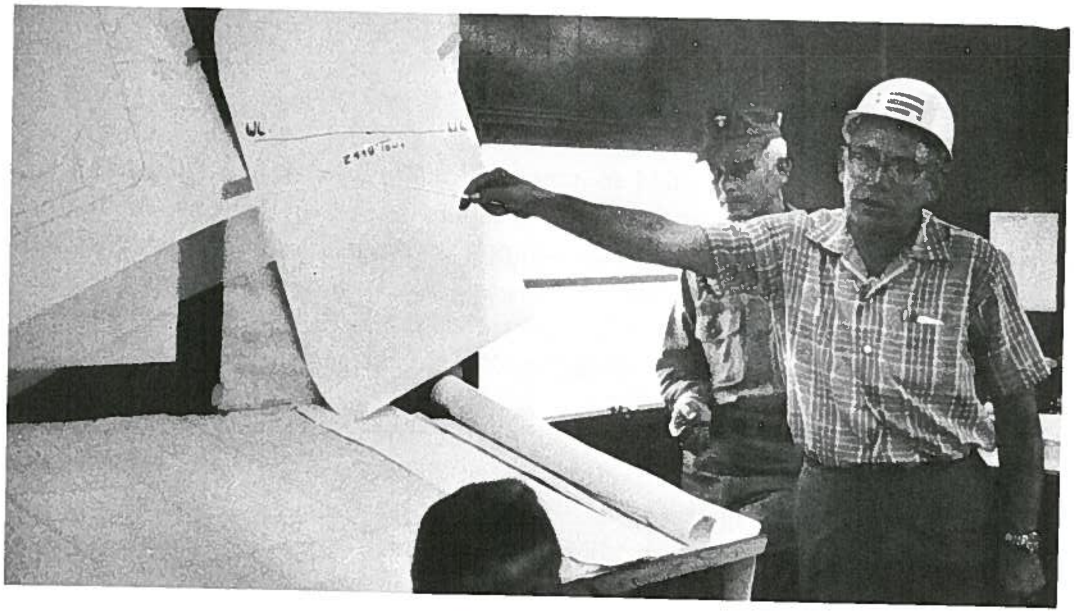
FORMULATION OF THE SALVAGE PLAN

Initial Planning

The Supervisor of Salvage dispatched Navy salvage experts to Port Huron in mid-June to survey the wreck and begin developing a proposed salvage plan. A basic concept and supporting procedures for removing the wreck were formulated within a few days and presented to COE representatives at Port Huron. Legal, financial and operational aspects of a Navy salvage effort were also discussed at this time.

The urgency of the situation was well recognized by the salvage planners. Because of the SMITH's unstable and rapidly deteriorating condition, a major salvage effort would be required and it would have to be mounted quickly. Delay would only complicate and render more difficult an already formidable salvage task. Consequently, the SUPSALV concept for removing the SMITH provided for the rapid concentration of available salvage resources, with the SMITH's stern section as the first target of operations.

The concept of salvage operations envisioned the extensive use of urethane foam to lighten each section of the wreck, and the installation of a hydraulic pulling system ashore



Salvage Master made extensive use of conferences and staff briefings to formulate plans and issue instructions. Complexity and rapid pace of salvage operations placed premium on effective oral communications. Navy On-Scene Commander (background) looks on.

SALVAGE MASTER BRIEFS SALVOPS STAFF

to clear the lightened sections from the river channel. The vast interior spaces of the sunken SMITH, open to the river, appeared invulnerable to conventional methods of providing buoyancy. Similarly, there was inadequate room ashore for the traditional use of Navy beach gear to provide pulling power. These two concepts were to evolve into the principal features of the SMITH salvage plan.

Planning Conference, 23 June

The Corps of Engineers officially requested the services of SUPSALV in removing the SMITH on 23 June. Initial plans were refined the same day during a conference at SUPSALV headquarters in Washington, D.C. Participants included SUPSALV personnel and representatives from the Murphy Pacific Marine Salvage Company (MYPAC) and the Harter Corporation. Murphy Pacific, SUPSALV's incumbent salvage contractor, was to provide a wide variety of salvage services, including the installation of urethane foam. Divers from the Harter Corporation were to provide all diving services under a MYPAC contract.

The purposes of the meeting were to: (1) assemble key personnel and brief them on the operation and their respective roles; (2) outline a general salvage plan; (3) prepare a preliminary bill of materials; and (4) issue the orders and instructions necessary to begin operations.

The importance of early mobilization of salvage resources was the dominant consideration throughout the meeting. Although the planners had only an incomplete picture of the salvage situation at this time, they decided to proceed with the operation, acting on the information that was available. Changes to initial plans would be made as required as the operation progressed.

Factors Influencing the Planning

In formulating a salvage plan, the salvors had only a partial set of ship plans, a series of photographs taken by on-site COE personnel, and the reports of the Salvage Master and other SUPSALV representatives who had visited the site only briefly. External diving surveys were not feasible because of the strong current; internal surveys were not advisable because of the unstable condition of the wreck which was in a rapid and continuous state of flux. The capsized hulk continued to settle even more deeply into the river bottom, making it less accessible to the salvors.

The critical planning factor was the requirement for early removal of the SMITH from the river channel. In spite of the Coast Guard's best efforts to mark the obstruction and control the flow of traffic, the wreck would present a major navigational hazard until removed. Shipping traffic on the river is always particularly heavy during the summer months. Commercial interests move much of their cargo at this time of year because the connecting channels often freeze over at certain points during the winter, thus closing this trade route to shipping. The SMITH removal effort would extend well into this summer period of increased shipping on the river.

All aspects of the salvage effort had to be planned with the dynamic forces of the St. Clair River in mind. The strong river current, normally flowing at rates of 7 to 9 knots, precluded normal diving operations. Moreover, it was making the SMITH increasingly unstable as it hammered ceaselessly against the overturned hull. Scouring action, particularly under the bow section, was washing away the river bottom. The current would have profound effects throughout the operation. Mooring and maneuvering of the salvage work platform, installing foam, performing underwater work, controlling the wreck sections as they were lightened and other salvage tasks would become more complex and dangerous as a result of these forces.

SMITH's design and construction also contributed to the complexity of the salvage task. In terms of watertight integrity, the construction of the freighter was such that it was in effect a single compartment 500 feet in length. Now broken and open to the river, it was obvious that extraordinary measures would be required to lighten the wreck sections. Estimates of the amount of urethane foam that would be needed, and calculations as to where and how it could be installed, comprised a significant portion of the planning effort.

KEY CONCEPTS OF THE SALVAGE PLAN

The salvage plan, as developed by SUPSALV and adopted by the Corps of Engineers, conceived that the operation would be conducted in three phases, each one identifying a major salvage task to be accomplished. The salvage force would clear the wreck sections from the channel, first the stern section and then the more difficult sunken bow. The two sections would then be prepared for towing to a remote site for final scrapping. The three phases were:

Phase I – Removal of the Stern Section

Phase II – Removal of the Bow Section

Phase III – Disposal of the Wreck Sections

Phase I – Removal of the Stern Section

The salvors decided to attack the stern section first because it was only partially submerged and therefore more accessible than the sunken bow section. Accessibility was critical because the strong river current precluded normal diving operations. The stern section was also farther out in the river than the bow. Removing it first would reduce the navigational hazard somewhat.

The concept for removal called for lightening the wreck in mid-channel and then pulling it ashore. A system of hydraulic pullers would be installed on the western (American) bank of the river. Concurrently, operations would be conducted in mid-channel to rig the wreck for pulling and to install urethane foam in its underwater compartments. The purpose of the foam was to provide buoyancy, lightening the wreck sufficiently to reduce its ground reaction to within the capability of the hydraulic pullers.

The removal concept was daring by any standard. Although foam delivery systems were available, the foam-in-salvage technique was still unproven in large scale underwater operations. Further, the hydraulic pulling system as such did not exist at the outset of work. Pullers would have to be obtained from commercial sources. Anchors for the pullers would have to be designed especially for the operation. Successful execution would place extraordinary demands on the operational leadership and technical competence of the salvage force.

Phase II – Removal of the Bow Section

The bow section had become totally submerged prior to the start of salvage operations. Although its condition was by no means stable, the salvors reasoned that, compared to the stern section, it could not get much worse for salvage purposes. Work on the bow was to be deferred until the stern had been cleared from the channel. It was anticipated that the same general approach used for the stern section could be applied to the bow. The bow would first be lightened with urethane foam and then towed ashore with the hydraulic pullers.

Detailed planning for bow removal was not undertaken until operations on the stern section were well along. The salvors wanted to acquire experience with the stern removal effort before finalizing plans for the bow. They were acutely aware, however, that some means had to be devised for gaining access to the submerged bow for underwater work. They solved this problem by designing a system of cofferdams to protect the divers during their descent and ascent through the water column. The concept for the use of these cofferdams became a major feature of the bow removal plan.

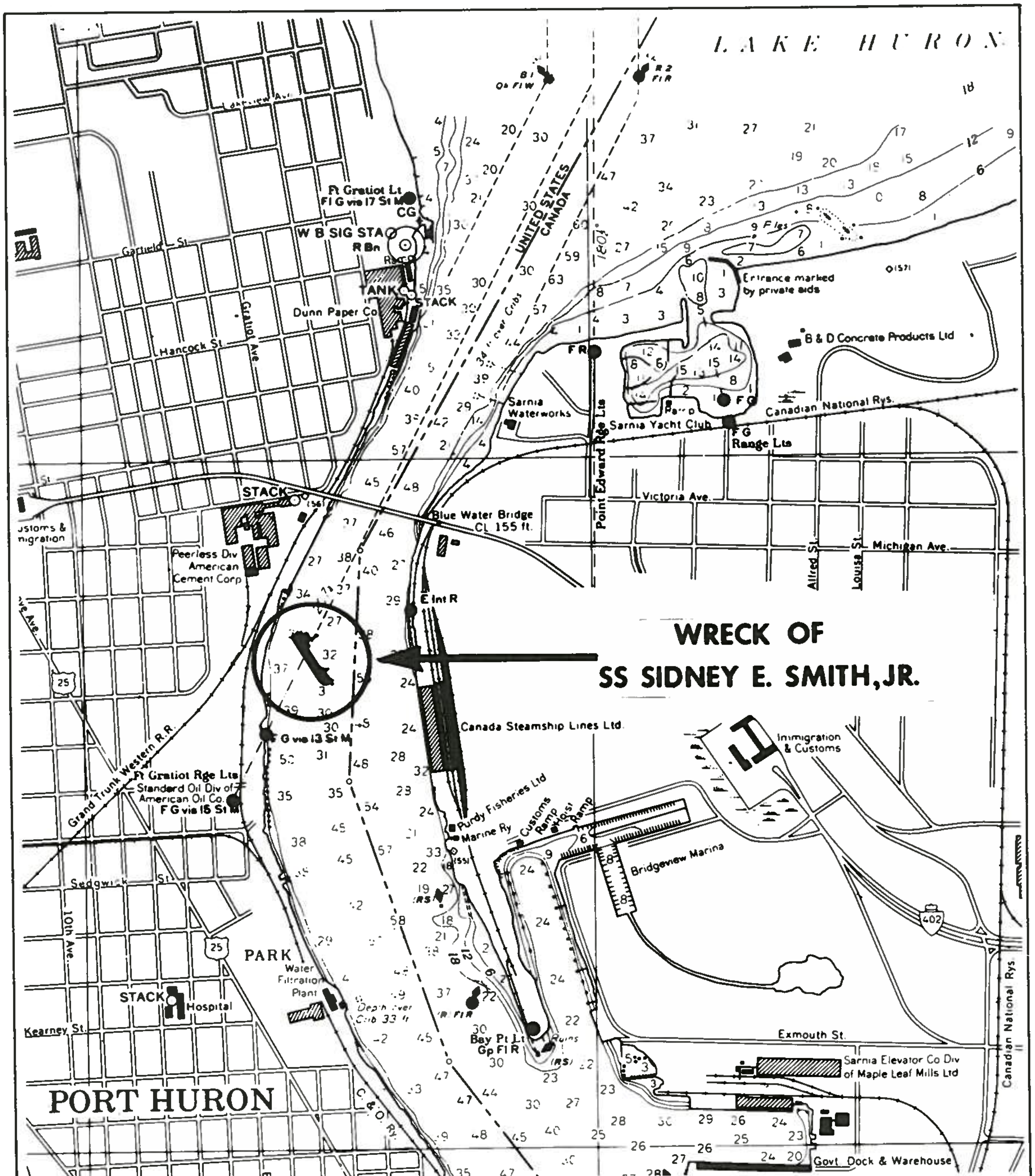
Innovations were incorporated into the plan as it evolved, derived from experience with the stern section. A more efficient foam delivery system was devised, tailored to the increased depth of the bow section. The hydraulic pulling system was realigned and new components were added to provide greater pulling power.

Phase III – Disposal of the Wreck Sections

Additional salvage work would be required once the wreck sections had been cleared from the channel. Each section had to be prepared for towing to a remote site for eventual final scrapping. The beached sections had to be restored to conditions of minimum list and trim, sufficient to transform them into reasonably stable floating objects.

The Corps of Engineers established specifications for the restoration. Each section had to attain a maximum draft of 24 feet and a list of less than 10 degrees. To meet these specifications and guarantee the stability of each section when refloated, the salvage force would have to remove a substantial amount of topside weight and install additional buoyancy.

The salvors planned to begin preparations of the stern section for towing as soon as it was cleared from the channel. This work would be undertaken concurrently with the removal of the bow section from the channel. The latter effort would, of course, retain priority until the channel was cleared. Disposal of the two wreck sections would proceed at a relatively routine pace as compared with the round-the-clock operations planned for removing them from the channel.



Narrows above Blue Water Bridge and bend just below bridge combine with strong current to create dangerous passage. Wreck, blocking downbound lane of channel, increases hazard. Coast Guard imposed one-way traffic controls near wreck area.

WRECK SITE IN ST CLAIR RIVER CHANNEL AT PORT HURON

CHAPTER 2
THE COLLISION AND ITS CONSEQUENCES

BASIC CIRCUMSTANCES OF THE COLLISION

St. Clair River – Site of the Collision

The St. Clair River is a vital artery in the interlocking system of waterways that comprise the Great Lakes area. Originating at Lake Huron, it flows south to Lake St. Clair, dividing Canada and the lower peninsula of Michigan en route. Lake St. Clair, in turn, provides water access to Detroit and, via the Detroit River, to Lake Erie. The river provides the only passage for ships transiting between Lake Erie and Lake Huron. Hence, it is one of the busiest and most important of the Great Lakes shipping lanes.

The river is treacherous as well as busy. Its narrow, restricted waters, swift currents and sharp bends combine to make it extremely dangerous for heavy shipping traffic. The navigational hazards are greatest at the northern end where the waters of Lake Huron empty into the river's source. The collision of the SIDNEY E. SMITH and PARKER EVANS occurred in this area, between the cities of Port Huron, Michigan, and Sarnia, Ontario. The huge Blue Water Bridge spans the river narrows between the two cities. A sweeping bend just south of the bridge creates eddies that further agitate an already swift and powerful current, typically flowing at 7 to 9 knots.

Ship traffic is controlled by designating "upbound" and "downbound" lanes in the river channel which is about 800 feet wide in the Port Huron area. Downbound ships from Lake Huron pass on the American side of the channel. Ships coming up the river from Lake St. Clair pass on the Canadian side. It is particularly difficult for downbound ships to negotiate the bend in the river because they must travel faster than the current just to maintain steerageway. They must therefore transit the narrows at a relatively high speed in preparation for entering the bend. The problem is aggravated by the fact that much of the river traffic includes tug and barge configurations, which are inherently difficult to control.

Maritime records for the 4 years preceding the SMITH-EVANS collision showed that the general area near the Blue Water Bridge had been the scene of four collisions with docks, three major ship collisions and four groundings. Although these accidents had no doubt disrupted river traffic temporarily, they had not blocked the channel. Coast Guard authorities had long been aware that the St. Clair River was vulnerable in this regard. Blocking the channel would not only slow the traffic to a snail's pace but would immediately create an additional navigational hazard.

The apprehension of the Coast Guard was well founded. The SMITH and the EVANS collided just south of the Blue Water Bridge at 0145 on 5 June 1972. The SMITH rolled over and sank in a few minutes, blocking the downbound lane of the channel. Four months of difficult and complex salvage operations would be required to clear the hulk from the channel.

Vessel Data – SIDNEY E. SMITH, JR.

The S.S. SIDNEY E. SMITH, JR., a U.S. steamer, was owned by the Erie Sand Steamship Company, Erie, Pennsylvania, with its home port also at Erie. The SMITH was a steel-hulled steamship 489 feet long, with a 52-foot beam, a 27-foot depth, and a displacement of 4,639 tons. Built in 1906 as a typical Great Lakes freighter, the SMITH was later modified to be a "self-unloading coal carrier," equipped to receive, carry, and discharge large quantities of coal. A substantial number of Great Lakes freighters are configured in a similar manner.

The SMITH did not have the structural stability and watertight integrity that are characteristic of oceangoing vessels. Her cargo holds and associated underwater spaces, although designed efficiently for the purpose of carrying coal, made her both vulnerable to damage and difficult to salvage.

Vessel Data – PARKER EVANS

The S.S. PARKER EVANS, a Canadian steamer, is owned by the Hindman Transportation Company, Ontario, Canada, with her home port at Owen Sound, Ontario. Built in 1908, the PARKER EVANS is a steel-hulled steamship with an overall length of 557 feet, a beam of 58 feet, a depth of 31 feet, and a displacement of 7,815 tons. She is engaged primarily in carrying bulk quantities of grain. Like the SIDNEY E. SMITH, she is a veteran Great Lakes freighter.

Although the two ships had almost the same overall dimensions, the EVANS was considerably heavier than the SMITH and presumably had greater structural strength. The EVANS survived the collision but the SMITH did not. However this was due more to the relative speeds and headings of the two freighters at the moment of impact. The greater weight of the EVANS, nevertheless, added to the forces that destroyed the SMITH.

CHRONOLOGY OF THE COLLISION

SMITH and EVANS Approach the Blue Water Bridge

The SIDNEY E. SMITH departed Toledo, Ohio, at 1045 on Sunday, 4 June 1972, bound for Lime Island, Michigan, with a partial coal cargo of 6,646 tons. The vessel was properly manned with all equipment operating satisfactorily as she proceeded up the St. Clair River at a "full ahead" speed of 9 mph. At a point abeam of the Port Huron Water Filtration Plant, the SMITH's conning officer ordered the slow right turn required to keep the vessel within the upbound lane as she approached the Blue Water Bridge. At about this time, the SMITH exchanged 1-blast whistle signals with the downbound freighter, PARKER EVANS, agreeing to the normal port-to-port meeting.

The EVANS had departed Thunder Bay, Ontario, on 2 June with an 11,090-ton cargo of grain. She, too, was properly manned, with all ship's gear operating normally. While on the Point Edward Range, prior to entering the St. Clair River from Lake Huron, the EVANS reduced her speed from "full ahead" to "half ahead" to conform with the downriver speed limit of 9 mph. Proceeding downbound on the Fort Gratiot Range, the EVANS was at a point approximately 2,600 feet above the bridge, when the whistle signals for the port-to-port meeting were exchanged.

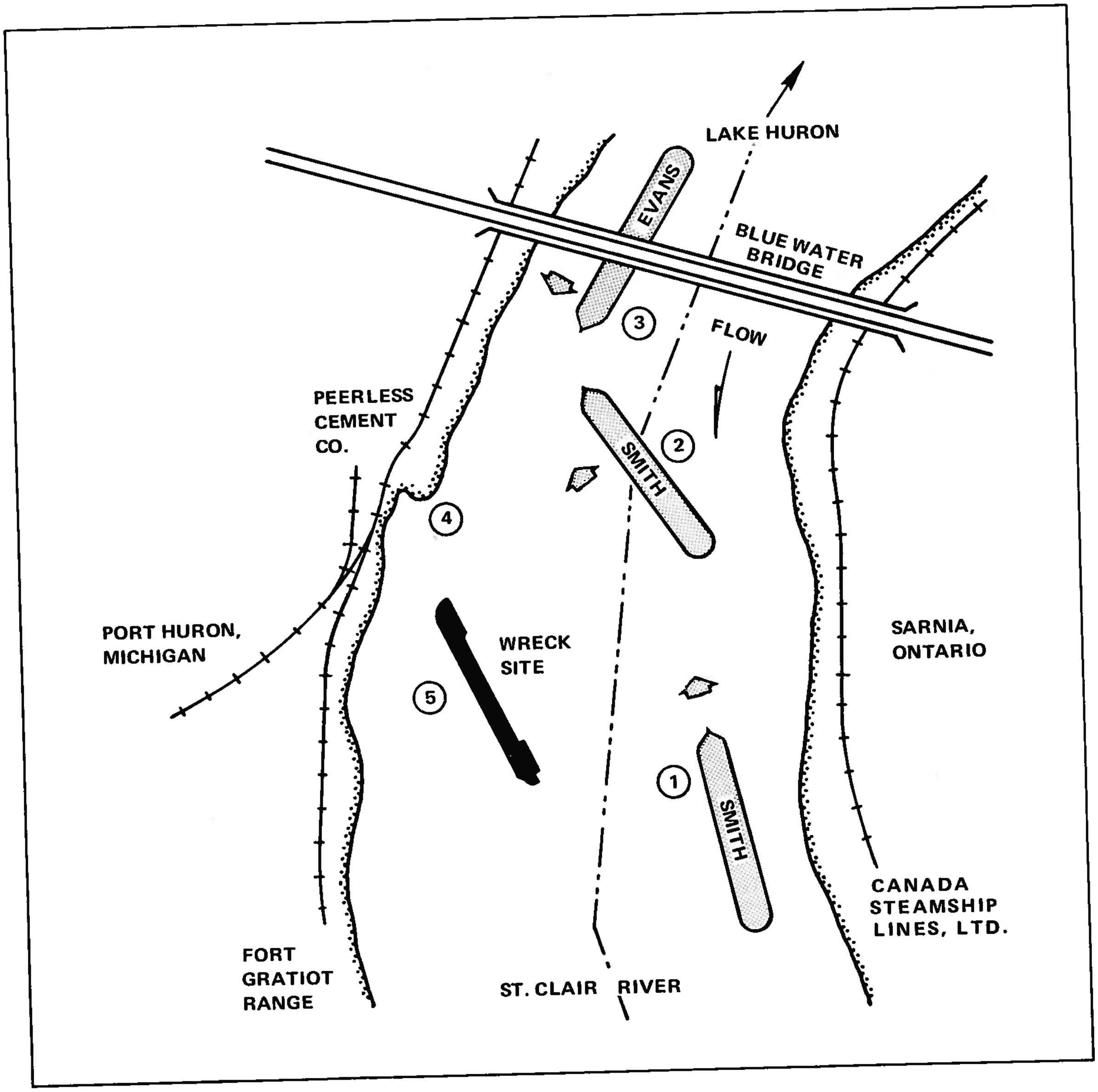
SMITH Veers Into Downbound Lane

Soon after the initial exchange of whistle signals, the SMITH's Second Mate became concerned that his ship, now abeam of the Fort Gratiot after range light, was getting too close to the Canadian shore. He therefore ordered some right wheel taken off. The SMITH responded by slowly angling back out toward the center of the channel as she approached the narrows beneath the Blue Water Bridge. Without warning, the SMITH's bow suddenly projected from the slow eddy currents along the protected Canadian shore out into the swift main stream of water shooting straight down the narrows from Lake Huron. The SMITH's bow was immediately set downstream, causing her forward momentum to carry her across mid-channel and into the downbound lane in spite of the hard right rudder which was ordered too late to rectify the situation.

The Collision Occurs

The Master of the EVANS had observed the SMITH's apparent difficulty in executing the right turn and eased his ship to the far right of the channel in order to give the SMITH more room. When the two vessels were approximately 700 yards apart, the SMITH's Second Mate realized that port-to-port passage was no longer possible and he sounded the danger signal followed by two blasts, proposing a starboard-to-starboard passage. Unfortunately, the ships were already in extremis and although both ordered "full astern," they collided moments later at a point just below the Blue Water Bridge, in the downbound lane of the channel.

The stem or bow area of the EVANS struck the starboard bow of the SMITH at or slightly aft of the break of the forward deck house and hold #1 (frame 35). The angle of



(1) *Close to Canadian shore after negotiating turn, upbound SMITH eased right rudder.*

(2) *Strong current caught bow, causing ship to veer across mid-channel.*

(3) *Downbound EVANS punctured SMITH starboard bow region, causing immediate flooding.*

(4) *After collision, SMITH drifted close to Peerless Co. dock, but was unable to tie up.*

(5) *Strong river current carried SMITH downstream where it soon sank, blocking downbound lane.*

SEQUENCE OF SMITH-EVANS COLLISION

impact was approximately 55 degrees relative to the bow of the SMITH. Rebounding from the initial impact, the EVANS' momentum caused her to strike the SMITH a second time 20 to 30 feet aft of the first point of impact. At this time, the EVANS' Master ordered "full ahead" in an attempt to hold the SMITH onto the nearby Peerless Cement Company's dock. The EVANS was unable to hold her position against the SMITH, however, as her stern was set rapidly downriver in the fierce current. At this point, the EVANS dropped her starboard anchor and swinging in on the current, managed to moor at a local asphalt company's dock below the Peerless dock.

SMITH's Crew Abandons Ship

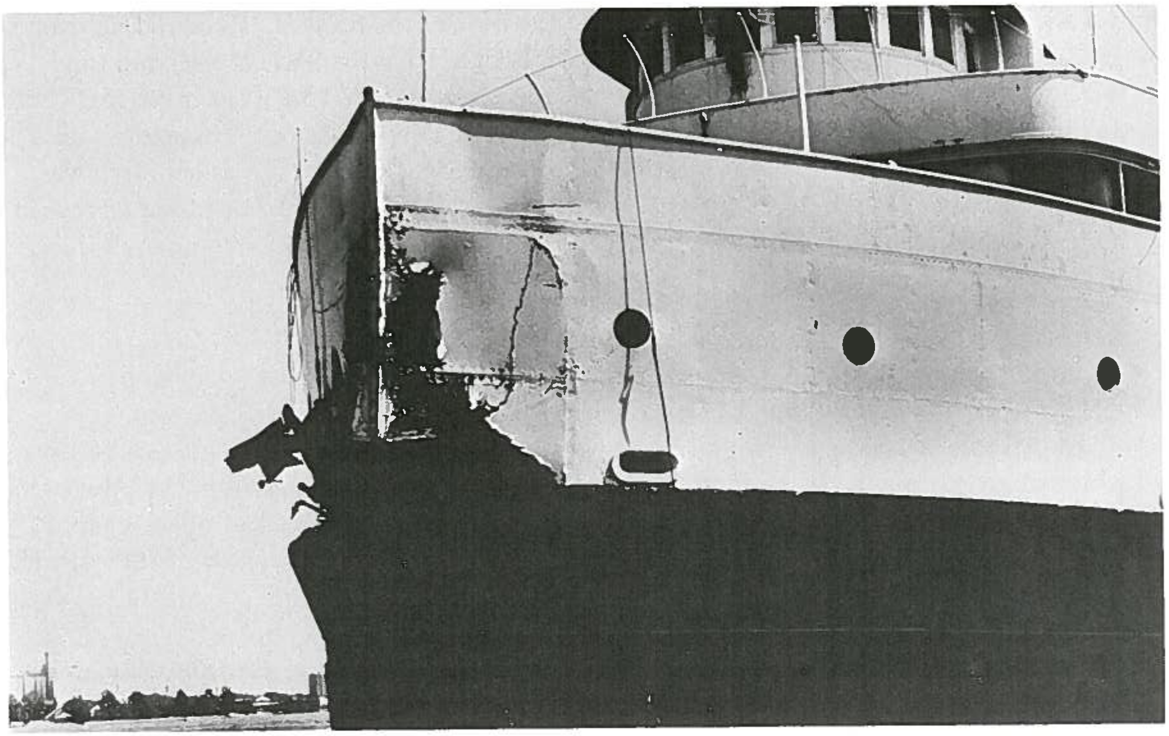
Immediately after the second impact, the Master of the SMITH arrived in the pilot house and assuming the conn, ordered "half ahead," hoping to beach his ship clear of the channel. However, he was forced to order "abandon ship" almost immediately because of the increasing starboard list.

When relieved of the conn, the Second Mate proceeded directly to the forecastle, dropped the SMITH's bow anchors and released chain several times as it became taut. He also attempted to pass mooring lines ashore when, at one point, the vessel's bow was approximately 6 feet from the southern end of the Peerless dock. Had there been line handlers ashore, mooring lines could have been secured and the SMITH would have settled to the bottom in shallow water, clear of the channel. Unfortunately, this was not to be.

The SMITH's starboard list became critical as the current caused her to swing back out into the channel. The crew did manage to abandon ship under extremely hazardous conditions just before she sank on her starboard side. Three crew members escaped to shore in a small work skiff. A Sarnia-Port Huron pilot boat executed a daring rescue of the remainder of the crew by maneuvering in the treacherous current close to the port side of the sinking freighter.

Response of the U.S. Coast Guard

The Sarnia-Port Huron pilot boat reported the situation by radio to the Coast Guard Station at Port Huron 5 minutes after the collision occurred. Coast Guard authorities immediately closed the upper portion of the St. Clair River to all traffic pending appraisal of the situation. Small boats from the Port Huron station were deployed to the scene followed by the Coast Guard buoy tender, ACACIA. Arriving at the collision site, the Coast Guard found all 60 crew members of the two ships safe. Inspection of the overturned SMITH revealed leaking diesel fuel, setting in motion oil pollution abatement actions by the Coast Guard.



PARKER EVANS survived collision despite extensive bow damage. Freighter remained in Port Huron several days for temporary repairs, then proceeded downriver to permanent repair site.

COLLISION WITH SMITH DAMAGES BOW OF PARKER EVANS

Coast Guard Report on the Collision

See Appendix A for the official U.S. Coast Guard report on the SMITH/EVANS collision. The collision chronology, as summarized in this chapter, is derived primarily from the Coast Guard report. The report provides additional details.

Departure of the PARKER EVANS

The PARKER EVANS sustained serious bow damage. However, the freighter was securely moored shortly after the collision, under complete control and in no danger of sinking. Temporary repairs were made to the bow over the next several days. The PARKER EVANS then departed the Port Huron area, proceeding down river for permanent repairs. She played no role in the ensuing salvage operations.

SINKING AND BREAKUP OF THE SMITH

Position of the Sunken Hulk

The SMITH overturned and sank within 20 minutes after the collision. The starboard side lay on the sandy river bottom, at a depth of about 40 feet. The port side of the hull remained exposed along almost its entire length, 10-15 feet above the surface of the water. The SMITH's after deck house and 13 hatch covers were clearly visible. The forward deck house, although still visible, was just below the surface. The nearly 500-foot long sunken hulk was positioned at about a 45-degree angle to the western (American) side of the river. The bow, closer in and upstream, was 250 feet from the shore. The stern, 550 feet from shore, protruded well out into the river channel, effectively blocking the downbound shipping lane.

The changing contour of the river bottom was to prove highly significant. Although the river bottom was originally flat, the river current scoured away the support beneath the bow section, creating a "hogging" condition whereby the SMITH's weight was not evenly distributed along the length of the hull. This uneven distribution, accentuated by the heavy topside weight of the pilot house, conveyor boom and A-frame, all located at the bow, was to generate stresses in the midship area that would eventually split the hulk.

Structural Damage and Flooding

The collision of the two large freighters had opened the SMITH's hull from the gunwale to beyond the turn of the bilge. Structural damage extended several frames forward and aft of the point of impact. Water immediately invaded the forward machinery space through the tear in the hull at frame 35 flooding this space. Unimpeded, the floodwater also proceeded aft through the conveyor tunnel into the cargo holds through the closed (but not watertight) hopper doors and from tank to tank along the starboard side where longitudinal piping penetrated the "watertight" bulkheads.

Flooding of the conveyor tunnel added a great volume of water to the vessel, decreasing its freeboard significantly and adding a substantial overturning moment. The second point of impact, which occurred about 25 feet aft of the initial gash, caused starboard side tank #2 outboard of hold #1 to flood and probably also caused flooding directly into hold #1 above the tank tops. In addition, the starboard side double bottom tank outboard of and beneath the forward machinery space flooded immediately, while the port side tanks remained dry. All this water pouring in on the starboard side resulted in a rapidly developing starboard list.

The SMITH's loose-fitting sectional hatch covers were positioned primarily to repel rain water and spray from the choppy Great Lakes. As the vessel's starboard rail and hatches

Morning after collision, wreck was already beginning to settle and break up. Water poured in through cargo hold hatches and at point of impact. Extensive flooding, plus rapid scouring of river bottom beneath bow region (right), created severe stresses on hull.

SMITH STILL INTACT BUT VULNERABLE TO FURTHER DAMAGE

dipped below the surface, more water poured into her holds. This combination of flooding through those holes produced directly by the collision's impact, and through other areas which lacked watertight integrity such as the hatch covers, was catastrophic, sinking the SMITH before any effective damage control actions could be taken.

Breakup Into Two Sections

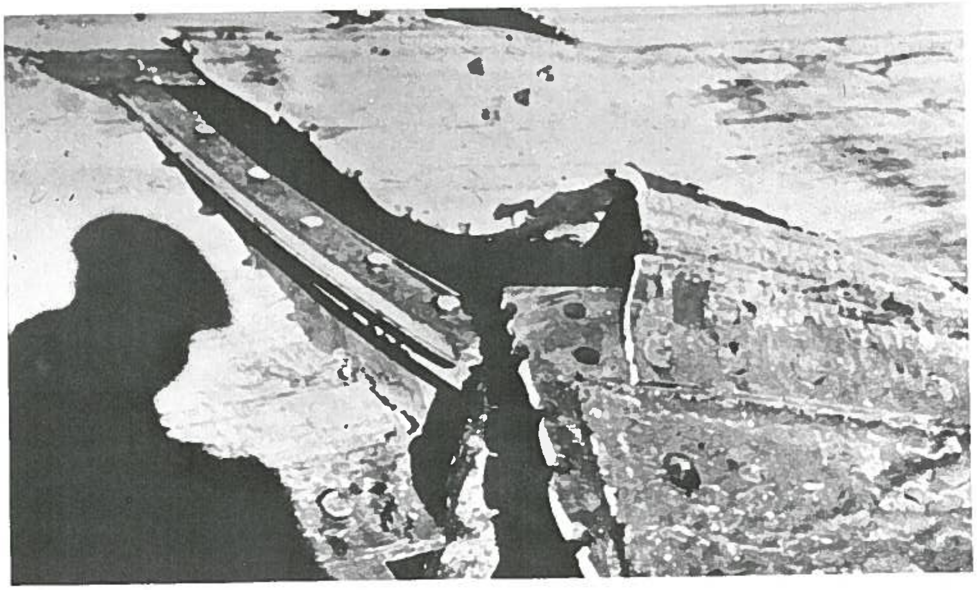
The condition of the sunken hulk deteriorated rapidly under the ceaseless attacks of the powerful river current. The current, deflected by the hulk, swirled around and under the forward section, producing a massive scouring action which carried away more and more of the sandy bottom. This scouring reduced and finally eliminated the already tenuous support for the bow, suspended over the depression. With nothing to support its forward weight, the hulk split in two sections.

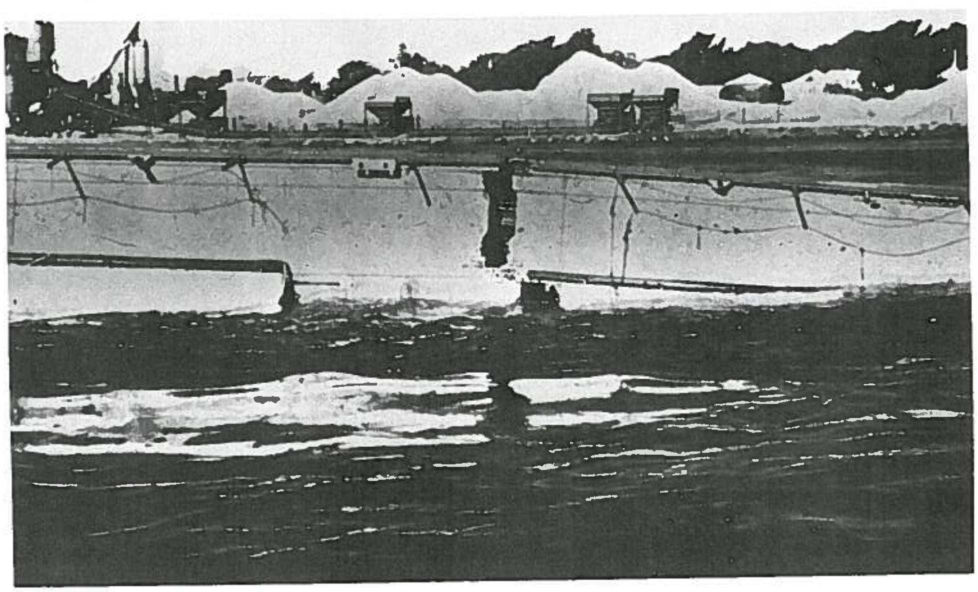
The breakup occurred on 6 and 7 June, the first 2 days after the collision. On 6 June, personnel surveying the wreck had observed that the exposed port side had developed a slight curve, clear evidence that great forces were working on the hull. Closer inspection revealed that three plates on the hull had already wrenched open. A few hours later a loud breaking sound was heard as one plate near the ship's rail split open. This was followed a few hours later by a series of cracking and popping sounds as the ship's rivets popped from the hull. By the following day, the hull was unmistakably broken, a long crack clearly visible across the hull at frame 85. The stern section, released from the bow's weight, stood higher above the surface. The bow, settling into the depression, was distinctly lower, though still visible. By 8 June, it was completely submerged.

Significance of the Breakup

The breakup created two separate salvage problems. The stern section, only partially submerged, was accessible to salvors. The sinking of the bow below the surface was immensely important because the river current was much too strong to permit diver access to the hulk through normal diving procedures. Although the river itself was not particularly deep, special measures would be needed to gain access to the totally submerged bow section.

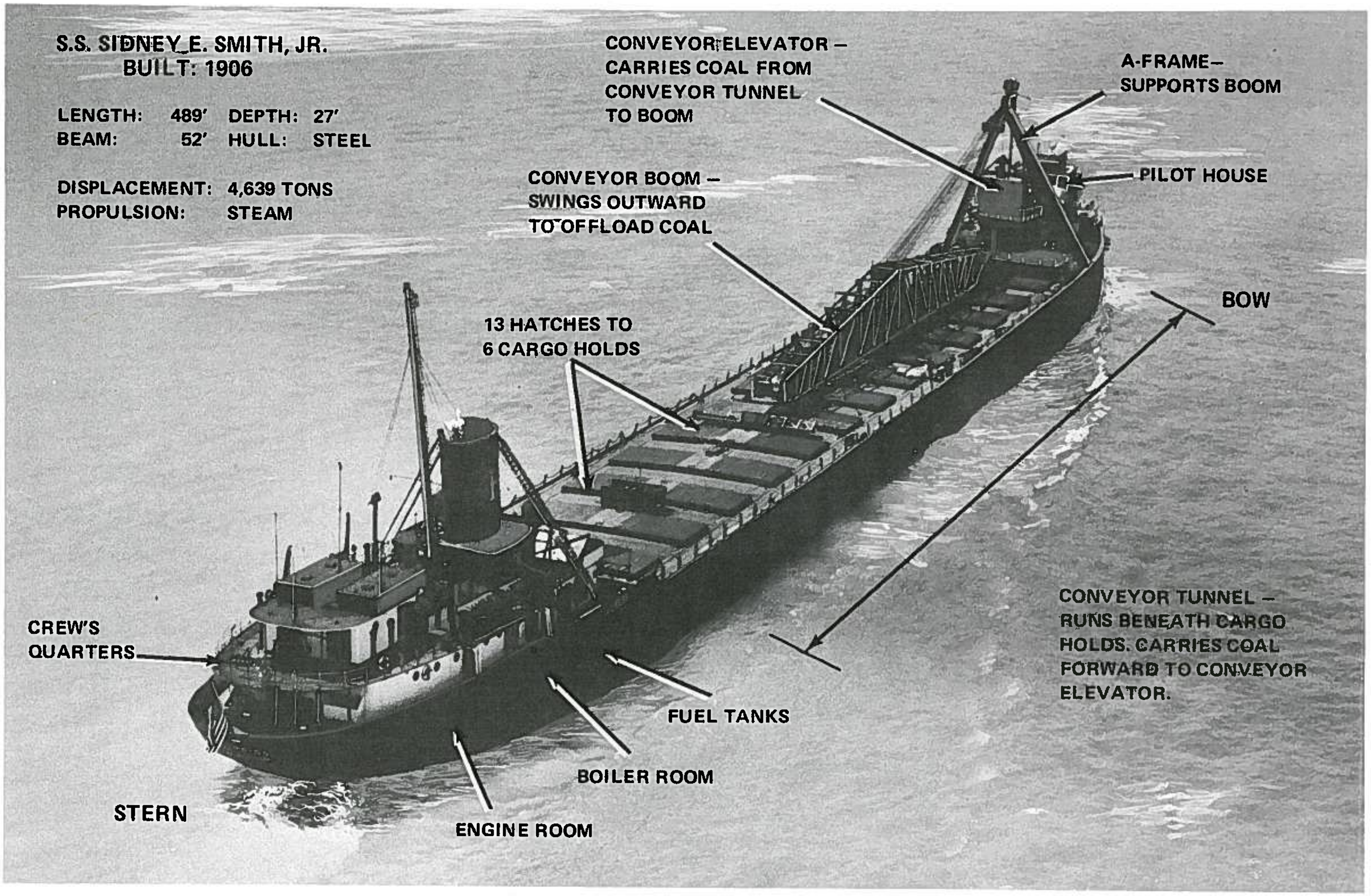
The stern section was to become the first target of salvage operations since it was still partially above water and therefore more accessible than the bow section. Immediate salvage action was necessary on the steadily sinking stern section before the current caused it also, to become totally submerged. The stern was also farther out in the channel, posing a greater navigational hazard than the bow. Work could be deferred on the bow section because, in a relative sense, its condition could not get any worse. However, the scouring action under the bow continued after the breakup, creating an ever deeper depression into





Bow began settling shortly after collision. Widening cracks marked progress of break-up over 3-day period. Bow section (bottom, right) slipped completely below surface by 8 June.

RIVER CURRENT SPLITS SMITH'S HULK IN TWO SECTIONS



Machinery for offloading coal dominates forward superstructure. Cargo holds, tanks and other interior spaces form vast underwater compartment with minimal watertight integrity. Freighter's design and construction make it exceptionally difficult to salvage.

SIDNEY E. SMITH – DESIGN AND CONSTRUCTION FEATURES

which the bow settled. The depth of the sunken bow continued to increase. Originally it had sunk in about 40 feet of water, but by the time salvage operations began, it had settled to a depth of nearly 90 feet. This increased depth was to become a major factor in removing the bow section.

DESIGN AND CONSTRUCTION OF THE SMITH

Configuration as a Coal Carrier

As a self-unloading coal carrier, the SMITH was equipped with a pair of coal conveyor belts which ran in a conveyor tunnel nearly the entire length of the ship. This tunnel was located beneath the SMITH's six cargo holds which formed a double row of coal hoppers. During offloading, these coal hoppers fed coal to the conveyor belts which carried the coal to the forward machinery space where it was deposited in a common hopper which fed the conveyor elevator. An additional single conveyor belt carried the cargo from the conveyor elevator on the ship's centerline along the conveyor boom to designated receiving facilities on the pier. This massive boom could swing out to either side from the centerline rest position to direct the flow of coal as desired.

Construction Aspects of Salvage Significance

Removal of topside weight is important in lightening and righting a sunken ship because it improves the ship's stability. The greater the topside weight, the higher is the center of gravity. Lowering the center of gravity makes the ship more stable. The elaborate and extremely heavy coal conveyor machinery and equipment on the bow section was an obvious threat to the bow's stability when raised and would require extensive work to remove.

The SMITH's hatch covers were designed to slide off and on easily for quick access to the cargo holds. When the freighter capsized, they fell off, leaving the cargo holds open to the river. Sealing these holds would require the fabrication and installation of new hatch covers, a major task in itself.

Broadly speaking, the interior spaces of the SMITH were so lacking in watertight integrity that each of the sunken sections became a vast underwater compartment. The progressive patching of individual spaces in order to make them individually watertight for conventional pumping or blowing with compressed air would have been a lengthy and perhaps impossible process. Consequently, the salvage force turned to the use of urethane foam as the principal means for providing buoyancy.

CHAPTER 3
PREVENTION OF OIL POLLUTION AND CONTROL OF SHIPPING TRAFFIC

PREPARATIONS FOR COMBATING OIL POLLUTION

Upon learning of the collision, Coast Guard authorities at Port Huron began immediately to implement their contingency plans for oil pollution abatement. First inspections of the wreck revealed that a topside storage tank had ruptured, releasing 2,000 gallons of diesel oil. The SMITH's Master estimated that 49,000 gallons of heavy Bunker C oil remained in the ship's fuel tanks. The danger of a major oil spill was clear and compelling. Highlights of operations to avert this threat are described herein; see Appendix B for the Coast Guard's detailed report on the subject.

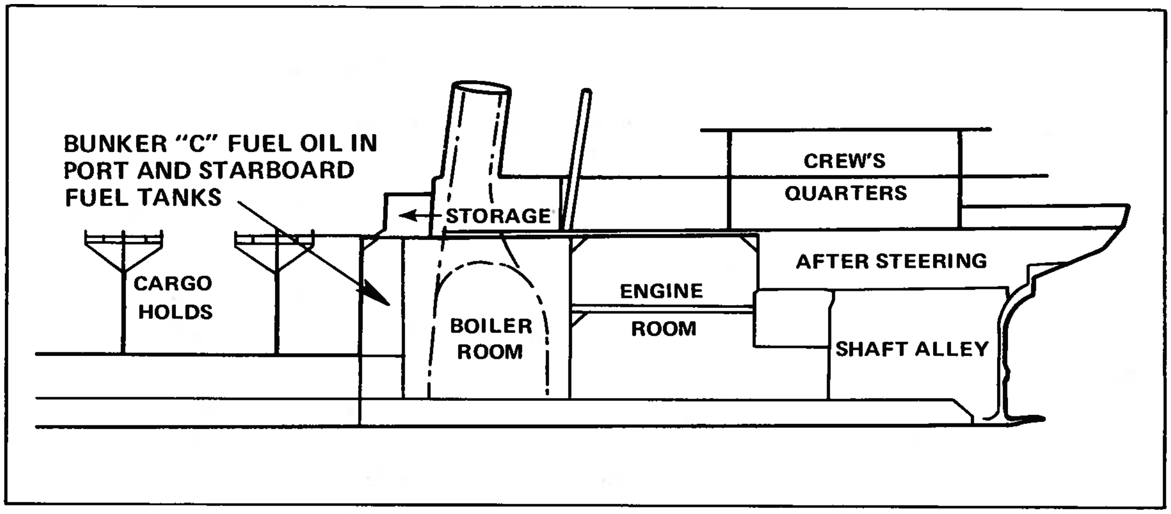
Deployment of Oil Pollution Control Forces, 5 June

The Captain of the Port (COTP), Detroit, senior Coast Guard Officer in the area, was immediately notified of the collision and its possible oil pollution consequences. All COTP, Detroit, personnel were recalled and arrangements made to mobilize pollution control equipment. The COTP then proceeded directly to the Port Huron Coast Guard Station to establish a command post and assume the duties of On-Scene Commander. COTP personnel remaining in Detroit notified the Environmental Protection Agency, the Michigan Water Resources Commission, the U.S. Army Corps of Engineers, and appropriate Canadian authorities. Representatives of each of these organizations were on the scene early on 5 June.

Preparations were made to contain the escaping oil downriver from the wreck. Several companies were contacted and commercial containment and recovery equipment was staged in Algonac State Park, designated as the "downriver central equipment station." Additional equipment from various sources was placed in a standby status. A downriver recovery force was hastily organized.

Focus on Defueling the Wreck

As estimates of the situation were developed during the first several hours after the collision, it became clear that the main effort should be concentrated on removing the oil from the wreck. Containment or recovery of the diesel oil that had already spilled downriver was not feasible. The current was flowing far too swiftly and, moreover, the amount of escaping oil appeared small.



Loaded fuel tanks in stern section of capsized SMITH presented immediate danger of massive oil spill as hulk began to break up. Coast Guard team concentrated its efforts on defueling these tanks as quickly as possible.

SMITH'S FUEL TANKS – TARGETS FOR OIL RECOVERY OPERATIONS

Accordingly, the focus of these early operations shifted quickly to the wreck itself. The Coast Guard National Strike Force (NSF) Team and the Marine Pollution Control Corporation (MPCC) were assigned the task of shipboard oil removal. COTP, Detroit, placed the downriver recovery force in a reserve role temporarily, holding it on station ready for response to the continuing threat of a massive spill of the Bunker C from the SMITH's two fuel tanks, located in the stern section just forward of the boiler room. These tanks became the key targets of oil recovery planning. They were not part of the SMITH's original construction, having been installed in the middle coal bunker when the freighter was converted to oil propulsion. The port tank was selected for pumping first because it was more accessible than the starboard tank. The port storage compartment, where the tank top was located, was still partially above the surface.

Anchoring the Stern Section, 6-8 June

The SMITH had appeared fairly stable when initially inspected on 5 June. By the next day, however, the forces of the river current were beginning to take their toll. The hulk began shifting position and its seams began opening on the port side. It appeared in imminent danger of breaking up. If the stern were to break off and bounce on the bottom or drift into some object, its fuel tanks would almost certainly rupture, spilling the Bunker C. It was apparent that the stern section would have to be anchored as soon as possible.

The SMITH's owners, at the request of the Coast Guard, dispatched a tug on the evening of 6 June to pick up heavy ground tackle and deliver it to the wreck site. The stern section was made secure with five anchors. Implantment of these anchors began on 7 June, as the hull was in the final stages of breaking up. The work was completed the next day. This anchoring system provided adequate stability for oil recovery operations and made the stern section secure against further movement, pending the commencement of salvage operations several weeks later.

Deployment of Oil Containment Booms, 6-7 June

Oil containment booms were deployed on 6 and 7 June at the direction of COTP, Detroit, as the threat of a massive oil spill mounted. Booms were emplaced at key sites in the river, downstream of the wreck, on both the American and Canadian sides. The current proved to be a major obstacle, hampering the work and tearing away several hundred feet of boom. The effort was terminated on 8 June when the immediate threat subsided, with the stern section firmly anchored and recovery of the Bunker C from the SMITH's fuel tanks well underway.

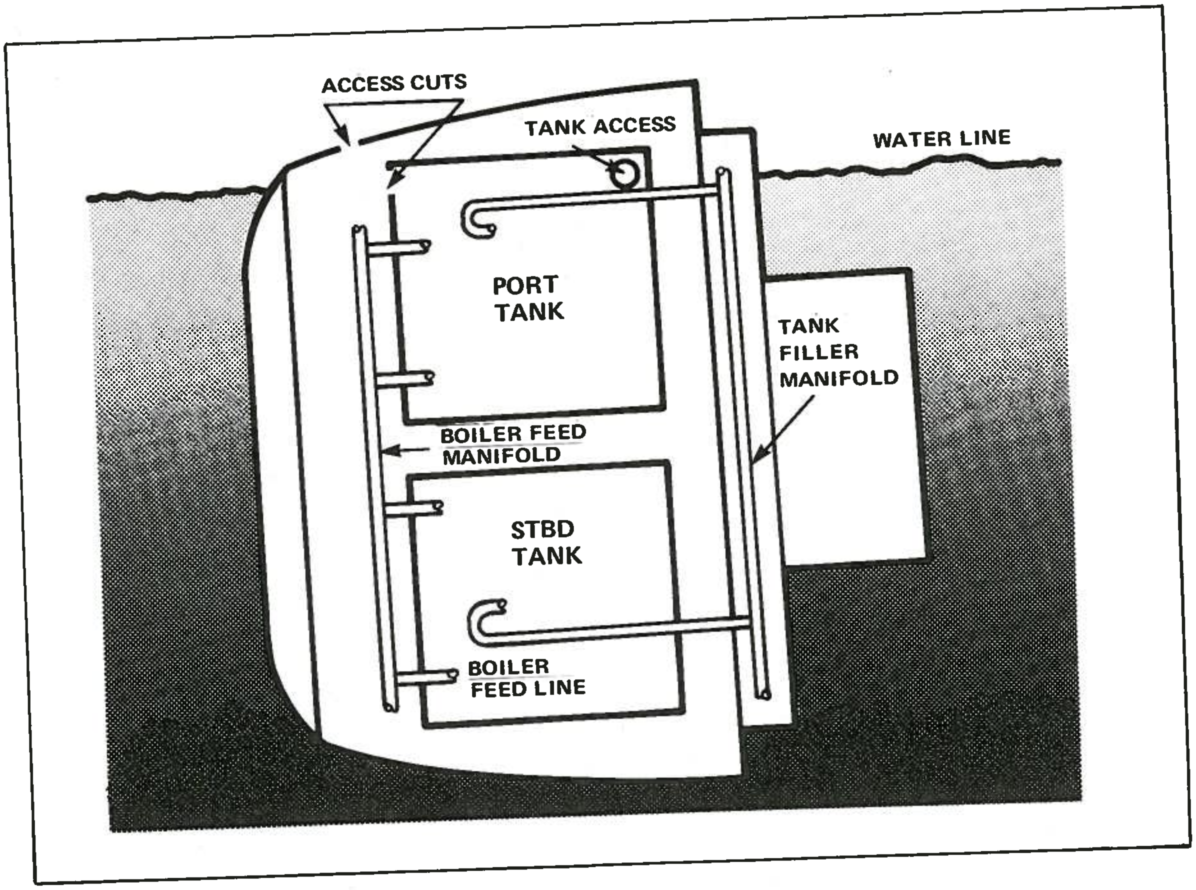
Deployment of these booms was an essential precautionary measure. Had the spill occurred as feared, they would have been useful in protecting key areas and in diverting the oil to calm waters where it could be recovered. The recovery force realized, however, that a great deal of additional work would have been necessary to install an adequate system. Fortunately, it was not required.

RECOVERY OF OIL FROM THE WRECK

Pumping the Port Tank, 7-9 June

Pumping of the port tank got under way on 7 June. The Coast Guard NSF Team installed an ADAPTS(1) system in the SMITH's port storage compartment. Access to the tank top was difficult because most of it was under water and the compartment was filled with galley stores of linen and foodstuffs. Steel shelving, extending about 15 feet into the compartment, obstructed the limited working space and hampered removal of debris. Part of this shelving had to be cut away to reach the tank top. After clearing the compartment for the ADAPTS equipment, the recovery team removed the manhole cover from the tank and began recovering oil. Operations with the ADAPTS system were soon forced to a halt, however, when the hydraulic system on the pump failed. The recovery team ordered the necessary parts in expectation of resuming operations on the following morning.

(1)ADAPTS (Air Deliverable Anti-Pollution Transfer System) - A submersible, double-staged, 10-inch hydraulic pump that may be air-dropped by parachute for pick-up on the water surface. It has its own hydraulic power source.



Coast Guard team pumped port tank first, using tank top and filler manifold. Both filler manifold and boiler feed manifold were then used in pumping starboard tank.

CROSS SECTION OF SMITH'S FUEL TANKS

Suction recovery by the Marine Pollution Control Corporation's barge, BUDA II (2), was started late on 7 June and continued throughout the night. Suction was taken on the filler manifold from the port tank. A 2-inch hose, and later a 3-inch hose, was adapted to the manifold's 5-inch line which was exposed to the swift current. Although recovery by the BUDA system was somewhat slow initially, the total amount of recovered oil by the ADAPTS and BUDA II pumping systems had reached 4,000 gallons by the end of 7 June.

Difficulties with the ADAPTS system were also experienced on 8 June, but pumping operations continued. In the course of two 10-minute periods of operation, the NSF Team reported recovery of nearly 9,000 gallons. During the afternoon, a steam-driven pump from

(2)BUDA II A 50-foot barge configured for oil skimming. The system has an 85-HP diesel engine and relies on vacuum and settling tank separation.

the Shell Oil Company in Sarnia, Ontario, was delivered. This pump, although it was 75 years old, proved to be the most reliable one used during the recovery. It replaced the BUDA II vacuum pump on the port tank. Because the cold temperature of the water had thickened the oil and slowed its flow, the oil in the port tank was heated with a steam coil to facilitate pumping operations.

With the arrival of the Shell steam-driven pump, the BUDA II vacuum pump was employed to skim the lube oils which had surfaced in the flooded engine room areas. Earlier in the day, a hole had been cut topside to provide access to the fuel tank piping. By midnight, however, this access hole had become submerged as the stern section continued to settle and roll throughout the day. An estimated 1,000 gallons of oil remained in the port tank that could not be recovered through the access hole. An unsuccessful attempt was made to remove this remaining oil with the ship's 1 1/2-inch transfer pump.

Pumping the Starboard Tank, 9-12 June

By 9 June most of the oil had been removed from the port tank. Suction from the steam-driven pump was then taken on the 5-inch fill line and the valve to the port tank was closed from the deckhouse. Since the valve to the starboard tank was open, suction on the line produced oil. Suction was maintained until water displaced oil below the fill pipe. About 5,000 gallons were removed from this tank, but as temperatures dropped close to 40^{o}, the oil became increasingly heavy and viscous, reducing the pumping rate considerably. Nonetheless, the NSF Team had succeeded in pumping almost 30,000 gallons to this point in the recovery effort.

Also on 9 June, the 1 1/2-inch boiler feed lines on the 4-inch boiler feed manifold were opened. A piping system was set up by opening and closing selected valves to draw suction only from the upper portion of the starboard tank. The Shell pump's line was connected to the boiler manifold. However, cold temperatures and the small feed lines limited the pumping rate to about 100 gallons an hour. Rough weather late in the day forced a temporary halt in pumping. Equipment was removed from the hulk as a precautionary measure.

Early on 10 June, all equipment was returned to the scene and pumping was resumed, principally from the starboard tank, continuing for the next 3 days. General skimming operations were also continued with the BUDA II barge during this period.

The manhole on the port tank top had by now become submerged as a result of the vessel's shifting. An explosive charge was used to cut another access hole into this tank and about a foot of oil was removed, using a gasoline-driven piston pump. This oil had either been left from ADAPTS pumping or had bled into the port tank from the starboard tank through crossover piping.

Pumping from the starboard tank continued at a low rate due to very cold temperatures. Efforts to heat the oil had begun with an attempt to insert steam into the tank through an intertank oil transfer line. When no appreciable gain in the pumping rate was achieved, it was concluded that the transfer valve was closed. A hard hat diver opened the valve on 12 June, allowing steam to enter the tank. The pumping rate then improved considerably and oil was recovered until early afternoon on 13 June using the portable piston pump.

CONCLUSION OF DEFUELING OPERATIONS

Results of Recovery Effort

Defueling operations were terminated on 13 June. The SMITH had essentially been completely defueled during the week-long effort. An insignificant residue of Bunker C, estimated at 200 gallons, remained, inaccessible in the starboard tank. Approximately 45,000 gallons of oil (diesel, lube and fuel) had been recovered from the wreck. The recovery force was released after securing the pumps and related equipment. The recovery barge was dispatched to deliver the oil across the St. Clair River to the Imperial Oil Company at Sarnia, Ontario.

Threat of Major Oil Pollution Averted

The oil recovery effort had clearly succeeded in averting a major oil pollution incident. The diesel oil spill at the time of the collision, dissipating quickly in the swift current, had produced no discernible adverse effects downriver. Very few complaints from citizens had been received, and the State of Michigan reported no harmful impact upon wildlife or property. Apart from eliminating the oil pollution threat, this defueling operation, expeditiously accomplished by the Coast Guard, paved the way for the subsequent salvage effort to remove the obstruction from the river channel that would be undertaken at the direction of the Corps of Engineers.

CONTROL OF SHIPPING IN WRECK AREA

Initial Traffic Control Survey

The sunken SMITH, blocking the downbound lane of the St. Clair River Channel, posed an extreme navigational hazard. A second collision could easily block both lanes, closing the river completely to all shipping traffic. A complete obstruction of the channel would have enormous commercial consequences in the Great Lakes area. It was not unusual for 1,500 ships to transit the river each month. Almost as much tonnage passes under the Blue Water

Bridge each year as through the Panama Canal. Corps of Engineers and Coast Guard officials were fully aware of the importance of clearing the channel and the implications of a second collision as they held up all traffic and surveyed the situation immediately after the sinking.

This initial survey indicated that the SMITH, still intact, lying on her starboard side with the port side above the water, was in a relatively stationary position. It was decided that vessels should be able to navigate the difficult passage, passing the wreck one at a time under carefully controlled conditions. The Coast Guard buoy tender, ACACIA, placed an obstruction marker buoy about 150 yards upstream from the SMITH's bow. The buoy would help divert downbound traffic to the Canadian side of the channel (normally the upbound lane). Three large ships were then allowed to pass the wreck, one at a time, on a trial basis. Following these experiments, temporary traffic control regulations were promulgated, reopening the river for one-way traffic.

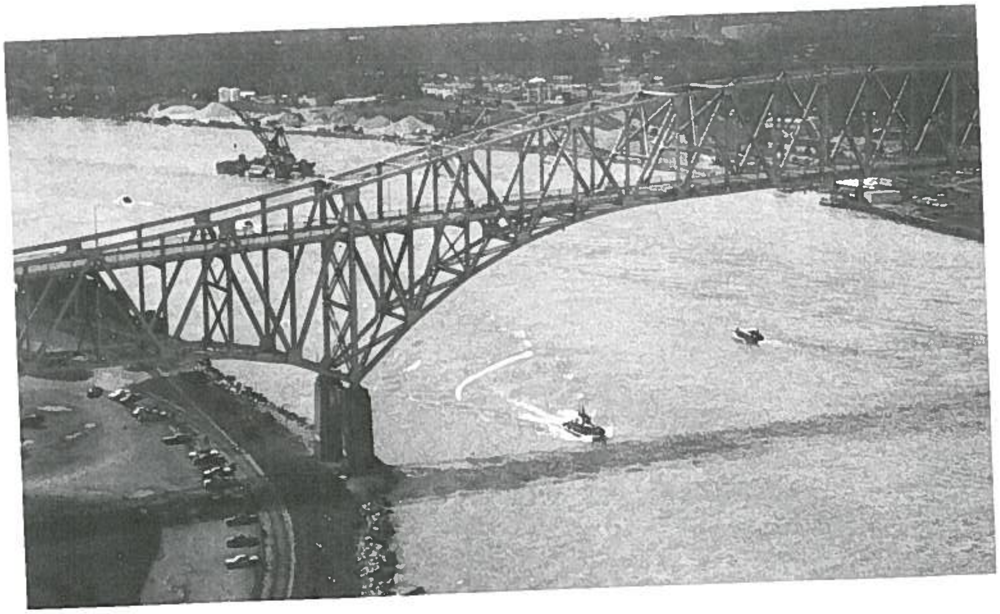
Temporary Traffic Regulations

These regulations were invoked on 5 June, the same day that the collision occurred. Initially passed to approaching vessels by radio, they were eventually promulgated in a Notice to Mariners. They were to remain in effect, with some modifications, until early October.

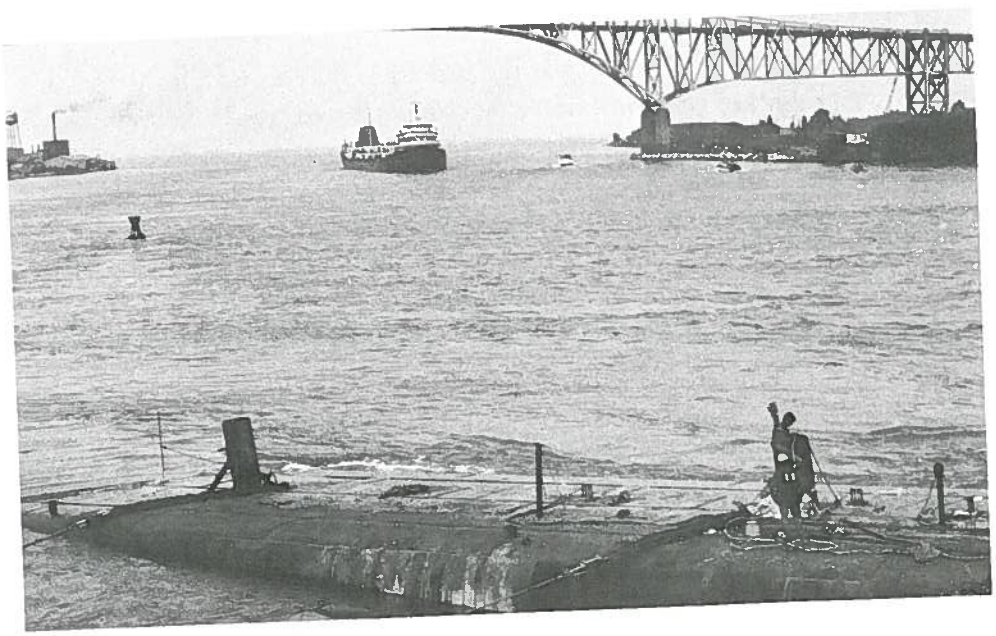
The key feature of these controls was the provision for one-way traffic passing the wreck area. Alternating periods of upbound traffic and downbound traffic were prescribed. The more difficult and dangerous downbound passage was permitted only during the daylight hours. Upbound traffic proceeded without interruption (at a regulated interval) during the hours of darkness, while downbound shipping was required to remain at anchor in Lake Huron, awaiting sunrise. During the day, periods of upbound and downbound traffic were alternated in an attempt to minimize a buildup of ships above or below the zone. Priority was often given the downbound traffic during the day to minimize the buildup at night.

Downbound passage through the wreck area was more hazardous than the upbound passage because in order to maintain bare steerageway, the downbound vessel had to make at least 3 or 4 mph through the water. This speed through the water, when added to the velocity of the current, caused the ship to approach the wreck at 10 to 12 mph, turning at the last possible moment to avoid the obstruction and negotiate the natural curvature of the channel. A strong northerly wind blowing out of Lake Huron made the turn even more difficult, combining with the swift current in setting the turning ship down onto the wreck. The upbound vessel, however, with a proper approach into the narrows, could transit the area rather slowly while maintaining sufficient steerageway by virtue of her speed through the water.

The first several days after the collision were particularly harrowing because the effect of passing vessels upon the SMITH's stability and structural integrity, as well as on oil seep-



Looking South (Downriver)



Looking North (Upriver) into Lake Huron

Salvage nest, just south of bridge, obstructs channel. Passing freighters, negotiating narrow, bending passage, posed constant threat to salvage force despite one-way traffic controls imposed by Coast Guard.

SALVOPS IN PROGRESS BELOW BLUE WATER BRIDGE

age, was unknown. Traffic had to be stopped a number of times as a precaution against possible hazards. Later, as experience was gained in controlling traffic in the wreck area, several refinements were incorporated in the initial regulations which facilitated vessel movement up and down the river.

Port Huron Control Center (PHCC)

To monitor traffic and traffic control procedures on the St. Clair River, the Port Huron Control Center (PHCC) was officially established on 19 June within the communications center of the small Port Huron Coast Guard station. The complement of regularly assigned station personnel was augmented by Coast Guard reserves. A round-the-clock watch bill was set up consisting of an Officer of the Day, and one enlisted radioman. A senior "traffic control officer" was also assigned to administer the PHCC and provide liaison with COE and COTP, Detroit. Portable radio equipment was brought in to back up existing equipment and extra telephone lines were installed to handle the increased communications traffic.

PHCC personnel were responsible for controlling traffic in the regulated zone and for observing and evaluating the efficacy of existing regulations. Since they could not visually monitor the flow of shipping in the regulated zone from within the communications center, the progress of each vessel approaching the zone was tracked by having the vessel report to the PHCC by radio from a series of prescribed check points. The vessels were obliged to observe "no passing" zones and maintain a proper interval. As each vessel neared the zone it was advised by the PHCC either to stand by or to proceed through the area.

IMPACT OF RIVER TRAFFIC ON THE SALVAGE FORCE

Threat of Downbound Freighters

The ships and barges transiting the channel, particularly the huge freighters, presented a serious threat to the salvage force. Each time that a downbound freighter passed under the Blue Water Bridge, it bore directly down on the salvors, veering at the last possible moment to avoid the wreck and negotiate the bend in the channel. The potential for a second and even more costly marine disaster remained high in spite of the traffic controls imposed by the COE and enforced by the Coast Guard.

The freighters often passed within 100 feet of the derrick barge salvage working platform. Several ships appeared to be out of control during their passage. On one occasion, a barge broke loose from one of its tugs and turned end for end while speeding past the wreck in the treacherous current. Throughout the removal operations, at least one Corps of Engineers tug stood by to render assistance which proved invaluable on several occasions. Divers

Huge freighters often came within 100 feet of salvage site. Danger was particularly acute from downbound ships.

PASSING FREIGHTER DWARFS WORKING SALVORS

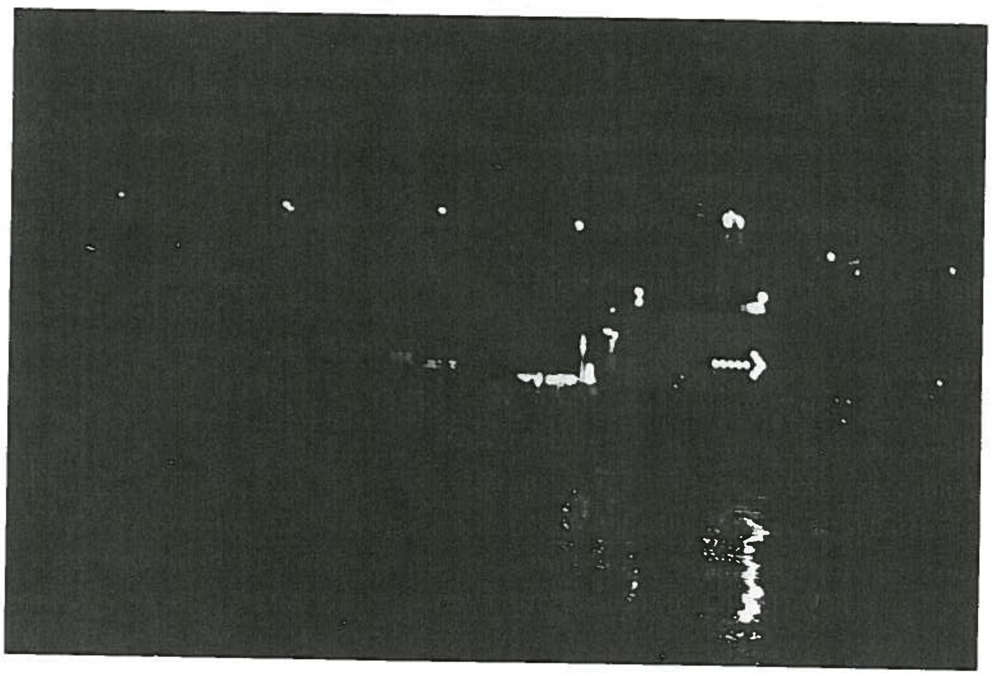
working within the submerged hulk were especially vulnerable. If a passing ship had hit the derrick barge and torn it loose from its moorings, they would have been in grave danger of being trapped without air.

Stern Removal Creates New Hazard

The salvage force cleared the SMITH's stern section from the channel on 6 August and turned its attention to the sunken bow section. Paradoxically, the removal of the stern section created new hazards. This section, although further out in the channel, had at least been visible much of the time. The bow section, totally submerged more than 20 feet below the surface, posed a formidable hidden threat to the passage of deep draft ships.

The obstruction buoy, maintained by the Coast Guard buoy tender, BRAMBLE, continued to mark the sunken bow. However, it seemed that this small buoy did not have the same visual and psychological impact as the 250-foot length of the stern rising out of the river. This situation was remedied on 16 August when the derrick barge was moored over the bow section. The barge, with its large crane, indicated the salvage site impressively. With removal operations being conducted 24 hours a day, the barge was always well lighted.

COE developed and issued instructions to cover the new situation. The Coast Guard incorporated these instructions in a Notice to Mariners on 7 August, explaining the circumstances at Port Huron and warning of the danger to shipping and small boat traffic arising



Derrick barge, principal platform for salvops, dominates salvage nest in mid-channel. Large blinking traffic arrows installed on barge to divert passing ships were especially effective at night.

DERRICK BARGE PROVES BEST MARKER OF WRECK SITE

from the wreck itself and from the removal operation. Ship traffic restrictions implemented earlier in the operation were continued.

Measures to Warn Ships and Divert Small Craft

Ships proceeding down river tended to stay well to the right in the channel thus passing closely by the wreck site. In addition, small craft frequently maneuvered between the derrick barge and the Port Huron shore, thus passing over the mooring lines. A large blinking traffic arrow was erected on the derrick barge on 16 August, directing all downbound traffic into the left of the channel, passing the barge on its outboard side. It proved so effective in highlighting the salvage site that a second arrow was procured 2 weeks later and placed on the other end of the barge facing the upbound traffic. The second arrow did not direct the upbound ships out of their normal transit lane, but was valuable in drawing attention to the mid-channel obstruction and instantly dispelling any possible ambiguity to proper traffic flow.

In addition, a line of international orange pennants was stretched between the barge and the beach as a further deterrent against crossing over the hidden mooring lines, especially to small craft which normally did not have to remain within the channel's boundaries. Floodlights were also used to make the pennants readily visible at night.

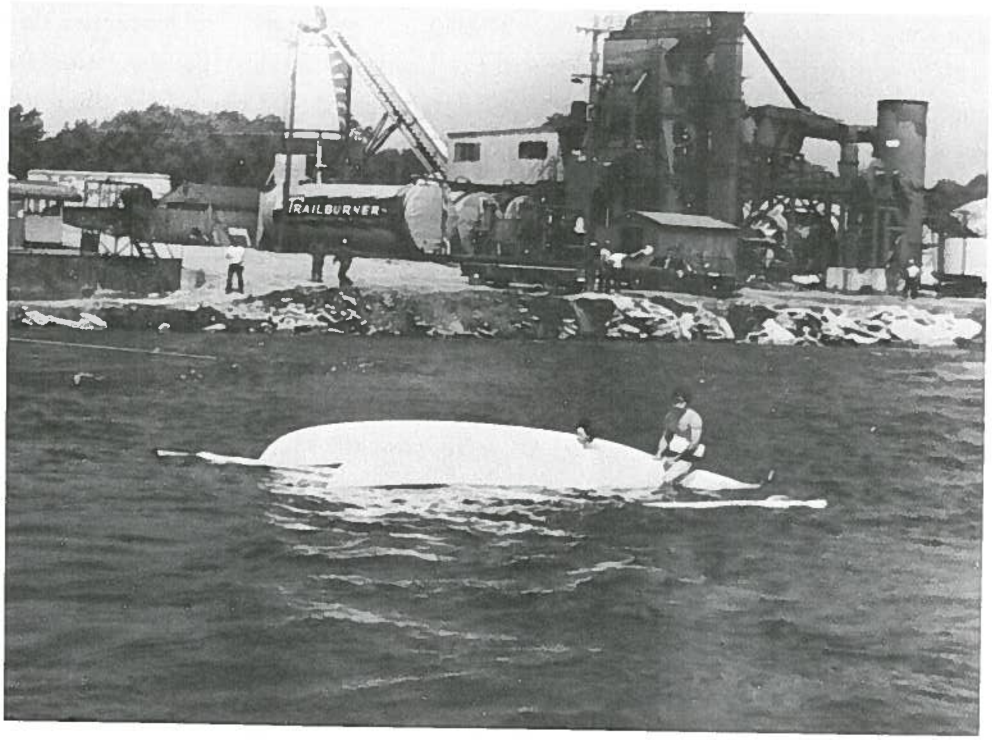
In spite of all the precautions taken by the salvors to prevent such incidents, several small craft, venturing too close, were carried by the swift current over the mooring wires or against the derrick barge itself. In one instance, a sailboat became lodged between an installed cofferdam and the barge. It swamped and was in imminent danger of being swept under the barge when a Coast Guard vessel extricated it. Fortunately, no one was injured in any of these small craft mishaps.

EFFECTS OF RESTRICTIONS ON SHIPPING TRAFFIC

Delays in Transit

The channel obstruction and the resulting temporary traffic control measures slowed the movement of ships through the regulated zone. At one point, early in the operation, as many as 80 large ships were forced to anchor in Lake Huron and in the river below the zone awaiting passage. Ships were anchored as far south as Western Lake Erie and Detroit. Later as a more effective control system was established, traffic proceeded much more smoothly.

The most common delays, caused by fog, would have occurred even without traffic control requirements. The buoy marking the wreck site was struck several times by passing ves-



Mooring wires and current made wreck area dangerous for small craft. Coast Guard imposed controls to divert craft from area. This one got too close.

MISHAP PROVIDES UNEXPECTED CLOSEUP VIEW OF SALVOPS

sels, requiring replacement or repositioning which also caused delays. Channel shippers estimated an average delay of 12 hours for each ship transiting the St. Clair River from the time of the collision until the wreck was removed.

Cooperative Efforts to Expedite Passage

COE and Coast Guard officials did everything possible to assure a safe and timely passage for the river traffic. Speed limits in the zone were revised by COE at 9 mph upbound and 12 mph downbound to assist with steerage of the vessels past the wreck. The PHCC expedited the passage by locating the anchorage areas for the waiting ships as close as possible to the restricted zone. As the last downbound vessel cleared the zone, the first upbound vessel was ready to move into the zone within a few minutes.

Cooperation by the shipping companies was excellent for the most part. The reduced shipping flow caused serious economic problems for them and for those industries dependent on the large freighters for movement of raw materials and products. However, the Coast Guard's traffic control efforts were a significant factor in minimizing the disruption to normal commerce on the river. During the most restricted period, 5 June - 4 October, a total of 6,300 vessels safely negotiated the hazardous passage.

NEW TRAFFIC CONTROLS UPON REOPENING OF CHANNEL

Modified Control Procedures, 22 September - 4 October

The SMITH's bow section was finally removed on 22 September, clearing the channel and paving the way for the implementation of permanent control measures. Before lifting the temporary regulations, it was necessary to verify that the channel was, in fact, clear of all obstructions to its charted depth. The Corps of Engineers surveyed the river bottom during the period 22-25 September for this purpose. The bottom was checked by a sweeping survey with a specially rigged barge. The barge, maneuvered by a pair of tugs, was directed along a grid pattern by a survey team with a pair of transits on the beach. No underwater obstacles were located. Depths recorded during the survey equaled or exceeded charted depths throughout the area.

The obstruction buoy was removed on 25 September, providing once again a full 800-foot wide river channel. The Coast Guard then continued to control river traffic for several days maintaining the one-way traffic restriction in the regulated zone. Downbound shipping, however, was no longer restricted to daylight-only passage through the zone. Downbound and upbound traffic was alternated day and night at the descretion of the traffic control officer.

New Permanent Traffic Regulations, 4 October

The Corps of Engineers established new traffic regulations on 4 October, featuring voluntary controls by ships' masters. The elevated speed limits (9 mph upbound, 12 mph downbound) were retained for improved steerageway. In the area of the Blue Water Bridge, the one-way traffic restriction became a permanent traffic control measure, intended to preclude meeting situations in this narrow stretch of the channel. This restricted area, about 1 1/2 miles long, stretches from just south of the Port Huron Water Filtration Plant to about 1/2 mile out into Lake Huron.

Ships approaching the bottleneck from above and below the Blue Water Bridge were to coordinate their movements by radio communications to ensure that at no time would the regulated zone contain both an upbound and a downbound vessel. Normally, the downbound vessel would transit the zone first. The zone, itself, was to be an area of no meeting, passing, coming about, or overtaking.

Follow-up by Coast Guard

The Coast Guard, after publishing COE's new permanent regulations in a Notice to Mariners on 4 October, terminated direct traffic control operations by its Port Huron Control Center the same date. Coast Guard personnel remained on scene after 4 October to monitor the flow of traffic and to evaluate the new traffic control procedures. The ships' masters accepted the responsibility for maintaining one-way traffic and, in general, the traffic flowed quite smoothly. Throughout the remainder of the SIDNEY SMITH scrapping/refloating operations, direct traffic control was resumed only on those rare occasions when the channel became heavily congested. After a reasonable period of time to adjust to the new regulations, the Port Huron Control Center was disestablished.

CHAPTER 4
ORGANIZING THE SALVAGE EFFORT

ROLE OF THE CORPS OF ENGINEERS

COE's Statutory Responsibility for Federal Navigation Channels

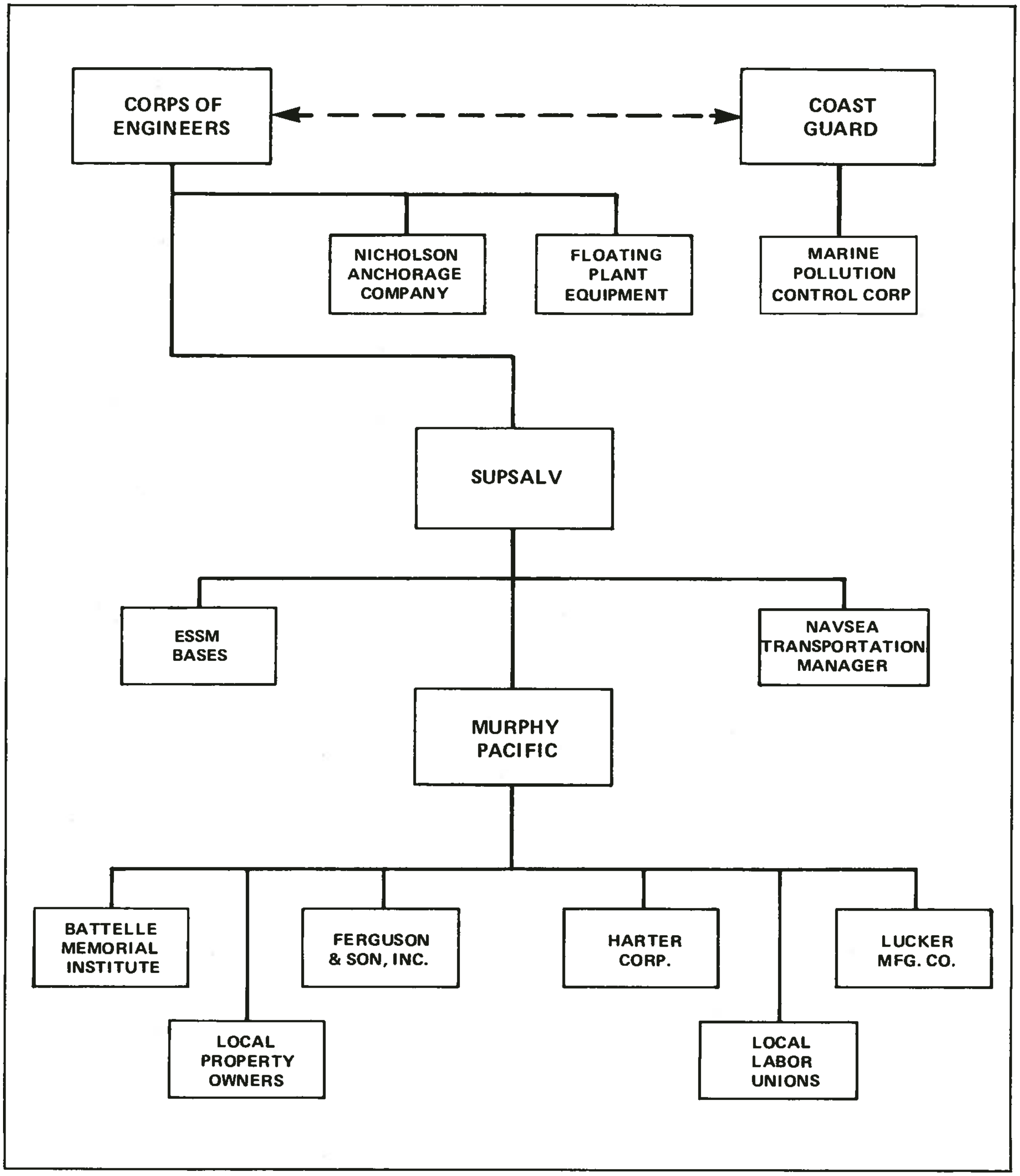
The Corps of Engineers (COE) is responsible for the construction and maintenance of federal navigation channels. This role of the Corps, with roots grounded deeply into the history of the United States, is formally assigned in federal legislation, the Rivers and Harbors Act of 1899, now codified into federal law in Title 33, U.S. Code. It includes responsibility for removal of obstructions from such channels.

The Corps' role in no way lessens or replaces the legal and financial obligations of the ship's owner when a wreck occurs, obstructing a federal navigation channel. The owner is fully responsible for marking the obstruction, removing the wreck and associated tasks. This responsibility remains, whether or not the Corps takes over the actual work. The Corps assumes direct control of wreck removal only when the public interest demands it. For example, there may be compelling reasons of urgency and safety involved which require the Corps to do the job itself.

Thus, when a wreck occurs, the owner is expected to assume responsibility for its removal, and the Corps proceeds initially on this basis, assisting him in every way possible. In the past, some owners have not taken the necessary action, anticipating that it would be less costly to them if the Government removed the wreck. However, a 1967 Supreme Court ruling established a precedent which allows the Government to recover removal costs from the owners of a sunken obstruction. Prior to this time, the Government could generally anticipate recovery of only a portion of the removal costs through the sale of the obstruction as scrap. Since 1967 this provision for Government recovery of costs has served as an incentive for owners to remove their ships from the wreck sites.

COE Assumes Direction of SMITH Removal

The St. Clair River Channel is a federally controlled shipping lane. Accordingly, when the SMITH sank, obstructing the channel, it became the responsibility of the COE District



Corps of Engineers, with statutory responsibility for river clearance, directed the overall effort. SUPSALV exercised operational control of salvage operations. Civilian contractors provided extensive salvage services and support.

ORGANIZATION CHART – SMITH SALVAGE OPERATIONS

Engineer at Detroit, Michigan, to see to it that the wreck was removed from the channel promptly and properly. At the outset, it was anticipated that the SMITH's owners, the Erie Sand Steamship Company, would perform the work. The company's representatives arrived at Port Huron quickly and solicited proposals from commercial salvors for removal of the wreck.

It became apparent within a few days after the collision that a major salvage effort would have to be mounted to remove the wreck from the channel. The SMITH had broken in two sections, and moreover, its condition continued to deteriorate. Of even greater concern to COE was the necessity for speed of response in undertaking the salvage task. It was imperative to get the removal effort under way as quickly as possible. A prolonged delay would not only further the disruption to shipping traffic but also increase the already grave danger of a second collision in the channel. COE representatives elected to review with the SMITH's owners the proposals received in order to evaluate their technical adequacy for the problem at hand.

In mid-June, with the wreck's condition worsening, the Erie Sand Steamship Company came to the conclusion that it would be in the company's interest to abandon the SMITH rather than pursue the task of wreck removal. The company submitted a letter of abandonment to the Corps of Engineers on 20 June. Although the Corps was now to assume direct control of the removal effort, it did not acknowledge the abandonment because it did not consider that the circumstances warranted releasing the SMITH's owners from their financial responsibility for removing it.

Although the proposals of the commercial salvors remained under active consideration, COE had begun developing other options prior to 20 June, including the use of its own salvage resources and those of the U.S. Navy's Office of the Supervisor of Salvage. SUPSALV representatives prepared a proposed salvage plan at COE's request, illustrating how the Navy's resources and techniques could be applied to solve the problem. After thoroughly evaluating the various proposals and options, the Detroit District Engineer announced on 23 June that SUPSALV would undertake the SMITH removal effort under the overall direction of the Corps of Engineers. Key factors in the COE decision were the urgency and complexity of the salvage task, the resources immediately available from SUPSALV and the technical superiority of the Navy's proposed salvage plan.

Background of COE Request for SUPSALV Services

SUPSALV first became involved in the SMITH operation on 6 June, the day after the SMITH/EVANS collision, when the Corps of Engineers requested a salvage specialist to serve as an advisor to COE on salvage matters. Two SUPSALV representatives proceeded immediately to Port Huron, surveyed the wreck site and met with the COE Detroit District Engineer.

DOCUMENTATION OF ADVANCE PAYMENT TO CONTRACTOR

Major salvage operations may require immediate financing beyond resources of contractor salvor. SUPSALV arranged advance payment to Murphy Pacific for SMITH operation.

DOCUMENT	PROVISION
TITLE 10, U.S. CODE "Armed Forces"	". . . §7364. Advancement of funds for salvage operations The Secretary of the Navy may advance to private salvage companies such funds as he considers necessary to provide for the immediate financing of salvage operations. These advances shall be made on terms that the Secretary considers adequate for the protection of the United States. . . ."
CONTRACT N000-24-71-C-0234 Department of the Navy and Murphy Pacific Marine Salvage Company	". . . Advancement of Funds. Pursuant to the provisions of 10 U.S.C. 7364 the Government may, on such terms as it deems appropriate, advance funds to the Contractor with respect to a specific task under this contract. . . ."
AUTHORIZATION By Department of the Navy for advance payment to Murphy Pacific	". . . the salvage effort is literally a race against time and a twenty-four hours a day, seven days a week chore. Under this maximum effort, the Contractor's working capital is inadequate to finance the removal of the wreck in addition to other company operations. c. An advance payment not to exceed $850,000 is required by the Contractor in order to perform the required salvage operation on a maximum effort basis without impairment. Such an advance payment will facilitate the national defense and is in the public interest. . . ."

the scope and complexity of the SMITH salvage effort, advance payments were authorized to support the work of SUPSALV's principal salvage contractor, the Murphy Pacific Marine Salvage Company.

Advantages of Using SUPSALV Resources

There were several advantages to the Corps of Engineers in using SUPSALV resources. By so doing, the Corps obtained not only the use of the Government's salvage specialists but also the services of SUPSALV's incumbent salvage contractor, the Murphy Pacific Marine Salvage Company (MYPAC).

MYPAC, one of the nation's leading commercial salvage firms, had been awarded the Government salvage contract on the basis of competitive bidding. Thus, when the Corps of Engineers gave SUPSALV operational control of the SMITH removal effort, SUPSALV, in turn, tasked this company to provide personnel, equipment, and services as directed by the

Navy On-Scene Commander. In terms of timeliness of response, SUPSALV's standing contract with MYPAC for marine salvage offered an obvious advantage over normal contractual arrangements involving lengthy bidding and negotiation procedures.

A major asset in itself is the intimate knowledge of the ocean engineering, diving and marine salvage communities that is available within the Office of the Supervisor of Salvage. As a nerve center of national and international marine salvage activity, this office maintains close liaison with the vast array of Government agencies and civilian firms that comprise these communities. Utilizing its extensive contacts, it can quickly marshal scientific and technical resources as the need arises. Thus, in the SMITH operation, when Murphy Pacific's foam engineers required assistance with foaming problems, SUPSALV committed experts from the Battelle Memorial Institute, Columbus, Ohio, to analyze the foam content and devise innovations to the foam delivery system to improve its output.

MOBILIZATION OF SALVAGE RESOURCES

Equipment requirements were developed during the 23 June planning conference and a bill of materials was prepared. It was decided that whenever feasible, equipment would be obtained from existing Government sources and shipped to the salvage site by Government carrier. Those services and equipments which were not readily available through existing Government channels or from standing contractor assets, would be procured from commercial sources by the Corps of Engineers and Murphy Pacific.

Emergency Ship Salvage Material (ESSM) Bases

Most standard items of salvage equipment (welders, compressors, generators, chain, wire, shackles, etc.) were drawn from a number of the strategically located SUPSALV "Emergency Ship Salvage Material" (ESSM) bases. Logistics specialists at the Office of the Supervisor of Salvage in Washington reviewed the bill of materials and arranged for the release and shipment of ESSM gear as required. Assisted by the NAVSEA transportation manager, these specialists also arranged for the shipment of designated equipment from commercial sources and took the necessary actions to expedite mobilization of equipment.

Corps of Engineers' Equipment and Services

The Corps of Engineers provided a large derrick barge, dubbed the Big D by the salvage force, as the principal support platform for the salvage effort. The barge's key capability was

Versatile barge provided large stable platform for salvops and heavy lift capability with huge, 60-ton crane. Barge, shown here moored to stern section, supported all phases of the operation. Salvors dubbed it the "Big D."

CORPS OF ENGINEERS' DERRICK BARGE, PRINCIPAL WORK PLATFORM FOR SALVOPS

a 60-ton crane which handled the installation of major items of salvage equipment, such as hatch covers, divers' access tubes and cofferdams. Deck space on the barge was used to stage the urethane foam delivery systems, with their heavy, bulky aerosol tanks containing the foam's chemical components, and other items of salvage equipment such as air compressors. The derrick barge provided a large, stable platform for diving, foaming, rigging of equipment and other salvage tasks. It was to become a familiar sight in the St. Clair River Channel over the next several months, moored at the wreck site and transporting equipment and supplies to and from the salvage base ashore.

In addition to the derrick barge, the Corps provided other support vessels, including several river tugs and a small barge. Through its Detroit District Office, the Corps also provided various accessory equipment and services such as soils investigation, chemical ("gas free") analysis, and a full-time surveying crew. The Corps also contracted with the Nicholson Anchorage Company of Bridgeville, Pennsylvania, for the design, fabrication, and installation of the anchoring system for the powerful hydraulic pullers.

U.S. Coast Guard Support of the Salvage Effort

The U.S. Coast Guard Station at Port Huron provided all traffic control and oil pollution abatement services in connection with the SMITH removal operation. The station's personnel and material resources had been augmented shortly after the sinking to organize the Port Huron Control Center for coordination of the upbound and downbound movement of ships and dispatching river patrols as required. The Coast Guard buoy tender, BRAMBLE, positioned and maintained an obstruction buoy which marked the wreck site as a navigational hazard. The Control Center issued appropriate "Notices to Mariners" to advise the ships transiting the St. Clair River of the navigational hazard. The Coast Guard National Response Team directed the Marine Pollution Control Corporation, a local oil pollution abatement contractor which had removed the SMITH's bunker oil shortly after the sinking, to return periodically to the wreck to remove pockets of residual oil which seeped from the ship's tanks into the engine room and adjacent compartments.

Salvage Role of Murphy Pacific (MYPAC)

Murphy Pacific provided salvage services and equipment as directed by the Navy On-Scene Commander. MYPAC's salvage specialists assisted the SUPSALV team in developing and implementing the salvage plan. The company's foam engineers provided, maintained and operated the urethane foaming equipment. MYPAC also procured the foam's chemical components from the Olin Mathieson Chemical Corporation, Cleveland, Ohio.

MYPAC contracted with the Harter Underwater Construction Corporation, Annapolis, Maryland, to provide all diving services. During the long months of salvage operations, these Harter divers were to perform critical underwater work in the SMITH's cargo holds, machinery spaces, and fuel and ballast tanks. The Harter divers proved extremely competent and professional. The diving team which first reported for duty on 26 June was retained throughout the operation. Retention of the same diving team was preferable to rotating different teams because it eliminated the need for orienting unfamiliar divers during crucial phases of the operation.

Hatch covers, cofferdams, and other special items of equipment were provided by Murphy Pacific through a steel fabrication subcontractor, James G. Ferguson and Son, Inc., of Port Huron. The Lucker Manufacturing Company of Philadelphia, Pennsylvania, was contracted for the design and fabrication of the hydraulic pullers used to haul the wreck sections from the river channel.

Murphy Pacific also made arrangements with local labor unions to procure the services of "pile bucks" and operating engineers as required. Pile bucks are versatile skilled laborers who are qualified in rigging, carpentry, cutting, welding, and other aspects of marine construction. These pile bucks comprised the bulk of the salvage force at Port Huron. Operating engineers were required periodically to operate cranes, bulldozers, and other heavy equipment on the job. Several other contracts were also made locally for office trailers, telephones, electricity, and other commercial equipment and services.

To accommodate this equipment, plus the pulling and anchoring systems, real estate was leased along the bank of the St. Clair River from the Blue Water Asphalt Company and the Peerless Cement Company. These firms moved their stockpiles of sand and gravel to make room for the salvage equipment. Attorneys from Murphy Pacific's New York office later finalized leasing and "hold harmless" (accident liability) agreements with the two companies and with the Grand Trunk Western Railroad Company which owned much of the riverfront property along the riverbank. Under a "hold harmless" arrangement, the owner of the property is not liable in any way for any action of the salvor.

ORGANIZATION OF THE SALVAGE FORCE

SUPSALV-COE Relationship

The Supervisor of Salvage was to remove the SIDNEY SMITH from the St. Clair River Channel for the Corps of Engineers on a cost-reimbursable basis. The working agreement between the two Government agencies was in many ways a typical customer-salvor relationship.

PRINCIPAL PARTICIPANTS IN SMITH SALVAGE OPERATIONS

AGENCY	MAJOR ROLE
US Army Corps of Engineers (COE), Detroit District	Responsible for overall wreck removal and provided all floating assets and various accessory equipment and services.
US Navy Office of Supervisor of Salvage (SUPSALV)	Operational control of salvage operations to remove the sunken SMITH from the river channel and prepare the hulk for disposal at a remote site.
US Coast Guard (CG) Port Huron, Mich.	Responsible for pollution abatement, traffic control, buoy maintenance, and issuance of appropriate "Notices to Mariners."
Murphy Pacific Marine Salvage Company (MYPAC) New York City	Under a Supervisor of Salvage contract, provided salvage services and equipment as directed by the on-scene SUPSALV representatives.
Harter Underwater Construction Corporation (Harter), Annapolis, Md.	Under a Murphy Pacific contract, provided all diving services for the SMITH salvage operation.
Nicholson Anchorage Company Bridgeville, Pa.	Under a Corps of Engineers contract, installed anchors and platforms for on-shore hydraulic pulling system.
Lucker Manufacturing Company, Philadelphia, Pa.	Under a Murphy Pacific contract, manufactured four 40-ton and two 100-ton hydraulic pullers for on-shore pulling system.
Emergency Ship Salvage Material (ESSM) Bases	Strategically located supply bases operated by SUPSALV provided most standard items of rigging and salvage equipment.
Battelle Memorial Institute Columbus, Ohio	Consulted with Murphy Pacific on urethane foam quality problems.
James G. Ferguson & Son, Inc., Port Huron, Mich.	Under a Murphy Pacific contract, fabricated steel hatch covers, cofferdams, installation guides, flounder plates, and other special equipment and fittings.

It was, however, a relationship conceived, primarily, to expedite wreck removal and, secondarily, to minimize cost through extensive use of Government assets. The Supervisor of Salvage retained responsibility for all aspects of Navy participation. He maintained close contact throughout the operation with his Army counterpart, the COE Detroit District Engineer.

Assignment of Key Personnel

The Corps of Engineers assigned a COE Resident Engineer and the Supervisor of Salvage assigned a Navy On-Scene Commander. Operating from a joint Army-Navy command post ashore, these two officials coordinated all aspects of the salvage operation.

The Senior Salvage Master from the Office of the Supervisor of Salvage functioned as Salvage Master for the operation. An Assistant Salvage Master was appointed from the Murphy Pacific Marine Salvage Company. The Salvage Master had day-to-day, direct responsibility for executing salvage operations.

Organizational Functioning

The SMITH removal effort involved the participation of Army, Navy, and Coast Guard agencies and an unusually large number of civilian contractors, either participating directly in the operation or furnishing equipment and services. These many diverse groups were extremely well integrated into a smoothly run operation. This was possible through the selection and use of experts, not only in operational areas such as diving and salvage, but the support areas as well. Legal experts handled such tasks as leasing of real estate at the salvage site; financial specialists established an efficient system for ensuring the proper flow of money throughout the long and expensive operation; and an effective public affairs and media relations effort was carried out by experts in that field. The joint procedures established by COE and SUPSALV proved very effective in coordinating the operational and administrative aspects of the salvage effort.

KEY PERSONNEL IN SMITH SALVAGE OPERATIONS

US ARMY CORPS OF ENGINEERS	
Detroit District Engineer	Col. Myron Snoke, USA
COE Resident Engineer	Mr. Fred Smith
US NAVY OFFICE OF SUPERVISOR OF SALVAGE	
Supervisor of Salvage, US Navy	Capt. E. B. Mitchell, USN
Navy On-Scene Commander	Cdr. Robert Moss, USNR
Salvage Master	Mr. Earl Lawrence
Assistant Salvage Master	Lt. Craig Mullen, USNR
Salvage Engineer	Mr. Jerry Totten
US COAST GUARD	
Captain of the Port, Detroit	Capt. F. H. Raumer, USCG
Port Huron Traffic Control Officer	Lcdr. G. Crane, USCGR
MURPHY PACIFIC MARINE SALVAGE COMPANY	
Vice President, Merritt Division	Mr. Peter Barracca
Salvage Master	Capt. Robert McKenzie
Systems Engineer	Mr. Dwain Aasved
HARTER UNDERWATER CONSTRUCTION CORPORATION	
President	Mr. John Harter
Operations Manager	Mr. Keith Moore
NICHOLSON ANCHORAGE COMPANY	
President	Mr. Peter Nicholson
LUCKER MANUFACTURING COMPANY	
President	Mr. Lawrence Lucker
BATTELLE MEMORIAL INSTITUTE	
Consultant	Mr. Arthur Coyle
JAMES G. FERGUSON & SON, INC.	
General Manager	Mr. John Campbell

CHAPTER 5
PLANNING FOR REMOVAL OF THE STERN SECTION

The salvors planned to lighten the stern section in mid-channel with urethane foam and then pull it clear of the channel with a system of hydraulic pullers. In order to implement these plans it was first necessary to prepare the hulk for foaming operations and to rig it for pulling. A major effort would also be required ashore to develop and install the hydraulic pulling system. In view of the urgency of clearing the channel, the salvors planned to proceed concurrently with the mid-channel and on-shore preparations.

PREPARING THE HULK FOR FOAMING

Apart from installation of the foam delivery system, itself, three other key tasks were identified by the salvage planners as prerequisites for the conduct of foaming operations. Hatch covers had to be installed to seal the open cargo holds. Access tubes had to be inserted into the cargo holds from topside to provide the divers with a means of entering and exiting these spaces for foaming operations. Finally, it was necessary to remove as much debris as possible from the cargo holds before installing the foam.

Design and Fabrication of Hatch Covers

The cargo holds in the SMITH's stern section were targeted as the principal underwater spaces to be foamed. These cargo holds were open to the river as their hatch covers had been dislodged when the ship capsized. Before foaming or other underwater work could begin in these spaces, it would be necessary to design, fabricate and install new hatch covers. The open hatches had to be covered, not only to contain the installed foam within the holds, but also to shield these spaces from the force of the river current. Foam must be installed in relatively still water in order to provide the proper buoyancy. The hatch covers would also provide shelter from the current for the divers working under water in the holds.

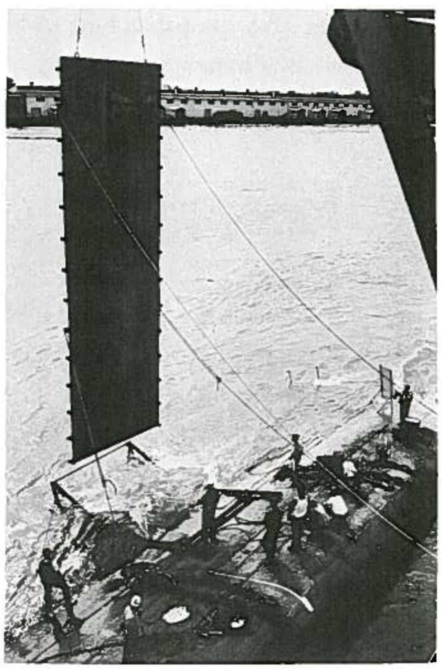
Drawings and specifications for new hatch covers were prepared by the salvors at the salvage site. The hatch covers were designed to slide over the existing hatch coamings. Each cover consisted of a 12-foot by 40-foot by 1/4-inch steel plate, with transverse stiffeners of channel stock welded to the plate. L-shaped steel clips were welded along the two longitudinal edges of the plate for alignment under the lip of the hatch coaming. Drawings and specifications were delivered to the Ferguson Steel Company at Port Huron on 25 June for fabrication of six hatch covers.

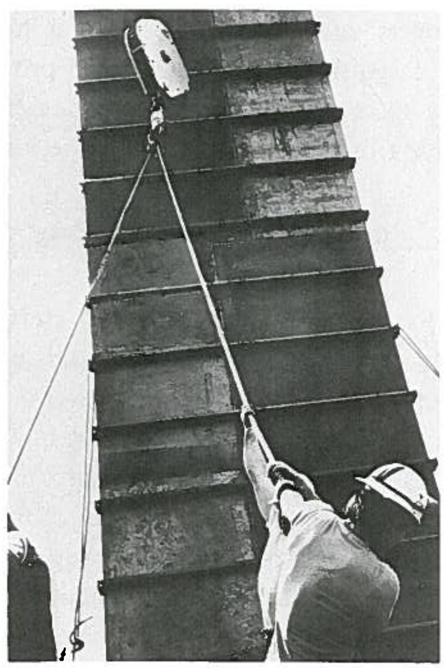
Diver Access Tubes

In order to install the urethane foam, it would be necessary for a diver to operate the foam gun inside the stern section's underwater compartments. Diver access tubes were incorporated in the plan for mid-channel operations to provide a means for the diver to enter and leave the compartments. These tubes of steel pipe, 60 feet in length with a 30-inch diameter, contained three "windows" which provided for diver exit from the tube at three different levels in the compartment being foamed. Divers would install foam in the compartment from the top down. When the compartment was completely foamed, the diver would reenter the bottom window and return topside through the access tube.

Removal of Debris from Cargo Holds

The salvors estimated that large quantities of coal still remained in the SMITH's holds. They also assumed that the strong river current had washed a substantial amount of sand





Hatch covers, 40′ by 12′, were designed to slide over SMITH's existing hatch coamings to seal cargo holds for foaming. Each cover is ¼″ steel plate, reinforced with transverse stiffeners.

HATCH COVERS – REQUIRED FOR STERN SALVOPS

and gravel into the wreck. Provisions had to be made to remove as much of this debris as possible before foaming the cargo holds. Removal was essential, not only to reduce the submerged weight of the vessel, but also to create the maximum possible space for installing the foam.

It was considered that some of the coal could be "washed" from the holds by using high pressure water jets. This work could be initiated prior to installation of the hatch covers. Once the hatch covers were in place, the remainder of the coal and other debris could be removed with airlifts. Both of these procedures were incorporated into the salvage plan.

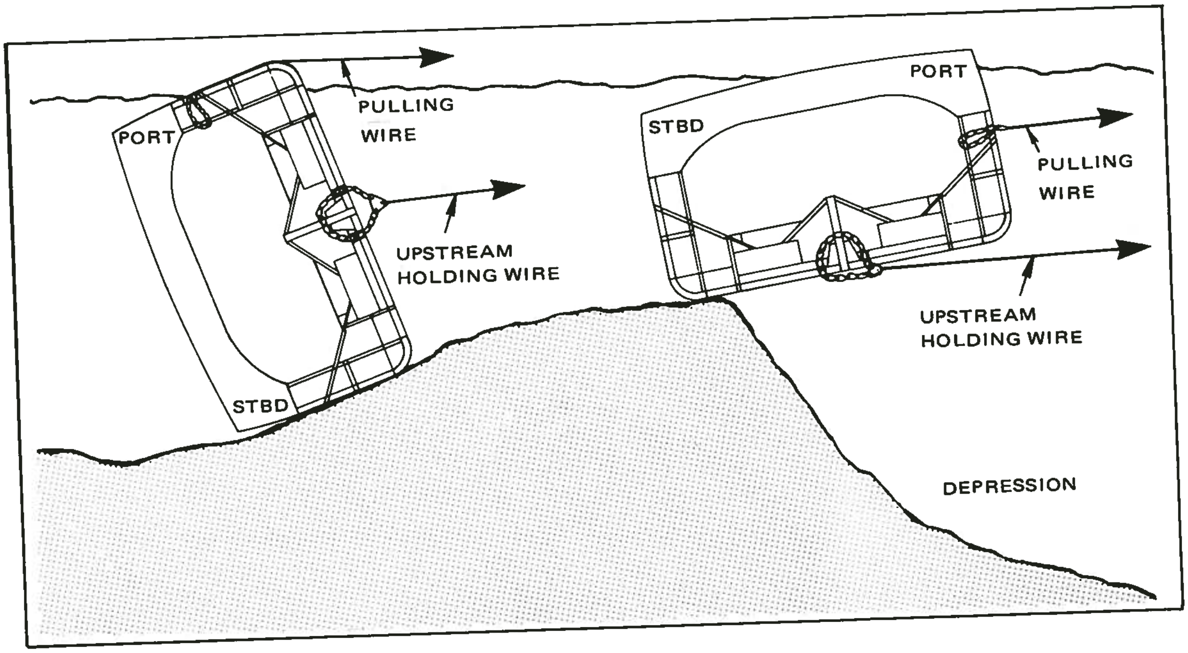
Considerable additional work would have to be accomplished in the cargo holds and other foaming spaces in preparation for installing the foam. Possible foam escape routes had to be sealed. Access and exit holes for the divers had to be burned in restricted areas. Each foaming space had to be methodically prepared by the divers before foaming could begin in that space.

PREPARING THE HULK FOR PARBUCKLING AND PULLING

Pull points for the wires from the hydraulic pullers ashore had to be rigged at key locations on the stern section. The selection of pull points was influenced by the requirement for parbuckling the hulk prior to pulling it from the channel.

Requirement for Parbuckling

It had been estimated initially that the lightened stern section could be hauled to the beach on its starboard side. However, as operations got underway, it became evident that parbuckling in mid-channel would be required. The depth of the water in which the stern lay and the varying depth along the path of retrieval made parbuckling to an upright position essential. On its way to shore, the stern section would first have to pass over a ridge only 23 feet beneath the water's surface and then across a depression nearly 90 feet deep. The SMITH's beam was 52 feet; her molded depth 30 feet. If pulled across the shallow ridge on the starboard side, approximately half of the total volume of the stern section would be out of the water, resulting in excessive ground reaction. If parbuckled to an upright position prior to retrieval, the stern section would cross the ridge with just several feet of the hull exposed and more than 75 percent of its total volume displacing water, if completely foamed.



Parbuckling was required in order to clear stern section over ridge on river bottom impeding path toward shore. Upright position would also facilitate control of shoreward movement across deep depression.

USE OF PARBUCKLING IN STERN RETRIEVAL STRATEGY

The increased buoyancy and decreased ground reaction, resulting from more complete immersion, would enable the pullers to move the stern section across the ridge in the upright position. It would also be easier to control the hulk during the subsequent shoreward movement across the depression.

In addition, parbuckling would provide access to spaces previously inaccessible for foaming. After righting the stern, divers could reenter it and install more foam if necessary. This opportunity for additional foaming was important. The salvors did not want to attempt the pull across the deep depression without assurance that the wreck was sufficiently lightened. Parbuckling would greatly increase the flexibility of the foaming plan.

Parbuckling would also simplify the beaching effort by rolling the stern section out of its scoured depression and starting it toward the beach. However, it also meant that the fully buoyant force of much of the installed foam would be exerted directly against the installed hatch covers rather than the port side of the ship. Thus, it later became necessary to reinforce the hatch covers beyond the original design.

The salvors also foresaw that if the hulk were parbuckled, it could be held against the ridge with hydraulic pullers, prior to the final pull to shore. With tension maintained on the pulling wires, the combination of the shoreward pulling force and the buoyant force of the installed foam would hold the hulk snugly against the slope. The stern section would thus be in a reasonably stable position for installation of additional foam as required.

The contour of the bottom near the wreck site was, of course, continually changing due to the scouring action of the current around the SMITH's hull. A survey team, provided by the Corps of Engineers, was assigned to monitor these changes by making periodic depth measurements with a depth-finding sonar, both around the wreck and along the planned path of the shoreward pull. Studying the contour data compiled by this team, the salvors concluded that, if the parbuckled stern section were held firmly against the slope, the current would eventually wash away the peak of the ridge, thereby eliminating the initial resistance to the shoreward pull. As a backup method for clearing away the obstruction, a clamshell bucket was placed aboard the derrick barge.

Rigging of Pull Points on the Stern Section

The pulling stations to be established on shore included two 100-ton hydraulic pullers and four 40-ton hydraulic pullers. It was necessary to rig pull points on the stern section for attaching the pulling wire from each of these pullers. The pull points would be rigged by securing heavy (2 1/4-inch) anchor chains around selected structural members and shackling the bitter ends of each chain loop to a flounder plate. The bitter ends of the pulling wire would then be attached to the flounder plate, completing the hookup to the hydraulic puller.

It was decided to rig the pull points for the 100-ton pullers around the keel since this was the strongest structural member. These two pullers, stationed upstream from the wreck, were to provide the holding force during the righting and pulling operations. It had been planned initially to rig pull points for the 40-ton pullers around the keel in the same manner. However, with the requirement for parbuckling, it became necessary to rig these pull points high on the port side of the hulk to provide a righting moment. Accordingly, the chains for the four smaller pullers would be rigged to transverse strength members evenly spaced on 24 -foot centers in the cargo holds.

In each case, it would be necessary for divers to enter the capsized wreck through the exposed port skin, topside, to accomplish the rigging. Access holes to admit the chains for the keel pull points would have to be burned through the ship's bottom. For the other pull points, the chains would be passed through holes burned through the port skin from topside.

PLANNING CONSIDERATIONS FOR FOAMING OPERATIONS

The employment of urethane foam in the SMITH salvage operation was essentially a new experience for Navy salvors. Foam had been used once before in 1965 to salvage the destroyer USS FRANK KNOX from a stranded position. The SMITH salvage, however, marked the first major underwater application of this technique.

See Appendix C for a detailed treatment of the use of urethane foam as a salvage tool and its applications in foaming the SMITH's stern and bow sections. Highlights are covered here and in succeeding chapters of the main body of the report.

Selection of Urethane Foam as Lightening Agent

The stern section had to be lightened before it could be pulled to shore. Lightening was required in order to reduce the hulk's submerged weight (ground reaction) to within the capability of the hydraulic pullers to be installed on shore. Urethane foam was selected as the principal lightening agent because it offered several advantages over the traditional method of dewatering by pumping or with compressed air. The extensive patching normally required for pumping and air blowing operations could be largely eliminated. In addition, introduction of the foam could improve the structural integrity of the hulk. Little was known about the structural damage resulting from the collision. The use of urethane foam provided the salvors with the flexibility to work around nearly any possible structural damage.

The key characteristic of urethane foam is its extremely low density as compared with water. A given volume of foam introduced into a flooded compartment will displace the same volume of water. The foam has a cellular structure, consisting of a mass of tiny, gas-filled cells held together in a solid matrix. Each cubic foot of foam can produce a net gain in buoyancy or added flotation force of approximately 60 pounds.

Selection of Aerosol Foam Delivery System

The salvors decided to use an aerosol delivery system for foaming the stern section. The aerosol system is a low pressure system for use at shallow depths. The stern section was only partially submerged and its underwater compartments were well within the depth limitations of the aerosol system. As its name suggests, the aerosol system is pressurized by nitrogen gas in the containers of the foam components. This feature makes the system simple and economical to operate as compared to more elaborate systems which use mechanical pumps to generate higher system pressure for foaming at greater depths.

Salvage estimates indicated that a large quantity of foam would be required to lighten the hulk sufficiently to pull it ashore. The anticipated size of the job imposed a requirement for large, 10,000-pound aerosol tanks for storing the foam's chemical components, isocyanate and polyol. Arrangements were made with the Olin Mathieson Chemical Corporation to provide these components, each preblended at the factory with the prescribed proportions of liquified fluorocarbons, surfactants and catylists. Preblending requires that each tank be pressurized with nitrogen at the factory in order to maintain the fluorocarbon (freon) in a liquid state. Additional nitrogen is introduced into the tanks at the salvage site to maintain system pressure during the delivery of the chemicals to the foam gun.

Provisions for Installing the Foam

There was ample space aboard the derrick barge for setting up the foam delivery station. Requirements for the station, itself, were very simple, consisting merely of the pair of aerosol tanks with each tank connected to its respective nitrogen supply and also to its delivery hose which, in turn, led to the foam gun. Each delivery hose had a flow meter, flow control valve and pressure control valve for measuring and controlling the flow of the liquid chemical and maintaining system pressure.

It was anticipated that most of the foam would be emplaced by a diver operating the foam gun from within an underwater compartment. The diver access tubes were to be inserted into the stern section's cargo holds for this purpose. However, the salvors also made provisions to use the probe method of foaming where feasible. In the probe method, the foam is emplaced from a point outside the compartment, using a pipe attached to the foam gun. In both the diver method and probe method, emphasis must be placed on foaming the compartment from the top down, keeping the nozzle of the foam gun buried in the unhardened, freshly poured foam as the work progresses downward. This technique minimizes foam/water contact during installation, a necessary procedure because excessive contact adversely affects the buoyancy of the foam.

Estimates of Foam Quantity and Quality

Foam buoyancy is the product of the weight of foam chemicals introduced into a compartment and their predicted or actual buoyancy yield. For example, if 100 pounds of chemicals have been pumped into a vessel and their yield is 20 pounds of buoyancy per pound of chemicals, then the product of 100 x 20 is 2000 pounds of installed buoyancy. All buoyancy quantities quoted in this report are based on predicted rather than actual yields. It was not possible for the SMITH salvors to calculate the actual yields because they had no way of measuring accurately the quality of the installed foam.

It was estimated initially that there was more than enough space within the SMITH's stern section to contain the amount of foam that would be required to lighten the vessel. Cargo holds #5 and #6 were huge compartments; in addition, the engine room, fuel tanks and other smaller spaces could be used for foaming. The progress of foaming in these various compartments had to be coordinated carefully with the installation of the on-shore pulling system. Excessive foam, before the pullers could take control, could easily make the lightened wreck unmanageable.

The salvors planned to concentrate the foaming initially in cargo hold #5 and then in hold #6. By carefully calculating the amounts of installed buoyancy (predicted yield) progressively emplaced and observing closely the effects of the foam on the wreck, they could successively refine estimates of remaining requirements. Ultimately, because of the foam's poor quality, they had to install much more foam than originally estimated and the foaming spaces, seemingly so ample at the outset, became at a premium near the conclusion of foaming operations.

DEVELOPMENT OF THE ON-SHORE PULLING SYSTEM

Background

The congested industrial area along the river front at Port Huron did not offer sufficient working space to accommodate a traditional beach gear purchase system for pulling the stern section to shore. Furthermore, soil surveys conducted by the Corps of Engineers revealed that the traditional "deadman" method of burying salvage anchors or concrete clumps at shallow depths would not provide adequate holding power. Confronted with these two problems, the salvors designed and installed a radically different pulling system.

Hydraulic pullers would be used in lieu of beach gear because they could be positioned close to the river bank, well within the available space ashore. The pullers, mounted on wooden platforms, would be secured to specially designed anchors, formed of concrete blocks with anchoring legs implanted deep underground.

Hydraulic pullers had never been used in Navy salvage operations. However, the salvors were familiar with the capabilities of commercial pullers in construction operations. Requirements were established for two 100-ton pullers and four 40-ton pullers. A procurement order for the pullers was placed with the Lucker Manufacturing Company by MYPAC. Concurrently, the Corps of Engineers proceeded with the design and installation of the anchors and puller platforms, utilizing the services of the Nicholson Anchorage Company.

Selection of Sites for the Hydraulic Pullers

The salvors could not calculate precisely how the stern section would react during the pulling operation. To provide maximum flexibility they planned initially to develop eight pulling sites, even though only six hydraulic pullers would actually be used. These eight sites, positioned in a wide arc along the river bank, would enable the salvors to vary the locations of the pullers depending on the circumstances encountered during the pulling effort.

Development of each site would be a major undertaking, entailing the implantment of anchor legs and construction of the anchor block and puller platform. As planning progressed, it became necessary to delete two of the originally proposed eight sites for reasons of economy. Reliance on only six sites proved to be adequate in spite of the reduced flexibility.

The exact location of each site was determined after making a detailed survey of the wreck's position, possible paths for pulling it toward the shore and the conditions along the river bank. It was decided to position the two 100-ton pullers well upstream to hold the stern section against the force of the river current. The four 40-ton pullers would be emplaced generally opposite the wreck in a relatively wide arc to provide most of the pulling power. The restraining force exerted on the wreck by the larger pullers upstream would not be quite parallel to the force of the river current. Therefore, a small component force vector from these pullers would also contribute to the pulling effort of the 40-ton pullers farther downstream.

The six pulling sites were to be constructed in pairs, with each pair comprising a pulling station. The following station designations were assigned to the sites:

Pulling Station ALPHA – Upstream

Pullers A and B (100-ton pullers)

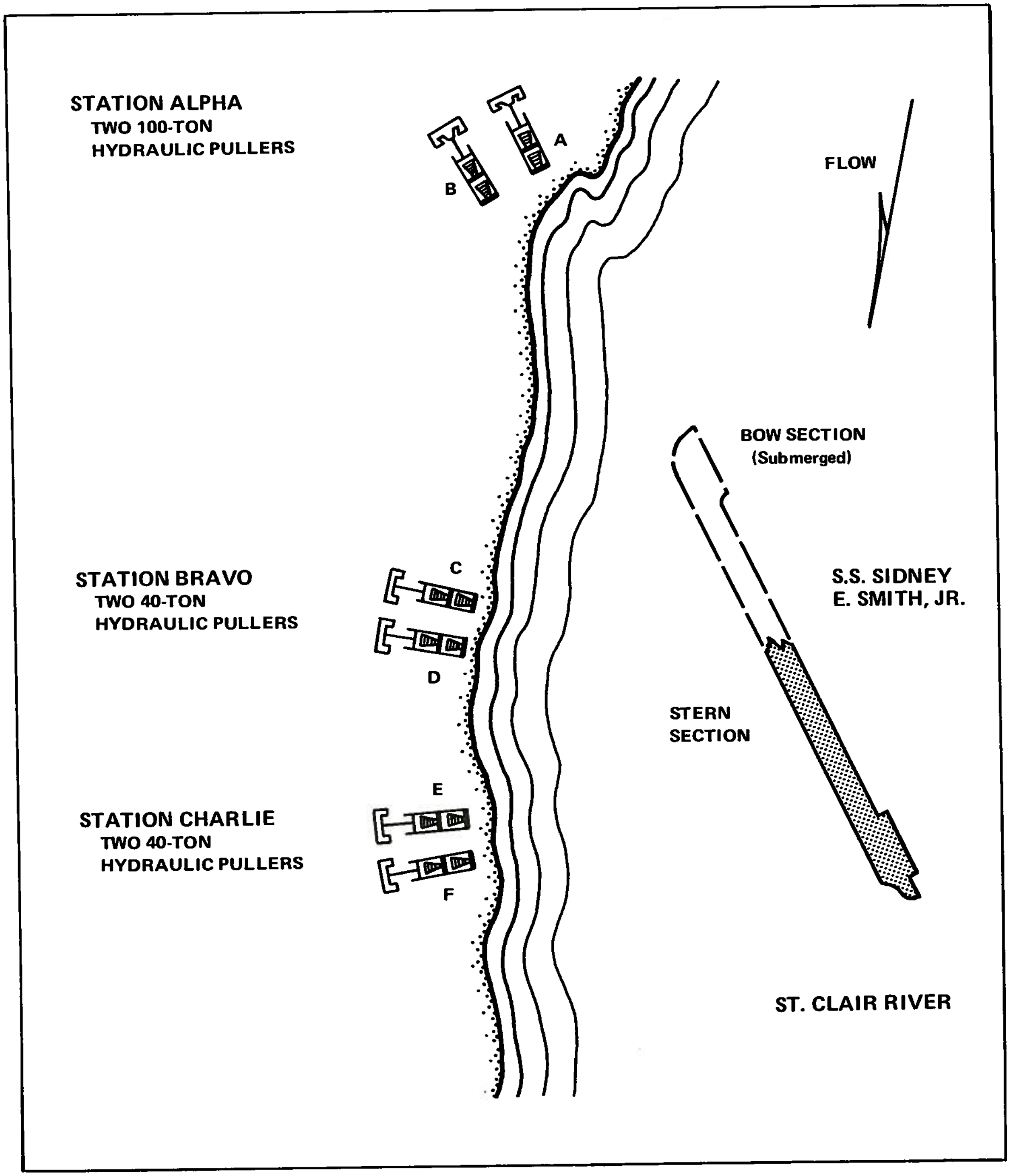
Pulling Station BRAVO – Opposite the wreck

Pullers C and D (40-ton pullers)

Pulling Station CHARLIE – Opposite the wreck

Pullers E and F (40-ton pullers)

The two additional sites for the hydraulic pullers that were deleted from the original plan had been tentatively located south of Pulling Station CHARLIE, slightly downstream of the wreck. This location was designated as Station DELTA. A pair of bulldozers, subsequently incorporated into the plan, pulled from this station during the stern removal operations.



Large pullers at Station ALPHA will hold stern section against force of river current. Smaller pullers at downstream stations will haul wreck to shore.

PLANNED LOCATIONS OF HYDRAULIC PULLERS

ANCHORS FOR THE HYDRAULIC PULLERS

Design Features

The basic design developed by the Corps of Engineers called for an anchor block of reinforced concrete secured to a pair of anchoring legs implanted deep underground. The legs, formed of wire bundles and concrete, were buried in dense sand and shale bedrock material which could withstand the calculated loads on the anchoring system. The legs, angling down and out from the anchor blocks to allow for varying angles of pull, ranged from 60 to 165 feet in length.

The anchor block was designed to withstand a working pull of 100-tons asserted by the hydraulic puller at angles which would vary as the stern section was moved closer to shore. To provide for these conditions, a padeye was cast into the reinforced concrete block in a way which distributed the load into the anchoring legs. The 100-ton working pull factor was adopted so that the large 100-ton pullers, as well as the 40-ton pullers, could be stationed at any of the six pulling sites as required.

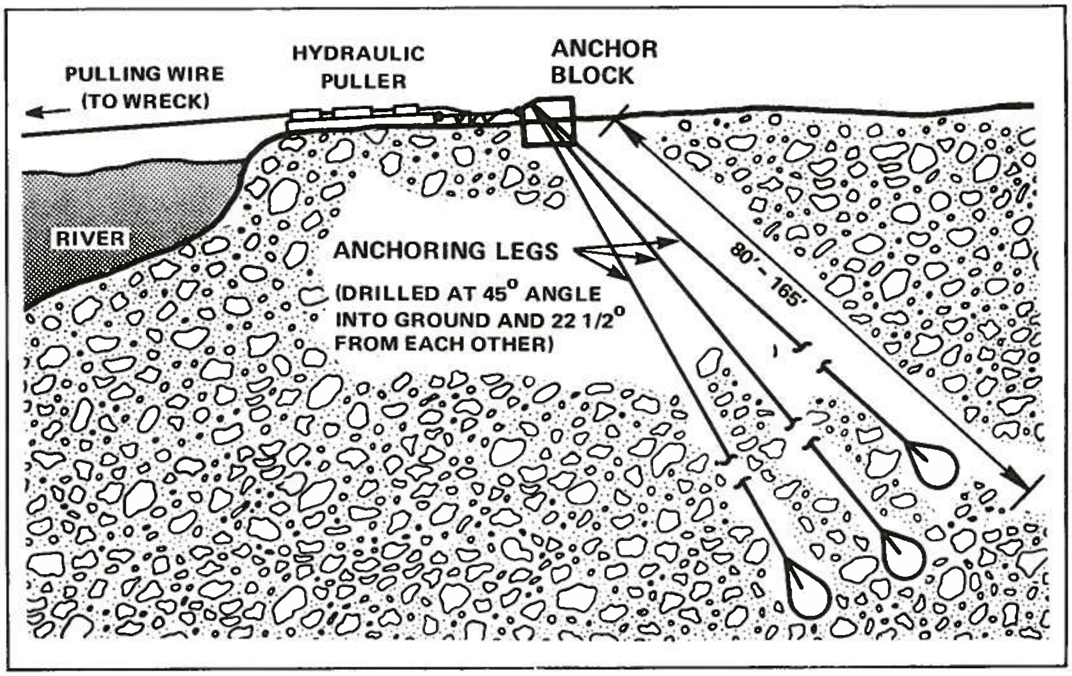
Other design changes were made, based on initial experience in installing and testing the anchoring system. For example, Blocks D, E and F were widened from 7 feet to 12 feet to provide greater resistance to movement when it was learned that Blocks A and B, which had been installed first, tended to move and rotate under the stresses generated during operational tests.

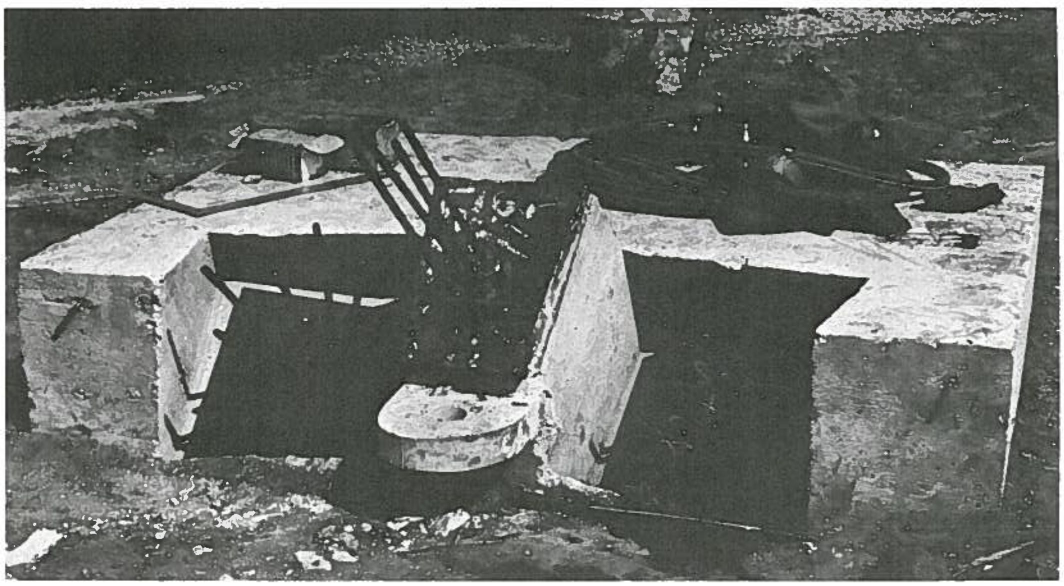
The two-leg configuration in the basic design was used in installing the anchor blocks at Pulling Stations BRAVO and CHARLIE. However, a third anchoring leg was added for each block at ALPHA, the upstream station. The additional leg, installed along the centerline of each block, provided increased stability as the two anchor blocks at this station would be subjected to greater loadings in holding the wreck section against the strong river current.

Installation of Anchor Legs and Blocks

The Nicholson Anchorage Company used its truck-mounted, hydraulic drilling rigs to bore the shafts for the anchor legs. These rigs, although built principally for rotary drilling, are also adaptable to percussive methods. They thus can cope with widely differing ground conditions. The anchor legs at Stations BRAVO and CHARLIE had to be grounded in shale bedrock, encountered at a depth of about 100 feet, as the material above this level was primarily porous clay, with inadequate holding power. Upstream, at Station ALPHA, the anchor legs were grounded at lesser depths in a formation of dense sand.

When the drill rig had penetrated to the prescribed depth, the drill pipe was withdrawn and replaced by numerous strands of wire rope. Concrete "grout" was then pumped into





Reinforced concrete block, secured by three legs buried deep into ground, can withstand 300-ton pull against padeye. Three legs provide extra strength against river current. Anchor blocks at downstream stations required only two legs.

ANCHOR BLOCK CONSTRUCTION AT PULLING STATION ALPHA

the holes under pressure, forming a clump at the bottom of each hole which hardened around the unlayed ends of the wire rope. The reinforced concrete anchor block was then formed and poured in a small excavation over the bundles of anchor wires. The bundles extended through cylindrical channels or tunnels in the block and through holes drilled in terminal plates on the leading edge of the block.

When the concrete had set, each wire was tensioned and secured to the appropriate terminal plate. An integral steel bar protruding from the front of the block served as a padeye for shackling the puller bridle. The concrete block had been poured around the bar which now extended through the block to a small backing plate.

Report of the Nicholson Anchorage Company

See Appendix D to this report for a copy of the Nicholson Anchorage Company's report on the design and construction of these anchor legs and blocks. The company's report provides detailed information on these subjects.

PLATFORMS FOR THE HYDRAULIC PULLERS

Design Requirements

A sturdy wooden platform had to be constructed in front of each anchor block to support the hydraulic puller and allow it to slide in a small arc around the block. This was necessary because the direction of pull would change continuously as the stern section was moved from mid-channel to the river bank. Based on experience gained during pulling operations, skids were later mounted beneath the puller. These skids allowed the puller to slide more easily across the wooden platform as the wreck changed relative bearing from the anchor block.

Construction Aspects

Although the size of the platforms varied, they were similarly constructed. Each platform consisted of a surface layer of 2-inch by 12-inch planking on a base of 12-inch by 12-inch timbers. Each platform was emplaced within a shallow excavation in order to provide a hard, flat surface, flush with the surrounding work area.

In most cases, the limited space available on the Peerless Cement Company and Blue Water Asphalt property required that the platforms be positioned at the very edge of the river bank. Three months into the operation, it became necessary to reinforce the platforms, and refill and surface the bank with asphalt and concrete because of the effects of erosion.

MANUFACTURE AND TESTING OF HYDRAULIC PULLERS

Role of Lucker Manufacturing Company

The Lucker Company, Philadelphia, Pennsylvania, manufactures hydraulic pullers for commercial use in bridge building, pipe laying and other large scale construction tasks. The pullers for the SMITH salvage operation were modeled after these commercial Lucker Pullers and built by the Lucker Company.

Requirements for the hydraulic pullers were confirmed during the 23 June planning conference at SUPSALV headquarters. The Lucker Company agreed on 26 June to provide the required pullers, and responded to the urgent request by beginning round-the-clock procurement and assembly efforts. Employees were called into the Lucker plant from their annual vacations and every effort was made to provide the finished products as soon as possible.

On-Site Installation and Testing

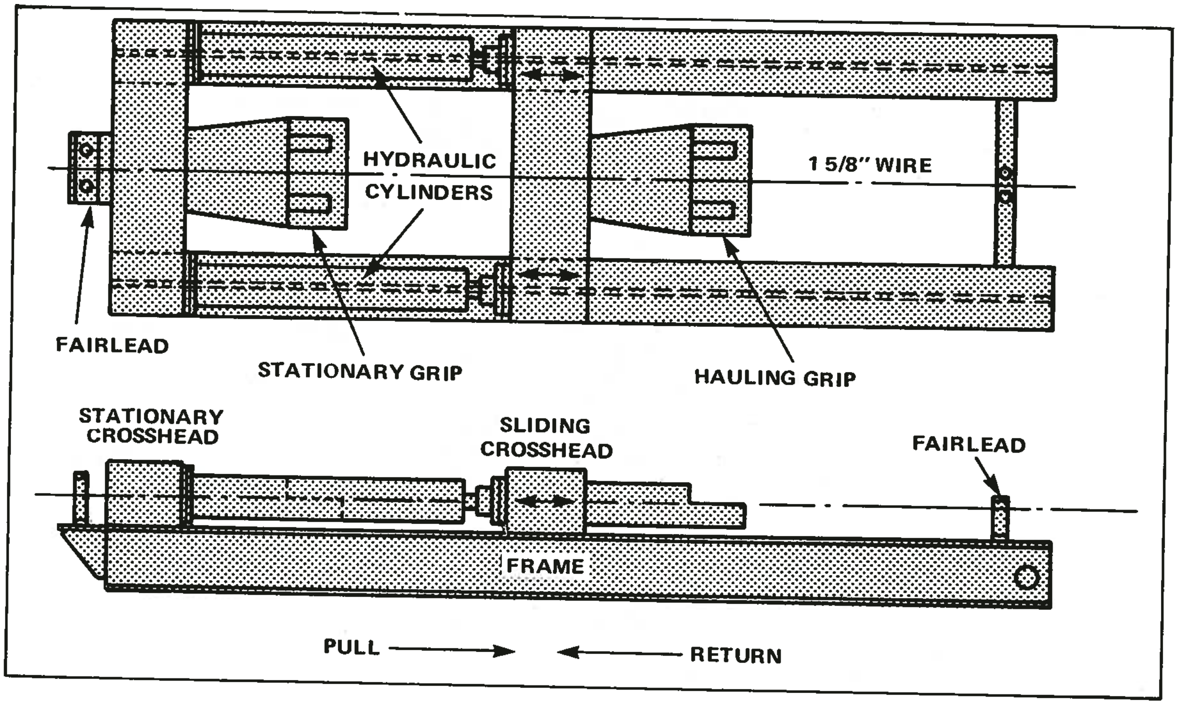
In accordance with MYPAC's instructions, the pullers were crated and trucked to the salvage site directly from the assembly line at the Lucker plant. As each puller arrived at Port Huron, it was placed upon its designated platform, secured to its anchor block by means of a wire rope bridle, and aligned to receive the pulling wire from the appropriate pull point on the wreck.

The pullers were delivered prior to testing of the completed systems. The salvors anticipated a number of discrepancies and were prepared to perform the typical post-test debugging procedures, feeling that the required corrections could be made on-site, and that pulling operations could begin earlier than if the testing and modification procedures were performed at the Lucker plant.

FUNCTIONING OF HYDRAULIC PULLER SYSTEMS

System Design Features

Each of the six hydraulic pullers constituted a pulling system consisting of the puller itself, an engine-driven hydraulic power source, and an operator's console. The system is compact and relatively simple in design. The two large systems, positioned upstream, were each rated at 200,000 pounds (100 tons) and configured to receive 2-inch pulling wire. The



Pressure of hydraulic cylinders moves sliding crosshead. Hauling grip moves with crosshead, pulling in length of wire. Stationary grip stops wire as cylinders retract, returning hauling grip to take in another length.

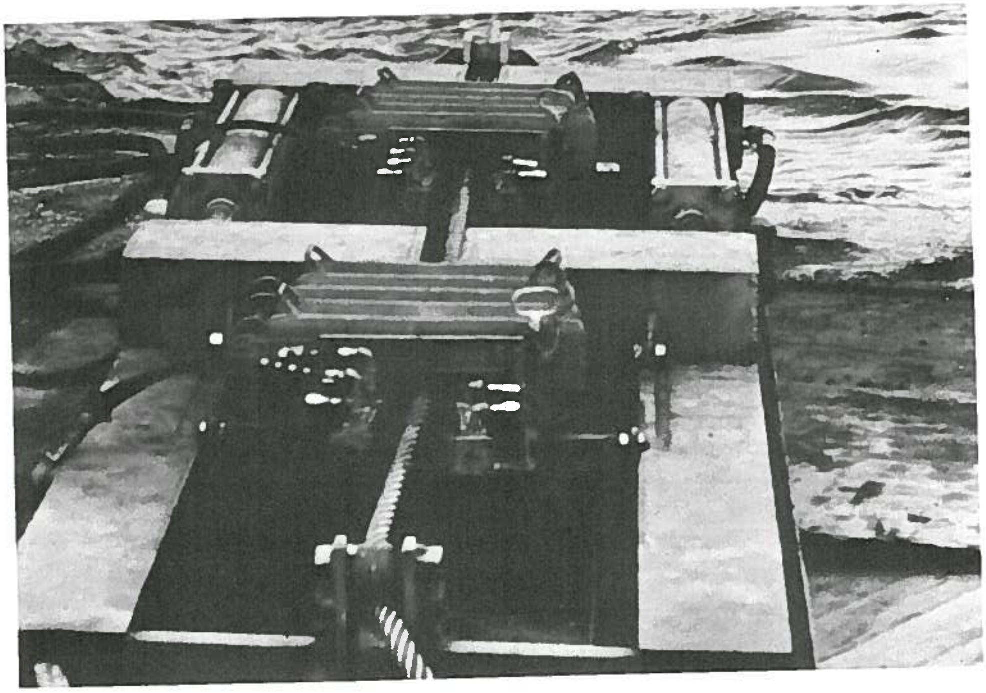
FUNCTIONING OF HYDRAULIC PULLER

other four systems, positioned downstream, were each rated at 80,000 pounds (40 tons) for use with 1 5/8-inch wire. All six systems had the same basic design features and functioned in a similar manner. The differences in capacity between the large and small systems required some minor differences in design.

Puller Unit

The puller assembly or unit consists primarily of a pair of Lucker cable grips, one a stationary grip and the other a hauling grip, and a pair of hydraulic cylinders mounted on a 3 1/2-foot by 16-foot heavy steel frame. The stationary grip butts against a stationary crosshead positioned between two wide flange frame members similar to I-beams. The hauling grip butts against a sliding crosshead secured to the two hydraulic cylinders. The sliding crosshead and the stationary crosshead are at opposite ends of the hydraulic cylinders.

The hauling grip grips the pulling wire as the hydraulic cylinders are activated. The expanding cylinders, anchored at the forward end against the stationary crosshead, force the

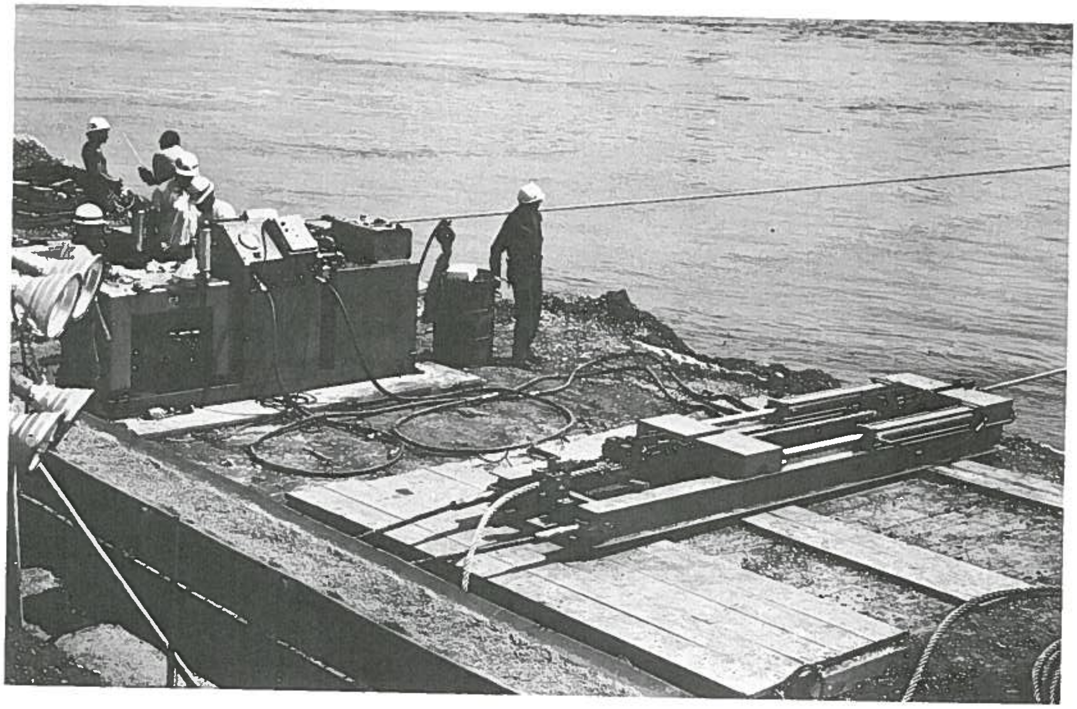


100-ton puller's hauling grip (foreground) and stationary grip (background) are controlled hydraulically. Note small hose connections on each grip. Larger hoses connect puller's hydraulic cylinders to power unit (not shown).

100-TON HYDRAULIC PULLER WITH 2-INCH PULLING WIRE

sliding crosshead back along the two wide flange frame members. The hauling grip moves back, drawing the wire in over the forward fairlead, through the stationary grip and out over the after fairlead. When the hydraulic cylinders reach the end of their stroke, the stationary grip holds the wire, allowing the cylinders and the hauling grip to return to the starting position to grip and haul in another length of wire. Thus, the pulling wire is hauled in by the continuous expansion and contraction of the hydraulic cylinders with the alternating grip/release cycle of the two grips. A fairlead at each end of the puller ensures proper alignment of the pulling wire within the system.

The cable grips for the 1 5/8-inch and 2-inch pulling wires differ in design. The former are spring loaded whereas the 2-inch grips are actuated by a pair of small hydraulic cylinders inserted into the circuitry of the larger puller cylinders. It is not necessary to thread the pulling wire through the cable grips since they can be opened to insert a continuous length of wire when neither end is available. Wire is inserted and removed from the puller by hand; all other operations of the puller system can be performed from the remote console. The



Operator's console, at left with gas-driven hydraulic power unit, is used to control puller operations. Photo shows sliding crosshead extended, almost ready for return movement to grip new length of 1-5/8" wire.

40-TON HYDRAULIC PULLER AT STATION BRAVO

cable grips are similar in operation to the carpenter stoppers employed with the Navy's standard beach gear.

In summary, the puller unit hauls in the wire by short lengths, in alternating pulling and holding cycles. Two grips are used to grasp the wire, one for each cycle.

Gas Engine and Electric Power

The hydraulic cylinders are capable of exerting their rated force on the pulling wire through the sliding crosshead/cable grip assembly when aligned with the hydraulic power source. The hydraulic cylinders are powered by a gas-driven, 2,000-psi, hydraulic vane pump, connected with each cylinder by a pair of high pressure hoses, each 40 feet in length. A 40-foot, multi-conductor, electrical control line connects the puller to the remote control console, completing the circuitry of the hydraulic puller system.

Control Consoles

The control console provides for operation of the puller either in an automatic or manual mode. The controls for the 40-ton machine vary somewhat from those for the 100-ton machine because of differences in the cable grips. The hydraulically actuated 2-inch grips for the 100-ton machine require an additional pair of cylinder control buttons on the console, one to open the wedges of the stationary grip and the other to open the wedges of the hauling grip. Apart from these additions, the control console for each type of machine is basically the same, consisting essentially of a force-pull control knob, a hydraulic pressure gauge, a cycle button for automatic operations, a stop button, and a set of buttons for non-automatic operation.

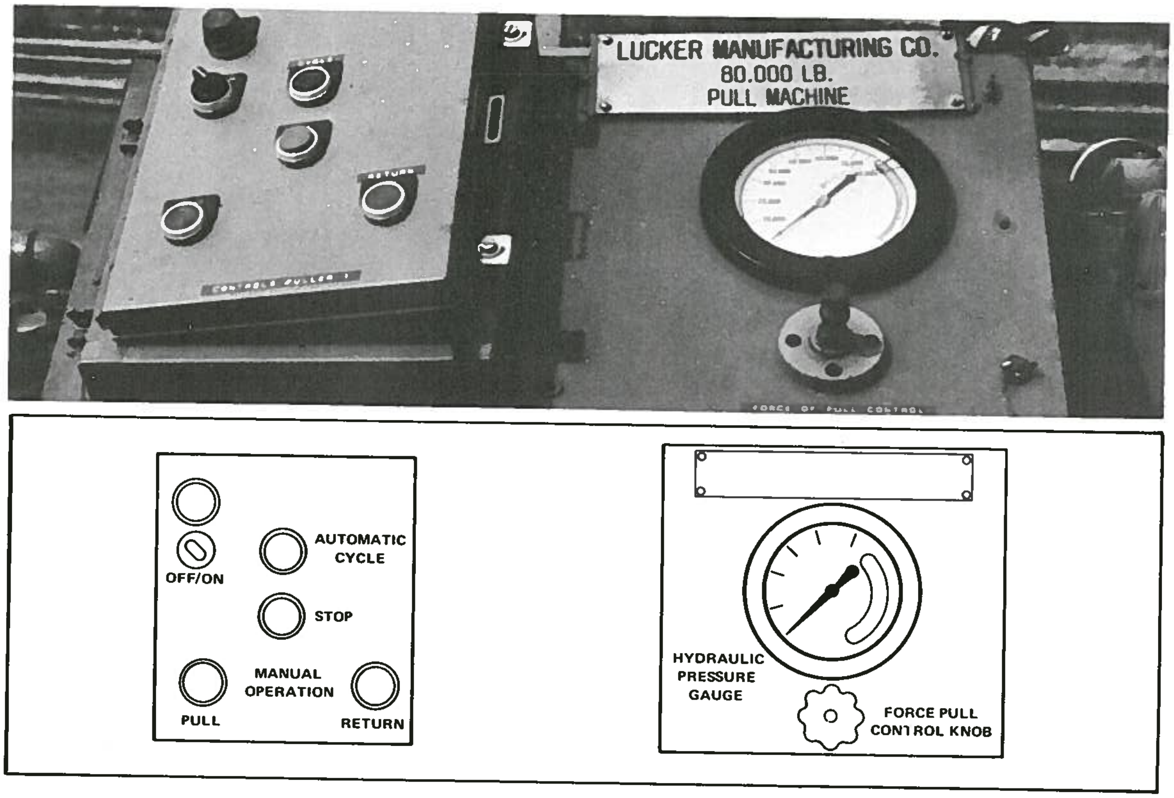
The force-pull control knob functions like a rheostat. Turning the knob clockwise or counter-clockwise increases or decreases the pull force applied to the wire in the grips. The pressure gauge, calibrated in pounds, provides a direct readout of the pull force being applied. The force applied by the system, as measured in pounds, equals the hydraulic pressure (psi) times the piston area ($inch^2$) in the two hydraulic cylinders.

One additional control, a throttle valve, positioned on the hydraulic power source, can be turned to regulate the flow of hydraulic fluid, controlling the pulling speed. Thus, valves on the control console and power source regulate the puller force and speed, respectively. These parameters are also a function of engine speed and vary from approximately 2/3 maximum force or speed at 1,600 rpm to full force or speed at 2,400 rpm.

PULLING SYSTEM CAPABILITY VS. FORCE REQUIREMENTS

Maximum Pulling Capability

The four 40-ton pullers are capable of exerting a maximum combined force of 160 tons. By positioning these four pullers in an arc along the beach, the four component force vectors added geometrically would yield a force somewhat less than 160 tons. However, the river current also produced a small force vector toward the beach. Thus the total beaching force to be applied by the combined action of the river current and the four pullers would be in the neighborhood of 160 tons. (This figure was approximated assuming a maximum pulling effort of 40 tons from each puller and a river current of 7 to 9 knots.)



Control knob functions like rheostat, adjusting pulling force as measured on gauge. System operates in either manual or automatic mode. 100-ton puller has similar console, with two additional buttons to operate hydraulic cable grips.

OPERATOR'S CONSOLE FOR 40-TON HYDRAULIC PULLER

Force Requirements

The salvors estimated the submerged weight of the SMITH stern section to be 2,800 tons, and the coefficient of friction was determined to be approximately 0.4 on the sand/gravel bottom of the river. Accordingly, the effective force required to move the wreck prior to foaming would be approximately 1,120 tons (2,800 x 0.4). Thus, with an anticipated maximum beaching force of 160 tons generated by the pulling gear arranged in accordance with the salvage plan, it would be necessary to install approximately 960 tons of foam buoyancy (reducing the anticipated ground reaction to 160 tons) in order to reduce the effective pulling force required to within the capability of the pulling system. Naturally, a generous safety factor would be applied to assure success.

CHAPTER 6
CONDUCT OF OPERATIONS—PHASE I
STERN SECTION REMOVAL

ON-SITE PREPARATIONS, 26 JUNE - 1 JULY

Salvage Operations Begin, 26 June

Key personnel of the salvage force assembled at the Port Huron work site on 26 June to get salvage operations under way. Although all required salvage material had been ordered to the scene by the most expeditious Government or commercial means possible, there were unavoidable delays in the delivery of certain items. On-site preparations got under way while awaiting equipment delivery.

Working areas at the salvage site were graded and covered with gravel. An Army trailer which had served as COE headquarters at the Coast Guard station since the sinking of the SMITH was brought to the salvage site. The trailer, equipped with electricity and telephones, was used as a joint COE-SUPSALV command post. Three additional trailers were later procured for use by a Navy combat camera team, the crew of laborers, and SUPSALV-MYPAC personnel. A 24-foot square Butler hut was also erected to provide a sheltered shop and storage facility.

Also arriving at the salvage site on 26 June was a soils expert from the COE Detroit District Office. His responsibility was to investigate the work site and assist in designing a suitable anchorage system for the hydraulic pullers. The Corps of Engineers assumed responsibility for installing the anchors at the designated pulling stations. The Nicholson Anchorage Company, Bridgeville, Pennsylvania, was engaged to assist with the design of the anchoring system and to carry out its installation.

A team of divers from Harter Underwater Construction Corporation also arrived at the salvage site on 26 June. This team set up its equipment and made preparations for conducting an inspection dive scheduled for the next day. Primarily, the divers were to inspect cargo holds #4, #5 and #6 to determine the amount of coal remaining in each hopper/hold and to generally check for conditions which might alter or delay implementation of the salvage plan.

Status of the SIDNEY SMITH, 26 June

As a result of the continuous scouring action of the current under the wreck, the condition of the SMITH had deteriorated continually from the time of its sinking. The bow section was completely submerged, well below the surface by 26 June. Much of the port side and part of the main deck of the stern section remained exposed above the surface. However, its position and attitude had not stabilized and the hulk continued to sink, with an ever increasing starboard list.

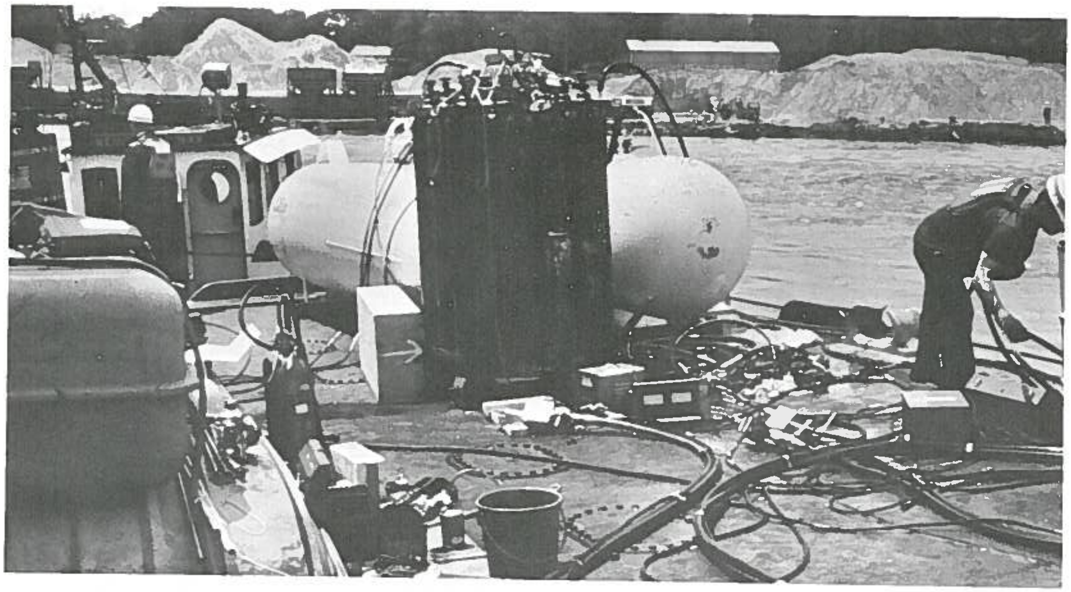
In order to be continually informed of the stern's position and attitude, the Corps of Engineers provided a survey crew to measure and record the changes. The stern's position, height above water level, and angle of list were recorded at half-hour intervals, 24 hours a day, and at shorter intervals when required during critical periods. The survey crew also used a portable, electronic depth sounder to keep track of changing bottom contours and of the depth and position of the sunken bow section.

Internal Diving Survey, 27-28 June

Using one of COE's large river tugs as a support platform, the Harter divers conducted inspection dives and internal diving surveys on 27 and 28 June. Hazardous accumulations of explosive or toxic gases are often generated by the decay of water-soaked organic matter within underwater compartments, making it essential to check the wreck before beginning salvage work. Because the SMITH's cargo was coal, the salvors did not anticipate such conditions within its compartments but decided to be certain in spite of the urgent time frame involved.

Cargo hold #4 was open to the atmosphere at the damaged forward bulkhead and therefore considered properly ventilated and safe for salvage operations. This allowed divers to cut access to and enter hold #4 from topside, while awaiting a gas analysis of holds #5 and #6 and of the machinery spaces. Later in the day, personnel from a gas testing laboratory in Detroit arrived, tested the compartments, and declared them safe for cutting and entry by divers.

Entering the wreck, the divers found conditions much as they had been reported or anticipated. Most of the sectional hatch covers had been dislodged from the coamings by the current and were hanging by restraining chains. Although the current had carried away much of the cargo, a substantial amount of coal remained, especially in holds #5 and #6. A significant quantity of sand and gravel had been washed into these open cargo holds as well. As much of this excess weight as possible would have to be removed before foam could be installed. Divers began removing some of the obstructions in the way of hatches over holds #5 and #6 in preparation for the installation of hatch covers.



Pair of large aerosol tanks supply foam components, isocyanate and polyol. Bank of nitrogen bottles pressurizes delivery system. Flow meters and readout devices are rigged to delivery hoses on deck.

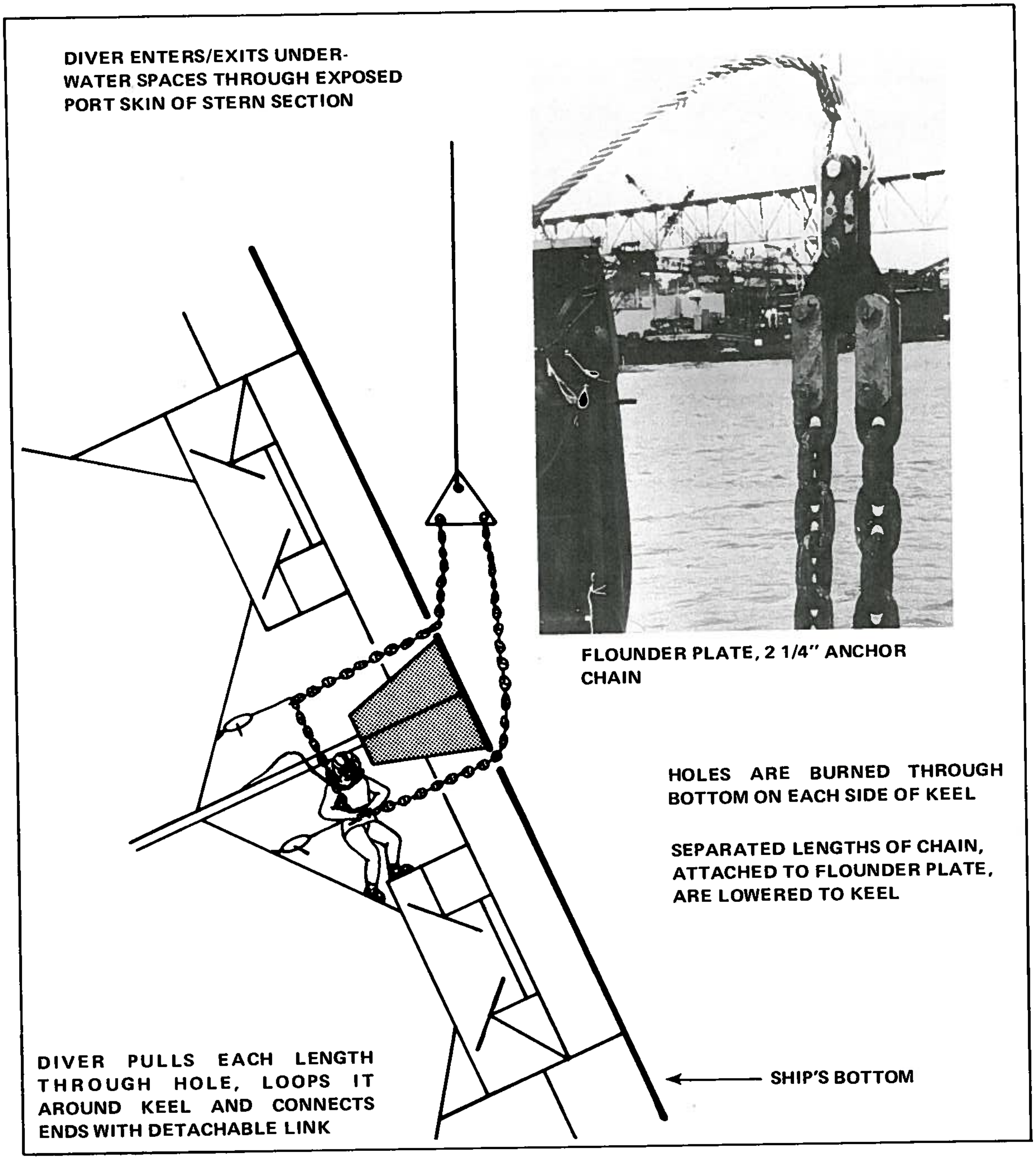
SALVORS INSTALL AEROSOL FOAM DELIVERY SYSTEM ON BARGE

Arrival of the COE Derrick Barge, 29 June

Full scale removal operations in mid-channel began with the arrival of the COE derrick barge on 29 June. As the primary salvage tender, the barge provided a large stable platform for diving, foaming, and other salvage tasks. A pair of high capacity, low pressure air compressors were installed on board the barge to provide air for the divers and to power all air-driven tools including the airlifts used to remove coal, sand, and gravel from the SMITH's cargo holds. The crane on the barge handled the installation of hatch covers and diver access tubes with ease and was most important in handling the foam tanks and other equipment items needed for the operation. During salvage operations on the stern, the barge was moored directly to the exposed portion of the wreck.

Passage of the S.S. SYLVANIA, 1 July

The upbound passage on 1 July of the ore carrier, S.S. SYLVANIA, a sister ship of the SMITH, provided an unexpected but welcome opportunity for diver orientation. Up to this time the divers did not have access to a complete, current set of ship's plans for the SMITH. Thus they had not been able to study the layout of the SMITH's compartments, making their movement throughout the interior of the hulk very difficult.



Procedure shown above was repeated to rig pull point for other hydraulic puller at Station ALPHA. Chain was looped around keel at same area, frame 94, and connected to puller's wire by flounder plate. Similar procedure was followed later in SMITH operation to rig keel pull points on bow section.

RIGGING STERN SECTION'S KEEL PULL POINTS

When contacted through the Coast Guard, the SYLVANIA's Master agreed to an inspection of his ship by the Harter divers. With SYLVANIA personnel as guides, the divers toured the vessel's cargo and machinery spaces, conveyor tunnel, and double bottoms. As a result of the tour, they gained a much better understanding of the internal layout and construction of the corresponding spaces aboard the SMITH.

MID-CHANNEL OPERATIONS, 29 JUNE - 16 JULY

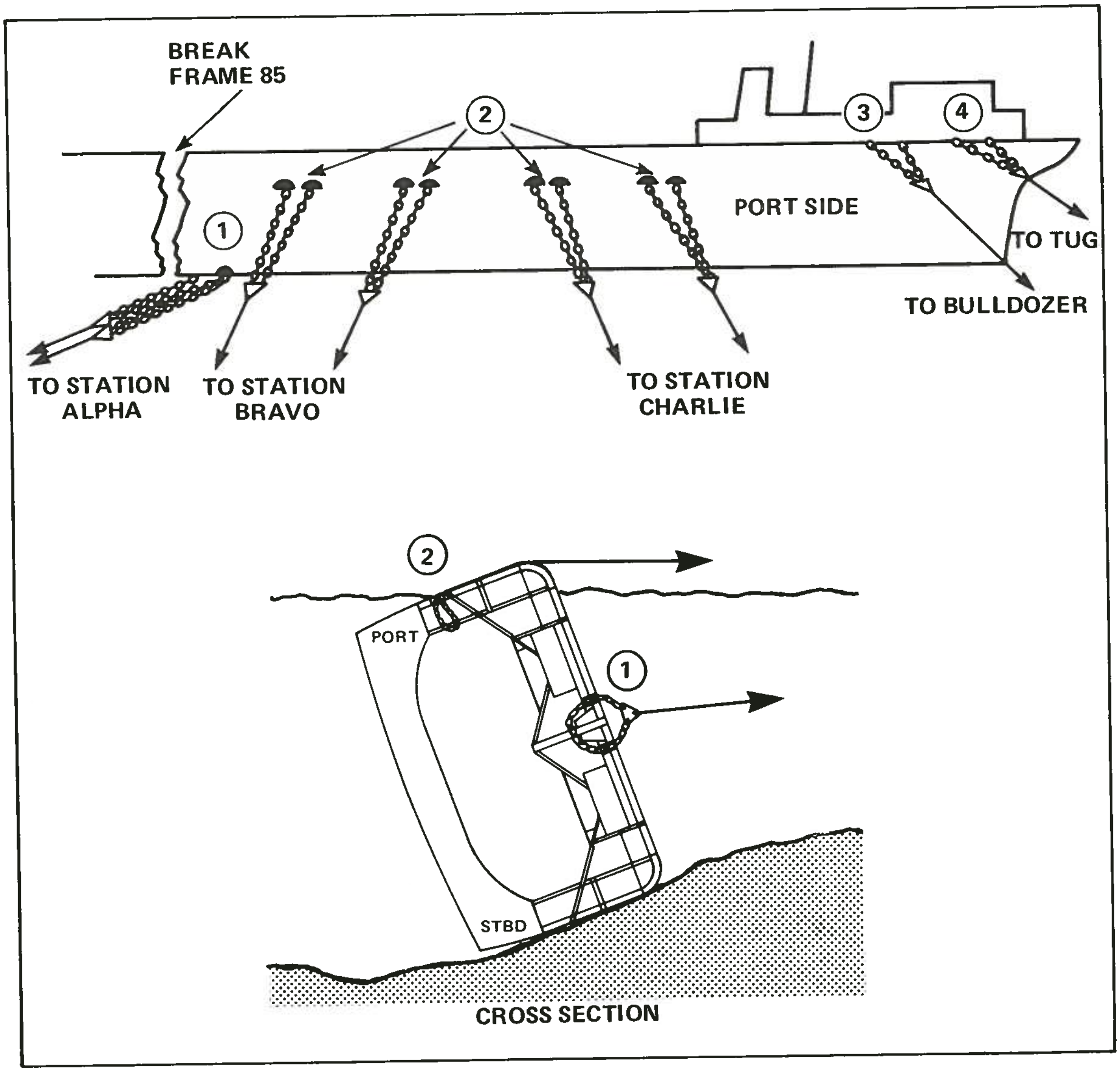
Rigging Pull Points on the SMITH's Stern, 29-30 June

After completing internal surveys on 27 and 28 June, divers began to prepare pull points on the SMITH's hull for attaching pulling wires. Pull points at frame 94, 30 feet aft of the break, were prepared first for the wires to the two large, 100-ton hydraulic pullers upstream at Pulling Station ALPHA. These pull points were rigged around the keel, the SMITH's strongest structural member.

Rigging had to be done from within the sunken hulk. The divers descended into cargo hold #4 through access holes cut in the wreck's exposed port skin. From this hold they gained access to the conveyor tunnel by cutting a crawl hole through the coal hopper. Then, at the underwater work site, they burned holes through the hull on either side of the keel to admit 2 1/4-inch anchor chains to be looped around the keel.

Two half-shot lengths of chain were then lowered externally over the turn of the bilge, and into the water along the bottom of the ship. When the chain was properly positioned, the diver was able to reach the two bitter ends and pull them in through the holes on either side of the keel and join them around the keel with a detachable link. The diver used a "come-along" for mechanical advantage in hauling the heavy chain into position for link-up. The bitter ends of the loop were temporarily secured topside, until joined with the pulling wire by means of a flounder plate.

According to the original salvage plan, wires to the four 40-ton hydraulic pullers downstream at Pulling Stations BRAVO and CHARLIE, which would perform the actual pulling, were also to be secured to the keel. However, in order to parbuckle the wreck to an upright position for subsequent refloating efforts, it became necessary to rig these pull points higher up on the port side. Holes were burned in the port skin at holds #5 and #6 on either side of four transverse strength members between hatches. A length of 2 1/4-inch chain was looped around each of the strength members. The bitter ends of each chain loop were then shackled to a flounder plate to which the pulling wire would be secured.



(1) *To hold wreck against current, pulling wires were attached to 2¼" chains looped around keel at frame 94.*

(2) *For parbuckling and shoreward pull, four pull points were rigged high on port side. Flounder plates connected pulling wires to 2¼" chains attached to each of four strength members 24' apart in cargo holds 5 and 6.*

(3) *For additional 27-ton shoreward pulling force from bulldozer, pull point aft on port side was rigged.*

(4) *Tow wire from tug to stern of wreck was rigged in attempt to separate stern from bow section.*

RIGGING OF PULL POINTS ON STERN SECTION

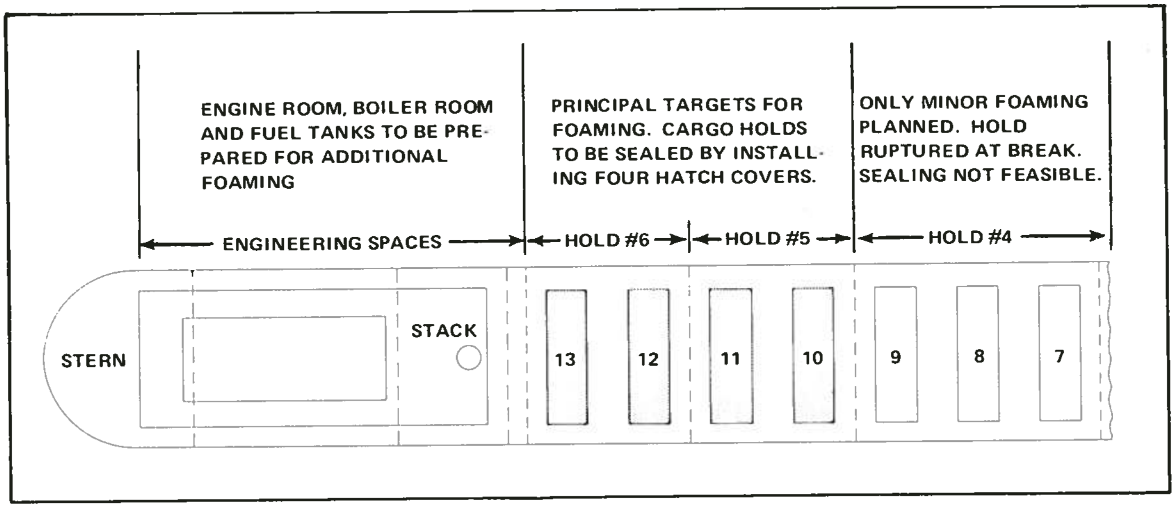
Four pull points, high on stern section's exposed port side, were rigged for parbuckling. Heavy, 2¼" anchor chains were looped around strength members inside hull through holes burned in port skin for attachment to pulling wires.

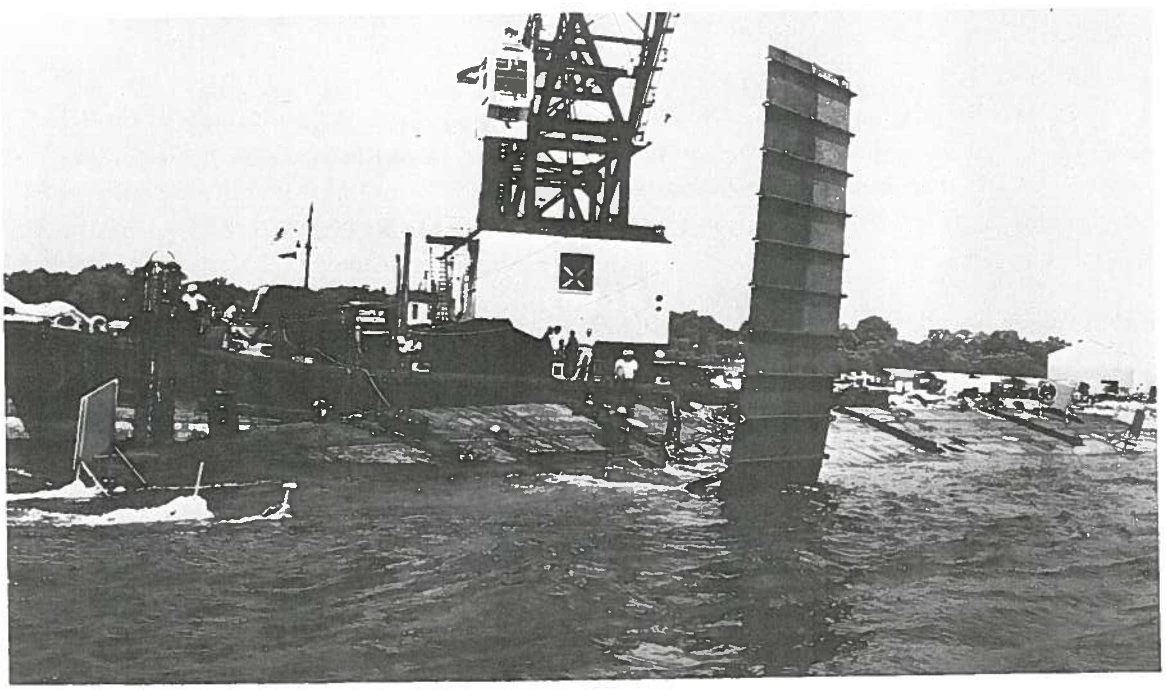
RIGGING PULL POINTS FOR PARBUCKLING

Hatch Cover Installation, 30 June - 4 July

Hatch covers were delivered to the salvage site as they were completed by the Ferguson Company. When the first cover was delivered on 30 June, preparations for their installation were well underway, including the inspection of hatch coaming areas by divers and the removal of the original covers, their lugs and retainer chains. Two unsuccessful attempts were made on 1 July to install this cover on hatch #13 of hold #6.

When the installation plans had been formulated originally, several feet of hatch coaming were still visible above the surface and thus accessible for hatch cover installation. By 1 July, however, not only had the hatch coamings disappeared, but also the deck edge and much of the port side of the stern section were underwater. This made it necessary to lower the hatch cover into the water prior to aligning the L-shaped clips under the lip of the hatch coaming. It proved impossible to align the clips properly, primarily because of irregularities in the coaming. The strong current also hampered the work, preventing precise maneuvering of the hatch cover by the divers.





Hatch covers were emplaced in succession over hatches 13, 12, 10 and 11, sealing cargo holds 5 and 6. Installation was accomplished in 3-day period despite difficulties in handling and securing the heavy, cumbersome steel covers.

HATCH COVERS SEAL CARGO HOLDS FOR FOAMING

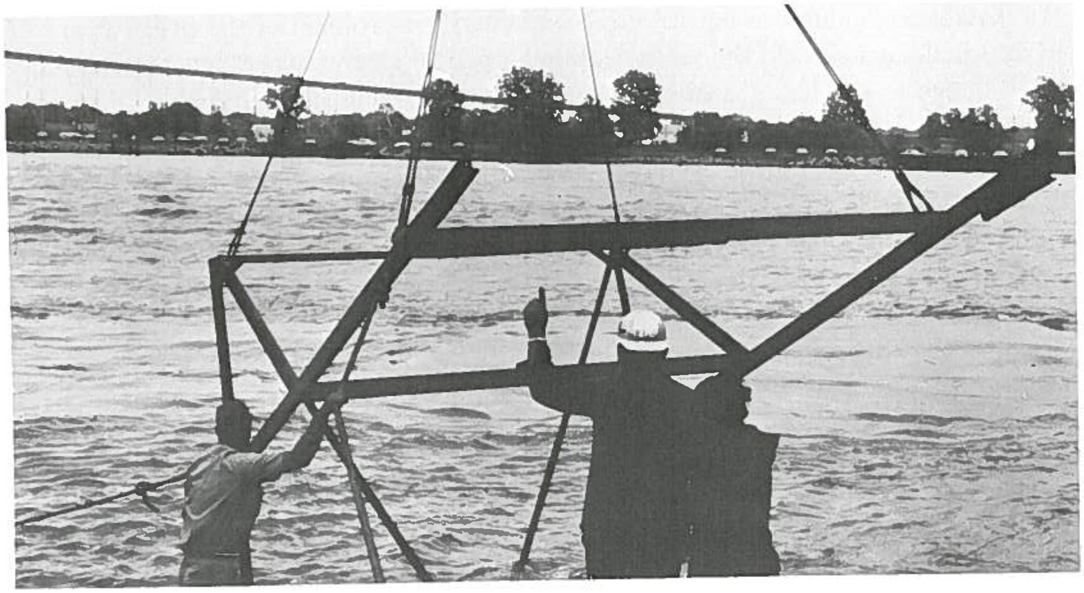
An installation guide was constructed to combat the problem of the river current. Fabricated of 3-inch angle stock, the guide featured a pair of steel tracks extending from above the water's edge to the hatch coaming. The tracks were held in position and heavily reinforced by a steel angle framework. When secured in position over the deck's edge, the tracks effectively extended the athwartships hatch coamings past the port deck edge and clear of the water. The L-shaped clips could be aligned with, and slipped under, the guide edges from topside as the cover was lowered to the water's surface. The guide thus held the hatch cover alignment against the adverse current and swell conditions of the river as the cover was lowered onto the hatch coaming.

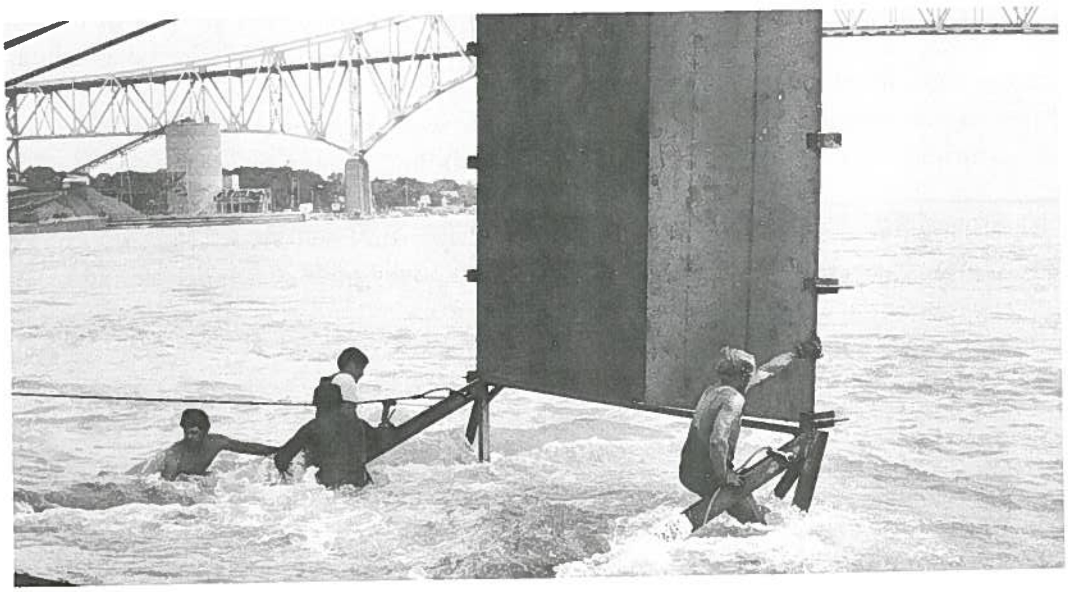
Additional problems were encountered during installation of the first hatch cover. The tracks of the installation guide had to be positioned precisely to allow the hatch cover clips to slide from guide to coaming without binding at this point. It was discovered that the athwartships hatch coaming was not parallel to the surface of the deck as had been assumed. Rather, it sloped upward from the deck at either side, peaking amidships. Until this discovery, the puzzled salvors encountered considerable binding of the sliding hatch covers. They had been aligning the guide track to be parallel to the main deck rather than parallel to the hatch coaming as required. A solution to this problem was to modify the guide to permit adjusting the track angle while hatch cover installation was in progress.

The salvors also discovered that double plating occurred at the corners of each hatch coaming where the athwartships or transverse coaming lip overlapped the longitudinal lip. Removal of this double plate by burning allowed the hatch cover to slide more easily from the guide to the coaming. Then, as the hatch cover was properly positioned on the hatch coaming, turnbuckles were used to prevent further sliding movement.

The first hatch cover was finally installed on 2 July on hatch #13. The other hatch covers had by now been delivered to the site. The hatch cover guide was repositioned over hatch #12 and installation of the second cover was begun. Work proceeded much more quickly with this cover and the two remaining covers on hatches #10 and #11 as the salvors applied the improved installation procedures. All four hatch covers were in place by 4 July, sealing cargo holds #5 and #6, the two principal spaces to be foamed.

The 3-day time span during this phase of the operation represented 72 working hours, the equivalent of nearly two normal work weeks. Much of this time was spent in the trial and error method of working out hatch cover installation problems. It is probable that if divers had been able to perform a typical external survey of the main deck area early in the operation, these problems could have been anticipated and solved more rapidly. Unfortunately, the hatch coaming areas were subjected to the full and direct force of the current and swell conditions of the river. Normal diving operations were impossible. That the hatch covers were installed successfully under these adverse conditions is indeed a tribute to the determination and ingenuity of the salvage force.





Salvors fabricated a steel framework (above) to guide hatch cover during lowering over hatch coaming. Guide functions as standoff against hull (below), enabling salvors to control hatch cover movement in turbulent current.

HATCH COVER INSTALLATION GUIDE

L-shaped clips on edges of hatch cover were designed to help hold cover in place over hatch. Some did not fit properly due to irregularities on hatch coaming and had to be modified in order to slide hatch cover into position.

SALVOR MODIFIES CLIP ON HATCH COVER

Diver Access Tubes Positioned, 4-5 July

Three diver access tubes were inserted into the wreck through holes burned in the exposed port skin. The first two were installed on 4 July in cargo holds #5 and #6, respectively, the principal spaces to be foamed. A third tube was inserted into the boiler room on 5 July, providing access to the machinery spaces which were also targeted for extensive foaming. The 60-foot long tubes, made up of welded sections of 30-inch diameter steel pipe, extended all the way down to the bottom level of each compartment.

These access tubes were essential for foaming. Foam must be installed from the top down. Each tube provided a vertical tunnel with three windows for entry and exit at three different levels. Starting at the top window the diver enters the compartment and installs foam until it progresses down to that level. He then repeats the procedure at the next two lower levels, covering each window with a soft patch as he finishes foaming at each level. With the compartment completely foamed, he then returns topside through the tube.

Three diver access tubes were inserted into cargo holds 5 and 6 through port side. "Windows" in each 60′ cylinder provided exit and entry within holds at three different levels for foaming.

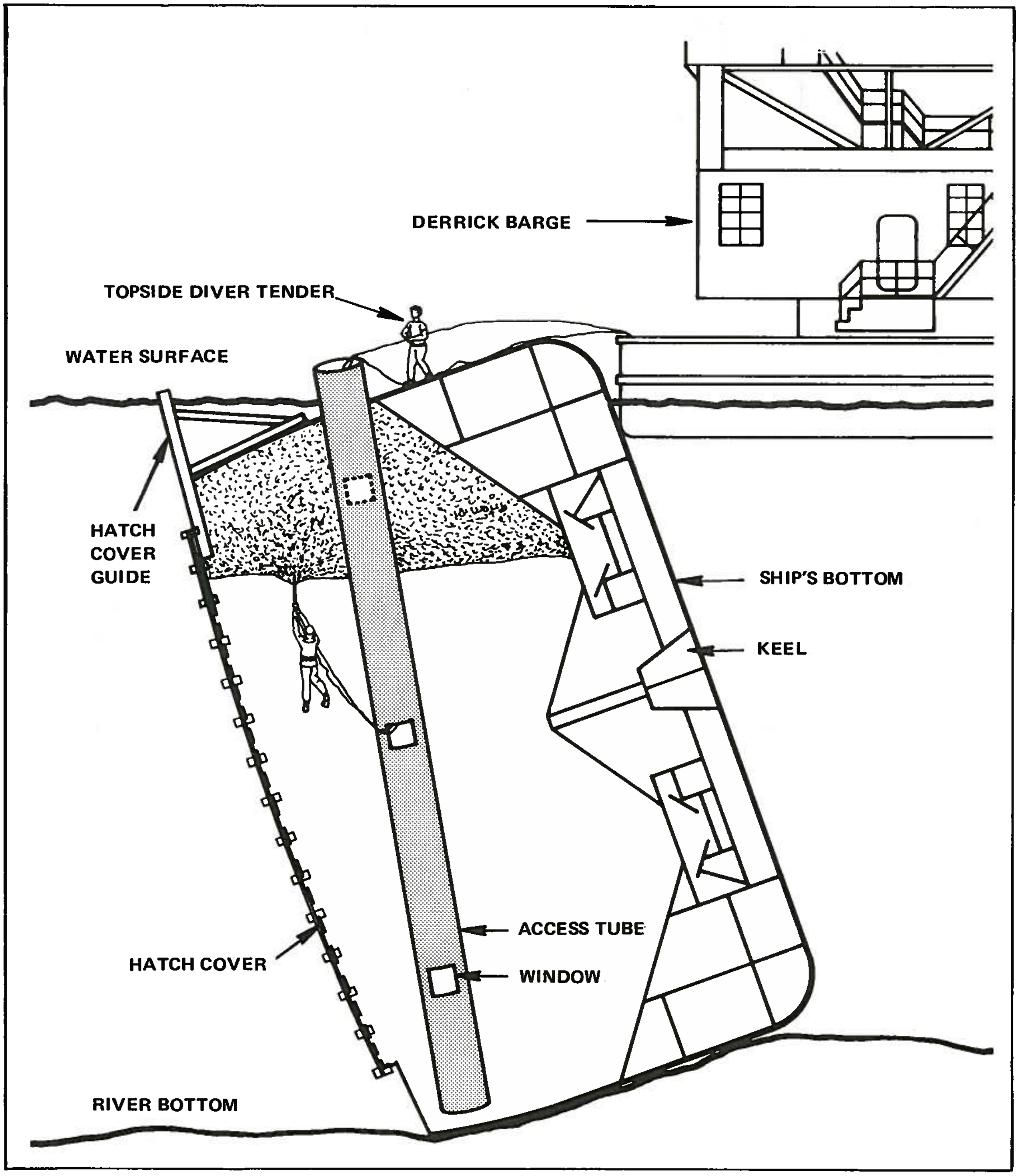
SALVORS TEND DIVER'S FOAM AND AIR HOSES AT TOP OF ACCESS TUBE

Debris Removal, 1-8 July

During their inspections of the stern section, the divers found that large quantities of coal still remained in the holds along with sand and gravel which had been washed into the wreck. Before the cargo holds could be foamed, as much of this debris as possible had to be removed in order to reduce submerged weight and make maximum space available for the foam. On 1 and 2 July, even before hatch cover installation was completed, a considerable quantity of coal was removed from hold #6 by "washing" the hold with a high pressure water jet.

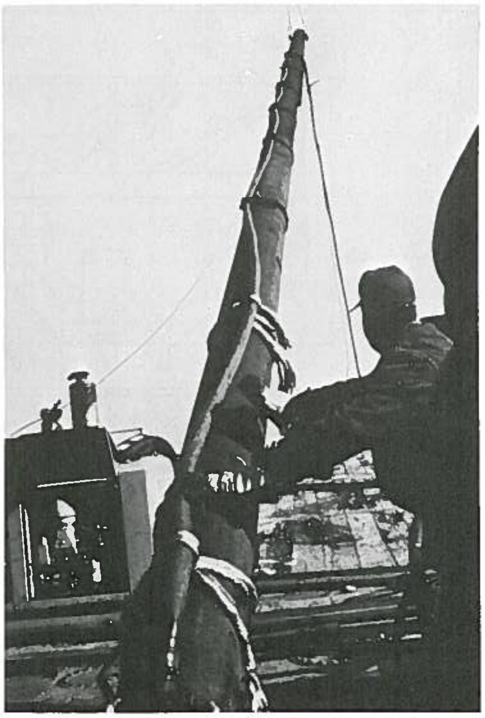
As soon as hatch covers and the diver access tubes were installed, salvors began airlift operations. A 6-inch diameter airlift was fabricated for use with one of the air compressors that had been installed on the derrick barge. Holes were burned in the exposed port skin of the wreck to allow lowering the airlift into cargo holds #5 and #6.

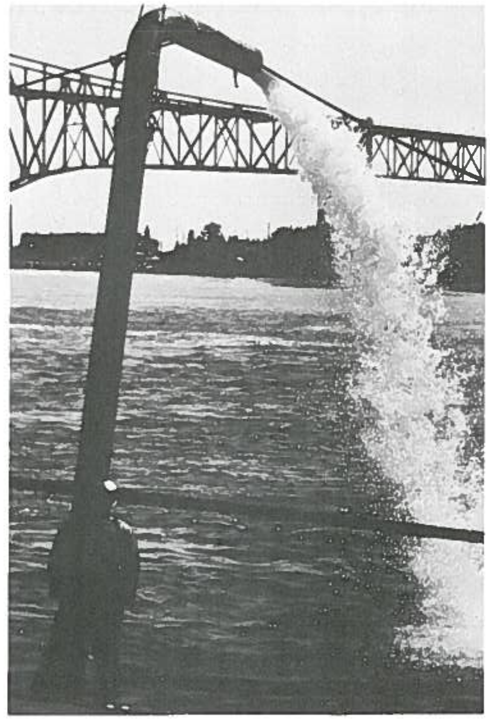
Two minor problems were encountered because of the coal's nugget size and submerged weight. The vessel manifest and early survey reports had indicated that the entire cargo con-



Diver foams cargo hold from top down, using each window in succession as foaming progresses to lower levels. Here, diver is tended from topside. Second diver went down to tend foaming diver when working in restricted spaces.

FOAMING IN CARGO HOLD FROM DIVER ACCESS TUBE





Air compressor feeds compressed air through air hose down to base of airlift pipe (left). Presence of air in water column inside airlift pipe creates pressure differential, forcing water, with coal nuggets and sediment, up through pipe for discharge into river (right).

AIRLIFT EXPELS COAL AND DEBRIS FROM CARGO HOLD

sisted of a fine grade of coal known as stoker coal. However, most of it turned out to be of a much coarser grade, and the 6-inch airlift proved inadequate for removing these relatively large, heavy nuggets. It was replaced with a 10-inch diameter airlift, which proved effective in removing the remaining debris. A second problem was the inability of the coal to gravity feed, or run, to the airlift intake because of its low submerged weight (density). Divers had to rake the coal to the intake, a lengthy and laborious task. Airlifting from hold #5 was completed on 5 July and from hold #6 on 8 July.

Meanwhile, other work was undertaken in preparation for foaming operations. All internal and external doors and hatches were secured with the exception of those few reserved for diver access to the designated compartments. Other foam escape routes were patched or plugged. Additional crawl holes were burned through decks and bulkheads for access to machinery spaces, fuel tanks, double bottom tanks, and other spaces to be foamed. Furthermore, to provide increased safety for the divers during foaming operations, all obstructions were burned away and loose objects removed. Loose deck plating scattered about the machinery spaces were secured and "diver traveling lines" were rigged in these compartments to guide the divers through the murky waters and maze of machinery. Hogging lines were also rigged at various levels in certain compartments to support the diver while he installed foam overhead.

Initial Foaming Operations, 4-16 July

Foaming of each compartment was undertaken as soon as it was readied, beginning in cargo hold #4 on 4 July. Because of considerable structural damage to the forward bulkhead, extensive underwater repairs would be necessary before this space could contain any large quantity of foam. It was for this reason that hatch covers were not installed. However, it was possible to install small amounts of foam in the topmost portions of this hold.

Foaming began on the first major space, hold #5, on 5 July. It was installed initially from topside using the probe method. Topside personnel also foamed an air pocket at the turn of the bilge which had remained above the surface of the water. The foaming hoses were then turned over to divers who entered the hold through the diver access tube and began foaming from the top down. As a safety precaution, a screen of expanded metal was installed on 6 July at the downstream end of the wreck to catch any foam that might escape.

Testing of a foam sample taken from hold #5 on 8 July indicated that it was of poor quality. The foam was not providing the desired buoyancy per pound of components installed. The reason could not be readily identified. Experts at the site concurred, however, that delivery temperatures of the foam's chemical components were below the optimum range of 70°F to 100°F. Air and water temperatures had dropped to levels which cooled the components beyond the 70°F lower limit, making it necessary to apply heat to the system from an external source. Although in-line heating units were available, they required greater system pressure than could be produced within the aerosol delivery system. For this reason, it was decided to preheat the component tanks.

On 8 and 9 July, a heating shed was assembled on a cargo barge moored alongside the derrick barge. Here, the large aerosol tanks could be slowly preheated to between 80°F and 90°F by several space heaters within the shed. Although the foam components cooled somewhat while traveling through the delivery hoses, their temperatures at the foam gun remained above the desired minimum of 70°F. The chemicals were preheated in this manner for the remainder of stern section foaming operations. Although preheating seemed to improve the quality of the foam installed, it soon became obvious that low component temperatures had not been the only foam production problem. Other problems were never isolated, however, and ultimately much more foam had to be installed than originally estimated.

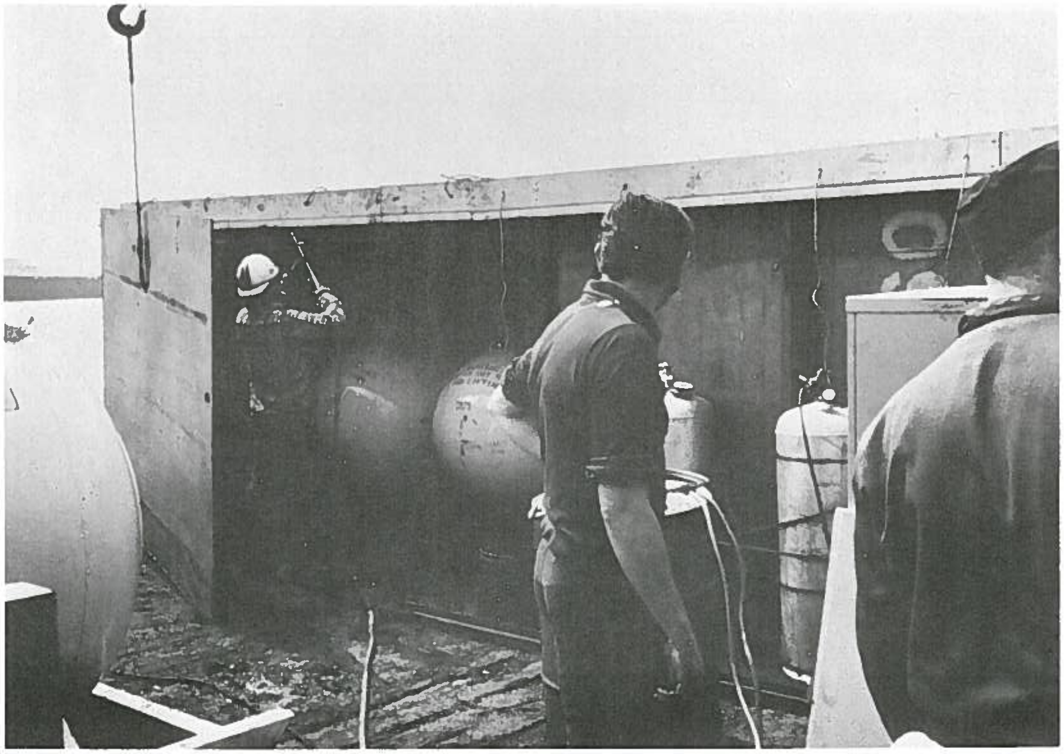
The buoyant force of the installed foam, while of uncertain value in the quantitative sense, had been contributing to changes in the attitude of the partially exposed stern sec-

Testing of foam samples confirmed salvors' belief that foam quality was poor. Causes proved difficult to pinpoint.

CHUNKS OF HARDENED FOAM REMOVED FROM CARGO HOLD

tion. The stern section was still settling into the sandy river bottom when foaming began on 4 July. The settling had slowed somewhat and its progressive effects were not as clearly visible as earlier in the operation. However, the periodic reports of the COE survey crew confirmed that it was continuing at a fairly steady rate. Introduction of foam buoyancy appeared to have the immediate effect of arresting the rate of sinking. On 9 July, after about 400 tons of foam buoyancy had been installed, primarily in hold #5, the survey crew reported that the stern section had stabilized.

During this period divers cleared obstructions in the machinery spaces, located fuel tanks, and marked and burned foam nozzle holes and water escape holes. About 200 tons of foam buoyancy were installed in double bottom tank #5. The divers had previously gained access to this tank by cutting through the coal hopper in hold #5. On 11 July a frame was fabricated on the wreck to assist in foaming the engine room. Divers began foaming this space the same day.



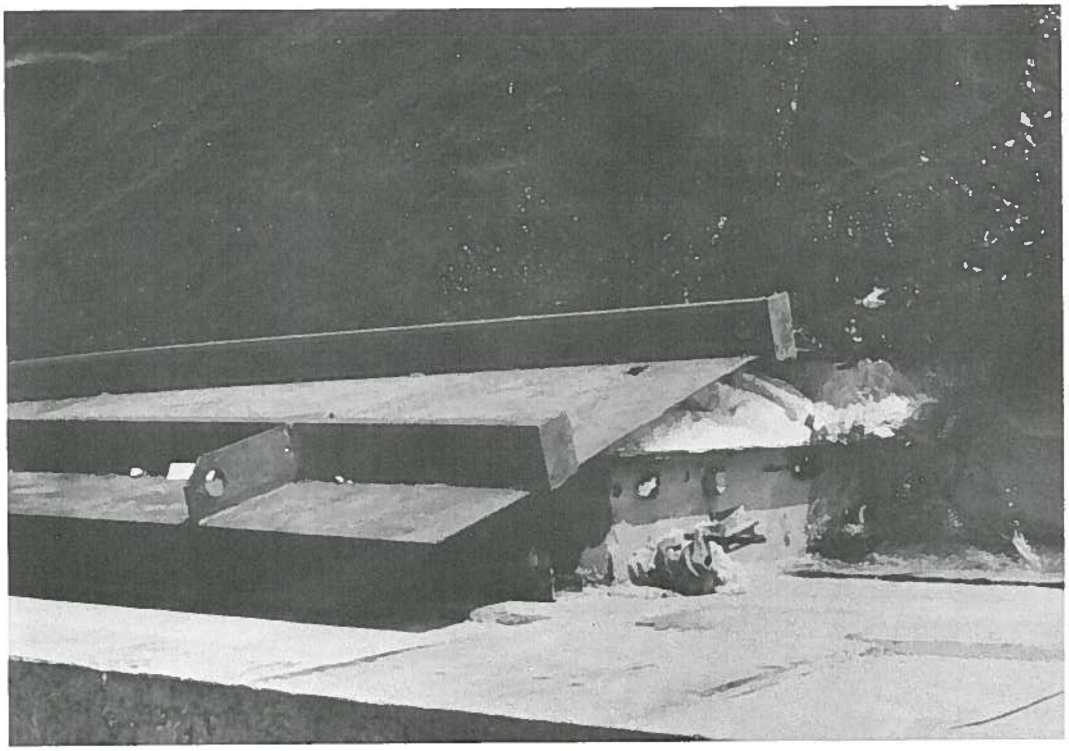
Tanks were heated externally with space heaters in this improvised shelter in an effort to improve foam quality. Low pressure in aerosol delivery system precludes in-line heating of chemicals.

HEATING SHED ON BARGE FOR AEROSOL TANKS

On 13 July, the salvors suffered a minor setback. The pressure of the expanding foam being installed in hold #5 forced the upper end of the hatch cover to break loose from the hatch coaming. A large amount of foam escaped. Some of the escaping foam was captured by the metal screen that had been installed at the downstream end of the wreck for that purpose. Divers immediately began to repair, reposition, and reinforce the hatch cover.

Foaming resumed in hold #5 on 14 July, continuing here and in the engine room through 15 July. The port and starboard fuel tanks, near the boiler room, were also foamed during this period, using the probe method. Concurrently, divers installed turnbuckle jigs around the other hatch covers on holds #5 and #6 to snug each cover more securely over the hatch.

Foaming and diving operations were shut down from 0001 16 July to 0600 17 July. About 1,700 tons of foam buoyancy had been installed at this point. This estimate was, of course, very rough because of the foam's uncertain quality. Moreover, the original estimate of the hulk's submerged weight before foaming was unreliable because of incomplete data. For these reasons, the stern could now be considerably lighter than estimated.



Foam, expanding and hardening in cargo holds, exerted great force against hatch covers. All four hatch covers were reinforced with strongbacks after initial installation in order to contain foam.

EXPANDING BUOYANT FOAM DISLODGES HATCH COVER

The salvors did not want to risk installing more foam until at least part of the pulling system could be made operational. Additional foam could suddenly make the wreck lively, breaking bottom suction or shifting its position. Should this occur without warning, divers working below would be endangered and control of the hulk could be easily lost. Therefore, the salvors wanted to use the pullers to maintain tension on the wreck, providing control and a positive indication of approaching positive buoyancy before a critical situation could develop.

ON-SHORE OPERATIONS, 29 JUNE - 19 JULY

Preparations ashore for pulling in the wreck were undertaken concurrently with mid-channel operations. Pulling stations were prepared, pulling wires aligned, and the hydraulic pullers installed and tested as soon as they arrived from the plant. Outdoor lighting was rigged at each pulling site, using Navy portable generators, in anticipation of round-the-clock pulling operations.

Preparing Pulling Station ALPHA, 29 June - 12 July

On 29 June, crews from the Nicholson Anchorage Company arrived on site with their drilling rigs and began drilling the first hole at Pulling Station ALPHA. After drilling was completed on 4 July, carpenters began preparing forms for the two anchor blocks. Concurrently, welders fabricated the reinforcing rod network for the blocks. Concrete was then poured into excavations over the wire bundles which had been installed and grouted in the drilled holes.

On 6 July, each wire strand at anchor block A was tensioned and secured to the three plates at the leading edge of the block. The following day the salvors began running the 2-inch pulling wires, using the tug KEWEENAW BAY. The wires were laid from the wreck along the river bottom to the completed anchor blocks. Carpenters began building the puller platforms on 8 July. Platforms A and B were completed on 12 July, just in time for the arrival of the 100-ton hydraulic pullers, trucked in from the Lucker plant.

Preparing Pulling Stations BRAVO and CHARLIE, 4-19 July

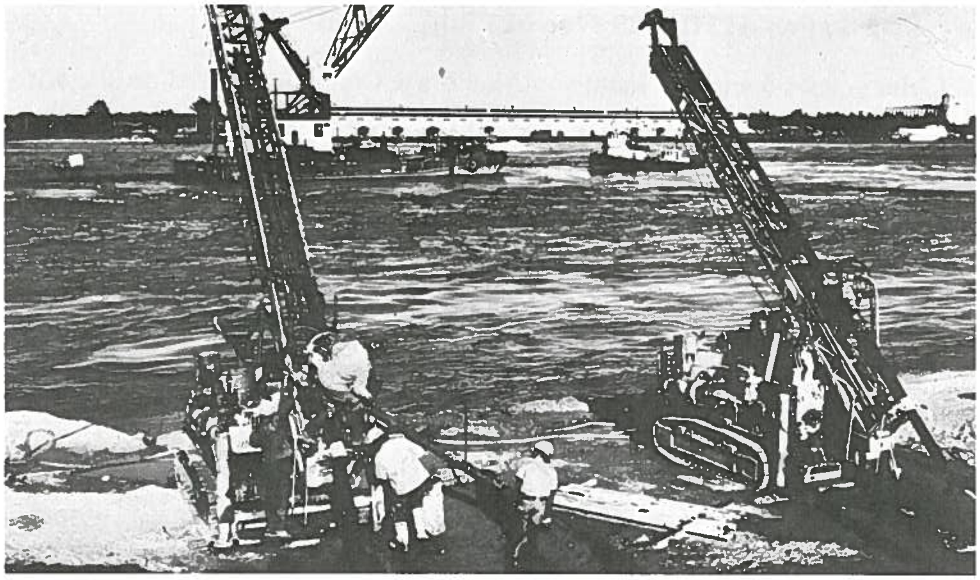
With drilling completed at Pulling Station ALPHA and other workmen preparing the anchor blocks there, the Nicholson Anchorage Company crew began drilling at Pulling Stations BRAVO and CHARLIE on 4 and 6 July, respectively. After drilling was completed, anchor block forms were prepared, reinforcing rod fabricated, concrete poured, and wire tensioned. Installation procedures at these two stations were the same as those for Pulling Station ALPHA, except that two, rather than three, anchoring legs were drilled at the downstream anchor blocks. Puller platforms were also built and pulling wire laid.

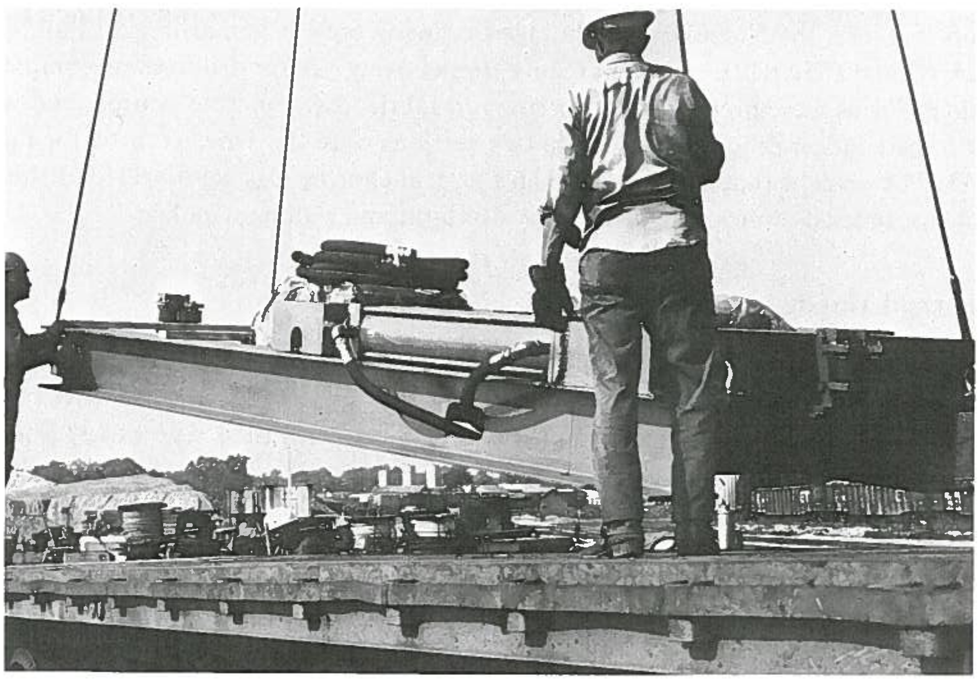
Installation and Testing of Hydraulic Pullers, 12-19 July

The two 100-ton hydraulic pullers were delivered to the salvage site on 12 July, right off the assembly line, untested. They were immediately set up on their platforms at Pulling Station ALPHA, secured to the anchor blocks, and aligned with their respective hydraulic power sources and control consoles. The 2-inch pulling wires were inserted into the cable grips and the whole system was then tested for the first time.

The initial tests revealed several problems, primarily in the hydraulic circuitry. The hydraulic piping was faulty and many of the hoses burst when tested. The hoses proved to be low or medium pressure hose, inadvertently substituted for the specified high pressure hose during assembly. The pullers were repiped and new hoses installed.

On 14 July, the hydraulic circuitry on puller A was completely realigned and the hoses and couplings upgraded. Subsequent tests and a pull strain of 31 tons proved satisfactory. The next day similar repairs were begun on puller B. On 17 July puller B was tensioned to 25 tons.





Drill rigs of Nicholson Co. penetrate 165′ underground, drilling holes for anchor legs. Below, hydraulic puller, fresh from assembly line at Lucker Co. plant, is lifted from truck at newly completed pulling station.

CONTRACTOR SUPPORT FOR INSTALLATION OF PULLING SYSTEM

An HD-21 bulldozer was positioned downstream at Pulling Station DELTA on 21 July followed by a second bulldozer at this station on 25 July.

BULLDOZER PROVIDES ADDITIONAL PULLING POWER

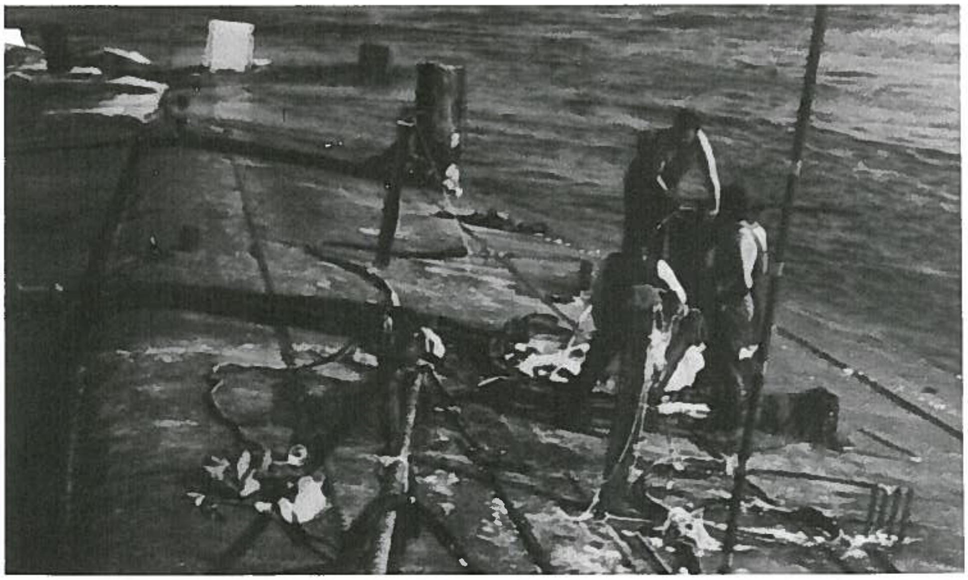
On 18 July, final adjustments were made to the pullers and pads in preparation for pulling operations. Personnel trained to operate the pullers were on hand and ready to begin work. However, delivery of the four 40-ton hydraulic pullers was delayed a day pending completion of testing at the factory. These arrived on 19 July. They were immediately installed and readied for operations.

Also on 19 July, an HD-21 bulldozer was positioned downstream of Pulling Station CHARLIE to provide additional pulling power. It was connected to a pull point aft on the stern section's port side, using 1 5/8-inch wire.

FIRST REMOVAL ATTEMPT, 17-23 JULY

Final Preparations, 17-21 July

Foaming resumed on 17 July although only the two 100-ton pullers were operational. Small amounts of foam were placed in hold #5, the boiler room and the engine room pending



Salvors tend diver foaming cargo hold from access tube. Fittings are also in place for foaming from topside by probe method. Chains are rigged to pull points on port side.

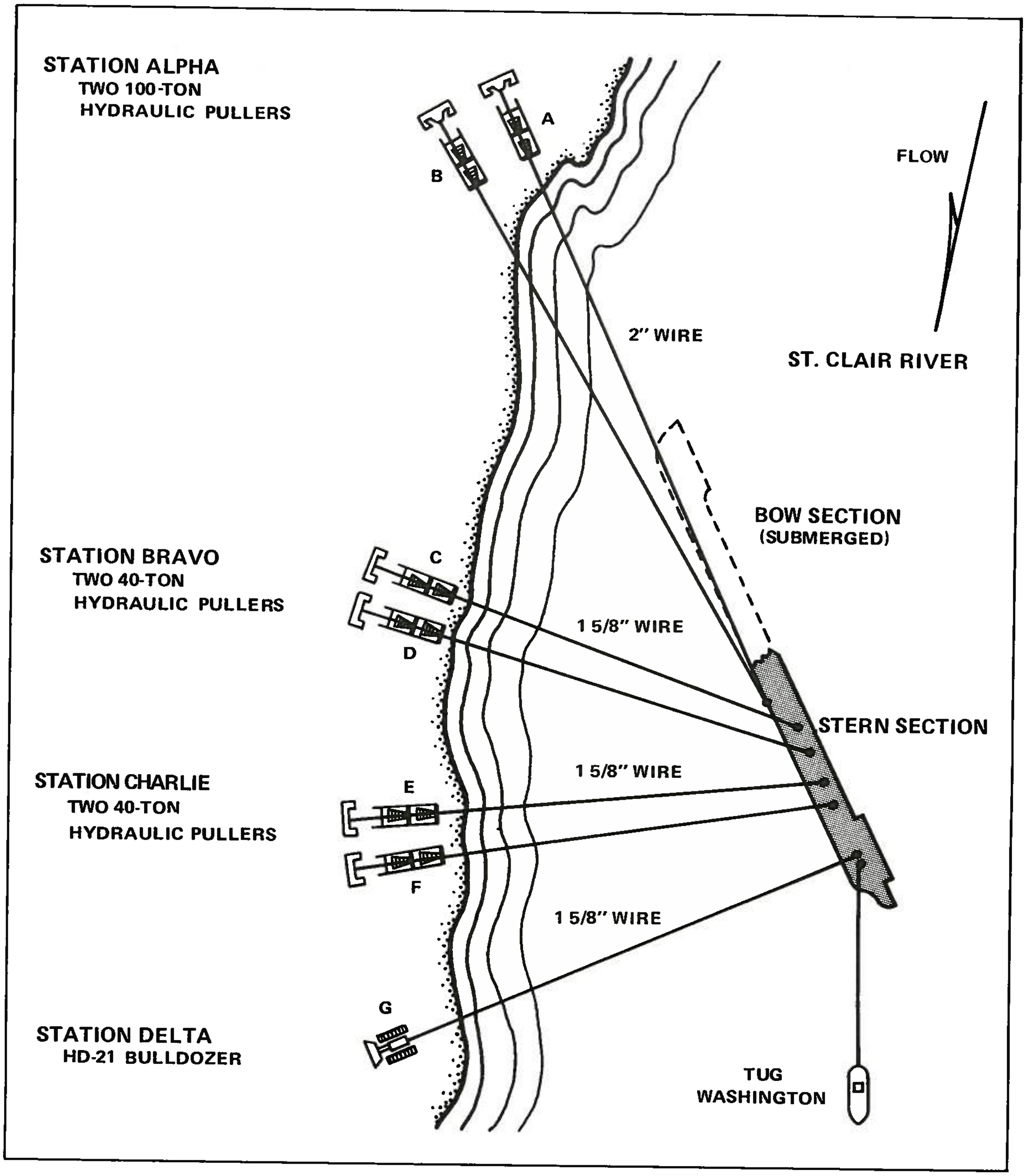
FOAMING IN PROGRESS ON STERN SECTION

the completion of the pulling system on 19 July. Starting on 19 July, the salvage force concentrated its foaming effort on hold #6. About 1,300 tons of foam buoyancy were installed in this hold through early 21 July in final preparation for the pulling effort. The stern section continued to rise slowly in this period, shifting slightly in a westerly direction.

Final rigging of the pulling system was accomplished on 20 July. All wires were tensioned to 10-12 tons. The head wires were then slacked while the bulldozer downstream made a trial pull with no visible effects. The stern continued to right and rise slightly during the day as foaming progressed in hold #6. The salvors prepared to devote the next day to an all-out effort to pull the wreck ashore.

First Pulling Effort, 21 July

On 21 July, a maximum strain was taken on all seven pulling wires. A 100-ton force was applied by each puller at Station ALPHA while a 40-ton force was applied by each puller at Stations BRAVO and CHARLIE. The HD-21 bulldozer pulled from its downstream location, Station DELTA. This maximum pulling effort was sustained throughout the day with no significant shoreward movement. Over 3,000 tons of foam buoyancy had been installed to this point, principally in the two cargo holds. This 3,000-ton figure was based on the pre-



Maximum pulling force from all four shore stations, plus later help from tug downstream, failed to dislodge stubborn stern section from mid-channel. After 3-day effort, wreck was partially righted but shoreward movement remained minimal.

PULLING SYSTEM FOR INITIAL STERN REMOVAL EFFORT

dicted buoyancy yield per pound of chemicals installed. The salvors realized that the actual buoyancy might well be considerably less than this amount because of the foam's uncertain quality. Nevertheless, this failure to dislodge the hulk after so much foam had been installed tended to confirm the suspicion that the two wreck sections might still be joined.

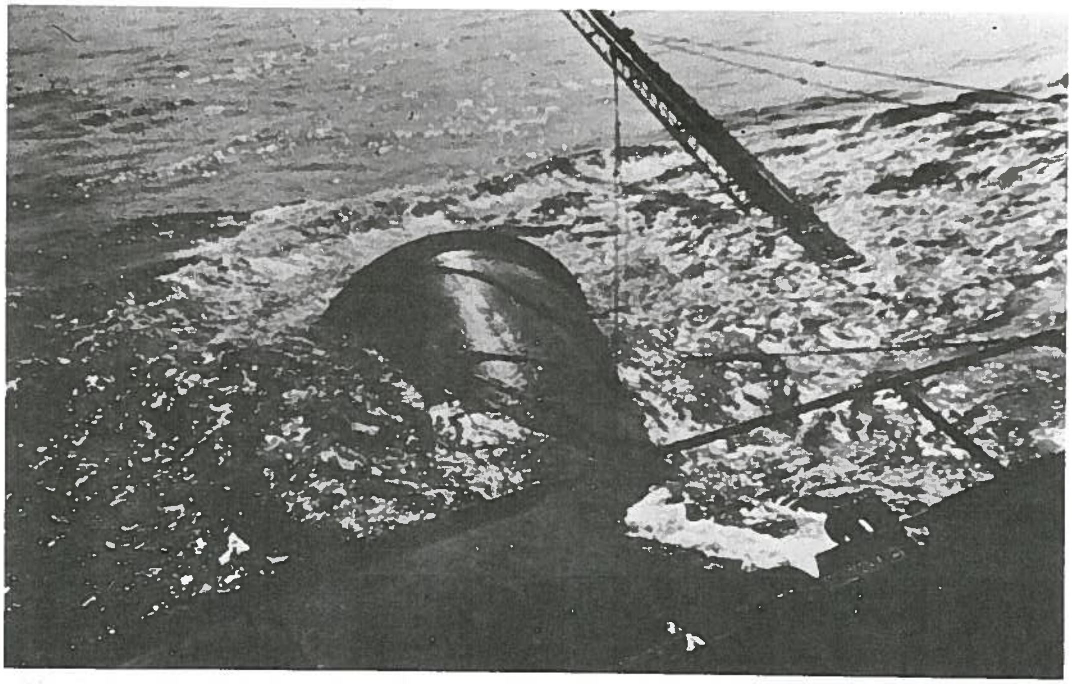
Divers were sent down to attempt a difficult, potentially hazardous inspection of the area of the break. The current was too strong to permit a thorough investigation and the starboard shell plating in the area of the break was covered with sand and gravel. Nevertheless, the divers did find evidence that part of the starboard shell plating and several strength members were still joined, although they could not determine the extent and strength of the connection. This was evidently one, although not necessarily the only, factor impeding the pull. It was also possible that the stern section was still too heavy for retraction. Conceivably the initial estimate of ground reaction had been low or the installed foam had produced less buoyancy than estimated.

While maximum tension was maintained on the pulling system, the large river tug WASHINGTON, with tow wire attached to SMITH's stern, pulled downstream for about 2 hours. It was hoped that this might separate the bow and stern sections if they were connected only by a few weakened strength members or merely jammed together. No movement was detected. By midnight on 21 July, the stern section had risen 8 to 12 feet, with masts and part of the superstructure visible above the water line, but shoreward movement remained minimal.

Severing the Connection Between the Two Sections, 22-23 July

The pulling force was maintained through 22 July to allow for a gradual breaking of bottom suction and parting of bow and stern sections. A second inspection dive late in the day confirmed that the two wreck sections were, in fact, connected by part of the starboard skin and several longitudinal strength members. The connection would have to be severed before either section could be beached. Oxy-arc cutting was considered but rejected as being too hazardous for divers because of the torn and mangled metal that would be encountered as the wreck separated. Instead, the salvors decided to implant plastic explosive charges to be detonated simultaneously.

These explosives were set at 2100. After the Coast Guard had been notified, all vessel and small craft traffic cleared, and the derrick barge moved back from the wreck, the explosives were detonated. Pulling wires were retensioned briefly, but no movement of the stern section was detected. The next day, a diver was sent down again to inspect the problem area. He discovered a small 3-foot section of the shell plating which had failed to part during the explosion. Divers returned and severed this final link using an oxy-arc rig. Maximum tension was again placed on the pulling wires but the stern section moved only 12 feet toward shore before it again bogged down.



Lateral force of hydraulic pullers and buoyancy of installed foam begin to lift and right the hulk. However, shoreward movement at this stage is minimal because, unknown to salvors, bow and stern sections are still joined.

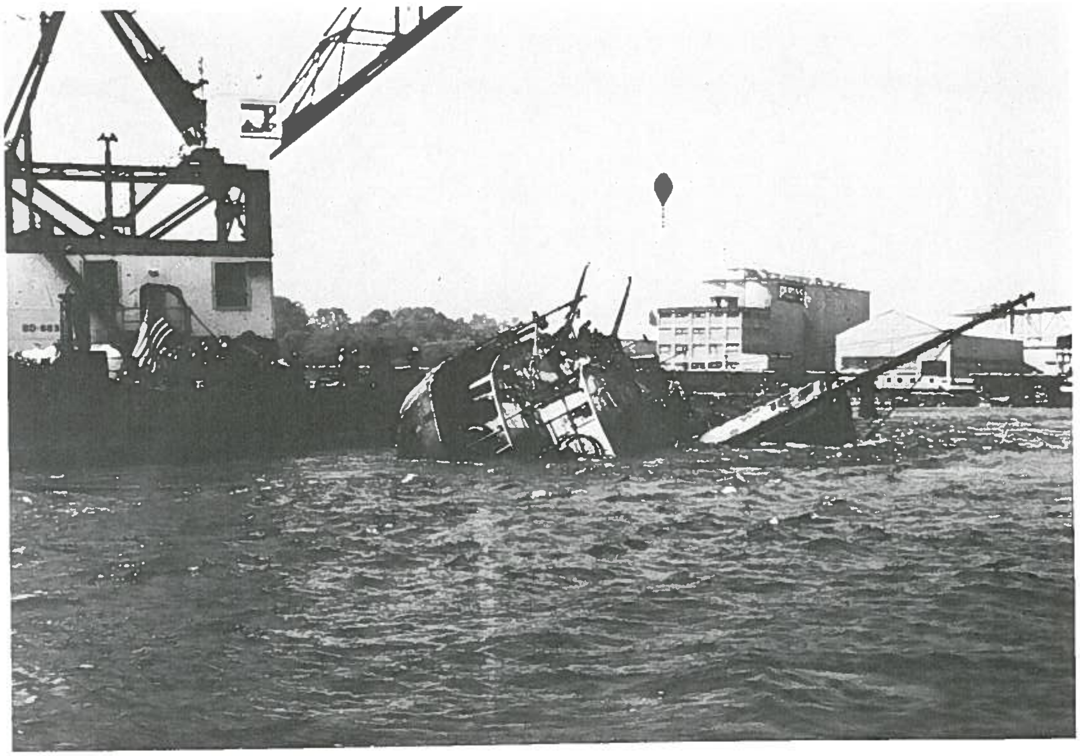
STERN SUPERSTRUCTURE BREAKS SURFACE

PREPARATIONS FOR SECOND REMOVAL ATTEMPT, 24 JULY - 2 AUGUST

The salvors decided to install more foam and rerig the pulling system for greater power before proceeding with another removal effort. The stern section had moved only a nominal distance toward shore during the first attempt, even after it had been severed completely from the bow section. Analyses of new foam samples confirmed that the actual installed buoyancy was considerably below predicted levels. The possibility also remained that the initial estimate of the SMITH's submerged weight had been too low. It was evident that more installed buoyancy and pulling power were necessary.

Additional Foaming, 24 July - 1 August

Preparations for additional foaming began on 24 July. The SMITH's boiler room and engine room were designated as the next major spaces to be foamed. Provisions were also made to install additional foam in cargo holds #5 and #6. Available foaming spaces, which had orig-



Initial pulling efforts failed to budge the hulk. Salvors then decided to install additional foam. Hatch covers were also reinforced at this stage before renewing pulling attempts.

PARTIALLY RIGHTED STERN SECTION RESISTS PULL TO SHORE

inally seemed ample for containing the required quantity of foam, now were at a premium. Because of the foam's poor quality, it became necessary to install much more foam than initially predicted in order to achieve the necessary buoyancy for lightening the wreck.

It took several days of difficult underwater work to prepare the boiler room and engine room. Although these spaces had been partially foamed previously, it was now necessary to do extensive patching and plugging in order to seal them adequately for containing large quantities of foam. Hatches and bulkhead openings in these spaces required patches as large as 9 feet by 12 feet to seal them adequately. The uptake area (ventilating shaft) in the boiler room proved especially difficult to patch. The divers eventually resorted to the use of burlap bags filled with straw to seal this area.

Intensive efforts were made during this period to reinforce the hatch covers on the SMITH's cargo holds. With additional foam to be installed in these holds and the stern section to be parbuckled to a nearly upright position, the hatch covers would have to withstand most of the full buoyant force of the foam. Large, 12-inch I-beams were positioned fore and aft between the hatch cover stiffeners as strongbacks over the hatch cover. The ends of each I-beam were clamped down by smaller I-beam "saddles", held by a pair of long bolts passing through the deck and secured below. In addition, several wires were run athwartships from gunwale to gunwale, over the entire hatch cover assembly, and tensioned by turnbuckles at one end.

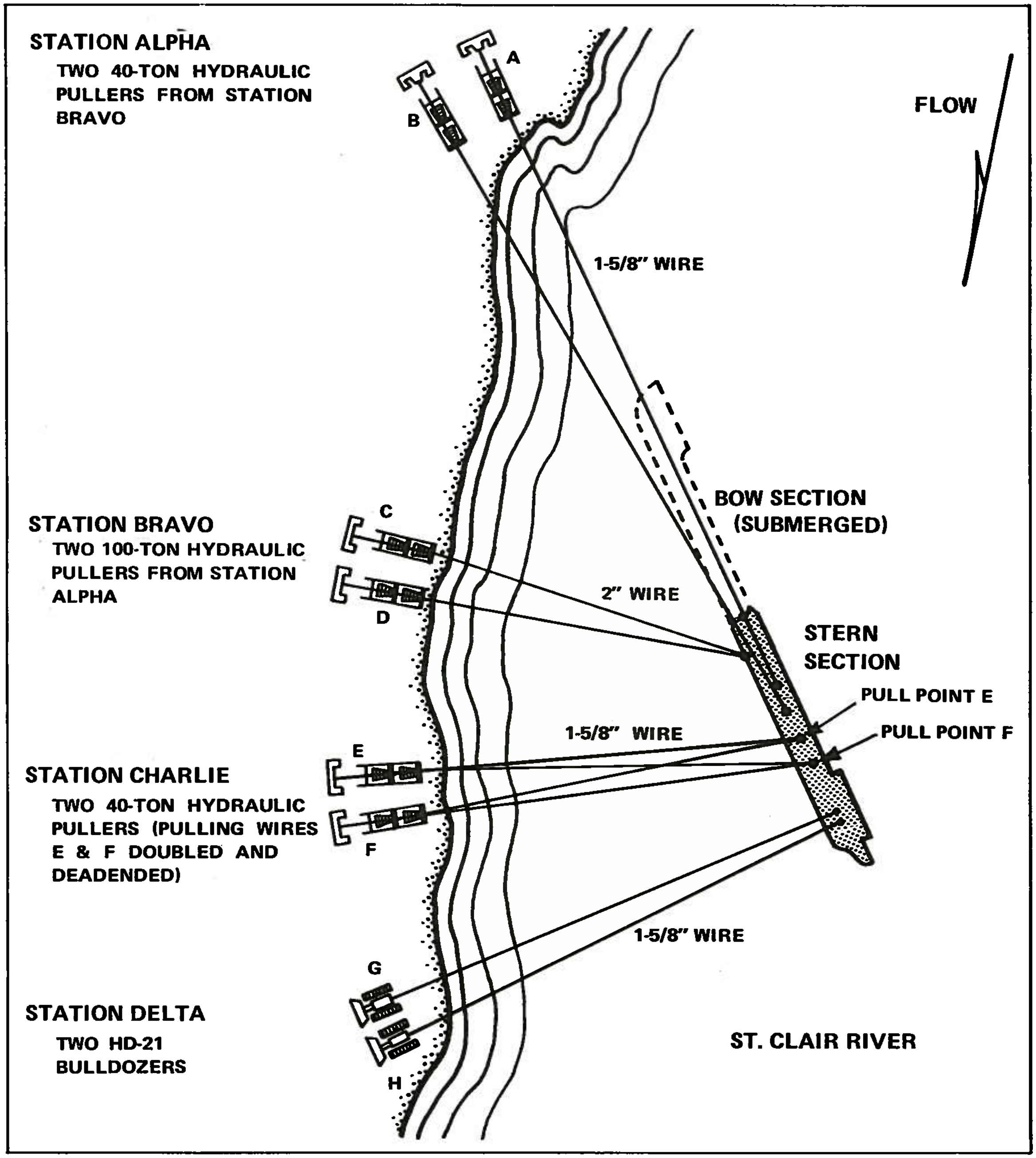
Foaming resumed on 26 July, first in the boiler room and then in the engine room. In order to foam the lower level of the engine room, the divers had to burn access holes from the machine shop into the after peak tank and finally into the lowest point of the engine room. Preparations for foaming cargo hold #5 and #6 went forward concurrently with the foaming of these spaces. The stern section's attitude at this time was high at the after end and trimmed well down by the forward end. The list to starboard decreased from 35 degrees to 24 degrees in the period 27-30 July. The additional foam was evidently lightening the wreck, thus assisting in the parbuckling effort.

Rerigging of Pulling System, 24-25 July

As the stern was being foamed in mid-channel, the pulling system ashore was being completely rerigged for greater pulling power. The more powerful, 100-ton hydraulic pullers were moved downstream from Station ALPHA, the upriver holding point, to Station BRAVO. They were replaced at Station ALPHA with the two 40-ton pullers from Station BRAVO. This switch effectively increased the shoreward pulling force by 120 tons. The upriver holding force was, of course, decreased by the same value. This trade-off was made based on the experience gained in the initial removal attempts. Less power was required to hold the hulk against the river current but more was required to actually pull it to shore.

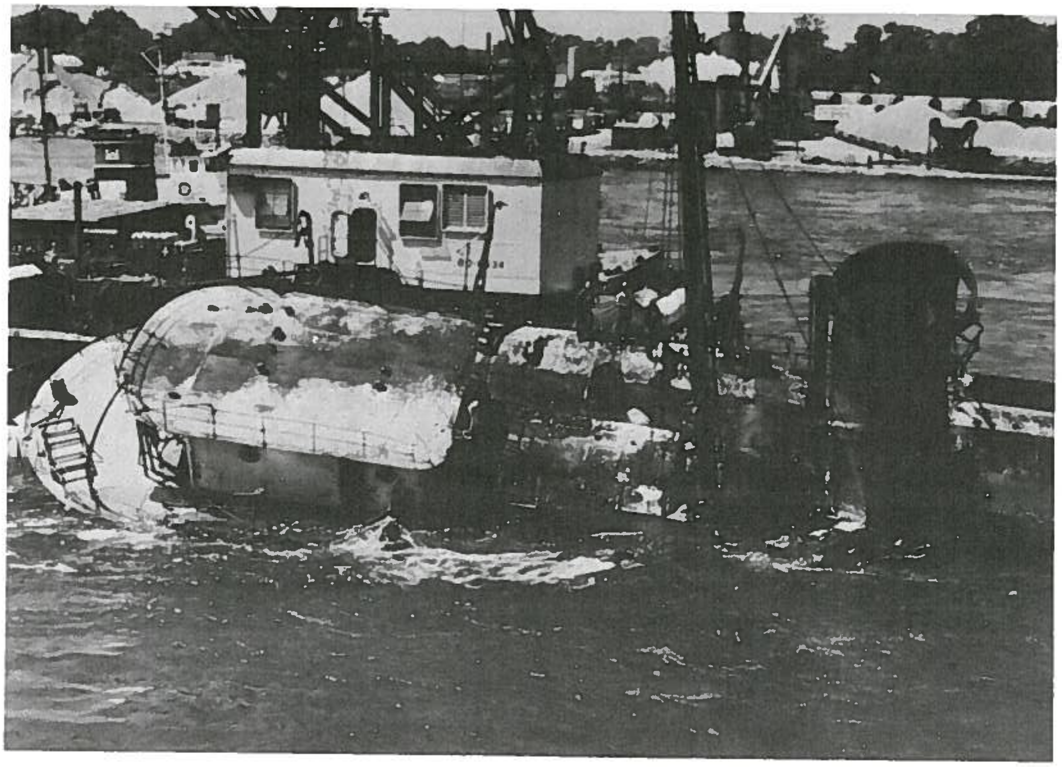
Another change to the salvage plan affected Pulling Station CHARLIE. Its pulling wires, E and F, were doubled with snatch blocks on the wreck. E wire was then deadended on F puller and F wire deadended on E puller. This gave the 40-ton pullers a 2:1 mechanical advantage. Thus, a maximum beaching force of 80 tons could be applied at both pull points E and F aboard the wreck.

In addition, a second HD-21 bulldozer was placed at Pulling Station DELTA to increase pulling power downstream. This additional dozer, designated puller H, was aligned with the first bulldozer, puller G, and connected to a pull point aft on the SMITH's port side with a 1 5/8-inch pulling wire. The addition doubled the 27-ton pulling force originally exerted at Station DELTA by the first dozer.



Complete rerigging of pulling stations for greater shoreward pulling force resulted in successful removal of stern. Station BRAVO received 100-ton pullers from Station ALPHA; rerigging at Station CHARLIE and on wreck doubled pulling force at pull points E and F; Station DELTA received additional bulldozer.

PULLING SYSTEM FOR FINAL STERN REMOVAL EFFORT



Foaming operations are nearing completion. Stern is held against shallow underwater ridge initially. River current washed away ridge peak, helping to free the hulk for shoreward pull.

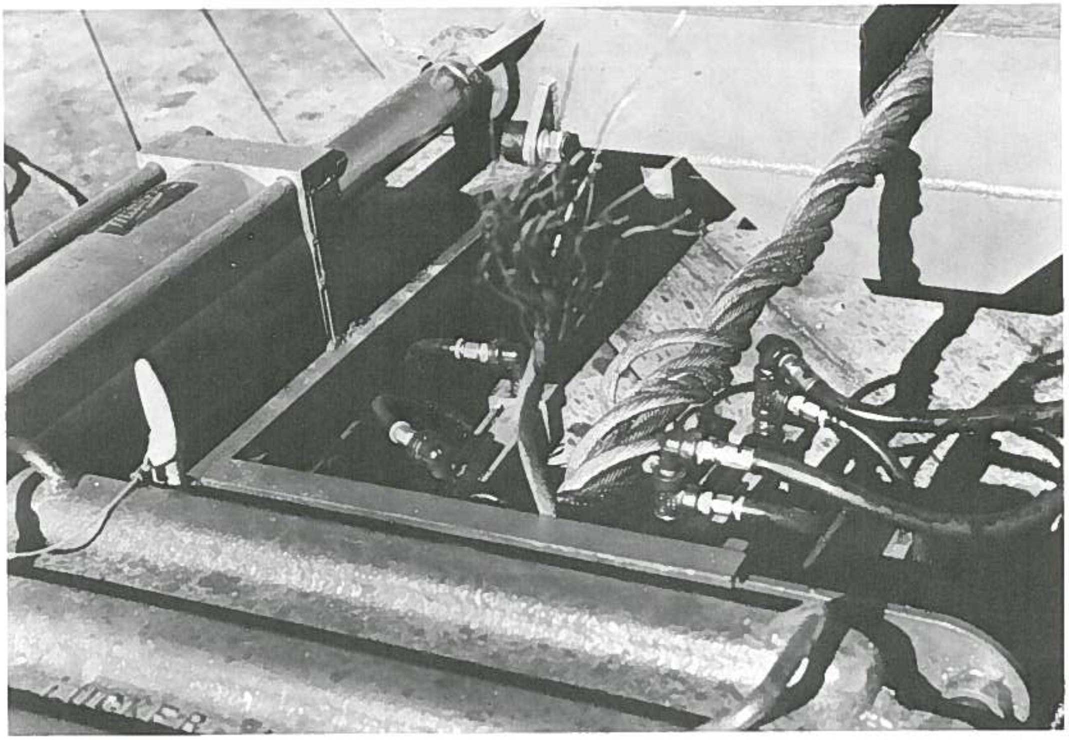
STERN SECTION JUST PRIOR TO FINAL PULL

SECOND REMOVAL ATTEMPT, 3-6 AUGUST

Stern is Dislodged, 3 August

The rerigged pulling system was ready for operations on 3 August. The salvors decided to renew the pulling effort on this date even though additional foam remained to be installed in cargo holds #5 and #6. Foaming commenced in hold #5 concurrently with the beginning of the pulling operation. The increased pulling power of the rerigged system paid immediate dividends as the stern was moved 31 feet toward shore during the first day of operations. At the end of 3 August, the hulk's attitude was now high at the after end with only an 11 degree list to starboard.

The effort on 3 August was interrupted for a short time when three strands of the pulling wire from a 100-ton puller at Station BRAVO parted, fouling the puller's cable grips. Repairs were made quickly, however, and the puller was down only a short time.



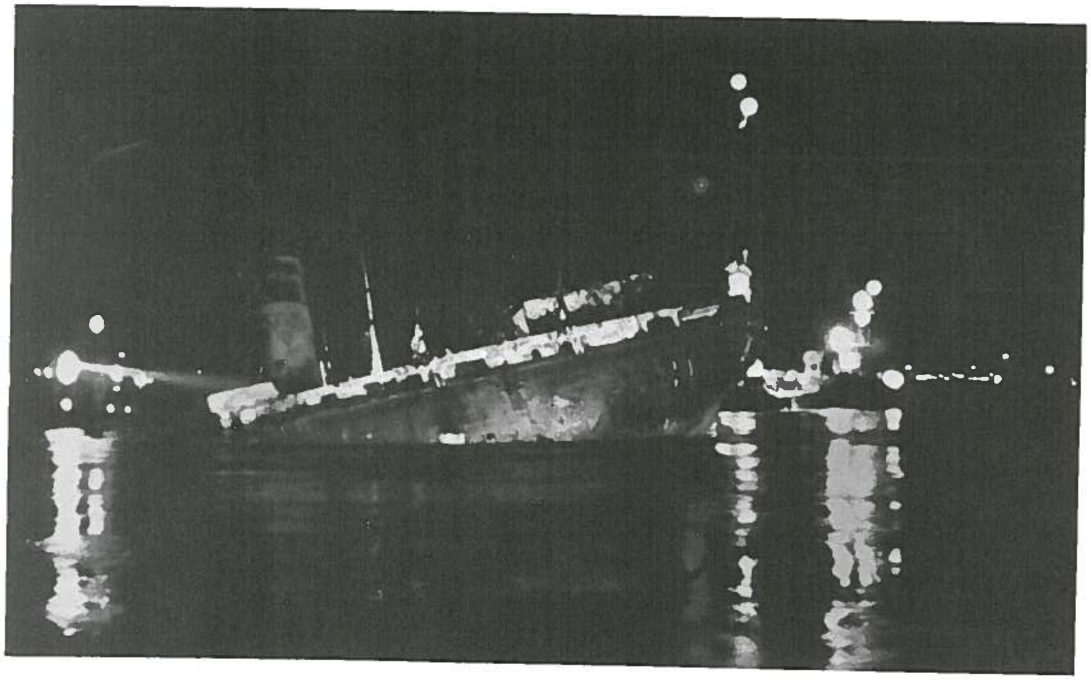
Three strands of the 2" pulling wire parted on 3 August. Repairs were made quickly. Photo shows puller's stationary grip. Grips on 100-ton puller are hydraulically activated (small hose connections).

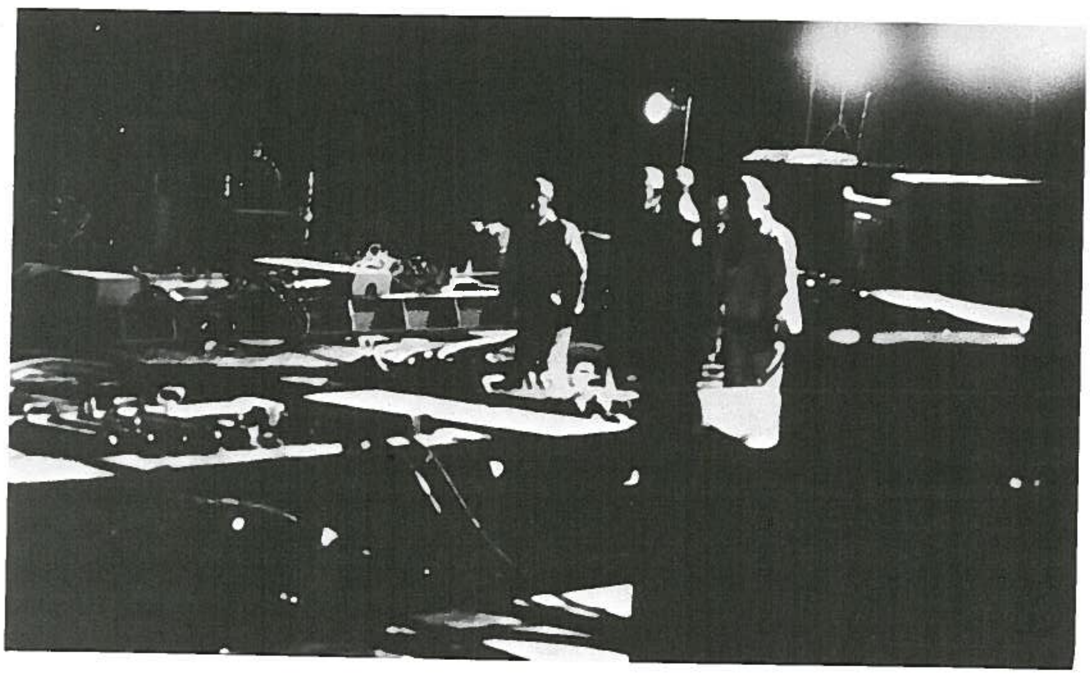
PARTED PULLING WIRE SNARLS 100-TON HYDRAULIC PULLER

Final Preparations, 4-5 August

No pulling was attempted on 4 and 5 August, although tension was maintained on the wires. The salvors wanted to keep the stern in its present position until enough additional foam had been installed to ensure a successful retraction across the deep trench between the wreck and the shore. The ridge between the wreck and this depression, which had been the source of earlier concern, was no longer a significant factor. Much of its peak had washed away as anticipated. The depression remained a problem, however, and it appeared prudent to wait until more foam could be placed in holds #5 and #6,

Repairs on the pulling platform at Station CHARLIE also had to be made on 4 August. The river bank fronting the platform had washed out due to high water and wave action. The bank was built up with blacktop and the platform reinforced with steel channels.





Final, 2-hour pull began just after midnight on 6 August. Stern section, broken end dragging bottom, came in easily, climaxing 41-day recovery effort.

MIDNIGHT PULL COMPLETES PHASE I SALVOPS

Holds #5 and #6 were topped off on 4 and 5 August, despite cold winds which made it difficult to heat the foam tanks to the proper temperature. The additional foam that had been installed since 26 July had by now brought about significant changes in the attitude and position of the wreck. By 5 August, the starboard list had been reduced from 11 degrees to 8 degrees, and the trim had been reduced to 14 degrees down at the forward end. The stern section was thus deemed ready for another removal attempt.

Successful Retraction, 6 August

Preparations for the retraction were completed late on 5 August. After moving the derrick barge downstream, clear of the wreck, the salvage force began the final pull just after midnight at 0400 on 6 August. Except for a little trouble in keeping the slack out of the wires, the Lucker pullers were able to pull the wreck parallel to the shoreline without incident. The stern section came in nicely with its forward end dragging bottom. It was secured on the beach at 0230 and held in place on the bank with pulling wires. This successful retraction, routinely achieved at night in 2 hours, was the culmination of 41 consecutive days of round-the-clock salvage operations.

Removal of the stern section from the shipping channel marked the completion of Phase I salvage operations. Much work remained to be done on the stern to prepare it for towing to a final scrapping site. However, the salvage force was now free to switch its main effort to Phase II, removal of the bow section, while a portion of the force proceeded with the disposal work on the stern.

CHAPTER 7
PLANNING FOR REMOVAL OF THE BOW SECTION

MAJOR FEATURES OF THE BOW REMOVAL PLAN

Basic Elements - Similar to Stern Removal

The plan for removing the bow section evolved during the course of stern removal operations. It was very similar to the stern removal plan, and took advantage of the experience gained and lessons learned in the earlier operation. The ground reaction of the hulk would be reduced by installing urethane foam. The lightened bow section would then be pulled ashore using hydraulic pullers. Salvors would work concurrently in mid-channel to prepare the hulk and ashore to rig the pulling stations. The salvage force was under continuing pressure to expedite removal of the bow because of its interference with the safe passage of commercial shipping in the channel.

Unique Requirements for Bow Removal

Despite the overall similarities, there were several fundamental differences between the two plans. These differences stemmed in large measure from the fact that the bow section, unlike the stern, was totally submerged, its starboard side bottomed at a depth of 90 feet. Its increased depth and relative inaccessibility imposed certain unique requirements in developing plans for its removal. For example:

- A mooring system would have to be implanted to hold the derrick barge in position over the submerged wreck.
- It would be necessary to devise a different foam delivery system, one which could function efficiently at the increased depth.
- Severe limitations on available foaming spaces within the bow section would necessitate a different foaming strategy.
- Cofferdams would have to be installed to give the divers protected access to the hulk for foaming operations.
- The on-shore pulling system would have to be rearranged and strengthened in order to provide increased pulling power.

The foregoing requirements are examined in detail in subsequent portions of this chapter.

MOORING SYSTEM FOR THE DERRICK BARGE

Requirements for Stability and Precision Maneuverability

During the stern removal operation, the derrick barge had been moored directly to the port side of the wreck. This was not possible with the submerged bow section; its high port side was from 23 to 26 feet beneath the water surface. As the bow removal plan was developed, a 6-point mooring system was designed to hold the barge in position over the wreck. This extremely stable moor would provide sufficient holding power to withstand the forces exerted by the river current against the barge and also provide the precision maneuverability required.

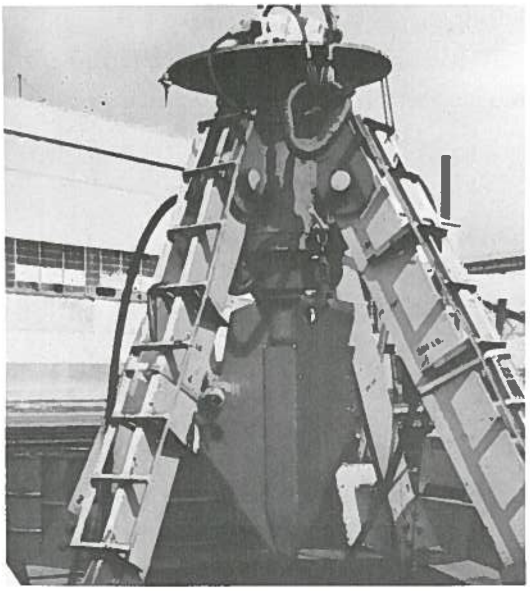
Stability and precision maneuverability within the moor were essential for the installation of the cofferdams. Each cofferdam had to be installed at a predesignated location on the bottom of the capsized wreck. Its proper positioning would be largely dependent upon the salvors' ability to maneuver the derrick barge (and attached cofferdam guide) a matter of inches or several feet in any direction.

Composition of the 6-Point Moor

The planned 6-point moor would consist of two legs positioned upstream from the submerged bow section to hold the derrick barge in position against the force of the swift current; two legs positioned downstream; and two legs running to mooring bollards on the Port Huron shore.

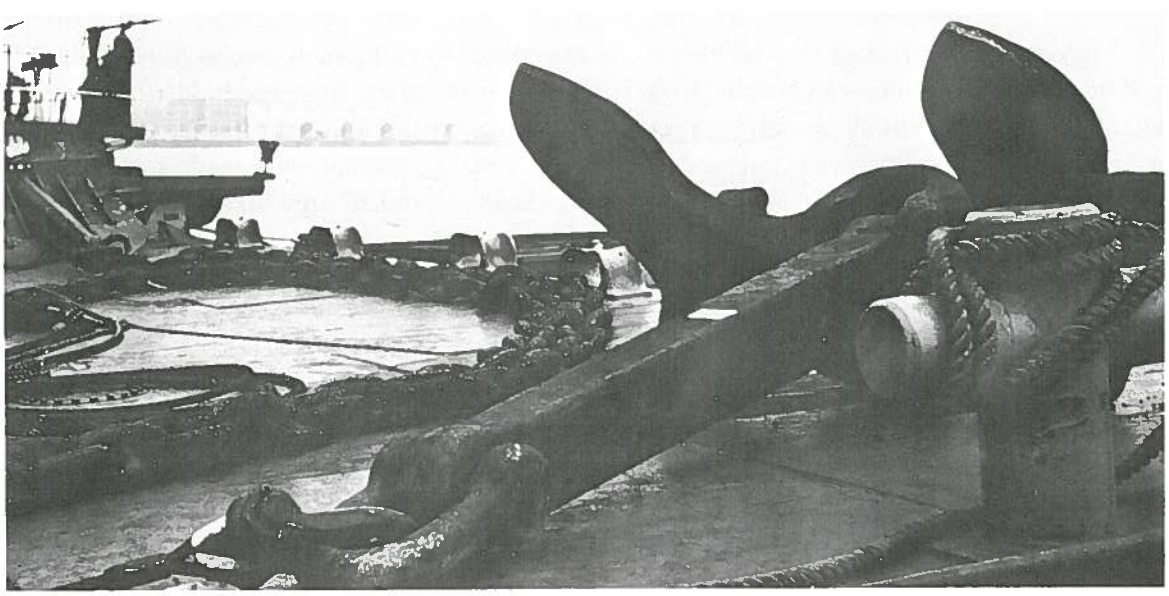
The plan called for the use of embedment anchors for the two upstream mooring legs since they would be required to withstand much greater forces than the other four legs. Developed by the Navy's Civil Engineering Laboratory (CEL) at Port Hueneme, California, the embedment anchor is essentially a fluked projectile driven down into the bottom by a large explosive charge. The shape of the projectile is designed to facilitate penetration and to maximize holding power once in place. Since the embedment anchor is a relatively new ocean engineering device, special Navy "stato" anchors were obtained as backups. Stato anchors are designed with unusually large flukes for greater holding power, particularly in loose sand or mud. Stockless anchors would be used for the other two mid-channel legs.

The ground tackle for this mooring system (anchors, anchor chain, wire rope and connecting shackles) was ordered to the salvage site before the stern removal operation was completed. A pair of 6,000-pound stockless anchors and all of the required 1 1/4-inch wire rope



EMBEDMENT ANCHOR

STATO ANCHOR



STOCKLESS ANCHOR (FOREGROUND)

Salvors planned to use newly developed embedment anchors for upstream mooring legs with stato anchors as backups in event embedment anchors failed. Stockless anchors would be used for downstream mooring legs.

ANCHORS FOR MOORING THE DERRICK BARGE

were procured locally. The anchor chain and connecting shackles were provided through the Navy Emergency Ship Salvage Material (ESSM) system. CEL supplied the experimental embedment anchors and an implantment crew as well as the pair of backup stato anchors.

PLANNING FOR BOW SECTION FOAMING OPERATIONS

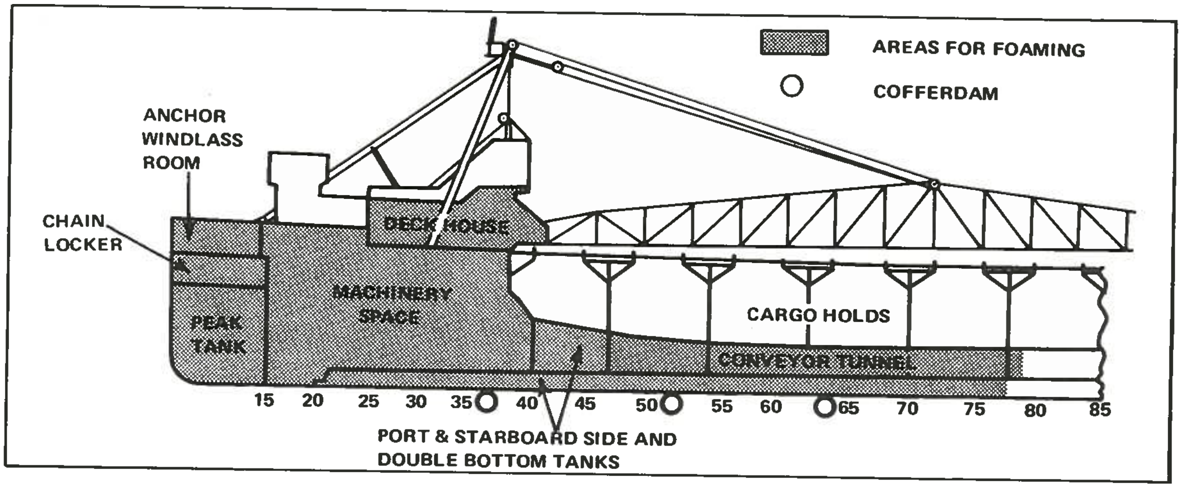
Planning Factors

In foaming the stern section, hatch coamings had been reasonably accessible, enabling the salvors to install hatch covers over the open cargo holds and subsequently foam these spaces. However, the hatch coamings on the bow section's cargo holds (#1,#2 and#3) were inaccessible, being well below the water surface. Hatch covers could not be installed and there was no way to seal these spaces for foaming. In fact, the swift current flowing into the open cargo holds would make it impossible for divers to enter these spaces.

In order to protect against turbulence in the spaces to be foamed, access holes would not be cut into the open cargo holds from within the hull. With the cargo holds thus excluded, plans for foaming operations focused on the forepeak, double bottom and side tanks, machinery spaces, conveyor tunnel and deck house area. Provisions were made to subdivide some of the larger compartments with canvas bulkheads stretched on wooden frames in an effort to control the lateral flow of unhardened foam across the foam/water interface. Lateral flow of fresh foam, if not controlled, increases foam/water contact, adversely affecting the foam's quality.

The salvors planned to foam the available tanks and compartments in a predetermined sequence, working generally from the center of the hulk toward the forward compartments. The total space available for foaming was limited. Moreover, once the shoreward pull was started no additional foam could be installed as the divers would no longer be able to use the cofferdams. It would be necessary to control the progress of the foaming effort very carefully. Conditions would not afford the flexibility and margin for error enjoyed during the stern section operations.

It was estimated that 1,700 tons of foam buoyancy would be required to lighten the vessel. Developing this estimate was complicated by the fact that the salvors did not have reliable data on the bow's submerged weight. For example, they were not certain how much sand and gravel had washed into the open cargo holds nor did they know whether the bow section's exceptionally heavy coal conveyor boom had been dislodged when the vessel capsized.



Bow section's cargo holds, unlike stern's, could not be foamed due to turbulence and impossibility of attaching hatch covers at wreck's depth. Foaming would be limited to tanks and spaces where water was calm.

CONCEPT FOR FOAMING BOW SECTION

No requirements for explosives and parbuckling were foreseen for bow operations. In removing the stern, explosives were employed to sever the two wreck sections and the stern section was parbuckled in order to haul it over a ridge on the river bottom. Parbuckling the bow would not be possible because of the planned placement of the cofferdams against the double bottoms. Fortunately, no obstacle lay in the bow section's projected path toward shore and parbuckling would therefore not be required. During the stern operations, experts had argued that both the blasting and parbuckling activities had contributed to the poor buoyancy characteristics of the installed foam. The problem of achieving improved buoyancy remained acute, however, in spite of the absence of these suggested contributing factors to poor quality foam.

Foam Delivery System for Bow Operations

The bow section was submerged at a depth of 90 feet, well beyond the limitations of the simple aerosol foam delivery system used for foaming the stern section. To provide the increased pressure required for foaming at this depth, the salvors devised a combintion aerosol-mechanical foam delivery system. This system also featured in-line heating of the chemicals and the use of other fittings designed to improve the efficiency of foaming operations. Every effort was made to anticipate and overcome the problems which had caused poor foam quality in stern section operations to the degree that these problems could be isolated and identified.

The combination system used the same type of aerosol tanks, pressurized with nitrogen, as used in the aerosol system. The nitrogen pressure drives the components through a pair of heat exchangers. After this in-line heating, the flow of each component to the foam gun is boosted with a mechanical pump. These pumps supply the high pressures required for large capacity foaming operations at greater depths than can be attained with the aerosol system alone.

The in-line heating capability was particularly important. The rapidly approaching fall season was already beginning to lower the air and water temperatures in the Great Lakes area. Bulk heating of the large aerosol tanks with space heaters had been employed with reasonable effectiveness in foaming the stern section during the late summer. In-line heating with heat exchangers is much more efficient but was not possible in the low pressure aerosol systems. The mechanical pumps in the combination system supplied the necessary pressure to overcome the pressure drop across the heat exchangers.

This combination system was configured especially for the SMITH salvage operation. It was not an existing system, stored and ready for use in a variety of salvage applications. The SMITH salvors designed and assembled it on site, using available equipment. Much of the equipment was procured by SUPSALV on the recommendations of the Murphy Pacific Marine Salvage Company (MYPAC) and the Battelle Memorial Institute, experts in the foam-in-salvage process.

See Appendix C for a detailed description of the combination aerosol-mechanical foam delivery system and related aspects of bow foaming procedures and techniques.

PLANNING FOR COFFERDAMS

Concept of Cofferdam Employment

The requirement for cofferdams arose from the fact that the strong river current precluded direct diver access through the water column to the submerged bow section. With the current flowing at 7 to 9 knots, it was not feasible for a diver to swim down to the hulk, 20 feet below the surface, and perform underwater work outside the hull. It would be necessary to protect him from the force of the current during his ascent and descent and give him access to the interior of the hulk. Cofferdams offered the ideal solution to this problem.

The concept of cofferdam employment envisioned the installation of four 100-foot long cofferdams, made up of 36-inch diameter steel pipe. The cofferdams would be mounted externally on the flat bottom of the bow section and extend upward, 6 to 10 feet above the water surface. A working platform would be constructed atop each cofferdam. From the cofferdams, divers could burn access holes into the SMITH's hull, emerge into the double bottoms and proceed from their initial entry points to other spaces, burning additional access holes as required.

Planned Locations of Cofferdams

The four cofferdams would be located to provide multiple diver access points along the approximate 250-foot length of the bow section. Positioned at roughly 50-foot intervals at frames 21, 36, 51 and 63, they would provide the tethered divers access to all internal spaces while maintaining a reasonably safe and rapid means of egress under emergency conditions. Each cofferdam would be lowered into place and secured at its designated location on the bottom of the wreck.

Control of the cofferdam during installation would be largely dependent upon the salvors' ability to maneuver the derrick barge (and the attached cofferdam guide) a matter of inches or several feet in any direction on the North-South, East-West axes. The angle of the cofferdam from the vertical axis and the depth or level of the cofferdam on this axis would be controlled during lowering, independent of barge movement. After all four cofferdams were properly installed, the barge would be moved back and secured 8 to 10 feet away from the cofferdams, with gangplanks leading to each of the four platforms. The salvors would then be ready to prepare the bow section for foaming and rigging pull points.

Cofferdam Design Characteristics

Each cofferdam was to be fabricated by welding together sections of 1/4-inch steel pipe, 36 inches in diameter, to form a single pipe 100 feet in length and open at each end. To provide access to appropriate areas of the bottom of the wreck, three windows would be cut in each cofferdam with flat, rectangular frames bordering the openings, 2 feet wide and 2 1/2-feet high. Eighteen bolt holes would be predrilled around the perimeter of each window frame. The three windows would be cut approximately 4 feet, 28 feet and 48 feet, respectively, above the bottom of each cofferdam. Their spacing varied somewhat with each cofferdam, depending upon which areas of the double bottom would provide the most convenient access to other spaces.

A large right-angle "knee-brace," fabricated from lengths of 6-inch wide flange metal stock, would be secured on each cofferdam, several feet above the top window. When the cofferdam was in position against the double bottoms, the knee brace would seat against the vessel's port side. The brace would provide a convenient "stop" when lowering the coffer-

Cofferdam guide, 28' long, cradles cofferdam during lowering into place against sunken bow section. A-frame keeps guide and cofferdam clear of barge. Screw-type jack controls guide angle.

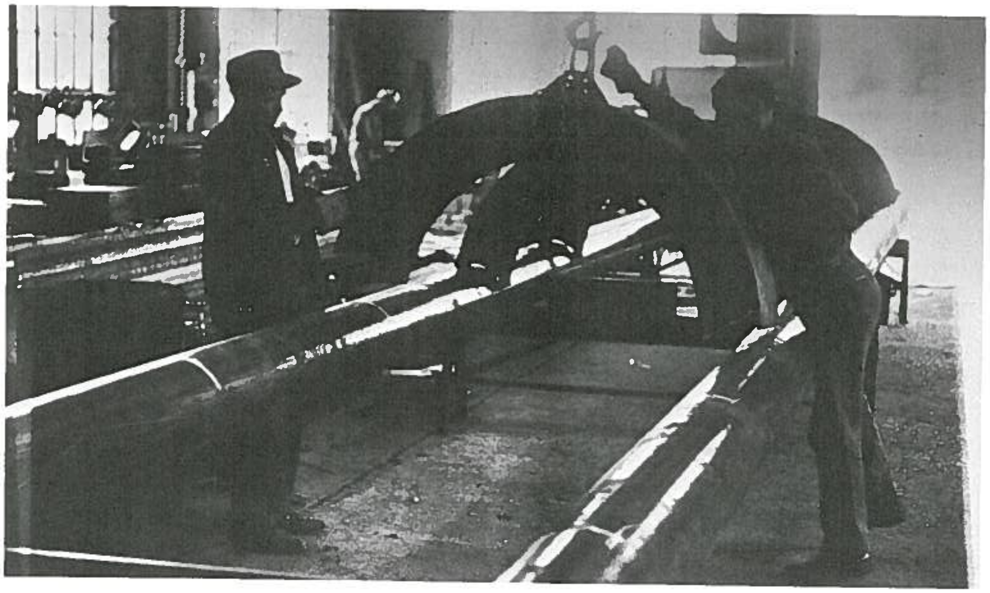
COFFERDAM GUIDE AND A-FRAME

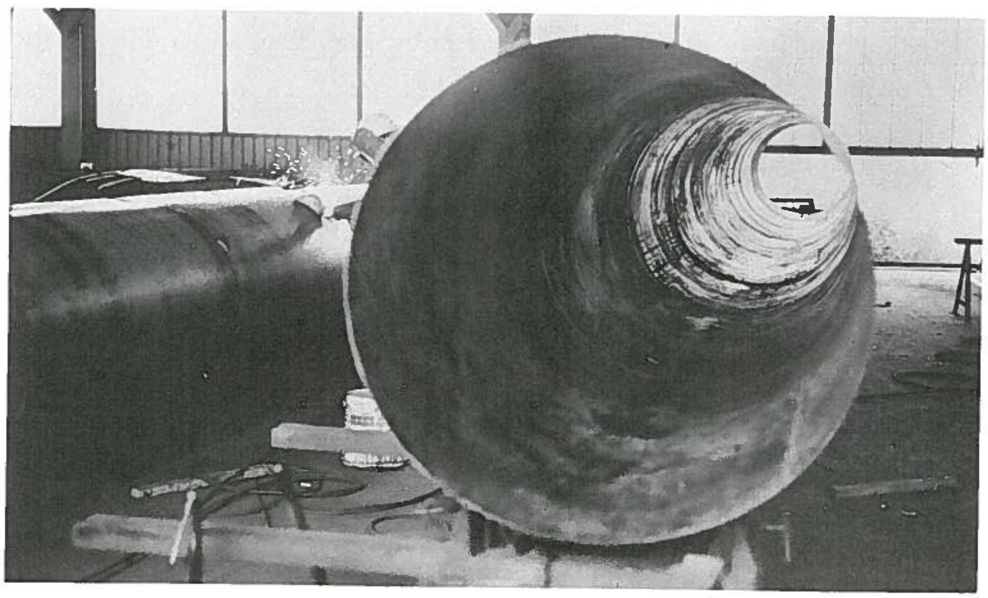
dam into position, as well as a fourth point of attachment for increased strength in securing the cofferdam to the wreck.

An A-frame and guide were to be fabricated to help control the cofferdam during the lowering procedure. The guide, a cradle-like device 28 feet long, would be attached to fittings on the A-frame installed on the deck of the derrick barge. It would hold the cofferdam in a fairly stable position against the force of the river current during lowering and installation. A screw-type jack would be mounted on the A-frame to control the angle of the cofferdam guide. This initial configuration of the A-frame and guide failed during the first attempt to install a cofferdam during the bow removal operation. Design changes were made to strengthen both components and the screw-type jack was replaced with a pair of hydraulic cylinders.

Report of the Ferguson Steel Company

The Ferguson Steel Company fabricated the cofferdams and related equipment according to specifications prepared by the salvage force. The company's report at Appendix E provides additional design details.





Ferguson steelworkers fabricated guide (above) and cofferdams (below) according to specifications developed by Salvage Master. Ferguson, a local Port Huron firm, also fabricated hatch covers and various special fittings for the operation.

FABRICATION OF COFFERDAMS AND GUIDE AT FERGUSON CO. PLANT

COFFERDAM INSTALLATION PROCEDURES

Requirement for Thorough Procedures

The strong river current left little margin for human error. Each time a diver entered the bow section, his life depended not only on the soundness of the basic concept but also upon the effectiveness of the methods used in installing the cofferdams. An unforeseen flaw in the installation plan, an undetected error in its implementation, or inadequate material specifications could easily result in structural failure of one or more components of the access system. Such a failure could not only cause a serious delay in the operation, but, more importantly, could leave a driver trapped in the wreck with a limited supply of emergency SCUBA air and no safe escape route to the surface.

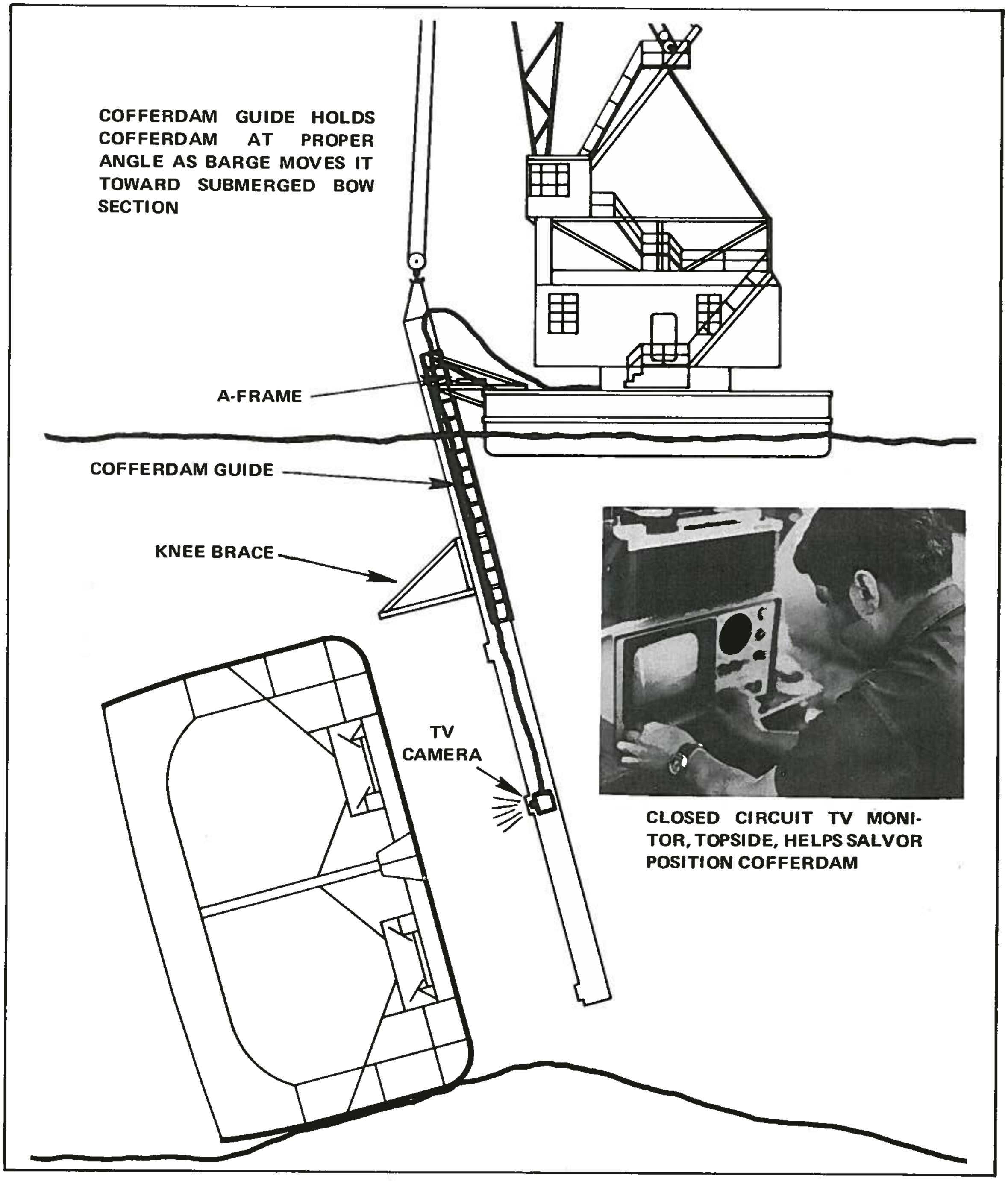
Detailed, step-by-step procedures were therefore developed and applied in installing the cofferdams. Nothing was left to chance. For example, the salvors anticipated the gradual loosening of the cofferdam attachment points during the first few days of "working" in the river current. Wrenches were placed at each of the three access windows in each cofferdam and in the side tank below the knee brace. For 3 days following the installation of each cofferdam, each time a diver entered the wreck at this point, his first task was to tighten down all nuts and bolts at the attachment points. On the fourth day, the nuts and bolts were again tightened and locking nuts were installed. These bolts were checked periodically for tightness during the remainder of the mid-channel operation.

The cofferdam installation procedures are summarized in the following paragraphs.

Lowering the Cofferdam into Position

The derrick barge, with the A-frame secured to its deck and the cofferdam guide attached to the A-frame, is first moored parallel to the wreck and slightly off it, on the downstream side. After the guide is positioned at the proper angle, the crane on the barge is used to place the cofferdam in the guide and lower it into the water.

Visual contact with the wreck is made using a closed circuit TV camera, prepositioned in the middle cofferdam window and monitored from a topside control station. The derrick barge is maneuvered upstream in its moor by heaving around on the upstream mooring legs while slacking off on the downstream legs. Once visual contact is achieved, the cofferdam can be maneuvered slowly into the proper position. Using fathometer readings to determine the end points of the bow section, salvors place the cofferdam at the proper frame number by measuring in from either end of the wreck. The angle of the cofferdam from the vertical must be adjusted until the middle window frame is seated against the bottom of the wreck. The



Barge moves cofferdam into place alongside wreck with aid of closed circuit TV camera. Jack on A-frame makes precise adjustments to cofferdam to insure flush contact with bottom of wreck.

LOWERING COFFERDAM INTO PLACE AGAINST BOTTOM OF BOW SECTION

middle window frames of each cofferdam will contact the flat bottom of the wreck only when the cofferdam is at the proper angle and only when all three window frames are flush against the bottom of the wreck. This condition can be achieved by maneuvering the derrick barge in the moor and adjusting the angle of the cofferdam guide.

Precise positioning of the cofferdam is most important in order to provide diver access through the three windows at the designated frame number and at the proper level along this frame. The angle of the cofferdam guide is adjusted to allow placing all three of the cofferdam's windows flush against the bottom of the wreck. This angle is varied as the bow section shifts position on the bottom of the river.

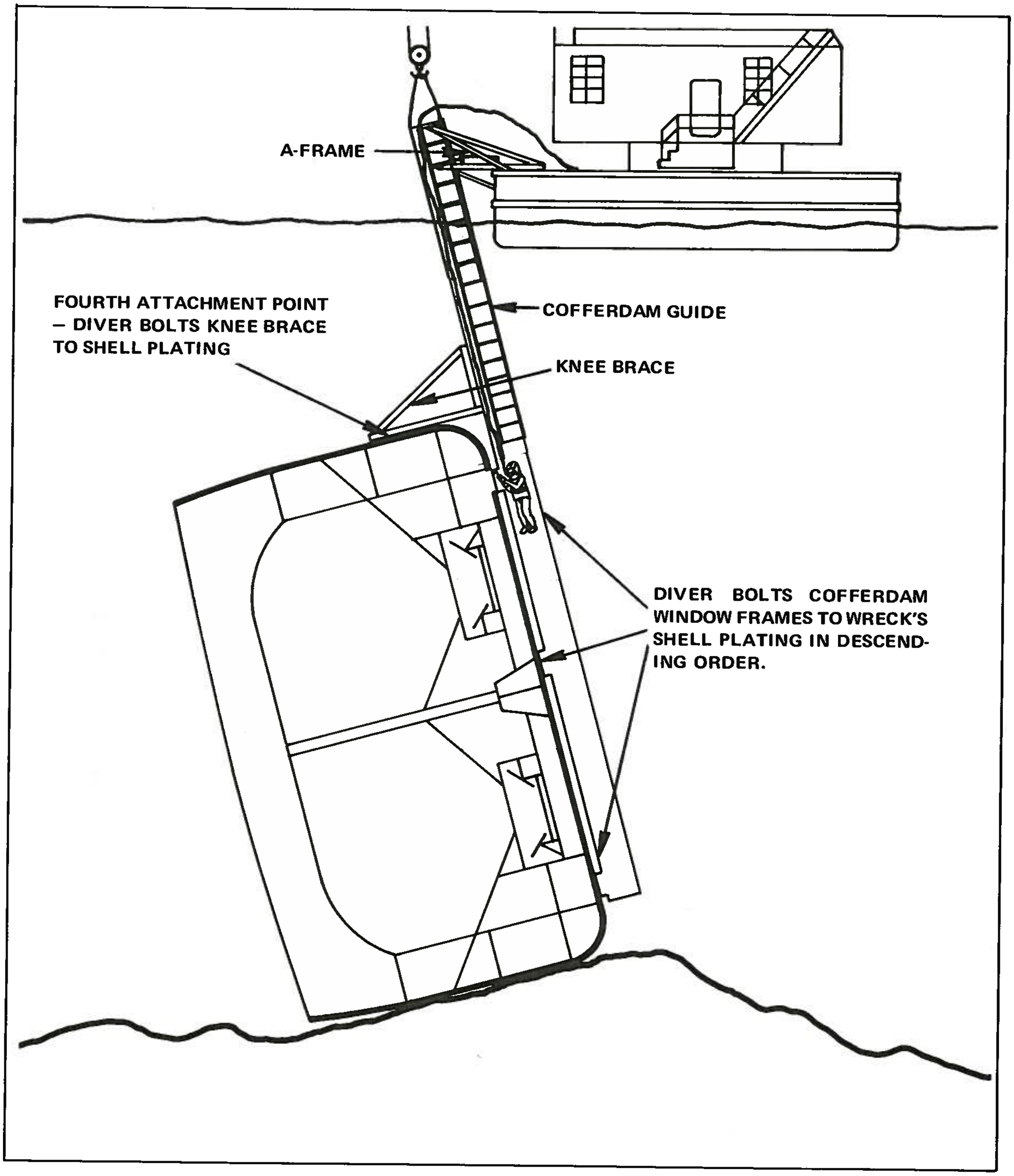
The cofferdam stops descending when the right-angle knee brace is seated against the port side of the wreck. The three windows will then be positioned at the predetermined access points. With the cofferdam now properly positioned, the mooring wires are again adjusted to press the cofferdam tight against the bottom of the wreck.

Attachment of Cofferdam to Wreck by Diver

With the cofferdam stabilized in the desired position, a diver descends through the cofferdam to first remove the TV camera and then bolt the three window frames securely to the shell plating of the wreck. After removing the TV camera, he proceeds to the top window and burns a rough access hole into the bottom shell plating. Then, placing the burning rod into one of the predrilled bolt holes, he burns a matching hole through the shell plating. Reaching through the access hole, he quickly pushes a bolt back through the hole to hold the alignment of the cofferdam to the wreck. After securing the first bolt with a washer and hex-nut, the diver repeats the process for each of the 18 bolt-holes around the perimeter of the window. A large, predrilled, plate-type washer is placed on each bolt prior to insertion through the roughly burned hole in the shell plating. This prevents the head of the bolt from pulling through the often large and irregular hole in the shell plating. A smaller, standard washer is placed bebetween the nut and the predrilled bolt holes in the window frame.

After tightening down all the bolts at the top window, the diver returns topside while the upstream mooring lines are slacked slightly to allow movement of the cofferdam in the guide. It was thought that allowing the cofferdam to ride more loosely in the guide might prevent the top window attachment from parting in the event of rough water. The diver then descends again into the cofferdam and repeats the bolting process with the two lower windows. As he completes bolting each window frame to the shell plating, he enlarges the access hole to the dimensions of the window frame, 24 inches wide, 30 inches high.

The knee brace is the fourth point of attachment. After securing the cofferdam to the shell plating at each of the three windows, the diver enters the side tanks from the top window



Diver descends through cofferdam to bolt its three window frames to wreck. For fourth attachment point, diver cuts through hull at top window, enters port side tank and secures knee brace.

PROCEDURE FOR SECURING COFFERDAM TO WRECK

burning access ports as required. Working his way along the frame at which he entered the wreck, he positions himself directly beneath the knee brace in the port side tank. By measuring out from the turn of the bilge, he determines the position of the end point of the brace. The diver then burns a small "reach hole" through the port side shell plating just beyond the end of the brace. Extending an arm out through the reach hole, he determines by feel the exact position of the knee brace and burns four bolt holes through the shell plating and through the wide flange brace member resting against it. The bolts are then inserted into the bolt holes and secured. Predrilled plate-type washers are used both externally and internally.

Installation of Working Platforms

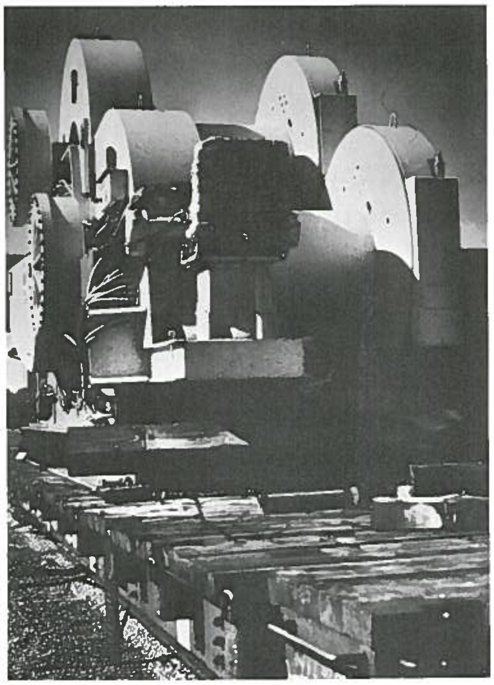
When the cofferdam is securely bolted to the bow section of the wreck at the three windows and at the knee brace, the A-frame and guide are no longer required to hold the cofferdam in position against the powerful current. The derrick barge is then moved back and positioned in such a way that a working platform can be placed atop the cofferdam. A safety railing, awning, and windbreak are added to the platform as required. Finally, gangplanks are installed for access to each platform from the barge.

PULLING SYSTEM FOR BOW REMOVAL

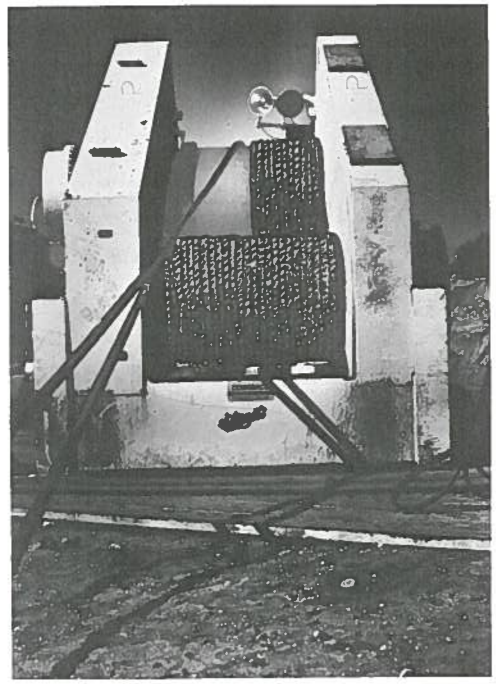
Requirement for Increased Pulling Power

In computing requirements for pulling power, the salvors relied initially on a critical estimate that 25 percent of the SMITH's stoker coal remained in the hoppers. There was no way of verifying the accuracy of the estimate because divers could not inspect the holds. As bow removal operations got underway, planners became increasingly concerned that the open cargo holds might have been partially filled with hundreds or even thousands of tons of sand and gravel from the turbulent river bottom. If such were the case, then the six hydraulic pullers already on hand might not be adequate, particularly in light of the limited spaces available for foaming.

The weight of the submerged bow section could not be calculated precisely. Among other unknown factors, the salvors did not know whether the SMITH's coal conveyor boom was still attached to the hull. Neither could they be certain of quality of the foam to be installed, even though every effort was being made to improve the efficiency of foaming operations: moreover, once pulling began, the cofferdams could no longer be used for additional foaming.



RB-150 WINCH



RB-97 WINCH

Both winches are twin drum, heavy duty hoists. RB-150 pulls total 300 tons, uses 2" wire. RB-97 pulls total 200 tons, uses 1-5/8" wire. Winches were deployed all the way from states of Washington and Lousisiana, respectively, to support salvage effort.

SKAGIT WINCHES FOR BOW SECTION PULLING SYSTEM

Considering these factors and the overall magnitude and complexity of the bow removal effort, the salvors decided to increase the on-shore pulling power. Arrangements were made to lease two powerful Skagit winches, an RB-97 and an RB-150. The two winches, with a combined total pulling force of 500 tons, are engineered for heavy lift and anchoring applications.

Plans and Preparations for Rigging the Pulling Systems

The bow section was to be pulled to shore on its starboard side. It could not be righted in mid-channel because of the cofferdams fastened to its double bottoms. The cofferdams would have to be removed before the bow section could be parbuckled. Therefore, pull points amidships would be rigged to the keel rather than high on the port side as on the stern section. Pulling wires from the upstream holding points at Station ALPHA would be secured to the hulk's anchor chains at their hawse pipes on the forecastle.

Experience in pulling the stern section ashore indicated that the hydraulic pullers would require certain design changes as well as routine overhaul before they could be used efficiently for bow removal operations. The Corps of Engineers planned to make certain modifications on-site with others to be made by the Ferguson Steel Company at its Port Huron plant. Modifications to be accomplished included a redesign of the hydraulic circuitry and the forward and after fairlead roller assemblies. This work was scheduled for completion by 18 September, in time for the beginning of pulling operations.

The salvors decided to position the two Skagit winches at Pulling Station BRAVO. The winches were far more powerful than the hydraulic pullers and Station BRAVO, directly opposite the wreck, was the location where the greatest pulling power would be required for the retraction of the submerged bow section. Station CHARLIE, immediately downstream from BRAVO, would also require substantial pulling power. Consequently, the salvors decided to position the two 100-ton hydraulic pullers at this location. The four 40-ton pullers would be concentrated at Station ALPHA, upstream of the wreck, to provide the necessary holding power against the force of the river current during the retraction operations.

CHAPTER 8
CONDUCT OF OPERATIONS— PHASE II
BOW SECTION REMOVAL

STATUS OF THE BOW SECTION, 7 AUGUST

Inspection Dive, 21 July

The SMITH salvors knew very little about the position and condition of the bow section as bow removal preparations began on 7 August. Since the collision in early June, it had become submerged in nearly 90 feet of water and the strong river current prevented divers from surveying the wreck externally. One inspection dive had been made just prior to the final separation of the two wreck sections on 21 July. Since direct descent to the bow through the water was impossible, the diver could reach the bow section only by descending through the exposed stern section. During the dive, he managed to work his way from the partial break forward to hold #2 by pulling himself along the gunwale. But because of the powerful current, he was forced to work back to the relative safety of the stern section and terminate his inspection.

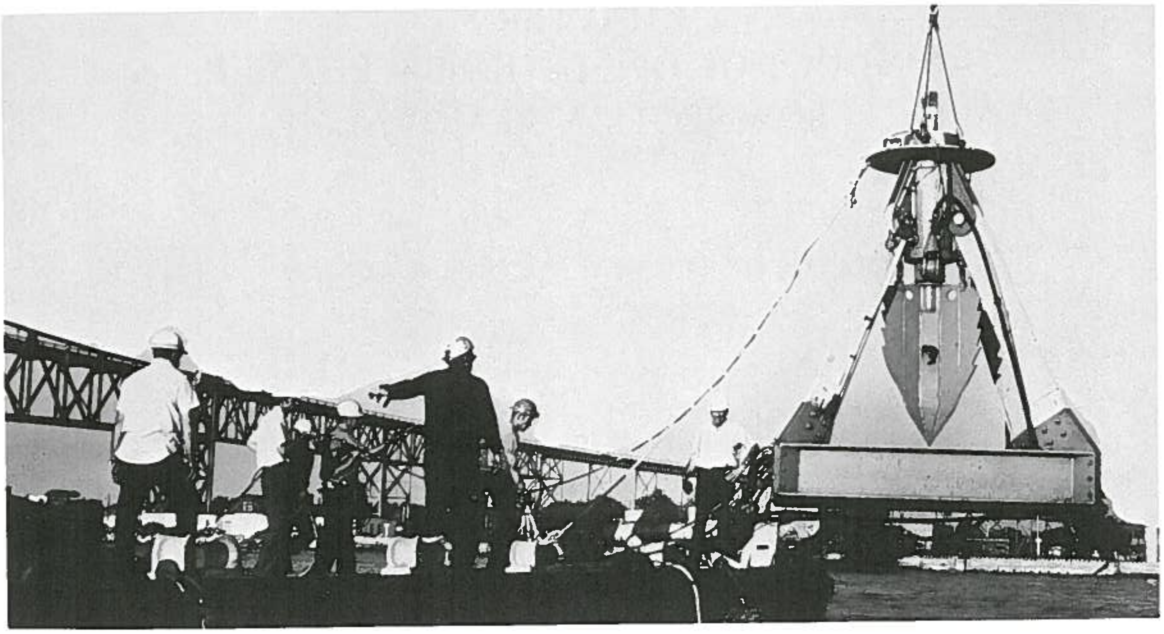
Limited Information Available

The hazardous conditions of the dive precluded a detailed underwater survey. The diver verified, however, that the wreck was lying on its starboard side, approximately 90 degrees from the vertical and slightly down by the bow.

Fathometer readings supported his estimation of the bow section's attitude. The reported depth of the submerged port side was 26 feet forward and 23 feet aft. As anticipated, the loose-fitting hatch covers were no longer in position, which meant the cargo holds were open to the river. The salvors assumed that approximately 75 percent of the stoker coal had been washed from the holds by the swift current. More information on the bow's condition was unobtainable until divers could enter the bow section's compartments through the cofferdams which were to be installed.

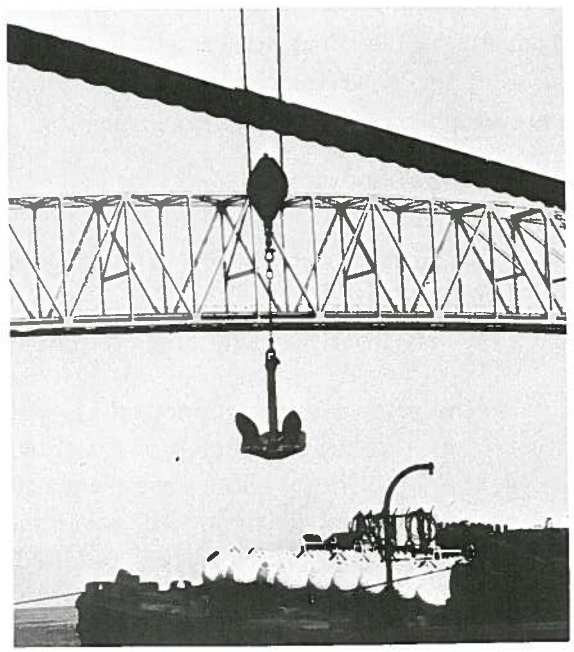
PREPARING THE 6-POINT MOOR, 7-16 AUGUST

Preparation of the mooring system, the first task of the bow removal operation, began on 7 August. Most of the ground tackle had already been loaded aboard the derrick



EMBEDMENT ANCHOR

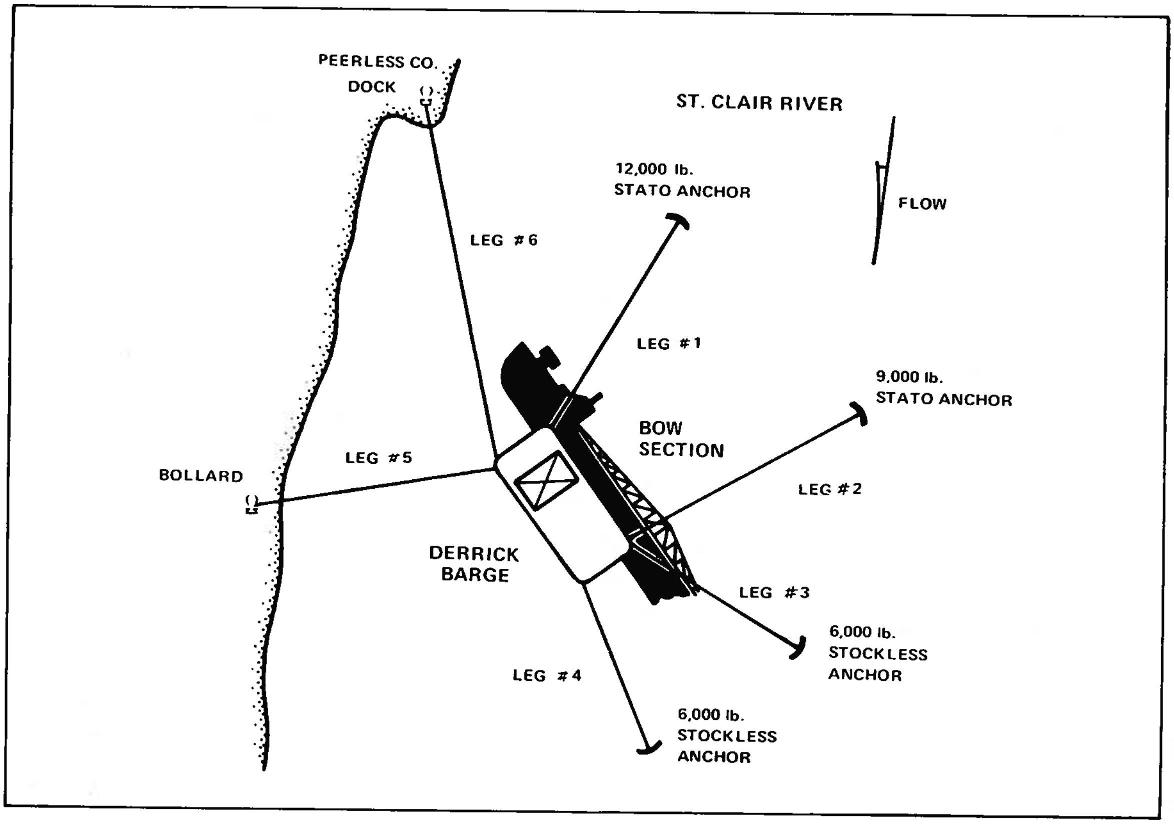
STATO ANCHOR



STOCKLESS ANCHOR

Attempts to implant the embedment anchors failed. Stato anchors were then substituted for the two upstream mooring legs. Stockless anchors were implanted for the other two mid-channel mooring legs as planned.

IMPLANTMENT OF ANCHORS FOR MOORING THE DERRICK BARGE



Moor is designed for stability and precision maneuverability necessary for mid-channel salvops. Mooring legs use 1-¼" wire rope. Strongest anchors are positioned upstream.

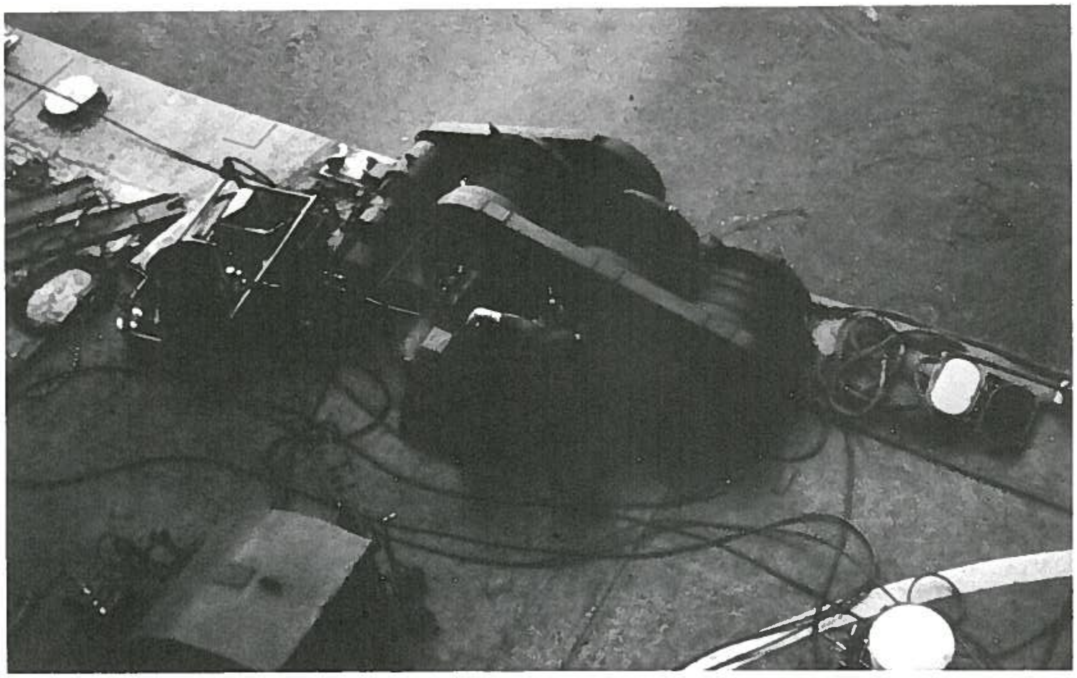
CONFIGURATION OF BARGE'S MOOR OVER SUNKEN BOW SECTION

barge. The special embedment anchors were not yet available so the next two days were spent installing the cofferdam guide and A-frame on the barge in preparation for cofferdam installation which would begin as soon as the barge was moored. Mooring operations got fully underway on 10 August with the arrival of the embedment anchors at the salvage site.

Failure of Embedment Anchors

On 12 August, mooring legs 1 and 2 were positioned upstream from the submerged bow. The first embedment anchor was lowered into position 240 feet, 130°T, from the southern tip of the Peerless Cement Company dock, and an explosive charge fired. Unfortunately, a shackle pin parted as the anchor penetrated the river bottom and the anchor was lost.

A few hours later, salvors made two attempts to implant the second embedment anchor. Initially, the explosive charge misfired, apparently as a result of water seepage into the charge's



Salvors used the derrick barge's two 3-drum winches to maneuver the moored barge by heaving around and slacking off on mooring wires. Precise maneuvering was crucial during cofferdam installation.

3-DRUM WINCH CONTROLS MOOR OF BARGE OVER SMITH'S BOW

container. The anchor was rerigged and refired on 13 August, this time successfully. The anchor penetrated the river bottom but became dislodged during a test pull of approximately 25 tons.

Configuration of the Moor

The capsized bow section was lying submerged on its starboard side with its bottom facing inboard to the Port Huron shore. The cofferdams were to be attached to the hulk's bottom. Accordingly, the barge had to be moored inboard, alongside the wreck, in a position from which the cofferdams could be installed and subsequently used.

The moor had six legs, four of them anchored in the stream and two connected to bollards on the Port Huron shore. The four anchored legs were made up of 1 1/4-inch wire rope connected to 2 1/4-inch anchor chain which was, in turn, shackled to each anchor. The heavy anchor chain kept these legs on the bottom and added strength to the moor. The two shore legs were made up exclusively of 1 1/4-inch wire rope.

Two winches, permanently installed aboard the derrick barge, were used to control the moor. Since each winch was configured with three drums, there was one for each of the six mooring legs. Utilizing these winches, located on opposite sides amidships, the salvors could heave around and slack off on one or more of the mooring wires as required to maneuver the barge within the moor.

Mooring legs 1 and 2, implanted upstream, had to withstand the heaviest loads. Accordingly, two Navy stato anchors were used for these legs following the failure of the embedment anchors: a 12,000-pound stato anchor for leg 1, the nothernmost leg; and a 9,000-pound stato anchor for leg 2, which projected well out into the shipping channel. Mooring legs 3 and 4, implanted downstream, each had a lighter, 6,000-pound stockless anchor.

Mooring leg 6, also upstream, was secured to a bollard at the dock of the Peerless Cement Company, almost directly north of the wreck. The bollard for leg 5 was located downstream on the riverbank, west of the wreck. These bollards were well suited for the task, being normally used for mooring ships and barges loading and unloading at the Peerless Cement Company yards.

Mooring legs 1, 2 and 6 ran from their respective winch drums through Berger fairleads deck-mounted at the three upstream corners of the moored barge. Roller chocks were used to align the other three legs with their winch drums. By 16 August, the derrick barge was secure in its 6-point moor over the submerged bow section, ready to support the installation of cofferdams.

COFFERDAM INSTALLATION, 17 AUGUST - 9 SEPTEMBER

Although four cofferdams had been planned, only three were actually installed. The salvors' intention of using a fourth cofferdam was abandoned when it was found that hull curvature in the proposed area would necessitate complete redesign of the cofferdam. Fortunately, a diving survey on 8 September revealed that the designated foaming spaces forward would be accessible without requiring this fourth cofferdam.

System Failure and Redesign, 17-26 August

The first cofferdam was placed in the cofferdam guide on 17 August and lowered into the water. The cofferdam was positioned against the bottom of the wreck, but it failed to descend sufficiently to allow the knee brace to seat against the port side of the wreck. The salvors were still attempting to correct this problem the next day when a major setback in the installation process occurred. The screw-type jack, used to control the guide angle, was carried away under the stress created by the force of the current against the cofferdam and guide.

Cofferdam didn't seat properly against bow bottom. Screw-type jack carried away and both cofferdam and A-frame were damaged. Salvors here are extricating cofferdam following the failure.

FIRST ATTEMPT TO LOWER COFFERDAM FAILS

As a result, the cofferdam and guide swung in sharply against the side of the barge, damaging the A-frame. Also, when the crane brought the cofferdam back up, it was discovered that the bottom third of the cofferdam had snapped off and had become lost in the river.

Both the A-frame and the cofferdam guide had to be redesigned. The cofferdams also needed strengthening. About 10 days would be required to perform these tasks. The derrick barge tripped out of the moor and returned to the Peerless dock to offload the damaged gear. During the next several days, while the cofferdam gear was being overhauled, the barge assisted in the stern section scrapping operation which was in progress ashore.

The Ferguson Steel Company at Port Huron, assisted by welders from the salvage crew, accomplished the overhaul, working around the clock from 18 to 27 August. The A-frame and guide were redesigned with strength members of increased size and number. A pair of hydraulic cylinders were procured to replace the screw-type jack. The remaining three cofferdams, which had just been delivered to the salvage site, were also strengthened by welding lateral and longitudinal stiffeners (4-inch I-beams) along nearly the entire length of each cofferdam. The joints between the short pipe sections on the cofferdams were also deep-welded, both internally and externally.

On 26 August, the new, partially-completed A-frame and cofferdam guide, and the first strengthened cofferdam, were delivered to the salvage site from the Ferguson plant. The A-frame and guide, with the new hydraulic cylinders, were installed on the derrick barge and their fabrication completed by adding final bracing members.

First Cofferdam Positioned, 27-29 August

The barge went back into its moor over the submerged bow section on 27 August. The first strengthened cofferdam was placed in the guide and lowered into the water. Using the closed-circuit TV camera, prepositioned in the middle window of the cofferdam and monitored from topside, the salvors maneuvered it into place at frame 63. (Frame 63 was located aft on the bow section approximately 60 feet forward of the break.) The divers encountered hazardous currents within the cofferdam caused by the Venturi Effect of water rushing past the cofferdam's window frames and open bottom. The first diver was nearly forced out into the river through the cofferdam bottom.

Bolting the window frames to the shell plating proved to be a long and difficult job. Each of the cofferdam's three window frames were predrilled with 18 holes. The diver had to burn corresponding holes in the shell plating and secure the frame with bolts and washers.

The divers finished bolting the window frames to the shell plating on 29 August. Then, entering the hulk for the first time, they bolted the knee brace to the shell plating as planned. A preliminary internal survey of the bow revealed considerable structural damage in the conveyor tunnel, side tanks, and machinery spaces. Concurrently, a work platform was placed atop this first cofferdam, completing the installation procedures.

Second Cofferdam Positioned, 29 August - 1 September

Welders on shore completed reinforcing the second cofferdam on 29 August. It was then floated out to the barge, using inflated air bags positioned inside the cofferdam. Floating the cofferdams out to the wreck site in this manner enabled the barge to remain in its moor rather than returning dockside to load the cofferdams. The long, cumbersome cofferdams could not be carried as deck cargo aboard other available surface craft.

The barge's crane lowered this second cofferdam into position on 30 August at frame 51, 36 feet forward of the first cofferdam. An unusually heavy current made the initial adjustments difficult. Although the barge and cofferdam guide appeared properly adjusted, the cofferdam would not descend to the proper depth. Divers found that the scouring action of the current had created a sand and gravel buildup against the bottom of the wreck which was blocking the descent of the cofferdam. The salvors decided to use an airlift to reduce this buildup.

After initial failure, salvors strengthened cofferdam and A-frame. A pair of hydraulic cylinders was substituted for the screw-type jack to control guide angle. Photo shows strengthened cofferdam about midway in lowering; knee brace (right) will eventually seat against top of sunken bow section.

SECOND EFFORT SUCCEEDS IN LOWERING COFFERDAM

Giant 100′ long cofferdams were awkward to handle and move. Salvors solved problem by putting inflated air bags inside cofferdam and floating it out to the barge for installation on bow section. Note cofferdam's newly installed lateral and longitudinal stiffeners.

AIR BAGS FLOAT COFFERDAMS TO BARGE

The airlift, installed within the cofferdam, removed some of the sediment. Lowering was completed and the top window was bolted into place without difficulty. However, when the diver tried to bolt the second window, he discovered that part of the buildup remained between the cofferdam and the wreck, preventing the second and third cofferdam windows from seating against the shell plating. Airlifting operations had to be resumed to remove this obstruction. Installation of this cofferdam was finally achieved on 1 September.

Third Cofferdam Positioned, 1-7 September

The third cofferdam was delivered from the Ferguson plant to the salvage site on 30 August. Welding of longitudinal stiffeners was accomplished on site. The cofferdam was floated out to the barge for installation on 1 September. While it was being lowered at frame 36, the stong current rushing past the open windows produced a pronounced twisting force on the cofferdam, causing it to bind in the guide. Rollers had to be installed on the cofferdam guide to prevent the binding.

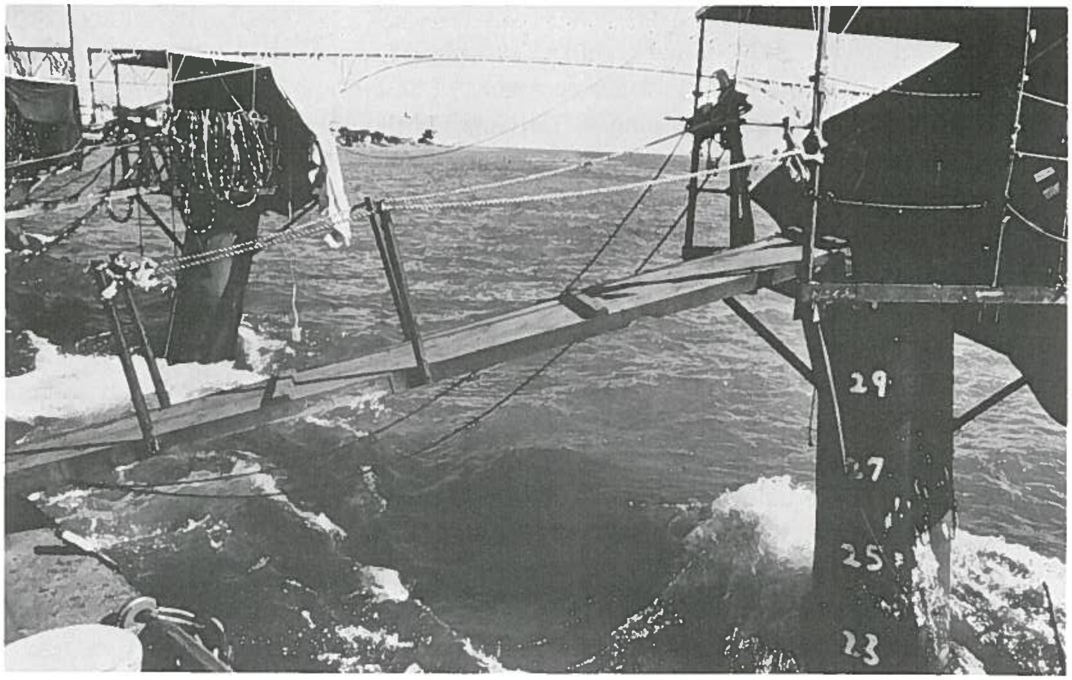
The cofferdam guide rollers were fabricated and installed on 2 September. After waiting another day because of bad weather, the cofferdam was finally lowered into place on 4 September. The rollers performed adequately, but once again a buildup of sand and gravel due to scouring prevented the cofferdam from descending to the proper level. The airlift was again used to reduce the buildup. The cofferdam was then lowered to the proper depth.

At this point, a different and more serious obstacle was encountered. The curvature of the hull at frame 36 was greater than at the locations of the first two cofferdams. As a result, the cofferdam would not seat correctly against the wreck. Realizing that modifications would be necessary, the salvors lifted the cofferdam out of the water and brought it aboard the derrick barge.

Three modifications were made, one to the knee brace and two to the cofferdam itself. The knee brace was lengthened from 8 to 12 feet so that it could make contact with the curving port side of the bow before the cofferdam descended too far into the water. The top window frame of the cofferdam was reconfigured to conform with the curvature of the hull at that point. Finally, the lower part of the cofferdam was cut off at the third window. The divers did not need access to the wreck through this window. Removal of the bottom portion facilitated lowering and positioning of the cofferdam. The top flange of the window was retained for use as a holding point. The modified cofferdam was lowered into place on 6 September. Divers finished installing it the next day.

Completion of Installation Effort, 7-9 September

Divers entered the wreck at frame 36 on 7 September to conduct a complete survey of the area forward of the third cofferdam. The survey was intended to determine if the fourth



Bow salvage proceeds with all three cofferdams in place. Numbers on cofferdam mark water depth to port (i.e., top) side of capsized bow section.

GANGWAY ACCESS FROM BARGE TO PLATFORMS ATOP COFFERDAMS

cofferdam could be deleted from the salvage plan without jeopardizing the safety of the divers or the success of the operation. The curvature of the hull at frame 21 was even more pronounced than at frame 36, thus making installation of the fourth cofferdam extremely difficult. After burning the required accesses and lengthening the life-line/air hose to 270 feet, the divers found that all designated foaming spaces, up to and including the forepeak, would be reasonably accessible from frame 36. Accordingly, it was decided to eliminate the fourth cofferdam.

The derrick barge was maneuvered in the moor to a position where it could best support operations at the three cofferdam locations. Gangways were laid between the barge and each cofferdam. Finally, safety railings, windbreaks and awnings were installed on the cofferdams' working platforms. Installation of the three cofferdams was completed on 9 September, enabling the salvage force to proceed with foaming operations.

PREPARATION OF BOW FOR FOAMING AND PULLING, 29 AUGUST - 15 SEPTEMBER

The first cofferdam was installed at frame 63 on 29 August. On the same day, divers entered the vessel at that point and began preparing the bow internally for rigging pull points and installing foam. Foaming preparations for the bow were essentially the same as those for the stern removal effort. Salvors had to burn access holes, inspect compartments, rig potential diver escape routes, and seal the foaming spaces. These preparations proceeded concurrently with installation of the remaining cofferdams. With completion of their installation on 9 September, the salvage force began devoting its main efforts to preparing the vessel for foaming.

Inspections by Divers, 26 August - 13 September

The first task confronting the diver as he entered the bow section was to inspect each space as he proceeded in order to determine the extent of structural damage and identify any unusual conditions which might necessitate a change in the planned sequence of preparations for foaming and pulling. Essentially all spaces capable of containing foam were inspected. These included the conveyor tunnel, machinery spaces, deck house, forward peak area and selected double bottom and side tanks.

The cargo holds could not be inspected internally. However, during this time, the divers had a brief opportunity to approach them externally. A very unusual slack in the normal current on 11 September, and again on 13 September, enabled them to survey the open cargo holds. Inspection of holds #1 and #2 revealed very little cargo remaining. A small amount of sand and gravel on the starboard gunwale and considerable accumulations previously discovered in the conveyor tunnel offset the less-than-anticipated coal cargo. The sand in the conveyor tunnel had apparently washed in around the closed hopper doors from the open cargo holds.

The divers managed to reach the conveyor boom on 13 September. They found that it was still secured in the boom rests. The river current resumed its normal strength at this time, forcing the divers to abort their dive before reaching the pilot house and crew's quarters.

Preparations for Foaming, 26 August - 15 September

In preparing the bow section for foaming, divers burned access ports and enlarged existing holes in the side and double bottom tanks to ease their fore and aft travel while foaming. They also cleared designated spaces of obstructions and floating debris which could hamper the installation of foam, restrict movement or prevent safe, rapid egress under emergency conditions.

Canvas bulkheads, mounted on wooden frames, were installed in the conveyor tunnel to divide the foaming space into smaller compartments in order to control the lateral flow of unhardened foam. Airlifts were used to remove sand, gravel, and other debris that obstructed burning and patching operations. In addition, all potential escape routes for the foam were sealed. Holes, cracks, and other areas of possible foam seepage were patched or plugged and doors and hatches secured. Foam equipment was set up aboard the derrick barge on 15 September and foaming operations began the next day.

Safety Measures, 10-14 September

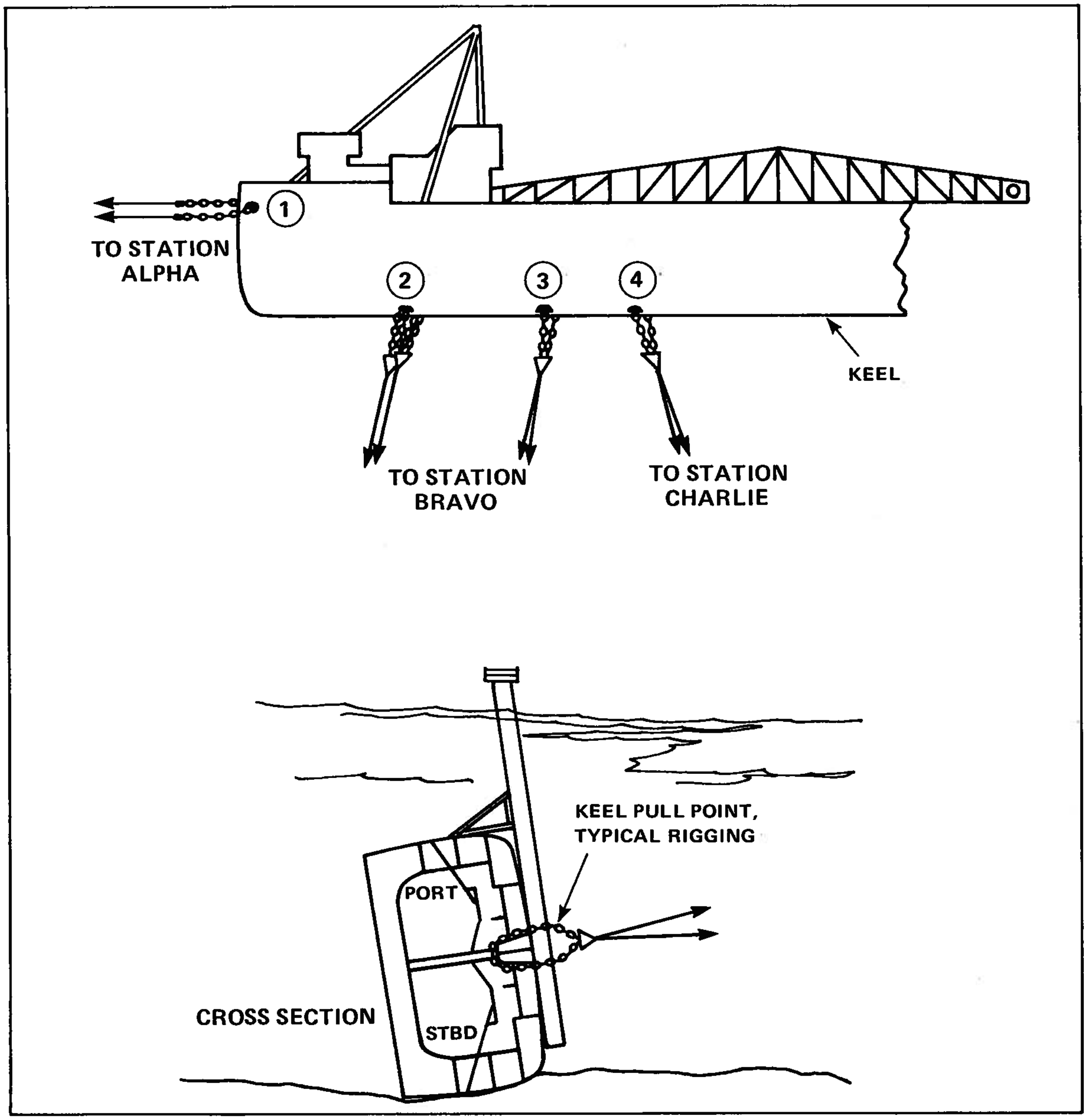
The salvage nest was in an exposed position. The derrick barge could easily be carried away by a downbound freighter or barge which failed to negotiate the bend in the river, cutting off any divers inside the wreck from their surface support platform. Consequently, six complete SCUBA "come home" rigs were placed in strategic locations inside the bow section to provide emergency air in the event the support platform did carry away or the surface supplied diving rig failed. Hand "traveling lines" were also rigged along the various access routes to help the divers to move quickly in reduced visibility should the need arise.

Divers prepared mooring points on the bow section on 14 September to permit direct mooring of the barge to the wreck. This direct moor would provide backup positioning stability in the event one or more of the primary mooring legs were carried away by a large vessel passing too close to the wreck site. For this "safety moor," divers burned small holes in the SMITH's bottom shell plating, just forward of the cofferdam at frame 51 and aft of the cofferdam at frame 36, adjacent to the top cofferdam windows. The mooring wires were secured to toggle bolts which were inserted through the holes from the outside and tripped open to prevent retraction.

Rigging of Pull Points, 12-15 September

Rigging of pull points got underway on 12 September. Pulling wires from the four 40-ton pullers at Station ALPHA upstream were connected to the SMITH's anchor chains. The remaining pull points were rigged in the same manner as those prepared for stern section retraction, but were positioned on the vessel's keel rather than high on the port side since there were no requirements for parbuckling.

Holes were burned through the double bottom to admit loops of chain around the keel for pull points at the designated locations. A pull point at frame 31 anchored the two 1 5/8-inch wires running out from the twin drums of the RB-97 winch at anchor block C. Another pull point at frame 46 held the two 2-inch wires from the RB-150 winch at anchor block D. The two 2-inch wires running from the 100-ton hydraulic pullers at Pulling Station CHARLIE were secured to a pull point at frame 56.



(1) *Anchor chain extending from hawse pipes for pulling wires to 40-ton hydraulic pullers.*

(2) *Double loop of 2" chain around keel at frame 31 for pulling wires to 200-ton Skagit winch.*

(3) *Single loop of 2¼" chain around keel at frame 46 for pulling wires to 300-ton Skagit winch.*

(4) *Single loop of 2¼" chain around keel at frame 56 for pulling wires to 100-ton hydraulic pullers.*

RIGGING OF PULL POINTS ON BOW SECTION

FOAMING THE BOW SECTION, 16-21 SEPTEMBER

Condition of Foaming Spaces

Foaming operations began on 16 September. Conditions remained hazardous in spite of the preparations that had been made. Most access holes between decks and bulkheads were just large enough for the diver to wriggle through. The SMITH had many restricted spaces even under normal conditions, due to built-in machinery, furnishings and other shipboard equipment. Now capsized and submerged in 90 feet of water, the bow section's underwater compartments presented many more obstructions, posing a formidable challenge for foaming operations.

Much floating debris and precariously balanced pieces of furniture and equipment still cluttered the wreck. The forward machinery space was filled from deck to overhead with a maze of engines, conveyor belts, hoppers, gears, and drive shafts. Most of the deck platings had been dislodged and scattered about, presenting additional obstacles.

Predetermined Sequence for Foam Installation

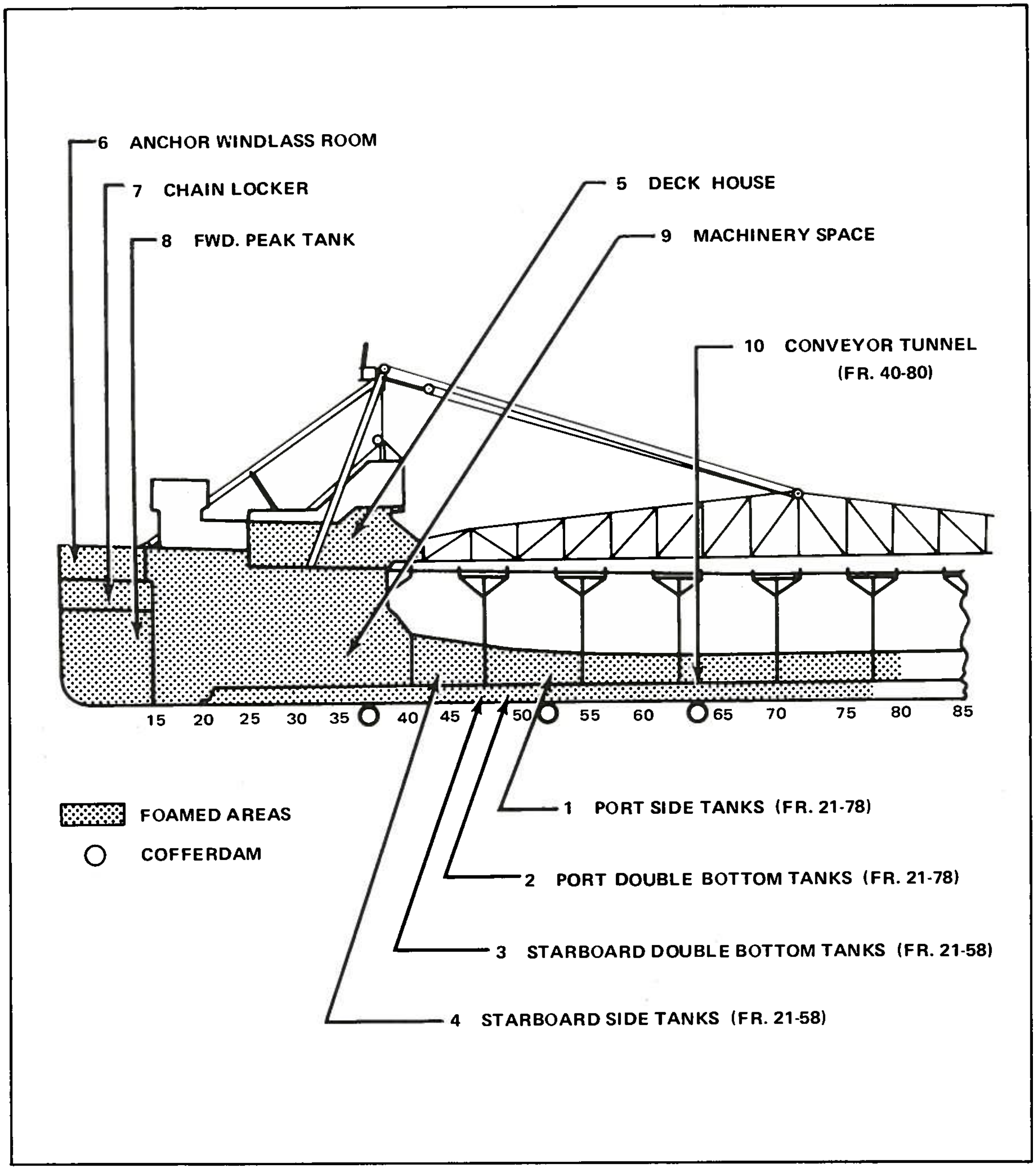
When planning the bow removal operation, the salvors had calculated that approximately 1,700 tons of foam buoyancy would be required to permit beaching of the bow section. Rather than attempting to estimate the buoyancy capacity of each bow section compartment, they chose to inject the foam material into the compartments in a predetermined sequence until enough of the chemicals had been installed to produce the required 1,700 tons of buoyancy.

The predetermined sequence of foam installation was also important for stability reasons. In order to provide for subsequent adjustments to list and trim when the hulk was refloated, the sequence of foaming the various spaces had been carefully planned. The divers first foamed the port and starboard side tanks and double bottom tanks. The swash bulkheads within the tanks were useful for subdividing these large free surface areas, breaking them up without completely eliminating free communication within the tank. In addition to longitudinal swash bulkheads, transverse swash bulkheads subdivided the side and double bottom tanks at 12-foot intervals (one every fourth frame) throughout their length.

After these tanks were foamed, divers began to install foam in the forward deck house, the forward peak area, and portions of the machinery space. In installing foam in each of these areas, divers worked forward, starting from the cofferdam at frame 63, then the one at frame 51, and finally the one at frame 36. When all the port side tanks had been foamed, they foamed the double bottom tanks, again working forward from the cofferdam at frame 63. This procedure was followed until approximately 1,700 tons of foam buoyancy had been installed.

Diver is assisted by tenders as he descends through cofferdam to foam compartments of submerged bow section.

BOW SECTION FOAMING OPERATIONS COMMENCE



From 16 to 21 September, divers installed more than 1700 tons of foam buoyancy in bow section's three structurally distinct areas: stem to frame 15; frame 15 to 40; and frame 40 to break. Numbers indicate sequence of tanks and spaces foamed.

SEQUENCE FOR FOAMING THE BOW SECTION

Port Side Tanks

The port side tanks from frame 78 forward to frame 21 were foamed first. Because of structural damage extending aft from frame 78, the bulkhead at this frame became the aftermost foam-tight boundary in the side and double bottom tanks. The bulkhead at frame 21 was the forward boundary for the side tanks.

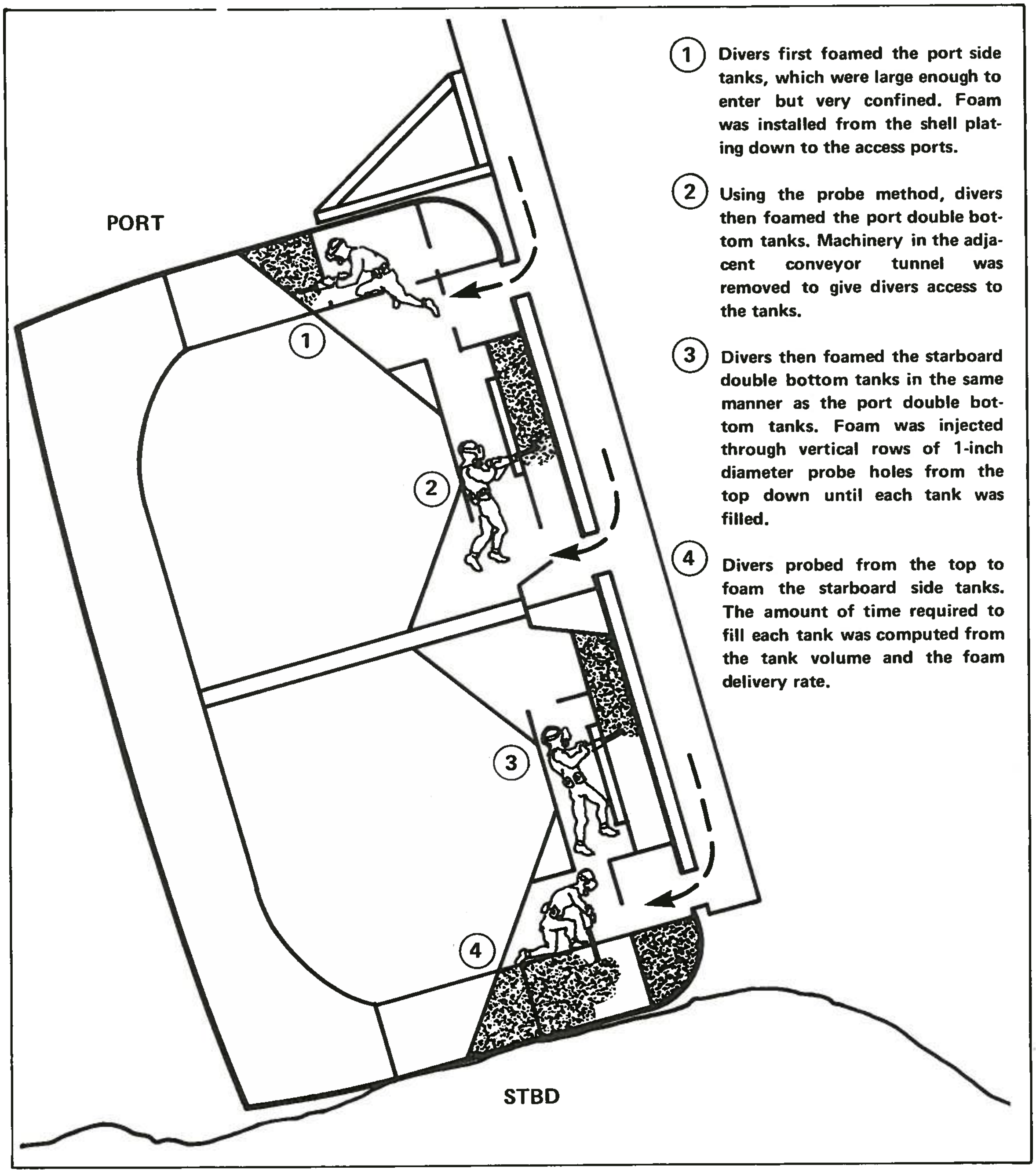
In preparation for foaming, access ports had been cut from the conveyor tunnel into each side tank and lightening holes had been enlarged to enable divers to move freely throughout the tanks while installing foam. The access ports had been burned at regular intervals along the length of the tanks to allow complete foaming inside. They also offered the divers a measure of safety; as the divers progressed through the long, narrow tanks while foaming, an access port was always nearby if a quick escape became necessary. In spite of the enlarged lightening holes, movement within these extremely confined spaces was very difficult and time-consuming.

Starting aft and working their way forward, a pair of divers with two complete foaming rigs entered the port side tanks in the area of the cargo hold from the conveyor tunnel. Here the divers installed foam from the port side shell plating back down to their access ports, moving fore and aft throughout each tank to bring the foam level down as evenly as possible. These lateral movements slowed foaming operations somewhat but were necessary to prevent foam from running too far or spilling over obstructions - conditions that would cause excessive foam/water contact with resulting adverse effects on foam quality. The divers then shifted operations to the port side tanks in the machinery space area, entering these tanks directly from the large machinery space.

Port Side Double Bottom Tanks

After installing foam in the port side tanks, the divers began foaming the port side double bottom tanks. Like the side tanks, this row of double bottom tanks was foamed from frame 78 forward to frame 21; however, unlike the side tanks, this area was not entered by the divers. The extremely limited space within the double bottoms, especially beneath the conveyor tunnel (frame 40 aft), forced the salvors to use the "probe method" in foaming these tanks.

In the probe method the foaming nozzle is inserted into the designated space through a probe hole from an adjacent compartment. Since fresh foam sets up in approximately 90 seconds, probe holes are positioned at vertical intervals which allow the complete expansion of each layer of foam prior to setting up. When the lower boundary of the descending foam mass has attained maximum buoyancy and becomes hard, it impedes expansion of the fresh



Divers descended cofferdams to interior of bow section and foamed tanks in sequence shown above. Machinery and obstructions in conveyor tunnel were removed to enable divers to foam double bottom tanks.

FOAMING THE SIDE AND DOUBLE BOTTOM TANKS

foam being installed at the upper boundary. Intervals between the probe holes are based upon the linear dimensions of the tank to be foamed and the volume of foam which can be installed in 90 seconds.

A vertical row of four, 1-inch diameter probe holes was burned into each port side double bottom tank, either from the conveyor tunnel (for tanks aft of frame 40) or from the machinery space (for tanks forward of frame 40). Portions of the conveyor belt machinery, adjacent to the double bottom tanks, had been previously cleared away in order to gain access to the port side tanks. These cleared spaces provided sufficient room for divers to foam the double bottom tanks by the probe method.

Starting aft and working forward, two foaming divers positioned themselves at adjacent probe foaming stations in the conveyor tunnel in the area of the cargo hold and began installing foam into the port side double bottom tanks. First, the foam nozzles were inserted into the top holes, located at or near the highest point in the tank. Each diver allowed the foam components to flow into the tank until he noticed foam at the level of the second probe hole, indicating that the tank was approximately half full. The diver then repositioned his foam nozzle in the third hole, just below the second, and continued installing the foam material. Because of their small diameter, the probe holes were self-sealing.

When foam reached the level of the fourth probe hole, at the low point in the tank, the diver secured his foam gun and proceeded forward to the next probe foaming location. The bottom probe hole at each location had been burned as low as possible in the respective tank to maximize tank capacity for foam. After installing foam in the double bottom tanks in the cargo hold area, the divers shifted operations to the machinery space and began foaming the double bottom tanks from that location, following the same procedure.

Starboard Side Double Bottom Tanks

After foaming the port side double bottom tanks, the foaming team returned aft and began installing foam in the starboard side double bottom tanks, again following the same procedures. Each tank was foamed in two stages by the probe method. These tanks were foamed from frame 58 forward to frame 21. Structural damage aft of frame 58 precluded foaming the remaining tanks.

Starboard Side Tanks

After the double bottom tanks had been foamed on both sides of the keel, the foaming team again moved aft and began foaming the starboard side tanks. Like the starboard side double bottom tanks, these tanks were foamed only as far aft as frame 58. They were foamed from the top, a single probe hole being burned into each tank.

The probe method was necessary because, although a diver could enter these tanks, he would have no way of exiting once foam had been installed. The only access for burning the probe hole was from above the tanks; hence, a vertical row of probe holes for foaming at different levels could not be used.

As foam entered the tank, water escaped through cracks in the shell plating and in the internal bulkheads which originated in the areas of collision damage. The salvors also found that the transverse "watertight bulkheads" between these tanks had, in fact, never been watertight. Water flowed easily between the tanks through over-sized holes positioned to accommodate the longitudinal ballast transfer piping which ran the length of the SMITH's double bottoms.

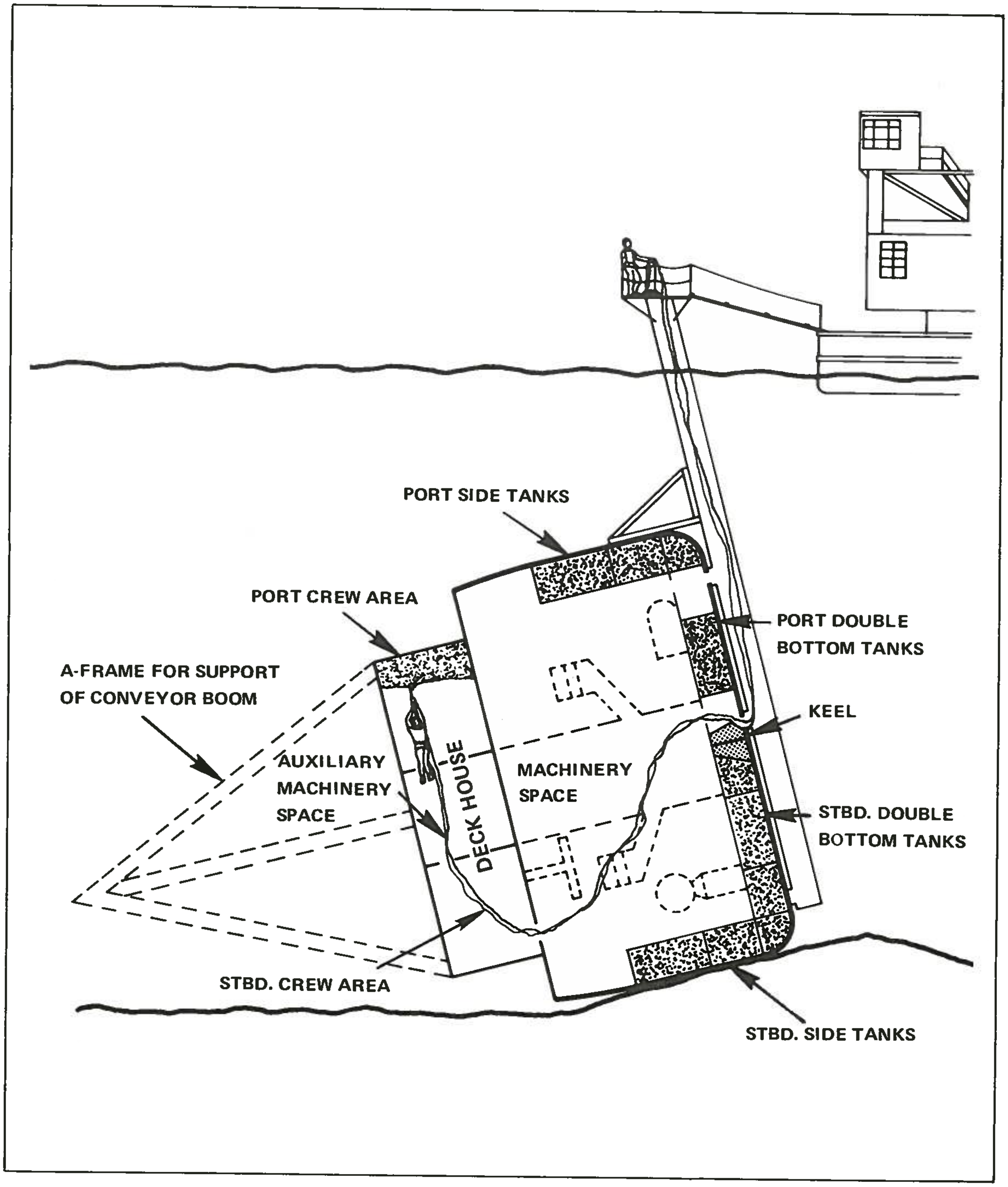
Because the diver could not see the progress of foaming in the starboard side tanks, the salvors computed required foam injection time based upon tank volume and foam delivery rate. The tank was assumed full when foam had been injected for the predetermined time period. In many areas, structural damage to the shell plating, or water trapped low in the tank, prevented complete foaming. This was evidenced by foam escaping to the surface or by back pressure at the probe hole. When either of these conditions occurred, the diver secured the foam gun and moved to the next tank. The 90-second time limit due to setting up of the foam was not a significant problem as most tanks were filled to the extent possible within this time limit.

Forward Deck House Area

The next area to be foamed was the forward deck house, frame 26 to frame 35, which contained crew's quarters on either side of a small auxiliary machinery space. Access through the forward machinery space to the deck house had been provided previously. Each access port was positioned as low as possible to permit maximum foam installation. The diver entered the machinery space from the cofferdam at frame 36 and made his way to the access port provided in the starboard berthing space. He then made his way up through the auxiliary machinery space and into the port side berthing space. The diver then foamed the three deck house spaces in reverse order, retracing his steps ahead of the descending mass of foam.

Areas Forward of the Machinery Space

From the deck house compartments, the foaming team shifted operations to the areas forward of the machinery space (frame 21 forward to the stem of the ship). Here the pair of



Diver foamed deck house after completing side and double bottom tanks. Completion of deck house marked half-way point; forward area, machinery space and conveyor tunnel remained to be foamed.

FOAMING THE DECK HOUSE, FRAMES 26 TO 35

divers completely foamed the anchor windlass room, the chain locker, and the forward peak tank. They entered the machinery space through the mid-level window in the third cofferdam (at frame 36) and proceeded forward to the machinery space bulkhead at frame 21. There, one diver remained on the machinery space side of the peak tank to tend the other diver as he entered through the access hole cut in bulkhead 21 to the forward peak tank and through the peak area decks to the chain locker and finally the anchor windlass room where he began foaming operations. The access holes in these spaces had been cut as low as possible to enable the diver to back out of the space as he completed foaming.

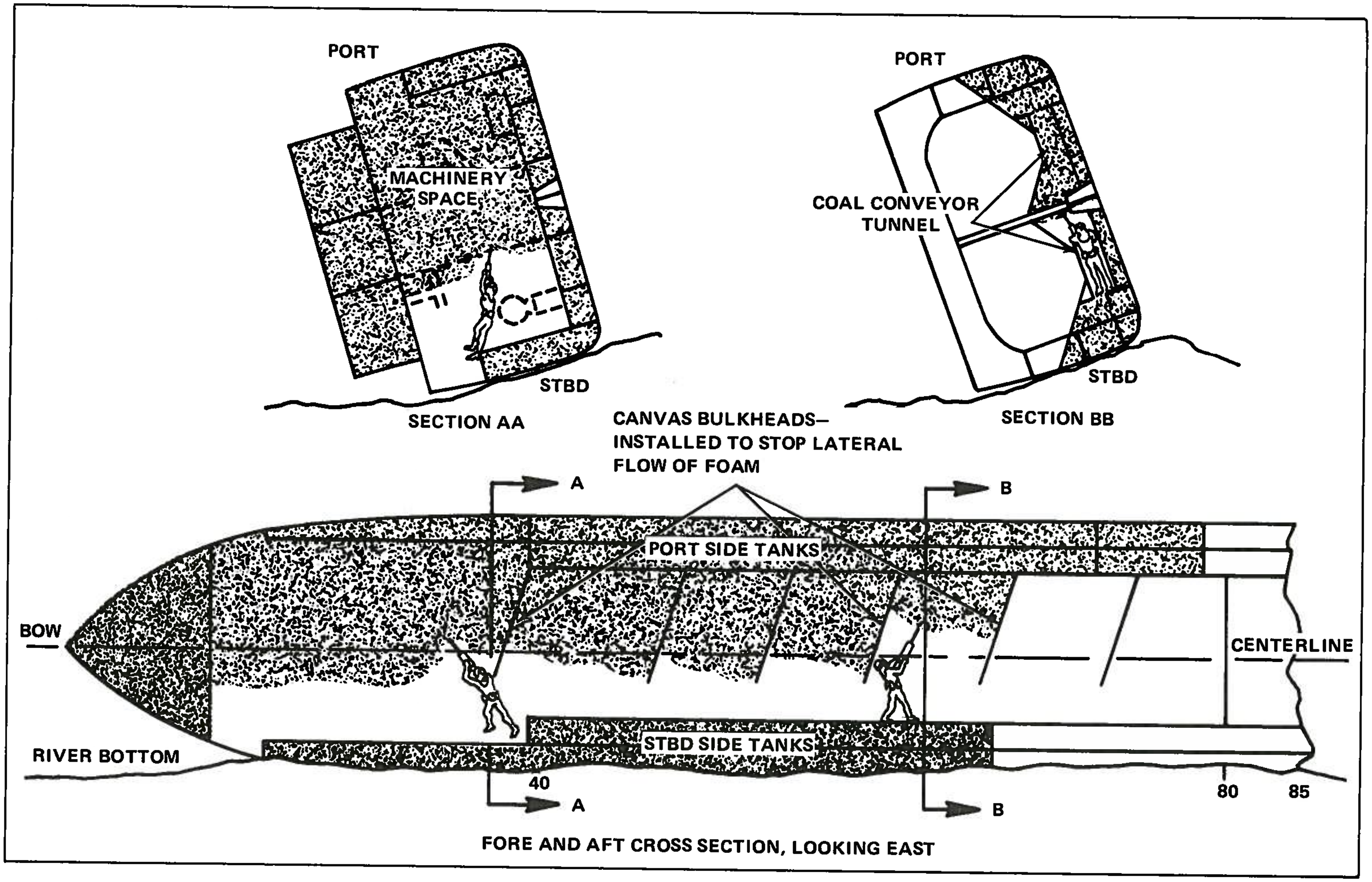
After entering the anchor windlass room near the starboard skin of the ship, the foaming diver proceeded to the high port side and began installing foam at this point. Again, keeping the foam nozzle buried in the layer of unhardened foam, he moved the rig laterally (fore and aft, and from deck to overhead), as the foam/water interface descended from the port to the starboard side of the compartment. Upon reaching the level of the access hole, the diver dropped down into the chain locker, proceeded to the high, port side, and repeated the foaming procedure in this compartment. When foaming began in the peak tank, the tending diver manned the second foaming rig and joined the first diver in order to increase the speed of the foaming process in this large space. The two divers foamed the peak tank from the high, port side down to the access port and returned through the port to the machinery space.

Portions of the Machinery Space

The divers next began to foam the upper portion of the machinery space (frame 15 to frame 40) from the port side shell plating down to the level of the port side of the conveyor tunnel. They did not install any foam below this level because of the possibility that it would flow aft into the conveyor tunnel, causing excessive foam/water contact and eventually escaping from the after end of the bow section which was open to the river.

Entering from the middle window of the third cofferdam, the divers proceeded to the high point in the machinery space. Using prescribed procedures, they installed foam down to the level of the conveyor tunnel, one diver working forward and the other aft.

To foam the next area, the machinery space, extending from the lower boundary of the upper portion of the machinery space to a level below the vessel's centerline, a bulkhead had to be installed at frame 40. This bulkhead, fabricated of canvas stretched over a wooden frame, prevented the escape of foam into the conveyor tunnel. After installing this bulkhead, the divers entered the machinery space again and installed foam to the lower boundary of the new bulkhead. While not particularly strong or rigid, the canvas barrier easily contained the foam material during its relatively brief hardening process.



Divers installed canvas bulkhead at frame 40 and foamed machinery space to a level just below ship's centerline. Divers then entered conveyor tunnel, installed additional canvas bulkheads, and foamed toward frame 80 until required 1,700 tons of buoyancy was achieved.

FOAMING THE MACHINERY SPACE AND CONVEYOR TUNNEL

Conveyor Tunnel - Completion of Foaming

The last bow section area foamed was the conveyor tunnel. Canvas bulkheads were installed to divide the tunnel into sections for controlling the flow of foam along its length.

Because the salvors were not certain at which point in the foaming sequence the 1,700-ton requirement would be achieved, they did not waste time in preparing the entire conveyor tunnel for foaming. Thus, the canvas bulkheads were installed one-at-a-time as required. The first bulkhead was placed approximately 25 feet aft of the frame 40 bulkhead. The first tunnel section was then foamed from the high port side down to the lower boundary of the bulkhead. Another five bulkheads were then installed and the foaming process repeated in this manner.

When foaming operations were terminated on 21 September, the conveyor tunnel had been foamed between frame 40 and frame 80. An estimated 1,700 tons of foam buoyancy had been installed in the wreck. Operations had been carried out as planned with few unforeseen problems. All foaming spaces had been filled in less than six full 24-hour work days.

ON-SHORE PREPARATIONS FOR PULLING OPERATIONS, 7 AUGUST - 21 SEPTEMBER

Overhauling the Hydraulic Pullers, 7 August - 18 September

After the SMITH's stern section had been pulled ashore, the six hydraulic pullers were freed for much needed overhaul and modification. The Corps of Engineers made several important modifications on site, including replacement of most of the external hydraulic circuitry and repositioning of the gasoline tanks and operator consoles for greater safety and more convenient operation.

Other modifications were accomplished by the Ferguson Steel Company at its Port Huron plant. The forward fairlead roller assembly on each puller was redesigned to provide greater reliability in both horizontal and vertical alignment of the pullers to the pulling wire. The salvors had found that, under tension, the pullers were often lifted clear of the wooden platforms or pushed down onto the platforms with great force, while slowly moving right or left on the platforms with the movement of the wreck. Lengths of quartered pipe were also welded to the pair of wide flange strength members comprising the base of each puller. These prevented the pullers from "hanging up" as they slid laterally across the wooden platforms.

Overhaul and modification to the hydraulic pullers was ordered on 7 August. The pullers were sent to Ferguson Steel in pairs as they became available. All pullers had been overhauled and made ready for rigging for the bow removal effort by 18 September.

Procuring Skagit Winches, 9-18 September

Investigations on 9 September confirmed the availability of two heavy duty Skagit winches needed to provide additional power in the pulling system. On 12 September, a Skagit RB-97 winch was leased from CONMAC, an authorized Skagit dealer in Belle Chasse, Louisiana. A Skagit RB-150 winch was leased a few days later directly from the manufacturer, the Bendix Skagit Corporation, Sedro Woolley, Washington. The RB-97 arrived by truck on 15 September and the RB-150 arrived by rail on 18 September.

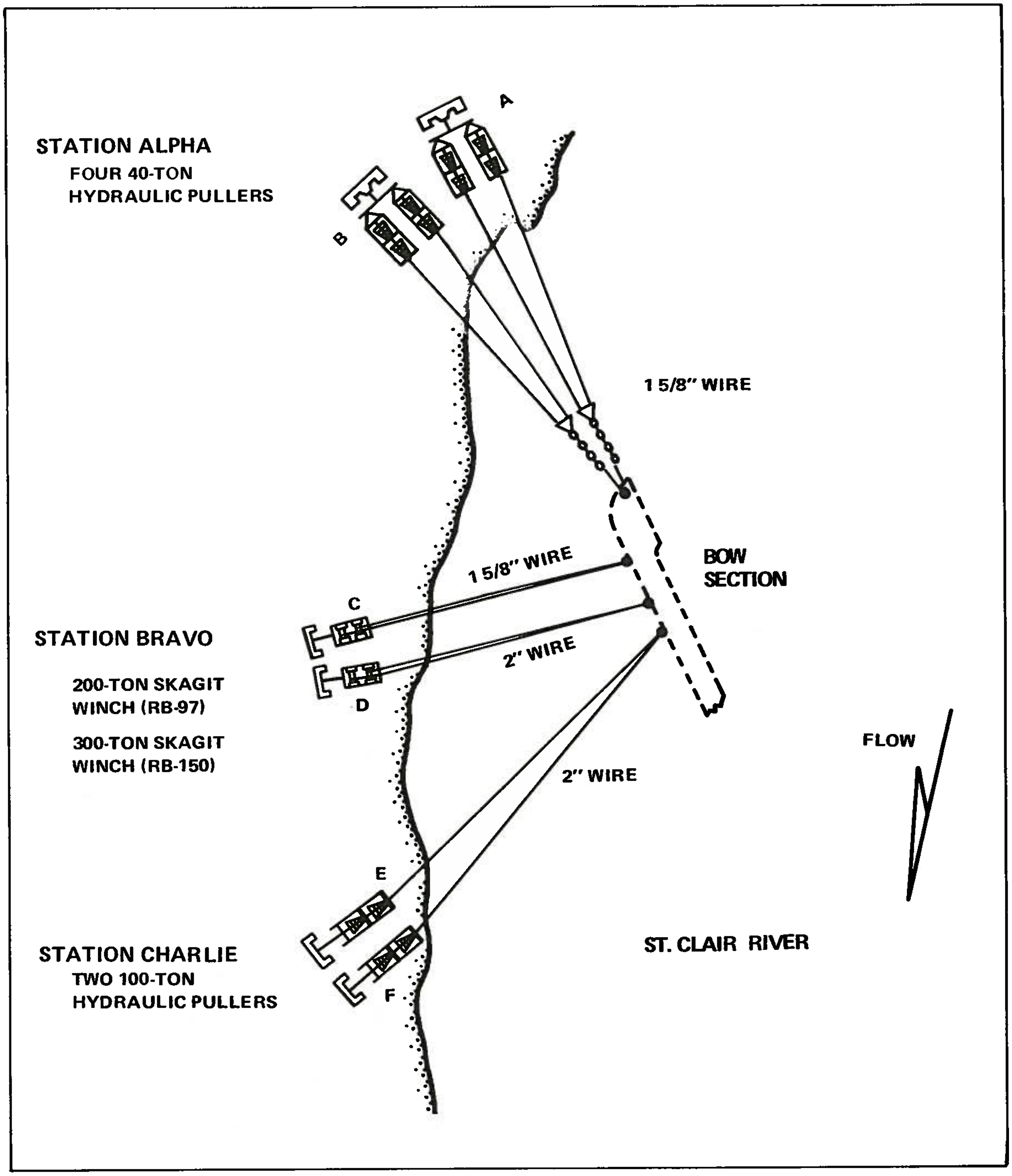
See Appendix F for specifications and preformance data on these winches.

Rigging the Pulling System, 18-21 September

The four 40-ton pullers at Station ALPHA were arranged in pairs, one pair being secured to each anchor block. Each pair was rigged to its anchor block using a specially designed spreader bar. The pulling wires from each pair were connected to the SMITH's port and starboard anchor chains respectively. The ship's anchors had previously been detached from these chains. Each chain was first pulled to remove all possible slack and the excess length burned off to accommodate the 1 5/8-inch holding wires which were then shackled to the chain's bitter end. The four pullers, as thus rigged, could apply a maximum holding force of 160 tons against the force of the river current during the shoreward pull by the Skagit winches and 100-ton pullers at Stations BRAVO and CHARLIE.

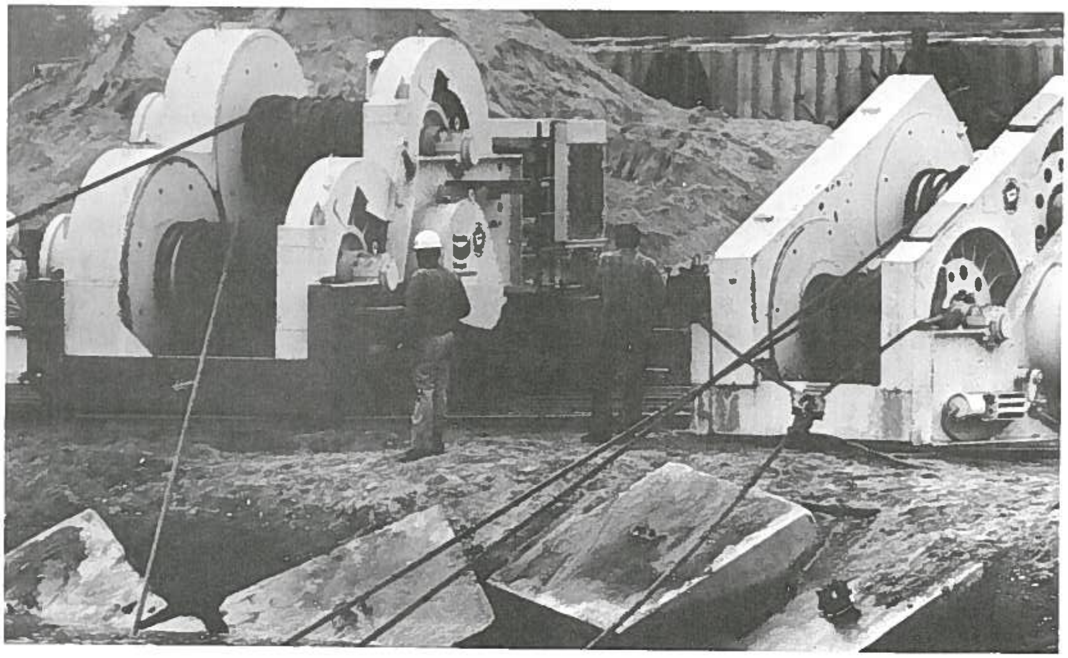
The two Skagit winches were installed at Station BRAVO as soon as they arrived at the salvage site. The salvage force had already extended and reinforced the platforms at this location in preparation for their arrival. The riverbank in front of the platforms had also been built up with concrete blocks. A heavy, 2-inch wire bridle was used to secure each winch to its anchor block. The bridle was attached to the winch at special padeyes, welded onto opposite sides of the winch frame. It was then plate-shackled to a U-bolt extending through the anchor block. Each winch had twin drums, with a pulling wire on each drum. The RB-150 model, with 2-inch pulling wires, could exert a maximum pulling force of 300 tons. The RB-97 winch, with 1 5/8-inch pulling wires, was capable of exerting a maximum pull of 200 tons. The pair of pulling wires from the RB-150 was secured to a pull point around the SMITH's keel at frame 46 and the pair from the RB-97 to another pull point at frame 31.

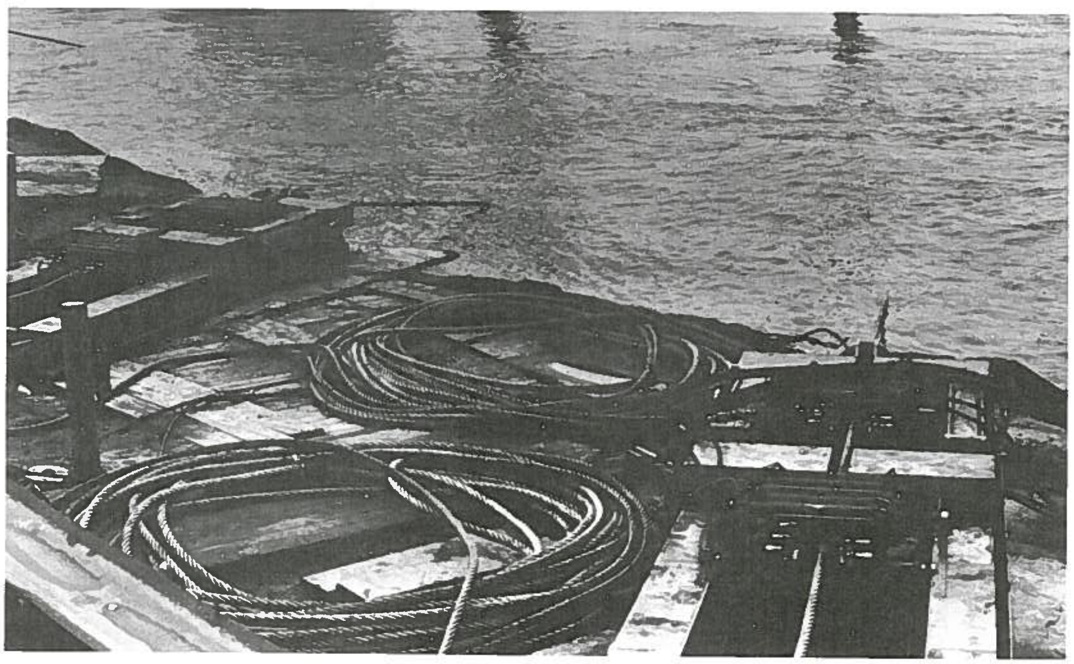
The two 100-ton pullers were set up at Pulling Station CHARLIE without difficulty. All the puller platforms and anchor blocks had been originally designed to accommodate either the 40-ton or 100-ton pullers. Consequently, no modifications were required. It was



Skagit winches at Station BRAVO and 100-ton pullers at Station CHARLIE provided the pulling force. Smaller pullers at Station ALPHA provided the holding force against the river current.

PULLING SYSTEM FOR BOW REMOVAL





Skagit winches at Station BRAVO (above) exert combined force of 500 tons. Two Lucker 100-ton hydraulic pullers downstream at Station CHARLIE reinforce the pulling effort.

STATIONS BRAVO AND CHARLIE GENERATE 700-TON PULL

necessary, however, to move the stern section, which had been beached in front of Station CHARLIE, downstream at this time in order to clear this station for pulling operations. Each 100-ton puller had one 2-inch pulling wire. Both wires were connected to the wreck at the same pull point, around the keel at frame 56. These two large pullers could generate a combined pulling force of 200 tons.

The winches at Station BRAVO and the 100-ton pullers at Station CHARLIE thus added up to a potential maximum beaching force of 700 tons. The actual maximum force was slightly less than this amount because the direction of pull was different from each anchor block. The precise force may be determined by geometric addition of the maximum force vectors of each puller and winch, considering the actual direction of pull. The force of the river current also exerted a small beaching force vector, perpendicular to the force exerted by the holding wires at Station ALPHA.

RETRACTION OF THE BOW SECTION, 21-22 SEPTEMBER

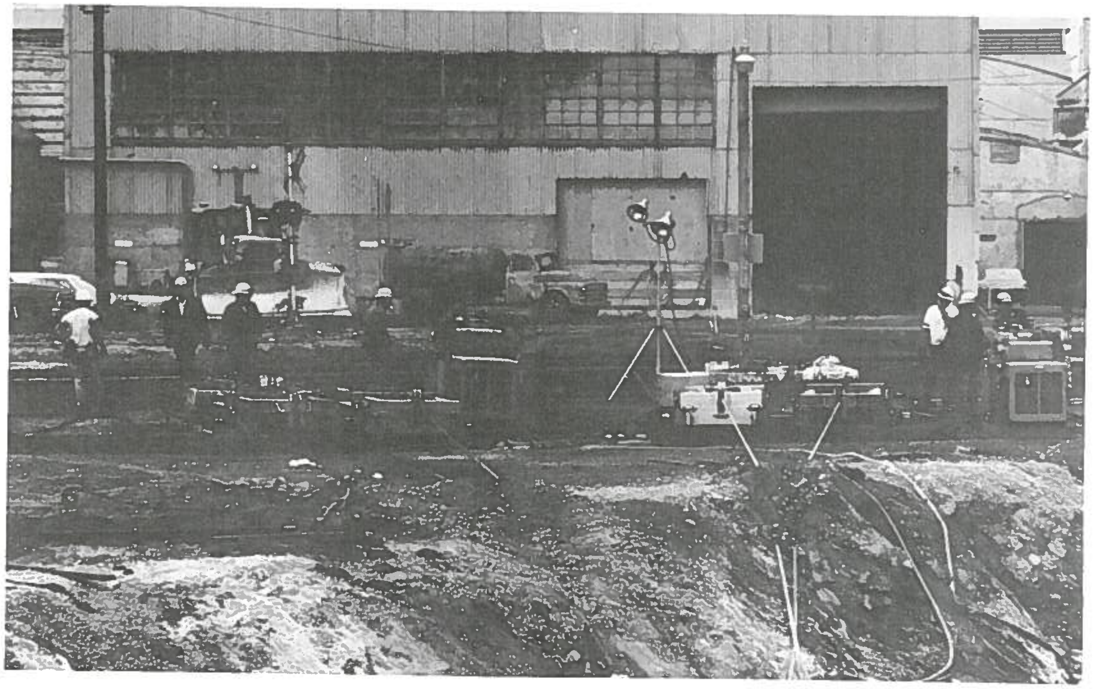
Breaking Bottom Suction

Foaming continued throughout the day on 21 September as the salvage force made final preparations for pulling operations. Approximately 1,700 tons of foam had been installed to this point. Calculations indicated that the SMITH's bow section was now from 400 to 600 tons negative, sufficiently light for a pulling attempt. After taking up the gangways to the cofferdams, the derrick barge moved clear of the wreck to a position downstream. With everything in readiness, pulling operations began at 1900 on 21 September.

All went well initially. Tension was gradually built up on the pulling wires from Stations BRAVO and CHARLIE to 20,000 pounds per wire as planned. Holding wires from Pulling Station ALPHA, upstream, were left slack as pulling began. The salvors wanted to use the force of the river current to help push the wreck approximately 100 feet downstream during the shoreward pull to its planned site upon completion of retraction. The four 40-ton pullers at Station ALPHA would control this downstream movement as required. The tension on each pulling wire was then gradually increased to 40,000 pounds. The wreck broke bottom suction shortly after the new level of tension was reached and maintained, and began to move toward shore.

Problems Occur at Stations ALPHA and BRAVO

At this time, a maximum pulling effort was ordered at Stations BRAVO and CHARLIE in order to exploit the initial shoreward momentum that had been generated. The wreck

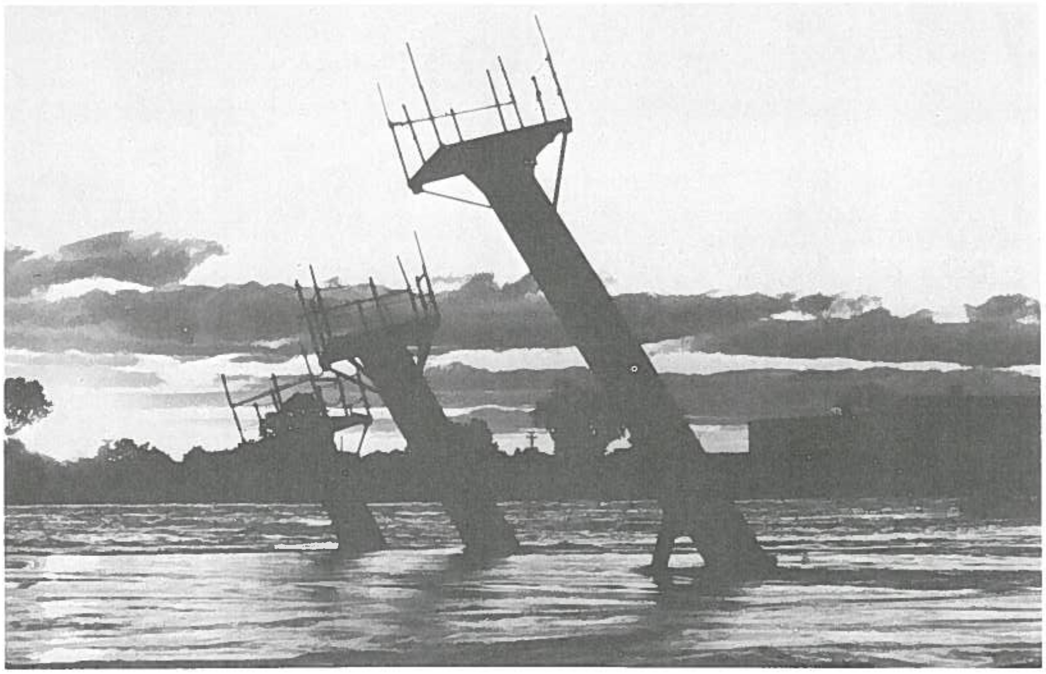


Each pair of pullers is rigged to one anchor block using a specially designed spreader bar. Holding wires to SMITH's anchor chains had to be rerigged after initial pulling attempt failed.

40-TON PULLERS RIGGED IN PAIRS AT STATION ALPHA

moved about 40 feet toward shore but, simultaneously, it also moved downstream farther and faster than anticipated. Tension was placed on the holding wires at Station ALPHA but this effort proved inadequate to control the downstream surge. A chain stopper on the forecastle of the wreck gave way, releasing the port anchor chain. The pair of holding wires attached to this chain went slack as the anchor chain began paying out. The entire load at Station ALPHA shifted to the other set of pullers. The sudden strain on the two holding wires from these pullers was excessive and one of them soon parted.

As these failures were occurring in rapid succession at Station ALPHA, the wreck grounded, pivoting on its broken after end with the forward end swinging in toward the beach. It was still submerged and still blocking the channel although it had moved about 40 feet closer to shore from its original position. Trouble was not confined to Station ALPHA during this first and unsuccessful pulling effort. At Station BRAVO, a heavy pull by the RB-150 winch damaged the winch's anchor block. The concrete cracked around the block's U-bolt connection to the winch.



Bow broke surface 100 feet from shore near end of all night pull, 21-22 September, after 3½ months on river bottom.

INCREASING HEIGHT OF COFFERDAMS MARKS PROGRESS OF PULL

Bow section rested 70 feet from shore morning after successful pull from mid-channel. Salvors moved barge alongside to survey wreck prior to start of Phase III, disposal operations.

BOW REMOVAL OPERATIONS CONCLUDED

The salvors worked far into the night to repair the damage at the two pulling stations. Temporary repairs were made quickly to the anchor block at Station BRAVO. About 20 turns of 7/8-inch wire were rigged around the base of the concrete block to act as a preventer. The work to put Station ALPHA back in operation was more complicated and tedious. The port anchor chain was pulled taut, bypassing the failed chain stopper. It was then burned off at the proper length and the holding wires were again secured to the chain's bitter end. The parted holding wire from the other pair of pullers was rerigged to the starboard anchor chain. These repairs were completed about 0400, paving the way for a second attempt to pull the bow section from the river channel.

Final Pull Shoreward

Pulling operations resumed at 0430 on 22 September. This time, things went smoothly. Within an hour, the bow had moved within 100 feet of shore where it became visible for the first time. After being hauled approximately 50 feet upstream, the wreck was grounded with the bow approximately 70 feet offshore. In this position, it was laying 75 degrees to the beach with the line of cofferdams aimed toward anchor block D at Station BRAVO. Pulling operations were secured for equipment maintenance and crew rest.

With the bow in this position, close to shore, it was out of the St. Clair River Channel, no longer posing a hazard to navigation. This action marked the completion of Phase II salvage operations. Removal of the bow section, beginning with the implantment of the moor on 7 August, had required 45 days of intensive salvage operations. The channel was now clear for the first time in the 3 1/2 months since the SMITH's collision and sinking. Further adjustments in the bow's position would be accomplished at a more leisurely pace during Phase III operations to dispose of the wreck sections.

CHAPTER 9
CONDUCT OF OPERATIONS—PHASE III
DISPOSAL OF WRECK SECTIONS

REQUIREMENTS FOR DISPOSAL OF WRECK SECTIONS

As soon as each section of the SMITH was pulled from the river channel, salvors began the process of transforming them into floating objects. This meant restoring each section to a condition of minimum list and trim. Weight had to be removed and foam installed until the draft was not greater than 24 feet and the list less than 10 degrees. These specifications had been established by the Corps of Engineers.

With the sections no longer obstructing the channel, disposal work could be conducted in 12-hour workdays, a comparatively routine pace as contrasted to the grueling 24-hour-day schedule that characterized mid-channel operations. Also, with the sections secured close to shore and in protected water, traditional refloating methods could be more easily used.

STERN DISPOSAL OPERATIONS, 7 AUGUST - 23 SEPTEMBER

Initial Preparations, 7-11 August

The stern section was successfully beached on 6 August. Disposal preparations began on the following day. Divers first inspected the stern to determine the condition of the cracked area and locate areas for additional foaming. A flat scow, the cargo barge #6472, was outfitted as the foaming and diving platform and moored between the stern section and shore. Several mobile land cranes were leased locally to support scrapping operations from the beach.

On 10 August, divers burned off the diver access tubes which were protruding through the skin of the vessel from cargo holds #5 and #6. The ship's rudder and propeller were also burned off and pulled to the beach.

In preparation for dewatering the boiler feed tank, a 2-inch water hose was installed in the starboard tank vent and an air manifold on the port side vent. A 600-cfm air compressor was moved to Pulling Station CHARLIE adjacent to the stern section for use in dewatering this tank. Initial efforts to pump air into the tank failed due to open valves and extensive cracks in the deck. Many hours were required to patch all the leaks and close the valves which had allowed air to escape.

Phase III, disposal operations, began on each wreck section as soon as it was pulled from channel. Barges and mobile land cranes tended stern section (above) as it was refloated and stabilized for final tow to disposal site.

DISPOSAL OPERATIONS IN PROGRESS ON STERN SECTION

The salvors had planned to install six inflatable air bags in the stern's conveyor tunnel for additional buoyancy. Installation of these bags started on 12 August but this work had to be deferred when they were found to be leaking. The bags were sent back to the manufacturer for repair and improvements to their relief valves. They were eventually placed in the conveyor tunnel as planned on 6 September.

Lightening the Hulk, 11-26 August

The salvage crew began removing excess topside weight from the hulk on 11 August. In addition, cutting operations got underway to trim off the stern section's broken end, forward of hold #5. The removed items were piled on the beach at the Peerless Cement Company Dock by the mobile land cranes. Staging areas were organized for the scrap and other material which would be shipped out. Combustible materials were removed in order to reduce fire hazards before burning away topside structures.

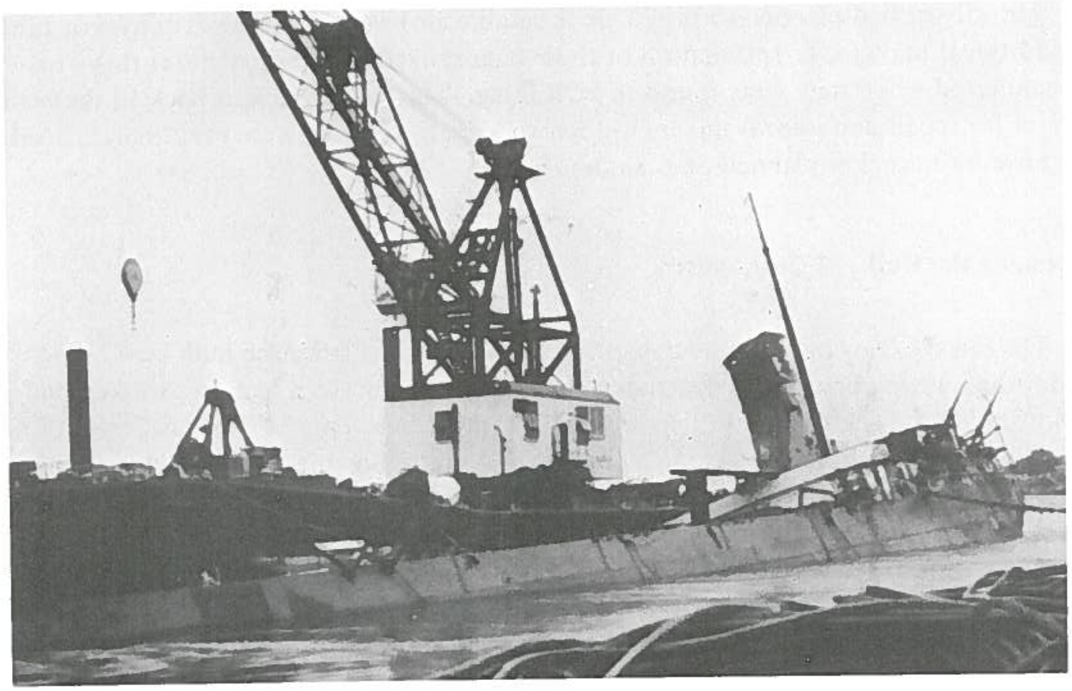
The derrick barge, which had been engaged in bow removal efforts in mid-channel, became available temporarily after the initial cofferdam implantment attempt failed and the cofferdams had to be strengthened. From 18 to 26 August, the barge lifted and placed ashore pieces of scrap and sections of the hull too heavy for the mobile land cranes.

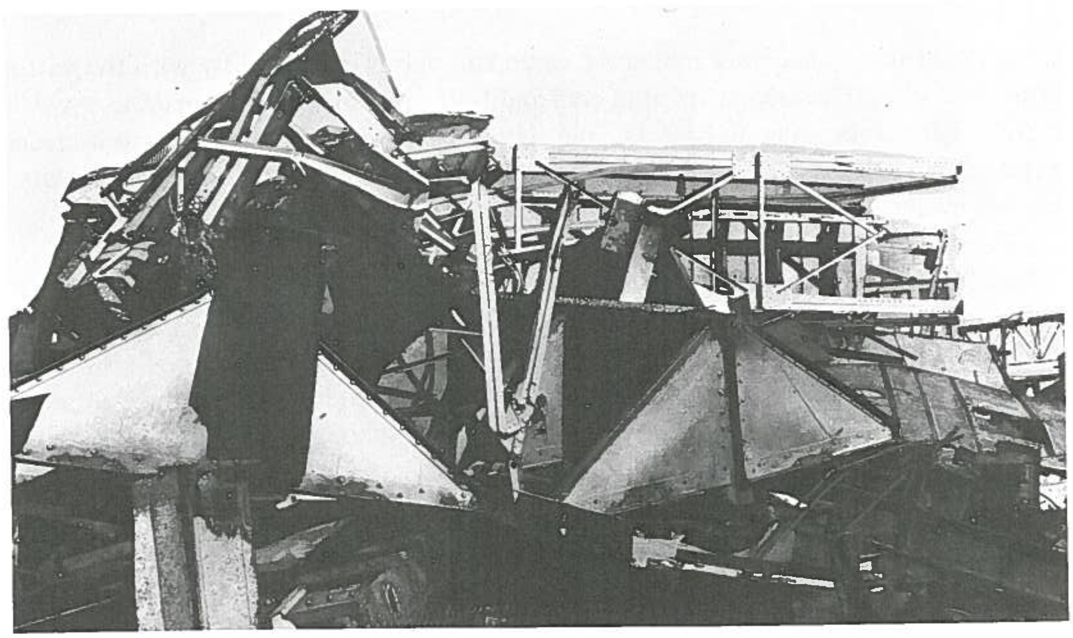
Work continued to remove remaining cargo and debris concurrently with the cutting of structural sections. The salvors airlifted coal and bottom debris prior to making any of the cuts. An airlift was installed in hold #4, and sand which had accumulated there was removed. With the tug WASHINGTON standing by to provide fire services if required, the salvors began cutting away the deck house.

Much had been accomplished by 26 August. The stack, mast, boat davits, deck winches and other topside weight had been removed. About 350 tons of scrap steel had been piled on shore. The scow was moved to the starboard side of the stern and pumps and airlifts had been rigged on the hulk. The stern was moored to the beach in order to release the hydraulic pullers for bow removal operations. Divers were still patching holes in preparation for pumping operations which were to begin on 27 August.

Pumping Operations, 27 August - 8 September

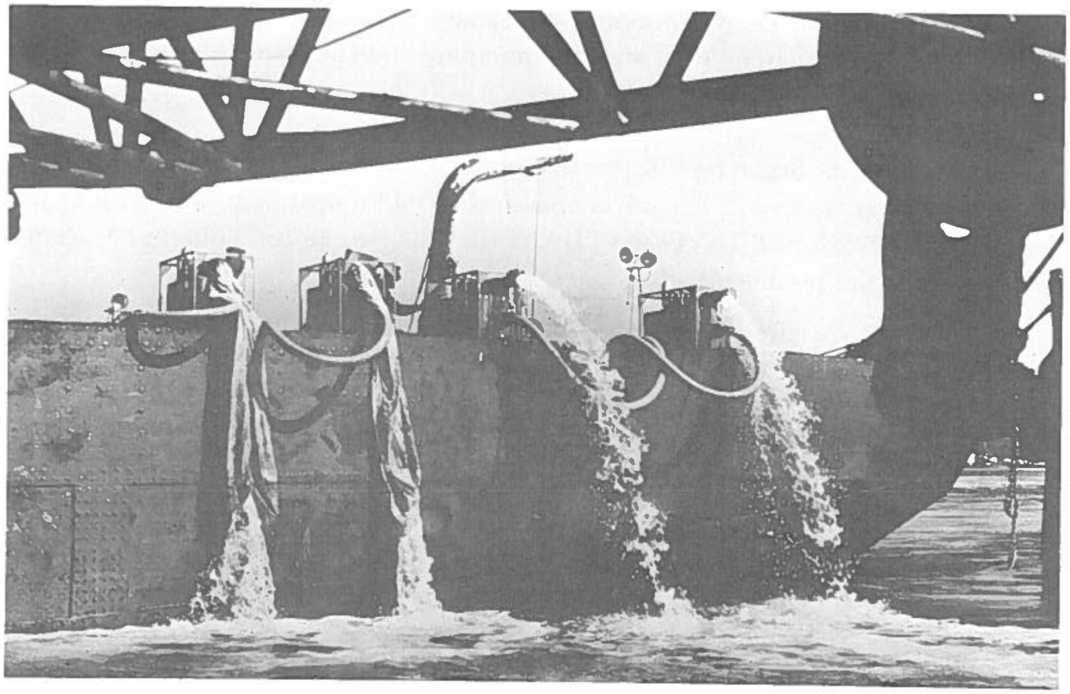
Pumping operations were conducted throughout the next 12 days in order to lighten the vessel and make it towable. Holes and cracks in the hull and watertight boundaries were patched and plugged and compartments dewatered using four 3-inch pumps and a salvage pump from the tug WASHINGTON. A 6-inch pump was also provided by the Corps of Engineers.





Derrick barge assisted mobile land cranes in stern disposal operations by lifting and placing heavy pieces of scrap ashore. Approximately 350 tons of scrap were temporarily piled near Peerless Co. dock.

EXCESS WEIGHT REMOVED FROM STERN SECTION



Compartments were patched and plugged, then dewatered using four 3" pumps (above), a 6" pump and tug pump. Pumping, plus installation of foam, brought wreck close to required list and trim conditions.

STERN RIDES WITH 20-FOOT DRAFT FOLLOWING DEWATERING

The starboard gunwale surfaced on 27 August, as the lightened stern section began to rise. By 29 August, the stern was about trim fore and aft with a 3-degree list to starboard. On 31 August, it was riding with about 5 feet of freeboard at frame 108 and drawing 20 feet aft.

Foam compartments were inspected and new foam added in spaces which could not be made watertight for pumping. Approximately 100 tons of foam were installed in hold #5. Work continued to obtain the specified 24-foot mean draft. Leaks were isolated and patched in the double bottom tank and boiler feed tank. Water leaks were controlled with periodic pumping by a 3-inch pump.

Removal of 200-Ton Section, 8-17 September

The hulk was open to the river from the break at frame 85 through hold #4 to the forward bulkhead of hold #5 at frame 108. This section, about 70 feet long and weighing 200 tons, could not be sealed. On 8 September, the salvors decided to cut it off as the stern was still not responding adequately, even with the pumping of all available spaces and removal of excess topside weight.

Cutting operations began on 9 September along with preparations for pulling the section to shore when it was removed. The salvors planned to pull it upstream, well clear of the area in front of Pulling Stations BRAVO and CHARLIE. The two 40-ton pullers at Station ALPHA would be used for this pulling effort.

Cutting was completed on 11 September and the section was pulled clear of the wreck and then part way up on the beach. However, it became jammed against old pilings and debris on the bottom next to the shoreline, preventing it from being pulled further upstream. The salvors used a 100-ton puller at Station BRAVO in an attempt to pull the section directly inshore over the pilings and debris. When this attempt failed, they moved the 100-ton puller to Station ALPHA. On 17 September, the 100-ton puller and the two 40-ton pullers at this station succeeded in pulling the 200-ton section about 150 feet upstream, well clear of Stations BRAVO and CHARLIE.

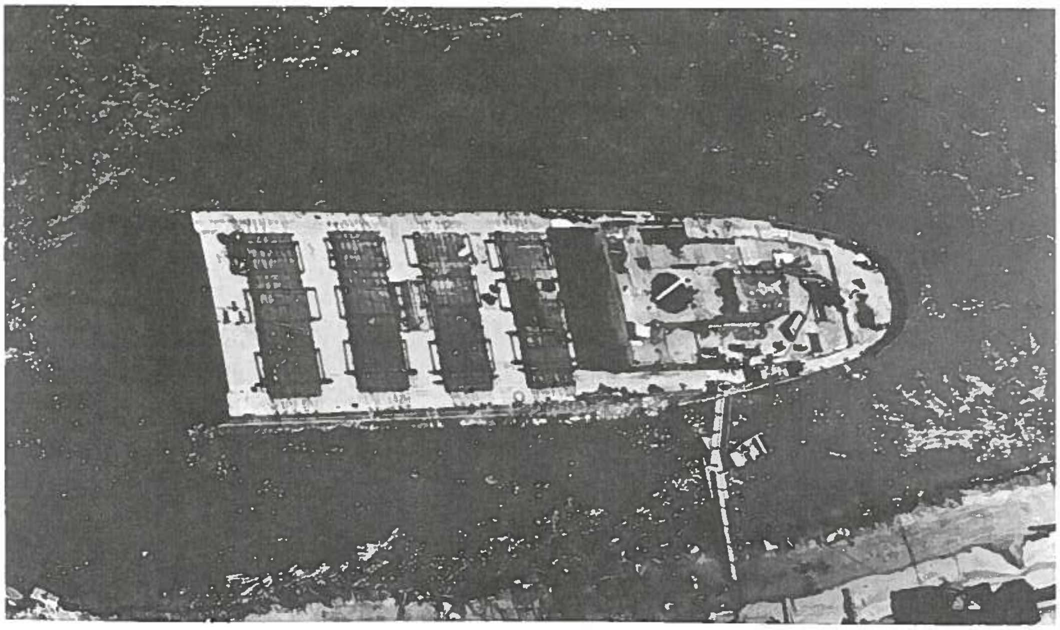
Removal of this large, heavy hull section from the wreck helped considerably. Upon completion of cutting operations on 11 September, the stern section was now afloat on a nearly even keel with a slight trim forward. It was riding well, with a draft of about 23-1/2 feet forward and 21 feet aft. The salvors moored it to the shore the next day and it continued to ride well. Two 3-inch pumps, operating intermittently, maintained proper water level.

Moving the Stern Section Downstream, 18-26 September

During the next few days, preparations were made to move the stern section downstream to a new location in order to clear Pulling Station CHARLIE and to make room for the bow section which was ready in mid-channel for pulling to shore. The section was moved on 20 September to the vicinity of Fort Gratiot Front Range Light. Considerable difficulty was encountered in mooring because of the extremely strong current. The stern section was moved again on 23 September, this time to the Peerless Cement Company Dock. Finally, on 26 September, the stern was moved to a more permanent location downstream and moored alongside the shore using three buried anchors and an existing bollard. She rode well in the new moor.

BOW DISPOSAL OPERATIONS, 23 SEPTEMBER - 19 NOVEMBER

When bow removal efforts were secured on 22 September, the bow was grounded approximately 70 feet off shore and laying 75 degrees to the beach with the line of cofferdams



Hatch covers remain in place over foamed cargo holds 5 and 6. To help refloat wreck, salvors removed 70′ long, 200-ton section of cargo hold 4 which was open to river.

STERN SECTION REFLOATED, AWAITING FINAL DISPOSAL

facing anchor block E. Although the channel was now clear, the salvage effort was not yet completed. Like the stern section, the beached bow section also had to be transformed into a floating object which could be safely towed to a disposal site. However, before refloating, the salvors first had to move the bow section closer to shore, remove the conveyor boom and cofferdams, and then parbuckle it to an upright position.

Preparations for Parbuckling, 23 September - 2 October

Bad weather and current conditions on 23 September delayed bow activities for 24 hours, but on the following morning the salvors remanned all pulling stations and began hauling the bow section closer to shore. By late afternoon they had succeeded in bringing the wreck to within 40 feet of shore. The turn of the bilge was now 3 to 4 feet above water and visible for a distance of about 30 feet.

With the bow section in this position, the salvors were now able to begin removing the coal conveyor boom and the three cofferdams. The next day, divers surveyed the wreck, burned away the boom's main block supports from the top of the A-frame, and began re-

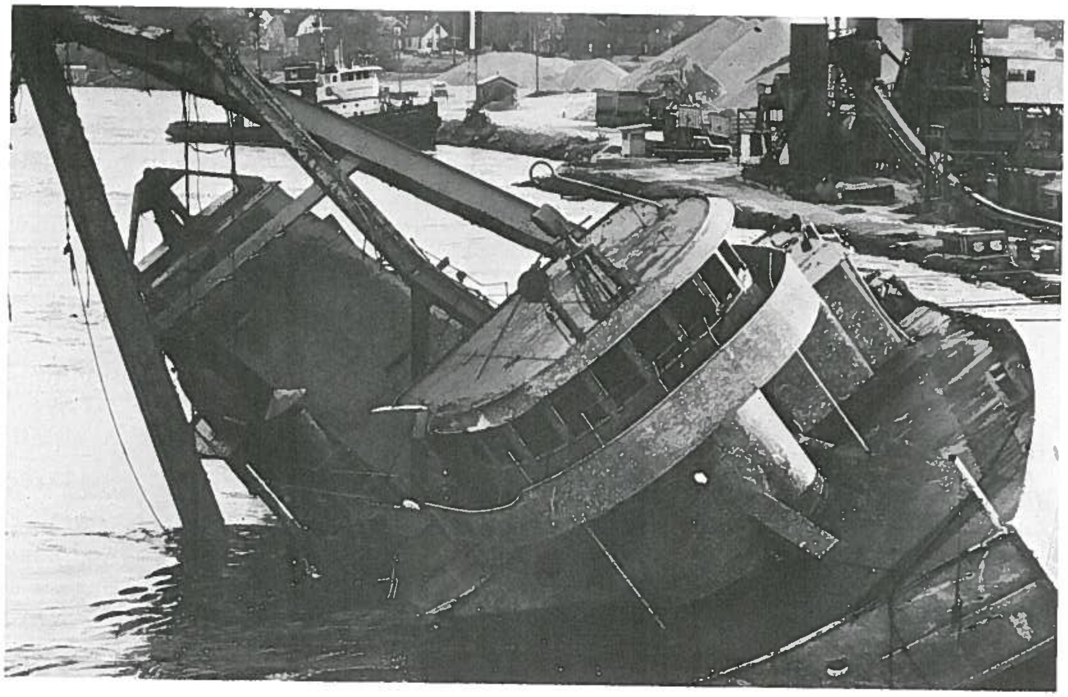
With bow section out of mid-channel, salvors removed cofferdams and SMITH's coal conveyor boom. Wreck was then more manageable for parbuckling.

COAL CONVEYOR BOOM LIFTED FROM BOW SECTION

moval of the boom itself. On 26 September, the conveyor boom was burned free of the wreck, cut in half and lifted to the beach where it would later be cut into smaller sections and placed on the scrap pile. Also, the salvors had cut off the tops of the cofferdams and placed them ashore.

Renewed pulling efforts on 29 September brought the wreck still closer to shore, but it remained hard aground. In addition, anchor block D at Pulling Station BRAVO was almost completely destroyed by the day's operation. The salvors reinforced the block with wide flange beams and additional cement.

By 2 October, the salvors had removed the remaining halves of the cofferdams from the bow section and bolted gasketed plates over the hull openings where the cofferdam windows had been. Parbuckling preparations were complete after the salvors rerigged the pull points on the wreck. The wires from the 200-ton Skagit winch at Station BRAVO remained rigged



With pull points on wreck rerigged, bow section was brought to within 40 feet of shore and parbuckled to 40° starboard list. Further parbuckling reduced list to 22°, but efforts were hampered by presence of submerged pier pilings beneath wreck.

BOW SECTION PARTIALLY RIGHTED

to their usual pull point around the keel, but the wires from the 300-ton Skagit winch now led to the base of the bow's unloading machinery. Also, the wires from the 100-ton hydraulic pullers at Station CHARLIE were moved to points on the main deck centerline beam. The pulling wires from the four 40-ton pullers, which remained rigged in pairs at Station ALPHA, led through the SMITH's bullnose to bitts on the forecastle.

Parbuckling Operations, 3-5 October

The first parbuckling attempt on the morning of 3 October failed after two pulling wires parted. The pulling wires had been led over the gunwale and had become chafed. To solve the chafing problem, the salvors rigged the wires to chains across the gunwale.

A second parbuckling attempt on 4 October from all pulling stations, plus the derrick barge hoisting at the top of the A-frame, succeeded in rolling the bow section up to a 40-degree list to starboard. A diver inspection the same day, however, revealed that old pier pilings beneath the wreck were preventing further parbuckling and shoreward movement.

To reduce the bow section's weight somewhat, the salvors removed the heavy conveyor boom A-frame. They then rigged the 200-ton Skagit winch's pulling wires to a new pull point on deck at the A-frame's former port side base and hooked up the derrick barge's lifting wire to chains rigged on deck at the A-frame's former starboard side base. A pull from the derrick barge and all stations on 5 October succeeded in rolling the bow section up to a 22-degree list to starboard, but the submerged pier pilings again prevented full parbuckling.

Foaming of Hold #2, 6-11 October

It became clear after the 5 October parbuckling effort that additional foam would have to be installed inside the wreck to raise it above the pilings and allow it to float freely. Thus, the salvors unrigged the four 1 5/8-inch pulling wires to Station ALPHA and kept all others tensioned as the derrick barge was moved between the beach and the wreck to conduct foaming operations in hold #2. In preparation for the installation of foam, the salvors airlifted debris from the compartment, patched the tunnel and hopper areas, and installed a hatch cover over the open hatch on 7 October.

The hold was divided into two separate compartments using burlap curtains and 1 1/4-inch pipe as stanchions to secure the curtains in order to restrain the foam from running too far while still in a semi-hardened state. On 8 October, the salvors began installing foam in the hold with three foaming nozzles while the tug KEWEENAW BAY stood by to pick up any loose foam that escaped into the river. Three days later, approximately 550 tons of foam buoyancy had been installed in hold #2. The added buoyancy apparently broke the bottom suction and the broken, after end came up slightly.

Subsequent Preparations, 11-25 October

The salvors retensioned D and E wires which had slackened when the wreck rose. The slight movement of the vessel caused by the retensioning, however, put an extra strain on the 200-ton winch's wires and essentially destroyed anchor block C. The salvors reanchored the winch by rigging a 1 5/8-inch chocker to anchor block D and 1-inch wire around both C and D blocks, but the tension on the 4 winch wires remained excessive. In order to relieve some of this tension and reduce the vessel's list, the salvors asked the Port Huron Fire Department to provide a pumper to jet away the bank beneath the wreck.

The water jetting on 11 and 12 October succeeded in settling the wreck down about 8 inches and relieved some of the strain on the pulling wires. But the vessel remained heavy. The derrick barge then moved into position alongside the hulk and offloaded the pilot house, gyro room, elevator, and boom handling machinery which the salvors had burned off to reduce topside weight. During the cutting operations, the tug WASHINGTON stood by to provide firefighting services as required.

From 10-25 October, the salvors concentrated on foaming hold #1. More coal was found in that hold than anticipated and had to be airlifted. Steel bulkheads were constructed and installed; holes and cracks from which foam could escape were patched; and hogging lines were installed to support divers during foaming operations. Foam was installed in the starboard side machinery space and the bow thruster machinery space as well as in hold #1. Although only a slight change in attitude was noted, there was now much less tension on the wires.

Refloating the Bow Section, 26-29 October

The salvors decided to try rocking the vessel off the pier pilings, using the derrick barge to provide the lifting force. The barge's crane was attached to a lift point at the base of the A-frame for this purpose. By alternately lifting and slacking with the barge's crane while maintaining tension on the pulling wires from the winches on the beach, the bow section could be dislodged from the pilings.

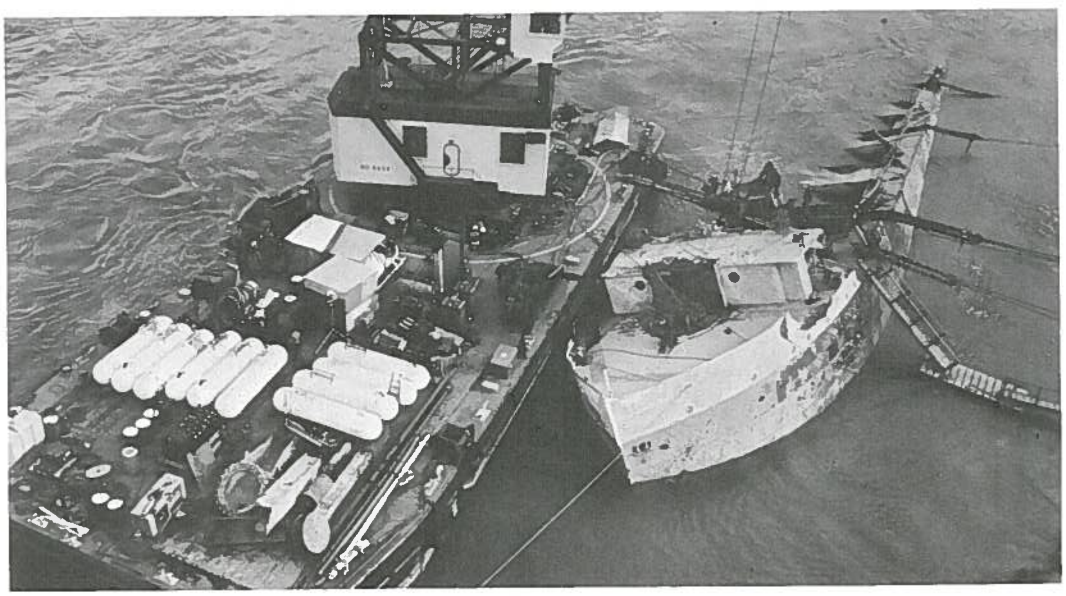
The first attempt failed on 26 October. The broken after end was still too heavy. The bow now had a 10-degree list to starboard and a 6-degree trim, down by the after end. More foam was required before it could be dislodged.

During the next 2 days, additional foam was installed in holds #1 and #2. The next rocking attempt was successful. By 29 October the bow section was definitely afloat. Its attitude was a 6-degree list to starboard and an even trim. With the bow now righted and floating, the Skagit winches were no longer needed. They were disconnected and prepared for return to their owners.

Completion of Operations, 29 October - 19 November

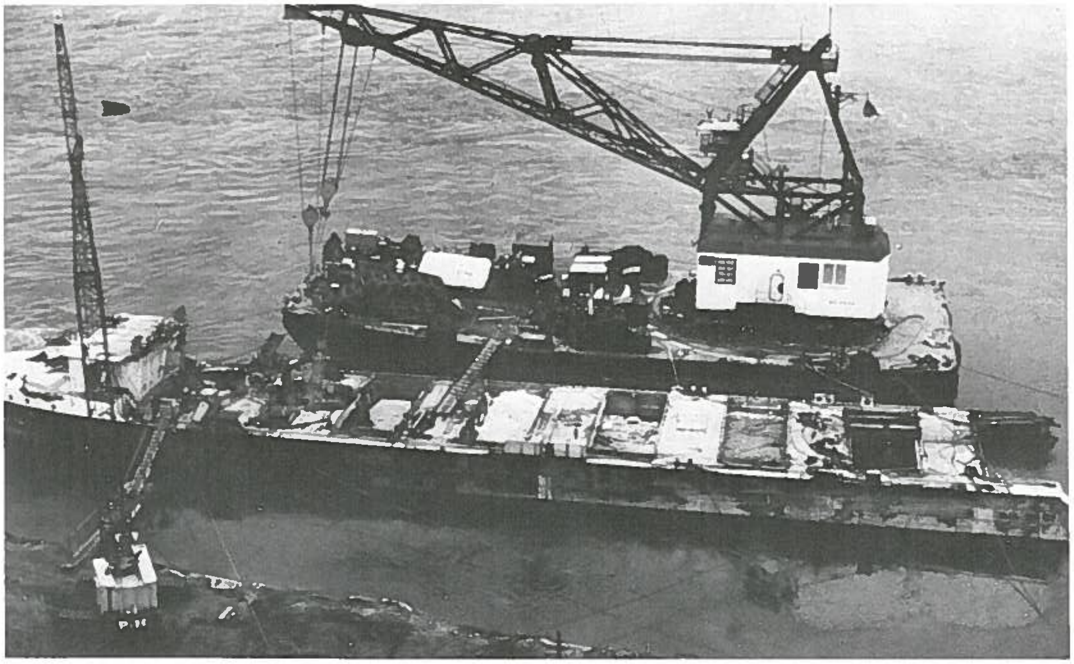
From 29 October to 3 November, work continued to construct bulkheads, patch holes, and install foam to make the bow section towable. A hatch cover for the elevator trunk was fabricated and installed and the space partially foamed by probing from the top. Salvors also began to disconnect the hydraulic pullers and remove the anchor blocks. Although the wreck was floating, it was still very heavy, listing 5 degrees to starboard and down by the stern about 2 degrees. There were 3 feet of freeboard on the port side aft. The starboard gunwale was awash.

Remaining work was accomplished during the next 2 weeks. Bulkheads and foam were installed in hold #3. Salvors continued dismantling the pulling platforms, packing unnecessary equipment, and generally cleaning up the yard area. On 19 November, all equipment was removed from the derrick barge. This final action marked the completion of Phase III efforts to dispose of the two wreck sections, bringing to a successful conclusion the SIDNEY E. SMITH salvage operation.



Using probe method, salvors installed additional foam in cargo hold 2 and other compartments. Foam, plus rocking motion applied by derrick, finally lifted wreck from pier pilings, allowing it to float freely.

ADDITIONAL FOAM AND PULLING FREES BOW SECTION



After bow section (top) was floated and stabilized, it followed stern section (bottom) in tow across St. Clair River to Sarnia, Ontario. Both were then sunk in excavations dredged along riverbank.

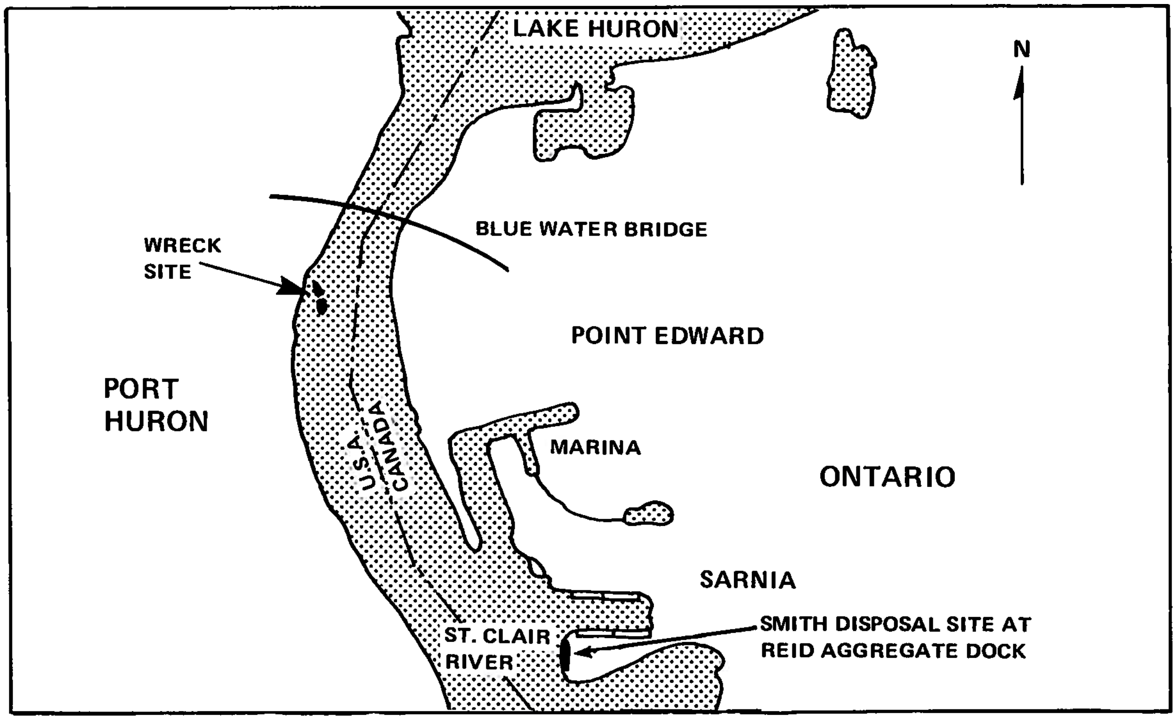
BOW AND STERN SECTIONS PRIOR TO FINAL DISPOSAL

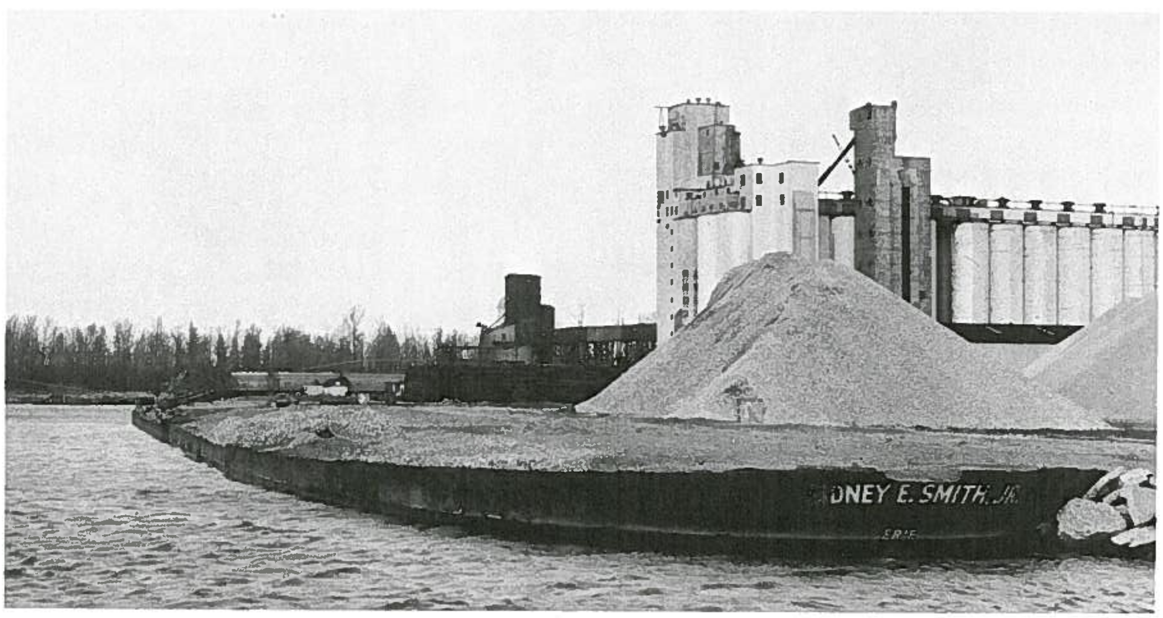
FINAL DISPOSITION OF THE SMITH WRECKAGE

The end result of the disposal effort was two floating wreck sections of less than 24-foot draft and 10-degree list and trim. In addition, hundreds of tons of high quality steel scrap remained on the riverbank. The Corps of Engineers had intended to sell all scrap and each wreck section at public auction to the highest bidder. The revenue from these sales would be used to defray the cost of the removal operation.

Unfortunately, the sale of the sections and scrap was disappointing. The scrap went for a mere $5.00 a ton and the Corps of Engineers was forced to pay nearly $260,000 in total disposal fees for both SMITH sections. Reid Aggregates Ltd. of Sarnia, Ontario, accepted delivery of the two wreck sections for use as a dock and erosion bulkhead along its waterfront.

On 11 November, the tug TABOGA towed the stern section to the Reid Aggregate dock. The bow section was moved there on 27 April 1973. At the Reid Aggregate dock, the hatch covers were removed, and a clam shell bucket was used to remove the urethane foam from the wreck. The two sections were then sunk in excavations dredged in the riverbank. The wreck was then filled with rock and gravel and capped with a permanent concrete deck. SMITH disposal was completed.





Sailing days over, SMITH still performs useful function in final resting place. City of Sarnia has long range plan to use this waterfront property as site for cultural center.

SMITH'S HULK PROTECTS SARNIA SHORELINE

CHAPTER 10
RETROSPECTIVE EVALUATION

The retrieval and disposal of the S.S. SIDNEY E. SMITH, JR., was a monumental salvage effort that required more than five months to complete. More importantly, it was a safe operation conducted without serious mishap or injury, despite a grueling schedule and hazardous working conditions that left no margin for error.

Underwater implanted urethane foam provided the only feasible means of lightening the wreck sections so that they could be pulled clear of the navigation channel. The foam's buoyant quality was poor or unpredictable, at best. On-site data and future analysis of the problem by appropriate technicians should help determine the causes of poor foam quality and lead to the refinement of this promising salvage tool.

The cofferdams that allowed foaming operations to be conducted on the bow section proved particularly effective. It is believed that the SMITH operation marked the first application of cofferdams as a protective shield for divers against a hazardous current. This successful use of cofferdams may set a precedent for their future use as a protection against other marine hazards, such as toxic chemicals, flaming oil, and dangerous marine life.

While the current was never underestimated by the salvors, its power surprised them on several occasions, notably during cofferdam installation. The salvors were quick to correct the damage done to the A-frame and cofferdam by the current, and installation proceeded without any change in the salvage plan.

The salvors also demonstrated their resourcefulness during hatch cover installation when they fabricated a special guide to allow proper alignment of the covers with the submerged hatch coamings. Once again, the salvors outlasted the current and proceeded with their original salvage plan.

The specially constructed hydraulic pullers proved consistently reliable and gave salvors a high degree of control over the wreck sections during both retrieval and parbuckling efforts. The flexibility of the pulling system allowed the pullers to be exchanged between stations as pulling requirements changed. After demonstrating their effectiveness as a salvage tool in the SMITH operation, hydraulic pullers quickly won acceptance within the salvage community.

The unique anchoring system also proved reliable. Except for the breakup of one anchor block during a final pulling effort on the bow section, all blocks held up for the duration of the salvage effort.

Despite the innovations of the SMITH salvage operation (foaming, cofferdams, hatch covers, hydraulic pullers and anchoring system), the salvage force did not shun the use of traditional salvage techniques. Traditional methods were applied in several important phases of the operation, including the rigging of pull points and in the refloating and stabilization of the wreck sections during disposal operations.

Finally, the SMITH salvage was a team effort involving the close cooperation of Navy, Army, Coast Guard and several commercial firms. Key provisions of the Salvage Act were exercised in order to obtain a significant advance of Federal funds for this task, thereby insuring that maximum salvage assets could be brought to bear in a timely manner.

APPENDIX A

U.S. COAST GUARD REPORT
ON
SMITH/EVANS COLLISION

–COPY–

Commanding Officer
Marine Inspection Office
424 Federal Building &
U.S. Courthouse
Detroit, Michigan 48226

7 Aug 72 11 24
C AC T AD A
HHSD 900D

5943/DET/7-72
1 August 1972

From: Investigating Officer
To: Commandant (GMVI)
Via: Commander, Ninth Coast Guard District (a)

Subj: SS PARKER EVANS and SS SIDNEY E. SMITH, JR., collision on 5 June 1972 on St. Clair River, with no loss of life or personal injury

FINDINGS OF FACT:

1. The downbound Canadian steamer PARKER EVANS, O.N. 306052 and the upbound U.S. steamer SIDNEY E. SMITH, JR., O.N. 202875, collided at about 0145 Eastern Standard Time, 5 June 1972 at the mouth of the St. Clair River near the Blue Water Bridge. The collision took place between U.S. and Canada and in U.S. waters approximately 2100 feet 025° true from Ft. Gratiot front range light (LL 1214). The area of the casualty is covered by Lake Survey Chart P43. The SIDNEY E. SMITH, JR. sank onto its starboard side in about 35 to 50 feet of water within 20 minutes after collision. The PARKER EVANS suffered major bow damage. There was no loss of life or apparent injury on either vessel. Timely effective action by the COTP Detroit averted a spill of some 45,000 gallons of bunker C oil from the SMITH's fuel tanks. The combined efforts of units from the Canadian DOT and Canadian Ministry of Environment, Corps of Engineers, Marine Pollution Control Corp., Environmental Protection Agency, McQueen Marine Ltd., Michigan Water Resources Commission and the National Strike Force successfully recovered almost all the oil from the SMITH which would have spread rapidly through the St. Clair River and Lake St. Clair. The sunken SMITH partially blocked the channel and traffic control was required for safe vessel transit in the area.

2. Vessel data:

Name:	PARKER EVANS	SIDNEY E. SMITH, JR.
Official Number:	306052	202875
Service:	Freight	Freight

Subj: SS PARKER EVANS and SS SIDNEY E. SMITH, JR., collision on 5 June 1972 on St. Clair River, with no loss or life or personal injury

Gross Tons:	7815	5398
Net Tons:	5725	4102
Hull:	Steel	Steel
Length:	556.7	489.0
Breadth:	58.0	52.2
Depth:	31.0	26.5
Built:	1908	1906
Propulsion:	Steam	Steam
Horsepower:	1878	1650
Home Port:	Owen Sound, Ont., Canada	Erie, Pa.
Owners/Operators:	Hindman Transportation Co. 1105 First Ave., East Owen Sound, Ont., Canada	Erie Sand Steamship Co. Ft. of Sassafras St. Erie, Pa.
Master:	Thomas Clyde Davis	Arn Kristensen
License:	Master, Inland #192260 2nd Mate, home trade	Unlimited Master, Great Lakes 1st Class Pilot #373060, Duluth Gary, Buffalo
Last Inspection:	14 April 1972	28 April 1972
Port Certificate Issued:	Goderich, Ont., Canada	Buffalo, New York

3. There were no deaths or record of personal injury.

4. The weather at the time of the collision was as follows: Clear, dark night, unlimited visibility, wind variable at 0-10 knots, air temperature 55°F, sea water 47°F, calm seas and a strong current running. Times in this report are Eastern Standard (+5 ZD). However, all transcribed and recorded testimony from Canadian witnesses was Eastern Daylight Savings Time (+4 ZD). Current studies of the St. Clair River near Blue Water Bridge, provided by the U.S. Corps of Engineers, taken 7 June 1972, show that downbound currents toward the Ft. Gratiot range vary from 4.22 MPH (statute) to 5.79 MPH. Currents on the upbound portion of the channel, in the area near Blue Water Bridge, range from 2.04 MPH near the Canadian shore to 5.65 MPH near center channel. Maximum currents of 5.93 MPH (statute) exist in midchannel at the Blue Water Bridge. Radar on each vessel was not in operation, but all navigational equipment including running lights was satisfactory.

5. Propulsion machinery and steering gear was operating satisfactorily on each vessel.

6. The SS PARKER EVANS (Canadian) departed Thunder Bay, Ontario, 2 June 1972 with a 11,090 ton grain cargo and draft of 20'11" fwd., 21'5" aft. The voyage continued without

event with all ship's gear operating normally, and the vessel manned in accordance with applicable regulations. At 0130 EST, 5 June 1972, while on the Point Edward Range about 1/2 mile above buoys 1 and 2 (LL #1220 and LL #1221) the engine speed was reduced from full ahead (about 80 RPM) to half ahead (46 RPM) with the speed through the water estimated at 9 MPH and 8 MPH over the ground. The reduction in speed was initiated to conform to St. Clair River speed limits. The master, Thomas C. Davis, was in charge of navigation of the vessel and the watch consisted of 2nd Mate Wilmer Stevens, Wheelsman Ronald Pennington and Third Engineer John H. Glover was in charge of the engine room. There was no bow lookout posted – reportedly due to fine visibility and the short distance of pilot house to bow station estimated as 20 feet. The starboard pilot house door was open and pilot house windows were closed. While proceeding downbound on the Ft. Gratiot range, just as the EVANS was about to blow a one blast signal for a port to port meeting, a one blast signal was heard from an upbound properly lighted vessel (which turned out to be the SIDNEY E. SMITH, JR.). The one blast was answered by the EVANS when about 2600 feet above Blue Water Bridge with the SMITH about 1700 feet below the bridge agreeing to the port to port meeting. As she proceeded downriver the EVANS was on Ft. Gratiot range when it was noted that the SMITH did not appear to be making her turn to proceed into Lake Huron. Orders were given to ease rudder to right in order to give the SMITH more room. The EVANS now opened the Ft. Gratiot range toward the U.S. shore at Port Huron. A very short time later (estimated as much less than a minute) and with the vessels about 2150 feet apart a danger signal was heard from the SMITH and immediately the EVANS' engine was ordered full astern and the rudder was placed midship. The engine was on full astern but there was not sufficient time to take off her forward way when her stem and bow area collided with the starboard bow of the SMITH at or slightly aft the break of the forward house. The PARKER EVANS rebounded from the initial impact area and again struck the SMITH at a point 20-30 feet astern of the first impact area. At about this moment, the EVANS' engine was ordered full ahead in an attempt to hold the SMITH onto the nearby Peerless Cement dock. Unable to hold the SMITH due to their stern swinging down in the current, the EVANS dropped her starboard anchor and was able to moor at the sand and stone dock 300 feet 180°T from Ft. Gratiot front range light (LL #1214). Other than the danger signal just prior to collision, no other signal was heard by the EVANS except a continuous long blast. After the agreement for the port to port meeting situation the EVANS did not further respond to any whistle signals. The geographic area of collision was stated as being at or just above the Blue Water Bridge on the American side of the channel and just on the U.S. side of Ft. Gratiot range. Security calls were not given by the PARKER EVANS nor heard from the SIDNEY E. SMITH, JR. The only lights of the SMITH sighted by the EVANS were her masthead, range and green starboard lights.

Subj: SS PARKER EVANS and SS SIDNEY E. SMITH, JR., collision on 5 June 1972 on St. Clair River, with no loss of life or personal injury

7. The SS SIDNEY E. SMITH, JR. (U.S.) departed Toledo, Ohio at 10:45 A.M. on 4 June 1972 and proceeded upbound with a partial coal cargo of 6646 tons, bound for Lime Island, Michigan. The vessel's draft was 17'3" fwd and 19'9" aft. The vessel's gear was operating satisfactorily and she was manned in accordance with the Certificate of Inspection. The deck watch consisted of 2nd Mate Henry W. Gaskins, Wheelsman Paul J. Diehl, Lookout Alfred Shanahan, and the watch engineer was 2nd Assistant Arthur L. Harvey. At about 1:00 A.M. EST, 5 June 1972 when the vessel was near Marysville Edison Plant, the master left the pilot house to avail himself of toilet facilities in his quarters. After the master left the bridge the watch was held by 2nd Mate Gaskins, who is licensed as Master unlimited, Duluth, Gary, St. Vincent and First Class Pilot, issue 1–4. Near Port Huron Traffic Buoy (LL #1211), a security call was heard from a downbound vessel OUZARDE from position at buoy 11 and 12 (LL #1230 and 1231) and a security call made stating position of steamer SIDNEY E. SMITH, JR. relative to the traffic buoy. The vessel proceeded normally up the river at a full ahead speed of about 9 MPH, 76 RPM to a point abeam the Port Huron water filtration plant (2400 feet 165°T from Ft. Gratiot front range light) where a slow right turn was ordered. At about the same moment, the SMITH reportedly heard the one blast signal of a downbound vessel which was sighted with the proper lights showing about 1 to 1½ miles up river. At this time, the SMITH answered the one blast assenting to a port to port meeting situation. When the ship was just below the Canada Steamship Lines freight sheds Mr. Gaskins indicated his feeling to the helmsman that the SMITH was getting too close to the Canadian shore and ordered some of the right wheel taken off. The helmsman removed an estimated five degrees of right wheel leaving about 20 degrees right rudder but did not put on left wheel. When about abeam of the Canada Steamship Lines freight shed the SIDNEY E. SMITH, JR. failed to respond to further right rudder orders even though the rudder angle was increased until the rudder was hard right. With her bow sagging or setting downstream the SMITH kept on a course which caused her to cross the range lights of the downbound vessel (which was the PARKER EVANS) as the SMITH headed toward the U.S. shore. Second Mate Gaskins saw both red and green side lights of the PARKER EVANS. At the same time period, when the vessels were 4 to 5 lengths apart, Second Mate Gaskins stated that he blew the danger signal and a cross signal of two whistles for a starboard/starboard passing. He put his engines full astern but did not order rudder changes from the hard right previously ordered. He also rang the general alarm, all a few seconds before the time of collision. The bow lookout seeing collision imminent in the bow area left his station and was later directed by Second Mate Gaskins to get lines ready on the port side. Captain Kristensen heard the vessel's general alarm followed almost immediately by the sound of the impact which aroused him from sleep on the chair in his cabin. He immediately hastened to the pilot house and using channel 16 attempted without success to call for assistance from the Port Huron Coast Guard Station. Captain Kristensen put the engine on half ahead and then due to a rapidly developing starboard

list ordered abandon ship by whistle signal. Gaskins met the SMITH's master Captain Arn Kristensen entering the pilot house door as Gaskins proceeded to the bow area and let go both anchors and as the anchor chain became taut released chain several times. Second Mate Gaskins then failed to get lines ashore even though the vessel's bow was at one time approximately six feet from the southern end of the Peerless Cement dock (approximately 1300 feet 12°T from Ft. Gratiot front range light (LL #1214) because line handlers were not available. The vessel rapidly listed to starboard and drifted down river and out into the main channel. The SMITH's crew abandoned ship shortly thereafter and just prior to the vessel sinking onto its starboard side. The crew was preparing lifeboats and rafts for launching when the pilot boat arrived and safely removed all but three of the crew from the SMITH. The remaining three crew members had abandoned ship in the work skiff. The SMITH sank starboard side down with part of the hull's port side above water at position 850 feet 030°T from Ft. Gratiot front range light (LL #1214). The emergency transmitter was not activated, nor was a Mayday called on channel 16 which Captain Kristensen was using to attempt to alert the Coast Guard Station, Port Huron. The SMITH has been abandoned by the owner, and the Army Corps of Engineers is attempting removal from the channel and salvage with a U.S. Navy salvage team.

8. Captain Robert Earl Campbell, master of the pilot vessel which carries Port Huron/Sarnia pilots, was in the pilot office located on the Sarnia side of the river at Purdy Fisheries when he heard the danger signal sounded by a vessel he later identified as the SIDNEY E. SMITH, JR. rapidly followed by a two blast signal and the sound of collision some few seconds later. He did not observe the impact, but called his deckhand to get underway to assist as possible. As he approached, the SIDNEY E. SMITH, JR. was lying port side toward the Peerless dock with her bow headed upstream and stern somewhat angled out. She was a short distance from the southern end of the Peerless Cement dock and listing rapidly to starboard. Campbell noted the crew along the port rail preparing to launch the port lifeboat and maneuvered in to help take some of the men ashore. There was little maneuvering room but Campbell took his boat into the narrow confined area between the dock and the stern of the SMITH where he was able to get a total of 31 of the 34 man crew aboard the pilot boat. He observed no others on the vessel. He landed the survivors at the Port Huron Pilot Station then at the request of the PARKER EVANS passed lines to shore so they could secure alongside the stone and gravel dock just below Peerless Cement dock. Captain Kristensen who was last off the SMITH could not account for all his crew members and requested further searching by the pilot boat. Soon afterward it was determined that the three missing crew members had abandoned ship with the small work skiff and were safely ashore.

9. The angle of collision impact was approximately 55 degrees relative to the bow of the steamer SMITH and the impact area was on the starboard bow of the SMITH at approximately the break of the forward house and #1 hold and side tanks. The holing of the SMITH's hull

in the area of collision resulted in the entire starboard side being opened to flooding. This resulted in a rapidly developing starboard list and the immediate sinking of the vessel.

10. There are no regulations or company instructions requiring the presence of the master in the pilot house during river navigation and this is left to the discretion of the master. However, in this instance Captain Kristensen fully intended to return to the pilot house prior to the transit of his vessel through the upper St. Clair River and into Lake Huron since he knew this to be a particularly hazardous portion of the river. Due to weather and operational commitments in the three days prior to the collision Captain Kristensen had a total of only about 6 hours sleep.

11. SA Gregory L. Anderson, 396-342 (586-92-6267) was on radio watch at Port Huron Station during the morning the collision occurred. He transmitted several routine messages between 0030 and 0133. At 0150 he heard the pilot boat calling on channel 16 (156.8 mkg.) stating that a collision occurred under Blue Water Bridge between the U.S. vessel SIDNEY E. SMITH, JR. and the PARKER EVANS. At 0205 the CG-44330 was underway enroute to the scene of the collision.

12. Records on file in the investigative section of the Detroit Marine Inspection Office indicate that within the last four years the general area near the Blue Water Bridge has been the scene of four collisions with docks, three major ship collisions, and four groundings.

APPENDIX B

U.S. COAST GUARD REPORT
ON
OIL POLLUTION ABATEMENT OPERATIONS

– C O P Y –

Captain of the Port
U.S. Coast Guard
Ft. of Mt. Elliott Ave.
Detroit, Michigan 48207

5922
20 July 1972

From: Captain of the Port, Detroit, Michigan
To: Commander, Ninth Coast Guard District (oil)
Commander, Ninth Coast Guard District (6)

Subj: Vessel Collision – Oil Spill St. Clair River

1. Enclosed herewith is the report covering the events following the collision of the steamer SIDNEY E. SMITH and PARKER EVANS in the St. Clair River at Port Huron, Michigan, on 5 June 1972. Also enclosed are the invoices as received by this command for equipment and services rendered.

F. H. Raumer

VESSEL COLLISION – OIL SPILL, ST. CLAIR RIVER

CASE 50053/72 PROJECT NR. 120039

1. At 050650Z JUN 72, SA Gregory ANDERSON, while on watch at CGSTA PORT HURON, received a call on 156.5 MHZ from the Sarnia-Port Huron Pilot Boat reporting the vessels SIDNEY E. SMITH JR. and the PARKER EVANS had collided beneath the Blue-water bridge on the St. Clair River. Though the EVANS sustained no major damage, the STMR SMITH sank in approximately 35 ft of water on the American side of the channel (position 42 59.5N 82 25.5W). All 33 POB on the STMR SMITH were rescued by the commercial tug ABURG and the pilot boat prior to its sinking. After the collision STMR EVANS proceeded to moorings at the Peerless Cement dock. All vessel movement on the St. Clair River was immediately stopped.

2. Within 15 minutes of the initial report, all 60 POB (27 POB on the STMR EVANS) were reported safe by 2 CG small boats on the scene. The CGC ACACIA placed a spotlight on scene to assist. It was immediately recognized that diesel fuel was coming from the STMR SMITH. The sunken vessel lost most of its 2000 gallons of diesel fuel, but there remained supposedly a potential loss of 49,000 gallons of bunker C fuel contained in two tanks in the stern. The situation evolved to the prevention of loss of more oil and a major spill in lieu of the moderate spill which was in progress.

3. Upon the initial report of the wreck, the station personnel immediately notified Group Detroit who in turn notified the Captain of the Port. All COTP Detroit personnel were re-called and preparations were made to get pollution control equipment on scene. CAPT F. H. RAUMER, Group Commander and Captain of the Port, Detroit, proceeded directly to CGSTA PORT HURON to set up a COTP Detroit command post, and assumed OSC, while the EPA, MWRC, COFE, and Canadian officials were contacted. By 051400Z representatives from these agencies were all on scene.

4. COTP personnel in Detroit and those who first arrived in Port Huron contacted several companies to get containment and recovery devices enroute to the area. Marine Pollution Control Corporation took their equipment, along with 1500 ft. of boom stored at Base Detroit, to the Algonac State Park, which was designated as a downriver central equipment station. VAC-ALL, vacuum, and tank trucks from Chem-Met Corporation were also directed to Algonac. CG small boats from CGSTA ST CLAIR FLATS, and ST CLAIR SHORES were directed to Algonac as were boats from EPA, MWRC, COFE, and Michigan Marine Salvage Co. Equipment from several other companies were requested to stand by in case they were needed. Although it was felt that containment and recovery of the 2000 gallons of diesel fuel was unfeasible, marine pollution control readiness was soon deployed for protection against the loss of the bunker C fuel.

5. In the course of the day (05 JUN) it was determined that the sunken STMR SMITH was resting fairly stable on its starboard side and the OSC allowed one-way vessel traffic, on a trial basis, to pass the wreck. Upon this successful action, traffic was resumed on a one-way basis under the control of the Port Huron Command Post.

6. At the command post, meetings were held to discuss the downriver deployment of booms, the removal of the bunker C fuel from the ship, and stabilization of the vessel with heavy ground tackle. The owners of the STMR SMITH as well as Canadian and U.S. officials were present for these discussions. Such meetings were continually held to discuss the operations as new developments arose.

7. Initially the actual deployment of booms was held back in that it would have been difficult to contain any of the diesel fuel sheens. However, on Tuesday, seams on the port side forward of amidships opened and there appeared the danger that the vessel would split. If the stern was to break off and bounce on the bottom or drift into some object it would most likely rupture the tanks and spill the bunker C. Upon this evaluation the COTP requested the activation of the U.S.–Canadian JRT and ordered the maximum deployment of booms and other standby equipment. River traffic was again closed pending future developments. It was requested that the CGC BRAMBLE be deployed from Detroit to Marine City to standby, while the CGC ACACIA stood by in Port Huron. It was also apparent that the stern would have to be anchored as soon as possible.

8. Two 500-foot sections of boom were deployed Tuesday at the Algonac State Park and one 250-foot section in the north channel off Harsen's Island. Booms were also deployed on the Canadian side of Stag Island and Chenal Ecarte. Approximately 2500 feet of boom, including 900 feet from Toledo, remained on standby at the park, and 700 feet of boom was placed on standby at the CGC ACACIA's dock in Port Huron. Hartley and Hartley was called on to send two vacuum trucks and crews to Algonac, and CGSTA SAGINAW RIVER brought 500 feet of boom from Dow Chemical in Bay City. Two MPCC Buda barges were deployed in the St. Clair River to be activated.

9. On Wednesday, the crack in the hull of the STMR SMITH had widened and the threat of a major oil spill was at a peak. The OSC placed the deputy OSC, CAPT J. BENNETT, Base Manager, Ministry of Transport, Ontario, in charge of the pollution aspect of the operation. This formally initiated the U.S./Canadian JRT. Representatives from the EPA, MWRC, MOTE, and the USCG worked under and assisted CAPT BENNETT.

10. Attempts were made to deploy booms in Port Huron, Marysville, and St. Clair, but each of these either failed immediately or would have had no effect with oil due to the current. At least two anchors were lost and several hundred feet of boom were torn or lost. Booms in the lower St. Clair River would have been more effective had there been a major spill.

11. Pumping operations from the stern of the STMR SMITH by the NSF and MPCC were started by mid-Wednesday and by Thursday night the threat of a major oil spill had subsided at least to moderate levels. Although the crack in the vessel widened quite substantially, removal of the oil from the STMR SMITH progressed at a slow but successful rate. By Friday it was determined that a reduction in pollution readiness was appropriate and by evening most of the crews were released to a standby status, subject to recall. All equipment down-river was released on Saturday as all that remained was a potential minor spill and the possibility of effective containment of such a spill in the swift currents was remote. The JRT was terminated Saturday morning and booms were completely removed by late Sunday.

12. Extensive day and night efforts were made to remove the bunker fuel from the STMR SMITH. This shipboard oil removal operation was conducted by the National Strike Force and Marine Pollution Control Corporation to prevent a major oil spill and to prepare for the commencement of removing the obstruction. CDR MASON, Branch Chief, Ninth Coast Guard District (oil), came to observe and assist in the operation and was assigned as OSC for shipboard oil removal. The basic chronology of that aspect in the operation is included as enclosure (1) of this report.

13. With all pollution containment and recovery equipment secured and the extensive ship-board oil recovery completed, the pollution phase of the operation was closed. At that point the owners of the STMR SMITH were advised that it was ready for the removal of the obstruction. It was requested that they take all due precautions with the possible 200 gallons of oil which remained in the vessel. The COFE Detroit was also advised as they would be supervising the remaining salvage operations.

14. Besides overtly responding to control the threat of a major oil spill, COTP was directly responsible for vessel traffic control in the St. Clair River. An important factor in allowing traffic to transit the area was to first clearly mark the wreck.

a. By early afternoon on 5 June following the collision the Cutter ACACIA had placed a 6x20 wreck buoy approximately 150 yards upstream and 300 yards out into the channel from the bow of the wreck. One-way traffic was thereupon resumed. Throughout the traffic control period upbound traffic has experienced little difficulty in maneuvering past the wreck buoy. Downbound traffic, however, set in towards the hulk and the buoy by the St. Clair River current, had experienced considerable difficulty in transiting the area, particularly in times of strong northerly winds.

b. On the morning of 10 JUN, as downbound traffic resumed after the routine over-night interruption, the downbound STMR WALTER A. STERLING struck and sank the wreck buoy. Downbound traffic was stopped, and upbound traffic was permitted to proceed through the wreck area as the CGC BRAMBLE set the back-up buoy.

c. Following this incident the BRAMBLE was dispatched to Base Detroit to pick up another back-up wreck buoy, which is currently with the CGC ACACIA at her Port Huron dock. The 8x20 buoy now on scene has also been struck several times and the need for occasional restationing during the salvage operations on the SMITH is anticipated.

15. The instructions used in traffic control were promulgated immediately during the pollution phase and later formally printed by the COTP Detroit (Enclosure 2). Briefly, the situation involved traffic limited to one way with priorities for upbound transit at night and downbound transit during hours of daylight. Special speed limits were invoked with specific checkpoints. Traffic was stopped at various times due to particular hazards and at times when there was concern with the STMR SMITH splitting in two. Many man-hours were expended and officer watches were set up for around the clock. This situation continued through the pollution phase and will prevail until the removal of the obstruction. Vessel Traffic Control on the St. Clair River will be the subject of a separate report.

16. Two District dpi personnel came on 5 JUN. One remained at the Command Post until the pollution phase was closed. They were confronted by masses of news media particularly on the first five days. The operation received overwhelming coverage in newspapers, radio, and TV across the U.S. and Canada. Releases were made in advance to be left with the watchstanders at night which contained a wrap-up of the day's operations and future plans. During the day they kept the reporters updated and away from the operations center. Without a dpi representative it would have been impossible to continue a smooth operation and have the public suitably informed. Several comments of appreciation were received by the news media as in Enclosure (3).

17. Communications was a very important aspect in the pollution phase as well as for Traffic Control. Backup URC 51 and URC 45FM units were placed on standby at the Command Post and Duty Officers were instructed as to their installation and use. Furthermore, it was considered that additional emergency communications equipment should be immediately available and thus a TCC was requested. When approved and when the AN/TRC-168 arrived, it was set up and ready for immediate use. Though it has somewhat limited remote capabilities, it would provide the necessary communications for the coordination of vessel traffic in Lower Lake Huron and the St. Clair River. See Enclosure (4).

a. Along with radio communications additional telephones were installed for use at the Command Post, at Algonac State Park, and at CG Base Detroit. These phones aided in locating pollution equipment, etc., while at the same time precluded overloading station phones which might be used for SAR. The installation of additional phones by Michigan Bell Telephone Co. was very prompt in that they had been alerted to such a request in November 1971 should an emergency occur.

ADDITIONAL TELEPHONES

Base Detroit

(313) 226 7820
226 7821
226 7822
226 7823

Sta Port Huron (COTP Command Post)

(313) 987 4863
987 4864
987 4865
987 4866

Algonac State Park (Downriver Center)

(313) 794 5128

b. At the completion of the pollution phase these were removed and one additional phone was installed in both the Comms. Center and in the Station's office. These will carry the overload during the period of Vessel Traffic Control.

Sta Port Huron

(313) 984 3311
984 3312

18. Many companies provide equipment or various services in addition to the Coast Guard. See enclosure (5).

19. Enclosed are photographs taken by Stuart Abbey Photographers. Unless they will serve any future purpose at the District Office, it is requested that they be returned to this command. See Enclosure (7).

20. Many personnel assisted CG Sta. Port Huron and COTP Detroit with this case. Coast Guard personnel included augmentation from Base Detroit, CG Sta. Belle Isle, CG Sta. Harbor Beach, COTP Chicago, COTP Toledo, COTP Cleveland, NIO Detroit, and CG District Nine. Members from the NSF from COMEASTAREA also assisted. The CGC ACACIA, CGC BRAMBLE, and Air Sta. Detroit assisted. Reserve officers and enlisted personnel were called

upon to help. Many long hours were expended with round-the-clock watches for traffic control, downriver pollution, and shipboard oil recovery. Attached in Enclosure (6) is a list of personnel who directly assisted with the operation. A list of civilian and other governmental people who also assisted is included.

21. On 28 June, during salvage operations being conducted by COFE Detroit and a Navy salvage team, approximately 100 gallons of oil was discovered accumulated in the aft engine spaces of the vessel. Being accessible and with the possibility of spilling due to the settling of the stern, MPCC was rehired to recover the oil as practicable. On 29 June nearly 165 gallons of oil were picked up by MPCC using a sludge pump and several 55-gallon barrels on the stern of the COFE Keweenaw Bay. Further accumulations of oil were present on 1 July and MPCC was again called out on scene where by they recovered another 50 gallons of oil. It was considered that the current and the shifting of the vessel caused the residual oil to seep off the tank walls and out of the piping systems. No significant accumulations were visible after MPCC completed cleanup on 1 July.

22. Additional Remarks

This case is considered to be unique in that three separate yet related operations were simultaneously encountered. They were:

a. Immediate action to prevent a major oil spill. This operation involved limited short term salvage, contracted for by the owner and the transport of equipment to scene from Amherstburg, Ontario. Also the movement of Coast Guard and their contracted men and equipment to scene with joint efforts to gain access to the oil contained in tanks in the stern of the wreck. The expertise and advice of U.S., Canadian and private salvage engineers was drawn upon to complete this phase of the operation without incident. A Coast Guard on-scene Commander was designated for oil recovery from the wreck.

b. Negotiations were opened immediately with the owners, salvage contractors, COFE and Coast Guard looking toward the long range salvage and removal of the obstruction in a most dangerous area of the St. Clair River. These negotiations were headed by COFE and their overview continues to the date of this report. The "obstruction" caused the second operation encountered: Namely the Traffic Control Operation. From the outset when the river was closed to navigation to allow time for evaluation and action in other operations, many inquiries were received from the shipping industry as to when traffic could again proceed. One way traffic was commenced on 5 June. However, constant evaluation was necessary to determine effect of passing vessels on the wreck and danger to further break up and loss of oil contained in the stern. The OSC found himself in a precarious situation, caught between the forces that demanded no further loss of oil and pollution and, the tie-up of shipping which at one stage of the operation found in excess of 80 Stmrs awaiting passage.

Many of them were standing by as far south as Western Lake Erie and Detroit. The OSC has no doubt in his mind that continued traffic hastened the break-up of the wreck. However, stabilization of the stern section with 5 anchors on 6 June enabled oil recovery and salvage forces to continue work in their efforts to minimize major pollution danger. One way traffic was continued throughout the operation and the tie up of shipping was decreased to a near normal situation which now exists.

c. The third operation was the moderate spill caused by the collision and the pressure being brought to bear by downriver citizens and groups to combat the spill. Constant surveillance was carried out on 5 and 6 June and large amounts of men, boats and equipment were staged on both the Canadian and U.S. shores. Some equipment was deployed, the greatest amount by Canadian forces. The oil already released was not recoverable. Some small pockets were reported and acted upon. The OSC decided not to immediately deploy all equipment on the moderate spill which was non-recoverable in the far reaches of the St. Clair River. Rather it was decided to hold the forces ready to combat the potential major spill. Wind and current conditions would be a major factor in deployment of forces should the spill occur.

d. As it turned out, the decision was correct. The major portion of containment and recovery forces were not fatigued but alert throughout the entire operation. Complaints from citizens were negligible and the State of Michigan reported no harmful impact upon wildlife and property.

e. On 7 June when the STMR SMITH began to visibly break up at a faster rate and the potential of all loss was greatest, it was decided to designate an OSC exclusively for the oil pollution operation. Captain BENNETT, the Deputy OSC and JRT member for the Canadian Government was so appointed. He had at his command all Canadian, U.S., EPA, COFE and State of Michigan forces. He effectively and commendably organized these forces into a coordinated effort, standing by to move at a moments notice. This operation was not de-activated until 10 June at which time 45,000 gallons of oil had been recovered and the potential for a major spill was removed.

BASIC CHRONOLOGY, SHIPBOARD OIL RECOVERY EFFORTS

5 Monday – No shipboard work.

6 Tuesday – Helo overflights indicated continued downriver sheen coming from the Smith. The only likely source was open vent lines from the vessel fuel tanks. With McQueen Marine on scene, it was decided to attempt plugging the vents. A hardhat diver from McQueen plugged the uppermost vent (port tank), but the current was too strong to permit plugging other vents.

With the vessel shifting slowly, it was decided that the wreck would have to be anchored in order to permit removal of the oil on board. At this time, the following equipment was on scene: work platform barge, McQueen's spud derrick barge, Tug Amherstburg, Corps of Engineers Tug Keweenaw Bay, Coast Guard 44', and M/U Buoy Tender. The Tug Amherstburg departed Tuesday night to pick up ground tackle for the job, at the direction of the vessel owners. CDR MASON was assigned OSC for shipboard oil removal. At 1000 AM on Tuesday the first two members of the National Strike Force arrived at Port Huron. Tuesday night a meeting was held to discuss oil removal tactics. Late Tuesday the vessel began to crack and the river was closed to navigation all night, except for brief test run periods.

7 Wednesday – During the day the Smith continued opening up (as she did throughout the operation). The Amherstburg arrived back on scene approximately 0800R. The remainder of the National Strike Force and the ADAPTS pump arrived via Coast Guard C-130 at Detroit's Selfridge Air National Guard Station during the morning and were delivered to the wreck scene in the afternoon. The Coast Guard Strike Force Team installed the ADAPTS pump in the Smith's port galley storage compartment.

The port tank top was located in this storage compartment. Removal of the tank top was hampered by the fact that most of it was under water and the compartment was filled with galley stores of linen and food stuffs. Debris removal was a job in itself as shelving extended about 15 feet into the compartment. Part of the steel shelving had to be hacksawed and removed to permit pump access to the manhole.

The manhole cover on port tank top was removed. Water packet was pumped out by ADAPTS system. Then oil came into compartment and was pumped. The hydraulic system on pump failed. Additional parts could not be obtained till early morning. The additional lighting that was ordered was late in arriving and it was decided to wait until the morning to place ADAPTS pump into the tank itself.

Buda II and Tug Judson arrived at 4:30 PM. Suction recovery by Marine Pollution Control Corp's Buda II started at 5:15 PM and continued throughout the night. The suction was taken on the loading manifold from the port tank. At first, a 2" hose was adapted to the 5" line, then a 3" hose was utilized. The fact that this manifold was exposed to the swift current and sea gave the pumping operation minimum recovery at first. Total recovery of oil by both systems was 4000 gallons. Due to fatigue and lack of lighting, the strike force secured at 2100R.

8 Thursday – Marine Pollution Control pumped continuously with Buda II. Lighting from Fondessy Enterprises in Toledo arrived at about 0300R and was used for the remainder of the operation. McQueen personnel secured the stern section of the now broken Smith with five anchors. Problems with the ADAPTS pump continued, although in the course of two ten-minute periods of operation, NSF personnel reported recovery of nearly 9000 gallons. During the afternoon, a steam pump from the Shell Oil Company in Sarnia, Ontario was delivered. This pump, despite its being approximately 75 years old, was the most reliable pump utilized during the recovery. A pump received from the Marathon Oil Co. was utilized in conjunction with the ADAPTS pump, taking oil through the tank top of the port tank. Oil in the port tank was heated with a steam coil to facilitate pumping.

Marine Pollution's Buda II vacuum pump was moved from loading manifold and Shell pump replaced it in pumping from the port tank.

Buda II then skimmed the lube oils that were contained in the flooded engine room areas.

Suction was maintained with steam pump until water displaced oil below the fill pipe.

During the day on Thursday a hole was cut into the fire room by McQueen crewmen at the suggestion of Clarence Craig, Marine Supt. of Erie Sand Steamship Co. It was cut at the stern of the bilge approximately 4 feet above the double bottoms. This gave access to the piping leading to the fuel tanks. An explosive meter test was taken by MPCC. By midnight the stern section of the wreck had settled and rolled so the tank access hole was under water and an estimated 1000 gallons of oil remained in the port tank that could not be recovered through the access hole. An attempt was made to utilize the ship's 1½" transfer pump. However, this was not successful.

Oil laden debris was removed from the after deck house living spaces through doors and ports utilizing boat hooks and fish nets by MPCC personnel starting late Thursday. The Buda II barge continued to work with vacuum hose removing oil in the engine room, fire room, and after engine room areas.

9 Friday – By Friday most of the oil had been removed from the port tank. About 0030R the suction from the steam pump was placed on the 6-inch fill pipe and the valve to the port tank was closed from the deckhouse on the Smith. If the valve to the starboard fuel tank had been closed it would not have been possible to open it because of the 6- to 7-knot current passing the ship – no diving was possible on the exposed weatherdeck. As luck would have it, the valve to the starboard tank was open and suction on the line produced oil. About 5000 gallons of oil were removed from this tank, but because of the viscosity of the oil, water was pumped sooner than should have been expected. The air temperatures Friday fell to the low 40's and the wind shifted out of the North 25 to 30 knots. Oil being pumped from the tanks became heavier and recovery rates decreased considerably. To this point approximately 30,000 gallons of oil had been recovered.

At 0800 Undersea-Specialties Co. skin divers from Port Huron started operations to open 1½" boiler feed lines on the 4-inch boiler feed manifold. The divers, by opening certain valves and closing others, set up the piping system so that suction would draw only from the upper portion of the starboard tank. The uppermost valve into the starboard tank tapped the tank from a point 36" down from the top of the tank. A 3" reducer was put on the 4" boiler feed manifold in order to adapt the lines to the 3" hose into the Shell Oil steam pump.

Due to the cold temperatures and the small 1½" boiler feed lines from the boiler manifold into the starboard tank, the recovery rate was slow. Rough volume measurements indicated a rate of approximately 100 gallons per hours.

Recovery of free floating oil in the fire room through the deck access hole was continued by the Buda II vacuum pump throughout the day.

At 1930R all equipment was secured due to rough weather. Barges and equipment were removed from the hulk of the Smith.

10 Saturday – All equipment was returned on scene on Saturday morning and pumping commenced at 0830R from the starboard tank. Pumping continued all day Saturday, Sunday, and Monday. On Saturday considerable debris was removed from the engine room area, including three drums of oil. The Buda II Barge continued general skimming operations.

Since previous above water access to the port tank had been lost due to the vessel's shifting, an explosive meter was used and an access hole was cut into the top of the port tank. Saturday night approximately one foot of oil was removed from the port tank that had either been left from ADAPTS pumping, or had bled into the port tank from the starboard through crossover piping. A gasoline driven piston pump was utilized for this purpose.

11 Sunday – Continued general skimming inside engine space and pumping on boiler feed line. The pumping rate continued slow with very cold temperatures (there was frost on the barge decks Saturday night). Efforts to heat the oil had begun on Saturday with an attempt to put steam into the extreme top of the starboard tank via an inter-tank oil transfer line. These were continued on Sunday by increasing pressure on the steam lines. A steam hose was burst in this effort on Sunday and it was determined that the valve to the tank was closed.

No appreciable gain in pumping rate was achieved on Sunday. However, weather conditions improved and a McQueen hard hat diver agreed to open the valve on Monday. To prepare for the hard hat diving, the access hole in the deck of the Smith was doubled in size.

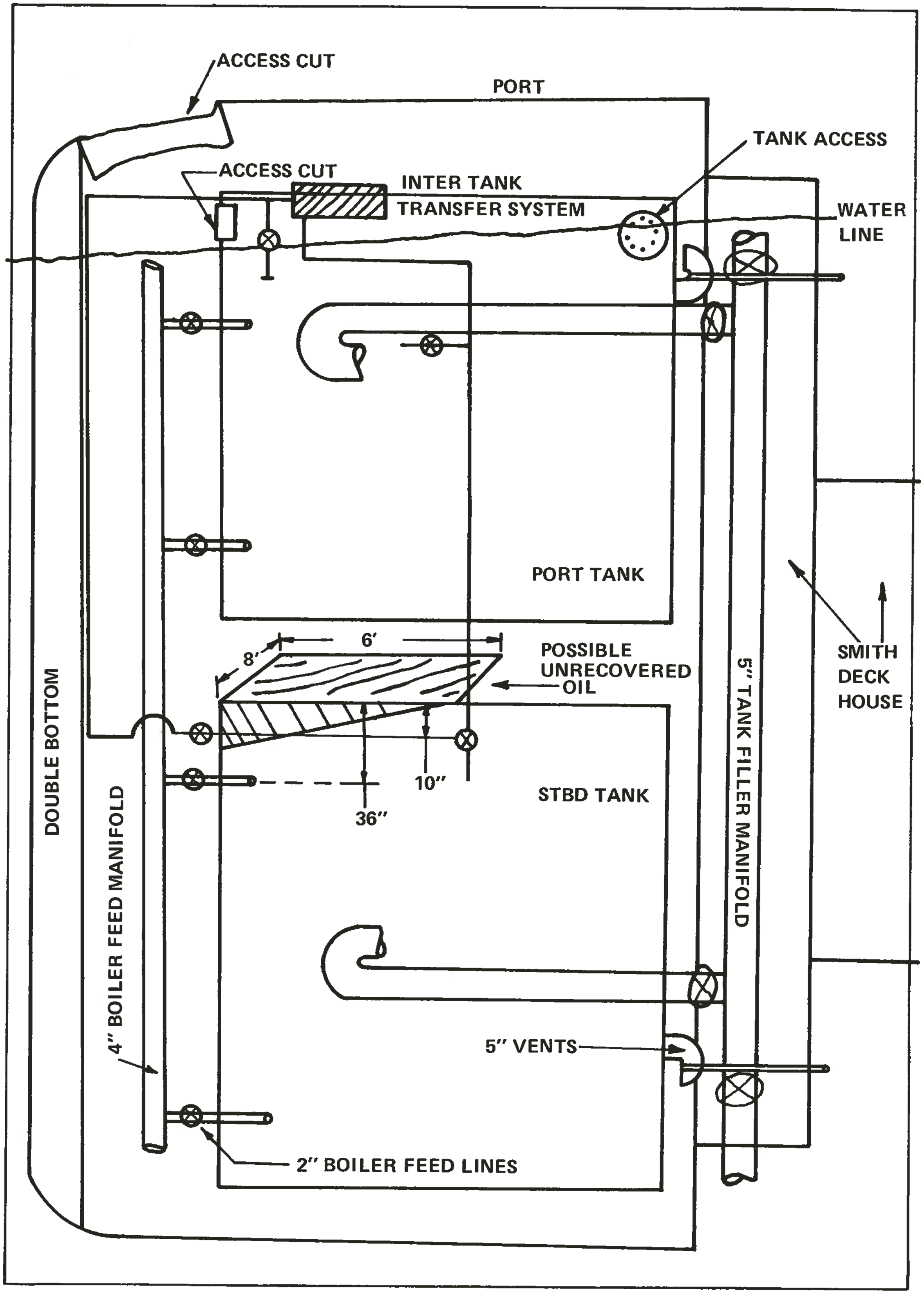
12 Monday – Finally water from the boiler feed line was obtained mid-afternoon Monday after a hard hat diver from McQueen opened inter-tank transfer valve to get good steam to starboard tank and improve the recovery rate considerably. The Shell Oil steam pump was secured. Steam was put to the boiler fuel feed line and suction was taken on the inter-tank transfer line, which was uppermost on the starboard tank. They utilized a portable piston pump for that recovery operation. Finally they reached water at 0100 Tuesday, and continued pumping for 1½ hours to clear out the lines. Calculations indicated the possibility that about 200 gallons could be left in the starboard tank unless it was drawn into the water suction operation by water agitation.

The crews steam-cleaned the hoses utilized in the pumping operation in preparation for terminating oil recovery efforts on Tuesday and secured 0400R.

13 Tuesday – Secured lighting, pumps, and equipment and the barge was released for oil delivery to Imperial Oil, Sarnia, Ontario at 1200R.

A final estimated quantity recovered was to be received upon unloading the barge; however, on scene estimates were that approximately 45,000 gallons of a combined total of 48,000 gallons of oil (diesel, lube, and fuel) were recovered at the wreck. It was estimated that less than 200 gallons remained on the Stmr Smith at termination of recovery operations.

The Buda II barge and MPCC personnel were released at 1600R from wreck. With a sigh of relief oil recovery operations terminated.



CROSS SECTION, SMITH FUEL TANKS

APPENDIX C

EMPLOYMENT OF URETHANE FOAM

IN

SMITH SALVAGE OPERATIONS

APPENDIX C

EMPLOYMENT OF URETHANE FOAM IN SMITH SALVAGE OPERATIONS

PURPOSE AND SCOPE

This appendix presents technical information on the use of urethane foam as a salvage tool and applications of foaming processes in the SMITH salvage operation. It provides a consolidated treatment of the subject, extending and amplifying the coverage in the main body of the report.

The following subjects are addressed in the appendix in the order indicated.

- Use of urethane foam as a salvage tool
- Basic foaming process
- Types of foam delivery systems
- Aerosol delivery system for foaming the SMITH's stern section
- Combination aerosol-mechanical delivery system for foaming the SMITH's bow section
- Foam formulations
- Preparation and storage of foam components
- Determination of foam quantity and quality
- Procedures for installing the foam

USE OF URETHANE FOAM AS A SALVAGE TOOL

Background

The idea of placing a gas in a sealed container to produce buoyancy underwater is perhaps 2,000 years old. The use of urethane foam as a salvage tool is a new application of this idea, an application made possible by modern technology. In the foaming process, liquid chemicals are pumped underwater where they react to form simultaneously both the gas and the sealed container around it. The Murphy Pacific Marine Salvage Company (MYPAC) has pioneered in the development of the process for both commercial and military salvage applications. "Foam-in-salvage" as a major flotation technique was first applied by the U.S. Navy during 1965 in salvaging the stranded destroyer, USS FRANK KNOX. The use of foam to lighten the sunken SMITH was the Navy's first major underwater application of the method.

Characteristics of Urethane Foam

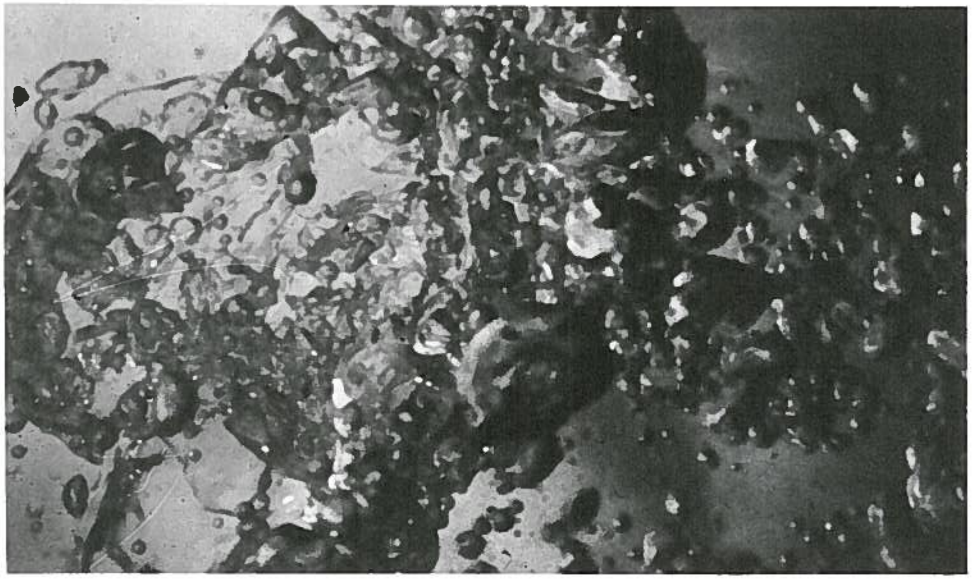
The employment of urethane foam as a salvage tool is based upon Archimedes' Principle, the fundamental law of flotation. The principle holds that a body wholly or partially immersed in a fluid is buoyed up by a force equal to the weight of the fluid it displaces. The key characteristic of urethane foam for salvage work is its low density as compared with water. High quality foam can attain a density as low as 2 lbs./ft.^{3} whereas the density of fresh water is 62.4 lbs./ft.^{3}. When introduced into a compartment of a sunken vessel, a given volume of foam displaces the same volume of water. Thus, each cubic foot of foam can provide a net gain in buoyancy or added flotation force of approximately 60 pounds.

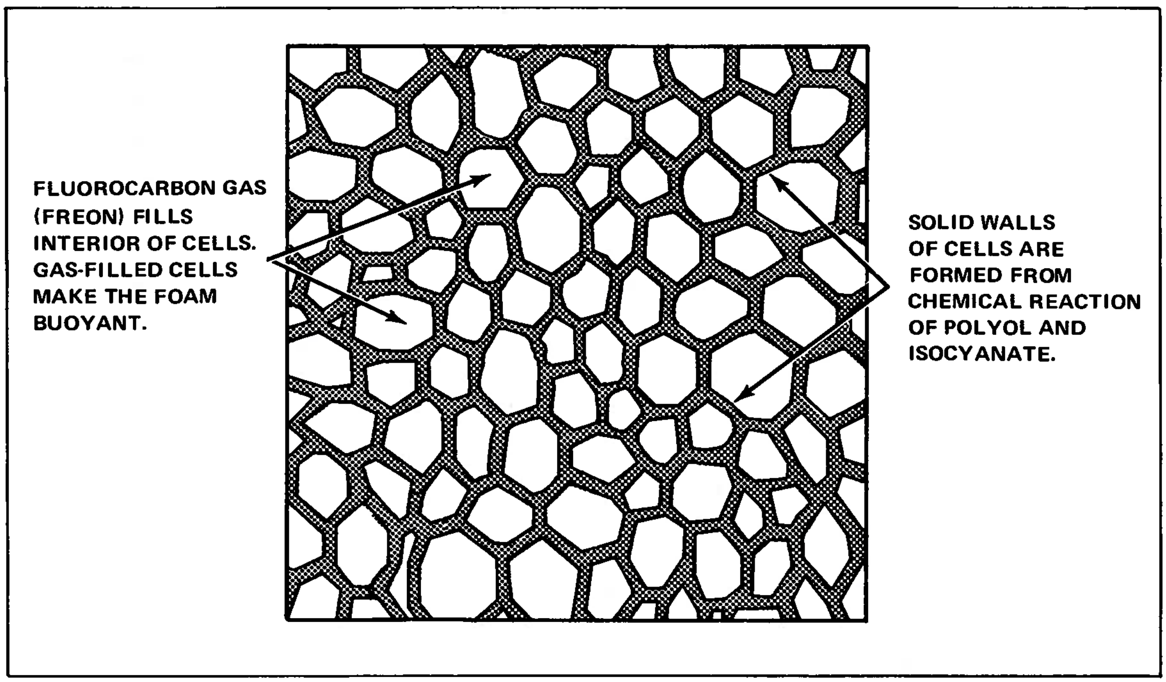
The foam's low density is the result of its cellular structure. It consists of a mass of tiny, rigid, gas-filled cells held together within a solid matrix. As "cast-in-place" within a compartment of a sunken vessel, it is an extremely light, yet sturdy, solid material, produced by the chemical reaction of two components, liquid isocyanate and liquid polyol, in the presence of fluorocarbon gas. Typically, each component is first blended with liquified fluorocarbon. The two are then mixed and simultaneously sprayed into the compartment through a nozzle. Within the compartment, the isocyanate and polyol react, producing a rapidly hardening, epoxy-like substance.

As the chemical reaction occurs, the liquified fluorocarbon, also released from the pressure of the delivery system, returns to its gaseous state forming tiny bubbles throughout the hardening, solid mass. The gas permeates the cellular mixture, expanding it radically and quickly to its final state, a rigid matrix of thin-walled, interconnected cells containing the trapped bubbles of fluorocarbon gas. This expanding volume of foam displaces an equal volume of water within the compartment. Since the foam is significantly lighter than the water it displaces, it provides a buoyant force, lightening the sunken vessel.

Foam vs. Air as a Source of Buoyancy

A traditional method of dewatering a severely holed compartment is to seal it by patching and then blow it dry with compressed air. Air, being lighter than foam, is a more efficient dewatering agent and is, of course, cheap and plentiful. Apart from these obvious differences, foam has several advantages and disadvantages when compared with air as a source of buoyancy.





Foam mass underwater (photo above) is made up of tiny, interlocking, gas-filled cells. Mass displaces water, providing buoyancy for sunken object.

CELLULAR STRUCTURE OF URETHANE FOAM

Advantages to using foam rather than air include the following:

- A foamed compartment need not be airtight as it must be to contain an air bubble.
- A hardened mass of salvage foam, unlike an air bubble, cannot escape from the compartment, nor does it shift about easily to cause stability problems.
- Foam has a self-sealing quality when applied in the vicinity of small holes and cracks; the foam material also sets very quickly. Larger openings must be patched or caulked, but these preparations need be far less extensive than those required for dewatering by air.
- The rigid foam material produces a bonus when cast in place underwater in that it increases the sunken vessel's structural strength and integrity.

Disadvantages to using foam as opposed to air include the following:

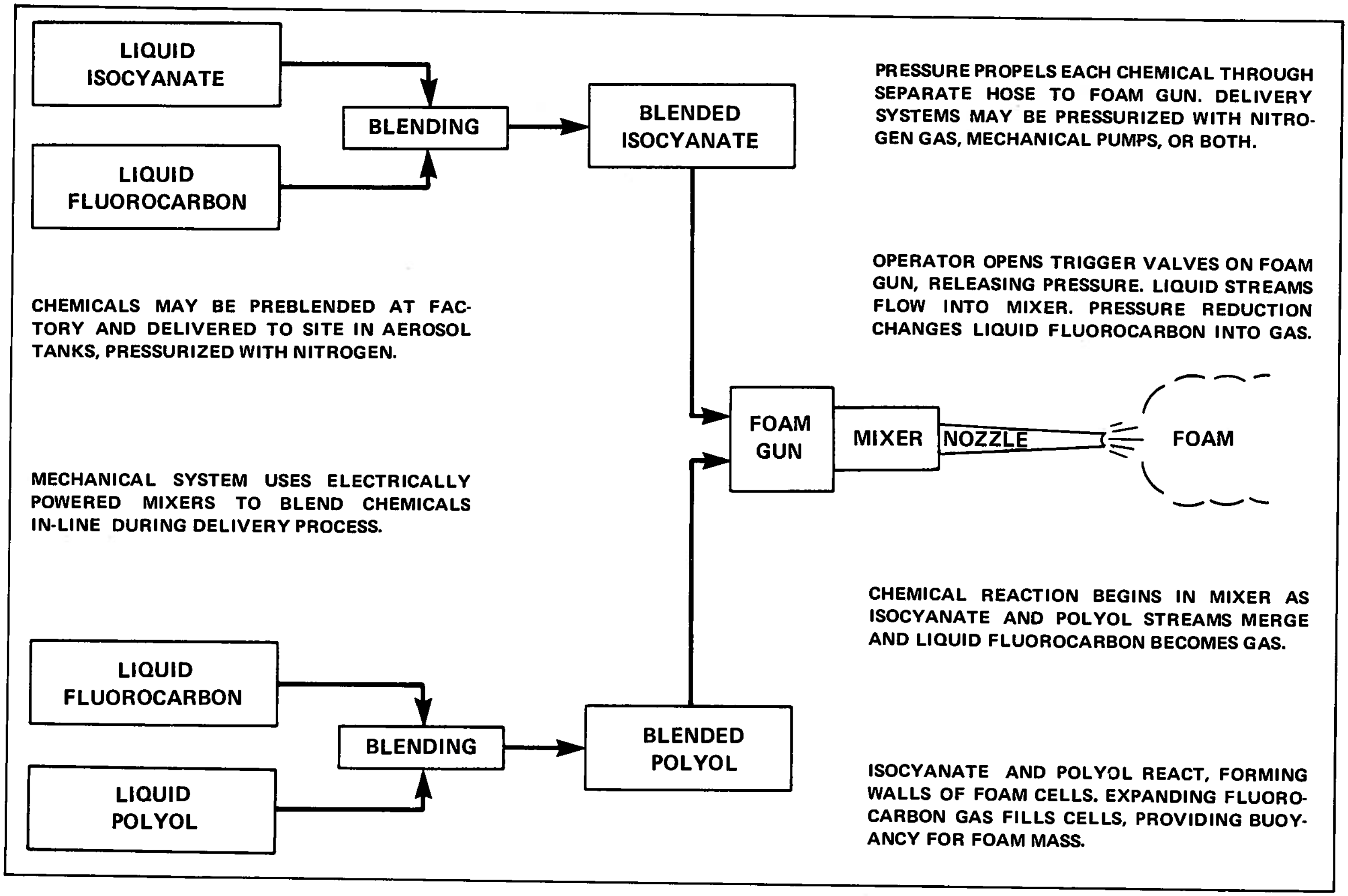
- Foam installed above a vessel's waterline, although it may provide buoyancy initially, immediately becomes excess topside weight when the vessel is refloated.
- If the foamed vessel is to be refurbished and placed back in service, or if it is to be sunk at a disposal site, the foam must be removed. Foam removal is a time-consuming task, involving a great deal of tedious hand labor.

Availability of Foam for Salvage Operations

Cost is the principal factor limiting the use of foam as a salvage tool. The chemical components are expensive as are the rental rates for delivery systems and the labor rates for the highly trained contractor personnel required to operate the system. Because of the expense, foam is generally employed only in special situations when other salvage techniques cannot do the job. The foam-in-salvage technique is still undergoing development and, consequently, has been used only in a few carefully selected cases. Efforts are being made to improve the quality and reliability of the foam and to design simpler and more efficient delivery systems. Cost is a limiting factor in the developmental effort as well as in operational salvage applications.

BASIC FOAMING PROCESS

The two chemical components which react to form the solid, cellular material of the foam are liquid isocyanate and liquid polyol. Reaction must occur in the presence of fluorocarbon gas to complete the structure of the foam by forming the gas-filled cells which make the material so buoyant. Liquified fluorocarbon (freon), known as the blowing agent, is first blended with each chemical. The fluorocarbon is maintained in a liquid state by pressurizing



Delivery systems are classified as aerosol, mechanical and combination aerosol-mechanical according to the types of pressure sources used in each system. Basic processes are similar in all three systems.

BASIC PROCESSES IN FOAM DELIVERY SYSTEMS

it to at least 75 psi. Depending on the type of delivery system used, it may be preblended and stored under pressure in the same container with the chemical or it may be stored separately and blended during the delivery process itself.

The chemical components are driven under pressure from their respective containers through separate delivery hoses to a foam gun. Pressure may be provided by pumps or by compressed nitrogen introduced into the containers. Each component is blended with the liquified fluorocarbon, either in the container or en route to the foam gun. Upon opening of trigger valves in the foam gun assembly, the two blended chemicals pass in a single stream through a mixing chamber where they are thoroughly mixed, still in a liquid state, and begin to react. The liquid mixture is immediately released through a foaming nozzle into the water-filled compartment. Here the chemical reaction takes place between the polyol and isocyanate. Simultaneously, the liquid fluorocarbon, released from the pressurized delivery system, resumes its gaseous state.

The chemical reaction of the liquid isocyanate and the liquid polyol causes rapid hardening and creates interlocking particles forming the walls of the foam cells. The expanding fluorocarbon gas, acting as the blowing agent, fills the voids in the cells. The resulting material consists of millions of interlocking tiny cells, somewhat like a mass of miniature ping-pong balls. Unlike ping-pong balls, however, the foam cells are not spheres but multi-flat-sided cells, glued and fitted to each other so that there are no open spaces between them. The foam mass hardens within a minute or so after being pumped from the gun, forming a large, light, solid mass which displaces an equal volume of water and which is too rigid to shift about easily underwater.

TYPES OF FOAM DELIVERY SYSTEMS

Three general types of delivery systems are available for the underwater application of urethane foam: aerosol, mechanical, and combination aerosol-mechanical. The three types are distinguished primarily by the pressurizing agents used to drive each system. Compressed nitrogen gas provides the pressure in the aerosol system whereas pumps are employed for this purpose in the mechanical system. The combination system uses both nitrogen and pumps, the latter to boost the pressure initially supplied by the nitrogen. The SMITH salvors used an aerosol system for foaming the stern and later switched to a combination system for foaming the bow.

Aerosol Delivery System

In the aerosol system, each chemical component is blended under pressure with its fluorocarbon blowing agent in an aerosol tank. Nitrogen gas, introduced into the tank, provides the necessary pressure to maintain the fluorocarbon in a liquid state and to propel the blended components through their respective delivery hoses to the foam gun. Nitrogen is used because it is cheap, readily available, and, most significantly, does not react with the chemicals. Other gases such as argon and helium could be used but they are too expensive. Compressed air cannot be employed because water vapor and oxygen in the air would react with the isocyanate component, causing hardening in the delivery system.

The aerosol system is basically a low pressure system, designed primarily for shallow water applications, down to 60 feet. The available pressure is 300 psi, the maximum rated capacity of each aerosol tank. Pressure losses across the delivery system in the hoses, flow meters and flow controllers further reduce the pressure actually delivered to the foam gun.

In earlier configurations, small, standard aerosol bottles were used to store the chemicals, with batching performed at the salvage site. Typically, the isocyanate and polyol would be shipped to the site in 55-gallon drums and then transferred to the 500-pound capacity aerosol bottles, followed by insertion of the fluorocarbon blowing agent and pressurizing with nitrogen. Although these aerosol bottles are economical for small jobs, this site batching is a difficult and time-consuming process. Further, it limits the speed of operations as the foam cannot be continuously pumped faster than the rate at which it is being batched.

The small tank, site batching method has now been generally superseded by a second configuration, the preblended large tank aerosol system. In this system, all blending is accomplished at the chemical factory prior to delivery of the chemicals. Each blended component is stored in large 5,000-pound or 10,000-pound capacity aerosol tanks. Preblending eliminates the requirement for site batching. The large tank aerosol system is particularly suitable for large, complex foaming operations at shallow depths. It has the same pressure and depth limitations as the small tank configuration. The system can be rigged, using manifolds, with several sets of delivery hoses for simultaneous foaming at different locations or rapid shifting from one foaming station to another.

Mechanical Delivery System

A mechanical delivery system has been developed for foaming applications down to 200 feet, beyond the depth limitation of the aerosol system. It is considerably more complex, employing high pressure screw pumps to drive the chemicals to the foam gun, and electric powered in-line mixers to blend each chemical with its fluorocarbon blowing agent during the delivery process.

This mechanical system is designed for continuous operations, with minimum operator intervention. It is capable of delivering large amounts of foam under high pressure. Hoses, foam guns, valves and other fittings are similar to those in the aerosol systems but designed for larger capacity and higher pressure. For example, the trigger valves on the foam gun are configured to handle up to 2,000 psi as compared to the 600-psi ratings for those in the aerosol system. The system can attain an output rate of 100 pounds of foam per minute. An electrical power source of at least 30 kilowatts is required for the various pumps in the system and the accessory heating unit.

Combination Aerosol-Mechanical Delivery System

This system uses compressed nitrogen gas to pressurize the tanks of the component chemicals as in the aerosol system. Booster pumps are used to drive the chemicals through the hoses to the foam gun. This boosting of the initial nitrogen pressure by mechanical pumps is the key feature of the combination system. Different configurations are possible depending on the types of equipment available and the circumstances of the salvage operation. The system can be rigged, using manifolds, to support several foam guns. System pressure can be attained comparable to that in the mechanical system. Both systems can function down to 200 feet. The use of large preblended aerosol tanks makes the combination system simpler and more practical than the mechanical system with its reliance on in-line blending.

The increased pressure supplied by the booster pumps permits the use of certain delivery system components which cannot be utilized in the aerosol system because of its low pressure. For example, the chemical components can be heated en route to the foam gun with an in-line heating unit which requires greater system pressure than can be produced within the aerosol system. In-line heating is more efficient than bulk heating of the large aerosol tanks prior to the delivery process, the only method available for the aerosol system. Other increases in efficiency can be attained by using different pressure controllers to regulate flow rate and a different mixing chamber to thoroughly mix the chemicals upon their discharge from the foam gun block.

AEROSOL DELIVERY SYSTEM FOR FOAMING THE SMITH'S STERN SECTION

Factors in Selecting the Aerosol System

The stern section of the SMITH was only partially submerged. Its underwater compartments were lying in 50 feet of water, well within the depth limitations of the aerosol delivery system. Salvage estimates indicated that a large quantity of foam would be required to lighten the hulk sufficiently to pull it ashore. These two factors, the shallow depth and the size of the job, led to the selection of the preblended, large tank aerosol delivery system for foaming the stern section. This system, with its inherent simplicity and economy, appeared ideally suited for the task at hand. Although the large aerosol tanks were heavy and cumbersome, there was adequate space aboard the derrick barge to stage them and align them in the delivery system.

Features of the Aerosol System

Each pair of aerosol tanks arrives at the salvage site with the fluorocarbon blowing agent preblended with the liquid isocyanate and liquid polyol, respectively. The tanks must be pressurized to at least 75 psi at the factory in order to maintain the fluorocarbon in solution. In aligning the tanks to the delivery system, a nitrogen cylinder is connected to the tanks at the salvage site. The nitrogen supplies the additional pressure required to drive the chemicals to the foam gun while maintaining at least 75 psi in the tanks and throughout the delivery system.

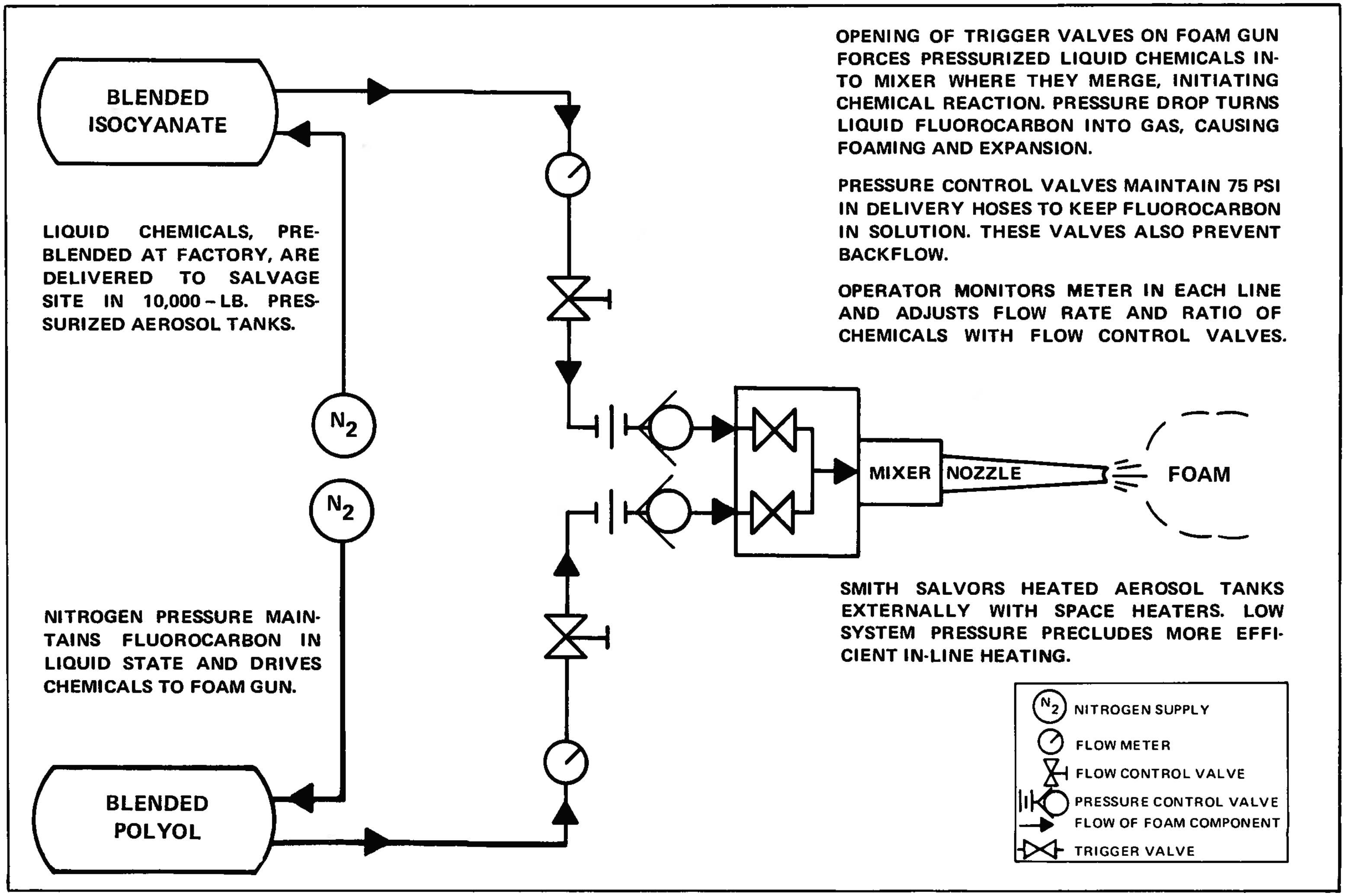
The operator, usually a diver, begins the foaming operation by opening a pair of trigger valves on the foam gun block. The liquid streams of isocyanate and polyol, propelled by the nitrogen pressure, flow into the mixing chamber where the streams merge, initiating the chemical reaction. Concurrently, the pressure drop across the foam gun assembly, caused by opening the valves, turns the liquified fluorocarbon into a gas, causing foaming and expansion.

Opening the trigger valves also causes a pressure drop across the delivery system to the foam gun block. It is necessary to control this drop so that a minimum of 75 psi is maintained in the system to ensure that the liquified fluorocarbon will not flash into gas prematurely. This is accomplished by a pressure control valve at the foam gun block. The valve closes if the pressure drops too low. This valve also prevents backflow in the system.

Flow meters are used to give a positive readout of the isocyanate and polyol flow in each delivery hose. The flow is controlled with a ball valve on the hose downstream from the flow meter. Pressure changes due to the diver changing depth, slight clogging of the mixing head, lowering of nitrogen pressure, or changes in the temperature of the chemical components will alter the ratio of flow between the components and often the total flow. The flow meter and flow control valve must, therefore, be constantly attended and adjusted.

A strainer assembly in each hose is used to remove particles of rust, impurities and flakes of hardened chemicals which would otherwise tend to lodge in small orifices causing either stoppages or changes in flow rates.

A special solvent, such as methylene chloride or acetone, is used to flush the foam gun assembly after use. The solvent is stored in an aerosol bottle, pressurized by nitrogen. A separate valve on the foam gun block controls the flow of the solvent. The foam gun and mixer must be cleaned of the isocyanate-polyol mixture immediately following foam gun shutdown in order to prevent plugging. Flushing must start before the foam hardens, usually within 10-15 seconds after the foam shot. Methylene chloride is used because it is normally nonflammable and safer than acetone and most other solvents.



Aerosol system is simple and flexible. Low system pressure limits it to shallow water applications down to 60 feet.

AEROSOL FOAM DELIVERY SYSTEM FOR STERN SECTION OPERATIONS

Heating the Chemical Components

Foam should be stored, mixed and pumped at an air temperature of 70°F to 100°F. If these conditions are met, foam may be placed in water as cold as 50°F, provided that the temperature is maintained in the hoses during delivery to the foam gun. Best foam properties are obtained when the foam leaves the gun at about 80°F. If too cold, the isocyanate will freeze and, if too hot, the polyol will polymerize and harden. Both extremes must be avoided in foam storage and foam use.

As foaming progressed on the SMITH's stern section, it became evident that air and water temperatures were dropping low enough to affect the quality of the foam. Some form of heating the chemical components was required. In-line heating units cannot be used in the aerosol system because they cause a large pressure drop during the delivery process. Accordingly, it was decided to heat the component tanks prior to their alignment in the delivery system.

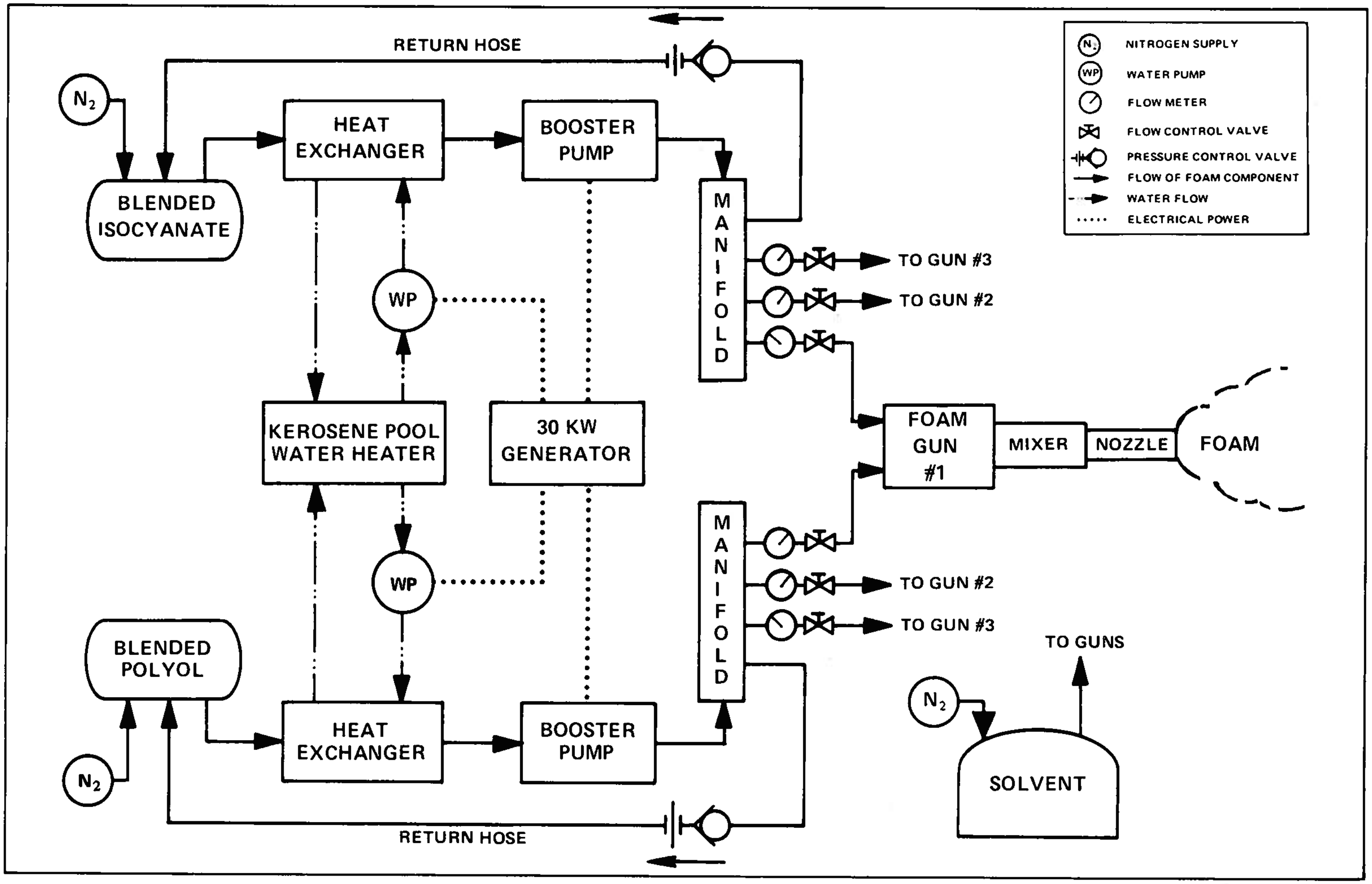
A heating shed was constructed on a flat scow (cargo barge) which was then moored at the wreck site alongside the derrick barge. The large aerosol tanks were placed inside this shed prior to use and heated externally with an array of space heaters. This process of bulk heating the tanks off-line, although relatively inefficient, raised the temperature of the stored chemicals to about 90°F which was sufficient for achieving the desired temperature of 80°F at the foam gun.

COMBINATION AEROSOL-MECHANICAL DELIVERY SYSTEM FOR FOAMING THE SMITH'S BOW SECTION

General Features

The combination system uses nitrogen to pressurize the foam components in their respective aerosol tanks as in the aerosol system. This initial pressure drives the components through a pair of heat exchangers. After this in-line heating, the flow of each component to the foam gun is boosted with a mechanical pump. As in the mechanical system, these pumps supply the high pressures required for large capacity foaming operations at greater depths than can be attained with the aerosol system alone.

This combination system was configured especially for the SMITH salvage operation. It was not an existing system, stored and ready for use in a variety of salvage applications. The SMITH salvors designed and assembled it on site, using available equipment to integrate those features of the aerosol and mechanical systems that could best meet the requirements for foaming the bow section. Much of the equipment was procured by SUPSALV on the recommendations of the Murphy Pacific Marine Salvage Company (MYPAC) and the Battelle Memorial Institute, experts in the foam-in-salvage process.



Foam components are first pressurized with nitrogen as in aerosol system. After heating, flow of each component is boosted with constant speed gear pump. System is designed to feed three foam guns.

COMBINATION FOAM DELIVERY SYSTEM FOR BOW OPERATIONS

The combination system used the same large aerosol tanks, with chemical components preblended at the factory, that had been employed in the aerosol system for stern operations. Each component was blended with an increased percentage of the fluorocarbon blowing agent to provide for optimum expansion under the conditions of higher ambient pressure that would be encountered at the increased foaming depths. A202 (MDI) foam was used principally in foaming the bow. The relatively unstable Freon 22 was added to increased amounts of the Freon 11 and Freon 12 blends used for foaming the stern. This addition of Freon 22 was designed to promote frothing at the greater depths.

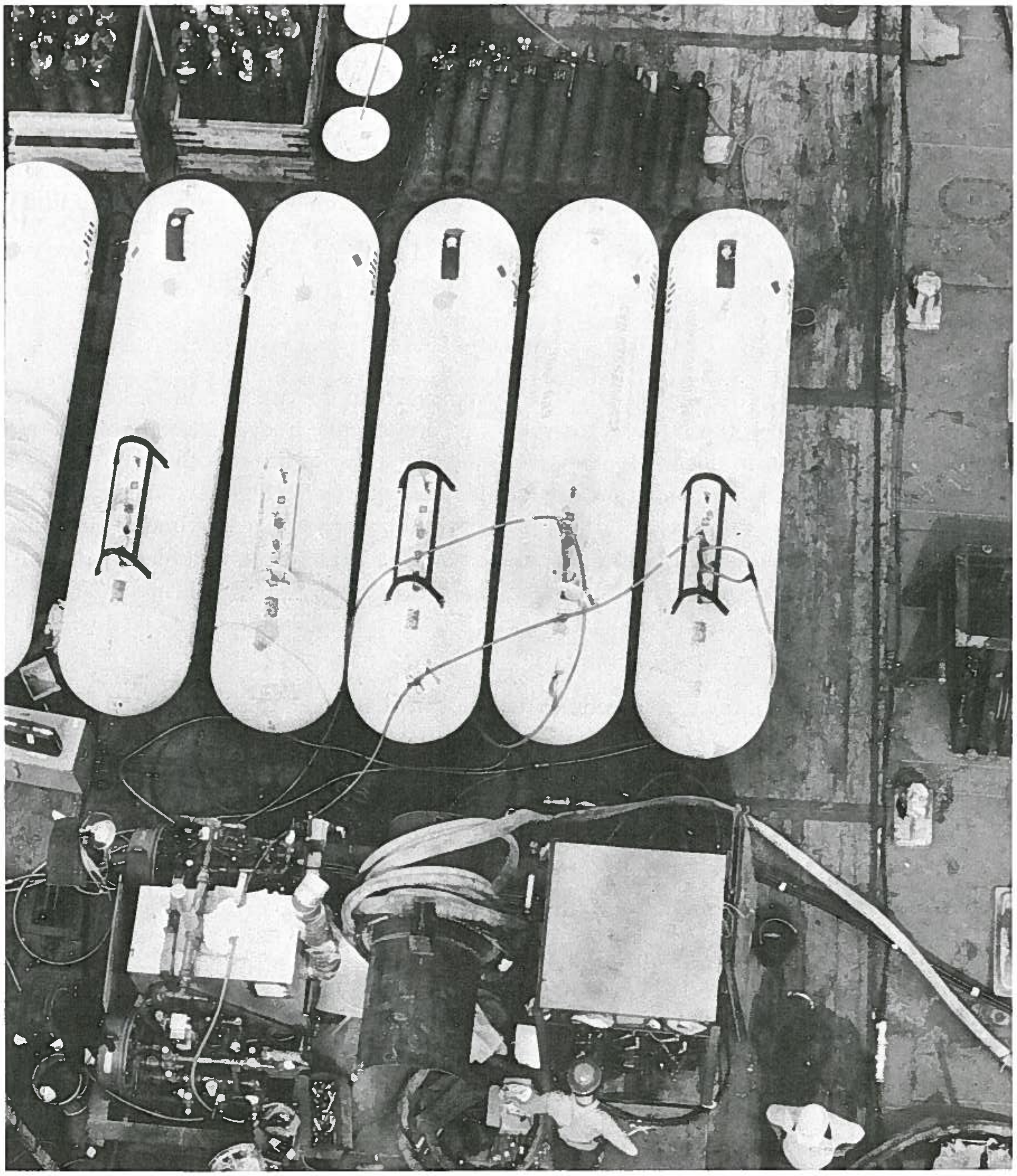
System Functioning

In the combination delivery system, nitrogen pressure in the component tanks, maintained between 70 and 100 psi, forces the chemical components, isocyanate and polyol, each preblended with its fluorocarbon blowing agent, through a pair of heat exchangers to the booster pumps. After a component pressure drop across the heat exchangers, the booster pumps increase component pressure to 500 psi. From the pumps, the components flow to a pair of manifolds which direct the components to one or more foam guns upon demand, or back to their respective tanks. The delivery system is configured to support three foam guns simultaneously.

The main pumps in the system, one in the isocyanate line and one in the polyol line, are constant speed, gear-type pumps, providing a constant (170 pounds per minute) component output to each manifold. When foaming is in progress, a portion of this output flows through the foam guns; the remainder is recycled back to the component tank through a pressure control valve. When the foam guns are shut off, the entire output of the booster pump is recycled back to the tank.

The pressure control valves, one in each hose, maintain high pressure at the foam guns, regardless of demand, by regulating the return flow to the component tanks. Each valve also preserves the pressure differential across the booster pump by preventing the unrestricted flow of the liquid chemical from the manifold to a region of lesser pressure, the component tank.

The console operator monitors the flow meter in each line and adjusts the flow control valves to ensure the proper rate of flow and ratio of each chemical component. The flow control valves are Waterman variable flow controllers which can be set to control the flow of material. Although they generate a pressure drop of 70 psi, these controllers provide more positive control and ease of operation than the simpler ball valve used in the aerosol system. The large pressure drop precludes their use in the aerosol system.



Pair of heat exchangers, flanking water heater (lower left), heat chemicals enroute to booster pumps, housed in control unit (lower right). Control unit also houses manifolds and flow meters. Right pair of aerosol tanks is on line.

FOAM DELIVERY STATION ABOARD BARGE

The foam gun assembly, although functionally similar to that in the aerosol system, has several important differences. The valves in the gun block are configured to handle the higher system pressure and output rate of the foam. The mixing chamber, between the foam gun and nozzle, is a Polytron baffle mixer in which a series of baffles within a section of aluminum pipe produce a zig-zag flow pattern creating the turbulence necessary to mix the foam components. This mixer generates substantial resistance to the flow of the components, causing a large pressure drop. A less efficient stream divider mixer was used in the aerosol system because it produced only a low pressure drop and was therefore more suitable considering the limited pressure available in the aerosol system.

An electrical system is required to drive the two booster pumps. The two water pumps for the in-line heat exchangers also require an electrical power source. A 30 KW generator installed aboard the derrick barge provided the necessary electric power.

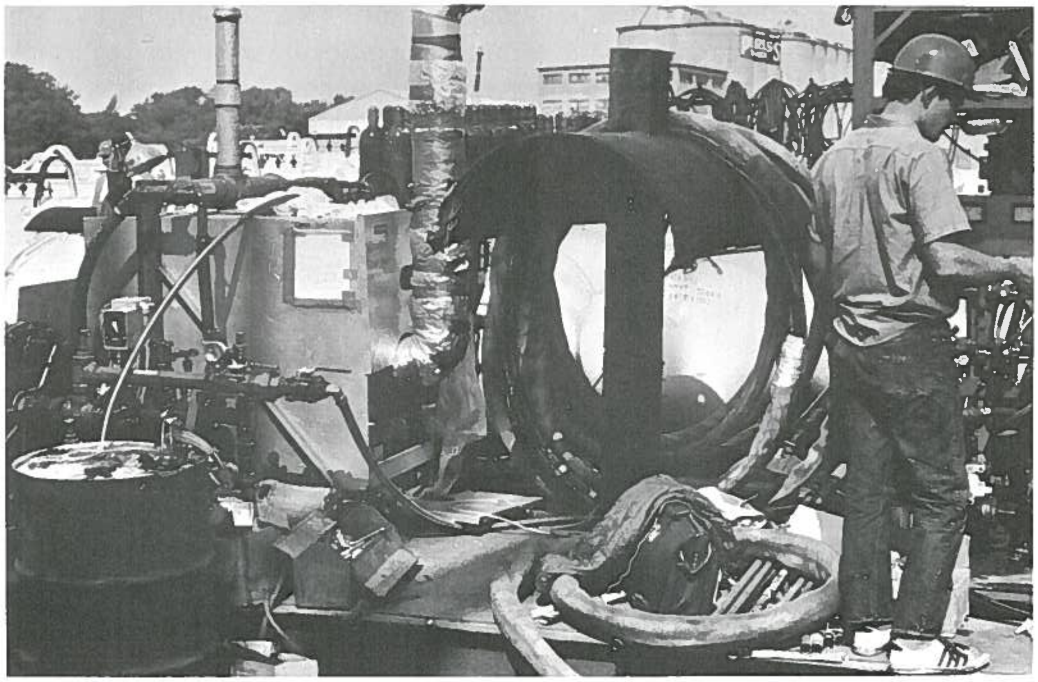
In-Line Heating of the Chemical Components

As preparations for bow removal operations got underway, it was clear that a more effective system for heating the chemicals would be required. The rapidly approaching fall season was already beginning to lower the air and water temperatures in the Great Lakes area. Bulk heating of the large aerosol tanks with space heaters had been employed with reasonable effectiveness in foaming the stern section during the late summer. However, the projected conditions for foaming the bow made it imperative to install an in-line heating system.

The heating system devised for bow operations employs a pair of heat exchangers, one in the isocyanate line and one in the polyol line, between the nitrogen-pressured aerosol tanks and the booster pumps. The heat exchangers are a heliflow type with circular casing made up of stainless steel tubes. The foam passes through the tubes, being heated by hot water en route. The heat of the foam, as it leaves the exchanger, regulates the flow of hot water, shutting it off when the foam reaches a preset temperature, usually 100°F.

The system, as used for bow foaming, raised the temperature of the liquid chemicals from as low as 32°F in the component tanks to 100°F upon discharge from the heat exchangers. The discharge temperature setting is varied according to the water temperature at the foaming depth and the length of the delivery hoses. Allowing for heat loss in the hoses, the setting is calculated to produce temperatures at the foam gun of 80°F, the desired level for foaming operations.

The heat source is a kerosene water heater which supplies hot water at 150°F. The hot water, circulated by an electrically powered pump, enters the exchanger at the foam component discharge end. The circulating pump cycles on and off as required to maintain the specified foam component temperature.



Kerosene drum (left foreground) fires water heater (left center). Heat exchange for isocyanate line is in front of heater; similar heat exchanger for polyol line (not shown) is behind heater. Portions of chemical delivery hoses (center) are jacketed in large hose for protection.

WATER HEATER AND HEAT EXCHANGER

FOAM FORMULATIONS

Basic Chemical Types: A502 (TDI) and A202 (MDI)

Two basic chemical types of foam are generally used. Each has a different isocyanate:

TDI – The isocyanate is Tolylene Diisocyanate (TDI)

MDI – The isocyanate is Diphenylemethane Diisocyanate (MDI). It is also called Polymeric Isocyanate.

When mixed with a polyol, TDI forms a white foam, while MDI forms a dirty yellow or brownish foam. Foams formed with these isocyanates are sometimes referred to simply by their colors, as white or brown foams. These two chemical types are further categorized numerically as A502 and A202 formulations, respectively.

The A202 (MDI) formulations are a more recent development than the A502 (TDI). The latter are a significant fire hazard and also give off toxic gases when burning. Although they must also be handled very carefully, the MDI foams are more fire retardant and less toxic and are therefore more suitable for applications in air than the older formulations. For underwater applications, the MDI foams set up more rapidly but tend to produce somewhat less buoyancy, especially at great depth. Both types have similar structural properties.

Both formulations were employed in the SMITH salvage operation. A502 (TDI) foam was used mostly for the stern section and the A202 (MDI) for the bow section. The change was primarily a matter of availability. The salvors would have preferred the white foam for the bow section also but could not get enough of it and, accordingly, substituted the brown (MDI) foam. However, the differences in the two types of foams did not significantly affect foaming operations.

Fluorocarbons

There are four fluorocarbons commonly used, depending on the water depth. The amount of fluorocarbon blended with each chemical component increases as the depth increases.

Typical applications are:

Depth	Fluorocarbon
0 – 75 ft.	Freon 12
75 – 125 ft.	Blend of Freon 12 and Freon 22
125 – 200 ft.	Blend of Freon 22 and Freon 13B1

These are the "frothing foams" which function as blowing agents in the isocyanate-polyol chemical reaction, providing the gas which expands and fills the cells of the urethane foam. Freon 11 is also often blended with the polyol; it froths only with the exothermic reaction of the isocyanate and polyol.

Ratio of Isocyanate Blend and Polyol Blend

The ratio of isocyanate blend to polyol blend is normally 1.3:1, by weight. Thus for every pound of polyol used, 1.3 pounds of isocyanate should be used. The isocyanate constitutes 56 percent of the weight of the total urethane mixture and the polyol, 44 percent.

This ratio remains constant with changes in depth. It is extremely important that it be maintained within 2 percent during pumping as foam pumped off ratio will be of poor quality. Excessive isocyanate creates brittle, crumbly foam. Excessive polyol makes the foam soft and slow to harden.

Other Foam Ingredients

A surfactant is generally blended with the polyol and may also be blended with the isocyanate. The function of the surfactant is to provide bubble stability in the foaming process. An amine catalyst is generally blended with the polyol to accelerate the chemical reaction with the isocyanate. Blending of these ingredients is accomplished at the factory.

PREPARATION AND STORAGE OF FOAM COMPONENTS

Auto Froth Factory Preparation

The Olin Mathieson Chemical Corporation provided both the A502 (TDI) and A202 (MDI) foams for the SMITH salvage operations. The isocyanate and polyol components of each type of foam were preblended at the factory with their liquified fluorocarbon blowing agents and with surfactants and catalysts as required. This preblended process, known as "auto-froth" is designed to provide thorough blends, accurately proportioned for designated depths. The factory preparation eliminates the laborious task of batching each chemical at the salvage site that is characteristic of the small tank aerosol system. It is also a simpler and somewhat more reliable process than blending each chemical with powered in-line mixers during the delivery process as is done in the mechanical system.

Composition of A502 (TDI) Foam

This white foam, as used in the SMITH salvage operations, was composed as follows:

Component A: POLYTRON A502, TDI PREPOLYMER

Isocyanate – A502 TDI
Fluorocarbon – Freon 12

Component B: POLYTRON A502 POLYOL

Polyol – A502
Fluorocarbons – Freon 11 and Freon 12
Surfactant
Amine Catalyst

Composition of A202 (MDI) Foam

This brown foam, as used in the SMITH salvage operations, was composed as follows:

Component A: POLYTRON A202 MDI PREPOLYMER

Isocyanate – A202 MDI
Fluorocarbons – Freon 12 and Freon 22

Component B: POLYTRON A202 POLYOL

Polyol – A202
Fluorocarbons – Freon 11, Freon 12, and Freon 22
Surfactant
Amine Catalyst

Storage in Large Aerosol Tanks

The isocyanate and polyol blends were each stored in large, 10,000-pound aerosol tanks, color-coded and labeled to prominently identify each component. The tanks were delivered by truck to the salvage site and stored aboard the derrick barge for hook-up to the delivery system.

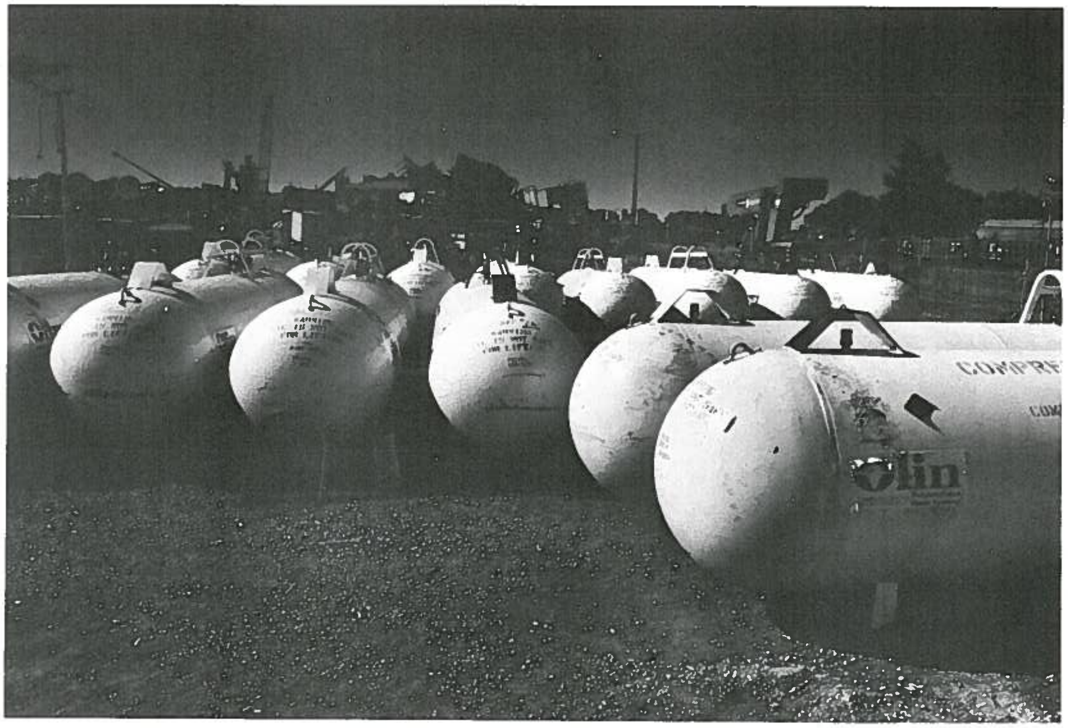
Preblending demands that the large storage tanks be pressurized in order to maintain the freon in a liquid state. The required pressure (minimum of 75 psi) is supplied by nitrogen, introduced into the tanks at the factory. Additional nitrogen is introduced into the tanks at the salvage site to maintain the pressure during delivery of the chemicals.

The Corps of Engineers derrick barge was well equipped, both in lifting capacity and deck space, to handle the large, 10,000-pound aerosol tanks containing the foam components. At one point during the foaming of the bow section, the barge's deck accommodated 14 of the component tanks (each of which occupied 54 square feet of space), plus all of the associated foaming equipment for the combination aerosol-mechanical delivery system.

DETERMINATION OF FOAM QUANTITY AND QUALITY

Estimating Weight and Volume of Foam

The quantity of foam implanted in a compartment is described in terms of tons of buoyancy installed. This measure is the product of the predicted buoyancy yield per pound of chemical components employed and the actual recorded weight of the materials delivered



Liquid chemical components of foam, polyol and isocyanate, were stored separately under nitrogen pressure in large aerosol tanks. Each component was pre-blended at Olin Mathieson factory with liquid fluorocarbon blowing agent.

AEROSOL TANKS STAGED FOR TRANSFER TO BARGE

into the compartment. For example, if the predicted yield is 20 pounds of buoyancy per pound of chemicals and 100 pounds of chemicals have been pumped into the vessel, the product of 20 x 100 is 2,000 pounds or 1 ton of installed buoyancy. The buoyancy figures quoted in this report are of predicted or anticipated yield.

The weight of urethane foam required can be determined if the amount of required foam buoyancy and depth of water are known. The weight of foam required is equal to the foam buoyancy required divided by the foam lift ratio (lift per pound of foam) for the particular depth. The lift required to raise a vessel to the surface is the vessel's buoyed weight. Buoyed weight is the difference between the displacement weight the vessel had before sinking and the buoyancy force provided by those parts of the sunken vessel such as solids and tanks that displace water.

It is necessary to check whether sufficient space is available in the sunken vessel for placement of the foam. The volume allowance for foam placement should be at least 1.25

times the volume of water to be displaced by the cold, cured foam. The greater volume is necessary because the hot foam has about 25 percent greater displacement than it has when cold and cured. Although rates vary, the foam loses about 10 percent from shrinkage and 15 percent from water absorption as it cools and hardens. Sunken vessels may have certain compartments that are inaccessible or unsuitable for foaming. If the available space is insufficient to hold the required volume of foam, additional forms of lift, such as pontoons, will have to be utilized.

Consideration of Foam Quality

Foam quality is a function of the actual buoyancy yield for a given weight of chemicals. Poor or low quality foam denotes foam whose actual buoyancy yield is significantly less than its predicted yield. In terms of its cellular structure, poor quality foam contains an excessive number of over inflated or under inflated cells which reduce the buoyancy yield. As the SMITH operation was to demonstrate, it is difficult to measure and control foam quality.

The foam mass forms and hardens very quickly as the isocyanate and polyol react chemically, forming the cell walls, and the fluorocarbon gas expands, completing the gas-filled cellular structure. The cells will not form properly if they are over inflated or under inflated during this process. With excessive gas pressure, the cells form and close initially but then expand and rupture, resulting in open cells which can absorb water. Water absorption increases the density of the foam mass, reducing its buoyancy. With inadequate gas pressure, the cells do not expand sufficiently. Although closed, these small cells have thicker walls and, of course, contain less gas than the properly inflated cells which make the foam mass buoyant. Thus both conditions, over inflation and under inflation, have adverse effects on buoyancy yield.

Over inflation occurs more frequently than under inflation. Foam, when installed, does not form perfectly in the sense that all of its cells are closed and properly inflated. Some cells will always be open. Typically, these portions of the foam mass will be soft and spongy, with very low buoyancy characteristics, as compared to the rigid structure of the sealed, gas-filled cells. Foam is generally considered to be of high quality when its open cell content does not exceed 10 to 15 percent. Such foam is achieving 85 to 90 percent of the efficiency it was designed to achieve according to its predicted yield.

Causes of Poor Foam Quality

Improper blending of the fluorocarbon (freon) gas with the isocyanate and polyol components is a major cause of poor foam quality. If the blend is too rich in freon, the excessive gas pressure will cause over inflation and rupture the cells. Conversely, if the blend is too lean in freon, some cells will under inflate. The proper blend of freon varies with changes in the depth of the foaming application and must be carefully controlled to achieve high quality foam.

Isocyanate reacts with water as well as with polyol. This property can lead to poor foam quality if contact between the foam components and the water is not minimized during the underwater installation procedure. If excessive contact occurs, the isocyanate and the water react chemically, giving off carbon dioxide gas and leaving insufficient isocyanate for the isocyanate-polyol reaction to produce enough matrix material to enclose the expanding gas. Under these conditions, the fluorocarbon gas, augmented by the carbon dioxide gas, over inflates and ruptures the cells, with adverse effects on buoyancy. Minimizing foam-water contact is emphasized in all underwater placement techniques but is often difficult to achieve in actual practice.

The optimum temperature range for the foam chemicals is between 70°F and 100°F. To form properly underwater, foam must cure and harden within one or two minutes after leaving the foam gun. At high temperatures, over expansion of the fluorocarbon gas occurs, causing the cells to over inflate and rupture. Conversely, in cold temperatures, the gas does not expand sufficiently or rapidly enough, leaving some cells under inflated. In either case, the quality of the installed foam is poor.

Causes of poor foam quality proved exceptionally difficult to isolate during the SMITH salvage operations. Low temperatures were thought to be a definite cause early in the operation. The salvors tried bulk heating of the chemical tanks during stern removal operations and later used in-line heat exchangers to heat the chemicals during bow removal operations. These methods succeeded in maintaining the foam chemicals within the prescribed temperature range but did not eliminate problems of poor foam quality. The quality remained poor in spite of stringent efforts to ensure effective control over factors such as the isocyanate-polyol ratio, proportion of freon in the blend, and foam placement procedures (by both the diver and probe methods) to minimize foam-water contact during installation.

Two distinctive features of stern removal operations may have adversely affected the foam's quality. The salvors parbuckled the stern section after installing foam. They also used explosives to separate the stern section from the bow section. Foam experts theorized that the explosives had permanently compressed much of the installed foam, reducing its buoyancy yield in the process. They also thought that parbuckling had caused the foam mass to shift position within the wreck, producing numerous cracks within its cellular structure and thus rupturing many of the foam cells. However, these, and other possible causes, could not be pinned down during the course of operations. The salvors were forced to compensate for the foam's poor quality by installing more foam than originally planned in order to achieve the required buoyancy.

Analyses of Foam Samples

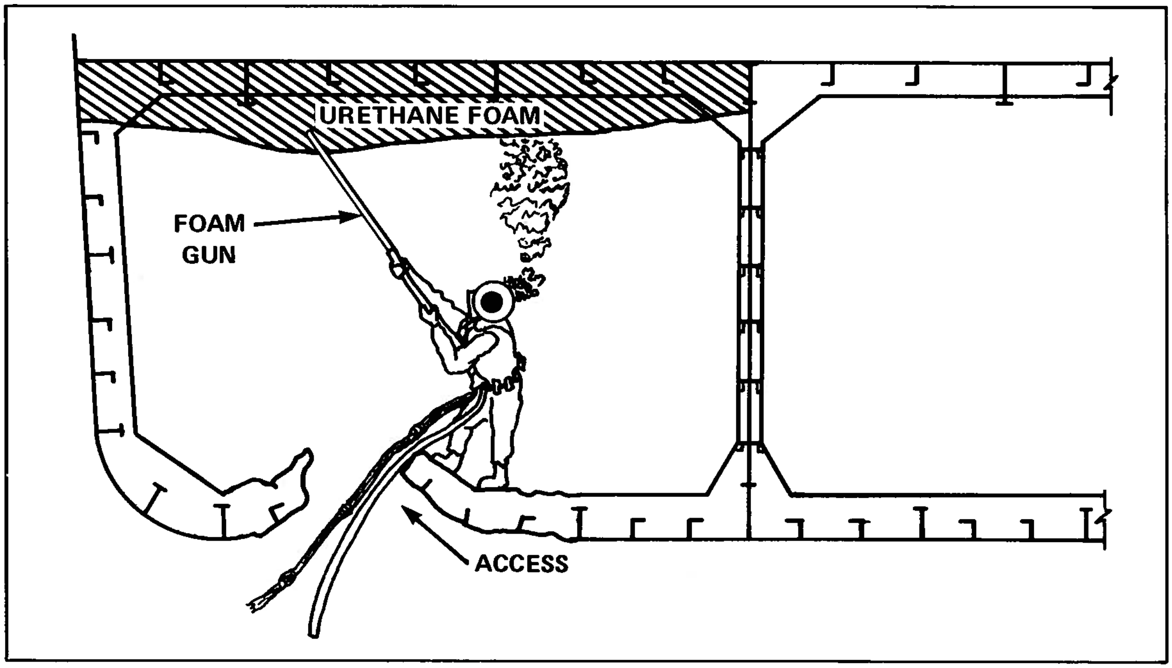
The primary technique of monitoring the quality of the installed foam is to cut out samples of the hardened material and bring them to the surface for examination. However, sampling and testing procedures at the job site are susceptible to significant inaccuracies as compared to those at laboratory facilities. In addition, there is no means of ensuring that the sample itself is representative of the entire batch of installed foam. Nevertheless, reasonably effective techniques of field checking foam buoyancy have been developed. The SMITH salvors made periodic analyses of foam samples during the course of operations. These analyses were useful in confirming the presence of poor quality foam.

PROCEDURES FOR INSTALLING THE FOAM

Minimizing Foam-Water Contact

Since the number of open cells and the resulting buoyancy loss is directly related to the extent of foam-water contact, the basic technique of installing foam is to minimize this contact during the placement and curing of the foam mass. Foaming procedures do not completely eliminate the foam-water contact but do minimize it so that only the outer boundaries of the mass make contact with the water in the flooded compartment. The main idea is to start by placing the foam at the highest part of the compartment and then work progressively downward, keeping the nozzle of the foam gun buried in unhardened foam. The foam should not be allowed to rise freely through the water. If it does, all of the foam will contact water and open cells will result.

Since the foam is extremely buoyant, it will seek the highest available space in the compartment, displacing at the same time an equal volume of water. For displacement to occur, there must be a water outlet at or near the bottom of the compartment. The compartment may be previously holed or a standpipe may be installed to provide an outlet. The compartment should be foamed in its entirety, working from the top down, in one continuous operation. As new foam is injected, initially in liquid form, it is protected from the water by the previously injected foam. It keeps a channel open through the previous foam as long as injection is maintained at a reasonable rate. As the fresh foam continuously forms in the previously pumped foam, only a small surface area contacts the water and higher quality foam is produced.



Diver installs foam in compartment from top down, keeping gun nozzle buried in fresh foam. Water is displaced as foam expands and hardens.

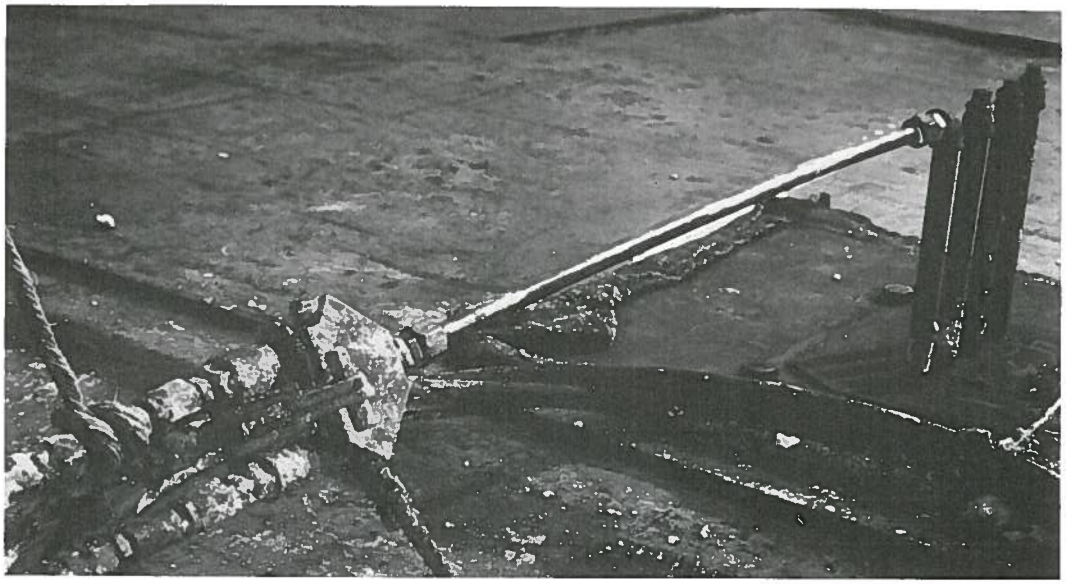
DIVER METHOD FOR INSTALLING FOAM

Placement of Foam by Diver

Generally, a diver is employed to operate the foam gun and position the nozzle in the compartment for best results. The typical nozzle is a length of 3/4-inch pipe. Starting at the top, the diver keeps the nozzle embedded in fresh foam as the foam expands downward. Although the procedure is simple to understand, it is sometimes difficult to implement. The diver may tend to stay well away from the foam for fear that it will foul his breathing apparatus. Unless he can hold on to something in the compartment, he may have to swim constantly to maintain the nozzle in position because his buoyancy is usually slightly negative or positive. Further, he must work to one side of the nozzle so that his exhaust air does not disturb the foaming process. On the SMITH salvage operation, the diver was further hampered by limited visibility within the compartment, as the water became clouded by suspended particles of foam materials.

Installation of Foam by the Probe Method

If conditions permit, a hole can be drilled through the top of a compartment and a female pipe connector mounted to receive a male connector attached to the nozzle of the foam gun. With this arrangement, the gun can be held in place by the coupling without continuous



Foam gun nozzle is attached to probe penetrating down into underwater compartment. Pipes in probe array are of increasing lengths for foaming from top down at successively lower levels. Foam gun may be switched quickly to a new pipe for continuous foaming.

FOAMING FROM TOPSIDE BY PROBE METHOD

tending by a diver or operator. Pumping, once started, must continue at a reasonable rate to ensure that the fresh foam keeps a channel open down through the previous foam. This technique is commonly called the "probe method."

SMITH salvors also employed a variation of the probe method for foaming certain submerged tanks that the diver could not enter. The diver cut a vertical row of probe holes in the side of the tank. Then inserting the nozzle through successively lower holes, he foamed the tank from the top down.

Considerable foaming was done by the probe method from topside in the SMITH. Typically, a set of three pipes was inserted down into the space, each pipe of different length to allow foaming at successively lower levels. The foam quality achieved with the probe method during the SMITH operation proved to be inferior to the foam produced by the direct diver method.

Operation of the Foam Gun Assembly

The foam gun assembly includes the gun proper (or gun block), the mixer and the nozzle. The guns used on the various systems are similar. The mechanical system employs different trigger valves in the gun block than the aerosol system in order to handle higher pressures, up to 2,000 psi, as compared with the 600-psi rating of the aerosol gun. The main valves, or trigger valves, for the foam components are ball valves fitted with a special split handle which allows the operator to simultaneously start or stop the flow of the isocyanate and polyol stream. The internal passages in the foam gun block are drilled holes. Mixing of the two chemicals begins in the block as the separate streams of polyol and isocyanate merge and are expelled into the mixer in one stream.

A third ball valve controls the flow of methylene chloride solvent. This valve is opened as soon as foaming ceases in order to flush the gun block and mixer of any remaining polyol and isocyanate which would otherwise harden, clogging these parts. The solvent system has two check valves on the gun block which prevent backflow of the polyol and isocyanate into the methylene chloride hose, but allow flow of the solvent into the gun block when flushing is required.

Three types of static mixing chambers are available to mix the liquid foam at the discharge end of the foam gun. One is a Polytron baffle mixer, a series of baffles in a section of aluminum pipe which produce a zig-zag flow pattern, creating the turbulence necessary to mix the foam components. A second type is a chip mixer or chip chamber, designed by MYPAC. It is simply a section of pipe with steel shavings inserted to provide the turbulence. A third type, also designed by MYPAC, is the Mark II mixer. This device has aluminum segments connected with stainless steel tie rods which alternately divide and consolidate the stream as it funnels through the mixer.

The gun nozzles are basically just sections of steel or aluminum pipe. A nozzle 6 feet long is considered ideal for diver application of foam underwater. Either 3/4-inch or 1-inch diameter pipe is used. The larger size outlet slows the foam velocity producing a slightly lighter, more buoyant foam. A shorter pipe nozzle, extended by a flexible hose, can also be used for ease of handling.

APPENDIX D

NICHOLSON ANCHORAGE COMPANY'S REPORT
ON THE
DESIGN AND CONSTRUCTION OF THE
SOIL ANCHORS AND CONCRETE REACTION BLOCKS

– C O P Y –

NICHOLSON ANCHORAGE COMPANY
P.O. BOX 308 BRIDGEVILLE, PENNSYLVANIA

September 25, 1973

Supervisor of Salvage
Naval Ship Systems Command (Code OOC)
Department of the Navy
Washington, D.C. 20360

Attn: Mr. E. F. Lawrence
Head Operations Division

REF: OOC:EFL:pam.
3930/1046
Ser 703/OOC

Gentlemen:

Enclosed is our report as requested in your letter of July 2, 1973. We trust that the information in the report meets the requirements for your report of the overall salvage operation.

If you have any questions or should you need any additional information, please do not hesitate to call on us.

Very truly yours,

NICHOLSON ANCHORAGE COMPANY

/s/

Peter J. Nicholson
President

PN:af

Enclosure

REPORT ON THE DESIGN AND
CONSTRUCTION OF THE SOIL ANCHORS AND CONCRETE
REACTION BLOCKS USED IN THE SALVAGE OF THE "SIDNEY E. SMITH"
1972

Due to the impractibility of assembling and using conventional lifting vessels at the wreck site, the plans called for each of the wreck sections to be winched from the deep channel into shallow water for final patching prior to being towed on a last voyage to the scrap yard. It was necessary to provide shore-side pulling points for the steady-pull hydraulic winches which were to be used for the removal work and which each exerted a pressure of up to 100 tons on the winch cables.

A usual method of providing the required reaction would be to construct large concrete 'deadman' anchor blocks having sufficient dead weight to resist horizontal loading, which in this case would be up to 300 tons. The problem facing the Corps was to provide the reaction in a situation where normal means would have proven extremely costly and would have taken an unacceptable amount of time to complete. The plan attached shows the extremely limited access, the proximity of the railroad and the asphalt company, both of which had to be maintained in full operation, and the limited width of the job site next to the shore. The whole was complicated by the very soft nature of the ground in certain parts of the site. It was at this point that the U.S. Army Corps of Engineers approached the Nicholson Anchorage Company to explore the possibility of using specialist ground engineering techniques to resolve the difficulties that were present.

The design developed by the Corps originally called for eight shore side pulling points constructed from reinforced concrete and having the resistance to horizontal movement taken by two post-stressed ground anchors per block. By modifying the horizontal angles at the anchors and repositioning the pulling points, it was found possible to omit one pair of blocks, a total of six being constructed finally. Each block was designed to withstand a working pull of 100 tons asserted horizontally by hydraulic pullers at angles which would vary as the sections of the sunken vessel were moved into the shore. To provide for these conditions, the pulling eye was designed to be cast into the reinforced concrete block in a way which distributed the load into the ground anchors. The anchors were set at an angle of 45° to each other on plan, i.e., 22½ either side of the block center line to allow for varying angles of pull. As each anchor could have been subjected to a direct pull, they were constructed to withstand horizontal loadings of 100 tons each. This meant that working loads of 150 tons per anchor resulted as they were drilled at an angle of 45° below horizontal. Safety factors of 2 against anchor pull-out were applied. This anchor and block configuration was adopted for each of the six pulling points. However, one additional anchor each was constructed for both Block A and Block B along the center line of the blocks. These were felt desirable to provide extra stability in view of the fact that these blocks were to be subjected to additional loadings due to the need to hold the vessel sections against the river flow which, at times, was as high as 10 MPH. The layout of the anchors and pulling point blocks can be seen from the accompanying sketch and details of a typical block are shown in the U.S. Corps of Engineers drawing.

Following the finalization and acceptance of the requirements of the U.S. Navy Department of Salvage and the structural and geo-technical designs of the Corps of Engineers and Nicholson Anchorage Company, the site construction work was commenced. Nicholson Anchorage Company carried out the whole of the work under the direction of the U.S. Army Corps of Engineers, Detroit District.

To give some idea of the speed with which events moved, it should be noted that the Corps of Engineers first took positive action on June 20th, when the owners of the vessel declared the ship abandoned. Nicholson Anchorage Company mobilized and started the work on July 1st, and, after working 14 hours per day, 7 days a week, completed the construction sequences by July 14th.

The work was then handed over to the U.S. Navy Salvage crews, as removal of the sunken sections of the freighter from the main navigation channels was a matter of the highest priority. The pulling began on 21 July and was completed by 5 October after which the work site was restored to its original condition and all of the ground level traces of pulling blocks and anchors were removed.

In considering the details of the anchor construction, it is necessary first to make mention of the varied geological conditions that were eventually encountered during the drilling. The Corps had commissioned a test boring on the site and this was carried on on the 28th of June. The log of the boring is attached, but basically it showed 9 ft. of fill, presumably waste from the asphalt plant, a further 14 ft. of gray silty sand before a very poor highly plastic clay was encountered which was found to overlay a thin band of hardpan and then dark gray to black shale at a depth of 99 ft. below ground surface. In view of the loads required in the anchors, the clay material was not considered as being capable of providing the passive reaction necessary, so the anchors were designed to be founded in the shale bed-rock material.

The first five vertical feet of this shale were ignored for load calculation purposes due to probable weathering and, therefore, uncertain load-bearing characteristics. As the anchors were to be at 45° to the horizontal, the total drilled depth to the top of the fixed anchorage zone was expected to be approximately 146 ft. As the top of the weathered rock would vary, the normal practice was followed of drilling through the clay to the top of shale and then a further 7 ft. to ensure penetration of the weathered zone, the fixed anchor drilled length following thereafter. A fixed anchor length of 15 linear feet was selected with one pair of conical under-reams cut at the bottom of the borehole. For calculation purposes, the under-reams were taken as being of 12" diameter opened at the bottom of a 4½" drilled hole. A value of 85 lbs P.S.I. shear along the surface of a cylinder of a diameter equal to that of the under-reams was used to compute the ultimate pull-out strength of the fixed anchor which was therefore 288 tons. This figure could then be resolved as giving a horizontal working load of 102 tons (100 tons required), a working load at 45° of 143 tons and a safety factor of 2.

However, the construction was complicated by the fact that a completely different set of geological conditions was encountered during the drilling of the first boreholes for pulling blocks A & B. No trace of the clay material was found, but, instead, relatively dense medium brown sand, slightly silty at times. This strate of non-cohesive material is known to occur widely in the area of Lakes Michigan and Erie and as similar conditions had been encountered previously at South Haven and Grand Haven, it was decided to proceed with the construction of pressure grouted sand anchors at these two particular block locations. An immediate decision of this nature was possible due to the fact that Nicholson Anchorage Company has developed drilling equipment and techniques that are sufficiently versatile to successfully accomplish anchor construction in most types of geological formations, and have the trained and experienced personnel on every contract competent to adapt to widely differing conditions and requirements.

Experience showed the sand to have a permeability of $K=10^{-1}$ to 10^{-2} cm/secs. and, therefore, to be penetrable by a cement grout. The following formula was used to determine the length of the fixed pressure grouted anchor zone:

$$L \text{ (ins.)} = \frac{576{,}000 \text{ lbs (ult. load)}}{P \times \pi \times D \tan \phi}$$

P = grouting pressure (equivalent to 2 lbs. per sq. in. per ft of overburden above the fixed anchor zone.)

D = diameter of pressure injected soil zone (estimated at 12")

ϕ = angle of internal friction of sand taken as 30° saturated.

This calculation showed that a pressure grouted anchor of 30 ft. would be required with a total length of 80 ft. to achieve the same loads as for the rock anchors. This formula, whilst being empirical, is derived from consideration of results of many anchor tests in granular materials and the pertinent theoretical soil mechanics concepts as applied to those results.

Due to the high standing water level it was essential that the boreholes should be fully supported by casing either through the plastic clay to a seating in rock or through the medium to coarse sand to the full designed depth.

The casing used was screwed flush jointed high tensile pipe of 5½-inch outside diameter. Drill rods were 2-7/8" diameter with standard A.P.I. threads, and 4½" roller cone drill bits were used. In order to prevent borehole caving, cavitation, or any other ground disturbance that would affect the geological structure and therefore the load bearing characteristics of the soil, the boreholes were cased as the drilling proceeded using a unique method. This allowed the casing to be advanced immediately behind the drilling bit at the same rate of penetration. Cuttings were removed by water flush, pumped through the drill rods and exhausted through the annular space between the rods and the inside of the casing. In this way, therefore, ground disturbance was virtually eliminated and a tight seal maintained between the casing and the soil for accurate control of the ensuing pressure grouting operation.

For the anchors constructed in sand, the casing and drill rods were advanced to the designed depths, the casing fully cleaned of drill cuttings and then the drill rods and bit were withdrawn leaving the casing ready for installation of the anchor tendon and subsequent pressure grouting. For the anchors founded in the black shale, the casing and drill rods were advanced together as previously described through the overlying soft, plastic silts and clays to the top of rock. After seating the casing into the rock drilling was continued for a further twenty feet in open hole at a diameter of 4½". After completion of drilling a special under-reaming tool was inserted in the borehole and twin under-cut cones were formed at the bottom, each having a diameter of 12-15 inches. The borehole was then cleaned and prepared for tendon placement and grouting.

The tendons were made up from high-tensile, pre-stressing cable having a nominal diameter of 0.6 inch and an ultimate strength of 270 K.S.I., and complying with the requirements of ASTM A416. The accompanying table gives the full specification of the material. With the exception of anchors A2 with 5 cables or strands, and B2 with 4 strands all anchors were made up from 8 strands. The cables were greased and PVC coated except for the bottom 20 ft. (30 ft. in sand anchors) which formed the fixed pressure grouted length. Over this length the strands were stripped of the PVC and de-greased, and the seven wires in each strand were then unwound to give an ample area of steel exposed to the grout and therefore good bond stress distribution.

With each anchor tendon a 1" grout pipe was inserted into the drilled and cased borehole so that the cement grout could be pumped into the hole from bottom upwards thus displacing any water of laitance that may have gathered. When the grout was seen to flow clean and undiluted from the casing, a pressure cap was screwed on and grout pressurization commenced. For the rock anchors a grout pressure of 100-125 P.S.I. was used to ensure filling of any voids in the shale and to compact the grout. After this pressure had been achieved, pressurization was discontinued. The borehole casing was then withdrawn to leave behind a column of grout surrounding the greased and sheathed cables through the soft clay overburden. For the sand anchors the pressure was allowed to build up to

75-80 P.S.I., only to prevent ground heave, and then the casing was withdrawn approximately 1 ft. After the pressure had again built up the casing was withdrawn a short distance once more. This sequence of operations was continued for the 30 ft. of fixed anchor length. The rest of the casing was then withdrawn to leave an unpressurized grout column as with the rock anchors. This pressurization method ensured an adequate compaction of the grout, fullest possible penetration of the cement into the surrounding grandular material and development of the full passive resistance to pull-out at the grout/soil interface.

The cement used for grouting was Type III, High Early Cement which permitted the anchors to be stressed after a curing period of only seven days. Water/cement ratios were varied to suit differing ground conditions but averaged 0.5 to 1.0. No sand or chemical additives were used in the mix. The grout was mixed in a colloidal paddle mixer fitted with two drums to permit continuous mixing and pumping. Pumping was by a "Moyno" constant flow screw pump capable of developing pressures of up to 250 P.S.I. and flows of up to 15 gallons per minute. A table giving anchor lengths, grout takes and post-tensioned loadings is attached.

The drilling rigs used on this contract were built by Nicholson Anchorage Company especially for undertaking the construction of soil and rock anchors. Based on a track mounted chassis, all main functions are carried out hydraulically. Included with these is a hydraulic powered high pressure air compressor. The drilling mast is long enough to carry 30 ft. of drill rod and casing and is adapted to drill at any angle between horizontal and vertical. The rotary drilling head has a hollow main drive shaft through which the flush to the drill bit passes via a flushing swivel on top of the head. Rotation speeds are variable between 0-200 R.P.M. and drilling torques of up to 5,000 ft/lbs. can be produced. Down feed pressures of up to 15,000 lbs and uplift pressures of up to 12,000 lbs. are available. Whilst the rigs are built principally with rotary drilling in mind, percussive methods are sometimes to be desired, particularly when penetrating hard rock formations.

To allow for this the rigs are made adaptable to use of down-the-hole percussion hammers driven by the rig mounted, high pressure air compressor, or from a separate machine depending on the prevailing conditions. The versatility of these machines in coping with widely differing ground conditions was readily demonstrated on this one job.

The concrete anchor blocks were of two types, the design being varied as the job progressed to suit site experience. Blocks A & B were rectangular in shape and had dimensions of 7 ft. wide x 5 ft. x 5 ft. deep. Plywood form work was used and supported by earthen backfill. 930 ft. of reinforcing bar was used per block, and cast in place was the special steel pulling eye to which eventually the winch cables would be fastened. These eyes were originally designed to be fabricated from 4" diameter material but nonavailability meant that an alternate was used, in this case 6" x 3" rectangular section tapered to 3" x 3" at the pulling eye. The anchor tendons were sleeved through the block and pockets were formed in the concrete to take the 18" square x 2" thick stressing plates. The drawing prepared by the Corps of Engineers shows the general arrangement used. Block C was constructed as above on the drawing but in light of the experience gained during anchor stressing on Blocks A & B when the blocks started to move and rotate, Blocks D, E, and F were widened from 7 ft. to 12 ft. to give an increased horizontal bearing area and thus greater resistance to movement. Blocks A & B also contained a third anchor constructed on the pulling eye center line but with the stressing plate below the eye.

Concrete used was 7 sack regular using High Early cement and it was brought to site by truck mixer. After placing, the concrete was compacted by electric poker vibrator. Cube crushing tests on this concrete showed strengths in excess of 4,000 p.s.i. at two days.

Anchor stressing commenced on 7th July with Block B. Using two 100-ton hydraulic jacks set equidistant either side of the anchor, simultaneous stressing of all eight strands was carried out. Loads were read in pounds per square inch on a pressure gauge attached to the hydraulic pump and converted to total anchor tonnage by reference to a jack calibration chart prepared by an independent testing laboratory. Anchor tendon deflection was determined by measuring jack extension at each load increment and movements in the concrete blocks were monitored optically by use of a transit.

Experience with simultaneous stressing of all tendons proved that some modification of procedures was desirable in order to reduce movements in the blocks caused by anchor stressing. Subsequent stressing was therefore done on all blocks by means of a single strand stressing jack. In this method each of the eight strands in the anchor tendon was stressed separately in a set sequence in increments up to the designated working load. Loads were applied to each strand and locked off by means of standard post tensioning barrels and grip wedges. The total load in each anchor was then computed by taking the sum of the locked-off loads held in each strand. After stressing operations were complete, the stressing pockets were filled with concrete and finished flush with the block surface.

The Navy Salvage crews took over the work and commenced the removal of the wreck almost immediately following final stressing of the anchors in the last block constructed. This part of the salvage project is reported elsewhere and, combined with the geo-technical works, proved to be a classical and unique operation of its kind. One last comment should be made here concerning the anchored blocks however. A report reached Nicholson Anchorage Company that one of the concrete blocks had proved insufficient to induce movement in one of the freighter sections. In consequence the salvage crews had rigged up three-part cable tackles to increase the load that could be applied by virtue of the mechanical advantage so obtained. Therefore, the block was subjected to a horizontal load of 300 tons instead of the 100 tons originally planned. It is understandable, then, that extensive cracking of the concrete block occurred. However, the anchors and pulling eye held quite satisfactorily and that part of the salvage operation was completed. It is doubtful if any other system could have been used and subjected to such gross overloading without inducing failure at some point. The safety factors designed into Nicholson Anchors were more than equal to the occasion.

Nicholson Anchorage Company would like to express its gratitude to the U.S. Army Corps of Engineers and to the Department of the Navy, Supervisor of Salvage, for the help and assistance received during the design and construction work carried out on site, and in the preparation of this report.

STRAND

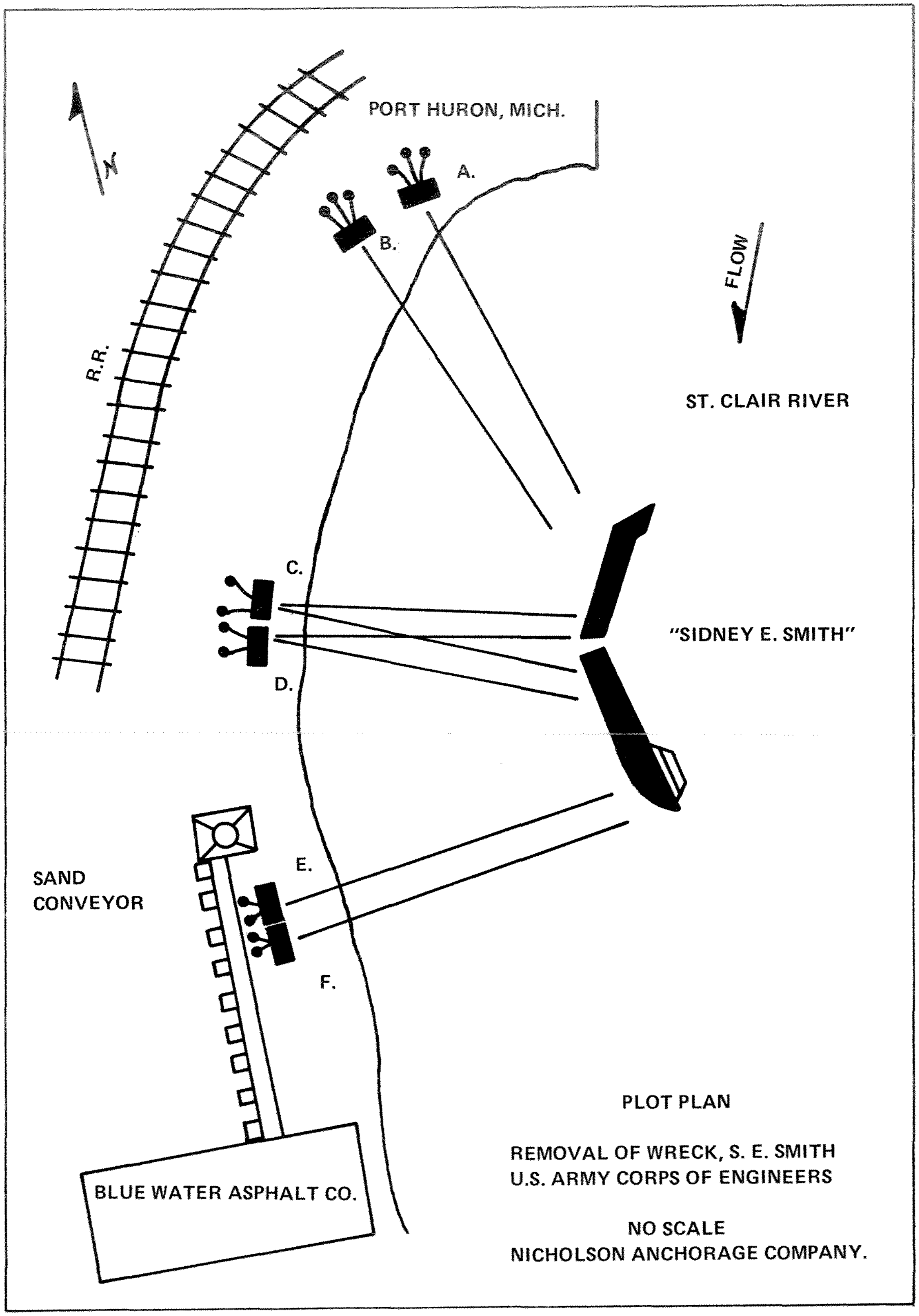
0.6 Dia. 270 ksi with the following Properties:

Nominal Area	0.215 in^2
Minimum Ultimate Strength	58,600 lbs.
Yield Strength (at 1% extension)	49,800 lbs.
Modulus of Elasticity (avg.)	28.6 x 10^6
Min. Elongation at Rupture	3.5% in 24"
Relaxation from 70% load at 20°C after 1000 hours	5.6%

The 0.6 dia. 7-wire strand has an ultimate strength (f's) of 270,000 psi and is produced and tested in accordance with the requirements of ASTM A 416. For permanent work, an extruded coating of 1/16" thick poly-vinyl chloride is provided for corrosion protection.

No. of Strands	Steel Area in^2	Weight lb/ft	Drilled Hole Dia. Inches	Max. Temp. Load Lbs. 0.8 f's	Tensioning Load Lbs. 0.7 f's	Working Load Lbs. 0.6 f's
1	0.215	0.74	4"	46,900	41,000	35,200
2	0.430	1.48	4"	93,800	82,000	70,300
3	0.645	2.22	4"	140,600	123,100	105,500
4	0.860	2.96	4"	187,500	164,100	140,600
5	1.075	3.70	4"	234,400	205,100	175,800
6	1.290	4.44	4"	281,300	246,100	211,000
7	1.505	5.18	5"	328,200	287,100	246,100
8	1.720	5.92	5"	375,000	328,200	281,300
9	1.935	6.66	5"	422,000	369,200	316,400
10	2.150	7.40	5"	468,800	410,200	351,600
11	2.365	8.14	5"	515,700	451,200	386,800
12*	2.580	8.88	5"	562,700	492,200	422,000

*Higher loads can be achieved using more strand.


PORT HURON, MICH.
N
R.R.
A.
B.
FLOW
ST. CLAIR RIVER
C.
D.
"SIDNEY E. SMITH"
E.
F.
SAND
CONVEYOR
BLUE WATER ASPHALT CO.
PLOT PLAN
REMOVAL OF WRECK, S. E. SMITH
U.S. ARMY CORPS OF ENGINEERS
NO SCALE
NICHOLSON ANCHORAGE COMPANY.

NICHOLSON ANCHORAGE
COMPANY

SALVAGE OF THE "SIDNEY E. SMITH"
ST. CLAIR RIVER
PORT HURON, MICHIGAN

For: U. S. Army Corps of Engineers
Date: Summer, 1972

ANCHORAGE MATERIAL: Black Shale

A unique application of ground anchoring is to be found near Port Huron, Michigan, where a coal freighter sank in the St. Clair River during the summer of 1972. Normal salvage operations involved pumping the broken hull full of liquid polyurethane, which expands 30 times over as it solidifies. Once afloat, the only problem was to move the 489-foot ship more than an eighth of a mile into shore where it could be plated and hauled away for scrap. Six concrete reaction blocks were to be installed on shore where two-inch cable could be attached and strung out to the ship. 100-Ton hydraulic pullers would then grasp the cables, pulling the ship in towards shore.

Fourteen Nicholson Rock Anchors were used here to tie back the concrete reaction blocks. (See Sketch.) Drilled 165 ft. at 45° to the vertical and under-reamed 15 ft. into the shale, each anchor was designed for horizontal working loads of about 100 ton. During the salvage operations, however, several anchors were actually subjected to horizontal pulls of 150 tons, proving the flexibility of such a system. At the same time, Nicholson Anchors provided a workable alternative to the pouring of yard after yard of deadweight concrete, an expensive and nearly impossible task in such a limited work area.

ANCHOR SCHEDULE – – – PORT HURON, MICHIGAN

BLOCK NO.	ANCHOR NO.	LENGTH	NO. STRANDS	CEMENT		ANCHOR POST TENSION	TOTAL BLOCK LOAD	ANCHOR TYPE
				TYPE	QUANTITY			
	1	80′	8	Hi-Early	18 bags	72 tons		Pressure Grouted
A.	2	60′	5	Hi-Early	16 bags	20 tons		Sand
	3	80′	8	Hi-Early	18 bags	64 tons	156 tons	″ ″
	1	85′	8	Hi-Early	20 bags	79 tons		Pressure Grouted
B.	2	60′	4	Hi-Early	15 bags	20 tons	171 tons	Sand
	3	80′	8	Hi-Early	21 bags	72 tons		″ ″
C.	1	160′	8	Hi-Early	10 bags	80 tons	160 tons	Under-Reamed
	2	159′	8	Hi-Early	10 bags	80 tons		Rock
D.	1	160′	8	Hi-Early	10 bags	80 tons	168 tons	″ ″ ″
	2	165′	8	Hi-Early	28 bags	88 tons		
E.	1	164′	8	Hi-Early	10 bags	88 tons	176 tons	″ ″ ″
	2	161′	8	Hi-Early	10 bags	88 tons		
F.	1	165′	8	Hi-Early	10 bags	88 tons	171 tons	″ ″ ″
	2	165′	8	Hi-Early	10 bags	83 tons		

APPENDIX E

JAMES G. FERGUSON & SON, INC. REPORT
ON
DESIGN DRAWINGS OF COFFERDAMS
AND HATCH COVERS

JAMES G. FERGUSON & SON, INC.

STRUCTURAL STEEL

WAREHOUSE STOCK — FABRICATION & ERECTION — CRANE RENTAL

2935 HOWARD ST., PORT HURON, MICHIGAN, 48060, P. O. BOX 967

Phone Area Code (313) 985-5178

July 25, 1973

Supervisor of Salvage
Naval Ship Systems Command (Code OOC)
Department of Navy
Washington, D.C. 20360

Attn: Lt. Mullen

Ref: Removal of Sidney Smith Freighter from the St. Clair River, Port Huron, Michigan

Dear Sir:

Enclosed please find all the drawings and sketches which were used on the structural steel which we fabricated and supplied for the removal of the Freighter Sidney Smith from the St.Clair River. Due to the immediate need of the fabricated material, standard shop drawings were not made, as you will note from the enclosed. The items covered by drawings or sketches are:

A. Hatch covers
B. Cofferdam guide
C. Cofferdam
D. Cofferdam platform
E. Hatch cover hooks
F. Hatch plate
G. Spreader clevis

I hope this material will be of use to you. Should you need any additional information, please do not hesitate to call us.

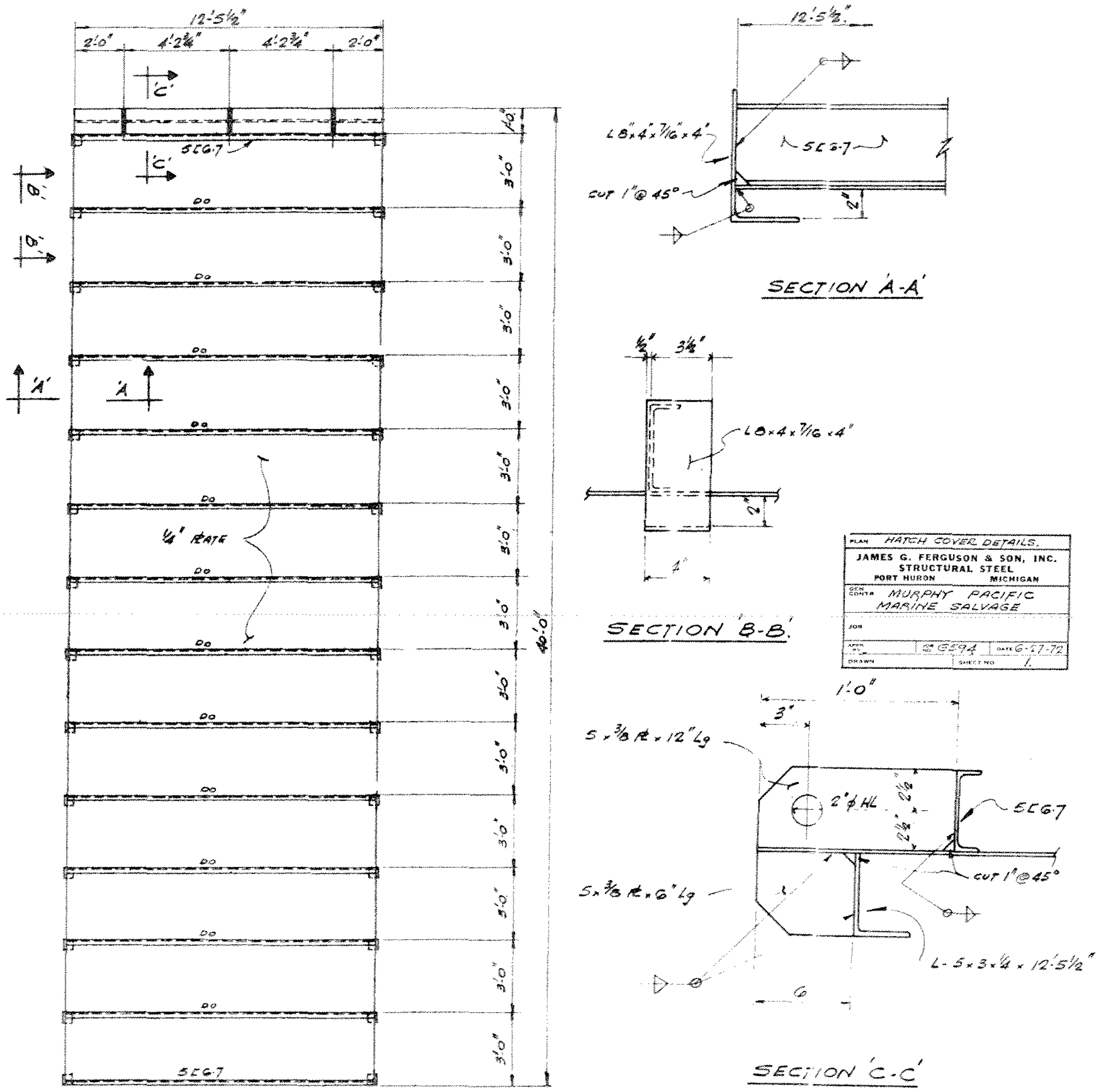
Very truly yours,

JAMES G. FERGUSON & SON, INC.

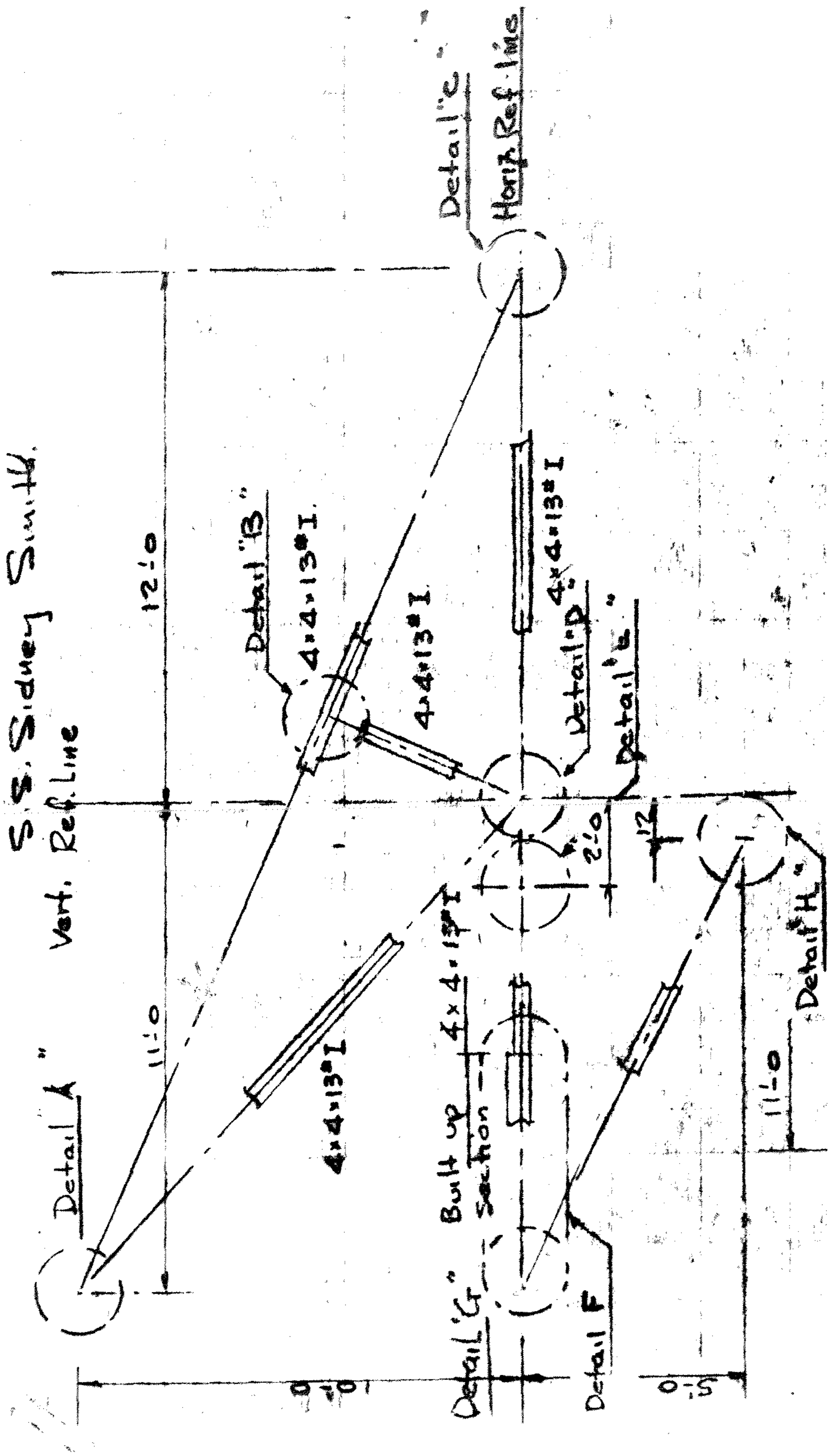
by- Kenneth Shaw

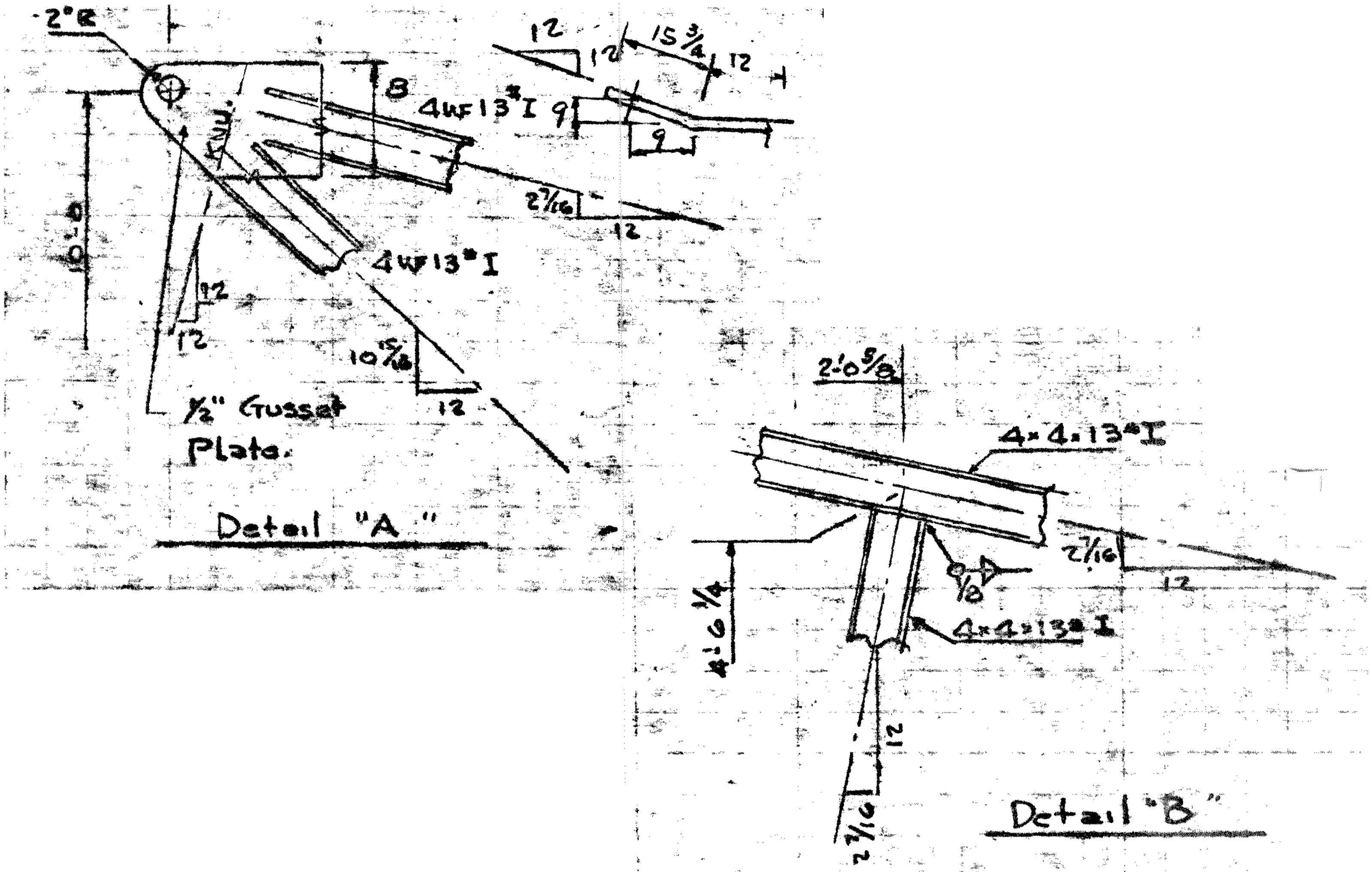
Kenneth Shaw
General Manager

KS:ep

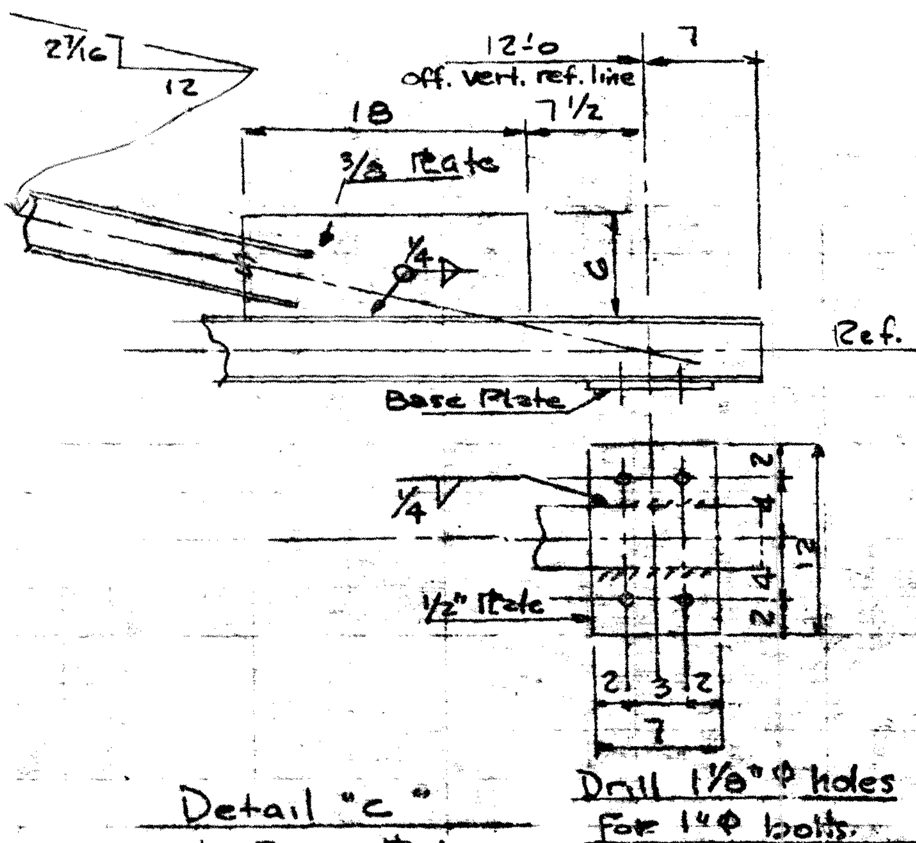


ITEM A – HATCH COVERS

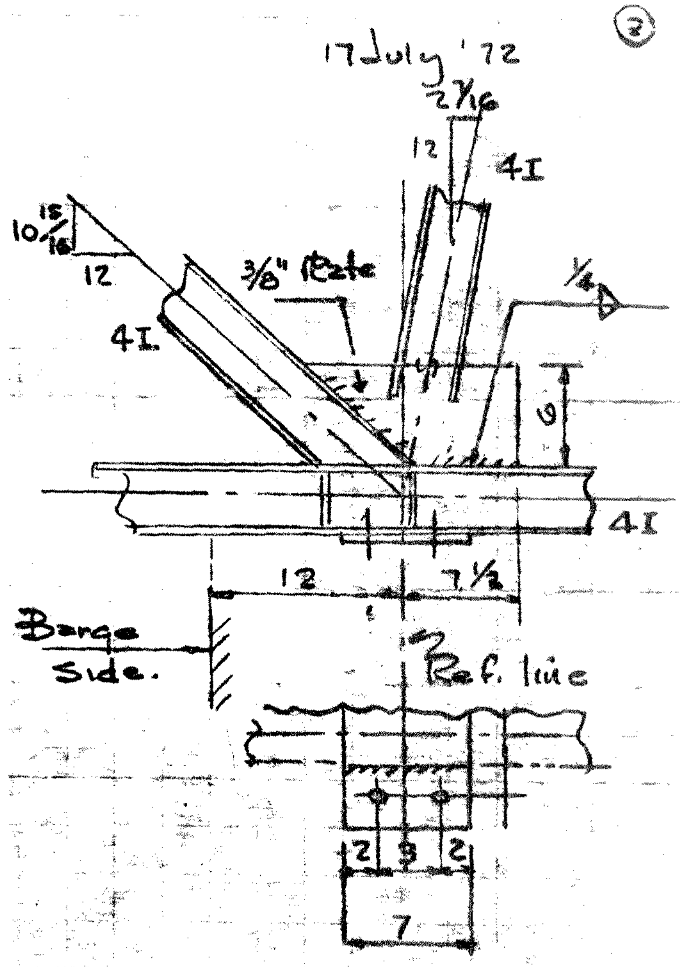

S.S. Sidney Smith
Vert. Ref. Line
Horiz Ref. line
Detail "A"
Detail "B"
Detail "C"
Detail "D"
Detail "E"
Detail F
Detail "G"
Detail "H"
12'-0
11'-0
11'-0
2'-0
5'-0
4×4×13# I
Built up Section
4×4×13# I



ITEM B (Continued) – COFFERDAM GUIDE

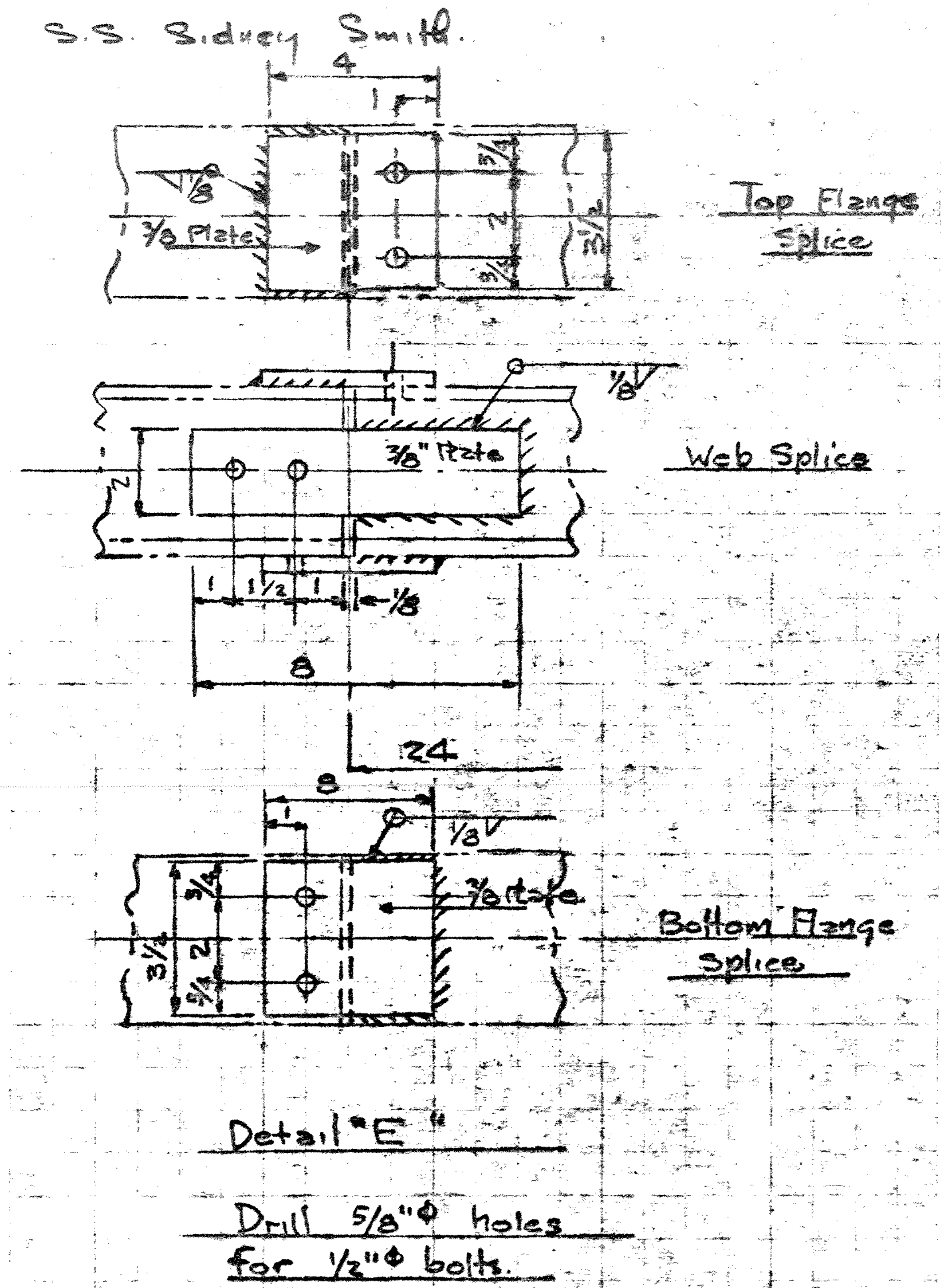


Detail "C"
with Base Plate.

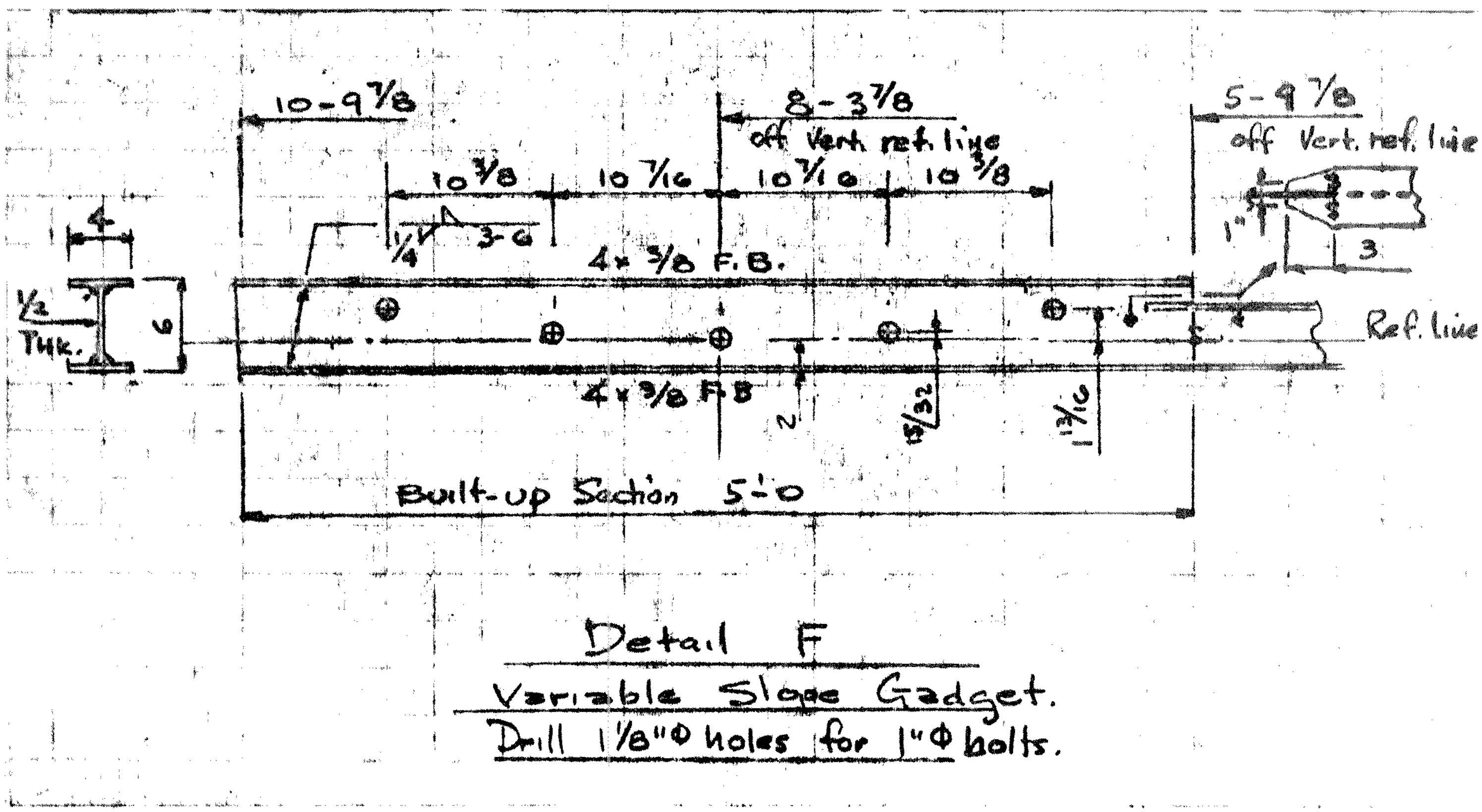


Detail "D"
with Base Plate.

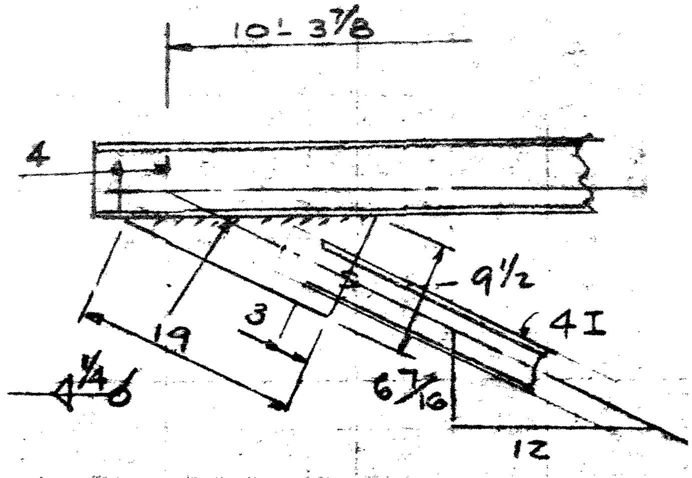
ITEM B (Continued) – COFFERDAM GUIDE



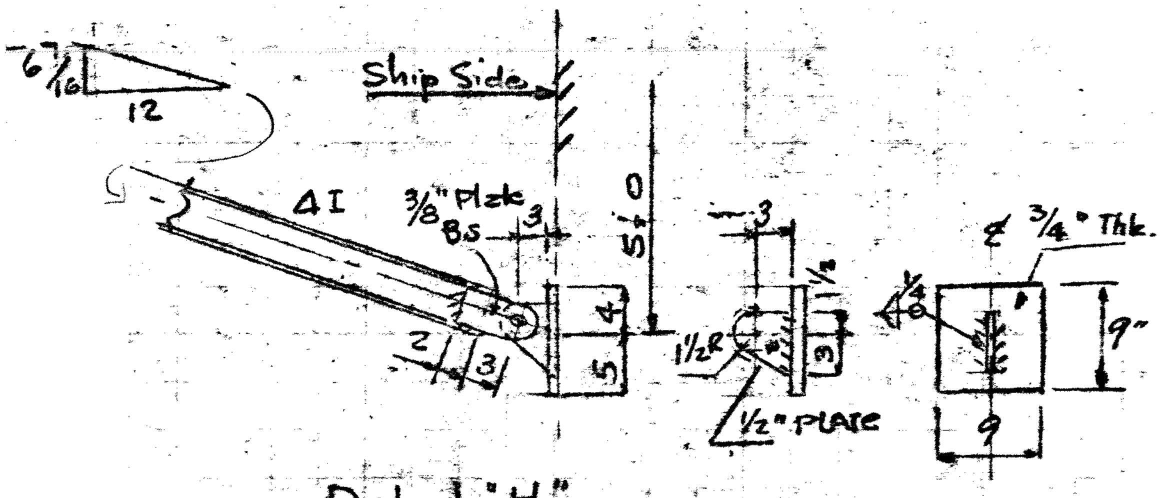
ITEM B (Continued) – COFFERDAM GUIDE



ITEM B (Continued) – COFFERDAM GUIDE



Detail "G"

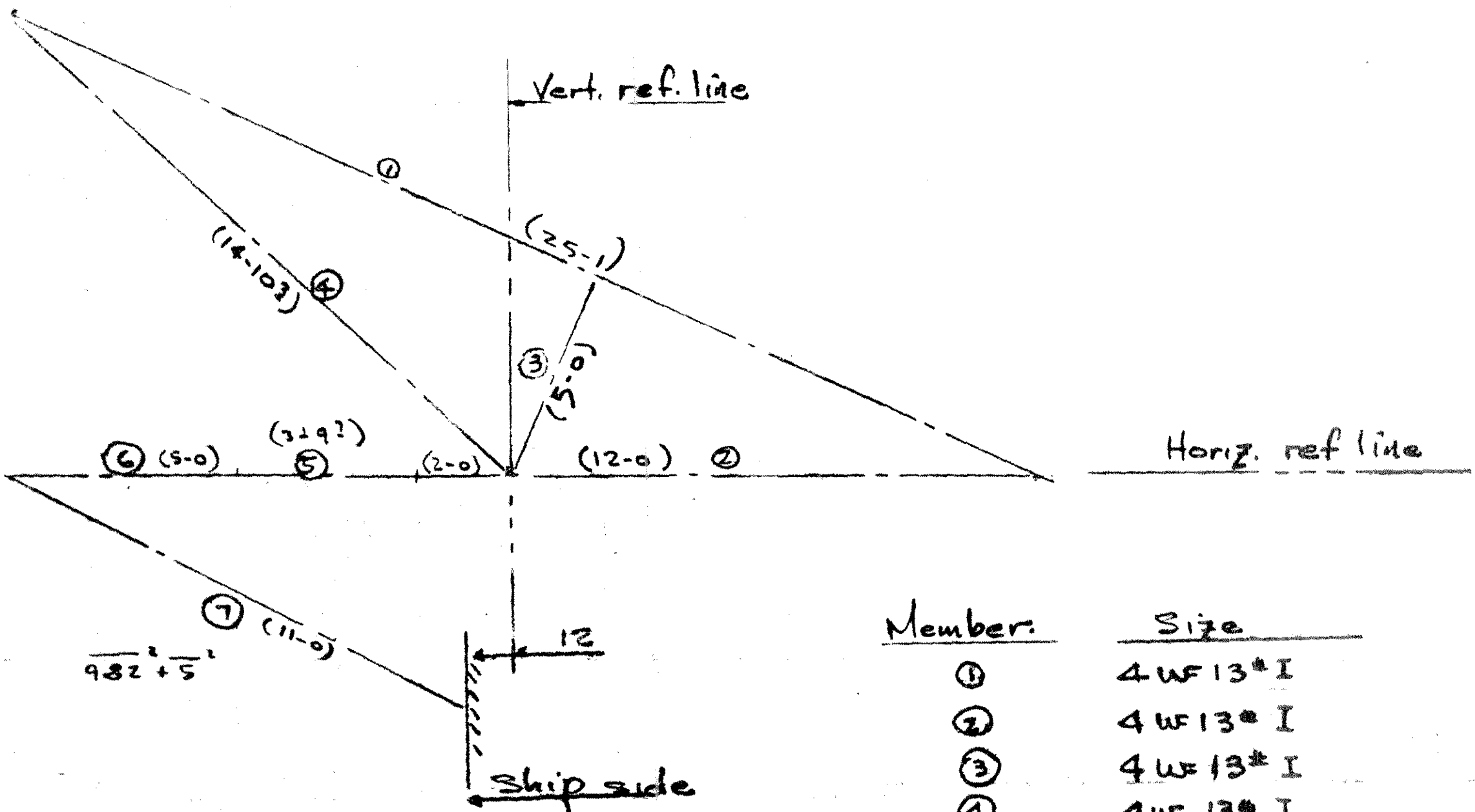


Detail "H"

Drill 1 1/8" Φ Hole

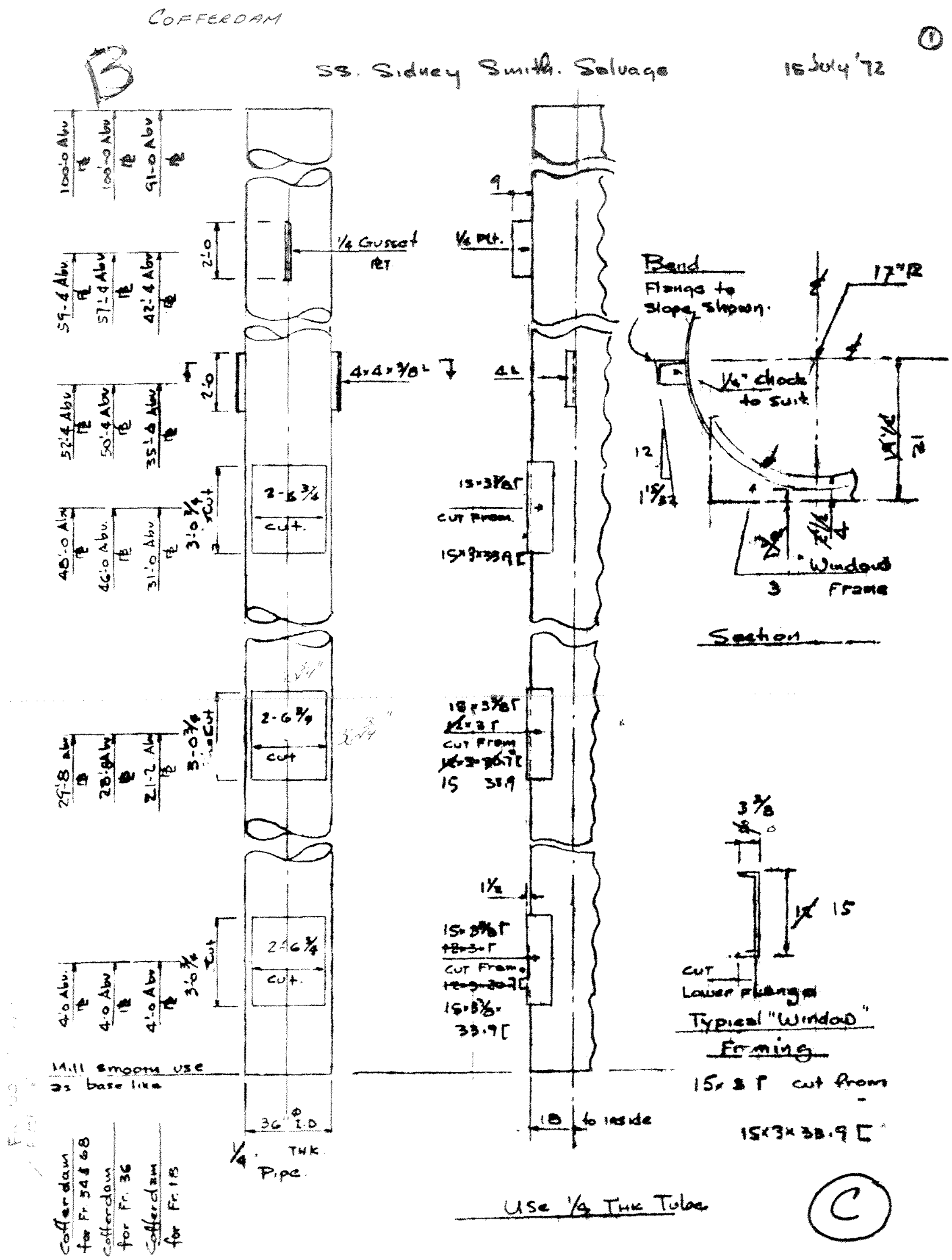
For 7/8 Φ pin

ITEM B (Continued) -- COFFERDAM GUIDE



Member	Size
①	4 WF 13# I
②	4 WF 13# I
③	4 WF 13# I
④	4 WF 13# I
⑤	4 WF 13# I
⑥	6×4 × 1/2/3/8 Built-up section
⑦	4 WF 13# I

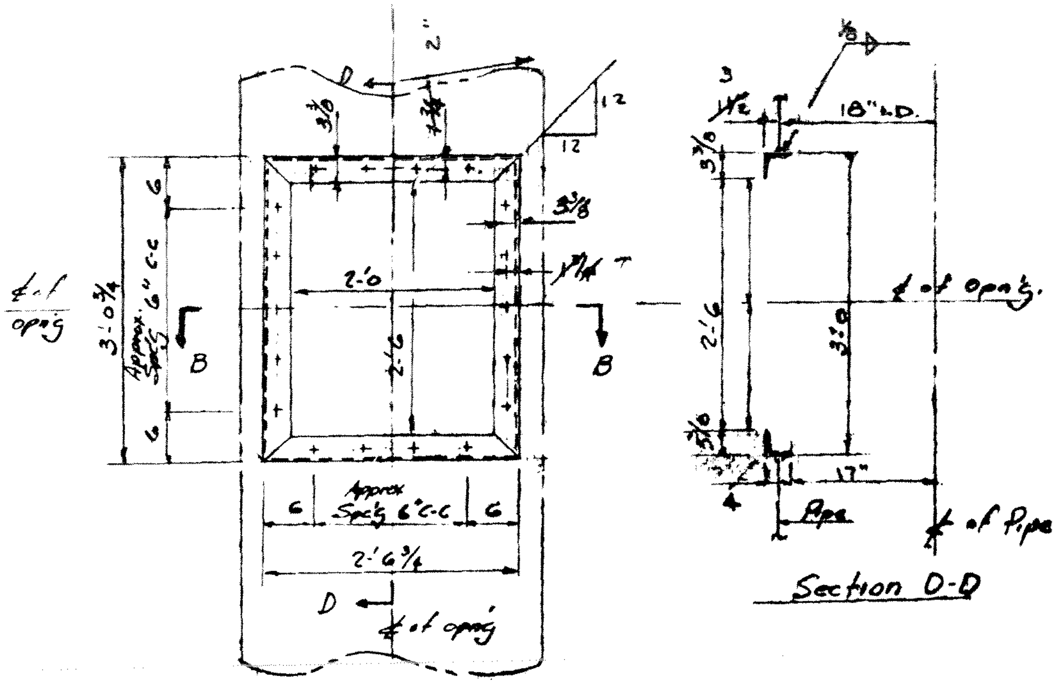
ITEM B (Continued) – COFFERDAM GUIDE

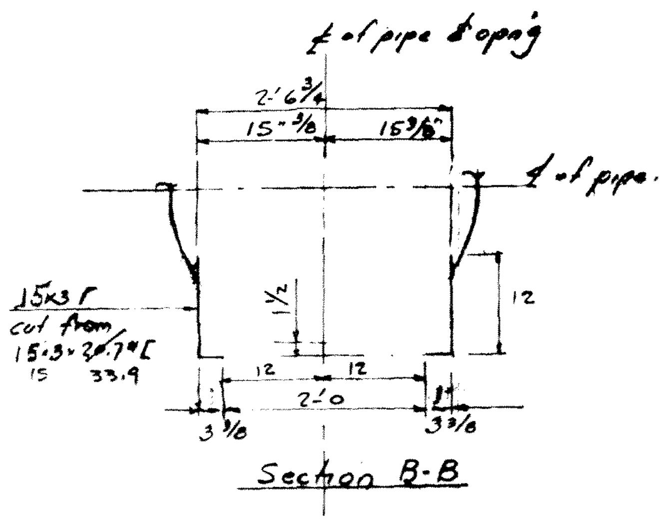


ITEM C – COFFERDAM

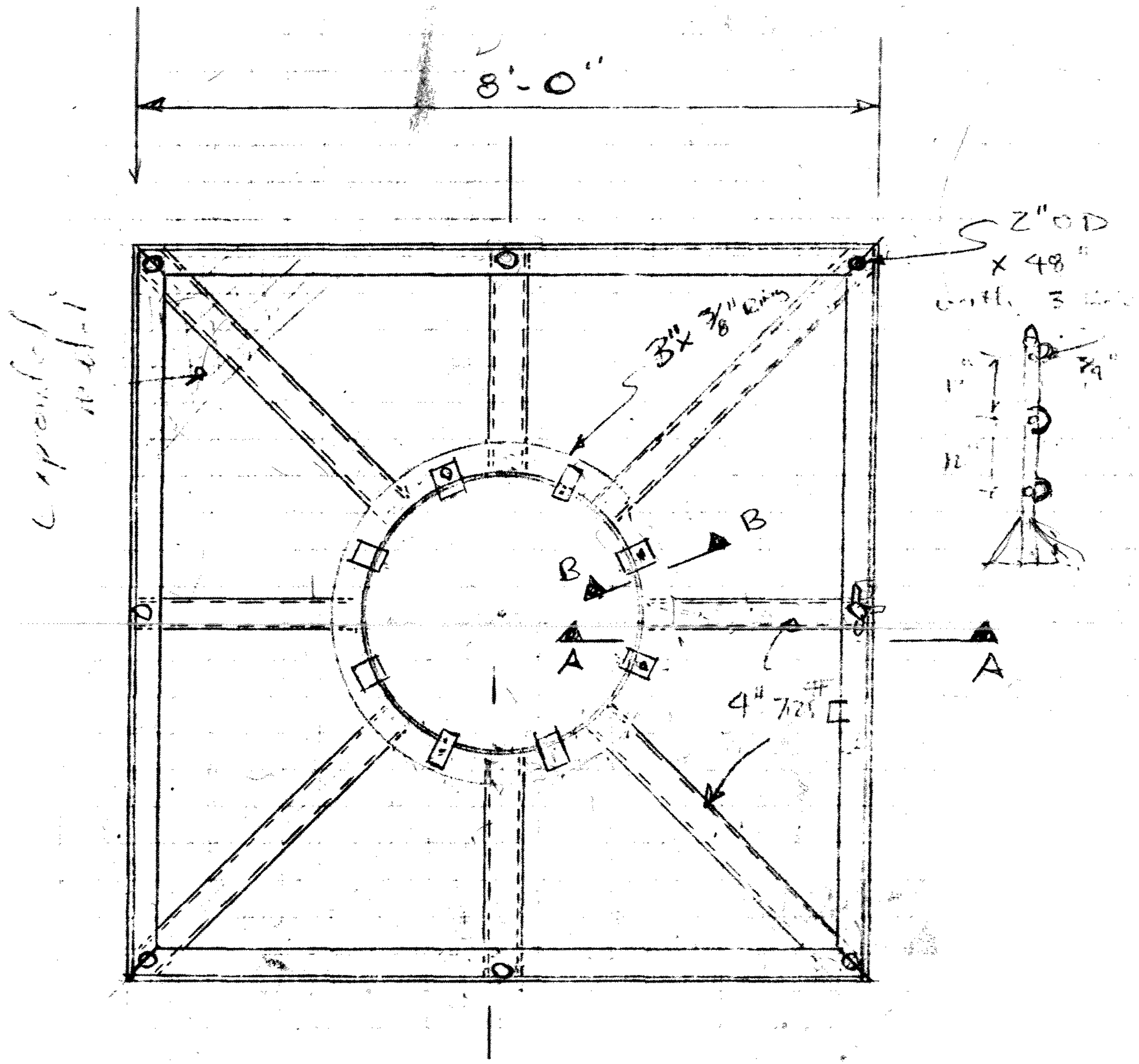
②

SS. Sidney Smith Salvage.

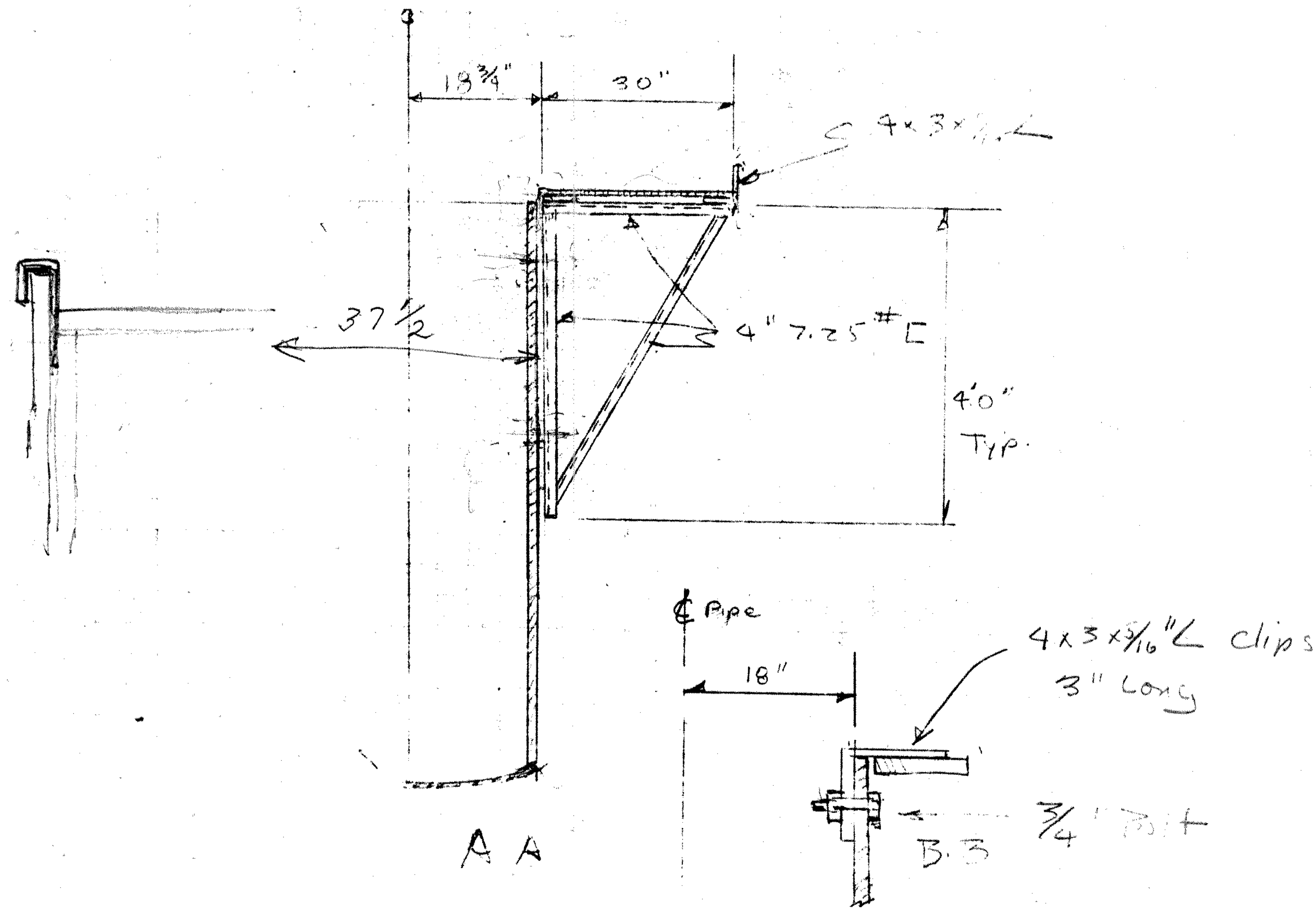




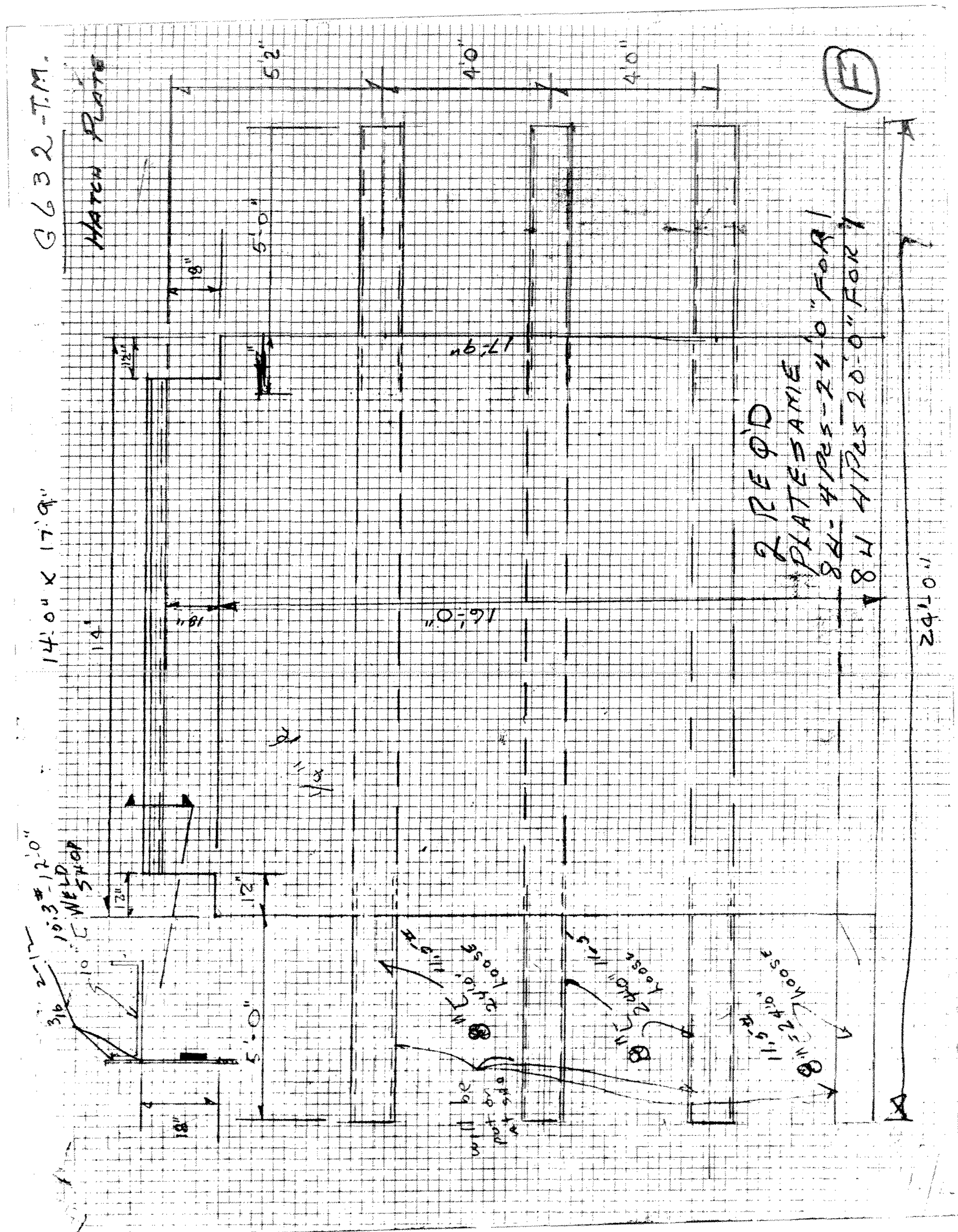
ITEM C (Continued) – COFFERDAM



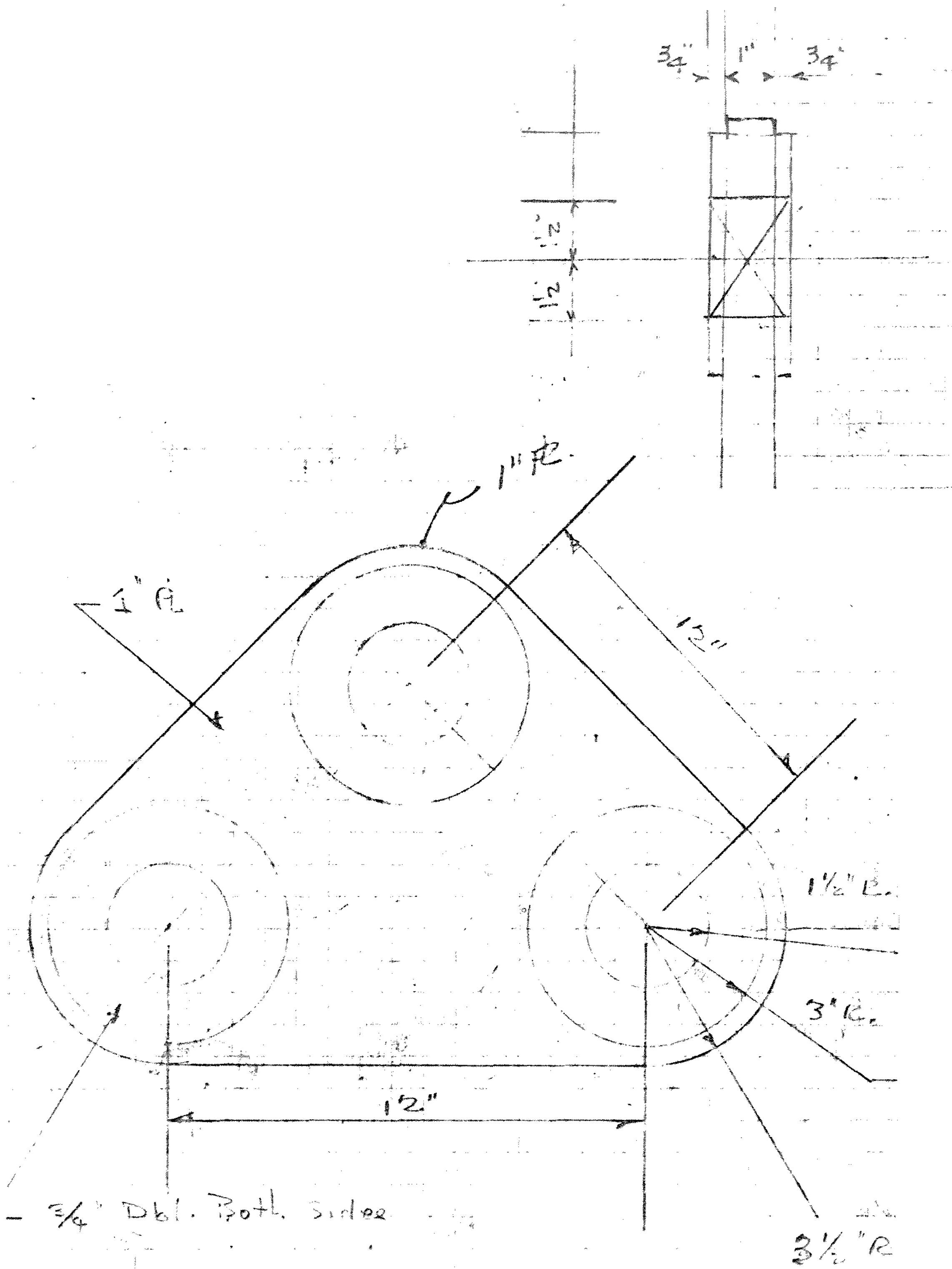
ITEM D – COFFERDAM PLATFORM



ITEM E – HATCH COVER HOOKS



ITEM F – HATCH PLATE



ITEM G – SPREADER CLEVIS

APPENDIX F

BENDIX SKAGIT CORPORATION REPORT
ON
SKAGIT WINCHES

Bendix

Skagit Corporation

P O Box 151
Sedro-Woolley, Wash 98284
Tel (206) 855-5311

A Subsidiary of
The Bendix Corporation

Supervisor of Salvage
Naval Ship Systems Command (Code 00C)
Department of the Navy
Washington, D.C. 20360

July 13, 1973

Attention: Lt. Mullen

Reference: 00C:EFL:Pam
3930/1046
Ser. 705/00C

Gentlemen:

In response to your request for information on the two Skagit hoists used in salvage operations of the sunken freighter "Sidney Smith" from the St. Clair River channel, we are enclosing brochures on the RB-97W and RB-150 hoists. Since the particular RB-150 used in the effort was equipped with a Caterpillar D-343 engine rather than the GM 12V-71 engines specified in the brochure, we've also enclosed engineering performance data for the specific unit.

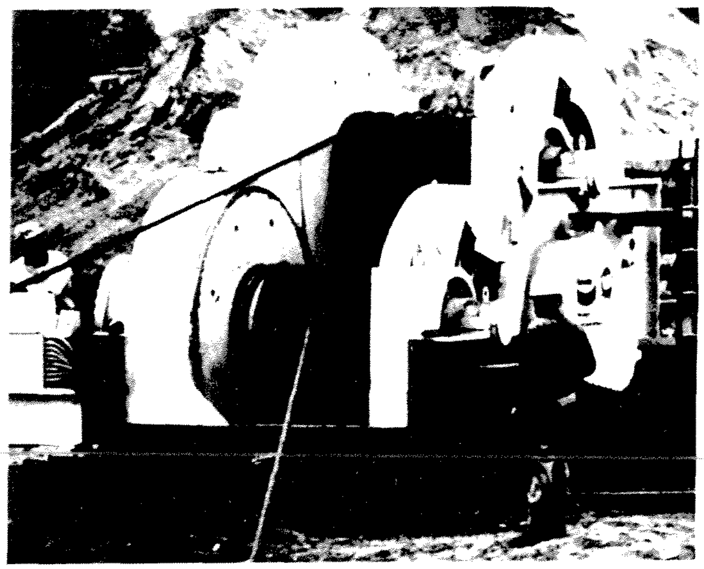
If you need additional data for use in preparing your salvage report, please advise.

Sincerely,

Fred W. Holder
Manager, Marketing-Communications

FWH:cm
Encl.

Skagit RB-150
Heavy Duty Hoist



Skagit Model RB-150 is one of Skagit's Line of RB Series Air Controlled Hoists . . . all built with full roller bearing construction and available in one, two, or three drum arrangements for every type of heavy duty service.

The RB-150 is designed for heavy lift and anchoring applications requiring from 4750 feet of 2" cable to 8440 feet of 1-1/2" cable.

The hoist has compound gearing in the drum set with choice of engines, sprocket ratios and Skagit's complete line of driving arrangements . . . including power shift transmissions, torque converters, dynamic braking drives and four-speed transmission . . . or electric drives . . . to meet specific speed-pull requirements.

The compound gearing is provided for extremely heavy lifts, pipe line work, anchor winch and related applications.

For more information on Skagit's complete line of construction hoists, contact your authorized dealers: Ross Equipment, Inc., Portland (503-253-1187) and Eugene (503-342-1196), Oregon . . . SECO, Inc., Tacoma (206-572-8630) and Chehalis (206-748-8657), Washington . . . CONMACO, Inc., Belle Chasse, Louisiana (504-362-8330) and Kansas City, Kansas (913-371-3930) . . . Skagit Equipment, Ltd., Langley (604-534-8566), B.C., Canada . . . or the factory: Skagit Corporation, a subsidiary of The Bendix Corporation, P.O. Box 151, Sedro-Woolley, Washington 98284 (206-855-5311).

Bendix **Skagit Corporation**

Skagit RB-150 Specifications

Capacities

DRUM SIZE

Flange Diameter	80"
Barrel Diameter	32"
Barrel Length	54"

CABLE CAPACITIES

8440' - 1-1/2"
6810' - 1-5/8"
6200' - 1-3/4"
5400' - 1-7/8"
4750' - 2"

NOMINAL RATING

Pounds Line Pull	130,000
FPM Line Speed	20

PULLING POWER *

Pound Maximum On Second Wrap *For Anchoring Service	250,000

MAXIMUM CABLE SIZE

Diameter	2"

MAXIMUM POWER

Rated Horsepower	400

BRAKE HOLDING POWER

Pounds Maximum at Second Wrap	260,000

NO LOAD SPEED

at Average Drum - FPM	238

DRUM SHAFT SIZE

Diameter	10-1/8"

AIR BRAKES

Diameter	70"
Width	10"

AIR FRICTIONS

Air Cylinder	36"
Friction Diameter	63"
Area - Square In.	1300

DRUM GEARS

Number Teeth	120
Stub Type - DP	1-1/2"
Face	10"

DRIVE PINION

Number Teeth	19
Stub Type - DP	1-1/2"
Face	12-1/2"

DRIVING ARRANGEMENT

Drive	TC
Hoist Gearing	Compound

ESTIMATED WEIGHT

2-Drum - Pounds	110,000

Construction Features

- Designed for heavy duty applications . . . built for long, hard usage with low cost maintenance and servicing. See rating and capacity information in Specification Data table.
- Roller bearing drums mounted on stationary shafts . . . to reduce frictional power loss . . . to give long, trouble-free service . . . easily adjustable bearings.
- Engineered with all shafts supported close to load centers for maximum shaft strength and rigidity.
- Drums are single piece cast steel . . . machined for perfect balance and designed for even spooling of 1-1/2" to 2" line.
- Roller bearing drum gears on stationary drum shafts; drive and intermediate gears on roller bearing shafts . . . adjustable bearings . . . wide-face, precision cut gears and pinions using highest quality gear steel.
- Rotating shafts have cartridge type roller bearings for easiest adjustment at ends of shaft.
- Choice of engines up to 400 horsepower . . . choice of torque converter, direct or multi-speed transmission drives.
- Compound hoist gearing to take full advantage of engine power for heaviest pulls on any type of application . . . optional sprockets in combination with choice of power units and drives to fit hoist for correct speed-pull ratios to suit the job.
- Air controls . . . easy to operate . . . conveniently located at control console . . . remote control arrangements and elevated enclosed cab also available.
- One-drum . . . Two-drum . . . Three-drum arrangements . . . waterfall design or drums in line . . . third drum underwinding or overwinding . . . provision available for line lead under drum set and power unit when specified as original equipment.
- Powerful air frictions with strong, positive-action, spring-loaded release . . . engineered to maximum hoist capacity . . . double face, cone-type friction blocks . . . large diameter and friction surface area. See Specification Data for Friction, Gear and Brake measurements.
- Wide, large-diameter air-operated brakes . . . self-energizing with release springs to prevent dragging . . . provisions for quick, easy adjustment at center of band . . . heat dissipating cast iron brake ring. Fail Safe type air brakes with air-off, spring-loaded-on features are available as optional extra.
- Air operated ratchet and dog . . . forged steel pawl . . . safe and easy-to-operate when holding load or maintaining tension on line . . . visual indicator to show when dog is engaged.
- Carefully designed guards to protect equipment and personnel . . . with access for servicing and maintenance.
- Oil tight gear cases . . . available for compound gearing.

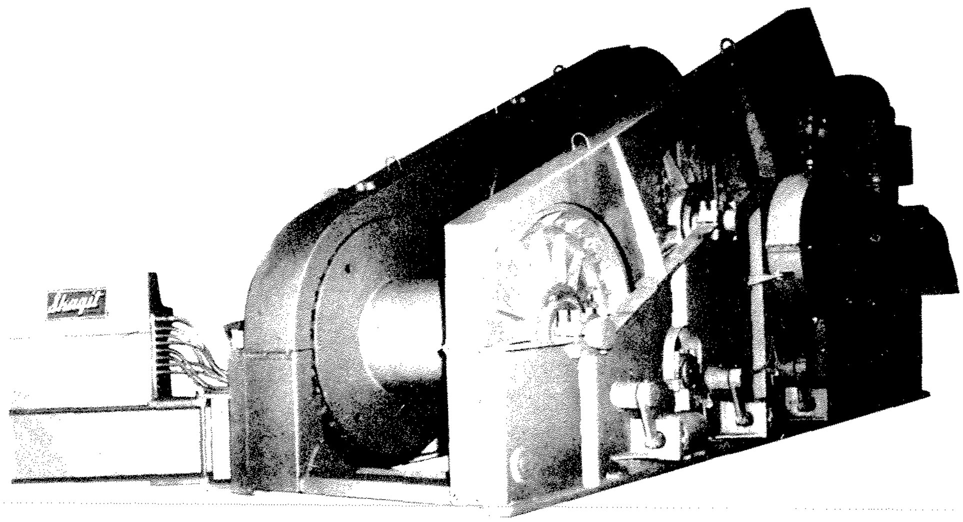
Typical Line Pulls in Pounds and Line Speed in Feet per Minute for the RB-150 with GM 12V-71 Engine, TD-11,500 Series Torque Converter, Compound gearing in Hoist with sprocket ratio of 21 to 78. Optional sprockets are available to adjust speed-pull requirements to fit the application.

RANGE	FULL DRUM	AVERAGE DRUM	BARE DRUM
High Range 70% Efficiency	18,800 @ 331	26,300 @ 238	43,300 @ 144
Maximum Efficiency	38,500 @ 207	53,700 @ 148	88,500 @ 90
Low Range 70% Efficiency	82,800 @ 87	115,400 @ 62	190,000 @ 38
Stall	120,700	168,100	277,000

ALL SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

C-3/73-033

Skagit RB-97W Heavy Duty Hoists



SKAGIT MODEL RB-97W is one of Skagit's Complete Line of RB Series Air Controlled Hoists . . . all built with full roller bearing construction and available in graduated sizes for every type of heavy duty service.

The RB-97W is engineered for heavy lift and anchoring applications requiring from 3250 feet of 1-3/4" cable to 8000 feet of 1-1/8" cable. It is a quality hoist in one, two or three drum arrangements and with many special features described on the reverse page. Single or compound gearing is optional with choice of engines, sprocket ratios and Skagit's complete line of driving arrangements . . . including power shift transmissions, torque converters, dynamic braking drives and four-speed transmissions . . . or electric drives . . . to meet specific speed-pull requirements.

The Single Reduction Gearing arrangement is designed for derrick, gin pole, power line pulling and related applications. The Compound Gearing arrangement is provided for the extra heavy work including pipe line pulling, heavy lifts, penstock lowering, anchor winch and related applications.

For Detailed Information on All Sizes of Skagit RB Series Hoist and Skagit's Complete Line of Heavy Duty Hoisting Equipment . . . Consult The Factory: Skagit Corporation, P.O. Box 151, Sedro Woolley, Washington.

Bendix **Skagit Corporation**

Skagit Model RB-97W Hoists — Specification and Capacity Data

DRUM SIZE	
Flange Diameter	66"
Barrel Diameter	26"
Barrel Length	44"
CABLE CAPACITIES	8000' - 1-1/8" 6475' - 1-1/4" 5360' - 1-3/8" 4500' - 1-1/2" 3850' - 1-5/8" 3250' - 1-3/4"
NOMINAL RATING	
Pounds Line Pull	48,000
FPM Line Speed	75
PULLING POWER*	
Pound Maximum On Second Wrap *For Anchoring Service	175,000
MAXIMUM CABLE SIZE	
Diameter	1-3/4"
MAXIMUM POWER	
Rated Horsepower	300
BRAKE HOLDING POWER	
Pounds Maximum at Second Wrap	200,000
NO LOAD SPEED	
at Average Drum - FPM	150
DRUM SHAFT SIZE	
Diameter	8"
AIR BRAKES	
Diameter	64"
Width	10"
AIR FRICTIONS	
Air Cylinder	26"
Friction Diameter	58"
Area - Square In.	1090
DRUM GEARS	
Number Teeth	108
Stub Type - DP	1-1/2"
Face	7"
DRIVE PINION	
Number Teeth	21"
Stub Type - DP	1-1/2"
Face	9"
DRIVING ARRANGEMENT	
Drive	TC
Hoist Gearing	Compound or Single Reduction
ESTIMATED WEIGHT	
2-Drum - Pounds	56,000

Check These RB-97W Construction Features

- Designed for heavy duty applications . . built for long, hard usage with low-cost maintenance and servicing. See rating and capacity information in Specification Data table.
- Roller bearing drums mounted on stationary shafts . . to reduce frictional power loss . . to give long, trouble-free service . . easily adjustable bearings.
- Engineered with all shafts supported close to load centers for maximum shaft strength and rigidity.
- Drums are single piece cast steel . . machined for perfect balance and designed for even spooling of 1-1/8" to 1-3/4" line.
- Roller bearing drum gears on stationary drum shafts; drive and intermediate gears on roller bearing shafts . . adjustable bearings . . wide-face, precision cut gears and pinions using highest quality gear steel.
- Rotating shafts have cartridge type roller bearings for easiest adjustment at ends of shaft.
- Rigid structural steel frame, heavily braced . . cast steel shaft pedestals and bearing supports.
- Choice of engines up to 300 horsepower . . choice of torque converter, direct or multi-speed transmission drives.
- Choice of hoist gearing to take full advantage of engine power on any type of application . . single reduction or compound gearing in hoist drum set to suit operating requirements for speed and pull ratios . . optional sprockets to fit hoist application . . all engineered to meet any combination of high, medium or low speed and pull requirements within the capacity of the hoist . . to provide the right speed-pull ratios for any type of service.
- Air controls . . easy to operate . . conveniently located at control console . . remoted control arrangements and elevated enclosed cab also available.
- One-drum . . Two-drum . . Three-drum arrangements . . waterfall design or drums in line . . third drum underwinding or overwinding . . provision available for line lead under drum set and power unit when specified as original equipment.
- Optional boom swingers . . detachable type or fixed type integral with hoist.
- Powerful air frictions with strong, positive-action, spring-loaded release . . engineered to maximum hoist capacity . . double face, cone-type friction blocks . . large diameter and friction surface area. See Specification Data for Friction, Gear and Brake measurements.
- Wide, large-diameter air-operated brakes . . self-energizing with release springs to prevent dragging . . provisions for quick, easy adjustment at center of band . . heat dissipating cast iron brake ring. Fail Safe type air brakes with air-off, spring-loaded-on features are available as optional extra.
- Air operated ratchet and dog . . forged steel pawl . . safe and easy-to-operate when holding load or maintaining tension on line . . visual indicator to show when dog is engaged.
- Carefully designed guards to protect equipment and personnel . . with access for servicing and maintenance.
- Oil tight gear cases . . available for compound gearing.

FOR COMPLETE INFORMATION ON THE RB-90W and THE COMPLETE LINE OF SKAGIT HEAVY DUTY HOIST FOR EVERY PURPOSE . . . CONSULT THE FACTORY: SKAGIT CORPORATION, P. O. BOX 151, SEDRO WOOLLEY, WASHINGTON.

Typical Line Pulls in Pounds and Line Speed in Feet per Minute for the RB-97W with GM 8V-71 Engine, TD-10,000 Series Torque Converter, Compound gearing in Hoist with sprocket ratio of 17 to 92. Single reduction gearing will provide faster speeds at correspondingly lower pulls; optional sprockets are available to adjust speed-pull requirements to fit the application.

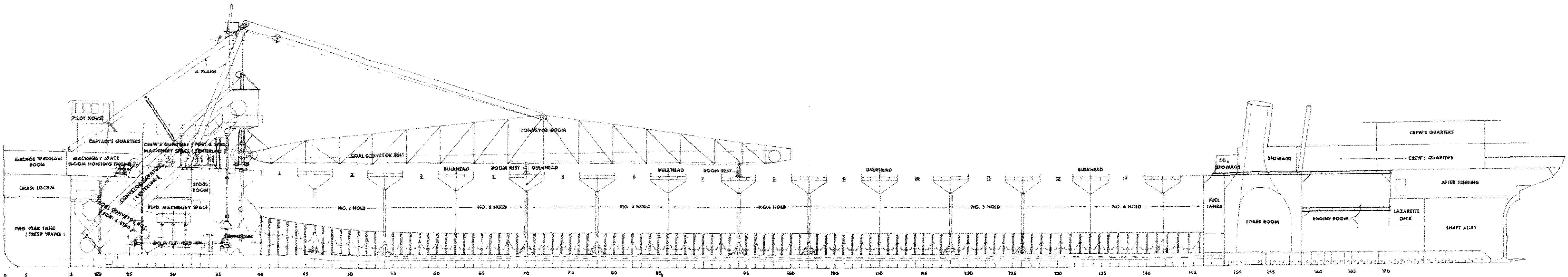
RANGE	FULL DRUM	AVERAGE DRUM	BARE DRUM
High Range 70% Efficiency	20,500 @ 263	28,500 @ 189	46,900 @ 115
Maximum Efficiency	38,100 @ 159	53,100 @ 114	87,200 @ 70
Low Range 70% Efficiency	72,000 @ 68	100,200 @ 68	164,700 @ 30

APPENDIX G

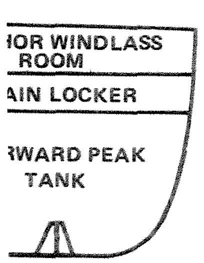
S.S. SIDNEY E. SMITH, JR.

CENTERLINE AND CROSS SECTION PROFILES

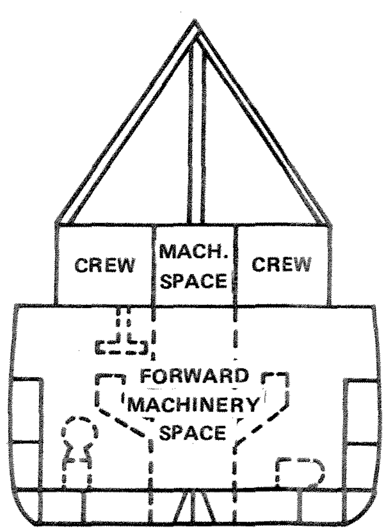
☆ U. S. GOVERNMENT PRINTING OFFICE : 1976 O - 221-518



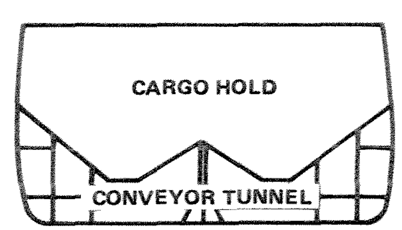
BREAK-UP OCCURRED
AT FRAME 85



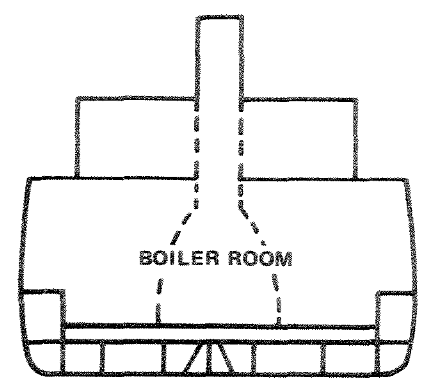
CTION, FRAME 5
ARD SPACES



CROSS SECTION, FRAME 35
FORWARD MACHINERY SPACE



CROSS SECTION, FRAME 100
TYPICAL CARGO HOLD



CROSS SECTION, FRAME 155
BOILER ROOM

PLAN OF GREAT LAKES COAL FREIGHTER
S.S. SIDNEY E. SMITH, JR.

LENGTH: 489′ DISPLACEMENT: 4,639 TONS
BEAM: 52′ PROPULSION: STEAM