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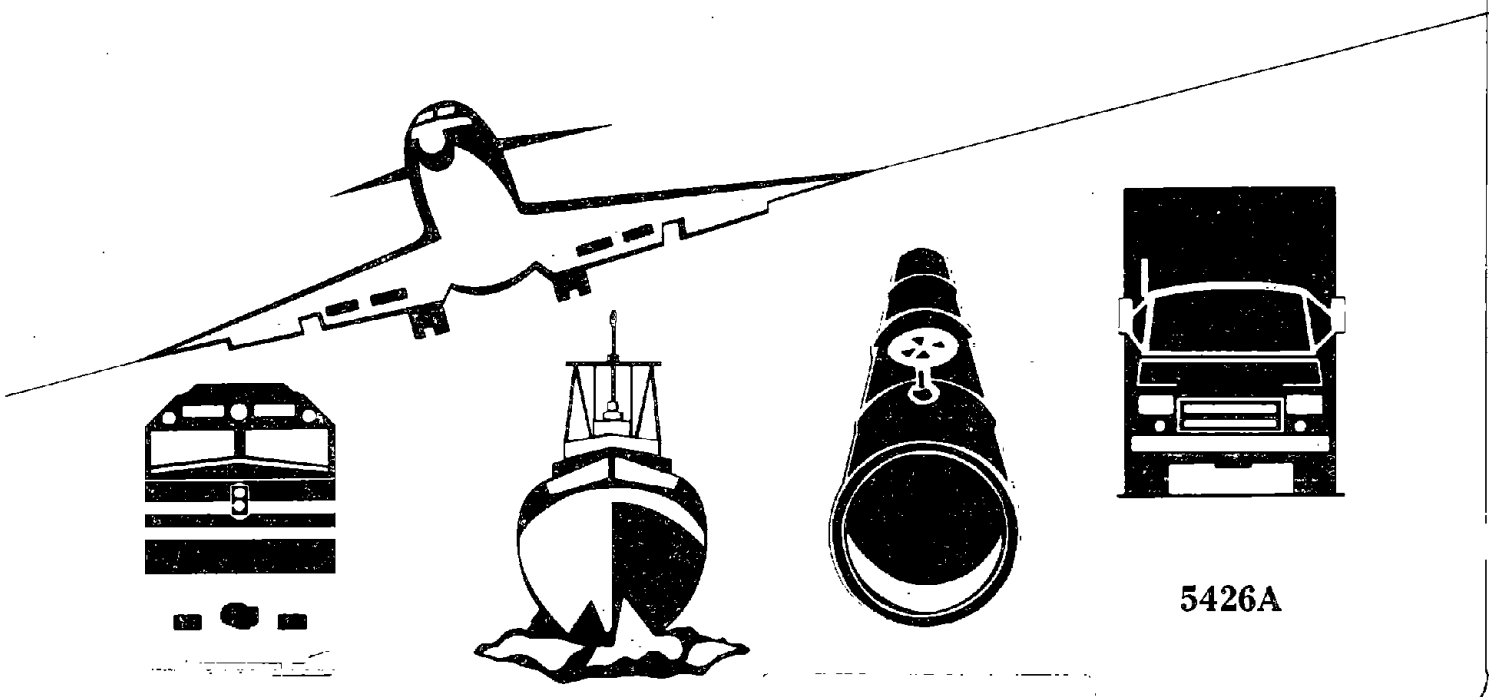
NTSB/MAR-91/04

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

MARINE ACCIDENT REPORT

EXPLOSION AND FIRE ABOARD THE U.S. TANKSHIP JUPITER BAY CITY, MICHIGAN SEPTEMBER 16, 1990



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FIRE AND EXPLOSION ABOARD THE U.S. TANKSHIP JUPITER BAY CITY, MICHIGAN SEPTEMBER 16, 1990

ADOPTED: OCTOBER 29, 1991
NOTATION 5426A

Abstract: This report explains the fire and explosion aboard the U.S. Tankship JUPITER, Bay City, Michigan, September 16, 1990. The safety issues discussed in the report are the adequacy of the ship berthing facilities at the Total Petroleum, Inc., terminal at Bay City; the adequacy of the mooring procedures aboard the JUPITER and at the Total Petroleum pier; the speed and track of the BUFFALO as it passed the moored JUPITER; the lack of a communications system to notify a vessel moored at a bulk fuel discharging terminal that another vessel was approaching in the channel; the adequacy of the disaster contingency plans for the area; and the installation of the flame screens in the ullage pipes aboard the JUPITER.

The National Transportation Safety Board made safety recommendations addressing these isssues to the U.S. Coast Guard, Total Petroleum, Inc., Cleveland Tankers, Inc., the Lake Carriers Association, the State of Michigan, and the Bay County Emergency Services.

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EXECUTIVE SUMMARY

On Sunday, September 16, 1990, the 392-foot-long U.S. tankship JUPITER was moored at the Total Petroleum, Inc., terminal (Total Petroleum) on the Saginaw River in Bay City, Michigan, discharging a cargo of unleaded gasoline. While the JUPITER lay moored at Total Petroleum's pier, the 635-foot-long bulk carrier BUFFALO entered the Saginaw River en route to a bulk materials handling facility at Midland, Michigan, to discharge a cargo of coal. As the BUFFALO passed the JUPITER, the tankship broke away from its berth and its stern swung out into the river, rupturing the discharge hose to the pier and damaging the pipeline on the pier. Gasoline spilled on the pier and onto the deck of the JUPITER. The electrical cables to two motor-operated valves that closed off the pipelines at the end of the pier were torn apart, causing sparks that ignited the spilled gasoline. Fire spread to the deck of the JUPITER, causing a series of explosions in the cargo tanks that destroyed the entire midship section of the vessel. One crewmember died during abandonment of the vessel. The JUPITER, valued at $9 million, was declared a total loss and later sold for scrap.

The safety issues discussed in the report are:

- The adequacy of the ship berthing facilities at the Total Petroleum, Inc., terminal at Bay City;
- The adequacy of the mooring procedures aboard the JUPITER and at the Total Petroleum pier;
- The speed and track of the BUFFALO as it passed the moored JUPITER;
- The lack of a communications system to notify a vessel moored at a bulk fuel discharging terminal that another vessel was approaching in the channel;
- The adequacy of the disaster contingency plans for the area; and
- The installation of the flame screens in the ullage pipes aboard the JUPITER.

The National Transportation Safety Board determines that the probable cause of the fire and explosions aboard the tankship JUPITER was the failure of Total Petroleum, Inc., to provide adequate mooring facilities for tankships such as the JUPITER, which allowed the vessel to break away from the pier because of surging caused by a passing vessel. Contributing to the accident were the inadequate procedures used aboard the JUPITER for managing the mooring lines and winches while other ships passed nearby and the fact that the BUFFALO was navigated to pass closer to the JUPITER than normal. Contributing to the severity of the accident were the lack of a reliable and timely alerting system that would have given the JUPITER's crew adequate time to take additional precautions to safeguard the vessel and the failure of the owners of the JUPITER and the U.S. Coast Guard to ensure that flame screens were properly fitted.

As a result of this investigation, the Safety Board made recommendations to the U.S. Coast Guard, Total Petroleum, Inc., Cleveland Tankers, Inc., the Lake Carriers Association, the State of Michigan, and the Bay County Emergency Services.

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

MARINE ACCIDENT REPORT

FIRE AND EXPLOSION ABOARD THE U.S. TANKSHIP JUPITER BAY CITY, MICHIGAN

SEPTEMBER 16, 1990

INVESTIGATION

Events Preceding the Accident

JUPITER.--At 0145, eastern standard time, on September 16, 1990, the 392-foot-long U.S. tankship JUPITER arrived at the Total Petroleum, Inc., (Total Petroleum) facility in Bay City, Michigan, loaded with 56,000 barrels of unleaded gasoline. (See figure 1.) Originally loaded at a Sun Oil Company refinery in Sarnia, Canada, the entire cargo was to be discharged at Total Petroleum's Bay City terminal.

By 0205, the crew had secured the JUPITER, starboard side to the pier heading upstream, and had rigged a boarding ladder. They moored the tankship as they had done before at the Total Petroleum facility, with six lines that consisted of two polypropylene lines and one wire rope cable from each of four constant-tension winches. (See figure 2.)

The winches were numbered 1 through 4 from forward. (For this report investigators have numbered the mooring pile clusters in similar order for reference.) The vessel's parallel midbody (straight sides of the hull) lay against Nos. 2 and 3 pile clusters. Nos. 1 and 4 mooring wires led fore and aft, respectively, to the Nos. 1 and 4 pile clusters, which were set back and made no contact with the vessel's hull. The No. 2 mooring wire was led aft as a spring line [1] and secured to the No. 2 pile cluster. Similarly, the No. 3 mooring wire was led forward as an after spring line to the No. 3 pile cluster. The two polypropylene mooring lines were led from the bow and stern to Nos. 1 and 4 pile clusters, respectively. The No. 3 pile cluster, shown in figure 3 after the accident, is typical of the pile clusters at Total Petroleum's terminal.

After securing the JUPITER to the Total Petroleum pier, the crew prepared to discharge its gasoline cargo. They connected the cargo hose and the bonding cable and gauged the tanks before they began discharging. It was expected that the cargo transfer would be completed during the morning and that the vessel would sail at 1200.

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[1] A mooring line that leads in a fore and aft or diagonal direction from a ship's side to ashore to constrain the ship's motion in a fore and aft direction when moored. Also used to draw a vessel alongside by the athwartship component of force exerted when the line is in tension and the vessel is in motion.

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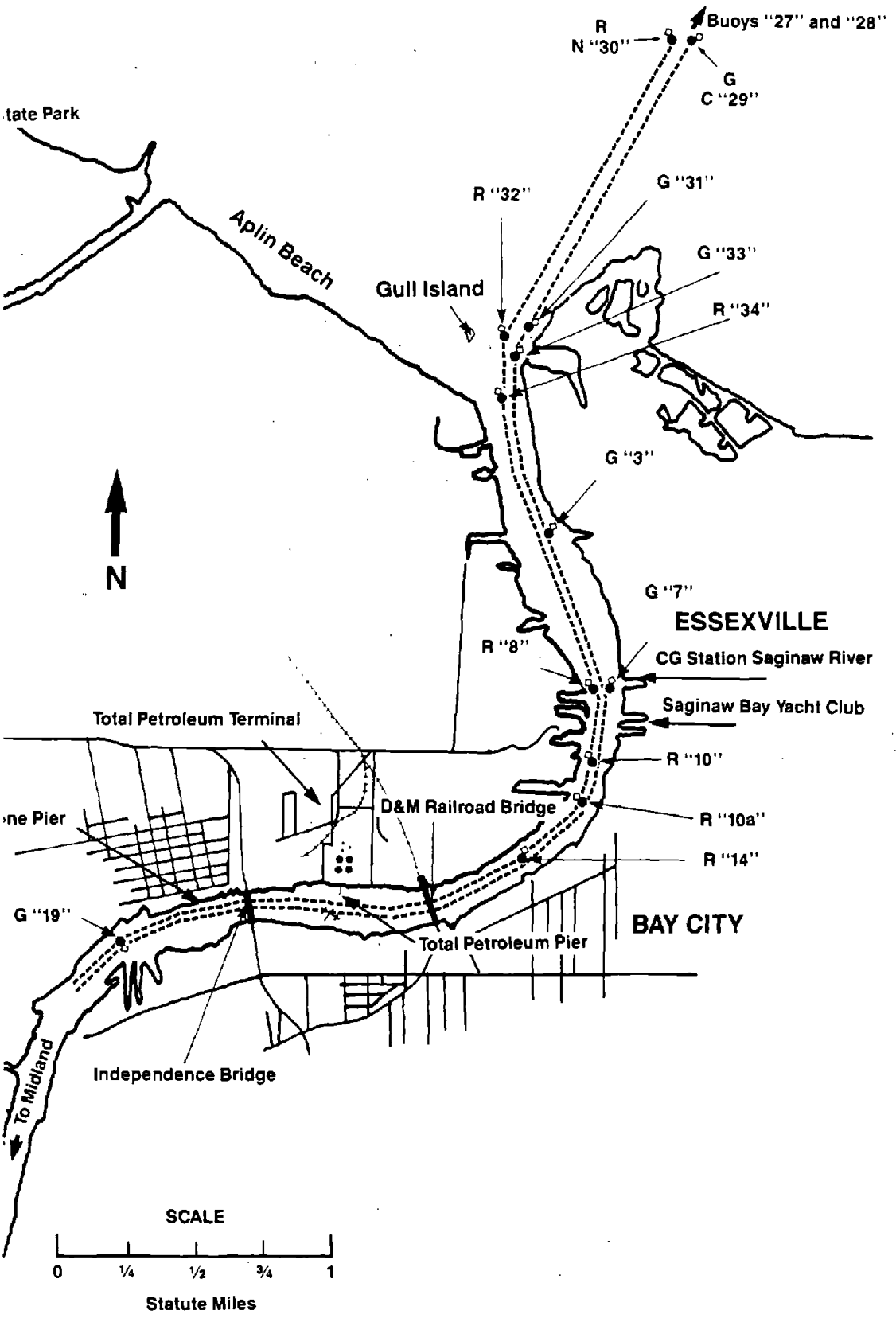

Figure 1.--Saginaw River at Bay City, Michigan.

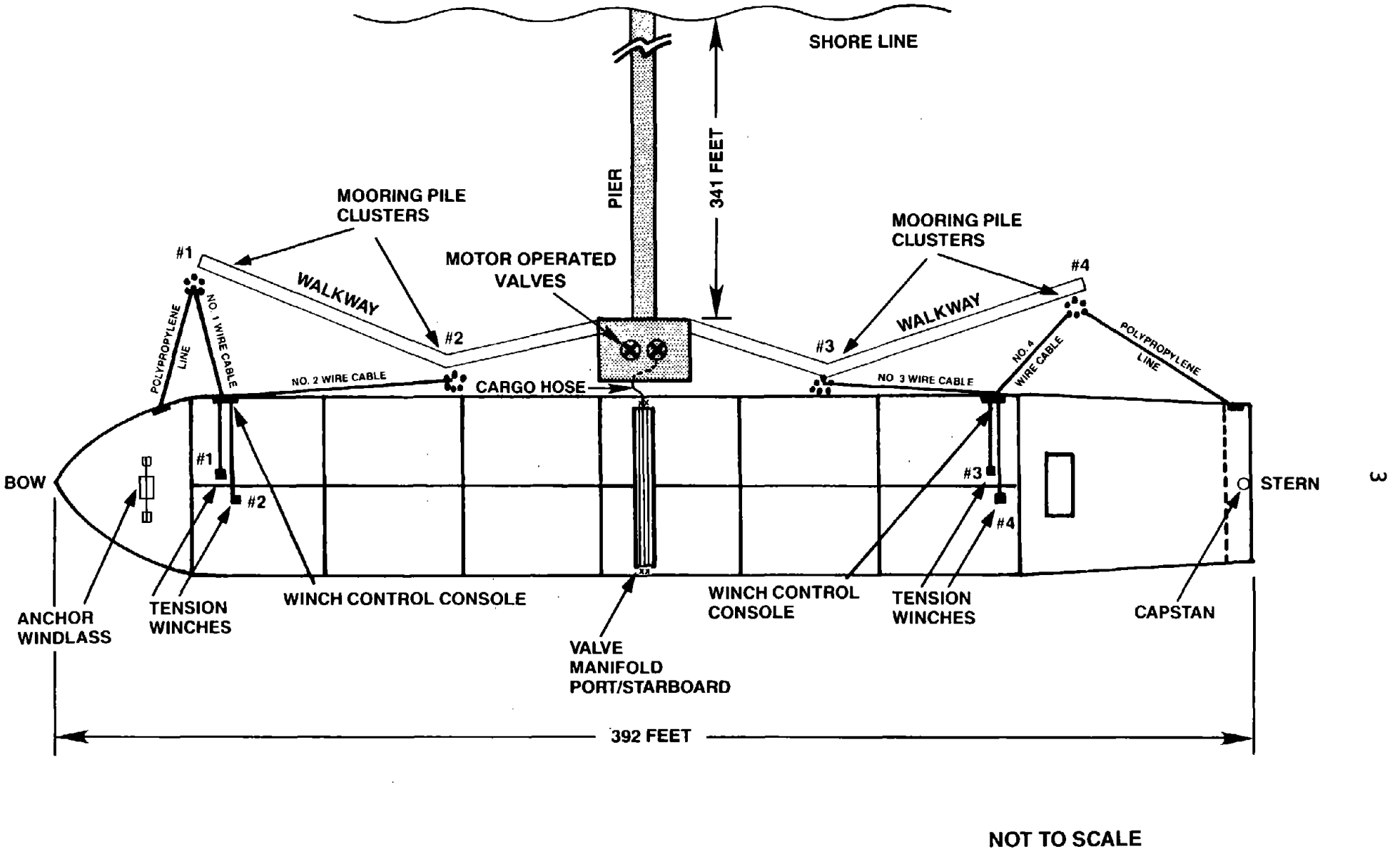

Figure 2.--JUPITER's mooring arrangement.

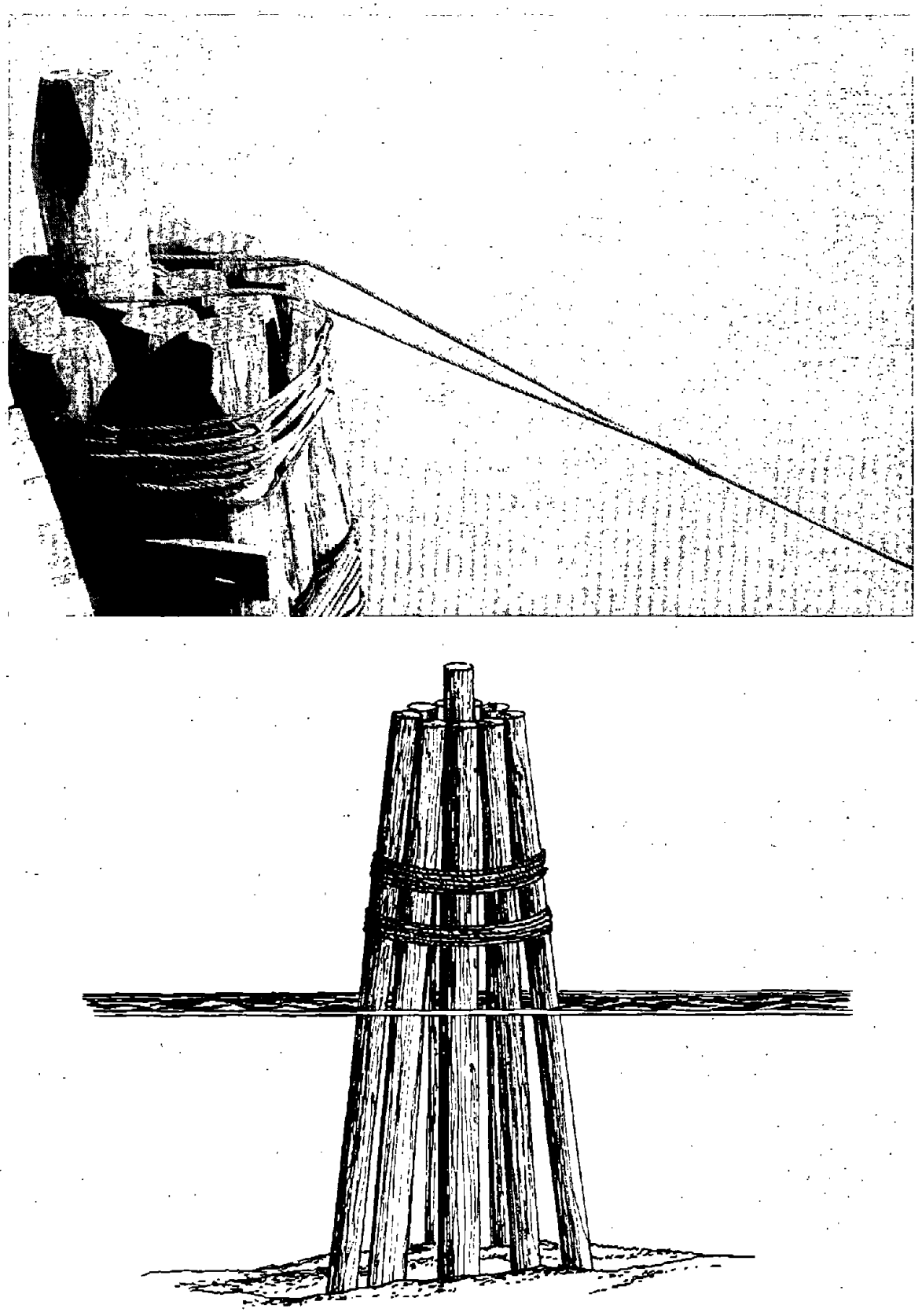

Figure 3.--No. 3 pile cluster, Total Petroleum terminal.

BUFFALO.--At 0655 on September 16, the 635-foot-long bulk carrier BUFFALO entered the entrance channel to the Saginaw River. The master, the first mate, and the wheelsman were on the bridge. The master was conning the vessel, giving orders to the wheelsman, and operating the engine controls himself. The first mate had broadcast a "security" call over VHF-FM channel 16, advising that the BUFFALO was inbound in the Saginaw River, bound for Midland. About 0700, he called Coast Guard Station Saginaw River (Station Saginaw River) for a tide reading. Station Saginaw River advised him that the height of the tide was (+) 33 inches. (A reading was taken later that indicated a height of [+] 28 inches). The BUFFALO's cargo, 13,585 tons of coal, gave the vessel a draft of 15 feet 6 inches forward and 18 feet 11 inches aft, for a displacement of 17,500 long tons.

At 0730, the third mate relieved the first mate as watch officer. The BUFFALO's master testified that he continued at full speed (approximately 11-12 knots according to the third mate) until 0800, when he reduced speed to 9 feet of pitch [2] (approximately 6-7 knots) as the vessel passed buoys 27 and 28. (Vessel operators consider these buoys the entrance to the Saginaw River.) According to the BUFFALO's log, wind velocity in Saginaw Bay was 20 knots from the northeast. Visibility was about 3 miles in light rain. At 0800, Station Saginaw River radioed the BUFFALO and asked whether the vessel was inbound or outbound. The master radioed back that he was inbound en route to the Midland Contracting pier. Shortly thereafter, the master broadcast a second security call, advising of his position and destination.

As the BUFFALO entered the narrow section of the river, the master reduced speed to 6 feet of pitch (approximately 4-5 knots). The master later testified that the bridge watch kept no record of the vessel's position in the river, the time of engine maneuvers, or the time of passing bridges, nor is it customary to do so on the Great Lakes. Deck log entries only indicated when the vessel entered the river and when it arrived at the pier in Midland.

The master testified that he maintained 6 feet of pitch while the BUFFALO passed the marinas near Station Saginaw River. He said, "I have no knowledge of how to equate that to knots. I just know that it's a safe speed to handle the ship without doing damage." As the BUFFALO started turning slowly to starboard toward the Detroit & Mackinaw (D&M) railroad bridge, he sighted the JUPITER moored at the Total Petroleum terminal. According to the master, he immediately reduced the pitch to 4 feet before adjusting the vessel's heading to pass through the right-hand draw (opening) of the swing bridge.

The master testified that 4 feet of pitch was the minimum speed at which he could operate the BUFFALO and still maintain control. Lowering the pitch control another position would have placed the propeller at zero pitch and caused the engines to idle. He said that at the reduced speed, the wind had some effect on the vessel's handling. The wheelsman testified that he had to apply extra rudder to compensate for the wind, but he had no difficulty steering. As the BUFFALO approached the railroad bridge on a westerly heading, the master stated that the northeasterly breeze caused the vessel to set to port toward the center span of the bridge. The BUFFALO passed through the draw with about 12-14 feet of clearance

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[2]Theoretical advance of a propeller in one revolution measured in feet. The BUFFALO was equipped with a controllable-pitch propeller with pitch settings from 0 to 16.5 feet in the ahead position.

on each side.[3] The BUFFALO's chief engineer also testified that the vessel's pitch was at 4 feet going through the D&M railroad bridge.

As the BUFFALO was passing, a local yacht owner was preparing to leave the Saginaw Bay Yacht Club pier, which was on the east side of the river about 1/4 mile upstream of the Coast Guard station. He testified that he waited until the bulk carrier went by and then maneuvered his 40-foot sailboat out into the river, following astern of the BUFFALO at a distance of about 300 feet through the D&M railroad bridge. He testified that after the BUFFALO was lined up to enter the draw, the propeller wash seemed to increase until the vessel passed clear of the railroad bridge and then the wash decreased, but the vessel did not appear to create any significant wake.

When the BUFFALO was about to enter the draw, the master sounded a whistle signal[4] to alert the bridge tender to open the Independence Bridge, a bascule-type highway bridge, 3/4 mile ahead. As the vessel's stern cleared the railroad bridge, the master ordered the wheelsman to steer to the right until the vessel was headed for the right-hand pier of the Independence Bridge. The wheelsman said that because of the BUFFALO's slow speed, he used hard right rudder to start the vessel swinging. The BUFFALO's third mate testified that the vessel's loran showed a speed of 2.85 knots about this time. The master testified that the BUFFALO was on the channel's centerline, but was favoring the "green," or left side. He estimated that the BUFFALO was 60-65 feet away when it passed abeam of the JUPITER. Because of the wind on his starboard quarter, he passed closer to the JUPITER than he otherwise would have. He stated, "Had there been no wind, we would have been further left." He testified that it was his belief that the passing of the BUFFALO did not cause the JUPITER to break away from the pier. He stated that he had piloted the BUFFALO in and out of the Saginaw River on four or five occasions during the current year without incident.

Accident

Action Aboard the JUPITER.--Aboard the JUPITER, cargo discharging continued while the BUFFALO continued its transit upstream. Shortly before 0800, the third mate (the 8-12 watch officer)[5] relieved the first mate (the 4-8 watch officer).[6] The two 8-12 watch able seamen (ABs) also relieved the two 4-8 watch ABs on deck. The third mate ordered the ABs to gauge the tanks to determine how much cargo remained aboard. The JUPITER's pumpman, who had been on duty since the vessel arrived at the terminal, was also on deck. About 0830, just as the JUPITER crew had

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[3]The right hand draw had a clear width of 96 feet (6 U.S Coast Pilot-198, 20th edition). The BUFFALO's beam was 68 feet.

[4]The Independence Bridge tender notifies 911 Central Dispatch whenever the bridge will be opened for marine traffic so that emergency vehicles can be rerouted if necessary. The bridge tender's clock and the 911 Central Dispatch time were not synchronized. The bridge tender's records show that the BUFFALO's whistle was sounded at 0833, that the bridge was opened at 0834, and that it was closed at 0840. The records of the 911 Central Dispatch show that the telephone call from the bridge tender was placed at 0831:41, answered at 0831:43, and completed at 0831:54. The bridge tender called 911 Central Dispatch at 0841:14 and reported the bridge closed.

[5]0800-1200, 2000-2400 watch.

[6]0400-0800, 1600-2000 watch.

completed gauging the tanks, the third mate saw a vessel (later determined to be the bulk carrier BUFFALO) approaching the D&M railroad bridge, which was 0.35 mile downstream of the Total Petroleum terminal. He testified that as the BUFFALO passed through the railroad bridge opening, he heard the sound of its whistle signaling to open the Independence (highway) Bridge, located about 0.4 mile upstream of the Total Petroleum terminal.

Three cargo pumps were operating at the time. The third mate ordered an AB to shut down the No. 2 cargo pump and attend to the forward mooring winch controls for Nos. 1 and 2 winches. He ordered the other AB to the after mooring winch controls for Nos. 3 and 4 winches.[7] The third mate testified that he then shut down Nos. 4 and 6 cargo pumps and went amidships with the pumpman to the valve manifold platform and started the hydraulic pump for the hose boom winch. The pumpman told the third mate that a ship was coming "awfully fast." He testified that he waved his arms in the direction of the BUFFALO as a signal to slow down. The AB at the after mooring-winch controls testified that the BUFFALO appeared to be closer to the JUPITER than he had observed in previous passages. The third mate testified that the flame screens were in place in the ullage [8]pipes at all 12 cargo tanks but the covers on the ullage pipes were left open. He testified:

> It's standard procedure for us to shut down the cargo transfer operation and to have people standing by the winches in this river and in other rivers whenever a boat is going to be passing or there's going to be a ship passing.

According to the terminal operator, as the BUFFALO approached the moored JUPITER, the level of the river rose about 4 feet, imparting a slight forward motion to the JUPITER. The tankship then surged aft about 8 to 12 feet as the water receded. He testified that as the BUFFALO passed abeam of the JUPITER, the tankship again surged forward with increased velocity until the No. 4 mooring wire cable grew taut and broke the center piling on the No. 4 pile cluster (see figure 4), releasing both the wire cable and the after polypropylene line. Both lines fell into the water.

The AB assigned to the after mooring winch controls testified that when he went to the winch control platform, he saw that the pile cluster that held the stern lines was leaning toward the JUPITER, pulled over by the tension on the No. 4 wire cable. The AB testified that he had time only to depress the start buttons for the Nos. 3 and 4 winches when the piling broke. He thought he saw the No. 3 mooring cable go slack and "splash" into the water. He did not know whether the line had parted or whether the No. 3 pile cluster had also broken. (Investigators later determined that neither the wire nor the piling had broken. The No. 3 wire mooring cable had slackened. When asked, the AB gave no explanation for the slack wire.) The AB testified that he did not heave on the No. 3 tension winch because it would have pulled the tankship forward. He testified that when he left the winch controls, the motors were off and the control levers were in the neutral position. The first mate testified that when he took over the No. 3 winch controls from the AB in an

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[7]Each winch had both port and starboard controls at four control consoles on each end of the main deck that were secured to the port and starboard bulwarks over an elevated platform, enabling the operator to see over the bulwarks to observe the wire cables.

[8]Distance between the liquid's surface in a tank and the reference point at the top of the tank. Crewmembers use this measurement to determine the amount of liquid in a calibrated tank.



Figure 4.--No. 4 pile cluster showing the broken mooring pile.

attempt to pull the JUPITER back to the pier, the winch motor was on and the control lever was in the neutral position. He pulled some slack out of the No. 3 wire cable with the winch, but because the wire was leading forward, he abandoned the attempt and left the No. 3 winch control lever in the neutral position.

Meanwhile, the other AB manned the forward winch controls for the Nos. 1 and 2 winches. The third mate stated that as the vessel surged forward, he believed that the center piling on the No. 2 pile cluster also broke. (A photograph taken shortly thereafter showed that the No. 2 center piling did not break but that later it burned almost to the water. See figure 5.) Because he was unable to use the No. 2 mooring cable to control the motion of the vessel, the AB glanced at the third mate

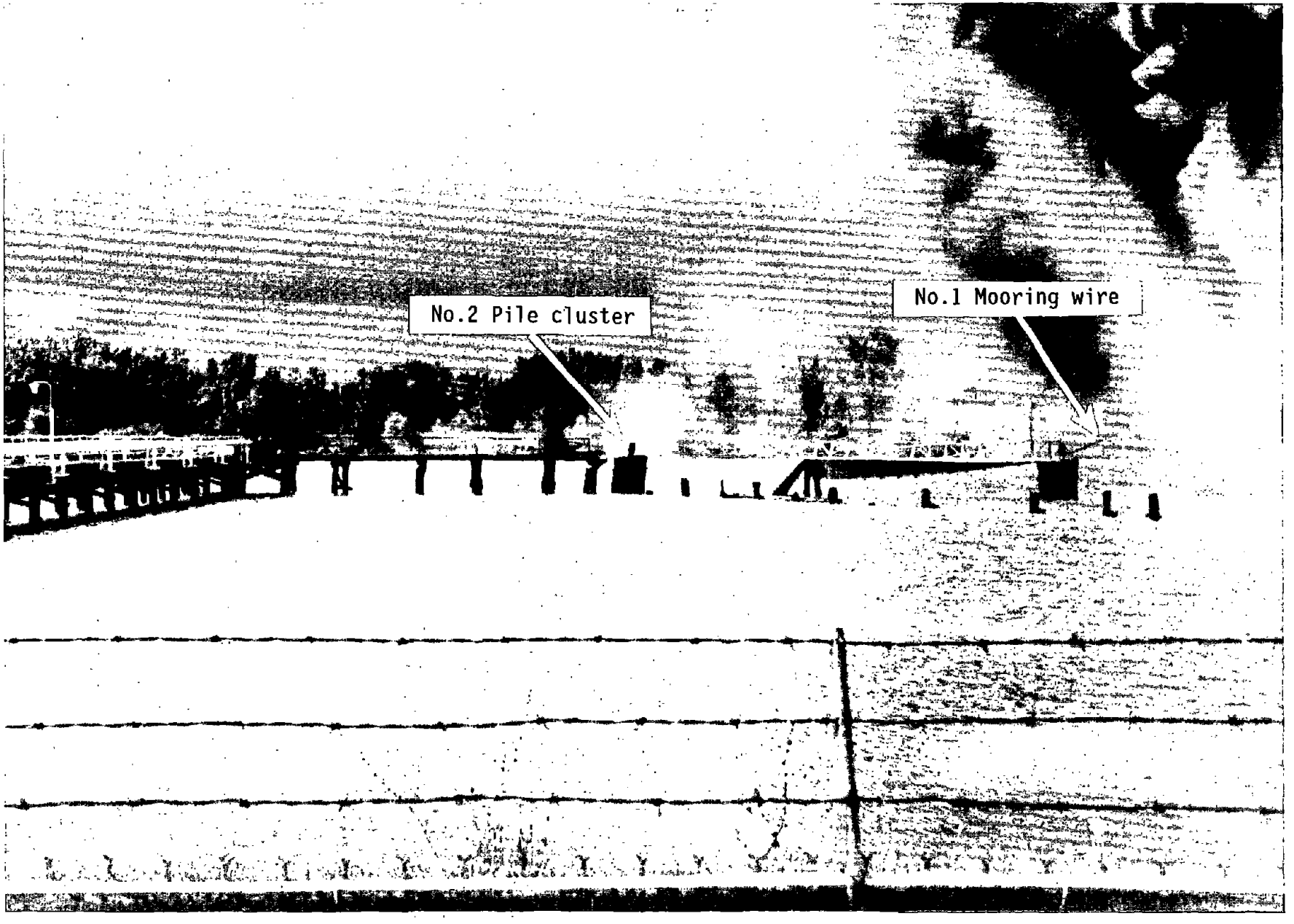

Figure 5.--JUPITER on fire during the morning of September 16.
(Photo courtesy of the Bay City Fire Chief.)

and threw up his hands, as if indicating that he believed he could do nothing more to stop the JUPITER from surging ahead. Several witnesses stated that as the No. 1 pile cluster leaned toward the vessel, the polypropylene line stretched tight and pulled clear of the piling to which it was secured. The line catapulted into the air and partially landed on the vessel's foredeck.

The stern of the BUFFALO had already cleared the JUPITER's bow when the tankship stopped moving astern and started to surge forward again. With no aft mooring lines to hold it, the vessel's stern then swung out into the river. The JUPITER's third mate and pumpman were amidships at the hose boom controls. When the hose stretched tight, the third mate and the pumpman lowered it to the deck to relieve the stress. The JUPITER's forward motion pulled the 12-inch pipeline off its foundation on the wooden pier, bending it in the upstream direction until it touched the upstream valve. (See figure 6.) The force of the motion caused a nitrogen purge line[9] to break where it entered the top of the pipe, spilling gasoline onto the deck of the pier. Even with the additional slack in the cargo hose, nonetheless, it pulled apart from the stress and spilled gasoline on the pier and on the tankship's deck. An electrical conduit to a junction box fastened to the pier that powered the motor-operated valves pulled apart. The pumpman testified that he twice saw sparks flash on the pier from the damaged electrical wires. He said that the second flash ignited the spilled gasoline.

The fire on the pier spread along the hose, onto the JUPITER's deck, and ignited gasoline retained by a spill containment rail. The third mate testified that as he ran forward to the vessel's bow, he looked back and saw the entire midships area engulfed in flames. Using his handheld radio, he called the terminal to ask that the motor-operated valve be closed but did not wait for a reply. Instead, he continued running to the bow; the AB who had been at the forward winch controls joined him. The third mate stated that he intended to use the bow telephone to report the fire and to let go an anchor if the JUPITER started to drift into the river. Before he got to the bow, however, an explosion occurred (see figure 7), followed by a loud roar of fire from the burning gasoline.

The third mate believed that more explosions were imminent. He stated that when he looked aft, the entire main deck was on fire. He turned to the AB and said, "Let's get out of here." Without taking time to don the lifejackets stowed forward or to take a ring buoy hanging on the forward bulwarks, both men jumped overboard from the bow.

The JUPITER's master testified that he had awakened at 0825 and gone to the ship's galley to give the cook instructions concerning some mail and the purchase of groceries. While he was in the starboard passageway, he heard the sound of a constant-tension winch operating. He described it as "groaning," or working hard. He ran to the after passageway door and saw the BUFFALO going by and the JUPITER moving away from the pier. The master testified that he then ran toward the pilothouse to call the BUFFALO to caution the master about speed in the river. As he approached the pilothouse, he saw that the forward and after winch controls and the cargo hose boom were manned according to "standard procedure." When he got to the pilothouse, however, he saw the pier breaking up and the cargo hose stretching taut despite his crew's efforts to lower it. He radioed the Coast Guard at

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[9]Nitrogen under pressure is used to clear the pipeline of product at the completion of a transfer.

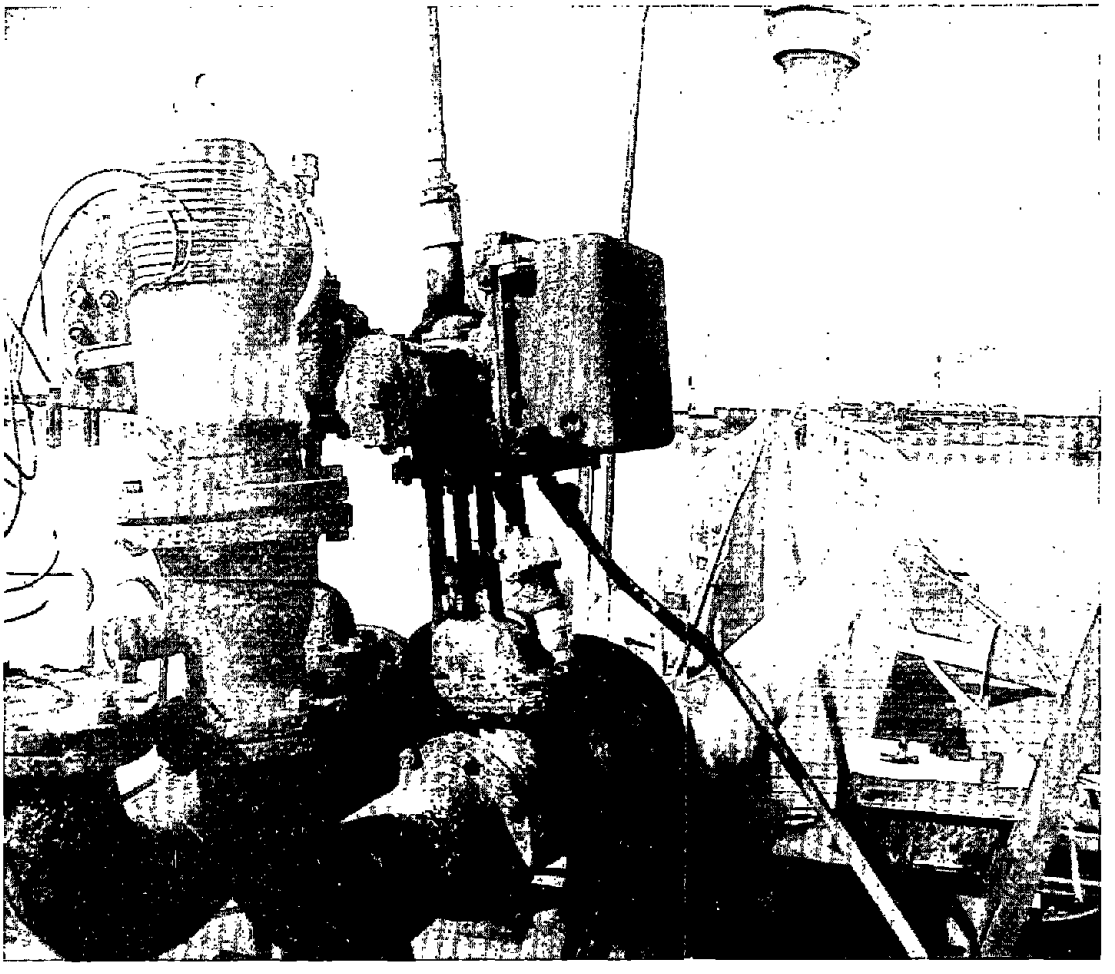

Figure 6.--Pipelines and valves on the Total Petroleum pier.

Station Saginaw River and reported that the JUPITER had been "sucked" off the pier and that the pier was breaking up.

During his testimony, the master said that the events that followed happened so quickly that he had difficulty keeping them in chronological order. He did recall maintaining radio contact with the Coast Guard. He also remembered starting up the fixed foam generator; however, because the foam lines on deck were damaged, pressure in the lines was too low to have any effect on the fire. The master ordered the crew to the stern of the vessel for an accountability check. Both first mates checked that crewmembers had donned either life jackets or exposure suits. After accounting for the crew, the master searched the crew quarters to ensure everyone

Figure 7.--Explosion aboard the JUPITER.

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was on deck and then ordered the crew to abandon ship. At 0850, he notified the Coast Guard that men were in the water.

Action Aboard the BUFFALO.--When the BUFFALO's master was piloting the vessel, the third mate, who had only limited duties, was monitoring the vessel's wake from time to time from the starboard side of the pilothouse. When the BUFFALO's stern was about 500-600 feet beyond the JUPITER's bow, the third mate noticed the JUPITER's stern swinging away from the pier. Almost immediately, he saw a fire start on the pier next to the JUPITER. He brought the fire to the attention of the master, who was conning the BUFFALO at the front windows of the pilothouse. The master walked over to the starboard side, looked back at the JUPITER, and saw the fire spread from the pier to the tankship. He testified that in a matter of seconds, the fire spread fore and aft along the deck of the JUPITER. He estimated that 30 seconds to 1 minute later, an explosion occurred. He overheard a voice, which he believed was the JUPITER's master, on his VHF-FM radio reporting the fire.

Meanwhile, when the bridge tender at the Independence Bridge heard the BUFFALO's whistle signal, he called 911 (at 0831:41) to inform the authorities that he would be opening the bridge. He testified that he routinely informed the 911 operator whenever he was about to open the bridge so that 911 personnel could reroute any emergency vehicle if necessary. He observed the JUPITER's stern swing away from the pier when the BUFFALO passed the tankship. He testified that as the BUFFALO approached the Independence Bridge, he radioed the vessel to check whether it had any problems. The BUFFALO replied that it had no problems. After the fire started on the JUPITER, the bridge tender called 911 again (at 0837:43) to inform them of the fire and that he would close the bridge as soon as possible after the BUFFALO went through in order to allow emergency vehicles to cross. The bridge tender's log showed the bridge was closed at 0840. He stated that the BUFFALO appeared to be traveling at the same speed that he had observed on previous passages of the vessel up the Saginaw River.

Action at the Total Petroleum Terminal.--After the JUPITER started discharging its cargo, the terminal operator remained in the vicinity of the pier and the tank farm. He carried a handheld radio and was available at all times to answer any call from either the terminal office or the vessel. About 0800, the operator, the terminal manager, and assistant manager went aboard the JUPITER and had breakfast. After dining, the two managers returned to the terminal office, and the terminal operator went to the pump building near the head of the pier. (See figure 8.)

While looking out the pump building's window, the terminal operator heard a whistle signal and saw a ship coming from the direction of the D&M railroad bridge. He stated that he recognized it as the BUFFALO and as it came closer, he became concerned about the speed of the vessel. Because he thought that the BUFFALO might be moving "too fast," he left the pump building and went out on the pier toward the JUPITER to watch the mooring lines. When he was about 100 feet out on the 396-foot pier, the BUFFALO was passing abeam of the JUPITER. He saw the tankship surge aft and then forward. He testified that when the boarding ladder fell away from the vessel, he turned and hurried back up the pier to close the valves. As he turned, he saw the 12-inch pipe on the downstream side of the pier being pulled over by the strain on the cargo hose from the JUPITER. He testified that he saw a "big flash of fuel" that quickly ignited and spread over two-thirds of the vessel's foredeck. As he ran up the pier, he shouted "Fire, fire" into his handheld radio. He

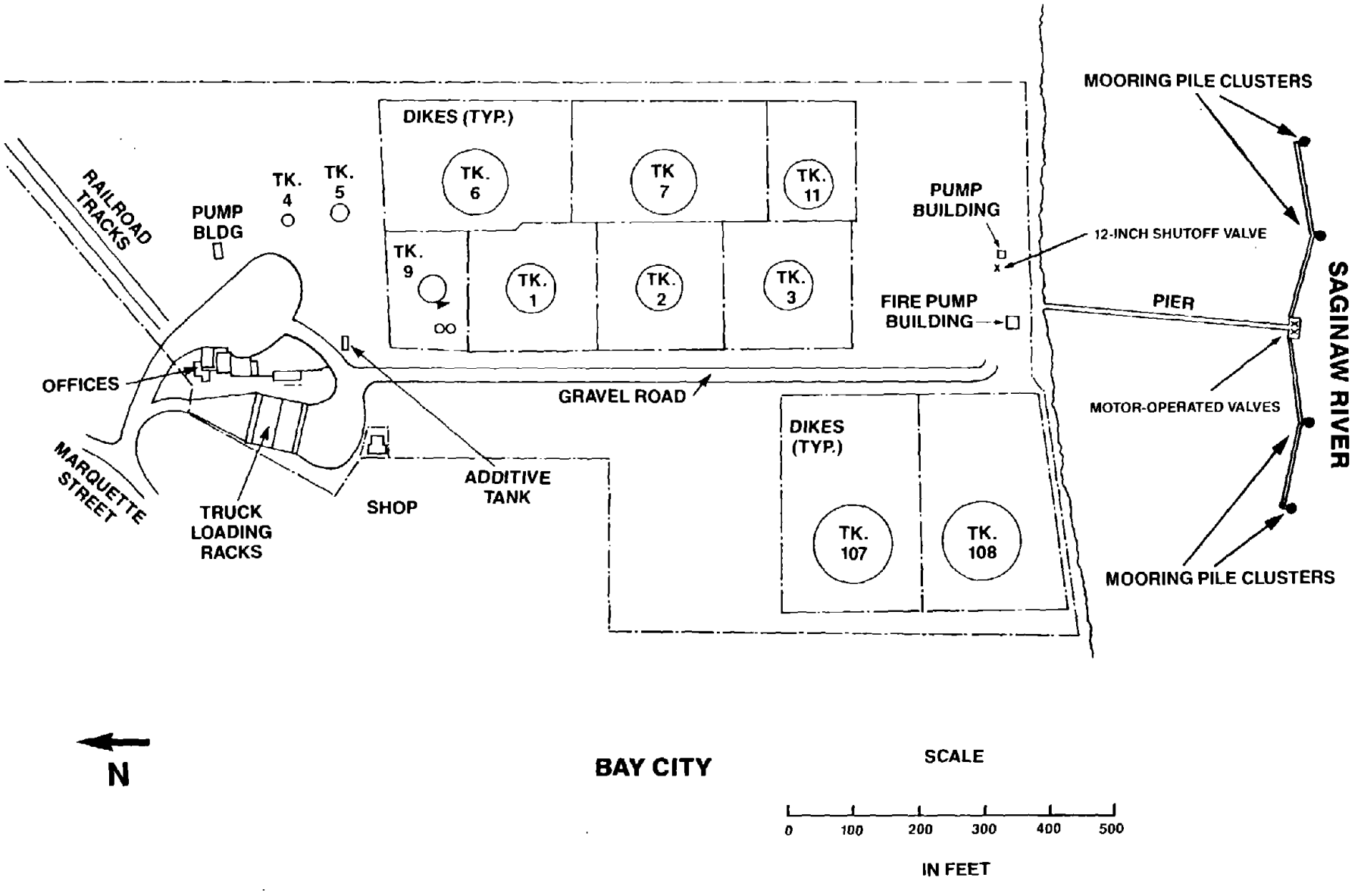

Figure 8.--Plan of Total Petroleum's Bay City Terminal.

ran to the valve that isolated the 12-inch pipe on the pier from the tank farm and quickly closed it.

The fire, fueled by gasoline trapped on deck by a spill containment rail, quickly engulfed the deck of the JUPITER. Eyewitnesses reported three explosions, two on the port side and one on the starboard side, immediately following the spreading fire. The explosion tore away sections of the main deck and caused part of the deck on the forward starboard side to fold over the side of the vessel. The flames forced the 18 crewmembers into the water, where all but one were rescued by Coast Guard and civilian boats. One crewmember drowned when he jumped into the water from the tankship's bow without a lifejacket. His body was recovered several days later.

The fire continued throughout September 16 and the next day. Professional fire fighting teams were hired to extinguish the blaze, assisted by several Coast Guard vessels and the Coast Guard Atlantic Strike Team. Because the JUPITER settled to the bottom and blocked the channel, the Saginaw River was closed to all marine traffic until a salvage team removed the remaining gasoline and moved the vessel clear of the channel. The tankship was later refloated and towed to a scrapping facility upstream.

Until October 21, when the JUPITER was moved clear of the channel, all vessels upstream of the accident site, including the BUFFALO, were prevented from entering or leaving the river.

Injuries to Persons

Injuries	Crew	Other	Total
Fatal	1	0	1
Serious	3	0	3
Minor	3	*1	4
None	11	0	11
Total	18	1	19

*A Dow Chemical employee suffered from smoke inhalation.

Damage

JUPITER.--The explosions and fire aboard the JUPITER damaged the vessel's entire midsection. The vessel, valued at $9 million, was declared a constructive total loss and sold for scrap. The lost cargo was valued at $55,000.

BUFFALO.--The BUFFALO sustained no damage as a result of this accident.

Total Petroleum Terminal.--The Total Petroleum pier sustained damage from the surging motion of the JUPITER and the ensuing fire. (See figure 9.) The estimated damage to the pier was $276,000.

Crew Information

JUPITER.--The 18-man crew of the JUPITER comprised 1 Coast Guard-licensed master, 3 Coast Guard-licensed mates, 4 Coast Guard-licensed engineers, 4 AB watchmen, 2 deckhands, 1 pumpman, 1 engine utilityman, 1 steward, and 1 porter. All unlicensed crewmembers held Coast Guard Merchant Mariner's documents. Each

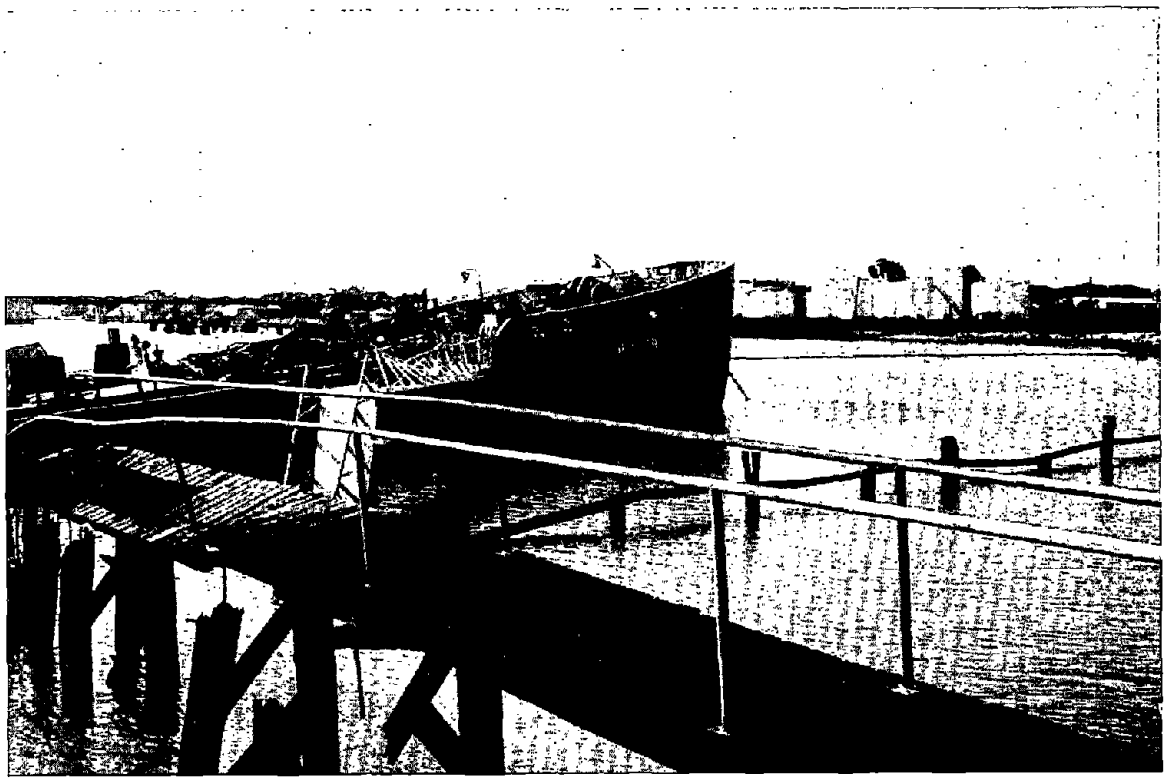

Figure 9.--Damage to Total Petroleum's pier.

of the three deck watches--12-4, 4-8, and 8-12-- was under the supervision of a mate who was responsible for cargo loading or discharging while in port and for navigation of the vessel while under way. The master had overall charge of the vessel. During cargo activity in port, the mate on watch supervised the pumpman. At other times, the chief engineer supervised the pumpman.

The master of the JUPITER had been sailing as a licensed officer since 1973. Before his assignment as master, he had sailed on deck in various ratings, including AB seaman. Except for one voyage offshore, he had gained his experience on Great Lakes vessels. He started working for Cleveland Tankers, Inc., owners of the JUPITER, in 1976 as a relief mate, serving aboard four of the company's vessels at various times. He had been master of the JUPITER for approximately 2 1/2 months during the current season. He testified that since 1976, he had averaged 3-5 calls per year at the Bay City terminal.

The first mate had been employed by Cleveland Tankers, Inc., for 10 1/2 years and each year had served some time aboard the JUPITER. He also had served on two other company tankships while employed with Cleveland Tankers. He graduated from the Great Lakes Maritime Academy in 1979 and held a Coast Guard license as master of Great Lakes vessels. He had served as first mate on the JUPITER since July 1990. The morning of the JUPITER accident, the regular first mate was

scheduled for vacation and had been relieved by another first mate at 0800 but had not yet departed the vessel when the accident occurred.

The replacement first mate had held a mate's license for Great Lakes vessels since 1980. He had been employed by Cleveland Tankers, Inc., since 1983, during which time he had served aboard the JUPITER intermittently. He had sailed on the JUPITER earlier in the year. In June, he transferred to the GEMENI, another company tankship, until his return to the JUPITER on the day of the accident. He reported aboard several hours earlier and had exchanged vessel information with the regular first mate.

The second mate had served 7-8 months aboard the JUPITER before the accident. A 1987 graduate of the Great Lakes Maritime Academy, he held a Coast Guard license as mate aboard Great Lakes vessels. He previously worked on the vessels of U.S. Steel's Great Lakes Fleet. He had been employed by Cleveland Tankers, Inc., since 1989, during which time he served aboard three of its vessels.

The third mate joined the JUPITER crew on June 10, 1990, shortly after graduating from the Great Lakes Maritime Academy. He had made two previous trips into Bay City, one of which was to the Total Petroleum terminal. He normally stood the 8-12 watch. He held a Coast Guard license as mate on Great Lakes vessels

The JUPITER's pumpman had 35 years experience sailing as a merchant seaman both offshore and on the Great Lakes. Employed by Cleveland Tankers, Inc., since 1981, the pumpman had sailed on several vessels in its fleet but mostly on the JUPITER.

The surviving 8-12 AB/watchman had sailed on seagoing vessels since 1957. He had been employed by Cleveland Tankers, Inc., aboard Great Lakes tankers since 1979, during which time most of his experience had been aboard the JUPITER.

BUFFALO.--The master of the BUFFALO received his first Coast Guard license in 1971 and started sailing as third mate in 1972. In 1982, he started sailing as master aboard Great Lakes vessels. He had prior experience as a master piloting vessels in the Saginaw River. During the current season, he had piloted the BUFFALO in the Saginaw river on five occasions. As part of his training, he had attended a 2-week shiphandling course at a special simulator school in Port Revel, France. His employer, American Steamship Company, also required him to observe shiphandlers on other company vessels before he was assigned as master.

On the day of the accident, the BUFFALO's master had slept 5 hours when he was called to the bridge at 0730. He testified that he felt rested and was not fatigued. He said that he followed his normal routine, that is, he did not eat breakfast and consumed "lots of coffee." He did not smoke or take medicine, alcohol, or drugs. He stated that he had no health problems and generally considered himself healthy.

The third mate, who served as watch officer during the BUFFALO's passage in the Saginaw River, had held a mate's license for the Great Lakes since 1979. He had worked aboard the BUFFALO since March 1990, usually as second mate rather than third mate. He started sailing on Great Lakes vessels at age 17 and worked his way up to AB and mate. During the current season, he had made 20-30 trips into the Saginaw River.

The AB/wheelsman at the BUFFALO's helm on the day of the accident had sailed on the BUFFALO since 1982. He had held a Coast Guard merchant mariner's document as AB since 1969. He had 13 years experience as a wheelsman and had made six or seven trips into the Saginaw River during 1990. His other duties aboard the BUFFALO included operating the conveyor belt and the cargo discharge boom.

Toxicological Testing

The Coast Guard regulations at 46 CFR 4.06--Mandatory Chemical Testing Following Serious Marine Incident Involving Vessels in Commercial Service--and at 33 CFR 95--Operating a Vessel While Intoxicated--require that the marine employer take all practicable steps to have individuals directly involved in a serious marine accident undergo a chemical test for drugs and alcohol. A law enforcement officer may order the marine employer to have additional individuals tested if, in the officer's opinion, they also were directly involved in the accident.

On September 16, the day of the accident, a Coast Guard boarding officer visited the BUFFALO at the Midland Marine pier to conduct a preliminary investigation of the accident and to ensure that chemical tests were performed on those crewmembers that were directly involved in the operation of the vessel. A representative of the marine employer stated that tests had been ordered for nine members of the BUFFALO's operating crew. Using the testing kits aboard the vessel, urine specimens were taken and sent to an independent laboratory where tests for drugs were performed. The results of the tests showed the specimens to be "drug-free" under the current Coast Guard regulations. Since the BUFFALO had berthed several hours before and some of the crew had already gone ashore and returned, it was decided that any results of a test for alcohol on the individuals concerned would not be conclusive since much time had elapsed. Therefore, testing for alcohol was not performed.

Immediately after the rescue of the JUPITER's crewmembers from the water, they were treated and released by the local hospital before any drug or alcohol tests were ordered. A company representative arranged hotel accommodations for them in Bay City. Later, four of the crewmembers who were on duty at the time of the accident were ordered to a local medical facility where they were tested for drugs, but not alcohol.[10] Testing for drugs was performed by an independent laboratory. The test results for drugs were reviewed by the testing facility's medical review officer (MRO), who determined that they were negative.

During the autopsy of the AB who drowned during the evacuation of the JUPITER (2 1/2 days earlier), blood specimens were tested for drugs and alcohol. Medical records indicated that no drugs were found. The blood was found to have an alcohol concentration of 0.02 percent.

Vessel Information

JUPITER.--In 1976, S.B.A. Shipyards in Jennings, Louisiana, built the JUPITER, a chemical tanker, for Cleveland Tankers, Inc., a division of the Ashland Petroleum Company. The tankship was documented by the Coast Guard in Wilmington, Delaware. The vessel had received its most recent Coast Guard inspection before the accident on March 21, 1990, in Milwaukee, Wisconsin. (See appendix D.) The Coast

[10]Exact times of the events were not available.

Guard completed the vessel's last hull inspection on drydock on April 7, 1987. Coast Guard records for both inspections show no outstanding discrepancies. The Safety Board's investigation found no deficiencies on the vessel except for the flame screen installation. The American Bureau of Shipping (ABS) classed the vessel *(Maltese Cross) A1 Oil Carrier,[11] Great Lakes and St. Lawrence River Service. The ABS classed its machinery *(Maltese Cross) AMS.[12] The following list shows the JUPITER's principal characteristics:

Length overall	392 feet
Length between perpendiculars	382.42 feet
Beam	60 feet
Molded depth	25 feet
Maximum draft	19.1 feet
Gross tonnage	4,263
Net tonnage	3,764
Deadweight tonnage	10,932
Horsepower	4,200

The JUPITER's main propulsion plant consisted of two General Motors diesel engines with Falk reduction gears coupled to two shafts, each of which was fitted with a stainless steel propeller. The vessel was equipped for bridge control of the engines. Three 300-kw diesel generators furnished electrical power.

The crew quarters were on the port and starboard sides of the main deck aft, over the engineroom. The galley and the messroom were located between the port and starboard passageways. The wheelhouse, situated over the crew quarters, had an unobstructed view over the bow. (See figure 10.)

The JUPITER's cargo tank section was divided into 12 tanks, 6 port and 6 starboard, separated by a single longitudinal bulkhead and 5 transverse bulkheads. (See figure 11.) Each of the JUPITER's port and starboard cargo tanks were interconnected by pipelines and valves to one of six electrically driven deepwell pumps.[13] Through a series of bypass valves, one or two pumps could discharge the cargo from a four-tank group. For example, a pump could discharge Nos. 1 and 2 port and starboard while another pump could discharge Nos. 2 and 3 port and starboard. Each pump discharged into a common manifold at the discharging/loading station amidships. A nonreturn valve on the discharge side of each pump prevented product backflow after the pump was secured. Each tank had a pressure/vacuum (P/V) valve fitted with a flame screen. The center of each tank had a 20-inch-diameter clean-out hatch through which an 8-inch ullage pipe was installed. (See figure 12.)

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[11]This classification indicates that the vessel has been built to the full requirements of the ABS Rules for Great Lakes service at the assigned freeboard as an oil carrier and that the equipment aboard the vessel, such as anchors and chains, complies with the rules.

[12]This classification indicates that the machinery has been built in accordance with the ABS rules.

[13]A fixed submersible pump installed at the bottom of a tank driven by a vertical shaft from a power source on deck.

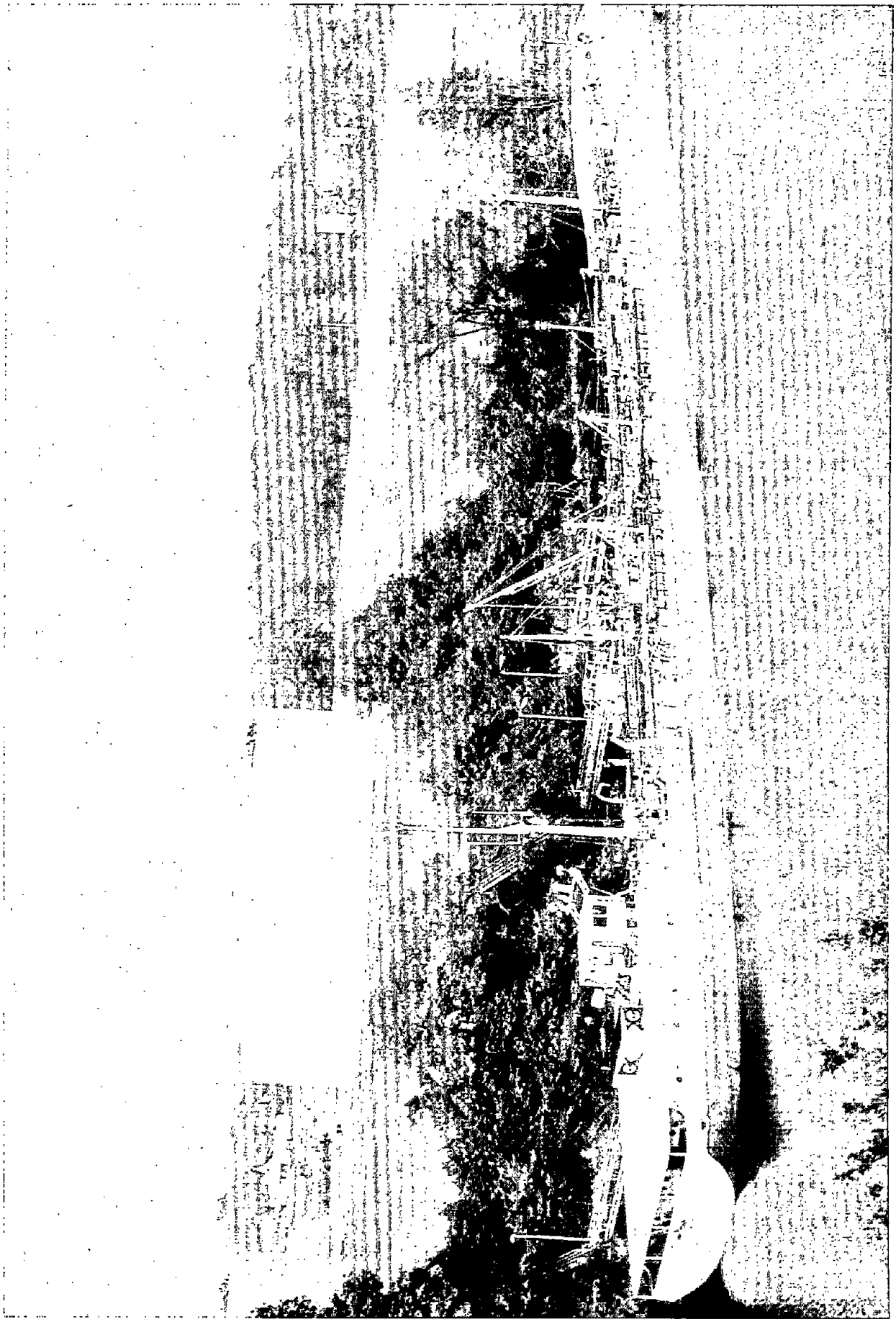
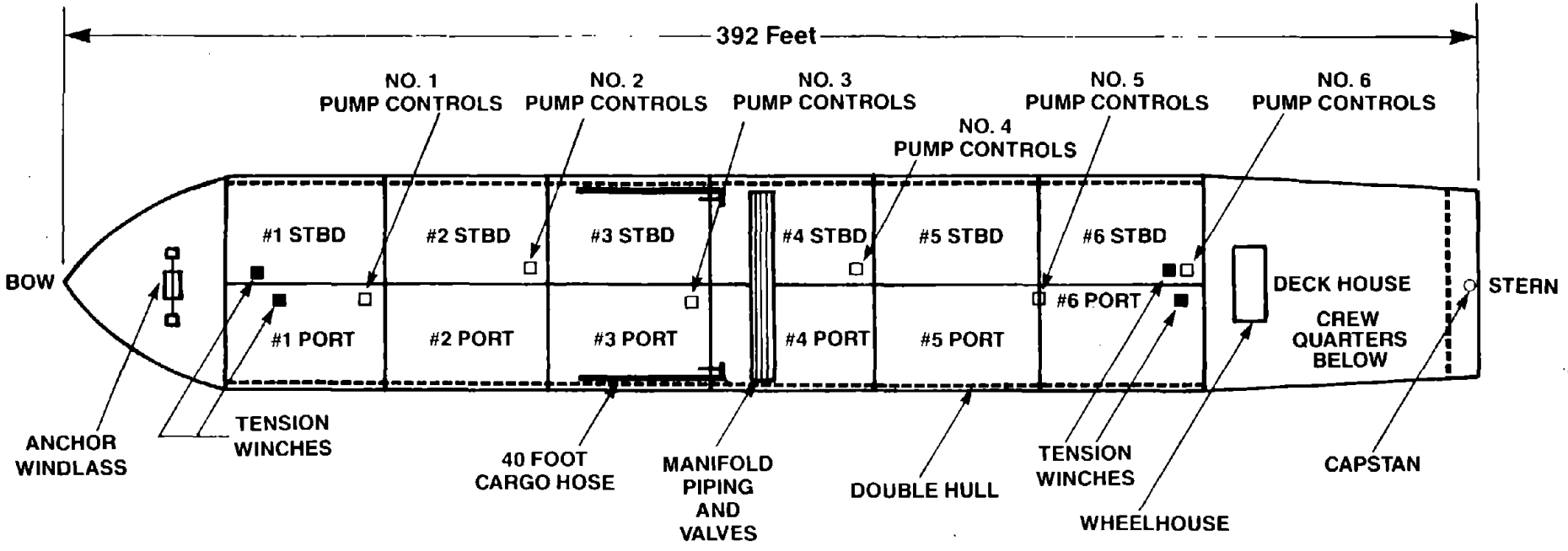


Figure 10.--M/V JUPITER.



M/V JUPITER

Figure 11.--JUPITER's tank arrangement.

The top of each ullage pipe was equipped with a closed gauging system and a flame screen. Four 1/2 x 1/2 x 1-inch pieces of steel stock, equally spaced and welded to the inner surface of the ullage pipe, supported the flame screens. (See figure 12.) The flame screen installation precluded the use of the closed gauging system. The JUPITER did not use the closed gauging system when carrying Grade B cargo because it was not required and because crewmembers found the gauge mechanism unwieldy and the gauging tape difficult to read through the heavy glass viewing port. Instead, crewmembers swung the gauge covers open and lowered handheld measuring tapes into each tank between the edge of the flame screen and the inside of the ullage pipe. They then left the tapes hanging with the gauge covers open. (The JUPITER was not equipped with an inert gas system.) The flame screen support did not provide a complete seal around the periphery of the screen. Cleveland Tankers, Inc., purchased the Coast Guard-approved 12-unit closed gauging system from the Petroleum Gauging and Appliance Company, Houston, Texas, and had it installed during construction of the vessel. Investigators could not determine whether the flame screen installation in the ullage pipes was part of the original purchase or whether the Coast Guard had approved it. Coast Guard construction standards for flame screens are contained in 46 CFR 30.10-25. A Coast Guard spokesman stated that a "common sense item" is that Coast Guard inspectors are expected to check to ensure that the flame screen provides a complete seal around the screen periphery.

The vessel was double-hulled with side tanks and double bottom tanks used exclusively for ballast water. The JUPITER had a separate ballast piping system with a dedicated ballast pump to fill or dewater the ballast tanks as necessary, usually during loading or discharging. Each ballast tank had goose-neck-type vent pipes along the port and starboard sides of the main deck. To prevent any product spilled on deck from running over the side, each side of the main deck had a 6-inch high steel plate fitted along the edge as a containment rail.

The JUPITER had the following safety equipment aboard: 3 20-man liferafts, 24 lifejackets, 23 immersion suits, 12 ring buoys (6 equipped with lights), an emergency position indicating radio beacon (EPIRB), fire hose, 5 fire axes, and 18 portable and semiportable fire extinguishers. On the main deck, the vessel had a fixed foam extinguishing system with four monitors, two aft over the crew quarters and two forward of the cargo tanks. A fixed halon fire extinguishing system protected the engineroom.

Cargo Operations Aboard the JUPITER.--After the crew secured the JUPITER at the pier, the second mate (the 12-4 watch officer)[14] met with the terminal representatives to exchange required cargo documents and to supervise the gauging of the cargo tanks to determine the amount of cargo aboard. The crew took the gaugings or ullages through the open ullage pipes. Because the cargo had been loaded in Canada, a cargo manifest had been prepared to obtain the necessary clearance by U.S. Customs before the vessel could begin discharging. At 0240, the second mate and terminal personnel completed their document exchange, including the execution of the Declaration of Inspection Prior to Bulk Cargo Transfer as required by Coast Guard regulations, 33 CFR 156.20, 156.150, and 46 CFR 35.35-30. (See appendix C.) Discharging commenced.

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[14] 0000-0400, 1200-1600 watch.

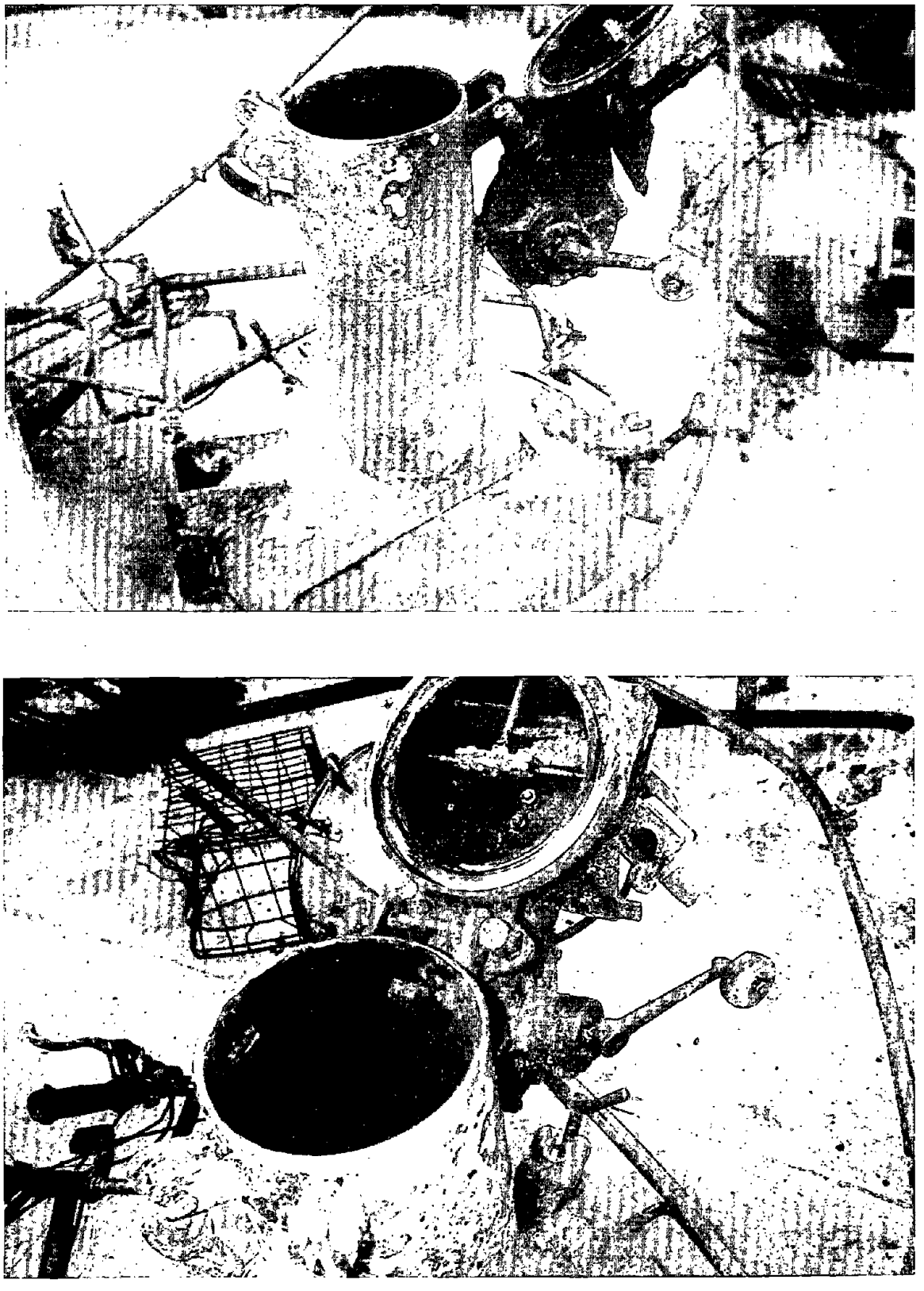

Figure 12.--Tank gauging device in open position.

Immediately after the vessel was made fast, a crewman passed a bonding cable to a terminal employee on the pier; the employee electrically grounded the vessel to shore by connecting the cable to the pipeline. The 8-12 watch (third mate and two ABs) rigged an 8-inch flanged cargo hose from the vessel to the pier. The vessel's hydraulically operated cargo hose boom supported the hose. The watch bolted the flanged ends to the cargo manifold on the vessel and to one of two pipelines on the pier. Terminal personnel removed a blank flange from the connection on the pier and, assisted by one of the 8-12 ABs, connected the JUPITER'S hose. After they made the connection, they opened the cargo tank valves and the valve at the loading/discharge manifold. Terminal personnel opened a motor-operated valve on the pier and the valves ashore to the receiving tanks. They tested a remote emergency shut-off switch that was connected to the motor-operated valve by an electrical cable and looped the cable over the railing at the gangway. In an emergency, the tankship's personnel could close (but not open) the motor-operated valve from the deck of the vessel. The terminal lent a VHF-FM handheld radio to the ship's watch officer for communicating with the terminal operator and the terminal office.

After the third mate and the two ABs finished connecting the cargo hose, the 12-4 watch (second mate and two ABs) took over the duties on deck. In addition to the regular watch, the JUPITER'S pumpman was also on duty to help the second mate open valves, start pumps, and take on ballast as required. The pumpman testified that he opened the No. 2 tank valves, port and starboard, and started the No. 2 pump. As the discharge pressure increased, he checked the connections. The second mate testified that he found no leaks. He stated that terminal personnel said that the shoreside valves were properly set and they were receiving the product.

Before crewmembers started additional pumps aboard the JUPITER, the watch officer ordered the discharging operation stopped from 0300 to 0335 while an outbound vessel, the 638-foot-long IRVIN L. CLYMER, passed in the river. A watch AB had sighted the outbound vessel approaching and notified the watch officer. The officer ordered the cargo pump stopped and the forward and after tension winch controls manned until the vessel passed clear. At 0400, the first mate relieved the second mate and the 4-8 ABs relieved the 12-4 ABs. The JUPITER'S pumpman remained on duty.

The JUPITER's six deep well pumps were each powered by a separate electric motor with separate controls in individual pump houses on the main deck. After 0400, crewmembers opened the Nos. 4 and 6 tank valves, port and starboard, and started Nos. 4 and 6 pumps. The pumpman testified that it was customary aboard the JUPITER to pump Nos. 2, 4, and 6 cargo tanks down 10 feet before opening the crossover valves to the remaining tanks. According to the JUPITER's pumping record, during the first mate's watch (0400-0800), power failures aboard the vessel caused the pumps to stop on two occasions, from 0510 to 0525 and from 0600 to 0615.

The 4-8 watch opened the remaining tank valves during its watch. By that time, three cargo pumps, Nos. 2, 4, and 6, were pumping from all cargo tanks. The JUPITER's cargo piping system was configured so that a series of cross connections enabled them to pump from all 12 tanks simultaneously. The third mate testified that when he ordered the two ABs to gauge the cargo tanks at 0815 to determine the amount of cargo remaining aboard, he wanted to establish a pumping rate to ascertain when discharging would be completed. As the men gauged the tanks, the third mate recorded the ullages. Shortly thereafter, the third mate determined that 22,268 barrels of unleaded gasoline remained to be discharged.

Automatic Constant-Tensioning Mooring Winches.--The JUPITER had four electrohydraulic constant-tensioning winches located on the main deck, two forward and two aft. The forward winches were paired and numbered 1 and 2 port and starboard, respectively; the after winches were paired and numbered 3 and 4 port and starboard, respectively. Each winch drum was rove with approximately 400 feet of 7/8-inch diameter wire rope cable that could be led to either side of the vessel. Each pair of winches was electrically interlocked so that crewmen could control direction of drum rotation, speed, and tension from either the port or the starboard console.

The winches on the JUPITER were operated in the following manner. To activate the winch, an operator had to have the control handle in the neutral position. (See figures 13 and 14.) After starting the electric motor by depressing the start button on the control panel, the operator moved the control handle outboard to the "pay out" position, allowing the wire to unreeve from the drum. He controlled pay out line speed by moving the control handle away from or back to the neutral position. To stop the wire movement, the operator returned the control handle to the neutral position.

To heave in on the wire cable, the operator moved the control handle inboard to the heave position. Again, he controlled line speed by moving the handle away from or back to the neutral position. At the maximum setting with no load on the wire cable, light line speed was 350 feet per minute. The rated line pull was 22,000 pounds at 55 feet per minute. To stop heaving the cable, the operator returned the control handle to the neutral position.

The position of the winch control handle for maximum heave is in the same direction as the standby position. The operator used this position to maintain constant tension on the wire cable and to hold the vessel alongside the pier. The winch could also be operated in this position unattended. When the control handle was in the standby position and the winch sensed full line tension, the brake set automatically. After 8 seconds, the electric motor stopped and did not restart for 105 seconds. After 105 seconds elapsed, the electric motor restarted to heave in any slack in the wire cable if necessary. The operator could cancel this mode of operation by moving the control handle out of the standby position or by depressing the stop button. An internal adjustment in the winch could be preset for the desired maximum holding tension in the standby mode. Maximum holding tension was 25,000 pounds. A note of caution in the operating manual for the winch states:

> As [when] unusual conditions are present which will cause rapid and extreme changes in line tension, this [standby] mode is not recommended.

The JUPITER's third mate testified that when the JUPITER's crew operated the constant tension winches, they moved the controls to the payout position so that they could run enough wire off the drum to reach the mooring pile on the pier. (Full pay out speed was approximately 350 feet per minute.) They then moved the winch controls to the heave position to remove the slack from the wire. When the wire was tight, they placed the control handle in the standby position to automatically heave until the preset tension was reached. The brake set automatically when full line tension was reached and the electrohydraulic motor stopped. They then depressed the stop button to maintain the brake setting and placed the control handle in the

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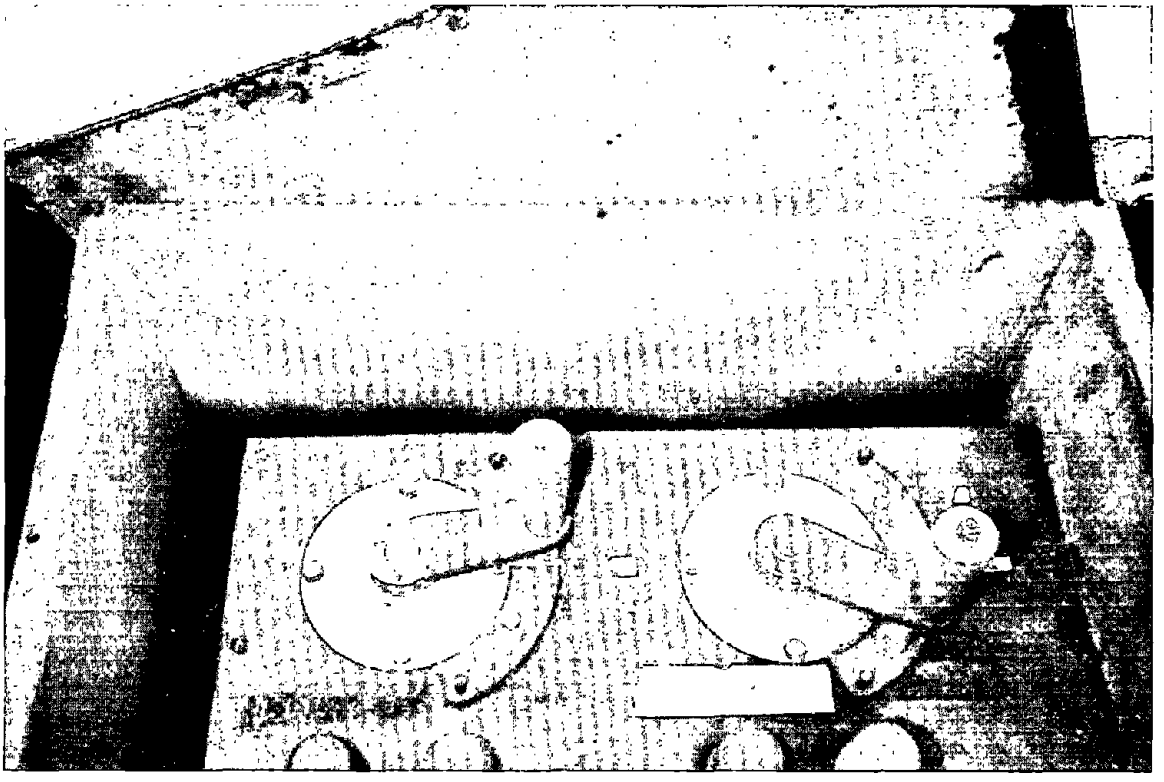

Figure 13.--Nos. 1 and 2 constant-tension winch controls, starboard side, forward.

neutral position. The third mate explained that with the winch in this mode, the crew could start it immediately when required. A manufacturer's representative pointed out, however, that when an operator started the winch motor with the control handle in the neutral position, the brake was automatically released. Investigators found most of the wire from the No. 3 winch payed out with no tension on it on the river bottom. The eye of the wire was over the mooring pile, and turns of wire were still on the winch drum. (This was the wire the third mate heard "splash" in the water.)

BUFFALO.--In 1978, the Bay Shipbuilding Corporation in Sturgeon Bay, Wisconsin, built the BUFFALO, a self-unloading bulk carrier, for the American Steamship Company. The vessel was documented by the Coast Guard in Philadelphia, Pennsylvania. Its last Coast Guard inspection before the accident was on March 20, 1989, in St. Ignace, Michigan. (See appendix E.) The Coast Guard's last hull inspection of the vessel on drydock was on March 23, 1988. The Safety Board's

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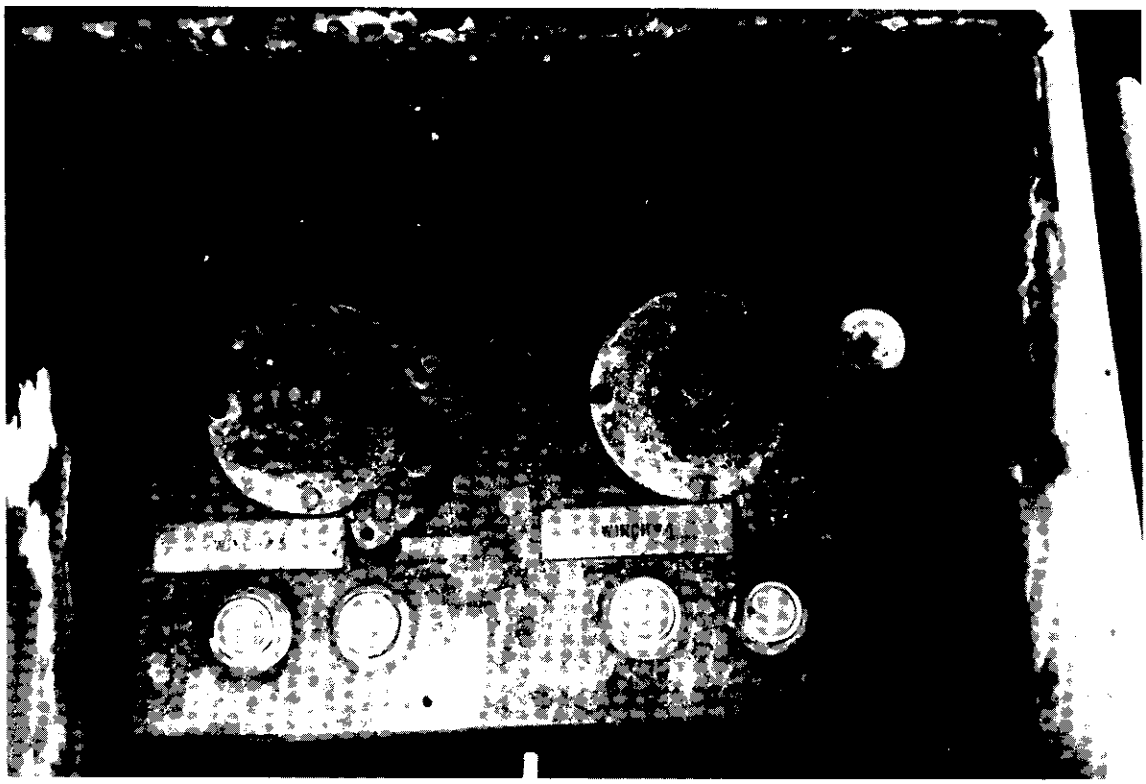

Figure 14.--Nos. 3 and 4 constant-tension winch controls, starboard side, aft.

investigation revealed no mechanical deficiencies. The ABS classed the vessel *(Maltese Cross) A1 (E) Great Lakes and St. Lawrence River Service and its machinery *(Maltese Cross) AMS. The BUFFALO's principal characteristics were:

Length overall	634.89 feet
Length between perpendiculars	617 feet
Beam	68 feet
Molded depth	40 feet
Maximum draft	27.3 feet
Gross tonnage	11,619
Net tonnage	8,036
Deadweight tonnage	28,770
Horsepower	7,200

The BUFFALO's main propulsion plant consisted of two General Motors B-20-645-E7 diesel engines with Falk reduction gears coupled to a single shaft fitted with a stainless steel controllable-pitch propeller that was controlled from the bridge. Three General Motors 670-kw AC generators furnished electrical power to the vessel. The BUFFALO was equipped with bow and stern thrusters.

The single deckhouse, located aft over the engineroom, contained the navigating bridge, crew quarters, galley, messroom, and conveyor machinery. (See figure 15.) The conveyer boom had an outreach of about 220 feet.

Twenty hatches provided access for loading to the BUFFALO's five cargo holds, which varied in length from 72 to 120 feet. Bulk cargos were discharged by means of two conveyor belts that transported the material to the discharge boom. When the BUFFALO had no cargo aboard, it could carry 14,154 tons of water ballast in 12 double bottom tanks, 6 port and 6 starboard, and the forepeak and afterpeak tanks.

The BUFFALO had the following safety equipment aboard: a 30-person lifeboat, 4 inflatable liferafts with a total capacity of 90 persons, 36 lifejackets, 32 immersion suits, 24 ring buoys (12 equipped with lights), a portable lifeboat radio, an EPIRB, fire hose, 8 fire axes, and 34 portable and semiportable fire extinguishers. A fixed halon fire extinguishing system protected the engineering spaces, and a fixed CO_2 system protected the emergency generator room.

Terminal Information

Located on the west side of the Saginaw River in Bangor Township, Bay County, Michigan, the Total Petroleum terminal was a wholesale petroleum facility. The terminal received most of its products by pipeline and stored them in above-ground tanks that had a total capacity of about 600,000 barrels. Terminal personnel loaded products into customer's trucks through loading racks at the north end of the terminal. The oil transfer facility, adjacent to the waterway, gave the terminal the ability to transfer products to and from vessels moored at the end of the 390-foot-long pier. According to the terminal operator, vessels berthed at the facility infrequently. He stated that the JUPITER was its "best customer" and recalled that the tankship averaged two to eight calls a season at the terminal. The JUPITER's master could not recall any prior problems from passing vessels while moored at the Bay City terminal.

The pier was a wood structure, built in 1986 by William W. Stender, Inc., Marine and General Contractor, Bay City, to replace a previous structure that dated from 1943. The deck of the pier, on which the two pipelines were mounted, was 6 feet wide. On the upstream side, a 10-inch welded steel pipe was used to transfer light heating oil products. On the downstream side, a 12-inch welded steel pipe was used to transfer gasoline products. Both pipelines were elevated approximately 2 feet above the deck at the river end of the pier to enable terminal personnel to clear the pipe of product after they completed transfer operations. Personnel cleared the pipelines using pressurized nitrogen from a 1 1/2-inch purge pipe installed on the pier and connected to the outer ends of the pipes. The terminal stored the nitrogen bottles in the firepump building near the head of the pier. Valves controlling the nitrogen were located in the pump building and on each branch line to the 10-inch and 12-inch transfer pipelines at the end of the pier.

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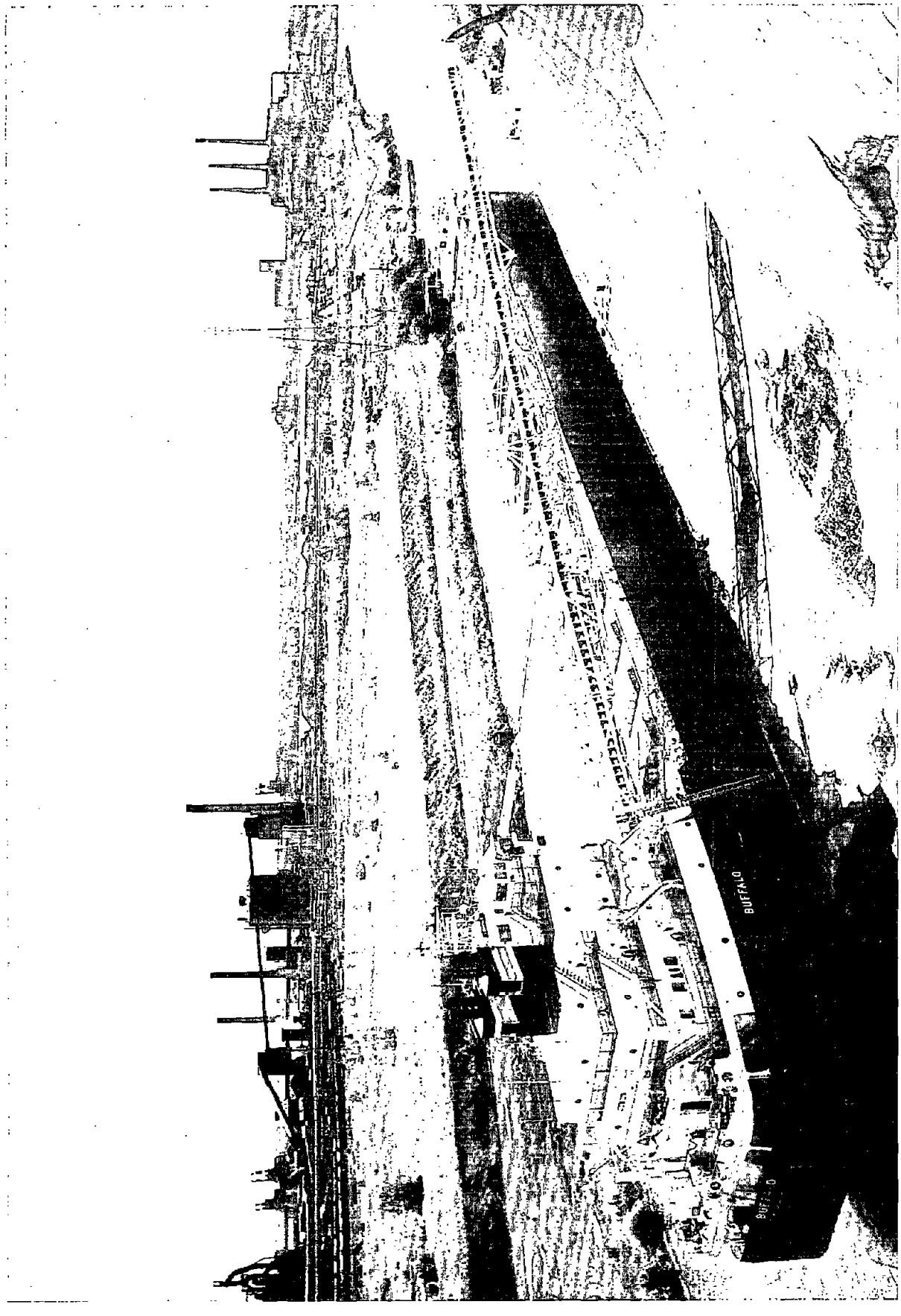

Figure 15.--M/V BUFFALO.

Manually operated gate valves adjacent to the pump building isolated the pier pipelines from the tank farm. When the fire started on the JUPITER, the terminal operator closed the 12-inch valve to isolate the pier from the rest of the facility. (See figure 8.) He also stated that the storage tanks were fitted with a flapper-type nonreturn valve that could be opened manually when product was to be transferred from the tank. According to Total Petroleum's area general manager, there are no check (nonreturn) valves between the pier and the pump building.

The river end of each pipeline was fitted with an 8-inch motor-operated nonrising stem gate valve. The valves were elevated to allow clearance for a drip tub under each outer flange connection in the event some product was unintentionally released while the transfer hose was being connected or disconnected. The outer flange at each valve had a 90° 8-inch elbow mounted in a vertical position to which a vessel's hose was bolted.

A weathertight metal box with exterior control buttons housed the controls for the motor-operated valves. A small portable metal box fitted with an electric wire long enough to reach a vessel's deck while it was moored at the pier contained a remote kill switch. When placed aboard a vessel, the single-button kill switch enabled vessel personnel to simultaneously close the motor-operated valves and stop the shoreside pump when the vessel was loading. The motor-operated valve could only be closed from the controls on the pier or by the kill switch aboard the vessel. However, terminal personnel could control the pumps from the pump building.

The four mooring pile clusters were positioned so that moored vessels lay against the two center clusters. Vessels such as JUPITER secured their mooring lines to the wood center pile of each cluster that extended above the other piles in each of the 12-14 pile clusters. The pilings were "Class B" size, at least 13-inches in diameter, approximately 55-feet long, and driven 20 to 21 feet into the river bottom. The pilings were spaced about 1 foot apart at the river bottom. The upper portions of the pilings were wrapped together with galvanized wire held in place with wire staples. The pile clusters (dolphins) were of the flexible type; the cluster will return to its original upright position after leaning due to a horizontal load. According to an industry guide, Design and Construction of Ports and Marine Structures written by Alonzo DeF. Quinn, pile clusters are used for mooring small vessels, generally under 5,000 deadweight tons.[15] Quinn includes industry standards for different sizes of pile clusters, as well as recommended leads for mooring vessels, in this publication.[16] The owner of the marine construction company that built and repaired the pier and pile clusters stated that his company built the original pier in 1943, probably to the standards used during that period, and replaced the pier in 1986. Records indicate that in 1985 Total Petroleum had the No. 3 cluster replaced. The company also had the No. 2 cluster upgraded by adding six additional white oak piles because it was subject to additional force when vessels were maneuvering

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[15]Design and Construction of Ports and Marine Structures by Alonzo DeF. Quinn, McGraw- Hill Book Company, 1972.

[16]The publication illustrates a method of mooring a vessel to a pier using six mooring lines that lead to six individual pierside mooring devices: a bow line leading ahead of the vessel, a forward breast line leading approximately 90° to the center line of the vessel, a forward spring line leading aft, an after spring line leading forward, an after breast line leading approximately 90° to the center line of the vessel, and a stern line leading aft of the vessel.

alongside when berthing. The contractor also believed that he installed the No. 4 cluster between 1983 and 1987. He stated that the average life of a 14-pile cluster is 15 to 20 years and that the average life of the center mooring pile is 10 to 12 years.

In May 1989, his company installed a fifth 21-pile cluster, about 50-80 feet upstream of the No. 1 pile cluster, specifically to moor a large "Amoco barge" that had its cargo valve manifold located at the after end of the vessel. This mooring device consisted of three 12-inch steel pilings driven in the center of a 21-pile cluster. Filled with concrete, these steel piles extended above the wood piles to which the barge's mooring lines were fastened. The 1989 improvements to the pier were authorized under a permit issued by the U.S. Army Corps of Engineers (USACE) on November 17, 1988, valid after authorization by State and local jurisdictions. A USACE review of a permit application and site is normally limited to determining a structure's location in the waterway and the potential environmental impact of the construction. The USACE review does not determine the adequacy of a structure for the mooring of vessels. The facility owner has the responsibility for identifying the scope of his needs and customarily employs a civil engineer to design an adequate structure.

In an affidavit dated March 4, 1991, the marine contractor stated that before each shipping season began, he visually inspected the pier and mooring pile clusters for signs of damage that may have occurred over the winter. The affidavit does not mention probing or similar tests to check for deterioration in the wood. No repairs or alterations had been made to the pier or the pile clusters since the May 1989 installation.

The facility's Terminal Operations Manual, dated October 1986, conforms to the Coast Guard regulations at 33 CFR Part 154, Oil Pollution Prevention Regulations for Marine Oil Transfer Facilities. This manual contains no instructions that require a vessel in the process of transferring a product at the facility to shut down loading/discharging operations when another vessel of significant size passes in the river. The decision whether to secure is left to the vessel personnel. The Coast Guard regulations do not specifically address when, or for what reason, transfer operations should shut down. However, 33 CFR 154.550 and 155.780 do address how to effect a shutdown between a vessel and the pier using the remote kill switch aboard the vessel. Total Petroleum met the communication requirements outlined at 33 CFR 154.560 and 155.785 by providing handheld radios to terminal and vessel personnel.

The most recent inspection took place on April 4, 1990, when Coast Guard inspectors from the Marine Safety Office in Detroit visited the Bay City Total Petroleum facility to check for compliance with Federal regulations pertaining to liquid bulk transfer facilities as outlined at 33 CFR 154. The terminal manager accompanied the inspectors during the inspection. The report prepared following this inspection indicated that the terminal was in compliance with the regulations, and inspectors found no discrepancies or hazardous conditions. However, the report did not address the terminal's mooring arrangements. Coast Guard regulations at 33 CFR 156.120--Oil Pollution Prevention and Hazardous Material Transfer Operations--address only the vessel's mooring arrangements. On August 23, 1990, Coast Guard inspectors conducted a "spot" inspection of the pier that included an examination of the valve arrangements; they noted no discrepancies.

Wreckage

JUPITER.--The 6-inch spill containment rail trapped burning gasoline on the deck of the JUPITER. At Nos. 1 and 2 port, at No. 3 starboard, and at Nos. 4 and 5 port cargo tanks, sections of the main deck were blown off, exposing the gasoline remaining in the tanks. Photographs taken by an eyewitness on the Independence Bridge indicate that the first explosion probably occurred on the port side of the vessel, possibly at Nos. 4 and 5 tanks, followed by explosions at No. 3 starboard and Nos. 1 and 2 port. A postaccident view of the vessel from the air showed the extent of the explosions. (See figure 16.) The longitudinal bulkhead separating the Nos. 1 and 2 port and starboard tanks had ruptured and pulled away from the tank's bottom plating, exposing the double bottom tanks below. (See figure 17.) The after bulkhead between Nos. 2 and 3 starboard tanks had split, and the surrounding steel area appeared to have been burned.

The hull buckled in two places at Nos. 3 and 5 tanks. The entire midships section sagged and settled to the bottom. However, a diving team found the bottom of the hull intact. Although distorted, both sides of the double hull remained intact and watertight. (See figure 18.)

On the main deck, the explosions tore off pipelines and other deck equipment, including the pipelines that were part of the fixed foam fire fighting system. (See figure 19.) Damage to the foam lines caused the pressure in the system to fall. As a result, the foam did not reach the cargo manifold area. The intense heat distorted the remaining portions of the main deck. The force of the explosion caused a section of deck plating at No. 1 port cargo tank to drape over the vessel's side. The blasts also blew away the foremast. A section was found on the bow of the tankship. The fore and aft catwalks and manifold platform at the loading/ discharge station were bent, and some parts were missing. The No. 2 constant-tension winch, originally located over No. 1 cargo tank near the centerline, was blown overboard and remains missing. Safety Board and Coast Guard investigators found the No. 1 winch control partially in the payout position and the No. 2 winch control partially in the heave position. (See figure 13.) Investigators found the Nos. 3 and 4 winch controls in the neutral position. (See figure 14.) The positions of the winch controls may have been disturbed by firefighters, salvors, and others before investigators boarded the vessel.

The bow section forward of the cargo tank section remained intact. Except for minor smoke damage, the storeroom forward was intact. The stern section, which included the engineroom, crew quarters, galley, storerooms, and messroom, was undamaged. After firefighters extinguished the fire, they found that the generators in the engineroom were still running. Salvage crews removed the remaining gasoline from the cargo tanks before the vessel was refloated, and they towed the JUPITER to a ship breaking facility in Bay City.

BUFFALO.--The BUFFALO sustained no damage as a result of this accident.

Total Petroleum.--The 12-inch pipeline was bent and pulled loose from its foundation (see figure 6). When the pipeline pulled loose, the 1 1/2-inch nitrogen purge line to the pipe broke. The aluminum walkway on the upstream side of the pier leading to the Nos. 1 and 2 mooring pile clusters was damaged. The fire damaged the motor-operated valves at the end of the pier and burned the No. 2 mooring pile cluster almost down to water level. The JUPITER's wire broke the center piling of the No. 4 cluster. The estimated cost of the repairs to the Total Petroleum pier was $276,000.

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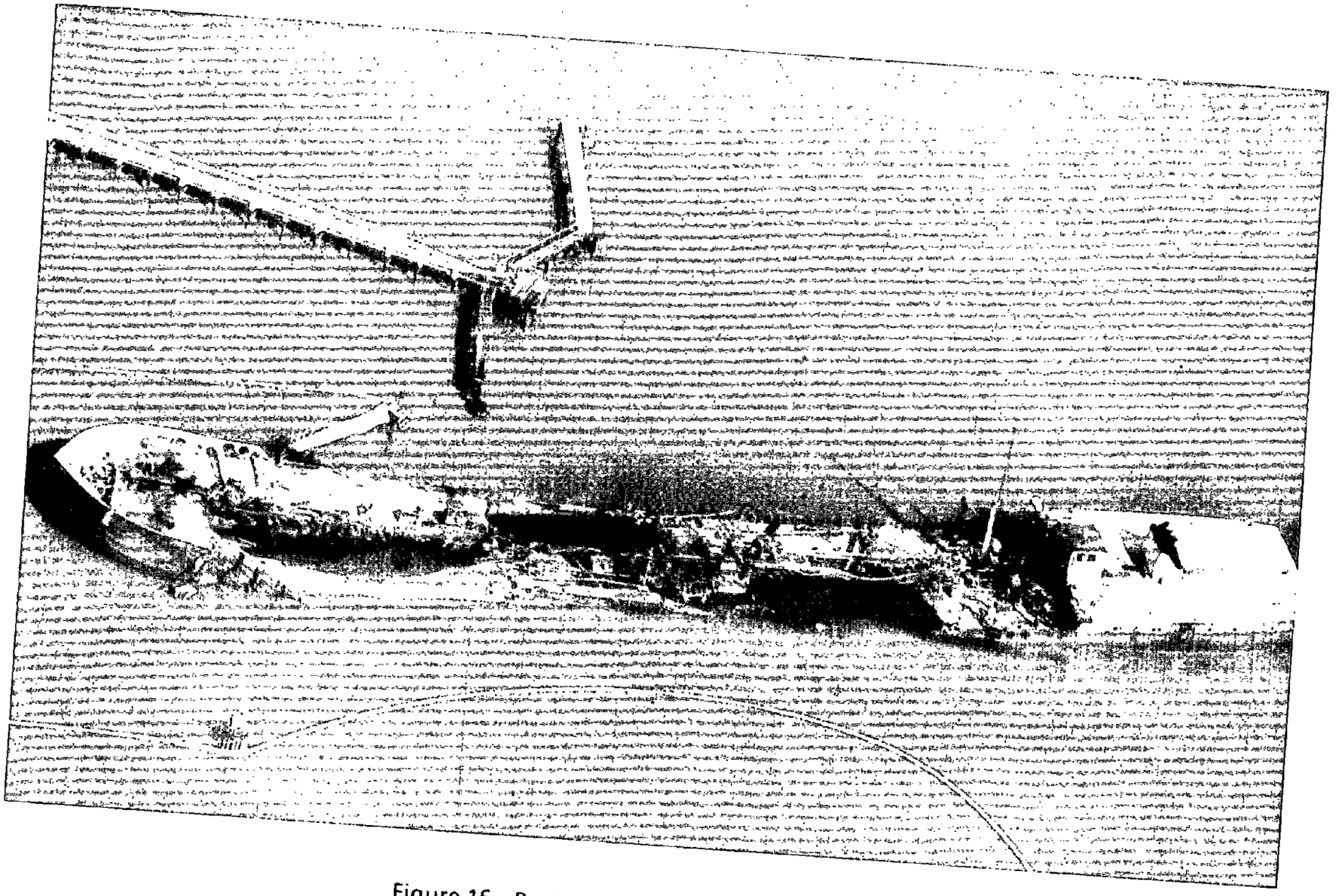

Figure 16.--Postaccident view of the JUPITER.
(Courtesy of the Bay City Times)

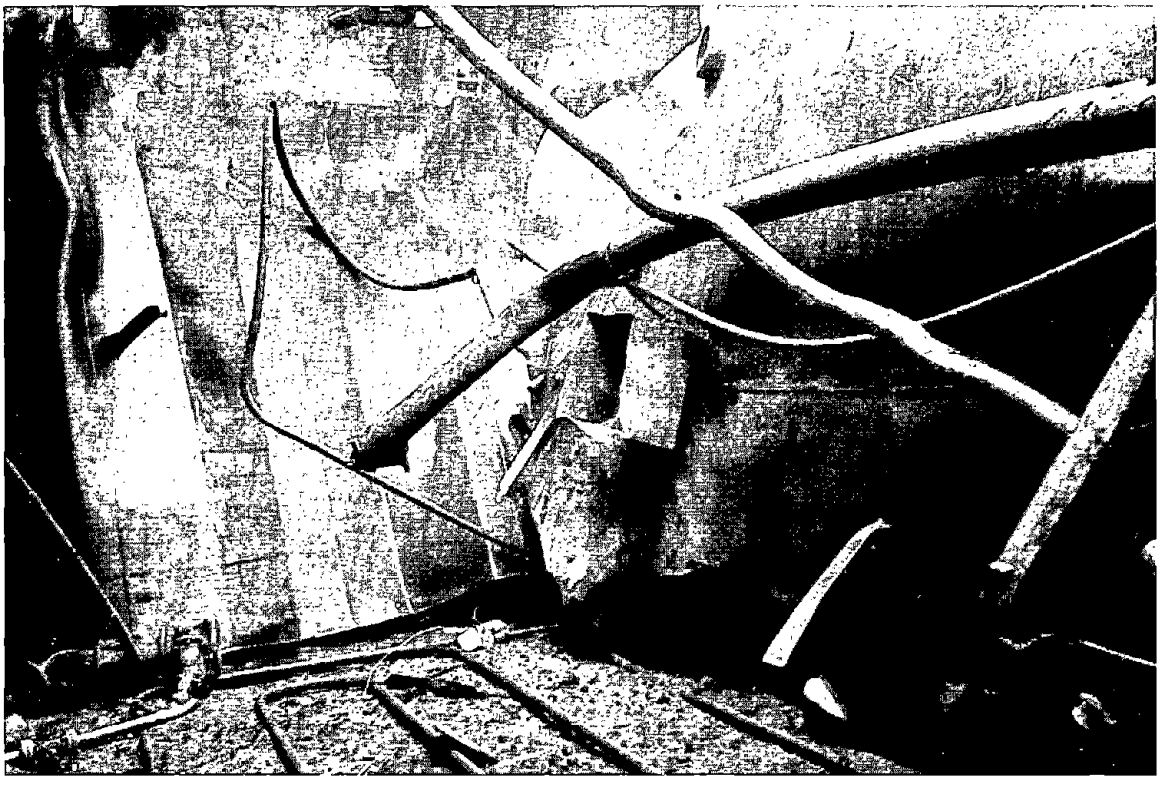

Figure 17.-- Damage to the bulkheads in No. 2 starboard cargo tank.

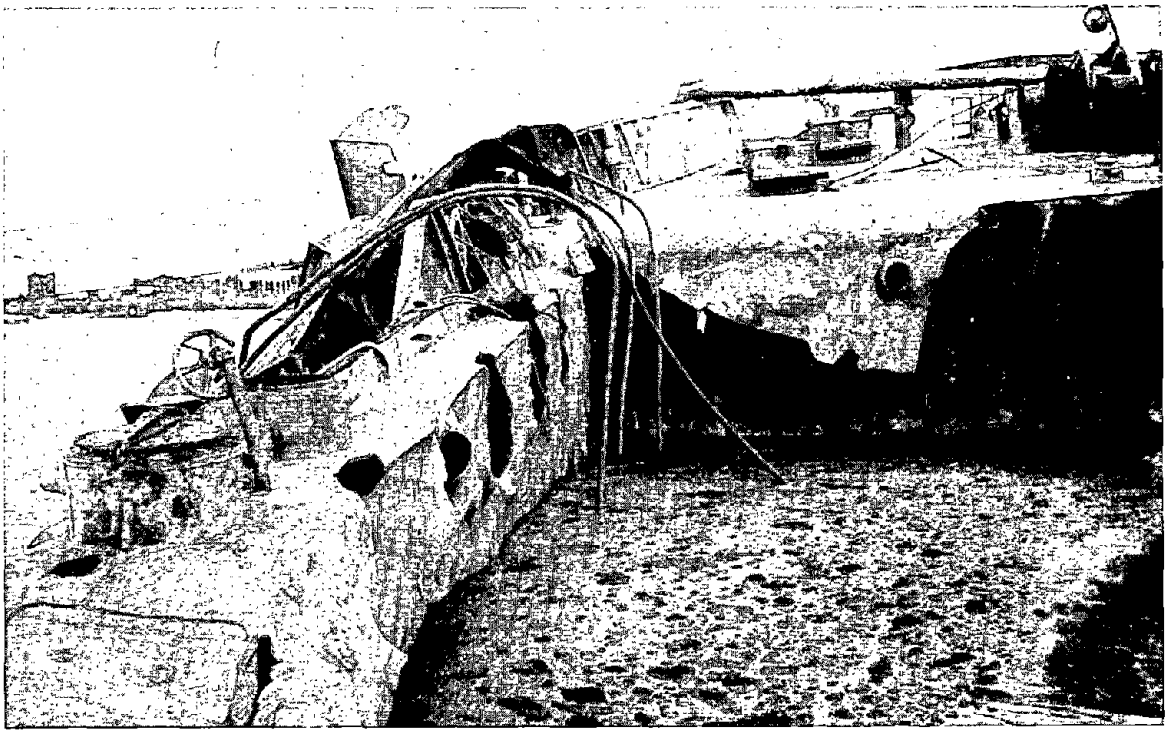

Figure 18.--Damage to No. 1 port cargo oil tank showing the double hull.

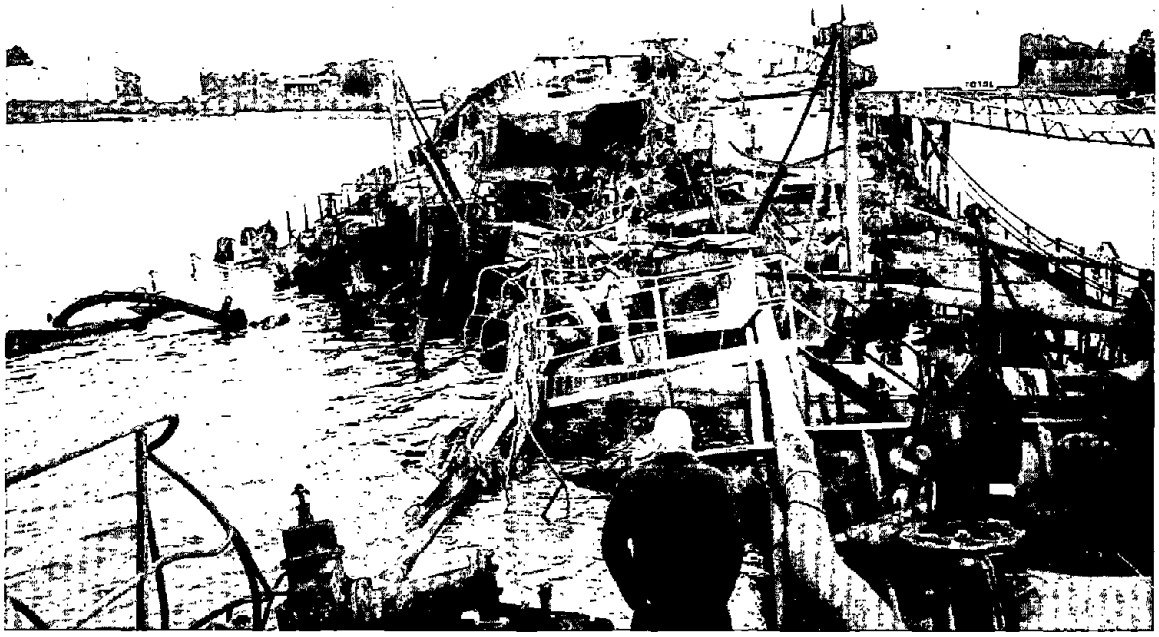

Figure 19.--View of the damage on the main deck.

Waterway Information

The Saginaw River is at the head of Saginaw Bay on the west side of Lake Huron. Vessels enter the river through a 350-foot-wide channel that is dredged to 27 feet and extends 13.5 miles. Channel buoys and a centerline range mark the channel. At the mouth of the Saginaw River, the channel width narrows to 200 feet. At Bay City, the channel depth is 26 feet. In the upper sections of the 22-mile-long river, depths decrease to about 15 feet at the south end of Saginaw City.

Bay City is about 2 miles from the mouth of the Saginaw River. The Total Petroleum terminal is on the west side of the river, about 1 1/2 miles farther upstream. Numerous wharves and waterfront facilities line both sides of the river. The BUFFALO's intended destination, the Midland Contracting Company pier, is approximately 6 1/2 miles from the river entrance. Vessels in the Bay City/Saginaw port area mainly transport commercial commodities, such as petroleum products, grain, limestone, coal, sand, gravel, and cement. Bay City/Saginaw is a designated customs port of entry.

The Saginaw River's mean monthly water level varies about 3 feet from the highest to the lowest. Heavy rains and flooding may cause unusually high water levels. Considerable fluctuations in the Saginaw's water level can occur during several hours of violent northeast or southwest winds. Vessels have grounded in the dredged channel during periods of unusually low water in Saginaw Bay. According to a USACE survey conducted in September 1990, at mean low water, the water depth in the dredged channel opposite the Total Petroleum berth was 26.8 feet. At the Total Petroleum pier, the depth at mean low water varied from 24 to 26 feet. The JUPITER, as moored, did not extend into the dredged channel, according to charts furnished by the USACE.

Meteorological Information

At 0800 on September 16, Coast Guard Station Saginaw Bay recorded the following weather observations: cloudy; visibility, 7 miles; easterly wind at a speed of 7 knots; air temperature 53°F; water temperature 71°F; barometer 29.82, rising. At 1000 on September 16, the station log entry indicated a 12-knot wind from the northeast.

According to the Sailing Directions for Lake Huron and Saginaw Bay region of Michigan, southerly through westerly winds prevail in the early autumn. From spring through fall, thunderstorms can produce short periods of high winds. Total Petroleum's terminal manager testified that cargo transfer operations between vessels and the terminal are usually suspended during thunderstorms.

Medical and Pathological Information

Survivors' Injuries.--Information in Bay City Medical Center's (BMC's) Emergency Disaster Flow Sheet/Log indicated that medical personnel examined 17 crewmembers from the JUPITER. Six men sustained injuries, three of whom were treated and released, and three were admitted to BMC. Medical records show that injuries sustained included burns to the face and hands, head injuries (closed), mild cold exposure, contusion on the lumbar spine, chest pains, headaches, ringing ears, a forehead laceration, and an abrasion on the lower leg. A Dow Chemical employee suffered smoke inhalation.

Fatal Injuries.--A 46-year-old male AB on board the JUPITER was reported missing on September 16. His body surfaced on September 19 at the Total Petroleum pier and was recovered by terminal personnel. An autopsy performed on September 20 at the BMC showed death was caused by asphyxiation due to drowning.

Survival Aspects

JUPITER.--A station bill posted in the JUPITER's crew quarters listed the fire and emergency duties and the abandon-ship stations for each crewmember, including any additional persons on board. (See appendix F.) The Coast Guard Marine Inspection Office at Toledo, Ohio, had approved this station bill on June 15, 1977. The document stated that the master was in command of all emergency operations. An emergency squad consisted of the mate and the crew on watch and three additional AB seamen. In the event of an emergency, each squad member was assigned specific items of emergency gear to bring to the scene.

The third mate stated that the JUPITER had placards and notices posted in each room and throughout the vessel that were clearly visible to the crew. The placards

and notices gave directions on how to don survival gear, as well as instructions in emergency procedures, including abandon-ship instructions.

The third mate also stated that fire and boat drills were held weekly aboard the JUPITER. During the drills, crewmembers activated one of the vessel's emergency systems to ensure that it was functioning properly. They pumped water through the foam lines to ensure the lines were clear and operational. At times, the crew donned survival gear, including exposure suits, to make sure the zippers and the battery-operated lights worked properly. At each weekly drill, weather permitting, the crew concentrated on a different aspect of an emergency procedure.

Terminal Response.--Because it had been raining on the day of the accident, the JUPITER'S third mate and the AB who manned the forward controls were wearing rain gear and heavy clothing. Neither man wore a lifejacket or an exposure suit when he jumped from the starboard bow into the water. While in the water, the third mate looked around and saw the AB about 10 feet away. The third mate stated that another explosion, which he believed emanated from the No. 1 tank, followed the first explosion. Fire spread on the surface of the water around the bow from gasoline that had splashed out of the tank. Both men swam toward the shoreline, about 300 feet away.

The third mate recalled that the AB was behind him. While he looked for something to swim to, he heard the AB yell, "Help me!" He saw the AB's arms go up in the air. The third mate believed that the man was tired and could not swim any farther. He swam back to the AB and put his right arm around his neck. The third mate was floating on his back. He stated that when he tried to pull him to safety, the AB kept sinking and dragging him down too. Each time the AB went under water, the third mate pulled him up to the surface. For a while, the third mate held onto the AB while he swam. He then held him by the collar and tried to pull him along, but the AB's weight was too much for him and he let him go. The AB disappeared under the water and was not seen alive again. The third mate swam to an old section of wood breakwater, crawled up on it, and lay there.

The terminal manager said that he was sitting in his office when he heard a whistle signal, which he knew came from a ship. He heard the terminal operator radio the fire alert and heard the JUPITER's mate radio that they were having a problem. The terminal manager called 911 (at 0835:45, according to the records of the 911 central dispatch) to report the fire on the JUPITER. From his office window, he could see fire on the forward end of the tankship. He testified that the fire equipment arrived about 5 to 10 minutes after he called 911.

After closing the valve ashore, the terminal operator ran back to the head of the pier. The assistant manager from the terminal office joined him. Both men noticed someone clinging to an old section of wood breakwater adjacent to the upstream side of the Total Petroleum pier. They ran to where a small open outboard motorboat was tied to the pier. Cutting loose the line holding the boat, they motored over to the third mate and pulled him into the boat.

They then went to the port side of the JUPITER to look for the AB but did not see him. They continued around the stern of the JUPITER and picked up the first assistant engineer and another crewmember. They attempted to pick up the cook but were unable to get him into the boat because of his size. They were able to drag the cook to shallow water, where he walked ashore. The boat put the three survivors ashore at the Total Petroleum dock.

Search and Rescue.--At 0837, a controller at the Coast Guard's 9th District Rescue Coordination Center (RCC) in Detroit, Michigan, heard a distress call on VHF-FM channel 16 from the JUPITER stating that the deck was engulfed in flames at the Total Petroleum dock about 2 1/2 miles from the mouth of the Saginaw River and that persons were in the water. At 0838, the RCC contacted Station Saginaw River and ordered a utility boat dispatched to the accident site as soon as possible.

Meanwhile, at 0845, the officer on duty (OOD) at Station Saginaw River received a call on VHF-FM channel 16 from the master of the JUPITER stating that the JUPITER and the Total Petroleum pier were on fire. The OOD sounded the Search and Rescue (SAR) alarm and briefed the coxswain of the 41-foot utility boat (CG 41466). At 0848, with five Coast Guardsmen aboard, CG 41466 got under way and proceeded to the Total Petroleum pier. About the same time, a Coast Guard auxiliarist, who was monitoring VHF-FM channel 16, heard an unidentified voice from the M/V JUPITER saying, "Help us! Help us! We are on fire!" Within minutes, another voice, believed to be that of the master, stated, "The BUFFALO's coming to us...we've severed our mooring lines and are engulfed in flames. Get us help immediately!" A husband and wife team who were Coast Guard auxiliarists donned their exposure suits and proceeded to their boat, USCG auxiliary boat No. 073 (CGA 073), located about 1/4 mile from the Coast Guard Station.

At 0849, the station recalled other Coast Guard personnel to provide assistance. The OOD broadcast the following marine advisory message on VHF-FM channel 16: "This is the Coast Guard Saginaw River. The Saginaw River has been closed due to a fire on board the M/V JUPITER." At 0851, CG 41466 and CGA 073 arrived at the scene. CG 41466, equipped with a 2 1/2-inch fire monitor on the bow, attempted to fight the fire but stopped when people on the stern began climbing over the side of the tankship. Some used a mooring line and others jumped into the water. The fire appeared to be more intense toward the bow. Coast Guard personnel stated that everyone jumping into the water from the JUPITER's stern was wearing a life preserver or an exposure suit. Both Coast Guard boats took survivors aboard.

At 0856, the JUPITER's master radioed that about 2/3 of the deck was on fire and that seven crewmen and an unknown number of dock workers were on board. He later said that at least 15 people were on board.

At 0858, CGA 073 contacted Station Saginaw River and reported that they had rescued five survivors who would need an ambulance when the boat arrived at the station. CG 41466 initially recovered seven survivors. They requested an ambulance for one survivor, whose hands were burned, and for others who were in shock. The burned person was treated aboard the CG 41466 before being transported to a hospital ashore. After the ambulances arrived, CGA 073 returned to the scene. At 0910, the Coast Guard dispatched CG 224310 to the scene with three Coast Guardsmen on board.

At 0912, the master informed the station that he had to leave the vessel. Coast Guard personnel on the rescue boats recalled that they yelled to the master to abandon ship and maneuvered the CG 41466 around to the JUPITER's stern to pick him up. As the master climbed down the mooring line from the stern and entered the water, another explosion occurred on board the JUPITER. He swam to CG 224310, which had arrived on scene at 0915. Later, CG 41466 transferred five other survivors to CGA 073, which transported them to shore for medical treatment.

At 0920, Station Saginaw River was informed that one person from the JUPITER was missing. The Coast Guard ordered all on-scene personnel to conduct a search in the immediate area. The search was unsuccessful.

At 0928, Station Saginaw River called the RCC in Detroit to brief them on SAR activities. They also advised the RCC that one person was still missing.

At 0935, CG 224310 maneuvered close to the D&M railroad bridge and found three more survivors from the JUPITER in waist-deep water near the shore. Two men were wearing exposure suits; the other man was wearing a yellow rain coat. At 0940, the CG 224310 transferred the three crewmen to the CGA 073, which took them to Station Saginaw River.

At 0945, the RCC requested that Station Saginaw River make another radio broadcast announcing that the Saginaw River was closed to all traffic. The RCC broadcast the same message. At 0955, the Coast Guard ordered all units to stand by and move 600 feet away from the JUPITER because by then the fire was too hot to get near. At 1000, the Coast Guard officially closed the Saginaw River to all traffic and established a safety zone in the area. CG 224310 reported that only one line was holding the tankship to its mooring.

At 1600, on September 17, 1990, Ashland Petroleum Company, parent company of Cleveland Tankers, Inc., requested that Coast Guard Group Detroit search for the body of the missing crewmember. Group Detroit lacked the trained divers and specialized equipment necessary to do a search. The Coast Guard ordinarily does not conduct body searches. Moreover, Group Detroit informed Ashland Petroleum Company that in this case, it could not conduct a search because its personnel were fatigued from the rescue effort. At 1610, RCC was advised of the request for a body search from Ashland and concurred with Group Detroit's decision not to comply.

Coast Guard personnel later picked up the third mate and the other two crewmen at the terminal and transported them to Station Saginaw River. After the third mate changed into dry clothes, he returned to the accident scene and provided information to the firefighters concerning the cargo aboard the JUPITER. He later went to the BMC, where doctors examined him and determined that he had not sustained any injuries.

In summary, the CG 41466 rescued seven persons, the CG 224310 rescued five persons (including the three whom Total Petroleum recovered and brought ashore near the D&M bridge), and CGA 073 rescued five persons.

The Coast Guard closed the SAR case on September 19, 1990, but ordered its Atlantic Strike Team to maintain a 24-hour safety and security zone patrol until salvors removed the remaining gasoline from the JUPITER.

Fire Department Response .--At 0835, the Bangor Township fire department's fire chief and assistant fire chief responded to a fire alarm at the Total Petroleum facility for the fire aboard the JUPITER. After being advised of conditions aboard the ship, the assistant chief ordered a second fire alarm sounded. The BMC also dispatched two ambulances to the accident site.

After discussing the situation with one of his firefighters, the Bangor Township fire chief decided to let the JUPITER burn to avoid risking the safety of the

firefighters until officials could obtain more information about the tankship. At least eight local fire departments provided mutual aid under the direction of the Bangor Township fire chief, who was named incident commander. The firefighters established command posts (CPs) at the Total Petroleum terminal and across the river opposite the oil terminal.

To contain spilled gasoline, the incident commander ordered oil containment booms deployed in the river between the tankship and the D&M railroad bridge. Local authorities determined that to stretch one boom across the river would require a 1,500-foot length of oil boom. Because the local area lacked enough lengths of boom to contain the existing spill, the authorites had to obtain additional booms from outlying areas. By 1111, 3,000 feet of oil boom had been gathered and delivered to the site. By afternoon, the Coast Guard had 6,000 feet of boom available. It rigged four oil booms across the river, two upstream and two downstream of the JUPITER. The Midland fire department and the Midland Dow Company furnished foam later to fight the fire on the JUPITER.

The fire department set up two 5-inch fire monitors on the Total Petroleum pier to keep the pier cool and to direct water on the mooring line and pile cluster holding the tankship. The fire pump at the terminal operated for more than 30 hours.

The local officials were concerned that the JUPITER might drift across the river because only one mooring line held the vessel. They obtained a 300-foot length of wire cable from a local power company and a large bulldozer from a local contracting company. After several attempts, they secured the wire cable between the JUPITER's anchor and the blade of the bulldozer on shore. By backing up the bulldozer, they pulled the JUPITER about 135 feet closer toward shore.

At 2345, Williams, Boots, and Coots, Inc., a commercial fire fighting firm from Texas, arrived on scene and began preparing for fire fighting operations the next day. The Coast Guard ordered its cutter, the BRAMBLE, a buoy tender, to assist in the fire fighting operation. The BRAMBLE was to be used as a platform from which firefighters could battle the JUPITER blaze. At 0815 on September 17, they loaded the necessary foam and equipment aboard the buoy tender. At 1230, the BRAMBLE got under way and proceeded to the scene of the fire. Firefighters performed foaming operations until 1645, when they declared the fire out. At 2112, however, the fire rekindled and burned throughout the night. At 1332 on September 18, the BRAMBLE got under way again and returned to the JUPITER. In less than 1 hour, firefighters extinguished the fire. The Coast Guard's on-scene commander (OSC), using personnel from the Atlantic Strike Team, monitored the JUPITER's status until workers offloaded all remaining gasoline.

The Coast Guard's responsibility concerning waterfront and shipboard fires is addressed in the Marine Safety Manual, volume VI, chapter 8, paragraph B, which states in part:

> Although the Coast Guard clearly has an interest in fighting fires involving vessels or waterfront facilities, local authorities are principally responsible for maintaining necessary firefighting capabilities in U.S. ports and harbors. The Coast Guard renders assistance as available, based on the level of training and the adequacy of equipment. The Commandant intends to maintain this traditional "assistance as available"

> posture without conveying the impression that the Coast Guard is prepared to relieve local fire departments of their responsibilities . . ..

Michigan State Police Response.--The Michigan State police emergency management division (EMD) is Michigan's emergency/disaster agency. In this accident, the EMD coordinated the State agency response and interfaced with Federal and local efforts. It arranged for State troopers to assist local law enforcement officers in securing the area affected by the explosion and fire. Additionally, the EMD provided the State police command trailer for use as a CP by all responders and provided personnel to staff the CP communications equipment. The EMD made arrangements for Department of Public Health personnel to sample and monitor air and water quality and for the Department of Natural Resources to deal with any issues concerning the environment, wildlife, and water quality to ensure compliance with State laws. The EMD provided helicopters for overflight assessment and videotaping of the emergency response activities.

Eight divers searched for mooring lines and other evidence pertaining to the tankship fire. In addition, the divers were to search for the missing person if the body had not been recovered before the gasoline dissipated on the surface of the water.

The assistant division commander stated that emergency personnel encountered no serious problems and that he believed that all agencies worked very well together in facing a serious threat to the community.

State Fire Marshal's Division.--At 0900, the commander of the hazardous material section notified the Michigan State fire marshal about the fire aboard the JUPITER. Accompanied by two officers from the fire marshal's division to assist him, he reported to the accident site to coordinate the fire fighting efforts.

Bay County Sheriff's Department.--At 0836, the Total Petroleum terminal manager notified the Bay County sheriff's department that a tankship was on fire at the terminal. The first sheriff's department unit arrived on scene at 0845. The sheriff's department dispatched four additional units to provide traffic control on the Independence Bridge and surrounding areas. They also dispatched three marine units (patrol boats), first to assist the Coast Guard with the search and rescue and then to assist in controlling traffic on the Saginaw River.

At 1800 on the day of the accident, the sheriff's department dispatched personnel to the Bay Harbor Marina, Sunset Shores, Bay City Yacht Club, and local waterfront residences to notify people that they might have to evacuate their property if the situation became worse.

Medical Response.--According to their records, the BMC received a call from the 911 central dispatch at 0837 stating that a tanker had exploded near the bridge. At 0840, BMC dispatched a paramedic unit to the accident scene, which was about 1 1/2 miles away. Upon arrival at 0846, the unit set up a triage area west of the command center. After the medical technicians had set up their facilities, the Coast Guard advised them that the Coast Guard personnel had picked up numerous survivors from the explosion and that the emergency medical technicians (EMTs) would meet them at the Wirt Stone pier south of the Independence Bridge. The paramedic unit moved its triage ambulance to the Wirt Stone pier. About this time, Coast Guard personnel brought seven survivors to the triage area to be treated.

Shortly thereafter, the paramedic unit requested that more ambulances and additional assistance be sent to the scene.

When the Coast Guard brought the JUPITER's master ashore, the EMT in charge questioned him about his crew, and he stated that, in addition to himself, 17 men were on the ship. He refused treatment and went to the nearby CP. The EMTs also went to the CP to treat the other survivors and to obtain the exact number and names of all crewmembers. They determined that all crewmen had managed to abandon ship and were in the water.

At 0920, the BMC ambulance supervisor and additional ambulances were dispatched to the scene. Medical personnel from other area emergency services were called to provide assistance as necessary.

After conferring with the BMC ambulance crew and Coast Guard personnel, the technician in charge of the first paramedic unit determined that one person was missing. He then advised the incident commander and the Coast Guard's OSC of the situation. By this time, EMTs had either examined and treated the other survivors at the scene or transported the injured to BMC for further examination. The emergency technician convinced the master to join the rest of his crew at the BMC for further examination.

The EMT-in-charge assigned another emergency technician to accompany a Coast Guard helicopter crew and to obtain an aerial overview of the fire. The EMT searched for the missing crewmember near the shoreline and in the river but was unsuccessful.

Critique of the Emergency Response.--Representatives of all agencies involved in the accident held an overview meeting of the incident at the Bay City city hall on December 6 to review the emergency response measures taken by the local authorities. They discussed problems that they encountered and proposed solutions to avoid similar difficulties in the future. A synopsis of the suggestions and observations made at the meeting is presented below:

- Emergency response agencies need additional communications equipment with compatible frequencies. Participants proposed using the 911 emergency center as a central dispatch.

- An organization chart should be developed that lists all emergency response agencies and appropriate points-of-contact to avoid the type of problems that occurred at the CP during the JUPITER incident.

- The fire burned for an extended period of time because of the lack of equipment and available trained personnel to extinguish it. In view of the limited amount and type of equipment and personnel devoted to the effort, the hazard abatement was handled well.

- The accident had minimal environmental impact because of the proper handling of the incident, the rapid cleanup, and the type of product involved.

- Approximately 300 persons from 35 agencies and industry interacted in an excellent manner.

Critique of the BMC Emergency Preparedness Procedures.--On September 20, officials of the BMC met to review the medical center's external disaster preparedness and to discuss several areas in which improvements could be made. The participants suggested the following:

- The medical center did not use the designated area for news media control. An accident of this nature required that the center reasonably accommodate the news media, as well as maintain adequate security.

- No one initially notified the switchboard of the potential for a "Code Red"[17] situation.

- In addition to social services staff, the hospital staff should have been available to counsel survivors and their families.

- The medical center should consider whether it can provide a more suitable area for discharged survivors and their families.

- A television set and possibly a cellular telephone should be bought for the control center so that center personnel have an improved means of communication with the accident scene and are better able to anticipate requirements in emergency situations.

The critique participants scheduled these issues for resolution by the Emergency Preparedness Subcommittee.

Disaster Preparedness.--At the time of the accident, Bay County Emergency Services activated its hazardous materials contingency plan. At 1000, the Governor proclaimed a state of emergency and implemented the Michigan State contingency plan. According to a representative from the Michigan State police EMD in Saginaw, Michigan, neither the State nor the county had guidelines for fighting shipboard fires, even though some government agencies had identified a need for such.

The incident commander responsible for fire fighting activities stated that local firefighters had not participated in any shipboard fire fighting training. In this accident, they implemented their standard operating procedures for fighting hazardous materials fires.

The incident commander and the Coast Guard's port safety officer from the Detroit (Michigan) Marine Safety Office concurred that local authorities and the Coast Guard had an unwritten agreement to provide mutual aid during accidents or disasters. They conceded that no fire fighting contingency plan included the Bay City port area.

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[17]The BMC's highest level of response to an external disaster, as stated in the center's Emergency Preparedness Manual.

The Coast Guard's Marine Safety Manual states in part:

> Paramount in preparing for vessel or waterfront fires is the need to integrate Coast Guard planning and training efforts with those of other responsible agencies, particularly local fire departments and port authorities.

Just 2 weeks before this accident, the Coast Guard and local agencies had held a disaster drill involving an oil spill. The Coast Guard and those agencies on the county's disaster plan periodically hold drills using different accident scenarios.

Tests and Research

Wood Mooring Pile. --Investigators sent a wood sample from the broken center mooring pile of the No. 4 pile cluster at the Total Petroleum's tanker berth to the U.S. Department of Agriculture's (USDA's) Forest Products Laboratory in Madison, Wisconsin, for examination. In its reply to the Safety Board (see appendix G), the USDA laboratory identified the species of the wood and concluded that decay was present. The report further stated that "characteristics of the wood cells at the fracture zone indicate that the wood was subject to brashness.[18]" The USDA laboratory could not specify the percentage of strength loss in the wood as a result of decay.

Hydrodynamic Studies.--Total Petroleum engaged a naval architect at the Massachusetts Institute of Technology in Cambridge, Massachusetts, to study the hydrodynamic interactions between the BUFFALO and the JUPITER.[19] In the course of his study, the naval architect analyzed factors that would affect the motion of the ships in the waterway. Using a computer program, he generated a simulation of the accident events as the BUFFALO passed the JUPITER. (See figure 20.)

The American Steamship Company (ASC), owners of the BUFFALO, engaged a consulting naval architect from Ann Arbor, Michigan, to conduct a separate study of the hydrodynamic interaction between the vessels.[20] The ASC's consultant used a different computer program to predict the interaction forces and moments that occurred during the passage of the BUFFALO.

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[18]Under certain conditions, wood fails abruptly, with minimal deflection and at lower than expected loads. These failures are characterized by cross breaks that lack the usual evidence of fibrous or splintering separation. Such brittle and weak behavior in wood is called brashness. ... and fungal decay causes brashness in wood. [Strength of Wood, Chapter 6].

[19]Preliminary Analysis of Hydrodynamic Interactions between the Motor Vessels JUPITER and BUFFALO in the Saginaw River, Bay City, Michigan by Professor J.N. Newman, Wayland, MA, 8 March, 1991, with addendum, July 18, 1991.

[20]Preliminary Report, the Interaction Between the M/V JUPITER and athe M/V BUFFALO and the Total Oil Terminal, Bay City, Michigan, on September 16, 1990 by Robert F. Beck. Report No. 91-1, March 15, 1991.

FIGURE 20a
NO INTERACTION

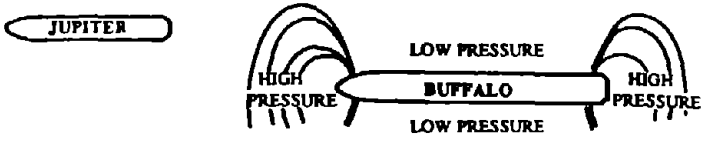

FIGURE 20b
START OF INTERACTION
Small Upstream Surge Force
Small Repulsive Force
Small Bow-In Yaw Moment

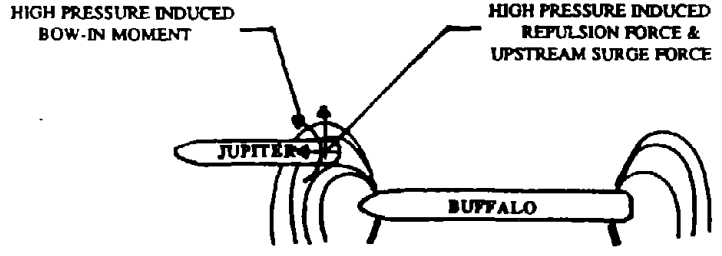

FIGURE 20c
MAXIMUM NEGATIVE SURGE FORCE AND YAW MOMENT
Near Maximum Downstream Surge Force
Very Small Side Force
Large Bow-Out Yaw Moment

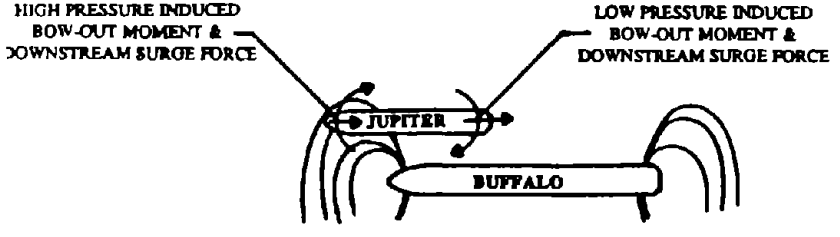

FIGURE 20d
MAXIMUM ATTRACTION FORCE
Small Surge Force
Large Attractive Side Force
Small Yaw Moments

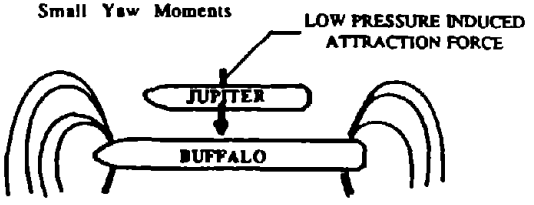

FIGURE 20e
MAXIMUM POSITIVE SURGE FORCE AND YAW MOMENT
Near Maximum Upstream Surge Force
Very Small Side Force
Large Bow-In Yaw Moment

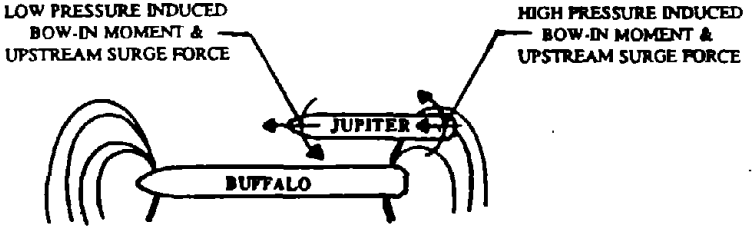

FIGURE 20f
SEPARATION PHASE
Small Downstream Surge Force
Small Repulsive Side Force
Small Bow-Out Moment

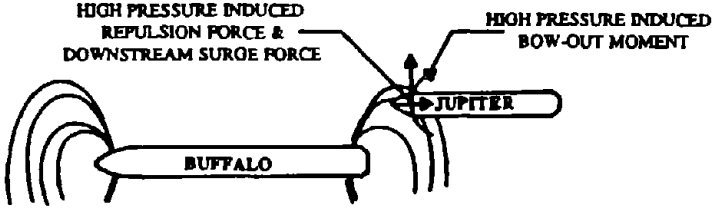

Figure 20.--Hydrodynamic interaction diagrams from Total Petroleum's report by Professor J. N. Newman.

In his report, the ASC's consultant explained the interaction forces that resulted at the following instances: when the larger vessel (the BUFFALO) approached the smaller vessel (the JUPITER), when the larger vessel passed abeam of the smaller vessel, and when the larger vessel cleared the smaller vessel.

Other Information

As a U.S. tankship, the JUPITER was subject to Coast Guard regulations at 46 CFR Parts 30-40, Subchapter D--"Tank Vessels." The regulations require that tank vessels be inspected biannually or more often if the local officer-in-charge marine inspection (OCMI), deems it necessary in order to determine whether a vessel is suitable to carry hazardous or flammable liquid cargo in bulk. The inspection covers the hull, cargo tanks, fuel tanks, ballast tanks, pressure vessels, piping, machinery, and equipment. Inspection of safety equipment is to include liferafts, lifejackets, exposure suits, all fire extinguishing equipment, and other required safety equipment. The Coast Guard regulations require that the vessel receive a drydock inspection every 5 years for examination of the underwater hull, through-hull fittings, sea valves, sea chests, and sea strainers.

ANALYSIS

As a result of its investigation of the fire and explosions aboard the JUPITER, the Safety Board found no mechanical deficiencies on the two vessels or in their equipment other than the design of the flame screen installation in the JUPITER's cargo tank ullage pipes. Investigators questioned vessel crews about their experience, work/rest cycles, and training, which were found not to have contributed to the accident. In determining the probable cause, the Safety Board considered the following factors:

- The adequacy of the JUPITER's mooring arrangement.
- The adequacy of Total Petroleum's mooring devices.
- The precautions that the JUPITER's crew took in anticipation of hydrodynamic forces that a passing vessel might generate.
- The BUFFALO's speed and position in the river.
- The adequacy of procedures that Total Petroleum's and JUPITER's operating manuals contained for alerting vessels moored at the Total Petroleum facility of an approaching vessel.
- The adequacy of the flame screen installation in the cargo tank ullage pipes.

General

A mooring system that limits vessel motion, thereby preventing momentum buildup, is essential to the safe transfer of liquid bulk cargoes between tankships and shoreside terminals. To prevent damage and possible spillage, the motion of a tankship along and away from a pier cannot exceed the limit of slack provided by the cargo transfer hoses. Crewmembers can restrict vessel movement along the

berth by running spring lines ashore from each end of the vessel to the terminal's mooring devices. To restrict vessel movement away from the pier, the crew should also run breast lines ashore as close to 90° as possible. Additional head lines and stern lines further secure the vessel against excessive motion.

The use of steel wire cables to moor vessels lessens the possibility of undue vessel motion along the pier because steel wire has limited elasticity compared with polypropylene or other fiber lines. When used with constant-tensioning winches, steel wire cables are the preferred method, particularly when used as spring lines, for mooring vessels. In addition, piers and mooring devices must be designed and constructed to accommodate the size of vessels expected to berth at a facility.

Accident

As the BUFFALO moved through the water, it generated an hydrodynamic pressure field that interacted with nearby shore structures and other vessels. The hydrodynamic effects are determined by the length, beam, and drafts of the ships, their lateral separation, water depths, and speed of the moving vessel. The forces produced can increase exponentially. In this case, the hydrodynamic forces affected the moored JUPITER and caused it to surge. According to an eyewitness, as the BUFFALO approached the JUPITER, it generated the initial upstream surge force that caused the water level to rise about 4 feet. (See figure 20b.) This force imparted a slight forward motion to the tankship, which was restricted mainly by the No. 2 and 4 mooring cables. As the BUFFALO continued past the smaller vessel, the direction of the hydrodynamic forces reversed. This downstream surge force caused the JUPITER to move aft with considerable force, placing a great stress on the No. 3 mooring cable. (See figure 20c.) Because the forward polypropylene line and the No. 1 mooring cable were used as breast lines, they offered little or no resistance to the aft surge. Only the No. 3 cable provided resistance to the JUPITER's aft motion. However, the No. 3 cable did not slow the aft motion because the winch brake was released when the AB started the winch motor and presumably payed out the cable to relieve the stress. When the JUPITER surged aft, the No. 2 and 4 wire cables became slack. Whether the AB on the forward winch controls removed the slack in the No. 2 mooring cable at this time and shut off power to the winch in order to set the brake is not known.

Moreover, if the AB manning the after winch controls was operating the No. 3 winch, he probably failed to notice the slack in the No. 4 cable. At this point in the passing, the BUFFALO generated near maximum upstream surge force which caused the JUPITER to quickly reverse its direction to a forward motion. (See figure 20e). As the JUPITER moved forward, only the No. 2 mooring cable offered resistance to the force. However, because it led aft as a spring line, the No. 2 cable caused the JUPITER's stern to swing away from the pier. As the BUFFALO's stern cleared the bow of the JUPITER, the interaction forces imparted a yawing or turning motion forcing the JUPITER's bow toward the shore, which caused the tankship's stern to swing out into the river. (See figure 20F.) When the No. 4 mooring cable became taut, the sudden shock-loading of the No. 4 mooring pile broke the pile. Both the No. 4 cable and the polypropylene line fell into the water, and the JUPITER's stern swung unchecked out into the river.

JUPITER's Mooring at the Total Petroleum Facility

When the JUPITER arrived at the Total Petroleum pier, the crewmembers moored the tankship at the facility as they had done on prior voyages. They led steel

wire cables from the four constant-tension winches to the center mooring pile of each of the four pile clusters adjacent to the pier, together with polypropylene lines from the bow and stern. They used the JUPITER'S No. 2 and 3 mooring cables as spring lines and ran the lines to the Nos. 2 and 3 pile clusters, respectively. They ran the No. 1 and 4 mooring cables to the No. 1 and 4 pile clusters, respectively. Because of the positioning of the No. 1 and 4 pile clusters, they led the bow polypropylene line slightly aft and the stern polypropylene line slightly forward to the same pile clusters as the No. 1 and 4 wire cables. Further, because the facility had only four pile clusters, they could not secure the polypropylene lines to separate mooring devices which, in this case, would have reduced the stress on each pile cluster, provided some redundancy, and if properly located, possibly limited the JUPITER's surging at the berth. While there was nothing wrong with the size of the pile clusters at the Total Petroleum pier, they were too few in number to adequately berth the JUPITER. Placing both bow lines and both stern lines to single mooring points does not provide enough security for the vessel if one of the mooring devices fails.

Moreover, because the JUPITER's bow extended beyond the No. 1 pile cluster and its stern extended beyond the No. 4 pile cluster, it appears that the berth was designed for smaller vessels and barges. Figure 2, the diagram of the JUPITER's mooring arrangement, shows that crewmembers could not run the bow and stern polypropylene lines in a manner that took full advantage of each line's potential. Because the after polypropylene was placed on the same pile cluster as the No. 4 steel wire cable, giving a forward lead to the line, the line was ineffective after the piling broke and its direction offered no protection to counter a forward surge by the vessel.

As the size of vessels berthing at the terminal increased, the mooring array also should have been modified to accommodate the larger vessels. An additional pile cluster at each end of the berth positioned beyond the JUPITER's bow and stern would not only afford better leads for the polypropylene lines, but would also provide the added security of additional mooring devices. The Safety Board concludes that the mooring arrangement at Total Petroleum's Bay City terminal should be upgraded so that vessels similar to the JUPITER can be moored using multiple mooring devices for bow and stern lines with proper leads fore and aft.

Because the JUPITER's forward polypropylene line led slightly aft and the No. 1 wire cable led slightly forward, both could be considered only partial breast lines. Given the limitations under which crewmembers had to run them, the lines were unable to prevent the vessel from surging aft. As figure 2 indicates, the lines were more suited to keep the vessel's bow alongside the berth. The figure also shows that the leads on both forward lines were not very effective in preventing the vessel from surging aft. If the forward polypropylene line had been led forward of the JUPITER's bow, it would have reduced the tankship's astern motion as the BUFFALO passed.

Over the years, many vessels had docked successfully at Total Petroleum's terminal, and its pier and mooring devices had received and passed visual examinations by the Coast Guard. However, the continued use of the wood mooring piles without a proper internal inspection of the piles ultimately resulted in a failure of one of the piles at a critical time. Although the USDA laboratory could not quantify the strength of the broken wood mooring pile, the test sample did show evidence of rot, indicating the strength of the wood piling had declined. The annual inspection of the pier and the mooring devices by the marine construction company should include probing of the wood pilings to determine whether the wood has

deteriorated to the extent that the strength of the pile may be affected. The Coast Guard should also include an examination of the mooring devices during its periodic inspections of the terminal.

Responsiveness of the JUPITER's Crew

Line Handling.--The AB assigned to the after winch control console, from which the Nos. 3 and 4 mooring wires were controlled, testified that when he started the winch motors, he was unable to take any action before the No. 4 mooring pile cluster broke. As spring lines, the Nos. 2 and 3 mooring wires were the only lines that could hold the vessel in position fore and aft to ensure that the JUPITER's valve manifold remained adjacent to the valves on the pier. The No. 3 mooring wire was critical to preventing any movement aft by the vessel. When the crew started the winches, however, the brakes automatically released. This allowed the wire cables to be pulled off the winch drum as the tension on the cable increased, constrained somewhat by the gear friction in the winch.

The AB testified that he had no time to manipulate the controls, but his testimony eliminates the only plausible explanation for the fact that the No. 3 wire cable had enough slack to make a splash that the third mate heard. If the No. 3 cable made a splash, either the No. 3 mooring pile broke or the wire payed out very rapidly as the vessel started to surge forward. As figure 5 shows, the No. 3 mooring pile did not break; therefore, the No. 3 cable must have payed out rapidly and continued to do so as the vessel's motion reversed. Since the AB testified that he had started the winch motor, it is reasonable to assume that because he was standing close to the taut wire, he instinctively placed the control lever in the pay out position as the wire became increasingly stressed to relieve the line tension as the vessel surged aft. The AB's post at the winch controls placed him between the Nos. 3 and 4 wire cables as they led away from the side of the vessel so that if the No. 3 wire cable broke, he would have been in the path of the wire as it sprang back. As a seaman, he knew that if the wire broke or released from the mooring pile, it would spring back to where he was standing and possibly strike him. When the vessel reached the limit of the surge aft and started forward, the wire cable, still paying out, then fell into the water, causing the "splash." Therefore, the Safety Board concludes that since the No. 3 wire cable failed to prevent the JUPITER from surging aft, it is most likely that the AB operating the constant-tension winch payed out the wire cable both to relieve the strain on it and as a precaution against breaking instead of using the winch to slow the aft motion of the vessel.

The third mate testified that when he heard the No. 3 wire cable splash in the water, he believed something was wrong with either the winch or its operation. Since the No. 3 winch successfully secured the vessel before the arrival of the BUFFALO, it is unlikely to have malfunctioned. The splash must have been the result of the AB's operation of the winch. The first mate testified that when he took over the winch controls from the AB, he hove in some of the slack in the No. 3 wire cable, but stopped when he realized that the vessel was rapidly moving forward. The amount of slack in the wire, some of which was due to the vessel's forward movement, must have been great enough to cause the first mate to start heaving the slack with the winch. Despite the AB's allegation that he did not move the control lever on the No. 3 constant-tension winch after starting the winch motor, the wire must have been paying out for a considerable amount of time to acquire enough slack to get the first mate's attention.

When the vessel's motion reversed and the JUPITER surged ahead with increased momentum, the No. 4 mooring wire quickly became taut and broke the center pile of the No. 4 pile cluster. The AB who manned the after winch controls testified that he had no time to respond to the forward surging of the vessel before the mooring pile broke. Had the AB had time to pay out the No. 3 wire cable, he could also have tended the No. 4 wire cable since the controls are in the same console. Had he controlled the No. 4 wire cable tension by removing the slack when the JUPITER surged aft, the buildup of speed forward would have been minimized and the sudden force or shock-loading on No. 4 mooring pile would have been greatly reduced. The No. 4 mooring pile may have held despite the pile's questionable strength. The manner in which the AB operated the JUPITER's constant-tension winches did not take full advantage of the features of the machines. Even though the brake had released, the constant-tension winch probably did not release the No. 4 wire cable fast enough to prevent the wire from shock-loading the mooring pile. Consequently, because the No. 4 pile cluster no longer secured the No. 4 wire, the No. 2 mooring wire took the entire force of the vessel's forward motion, constrained only by the brake or the gear friction in the winch.

Because the AB who manned the No. 2 winch died, the Safety Board could not determine what action, if any, he had taken to regain control of the vessel. Although investigators found the No. 1 winch control in the pay out position and the No. 2 winch control in the heave position, the Safety Board cannot be certain that the deceased AB left the controls in those positions. Because the No. 2 mooring wire served as a spring line and was secured to the same pile cluster against which the vessel rested forward, the cluster acted as a pivot point around which the vessel swung due to the component of force of the line in tension and the motion of the vessel as it surged forward, swinging the stern out into the river.

When the third mate assigned the ABs to the winch controls, he expected that they would operate the winches in a manner necessary to control any vessel motion caused by the passing of the BUFFALO. The purpose of starting the winch motors is to adjust the wire cables if necessary. If no adjustment is required, releasing the brakes on the constant-tension winches, particularly on the Nos. 2 and 3 winches, defeats their purpose, which is to hold the vessel in place. The Safety Board believes that the ABs who manned the JUPITER's constant-tension winch controls, especially the Nos. 3 and 4 winch controls, did not make the most effective use of the machines to prevent the JUPITER from surging at its berth when the BUFFALO passed.

Several observations can be made based on the photograph in figure 5. Contrary to the third mate's testimony, the motion of the vessel as it surged forward did not break the No. 2 mooring pile. (The No. 2 pile cluster subsequently burned down close to the water.) Moreover, the stress on the No. 1 wire cable as seen in the photograph, further indicates that the brake held, which prevented the vessel from drifting out into the river. The fact that the No. 1 winch brake held when the wire cable was subjected to its greatest stress further indicates that either the AB stopped the winch motors before he ran forward or the explosions caused a loss of power. This further supports the Board's conclusion that the AB manning the after winch controls did not operate the Nos. 3 and 4 winches properly.

Precautionary Measures Taken Aboard the JUPITER.--As the BUFFALO approached, the JUPITER's crewmembers expected their vessel to react to the hydrodynamic forces generated by a another passing vessel. Before manning the controls for the constant-tension winches, they stopped the cargo pumps and

started the hydraulic pump for the hose winch. The third mate, who was the watch officer at the time of the accident, explained that they took these precautions whenever the vessel was alongside a pier in a narrow waterway and another vessel was approaching. Although the JUPITER's operating manual did not include these precautions, the crew understood that they should follow them.

The crewmembers' precautions, however, should have included closing the manifold valve and the ullage pipe covers on the vessel and closing the motor-operated valve on the pier. If they had used the remote switch to close the pier valve and the ship's manifold valve, spillage would have been limited to what was in the cargo hose when it ruptured. Given the short period of time that they had to respond, it is doubtful whether they could have completed these additional precautionary measures during the time available. Moreover, any opportunity to close the valves and the ullage covers quickly vanished when the fire started. The Safety Board believes that because of the potential danger to vessel and crew and the possibility of polluting the environment, Cleveland Tankers, Inc., should include procedures in its fleet operating manuals for stopping the transfer operation when other vessels pass in the waterway. These procedures should also include a requirement that the appropriate valves be closed to limit spillage and that ullage covers be closed to redirect venting of the tanks through the P/V valves.

Arrival of the BUFFALO

When the BUFFALO arrived off the entrance to the Saginaw River, the first mate, as watch officer, broadcast a security call over VHF-FM channel 16 to advise marine traffic in the area of the vessel's position and destination. Following the security call, he established radio contact with Station Saginaw River and requested the height of the river. Later, as the BUFFALO entered the river, Station Saginaw River called the vessel and asked whether it was inbound or outbound. After responding to the question, the master broadcast a second security call, giving his vessel's position and destination. Since the JUPITER's crew did not customarily man the navigating bridge or monitor the VHF-FM radio while the vessel was moored, the watch officer on the tankship was unaware of the BUFFALO's approach. The crew on deck was expected to watch for approaching vessels. The third mate first became aware of the BUFFALO's presence when he heard its whistle signal requesting the opening of the Independence Bridge and when he sighted the vessel passing the D&M railroad bridge.

Because the JUPITER's crewmembers were busy tending to the cargo transfer, they could easily have failed to notice the BUFFALO, particularly if the BUFFALO's master had opted to call the Independence Bridge by VHF-FM radio rather than sounding a whistle signal. The Safety Board believes that current practices fail to ensure that personnel aboard a vessel moored at the terminal or terminal personnel have sufficient time to suspend transfer operations and take precautionary measures. The radio watchstander at Station Saginaw River was aware of the BUFFALO's presence in the river and could have telephoned the Total Petroleum terminal to alert terminal personnel that large vessels were moving in the waterway; those personnel in turn could have notified the JUPITER. The Safety Board believes that the infrequency of large vessel transit in the Saginaw River does not warrant a formal, structured vessel traffic system; it does believe, however, that the Coast Guard could enhance area waterway safety and security by requiring vessels to call Station Saginaw River and advise them of their expected movement so that the Coast Guard could alert area terminals if necessary. Because the Safety Board advocates that tank vessels berthed at the Total Petroleum take additional

precautionary measures when discharging cargo, it is essential that both the berthed vessel and terminal personnel be notified by the Coast Guard of impending traffic so that they can undertake shutdown procedures in a timely manner.

Speed of the BUFFALO

The record of the BUFFALO's transit in the Saginaw River from the time it entered the waterway until it arrived off the Midland Contracting Company's pier did not include the speed of the vessel at various points during the voyage or the times that the vessel passed bridges, landmarks, and navigational aids. The BUFFALO's logbook shows that the vessel passed the front range marker of the entrance channel range at 0800 and that it arrived off the Midland Contracting pier at 0920. Station Saginaw River's records indicate that the vessel passed the station at 0815. Safety Board investigators calculated the BUFFALO's average speed between the river entrance and the Midland pier, a distance of 6.5 miles, to be about 4.8 knots or 5.5 mph. The vessel's speed between the river entrance and the D&M railroad bridge, a distance of 2.8 miles, was 5.4 knots, or 6.2 mph. Based on the estimated transit time (10 minutes) between the D&M Railroad Bridge and the Independence Bridge, a distance of 0.7 miles (1,417 yards), when the BUFFALO passed the JUPITER, the BUFFALO's speed was approximately 4.2 knots, or 4.8 mph. Board investigators took the times from the automatic time records of the 911 central dispatch when the bridge tender called in to report the opening and closing of the Independence Bridge. To calculate speed using the time record of the 911 central dispatch, it was assumed that the bridge tender placed the call to 911 at the same interval following the passage of the BUFFALO through each bridge.

The BUFFALO's master became aware that the JUPITER was moored to the Total Petroleum pier when he visually sighted the vessel on his approach to the railroad bridge. He testified that when he saw the JUPITER at the Total Petroleum facility, he immediately adjusted his vessel's propeller pitch setting to 4 feet and maintained that setting until he passed the JUPITER. The master stated that it was the minimum pitch he could use and still maintain control of the vessel, although he testified that he could not relate pitch to speed and did not know what speed was equivalent to the 4-foot pitch setting in the Saginaw River. Investigators could not verify the BUFFALO's speed as it passed the JUPITER because, like most Great Lakes vessels, the BUFFALO did not maintain a pitch/speed record during the river passage. However, both the master and the chief engineer testified that 4 feet of pitch was the minimum setting before the propeller went to zero pitch. The master stated that at zero pitch, he would lose control of the vessel. Although the Safety Board believes that the BUFFALO had a 4-foot pitch setting on its engine controls when it passed the JUPITER, the Board cannot determine whether the vessel had slowed to the corresponding speed by the time it reached the JUPITER.

The BUFFALO's master testified that because of the effect of the wind on his vessel's starboard side, he steered closer to the JUPITER than he ordinarily would have to avoid setting over to the opposite bank. He was aware that he passed abeam of the tankship with about 60-65 feet of clearance. Members of the JUPITER's crew corroborated the clearance between the vessels. The port side of the JUPITER was outside, but close to the western edge, of the 200-foot-wide channel. The BUFFALO's beam was 68 feet. Thus, the centerline of the BUFFALO was within a few feet of the center of the dredged channel, placing its port side about 70 feet from the channel's eastern edge. According to the master's testimony, he believed that if he had steered any closer to the eastern side of the channel, the BUFFALO would have grounded. His statement that he passed "closer than normal" to the

JUPITER because of the wind on his starboard side implies that in the past he had passed vessels at the Total Petroleum terminal with greater clearance by navigating closer to the opposite bank. As an experienced shiphandler, the BUFFALO's master should have been aware that by passing closer to the JUPITER, the hydrodynamic forces generated by the BUFFALO would have a greater effect on the moored vessel. In short, if he had to pass closer to the JUPITER, the master should have used less speed. If a reduction in speed was not a viable option, he should have passed the JUPITER at a greater distance. The Safety Board believes that when the BUFFALO passed closer than normal to the JUPITER without a further reduction in speed, the combination of speed and proximity resulted in hydrodynamic forces that caused the tankship to surge heavily at the berth and subsequently to break away.

Because the mate on watch on the bridge of the BUFFALO had limited duties (watching the wake), he could have readily logged the times that the vessel passed buoys and bridges. The Coast Guard regulations in 33 CFR Part 164 for vessels over 1,600 gross tons require that the vessel's position be placed on the navigation chart of the area and that the person directing the movements of the vessel set the speed with consideration for underkeel clearance and damage that might be caused by the vessel's wake and for any local vessel speed limit. (See appendix I.) Large vessels, such as the BUFFALO, should maintain an accurate record of the engine maneuvers and courses steered, either manually or automatically, so that if the speed of the vessel becomes a safety issue, the appropriate records are available. Moreover, such records would allow investigators to recreate a vessel's trackline, further aiding the investigation of marine accidents. By maintaining accurate records of the vessel's maneuvering, including necessary speed reductions to safely pass vessels berthed in narrow waterways, masters and pilots will become more aware of the hazards of navigating large vessels in narrow waterways. Continuous attention to the vessel's speeds and courses is necessary because of the possible damage from wake or other hydrodynamic phenomena when vessels move. The Safety Board believes that the bridge watch of vessels over 1,600 gross tons that transit the Great Lakes and its tributaries should record the vessel's position at regular intervals and have a means of recording the times of engine maneuvers, as well as a means of continuously recording the vessel's compass headings (course recorder).

Total Petroleum's Inspection of Its Pier

Total Petroleum's periodic inspections of its Bay City pier apparently did not include an adequate examination of the mooring piles. A visual inspection by the marine construction company failed to detect the defects in the wood. From its appearance, the wood section that the USDA laboratory analyzed did not seem to be strong enough to properly secure a vessel the size of the JUPITER, especially a vessel large enough to be affected by the momentum caused by hydrodynamic forces created by a passing vessel. Further, the marine contractor had not sounded or probed the center pile in the No. 4 pile cluster during his last examination. The strength of the center pile was critical to the safe mooring of vessels because it functioned as a mooring device. If Total Petroleum had properly inspected and maintained the center pile, the evidence of rot would have been discovered and the necessary repairs could have been made in a timely fashion. Because vessels berth infrequently at the Bay City terminal, Total Petroleum had ample time to schedule any repairs without affecting vessel use of the pier. The Safety Board concludes that Total Petroleum was remiss in its examination of the mooring facilities at its pier; the company should have arranged for a condition survey of the mooring pile clusters at regular intervals, particularly of the strength of the center pile to which vessels' mooring lines are secured.

Spread of the Fire

When gasoline spilled onto the pier from the broken nitrogen purge line connection on the 12-inch pipeline, sparks from the damaged electrical conduit ignited the gasoline. The fire quickly spread to the deck of the tankship and ignited the gasoline that spilled from the ruptured cargo hose. Contained by the 6-inch spill rail, the burning gasoline spread throughout the midships area and around the open ullage pipes. Because the inside periphery of the ullage pipes had no continuous shoulder or ledge to properly support the flame screens and completely seal the space around the periphery of the flame screens (the clearance between the pipe and the edge of the flame screen was wide enough to allow a measuring tape to be kept in the ullage pipe without removing the screen), the fire on deck probably propagated into the tanks through the open ullage pipes. The design of the flame screens conformed to the applicable Coast Guard regulations (46 CFR 30.10-25--"Flame Screens"); however, the installation of the screens in the ullage pipes rendered them ineffective because the clearance around the edge of the screen was greater than the mesh of the screen itself. The Coast Guard regulations do not address this problem. Instead, a Coast Guard spokesman characterized it as a "common sense" item that inspectors should check during Coast Guard vessel examinations. Therefore, the Safety Board urges the Coast Guard to tell their inspectors to pay particular attention to flame screen installations to ensure that the flame screen completely seals the opening around its periphery.

Moreover, if crewmembers had closed the ullage pipe covers when the JUPITER stopped discharging and allowed the tanks to vent through the P/V valves, the explosions most likely would not have occurred. The vessel's crew probably could have extinguished the gasoline fire on deck using the fixed foam extinguishing system before the heat caused ignition in the tanks. The Safety Board concludes that the most likely cause of the explosions was the propagation of fire around the improperly designed flame screens in the open ullage pipes and into the cargo tanks.

Total Petroleum's Operating Manual

Total Petroleum prepared the operating manual used by the Bay City facility in accordance with 33 CFR Part 154. Approved by the Coast Guard, the manual includes descriptions of the types and grades of liquid petroleum products handled at the terminal, the hazards involved, and instructions for the safe handling of the products. It also includes procedures that terminal employees should follow in the event of spills, instructions on how to care for persons exposed to the material, what equipment is available at the terminal for containment and recovery, and the names of persons and agencies, Federal, State, and local, to notify in the event of a spill.

However, the manual does not outline the procedures that terminal employees should follow when a vessel berthed at the terminal during transfer operations is approached by another large vessel. Total Petroleum leaves such procedures to the discretion of the vessel personnel in charge of the transfer operation. Although the Declaration of Inspection Prior to Bulk Cargo Transfer (see appendix C) lists requirements personnel must comply with before transfer may begin, the terminal's operating manual does not state that transfer operations should cease during passage of river traffic or in the event of other hazards developing that could affect the operation's safety. The Safety Board believes that the terminal should be more involved with vessel transfer operations that may seriously affect the outcome of a spill or casualty. The Board also believes that the operating manual of the Total

Petroleum facility should include a provision for notifying a vessel berthed at the terminal when other vessels of significant size are expected to pass in the waterway so that the crew can halt transfer operations in a timely manner.

During April 1990, Coast Guard examiners inspected the Total Petroleum facility at Bay City and reviewed the company's Terminal Operations Manual for compliance with Federal regulations; they made another "spot" inspection in August 1990. Inclusion of shutdown procedures in the Coast Guard regulations would ensure that the operators of the terminal and the vessel both have responsibility for the vessel's safety and for safeguarding the waterway from pollution. Although the Coast Guard approved the Bay City facility's operating manual, acknowledging that it was in compliance with existing regulations for liquid bulk transfer operations, the manual does not address a shutdown requirement by vessels transferring liquid cargo when large vessels are expected to pass. The Safety Board believes the Coast Guard should amend the regulations so that Coast Guard-approved Marine Oil Transfer Facility operating manuals include procedures for stopping the transfer of product between the terminal and tankships moored at the terminal when the danger of surging exists from passing vessels.

Terminal Responsibility for Tankships Moored at the Facility

The terminal's manager was in the terminal office when the BUFFALO sounded its whistle to open the Independence Bridge. Although he had a VHF-FM radio in the office, he had it tuned to the frequency of the handheld radios carried by the terminal operator and the watch officer aboard the JUPITER. Because a shoreside facility is not required to monitor VHF-FM channel 16, the terminal manager was not aware of the approaching vessel until he heard its whistle. When a vessel is moored and transferring liquid cargo, early knowledge of an approaching vessel would enhance the safety of both the terminal and the vessel. Terminal personnel could be alerted by Coast Guard Station Saginaw River that a vessel is expected to pass in the river. The terminal personnel could then notify the vessel berthed at the terminal. If the terminal manager had known earlier of the BUFFALO's presence in the river, he could have alerted the watch officer on the JUPITER sooner.

Critical functions, such as suspending cargo transfer operations and manning the mooring winches, should not be left to chance. Terminal personnel should share responsibility for notifying vessels at their facility of ships moving in the river when transfer operations are under way. Because the terminal operator and the JUPITER's deck officer each had a handheld radio that was tuned to the radio at the terminal manager's office, the information could have been passed quickly. As a backup, the terminal operator, who was positioned near the JUPITER with his handheld radio, could also have notified the vessel. The Safety Board believes that as an added back up, operations at the Total Petroleum terminal should include receiving information from Station Saginaw River so that terminal employees can give timely notice to vessels loading or discharging at the Total Petroleum pier.

Survival Factors/Search and Rescue

Coast Guard Response.--When Coast Guard personnel at Station Saginaw River received word that the JUPITER had suffered explosions and was on fire, they immediately dispatched a boat and were on scene 13 minutes after receiving notification from the RCC. If the fire and explosions had forced the tankship's crew into the water before the Coast Guard rescue units arrived, the chance of injuries would have increased. The Coast Guard station's location close to the accident site

enabled the boats to reach the scene quickly. When the Coast Guard units attempted to fight the fire, they soon realized it was beyond their capability and concentrated their efforts on recovering persons from the water. The Safety Board believes that the Coast Guard units involved should be commended for their promptness and their decision to attend to the JUPITER's crew first. The Safety Board concludes that the timely and effective on-scene response from the Coast Guard units limited the fatalities and injuries.

Abandon Ship Procedures.--Within minutes of the explosion, the JUPITER's master had notified the Coast Guard of the accident and started to assemble the crewmembers on the stern of the vessel for a personnel check. Both first mates made certain that all crewmembers on the stern had donned either lifejackets or exposure suits before the master gave the order to abandon ship. Unfortunately, the third mate and an AB were trapped on the bow and did not have the time to get lifejackets before jumping into the water. The Safety Board believes that the AB who drowned could have survived had he been able to locate and don one of the lifejackets that were stowed forward before he jumped overboard. Since the crew did not have the capability to extinguish the fire, the most expedient thing that the master could do was to quickly get the crew off the vessel in a safe manner. At the time, it was uncertain whether more explosions would follow. Considering the loss of pressure in the fixed foam extinguishing system, the master was prudent in ordering his crew off the vessel instead of having it stay aboard to fight the fire.

Response by Local Authorities.--Despite the timely response of local fire and other emergency units, fire fighting efforts were not immediately effective because of the magnitude of the fire. Through their combined efforts, local firefighters, the Coast Guard, and a commercial fire fighting company extinguished the fire after it had burned for 2 1/2 days. During a December 6 critique of the initial response held at the Bay City City Hall, participants agreed that they allowed the fire to burn because "there was no equipment or trained personnel to extinguish it." Although shipboard fires, in particular tankship fires, occur infrequently in the Bay City/Saginaw River area, the JUPITER accident highlights the fact that local fire departments need specific training in fighting shipboard fires.

Units from Station Saginaw River assisted in deploying the oil booms, and the Coast Guard district commander provided the buoy tender BRAMBLE as a platform from which commercial fire fighters could work. The Bay City area does have a contingency plan, but the plan does not provide for training in shipboard fires or other marine catastrophes. The Safety Board has previously recommended that the Coast Guard integrate Coast Guard planning and training efforts with those of local authorities in developing port contingency plans that involve participation by the local waterfront facilities, the local fire and police departments, existing port authority agencies, and other disaster preparedness agencies. In 1985, as a result of a cruise ship fire in Port Canaveral, Florida, the Safety Board issued the following recommendation to the Coast Guard:

> M-85-29
>
> Direct the Captain-of-the-Port, Jacksonville, Florida, to participate in establishing a port contingency plan for Port Canaveral with the Canaveral Port Authority and local jurisdictions in the port community.

A similar recommendation (M-85-36) was made to the Canaveral Port Authority.

The recommendation to the Coast Guard has been incorporated in the Marine Safety Manual;[21] it directs the captain-of-the-port (COTP) to develop a fire fighting contingency plan that addresses fire fighting in each port in the COTP zone. The recommendation to the Canaveral Port Authority resulted in acquisition of and training in the use of emergency equipment in the port. Both recommendations have been classified "Closed--Acceptable Action." The Safety Board recommends that the Detroit Coast Guard COTP, who has responsibility for the Bay City/Saginaw River area, in cooperation with local authorities, develop a port contingency plan that includes shipboard fire fighting training and drills.

Toxicological Testing

Because the results of chemical tests for drugs and alcohol are dependent on how soon the samples are taken after an incident, the Coast Guard regulations require that the marine employer ensure that the necessary specimens are collected as soon as practicable after an incident occurs. The Safety Board recognizes that the JUPITER operator and master were concerned about the rescue of the crew and were engaged in other emergency measures immediately after the accident. Nonetheless, the operator and master were responsible for having crewmembers provide samples for toxicological testing, and they should have fulfilled that responsibility by notifying the hospital to collect specimens from the injured crewmembers who were taken there. The uninjured crewmembers should have been taken for testing as soon as emergency conditions had abated. Because specimens were not obtained until the following day, meaningful tests for alcohol were not possible.

The accident occurred about 0835, but the crew of the BUFFALO did not recognize for some time their role in the accident. That afternoon a Coast Guard officer informed the BUFFALO master of his ship's involvement and the need for collecting specimens. Some of the crew had already gone ashore. About 1900, the marine employer took urine specimens from nine crewmembers, and the specimens were tested for drugs. Again, it was not feasible to perform meaningful tests for alcohol. However, the Safety Board believes that as soon as Coast Guard officials arrived on the BUFFALO, they should have notified the master to collect urine specimens that may have made it feasible to test for alcohol.

The Safety Board received only the MRO's assessment of the toxicological testing results on the crewmembers of both vessels; it did not receive the laboratory results. The information received did not include the time the specimens were collected or the drugs that were included in the testing protocols. Investigators determined, based on phone conversations with consultants involved in the evaluation of testing results, that those results did not include results of alcohol testing and that the MROs did not know whether tests had been done for alcohol.

The MRO's report states that the individuals on the BUFFALO "met the drug-free requirements specified under U.S. Coast Guard regulations (46 CFR Parts 4, 5, and 16)." The MRO's report regarding the JUPITER crewmembers states that the individuals "underwent a substance abuse test in accordance with applicable DOT regulations." However, because alcohol was not included in either of the MRO's

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[21] U.S. Coast Guard Marine Safety Manual, volume VI, chapter 8, paragraph B.

reviews, the Safety Board does not agree that the crewmembers underwent abuse testing in accordance with 46 CFR Parts 4, 5, and 16, which require testing for alcohol.

The Safety Board is concerned that sampling for drug tests was not carried out in a timely manner, and because of the lack of timely response, that testing for alcohol was not carried out. The Board is also concerned that MRO reports on each of the vessel appear to be misleading.

CONCLUSIONS

Findings

1. The BUFFALO was proceeding at 4 feet of pitch when it passed the JUPITER; however, based on the lack of substantiating evidence, such as engine maneuvering records, investigators could not determine the BUFFALO'speed.

2. The BUFFALO'S speed and close proximity to the JUPITER resulted in large hydrodynamic forces that caused the JUPITER to surge at the pier, break the No. 4 mooring pile, and swing out into the river, rupturing the flexible discharge hose.

3. Total Petroleum's four mooring devices at its Bay City terminal were inadequate to safely berth the JUPITER.

4 By the time they sighted the BUFFALO as it passed through the Detroit and Mackinaw railroad bridge, The JUPITER's crewmembers had sufficient time only to stop the cargo pumps and man the constant-tension winches to protect the tankship from the effects of hydrodynamic forces generated by a vessel passing in the river. It is doubtful that they had sufficient time to take additional precautions, such as closing the ullage covers and the discharge valve at the cargo manifold.

5. The JUPITER's crewmembers did not have an alert system that would give them reliable and timely notification of the BUFFALO's impending passage in the Saginaw River.

6. The No. 3 wire cable failed to prevent the JUPITER from surging aft because when the AB started the winch motor, the brake released, and allowed some cable to pay out. Moreover, the AB probably paid out additional cable to relieve the stress.

7. The JUPITER crew's failure to take up the slack in the No. 4 wire mooring cable when the tankship first moved astern resulted in shock-loading on the No. 4 mooring pile when the vessel surged ahead.

8. Sparks from the damaged electrical conduit ignited the spilled gasoline on the pier, and fire spread to the deck of the JUPITER.

9. Explosions resulted when the flame front passed around the improperly installed flame screens in the open ullage pipes and entered the cargo tanks.

10. The operating manual for the JUPITER was inadequate because it failed to include specific instructions that vessel personnel were to follow when danger of surging from a passing vessel existed.

11. The JUPITER burned for 2 1/2 days until a commercial firefighting company extinguished it because local firefighters were not trained or equipped to fight shipboard fires.

12. The disaster contingency plan for the Saginaw River/Bay City area was inadequate because it did not include training in fighting shipboard fires for local fire departments.

13. Postaccident drug and alcohol testing procedures were not followed.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the fire and explosions aboard the tankship JUPITER was the failure of Total Petroleum, Inc., to provide adequate mooring facilities for tankships such as the JUPITER, which allowed the vessel to break away from the pier because of surging caused by a passing vessel. Contributing to the accident were the inadequate procedures used aboard the JUPITER for managing the mooring lines and winches while other ships passed nearby and the fact that the BUFFALO was navigated to pass closer to the JUPITER than normal. Contributing to the severity of the accident were the lack of a reliable and timely alerting system that would have given the JUPITER's crew adequate time to take additional precautions to safeguard the vessel and the failure of the owners of the JUPITER and the U.S. Coast Guard to ensure that flame screens were properly fitted.

RECOMMENDATIONS

As a result of its investigation of this accident, the National Transportation Safety Board made the following safety recommendations:

--to the U.S. Coast Guard:

> Amend 33 CFR Part 154, "Oil Pollution Prevention Regulations for Marine Oil Transfer Facilities," to require that the Facility Operating Manual include procedures for stopping the transfer of product between a vessel and the terminal when a danger of surging exists from passing vessels. (Class II, Priority Action) (M-91-31)
>
> Direct the captain-of-the-port of Detroit to instruct the officer-in-charge of Coast Guard Station Saginaw River to notify in a timely manner area marine bulk oil/hazardous material terminals in the Bay City/Saginaw port area within Coast Guard jurisdiction of impending river traffic so that personnel at the terminals and aboard moored vessels can take appropriate measures to suspend the transfer operations, thereby enhancing safety. (Class II, Priority Action) (M-91-32)

Direct the captain-of-the-port of Detroit to work with State and local jurisdictions to establish a port contingency plan for the Saginaw River/Bay City port area that includes training and drills for shipboard fire fighting. (Class II, Priority Action) (M-91-33)

Include in the Coast Guard inspection instructions for marine oil transfer facilities a requirement that inspectors check the condition of the mooring facilities. The inspection should include a determination of the overall adequacy of the mooring facilities to safely berth vessels of varying lengths. (Class II, Priority Action) (M-91-34)

Instruct Coast Guard inspectors to determine that the flame screens installed aboard tankships provide a complete seal around the periphery of the screen. (Class II, Priority Action) (M-91-35)

Disseminate the information contained in this accident report to the marine industry by means of Coast Guard publications and notices, emphasizing the requirements of 33 CFR Part 164. (Class II, Priority Action) (M-91-36)

--to Cleveland Tankers, Inc.:

Amend your fleet operating manuals to include written procedures for suspending the bulk transfer of hazardous liquids when a danger of surging exists from passing vessels. These written procedures should include, but not be limited to, stopping pumps, closing valves at the loading/discharge manifold, closing ullage pipes or other tank openings, notifying terminal personnel, and manning and operating mooring winches. (Class II, Priority Action) (M-91-37)

Modify, as necessary, the flame screen installations aboard the vessels in your fleet so that they provide a complete seal around the periphery of the screen. (Class II, Priority Action) (M-91-38)

--to Total Petroleum, Inc.:

Include probing of the wood pilings during your annual inspection of the pier and the mooring devices to determine whether the wood has deteriorated to the extent that the strength of the pile may be affected. (Class II, Priority Action) (M-91-39)

Require that all vessels using your facility have a forward and aft lead for their bow and stern lines. (Class II, Priority Action) (M-91-40)

Amend the Bay City Terminal Operations Manual to include procedures for shutting down loading/discharging operations in a timely manner aboard vessels moored at the terminal

when a danger of surging exists from vessels transiting the waterway adjacent to the terminal. (Class II, Priority Action) (M-91-41)

Establish a procedure for receiving river traffic information from Coast Guard Station Saginaw River when transfer operations are in progress so that terminal personnel can notify vessels at your Bay City facility of such traffic in a timely manner. (Class II, Priority Action) (M-91-42)

--to the Lake Carriers' Association:

Recommend that your members establish a procedure aboard their vessels to record engine maneuvers, either manually or automatically, when entering or leaving port and at other times during a voyage when maneuvering by engines is required, and have a means of continuously recording the vessels' headings (course recorder). (Class II, Priority Action) (M-91-43)

--to the State of Michigan:

Direct the Michigan Department of State Police, Emergency Management Division, to amend the County Emergency Planning Workbook, dated November 1986, to include provisions for shipboard firefighting training and to include procedures for fighting shipboard fires in the State Contingency Plan. (Class II, Priority Action) (M-91-44)

--to Bay County Emergency Services:

Amend the Bay County emergency contingency plan to include guidelines for fighting shipboard fires. (Class II, Priority Action) (M-91-45)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ James L. Kolstad
Chairman

/s/ Susan M. Coughlin
Vice Chairman

/s/ John K. Lauber
Member

/s/ Christopher A. Hart
Member

/s/ John A. Hammerschmidt
Member

October 29, 1991

APPENDIXES

APPENDIX A

INVESTIGATION

The National Transportation Safety Board was notified of the accident on September 16, 1990, through its North Central Regional Office. The Safety Board conducted its on-scene investigation jointly with the U.S. Coast Guard from September 17, 1990, through September 28, 1990, and on November 27, 1990, in Bay City, Michigan.

Total Petroleum Corporation, American Steamship Company, and Cleveland Tankers, Incorporated, participated in the investigation as parties. The estate of John Sexton, deceased, participated in the joint NTSB/USCG public hearing as a party.

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APPENDIX B

PERSONNEL INFORMATION

David L. Beckwith

Captain David L. Beckwith, 44, master of the JUPITER, had been employed continuously by Cleveland Tankers since 1976. He had sailed on four company tankers and was master of the JUPITER for 2 1/2 months during the 1990 shipping season. He alternated between the company vessels on a regular basis. He started his sailing career in 1964 aboard U.S. Steel vessels in an unlicensed capacity. He had been a licensed deck officer since 1973 and held a master's license, unlimited tonnage, for the Great Lakes with a first class pilot's endorsement and an unlimited radar observer's endorsement. Since 1976, he had visited the Total Petroleum terminal at Bay City about three to five times a year.

Peter Walton

Peter Walton, 34, was first mate aboard the JUPITER until 0800 on the day of the accident. His replacement had assumed the duties as first mate, and both were on the vessel when the fire and explosion occurred. Peter Walton had served aboard the JUPITER for about 2 1/2 months during the current shipping season. He had been employed by Cleveland Tankers since his graduation from the Great Lakes Maritime Academy in 1979. He served aboard the JUPITER for a period of time each season and on two other company tankships. He held a Coast Guard license as master near coastal and Great Lakes, including first class pilot, unlimited tonnage, and an endorsement as unlimited radar observer.

George A. Defrain

George A. Defrain, 39, had assumed the duties as first mate at 0800 on the day of the accident. He had been employed by Cleveland Tankers since 1983 and had served aboard other company vessels each shipping season. He had served aboard the JUPITER earlier during the current shipping season. He held a Coast Guard license as mate, Great Lakes and inland waters, and as first class pilot, Great Lakes, unlimited tonnage. He had a radar endorsement. Before 1980, he served in unlicensed capacities aboard Great Lakes and inland vessels.

James M. Stengel, Jr.

James M. Stengel, Jr., 24, second mate of the JUPITER, had graduated from the Great Lakes Maritime Academy in 1987. He first worked aboard vessels of the U.S. Steel Corporation's Great Lakes fleet. He was employed by Cleveland Tankers about 1 1/2 years before the accident. He had about 7 to 8 months experience aboard the JUPITER. He held a Coast Guard license as mate and first class pilot, unlimited tonnage, for the Great Lakes and a radar endorsement.

Daniel A. Rentschler

Daniel A. Rentschler, 28, third mate of the JUPITER, joined the vessel soon after his graduation from the Great Lakes Maritime Academy in June 1990. The day of the accident marked his second visit to Total Petroleum's Bay City terminal. He held a Coast Guard license as mate and first class pilot, unlimited tonnage, for the Great Lakes and an unlimited radar observer's endorsement.

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James Warren

James Warren, 52, the JUPITER's pumpman had been employed by Cleveland Tankers since 1981. He started sailing in 1955 and had served in all unlicensed capacities in the engineroom. He held a merchant mariner's document with endorsements as engineman, fireman, oiler, tankerman, pumpman, and ordinary seaman.

Randall J. Skinner

Randall J. Skinner, 61, an 8-12 AB/watchman, had been employed by Cleveland Tankers since August 1979, during which time most of his experience had been aboard the JUPITER. He started his seagoing career on deep-sea tankships and cargo vessels in 1957 and has held a merchant mariner's document as AB since 1970. He started sailing on Great Lakes vessels in August 1979.

John Macfalda

John Macfalda, 42, master of the BUFFALO, held a Coast Guard license as master and first class pilot, unlimited tonnage, for the Great Lakes with an unlimited radar endorsement. He had been employed by American Steamship Company since 1971. With the exception of a few years following a company/ union change in the seniority system, he had sailed as master since 1982. His experience included service aboard the larger 1,000-foot-long Great Lakes vessels. His training included a shiphandling course in Port Revell, France, and observing other shipmasters handle Great Lakes vessels of various sizes.

Richard P. Hollingsworth

Richard P. Hollingsworth, 35, the BUFFALO's third mate, had been employed aboard the vessel since its fitting out for the 1990 shipping season in March. He sailed mostly as second mate, occasionally as third mate. He held a Coast Guard license as mate and first class pilot, unlimited tonnage, for the Great Lakes with a radar endorsement. He started sailing when he was 17 and had been licensed since 1979. He estimated that he had been into the Saginaw River about 20-30 times during the current season.

Daniel L. Meyers

Daniel L. Meyers, the AB/wheelsman at the BUFFALO's helm when it passed the JUPITER on the day of the accident, had been sailing since 1966. He had held a merchant mariner's document as AB since 1969. He had 13 years experience as a wheelsman on Great Lakes vessels. He joined the BUFFALO in 1982 and, except for the seasonal layup during the winter, had sailed aboard the bulk carrier continuously.

Alan P. Garner

Alan P. Garner was the terminal manager at Total Petroleum's Bay City terminal. He had been employed by the company for 5 years. He held no Coast Guard documents or licenses. His duties as terminal manager included scheduling of pipeline deliveries, working with the product supply department when vessels were

due, managing truck traffic through the terminal, and ensuring that the terminal had sufficient products for sale.

Elmer Seltz

Elmer Seltz was the terminal operator on the day of the accident. He had been employed by Total Petroleum for 23 years. He held no Coast Guard documents or licenses. His responsibilities included general maintenance around the terminal and the truck loading racks. He helped tie up vessels calling at the terminal and connected the hoses. He also lined up the terminal's valves and operated the pumps to transfer product as necessary.

APPENDIX C

DECLARATION OF INSPECTION PRIOR TO BULK CARGO TRANSFER

VESSEL JUPITER

TRANSFER FACILITY TOTAL

LOCATION BAY CITY, MI

TIME & DATE TRANSFER STARTED _____

PRODUCTS
NV

The following list refers to requirements set forth in detail in 33 CFR 156.20, 156.150 and 46 CFR 35.35-30. The spaces adjacent to items on the list are provided to indicate that the detailed requirements have been met.

	Deliverer	Receiver
1. Vessels Moorings 156.120 (A)		AG
2. Hoses; length and support 156.120 (B) (C)		AG
3. Hoses or Loading Arms condition 156.120 (I) (J) 156.170		AG
4. Transfer System Alignment 156.120 (D)		AG
5. Transfer System; unused components 156.120 (E) (F)		AG
6. Transfer System; fixed piping 156.120 (G)		AG
7. Transfer Systems; monitoring devices 156.120 (L) 154.525		AG
8. Overboard Discharges/Sea Suction Valves 156.120 (H)		AG
9. Connections 156.130; 156.120 (K) (P)		AG
10. Discharge Containment System 156.120 (M) (N)		AG
11. Scuppers or Drains 156.120 (O)		AG
12. Emergency Shutdown 156.120 (R)		AG
13. Spill & Emergency Shutdown Procedures 156.120 (R) 156.125		AG
14. Person in charge; on vessel/on facility 156.120 (S) (T)		AG
15. Sufficient Personnel 156.120 (U)		AG
16. Communications/Language Fluency 156.120 (Q) (V)		AG
17. Transfer Conference 156.120 (W)		AG
18. Agreement to begin transfer 156.120 (X)		AG
19. Lighting (sunset to sunrise) 156.120 (Y) (Z)		AG
20. Warning Signs & red Warning Signals (35.35-30)		AG
21. Repair Work Authorization (35.35-30)		
22. Boiler and Galley Fires Safety (35.35-30)		AG
23. Fires or Open Flames (35.35-30)		AG
24. Safe Smoking Spaces (35.35-30)		AG

I do certify that I have personally inspected this facility or vessel with reference to the requirements set forth in Section 35.35-30 and that opposite each of them I have indicated that the regulations have been complied with.

Person in Charge Receiving Unit	TITLE	TIME AND DATE
Alan Harmon	Terminal Mgr.	0340 9-16-90
Person in Charge Delivering Unit		
[signature]	2nd mate	0200 9/16/90

TIME AND DATE TRANSFER COMPLETED

DISTRIBUTION: ORIGINAL - Retained by Master
PINK COPY - Terminal Superintendent
YELLOW COPY - Cleveland Office

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APPENDIX D

U.S. COAST GUARD CERTIFICATE OF INSPECTION, JUPITER

CERTIFIED TO BE A TRUE COPY
D.J. Rightmyer LCDR 21 Sep 90
SIGNATURE RANK DATE

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

CERTIFICATION DATE: 21MAR90
EXPIRATION DATE 21MAR92

Certificate of Inspection

IMO NUMBER: 7367287

LAST HULL EXAM: 07APR87 DRYDOCK

VESSEL NAME	OFFICIAL NUMBER	CALL SIGN	SERVICE
JUPITER	D571820	WZC7603	TANK SHIP
HOME PORT	HULL MATERIAL	HORSEPOWER	PROPULSION
PHILADELPHIA, PA	STEEL	4200	DIESEL REDUCTION

PLACE BUILT	DATE BUILT	GROSS TONS	NET TONS	DWT	LENGTH
JENNINGS, LOUISIANA	15DEC76	4263	3764	10932	384.00

OWNER
CLEVELAND TANKERS INC
100 WEST TENTH AVE
WILMINTON, DE 19899

OPERATOR
CLEVELAND TANKERS, INC
55 PUBLIC SQ. PO BOX 6479
CLEVELAND, OH 44101

THIS VESSEL MUST BE MANNED WITH THE FOLLOWING LICENSED AND UNLICENSED PERSONNEL, INCLUDED IN WHICH THERE MUST BE 3 CERTIFICATED LIFEBOATMEN AND 0 CERTIFICATED TANKERMAN

1 MASTER	___ MASTER & 1ST CLASS PILOT	4 ABLE SEAMEN	1 CHIEF ENGINEER	___ FIREMEN/WATERTENDERS
___ CHIEFMATE	___ ___ CLASS PILOT	2 ORDINARY SEAMEN	___ 1ST ASST ENGINEER	___ OILERS
___ 2ND MATE	___ RAD O OFFICER(S)	___ DECKHANDS	___ 2ND ASST ENGINEER	___ ___
3 LIC MATES	___ ___ OPERATOR(S)	___ ___	2 ASSIST ENGRS	___ ___

IN ADDITION THIS VESSEL MAY CARRY 0 PASSENGERS, 4 OTHER PERSONS IN CREW, 3 PERSONS IN ADDITION TO CREW AND NO OTHERS TOTAL PERSONS ALLOWED 20

ROUTE PERMITTED AND CONDITIONS OF OPERATION

GREAT LAKES

THE ELIMINATION OF WATCHSTANDING QMEDS AND LICENSED ENGINEERS IN THE MACHINERY SPACES IS CONTINGENT UPON THE PROPER OPERATION OF THE AUTOMATED CONTROL/MONITORING SYSTEMS. ALTERATIONS TO OR FAILURE OF THESE SYSTEMS MUST BE REPORTED IMMEDIATELY TO THE OCMI WHO ISSUED THE VESSEL'S CERTIFICATE OF INSPECTION.

*** SEE NEXT PAGE FOR ADDITIONAL CERTIFICATE INFORMATION ***

WITH THIS INSPECTION HAVING BEEN COMPLETED AT MILWAUKEE, WISCONSIN ON 21MAR90, THIS VESSEL IS CERTIFIED BY THE OFFICER IN CHARGE, MARINE INSPECTION, MILWAUKEE, WI TO BE IN ALL RESPECTS IN CONFORMITY WITH THE APPLICABLE VESSEL INSPECTION LAWS AND THE RULES AND REGULATIONS PRESCRIBED THEREUNDER.

PERIODIC REINSPECTIONS

DATE	ZONE	SIGNATURE

THIS CERTIFICATE ISSUED BY
W. R. HAMILTON, USCG
OFFICER IN CHARGE MARINE INSPECTION
MILWAUKEE, WI
INSPECTION ZONE

DEPT. OF TRANSP., USCG, CG841 (Rev. 3-81)
PREVIOUS EDITIONS ARE OBSOLETE
SN

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APPENDIX E

U.S. COAST GUARD CERTIFICATE OF INSPECTION, BUFFALO

OMB No. 2115-0517

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

CERTIFICATION DATE 20MAR89
EXPIRATION DATE: 20MAR91
IMO NUMBER: 7620353

Certificate of Inspection

LAST HULL EXAM: 23MAR88 DRYDOCK

VESSEL NAME	OFFICIAL NUMBER	CALL SIGN	SERVICE
BUFFALO	D596352	WSX6134	FREIGHT SHIP

HOME PORT	HULL MATERIAL	HORSEPOWER	PROPULSION
PHILADELPHIA, PA	STEEL	7200	DIESEL REDUCTION

PLACE BUILT	DATE BUILT	GROSS TONS	NET TONS	DWT	LENGTH
STURGEON BAY, WISCONSIN	01JAN78	11619	8036		617.00

OWNER	OPERATOR
FIRST NAT BANK OF CONNECTICUT BENEFIT CONNELL RICE & SU ONE CONSTITUTION PLAZA HARTFORD, CT 06115	AMERICAN STEAMSHIP COMPANY 3200 MARINE MIDLAND CNTR. BUFFALO, NY 14203

THIS VESSEL MUST BE MANNED WITH THE FOLLOWING LICENSED AND UNLICENSED PERSONNEL, INCLUDED IN WHICH THERE MUST BE 3 CERTIFICATED LIFEBOATMEN AND 9 CERTIFICATED TANKERMAN.

1 MASTER	___ MASTER & 1ST CLASS PILOT	3 ABLE SEAMEN	1 CHIEF ENGINEER	___ FIREMEN-WATERTENDERS
___ CHIEFMATE	___ ___ CLASS PILOT	___ ORDINARY SEAMEN	1 1ST ASST. ENGINEER	3 OILERS
___ 2ND MATE	___ RADIO OFFICER(S)	___ DECKHANDS	1 2ND ASST ENGINEER	___ ___
3 ___ MATES	___ ___ OPERATOR(S)	6 DECK UTILITY	1 3D AST ___ ENG'RS	___ ___

IN ADDITION, THIS VESSEL MAY CARRY 9 PASSENGERS, 7 OTHER PERSONS IN CREW, 4 PERSONS IN ADDITION TO CREW, AND TOTAL PERSONS ALLOWED 31

ROUTE PERMITTED AND CONDITIONS OF OPERATION

GREAT LAKES AND THE WATERS OF THE ST. LAWRENCE AS FAR EAST AS ANTICOSTI ISLAND.

SPECIAL STEELS HAVE BEEN UTILIZED DURING CONSTRUCTION. THE CONSTRUCTION PORTFOLIO SHALL BE CONSULTED PRIOR TO ANY REPAIRS OR ALTERATIONS.

*THREE OF THE DECK UTILITY PERSONS MUST HOLD THE ENDORSMENT FOR ABLE SEAMEN.

*** SEE NEXT PAGE FOR ADDITIONAL CERTIFICATE INFORMATION ***

WITH THIS INSPECTION HAVING BEEN COMPLETED AT TOLEDO, OHIO ON 20MAR89, THIS VESSEL IS CERTIFIED BY THE OFFICER IN CHARGE, MARINE INSPECTION, TOLEDO, OHIO TO BE IN ALL RESPECTS IN CONFORMITY WITH THE APPLICABLE VESSEL INSPECTION LAWS AND THE RULES AND REGULATIONS PRESCRIBED THEREUNDER.

PERIODIC REINSPECTIONS		
DATE	ZONE	SIGNATURE

THIS CERTIFICATE ISSUED BY:

J. L. CONVERSE, LCDR, USCG
OFFICER IN CHARGE MARINE INSPECTION
ST. IGNACE, MI
INSPECTION ZONE

DEPT. OF TRANSP., USCG, CG-841 (Rev. 3-85)
PREVIOUS EDITIONS ARE OBSOLETE

SN 7530-00-FOI-0370

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APPENDIX F

EMERGENCY STATION BILL, JUPITER

CG-[illegible] (Rev. 10-[illegible])
U.S. COAST GUARD

UNITED STATES COAST GUARD

SPECIMEN OF A STANDARD STATION BILL PREPARED FOR FREIGHT AND TANK SHIPS CARRYING PERSONS IN ADDITION TO CREW

STATION BILL

SIGNALS

m - v (tanker) JUPITER
(Name of ship)

Cleveland Tankers, Inc.
(Name of company)

FIRE AND EMERGENCY—Rapid ringing of the ship's bell and continuous ringing of general alarm bells for a period of at least 10 seconds.
ABANDON SHIP—More than 6 short blasts and 1 long blast on the whistle and the same signal on the general alarm bells.
MAN OVERBOARD—Hail, and pass the word "MAN OVERBOARD" to the bridge.
DISMISSAL—From FIRE AND EMERGENCY stations, 3 short blasts on the whistle and 3 short rings on the general alarm bells.

S P E C I A L S I G N A L S

FIRE FORWARD.....ONE LONG & ONE SHORT BLAST ON SHIP'S WHISTLE, SAME ON GENERAL ALARM

FIRE AFT.....ONE LONG & TWO SHORT BLAST ON SHIP'S WHISTLE, SAME ON GENERAL ALARM

RESCUE BOAT REQUIRED.....THREE LONG & THREE SHORT BLAST ON SHIP'S WHISTLE

FOAM REQUIRED.....AUTOMATED FOAM SYSTEM WILL BE ACTIVATED FROM BRIDGE

EMERGENCY SQUAD

EMERGENCY SQUAD WILL CONSIST OF THE MATE AND CREW ON WATCH PLUS THREE OTHER ABLE SEAMEN

BERTH NO.	RATING	FIRE & EMERGENCY DUTIES	ABANDON SHIP STAT
A	MASTER	MAN BRIDGE - ASSUME COMMAND OF ALL OPERATIONS	LIFERAFT NO. 1 OR IN COMMAND
1	FIRST MATE	MAN BRIDGE - ASSIST MASTER AS DIRECTED - SECOND IN COMMAND	IN COMMAND LIFERAFT NO. 1
2	SECOND MATE	IN CHARGE OF EMERGENCY SQUAD AS DIRECTED - PROVIDE FLASHLIGHT	IN COMMAND LIFERAFT NO. 2
3	THIRD MATE	IN CHARGE RESCUE BOAT - PREPARE FOR LAUNCHING - PROVIDE EXTRA LINE	SECOND IN COMMAND LIFERAFT NO. 1
4	CHIEF ENGINEER	CONTROL ROOM - IN COMMAND ENGINE ROOM - SECURE VAPOR BOILER	SECOND IN COMMAND LIFERAFT NO. 2
5	ASSISTANT ENGINEER	ENGINE ROOM - ASSIST CHIEF ENG'R. CLOSE WATERTIGHT DOOR - SECURE A/C	LIFERAFT NO. 1
6	ASSISTANT ENGINEER	ENGINE ROOM - ASSIST CHIEF ENG'R. SECURE VENTILATION	LIFERAFT NO. 2
7	12/4 A/B WATCHMAN	EMERGENCY SQUAD - PROVIDE PORTABLE CO-2 EXTINGUISHER & FLASHLIGHT	LIFERAFT NO. 1
8	4/8 A/B WATCHMAN	EMERGENCY SQUAD - PROVIDE PORTABLE DRY CHEM. EXTINGUISHER & FLASHLIGHT	LIFERAFT NO. 2
9	8/12 A/B WATCHMAN	EMERGENCY SQUAD - PROVIDE FIRE AXE, WRECKING BAR & FLASHLIGHT	LIFERAFT NO. 1
10	12/4 O/S DECKHAND	EMERGENCY SQUAD - PROVIDE FRESH AIR BREATHING APPARATUS - RESCUE BOAT	LIFERAFT NO. 2
11	4/8 O/S DECKHAND	EMERGENCY SQUAD - PROVIDE FRESH AIR BREATHING APPARATUS - RESCUE BOAT	LIFERAFT NO. 1
12	8/12 A/B DECKHAND	EMERGENCY SQUAD - PROVIDE FLASHLIGHT & ASSIST 3RD MATE WITH RESCUE BOAT	LIFERAFT NO. 2
13	PUMPMAN	EMERGENCY SQUAD - SECURE ALL VENT COVERS, PUMPROOM, CARGO OPENINGS	LIFERAFT NO. 1
14	ENGINE UTILITYMAN	ENGINE ROOM - ASSIST ENGINEERS - LEAD OUT FIXED DRY CHEMICAL HOSE	LIFERAFT NO. 2
15	STEWARD	SECURE GALLEY FIRES, BLOWER FANS, A/C, STOREROOM, CLOSE ALL DOORS	LIFERAFT NO. 1
16	PORTER	ASSIST STEWARD - SECURE LIVING QTRS AROUSE, WARN, LEAD OUT GUESTS	LIFERAFT NO. 2
[illegible]	[illegible]	ENGINE ROOM - ASSIST CHIEF MAN FIRE & GEN. SERVICE PUMP	LIFERAFT No. 1

Franklin L. Buck
Master

Submitted & approved USCG-MIO
Toledo, Ohio 6-15-77 chd

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APPENDIX G

USDA FORESTRY LABORATORY'S REPORT ON WOOD PILE SAMPLE

United States Department of Agriculture | Forest Service | Forest Products Laboratory | One Gifford Pinchot Dr. Madison, WI 53705-2398

Reply to: 4710(I)

Date: November 9, 1990

Mr. Spencer Phillips
Physical Science Technician
National Transportation Safety Board
Washington, DC 20594

Dear Mr. Phillips:

This letter summarizes our November 6 phone conversation regarding the wood sample sent with your October 24 letter.

The sample is a species of the oak (Quercus) belonging to the white oak group. It consists of a lighter-colored sapwood area and a slightly darker-colored heartwood area.

Terry Highley, project leader of the Biodeterioration of Wood group, examined the piece and concluded that decay was present.

The characteristics of the wood cells at the fracture zone indicate that the wood was subject to brashness. The enclosed page describes this condition and its consequences.

Your sample is being returned under separate cover. The streak on the flat surface is the result of a chemical solution I applied as part of the analysis.

Sincerely,

DONNA J. CHRISTENSEN, Botanist
Center for Wood Anatomy Research

Enclosure

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PHONE: (608) 231-9200
TELEX: 7400032
FACSIMILE: (608) 231-9592

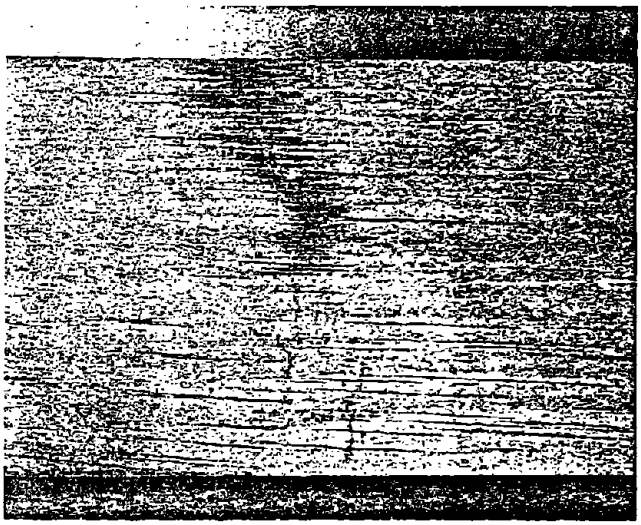
Compression failures

During severe wind storms or under heavy snowload the bole of a tree may be bent excessively. This also sometimes occurs during blowdown or in felling a tree. When the bole of a tree is bent like one giant beam, the wood in the concave side can fail in compression without tension failure developing in the convex side. The compression damage to the tree goes unnoticed. In the wood, the result is irregular planes of buckled longitudinal cells, called **compression failures**. These localized planes of damage generally run crosswise to the grain. In rough lumber they are virtually impossible to detect, but on planed or sanded longitudinal surfaces they are usually visible, appearing as wrinkles across the grain *(1)*. Compression failures are extremely detrimental to members stressed in bending, for the buckled cell structure fails readily in tension, resulting in sudden beam failure at lower-than-normal stress levels. Critical structural members, such as ladder rails, scaffolding, aircraft parts or boat spars, must be carefully inspected to exclude material with compression failures. Wood containing compression failures is also unsuitable for steam-bending work.

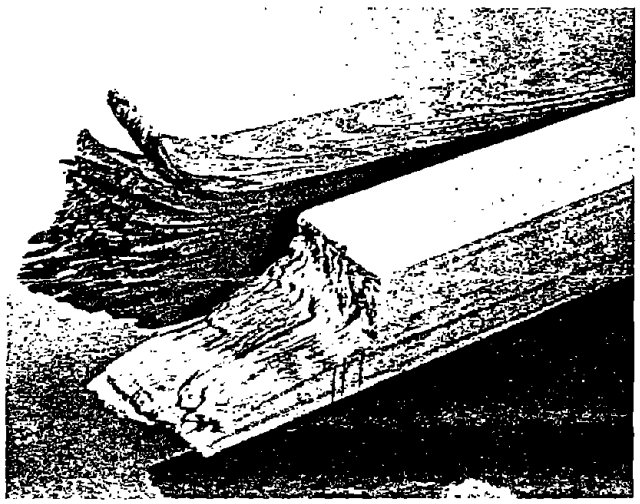
Brashness—Normal wood is characteristically tough. When it breaks in bending, the cell structure progressively separates as splintering fractures. Audible cracking and creaking accompany the gradual failure of the wood. There is considerable deformation, well beyond the elastic limit, before total failure finally takes place.

Under certain conditions, wood fails abruptly, with minimal deflection and at lower than expected loads. These failures are characterized by cross breaks that lack the usual evidence of fibrous or splintering separation. Such brittle and weak behavior in wood is called **brashness** *(2)*. The fibrous breaking of normal wood might be compared to the breaking of a stringy stalk of celery, while the brash failure of wood would be analogous to the abrupt snapping of a carrot.

As described above, wood damaged by compression failures will exhibit brashness when stressed in bending. Reaction wood in conifers (compression wood) also shows brashness, even though its density is greater than normal wood. Extreme growth rates may also produce brashness. In ring-porous hardwoods, extremely slow growth results in low-density wood because of the large percentage of earlywood vessels. This wood is characteristically brash and is especially troublesome in steam-bending. Among conifers, moderately slow but healthy growth produces dense, strong wood. Extremely slow growth, as in stunted or overmature trees (wood with 35 or more rings per inch) may also produce brash wood. Extremely fast growth in conifers, reflecting the low density of the dominant earlywood, also tends to be brash. The wide-ringed growth of pronounced juvenile wood is especially prone to brashness. Prolonged exposure to high temperature and fungal decay are other causes of brashness in wood.



1—Compression failures appear on longitudinal faces of surfaced lumber as wrinkles across the grain.



2—Normal gradual splintering failure in catalpa beam, top, contrasts with abruptly cracked (brash) white pine beam that contains reaction wood, above.

Reproduced from best available copy.

APPENDIX H

EXCERPTS FROM CFR PART 164-NAVIGATION SAFETY REGULATIONS

30, 1964. Redesignated by CGD 81-017, 46 FR 28154, May 26, 1981]

PART 164—NAVIGATION SAFETY REGULATIONS

Sec.

164.01 Applicability.
164.02 Applicability exception for foreign vessels.
164.03 Incorporation by reference.
164.11 Navigation underway: General.
164.19 Requirements for vessels at anchor.
164.25 Tests before entering or getting underway.
164.30 Charts, publications, and equipment: General.
164.33 Charts and publications.
164.35 Equipment: All vessels.
164.37 Equipment: Vessels of 10,000 gross tons or more.
164.38 Automatic radar plotting aids (ARPA).
164.39 Steering gear: Tankers.
164.40 Devices to indicate speed and distance.
164.41 Electronic position fixing devices.
164.42 Rate of turn indicator.
164.51 Deviations from rules: Emergency.
164.53 Deviations from rules and reporting: Non-operating equipment.
164.55 Deviations from rules: Continuing operation or period of time.
164.61 Marine casualty reporting and record retention.

AUTHORITY: 33 U.S.C. 1223, 46 U.S.C. 3703. Sec. 164.61 also issued under 46 U.S.C. 6101; 49 CFR 1.46 (n).

§ 164.01 Applicability.

(a) This part (except as specifically limited herein) applies to each self-propelled vessel of 1600 or more gross tons (except foreign vessels described in § 164.02) when it is operating in the navigable waters of the United States except the St. Lawrence Seaway.

[CGD 83-004, 49 FR 43466, Oct. 29, 1984]

§ 164.02 Applicability exception for foreign vessels.

(a) This part (including §§ 164.38 and 164.39) does not apply to vessels that:

(1) Are not destined for, or departing from, a port or place subject to the jurisdiction of the United States; and

(2) Are in:

(i) Innocent passage through the territorial sea of the United States; or

(ii) Transit through navigable waters of the United States which form a part of an international strait.

[CGD 77-063, 44 FR 66530, Nov. 19, 1979, as amended by CGD 79-148, 45 FR 54039, Aug. 14, 1980]

§ 164.03 Incorporation by reference.

(a) Certain materials are incorporated by reference into this part with the approval of the Director of the Federal Register. The Office of the Federal Register publishes a table, "Material Approved for Incorporation by Reference," which appears in the Finding Aids section of this volume. In that table is found the date of the edition approved, citations to the particular sections of this part where the material is incorporated, addresses where the material is available, and the date of the approval by the Director of the Federal Register. To enforce any edition other than the one listed in the table, notice of the change must be published in the FEDERAL REGISTER and the material made available. All approved material is on file at the Office of the Federal Register, Washington, DC 20408 and at Room 4402, U.S. Coast Guard Headquarters, 2100 Second St. S.W., Washington, D.C.

(b) The materials approved for incorporation by reference in this part are: Radio Technical Commission For Marine Services (RTCM) Paper 12-78/DO-100 dated 12/20/77.

[CGD 81-081, 47 FR 58244, Dec. 30, 1982]

§ 164.11 Navigation underway: General.

The owner, master, or person in charge of each vessel underway shall ensure that:

(a) The wheelhouse is constantly manned by persons who:

(1) Direct and control the movement of the vessel; and

(2) Fix the vessel's position;

(b) Each person performing a duty described in paragraph (a) of this section is competent to perform that duty;

(c) The position of the vessel at each fix is plotted on a chart of the area and the person directing the movement of the vessel is informed of the vessel's position;

(d) Electronic and other navigational equipment, external fixed aids to navigation, geographic reference points, and hydrographic contours are used when fixing the vessel's position;

(e) Buoys alone are not used to fix the vessel's position;

NOTE: Buoys are aids to navigation placed in approximate positions to alert the mariner to hazards to navigation or to indicate the orientation of a channel. Buoys may not maintain an exact position because strong or varying currents, heavy seas, ice, and collisions with vessels can move or sink them or set them adrift. Although buoys may corroborate a position fixed by other means, buoys cannot be used to fix a position: however, if no other aids are available, buoys alone may be used to establish an estimated position.

(f) The danger of each closing visual or each closing radar contact is evaluated and the person directing the movement of the vessel knows the evaluation;

(g) Rudder orders are executed as given;

(h) Engine speed and direction orders are executed as given;

(i) Magnetic variation and deviation and gyrocompass errors are known and correctly applied by the person directing the movement of the vessel;

(j) A person whom he has determined is competent to steer the vessel is in the wheelhouse at all times; [1]

(k) If a pilot other than a member of the vessel's crew is employed, the pilot is informed of the draft, maneuvering characteristics, and peculiarities of the vessel and of any abnormal circumstances on the vessel that may affect its safe navigation.

(l) Current velocity and direction for the area to be transited are known by the person directing the movement of the vessel;

(m) Predicted set and drift are known by the person directing movement of the vessel;

(n) Tidal state for the area to be transited is known by the person directing movement of the vessel;

(o) The vessel's anchors are ready for letting go;

(p) The person directing the movement of the vessel sets the vessel's speed with consideration for:

(1) The prevailing visibility and weather conditions;

(2) The proximity of the vessel to fixed shore and marine structures;

(3) The tendency of the vessel underway to squat and suffer impairment of maneuverability when there is small underkeel clearance;

(4) The comparative proportions of the vessel and the channel;

(5) The density of marine traffic;

(6) The damage that might be caused by the vessel's wake;

(7) The strength and direction of the current; and

(8) Any local vessel speed limit;

(q) The tests required by § 164.25 are made and recorded in the vessel's log; and

(r) The equipment required by this part is maintained in operable condition.

(s) Upon entering U.S. waters, the steering wheel or lever on the navigating bridge is operated to determine if the steering equipment is operating properly under manual control, unless the vessel has been steered under manual control from the navigating bridge within the preceding 2 hours, except when operating on the Great Lakes and their connecting and tributary waters.

(t) At least two of the steering gear power units on the vessel are in operation when such units are capable of simultaneous operation, except when operating on the Great Lakes and their connecting and tributary waters.

[CGD 74-77, 42 FR 5956, Jan. 31, 1977, as amended by CGD 83-004, 49 FR 43466, Oct. 29, 1984]

§ 164.19 Requirements for vessels at anchor.

The master or person in charge of each vessel that is anchored shall ensure that:

(a) A proper anchor watch is maintained;

(b) Procedures are followed to detect a dragging anchor; and

(c) Whenever weather, tide, or current conditions are likely to cause the vessel's anchor to drag, action is taken

[1] See also 46 U.S.C. 672, which requires an able seaman at the wheel on U.S. vessels of 100 gross tons or more in narrow or crowded waters or during low visibility.

to ensure the safety of the vessel, structures, and other vessels, such as being ready to veer chain, let go a second anchor, or get underway using the vessel's own propulsion or tug assistance.

[CGD 74-77, 42 FR 5956, Jan. 31, 1977]

§ 164.25 Tests before entering or getting underway.

(a) Except as provided in paragraphs (b) and (c) of this section no person may cause a vessel to enter into or get underway on the navigable waters of the United States unless no more than 12 hours before entering or getting underway, the following equipment has been tested:

(1) Primary and secondary steering gear. The test procedure includes a visual inspection of the steering gear and its connecting linkage, and, where applicable, the operation of the following:

(i) Each remote steering gear control system.

(ii) Each steering position located on the navigating bridge.

(iii) The main steering gear from the alternative power supply, if installed.

(iv) Each rudder angle indicator in relation to the actual position of the rudder.

(v) Each remote steering gear control system power failure alarm.

(vi) Each remote steering gear power unit failure alarm.

(vii) The full movement of the rudder to the required capabilities of the steering gear.

(2) All internal vessel control communications and vessel control alarms.

(3) Standby or emergency generator, for as long as necessary to show proper functioning, including steady state temperature and pressure readings.

(4) Storage batteries for emergency lighting and power systems in vessel control and propulsion machinery spaces.

(5) Main propulsion machinery, ahead and astern.

(b) Vessels navigating on the Great Lakes and their connecting and tributary waters, having once completed the test requirements of this subpart, are considered to remain in compliance until arriving at the next port of call on the Great Lakes.

(c) Vessels entering the Great Lakes from the St. Lawrence Seaway are considered to be in compliance with this sub-part if the required tests are conducted preparatory to or during the passage of the St. Lawrence Seaway or within one hour of passing Wolfe Island.

(d) No vessel may enter, or be operated on the navigable waters of the United States unless the emergency steering drill described below has been conducted within 48 hours prior to entry and logged in the vessel logbook, unless the drill is conducted and logged on a regular basis at least once every three months. This drill must include at a minimum the following:

(1) Operation of the main steering gear from within the steering gear compartment.

(2) Operation of the means of communications between the navigating bridge and the steering compartment.

(3) Operation of the alternative power supply for the steering gear if the vessel is so equipped.

(92 Stat. 1471 (33 U.S.C. 1221 et seq.); 49 CFR 1.46(n)(4))

[CGD 77-183, 45 FR 18925, Mar. 24, 1980, as amended by CGD 83-004, 49 FR 43466, Oct. 29, 1984]

§ 164.30 Charts, publications, and equipment: General.

No person may operate or cause the operation of a vessel unless the vessel has the marine charts, publications, and equipment as required by §§ 164.33 through 164.41 of this part.

[CGD 82-055, 48 FR 44535, Sept. 29, 1983]

§ 164.33 Charts and publications.

(a) Each vessel must have the following:

(1) Marine charts of the area to be transited, published by the National Ocean Service, U.S. Army Corps of Engineers, or a river authority that—

(i) Are of a large enough scale and have enough detail to make safe navigation of the area possible; and

(ii) Are currently corrected.

(2) For the area to be transited, a currently corrected copy of, or applica-

ble currently corrected extract from, each of the following publications:

(i) U.S. Coast Pilot.

(ii) Coast Guard Light List.

(3) For the area to be transited, the current edition of, or applicable current extract from:

(i) Tide tables published by the National Ocean Service.

(ii) Tidal current tables published by the National Ocean Service, or river current publication issued by the U.S. Army Corps of Engineers, or a river authority.

(b) As an alternative to the requirements for paragraph (a) of this section, a marine chart or publication, or applicable extract, published by a foreign government may be substituted for a U.S. chart and publication required by this section. The chart must be of large enough scale and have enough detail to make safe navigation of the area possible, and must be currently corrected. The publication, or applicable extract, must singly or in combination contain similar information to the U.S. Government publication to make safe navigation of the area possible. The publication, or applicable extract must be currently corrected, with the exceptions of tide and tidal current tables, which must be the current editions.

(c) As used in this section, "currently corrected" means corrected with changes contained in all Notices to Mariners published by Defense Mapping Agency Hydrographic/Topographic Center, or an equivalent foreign government publication, reasonably available to the vessel, and that is applicable to the vessel's transit.

[CGD 82-055, 48 FR 44535, Sept. 29, 1983]

§ 164.35 Equipment: All vessels.

Each vessel must have the following:

(a) A marine radar system for surface navigation.

(b) An illuminated magnetic steering compass, mounted in a binnacle, that can be read at the vessel's main steering stand.

(c) A current magnetic compass deviation table or graph or compass comparison record for the steering compass, in the wheelhouse.

(d) A gyrocompass.

(e) An illuminated repeater for the gyrocompass required by paragraph (d) of this section that is at the main steering stand, unless that gyrocompass is illuminated and is at the main steering stand.

(f) An illuminated rudder angle indicator in the wheelhouse.

(g) The following maneuvering information prominently displayed on a fact sheet in the wheelhouse:

(1) A turning circle diagram to port and starboard that shows the time and distance and advance and transfer required to alter course 90 degrees with maximum rudder angle and constant power settings, for either full and half speeds, or for full and slow speeds. For vessels whose turning circles are essentially the same for both directions, a diagram showing a turning circle in one direction, with a note on the diagram stating that turns to port and starboard are essentially the same, may be substituted.

(2) The time and distance to stop the vessel from either full and half speeds, or from full and slow speeds, while maintaining approximately the initial heading with minimum application of the rudder.

(3) For each vessel with a fixed propeller, a table of shaft revolutions per minute for a representative range of speeds.

(4) For each vessel with a controllable pitch propeller, a table of control settings for a representative range of speeds.

(5) For each vessel that is fitted with an auxiliary device to assist in maneuvering, such as a bow thruster, a table of vessel speeds at which the auxiliary device is effective in maneuvering the vessel.

(6) The maneuvering information for the normal load and normal ballast condition for:

(i) Calm weather—wind 10 knots or less, calm sea;

(ii) No current;

(iii) Deep water conditions—water depth twice the vessel's draft or greater; and

(iv) Clean hull.

(7) At the bottom of the fact sheet, the following statement:

WARNING

The response of the (name of the vessel) may be different from that listed above if any of the following conditions, upon which the maneuvering information is based, are varied:

(1) Calm weather—wind 10 knots or less, calm sea;

(2) No current;

(3) Water depth twice the vessel's draft or greater;

(4) Clean hull; and

(5) Intermediate drafts or unusual trim.

(h) An echo depth sounding device.

(i) A device that can continuously record the depth readings of the vessel's echo depth sounding device, except when operating on the Great Lakes and their connecting and tributary waters.

(j) Equipment on the bridge for plotting relative motion.

(k) Simple operating instructions with a block diagram, showing the change-over procedures for remote steering gear control systems and steering gear power units, permanently displayed on the navigating bridge and in the steering gear compartment.

(l) An indicator readable from the centerline conning position showing the rate of revolution of each propeller, except when operating on the Great Lakes and their connecting and tributary waters.

(m) If fitted with controllable pitch propellers, an indicator readable from the centerline conning position showing the pitch and operational mode of such propellers, except when operating on the Great Lakes and their connecting and tributary waters.

(n) If fitted with lateral thrust propellers, an indicator readable from the centerline conning position showing the direction and amount of thrust of such propellers, except when operating on the Great Lakes and their connecting and tributary waters.

(92 Stat. 1471 (33 U.S.C. 1221 et seq.); 49 CFR 1.46(n)(4))

[CGD 74-77, 42 FR 5956, Jan. 31, 1977, as amended by CGD 77-183, 45 FR 18925, Mar. 24, 1980; CGD 83-004, 49 FR 43466, Oct. 29, 1984]

§ 164.37 Equipment: Vessels of 10,000 gross tons or more.

(a) Each vessel of 10,000 gross tons or more must have, in addition to the radar system under § 164.35(a), a second marine radar system that operates independently of the first.

NOTE: Independent operation means two completely separate systems, from separate branch power supply circuits or distribution panels to antennas, so that failure of any component of one system will not render the other system inoperative.

(b) On each tanker of 10,000 gross tons or more that is subject to Section 5 of the Port and Tanker Safety Act of 1978 (46 U.S.C. 391a), the dual radar system required by this part must have a short range capability and a long range capability; and each radar must have true north features consisting of a display that is stabilized in azimuth.

(Titles I and II, 86 Stat. 426, 427 (33 U.S.C. 1224; 46 U.S.C. 391(a); 49 CFR 1.46(n)(4))

[CGD 77-016, 43 FR 32112, July 24, 1978, as amended by CGD 79-033, 44 FR 26741, May 7, 1979; CGD 79-033, 47 FR 34389, Aug. 9, 1982]

§ 164.38 Automatic radar plotting aids (ARPA).

(a) The following definitions are used in this section—

"Bulk" means material in any quantity that is shipped, stored, or handled without benefit of package, label, mark or count and carried in integral or fixed independent tanks.

"Constructed" means a stage of construction where—

(1) The keel is laid;

(2) Construction identifiable with a specific ship begins; or

(3) Assembly of that ship has commenced comprising at least 50 tons or 1 percent of the estimated mass of all structural material, whichever is less.

"Hazardous material" means—

(1) A flammable liquid as defined in 46 CFR 30.10-22 or a combustible liquid as defined in 46 CFR 30.10-15;

(2) A material listed in table 151.05 of 46 CFR 151.05, table 1 of 46 CFR 153, or table 4 of 46 CFR Part 154; or

(3) A liquid, liquefied gas, or compressed gas listed in 49 CFR 172.101.