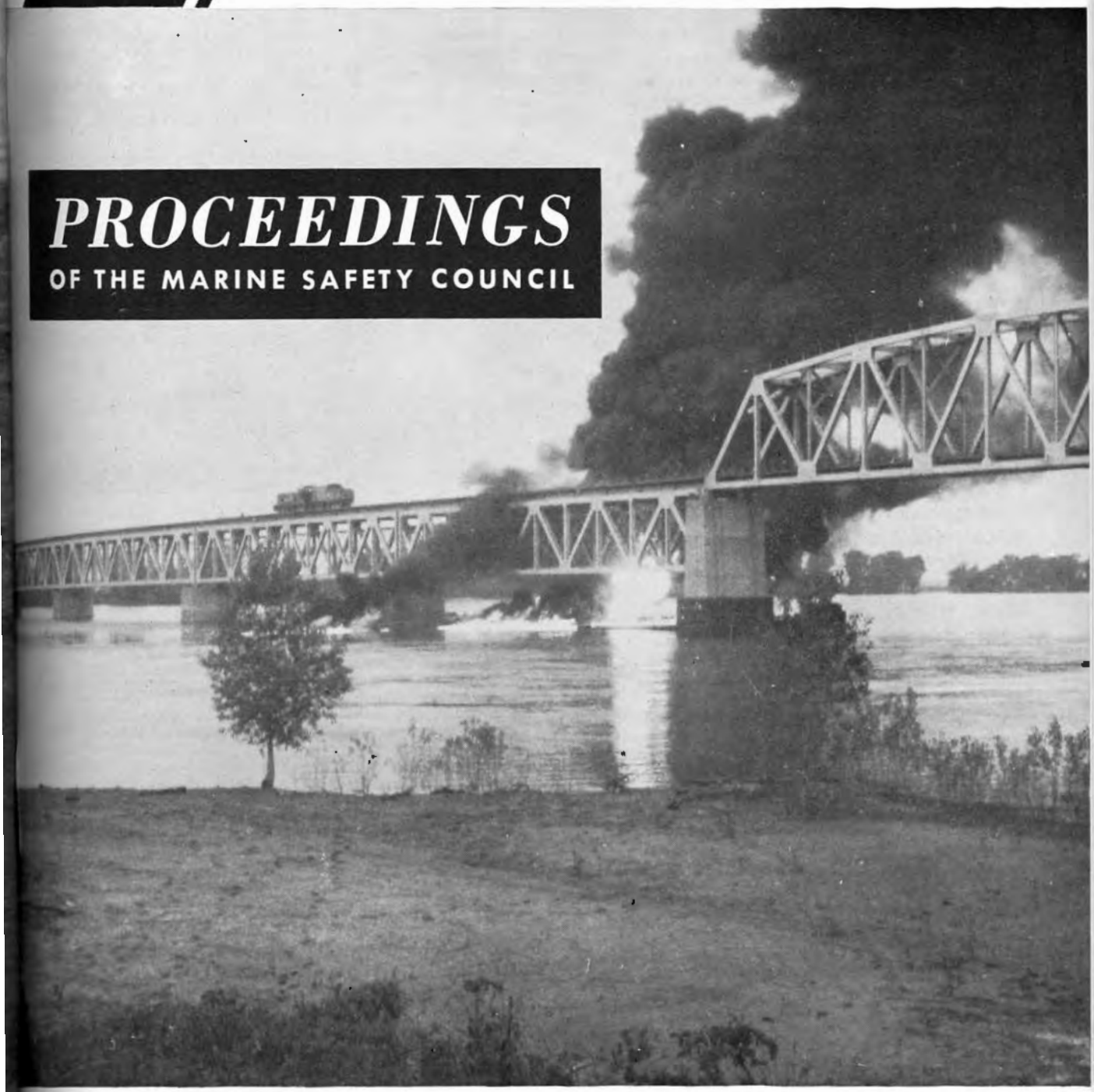
COAST GUARD



PROCEEDINGS
OF THE MARINE SAFETY COUNCIL

Vol. 28, No. 5 CG-129 May 1971

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Fire and Explosion on Tank Barge *MOS 106* . . .

PROCEEDINGS

OF THE

MARINE SAFETY COUNCIL

CHANGE IN NAME

The Merchant Marine Council, after almost 30 years of advisory work with the Coast Guard's regulatory responsibilities, has been reorganized. Effective March 10, 1971, the Council began operating with the six permanent members listed in the masthead under the title Marine Safety Council. The Council will continue, however, to advise the Commandant on proposed changes to Coast Guard regulations.

CONTENTS

COVERS

FRONT COVER: The Tank Barge *MOS 106,* burning intensely, lodged against the upstream side of the Chicago, Burlington & Quincy Railroad bridge span at Mile 328. Fortunately for the Quincy, Ill., waterfront just downstream, the barge did not become dislodged from the railroad bridge piers.

BACK COVER: The super cargo liner Prudential Oceanjet was built at Bethlehem's Sparrows Point Shipyard. *Courtesy Prudential Lines Inc.*

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CHANGING PROPELLERS THE HARD WAY

The pilot of this towboat was forced to leap into the chilly waters of the Wolf River near Memphis, Tenn., when a cable, supporting the vessel while propellers were changed, suddenly parted. No one was injured and the craft was refloated the same day.

Radiotelephone and Port Safety Bills Before Congress

Proposals concerning bridge-to-bridge radiotelephones and ports and waterways safety are being considered by the 92d Congress. Both bills died at the end of the 91st and had to be resubmitted.

President Nixon, in a special message to Congress on January 26, commented on the radiotelephone legislation in this manner:

> With the increasing number of vessels operating on inland and coastal waterways, the danger of accidents and collisions has become more serious. To help prevent unnecessary loss of life and property in future years, I am again proposing to the Congress legislation requiring that certain vessels transiting these waterways carry equipment for direct bridge-to-bridge contact. While most vessels today carry radio equipment, there is not always a compatible and open communication channel between two ships—and hence, they often cannot communicate even the most basic navigational information. Many vessels are already adequately equipped to meet the new requirements; the cost to the remaining shipowners would not be great.

On the subject of the ports and waterways legislation, the President said:

> As commerce grows, and as world trade expands, more and more great ships use American waters. Many carry hazardous cargoes — potential dangers to America's ports, harbors, waterfront areas, the waters themselves, and the resources they contain. There would, I believe, be a substantial benefit in the creation of a coordinated safety program. And I again ask that the Secretary of Transportation be empowered to prescribe standards and regulations, and to act upon them, to give the protection the Nation increasingly needs. ⚓

New Examinations For Certain Licenses

The license examinations for Second and Third Mates and Second and Third Assistant Engineers are presently undergoing complete revision to more nearly reflect the job skills required aboard modern vessels and to convert to multiple-choice format to improve administration. The new examinations being developed for licenses as Second or Third Mate will be based on the 1971 editions of *The Nautical Almanac, Tide Tables,* and *Tidal Current Tables.* It is anticipated that the new examinations will be in general use after January 1973.

The Nautical Almanac may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402, and is often available from dealers who sell Oceanographic Office charts. The *Tide Tables* and *Tidal Current Tables* are available from National Ocean Survey (formerly Coast and Geodetic Survey), Distribution Division C44, Washington, D.C. 20235, and its sales agents. ⚓

FIRE AND EXPLOSIONS ON LA GRANGE, MISSOURI ON MAY

These two views of the M/V *Martin* show the burned-out galley (at the stern) and adjoining spaces.

The actions taken on the Tank Barge *MOS 106* case follow in chronological order

MARINE BOARD OF INVESTIGATION

FINDINGS OF FACT

1. At or about 2115 CDST on 12 May 1969, fire and explosions occurred on the tank barge *MOS 106* while unloading a cargo of gasoline at the Triangle Oil Refining Company's loading facility on the Upper Mississippi River at La Grange, Mo. The tank barges *MOS 106* and the *MOS 104* with the towboat M/V *Martin* alongside were docked at a floating dock-barge. The casualty r sulted in the loss of life of six persons who were on boar or in the vicinity of the *MOS 106*. Two persons were i jured, resulting in their incapacitation for a period excess of 72 hours. There was material damage to five ve sels, including two barges downstream from the termin facility which were damaged by burning gasoline on th water and by collision after the three vessels at the doc barge were set adrift after the fire started.

TANK BARGE MOS 106 AT ON MISSISSIPPI RIVER 12, 1969

2. *Vessel data:*

NAME:	M/V *Martin*	*MOS 106*	*MOS 104*	*UM 219*	*CHEM 40*
O.N.:	260333	270535	270534	244453	295716
SERVICE:	Towboat	Tank barge	Tank barge	Hopper barge	Tank barge
BUILT:	1950	1955	1955	1965	1964
GROSS TONS:	183	1,428	1,368	945	822
NET TONS:	124	1,428	1,368	945	822
LENGTH:	100′	290′	290′	195′	195′
BREADTH:	26′	50′	48′	35′	35′
DEPTH:	9′	12′	12′	12′	12′
PROPELLED:	Motor	Non-self-propelled	Non-self-propelled	Non-self-propelled	Non-self-propelled
MANNING	9	Unmanned	Unmanned	Unmanned	Unmanned
HOME PORT:	Peoria, Ill.	Peoria, Ill.	Peoria, Ill.	Minneapolis, Minn.	Wilmington, Del.
OWNER	Meljoy Transportation Co.	Meljoy Transportation Co.	Meljoy Transportation Co.	Upper Mississippi Towing Co.	American Commercial Barge Line Co.
OPERATOR	Owner	Owner	Owner	Owner	Owner
CERTIFICATED:	Uninspected	Grade B cargo	Grade B cargo	Uninspected	
DATE:	NA	13 April 1968	2 March 1968	NA	10 May 1968
PORT:	NA	Memphis, Tenn.	Port Arthur Tex.	NA	Port Arthur, Tex.
REINSPECTED:					
DATE:	NA	20 February 1969	20 February 1969	NA	
PORT:	NA	Memphis, Tenn.	Memphis, Tenn.	NA	

The *MOS 104* and *MOS 106* were steel tank barges of similar construction with 10 cargo tanks, a sloping bow rake compartment and a box end stern rake compartment. The barges were divided longitudinally by one centerline bulkhead and six transverse bulkheads between tanks. The cargo transfer piping located near the centerline bulkhead at the bottom of each tank was fitted with valves in each compartment controlled by means of reach rods located on deck to regulate the transfer of cargo. Each tank had an expansion trunk, fitted with a manhole and an approved type pressure vacuum relief valve. Each manhole was fitted with a gasket and four dogs for securing the cover. No sounding tubes were fitted on the expansion trunks. Each vessel was equipped with a deep well cargo pump driven by a six-cylinder, GM 71 series diesel engine mounted on the deck.

The *CHEM 40* was a double skin barge loaded with a cargo of nonflammable, nonhazardous liquid fertilizer.

The *UM 219* was an open hopper type barge used for the transportation of grain and other nonhazardous materials.

The M/V *Martin* was a single shaft steel towboat powered by a 1,200 hp. diesel engine and was being used to push the barges *MOS 106 and MOS 104.*

3. The following persons died as a result of the casualty:

William R. OPITZ—License No. 293545, endorsed as master of steam and/or motor vessels of not over 1,400 tons upon rivers; also, first class pilot from Mile 26.7 UMR to Mile 605.3 LMR. Master of the M/V *Martin*. Address: Memphis, Tenn. Captain Opitz died at St. Mary's Hospital in Quincy, Ill., on 16 May 1969, as a result of burn injuries.

Walter C. MITCHELL—USMMD Z–344706, endorsed as Tankerman, Grade "B". Employed as Triangle Oil Refinery Manager, La Grange, Mo.

Albert FRIEDEN—Employed as Triangle Oil Refinery Co. Terminal Assistant, La Grange, Mo.

Lewis HAGANHOFF—Truckdriver, La Grange, Mo.

Aaron GEAN—Deckhand, M/V *Martin,* Address: Alton, Ill.

Glenn H. MAPLES—USMMD Z–1068681, endorsed as Tankerman, Grade "B". Triangle Oil Refinery Manager, La Grange, Mo.

The following persons were injured as a result of this casualty and incapacitated in excess of 72 hours. They were treated at Blessing Hospital and St. Mary's Hospital in Quincy, Ill.:

W. A. MORRISON—Unlicensed Assistant Engineer of the M/V *Martin*. Address: Marble Hill, Mo.

Oren McPHERSON—Cook of the M/V *Martin*. Address: Memphis, Tenn.

4. The weather at the time of the casualty was clear, with a slight westerly wind. The water was calm, with a river current of approximately 2 knots.

5. On 5 May the M/V *Martin* with the tank barges *MOS 104* and *MOS 106* arrived at the Oklahoma Mississippi River Pipeline Co. loading facility dock in West Memphis, Ark., where 908,000 gallons of gasoline were loaded in the tank barge *MOS 106* and 922,000 gallons in the *MOS 104*. The draft of the *MOS 104* was 8′8″ forward and 9′ aft.

The draft of the *MOS 106* was 8′9″ forward and 9′ aft. Approximately 20 empty 55-gallon drums were received aboard and stowed on dunnage along the centerline of the *MOS 106,* in the vicinity of No. 3 cargo tank. At or about 2255 on 6 May the M/V *Martin* departed upbound in the Mississippi River with loaded tank barges *MOS 106* and *MOS 104,* enroute to La Grange, Mo. The two barges were coupled together stern to stern in tandem with the *MOS 104* as the lead barge and the M/V *Martin* coupled to and pushing on the rake end of the *MOS 106.*

6. At or about 0530 on 9 May 1969, the M/V *Martin* and *MOS 106* sustained damage due to a collision with the west span pier of the Cape Girardeau, Mo., highway route 146 bridge while being navigated by George T. Reeves, an unlicensed pilot. The collision broke the coupling wires and the vessels were set against nearby structures and other vessels by the current. Damage to the *MOS 106* included indentations in the shell plating, an 8″ fracture in way of No. 3 starboard cargo tank, and an 8″ diameter hole in way of No. 1 port cargo tank. (The tanks are numbered 1 to 5 starting at the rake end of the barge.) A large quantity of gasoline cargo, approximately 2,500 barrels, was lost into the river from the two damaged tanks. A wooden plug was driven into the hole in No. 1 port cargo tank shell plating and the *MOS 106* was moved to the American Oil Co. dock at Cape Girardeau, Mo. The M/V *Martin* suffered damage to the engine cooling system (skin cooler) and required drydocking at Cape Girardeau.

7. All of the gasoline cargo contained in No. 1 port cargo tank escaped. The cargo remaining in No. 3 starboard cargo tank (about 40,000 gallons) was transferred by the use of shore pumping facilities by pumping into No. 3 port tank and gravitating from that tank to No. 1 starboard tank and No. 2 port and starboard tanks. The tank soundings prior to this transfer were 11′2″ in No. 3 port; 10′8″ in No. 2 port; 10′9⅝″ in No. 2 starboard and 10′9⅜″ in No. 1 starboard. Ullages in these tanks after the transfer of cargo were not available.

The Officer in Charge, Marine Inspection, Cairo, Ill., was notified of the casualty and a Coast Guard marine inspector was sent to the scene. Following his examination of the damage, the certificate of inspection was withdrawn from the *MOS 106*. Subsequently, after it was determined that there was little likelihood of any further leakage of gasoline, the *MOS 106* was found safe to continue its voyage and a Permit to Proceed was issued.

The tow, made up as before, continued upbound passing through five locks without incident. No leakage of

gasoline from the damaged tanks was noted. Upon arrival of the M/V *Martin* and tow at the Triangle Oil Refining Co. facility at La Grange Mo., at or about 1745 on 12 May 1969, the barge *CHEM 40* was moved from the Triangle facility dock barge and tied up approximately 200 feet downstream alongside the barge *UM 219* at a grain elevator. This move was accomplished by the *Martin* alongside the *CHEM 40,* with her two gasoline barges still made up forward of the *Martin.* When the cargo discharge hose from the *CHEM 40* was disconnected, there was a spillage of liquid fertilizer on the dock barge, some of which was later tracked onto the *MOS 104* and *106.* The *MOS 104* and *MOS 106* were moored at the facility with the stern couplings of both barges approximately amidship on the Triangle Oil Refining Co.'s dock barge. This steel mooring barge was a converted gravel barge approximately 128′ long and 26′ wide. It was permanently moored, by means of cables and spars and was equipped with a metal catwalk to the bank. It contained an electrically driven deep well cargo transfer pump, headers and associated piping for offloading of cargo. A metal shed was constructed on the upstream end of the barge to house tools and a small office. There was a rubber cargo hose located beneath the catwalk to transfer the cargo between the barge and shoreside facilities. The deck of the barge was covered with concrete to provide a working platform. After positioning the tank barges *MOS 104* and *MOS 106,* the M/V *Martin* tied up on the outboard side of the tow with its portside amidship, directly adjacent to the coupling between the two barges with the bow headed upstream.

9. The discharge hose was connected to the *MOS 106* by Mr. George T. Reeves, the pilot, Mr. Joseph Stevens, the mate, and Aaron Gean, one of the deckhands. When the hose was connected to the *MOS 106,* Chief Engineer Walter Mitchell came out on the barge from the *Martin* and started the diesel pump engine of the *MOS 106* (the pump that was to be used for offloading the cargo) and let it run at idling speed. Captain Opitz, the M/V *Martin's* Master; Mr. Glenn Maples, Triangle Oil Co. dock manager, and Mr. Albert Frieden, Mr. Maples' assistant, were gaging the tanks while the preparations for offloading were being made. When Mr. Maples indicated he was ready to commence pumping, the pump was engaged. A leak was noted at the flanged fitting to the discharge hose on the dock barge, whereupon the pump was shut down at the request of Mr. Maples while the joint was repaired. This was done by installing more bolts in the flange and tightening the existing bolts. While the joint was being tightened, Chief Mitchell departed the barge and returned to the towboat. Mr. Reeves engaged the pump and started offloading cargo from No. 1 starboard tank with only a small intermittent drip of gasoline from this flange fitting. Leakage from this connection was caught in a drip pan.

The extreme buckling which resulted on the tank barge MOS 106 can be seen in these two photographs which were taken from essentially the same position looking in opposite directions. The Chicago, Burlington & Quincy Railroad bridge is visible in the upper picture.

10. While going ashore at or about 2030, Reeves, the pilot, observed Captain Opitz laying out a garden hose from the *Martin* to the *MOS 106.* This was also observed by the mate, Joseph Stevens, who directed the deckhand, Larry Thompson to assist the Captain. Thompson used the water hose to wash down the deck and swept the wash water over the outboard side of the barge. Some of the wash water which he could not reach remained under the drums located on deck near No. 3 cargo tank hatches. Thompson stated that eight of these drums had been filled with gasoline during the voyage. He was of the opinion that the substance he was washing from the deck was

This interior view taken 2 days after the incident, shows the scorched remains of the oil-fired galley range on the M/V *Martin*.

gasoline. Thompson, age 19, was the only surviving witness on deck at the time the fire started and had only limited experience on vessels. He had joined the M/V *Martin* at Hartford, Ill., on the day prior to the casualty. His prior service on vessels of any type had been 4 days as deckhand on another towboat handling coal barges.

11. While unloading, a strong odor of gasoline was noticed approximately 15 minutes before the first explosion by the mate Joseph Stevens, while he was getting ready for bed onboard the M/V *Martin*. The No. 1 starboard cargo tank had been emptied and approximately one-third of the cargo had been pumped from the No. 2 starboard tank when the fire started at or about 2115. There was an explosion soon after the fire started, followed by a series of explosions, throwing gasoline on the *MOS 104*, the M/V *Martin*, and the terminal facility barge. The shell plating of the *MOS 106* at No. 2 port and No. 2 starboard tanks ruptured, allowing burning gasoline to be carried downstream, partially engulfing the *CHEM 40* and the *UM 219* at the grain elevator. Shortly afterward, the head wire of the *MOS 104* was cut by someone, allowing the tow to swing out into the stream. The swinging of the tow damaged and sank the dock barge. The tow broke loose and was carried downstream by the river current where it collided with *CHEM 40* and *UM 219*, breaking their moorings and throwing burning gasoline on their decks in addition to setting the grain elevator on fire. This allowed all five vessels to be carried downstream. The five vessels, the loading facility, and the grain elevator were then on fire. Fires on the grain elevator and loading facility were eventually extinguished by local firemen. The fires on the *CHEM 40* and *UM 219* burned themselves out and the barges grounded on wing dikes in the river. The M/V *Martin* and the *MOS 104*, adrift and still on fire, also grounded on wing dikes at Miles 329 and 330 Upper Mississippi River. The *MOS 106*, burning intensely, lodged against the upstream side of the Chicago, Burlington, & Quincy Railroad bridge span at Mile 328.

12. The Coast Guard Rescue Coordination Center in St. Louis, Mo., was notified at 2222 on 12 May 1969. At 2350, three officers from the Captain of the Port's office in St. Louis were dispatched to the scene, arriving there at 0215 on 13 May 1969. Evaluation of the situation revealed a serious threat to the Quincy, Ill., waterfront, should the burning tank barge *MOS 106* become dislodged from the railroad bridge piers. Contact was made with the local fire department with regard to water transportable firefighting equipment. The fire department advised that the only equipment they had was a pumper type truck which was not transportable by water. Corps of Engineers officials, city officials, and railroad officers requested Coast Guard assistance in extinguishing this fire. The On-Scene Commander from St. Louis Captain of the port office agreed that the Coast Guard should assist in extinguishing the barge fires if it became apparent that the town of Quincy was endangered. In preparation for such assistance, the On-Scene Commander, at about 0230, requested additional men and equipment from Coast Guard forces in St. Louis, Mo. At about 0530, seven Coast Guardsmen with six P–60 pumps and 500 gallons of foam concentrate departed St. Louis in two trucks bound for Quincy. At about this time, the fires on the *MOS 104* and the M/V *MARTIN*, still on the wing dikes, burned themselves out. At about 1100, the barge *MOS 106* started to sag and the port side amidship became awash, extinguishing some of the intense flames near the center section, but there was still a great amount of fire from the tank hatch openings and from the gasoline on the water. When it became evident that the barge might break in half and dislodge itself from the bridge, firefighting efforts were started by the On-Scene Commander using the equipment that had arrived from the Coast Guard Base, St. Louis, Mo. This equipment was placed on a 100-foot barge which had been volunteered by Mr. M. W. Boudreaux of the Northeast Power Co., Palmyra, Mo. The towboat pushing this barge was operated by Mr. Charles Leabig of Quincy, Ill. The approach to the burning barge was made by heading upstream from Quincy to the railroad bridge. Fortunately, the breeze was

also upstream blowing smoke and flames away from the firefighters on the bow of the Northeast Power Co. barge. The fire was extinguished at or about 1250. A total of 275 gallons of foam were applied by eight Coast Guardsmen from St. Louis, and six firemen from Quincy, Ill. The Coast Guard Cutter *Goldenrod* arrived at 1300. This vessel stood by throughout the remainder of the day as a reflash watch and remained in the area until 19 May 1969, when she departed for her homeport at Keokuk, Iowa. The *MOS 106* remained hung up on the bridge until the evening of 14 May, at which time it was removed by the owner to a point 2 miles upstream from the bridge where it was later offloaded safely.

13. There were four men on the *MOS 106* and three men in the immediate vicinity of the Triangle facility barge at the time of the casualty. Mr. Larry Thompson was the only one of these seven men to survive. The other six men were killed by burns or drowning. One of these six men was Lewis Haganhoff, a truckdriver who was not employed by either the owner of the loading facility or the owner of the vessels involved. Thompson testified that while he was washing and sweeping down the deck, he observed a small flame coming down the deck toward him from the upstream end of the barge. He dropped his broom and ran to the south end of the *MOS 106* where he met Aaron Gean, the other deckhand. When the first explosion occurred, the two deckhands jumped into the river. Aaron Gean did not have a lifejacket on, so Thompson told Gean to hold on to his lifejacket and try to swim toward the bank. They were carried downstream by the current into the *CHEM 40* where Gean held on until his hand slipped off and he went under the barge. Thompson was carried downstream where he reached the bank below the grain elevator. He rested, then walked to La Grange where he was taken to the hospital in Quincy, Ill., for treatment of a knee injury. Immediately after the first explosion, W. A. Morrison, the assistant engineer, and Ray Crawley, the deckhand, ran into Stevens' (the mate's) room from the adjoining compartment and told him the barge was on fire and that it had blown fire into their berthing compartment. Stevens left his room and started back toward the stern for a fire extinguisher where he met McPherson who had already obtained an extinguisher. They both went in through Stevens' room in an attempt to extinguish the fire in the adjoining room, but the smoke was so bad they were forced out. Stevens got dressed and went with the other three men to the bow of the towboat at which time another explosion took place. Stevens ran back to his room for a lifejacket and returned to the bow of the towboat. Then going to the deck of the *MOS 104,* he jumped overboard from the inshore side.

Reeves, the pilot, observed the fire from a bar and restaurant located approximately 100 yards from the loading facility. He saw a large burst of flame in the direction of the dock barge followed by an explosion. He noted a man being blown through the air toward the bank. As Reeves ran toward the barges, he saw a man in flames run across the deck of the *MOS 104* and jump in the river just forward (upstream) of the M/V *Martin*. When he got near the forward barge, he noticed that four men from the towboat, Stevens the mate, McPherson the cook, W. A. Morrison, the assistant engineer, and Ray Crawley, the deckhand, had run out on the bow of the *MOS 104*. He yelled at them to jump into the river. Stevens did jump and was being carried under the dock barge by the current when McPherson pulled him out. Reeves then ran back to Pete's Boathouse and asked Pete Brandt, the owner, to get his boat. The two men put out in Brandt's small boat and took the four men ashore from the port bow of the *MOS 104*. Reeves and Brandt then returned in the boat to the M/V *Martin* to see if anyone was still aboard. As they approached the *Martin,* the entire aftersection was on fire and there were flames from the gasoline pouring out into the river from the *MOS 106*. In fear of getting caught in the flames, they returned to the dock at Pete's Boathouse.

There were four men in a gasoline service station located approximately 300 yards from the loading facility. One of these men was standing at the rear window when he saw and heard flames come up from the midsection of the *MOS 106*. Soon thereafter, he saw three men running toward the edge of the barge on the bank side. He did not see these men after the first of several explosions which occurred shortly after the first flames appeared. By the time the four men from the service station reached the scene, the entire barge *MOS 106* was on fire.

14. The galley range of the M/V *Martin* was in operation at the time of the casualty. After the evening meal, the range had been cleaned and the oil burner had been relighted by Oren McPherson, the cook. This was common practice on the M/V *Martin* as the galley range provided the only means of supplying hot water to the showers and wash basins. The galley door facing the barges *MOS 104* and *106* in the vicinity of the cargo hose connections was open.

15. Conditions on the *MOS 106* following the casualty and the extinguishment of the fire were as follows:

a. No. 1 starboard tank bulged and ruptured.

b. No. 2 port and starboard tank bulged and ruptured.

c. No. 3 port tank split at the bulkhead of No. 2 tank from deck knuckle to keel.

d. All bulkheads to cargo tanks 1, 2, and 3; port and starboard, were ruptured allowing the remaining cargo to escape into the river.

e. Both forward and after void compartments were dry and watertight.

f. Vessel had sagged approximately 6 feet in the center section.

g. All hatch covers were off. None of the securing dog bolts were stripped (indicating that the hatch covers

had been open or at least not dogged down).

h. No. 4 port and starboard tank and No. 5 port and starboard tanks had approximately 10 feet of gasoline in each tank.

i. Approximately 15 empty 55-gallon drums were scattered about the deck amidship. Half of these drums had exploded.

j. The aftersection in the vicinity of the pump engine was badly scorched, but not severely burned.

k. The remains of three small portable gasoline-driven stripping pumps were located on deck—one forward, one amidship, and one aft. The amidships portable pump engine did not have a muffler attached and burned out hose couplings were still attached to the suction and discharge connections of the pump. These pumps were not in use at the time of the casualty.

The *MOS 106* continued to leak gasoline from No. 3 port tank, continuing until the evening of 15 May 1969 at which time there were no longer indications of gasoline downstream from the barge.

16. During the afternoon of 13 May 1969, the M/V *Martin* was removed from the wing dike and brought to Quincy, Ill. The complete interior of the crews' quarters and galley were burned out by the fire. The M/V *Martin* was later towed downstream to Greenville, Miss. The *MOS 104* was removed from the wing dike at Mile 330 on the morning of 14 May 1969, and taken to Alexandria, Mo., to be offloaded. None of the cargo on this barge was burned or lost.

On 15 May 1969, the *CHEM 40* and *UM 219* were picked up by downbound tows and taken to the St. Louis area for repair of fire damage and hull damage sustained when they had been struck by the burning tow drifting down the river.

On 16 May 1969, the *MOS 104* was brought back downstream from Alexandria, Mo., empty, and moored alongside the *MOS 106*. Offloading of the Nos. 4 and 5 port and starboard tanks of the *MOS 106* onto the *MOS 104* commenced on the morning of 17 May. The cargo pump and engine on the *MOS 106* had not been substantially damaged by the fire and were used for this operation.

17. Searches for survivors along the river were unsuccessful and the Quincy Volunteer Rescue Squadron conducted dragging operations throughout the week of 12–17 May 1969, with negative results. In addition to the dragging operations, this rescue squad provided around-the-clock patrols to keep sightseers and boaters away from the hazardous areas. The bodies of Aaron Gean, Walter Mitchell, and Lewis Haganhoff have subsequently been found on the bank downstream from La Grange, Mo.

CONCLUSIONS

1. The cause of the casualty to the extent determinable was the ignition of a concentration of explosive gasoline vapors surrounding the tank barges and towboat. The most probable source of vapor ignition was the open-flame galley range which was in operation on board the M/V *Martin* at the time of the casualty. While there are a number of potential sources of vapor ignition under the circumstances prevailing in this case (for which precautions must always be taken) the only direct evidence of such a source at the time of the explosion was the fire in the galley range. The most probable cause of the explosive vapors was a gasoline spill on one of the barges. While there was no direct evidence as to the source of such a spill (due to the unfortunate death of all experienced witnesses who would have been in a position to know) it was possibly caused by an overflow of gasoline from the open hatch of No. 3 port tank, the area where the first explosion occurred. There was evidence of the presence of gasoline in that area, along with the water that was being used to wash down the decks and undamaged threads on the dogs for the missing hatch cover of No. 3 tank, indicate that the cover was not securely closed at the time of the explosion. It is likely that No. 3 port was almost completely full following the transfer of cargo from the damaged tanks into the forward tanks at Cape Girardeau, Mo. on 9 May 1969. It follows that gasoline may have overflowed from that tank due to a change in trim as No. 1 and No. 2 cargo tanks were discharged.

2. The following failures are considered to be contributing causes of the casualty and negligence on the part of the certified tankermen and the deck officer on duty (all of these personnel are deceased):

a. Failure to remove the M/V *Martin* and it's potential sources of ignition from the immediate vicinity of the offloading barges.

b. Failure to investigate and ascertain the source of the vapors.

c. Failure to take timely action to eliminate the cause of the vapors.

d. Failure to secure the offloading operation after a gasoline spill.

e. Failure to maintain the cargo tank hatch covers securely closed.

3. There is no evidence that the damage sustained by the Barge *MOS–106* as a result of the collision with the Cape Girardeau, Mo., bridge on 9 May 1969 was contributory to this casualty. Since the damaged tanks were emptied shortly after that earlier incident, there was no leakage of gasoline from them at La Grange, Mo., or while transiting the river and various locks enroute.

4. There is no evidence of violations of laws relating to vessels warranting referral to the U.S. attorney or action under the administrative penalty provisions.

5. a. The casualty may have been prevented had proper precautions been exercised to prevent the accumulation of gasoline vapors in hazardous concentrations during the cargo transfer operation and had immediate remedial measures been instituted upon discovery of the

accumulation of vapors. Removal of the M/V *Martin* from the immediate proximity of the cargo connections on the barges would have eliminated several sources of ignition and, as well, reduced the number of victims by removing the off-duty personnel from the vicinity.

b. Precautions that should have been exercised while handling the gasoline cargo are described in "A Manual for the Safe Handling of Inflammable and Combustible Liquids, CG 174" and in "Rules and Regulations for Tank Vessels, CG 123." These publications contain simple, easy to read instructions regarding general safety precautions and cargo handling, including material on pertinent subjects:

(1) Overflow of "topped off" tank due to change of vessel trim.

(2) Fires or open flames in compartments facing, open or adjacent to that part of the deck in which cargo connections have been made.

(3) Inspection to determine whether galley fires can be maintained with reasonable safety.

(4) Vessels coming alongside in way of cargo tanks.

(5) Stopping transfer when there is a bad spill on deck.

(6) Prompt report of leakage to the person in charge.

(7) Proper hose connections with drip pans.

RECOMMENDATIONS

1. That continued support be given to legislation requiring the licensing of responsible operating personnel on towing vessels. In addition to enhanced safety resulting from greater competency based on professional knowledge, experience, and background, a licensing program would provide better means of enforcing safety rules, including revocation or suspension proceedings against licenses or certificates of offenders.

2. That the Coast Guard institute a study to determine the feasibility of and methods of implementing and enforcing requirements to reduce hazards on towing vessels operating with tank barges. For example: (1) Preventing vessels with a source of ignition from being alongside, and (2) keeping all cargo tank hatch covers securely closed during the loading and offloading of flammable products.

3. That, in the interim, appropriate action should be taken to alert all persons engaged in the handling of hazardous cargoes as to the dangers involved and how they may be reduced by proper operating practices. This should include the continued publication of instruction manuals and wide dissemination of this report, after action by the Commandant and the National Transportation Safety Board.

5 November 1969.

Another photograph of the M/V *Martin* taken a few days after the fire shows extensive damage to the interior of the towboat.

COMMANDANT'S ACTION

1. The record of the Marine Board of Investigation convened to investigate subject casualty has been reviewed and the record, including the Findings of Fact, Conclusions, and Recommendations, is approved, subject to the following comments and the final determination of the cause by the National Transportation Safety Board.

SYNOPSIS OF FINDINGS OF MARINE BOARD OF INVESTIGATION

1. While discharging a cargo of gasoline, a fire and explosion occurred on the tank barge *MOS 106* at about 2115 CDST, 12 May, 1969. The *MOS 106*, along with the tank barge *MOS 104* and towboat M/V *Martin*, was moored to the floating dock barge of the Triangle Oil Refining Co. at La Grange, Mo., on the Upper Mississippi River. The casualty resulted in the loss of six lives.

2. The *MOS 106* had been loaded with 908,000 gallons of gasoline at West Memphis, Ark., on 5 May 1969. 2,500 barrels (approximately 138,000 gallons) of this cargo were lost at Cape Girardeau, Mo., on 9 May 1969 when two tanks were ruptured as a result of striking a highway bridge. The remainder of the cargo from the two damaged tanks was transferred to four other tanks of the barge.

3. Upon arriving at La Grange at 1745 on 12 May 1969, the *MOS 106* and *MOS 104* were made fast to the Triangle Oil Refining Co.'s dock barge, whereupon the discharge hose was connected to the *MOS 106* to unload the cargo. A leak was discovered at the flange of the hose on the dock barge when pumping began, and pumping was stopped until the joint was repaired. When the pumping resumed, there was only a small intermittent

drip of gasoline from the discharge flange and was caught in a drip pan on the dock barge.

4. There were approximately 20 55-gallon drums stowed on the centerline of *MOS 106* in the vicinity of No. 3 cargo tank. It was reported that eight of these drums were filled with gasoline.

5. Just prior to the fire, a deckhand was washing down the deck of the *MOS 106* and sweeping the wash water over the side of the barge. He stated that gasoline was mixed with the water he was washing overboard. He saw a small flame coming down the deck toward him from the upstream end of the barge, ran aft, and jumped over the side at the time of the first explosion.

6. Evidence in the record shows that the hatch covers on the *MOS 106* were open at the time of the casualty and that a strong gasoline vapor surrounded the *MOS 106* and the M/V *Martin* prior to the fire and explosion. The record discloses that the oil-fired galley range on the M/V *Martin* was in operation prior to and during the fire.

REMARKS

1. The specific source of and the exact location of the fire and explosion could not be determined due to the lack of eyewitnesses and the great amount of structural damage found after the casualty.

2. While a concentration of gasoline vapors undoubtedly supplied the explosive mixture causing this casualty, any determination as to the source of ignition must be purely conjectural based upon the limited facts available. However, assuming the initial explosion to have occurred and fire to have started on the *MOS 106,* a number of potential sources of gasoline vapor becomes evident. The open hatch covers and the gasoline on the deck of the barge are two sources that reflect this possibility.

3. Although the source of ignition was not positively determined, the most likely area of ignition was the flame in the galley range. There could have been other sources of ignition; however, this is not supported in the record. The manner in which the gasoline was deposited on deck of the *MOS 106* is not revealed. There are several possibilities; however, it would be highly speculative to attempt to pinpoint one possibility over others without evidence.

4. Legislation requiring the licensing of persons in charge of the navigational watch of towing vessels is now pending in Congress.

5. The Coast Guard is conducting a long-range study of towing vessels and gathering other statistical information from towing vessel casualties. Methods of reducing hazards on towing vessels operating with tank barges will be included.

6. The dangers of transporting, handling, and storing gasoline will be emphasized through widespread circulation of this report. The *Proceedings of the Merchant Marine Council* will feature the entire report in a future publication. By this action, managers recommending candidates for certification as tankerman are urged to have them study the hazards involved of handling gasoline. Familiarity with the following publications are included:

a. A Manual for the Safe Handling of Inflammable and Combustible Liquids, CG–174.

b. Rules and Regulations for Tank Vessels, CG–123.

c. Fire Fighting Manual for Tank Vessels, CG–329.

These publications are available at no charge from all Coast Guard Marine Inspection Offices and from Coast Guard Headquarters.

22 July 1970.

C. R. BENDER,
Admiral, U.S. Coast Guard,
Commandant.

ACTION BY NATIONAL TRANSPORTATION SAFETY BOARD

This casualty was investigated by a U.S. Coast Guard Marine Board of Investigation convened at Quincy, Ill., on May 20, 1969. A representative of the National Transportation Safety Board attended the proceedings as an observer. The National Transportation Safety Board has considered only those facts in the investigative record which are pertinent to the Safety Board's statutory responsibility to determine the cause or probable cause of the casualty and to make recommendations.

SYNOPSIS

On May 12, 1969, at about 2115 CDST, Meljoy Transport Co. tank barge *MOS 106* caught fire and exploded at the Triangle Oil Refining Co. loading facility on the upper Mississippi River at La Grange, Mo. Tank barge *MOS 104* and towboat M/V *Martin* were also moored at that facility and were involved in the subsequent fire.

These three vessels, and two others downstream from them which also became involved in the fire, were damaged in varying degrees. The loading facility and a grain elevator were damaged by fire. The Chicago, Burlington, & Quincy Railroad bridge, the Quincy waterfront and the town of Quincy, Ill., itself, were endangered by the burning and drifting vessels. In addition, approximately 270,000 gallons of gasoline were burned and/or lost into the waters of the river.

Six persons were killed, one was injured seriously.

The National Transportation Safety Board finds that the probable cause of this casualty was a gasoline spill on the deck of the *MOS 106,* producing an explosive gasoline vapor-air mixture which was ignited by the galley range on the towing vessel *Martin.*

The following are considered to be contributing causal factors:

1. The transfer of approximately 40,000 gallons of salvaged gasoline into tanks No. 1 starboard, No. 2 port, No. 2 starboard, and No. 3 port.

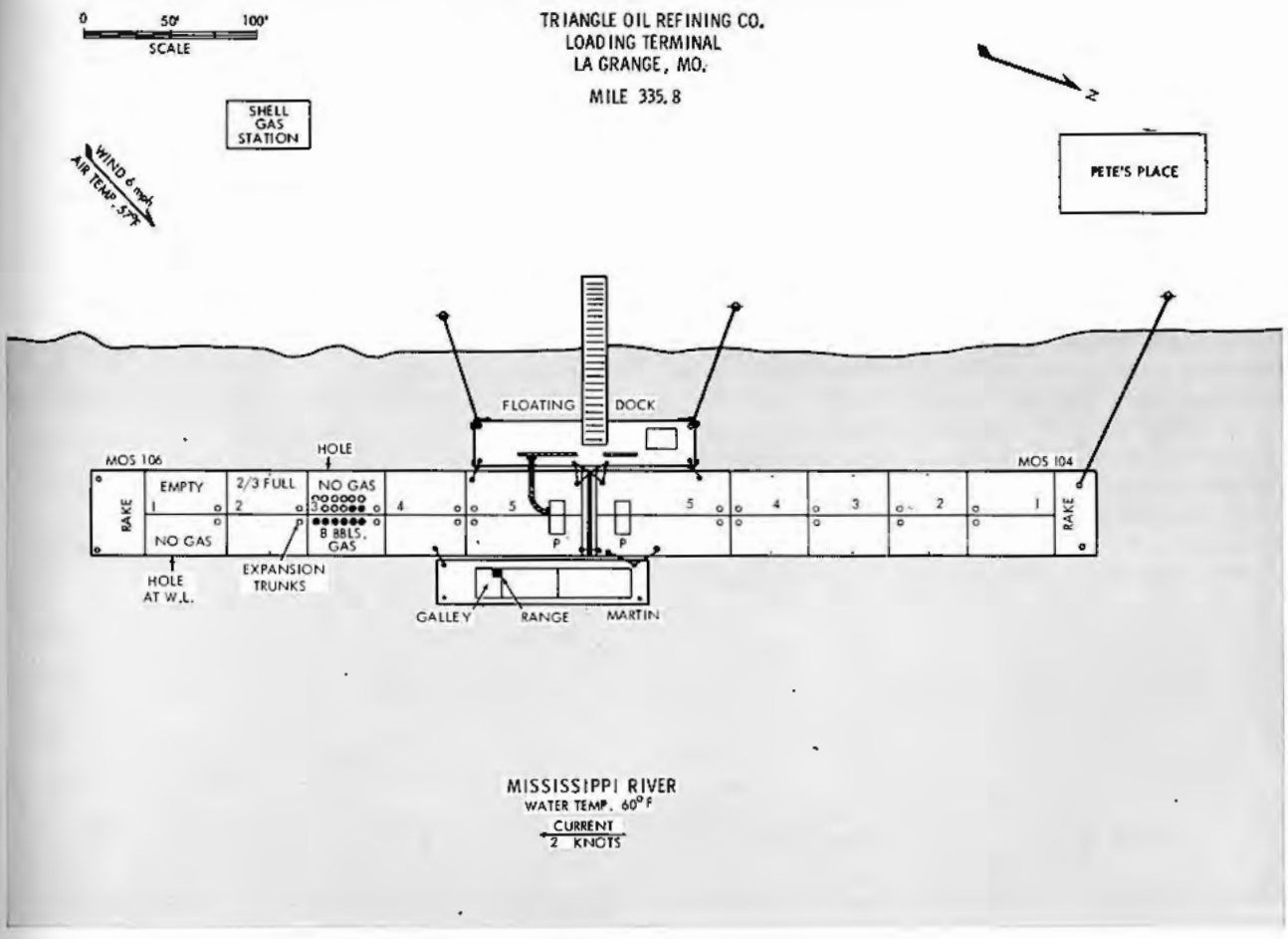


Figure 1

2. An approximate 1° trim by the stern during the offloading operations, which was not abnormal.

3. Either (a) a combination of a vapor pressure buildup and thermal expansion of the vapors and liquids in tanks No. 2 port and or No. 3 port, or (b) the gravitation of cargo from No. 2 port tank to No. 3 port tank, either of which resulted in an overflow of gasoline through the expansion trunk.

4. The absence of practical and specific recommendations or standards limiting the maximum allowable filling of tanks, both in the state of the art and in applicable Coast Guard rules, regulations and manuals.

SUMMARY OF FACTS

A tow, consisting of the uninspected towing vessel M/V *Martin*, pushing the inspected tank barges *MOS 104* and *MOS 106*, collided with the west span pier of the Cape Girardeau, Mo., highway bridge on May 6, 1969. The barges had been loaded with gasoline in West Memphis, Ark., and the tow was proceeding to La Grange, Mo., to discharge its cargo. As a result of the collision with the pier, the No. 1 port tank and No. 3 starboard tank of the *MOS 106* were holed at the waterline. About 138,000 gallons of 94.2-octane gasoline were lost. Approximately 40,000 gallons of gasoline were salvaged from the damaged tanks, and distributed in the No. 1 starboard, No. 2 port and starboard, and No. 3 port tanks of *MOS 106*. Nos. 4 and 5 tanks contained 99.5-octane gasoline. However, the tank barge *MOS 104* was carrying the 94.2-octane gasoline in all 10 tanks and had ullage space available for a portion of the salvaged gasoline, but this barge was not used.

A Coast Guard inspector issued the *MOS 106* a permit to proceed to La Grange, Mo., to discharge her cargo prior to effecting permanent repairs. No leakage of gasoline was noted en route to her destination, which included transit of several locks. The tow arrived at the Triangle Oil Refining Co. terminal at La Grange, on May 12th. The *MOS 106* and *MOS 104* were moored, stern to stern, alongside the terminal floating dock, with the *Martin* moored outboard of the barges, heading upriver. The oil-fired galley range on the tug was operating, and the galley door and windows were opened. Figure 1. shows the arrangement of the tow at the oil terminal.

Weather conditions at the time of discharge operations were broken clouds, wind about 5 knots from the southwest, air temperature about 60° F., and water temperature 60° F. The wind was blowing from the direction of *MOS 106* over the *Martin*. Sunset occurred at 2011.

Discharge operations on the *MOS 106* commenced about 1900, using the tow's hose and diesel cargo pump. A small leak at the dock manifold developed when pumping started, but was corrected, and transfer resumed about 2000. The master, chief engineer, and deckhand of the *Martin*, along with two oil terminal employees, were on the *MOS 106* at the time of the casualty. The master was not licensed, and was not required to be, but held a tankerman's certificate, and was in charge of operations. During the pumping operation, the mate of the *Martin* advised the master that he noticed a strong odor of gasoline in the quarters of the towing vessel, stronger than on deck of the barge. The master told him not to worry about it, and the mate went to bed.

The deckhand, who was the only surviving eyewitness of the casualty, stated that the master told him to wash off a gasoline spill on the barge, using a hose and broom. No other work was in progress on deck. About eight drums of gasoline were stowed on pallets over the No. 3 tanks and he was unable to sweep the gasoline from underneath them. Apparently, the gasoline had been pumped previously from the *MOS 104* into the drums utilizing a portable pump. He stated the spill covered half the deck of the *MOS 106*, running over on the river side, astern of the *Martin*. The fire started at 2115 from the direction of the stern of the *MOS 106* and ran toward the drums of gasoline stowed on deck over the No. 3 cargo tanks.

A series of explosions sprayed burning gasoline over the *MOS 106*, the stern of the *MOS 104*, the afterport side of the *Martin*, and on the floating terminal dock. At the time of the casualty, the starboard No. 1 tank and about one-third of starboard No. 2 tank had been discharged into a terminal tank. The deckhand, wearing a life preserver, jumped off the rake end of the barge and swam ashore. The four other persons on deck, a deckhand asleep on the *Martin*, and a truck driver on the floating dock were killed. A record of the soundings of gasoline in the *MOS 106* tanks on arrival at the Triangle Oil Terminal was burned with the clothing of the master of the *Martin*.

Damage to the *MOS 106* was concentrated in the forward tanks, No. 1 starboard, No. 2 port, and No. 2 starboard. These tanks were bulged and ruptured on deck, and on the sides. No substantive damage resulted in the after portion of this barge. The drums over No. 3 tanks exploded. The *MOS 104* was not damaged appreciably, the galley and living spaces on the *Martin* were gutted by fire, and the north end of the dock barge sank. After the fire threatened the shore facilities, an unidentified person severed the wire securing the rake end of the *MOS 104* to a deadman on shore. The nylon lines connecting the stern ends of the two barges burned, and the two barges and the *Martin* drifted downstream. Burning gasoline from the *MOS 106* spread over the river surrounding the barge, and ignited a nearby grain elevator downstream. The drifting tow also collided with the barges *CHEM 40* and *UM 219*, breaking these barges away from their moorings, and fire from the burning tow ignited them. The *MOS 106* lodged against the upstream side of the Chicago, Burlington & Quincy Railroad span, causing some damage to railroad ties, due to the intensity of the fire. It was fortunate that the *MOS 106* did not drift down on the waterfront facilities in Quincy, or more extensive damage could have occurred.

The fires on the *CHEM 40, UM 219, MOS 104*, and *Martin* burned themselves out. Shore firefighting forces extinguished the fire at the grain elevator. Firefighting equipment was supplied by the Coast Guard Captain of the Port in St. Louis and transported on a barge volunteered by the Northeast Power Co. to extinguish the fire on the *MOS 106*. Examination of this barge after the fire revealed that all the hatch covers were off, and none of the securing dogs were stripped. Some of the dogs were melted, but it appeared that none had been secured prior to the fire.

ANALYSIS

The source of the explosive gasoline vapors and the source of ignition were not positively established by the investigation, due to the loss of all but one eyewitness. However, the report of the Coast Guard Marine Board of Investigation concludes that the most probable source of explosive gasoline vapors was a gasoline spill on deck of the *MOS 106*, possibly from overflow from No. 3 port tank. This report further indicates that the galley fire on the *Martin* was the most probable source of ignition. The Commandant's action on this report concurs in these general conclusions, but notes that the manner in which gasoline was deposited on deck was not revealed, and "it would be highly speculative to attempt to pinpoint one possibility over others without evidence."

The Safety Board concurs with the Marine Board and the Commandant in their conclusions that the most probable source of ignition was the flame in the galley range of the *Martin*. There is no evidence in the record which would indicate a more likely source.

The Safety Board analyzed the various sources of gasoline spills and gasoline vapors in order to determine the most probable cause of this casualty. It should be noted that the Board knows of no methods for calculating precise estimates of vapor concentrations in air for varying distances and atmospheric conditions where the source of the vapor is evaporation from the surface of liquid gasoline.

Several sources of gasoline vapor were developed by the investigation. Prior to the fire, about eight drums loaded

with gasoline were located on wood dunnage on the centerline of the *MOS 106* No. 3 tanks. These drums required venting to relieve pressure, suggesting that they had been overfilled. Presumably, they had been filled from the gasoline in the tanks of the *MOS 104* or *106*. Three portable gasoline pumps were available for such a transfer. A small drum of gasoline was stowed on the barges for fueling the portable pumps. The surviving deckhand testified he vented the drums, wiped up some gasoline from the drumheads, and left some rags and a small quantity of gasoline in an open bucket on the *MOS 104*.

Considering the small quantity of gasoline vapor involved, the location of it in open moving air and the distance from the probable source of ignition (over 150 feet), it is very unlikely that a sufficient quantity of vapors could have accumulated and reached the lower explosive limit.

Another small gasoline spill occurred on the floating dock during the initial stage of discharge. This was caused by a poor connection between the hose flange and the manifold. Additional bolts were installed, reducing the leak to a very slight drip which was caught in a drip pan. Estimates of this spill were a gallon or less. The fire and explosion occurred an hour and a quarter later. The quantity of gasoline available for evaporation during this time precludes this spill from being a logical source of the vapors which caused the fire and explosion on the *MOS 106*.

There is a possibility that some gasoline may have leaked from the barge *MOS 106* due to the damage sustained in collision with the Cape Girardeau Highway Bridge. The Coast Guard inspector stated that there was a possibility that the damage in No. 3 starboard tank could have extended into No. 2 starboard. Fractures in the bulkhead between these two tanks, or on the starboard side of the barge at this bulkhead, could have caused leakage through the hole in the side of No. 3 starboard tank. However, no evidence of leakage from this tank was noted during the trip from Cape Girardeau to La Grange, including transit of several locks. Leakage from either side would be carried downstream on the surface of the river by the 2-knot current, away from the *Martin*. Therefore, this possible source of explosive gasoline vapors does not appear to be a contributing cause.

Although not developed by the investigation, there is a possibility that a gasoline spill could have resulted from a rupture of the transfer hose. This hose was burned, so there is no evidence of this possible source of a gasoline spill. The pumping operations had been in progress for an hour and a quarter, with four persons in the vicinity of the pump. Had the hose burst, the pump could have been stopped quickly by one of these experienced persons. Moreover, the fire damage was concentrated in the area forward of the No. 3 tanks. Little fire damage occurred in the after portion of the barge where the pump and transfer hose were located. This virtually rules out the hose as a source of a gasoline spill.

Another source of gasoline vapor was the terminal storage tank in which the gasoline was transferred. The *MOS 106* pumping rate was about 2,900 bbls./hour; approximately 271 cu. ft./minute of air, with some gasoline vapor, would be displaced from the tank. This tank was about 4,000 feet from the dock. It is possible that some gasoline vapor would be carried by the light westerly breeze over the barges and towing vessel. However, the dispersal characteristics of these vapors in air which has moved more than 4,000 feet make it unlikely that this gasoline/air mixture would be in the explosive range by the time it reached the dock area.

There is also the possibility of evaporation and vapor diffusion from open cargo tank expansion trunk hatches on the *MOS 106*. These covers were oval in shape, approximately 18 by 20 inches. Even assuming all 10 hatches were open, which is doubtful, there would have been an area of about 21 square feet for evaporation and vapor diffusion to take place. Due to the wide spacing of these hatches over the deck of the barge, there was little likelihood of the evaporated vapors reaching the lower explosive limit near any source of ignition.

Other possible sources of spillage on deck include leaks in the deck, expansion trunks, joints, or around the cargo valve reach rods, and leakage from the drums of gasoline on deck. The record does not support any of these possibilities.

Another possible source would be a gasoline spill caused by a buildup of vapor pressure in the cargo tanks resulting in the gasoline being forced out through the open hatches in the expansion trunks. In order to evaluate this possibility, the following technical information and facts of the case must be considered.

Tank No.	*Amount originally loaded (gallons)*	*Capacity of tank (gallons)*	*Amount to fill to capacity*
No. 1 starboard.....	96, 976	109, 165	12, 189
No. 2 starboard.....	94, 426	109, 165	11, 739
No. 2 port.....	95, 571	109, 165	13, 594
No. 3 port.....	100, 103	109, 165	9, 062
Total.....			46, 584

The approximate explosive range for gasoline vapor at 70° F. is from 1.4 to 6 percent by volume, or 0.004 lbs./ft.^{3} to 0.017 lbs./ft.^{3} by weight. An experimentally measured evaporation rate for gasoline has been reported to be 0.57 inches per hour with about a 2-m.p.h. wind at 60° F. For the concentration of gasoline in moving air to reach the lower explosive limit, assuming all the evapo-

rated gasoline built up the vapor concentration cumulatively, a 1-foot-wide patch of air would have to travel at least 6.7 linear feet at 2 miles per hour over a gasoline surface. These calculations provide a coarse estimate only, because of the complexities involved in diffusion of evaporated vapors in open air.

Only a large gasoline spill would have covered an area with a diameter larger than the minimal 6.7 linear feet. The surviving deckhand testified that the gasoline on the deck of this barge covered more than half the deck with gasoline, extending from a foot or two of the dock side, to the river side of the barge, including the area on No. 3 tanks where the gasoline drums were located. While washing down, the gasoline and wash water spilled over the port or river side of the barge. The southwest wind would blow the vapors over the *Martin*. The mate's testimony substantiates the presence of strong gasoline vapors on board the vessel. He stated the gasoline vapors were stronger on the *Martin* than on the barge.

The hatch covers were apparently not dogged down after soundings were taken on arrival at the Triangle Oil Terminal. The record of these soundings was lost but an estimate can be made of the amount of gasoline in the tanks which received the gasoline salvaged after the collision with the highway bridge.

Approximately 40,000 gallons of gasoline salvaged from the damaged No. 1 port and No. 3 starboard tanks were distributed in these four tanks. Thus, there was only 6,548 gallons of total slack space in these tanks. The distribution of the salvaged gasoline among these four tanks is not available. Neither is the sequence of topping them off with the additional gasoline. Therefore, it is quite possible one or more of these four tanks could have been filled to capacity. Apparently, the four aftertanks were not used because they contained higher octane gasoline. The tanks topped off were filled to 98.5 percent of capacity, in the aggregate, compared with 84.4 percent when originally loaded. This would be an average of 5 inches of slack in each tank if each was evenly filled.

If the tanks were full, and the hatches not dogged down, a 2° trim by the stern would cause an overflow from the top of an expansion trunk. These expansion trunks were 1 foot 9 inches high, 36 inches in diameter, and the afterpart of the trunks were 48 feet 3 inches from the forward bulkhead in the tank. With 5 inches of slack in a tank (assuming even distribution of the salvaged gasoline in the four tanks), the bottom of the expansion trunk would be covered if the vessel were trimmed 0.5° by the stern.

After pumping for an hour and a quarter, all the gasoline in No. 1 starboard and one-third of the gasoline in No. 2 starboard had been pumped ashore. At the time of the casualty, the barge had about a 1° of trim by the stern. This trim alone would not have caused a spill of gasoline from the expansion trunks, but during this period of discharge, the gasoline would have covered the bottom of at least one of these trunks. This is predicated on there being 6,584 gallons of aggregate ullage in the tanks, topped off with the salvaged gasoline.

As the bottom of the expansion trunk became covered by the level of the gasoline, thus sealing off the tank vents located in the expansion trunks, the vapors in the vapor space could no longer escape to the atmosphere. At the same time, warming of the liquid gasoline would accelerate the evaporation process, thus increasing the vapor pressure. Also, a limited amount of thermal expansion of the vapor and the liquid would occur. This combination of events, coupled with the fact that the expansion trunk covers were not secured, would result in a rise in the liquid level in the expansion trunk.

For each 0.1 p.s.i. increase in pressure, there would be a rise in the liquid level in the expansion trunk of about 3.8 inches. A temperature rise of about 3.5° F. in the vapor space would create a 0.1 p.s.i. pressure rise. Thus, approximately a 15° rise in temperature of the vapor space and the liquid, combined with the increased trim by the stern as the cargo was being transferred from the forward tanks, could be expected to raise the liquid level in the expansion trunks of the filled tanks. The barge deck plates, warmed throughout the day by the sunshine, provided a substantial heat source to supply the heat to raise the gasoline and vapor space temperatures, even though ambient temperatures had begun to decline as the barge was being unloaded.

Evidence developed by the Marine Board supports the occurrence of these phenomena. First, the increase in vapor pressure in the drums stowed on deck which resulted in the generation of internal pressure in the drums, to such a degree the pressure had to be relieved manually by the deckhand. Secondly, the thermal expansion of the gasoline in one or more of the drums caused small quantities to spill onto the tops of the drums. Because of their size and location, the drums would have been warmed more quickly and to a greater degree than the cargo tanks, but the same warming tendency would have existed for both on the day of the casualty.

It therefore follows that the sun, almost at its maximum declination on this day, heated the deck plating of the *MOS 106,* causing an increase in the vapor pressure in the cargo tanks. While the sun had set before the casualty, the heat reservoir formed by the deck plating would continue the warming, thus causing an increase in vapor pressure in such tanks well beyond the time of the casualty. This warming, in conjunction with the increase in trim by the stern, probably forced gasoline from the expansion trunks from either or both the port Nos. 2 and 3 tanks. At the time of the casualty, the other tanks were not as fully loaded. No. 1 port and No. 3 starboard contained water, Nos. 1 and 2 starboard had been discharged. The No. 4 tanks had almost 3 feet of ullage, and the No. 5 tanks about 11 inches of ullage (expansion trunks on No. 5 tanks are located forward in the tanks).

Another condition which could have caused gasoline to

overflow through an open hatch cover in No. 3 port tank would be a lack of watertight integrity between Nos. 2 and 3 port tanks. If the transverse bulkhead between these two tanks leaked directly below the main deck, the gasoline in No. 2 could gravitate into No. 3.

The vertical crack in this bulkhead, specifically referred to in the testimony, most likely was the result of one of the explosions during the casualty. However, accelerated corrosion of the deck stringers and the upper portion of tank bulkheads is not an unusual occurrence in older gasoline barges.

If such a condition did exist, it could account for both a spillage through the expansion trunk hatch in No. 3 port and the fact that an explosion occurred in No. 2 port but not in No. 3 port. Obviously, if enough gasoline gravitated from No. 2 port to No. 3 port, the latter would have very little if any vapor in it while the former would have an increased amount of air in it to create a hazardous mixture of gasoline vapor and air. Therefore, the likelihood of an explosion occurring would be greater in No. 2 port than in No. 3 port.

It is concluded that the spillage of gasoline occurred from the No. 2 port tank and/or the No. 3 port tank via the open hatches. The cause of the spill could have been either a combination of a vapor pressure buildup and thermal expansion or a gravitation of cargo from No. 2 port into No. 3 port. The deckhand's testimony and the damages sustained by the barge support this conclusion. In the absence of testimony or evidence of the exact ullages in each tank, we cannot assign greater probability to one or the other possible causes.

The Board has also considered the implications of the relatively large volume of liquid overflowed in the spill. It would appear that a large volume could be accounted for by the continued vaporization of liquid fuel which would continue to vaporize after a pressure had been reached inside the tank sufficient to cause the overflow. Vaporization increases the volume of liquid fuel by several hundred times so that the vaporization of only one-tenth of a gallon under these conditions could cause an overflow of 30 to 60 gallons from the expansion trunk. Similarly, continued leakage through the crack between the two tanks could account for a large volume of fuel.

The galley range is the most probable source of ignition of the explosive gasoline vapor. There are other possible sources, such as electrical equipment on the *Martin,* smoking onboard the towing vessel or barge, static electricity, and sparks produced by metal-to-metal impact, but none of these are supported by the evidence. It is known that the oil-fired galley range was burning at the time of the causualty. Also, gasoline vapors in the galley would be drawn into the range by the blower and exhaust system during its normal operation.

The Board has considered whether the issuance of the permit to proceed by the Coast Guard inspector after the Certificate of Inspection had been withdrawn should be considered a causal factor in this casualty. The permit to proceed was issued after the fuel had been redistributed in other tanks of the *MOS 106.* It appears that neither the Coast Guard inspector nor the master of the M/V *Martin* gave consideration to the possibility of overfilling the tanks.

A permit to proceed is accompanied by careful analysis of the safety of the movement including all the factors, particularly with reference to the protection of the general public. The accident might have been avoided by requiring that the cargo be redistributed into *MOS 104* as well as the available tanks of *MOS 106.* However, there were no specific standards available at the time of this accident to enable the master or the Coast Guard inspector to determine the maximum safe cargo capacity for each tank. Although "A Manual for Safe Handling of Inflammable and Combustible Liquids" (CG–174) provides a general guideline of 1 to 3 percent ullage to allow for possible temperature increase during a voyage, this guideline is too general to be of practical use to the man in charge of topping off the tanks onboard a tank vessel. Also, this brief one-sentence guideline gives inadequate emphasis to this potential danger. In other modes of transportation, more specific and useful criteria are provided. For example, Title 49 CFR, Part 173.116 provides criteria for the filling of containers with inflammable liquids which are transported by rail, highway, or water. This explanation of the accident has been developed only by the most careful analysis which considered several areas of expertise. Also, this analysis took place at a time after the possibility of the hazard was pointed out by the occurrence of the accident. The prediction of this phenomenon by a single Coast Guard inspector working under field conditions would not normally be anticipated.

Thus, the issuance of the permit to proceed is not regarded as a causal factor. The absence of practical and specific guidelines, recommendations, or standards establishing limits for the filling of tanks is a significant causal factor.

PROBABLE CAUSE

The National Transportation Safety Board finds that the probable cause of this casualty was a gasoline spill on the deck of the *MOS 106,* producing an explosive gasoline vapor-air mixture which was ignited by the galley range on the towing vessel *Martin.*

The following are considered to be contributing causal factors:

1. The transfer of approximately 40,000 gallons of salvaged gasoline into tanks No. 1 starboard, No. 2 port, No. 2 starboard, and No. 3 port.

2. An approximate 1° trim by the stern during the offloading operations, which was not abnormal.

3. Either (a) a combination of a vapor pressure buildup and thermal expansion of the vapors and liquids in tanks No. 2 port and/or No. 3 port, or (b) the gravitation of cargo from No. 2 port tank to No. 3 port tank,

either of which resulted in an overflow of gasoline through the expansion trunk.

4. The absence of practical and specific recommendations or standards limiting the maximum allowable filling of tanks, both in the state of the art and in applicable Coast Guard rules, regulations, and manuals.

The Safety Board concurs in the conclusions of the Marine Board that the following were also contributory causal factors:

1. The presence of the M/V *Martin* and its potential sources of ignition immediately alongside the barges during discharge operations.

2. Failure of the master to investigate and ascertain the source of the vapors.

3. Failure of the master to take timely action to eliminate the source of the vapors.

4. Failure of the master to keep the tank hatch covers securely closed.

Loss of life was caused by the violent release of energy due to ignition of explosive vapors near the deck of the barge, dispersal of flaming gasoline from explosive rupture of the loaded drums caught in the fire, and the wind-borne dispersal of burning gasoline vapors over the *Martin* and the floating dock.

RECOMMENDATIONS

The Safety Board concurs in the recommendations of the Marine Board of Investigation. We further support such recurrent training programs as the tankerman course proposed for the National River Academy. Such educational and recurrent training programs are effective methods for reducing accidents involving dangerous cargo. They should receive the full support of the maritime industry.

In addition, it is recommended that:

1. The owners and operators of all tank vessels and tank barges which are not required to have loadlines, provide each vessel or barge with a maximum loading capacity guide, such guide to cover the petroleum products normally carried and the seasonal temperature variations normally encountered in the area of operations.

2. The Coast Guard, as a part of its review of tank vessel and tank barge casualties, evaluate the effectiveness of the safe handling procedures as recommended by the Rules and Regulations for Tank Vessels (Title 46 CFR, Parts 30 to 40) and the Manual for the Safe Handling of Inflammable and Combustible Liquids. The intent of such a review would be to determine whether some of the current recommended procedures should be made mandatory by regulation.

By the National Transportation Safety Board:

Adopted this 7th day of January, 1971:

/s/ JOHN H. REED,
Chairman.

/s/ OSCAR M. LAUREL,
Member.

/s/ FRANCIS H. MCADAMS,
Member.

/s/ LOUIS M. THAYER,
Member.

/s/ ISABEL A. BURGESS,
Member.

STORES AND SUPPLIES

Articles of ships' stores and supplies of a dangerous nature certificated from January 1, 1971, to March 15, 1971, inclusive, for use onboard vessels in accordance with the provisions of Part 147 "Regulations Governing Use of Dangerous Articles as Ships' Stores and Supplies on Board Vessels" are as follows:

CERTIFIED

Economics Laboratory, Inc., Osborn Building, St. Paul, Minn. 55102. Certificate #891, dated January 6, 1971, MAGNUS 729.

Maritec Corp., 860 River Rd., Edgewater, N.J. 07020. Certificate #892, dated January 7, 1971, MARITEC ELECTRICAL SOLVENT 40W.

Chemola Corp., 8502 Glenvista, P.O. Box 34215, Houston, Tex. 77034. Certificate #893, dated January 12, 1971, DESCO NF–2000 INDUSTRIAL SOLVENT AND CLEANER; certificate #894, dated January 20, 1971, TAP; certificate #895, dated January 20, 1971, 745 HAND CLEANER.

Apollo Chemical Co., 250 Delawanna Ave., Clifton, N.J. 07014. Certificate #903, dated February 8, 1971, PENTRON A–77.

Marine and Ship Supply, Inc., 110 Brannan St., San Francisco, Calif. 94107. Certificate #905, dated February 25, 1971, NYSTOL #27.

RECERTIFIED

Hysan Products Co., 919 West 38th St., Chicago, Ill. 60609. Certificate #502, dated January 6, 1971, HYSOLV.

Ferrous Corp., P.O. Box 1064, Bellevue, Wash. 98004. Certificate #189, dated January 20, 1971, FE–4 HYDROCARBON FUEL CATALYST; certificate #191, dated January 20, 1971, FE–6 HYDROCARBON FUEL CATALYST.

AFFIDAVITS

The following affidavits were accepted during the period from February 15, to March 15, 1971:

Chase Brass & Copper Co., Cleveland, Ohio 44108, VALVES & FITTINGS.

Custom Alloy Corp., Califon, N.J. 07830, FITTINGS.

Rich Manufacturing Co., P.O. Box 910, Corona, Calif. 91720, VALVES, FITTINGS, & FLANGES.

The Weatherhead Co., 300 East 131st St., Cleveland, Ohio 44108, FITTINGS.

MERCHANT MARINE SAFETY PUBLICATIONS

The following publications of marine safety rules and regulations may be obtained from the nearest marine inspection office of the U.S. Coast Guard. Because changes to the rules and regulations are made from time to time, these publications, between revisions, must be kept current by the individual consulting the latest applicable Federal Register. (Official changes to all Federal rules and regulations are published in the Federal Register, printed daily except Sunday, Monday, and days following holidays.) The date of each Coast Guard publication in the table below is indicated in parentheses following its title. The dates of the Federal Registers affecting each publication are noted after the date of each edition.

The Federal Register will be furnished by mail to subscribers, free of postage, for $2.50 per month or $25 per year, payable in advance. The charge for individual copies is 20 cents for each issue, or 20 cents for each group of pages as actually bound. Remit check or money order, made payable to the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Regulations for Dangerous Cargoes, 46 CFR 146 and 147 (Subchapter N), dated January 1, 1970 are now available from the Superintendent of Documents price: $3.75.

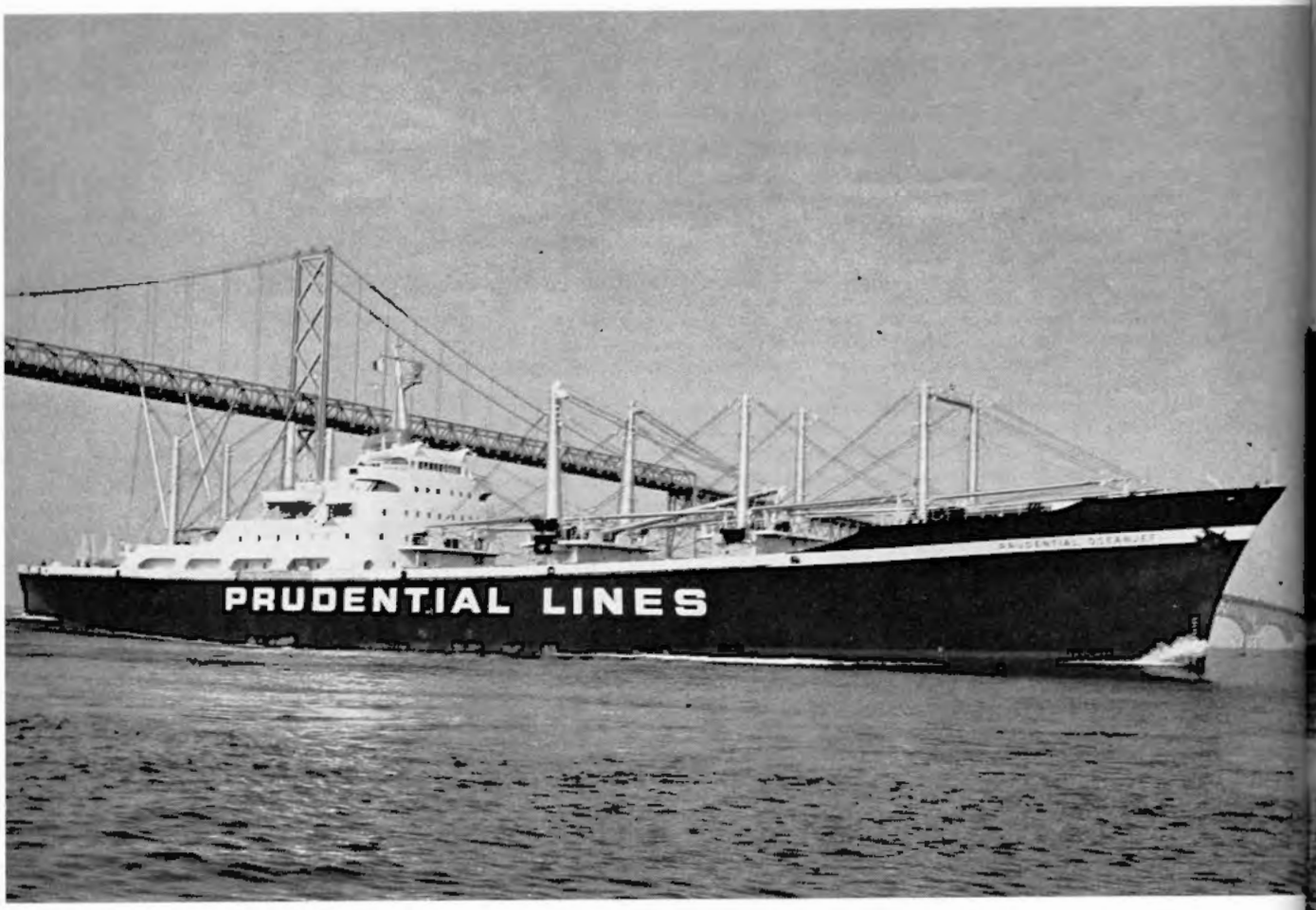
CG No.	TITLE OF PUBLICATION
101	Specimen Examination for Merchant Marine Deck Officers (7–1–63).
108	Rules and Regulations for Military Explosives and Hazardous Munitions (5–1–68). F.R. 6–7–68, 2–12–69, 10–29–69.
115	Marine Engineering Regulations and Material Specifications (7–1–70). F.R. 12–30–70.
123	Rules and Regulations for Tank Vessels (5–1–69). F.R. 10–29–69, 2–25–70, 6–17–70, 10–31–70, 12–30–70.
129	Proceedings of the Marine Safety Council (Monthly).
169	Rules of the Road—International—Inland (9–1–65). F.R. 12–8–65, 12–22–65, 2–5–66, 3–15–66, 7–30–66, 8–2–66, 9–7–66, 10–22–66, 5–11–67, 12–23–67, 6–4–68, 10–29–69, 11–29–69.
172	Rules of the Road—Great Lakes (9–1–66). F.R. 7–4–69, 8–4–70.
174	A Manual for the Safe Handling of Inflammable and Combustible Liquids (3–2–64).
175	Manual for Lifeboatmen, Able Seamen, and Qualified Members of Engine Department (3–1–65).
176	Load Line Regulations (2–1–71).
182	Specimen Examinations for Merchant Marine Engineer Licenses (7–1–63).
184	Rules of the Road—Western Rivers (9–1–66). F.R. 9–7–66, 5–11–67, 12–23–67, 6–4–68, 11–29–69.
190	Equipment Lists (8–1–70). F.R. 8–15–70, 9–29–70.
191	Rules and Regulations for Licensing and Certificating of Merchant Marine Personnel (5–1–68). F.R. 11–28–68, 4–30–70, 6–17–70, 12–30–70.
200	Marine Investigation Regulations and Suspension and Revocation Proceedings (5–1–67). F.R. 3–30–68, 4–30–70, 10–20–70.
220	Specimen Examination Questions for Licenses as Master, Mate, and Pilot of Central Western Rivers Vessels (4–1–57).
227	Laws Governing Marine Inspection (3–1–65).
239	Security of Vessels and Waterfront Facilities (5–1–68). F.R. 10–29–69, 5–15–70, 9–11–70, 1–20–71.
249	Marine Safety Council Public Hearing Agenda (Annually).
256	Rules and Regulations for Passenger Vessels (5–1–69). F.R. 10–29–69, 2–25–70, 4–30–70, 6–17–70, 10–31–70, 12–30–70.
257	Rules and Regulations for Cargo and Miscellaneous Vessels (8–1–69). F.R. 10–29–69, 2–25–70, 4–22–70, 4–30–70, 6–17–70, 10–31–70, 12–30–70.
258	Rules and Regulations for Uninspected Vessels (5–1–70).
259	Electrical Engineering Regulations (3–1–67). F.R. 12–20–67, 12–27–67, 1–27–68, 4–12–68, 12–18–68, 12–28–68, 10–29–69, 2–25–70, 4–30–70, 12–30–70.
266	Rules and Regulations for Bulk Grain Cargoes (5–1–68). F.R. 12–4–69.
268	Rules and Regulations for Manning of Vessels (5–1–67). F.R. 4–12–68, 4–30–70, 12–30–70.
293	Miscellaneous Electrical Equipment List (9–3–68).
320	Rules and Regulations for Artificial Islands and Fixed Structures on the Outer Continental Shelf (11–1–68). F.R. 12–17–68, 10–29–69.
323	Rules and Regulations for Small Passenger Vessels (Under 100 Gross Tons) (7–1–69). F.R. 10–29–69, 2–25–70, 4–30–70, 10–31–70, 12–30–70.
329	Fire Fighting Manual for Tank Vessels (7–1–68).

CHANGES PUBLISHED DURING MARCH 1971

The following have been modified by Federal Register:

(No Change)

National Transportation Week
May 16–22



National Maritime Day May 22