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AD NUMBER

AD367486

CLASSIFICATION CHANGES

TO: unclassified

FROM: confidential

LIMITATION CHANGES

TO:

Approved for public release, distribution unlimited

FROM:

Distribution: USGO: others to Director, Defense Atomic Support Agency, Washington, D. C. 20301.

AUTHORITY

DSWA ltr., 18 Apr 97; DSWA ltr., 18 Apr 97

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BUREAU OF SHIP GROUP

TECHNICAL INSPECTION REPORT

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By *John H. Doyette* Date 24 SEP 1953

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OPERATION CROSSROADS.
U.S.S. FALLON (APA81)

TEST BAKER.

VOLUME 1 [U].

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Washington, D. C. 20301

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**BUREAU OF SHIPS GROUP
TECHNICAL INSPECTION REPORT**

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Director
Defense Atomic Support Agency
Washington, D. C. 20301

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F.X. Forest,
Captain, U.S.N.

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USS FALLON (APA81)

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USS FALLOI (APA81)

U.S.S. FALLON (APA 81)

SHIP CHARACTERISTICS

Building Yard: Consolidated Steel Corp.; Wilmington,
California.

Commissioned: 14 February 1945.

HULL

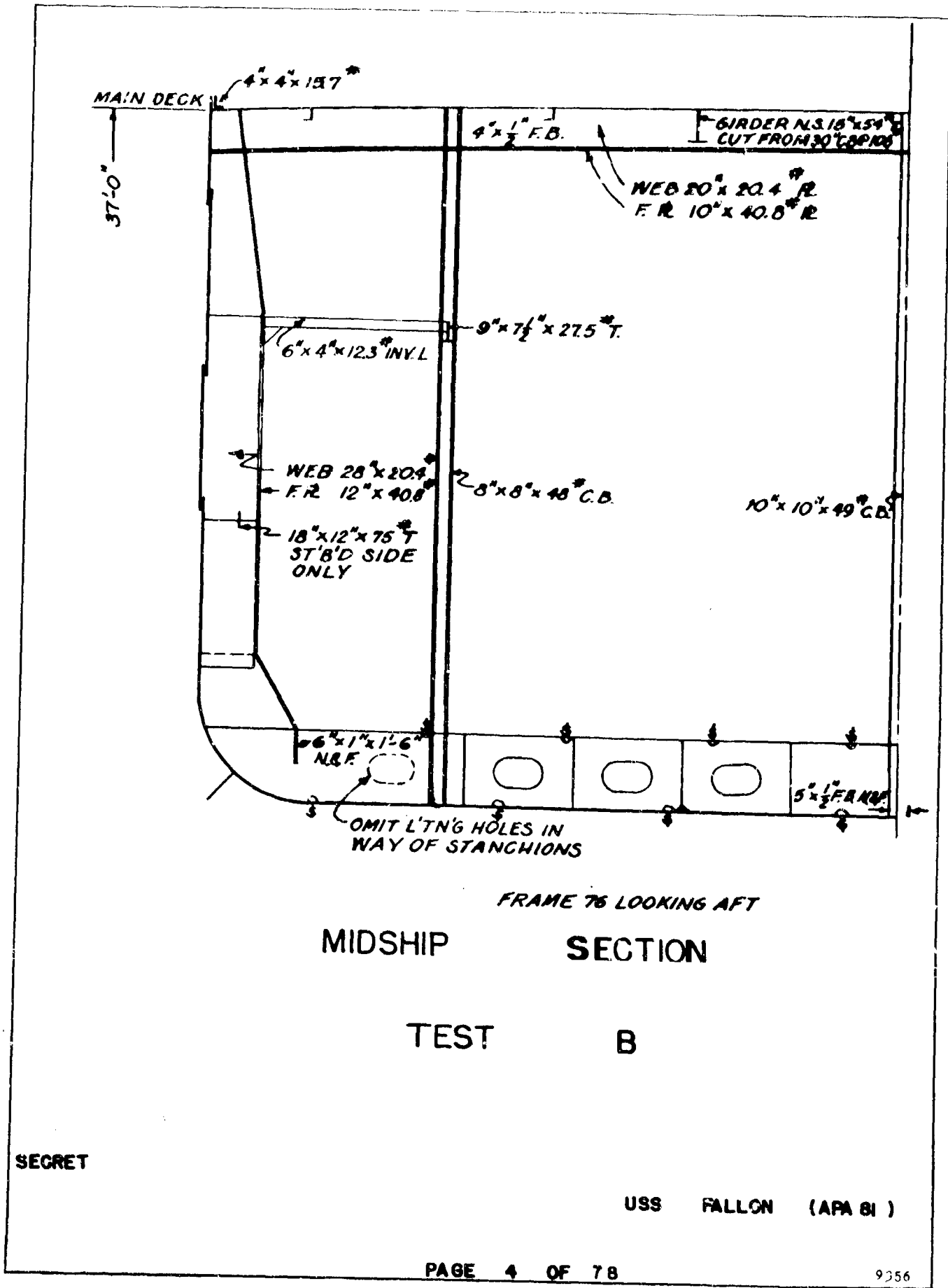
Length Overall: 426 feet 0 inches.
Length on Waterline: 400 feet 0 inches.
Beam (extreme): 58 feet 0 inches.
Depth (molded to upper deck): 37 feet 0 inches.
Drafts at time of test: Fwd. 11 feet 3 inches.
Aft. 17 feet 4 inches.
Limiting displacement: 7,080 tons.
Displacement at time of test: 6,259 tons.

MAIN PROPULSION PLANT

Main Engines: Two sets of Westinghouse steam tur-
bines, directly connected to Westinghouse main gen-
erators. Two main shaft motors.
Main Condensers: Two are installed in ship.
Boilers: Two Babcock and Wilcox boilers are in-
stalled in ship. 465 psi gauge - 750° F.
Propellers: Two are installed.
Main Shafts: Two are installed in ship.
Ships Service Generators: Five are installed in
ship. Three - 250 KW. 450 V. - A.C. and Two -
100 KW. - 120/240 V. - D.C.

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TECHNICAL INSPECTION REPORT

OVERALL SUMMARY

I. Target Condition After Test.

(a) Drafts after Test; list; areas of flooding, sources.

HULL

Observed drafts and list: Draft forward; aft; List

Before Test B.	11' 3"	17' 4"	0°
After Test B.	16' 6"	20' 0"	5° S

The vessel was beached on the day following Test B. Prior to beaching her drafts were as indicated above. The ship flooded to the waterline, which was just below the first platform level, between bulkheads 68 and 124. In addition, both shaft alleys flooded completely through broken cooling water lines and through damaged stern tube stuffing glands. The forward machinery space (frames 68 to 83) flooded through a broken rubber flexible connection in the overboard discharge from the main condenser. The main injection and overboard discharge valves in this space had been left open as part of the test. The auxiliary machinery space flooded slowly through bulkhead 83 from the forward machiner spaces. The only observed leak in bulkhead 83 is an enlarged hole around a three inch pipe line. The after machinery space flooded through a tear in the port shell plating at its connection to the tank top, in way of the buckle between frames 93 and 94. There is also leakage into this space from the starboard shaft alley through the shaft gland in bulkhead 108 and through leaking sounding tubes from the inner bottom tanks below. Cargo hold No. 2 flooded from leakage around the hatches of the port and starboard shaft alley access trunks.

The vessel is considered to be stable. The list was largely due to the shifting of concrete block ballast in the forward hold

MACHINERY

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All machinery spaces were flooded by water and fuel oil entering through the shaft glands, a broken connection to the forward main condenser, a ruptured fuel oil tank, and possibly other sources.

ELECTRICAL

Drafts and list were not noted.

Both engine rooms and auxiliary machinery space, were flooded, other flooding was not noted.

(b) Structural damage.

HULL

Structural damage on the FALLON is extremely severe. The ship apparently experience a aeries of violent hogging and sagging movements as evidenced by buckling of shell plating and decks amidships and by shear wrinkles in plating at the quarter points. In addition, the vessel appears to have a permanent transverse curvature with the mid-ship portion moved to starboard relative to the ends. There is also evidence of a twist in the hull such that the foremast was inclined to starboard relative to the mainmast. There is no apparent damage to the masts themselves. The principal compression failure in the lower flange of the hull girder occurred at frames 93-96. The shell plating on the port side has a pronounced vertical wrinkle between frames 93-94 which starts at about the 15 foot waterline and increases in magnitude toward the bottom of the vessel. The wrinkles are about six inches deep at the waterline and extends entirely across the bottom. The shell is torn between frames 93-94 for a length of about eight inches. It has a maximum opening of about 3/4 inch at the welded intersection of the tank top with the shell. The tank top (inner bottom) is wrinkled between frames 93 and 94 from the port side, inboard, at least 20 feet, and presumably entirely across the vessel. The starboard shell is also wrinkled in this area with the most pronounced buckle at frame 95-96. a second compression failure, originating in a sagging condition, is located at frame 98 on the port side. The wrinkle starts below the waterline and continues up to the main deck. This wrinkle is reflected in the main and upper decks and appears to be present in the after stack. Another compression

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USS FALLON (APA81)

wrinkle runs from the main deck to below the waterline at frame 125 on the port side. A pronounced pattern of shear wrinkles appears in the area of the neutral axis between frames 40 and 60 on the port side. The pattern is upward and forward. A light panel failure is present on the starboard side opposite.

In addition to these evidences of severe bending stresses failures due to a strong underwater shock, principally affecting the bottom and port side, are present. The port shell is severely dished between the tank top and the first platform. The maximum effect extends approximately from bulkhead 68 to frame 100. Forward and aft of these limits, moderate dishing between frames occurs. Between bulkheads 83 and 93 in the Auxiliary Machinery Space, the entire panel is dished about six inches and all transverse stiffeners on the panel are tripped. In the forward Machinery Space (frames 68-83), the port shell is dished about two to three inches in the same location and transverse stiffeners show evidence of high stress. A similar condition exists in the forward portion of the After Machinery Space. The starboard shell is also dished but more lightly and generally between frames. Bulkheads 68, 83, 93, 108, and associated web frames, suffered considerable distortion adjacent to the port shell. The bottom of the vessel evidently moved violently upward under the action of the underwater shock wave. This movement resulted in the crushing of all main bulkheads in the midship half length along their bases. Severe distortion generally extends up to the second platform. Centerline girders (H-sections) in the machinery spaces are badly buckled in the lower portion. The upward force was transmitted via bulkheads and stanchions to the upper levels. All web girders, bulkheads, and stanchions in the machinery spaces and forward and after holds, up to the upper deck, exhibit signs of severe working in compression. Decks and platforms are distorted and moved with accompanying damage to machinery thereon. Crushing of lockhouse sides in way of main bulkheads has been amplified by downward movement of the main structure during whipping of the ship girder.

MACHINERY

No comment.

ELECTRICAL

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Structural damage was not noted in detail, but was general throughout the vessel. Much machinery shifted, with possible damage to foundations. Numerous bulkheads, vent ducts and other light sheet metal installations were distorted, with resultant damage to electrical installations mounted thereon.

(c) Other damage.

HULL

Severe distortion of the hull resulted in the inoperability of most machinery and electrical equipment. No actual failures of structural foundations of major machinery units were observed although shock and deflection of the foundations resulted in general shearing and elongation of holding down bolts. Piping suffered severe shock damage which rendered much equipment inoperable.

MACHINERY

The machinery of this vessel was so severely damaged by Test B that it is believed to be beyond economical repair. Both boilers had casings ruptured, foundations failed, extensive damage to brickwork, etc. The forced draft blower jammed. Holding down bolts of the forward main motor sheared off. Foundation bolts of both main turbines and the after main motor were loosened. All main motors and main turbines are probably out of alignment. The main condenser foundations buckled. Nearly all pumps are badly out of alignment because of foundation failures. All ship's service generators are out of alignment from foundation failures. Two cargo winches were knocked overboard. Other deck machinery was severely damaged. There is much other damage not listed here.

ELECTRICAL

Damage to the ship's electrical equipment was due to flooding, to shock and to collapse of supporting structure. Both main motors had shifted on foundations. The after main generator the after main engine control board and numerous auxiliaries had also shifted. All machines and switchboards in the three machinery spaces were

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flooded with both water and fuel oil.

Some local wiring was broken or pulled from boxes by collapsing supporting structure. Shock caused a general dislodging of heavy electrical equipment in the superstructure spaces.

II. Forces evidenced and Effects Noted.

(a) Heat.

HULL

There is no evidence of heat.

MACHINERY

There was no evidence of heat.

ELECTRICAL

There was no evidence of heat on the vessel.

(b) Fires and Explosions.

HULL

There were no fires or explosions.

MACHINERY

There was no evidence of fires or explosions.

ELECTRICAL

There were no fires or explosions on the vessel.

(c) Shock.

HULL

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USS FALLON (APA81)

There is considerable evidence of underwater shock which resulted in shearing of holding-down bolts, in undogging of doors, and in damage to delicate equipment. Light bulbs were not shattered except in isolated instances. There is much evidence of violent movement of the vessel which resulted in displacement of deck and main machinery, furniture, and equipment, and in shifting of the permanent ballast.

MACHINERY

The FALLON received an underwater shock of tremendous magnitude, as evidenced by the damage listed above and numerous other examples.

ELECTRICAL

Shock caused great damage throughout the vessel. Much machinery, auxiliary machinery, and heavy pieces of electrical equipment was displaced from foundations by shock. The emergency diesel generator although not damaged in itself, was put out of action by the dislodging and breakage of the diesel starting batteries.

(d) Pressure.

HULL

Dishing of the port shell and bottom resulted from the underwater pressure wave. The deformation of the shell caused distortion of frames, brackets, and bulkheads connected to the shell plating. Some evidence of air blast pressure may be seen in the slight dishing of superstructure bulkheads.

MACHINERY

There was little, if any, evidence of pressure. The stacks were moderately dished but this may have been caused by the heavy mass of water falling on the vessel immediately after Test B.

ELECTRICAL

No pressure effects were found in any electrical equipment.

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- (e) Any effects apparently peculiar to the Atom Bomb.

HULL

In addition to the phenomenon of radioactivity, the huge wave generated by the Test B detonation seriously strained the hull and dislodged equipment. Such surface disturbance have never been experienced before during underwater detonations.

MACHINERY

An underwater shock of this magnitude is apparently peculiar to the Atom Bomb.

ELECTRICAL

No effects peculiar to the atom bomb were found on any electrical system.

III. Effects of Damage.

- (a) Effect on machinery, electrical, and ship control.

HULL

The ship was left without power or lighting.

MACHINERY

The machinery plant is completely inoperable. The plant as a whole is believed to be beyond economical repair as many units appear to be unsalvageable. A few scattered auxiliaries may be operable but no power is available for them. A more complete inspection than was possible in this case would undoubtedly disclose additional damage.

ELECTRICAL

The shifting of the forward and after main motors,

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USS FALLON (APA81)

the after main generator and the after main control board would have disabled the vessel even if no flooding had occurred. Flooding of the machinery spaces put all main machinery and auxiliaries out of commission.

(b) Effect on gunnery and fire control.

HULL

Loss of power would have inhibited fire control.

MACHINERY

No comment.

ELECTRICAL

The loss of all electrical power would have put the guns on manual operation.

(c) Effect on watertight integrity and stability.

HULL

Stability was reduced considerably but the vessel is believed to have remained in a stable condition with positive metacentric height. Watertight integrity is reduced considerably by crushing of bulkheads, by piping failures, and by the tear in the port shell. All openings were of such size that control of flooding by active damage control was possible.

MACHINERY

No comment.

ELECTRICAL

The failures in the electrical system had no effect on the watertight integrity and the stability.

(d) Effect on personnel and habitability.

HULL

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Excluding the effects of radioactivity, personnel casualties from shock and wave action would have been severe. Habitability of the ship was reduced by desarrangement of furniture and equipment and the loss of all power.

MACHINERY

It is estimated that a high percentage of the crew below decks would have been casualties from the effect of the shock, and that all topside personnel would have been lost. The ship was made uninhabitable by loss of power, extensive damage, flooding, and high radioactivity.

ELECTRICAL

The loss of all electrical power would cause failure of ventilation, some galley equipment, water pumps and lighting with the corresponding loss of habitability. Electrical failures would not have affected personnel directly.

- (e) Total effect on fighting efficiency.

HULL

Extreme hull damage, loss of all power and lighting, and heavy personnel casualties would have severely reduced the fighting efficiency of the vessel. If at sea, all efforts would have had to be directed toward saving this badly damaged vessel and toward getting her to port.

MACHINERY

Fighting efficiency was completely destroyed.

ELECTRICAL

The disabling of both main propulsion generators and motors by movement on the foundations would have reduced mobility and fighting efficiency to zero.

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IV. General Summary of Observers' Impressions and Conclusions.

HULL

Material damage to hull and machinery was extreme and bordered on complete destruction.

MACHINERY

It is believed that this vessel would have been lost if she had been in the open sea at the time of the test.

ELECTRICAL

The total fighting effectiveness of the vessel would have been lost.

Casualties would have been high.

Almost all failures of electrical equipment were due to failure of supports or foundations, due to inherent weakness of the equipment.

The failure of the main motors and other large electrical machines, by shifting on the foundations, is comparable in importance with the buckling that occurred in the hull; and the general damage with attendant high personnel casualties through the superstructure and weather spaces.

V. Any Preliminary General or Specific Recommendations.

HULL

The performance of this vessel greatly exceeded expectations. No remedial action is indicated and it is not considered practicable to design this type of vessel to resist the high forces experienced by the FALLON.

MACHINERY

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It is doubtful whether machinery can be designed to withstand such a severe shock at such a close range. However, it is recommended that efforts be made to improve the resistance of all machinery to shock.

ELECTRICAL

In view of the general structural damage and the serious hull failure, it is not deemed necessary to attempt any strengthening or stiffening of electrical machinery foundations without a general redesign of the entire Vessel.

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TECHNICAL INSPECTION REPORT

SECTION I - HULL

GENERAL SUMMARY OF HULL DAMAGE

I. Target Condition After Test.

(a) Drafts after test; list; general areas of flooding, sources.

Observed drafts and list:	Draft forward;	Aft;	List
Before Test B	11' 3''	17' 4''	0°
After Test B	16' 6''	20' 0''	5° S

The vessel was beached on the day following Test B. Prior to beaching her drafts were as indicated above. The ship flooded to the waterline, which was just below the first platform level, between bulkheads 68 and 124. In addition, both shaft alleys flooded completely through broken cooling water lines and through damaged stern tube stuffing glands. The forward machinery space (frames 68 to 83) flooded through a broken rubber flexible connection in the overboard discharge from the main condenser. The main injection and overboard discharge valves in this space had been left open as part of the test. The auxiliary machinery space flooded slowly through bulkhead 83 from the forward machinery space. The only observed leak in bulkhead 83 is an enlarged hole around a three inch pipe line. The after machinery space flooded through a tear in the port shell plating at its connection to the tank top, in way of the buckle between frames 93 and 94. There is also leakage into this space from the starboard shaft alley through the shaft gland in bulkhead 108 and through leaking sounding tubes from the inner bottom tanks below. Cargo hold No. 2 flooded from leakage around the hatches of the port and starboard shaft alley access trunks.

The vessel is considered to be stable. The list was largely due to the shifting of concrete block ballast in the forward hold.

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USS FALLON (APA81)

(b) Structural damage.

Structural damage on the FALLON is extremely severe. The ship apparently experienced a series of violent hogging and sagging movements as evidenced by buckling of shell plating and decks amidships and by shear wrinkles in plating at the quarter points. In addition, the vessel appears to have a permanent transverse curvature with the midship portion moved to starboard relative to the ends. There is also evidence of a twist in the hull such that the foremast was inclined to starboard relative to the mainmast. There is no apparent damage to the masts themselves. The principal compression failure in the lower flange of the hull girder occurred at frames 93-96. The shell plating on the port side has a pronounced vertical wrinkle between frames 93-94 which starts at about the 15 foot waterline and increases in magnitude toward the bottom of the vessel. The wrinkle is about six inches deep at the waterline and extends entirely across the bottom. The shell is torn between frames 93-94 for a length of about eight inches. It has a maximum opening of about 3/4 inch at the welded intersection of the tank top with the shell. The tank top (inner bottom) is wrinkled between frames 93-94 from the port side, inboard, at least 20 feet, and presumably entirely across the vessel. The starboard shell is also wrinkled in this area with the most pronounced buckle at frames 95-96. A second compression failure, originating in a sagging condition, is located at frame 98 on the port side. The wrinkle starts below the waterline and continues up to the main deck. The wrinkle is reflected in the main and upper decks and appears to be present in the after stack. Another compression wrinkle runs from the main deck to below the waterline at frame 125 on the port side. A pronounced pattern of shear wrinkles appears in the area of the neutral axis between frames 40 and 60 on the port side. The pattern is upward and forward. A light panel failure is present on the starboard side opposite.

In addition to these evidences of severe bending stresses, failures due to a strong underwater shock, principally affecting the bottom and port side, are present. The port shell is severely dished between the tank top and the first platform. The maximum effect extends approximately from bulkhead 68 to frame 100.

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USS FALLON (APA81)

Forward and aft of these limits, moderate dishing between frames occurs. Between bulkheads 83 and 93 in the Auxiliary Machinery Space, the entire panel is dished about six inches and all transverse stiffeners on the panel are tripped. In the Forward Machinery Space (frames 68-83), the port shell is dished about two to three inches in the same location and transverse stiffeners show evidence of high stress. A similar condition exists in the forward portion of the After Machinery Space. The starboard shell is also dished but more lightly and generally between frames. Bulkheads 68, 83, 93, 108, and associated web frames, suffered considerable distortion adjacent to the port shell. The bottom of the vessel evidently moved violently upward under the action of the underwater shock wave. This movement resulted in the crushing of all main bulkheads in the midship half length along their bases. Severe distortion generally extends up to the second platform. Centerline girders (H-sections) in the machinery spaces are badly buckled in the lower portion. The upward force was transmitted via bulkheads and stanchions to the upper levels. All web girders, bulkheads, and stanchions in the machinery spaces and forward and after holds, up to the upper deck, exhibit signs of severe working in compression. Decks and platforms are distorted and moved with accompanying damage to machinery thereon. Crushing of deckhouse sides in way of main bulkheads has been amplified by downward movement of the main structure during whipping of the ship girder.

(c) Other damage.

Severe distortion of the hull resulted in the inoperability of most machinery and electrical equipment. No actual failures of structural foundations of major machinery units were observed although shock and deflection of the foundations resulted in general shearing and elongation of holding down bolts. Piping suffered severe shock damage which rendered much equipment inoperable.

II. Forces Evidenced and Effects Noted.

(a) Heat.

There is no evidence of heat.

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USS FALLON (APA81)

(b) Fires and explosions.

There were no fires or explosions.

(c) Shock.

There is considerable evidence of underwater shock which resulted in shearing of holding-down bolts, in undogging of doors, and in damage to delicate equipment. Light bulbs were not shattered except in isolated instances. There is much evidence of violent movement of the vessel which resulted in displacement of deck and main machinery, furniture, and equipment, and in shifting of the permanent ballast.

(d) Pressure.

Dishing of the port shell and bottom resulted from the underwater pressure wave. The deformation of the shell caused distortion of frames, brackets, and bulkheads connected to the shell plating. Some evidence of air blast pressure may be seen in the slight dishing of superstructure bulkheads.

(e) Effects apparently peculiar to the atom bomb.

In addition to the phenomenon of radioactivity, the huge wave generated by the Test B detonation seriously strained the hull and dislodged equipment. Such surface disturbance have never been experienced before during underwater detonations.

III. Effects of Damage.

(a) Effect on machinery, electrical and ship control.

The ship was left without power or lighting.

(b) Effect on gunnery and fire control.

Loss of power would have inhibited fire control.

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(c) Effect on water-tight integrity and stability.

Stability was reduced considerably but the vessel is believed to have remained in a stable condition with **several feet of positive metacentric height**. Watertight integrity is reduced considerably by crushing of bulkheads, by piping failures, and by the tear in the port shell. All openings were of such size that control of flooding by active damage control was possible.

(d) Effect on personnel and habitability.

Excluding the effects of radioactivity, personnel casualties from shock and wave action would have been severe. Habitability of the ship was reduced by disarrangement of furniture and equipment and the loss of all power.

(e) Effect on fighting efficiency.

Extreme hull damage, loss of all power and lighting, and heavy personnel casualties would have severely reduced the fighting efficiency of the vessel. If at sea, all efforts would have had to be directed toward saving this badly damaged vessel and toward getting her to port.

IV. General Summary of Observers' Impressions and Conclusions.

Material damage to hull and machinery was extreme and bordered on complete destruction.

V. Preliminary General or Specific Recommendations of Inspection Group.

The performance of this vessel greatly exceeded expectations. No remedial action is indicated and it is not considered practicable to design this type of vessel to resist the high forces experienced by the FALLON.

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USS FALLON (APA81)

VI. Instructions for loading the vessel specified the following:

ITEM	LOADING
Fuel Oil	100%
Diesel Oil	100%
Ammunition	100%
Potable and reserve feed water	95%
Salt water ballast	None

Details of the actual quantities of the various items aboard are included in Report 7, Stability Inspection Report, submitted by the ship's force in accordance with "Instructions to Target Vessels for Tests and Observations by Ship's Force" issued by the Director of Ships Material. This report is available for inspection in the Bureau of Ships Crossroads Files.

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USS FALLON (APA81)

DETAILED DESCRIPTION OF HULL DAMAGE

A. General Description of Hull Damage.

(a) Overall condition of vessel.

The FALLON is seriously damaged. The hull girder has failed in compression in both the upper and lower flanges as a result of longitudinal bending. Extensive flooding has occurred in all machinery spaces and the after hold. Shock damage and flooding has rendered the ship inoperable with no light or power. Furniture and equipment have been thrown about and wrecked. The permanent ballast has been displaced. Piping and ventilation systems have failed extensively. As a result, the vessel has been rendered helpless and is in a precarious state with respect to its ability to survive in a seaway. Photos pages 2 to 38 are general views of the exterior of the ship before and after Test B. See damage diagram, page 78.

(b)§(c) The two principal areas of hull damage are the compressive failures between frames 93 and 99 which resulted from bending stresses and the panel failure of the hull plating below the waterline on the port side which resulted from the underwater pressure wave. In addition, nearly all main strength members in the mid-ship half-length show evidence of having been stressed highly with many local failures in way of discontinuities.

(d) Principal areas of flooding with sources.

The forward machinery space flooded to the waterline through a damaged rubber expansion joint in the main condenser overboard discharge. The auxiliary machinery space flooded to the waterline from the forward machinery space through damage in bulkhead 83. The after machinery space flooded through an open sounding tube, a rip in the shell plating in way of the compression failure, and through the starboard shaft gland from the starboard shaft alley. Both shaft alleys flooded through the stern tubes. The after hold flooded from the shaft alleys through the hatches.

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(e) Residual strength, buoyancy and effect of general condition of hull on operability.

The residual strength of the hull girder has been reduced approximately 50%. Flooding, although extensive, has not seriously reduced buoyancy and stability. Shifting of the concrete permanent ballast has caused a starboard list. (Photo 2197-2; page 39). The general weakened condition of the hull is such as to make any operation of the vessel hazardous.

B. Superstructure.

(a) Description of damage.

The forward deckhouse, frames 27 to 35, is generally intact except for the lookout tub on the starboard side, frame 28, which is dished on the port forward sector. This tub is fastened to the deck by four clips (Photo. 156-7; page 40).

The superstructure, midships, between holds 1 and 2, has suffered rather heavy damage especially in the interior. The structural damage to the top of the house is negligible, being limited to a weld failure at the bottom of the after stack (after port quarter) and a compression wrinkle in the deck at frame 88 (Photo. 159-4; page 41). Structural damage increases on each succeeding lower deck level.

The stacks are severely dished on all sides with the heaviest buckles in way of the Test A damage on the after port quarter. (Photo. 156-12; page 42).

On the navigation bridge level, the face of the wheel house is dished approximately 3 inches (Photos. 156-8, 2062-11; pages 43 and 44). There are slight compression waves in the deck outboard of the house, port and starboard (Photos. 163-5, 159-2, 163-4, 159-3; pages 45 to 48). Heavy buckling occurs at frames 83 to 85, port and starboard and continues across the deck between frames 86 and 88 (Photo. 163-3, 159-1; pages 49 and 50). This is the passageway between the two houses where there is the least resistance to bending. On the port side of the house (bridge level) the plating is buckled between frames 98 and 102 and between frames 86 and 95 where it continues on the 02

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level. The door at frame 92, port, is dished approximately 3 inches and is jammed (Photo. 163-2; page 51).

On the superstructure deck (02 level) the plating on the port side of the house is washboarded one to two inches for the full length with the worst condition around frame 83 (Photo. 159-6; page 52). The starboard side is only lightly washboarded. (Photos 159-1, 7; pages 50 & 53). The longitudinal bulkheads along the centerline passageway are fairly smooth except for light waves at frames 86 and 99. (Photos. 163-7, 10, 11; pages 54 to 56). The overhead deck stiffeners are slightly bent and the side brackets are buckled, port and starboard, for the length of the house (Photos. 163-6, 8, 9; pages 57 to 59). There are light compression waves in the 02 deck, most noticeably outside of the house, port and starboard.

On the upper deck (01 level) the sides of the house are lightly washboarded and bowed inboard approximately 1/4 to 1/2 inch. The deck is fairly smooth with a longitudinal hump between the house and deck edge on the starboard side between frames 80 and 100. The companionway trunks, port and starboard, at frame 64 and 85, which are located inboard of the longitudinal supporting bulkhead below, have forced the deck down approximately one inch. The trunks at frame 85 are severely buckled (Photos. 159-5, 8, 10, 12; pages 60 to 63). It is interesting to note that the sides of the deck house are severely wrinkled at the deck over the heavy transverse bulkheads, frames 68, 83, and 93. These solid spots indicate that the superstructure house is down from one to two inches relative to the upper deck.

Inside the midship deck house on the upper deck, the longitudinal bulkheads along the centerline passageway have a slight dish. Some buckling of brackets under the 02 deck at the sides is evident in the vicinity of frames 76 and 100 (Photo. 2880-3; page 64). Bulkhead 83 is lightly buckled. (Photo 2880-2; page 65). Two pipe stanchions at frame 76, centerline, are bowed two to three inches and two sounding tubes are pushed vertically through the deck about two inches (Photos. 163-12, 2880-1; pages 66 and 67). The ammunition hoist trunk near the centerline at frames 92 to 93 is severely buckled. There is some buckling of the longitudinal centerline bulkheads near frame 105 (Photos.

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2880-5, 6, 8; pages 68 to 70). There is a compression wrinkle in the deck near the centerline between the No. 2 hatch coaming and the deck house frame 109 (Photo. 2880-9; page 71).

The after deck house top is damaged only slightly. The mainmast radar screen has fallen to the house top, (Photos. 2195-10 156-3; pages 72 and 73), damaging the emergency steering station. The starboard gun tub foundation enclosure is crushed. The overhead and port bulkhead of the gear locker are moderately dished. The doors to the carpenter shop, port side of deckhouse, are blown in (Photo. 156-5; page 74). There are deep wrinkles in the longitudinal bulkheads of the fan room. (Photos. 2084-3, 4; pages 75 and 76). Sheathing around the 40 MM director tub is dished (Photo. 156-2; page 77).

Throughout the main superstructure area there is considerable dislocation of equipment and scattering of loose gear (Photos. 163-10,12, 156-5, 2880-4, 2195-12; pages 55, 66, 74, 78 and 79). In general light bulbs are intact but lockers, berths and other gear have been violently thrown about (Photo. 159-1; page 50). Many ventilation ducts have failed in the lower levels, midship. Ladders are knocked out of foot sockets. Ladder handrails are broken at the deck (Photos. 2974-2, 156-11; pages 23 and 80). All davit tracks are buckled. Davits on the starboard side are cracked along the weld at the upper deck connection.

(b) Causes of damage in each area.

The damage to the superstructure is believed to be due principally to underwater shock. This shock was vertical in direction and approached from the starboard bow. This is substantiated by the fact that the damage to structure is most severe in the lower levels where the superimposed loads are the greatest. The damage diminishes approaching the deck house top. Another contributing factor to the damage was the longitudinal bending of the hull girder causing compression wrinkles in the decks and longitudinal bulkheads through the middle body. In general, equipment was thrown to starboard. This is believed to be due to the inertia of the equipment as the ship was moved to port under the impact of the shock wave.

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(c) Evidence of fire in superstructure.

There is no evidence of fire.

(d) Estimate of relative effectiveness against heat and blast.

There is no evidence of blast or heat.

(e) Constructive criticism of superstructure design or construction, including important fittings and equipment.

Damage would have been reduced if furniture and equipment, especially ventilation, were more securely fastened to bulkheads and decks.

C. Turrets, Guns and Directors.

Not Applicable.

D. Torpedo Mounts, Depth Charge Gear.

Not Applicable.

E. Weather Deck.

(a) General condition of deck and causes of damage.

The weather deck consists of the upper deck from bow to stern and a weather passageway, port and starboard, at the main deck level between frames 59 and 123. The upper deck is in good condition forward of the forward deck house, frame 27. The deck is dished on either side of No. 1 cargo hatch a maximum of 2-1/2 inches (Photos. 2197-1 and 4; pages 81 and 82). The cover to the centerline hatch at frames 56-58 is dished severely. (Photo. 2197-6; page 83).

In way of the midship superstructure, structural damage on the main deck indicates that the upper deck has taken a general downward movement of about two to six inches. Scratch gauges located in the main

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deck passageways indicate a maximum permanent deflection of about two inches of frame 85. This movement is most evident in way of the superstructure supports. Between frames 64 and 105, all transverse and longitudinal bulkheads and all stanchions show heavy buckling. Details of these failures are described in Item G. The exposed portion of the upper deck in this area is buckled and is depressed slightly over the main deck weather passageways.

The longitudinal bulkhead forming the inboard boundary of the starboard main deck weather passageway has sharp longitudinal wrinkles at the deck, at frames 68, 76, 83, 93 and 100, with lighter waves at frames 105, 109, and 122. The same condition is generally repeated to a lesser extent in the port longitudinal bulkhead. The locations of the deformations are in way of main structural supports for the upper deck, indicating that intermediate panels and stiffeners are bowed downward and the upper deck is depressed throughout this area. (ENCLOS 2974-2, 159-11, 1712-2, pages 23, 84, and 85).

The upper deck aft of the midship superstructure is generally intact.

The deck deflections forward and over the main deck weather passageways are probably the result of loads imposed by the falling water and the wave generated by the bomb detonation. The downward movement of the upper deck under the midship superstructure is probably the result of under water shock.

(b) Usability of deck in damaged condition.

The deck is entirely usable in the damaged condition.

(c) Condition of equipment and fittings.

1. Mooring and towing fittings are largely intact.
2. Dislodgement of winches occurred. Winches are thrown to starboard relative to their foundations as the result of inertia as the ship moved to port. One winch was lost overboard. The holding

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down bolts parted (Photos 2197-1, 4, 156-9, 2197-5, pages 81, 82, 86 and 87). The port boom on the foremast has become unshipped and fallen to starboard so that it hangs over the ship's side (Photos. 2997-2, 2974-1, 2197-1, 5; pages 21, 22, 81 and 87). The forward leg of #3 Welin davit has pulled from the roller tracks, allowing the strong-back to fall (Photos. 2974-2, 159-9, 2099-3, 1784-11, pages 23, 88, 89 and 90). All roller tracks show evidence of deformation in way of the rollers. Many liferafts and other light gear have been dislodged from their stowages (Photos. 156-3, 2987-9, 10, pages 73, 91, 92). The stern ensign staff is bent to starboard (Photo 2195-11, page 93). The masts appear to be undamaged although the radar screen has fallen from the mainmast. (Photo. 156-6, page 94).

F. Exterior Hull. (above water line)

(a) Condition of exterior hull plating and causes of damage.

The stem is severely dented at approximately 5 feet below the weather deck, apparently from contact with another vessel. (Photo 2988-8, page 18). The shell plating suffered moderate wrinkling and dishing at frame 10, port, and from frames 30 to 141. At frames 92 and 98, port, a severe wrinkle extends from the sheer strake to below the waterline. (Photo. 1712-5, page 95). A similar wrinkle exists on the starboard side at frame 94. (Photo. 161-10, page 96). The wrinkles at frames 92 and 98, port, and at 94, starboard, appear to be associated. An interior examination indicates that they constitute an area of circumferential shell failure in compression.

Areas of most severe wrinkling and washboarding are, frames 30-57, 90-100, 104-110, and 130-141. These may have resulted from shearing forces due to hogging and sagging of the vessel. (Photos. 2988-6, 5, 4, 3, 2, 1, 161-2, 3, 7, 6, 4, 5, 2979-9, 1712-3, 2997-1, pages 97 to 110 and 24).

(b) Condition of exterior hull fittings and causes of damage.

Hull fittings are apparently intact.

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(c) Details of any impairment of sheer strakes.

The sheer strakes are damaged locally, apparently by tugs alongside. (Photos 2988-8, 7, pages 18 and 111). The sheer strakes in way of midship shell buckles did not have any failures as determined by visual inspections.

(d) Condition of side armor belt, if fitted externally.

There is no side armor fitted on this vessel.

G. § I. Interior Compartments (above and below waterline).

(a) Damage to structure and causes.

The interior structure appears to be undamaged forward of bulkhead 27. Bulkhead 27 shows signs of compression loading, especially on the after face. (Photo. 2527-4, page 112). In compartment A-203-A, on the first platform between frames 27 and 40, the main deck longitudinals overhead show evidence of strain. At frame 35 the port 8 inch diameter stanchion between the first platform and the main deck is slightly buckled. (Photo. 2218-10, page 113). The starboard stanchion is fractured just below the welded connection to the overhead. (Photos. 2218-11, 12, pages 114 and 115). At bulkhead 40, bracket connections to the main deck longitudinals show stress patterns in the flanges. (Photos. 2527-1, 2, pages 116 and 117). The locker and escape trunk bulkheads in the center of compartment A-203-A, frames 32 to 33, are crumpled as a result of deflection of the main deck. (Photos. 2218-12, 2527-3, pages 115 and 118).

On the second platform in S.D. Stores, A-303-A, there are indications of stress in structures supporting the first platform but to a lesser degree than on the deck above. (Photo. 2527-6, page 119). Stress marks appear in the port and starboard stanchions, frame 35. (Photos. 2527-7, 8, pages 120 and 121).

On the tank top level, compartment A-404-A, between frames 27 and 40, the structure supporting the second platform shows slight signs of loading. The shell plating is uniformly dished between stiffeners,

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port and starboard. (Photos. 2527-9, 2195-3, pages 122 and 123). The shell stiffeners between frames 35 and 40 on the starboard side show stress lines in paint on flanges at approximately mid-height of the compartment.

In No. 1 hold, frames 40 to 56, the shell frame brackets under the upper deck on the starboard side are buckled because of deflection of the upper deck. The port passageway bulkheads and stanchions, frames 40 to 56, are buckled. (Photo. 2197-7, page 124). The stanchions at frames 46 and 47 starboard, are broken away from the main deck. (Photo 2197-10, page 125). The deep column supporting the starboard hatch girder at bulkhead 40 is strained in the web. (Photo. 2196-10, page 126). The deep column supporting the starboard hatch girder at bulkhead 56 is also strained and the bulkhead wrinkled. (Photo. 2196-12, page 127). Lockers, bunks, and other gear in the hold area are disarranged. (Photos. 2197-9, 12, 2218-7, pages 128 to 130). Both the upper deck and main deck hatch pontoons have been thrown into the hold. (Photo 2218-8, page 131).

Bulkhead 40 is slightly buckled on the starboard side between the first platform and the main deck. (Photo 2195-1, page 132). The inward movement of the port shell plating has buckled bulkhead 40 below the main deck level. (Photo. 2196-11, page 133). The deep column supporting the port hatch girder at frame 40 is slightly buckled in the web. At bulkhead 56, the deep column supporting the starboard hatch longitudinal is wrinkled in the web and the main deck is deflected. (Photo 2159-2, page 134). The deep girder supporting the starboard hatch longitudinal under the first platform at bulkhead 56, is distorted. (Photo. 2195-6, page 135). Bulkhead 56 is slightly buckled. The shell plating on the starboard side is bulged inboard about two or three inches near the turn of the bilge. Similarly, the port shell plating is bulged inboard about 3/8 of an inch above the bilge. (Photos. 2195-4, 5, pages 136 and 137).

The main deck is not subdivided by watertight bulkheads between bulkhead 56 and bulkhead 108. Within this area are troop and crew's mess, galley, scullery, uptake, casings, and services in the garbage disposal room on the port side, bulkhead 56 and the longitudinal

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bulkhead aft of frame 56 are buckled from deflection of the upper deck. (Photo. 2196-1, page 138). This is at the forward end of the port weather passageway. On the starboard side, the forward bulkhead of the weather passageway frame 59, is buckled severely. (Photo. 159-11, page 84). The starboard quarter-span stanchion at frame 62 is buckled. (Photo. 2196-6, page 139). Bulkhead 68 and its stanchions are buckled severely. (Photos. 2196-2, 3, 5, 161-1, 1689-11, pages 140 to 144). The starboard longitudinal bulkhead adjacent to the weather passageway is buckled from frame 56 to frame 64. (Photos. 2196-8, 7, 9, pages 145 to 147).

Between frames 68 and 108 on the main deck, nearly all interior structural bulkheads are somewhat distorted. The principal damage to bulkheads appears to be crushing near the top, apparently as the result of movement of the hull below the upper deck level with respect to the superstructure. This movement apparently caused the deflection of the upper deck. Bulkhead 68 is bowed aft across its entire length with a maximum deflection of about eight inches on the port side. Bulkhead 83 is crushed in way of the longitudinal bulkheads of the deck house above. (Photos. 1689-10, 12, pages 148-149). The stanchion at frame 88, starboard in the galley, is bowed about eight inches. (Photo. 1789-4, page 150). The partial transverse bulkheads at frame 93 are badly buckled. The heavy girder at frame 93 is badly distorted in the web and flange near its connections to these bulkheads. (Photos. 1789-3, 2987-6, & 11, pages 151-153). The heavy longitudinal girder under the upper deck on the port side, just forward of bulkhead 108, has been highly stressed as evidenced by cracked paint on the flange.

Below the main deck, bulkhead 68 and stiffeners are bowed forward into the dry provision room. (Photo. 2195-7, page 154). On the second platform level, bulkhead 68 is heavily buckled. (Photo 2195-8, page 155).

The major structural damage in the Forward Machinery Space (frames 68 to 83) is below the upper platform level and appears to have resulted from underwater shock and sudden upward displacement of the ship as a whole. The heavy H-section centerline stanchion at frame 76 is badly worked. (Photos 4227-8, 9, pages 156 and 157). Below the lower platform the stanchion is buckled and the flanges crippled. There is

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another buckle above the upper platform. The flanges and web of the pillar are stressed at approximately one foot intervals along its entire length. The brackets connecting the starboard shell frames to the main deck transverse beams are buckled. (Photos. 4227-10, 11, pages 158-159). The port and starboard shell plating just above the tank top is dished between each frame and the frames themselves have buckled inboard. The maximum deflection is about two or three inches at about three feet above the tank top. The starboard deep web frame (frame 76) is stressed and the flange contains some small cripples near the lower bracket. The upper platform is displaced downward at least two inches. Nearly all of the supporting stanchions (I sections) are buckled.

The after bulkhead (bulkhead 83) is crushed just above the tank top near the port shell connection. Long diagonal wrinkles appear in the bulkhead further inboard, suggestive of compression loading. It is believed that this bulkhead lost some of its watertightness by distortion of stuffing boxes and packing glands. The fuel oil settling tank built onto the forward side of bulkhead 83, to starboard of the centerline, has been crumpled. (Photo. 4227-7, page 160). The damage diminishes from the tank top upward. It is possible that this tank is ruptured in way of the tank top as considerable heavy oil and sludge was present in the flooded compartment. Another source of oil leakage, not investigated, would be the sounding tube connections to the tank top.

Most of the machinery structural foundations appear to be intact. Closer investigation may reveal some misalignment. There is extensive failure of holding down bolts and most machinery and electrical items are inoperable.

Bulkhead 83 is bulged aft into the store rooms and auxiliary machinery space (frames 83 to 90), wrinkling the second platform between the bulkhead and the fresh water tanks. Bulkhead stiffeners are distorted and tilted in way of the maximum deflection, which is to starboard of the centerline. On the first platform level, bulkhead 83 is bulged aft. (Photo. 1789-7, page 161). The port stanchion at frame 88 is buckled. (Photo. 1789-8, page 162). Below the second platform level, bulkhead 83 is bulged aft with maximum deflection to starboard. The forward, port, and starboard, sides of the fresh water tank are bulged

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outboard about six to eight inches. At the connection to the tank top, the tank bulkheads are sharply crimped and the starboard forward corner is open. At the time of inspection, water was flowing from the rupture.

The port shell from frames 83 to 93 between the second platform and tank top is dished inboard about six inches as a panel and all stiffeners are tripped aft. Top and bottom brackets of the shell frames are upset and bent aft. The starboard shell in this space is only slightly dished (about two to three inches) and the stiffeners are smoothly deflected, not tripped.

Two H-section pillars on the port side between the second platform and tank top are collapsed. The tank top is not deformed generally but is locally dished under foundations..

Transverse bulkhead 93 is wrinkled on the port and starboard sides, outboard of the fresh water tanks, indicating compressive loading of the bulkhead.

The principal structural damage to the ship is most evident in the After Machinery Space (frames 93 to 108). The shell has compression buckles which increase in intensity from the main deck to the tank top. The general area of failure is between frames 93 and 99. On the port side, two principal wrinkles occur. One, between bulkhead 93 and frame 94, reaches a depth of about six inches at the tank top. At this connection, the shell plating is torn over a length of eight inches and has a maximum opening of approximately 3/4 inch. This wrinkle continues across the tank top with a depth of about three inches. It could be observed to a point about twenty feet inboard of the shell where it became obscured by the oil and water in the bilges. The second principal wrinkle, between frames 96 and 97, port, starts in the sheer strake and increases in depth to below the waterline. (Photo 4228-5, page 163). It finally blends into the panel deformation of the shell which occurs between the second platform level and the tank top. It is accompanied by a wrinkle in the first platform flat. (Photo. 4228-6, page 164). The port shell between the tank top and the first platform level is dished throughout the length of the machinery space. The dishing is most pronounced between frames 83 and 100, in which area it is accompanied by tripping of angle shell stiffeners and working of the bracketed connections between the shell stiffeners and the tank top.

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Although the starboard shell is generally wrinkled between frames 93 and 99, the most pronounced buckle is between frames 96 and 97, (photo. 4227-12, page 165). This buckle increases in intensity from the main deck to the tank top and reaches a depth of about 4 inches. A vertical scratch gage at frame 100, port, indicates a maximum deflection of 1-1/2 inches and a permanent set in the main deck of one inch. A second vertical scratch gage at frame 100, centerline, indicates a maximum deflection of 4-1/2 inches and a permanent set of 2-1/8 inches. Further evidence of movement of the main deck with respect to the tank top is seen in the damage to bulkheads 93 and 108. These bulkheads are crushed near the overhead under the principal main deck longitudinal girders. They have failure patterns over the outboard 12 feet with wrinkles extending upward and outboard on each side.

The damage to the shell and bulkheads and the deflection of the main deck have caused failure of column supports, (photos 4228-7, 3 and 8, pages 166 to 168), and distortion of the operating platforms and workshops flats. The distortion of the operating platform has been accompanied by twist of the foundations of machinery units located thereon.

The fuel oil settling tanks located between frames 104 and 108, to port of the centerline are distorted by the movement of structure (photos 4228-2, 4, pages 169 and 170).

There is little evidence of structural damage above the main deck in way of No. 2 hold (frames 108 to 124) although deflection of the upper deck has distorted joiner bulkheads in this area. (Photo 2987-8, page 171). The examination of structure in No. 2 hold below the main deck was cursory due to vapor concentrations in this area. The only visible damage is to the forward bulkhead (bulkhead 108) which contains a series of wrinkles which are from 1 to 2 inches in depth. Equipment and gear in the hold are disarranged and damaged. (Photo 142-7, page 172).

Aft of No. 2 hold, a fracture in the weld that connects the upper deck starboard longitudinal girder to transverse bulkhead 124 has occurred along the entire length of the flange connection and extends

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about 3" up into the web connection. (Photos 2083-5,11, pages 173 and 174). The port longitudinal is strained. (Photo 2083-10, page 175). At the connection of the port longitudinal girder to transverse bulkhead 135, a considerable amount of work has been performed by the girder and vertical bulkhead stiffener. (Photos 2083-6, 7, pages 176 and 177). It is apparent that relative movement of the decks applied compressive forces at this point, bending the girder over the standing flange of the vertical stiffener. Wrinkling of the panel indicates loading at the top (Photos 2083-8,9, pages 178 and 179). Directly over the girder the longitudinal bulkheads of the fan room are badly buckled at its connection to the upper deck. (Photos 2084-3,4, pages 75 and 76). This would indicate relative movement in both directions upward and downward, as it appears that no permanent deflection was recorded in the upper or main deck. The same conditions prevail to a lesser degree at the starboard girder's connection to transverse bulkhead 135. (Photos 2084-1,2, 2083-12, pages 180 to 182). Lueder's lines appear at in the webs of the port and starboard girder at the intersection with transverse bulkhead 135.

In compartment C-201-L, on the first platform between bulkheads 124 and 135, similar evidence of strain are present to a lesser degree. At bulkhead 124, the port and starboard main deck longitudinal girders are strained in the flanges. (Photos 2084-11, 2218-2, pages 183 and 184). The main deck girders are strained at their intersection with transverse bulkhead 135 but not nearly so badly as the upper deck girders at this intersection. The flanges of the port and starboard main deck girders are bowed over the vertical stiffeners and their webs compressed. (Photos 2084-5,6,7,8, pages 185 to 188).

At frame 129 between the main deck and first platform the pipe stanchion on the starboard side is considerably bowed and has failed at its connection to the first platform. (Photos 2084-9, 10, pages 189 and 190). A similar failure occurred to the port stanchion except fracture of the stanchion was at its connection to the main deck girder. (Photos 2084-12, 2218-1, pages 191 and 192).

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Below the first platform level, evidences of strain between bulkheads 124 and 135 are very slight. Stress lines are evident in the connection of the port longitudinal girder under the first platform to bulkhead 135. (Photo 2218-4, page 193). The port stanchion at frame 129 is strained slightly at its connection to the first platform girder as evidenced by cracked paint. (Photo 2218-5, page 194). The port shell plating between the first and second platforms shows a shallow deformation between bulkheads 124 and 135. This is a continuation of the panel failure most evident in the middle body in way of the machinery spaces. (Photo 2218-3, page 195).

Structural damage in the after part of the ship is slight. Bulkhead 135 is buckled moderately in way of the port and starboard upper deck longitudinals. At frame 157, in the steering gear room (first platform level), the deck beam overhead has a permanent set to port and starboard of the centerline stanchion. Paint is flaked on the web of the beam. (Photo 4206-2, page 196).

(b) Damage to joiner bulkheads and causes.

Joiner bulkheads throughout the vessel are damaged generally. The principal cause of damage is the movement of adjacent structural members. Some damage was caused by shock and from impact of furniture and equipment against the bulkheads.

Joiner bulkheads in the port passageway aft of frame 27 on the main deck are buckled as the result of deflection of the upper deck. The joiner bulkheads forming the after and starboard sides of the fire and rescue party locker are buckled at frame 35 under the longitudinal girder. (Photo 2218-9, page 197). Joiner work in way of No. 1 hold (frames 40 to 56), is damaged extensively.

Longitudinal joiner bulkheads on the port side of the main deck hold space are distorted. (Photo 2197-7, page 124). Between bulkhead 56 and bulkhead 108 on the main deck, joiner bulkheads are badly bulged and distorted due to the movement of the upper deck. (Photos 2196-2,3,5, 1689-12, 2196-4, 2880-10,12,11, 2281-1, 1789-1, pages 140, 141, 142, 149, 193 to 203). Below the main deck, joiner

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work connected to distorted structural members is damaged. (Photos 2195-7,8, 1789-7,8, pages 154, 155,161,162.)

In way of No. 2 hold, joiner bulkheads on the main deck are buckled and torn. (Photos 2987-7, 2083-4, pages 204, 205). In C-301-A, S.D. Stores on the second platform (frames 124 to 135), expanded metal bulkheads have been torn by shifting cargo. (Photo 2218-6, page 206).

(c) Details of damage to access closures and fixtures.

Watertight doors are damaged as follows:

1. Door to Canvas and Awning room, frame 17-1/2, 1st platform, is off its hinges and the upper hinge pin is missing.
2. Door into port locker, frame 25, in way of escape trunk is off the upper hinge.
3. Door, frame 19, port, on the weather deck is jammed shut.
4. The door in bulkhead 40 on the port side, main deck, is torn from its hinges and thrown aft and to port into compartment A-104-L.
5. Quick acting door to escape trunk B-205-3MT at main deck, frame 92, has been thrown from hinges. (Photo 1789-6, page 207).
6. The starboard shaft alley escape trunk door is jammed shut.

(d) Condition of equipment within compartments.

As a result of shock and violent wave action, the general condition of equipment throughout this vessel is that of dislodgement and disorder. Stowage bins and trays are down, furniture smashed, lockers displaced, berths and berth stanchions disarrayed.

Typical details of equipment damage are as follows:

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1. Sheet metal bins in S.D. Stores, A-303-A, 2nd platform, are collapsed and show signs of upward shock. (Photos 2527-7,5, pages 120 and 208). The contents are thrown as much as five feet from the original stowage.
2. Practically all dishes in the CPO mess, frame 35-40, port side, are broken.
3. Equipment in the ships service compartment, scullery, galley and bakery is in disorder. (Photos 1789-4,3, 2196-4, 2880-10, 1789-1, 2, pages 150, 151, 198, 199, 203, 209).
4. Lockers, berths, and other equipment in crews berthing and messing spaces are in disorder. (Photos 2218-10, 2197-10,9, 2218-7, 2197-8, 1689-10, 12, 2084-10,12, 2987-8, 7, 2083-2,1, pages 113, 125, 128, 130, 210, 148, 149, 190, 191, 171, 204, 211, 212).
5. On the upper deck at frame 137, starboard, CO₂ bottles and plywood stowage are disarranged. (Photo 2195-12, page 79).
6. Gear is disarranged in the carpenter shop at frame 131, upper deck. (Photo 156-5, page 74).
7. Laundry equipment is thrown to starboard. A water cooler in the laundry was badly damaged and thrown to starboard. (Photo 2987-5, page 213). Cast iron laundry tub feet remained intact.
8. In the emergency diesel generator room, a battery tray and batteries are thrown to starboard.
9. In compartment C-203-2A, frame 146, CO₂ bottles are disarranged and thrown to starboard.
10. Machinery on engine room flats is disarranged (Photo 4228-1, page 214).

(e) Fire and flooding.

There were no fires. Flooding extends from bulkhead 68 (the forward bulkhead of the forward machinery space) to bulkhead 124

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(the after bulkhead of #2 hold). In addition, the shaft alleys are flooded. The forward machinery space (frames 68 to 83) flooded to the waterline through the failure of the rubber expansion joint in the overboard discharge from the main condenser. The main injection and overboard discharge valves were open for test purposes. The auxiliary machinery space (frames 83 to 93) flooded to the waterline from both machinery spaces through leaky bulkhead shaft glands. In addition, bulkhead 83 has leaky wiring stuffing tubes and is damaged around a three inch pipe which penetrates the bulkhead. The after machinery space (frames 93 to 108) flooded to the waterline through an eight inch rip in the shell plating at frame 95, port, which has a 3/4 inch opening. The rip is at the tank top level in way of the shell compression failure. Water is also leaking into the after machinery space through the bulkhead shaft gland from the starboard shaft alley and through an open sounding tube to C-903-F. C-903-F is open to the sea. No. 2 hold (frames 108 to 124) flooded to the waterline from the shaft alley hatches which were jarred loose by underwater shock. Both shaft alleys flooded full through the stern tubes and by failure of a water lubricating line to the stern bearing.

The starboard side of A-403-A was flooded to a depth of eight inches with oil escaping from A-903-F through a leaky pipe. (Photo 2527-10, page 215). A-903-F is probably open to the sea or was put under pressure by the working of the ship.

(f) Damage in way of piping, cables, ventilation ducts, shafts, etc..

Damage to piping and shafts which contributed to flooding is discussed in sub-item (e). Technical details of piping failures are contained in the machinery report. Technical details of wiring failures are contained in the electrical report. Details of ventilation damage are discussed in Item M.

(g) Estimate of reduction in watertight subdivision, habitability, and utility of spaces.

The watertight integrity of spaces in the midship area of the vessel is decreased somewhat by small openings in bulkheads and shell plating and by piping failures. All openings are small

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enough to be plugged. Habitability of all spaces between frames 40 and 135 is reduced sharply by shock damage and flooding. The utility of all spaces is largely destroyed by damage to equipment therein.

H. Armor Decks and Miscellaneous Armor.

Not Applicable.

J. Underwater Hull.

(a) Interior inspection of the underwater hull.

An interior inspection of the port shell shows severe working of the hull. At frame 38, there is a slight vertical wrinkle about one inch deep. Between frame 40 and 60, near the neutral axis, a pronounced pattern of diagonal shear wrinkles occurs in the form of panel failures between shell frames. The pattern slants up and forward. At frame 95 a six inch wrinkle starts at approximately the 15 foot waterline. It increases in magnitude toward the bottom of the vessel and continues around the bottom. At the intersection of the shell and tank top there is an eight inch tear in the shell. The width of the opening is about 3/4 of an inch. Underwater photograph, No. S-48-6, page 216, indicates the character of the buckle near the port bilge. The starboard shell plating has a pronounced six-inch deep double wrinkle at frame 95 which is part of the same wrinkle on the port side. Underwater photograph No. S-43-10, page 217, shows this wrinkle at the waterline. The character of the wrinkle below the waterline is shown in underwater photograph No. S-47-30; page 218. The severity of the compressive failure in the lower flange of the hull girder is illustrated in underwater photograph No. S-47-31, page 219. Below the turn of the bilge, the plating has torn in way of tank C-903-F. This hole has been plugged by divers as seen in the above photograph.

In addition to the failures caused by bending stresses, the port shell has suffered a major panel deflection of the underwater body as the result of the underwater shock wave. The failure extends from approximately frame 30 to frame 140 between the first platform and the turn of the bilge. The maximum indentation is in way of the auxiliary machinery space (frames 83 to 93) and reaches a depth of about six inches.

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The starboard underwater shell plating has several minor panel failures near the quarter points which are probably due to shear stresses. The most prominent wrinkle is in the neighborhood of frame 55.

(b) Effect of damage on buoyancy, operability, maneuverability.

Extensive flooding has reduced the reserve buoyancy of the vessel considerably. Operability is considered to be seriously impaired by the major strength failures in the hull between frames 93 and 99. Maneuverability is not affected.

(c) Any known or suspected damage to:

1. Shafts and propellers.

Underwater photographs indicate that no damage occurred.

2. Struts.

No damage is suspected.

3. Rudders.

Underwater photograph No. S-46-18, page 220, shows the rudder to be intact and also shows the port propeller strut.

4. External keels.

The only known damage is to the port bilge keel as shown in underwater photograph No. S-48-8, page 221.

(d) Details of impairment of the keel structure.

The condition of the keel structure could not be inspected but the keel is believed to have failed in compression at frame 95.

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K. Tanks.

(a) Condition of tanks in areas of damage.

A leak in way of the piping just forward of bulkhead 40 on the starboard tank top has allowed fuel oil from A-903-F (inner bottom tank) to enter the S.D. Stores space just above. The oil is confined to the starboard corner between the shell and the 40mm magazine bulkhead and is a maximum of eight inches deep (photo 2257-10, page 215). C-903-F is open to the sea through a small tear in the shell. Observations of the conditions of other tanks could not be made but it is probable that several, especially in way of the structural failure at frame 93-99, are open to the sea or contaminated. Some damage may be attributable to beaching.

(b) Contamination of liquids.

Not observed.

(d) Damage to torpedo defense system.

Not Applicable.

L. Flooding.

(a) Description of major flooding areas.

The following compartments were flooded, either full or to the outside waterline:

1. Forward Machinery Space (frames 68-83).
2. Auxiliary Machinery Space (frames 83-93).
3. After Machinery Space (frames 93-108) .
4. No. 2 Hold (frames 108-124).
5. Port Shaft Alley.
6. Starboard Shaft Alley.

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(b) Sources of flooding.

The forward machinery space flooded through the failure of the rubber expansion joint on the overboard discharge from the main condenser, the valves to which were open for the test. A strap supporting the overboard discharge line failed allowing one section of the line to drop about three inches and causing the rubber joint to fail. The auxiliary machinery space flooded from both machinery spaces through damaged stuffing boxes, shaft glands, and a tear in bulkhead 83. The bulkhead was torn where a three inch pipe passed through the bulkhead. The after machinery space flooded through the port shell plating which was torn in way of a severe wrinkle, frame 95, at the welded connection to the tank top. This space was also taking water through the starboard shaft gland in bulkhead 108 and from C-903-F through the sounding tube. The shut-off valve on this tube was faulty. The after hold flooded through the shaft alley hatches. The shaft alleys flooded from the stern tubes.

(c) It is believed that flooding of all spaces was subject to damage control.

M. Ventilation.

(a) Damage to ventilation system and causes.

The damage to ventilation systems is principally due to shock. There is no evidence of blast. The shock resulted in damage to runs of duct-work due to the failure of hanger straps. Some damage resulted from impact of structure on equipment. Closures were not generally affected except where struck by solid objects. Damage to ventilation ducts occurred throughout the length of the vessel both high and low in the ship. (Photos. 163-6, 2880-3,6,4, 2218-12, 7, 2197-9, 8, 12, 2195-2, 4223-4, 2084-12, 1789-1, 9, 1689-9, pages 57, 64, 69, 78, 115, 128, 129, 130, 134, 170, 191, 203, 210, 222, 223).

(b) Evidences that ventilation systems conducted heat, blast, fire or smoke below decks.

There is no evidence of heat, blast or fire.

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(c) Evidences that ventilation system allowed progressive flooding.

None.

(d) Constructive criticism of design and construction of system.

Ventilation ducts have poor resistance to shock. The number of strap supports should be increased and the strap should be shock resistant. Investigation should be made of the possibility of carrying ducts on the deck along the foot of bulkheads instead of suspended from the overhead. If practicable, ventilation units should be more self-contained, serving a reduced number of compartments, thus eliminating long runs of ductwork.

N. Ship Control.

(a) Damage to ship control stations and causes.

The master compass pedestal on the navigating bridge level, aft of the stakes, is damaged and thrown to starboard.

On the after deckhouse top, the emergency compass and its pedestal are demolished as a result of being struck by the radar screen from the mainmast top, (photo 2195-10, page 72).

Machinery and foundations in the steering engine room appear intact. The centerline stanchion in this compartment, frame 157, appears undamaged, even though the overhead deck beam suffered a permanent downward set to port and starboard of this stanchion.

Interior communications are essentially intact but no power is available.

(b) Constructive criticism of ship control systems.

Ship control systems appear to be adequate for this class of vessel.

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O. Fire Control.

Not Applicable.

P. Ammunition Behavior.

No comment.

Q. Ammunition Handling.

No comment.

R. Strength.

(a) Permanent hog or sag.

It appears that the vessel hogged and sagged violently during the test, resulting in the compressive failure around the hull girder.

Severe compression failures have occurred amidship between frames 93 and 99. One buckle extends from above the waterline on either side down around the bottom. Another buckle extends from below the waterline to the main deck on either side. The main and upper decks are both buckled in this vicinity. The superstructure expansion joint has moved violently, resulting in damage to the deckhouse bulkhead.

The final position of the superstructure expansion joint although very near its normal position indicates a slight permanent sag in the hull. This is reasonable considering the weight of water taken aboard amidships. In the absence of a deck survey, it is not definitely established.

(b) Shear strains in hull plating.

There are definite diagonal shear wrinkles in the hull at the forward quarter point, port side, near the neutral axis.

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The wrinkles carry up and forward and are indicative of the severity of longitudinal bending stresses. Minor indications of shear stresses are also evident on the starboard side and at the after quarter point, both port and starboard.

(c) Evidence.

Transverse stresses in the hull girder have resulted in a permanent bending of the hull girder. The midship portion of the vessel is displaced to starboard relative to the two ends of the vessel. This is also borne out by the depth of compressive failures and shear wrinkles on the port side relative to those on the starboard side which indicates that the port side plating was subjected to higher compressive stresses than the starboard side plating. In addition, the hull girder is apparently twisted so that the foremast is inclined to starboard relative to the main mast. No distortion is apparent in the masts themselves.

(d) Details of any local failures in way of structural discontinuities.

There is no evidence of failure around the hatch girders. Local failures take the form of failures in or near welds in the flanges of the principal girder supports for the main port and starboard longitudinals beyond the hatches, under the upper deck. These failures were most evident in the area of frames 124 to 135. (Photos. 2218-11, 12, 2083-5, 11, 2084-9, 2218-1, pages 114, 115, 173, 174, 189, 192).

(e) Evidence of panel deflection under blast.

The port side shell plating below the waterline has suffered a major panel deflection under the pressure of the underwater shock wave. The principal area of depression extends from frame 68 to about frame 100 with the maximum dishing in way of the auxiliary machinery space. Slight dishing between frames exists forward of frame 68 and aft of frame 100.

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Machinery foundations have suffered considerably from the underwater shock. Nearly all foundations are distorted or sagged. Many holding down bolts are loosened or failed. Nearly all machinery and electrical gear is inoperable as a result.

S. Miscellaneous.

No comment.

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TECHNICAL INSPECTION REPORT

SECTION II - MACHINERY

GENERAL SUMMARY OF MACHINERY DAMAGE

I. Target Condition After Test.

(a) Drafts after test; list; general areas of flooding, sources.

All machinery spaces were flooded by water and fuel oil entering through the shaft glands, a broken connection to the forward main condenser, a ruptured fuel oil tank, and possibly other sources.

(b) Structural damage.

No comment.

(c) Other damage.

The machinery of this vessel was so severely damaged by Test B that it is believed to be beyond economical repair. Both boilers had casings ruptured, foundations failed, extensive damage to brickwork, etc.. The forced draft blower jammed. Holding down bolts of the forward main motor sheared off. Foundation bolts of both main turbines and the after main motor were loosened. All main motors and main turbines are probably out of alignment. The main condenser foundations buckled. Nearly all pumps are badly out of alignment because of foundation failures. All ship's service generators are out of alignment from foundation failures. Two cargo winches were knocked overboard. Other deck machinery was severely damaged. There is much other damage not listed here.

II. Forces Evidenced and Effects Noted.

(a) Heat.

There was no evidence of heat.

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(b) Fires and explosions.

There was no evidence of fires or explosions.

(c) Shock.

The FALLON received an underwater shock of tremendous magnitude, as evidenced by the damage listed above and numerous other examples.

(d) Pressure.

There was little, if any, evidence of pressure. The stacks were moderately dished but this may have been caused by the heavy mass of water falling on the vessel immediately after Test B.

(e) Effects apparently peculiar to the atom bomb.

An underwater shock of this magnitude is apparently peculiar to the atom bomb.

III. Effects of Damage.

(a) Effect on machinery and ship control.

The machinery plant is completely inoperable. The plant as a whole is believed to be beyond economical repair as many units appear to be unsalvageable. A few scattered auxiliaries may be operable but no power is available for them. A more complete inspection than was possible in this case would undoubtedly disclose additional damage.

(b) Effect on gunnery and fire control.

No comment.

(c) Effect on water-tight integrity and stability.

No comment.

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(d) Effect on personnel and habitability.

It is estimated that a high percentage of the crew below decks would have been casualties from the effect of the shock, and that all topside personnel would have been lost. The ship was made uninhabitable by loss of power, extensive damage, flooding, and high radioactivity.

(e) Total effect on fighting efficiency.

Fighting efficiency was completely destroyed.

IV. General Summary.

It is believed that this vessel would have been lost if she had been in the open sea at the time of the test.

V. Preliminary Recommendation.

It is doubtful whether machinery can be designed to withstand such a severe shock at such a close range. However, it is recommended that efforts be made to improve the resistance of all machinery to shock.

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DETAILED DESCRIPTION OF MACHINERY DAMAGE

A. General Description of Machinery Damage.

(a) Overall condition.

The entire engineering plant was made inoperable by damage caused by underwater shock. All engineering spaces were flooded but were dewatered immediately prior to inspection. The boilers were damaged, the foundations of heavy machinery had buckled, holding down bolts were stretched, many pipe hangers had failed allowing pipes to drop and the entire machinery spaces and all equipment were covered with a heavy coating of fuel oil (photo 4227-6, page 224).

(b) Areas of major damage.

Main and auxiliary engine rooms.

(c) Primary cause of damage in each area of major damage.

The primary cause of damage was underwater shock. Flooding was a secondary cause of damage.

(d) Effect of target test on overall operation of machinery plant.

The machinery plant was made completely inoperable as a result of shock.

NOTE: This vessel had very high radioactivity after Test B, and had been beached to prevent sinking. All machinery spaces were flooded to the water line. Salvage operations were conducted with difficulty because of high radioactivity and shallow water alongside. She was finally pumped out sufficiently to permit visual inspection. The inspection, which was as thorough as possible under the circumstances, was handicapped by the lack of lights on board, a heavy coating of fuel oil, water remaining in places such as boiler casings, and the limited time personnel could remain aboard due to high radioactivity. No power was available for testing machinery. It was not practicable to

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open any machinery for interior inspection or to take measurements for checking alignment, etc.. Numerous defects, which could not be discovered by an inspection of this nature, doubtless exist. No photographs were taken because of the danger of broken flash bulbs igniting the potentially explosive mixture of fuel oil vapor and air.

B. Boilers.

The boilers, especially the after one, had suffered from shock damage which ruptured casings, distorted foundations, and rendered them unfit for further steaming. Failure of the economizer and side casing foundations caused the side casings to buckle and may have allowed the economizer to sag. Both boilers are inoperable and would require major repairs to make them operable. The after boiler is probably beyond repair.

(a) Air casings.

Boiler casings were buckled and ruptured at joints by the relative motion between the ship's structure and the boilers.

(b) External fittings.

External fittings appeared to be undamaged except for small superheater drain lines which were sheared just below the valves due to shifting of the floor plates. Soot blowers were stuck but it could not be determined whether this was due to binding in the elements or head mechanism from the blast or if it was caused merely by the mechanisms being fouled by the oil and water.

(c) Fuel oil burner assemblies.

Fuel oil burner assemblies were not removed for a detailed inspection. A visual inspection of the oil pressure parts showed no damage.

(d) Brickwork and furnaces.

The furnaces were not examined as they contained a large quantity of oil and water at the time of the inspection, but from the

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effect of the test on the ship's structure and the boiler parts, it is believed that the brickwork is badly cracked. Plastic fire brick is probably spalled and floor bricks dislodged.

(e) Foundations.

The main foundations under the water drums were not accessible and were not observed. The economizer and side casing foundations were distorted and had failed at the vertical welds. The header foundations in the after fire room had some loose bolts and one bolt was sheared on the sliding foot. The bolts of the header foundations in the forward fireroom were stretched.

(f) Stacks and uptakes.

The outer casing of both stacks had been slightly dented during Test A and only a small amount of additional dishing was discernible after Test B. No damage to uptakes was observed.

C. Blowers.

The blowers in #2 engine room only were inspected. Blower #3 in this space turned freely by hand but its shutters could not be operated. No. 4 blower could not be operated. No. 4 blower could not be turned by hand but its shutters could be operated. Although there was no visible evidence of distortion or misalignment of these blowers, a buckle in the deck nearby is an indication that some distortion has probably occurred either to the blower foundations or to the ducts.

D. Fuel Oil Equipment.

No damage to the fuel oil system was found by visual inspection. The time available for inspection and the equipment being covered with fuel oil did not permit a comprehensive examination.

E. Boiler Feedwater Equipment.

The feedwater equipment appears to be undamaged from a visual inspection. None of the equipment was tested.

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(a) Heaters.

Not Applicable.

(b) Deaerating feed tanks.

Except for a very slight buckling of the angle support, the deaerating tanks were undamaged.

(c) Feedwater tanks.

Undamaged.

F. Main Propulsion Machinery.

No damage to the main turbines or their generators could be detected from external inspection. However, the structural foundations were buckled and bent, probably causing misalignment of the turbines.

The holding down bolts of the main motor in the forward engine room were all sheared off. The foundation bolts of the main turbines in both engine rooms were loosened. The foundation bolts of the main motor in the after engine room were loosened.

G. Reduction Gears.

Not Applicable.

H. Shafting and Bearings.

No damage to the shafting or spring bearings was found by visual inspection. However, due to the heavy shock, the shafting is believed to be misaligned.

(a) Shafting.

Apparently undamaged.

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(b) Bearing and bearing foundations.

Apparently undamaged.

(c) Alignment.

Impossible to check visually, but the shafting is believed to be out of alignment.

(d) Stern tubes, bulkhead packing glands, etc..

The stern tubes were not inspected because of flooding of the shaft alleys. The packing gland of the starboard shaft in the after bulkhead (after engine room) was leaking.

I. Lubrication System.

Apparently undamaged except as noted below.

(a) Coolers.

Apparently undamaged.

(b) Filters and strainers.

Apparently undamaged.

(c) Purifiers.

The bowl and drive shaft were misaligned. This was apparently caused by shock. No parts were broken.

J. Condensers and Air Ejectors.

The main and the auxiliary condensers in the engine rooms are apparently undamaged. However, the foundations were buckled and this undoubtedly has caused misalignment of the generators connected to the auxiliary condensers, and probably leaks in the condensers.

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(a) Water boxes.

The main condenser water boxes were apparently undamaged. The injection head of the auxiliary condenser in the auxiliary machinery room was broken off above the flanged connection.

(b) Shell and shell connections.

The shell and shell connections were apparently undamaged except as noted above, however, it is believed many of the shell connections are in a leaky condition due to the magnitude of shock sustained by them.

(c) Expansion joints.

The rubber expansion joint of #1 main condenser overboard discharge line failed due to displacement of the line when its hanger carried away. This failure flooded #1 engine room as the main injection and overboard valves were open during the test.

(d) Air ejectors.

Apparently undamaged.

(e) Interior and after condensers.

Apparently undamaged.

(f) Miscellaneous valve fittings.

Valves and fittings were apparently undamaged. All structural foundations of main and auxiliary condensers were buckled and bent. It is believed that none of the condensers are now operable. There are probably interior leaks in all condensers.

K. Pumps.

The damage to pumps was consistent with damage to the other equipment on this vessel, being practically universal and severe. All machinery compartments had been flooded, hence all pumps were made inoperable.

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Without consideration of flooding, pumps were severely damaged. All reciprocating pumps observed, including main feed pumps, auxiliary feed pumps, ballast and bilge pumps, fire and flushing pumps were thrown out of alignment to such an extent that they could not be operated. Holding down bolts are loose or broken and mounting lugs and feet, which could not be observed due to the heavy coating of fuel oil which had been deposited over the entire machinery space and all equipment are doubtless broken.

Centrifugal pumps fared little better. Main and auxiliary circulating pumps, condensate pumps, distilling plant pumps and fresh water pumps, while not apparently badly damaged as units, are inoperable due to the practically universal failure of their foundations. Vertical pumps are in most cases askew and horizontal pumps are no longer horizontal but have been pushed to many odd angles due to distortion of foundations.

The comments below are indicative of the damage sustained and do not include all damage to pumps, but rather specific damage to some observed units.

(a) Feed pumps.

The reciprocating main and auxiliary feed pumps had been twisted out of alignment and are inoperable. The structural plate to which the steam end was secured had buckled and bolts either sheared or twisted.

(b) Circulating pumps.

No. 1 main circulating pump has a broken mounting foot on the driving turbine. No. 2 main circulating pump was flooded and was not observed. The auxiliary circulating pumps are apparently undamaged except by flooding.

(c) Condensate pumps.

Steam driven condensate pump #2 has a broken governor valve on the turbine. This valve casting is integral with the turbine casing and is of steel. Further damage to condensate pumps was not observed, due to flooding and oil covering.

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(d) Fire pumps.

Reciprocating pumps. Damage is similar to that incurred by reciprocating feed pumps.

(e) Lube oil pumps.

The lube oil pumps are apparently undamaged.

(f) Fuel oil pumps.

The motor driven fuel oil service pumps are apparently undamaged except from flooding. The small horizontal reciprocating standby pumps are apparently undamaged.

L. Auxilliary Generators. (Turbines and Gears).

The auxilliary generators (turbines and gears) on #1 #2 and #3 units are apparently undamaged, although these units are probably misaligned from the failure of the supporting foundations. All three units have been flooded with salt water and fuel oil, thus making them inoperable.

(a) Foundations.

The foundations of all three units show buckling and are badly deformed. This causes stretching of bolts. All foundation bolts are loose. One foundation bolt is missing from #1 generator foundation.

(b) Turbines (or engines).

The turbines are apparently undamaged. This distorted condition of foundations indicates probable misalignment between turbines and reduction gears. None of this machinery has been turned over.

(c) Gears.

The reduction gears are apparently undamaged, although there may be misalignment due to foundation failure. No fractures were noted on visual inspection.

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(d) Coolers.

Apparently undamaged, from visual inspection.

(e) Governors.

All cantilever hydraulic governor mechanisms are apparently undamaged. Overspeed trips were worked by hand.

(f) Valves and fittings.

Apparently undamaged. All plastic thermometers stood the shock very well. No. 1 auxiliary generator set is apparently undamaged. From exterior visual observation, but the heavy coating of fuel oil may hide some defects. There is evidence of movement of the unit as foundation bolts are loose and one bolt missing. This unit was not turned over. The foundation supporting this unit is badly deformed. This allowed the bed plate of the unit to move down and to starboard slightly. This may have caused misalignment of the turbine and reduction gears. No. 2 auxiliary generator set is apparently undamaged, although its foundation is badly deformed and all bed plate holding down bolts are loose. This unit's dynamo condenser suffered damage (see Item "j") which makes it inoperable. No. 3 auxiliary generator set was apparently undamaged. The bed plate is apparently undamaged. All the holding down bolts between bed plate and foundation are loose. The foundation is buckled and shows signs of upward movement having occurred.

M. Propellers.

Not observed.

N. Distilling Plant.

There was general displacement of the units. Apparently all of the gages are inoperable as evidenced by the position of the pointers. Piping attached to the plant was noted to have moved. No broken parts were noted, however, it is believed that pipes are leaky and that all the pumps belonging to the plant are inoperable.

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O. Refrigeration Plant.

The refrigeration compressors had been subjected to severe shock and are covered with oil which precluded close examination of the mounting lugs. These are doubtless broken as the material is cast iron. The motor of #2 compressor had been torn from its foundation and thrown against the compressor.

P. Winches, Windlasses, and Capstans.

There is considerable damage to the forward and after cargo winches as noted below. The anchor windlasses and capstans appear to be undamaged.

(a) Foundations and bed plates.

The forward starboard outboard cargo winch and the after starboard outboard cargo winch are completely missing from the vessel. The foundation bolts had been sheared, probably from shock, and the winches probably carried away with the roll of the vessel. (photos 1692-8, 11, pages 225 and 226).

The forward port outboard cargo winch foundation bolts were sheared and the winch is off its foundation and resting against the forward deck house (photo 1692-9, page 227).

The inboard foundation bolts on both forward inboard cargo winches were sheared (photo 1692-10, page 228).

(b) Boat davits.

No 3 davit. The forward davit head was knocked out off the trackway and is hanging over the side, supported only by the outboard rollers and the strongback. (photo 2099-2, page 229).

No. 1 davit. This davit shows evidence of shock as both trackways in way of the trackway rollers are bulged upward to the contour of the rollers (photo 2099-3, 4, pages 89 and 230).

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Q. Steering Engine.

There is no apparent damage to this engine. The spare parts boxes were thrown about and damaged.

The after steering stand had been damaged as a result of falling gear.

(a) Miscellaneous (steering stands, gages etc.).

The after deck house steering stand was damaged by falling objects (photo 1692-12, page 231).

R. Elevators, Ammunition Hoists, etc..

Elevators - not applicable.

Forward and after ammunition hoists were not observed due to compartment's being inaccessible. The amidships ammunition hoist has no apparent damage.

S. Ventilation (Machinery).

Ventilation blowers on the following compartments were inspected, found intact, and apparently undamaged.

Fan Room	H-0102-E	3 blowers
Compartment	E-0113-3	2 blowers
Compartment	A-104-L	1 blower
Compartment	C-106-I	4 blowers
Compartment	C-0113-3	3 blowers

T. Compressed Air Plant.

The compressor is intact and apparently undamaged with the exception of loose holding down bolts.

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U. Diesels (Generators and Boats).

The diesel engine of the emergency generator is apparently undamaged. The exhaust piping and supply lines are intact but the battery tray has been jammed from its rack. Battery casings are cracked and the acid spilled. The tray rests partly on the diesel engine and partly on its rack.

(a) Foundations.

There is no apparent damage to the foundations, although the after holding down bolt on the starboard side is loose.

V. Piping Systems.

The main steam piping appears to be undamaged except as noted below. It was not tested.

(a) Forward engine room.

Failure of spring hanger rods caused the steam manifold at the boiler, a section of steam line to the 100 Kw D.C. generator and the after section of the crossover line from the after engine room to drop 3 to 4 inches. Damage may exist under the pipe insulation at the boiler manifold, however, the remainder of the lines in this space appear to be intact.

(b) After engine room.

Failure of spring hanger rods caused a long section of the crossover line from the forward engine room and a section of line to the turbo-generator to drop about 6 inches. In view of the long length of unsupported line, it is possible that leaks may exist in flange joints.

NOTE: The failure of spring hangers in practically all cases occurred in the rods below the spring assembly. These rods failed in tension. Some hangers failed at their connection to ship's structure. The constant tension spring hanger failed at their connection to ship's structure. The constant tension spring hanger in the after engine room is still intact whereas the rod broke below the spring assembly of the similar hanger in the forward engine room.

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(c) Auxiliary steam.

Except for failure of four strap hangers, the auxiliary steam lines appear to be undamaged. None of the piping was tested.

(d) Auxiliary exhaust.

The auxiliary exhaust lines appear to be undamaged. These were not tested.

(e) Condensate and feedwater.

From a visual inspection, the condensate and feed piping appears to be undamaged. It was not tested.

(f) Fuel oil.

The fuel oil piping appears to be undamaged. None of it was tested.

(g) Valves.

In the after engine room the sounding rod valve of tank C-003F was either inadvertently left open or the hand lever snapped over to the open position due to shock. This valve is a quick opening gate valve and can be flipped open very easily. Due to the flooded condition of the tank and the open position of the valve, water gushed into the engine room. This leakage, combined with the leak through the shaft gland of #1 shaft and a hole in the shell plating, caused flooding of the engine room.

(h) Lubricating oil.

The lubricating oil piping appears to be undamaged. The lines were not tested.

(i) Fire main and sprinkling.

Due to the limited time available for inspection, only the fire main in the engine rooms was observed. Except for a broken off strap hanger the lines in these spaces appear to be intact. They were not tested.

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(j) Condenser circulating water.

The circulating water piping appears to be undamaged except as noted below. None of the piping was tested.

The cast injection nozzle on the head of #2 auxiliary condenser was fractured as a result of the condenser foundation failure. Flooding from the sea through the ruptured nozzle did not occur since the sea valves were closed during the test.

The rubber expansion joint in #1 main condenser overboard line failed at the fillet of the outboard flange. Failure of the strap hanger outboard of the joint permitted the line to drop 3 to 4 inches. Dropping of the line is believed to be the cause of the rubber joint failure. Since the sea valves of the condenser were open during the test, flooding of the engine room occurred through the damaged joint.

(k) Drain main.

The drain main piping appears to be undamaged. It was not tested.

(l) Hydraulic.

The hydraulic lines appear to be undamaged. They were not tested.

(m) Gasoline.

Not observed.

(n) Fresh water.

The piping of this system appears to be intact except as noted below. It was not tested.

All piping attached to the hot water heater was badly crushed as a result of the heater coming adrift from its foundation.

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(c) Distilling plant.

The piping appears to be intact except as noted below. It was not tested.

All of the piping attached to the pumps were bent and twisted due to failure of the pump foundations.

NOTE: It should be noted that both engine rooms were flooded as a result of the test and were pumped out a few hours prior to the inspection. All pipe lines below the upper grating were heavily coated with oil. This, together with lack of adequate ship's lighting and time for inspection permitted only limited observation.

W. Miscellaneous.

Some foundation bolts of the gasoline hoist bulkhead mounted had sheared and the machinery dropped about 1/2-inch. (photo 2099-5, page 232).

(a) Laundry.

There was no apparent damage found on visual inspection of the laundry machinery. The refrigerated drinking fountain in the laundry is badly damaged in that all casings are distorted and the compressor was thrown out of alignment with its motor. This damage is secondary and was apparently caused by a desk which had been hurled against the fountain.

(b) Bakery.

The bread mixer was jarred loose from its holding down clips and was twisted on its base. The outboard end had moved forward approximately 3-inches, the inboard end was displaced about 3 inches aft. The failure was in the welded clips.

The bake oven oil burners were jarred loose and are adrift. Oven doors are broken off and the racks in the oven are distorted.

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(c) Galley.

All steam kettles were jarred from their bases and are held only by the steam and drain lines. The pressure cooker was thrown to the deck and the steam and drain lines to it are ruptured.

The ice cream freezer is badly damaged. The agitator and freezing cylinder was torn loose from its base and is on the deck. The freezing system is badly out of order in that the condenser is adrift and the compressor jarred from its foundation.

The cold box is badly damaged. The evaporator coil is adrift and several lines inside the box are ruptured. All shelves and trays are out of place and badly warped.

The galley ranges are badly damaged in that the cast tops were broken and all brick lining was shaken out of position. Oven doors are distorted and will not close. The oil burners were jarred out of place and the lines ruptured.

(d) Machine shop equipment.

The machine shop is practically a total wreck. The lathe is broken at the foundation, has been overturned and is beyond repair. The platen of the milling machine had been thrown upward on its vertical ways and had struck the milling cutter with sufficient force to bend the arbor into an arch. As the platen fell the foundation (cast iron) was broken. The work bench had been overturned. The drill press had broken at the foundation, overturned, and is beyond repair. The motor driven grinder is the only piece of machine shop equipment that escaped damage. The machine shop is above the area of flooding.

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TECHNICAL INSPECTION REPORT

SECTION III - ELECTRICAL

GENERAL SUMMARY OF ELECTRICAL DAMAGE

I. Target Condition After Test.

- (a) Drafts after test; list; general areas of flooding, sources.

Drafts and list were not noted.

Both engine rooms, the auxiliary machinery space, were flooded, other flooding was not noted.

- (b) Structural damage.

Structural damage was not noted in detail, but was general throughout the vessel. Much machinery shifted, with possible damage to foundations. Numerous bulkheads, vent ducts and other light sheet metal installations were distorted, with resultant damage to electrical installations mounted thereon.

- (c) Damage to electrical systems.

Damage to the ship's electrical equipment was due to flooding, to shock and to collapse of supporting structure. Both main motors had shifted on foundations. The after main generator the after main engine control board and numerous auxiliaries had also shifted. All machines and switchboards in the three machinery spaces were flooded with both water and fuel oil. Some local wiring was broken or pulled from boxes by collapsing supporting structure. Shock caused a general dislodging of heavy electrical equipment in the superstructure spaces.

II. Forces Evidenced and Effects Noted.

- (a) Heat.

There was no evidence of heat on the vessel.

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(b) Fires and explosions.

There were no fires or explosions on the vessel.

(c) Shock.

Shock caused great damage throughout the vessel. Much machinery, auxiliary machinery, and heavy pieces of electrical equipment was displaced from foundations by shock. The emergency diesel generator although not damaged in itself, was put out of action by the dislodging and breakage of the diesel starting batteries.

(d) Pressure.

No pressure effects were found in any electrical equipment.

(e) Effects apparently peculiar to the atom bomb.

No effects peculiar to the atom bomb were found on any electrical system.

III. Effects of Damage.

(a) Effect on propulsion and ship control.

The shifting of the forward and after main motors, the after main generator and the after main control board would have disabled the vessel even if no flooding had occurred. Flooding of the machinery spaces put all main machinery and auxiliaries out of commission.

(b) Effect on gunnery and fire control.

The loss of all electrical power would have put the guns on manual operation.

(c) Effect on watertight integrity and stability.

The failures in the electrical system had no effect on the watertight integrity and the stability.

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(d) Effect on personnel and habitability.

The loss of all electrical power would cause failure of ventilation, some galley equipment, water pumps and lighting with the corresponding loss of habitability. Electrical failures would not have affected personnel directly.

(e) Total effect on fighting efficiency.

The disabling of both main propulsion generators and motors by movement on the foundations would have reduced mobility and fighting efficiency to zero.

IV. General Summary of Observers Impressions and Conclusions.

The total fighting effectiveness of the vessel would have been lost. Casualties would have been high.

Almost all failures of electrical equipment were due to failure of supports or foundations, few to inherent weakness of the equipment. The failure of the main motors and other large electrical machines, by shifting on the foundations, is comparable in importance with the buckling that occurred in the hull; and the general damage with attendant high personnel casualties through the superstructure and weather spaces.

V. Recommendations.

In view of the general structural damage and the serious hull failure, it is not deemed necessary to attempt any strengthening or stiffening of electrical machinery foundations without a general re-design of the entire vessel.

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DETAILED DESCRIPTION OF ELECTRICAL DAMAGE

A. General Description of Electrical Damage.

(a) Overall condition.

All engine room and auxiliary engine room equipment was flooded by salt water and fuel oil. Equipment in spaces above the flooded area was in general disarray, having been broken loose from its foundations and mountings.

(b) Areas of major damage.

Damage was general throughout the vessel with engineering spaces suffering the most; due to the added damage of flooding.

(c) Primary causes of damage in each area of major damage.

Damage in engineering spaces was caused by underwater shock and flooding.

Damage to main deck and superstructure was caused by underwater shock and tons of salt water falling on the ship.

(d) Operability of electrical plant.

Plant was inoperable after test.

(e) Type of equipment most affected.

Type of equipment most affected was main propulsion and ship's service generators, main propulsion motors, master gyro compass, and storage batteries.

B. Electrical Propulsion Rotating Equipment.

1. Forward main motor - all holding down bolts missing, bearing cap bolts loose, and motor appears to be out of line with main shafting.

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2. Two outboard holding down bolts on after main motor are stretched. All others are loose.

3. Forward and after main generators - all holding down bolts are loose. Foundation for after main generator appears to be out of alignment.

4. No damage was observed to brush rigging or windings of any main propulsion motor or generator.

5. All machines were flooded out by fuel oil and water.

6. In view of the general damage of electrical and other equipment throughout the vessel and to the hull itself, it is believed that the design of the main propulsion machinery is comparable to other electrical equipment and the vessel in general. Therefore, no change in design is recommended.

C. Electric Propulsion Control Equipment.

1. From visual inspection it appears that the forward switchboard was operable. Minor damage noted was a broken handle on the main set up switch and the shaft revolution indicator was loose in its case.

2. The after main switchboard was inoperable due to warping of the board when the board foundation moved out of position. Approximately 50% of the arc chutes were found on the deck having been thrown clear of their contactors.

3. Both switchboards were submerged in salt water and fuel oil.

4. The box frame mounting of the main propulsion switchboard is considered to be of satisfactory design. In view of the number of arc chutes which were displaced on this vessel and on other vessels of the same class, it is believed that a change in the method of securing arc chutes would be desirable. No part of the shields or mountings failed during the test, but the shock dislodged the shields as by normal removal for servicing.

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D. Ship's Service Generators.

1. One holding down bolt missing on forward ship's service generator; all remaining holding down bolts on all generators were found to be loose.

2. Foundation on after generator appears to be out of alignment. All ship's service generators were flooded with salt water and fuel oil.

3. Ship's service generators are considered to be in the same class of design and to have the same ruggedness as the main propulsion machinery.

E. Emergency Generators.

There is no visible damage to the emergency generating plant. Plant was inoperable due to loss of diesel engine starting batteries.

F. Switchboards and Distribution Panels.

1. The forward ship's service switchboard shows no visible damage except from salt water and fuel oil flooding. The after ship's service board moved forward and distorted a small amount but not enough to short circuit any bussing or to make the switching inoperative. The afterboard was flooded with water and fuel oil.

2. There was no damage observed in any other switchboards or distribution panels.

G. Wiring, Wiring Equipment and Wireways.

1. The only damage observed in any wiring or wireways was due to failure of supporting bulkheads and structures.

2. Reference the following photographs: 1791-7, page 234; 1791-6, page 258; 1791-8, page 245; 1692-9, page 227; 1692-11, page 226; 1791-3, page 243; 1791-6, page 258; 4206-1, page 248; 4206-3, page 233; 4206-6, page 237.

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H. Transformers.

1. Only one transformer was observed to be out of place. It is not known whether there was any damage other than being displaced from its mounting. This transformer was bulkhead mounted in the pilot house. Ref. photograph 4206-3, page 233.

2. Considering the amount of damage in this area, it is not surprising that this transformer was displaced, but it is believed that the mounting design was adequate in comparison with other equipment in the same space. No recommendations are made.

I. Submarine Pre-elling Batteries.

Does not apply to this vessel.

J. Portable Batteries.

1. Portable batteries in the following spaces were thrown from their normal stowage by shock. Gyro compass batteries; diesel starting batteries; radio supply batteries, with resulting damage of broken cases, spilled acid, cracked covers and complete destruction of cells in some batteries. Ref. photographs 2979-6, page 253; 1791-1, page 252; 4206-1, page 248.

2. No special securing methods were used on any of these battery stowages.

3. It is believed that if the portable storage batteries on this vessel had been secured in their normal stowage space by the latest approved design of securing bars, the damage to batteries would have been nil, or very minor at the most. It is recommended that all present and future portable battery installations be properly secured.

K. Motors, Motor Generator Sets and Motor Controllers.

1. The following motor derangements were noted:
Anchor windlass motor shows evidence of slight movement on foundation.

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2. Holding down bolts on the ice machine motor located in the forward engine room were sheared off allowing motor to be displaced.

3. Hot water pump in forward engine room was crushed by falling hot water tank.

4. All arc chutes were missing from the anchor windlass control panel.

5. The controller panel on the port after cargo winch had one contactor holding coil displaced due to the breaking of the securing bolt. Ref. photographs 1791-4, page 257; 1791-5, page 249; 1791-10, page 241.

6. It is recommended that some form of retaining clip or strap be placed on motors, not to increase the strength of the holding down bolts, but to prevent the motor from becoming a missile hazard after the holding down bolts fail.

L. Lighting Equipment.

The only observed damage to lighting equipment consisted of broken lamps and displacement of fixtures on distorted bulkheads and decks.

M. Searchlights.

The port 24" signal searchlight sustained a broken dome glass. (There was no close-up inspection of 24" searchlights. All observations were made from the signal bridge due to high radioactivity in the area).

N. Degaussing Equipment.

Not observed.

O. Gyro Compass Equipment.

1. The master gyro compass was thrown downward

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with such violence that the element tore loose from the suspension springs and was smashed on impact with the bottom of the binnacle. Photograph numbers 2979-4, page 254; 2979-5, page 253, shows this damage.

2. The bearing repeater compass on the port wing of the navigation bridge was forced from its gimbal ring by shock. Reference photograph 1791-3, page 243.

3. The present design of gyro compasses will not survive shocks such as many target ships received in test B, without damage ranging from minor to complete destruction. It appears that the total vertical and horizontal movement of the ship is far too fast for the sensitive element to follow with the present coil spring mounting might be an improvement over the present design.

The binnacle-ring and binnacle ring bearings in gyro bearing repeaters should be re-designed to prevent them from being disassembled by shock.

P. Sound Powered Telephones.

Not observed.

Q. Ship's Service Telephones.

This item does not apply to the vessel.

R. Announcing Systems.

1. A few reproducers were dislodged from the mountings by falling bulkheads. Amplifiers were intact and from visual inspection appear to be operable, although the door for the amplifier rack was distorted.

2. No recommendations for change of design are made in this report. The mounting design of the 1MC amplifier appears to be satisfactory as it was located in the same compartment with the master gyro compass. Ref. Item O of this report.

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S. Telegraphs.

1. Engine order telegraphs in both engine rooms sheared their mounting bolts. Instrument appears to be operable.

2. It is recommended that engine order telegraphs be mounted with approved shock mounting.

T. Indicating Systems.

1. The hinged panels of both engine room salinity indicators unlatched allowing the instrument to fall downward with probable damage to the meters.

2. It is recommended that the present panel latches be replaced with positive fasteners.

U. L. C. and A. C. O. Switchboards.

1. All boards are intact and appear to be undamaged and operable.

2. No recommendations are made in this report. The present design appears to be adequate.

V. F. C. Switchboards.

This item does not apply to the vessel.

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APPENDIX

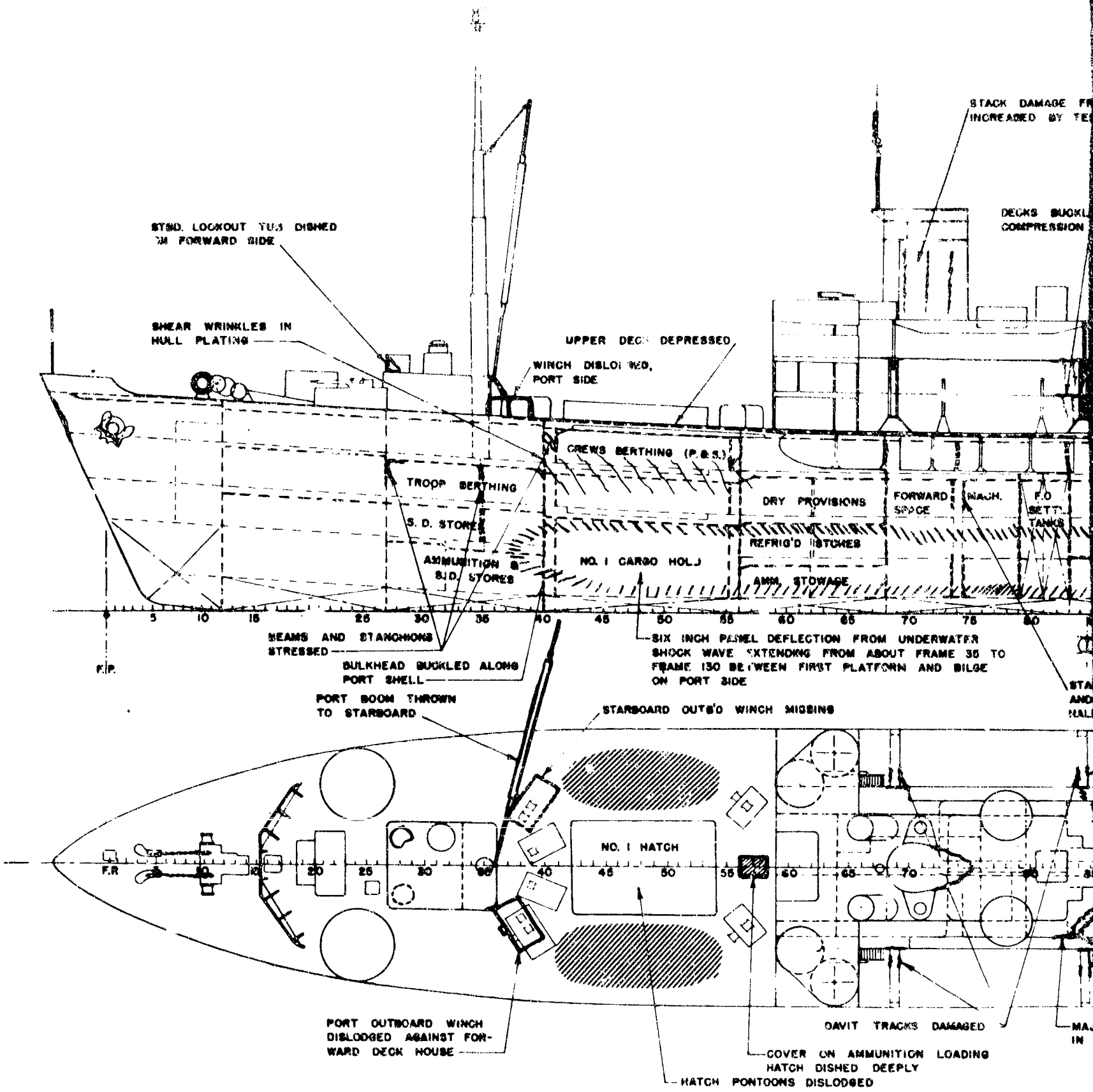
SHIP FLOODING DIAGRAM

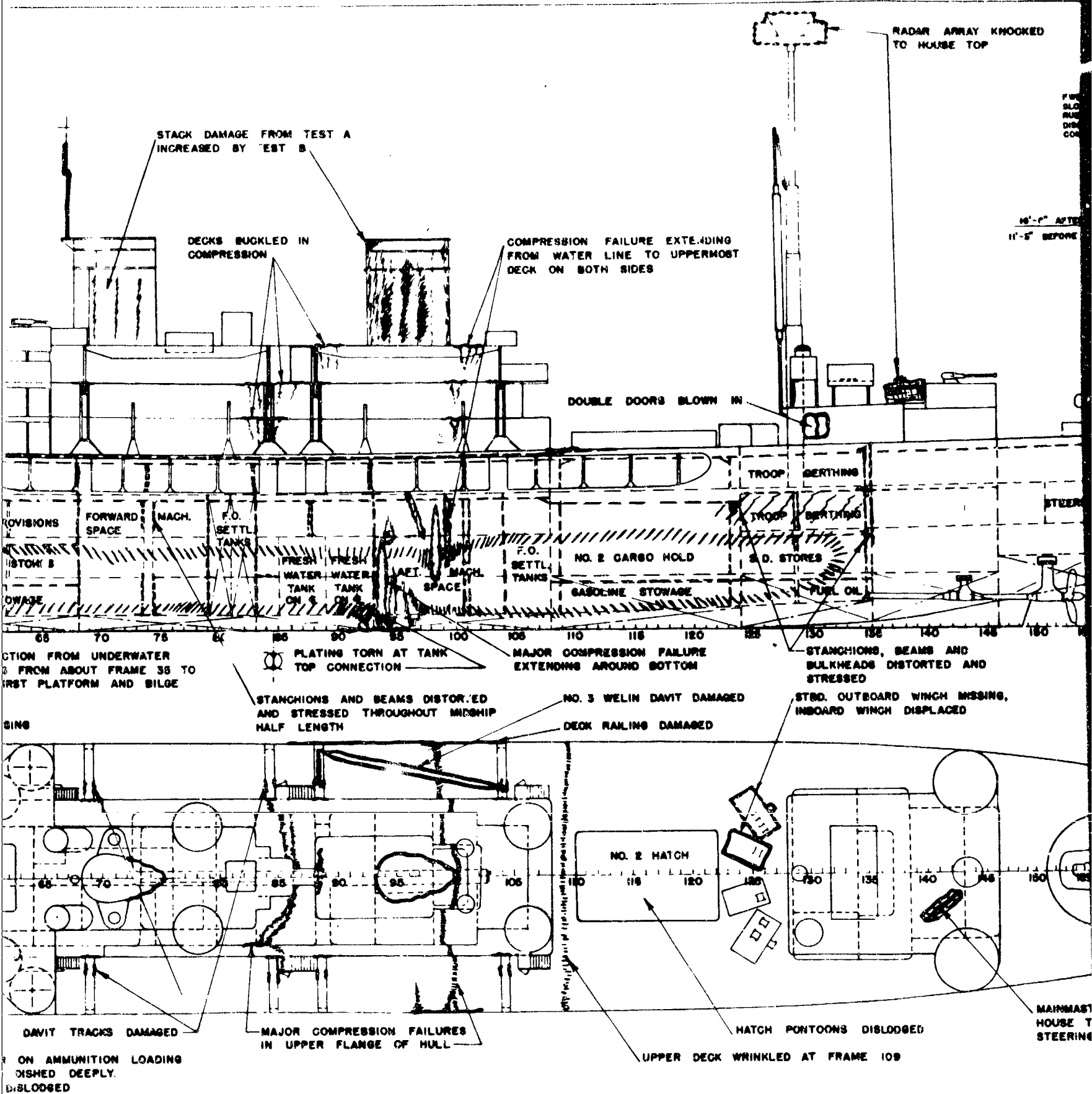
TEST BAKER

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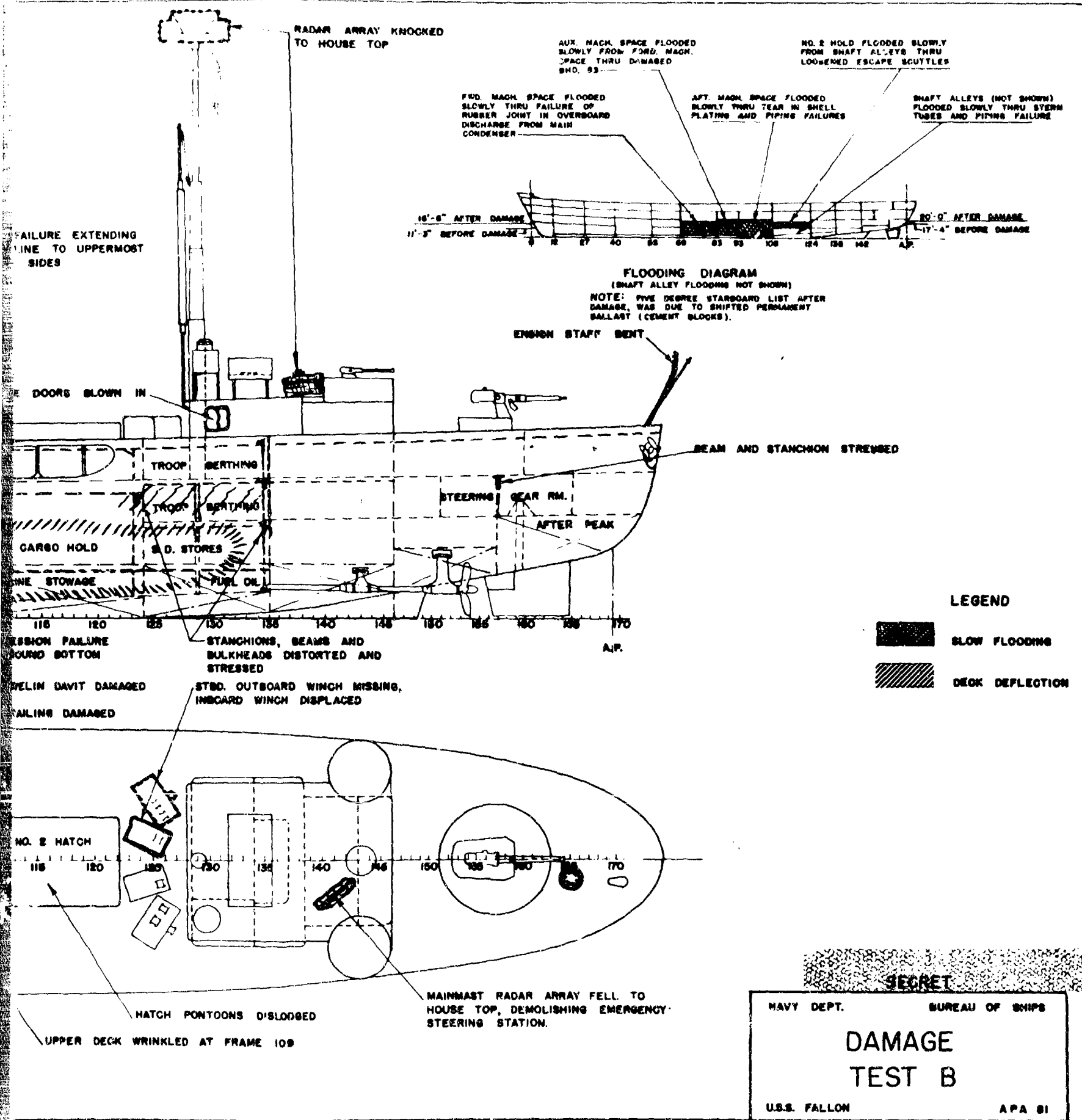
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2



FLOODING DIAGRAM
 (SHAFT ALLEY FLOODING NOT SHOWN)
 NOTE: FIVE DEGREE STARBOARD LIST AFTER DAMAGE, WAS DUE TO SHIFTED PERMANENT BALLAST (CEMENT BLOCKS).

LEGEND
 [Solid black box] SLOW FLOODING
 [Hatched box] DECK DEFLECTION

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NAVY DEPT. BUREAU OF SHIPS
DAMAGE TEST B
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Defense Special Weapons Agency
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Alexandria, Virginia 22310-3398

TRC

18 April 1997

MEMORANDUM FOR DEFENSE TECHNICAL INFORMATION CENTER
ATTENTION: OMI/Mr. William Bush (Security)

SUBJECT: Declassification of Reports

The Defense Special Weapons Agency has reviewed and declassified the following reports:

AD-367489 XRD-133-Volume 1
U.S.S. Gasconade (APA 85), Test Baker, Volume 1, Operation Crossroads, Bureau of Ships Group, Technical Inspection Report, Director of Ship Material, Joint Task Force Once. Approved by F. X. Forest, Captain, U.S.N., 77 pages.

AD-367486 XRD-130-Volume 1
U.S.S. Fallon (APA81), Test Baker, Volume 1, Operation Crossroads, Bureau of Ships AGroup, Technical Inspection Report, Director of Ship Material, Joint Task Force One. Approved by F. X. Forest, Captain, U.S.N., 78 pages.

AD-377466 XRD-213
Director of Ship Material, Joint Task Force One, Operation Crossroads, Gross Damage Report, Test Able, dated 6 July 1946.

The DTIC accession number was not available. This office is not sure if DTIC was on distribution for the cited reports.

However, the reports are now **approved for public release; distribution statement "A"** now applies.

Arldith Jarrett
ARDITH JARRETT
Chief, Technical Resource Center