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AD366699

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DSWA ltr., 4 Apr 97; DSWA ltr., 4 Apr 97

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9 BUREAU OF SHIPS GROUP TECHNICAL INSPECTION REPORT.

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6 OPERATION CROSSROADS.

SPECIAL REPORTS ON HULL ITEMS [U].

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TECHNICAL INSPECTION REPORT

SPECIAL REPORTS ON HULL ITEMS

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INTRODUCTION

The "Special Reports on Hull Items" contained in this volume are as follows:

1. Submarine Salvage Fittings.

2. Study of Flooding Sources.

3. Turret Structure.

4. Study of Fire and Paint.

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TECHNICAL INSPECTION REPORT

SUBMARINE SALVAGE FITTINGS

RESTRICTED DATA

ATOMIC ENERGY ACT - 1946

SPECIFIC RESTRICTED DATA CLEARANCE [illegible]

USE MILITARY CLASSIFICATION [illegible]

BY:

H. A. Arnold,
Commander, U.S.N.

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SUBMARINE SALVAGE FITTINGS

SECTION I - TESTS ABLE AND BAKER

1. Submarine salvage operations conducted at Bikini after test B disclosed a serious weakness in design of salvage fittings. Damage to the superstructure of the sunken submarines rendered the salvage fittings useless and hindered rather than aided the operation of raising the vessels.

2. On the PILOTFISH, APOGON and SKIPJACK, the underwater shot had displaced the main deck in certain locations by an amount varying from 1/2 inch to about 3 inches. This resulted in preventing access to the reach rod or tail pipe, air leaks at the tank top, and/or jamming of the valve operating reach rod. In salvaging the PILOTFISH, none of the connections could be used as found. As a preliminary step, it was necessary to cut away the main deck around each fitting, a time consuming job at a depth of 170 feet. The same situation existed for about 40% of the salvage connections of the APOGON and SKIPJACK.

3. A similar condition was found on the SKATE after test A as a result of severe damage to the main deck and superstructure caused by air blast. Six main ballast tanks were found flooded. One of these, No. 7 main ballast, flooded because the after capstan head was blown over into the main vent valve. The remainder flooded as a result of distorted and leaky tank salvage valves which permitted the tanks to vent. In each case, the tail pipe cap had been torn off or the tail pipe and valve had been damaged below the cap. In addition to these leaking fittings, every other salvage fitting on the ship, both compartment and tank, was distorted to the extent that it is questionable whether any one could have been used for the purpose intended.

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SUBMARINE SALVAGE FITTINGS

SECTION II - RECOMMENDATIONS

1. By suitable redesign it might be possible to make salvage fittings more rugged, eliminate their present juxtaposition to the main deck and give them a certain degree of protection. For the tanks, as an example, it is possible that the valves might be moved outboard of the superstructure and recessed into the tank top, thus eliminating the need for an extension rod and a long vulnerable tail pipe as well as protecting the valve. However, such a proposition has disadvantages and does not appear at all tenable for compartment salvage fittings.

2. In lieu of redesign it is proposed that salvage fittings for tanks and compartments be eliminated. In the past war it was common practice to blank off salvage fittings. In any future war they would introduce a hazard as was shown by the SKATE damage. Under conditions of atomic attack and with the present design of salvage fittings, it is not difficult to imagine a situation in which an end compartment is flooded and all the adjacent tank salvage valves are either blown off or leaking to such an extent that the ballast tanks could not be blown, thus resulting in an up-ended submarine. This is perhaps the extreme case, but damage of this nature to a much lesser degree could be serious, especially in enemy controlled water.

3. In times of peace, when a submarine has been sunk by non-violent means, the present salvage valves have functioned satisfactorily. However, in the last ten years there have been only two submarines salvaged, the SQUALUS (SS192) and LANCETFISH (SS296). (This does not include the SKIPJACK which was participating in a special test in which the possibility of sinking was so great that special fittings installed prior to the test might have been justified). Considering the cost of manufacturing, installing and maintaining each fitting, the relative ease with which a diver can burn holes in the tanks in which to insert a blow fitting, and the structural weaknesses introduced by the fittings, continued installation of salvage connections does not appear justified. It is therefor recommended that salvage fittings be eliminated on all submarines.

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SECTION II - RECOMMENDATIONS

4. It is emphasized that the above discussion is concerned only with the salvage of submarines. The rescue of personnel from sunken submarines is an entirely separate issue and one on which vigorous effort should be expended to develop suitable rescue apparatus to function at depths to which modern submarines will operate.

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TECHNICAL INSPECTION REPORT

STUDY OF FLOODING SOURCES

BY:

J. B. Shirley,
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STUDY OF FLOODING SOURCES

SECTION I - GENERAL

1. The importance of maintaining the highest standard of watertight integrity has been stressed many times. These atomic tests again showed the damage that can result from minor sources of flooding or leakage. Many ships had serious damage as a result of progressive flooding. Progressive flooding not only decreases the residual stability and hence its safeness and utility as a fighting vessel but also increases the damage to equipment and to the habitability or utility of compartments. Due to progressive flooding, what might have been a problem of slight repair or adjustment became a major problem of equipment overhaul and of cleaning the ship or resulted in loss of the ship.

2. Progressive flooding is permitted by many seemingly small leaks that when added together permit serious flooding. On the assumption that air tests of typical sections of the capital ships would give an average representation of their watertight condition, these vessels were tested at the bow, amidships, stern and the quarter points. The destroyers were completely air tested or visually inspected. The transports, LST's, and the LCI (L)'s were visually inspected and had chalk tests made on pertinent doors and hatches. Where leaks were found remedial action was taken whenever feasible.

3. The representative tests on the capital ships revealed the following information with respect to the watertightness. The spaces were tested in accordance with the ships air test schedule. Excellentcompartments were those having less than the allowable pressure drop. Passable compartments were those within the allowable pressure drops. Unsatisfactory compartments had pressure drops exceeding the allowable limit.

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STUDY OF FLOODING SOURCES

Ship	Percentage results of tests on compartments: excellent	passable	unsatis-factory	Total number compts. tested
Arkansas	15.7	8.6	75.7	70
New York	5.1	13.6	81.3	59
Nevada	41.6	25.8	32.6	89
Pennsylvania	62.3	3.3	34.4	61
Saratoga	25.8	18.6	55.6	97
Independence	58.5	38.4	3.1	65
Pensacola	19.2	38.5	42.3	52
Salt Lake City	8.0	34.0	58.0	50
Prinz Eugen	17.4	13.0	69.6	23
Average	28.2%	21.5%	50.3%	

4. All the destroyers were similar in that all had very good conditions with respect to the number of compartments having a Passable or Excellent rating. Representative ships had the following conditions:

Ship	Compartments Pass. or Exc.	Compartments Unsatisfactory
Ralph Talbot	51	3
Rhind	63	4
Mustin	52	4
Wainwright	50	9

5. As representative figures, the capital ship tests showed that approximately one-half of the compartments would easily permit progressive flooding varying from a free to a limited flow and that approximately one-fourth would permit from a limited to a light flow. However, several pertinent factors must be remembered. The majority of the tested spaces are at or below the waterline. Spaces above those tested are not watertight or

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airtight and require only visual inspections. In addition, those compartments which were passable or excellent usually required a considerable period of time, which included checking and tightening of closures, to reach the desired condition. Closing-off one compartment to a passable condition might require anything from a few minutes to several hours in comparison with the few minutes allowed under actual operating conditions. As an indicator, the figures represent a higher degree of watertightness than actually exists. Similarly, the figures on the destroyers represent a higher quality of watertightness than actually exists.

6. The following tabulation of the types of leakage that occurred on the capital ships shows the average frequency of occurence and can be used as a rough guide for other ships. The percentages for each group will vary with the type of vessel, its age, its past service and maintenance, and the training of personnel in damage control procedure of closing watertight fixtures.

(a) 30% caused by leakage through bulkheads or decks resulting from bolt or screw holes, imcomplete or poor welding along seams, or opened riveted seams.

(b) 20% caused by poorly fitting or warped doors, hatches, or ammunition hoist covers.

(c) 20% caused by non-tight electric cable stuffing tubes.

(d) 10% caused by ventilation systems through pierced ducts and leaky valves or fittings.

(e) 4% caused by leakage through stuffing boxes on dogs of hatches and doors.

(f) 4% caused by leaky rivets.

(g) 3% caused by leakage into piping systems.

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(h) 2% caused by leaky valves or deck fittings such as sounding tube caps or deck drains.

(i) 2% caused by leaky reach rod stuffing boxes.

(j) 2% caused by leaky bolted closure plates.

(k) 2% caused by leaky wiring junction boxes and out through wiring cables.

(l) 1% caused by design failure to install closure or fitting to isolate a compartment.

7. The flooding that occurred on the ships that remained afloat after the atomic tests has been compiled in Figures 1, 2, and 3. For this report, the sources of flooding have been divided into primary and secondary sources with sub headings that generally show whether the source is or is not a direct result of the test A. A primary source is defined as a source for initial entry of water into the hull or for initial escape of oil or water from a compartment or piping system which was intact prior to the test. A secondary source is defined as a source which permits progressive flooding of additional spaces after an initial source occurs. All sources are summarized in the total column without regard as to whether they are primary or secondary sources in order to form a comparative tabulation of all sources.

8. No attempt has been made to evaluate the seriousness or intensity of flooding as a result of any source or the number of spaces flooded as a result of any source. Since the majority of flooding even ships with a significant number of spaces flooded, occurred as a result of small leaks that accumulated over a considerable period of time, it is felt that roughly each source could be given an equal value with respect to the flooding rate and still would give a fairly accurate indication of the seriousness and intensity of the flooding. Therefore each source has been summarized in two ways. The upper figure in each block indicates the number of ships of that class which had flooding as a result of

that undivided source. The lower figure indicates the number of times that the source occurred in that class of ship. The lower figure then roughly indicates the seriousness of flooding that occurred. For example in test B, Item 10:

		PRIMARY			SECONDARY			TOTAL	
ITEM	SOURCE	CAPITAL SHIPS	TOTAL	%		TOTAL	%	SOURCE & FREQ.	%
10	BROKEN PIPE LINES TO INTERNAL SYSTEMS	1 2	2 3	2.0 1.4	1 1	3 16	6.0 8.2	5 19	3.3 4.6

9. Broken pipe lines to internal systems as a primary source of flooding occurred on one capital ship two times and on a total of two ships three times. 2.0% of the primary sources were broken pipe lines to internal systems and primary flooding through this type of source roughly permitted 1.4% of the primary flooding. In addition the same type of leakage permitted secondary or progressive flooding on one capital ship one time and on a total of three ships sixteen times. As a secondary source of flooding broken pipe lines to internal systems were 6.0% of the secondary sources and roughly permitted 8.2% of the secondary flooding. As a recapitulation broken pipe lines to internal systems occurred on five of the target vessels, nineteen times. 3.3% of the total sources were broken pipe lines to internal systems which permitted roughly 4.6% of the total flooding.

STUDY OF FLOODING SOURCES

SECTION II - TEST ABLE

A. General.

1. Ships in test A had very little flooding as a direct result of the test. The principal primary sources of flooding were opened shell seams, leaky sea valves, and broken pipe line.

2. The only secondary sources were open pipe lines on the NAGATO. Normal and excessive leakage occurred in rudder trunks, stern tubes, and in engineering spaces. However, the flooding was not serious on any ship. All flooding except for the opened shell seams on the SALT LAKE CITY, NEVADA, and ARDC 13 could have been stopped or handled in routine pumping of bilges. The opened shell seams on the SALT LAKE CITY and the NEVADA would only have required isolation of the tanks. The flooded tanks would not seriously impair the strength or stability of the ships. The cracks in the concrete hull of the ARDC 13 could have been controlled after a few hours by ships force.

B. Discussion of Figure 1, page 2-20.

1. 71.6% of the target ships had no flooding as a direct result of the test. However, many of the ships had water enter by normal leakage through stern tubes, rudder trunks, and leaky piping connections.

2. Opened shell seams flooded one fuel oil tank on the SALT LAKE CITY, four voids on the NEVADA, and the main machinery space on the beached LCT 812. The concrete ARD C 13 had a crack in the hull that permitted flooding by two spaces. 13.3% of the total sources permitted 19.5% of the total flooding.

3. The PENSACOLA had one magazine partially flooded from an adjacent fuel oil tank through opened seams. 3.3% of the total sources permitted 2.4% of the total flooding.

STUDY OF FLOODING SOURCES

4. A broken fresh water line on the PRINZ EUGEN partially flooded a passageway. 3.3% of the total sources permitted 2.4% of the total flooding.

5. Open pipe lines allowed secondary flooding which partially flooded the NAGATO engine rooms and by back flow in a common gravity drain line partially flooded one magazine on the ARKANSAS. These four lines were the only sources of progressive flooding in test A. 6.7% of the total sources permitted 9.8% of the total flooding.

6. The LCI (L) 327 had normal leakage by seepage through the hull and piping connections in the engineering space. Five of the LCT's, LCVP's, and LCM's similarly had engineering spaces with flooded bilges. Normally in the small craft most of the leakage came through the stern tubes. 20.0% of the sources permitted 14.7% of the flooding.

7. Open or leaky sea valves permitted flooding of three fuel oil tanks on the NAGATO. Failure of scupper valves permitted backflow in plumbing drain lines on the GENEVA. 6.7% of the total sources permitted 12.2% of the total flooding.

8. The starboard stern tube normal leakage on the INDEPENDENCE permitted partial flooding of the shaft alley. One stern tube of an LCT had no packing in the stern tube prior to the test. The engine room was flooded through this source. 6.7% of the total sources permitted 4.9% of the total flooding.

9. The stern tubes partially flooded three shaft alleys on the NAGATO, contributed to the foundering of the LCM 1, and partially flooded the engine room of the LCM 4. This leakage was greater than normal and on the NAGATO probably was caused by propulsion shaft vibration loosening the packing. 10.0% of the total sources permitted 12.2% of the total flooding.

10. Rudder trunk normal leakage on the SALT LAKE CITY flooded the rudder trunk void,*on the PENNSYLVANIA partially flooded the Tiller Room, and on the LCI (L) 620 partially flooded the after steering space. 10.0% of the total sources permitted 7.3% of the total flooding.

11. Rudder trunk excessive leakage as a result of the test partially flooded the ARKANSAS steering engine room and overflowed contributing to further flooding. The rudder void on the RALPH TALBOT was partially flooded by over normal leakage. This increased leakage was probably caused by vibration of the rudder shaft loosening the packing. 6.7% of the total sources permitted 4.9% of the total flooding.

12. The LCM 1 took water on board through her ramp either from waves or due to pitching as a result of the test. 3.3% of the total sources permitted 2.4% of the total flooding.

13. On three of the small craft flooding from unknown sources occurred. The sources were most probably hull leaks from previous beaching operations. 10.0% of the total sources permitted 7.3% of the total flooding.

14. The LCM 1 was found in a semi submerged condition. This vessel had leaking stern tubes. Water taken on board through the ramp and the stern tubes contributed to her foundering. 1.1% of the target ships capsized.

C. Submarines.

1. The submarines in test A had only one, the SKATE, with any flooding. Six main ballast tanks were flooded. The SKATE was beached to prevent any possibility of her loss.

STUDY OF FLOODING SOURCES

SECTION III - TEST BAKER

A. General.

1. Ships in test B had serious amounts of flooding primarily in engineering spaces and compartments in the after body. Except on the HUGHES and the LST 133 negligible flooding occurred in the forward part of the ships. This may be attributable to two factors, first, the few shell openings and second, the vibration of the stern when underway loosening structure. The flooding was seriously aggravated by the fact that no personnel were on board for a considerable period of time after the test. This allowed minor leakage to accumulate and thus result in serious flooding. Only on a few ships would flooding have been serious if damage control parties had been able to function immediately or within a few hours. The principal primary sources of flooding were opened shell seams, broken piping, rudder trunks, stern tubes, and cargo hatches. The secondary sources were broken or open pipe lines, loosened doors and hatches, bulkhead fittings such as shaft glands or stuffing tubes, and holes in the decks or bulkheads.

2. Flooding on all ships, except six through opened shell seams or holes, could have been brought under control by damage control parties within a very short time. The flooding on the NEW YORK and the PENNSYLVANIA could have been isolated in a few voids and after trimming tanks. The flooding on the NEVADA added very little weight to the ship since the opened tanks had been ballasted to about 90% capacity but was serious in that it opened many fuel oil tanks to the sea. These tanks were in poor condition prior to the test with slight leakage between tanks. The SALT LAKE CITY had one fuel tank opened to the sea. This tank could have been isolated. The FALLON had tears in the shell plating. The opened tank could have been isolated and the hole in the after machinery space temporarily plugged. The ARDC 13 concrete hull had been cracked in test A. This vessel later capsized due to progressive flooding of the port side pontoons. Damage control parties could have kept her afloat.

3. Leakage of water into the ships after test B is a serious radiological problem. What would be considered normal leakage becomes a potential health hazard. Normal leakage in engineering spaces and through stern tubes and rudder trunks occurred on approximately one-third of the ships.

STUDY OF FLOODING SOURCES

B. Discussion of Figures 2 and 3, pages 2-21 and 2-22.

1. 38 of the target ships had no flooding as a direct result of the test. However, many of these ships had normal leakage of radioactive water into the hull.

2. Normal leakage through stern tubes resulting in partial flooding of the shaft alleys occurred on the PENNSYLVANIA on two shafts and on the INDEPENDENCE on one shaft. Two destroyers, the WAINWRIGHT and MUGFORD, and four transports, the BANNER, BRACKEN, BUTTE, and CATRON, had leakage through all stern tubes. 7.8% of the primary sources permitted 7.2% of the primary flooding. 5.3% of the total sources permitted 3.9% of the total flooding.

3. Stern tube excessive leakage contributing to the flooding of other spaces occurred on one shaft of the PENNSYLVANIA, MUSTIN, and MAYRANT, and on all shafts of the HUGHES, BRULE, FALLON, GASCONADE, LST 133, and five small craft. 13.6% of the primary sources permitted 10.0% of the primary flooding. 9.3% of the total sources permitted 5.4% of the total flooding.

4. Rudder trunk normal leakage occurred on the PRINZ EUGEN and the SALT LAKE CITY where the steering gear voids flooded with a negligible overflow. Similarly the LCI (L)'s 615 and 620 had minor leakage into the steering gear compartment. 3.9% of the primary sources permitted 1.8% of the primary flooding. 2.7% of the total sources permitted 10% of the total flooding.

5. Rudder trunk excessive leakage contributing to the flooding of other spaces occurred on the NEW YORK, PENNSYLVANIA, and NEVADA. The LCT 1113 had the steering gear compartment flooded. 3.9% of the primary sources permitted 1.8% of the primary flooding. 2.7% of the total sources permitted 1.0% of the total flooding.

6. Opened shell seams and holes occurred on six ships as a result of the test and on one ship after she was beached. The NEW YORK had 12 voids, ~~fuel oil tanks, or trimming~~ tanks flooded. The

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PENNSYLVANIA had 7 tanks and voids in way of the torpedo patch flooded. The NEVADA had 21 fuel oil tanks flooded. The SALT LAKE CITY had one fuel oil tank flooded. The HUGHES had shell openings which occurred after the test that flooded two spaces and contributed to further flooding while the ship was beached. On the FALLON a fuel oil tank and the after machinery space were flooded through holes in the shell. ARDC 13 had cracks in the concrete underwater body that resulted in the ship capsizing. 4.9% of the primary sources permitted 19.4% of the primary flooding. 3.3% of the total sources permitted 10.5% of the total flooding excluding the flooding on the ARDC 13.

7. Opened internal boundaries occurred on the HUGHES after the beaching operation and caused flooding of one space. On the PENSACOLA one fuel oil tank bulkhead had rivets sheared permitting drainage of the tank into the shaft alley. The GASCONADE had inner bottom tank tops slightly opened permitting oil to escape from a fuel oil tank into the after machinery space. Secondary flooding rom opened internal boundaries occurred on the NEW YORK, SALT LAKE CITY, and the PENSACOLA as a result of the test. On the NEW YORK a steering foundation pad tore the deck permitting flooding from the after trimming tank. On the SALT LAKE CITY one inner bottom fuel oil tank flooded from the after engine room. On the PENSACOLA 5 inner bottom fuel oil tanks had opened seams into the after engine room. On the FALLON the auxiliary machinery space flooded from the forward machinery space through a torn bulkhead. 1.9% of the primary sources permitted 0.9% of the primary flooding. 6.2% of the secondary sources permitted 6.8% of the secondary flooding. 3.3% of the total sources permitted 3.6% of the total flooding.

8. Secondary leakage resulting in partial flooding through previously non-watertight boundary connections such as seams or joints occurred on the NEW YORK in 3 of the 5" magazines and on the PENNSYLVANIA in one magazine and two other spaces. 6.2% of the secondary sources permitted 6.3% of the secondary flooding. 2.0% of the total sources permitted 2.9% of the total flooding.

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STUDY OF FLOODING SOURCES

9. Broken pipe lines to sea connections, many of which were 1'' diameter or smaller permitted flooding on 10 ships. The NEVADA had the port engine room bilges flooded from a cracked flange in the condenser overboard discharge and one compartment partially flooded from a split overboard discharge line. The SALT LAKE CITY had the after engine room flooded through a broken salt water line nipple and corroded plug. Her forward engine room had minor leakage through a four inch crack in number 1 main injection. The PENSACOLA had a shaft alley flooded through a broken 2'' salt water line. The MUSTIN had the forward fireroom and the after engine room flooded from broken 1/2'' sea chest blow out lines. Her forward engine room had leakage from the main condenser cooling system. The HUGHES had the after engine room flooded through 4 leaks in broken 3/4'' or small piping which were, a sea chest steaming out connection, a vent line on the condenser, a pump relief valve, and a lub oil cooler drain line. The forward engine room had leakage through a cracked lub oil cooler discharge line, two broken sea chest blow out connections, and a overboard discharge valve. The MAYRANT had the forward engine room flooded from a broken 3/8'' salt water recirculating line and the after engine room from a broken 3/4'' cooling line. The BRULE and CATRON had their forward machinery spaces and the GASCONADE had the after machinery space flooded from small broken salt water lines. The FALLON had the forward machinery space flooded from a damaged rubber expansion joint in the main condenser overboard discharge and the shaft alley flooded from a broken stern tube water lubricating line. 9.7% of the primary sources permitted 10.8% of the primary flooding. 6.6% of the total sources permitted 5.8% of the total flooding.

10. Broken pipe lines to internal systems permitted primary flooding on the SALT LAKE CITY of the after gyro room from a ruptured fire main riser and of the after fire room from a ruptured ballasting line. On the FALLON one forward space was partially flooded with oil that escaped from a leaky pipe. Secondary leakage also occurred. The NEW YORK had leakage from the after trimming tank through a ruptured drain line. The HUGHES had the emergency diesel room flooded from the forward fire room

through a broken 3/4" day tank drain line. The after engine room had leakage through a ruptured main condenser and out through a broken fresh water gage glass. One magazine flooded through two broken 3/4" pipes in the overhead. The LST 133 had many manifolds and piping cracked throughout the ship and especially in the engine room and ballast control room. 1.9% of the primary sources permitted 1.4% of the primary flooding. 6.2% of the secondary sources permitted 8.4% of the secondary flooding. 3.3% of the total sources permitted 4.6% of the total flooding.

11. Secondary leakage through open piping systems occurred on five ships. On the NEW YORK backflow in the after gravity drain line flooded 3 of the 14" magazines. On the NEVADA a similar system flooded the H.P. air compressor room, a storage compartment, and an access trunk. On the SALT LAKE CITY in the after fire room and after engine room, open funnel drain lines and sounding tubes permitted flooding of 7 fuel oil tanks. On the HUGHES the emergency diesel room partially flooded through an open 2" pipe connection from the forward fire room. On the FALLON the after machinery space had leakage through an open sounding tube from a fuel oil tank that had been opened to the sea. 10.4% of the secondary sources permitted 11.0% of the secondary flooding. 3.3% of the total flooding permitted 5.1% of the total flooding.

12. A sea valve that had been left closed but was found in an open condition permitted flooding of a tank on the PRINZ EUGEN. 1.0% of the primary sources permitted 0.5% of the primary flooding. 0.7% of the total sources permitted 0.2% of the total flooding.

13. Sea valves in the SALT LAKE CITY engine rooms and the MAYRANT's main condenser flapper valve and overboard gate valve had increased leakage as a result of the test around valve stems and packing. 1.9% of the primary sources permitted 1.8% of the primary flooding. 1.3% of the total sources permitted 1.0% of the total flooding.

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14. Petcock sounding valves on the MAYRANT jarred open and permitted primary flooding from 3 fresh water tanks into the after engine room. Secondary flooding on the LST 133 through open valves in the ballast lines and a check valve permitted water to distribute throughout the ship. 1.0% of the primary sources permitted 1.4% of the primary flooding. 2.1% of the secondary sources permitted 2.1% of the secondary flooding. 1.3% of the total sources permitted 1.7% of the total flooding.

15. Normal leakage in engineering spaces such as engine rooms, fire rooms, underwater sound rooms or emergency diesel rooms due to leaky valve stems, pipe connections, leaky gaskets, and structural seams occurred on 26 ships. The following ships had such leakage varying from a few inches to 3 feet in depth, the INDEPENDENCE in 8 spaces, PRINZ EUGEN in 3 spaces, PENSACOLA in 1 space, MAYRANT in 1 space, WILSON in 4 spaces, RHIND in 2 spaces, TRIPPE in 5 spaces, RALPH TALBOT in 4 spaces, BANNER in 3 spaces, BRAKEN in 1 space, BRISCOE in 2 spaces, BUTTE in 1 space, GASCONADE in 2 spaces, LST 52 in 2 spaces, LST 661 in 1 space, LCI (L) 332 in 1 space, LCI (L) 615 in 1 space, LCI (L) 327 in 1 space and the LCI (L) 329 in 1 space. 25.2% of the primary sources permitted 23.5% of the primary sources permitted 23.5% of the primary flooding. 17.2% of the total sources permitted 12.6% of the total flooding.

16. Secondary leakage occurred through main propulsion shaft glands whenever the water reached the height of the bulkhead penetration on the PENNSYLVANIA, SALT LAKE CITY, PENSACOLA, MUSTIN, MAYRANT, CATRON, FALLON, GASCONADE, and the LST 133. 18.8% of the secondary sources permitted 15.2% of the secondary flooding. 5.9% of the total sources permitted 7.0% of the total flooding.

17. Secondary leakage through leaky hatches that primarily had had the dogs jarred loose but also through open hatches occurred in 10 ships. On the NEW YORK water leaked downward through non-tight hatch to partially flood a storeroom. On the PENSACOLA water flooded the ice machinery room with overflow from a shaft

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alley through a non tight hatch. On the HUGHES hatches permitted water to enter 9 spaces. On the FALLON the after cargo space flooded from the shaft alleys through hatches that had been jarred loose. On the LST 133 one space was partially flooded through an open hatch. The LCT 812 engine room flooded through an open hatch. The LCT 1187 had one void flooded through a loose manhole cover. The LCM 1 had the engine room and one void and the LCM (B) had the engine room and one compartment flooded through open hatches. 18.8% of the secondary sources permitted10.5% of the secondary flooding. 5.9% of the total sources permitted 4.9% of the total flooding.

18. Secondary leakage through leaky doors that primarily had had the dogs loosened occurred on 4 ships. The NEW YORK had 15 compartments and the PENNSYLVANIA had 11 compartments with flooding through loosened doors. The HUGHES had 11 compartments flooded through doorways either directly as a result of the test or after beaching. The LST 133 had water enter from the tank deck through an open door. 8.3% of the secondary sources permitted 19.9% of the secondary flooding. 2.7% of the total sources permitted 9.2% of the total flooding.

19. Electrical stuffing tubes in decks and bulkheads which had not been plugged after removal of wiring or which had non watertight packing contributed to secondary flooding on 5 ships, the NEW YORK in 2 spaces, the PENSACOLA in 1 space, the HUGHES in 4 spaces, the MAYRANT in 1 space, and the FALLON in 1 space. 10.4% of the secondary sources permitted 4.7% of the secondary flooding. 3.3% of the total sources permitted 2.2% of the total flooding.

20. Secondary leakage through bulkhead and deck fittings such as reach rod stuffing boxes and especially the steering rod glands occurred in 12 spaces on the NEW YORK and 12 spaces on the NEVADA. 4.2% of the secondary sources permitted 12.5% of the secondary flooding. 1.3% of the total sources permitted 5.8% of the total flooding.

21. Unplugged bolt and screw holes in decks and bulkheads permitted secondary flooding on the NEW YORK in 1 space and on the PENNSYLVANIA in 2 spaces. 4.2% of the secondary sources permitted 1.6% of the secondary flooding. 1.3% of the total sources permitted 0.7% of the total flooding.

22. Entry of water from the wave, water column, or steam cloud as primary flooding occurred, on the HUGHES where water entered through previously damaged main deck doors to flood 3 compartments, on the DAWSON where water entered through the forward cargo hatch and the smokestack, on the FALLON where it entered topside structure and cargo hatches, and on both the LST 52 and LST 133 where it entered the cargo hatches. The LCM (B) and the LCVP's 7, 8, 11 and 12 which were beached on Binini Island had water in the bilges which came from the wave that reached the island. 9.7% of the primary sources permitted 5.9% of the primary flooding. 6.6% of the total sources permitted 3.2% of the total flooding.

23. The MAYRANT had 2 spaces partially flooded with water that came through ventilation systems in the superstructure. Numerous ships had water enter through ventilation ducts during the decontamination washing of the ships. This occurred after fittings were jarred loose or previously damaged. In addition the high pressure hose was directed upward from the ship and hitting directly or splashing into cowls. 1.0% of the primary sources permitted 0.9% of the primary flooding. 0.7% of the total sources permitted 0.5% of the total flooding.

24. Leakage came through No. 1 gun mount on the HUGHES to partially flood 1 compartment. 1.0% of the primary sources permitted 0.5% of the primary flooding. 0.7% of the total sources permitted 0.2% of the total flooding.

25. Unknown primary sources of flooding occurred on the NEW YORK in 1 space, on the PENSACOLA in 2 spaces, on the LST 125 in the engine room, and on the LCI (L) 620 in 2 spaces. Unknown sources on 8 small craft were presumably previous beaching

damage or stern tube leakage. An unknown secondary source of leakage on the HUGHES existed between the forward fire room and the forward engine room. On the LST 125 overflow from the engineering space partially flooded the vehicle deck. 11.6% of the primary source permitted 12.2% of the primary flooding. 4.2% of the secondary sources permitted 1.0% of the secondary flooding. 9.3% of the total of sources permitted 7.0% of the total flooding.

26. The ARDC 13 had leakage through shell cracks that eventually caused her to capsize. The LCT 1114 was capsized. She had no visible evidence of damage to the bottom or the shell plating.

C. Submarines.

1. The submarines in test B had two, the PARCHE and the SKATE, with no flooding. The PILOTFISH sank due to undetermined flooding sources which were probably tears in the hull plating. In the other submarines the determinable sources of flooding were leaky valves, blow lines from main ballast tanks, and periscope stuffing box, a hull crack, and possibly 2 hatches.

D. Progressive flooding.

1. Progressive flooding in test B was permitted by approximately one-third of the sources and accounted for approximately one-half of the flooding. Approximately 43.7% of the secondary sources directly attributable to the test such as broken piping, open boundaries, loosened doors, and unknowns permitted approximately 46.6% of the secondary flooding. Approximately 31.3% of the secondary flooding sources that personnel could have prevented such as open pipe lines, open valves, and propulsion shaft glands permitted approximately 28.3% of the secondary flooding. Approximately 25.0% of the secondary sources which were not tight prior to the test such as bolt holes in decks, unplugged stuffing tubes, or leaky seams permitted 25.1% of the flooding.

STUDY OF FLOODING SOURCES

SECTION IV

CONCLUSIONS AND RECOMMENDATIONS

As a result of the tests it appears that the following four design changes are necessary, first, the dogs on doors and hatches to prevent loosening, second, the small piping connections to sea chests to prevent breakage outboard of the sea valve, third, the supports for small piping to prevent the pipe from breaking when subjected to vibration and whip, and fourth, the main propulsion shaft glands to give a higher degree of watertightness. The following two sources of water entry should be given consideration with the idea of preventing the entry of contaminated water into the hull of the ship, first, stern tubes, and second, rudder trunks. Vigorous participation of ships personnel in air testing and visual inspection of structure to maintain and to restore the highest quality of water tight subdivision is necessary in order to remove progressive flooding sources through bulkhead and deck fittings stuffing tubes, unplugged wiring tubes, or holes in decks and bulkheads.

Test A

Source & Frequency of Flooding

		Primary								Secondary								Total	
	Source	Capital Ships	DD's	APAs	YO YOG ARDC	LSTs LCIs	Small Craft	Total	%	Capital Ships	DDs	APAs	YO YOG ARDC	LSTs LCIs	Small Craft	Total	%	Source & Freq.	%
1	No flooding as a result of the test	4	9	16	2	11	21	63	71.6									63	71.6
2	Opened Shell seams or holes	2 5			1 2		1 1	4 8	14.3 21.7									4 8	13.3 19.5
3	Opened internal boundaries	1 1						1 1	3.6 2.7									1 1	3.3 2.4
4	Broken pipe lines to internal systems	1 1						1 1	3.6 2.7									1 1	3.3 2.4
5	Open pipe lines to internal systems									2 4						2 4	100.0 100.0	2 4	6.7 9.8
6	Engineering spaces normal leakage					1 1	5 5	6 6	21.5 16.2									6 6	20.0 14.7
7	Sea valves, open or leaking	1 3		1 2				2 5	7.1 13.5									2 5	6.7 12.2
8	Stern tubes, normal leakage	1 1					1 1	2 2	7.1 5.4									2 2	6.7 4.9
9	Stern tubes, excessive leakage	1 3					2 2	3 5	10.7 13.5									3 5	10.0 12.2
10	Rudder trunks normal leakage	2 2				1 1		3 3	10.7 8.1									3 3	10.0 7.3
11	Rudder trunks excessive leakage	1 1	1 1					2 2	7.1 5.4									2 2	6.7 4.9
12	Wave flooding through ramp						1 1	1 1	3.6 2.7									1 1	3.3 2.4
13	Unknown						3 3	3 3	10.7 8.1									3 3	10.0 7.3
14	Semi-submerged						1	1	1.1									1	1.1

Figure

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Test B

		Source & Frequency of Flooding																	
		Primary								Secondary								Total	
Item	Source	Capital Ships	DDs	APAs	YOG ARBC	LSTs LCIs	Small Craft	Total	%	Capital Ships	DDs	APAs	YOG ARBC	LSTs LCIs	Small Craft	Total	%	Source & Freq.	%
1	No flooding as a result of the test	1	8	12	1	8	8	38	43.7									38	43.7
2	Stern tubes, normal leakage	2 4	2 4	4 8				8 16	7.8 2.2									8 16	5.3 3.9
3	Stern tubes excessive leakage	2 5	3 4	3 6		1 2	5 5	14 22	13.6 10.0									14 22	9.3 5.4
4	Rudder trunks normal leakage	2 2				2 2		4 4	3.9 1.8									4 4	2.7 1.0
5	Rudder trunks excessive leakage	3 3					1 1	4 4	3.9 1.8									4 4	2.7 1.0
6	Opened Shell seams or holes	4 41	1 (Beaching)	1 2	1 (Capsized)			5 43	4.9 19.4									5 43	3.3 10.5
7	Opened internal boundaries	1 1	1 (Beaching)	1 1				2 2	1.9 0.9	2 12		1 1				3 13	6.2 6.8	5 15	3.3 3.6
8	Non watertight boundaries									2 6	1 6					3 12	6.2 6.3	3 12	2.0 2.9
9	Broken pipe lines to sea connections	3 6	3 13	4 5				10 24	9.7 10.8									10 24	6.6 5.8
10	Broken pipe lines to internal systems	1 2		1 1				2 3	1.9 1.4	1 1	1 4			1 11		3 16	6.2 8.4	5 19	3.3 4.6
11	Open pipe line to internal systems									3 19	1 1	1 1				5 21	10.4 11.0	5 21	3.3 5.1
12	Sea valves, open or leaking	1 1						1 1	1.0 0.5									1 1	0.7 0.2
13	Sea valves, leaking around stems	1 2	1 2					2 4	1.9 1.8									2 4	1.3 1.0
14	Valves, open, in internal systems		1 3					1 3	1.0 1.4					1 4		1 4	2.1 2.1	2 7	1.3 1.7
15	Engineering spaces normal leakage	5 12	5 16	5 9		6 7	7 8	26 52	25.2 23.5									26 52	17.2 12.6

Figure 2

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Test B (con't)

Item	Source	Source & Frequency of Flooding: Primary — Capital Ships	Primary — DDs	Primary — APAs	Primary — YOG ARDC	Primary — LSTs LCIs	Primary — Small Craft	Primary — Total	Primary — %	Secondary — Capital Ships	Secondary — DDs	Secondary — APAs	Secondary — YOG ARDC	Secondary — LSTs LCIs	Secondary — Small Craft	Secondary — Total	Secondary — %	Total — Source & Freq.	Total — %
16	Main propulsion, shaft glands									3 15	2 5	3 7		1 2		9 29	18.8 15.2	9 29	5.9 7.0
17	Leaky or jarred loose hatches									2 2	1 9	1 2		1 1	4 6	9 20	18.8 10.5	9 20	5.9 4.9
18	Leaky or jarred loose doors									2 26	1 11			1 1		4 38	8.3 19.9	4 38	2.7 9.2
19	Electrical stuffing tubes									2 3	2 5	1 1				5 9	10.4 4.7	5 9	3.5 2.2
20	Bulkhead and deck fittings									2 24						2 24	4.2 12.5	2 24	1.3 5.8
21	Holes in decks and bulkheads									2 3						2 3	4.2 1.6	2 3	1.3 0.7
22	Wave or steam entry in Cargo hatches, Smoke stacks, Superstructure		1 3	2 3		2 2	5 5	10 13	9.7 5.9									10 13	6.6 3.2
23	Ventilation trunks wave or steam entry		1 2					1 2	1.0 0.9									1 2	0.7 0.5
24	Gun mount		1 1					1 1	1.0 0.5									1 1	0.7 0.2
25	Unknown	2 3				2 3	8 21	12 27	11.6 12.2		1 1			1 1		2 2	4.2 1.0	14 29	9.3 7.0
26	Capsized				1		1	2	2.3									2	2.3

Figure 5

BUREAU OF SHIPS GROUP

TECHNICAL INSPECTION REPORT

TURRET STRUCTURE

BY:

J. C. Madison,
Naval Architect (P - 4)

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TURRET STRUCTURE

SECTION I - TEST ABLE

1. In test A, structural damage to the main battery turrets and mounts was caused principally by blast. Heat from the bomb was very intense but of short duration. This resulted in scorching and blistering of paint on the outside surfaces. There is no recorded rise in temperature within the turrets or mounts that can be attributed to the bomb.

2. The armor box and barbettes as installed on the target ships appear to provide adquate protection for internal structure and equipment against blast and heat under the test conditions. Damage within the turrets was the result of either violent movement of the ship and turrets or of forces transmitted to the inside, as in the case of the ARKANSAS, by means of the guns. Some of the turrets were in condition "Y" during the test with hatches or doors in the gun house open. In a few such instances the blast caused damage to interior bulkheads or ventilation pipes in the vicinity of the access openings. Ballistic considerations will therefore most likely continue to be the governing factor in armor design.

3. Powder and projectiles were in normal stowages and also were displayed in the gun chambers of many turrets during the test. In turrets which were in condition "Y" this ammunition necessarily was not fully protected. Although this ammunition was disarranged in many places it remained stable.

4. ARKANSAS: The only structural damage which affected operability occurred on this ship. In turret 4, the right trunnion of the right gun was fractured. Although the gun can be elevated with ease, it cannot be fired. The nature of the fracture indicates that the failure was caused by an upward force. During the test the gun was trained so that it was pointing in the general direction of the bomb detonation. Both guns were elevated to the maximum of 15° and the breech end was resting on the elevation stops. It is believed that the blast struck the underside of the gun barrels which acted as levers in conjunction with the elevation stops

functioning as fulcrums. As a result, considerable force was exerted on the trunnions. The cap square for the trunnion is not bolted down, as is the general practice in turrets of later design, but is fitted into grooves machined in the trunnion block. The machine grooves have sharp corners in which the fracture originated (photo 1991-1; page 3-10). A Naval Shipyard availability of several weeks duration would probably be required to repair the damage. If a similar casualty were to occur in a modern turret it is likely that the cap square holding down bolts would fail first. It would be comparatively easy to replace damaged bolts, and it would be possible for the ship to make at least temporary repairs.

5. SALT LAKE CITY: In Mounts 1 and 2, the left trunnion support is distorted and forced outward, causing misalignment of the bearing and excessive side thrust clearance. This condition does not prevent elevation or firing of the guns but trouble would probably develop after repeated use. The blast wave emanated from the port quarter and apparently caused a violent movement to starboard of the bow of the ship and Mounts 1 and 2. Because of the inertia of the slide and guns, force was exerted on the left trunnion supports. This force caused bending of the left trunnion supports between the shelf plate at the bottom and the tie rod at the top. The permanent deformation is accompanied by an increase of about 3/8" in side thrust clearance (Photo 1915-6; page3-9). Damage to the trunnion bracket might have been greater had the slide not transmitted some force to the gun port plating with which it came in contact (Photo 1915-4; page3-21). The trunnion brackets are designed to withstand, in transverse thrust, forces induced by a normal amount of roll. Consideration should be given to the design of all features of gun trunnion brackets, since failure of this part would greatly reduce the fighting efficiency of the ship.

6. NEVADA: The ventilation ducts under the overhang of the turrets are badly dished from the blast. Welded seams at the edges failed. The ducts are constructed of 7 1/2# plating and the panel size is 58 1/2" x 72". A continuation of the same duct runs up the outside and is welded to the rear side plate of the armor box. On turret 4 all of these connecting welds failed. In view of the vulnerability of light plating to blast it appears that exposed ventilation ducts should be eliminated.

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7. PENSACOLA: In Mount 2, the transverse bulkhead between the gun chamber and range finder compartment is bulged forward sufficiently to bend the aluminum projectile scuttle frames and make the scuttle doors inoperable. This damage was probably caused by blast since the turret was in condition "Y" with all four doors in the gun house open during the test. Mount 4, also in condition "Y" during the test, had the left front door of the gun house blown off.

8. Although the PENSACOLA was closer to the bomb detonation than the SALT LAKE CITY the trunnion brackets were not similary damaged. This probably is due to the fact that the blast struck the PENSACOLA almost dead astern causing relatively less movement to the ship than was experienced by the SALT LAKE CITY.

9. SAKAWA: This is the only target ship, having gun turrets or mounts of a caliber of six inch or over, that was sunk in test A. The SAKAWA had three six inch twin mounts installed but the guns had all been removed prior to the test and the gun ports were closed with a 5# patch plate. This patch extended well back into the roof plate. It was attached with a full periphery fillet weld but was not stiffened in any manner. The unsupported panel size of this patch on the roof alone is 7' 2" wide and 9' 0" long. As a result of the test the patch plate on the after mount was completely crushed in and on the forward mounts it was dished in a fore and aft direction in the form of a "V" for a maximum depression of about two feet (Photos 1859-11 and 1832-6; pages 3-11,12). The gun house plating, which is 5/8 inch thick, apparently was not dished by the blast. The sinking condition of this ship did not permit a complete inspection of the damage.

10. The NEW YORK, PENNSYLVANIA, NAGATO and PRINZ EUGEN received no turret structural damage as a result of test A.

TURRET STRUCTURE

SECTION II - TEST BAKER

1. In test B damage to turret structure was caused by underwater shock and violent action of the ships. Damage was confined principally to holding down clips and supporting structure under the barbettes and stools. In general, powder and projectile stowages were shaken up and disarranged, (Photo 4222-11; page 3-20). All ammunition remained stable.

2. PENSACOLA: All four mounts are heavily damaged, particularly Mounts 1 and 2. The primary failure in each case is the pivot seal casting and its holding down bolts. The pivot seal casting, in addition to housing the weather seal, functions as a holding down clip for the mount and as a retainer for the radial thrust needle bearings (See sketch on page 3-8). The failure allowed the mounts to lift from the training race. Ball and roller bearings were displaced, and the mounts came to rest in a skewed position. Extensive damage to the rotating structure below the shelf level in Mounts 1 and 2 resulted from the primary failure. All of the mounts are completely inoperable as a result of this damage. Below Mount 1, the transverse bulkhead on the second platform at frame 27, port, and the door in this bulkhead, which provides access between A-412-M and A-411-M are severely buckled. Below Mount 2, bulkhead 33 on the first platform is severely damaged. (Photos 158-4, 1677-2, 1677-1, 1678-8, and 1685-10; pages 3-13 to 3-17).

3. NEW YORK: The holding down clips of Turrets 3, 4 and 5 are damaged as a result of the turret having lifted. In turret 3 the rear and right holding down clips show evidence of having been drawn up tightly and are bent outward. In Turret 4 the right holding clip has completely broken. In Turret 5 the rear holding down clip has fractured starting at the right end and extending for about one-half of its length. (Photo 4164-5; page 3-18). The left clip is fractured slightly at the front end. The clips in Turrets 1 and 2 do not show evidence of failure. In compartments D-36-P and D-36-S under turret 5, the stanchion support under the barbette and stool shows evidence of strain and the web is buckled.

This was caused by the underwater shock being resisted by the inertia of the turret and barbette. Operability of these turrets is not affected by structural damage but three guns were made inoperable by the failure of their elevating screw-oscillating bearings. (Photo 4222-7; page3-19).

4. NEVADA: There is evidence that Turrets 1 and 2 lifted and that the holding down clips came into action. In Turret 2 the connecting bolts for the rear clip sheared and the clip fell between the barbette and stool. This does not interfere with the train of the turret or prevent its operation. On the first platform under Turret 1, the transverse bulkhead at frame 32 is buckled at the top in three places. The longitudinal bulkhead on the port side of the 14" handling room A-421-B is also slightly buckled at the top. Under Turret 2 the transverse bulkhead at frame 48 was buckled across the entire top.

5. The PENNSYLVANIA, SALT LAKE CITY and PRINZ EUGEN received no structural damage as a result of test B. The ARKANSAS and NAGATO were sunk in this test before any survey of damage to the turrets could be made.

TABLE "A"

SHIP	NAME	MAIN BATTERY	Approx. horizontal distance from bomb blast to ship in yards. Test A	Test B
BB38	PENNSYLVANIA	4-Triple 14" - 45 Cal. Turrets.	1600	1300
BB36	NEVADA	2-Triple and 2-Twin 14"- 45. Cal. Turrets.	600	1000
BB34	NEW YORK	5-Twin 14" -45 Cal. Turrets.	1600	1200
BB33	ARKANSAS	6-Twin 12" Turrets.	600	250
ExJap	NAGATO	4-Twin 16" (abt.) Turrets.	850	700
CA24	PENSACOLA	2-Triple and 2-Twin 8"-55 Cal. Mounts.	750	700
CA25	SALT LAKE CITY	2-Triple and 2-Twin 8"-55 Cal. Mounts.	900	1200
IX300	PRINZ EUGEN	4-Twin 8" (abt.) Turrets.	1250	1700
ExJap	SAKAWA	3-Twin 6" (abt.) Mounts.	500	—

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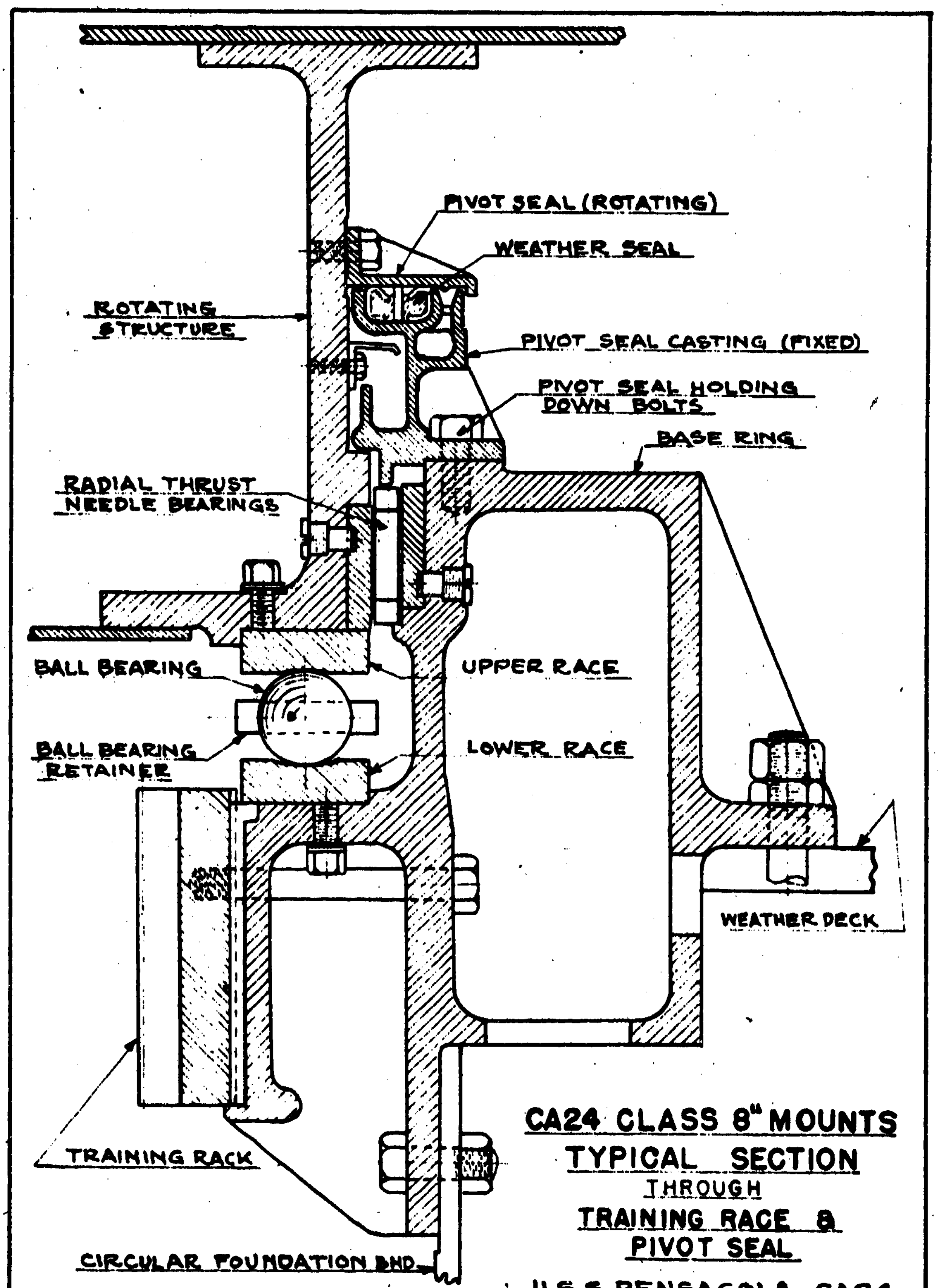
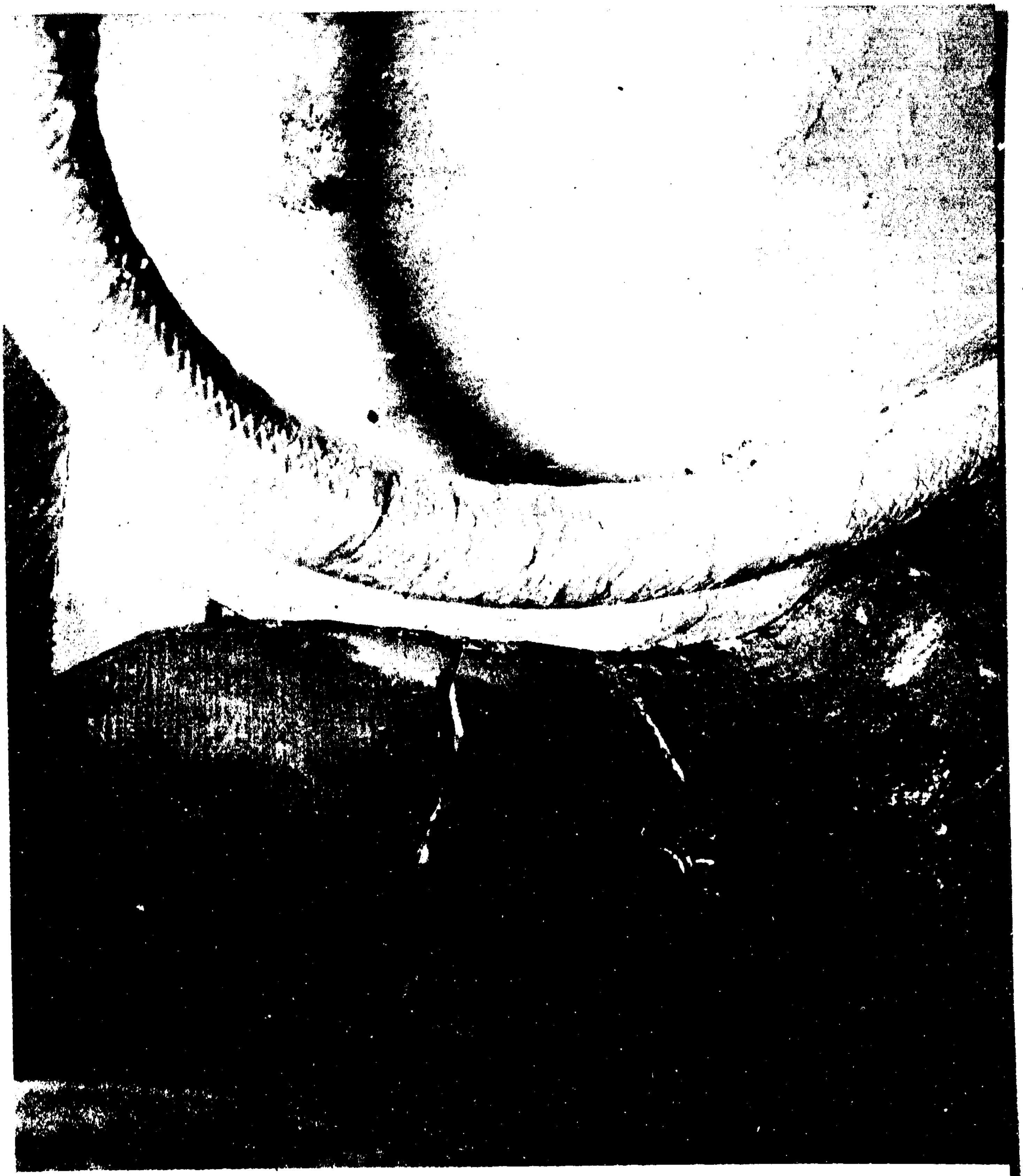


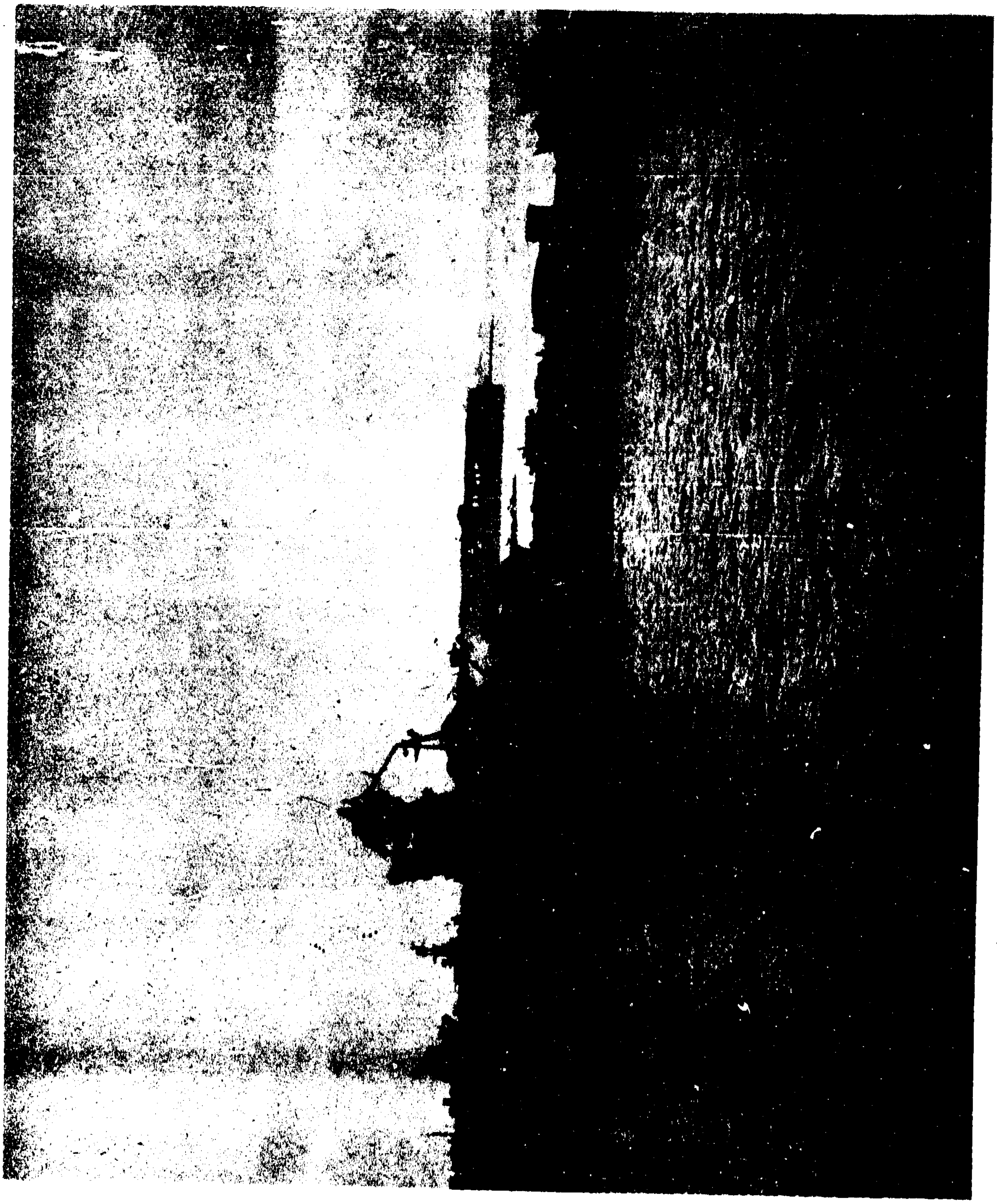
CA24 CLASS 8" MOUNTS
TYPICAL SECTION
THROUGH
TRAINING RACE &
PIVOT SEAL

U.S.S. PENSACOLA CA24

AA-CR-82-1915-6. SALT LAKE CITY. Mount 1, left trunnion looking to right and to the rear after Test A.

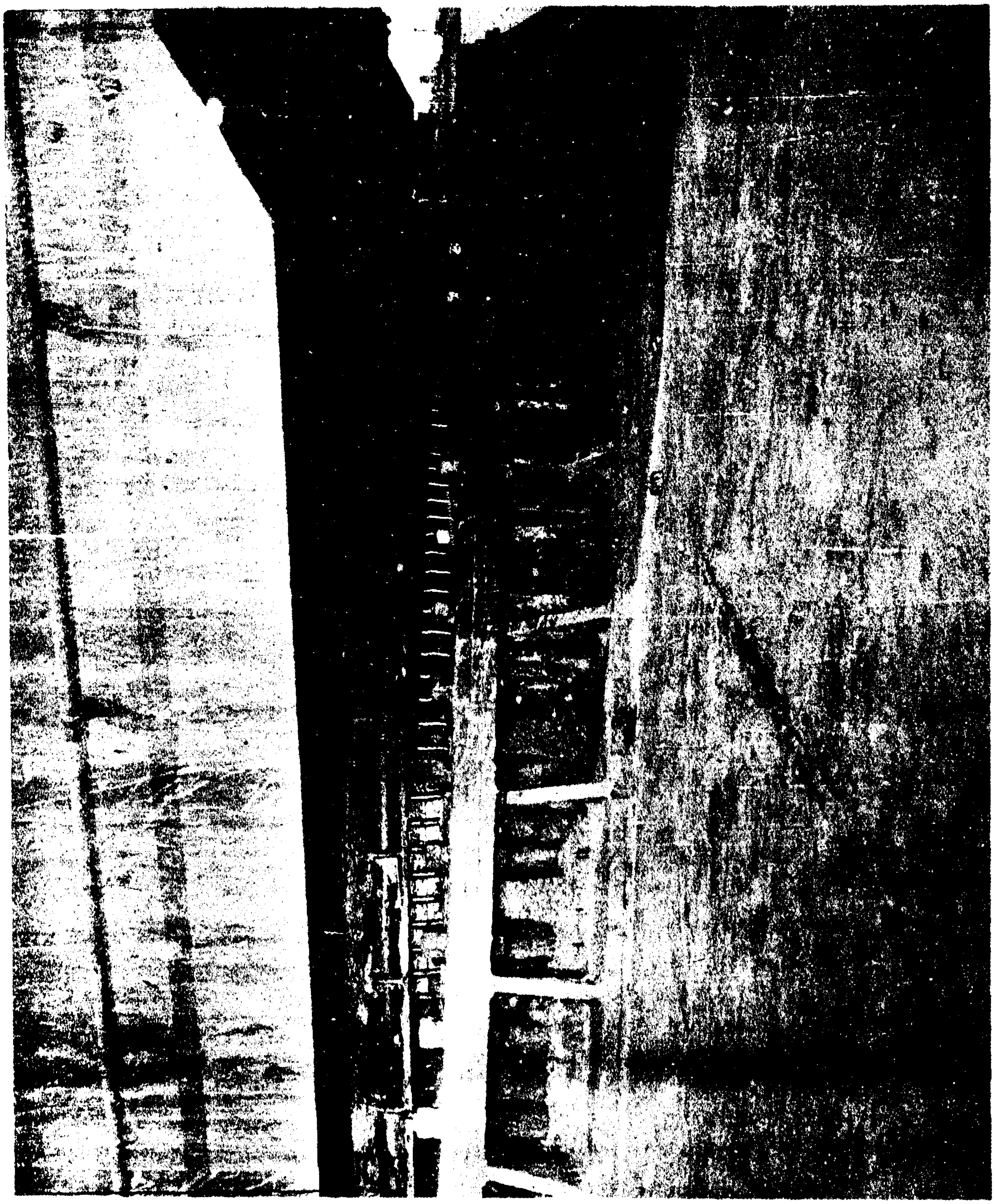


AA-CR-234-1991-1. ARKANSAS. Turret 4 - right trunnion of the right gun after Test A.



AA-CR-62-1859-11. SAKAWA. View from port beam after Test A.

AA-CR-62-1832-6. SAKAWA. View from port quarter after Test A.



AB-CR-66-158-4. PENSACOLA. Mount 2 - looking forward and to starboard at base ring after Test B.

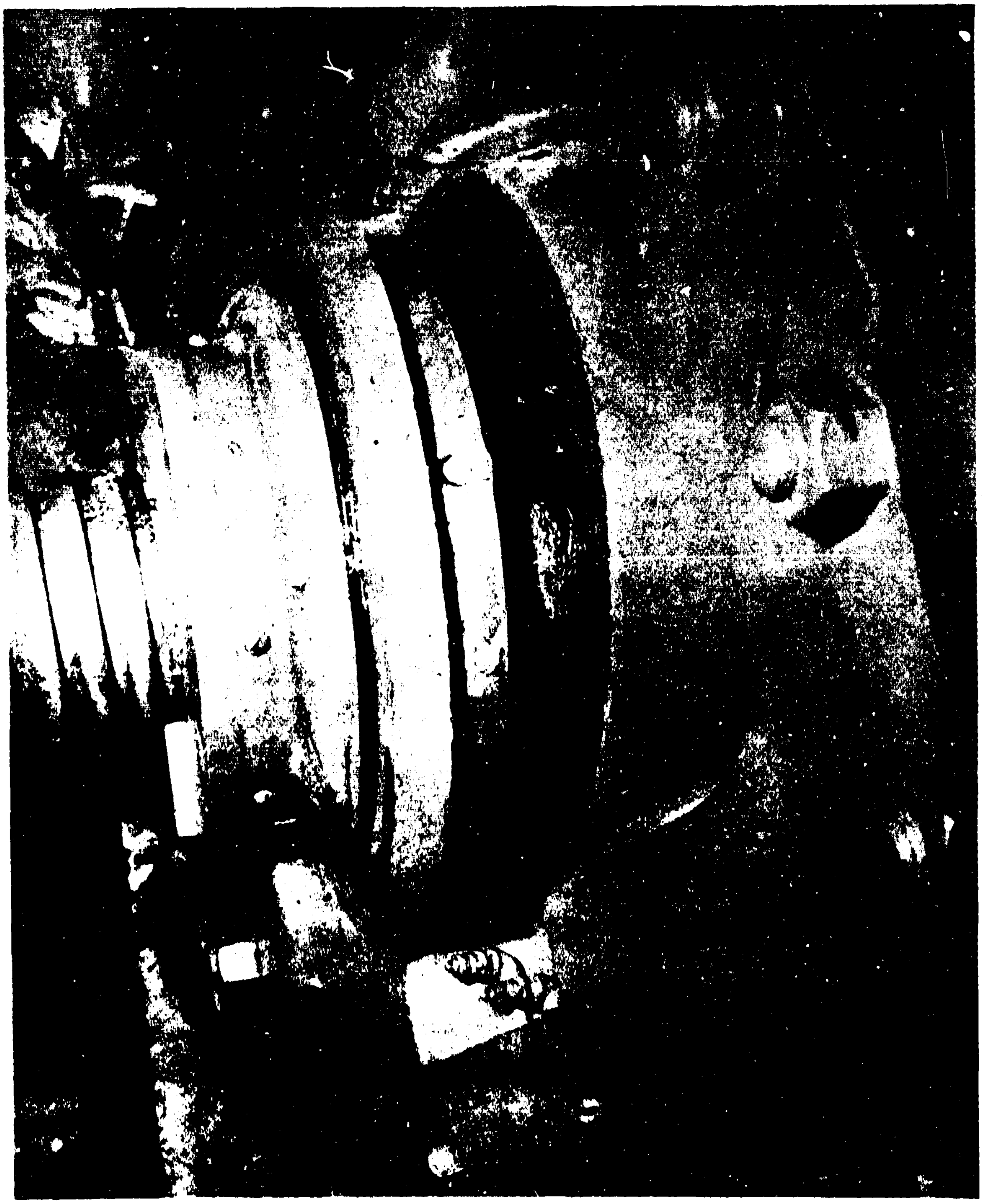
AB-CR-80-1677-2. PENSACOLA. Mount 2. Training pinnion. View from underside - teeth disengaged and lower portion of bearing missing after Test B.

AB-CR-80-1677-1. PENSACOLA. Mount 2. Training race ball bearings and retainer displaced after Test B.

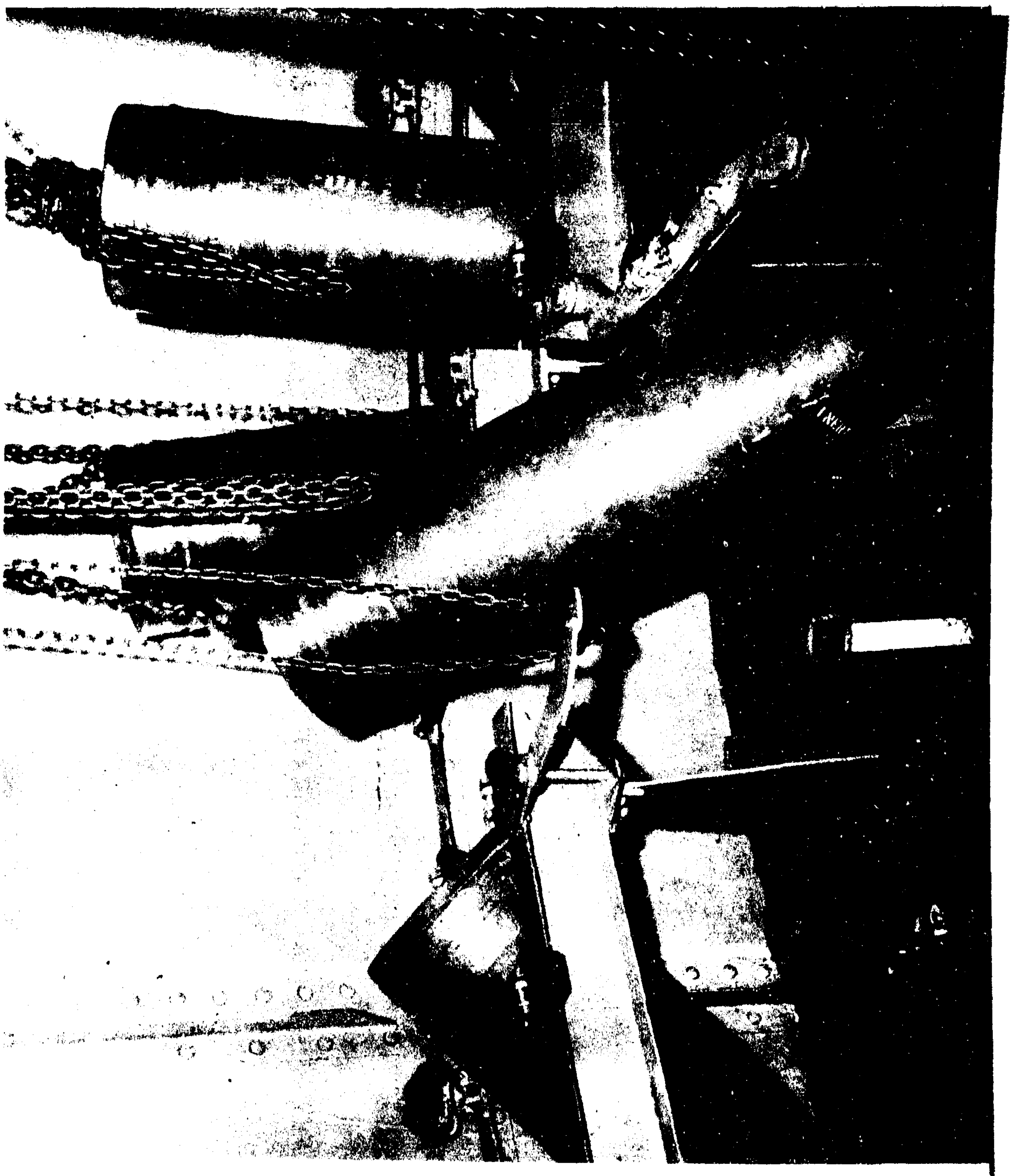
AB-CR-80-1678-8. PENSACOLA. Mount 2. Typical damage to underside of powder circle flat after Test B.

AB-CR-97-1685-10. PENSACOLA. Mount 2. Crushed powder hoist and tray after Test B.

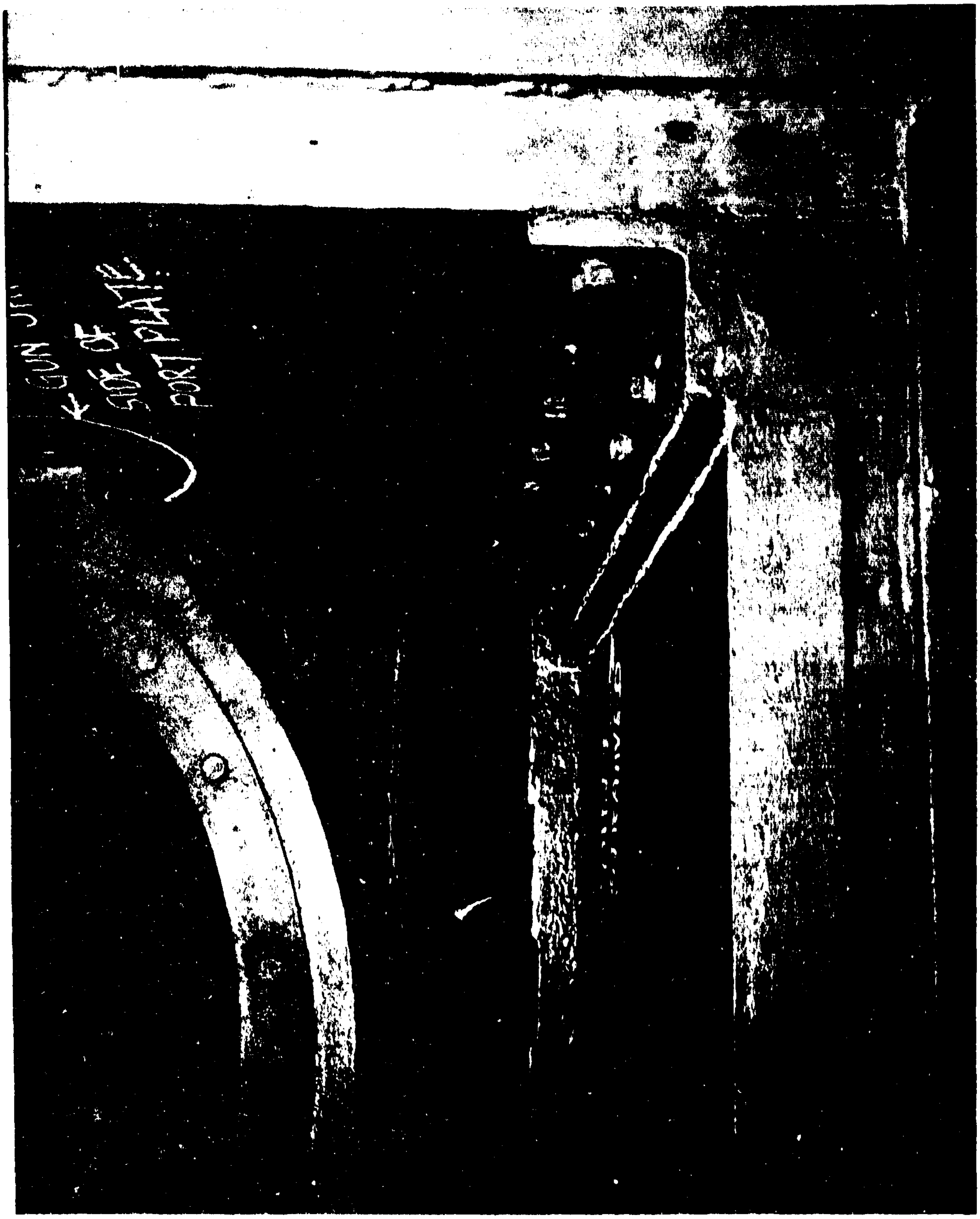
AB-CR-62-4164-5. NEW YORK. Turret 5. Annular space between barbette and stool. Fracture in rear holding down clip after Test B.



AB-CR-82-4222-7. NEW YORK. Turret 5. Left gun, elevating screw oscillating bearing after Test B.



AB-CR-82-4222-11. NEW YORK. Turret 4. Projectile transfer level. Disarrangement of projectiles after Test B.



AA-CR-82-1915-4. SALT LAKE CITY. Mount 1, showing where gun came into contact with gun port plating in Test A.

BUREAU OF SHIPS GROUP

TECHNICAL INSPECTION REPORT

STUDY OF FIRE AND PAINT

BY:

J. B. Shirley,
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STUDY OF FIRE AND PAINT

SECTION I - TEST ABLE

A. Time of outbreak of fires.

1. In test A numerous small fires occurred on widely dispersed ships. These fires became noticeable over a considerable period of time. Material must have been set on fire immediately, but the air blast that followed blew out the flames. Smoldering material then gradually began to break into flames. The following table lists the approximate times that smoke became visible to observers in PBM Charlie who had excellent visibility while flying near the array.

Ship	Time first smoke observed
U.S.S. BLADEN (APA63)	0927
SAKAWA (Ex-Jap CL)	0950
U.S.S. PENSACOLA (CA24)	0950
U.S.S. SARATOGA (CV3)	0950
U.S.S. INDEPENDENCE (CVL22)	0950
U.S.S. NEVADA (BB36)	0950
U.S.S. YO 160	0950
U.S.S. BRISCOE (APA65)	1010
U.S.S. WILSON (DD408)	101[illegible]
NAGATO (Ex-Jap BB)	1030
U.S.S. BUTTE (APA68)	1105
U.S.S. LCT 816	1130
U.S.S. CORTLAND (APA75)	1135
U.S.S. NIAGARA (APA87)	1135
U.S.S. NEW YORK (BB34)	1155
U.S.S. BANNER (APA60)	1155
U.S.S. PENNSYLVANIA (BB38) (explosion)	1307

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B. Significant fires.

1. Fires occurred on the ANDERSON, LAMSON, and CARLISLE immediately after the burst. Photographs of these ships indicate that the ships are on fire but do not show what is burning. On the LST's 52 and 661 some exposed test ammunition in powder bags burned without doing damage to adjacent ammunition or to the ship.

2. On the CORTLAND in the outer part of the array, two boats were burned with secondary damage to paint, insulation, and wiring on the adjacent wardroom bulkhead. The cause of this fire is undetermined.

3. On the INDEPENDENCE a gasoline truck which was blown into the after well from the flight deck and an airplane on the flight deck burned. There was no gasoline in either of these, and the fires are probably secondary effects of the main fires in this area. Fire spread thr ugh the after superstructure and at about 1400 reached the torpedo workshop. In the workshop, twelve HBX loaded torpedo warheads burned without detonating and some low order explosions occurred due to external heat on the air flasks.

4. Exposed U.S. Army test clothing on widely spaced ships either burned completely or had small sections burned out. On the NEW YORK a combined fire occurred in U. S. Army test clothing and in the flag bag above. On the NEVADA and PENNSYLVANIA, fires in exposed U.S. Army equipment consisting of liquid containers caused ex losions.

5. On the RHIND, canvas bloomers on Nos. 1 and 4 gun mounts, painted with fire retardent paint caught on fire and burned.

C. Incendiary energies.

1. The indendiary energy responsible for the scorching of material and for the few fires that occurred appears to have existed in several forms with overlapping effects. One form of

energy appeared to be thermal radiation from the extremely hot center of the bomb fission. A second form of energy appeared to be a heat wave, perhaps an extremely hot blast of wind. A third possible form appeared to be a result of electrical energy or short wave radiation. A fourth, but secondary, source of fires occurred when winds blew smoldering embers into contact with inflammable objects. This occurred on the PENSACOLA where a fire hose burned. Effects of these forms of energy decrease with increased distance and are distinguishable only in a few isolated cases. Since all fires that occurred and all singeing or charring are similar, no estimate can be made as to the amount of damage attributable to each form of energy. However, from secondary effects and from isolated cases it is apparent that the forms of energy existed.

D. Factors aiding combustion.

1. In conjuction with the incendiary energy several factors inherently part of the material structure assisted in the absorption of the energy necessary to raise the temperature to the smoldering or burning point. Dark surfaces absorbed more thermal energy. For example label plates with black letters on a white background had the black letters charred while the white was sometimes untouched. A notice posted on a bulletin board had the writing burned into the backing. Loosely woven or frayed surfaces such as burlap and cotton or manila lines with frayed ends burned while closely woven material such as fire hoses only singed or charred.

E. Factors opposing combustion.

1. In opposition to the indendiary energy several factors prevented wide spread fires with possible disastrous effects. The extremely short time of exposure of the materials to the indendiary energy allowed only the outer fibers to reach the burning point. The high wind that followed the burst, although heating material, blew out many fires. The distance of the surviving ships from the burst allowed dispersion or cooling of the incendiary energies. The small amounts of inflammable equipment exposed, exclusive of test materials and paint on the ship's structure, allowed fires to burn

themselves out without overheating adjacent structures. The natural and artificial restrictions to the spread of fires such as widely dispersed, small amounts of combustible material and the shielding effect of the ship's structure, since normally ship board material is stored under overhangs and out of the weather, greatly reduced the amount of material directly exposed to the burst.

F. Thermal radiation.

1. Energy appearing as thermal radiation which traveled in a straight line and was reflected by bright surfaces, made very sharply outlined shadows on ships near the blast and detectable shadows on all ships except in the extreme outer part of the array. This was noticeable in the shadows of the ships structure, of ladders, and even of life lines. The outlines were scorched or charred into paint and wood surfaces with a very clear definition. The outlines were so definite that remarkably consistent estimates of the location of the bomb burst could be made on ships even in the outer half of the array. This energy was reflected by bright surfaces. For example, on the HUGHES this energy was reflected upward by an unpainted aluminum deck under an overhand and gave a sharp outline of the overhang.

G. Heat wave.

1. Energy appearing as a heat wave which followed aerodynamic laws made airflow patterns around corners on many ships. This effect was more noticeable in the inner part of the array. Smoke stacks had paint blistered almost all the way around. Overhangs had patterns of scorched or blistered paint where eddy currents existed. 40mm gun tubs in exposed spaces had on the outside toward the blast definite straight line shadow patterns of adjacent structure. On the inside curved pattern lines traced the path where a wind swirled over the rim and around the inner surface.

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H. Electrical energy or short wave radiation.

1. Unexplainable fires with repeated peculiar circumstances which could not be directly attributed to thermal radiation or a heat wave occurred on widely spaced ships. From the circumstances, it is possible that the third cause of fires was some kind of electrical energy or short wave radiation. Metal helmets packed in cardboard boxes with cardboard spaces had the box and spacers burned or severely scorched while adjacent cardboard boxes were only slightly singed. Exposed metal, liquid containers, exploded from internal vapor pressure built up by the generated heat while adjacent containers of dry food were undamaged. A galvanized rat cage originally suspended from a halyard burned the outline of the cage into the deck where it fell. A coil of wire lying on deck had the rubber insulation burned. On one ship, two adjacent boat gripes were made up of manila covered with canvas. Three of the ends were secured with manila seizing while the fourth end was secured with galvanized wire. The end secured with the wire burned while the remainder of the gripes was only slightly singed. A bucket of paint, inadvertently left exposed on the LCT 816, burned while adjacent paint on structure was only scorched and blistered. Apparently the volatiles in the paint carrier were overheated and caught on fire.

I. Types of materials affected.

1. Canvas or cotton articles such as firehoses, tarpaulins, swabs, flags, and mattress covers were burned or scorched on all except the outer ships. Dirty, blackened canvas or dark colored cloth burned while new canvas or light colored material nearby was untouched or only singed. On many ships the Yoke flag left at the yardarms upon evacuation had the dark sections burned and the light section charred. Commission pennants had all the blue charred, leaving only a few strands holding the undamaged white stars together. Paint was blistered or scorched on all except the extreme outer ships with dark colored paints more affected than light paints. Manila hawsers and lines and cotton signal halyards that were old and darkened from use or frayed, burned while

new or clean lines were only singed or charred. Life rafts covered with painted canvas had small surface holes burned and smoldering continued in the interior for several hours. Wood structure on many ships and broom or swab handles were singed and burned at localized spots where the wood normally would be darkened from usage. U.S. Army test materials wrapped in burlap and secured with thin straps burned or smoldered for several hours.

J. Depth of paint damage.

1. Damage to paint was spectacular in that exposed surfaces were darkened, blistered, and scorched. Darkening of the surfaces was partially attributable to the soot that was blown out of the smoke stacks. Other damage to the paint surfaces was due to the effects of heat. All heat phenomena observed can be explained by elementary laws of physics and can be reproduced in laboratory using any radiant heat sources. Burning paint was extinguished by the air blast so that paint fires lasted only a few seconds. Only the top layer of paint (0.001 to 0.003 inches thick) was affected, with the possible exception of the NEVADA and other ships within 800 yards of the burst. These ships had two coats of paint damaged. However, the SKATE had little paint blistering and scorching. This may be due to the nearness of the ship to the burst so that a very short time elapsed between the arrival of the heat and the extinguishing air blast.

K. Effects of color and pigmentation on paint damage.

1. Dark colored paints were more damaged than light paints. On the CRITTENDEN, which was very close to the blast, a steel bulkhead had been partially painted black under a ladder. The black paint was badly blistered while the regular light gray paint was almost untouched. However, on the TUNA, haze gray paint over yellow chromate and over green paint was more affected than adjacent paint. Paint on wooden surfaces was more blistered than on steel surfaces. A peculiar case of paint darkening over a period of several days was reported on the INDEPENDENCE. Some of the

seemingly unassociated cases of light and heavy blistering on the same structure may be partially attributable to unevaporated volatiles in the paint. Paints containing organic pigments such as toluidine toner were especially susceptible to damage. Good baking pigments stood up well and did not carbonize or darken. The type of coating and the percentage of pigment content are factors in paint damage. Baked alkyds stood up remarkably well, as did most of the aircraft paints. Enamels stood up much better than highly pigmented coatings.

L. U.S. Army ground group final report.

1. The following quotations are taken from the Final Report of the Army Ground Group:

(a) "The apparent ability of dense and thick rubber elements such as pneumatic tires and electrical cables to withstand the heat, blast pressure, and radioactivity generated by the atomic bomb was noteworthy. They were apparently undamaged except for superficial scorching at a distance of approximately 600 yards from the burst. At this distance, however, thin rubber coatings and sponge rubber were charred.

(b) "Some exposed Army items such as wrapped propelling charges and mortar powder increments in plastic casings were destroyed at a distance within 2100 yards.

(c) "Plastics of all kinds were highly susceptible to the heat generated by the atomic bomb. Many of them fused, caught fire or changed texture. Some were fused at as great a distance as 3000 yards from the burst. The plastic casings of the double base powder increments which burned at about 2200 yards evidently transmitted radiation to the inclosed powder which heated to the ignition point. Laminated panels of glass and metals separated because of a breakdown of the plastic bonding compound.

(d) "As a bonding agent in laminated panels, plastics also failed to withstand the radiation. Plastics of the thermo setting types were much less affected by flash than the thermoplastic type".

M. Location of types of damage.

1. Figure 1 shows the widespread and fairly even distribution of damage to the ships in test A. The following symbols are used with a sub "s" or "b" to indicate singeing, scorching, or burning:

A	U.S. Army test material wrapped in burlap or cardboard.
Am	U.A. Army ammunition exposed on deck.
C	Canvas or cotton, fire hoses, swabs, flags.
Cl	Cloth, rubberized, that burned.
F	Fire.
Fo	Fire in oil soaked boat bilges.
Fw	Fire, wind blow embers into other combustibles.
I	Insulation.
L	Lines, lifelines, halyards, manila or cotton, thrum or cocoa matting.
M	Mattress cover.
P	Paint on structural surfaces.
Ptb	Bucket of paint left exposed that burned.
R	Life rafts.
T	Tar on rigging reduced to carbon.
W	Wood, structures, broom or swab handles.
1	Foreign substance in flagbags.
2	Cans exploded.
3	Heat reflected by bright surfaces.
None	No evidence of heat or fires.

ATOMIC BOMB TEST

TARGET ARRGT

TEST A

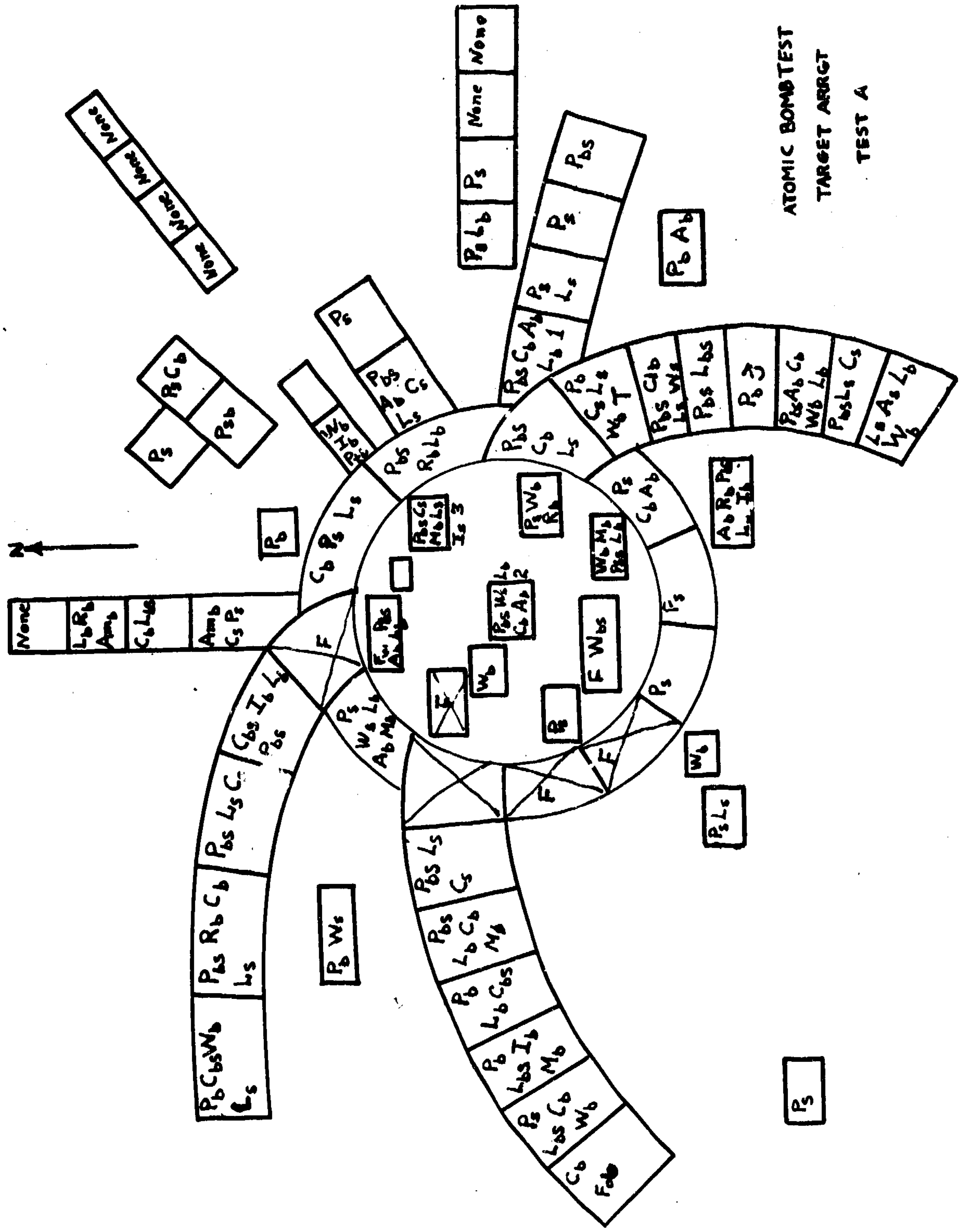

FIGURE 1

STUDY OF FIRE AND PAINT

SECTION II - TEST BAKER

A. General.

1. There were no fires, explosions or damage to paint as a direct result of test B.

B. Radioactive contamination of paint.

1. In test B, radioactive particles lodged on exposed painted surfaces. The removal of the radioactivity is a problem of prime importance. Tests on small painted parts showed that the radioactivity was confined to the paint. Where there were more than three or four coats of paint, almost all the radioactivity seemed to be confined to the top three or four coats. A major part of the radioactivity was in the top coat and progressively lesser amounts were in the next two or three coats.

STUDY OF FIRE AND PAINT

SECTION III

CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions.

1. A paint to offer maximum resistance to damage from an air burst should be:

(a) Light in color.
(b) Low in pigmentation.
(c) Baked rather than air dried.
(d) Without organic pigment other than carbon.

2. Research should center around the radioactivity absorption of the painted surfaces. Some of the suggested lines of attack are:

(a) Quick and efficient removal of the present types of paint used on shipboard.

(b) Development of paint film with resistance to the absorption of radioactive particles.

(c) Development of a film, such as the strippable coatings used in ship preservation, that after application can be easily removed from the top of an orthodox paint. This film either to remove radioactivity from a contaminated surface or to prevent contamination of painted surfaces in the future.

(d) A new type of easily removable coating attached to the external surfaces of the ships.

(e) The possibility of using bright non rusting unpainted surfaces for topside structure.

3. The majority of the serious fires occurred on ships within the sinking range and the probable total deaths of personnel range.

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STUDY OF FIRE AND PAINT

The fire on the INDEPENDENCE and the fires on other ships that floated, even for a few hours after the test went unattended and thus progressively grew over a period of several hours.

B. Recommendations.

1. No changes are recommended in the present practice of elimination and reduction of fire hazards. However, the burning of the canvas bloomers on the RHIND requires further investigation.

[redacted]
...ERGY ACT - 1946
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... MILITARY CLASSIFICATION SAFEGUARDS

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Defense Special Weapons Agency
6801 Telegraph Road
Alexandria, Virginia 22310-3398

TRC 4 April 1997

MEMORANDUM TO DEFENSE TECHNICAL INFORMATION CENTER
ATTN: OMI/Mr Bill Bush

SUBJECT: Declassification of Documents

The following is a list of documents that have been declassified and the distribution statement changed to Statement A, Approved for Public Release.

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Ardith Jarrett

ARDITH JARRETT
Chief, Technical Resource Center