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U.S.S. RENO (CL96)

Torpedo Damage

Off Luzon

3 November 1944

Class.....ATLANTA (CL51)	Length (O.A.).....541 Ft. 0 In.
Launched..... 23 December 1942	Beam (Extreme)..... 53 Ft. 0 In.
Displacement..... 6000 tons (Standard)	Draft (Before Damage) Mean..... 20 Ft.10-1/2 In.

References:

(a) C.O. RENO ltr. CL96/A16-3, Serial 008, of 18 November 1944 (Action Report).

(b) C.O. RENO ltr. CL96/L11-1, Serial 003, of 15 January 1945 (War Damage Report).

(c) CINCPAC ltr. A16-3/Nov, Serial 005866, of 21 April 1945 (2nd Endorsement on Action Report).

(d) COMTHIRDFLT ltr. A16-3/(11), Serial 0058, of 16 January 1945 (1st Endorsement on Action Report).

LIST OF PLATES

LIST OF PHOTOGRAPHS

SECTION I - FOREWORD

1. Torpedo damage of RENO, 3 November 1944, is of unusual interest. RENO, on being damaged, assumed a considerable port list. About nine hours later, after progressive flooding had occurred and certain damage control measures had been taken by ship's force, this port list suddenly reversed to starboard. This reversal of list demonstrated clearly that negative GM had developed. ERIE (PG50)* also experienced a sudden reversal of list under similar circumstances of negative GM and small reserve of dynamical stability. ERIE was less fortunate, however, as she rolled over completely, while RENO reached a point of equilibrium at 16 degrees to starboard.

2. In spite of the progressive loss of power and stability, RENO was saved, due in large part to the courage and perseverance of the ship's force during the 700-mile voyage to Ulithi. At no time was any thought of abandoning ship entertained. Perhaps this is the most important lesson in damage control. At any rate, RENO had learned it well.

SECTION II - SUMMARY

3. RENO was torpedoed at 2325 on 3 November 1944, while a unit of a Task Force preparing for a strike against Luzon. The submarine which presumably fired the torpedo was not detected. The torpedo struck on the port quarter in way of a fuel oil tank, 16 feet abaft the after engineroom. Fuel oil was blown up through holes blasted in the main and second decks, splattering the entire structure aft. Living spaces C-201-L and C-305-L were opened to the sea and flooded immediately. Flooding on the second deck progressed rapidly through open doors from bulkheads 77 to 110. The after engineroom flooded through a 10-foot hole in the after bulkhead, causing the loss of all power in the after section of the ship, including power to the steering gear. The after fireroom filled with smoke and had to be abandoned. The forward machinery spaces were intact, however, and RENO continued underway at 12 knots on the starboard shaft.

4. The outstanding feature of this case of war damage was the condition of negative initial stability that developed soon after RENO was torpedoed. Compartments on the second deck quickly flooded to the waterline for a length of 132 feet. Progressive partial flooding of other compartments, particularly the after fireroom (B-3) and the main issue room (C-311-AL), materially increased the large free surface area. The initial list to port of 7 degrees due to off-center flooding and low initial stability slowly increased, reaching a maximum of 16 degrees as the stability was progressively impaired with the increase in free surface area. Efforts to correct this list by pumping forward port fuel oil tanks overboard and transferring liquids to starboard tanks were culminated the next morning in a sudden reversal of list from 7 degrees port to 20 degrees starboard reaching equilibrium at 16 degrees starboard. RENO was making 7 knots at the time.

5. Seepage of water through electric cables short-circuited the main switchboard in the forward engineroom, initiating recurrent electrical fires in this vicinity which, coupled with the smoke and lack of ventilation, made it necessary to abandon the forward plant. The forward emergency Diesel generator lost Diesel oil suction and stopped. RENO was taken in tow by ZUNI (ATF95) about noon on 4 November.

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* BuShips War Damage Report No. 31

6. Most members of the crew were transferred to accompanying destroyers in the afternoon. A salvage party of 17 officers and 225 men remained on board RENO to continue pumping, shoring and restoring facilities preparatory to lighting off the forward plant.

7. Early in the morning of 5 November, towing was stopped and ZUNI called alongside to furnish additional pumping facilities and power. During the afternoon sufficient free surface was eliminated to restore positive GM and towing was resumed.

8. The remainder of the voyage was without incident and RENO anchored at Ulithi on 10 November. During the elapsed week, RENO had traveled 700 miles and weathered a typhoon. Approximately 1100 tons of water had been pumped from flooded compartments and the forward emergency generator and forward propulsion plant had been placed back in operation. Temporary above-water repairs were made at Ulithi and RENO proceeded to Manus where a temporary patch was installed in ABSD-2 prior to the voyage to the mainland. RENO arrived at Navy Yard, Charleston, on 22 March 1945 where all battle damage was repaired and approved alterations were accomplished. RENO was returned to service on 30 September 1945.

SECTION III - NARRATIVE

(Plate I and All Photographs)

9. This report is based on the references and inspections of the ship by Bureau representatives at Ulithi and Navy Yard, Charleston. The photographs were furnished by the Commanding Officer and Navy Yard, Charleston. The plate was prepared by the Bureau.

10. On 3 November 1944, RENO was proceeding in company with a Task Force for a strike against Luzon. Speed was 15 knots, base course 330 degrees (T), zigzagging in accordance with a prescribed plan. The moon was bright and the sea was smooth with low, short swells from the northeast. Material Condition BAKER was in effect. The engineering plant was operating in split condition.

11. At 2325 a torpedo, apparently fired from an undetected submarine, struck RENO on the port quarter, detonating at frame 92, several feet below the first platform level. The shock effect was severe throughout the ship although the flexural vibration of the hull was only moderate. A huge geyser of fuel oil and water was thrown up through large holes blown in the main and second decks, drenching the after part of the ship. A section of the deck in C-201-L, 24 feet long by 12 feet wide (Photo 4) was blown up through the hole in the main deck, descending on that deck at frame 116 port. 40mm gun. No. 6 was thrown off its foundation and landed on the port torpedo tube mount. Smoke and fumes rose from the port quarter; however, there was no fire. General Quarters was sounded and all hands went to their battle stations. Material Condition ABLE was set insofar as possible. RENO began listing to port, reaching 7 degrees within 2 minutes after being hit.

12. A hole 33 feet long and 22 feet around the girth of the ship was blown in the shell plating. Compartments C-201-L and C-305-L were opened to the sea. A 10-foot hole was blown in the port side of bulkhead 88, flooding the after engineroom (B-4) rapidly, although all personnel made good their escape. Power and lights went out in the after section of the ship when the turbo-generators in the after engineroom were flooded. The after emergency Diesel generator in C-416-E cut in

automatically, but took the load only for a short time before being flooded out through the overboard exhaust pipe line. The after fireroom (B-3) filled with smoke and fuel oil vapor, which, combined with the loss of power to the ventilation blowers, made this space untenable. The boilers and other machinery were secured and the fireroom abandoned. As soon as the after engineroom was flooded, the after fireroom began to flood through leaky steam expansion joints, the starboard shaft packing gland and electrical stuffing tubes in the after bulkhead. This flooding was controlled by ship's pumps until 0900 on 4 November when the forward machinery plant was secured after which time the after fireroom flooded progressively to a depth of 14 feet.

13. Following the hit the forward machinery plant remained intact, and RENO continued underway at 12 knots on the starboard shaft. Course was set for Ulithi, 700 miles distant. Engine order control from the bridge to the forward engineroom was fully operative. Steering control was lost immediately following the hit. Casualty power leads were run to the steering gear room but when power was applied to the motors, the rudder went to hard right and no movement of the trick wheel had any effect upon it. The emergency rudder jacking gear was then ordered to the steering gear room. RENO swung to starboard until the rudder was eased with the emergency gear. The action of the rudder in going to hard right was later found to have been caused by connecting up the casualty power with incorrect phase relation.

14. All gyro repeaters were put out of commission by the shock of the explosion and the ship's heading had to be obtained from the standard compass abaft the forward director. The master gyro in the I.C. room was rendered inoperative. Communications could not be established with the after gyro room (C-405-E) which was later found to have been flooded almost immediately.

15. The fire alarm in the I.C. room indicated that all after magazines were overheating. Orders were given to flood 5-inch magazines C-407-1M and C-411-M. C-412-2M was also ordered flooded if the situation warranted. Access to all remote control stations was denied by flooding which prevented the execution of the order to flood magazines. Efforts to sprinkle magazines were soon discontinued due to the absence of fire or excessive heat in their vicinity. Apparently, the indicator to the fire alarm board had short-circuited, giving erroneous temperature readings.

16. On the second deck flooding spread rapidly from C-201-L which was open to the sea. Bulkhead 88 had been damaged and doors 2-88-1 and 2-88-2 were open, permitting B-207-L to flood to the waterline from C-201-L. Doors 2-77-2 and 2-77-3 were open, although only passageway B-206-4EL flooded to any appreciable degree. This marked the forward limit of the flooding on the second deck level. Abaft C-201-L, bulkhead 96 was holed on the port side at the second deck level and doors 2-96-1 and 2-96-2 in this bulkhead were open, permitting crew's quarters C-202-L to flood to the waterline immediately. Repair III in this space had to be abandoned. Second deck compartments abaft bulkhead 96, namely C-203-1L, C-203-2L and C-203-3L, soon flooded to the waterline through open doors in bulkhead 103 and non-watertight bulkheads. A small amount of water spilled over the door sills in bulkhead 110 into C-206-L.

17. On the first platform level, crew's quarters (C-305-L) and 40mm magazine (C-304-M) were open to the sea. C-302-AM flooded from C-201-L through hatch 2-89 which was open. C-301-M flooded from C-302-AM around the distorted frame of door 3-89. Bulkhead 96 was holed in many places on the port side above the first platform, thus flooding the ice machine room (C-307-8E). The first platform was split in way of the butter and egg room (C-307-4A), allowing this space

to flood. The remainder of the compartments between bulkheads 96 and 103 were separated only by light airtight bulkheads which failed under water pressure and caused the meat room (C-307-6A), fruit and vegetable room (C-307-5A), vestibule (C-307-2A), passage (C-307-1T) and laundry room (C-307-3E) to flood completely. Hatch 2-104 was open at the time of the hit but was closed when Material Condition ABLE was set. It was later found to be improperly dogged, permitting the main issue room (C-311-AL) to flood progressively from C-203-2L to within two feet of the overhead.

18. On the second platform level, fuel oil tanks C-404-F, C-408-F, C-604-F, and C-902-F were destroyed or severely damaged and these spaces flooded immediately. Hatch 3-89 and door 4-89 were open to provide cooling air to demolition charge locker (C-401-1/2M) permitting this space and 40mm ammunition handling room (C-401-M) to flood from C-302-AM. Electric booth (C-401-1E) flooded through the airtight door to C-401-M. The STS longitudinal bulkhead outboard of magazines C-402-1/2M, C-406-M and C-402-T was displaced inboard several feet tearing loose from the first platform (1.25-inch STS) which was blown upward (Photo 7), permitting all of the above compartments to flood rapidly. The after bulkhead of C-406-M was split, flooding 20mm magazine (C-406-1/2M). In addition, door 4-96 between C-406-M and 5-inch handling room C-407-1M was distorted, allowing the latter compartment to flood. Bulkhead 99 was sufficiently distorted to cause door 4-99 to leak, flooding C-411-M from C-407-1M. Leakage around door 4-103 from C-411-M flooded 5-inch handling room C-412-2M. Similarly, 5-inch powder magazine C-415-M progressively flooded through door 4-105 from C-412-2M. As the ship listed to port the after emergency Diesel generator room (C-416-E) flooded to a depth of 4 feet through the engine exhaust pipe line which pierced the port shell plating below the main deck level. A blown-out gasket in the cooling water line and an open drain line were also sources of leakage into this compartment. A gasket on the sea suction line of the electric emergency fire pump was dislocated by the underwater shock, flooding compartment C-420-A. Distortion of doors 4-118-1 and 4-118-2 allowed trunk C-420-T and 20mm magazine C-419-M to flood progressively.

19. By 2344 the list had reached 10 degrees port and appeared to be increasing. To reduce the list fuel oil was pumped overboard from several port tanks forward through the port fueling connection at frame 53 on the main deck. By 0008 on 4 November the list had been reduced to 9 degrees to port. Pumping operations were continued and all hands were directed to shift movable weights from port to starboard.

20. In spite of these efforts to right the ship, the list slowly increased, reaching 15 degrees to port at 0222. At this time oil pumping operations were stopped for fear the resulting adverse effect on the stability characteristics would reach dangerous proportions.

21. At 0230 the main switchboard in the forward engineroom was short-circuited when water seeping through the cables from flooded areas reached the bus bars. All electrical power, including that to the radars, was lost throughout the ship. The battery-operated portable voice radio was rigged in Battle I and became the only means of radio communication available. The forward emergency Diesel generator started, but could not be put on the line due to shorts in the distribution board. As a result, all blowers were stopped. The resultant increase in temperature in the machinery spaces made it necessary to relieve the watch at five-minute intervals. Repair II was forced to abandon its station in B-204-L, above the forward engineroom, due to the excessive heat. However, RENO continued underway on the starboard shaft.

22. The forward emergency Diesel generator distribution board was cleared at 0300 by cutting out the bus tie on the main switchboard. The list had increased to 16 degrees to port at this time.

23. When passage (B-206-4EL) flooded, the evaporators were abandoned. Hence, any reserve feed water that was used thereafter could not be replaced. No. 2 boiler was secured at 0420 to conserve feed water.

24. By 0500 the list was reduced to 15 degrees to port. Efforts to right the ship by jettisoning and shifting weights were continued. The port depth charges were set on "safe" and jettisoned. After daybreak parts of 40mm mount No. 6 were cut away and jettisoned. All topside ammunition was shifted to starboard. The effect on list of these weight movements was not readily apparent.

25. Efforts to reduce the extent of flooding were commenced soon after damage was received. It was found that door 2-103-2 could not be closed because the door frame was warped. The door was removed and the opening blanked off by heavy timbers. The forward bulkhead of C-203-L was shored during the next three days as a precautionary measure. At 0800 on 4 November attempts were made to lower the water in compartment C-203-L with handy-billies, but the large amount of leakage into the compartment and the limited capacity of the pumps prevented any appreciable progress. At 0830 these pumps were shifted to the after fireroom, where an inspection had indicated that efforts to pump the compartment dry would be more successful.

26. At 0600 KNAPP (DD653) came alongside and supplied reserve feed water to RENO's starboard tanks, which reduced the list to 10 degrees to port by 0740. During this period every effort was made to fill the starboard oil and fresh water tanks; transfer of liquids was taking place constantly. By 0830 on 4 November the list had decreased to 7 degrees to port. Suddenly it was noted that RENO had come upright and was rapidly listing to starboard. By 0850 the list had reached 20 degrees to starboard. All pumping and weight removal measures were shifted to remove the starboard list. By 0910 the starboard list was reduced to 16 degrees. During this reversal of list, RENO was making seven knots through the water.

27. At 0858 insulating material started to burn in the vicinity of the main switchboard in the forward engineroom, but was extinguished with CO_2. However, smoke continued to be emitted from various electrical fittings, and this smoke, together with the lack of adequate ventilation, restricted the activities in the forward engineroom. In view of the difficulties in the engineroom, the starboard engine was secured at 0910 and RENO lay dead in the water. Preparations were begun for towing RENO to Ulithi.

28. At 0925 the two starboard paravanes and five starboard Mark 7 depth charges were jettisoned. All four torpedoes were jettisoned at 1000, and preparations were made to jettison the starboard torpedo mount.

29. A second fire broke out near the main switchboard in the forward engineroom at about 0925, but was quickly extinguished again with CO_2.

30. Two additional handy-billies were obtained from COGSWELL (DD651) and these were put into operation pumping out compartment C-203-L.

31. At 1125 on 4 November ZUNI (ATF95) took RENO in tow at approximately 5 knots. The starboard list seemed to be steady at 12 degrees. Movable weights continued to be jettisoned and shifted to port to assist in list correction.

32. A third fire broke out in the forward engineroom in the vicinity of the main switchboard at 1140. The damage control officer put on a rescue breathing apparatus and succeeded in extinguishing the fire with CO_2. The threat of a recurrent flare-up necessitated a second trip in the engineroom with an additional CO_2 extinguisher. As it was apparent that something more effective than portable CO_2 extinguishers was necessary, the damage control officer made a third trip into the engineroom and thoroughly extinguished the fire with a single 1-1/2-inch fog nozzle.

33. The forward emergency Diesel generator, which had been carrying the electrical load, lost fuel oil suction and stopped at 1400, leaving RENO without any electrical power. Continued efforts to start the Diesel engine were unsuccessful at this time.

34. In view of the critical situation and the inadequate facilities on board, wounded and excess personnel and the ship's records were transferred to escorting destroyers during the afternoon of 4 November. A nucleus of 17 officers and 225 men remained aboard to continue salvage efforts. During the debarkation the main deck starboard was awash abaft frame 55. At about this time the starboard torpedo mount was jettisoned.

35. With the approach of darkness at 1800 and the menace of enemy submarines in the area, RENO was secured and no lights were permitted topside. During the night the list slowly increased reaching 21 degrees starboard at 0145 on 5 November. At this time the Commanding Officer ordered ZUNI to slip her tow and come alongside to assist RENO in pumping out flooded compartments. To improve stability and buoyancy 120 cases of 20mm ammunition, 450 cases of 40mm ammunition, 20 50-pound CO_2 and 10 50-pound oxygen cylinders and 20 crates of potatoes were jettisoned. Preparatory to pumping the after crew's mess (B-207-L), doors 2-88-1 and 2-88-2 were removed at their hinges and the openings blanked with 2-inch by 12-inch planks. ZUNI transferred a 6-inch gasoline-driven pump and several 3-inch gasoline handy-billies which were used in pumping B-207-L. A fixed 4-inch pump on ZUNI was rigged to take suction on RENO's after fireroom. In addition, ZUNI furnished RENO a 3-inch gasoline-driven pump and two electric submersible pumps, as well as 220 volt power, to pump out the after fireroom. At 1000 two submersible pumps were transferred to the forward engineroom long enough to pump out a small amount of water that had collected in the bilges.

36. The service pump and purifier bowl were removed from the after Diesel generator and installed on the forward Diesel generator. Power was regained on the forward Diesel generator at 0800 on 5 November using Diesel oil furnished by ZUNI.

37. The list decreased rapidly as pumping operations progressed, being 7 degrees to starboard at 1330. At 1435, CAPERTON (DD650) came alongside to furnish RENO feed water. At about this time, the after Diesel generator room (C-416-E) was dried out with handy-billies and bucket brigades. All efforts to start the after Diesel engine failed, however, and it remained inoperative during the remainder of the trip to Ulithi. Later in the afternoon the after fireroom and after crew's mess were pumped down.

38. By 1610 on 5 November the list had been reduced to 4 degrees to starboard. The situation appeared favorable and it was decided to proceed with the towing operation. At 1707 ZUNI got underway again with RENO in tow. The list was 3 degrees to starboard. During the night of 5 November the wind increased to 24 knots, intermittently;

however, the list increased only to 6 degrees. The reactions of RENO to the wind and sea were gratifying and it appeared that the survival of RENO was almost assured.

39. Though minor leakage subsequently occurred in the after fireroom and after crew's mess, it was quickly detected and eliminated with electric submersible pumps.

40. During 6 November electrical equipment required to restore power to the forward machinery spaces and below-decks ventilation blowers was obtained from KANPP, CAPERTON and COGSWELL.

41. Pumping operations also continued during 6 November. A 3-inch gasoline-driven pump was rigged to take suction in trunk C-421-T. C-419-M and C-420-A were pumped out in succession. During the morning of 6 November the forward bulkhead of C-203-L was further shored and pumping of C-203-L was commenced. By 1600 C-203-L was pumped down below the coaming of hatch 2-104, providing access to C-311-AL. One pump was diverted from C-203-L to pumping out C-311-AL. C-203-L was pumped down completely. As darkness came, pumping activities were stopped and all watertight fittings were closed.

42. By 1625 ATR50 had joined ZUNI and was towing RENO in tandem.

43. Reports were received indicating that the center of a typhoon would probably pass within 300 miles of RENO. To assist in preventing excessive working of the ship, the list was reduced to 2-1/2 degrees starboard during the evening of 6 November by shifting ballast. The course of 060 degrees (T) appeared best for the condition of the sea.

44. During the early morning hours of 7 November, efforts were begun for putting the evaporators back into operation. ARAPAHO manufactured the required flanges so that a jury-rig could be made to obtain sea water from the firemain. As 1830 No. 2 evaporator was started.

45. Plans were made to operate the starboard shaft as a means of increasing the speed of the tow. The blowers in the forward machinery spaces were started, obtaining their power from the forward emergency Diesel generator. At 0730 on 7 November a watch was set in the forward fireroom and engineroom to check equipment preparatory to lighting off. Fires were lighted under No. 2 boiler at 0930 and the speed of the starboard shaft was slowly built up to 45 rpm by 1530.

46. During the seventh a strong wind, reaching a force of 35 knots at 1430, churned the seas. RENO rode out the rough weather without difficulty although the stern was often more than two feet under water.

47. Pumping operations were resumed at 0830 on the seventh. A wooden barricade was built around hatch 1-117 to prevent the seas which swept over the main deck from pouring into second deck compartments. Two 3-inch gasoline-driven pumps were lashed to stanchions in C-206-L. The suction hoses were led forward into compartment C-203-L and down hatch 2-104 into main issue room (C-311-AL) while discharge lines, both water and engine exhaust, were led topside via main deck hatches. Pumping continued in C-311-AL until sunset at 1730, when the ship was secured for the night.

48. During the evening of the seventh, the forward gyro-compass in the I.C. room (A-411-C) was placed in commission.

49. By 0530 on 8 November both sets of evaporators were in operation. The gyro-repeaters were energized from the forward gyro-compass. The electrical load was being supplied by the forward emergency Diesel generator. The wooden barricades around hatch 1-117 and scuttle 1-110 were washed overboard during the night and had to be rebuilt. Pumping operations in C-311-AL were then resumed and this space was dewatered and secured at 1500. A small leak in the deck at a stuffing tube which carried a flexible sprinkling valve control rod was found and caulked to prevent further leakage.

50. By the morning of the ninth, the seas had abated sufficiently to permit emergency structural repairs topside. A 3-foot by 5-foot section of 10-pound plate was welded over the ruptured butt in the main deck stringer at frame 94-1/2. Three 4-inch pipe stiffeners were welded between the deckhouses at frames 91 and 92 (Photo 17) to prevent cracks in the main deck from progressing.

51. Throughout 9 November personnel were engaged in removing fuel oil from below deck spaces and cleaning up compartments in the vicinity of the damaged area. Sufficient repairs were made to restore firemain pressure throughout the ship. A watch was set on the remaining 40mm mounts and lookouts were stationed as a special anti-submarine precaution.

52. During the day the speed of the starboard shaft was increased so that the towing services of the ATR50 were no longer required. ZUNI continued with the tow, however, and RENO made approximately 6.5 knots.

53. Beginning at daylight on 10 November the speed of the starboard shaft was gradually increased to 96 rpm at 0800. This speed was maintained throughout the day except for a short period when a steam joint in the forward engineroom developed a leak.

54. At 1525 Ulithi was sighted about 25 miles distant. Preparations were made for coming into port and the 3-degree starboard list was removed. RENO dropped anchor at Ulithi at 2156 after a 700-mile trip.

55. Temporary above-water repairs were effected at Ulithi under the direction of Commander Service Squadron Ten. VESTAL (AR4), assisted by the ship's force, repaired the holes in the main and second decks. Three 24-inch welded T-beam stiffeners were installed on the port side of the main and second decks, extending continuously between frames 77 and 103, a distance of 104 feet (Photo 18). The port sheer strake was largely intact, but it was reinforced by two longitudinals on the outside of the shell plating in way of the existing longitudinals (Photo 18). Five-inch gun mounts Nos. 4 and 5 were removed and retained at Ulithi. Compartments C-412-2M and C-415-M were pumped out. However, dewatering of all compartments had to be delayed until arrival at Manus, where adequate drydocking facilities were available.

56. The trip to Manus for final temporary repairs was made under tow, inasmuch as it was considered inadvisable to continue to operate the starboard shaft because it passed through the after engineroom which was still flooded. RENO was placed in ABSD-2 on 8 January 1945, where ABSD-2, WHITNEY (AD4), Repair Unit Navy 3205 and the ship's force completed temporary repairs and preparations for return to the United States. These included dewatering all compartments, patching the hole in the shell plating, preserving the machinery in the after machinery spaces and removing the port propeller and shafting.

57. RENO was undocked on 12 February and proceeded under her own power to Navy Yard, Charleston, arriving 22 March 1945. There all battle damage was repaired and many authorized alterations completed. RENO returned to service on 30 September 1945.

SECTION IV - DISCUSSION

A. Types of Torpedoes

58. The approach of the torpedo which struck RENO was not observed, nor was the submarine, which presumably fired it, detected. It was a relatively shallow running torpedo, with approximately a 10-foot depth setting. The explosion consisted of a single detonation; the noise of the explosion was a dull, heavy thud. A flash was noticed by topside observers, but no flame was emitted nor were any fires started.

59. The extent of the opening in the hull and the damage to the main and second decks were somewhat less than that which would be expected from a "Type 92" Japanese 21-inch electric submarine torpedo. This torpedo is known to contain an explosive charge of 660 pounds (60 per cent TNT, 24 per cent HND, 16 per cent Al). This type contained the smallest charge of any submarine torpedo in use by the Japanese at the end of the war. The Japanese did possess a 21-inch submarine torpedo containing a smaller charge, but at the time of the attack it was considered obsolete. There is a remote possibility, however, that this "6th year type" torpedo, with a warhead containing 451 pounds of picric acid, was used against RENO.

B. Structural Damage

60. Structural damage was restricted to the area of the hit. There was no wrinkling of the deck or shell plating in way of the hit nor at the quarter-points as a result of flexural vibration of the hull. The shell plating was ruptured over an oblong area, approximately 33 feet long and 22 feet around the girth of the ship, between frames 88 and 96, and around the girth between 10 and 32 feet below the main deck level (Photo 5). Serious indentations of the shell plating occurred around the periphery of the hole from frame 80 to 105 and several feet above and below the hole. The seam joining "B" and "C" strakes port was torn from the after part of the hole as far aft as frame 105. The aftermost plate of the armor belt (3.75-inch STS), which extended eight feet over the opening in the shell plating, was only slightly distorted (Photo 6).

61. The 3.75-inch STS transverse bulkhead at frame 90 between the first platform and second deck remained intact. Bulkhead 88 between the main and second deck was thus shielded sufficiently so that it could later be shored and made tight. Below the first platform, bulkhead 90 has an STS strake 3 feet 9 inches high that tapers from 3.75 at the top to 1.8 inches at the bottom. Thence, 0.75-inch STS extends to the shell connection. The section of this bulkhead outboard of the port longitudinal STS bulkhead was demolished at the bottom; the riveted connection at the first platform level failed and the upper part of the bulkhead was blown against bulkhead 88.

62. The port longitudinal STS bulkhead (tapered from 3.75 to 0.75 inches, similar to bulkhead 90), only 14 feet from the point of detonation, was pulled away at the riveted connection to bulkhead 90 and to the 1.25-inch STS first platform between frames 90 and 100 and was carried to starboard by the force of the blast (Photo 5). However, this longitudinal armored bulkhead remained practically intact and was effective in restricting the depth of damage, the main force of the explosion being

directed upward as evidenced by extensive damage to the main and second decks. This restriction of the depth of damage preserved sufficient structural strength for RENO to travel 700 miles through rough seas with no apparent progressive failure. The 1.25-inch STS deck over C-406-M, C-402-T, C-402-1/2M and C-405-E was raised about 3 feet and split at a welded butt (Photo 7).

63. Inspection of the decks and bulkheads in way of the damage by a representative of the Bureau of Ships failed to reveal any evidence of fragment attack. C-404-F (14 feet wide), directly in the path of the explosion, was full of fuel at the time and was apparently effective in reducing the velocity of the fragments to a negligible value.

C. Machinery Damage

64. The damage sustained by the machinery in the after engineroom was primarily caused by the 67-day period of submergence in salt water. The port shaft coupling bolts were pulled through the flange at the main reduction gear by the force of the explosion allowing the shaft to slip aft 54 inches (Photo 12). The shaft did not tear a hole in the engineroom bulkhead as in the case of HOUSTON (CL81)* and CANBERRA (CA70).**

65. Two starboard spring bearings in the flooded after engineroom wiped en route to Ulithi while operating with No. 1 shaft submerged in the mixture of salt water and fuel oil in that space. This difficulty has been encountered before, but to date no practical remedy has been proposed.

66. The progressive loss of all main and emergency power aboard RENO during the 14-hour period immediately after damage seriously impaired damage control efforts. The rapid flooding of the after engineroom resulted in the loss of all power aft. The after emergency Diesel generator cut in and took the load, but flooded out a short time later when the exhaust pipe line submerged.

67. The loss of ventilation in the after fireroom forced this space to be abandoned. Normal power to the blowers of the after fireroom was supplied from the after main board in the after engineroom, while emergency power was provided from the after Diesel generator through the same board. There was no duplicate set of leads to the after fireroom blowers from the forward main board, as was also the case with SAVANNAH (CL42).*** On all cruisers alternate power has been authorized from the forward board to the blowers in the after machinery spaces and from the after board to the blowers in the forward machinery spaces so that a similar casualty should not occur again.

68. The main switchboard in the forward engineroom short-circuited at 0230 on 4 November, about three hours after damage was received, due to water seeping through the electric cables from the damaged area. As this type of casualty has occurred many times before, much effort has been devoted to its elimination. Cable manufactured since the early part of 1945 has been sealed internally throughout its length. In addition, cable end sealing remains mandatory on new construction. Sealing of cable ends of important power circuits has been authorized for ships in service, but the heavy work load at the various Yards and the magnitude of the work involved precluded large-scale accomplishment of this alteration during the war. Numerous ships have avoided this difficulty by stripping the switchboard of all cables which enter flooded spaces.

69. Commander Third Fleet states in his endorsement, reference (d), on RENO's action report, reference (a):

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* BuShips War Damage Report No. 53
** BuShips War Damage Report No. 54
*** BuShips War Damage Report No. 44

"Personnel should be instructed to immediately disconnect from switchboards those cables which pass through flooded spaces to prevent shorting and loss of power throughout the ship."

70. The forward emergency Diesel generator started after the forward main board short-circuited, but could not be cut in due to short circuits in its distribution board. At 0300, however, the board was cleared by cutting out the bus tie on the main switchboard, and power was regained to emergency circuits forward. At 1400 on 4 November the Diesel generator stopped, leaving RENO without any power. Later investigation disclosed that both the Diesel oil service pump and the purifier had started, presumably by the shock of the torpedo detonation, and had run under no-load conditions until the service pump burned out. Thus, the Diesel generator ran by gravity feed only until the service tank was emptied. The purifier takes suction from the storage tank, but when the large port list occurred the purifier lost its water seal and could not be used in place of the service pump. The service pump and the purifier bowl were transferred from the after emergency Diesel engine, and after necessary adjustments were made, the forward Diesel generator was started at 0800 on 5 November using Diesel oil furnished by ZUNI instead of possibly contaminated Diesel oil from ship's tanks. RENO could not run the risk of many false starts of the Diesel generator as there were no means of recharging the starting batteries.

71. The forward emergency Diesel generator proved to be the only source of electrical power aboard RENO during the remainder of the passage to Ulithi as neither the after emergency Diesel generator nor the main distribution switchboard in the forward engineroom could be put back into operation.

D. Fires

72. Previous war experience has demonstrated that when a torpedo detonates in way of side fuel oil tanks sufficiently deep so as not to rupture the weather deck there is usually insufficient oxygen to sustain combustion. This was evident on CHESTER (CA27)* and MINNEAPOLIS (CA36)*, where torpedo detonations in way of side fuel oil tanks did not rupture the armored second deck, and no fires occurred. Usually, when the weather deck has been ruptured, serious fires have ensued. In these cases the oil is finely atomized and mixed with air by the detonation. The vapor thus formed is easily ignited by the heat of detonation of the torpedo or any other source of heat or flame. This is the reason for the high incidence of fires on loaded tankers when hit by torpedoes. Among cruisers, PENSACOLA (CA24)** and NORTHAMPTON (CA26)*** are notable examples. PENSACOLA fought the fire for 12 hours before it was extinguished, and NORTHAMPTON was unable to bring the fire under control before she sank 3-1/2 hours after being hit.

73. RENO was fortunate that there were no fires as a direct result of the torpedo explosion. The electrical fires which subsequently occurred in the forward engineroom were kept under control by prompt action of damage control personnel. However, these fires did cause the forward engineroom to be abandoned temporarily and the damage done to the forward main switchboard prevented the turbo-generators being put back into use before arrival at Ulithi.

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* BuShips War Damage Report No. 36
** BuShips War Damage Report No. 35
***BuShips War Damage Report No. 41

E. Flooding and Stability

(Plates II and III)

74. RENO had completed fueling at 0900 on the morning of the damage. Drafts taken at this time indicated a displacement of 8650 tons which closely approximates Condition M (maximum load) shown in the Inclining Experiment Data. The GM corresponding to this displacement is about 3.6 feet, corrected for free surface in the ship's tanks.

75. Stability was seriously reduced by the partial flooding of four second-deck living compartments between bulkheads 77 and 110, which destroyed about 32 per cent of the waterplane area soon after the torpedo hit. Calculations indicate that GM was quickly reduced, to approximately zero at a displacement of 11,100 tons. Off-center flooding of B-946-F, C-408-F and C-604-F caused the ship to take an initial list to port of 7 degrees within two minutes after being hit. Before damage, B-946-F was about half full, C-408-F was about two-thirds full and C-604-F was empty. The complete flooding of these three tanks produced an off-center moment of about 770 foot-tons. Progressive partial flooding of C-311-AL, C-416-E and probably B-3 presented sufficient free surface to cause a condition of negative GM to develop and the list began to increase progressively, reaching a maximum of 16 degrees to port at 0300 some 3-1/2 hours after damage was incurred. Progressive flooding of B-206-4EL and B-942-F also increased the port moment of off-center flooding from 770 foot-tons to 1360 foot-tons.

76. In an effort to control the list roughly 160 tons of fuel oil were pumped overboard between 2344 and 0222 from port forward tanks and approximately 25 tons of water were transferred from port to starboard tanks. This gave a starboard moment of approximately 2230 foot-tons which more than counter-balanced the port moment of 1360 foot-tons of off-center flooding. It is probable that some of the reserve feed water was pumped overboard as an acute shortage of boiler feed water was reported at 0420, 4 November, less than five hours after the torpedo hit, although most of the reserve feed water tanks were reported full just before RENO's damage was received. Also, during the night personnel were directed to shift all movable weights to starboard. Finally, during the early morning of 4 November, fresh water was taken aboard from KNAPP, producing sufficient starboard moment to cause a sudden reversal of list at 0830 from 7 degrees port to 20 degrees starboard at 0850. The position of equilibrium finally reached, however, was 16 degrees starboard. Information on the amount of liquids transferred and the extent of flooding at the time of reversal of list is subject to question; hence, it is difficult to make a reliable calculation of the GM just prior to the reversal of list. Calculations based on the best information available of the extent of flooding and transfer of liquids, indicate a negative GM of 0.9 foot at a displacement of 11,250 tons at the time of the lurch.

77. As a check on the calculations which gave the results described in paragraph 76, a statical stability curve (Plate III) was derived as described below without calculating the virtual rise in the center of gravity due to free surface or the listing moment. The method used here was introduced in an effort to portray the conditions that must have existed at the time of the lurch. While not exact at large angles of list this analysis is interesting as it gives a complete picture of the approximate shape of the statical stability curve for the condition during the lurch. The general shape of this statical stability curve was deduced from the manner in which RENO was reported to have behaved. In the following discussion "negative righting moment" is used to refer to the moment inherent in the ship in the range of instability that acts to increase the angle of list of the ship as contrasted with "righting moment" which

acts to reduce the list. Used in this manner a "negative port righting moment" would act to increase the port list while a "port righting moment" would act to reduce a port list. At small angles of list, loss of stability due to free surface may be assumed to act as a rise in the ship's center of gravity. The lurch from port list to starboard was positive proof that negative GM existed. With negative GM and a port list, a starboard moment must have been applied to reverse this list. As the starboard listing moment was applied an approximately proportional reduction in port list occurred at first. In order to produce a lurch, the applied starboard listing moment first must have balanced the port moment of off-center flooding and then built up and become equal to the maximum negative port righting moment. Thus, when the starboard listing moment was equal to the maximum negative port righting moment produced as a result of the negative stability (Point "A" on Plate III) the ship suddenly lurched to starboard and assumed a starboard list. The starboard list at which equilibrium was reached was far enough beyond the range of negative starboard righting moment due to instability such that a positive starboard righting moment developed and balanced the starboard listing moment. As the angle of port list from which the lurch began was within the range of instability, the starboard angle of list at which equilibrium was reached must have been considerably larger. Inasmuch as the time required for RENO to lurch to starboard and assume its new position of equilibrium was relatively short, no appreciable change in the starboard listing moment probably occurred. Therefore, the value of the starboard righting moment at the angle of equilibrium must have been approximately equal to the value of the maximum negative port righting moment produced as a result of negative stability. This means that the maximum ordinate of the statical stability curve on the port side (ordinate of Point "A") must be equal to the ordinate at about 16 degrees starboard list where equilibrium was reached. By trial and error a rise in the center of gravity was determined which would give a corrected statical stability curve that would fit the condition described above where the righting moment at 16 degrees starboard list is equal to the maximum negative port righting moment due to negative stability.

78. In developing Plate III the statical stability curve for the ship in an undamaged condition and a displacement of 11,250 tons was derived from the cross curves of stability (Curve A, Plate II). An assumed KG of 20 feet was used in developing the cross curves of stability. Curve B, Plate II, was plotted equal to 3.7 sine θ. The difference between Curve A and Curve B gives a statical stability curve corrected to a KG of 23.7 feet, which when multiplied by the displacement of the ship gives the statical stability curve of Plate III. The value of KG equal to 23.7 was selected because it was found by trial and error to give a righting moment at about 16 degrees starboard list equal to the maximum negative port righting moment due to instability. The statical stability curve of Plate III was plotted in terms of righting moment in foot-tons versus list to give the picture more clearly in moments. Plate III is a statical stability curve representing the condition of the ship at the time of the lurch. The shape of the curve to the right of the axis through the origin is that of a ship having negative initial stability and that to the left is the same curve with opposite sign.

79. If data from this empirically derived curve are compared with calculated data obtained independently, the range of variation appears commensurate with the accuracy of the observations upon which the calculated data were based. From the statical stability curve of the ship at the time of the lurch from port to starboard (Plate III) the ordinate of point "A" was read as 660 foot-tons and this value was equal to the starboard listing moment acting throughout the lurch. The port moment of off-center flooding of about 1360 foot-tons subtracted from the starboard moment produced by shifted liquids

of about 2230 foot-tons gives a calculated starboard listing moment of approximately 870 foot-tons as compared with the 660 foot-tons listing moment obtained from Plate III. The ordinate at 57.3 degrees of the tangent to the statical stability curve at 0 degrees is equal to GM. By use of this fact, GM may be derived from Plate III. The slope of the tangent to the curve at 0 degrees multiplied by 57.3 degrees and the vertical scale, then divided by the displacement and the horizontal scale will give GM in the proper units. GM obtained in this manner is approximately 0.5 foot negative as compared with a calculated value of 0.9 foot negative referred to in paragraph 76 above. This is a reasonably good check on the condition of the ship considering the lack of exact information on the extent of existing flooding and the amount of liquid transfer just prior to the time of the lurch.

80. Although the method of analysis illustrated by Plate III is admittedly not exact at large angles of list as stated in paragraph 77, it will be noted from the curve that the range of stability was reduced considerably, to about 36 degrees. The above discussion indicates that a condition of negative GM and greatly reduced range of stability undoubtedly existed in the early morning hours of 4 November. This, of course, means that reserve of dynamical stability at that time was very meager. The ship was in grave danger of capsizing.

81. Under the circumstances explained above it may be considered surprising that RENO did not capsize. Among the factors that resisted, and helped to prevent capsizing, the following seem to have been important. Compartment C-311-AL had a longitudinal wire mesh bulkhead which, blocked with material in the compartment, certainly slowed the flow of water from port to starboard as the ship rolled. Debris in the living compartments also must have prevented the rapid shift of damage water in these spaces. These restrictions, preventing free flow of damage water from port to starboard, certainly slowed down the lurch of RENO, thus restricting the accumulation of the dynamic energy of the lurch. After listing 9 degrees to starboard, the free surfaces in C-311-AL and C-203-L could no longer extend the full width of the compartment. The free surfaces were, therefore, reduced in area at larger angles of list with a resulting improvement in the stability of RENO in the inclined position. The pocketing effect was not so effective in the other living spaces because the compartments below also were open to the sea permitting the free surface to extend the full width of the ship in most cases. It is difficult to compute the magnitude of these effects but certainly they contributed materially to keeping RENO upright. On Plate III the hatched areas between 7-1/2 degrees port and 16 degrees starboard indicate the amount of dynamic energy that would have been accumulated by the ship in the lurch from port to starboard had rolling been unrestricted. The hatched area from 16 degrees starboard to 20 degrees starboard indicates the amount of reserve dynamical stability used in stopping the roll. Had the roll been unrestricted these two areas would have been equal. But the amount of dynamic energy accumulated by the ship was considerably less than the hatched area between 7 degrees port and 16 degrees starboard due to the restriction in rolling as discussed above. The remaining area beyond 20 degrees starboard indicates the meager margin of dynamic stability that prevented the vessel from capsizing.

82. After reversal of the list, 45 tons of ballast water were taken aboard in the forward port tanks and 70 tons of fuel oil were shifted from starboard tanks to port tanks, reducing the starboard listing moment of the shifted liquid from 2230 foot-tons to 750 foot-tons. This subtracted from the port moment of off-center flooding of 1360 foot-tons gives 610 foot-tons acting port listing moment. Had sufficient liquids been shifted to port to have given 870 foot-tons port listing moment instead of 610 foot-tons the ship would have been expected to lurch back to port. In spite of the removal of the starboard moment,

the list to starboard increased. This can only be attributed to progressive flooding increasing the free surface effect with a corresponding reduction in stability. After 0900 on 4 November it was reported that steam was not available for pumping due to the loss of feed water to the boilers. Flooding of B-3 could no longer be controlled and this compartment flooded to a depth of 14 feet. Starboard list reached a maximum of 21 degrees by 0145 on 5 November. It was realized that RENO was in a precarious condition. Towing was stopped and efforts were devoted to improving the stability characteristics. The GM as calculated with the rough data at hand was about 0.7 foot negative at a displacement of 11,800 tons.

83. It was not until the afternoon of 5 November when B-207-L, B-3 and C-416-E were pumped out that a sufficient amount of free surface was eliminated to restore positive GM to RENO. GM was then about 1.0 foot at a displacement of 11,100 tons.

84. With C-419-M, C-421-T, C-203-L and C-311-AL pumped out before arrival at Ulithi, GM had been increased to about 2.2 feet at a displacement of 10,700 tons. During the 700-mile voyage to Ulithi 1,100 tons of water were pumped overboard. All of the flooded compartments, however, were not dewatered until RENO was later docked in ABSD-2 at Manus.

85. There were reasons for suspecting a condition of negative GM soon after damage. The second deck was flooded from frame 77 to 110, a distance of 132 feet, destroying about 32 per cent of the waterplane area. As stated in FTP-170(B) paragraph 4-17:

> "Negative GM with unsymmetrical flooding ... The condition should be suspected if the list is out of all proportion to that indicated by the flooding effect diagram and if there is extensive free surface. If it is suspected, correction of list should be undertaken very cautiously but never by pumping from bottom tanks."

As mentioned above free surface was extensive. The flooding effect diagram indicates a list of 10 degrees by addition of all off-center flooding effects between frames 77 and 110. As all of these off-center tanks were fuel oil tanks, any listing moment must be due to the complete filling of these tanks. RENO was fueled the morning of 3 November; so it is reasonable to presume that most of these fuel oil tanks were nearly full. Reference (b) listed seven of these tanks as full, one about two-thirds full, two about half full and only one tank empty at the time of the torpedo hit. Therefore, off-center weight that could be added by the complete flooding of these fuel oil tanks was very limited. By the criteria mentioned above, negative GM could have been suspected by 0300, 4 November, when the list had progressively increased to 16 degrees port in spite of efforts to remove the list by pumping overboard 160 tons of fuel oil from port tanks and transferring 25 tons of water from port to starboard tanks. The lurch from port to starboard during the morning of 4 November was definite proof of negative GM. In this connection the following from FTP-170(B) is quoted:

> "4-16. Symmetrical flooding but GM negative after damage ... Efforts to remove such a list by pumping liquids overboard or from one tank to another or by counterflooding will result in an approach toward the upright in a normal fashion until at some angle short of the upright position the ship will suddenly lurch to a larger angle on the opposite side."

This removal of list is extremely dangerous because if during the lurch the ship builds up more dynamical energy than the reserve of dynamical

stability in the damaged condition, capsizing will result. This was the case with ERIE (PG50)* which capsized under circumstances of negative GM and small reserve of dynamical stability.

86. The Commander-in-Chief, U.S. Pacific Fleet, in his endorsement, reference (c), on RENO's action report, reference (a), stated:

> "The following comments are offered:
>
> "(a) The ship was undoubtedly in a condition of negative stability described accurately by paragraphs 4-16 and 4-17 of FTP-170(B).
>
> "(b) Apparently the ship's force failed to recognize the condition of negative stability and in their efforts to correct the list took steps specifically warned against by FTP-170(B).
>
> "(c) As a result of the steps taken to correct list the ship lurched from 7 degrees port to 20 degrees starboard and the fact that the ship was unstable in the upright position became apparent."

F. Damage Control Notes

87. U.S. Naval vessels are designed with a high degree of watertight integrity to limit flooding after underwater damage. In any condition other than General Quarters, watertight integrity must be sacrificed to provide accessibility and ventilation. Unfortunately, Material Condition BAKER on RENO did not provide a very high degree of watertight integrity. Watertight doors which were open on the second deck went under immediately after damage was received, and extensive flooding on this deck was the inevitable result.

88. If the second deck doors had been closed, the flooding forward would have stopped at bulkhead 77. The frame of door 2-103-2 was warped so that it could not be closed. However, had this door been closed when the torpedo hit, it might have deformed with the frame and bulkhead and permitted only minor leakage. If the flooding aft could have been stopped at bulkhead 103, eliminating the large free surfaces in C-203-L and C-311-AL, RENO would have maintained positive initial stability. Also, there is a possibility that if the doors 2-88-1 and 2-88-2 had been closed, they might have remained closed and slowed the flooding of B-207-L to such an extent that it could have been controlled. There are many instances in war damage experience of closed doors deforming with the bulkheads and yet remaining reasonably tight. However, once a deformed door is opened, it usually has proved impossible to make it reasonably watertight again except where circumstances have permitted shoring.

89. Hatch 2-104 was closed after damage was received but leaked permitting partial flooding of C-311-AL from C-203-L. On the second platform flooding progressed through doors between magazines although the structural damage sustained on this level aft of frame 96 was minor. Flooding blocked access to these spaces, preventing checking the closures for leaks and tightening as necessary to stop them. These examples illustrate the fact that all openings in watertight boundaries even when closed are a threat to the watertight integrity of the vessel. The elimination of such openings measurably improves the ability of a vessel to survive after damage.

90. It cannot be overemphasized that the ability of any ship to absorb underwater damage is proportional to the degree of watertight integrity in effect when damage is received. As an illustration, NEW ORLEANS (CA32)** survived after the loss of 150 feet of her bow, while INDIANAPOLIS

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* BuShips War Damage Report No. 31
** BuShips War Damage Report No. 38

(CA35) capsized and plunged within 15 minutes after damage which resulted in about the same initial trim by the bow. One of the major reasons why NEW ORLEANS survived and INDIANAPOLIS sank so rapidly was the difference in degree of watertight integrity in effect. NEW ORLEANS was at General Quarters and flooding aft was stopped at the first intact bulkhead. INDIANAPOLIS was in Modified Condition YOKE with watertight doors on the second deck open permitting flooding to progress aft rapidly and destroy all stability characteristics as well as reserve buoyancy.

G. Miscellaneous Comments

91. The Commanding Officer, in reference (b) made several recommendations which are briefly discussed below.

> (a) "It is recommended that 4" gasoline pumps be allowed this class of vessel ..."

Four Model P-500 pumps have been added to the allowance list. These are gasoline engine driven centrifugal pumps rated to deliver 500 gpm at a discharge head of 100 psi when operating with a suction lift of 15 feet.

> (b) "The number of electric, portable, submersible pumps should be increased from eight allowed this vessel to twelve."

The portable electric submersible pump has proved invaluable in controlling flooding in damaged ships. The Bureau has reviewed the allowance of portable pumps and considers that the present allowance of eight is adequate with the addition of the four P-500 pumps.

> (c) "The J-type portable hand lantern proved invaluable... but experience has proved the inadvisability of stowing all spare batteries and bulbs in one storeroom."

The Bureau concurs that it is inadvisable to store all spare batteries and bulbs in one storeroom.

> (d) "The amount of shoring allowed this vessel should be increased by one hundred per cent ..."

The allowance has been doubled and stowage provided for same. The necessity for weight compensation has resulted in receiving requests from some ships of this class to reduce the allowance to the original amount.

> (e) "It is recommended that the sprinkling control stations for the forward and after groups of magazines be located topside. This may be in addition to the sprinkling control valves located in A-411-C (I.C. room) for the forward group and C-405-E (after gyro room) for the after group."

Flooding of the second deck made it impossible to sprinkle the magazines. The surrounding of the magazines by damage water which made it impossible to sprinkle the magazines also made it unnecessary to do so. The correct decision of when to sprinkle the magazines is often one of the most difficult to make. The fire-alarm board on RENO erroneously indicated overheating of all after magazines immediately after damage. However, sprinkling of RENO's magazines would have been unwise as the ship needed all the buoyancy aft and stability that were possible to conserve; both of which would have been adversely affected by sprinkling. All the after magazines did progressively flood, but it could not have been known at the time of damage that sprinkling

would make no difference in the extent of flooding. On cruisers designed since the beginning of the war the sprinkling control stations for the forward and after groups of magazines have been located on the damage control deck where they are convenient to the repair parties. This appears to be about the best location possible as a topside sprinkling control station is very vulnerable to surface attack and fires. Had the magazine sprinkling control station on RENO been located on the second deck in accordance with present policy, it might have remained operative and accessible after damage was received. The added weight and complication of the magazine sprinkling system by an additional control station does not appear justified on a ship as small as RENO.

(f) "All compartments below the main deck except engineering spaces, should be divided by fore and aft watertight bulkheads."

Longitudinal bulkheads would help limit the extent of transverse flooding, but only by increasing off-center flooding. Greater angles of list after damage would result in spite of a reduction in free surface area. If the off-center flooding of RENO had been increased by the installation of longitudinal bulkheads with larger angles of list resulting, RENO probably would have capsized. Design features which limit list after damage are carefully built into naval ships. It is noted that all off-center flooding on RENO, except flooding of passage B-206-4L, was due to complete flooding of fuel oil tanks. As most of these tanks were at least partly full, the listing moment was relatively small.

(g) "If quick-acting doors are to be retained they must be of a more rugged construction than those installed on this type of vessel. There were too many cases of doors and door frame distortion."

The Bureau is engaged in a study to increase the blast resistance of doors. Quick-acting doors are considered essential to facilitate access. Also, the necessity of weight control by limiting the amount of material that can be used makes design of a door with satisfactory blast-resistant qualities most difficult. War experience has shown that any door in a watertight bulkhead is a possible source of trouble. The most certain way of eliminating this trouble is to eliminate the door. In RENO all doors between magazines leaked even when their distance from the point of detonation was so great that it is unlikely that they were subjected to blast. RENO was designed before the war and therefore without the benefit of war experience. On later designs doors in main transverse bulkheads below the damage control deck have been eliminated wherever possible with a measurable improvement in the watertight integrity. As stated in paragraph 88, war experience has been that once closed and properly dogged, doors frequently remain reasonably tight even though the door frame and bulkhead are deformed by damage, but that when opened after damage these doors usually cannot be closed again except where circumstances permit shoring. To stiffen the door frame so that its door can be closed readily after the bulkhead has been deformed by blast would probably require a prohibitive amount of additional weight.

(h) "Ventilation for below decks spaces should be increased generally..."

Many ventilation alterations on RENO have subsequently been accomplished. It is considered that ventilation on RENO is now equal to that of other naval vessels.

(i) "An auxiliary system of steering control independent of electrical circuits should be accomplished."

Dual, submersible, emergency steering gear equipment has since been installed in the steering gear space. The unit is connected to the

main hydraulic steering gear piping and arranged to be operated by normal, emergency, or casualty power from within or outside the space and manually from outside the space. Hand-operated emergency steering and rudder positioning equipment has been installed for use manually from within the space.

(j) "It is recommended that the boat davit housings be redesigned and built inside of the skin of the ship."

The original boat davit design was an effort to obtain a satisfactory davit with the least possible weight. Additional experience has emphasized the importance of clear sides for coming alongside other ships.

A ShipAlt has been issued to install pedestal type davits inboard of the shell.

H. Conclusion

92. The Commander-in-Chief, U.S. Pacific Fleet in his endorsement, reference (c), on RENO's action report, reference (a), stated:

"Nothing in the above can detract from the fact that the ship was saved by the courage, perseverance and determination of her Captain, officers, and crew."

Faced with a demonstrated critical stability condition, as stated before, the thought of abandoning RENO was never entertained. Perhaps this is the most important lesson of damage control.