U.S.S. CHESTER (CA27)
Torpedo Damage
Solomon Islands
20 October, 1942

U.S.S. MINNEAPOLIS (CA36)
Torpedo Damage
Battle of Lunga Point
30 November, 1942

	USS CHESTER	USS MINNEAPOLIS
Class.....	Heavy Cruiser	Heavy Cruiser
Launched.....	3 July, 1929	6 September, 1933
Displacement (standard).....	10,000 Tons	10,000 Tons
Length (O.A.).....	600'-3"	588'-0"
Beam (O.A.).....	66'-1"	61'-9"
Draft (Designed).....	19'-8"	21'-7"

U.S.S. CHESTER

References:
(a) C.O. CHESTER CA27/A9/A16-3/(057) of 27 October, 1942, Report on Torpedo Hit.
(b) C.O. CHESTER CA27/A9/L11-1/(058) of 28 October, 1942, War Damage Report.
(c) C.O. CHESTER CA27/A9/L11-1/(079) of 23 November, 1942, Repairs.
(d) C.O. CHESTER CA27/A9/L11-1/(085) of 11 December, 1942, War Damage Report.
(e) Comdt. N.Y. Norfolk CA27/L11(2-MDH)3321 of 10 June 1943, War Damage Report.

U.S.S. MINNEAPOLIS

References:
(f) C.O. MINNEAPOLIS CA36/A9/L11-1(00106) of 15 March, 1943, War Damage and Damage Control Measures.
(g) C.O. MINNEAPOLIS CA36/A16-3(0247) of 6 December, 1942, Action Report.
(h) Comdt. N.Y. Pearl C-L11-1/CA/NY10(Y-01326) of 2 July, 1943, War Damage Report.

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SECTION I - FOREWORD

1. CHESTER and MINNEAPOLIS were each damaged by one torpedo striking the shell below the side armor and in way of the machinery spaces. In addition, MINNEAPOLIS was struck on the bow by a second torpedo. The similarity of the damage amidships and the fact that the two cases, when considered together, present a fairly complete picture of the effects on heavy cruisers of single torpedo detonations in the middle body below the armor belt, indicated the desirability of issuing a combined report rather than a separate report for each vessel.

2. Both cases also present, for cruiser-type vessels, what can be considered as typical engineering conditions likely to be encountered when a single torpedo hits in the machinery spaces. The manner in which the engineering personnel of each vessel handled the situation and kept the remaining portions of the machinery plant in operation is of considerable interest. The engineering history of each vessel therefore has been given in some detail.

3. The war damage reports submitted by each vessel and the supplementary reports prepared by the yards at which final repairs were made were unusually complete. The photographs of damage to CHESTER were furnished by the ship and the Navy Yard, Norfolk. The photographs of damage to MINNEAPOLIS were furnished by the ship and the Navy Yard, Pearl Harbor. The plates were prepared by the Bureau from plans supplied by the two yards.

SECTION II - SUMMARY

A. CHESTER

4. USS CHESTER was torpedoed on the night of 20 October, 1942. The torpedo, fired from an enemy submarine, struck and detonated on the starboard side in way of the forward engine room.

5. The resulting damage to the hull and machinery was extensive. The shock effect was considerable although not extreme. Flexural vibration was moderate. The forward engine room and No. 3 fireroom and the wing tanks in way of these spaces were opened to the sea. Slow flooding in No. 4 fireroom occurred through the shaft tube glands at bulkhead 83. Slow flooding also occurred in the after engine room through various pipe lines to the forward machinery spaces. Flooding in these two latter spaces was controlled. The main steam lines were broken at the slip joints at bulkhead 76. This eliminated the two forward firerooms as a source of steam for the after engine room. Boiler pressure in No. 4 fireroom was lost temporarily as a result of steam escaping through ruptured main steam lines forward before the proper valves could be closed. Thus, all power was lost until boilers 7 and 8 could be lit off again and pressure built up.

6. After emergency repairs at Espiritu Santo CHESTER proceeded to Sydney, Australia, arriving there on 23 October. Additional temporary repairs were made at Sydney and CHESTER then proceeded to the Navy Yard, Norfolk where permanent repairs, together with authorized alterations, have been completed (photo 27).

7. Although the hull of CHESTER absorbed the effects of structural damage and flooding in a satisfactory manner, complete loss of propulsive and electrical power was narrowly avoided. This could have occurred easily had the engineering force been less vigilant. Pipe lines constituted an unnecessary source of difficulty in that they permitted considerable leakage into the after engine room from the forward engine room and No. 3 fireroom. Some of these lines were open because they were not provided with the valves necessary to permit separation of the various spaces. Other lines were open because of the operational set-up of the machinery plant. A number of piping alterations have been completed on CHESTER, and authorized for the other vessels of the class, which will correct, in large part, the design defects noted.

B. MINNEAPOLIS

8. At 2327 on 30 November, 1942 MINNEAPOLIS, while participating in the battle of Lunga Point, was struck on the port side by two torpedoes. Both detonated almost simultaneously. One hit just forward of No. I turret and the other in way of No. 2 fireroom.

9. As a result of the forward hit, the bow structure forward of frame 20 was almost severed although it remained with the hull, hanging down at a sharp angle, until removed at Tulagi. Gasoline, which was blown up from ruptured stowage tanks in the bow, drenched the forward part of the ship. Vapors from this gasoline ignited instantly and burned violently for a few minutes. Fortunately the fire was extinguished in a few minutes by the geyser of water accompanying the explosion and washing over the forecastle, and by the prompt action of the firefighting party.

10. The hit in way of No. 2 fireroom tore a large hole in the shell and inner bulkhead of the wing tanks. The three forward firerooms were opened to the sea and these flooded immediately.

11. Steam pressure dropped rapidly and the ship slowed to a stop. Steering control was lost momentarily. Effective work by engineering personnel quickly restored steam pressure in No. 4 fireroom. MINNEAPOLIS was then able to go ahead slowly. A five degree list to port was assumed gradually. The vessel went down by the head some 12 feet at frame 20.

12. Immediately after damage MINNEAPOLIS turned toward Lunga Point. The Commanding Officer intended to beach the vessel if such a step was required to prevent sinking. While en route to Lunga Point inspection of damage revealed that MINNEAPOLIS was not in serious danger of sinking. The course was changed then for Tulagi. MINNEAPOLIS arrived at Tulagi about 0900 on 1 December where the ship was moored to palm trees and stumps.

13. In Tulagi bulkheads were shored, the bow forward of about frame 20 was removed and the vessel placed in condition for the passage to Espiritu Santo. Temporary repairs were made by the ship's force with the assistance of a Construction Battalion based ashore and ORTOLAN. On 5 December a gasoline vapor explosion occurred forward resulting in the loss of some seven feet of hard-won freeboard forward.

14. MINNEAPOLIS departed Tulagi on 12 December and arrived at Espiritu Santo on 16 December. After additional temporary repairs MINNEAPOLIS, in company with other vessels, departed on 7 January, 1943 for the Navy Yard, Pearl Harbor. Boiler tube failures in Nos. 7 and 8 boilers caused the loss of propulsive power some 20 hours after leaving Espiritu Santo. VIREO took her in tow and returned her to Espiritu Santo where the two boilers were partially retubed by RIGEL. She then got under way on 12 February, arriving at Pearl Harbor on 2 March. She was placed in drydock at Pearl Harbor on 6 March and permanent structural repairs were completed there. She then proceeded to the Navy Yard, Mare Island via Navy Yard, Puget Sound, arriving on 22 April. At Mare Island the new bow section installed at Pearl Harbor was completely fitted out and firerooms Nos. 1, 2 and 3 were re-boilered. MINNEAPOLIS returned to service on 9 September, 1943, (Photo 28).

15. To date MINNEAPOLIS has been the only U.S. cruiser to survive two torpedo hits. This, in itself, was a noteworthy achievement and was made possible by the prompt and effective damage control measures taken by the crew. The hazard of carrying gasoline was plainly demonstrated again, although no vapor explosion occurred during the hours immediately following the action. The gasoline fire which followed immediately after the detonation did not have particularly serious effects other than the embarrassment caused by illuminating the area of action.

16. The destruction of the bow was inevitable under the circumstances of a torpedo detonation in the narrow forward portion of the hull where the ship girder, because of the narrow beam, is apt to be almost completely destroyed. The machinery arrangement with four firerooms forward followed by two engine rooms does not permit a physical separation of the plant into two independent units. At the time of damage, however, each propulsive unit was being supplied with steam from a separate fireroom. It was largely because of this fact that steam was quickly available from No. 4 fireroom. Had the steam lines been cross-connected in the firerooms the situation would have been much more difficult.

17. The advantages of two completely independent propulsive units have long been recognized, and all cruiser type

vessels of recent design now have machinery plants so arranged. During the repair period a number of changes were made in the layout of drains and cross-connections which will permit a more complete operational separation of the plant than was possible formerly.

III - NARRATIVE

A. CHESTER

(Plate I, Photos 1 through 14)

18. On the night of 20 October, 1942, a task force of which CHESTER was a unit, was in the area between the New Hebrides and the Solomon Islands, about 230 miles west-southwest of Espiritu Santo. The weather was calm and clear. The moon, only four days from full, was working out from behind a partial cumulus overcast. The surface visibility was good. CHESTER, third in a column of three cruisers, was steaming southeast at 19 knots. The formation was screened by four destroyers and was zig-zagging. The ship was in condition of readiness II, material condition YOKE, with the engineering plant in condition ZED and boilers 1, 2, 7 and 8 in use. Boilers 3, 4, 5 and 6 were hot, but the firerooms had been secured and the crews had gone topside to stand by shortly after 2100. Main steam line stops at bulkhead 76 were closed to split the plant, but complete separation was not in effect as only one feed pump was operating and the feed heater drain line was open between the two engine rooms. Two planes were on board with gas tanks filled. In order to permit jettisoning quickly, the wings of both planes were folded back and the cars were in the launching position with the catapults trained out.

19. At 2120 CHESTER was struck at frame 73 in way of the forward engine room by a torpedo from the starboard quarter; a second torpedo was seen to pass ahead and broach on the port bow. The immediate effect of the hit was to cause a sharp upward heave and a heavy roll to port followed by a low frequency whipping motion of sufficient amplitude at the bow to throw officers' bunk springs and mattresses together with occupants clear of the bunks. The noise of the detonation was loud but dull. There was no noticeable flash or flame and no fires resulted from the explosion. The absence of fire was particularly fortunate as the whipping motion following the hit had ruptured gasoline tanks on both airplanes and had dumped the port plane off the catapult car and over on its side. The starboard plane was catapulted as soon as the wings, which had been torn loose by the explosion, were lashed back. The port plane was broken up in order to get it over the side.

20. All power was lost temporarily and the ship swung to starboard. Within a few minutes, the ship listed to starboard three degrees. Fires had died out in firerooms 7 and 8 (see paragraph 35) but by 2245 steam was raised on boilers 7 and 8 and the ship went ahead.

21. The detonation of the torpedo wrecked the starboard side of the forward engine room and the forward starboard corner of No. 3 fireroom (plate I, photos 1 and 2). The rupture in the hull extended between frames 67 and 79 longitudinally and spanned strakes "D", "E" and "F" vertically. It formed an irregular opening somewhat the shape of a large "T" with a 48-foot cross along the lower edge of the armor belt and a 25 foot leg centered at frame 73. The upper and lower (2-1/4-inch) strakes of STS side armor were blown loose between frames 66 and 88. One STS plate in the upper strake between frames 68 and 74 was blown off. The hull was dished inboard in an area surrounding the "T" shaped rupture.

22. Small wrinkles in the "A" strake on both sides of the keel at frame 69 and also at frame 80 (plate I) occurred as a result of flexural vibration. The vertical keel suffered only minor deflection.

23. The rupture in the inner hull (plate I) was considerably larger in area than that of the outer hull. The tear resembled a large "U" in outline with upper legs at frames 68 and 78, each at the level of the second deck and with the base at frame 72 at the double bottom. Rivets joining the inner bottom stringer angle to the second deck were sheared and the inner bottom was blown inboard against and over machinery in the forward engine room. The starboard one-third of bulkhead 76, No. 1 shaft and No. 3 fireroom starboard airlock were all jammed against the starboard forward corner of No. 5 boiler. The shaft dented the starboard mud drum of No. 5 boiler about four inches.

24. The second deck (1-inch STS) was reported to have been blown upward a maximum of about two feet immediately over the center of the explosion and then to have settled in a somewhat warped condition to its original level. The amplitude of the distortion of the deck in its final position varied from ten inches at the shell to zero at the centerline.

25. The starboard one-third of bulkhead 76, as noted in paragraph 23, was demolished (photo 8). The remainder of this bulkhead below the second deck was deeply wrinkled between stiffeners and the latter were bent and distorted. Bulkhead 64 was sprung and buckled slightly between the main and second decks. Below the second deck this bulkhead was subjected to a water head for a period of 29 days due to flooding of the forward engine room. It was shored from No. 2 fireroom (photo 13) but there was some deformation of plating between stiffeners. There was some weeping at countersunk rivets. Bulkhead 83 also was subjected to a pressure head from the flooding of No. 3 fireroom. The ship's forward motion when underway increased the pressure against this bulkhead. There was considerable deformation of plates between stiffeners. The bolts securing the two flanges of the starboard outboard shaft (No. 1 shaft) coupling in No. 3 fireroom pulled through the forward flange (photo 9). The shaft gland in bulkhead 83 abaft this flange was damaged

slightly by the initial distortion of the shaft. Some three hours later, however, as described in paragraph 26, this shaft commenced to rotate and slipped aft causing additional damage to the shaft gland and the soft patch in the bulkhead. This caused a considerable increase in the rate of leakage into No. 4 fireroom. Thus, the delay in securing No. 1 shaft almost caused the complete and permanent loss of propulsive power as a result of subsequent flooding (operating personnel did not know the shaft was broken, inasmuch as the break was in the flooded No. 3 fireroom).

26. A number of frames and longitudinals were damaged to a varying extent. Transverse web frames 67, 70, 73 and 76 between the main and second decks were distorted. All second deck longitudinals on the starboard side over the forward engine room abaft frame 68 were either destroyed or forced to port. The 24-inch centerline girder in the forward engine room (photo 6) was deflected to port between frames 72 and 76. The 12-inch pipe stanchion on the centerline at frame 72 was flattened for about three feet of its length by the impact of the starboard condenser squeezing it against the port condenser (photo 5). The vertical keel in way of the damaged area was slightly distorted.

27. Practically all the machinery on the starboard side of the forward engine room was wrecked completely. The reduction gear (photo 3) was moved to port 32 inches and rotated through a 15 degree arc about the inboard pinion as an axis. The starboard high and low pressure turbines (photo 4) were carried away from their foundations and thrown to port several feet. The starboard cruising turbine and bull gear were forced upward and to port about 20 inches. The starboard main condenser saddle carrying the condenser with it was moved forward 11 inches and to port some 12 inches at the after end and 20 inches at the forward end (photo 5). This forced it hard up against the port condenser. Auxiliary machinery in this vicinity was similarly damaged.

28. No. 5 boiler (photo 8) was unseated from its saddle and forced aft eight inches and to port about 12 inches at the forward end and 6 inches at the after end. No. 5 forced draft blower foundation was forced 6 inches to port. Pumps, compressors, piping and other fireroom auxiliary units in this vicinity were also moved from their foundations and badly damaged.

29. Both main steam lines (photo 7) were broken at bulkhead 76. This resulted in the loss of steam from the forward firerooms. Branch steam lines to Nos. 5 and 6 boilers were broken. These boilers were immediately made inoperative by damage and flooding. Drain lines along the starboard side between the feed tank in the forward engine room and the one in the after engine room were ruptured. This caused contamination of the feed water as well as flooding into the after engine room from the hot well which overflowed.

30. The fire main was ruptured at the first flange forward of bulkhead 76 on the starboard side. The reach rod to the second deck for remote operation of the cut-off valve at bulkhead 76 was jammed so that local operation of the valve was necessary.

31. The main drain line was intact but was inoperable forward of bulkhead 83 until drydocking because of the inaccessibility of valves in flooded machinery spaces.

32. The starboard fuel oil transfer line was carried away between frames 66 and 78 and the port line was inoperable because of the inaccessibility of valves in the flooded spaces. A four-inch fuel oil hose was used as a jumper between weather deck connections at frames 50 and 92 to transfer fuel oil from intact forward tanks to the after service tanks.

33. Miscellaneous damage resulting from shock was as follows:

(a) The CXAM radar antenna frame was bent, (photo 1).

(b) The forward main battery FC radar antenna foundation was fractured, carrying away the wiring at the base.

(c) The starboard 24-inch signal searchlight was knocked from its base but was prevented from falling overboard by wiring and the platform railing.

(d) The seams of the gasoline tanks of both planes were split and gasoline spilled out and ran over the main deck.

34. The immediate effect of the damage was to immobilize the forward engine room and No. 3 fireroom because of damage and flooding from the sea. The rupture of the main steam lines at bulkhead 76 caused loss of steam to the after engine room (see paragraph 35 for details). No. 4 fireroom flooded slowly through the damaged glands of both No. 1 and No. 4 shafts in bulkhead 83. The after engine room started to flood at a rate of about 20,000 gallons per hour through the stern tube gland, the packing of which had been partially carried away by shock transmitted through No. 1 shaft, and the considerable overflow from the hotwell and fresh and salt water funnel drains. The hotwell overflowed because the equalizing and feed heater drain lines, by which it was connected to the hotwell in the forward engine room, were ruptured in way of the torpedo detonation and thus permitted salt water from the sea to flood the tank. There was negligible leakage through cable fittings in bulkheads. Flooding caused a starboard list of about three degrees.

35. The loss of steam caused the after engines to stop. Steering control was lost temporarily. No auxiliary battery power was available immediately because of shorted leads in the flooded spaces. The loss of steam also caused the fuel oil service pumps to stop which resulted in the fires dying out in Nos. 7 and 8 boilers. It was imperative that steam be raised as quickly as possible as the ship was without power for pumps and water in the after engine room and No. 4 fireroom was approaching the level of the floor plates. Bulkhead steam stops were closed to isolate the lines forward. The fuel oil service pumps were turned over by hand, allowing oil to flow by gravity from the service tanks through the burners onto the furnace floor. The air lock to No. 4 fireroom was opened and the oil was lit off under the hot boilers

without forced draft or atomized oil. Just as soon as sufficient steam was available, power was restored and the ship went ahead, gradually working up to eight knots. The flooding in the after engine room was controlled by the fire and bilge pumps and electric submersible pumps. Water ballast was pumped out of B-905 to correct the list.

36. At about 0101, 21 October, No. 1 shaft commenced to revolve and slipped aft. The shaft flange pulled up hard against the soft patch through which the shaft passes in bulkhead 83 (photo 9) and caused a large increase in the amount of water leaking through the gland into No. 4 fireroom. The ship was stopped and the rate of flow was reduced somewhat by wrapping toweling, blankets and life jackets around the shaft and then binding them with manila line. This makeshift packing was then backed up by a three-inch angle and 4" by 4" timber shores. The leakage into No. 4 fireroom increased and despite the fact that the two bilge pumps were pumping from this space the water continued to rise. (Reference (a) reported that the rate of leakage was about 20,000 gallons per hour, however, it is apparent that it must have been greater as the available pumping capacity could have handled this quantity easily). By 0200 the water had almost reached the floor of No. 7 boiler and it was necessary to secure that boiler. At about this time the boiler repair party succeeded in cutting a hole in the suction line of the fuel oil booster pump below the floor plates and by the use of this additional pump flooding was controlled just a few minutes before it would have been necessary to secure No. 8 boiler. At 0450, No. 7 boiler was cut in again.

37. Although flooding was finally brought under control, it was essential that No. 1 shaft be secured against further movement before getting under way again. Two measures were taken to accomplish this. First, a chain was passed around the propeller, the hub of which was approximately 18 feet under water. Several attempts were made to pass the chain using shallow water diving equipment but these were unsuccessful. It was finally passed around the propeller by diving without the use of diving equipment. Two turns of a 3/4-inch chain were passed in a figure-of-eight about the lower blade and the cone. The ends of the chain were shackled to the eyes of a 1-5/8-inch steel cable which was hauled taut by means of a chain fall and secured to bitts on the main deck through a chock at frame 118. The second measure was to weld some 3" by 3" angles to the shaft, with ends butting against the forward and after faces of spring bearings and to parts of the ship's structure and boiler foundations. At 0526 this work was completed and the ship went ahead at 7 knots.

38. At 1352 trouble was experienced with priming of the boilers, the feed system having been contaminated through the ruptured feed heater drain lines previously mentioned. It was necessary to slow to 2 knots, but by 1738 speed was increased to 7.5 knots, which was considered the maximum permissible for the forward bulkhead of No. 4 fireroom. Espiritu Santo was reached without further incident at 0838, 23 October, and there temporary repairs were undertaken to render the ship as seaworthy as possible.

39. The leakage into No. 4 fireroom through the glands of shafts No. 1 and No. 4 was the most critical factor because of its menace to the only remaining source of steam for the after main engines. After several unsuccessful attempts, a diver from NAVAJO was able to reach these glands on the flooded side and by drifting shredded kapok into the leaks reduced them sufficiently to permit welding operations on the No. 4 fireroom side. A cofferdam (photo 10) was then constructed around No. 1 shaft utilizing the bulkhead and adjacent bulkhead stiffeners with a welded plate cut to give a snug fit around the shaft. No. 4 shaft gland was secured by welding a ring in place.

40. The detonation had opened the connection between the second deck and shell for a considerable length. This was dangerous, as, in a rough sea, the second deck would be exposed to flooding. Considerable working between the deck and shell had occurred in the passage to Espiritu Santo. It was thus of considerable importance to close this opening. The manner in which this was done is of interest. Long 1-inch bolts were inserted in as many of the second deck stringer angle and shell rivet holes as could be aligned. By means of these bolts and chain falls the shell was pulled back to within three inches of the deck edge. Wooden blocks and wedges were then inserted and driven into the remaining gap (photo 11). In order to complete the seal, a 10-pound gusset plate was welded at a 45 degree angle between the deck and the shell and six temporary frames were installed (photo 12).

41. A ruptured seam in the second deck at frame 69 was reinforced by welding two 3" by 8" channel strongbacks across the rupture. Six 3-1/2-inch pipe stanchions (photo 12) were installed by welding between the second deck and a main deck longitudinal. The buckled portion of bulkhead 76 above the second deck, including a watertight door, was cut away and replaced by a 10-pound welded plate to restore the watertight integrity of this bulkhead.

42. The watertight boundaries, bulkheads 64 and 83, were subjected to a considerable pressure head from flooding. The pressure caused a reported maximum deflection of about two inches between stiffeners, and caused some countersunk rivets to weep. Both bulkheads were shored. In No. 4 fireroom the after flanges of the stiffeners on bulkhead 83 served as convenient support for wedging horizontal reinforcing members of 4" by 4" timber as shown in photo 14. In addition to these, some 3" by 4" steel angles were welded diagonally between the centerline bulkhead stiffener and the centerline girder under the second deck.

43. The shoring of bulkhead 64 presented a more difficult problem due to the congestion of auxiliary machinery and piping. The shoring was divided into upper and lower courses. The former was braced against blower foundations and second deck longitudinals, and the latter against the main injection sea chest, boiler foundations and mud drums. Part of the upper course of shoring on this bulkhead is shown in photo 13.

44. Inasmuch as the main drain line was inoperative forward of No. 4 fireroom it was considered necessary to increase

the ship's portable pumping capacity. For this purpose one 6-inch and three 3-inch diesel driven pumps were borrowed from NAVAJO.

45. These measures enabled the vessel to ride safely through a moderate gale without further damage while en route to Sydney, Australia, where sufficient additional repairs were made to permit passage to the United States. The opening in the shell was closed by a temporary structure. Temporary steam lines (photos 3 and 4) were run to connect the Nos. 1 and 2 firerooms with No. 4 fireroom. Following these the ship returned to the United States for final repairs, arriving at Norfolk on 27 January, 1943. CHESTER returned to service on 15 August, 1943.

B. MINNEAPOLIS

(Plate II, Photos 15 through 26)

46. During the evening of 30 November, 1942 MINNEAPOLIS was the flagship and guide of a task force which was proceeding west at a speed of 20 knots along the north coast of Guadalcanal Island. A Japanese force was expected to attempt the reinforcement of enemy forces on the Island during the night and the U.S. force was directed to intercept the Japanese. The sea was calm, the wind was 10 knots from the east, and the sky was overcast.

47. The enemy force was detected by radar, bearing 290 degrees. Estimates of the enemy strength by the forces afloat place it as eight destroyers, of which six were probably acting as transports. At 2320 MINNEAPOLIS and other ships of the task force commenced firing to port. Although under fire from the enemy, MINNEAPOLIS did not receive any hits from gunfire.

48. At 2327* MINNEAPOLIS was struck by two torpedoes on the port side. These detonated almost simultaneously. NEW ORLEANS**, the second cruiser in the column, was struck by a torpedo some 20 to 30 seconds after MINNEAPOLIS. The Commanding Officer of the MINNEAPOLIS gave the opinion that these were surface torpedoes fired from destroyers or cruisers. This opinion is shared by most observers and by the various staffs who have analyzed this action. On MINNEAPOLIS one torpedo detonated at about frame 17, and the other below the armor belt at about frame 64, both on the port side. After the detonations MINNEAPOLIS' turrets were able to fire two additional salvos before loss of power forced her out of action. List reported was about 5 degrees to port.

49. No flash of flame directly attributable to the torpedo detonations was noticed. The forward torpedo ruptured the gasoline tanks in the hold between bulkheads 12 and 17-1/2 and gasoline was thrown up and over the forecastle in the

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* As logged by MINNEAPOLIS. The logs of other vessels present indicate the time as about four minutes earlier.
** BuShips War Damage Report No. 38.

vicinity of the hit. In addition, gasoline ran out on the surface of the water. The gasoline was ignited almost immediately and a severe fire burned briefly but violently. Smoke and flames created a huge torch. The column of water thrown up by the detonation of the torpedo deluged the forecastle and washed much of the burning gasoline over the side. Prompt action by the forward repair party extinguished all fires which remained after the ship drove clear of the pool of burning gasoline on the surface. Within seven or eight minutes all fires were extinguished.

50. The torpedo which struck at frame 64 completely wrecked boilers Nos. 1, 2, 3 and 4 and severely damaged boilers Nos. 5 and 6. The three forward firerooms were opened to the sea and flooding of these spaces was instantaneous. Steam from boilers Nos. 7 and 8 dropped in pressure to 200 pounds and the ship quickly lost way and stopped dead in the water. Within a few minutes, however, pressure on boilers Nos. 7 and 8 was restored to normal (300 pounds) and the ship went ahead at three to four knots.

51. Shock was appreciable but not extreme. In general, only a few items of machinery remote from the immediate vicinity of the damage were jarred out of alignment. Minor flexural vibration of the ship in the horizontal plane was noted and a definite shudder in the vertical plane was reported to have lasted for several seconds. The vessel seemed to rise upward at the bow and move to starboard. The detonations threw columns of water as high as the foretopmast, and water three to four feet deep washed over the main deck abaft the break in the forecastle.

52. The forward torpedo detonated about frame 17 in the vicinity of the first and second platforms. The bow structure (photo 15) was almost completely severed at frame 20. Forward of this point the bow structure was folded down at an angle of approximately 45 degrees. The bow did not carry away and had to be cut off at Tulagi. The upper starboard strakes and longitudinals provided the point of attachment for the remaining bow structure. The vertical keel was undamaged aft of frame 20-1/2. The outer flat keel at the centerline (photo 18) ripped off, shearing through the line of rivets at frame 22-1/2. Light metal bulkheads aft of frame 25 on the second, main and upper decks were somewhat distorted. Free flooding below the second platform extended back to bulkhead 30. Above the second platform bulkhead 23 remained tight up to the second deck. On the second deck flooding extended back to bulkhead 34, the first watertight bulkhead abaft the damage.

53. The torpedo which detonated at frame 65 apparently hit some 10 to 12 feet below the waterline, thus placing it well below the side armor. The resulting hole in the shell (photos 21 through 23) extended from frame 59 to frame 67 longitudinally and from the upper edge of "A" strake to the lower edge of "G" strake vertically. The wing tank longitudinal bulkheads with transverse floors, frames and longitudinals were carried away over approximately the same area as the damage to the shell. Forward and aft of the hole the shell was indented over a large area. One armor plate, frames 60 to 67. was blown off (photo 21).

54. The "A" strake was wrinkled and distorted from frame 58-1/2 to frame 68. Bulkhead 60 was demolished below the second deck on the port side of the centerline. It was wrinkled beyond the centerline to the starboard wing tank bulkhead. Bulkhead 67 was damaged almost as extensively as bulkhead 60. Bulkhead 53 was undamaged and bulkhead 74 was only slightly buckled. The second deck (2-1/4" STS) was deflected up over No. 2 fireroom approximately 2 feet. The distorted area extended from frames 55 to 68 and some 11 feet beyond the centerline to starboard. The second deck connection to the port shell, behind the armor belt, remained structurally intact although watertightness of the connection was destroyed. Above the second deck transverse and longitudinal watertight and non-watertight bulkheads were distorted and buckled as shown on plate II. The starboard longitudinal bulkhead bounding the uptakes remained intact. The ship went down by the head and the waterline in way of these spaces was well over the second deck level. Water then entered the area immediately over these firerooms through the boiler uptake and air intake openings and also through the shell connection on the second deck. All the port and centerline compartments on the second deck between bulkheads 53 to 74 were flooded to a depth of from three to five feet (plate II).

55. The 5" ammunition hoists on the port side at frames 67 and 63 were forced out of line and pushed up some eight inches through the main and upper decks. As a result, local buckling occurred in the main and upper deck plating in way of the hoists.

56. There was a slight longitudinal buckle between frames 68 and 63 on the main deck just outboard of the port bulkhead of the enclosure for the uptakes to Nos. 1 and 2 firerooms. On the upper deck some planking was split and the deck plating was wrinkled over a small area just forward of No. 3 5" gun.

57. At the time of damage, condition ZED was in effect throughout the machinery spaces and the plant was segregated for battle. The cross-connection stops in the main steam lines were closed so that each of the four main units was taking steam from separate firerooms. While definite information is not available as to the details of the separation, it is believed that No. 1 engine was taking steam from No. 1 fireroom; No. 2 engine from No. 4 fireroom; No. 3 engine from No. 3 fireroom and No. 4 engine from No. 2 fireroom. Feed heater drains, fresh water funnel drains and salt water drains were open and could not be segregated.

58. Damage to the machinery in the firerooms was extensive. Boilers 1 to 4 inclusive were completely wrecked. Boilers 5 and 6 in No. 3 fireroom were extensively damaged, but were salvageable. Boilers 7 and 8 suffered no initial damage, but long operation under the unfavorable circumstances of salt water feed made necessary considerable minor repairs and the replacement of tubes. The auxiliary machinery in Nos. 1, 2 and 3 firerooms was either lost through the opening in the hull, demolished by direct attack, or damaged beyond repair by long immersion. The main steam lines were badly bent and distorted in No. 2 fireroom. It was noted in the Commanding Officer's report that boiler

brickwork in both Nos. 3 and 4 firerooms withstood shock with very little distortion of the casings. In restoring MINNEAPOLIS to service, however, no brickwork was ultimately salvaged.

59. Immediately following the torpedo detonations the overload lights and buzzers on the main switchboards came on and general lighting went out. The auxiliary lighting circuits were energized from the forward and after batteries. The forward master gyro oscillated wildly. The relay-operated hand lanterns, presumably to be actuated by failure of the general and battle lighting circuits, did not illuminate, although the reasons for the failure were not reported. It is noted that this is the first instance reported to the Bureau of failure of these lanterns.

60. With the exception of two dead circuits to the flooded firerooms the sound-powered telephones remained in normal operation. The general electrical power failure caused all other telephones to go dead.

61. Immediately following the damage and with the immobilization of Nos. 1, 2 and 3 firerooms, Nos. 1, 3 and 4 main engines and Nos. 1 and 2 main generators located in No. 1 engine room stopped. The steam supply from No. 4 fireroom for No. 2 main engine dropped in pressure to 200 pounds. The cause of this drop in steam pressure was not reported, but it is a reasonable probability that it was due to a temporary loss of feed water. No. 2 main engine with its auxiliaries was stopped for a few minutes to allow pressure to be built up again in Nos. 7 and 8 boilers. Nos. 3 and 4 generators were also cut out. This was unquestionably the cause of the power failure to the turrets. No. 4 fireroom shifted to emergency feed suction and all burners on both of these boilers were cut in. The main steam stops in the engine rooms in the main steam lines to the Nos. 1, 2 and 3 firerooms were, of course, closed.

62. After steam pressure failed but before engine No. 4 came to rest, a slug of sea water entered the high pressure turbine through the main steam line to No. 2 fireroom. Sea water apparently had entered this line through damaged branch lines forward or at the cracked bulkhead connection at frame 67. A small leak in the superheated steam line in the forward engine room made the heat so intense that it had to be abandoned until blowers could be put in operation.

63. The feed heater drains for Nos. 1, 2 and 3 firerooms quickly contaminated the main feed tanks (hotwells) in both engine rooms before valves on these drains could be closed. The feed bottom (B-928-W) in No. 4 fireroom was also contaminated through open funnel drains from the forward firerooms. It is probable that a considerable quantity of feed water was lost through broken piping in No. 3 fireroom before the feed pump in the after engine room serving No. 3 fireroom could be stopped. Emergency feed was taken from D-927-W but this tank was soon dry. The cut-out valve on the funnel drain line in No. 4 fireroom was jammed and in a partially open position, and leakage via this line,

combined with that through bulkhead 74 (the forward bulkhead in No. 4 fireroom), eventually became greater than the fire and bilge pump in No. 4 fireroom could handle. The fire and bilge pumps in the forward and after engine rooms then were used to augment drainage of No. 4 fireroom. In the meantime, sea water was admitted into the main feed tank in the after engine room through the feed heater drains from the forward firerooms, and this water had to be fed to the boilers. Compound was injected into each boiler hourly and the bottom blows were opened every 15 minutes.

64. The situation, while steam pressure was being built up in Nos. 7 and 8 boilers, was thus critical. Nos. 1, 2 and 3 firerooms were flooded completely. Some 10 compartments on the second deck over these firerooms (as shown on plate II) were flooded up through boiler uptakes and the air supply intakes. The draft forward had increased to some 32 feet which put the waterline only a few feet below the level of the main deck. The vessel had a list of some five degrees to port. Before the ship came to a dead stop the wash of the sea, combined with the large geysers of water following the detonations, momentarily submerged the forward part of the ship. Oil was reported to have been blown out of the uptakes and air intakes from the damaged firerooms. The forecastle was bent down at an angle of about 45 degrees at frame 20. Water on the main deck extended back to bulkhead 34. When the ship stopped, water on the main deck drained out, most of it pouring out at the break. Some, however, went down the 1"1 ammunition hoist into handling room A-503-M. The small arms and bomb magazines in the hold forward had been flooded as a result of damage from the torpedo hit. The 40mm magazines on the second platform aft were flooded intentionally due to the fact that smoke was seen coming out of the ventilation ducts to these spaces. Bulkhead 74, between Nos. 3 and 4 firerooms, was leaking slightly. This then was the situation which confronted damage control and engineering department personnel.

65. When normal steam pressure on Nos. 7 and 8 boilers had been restored, Nos. 2 and 3 propulsive units were put back in operation and Nos. 3 and 4 main generators started and placed on the board. The ship then had interior lighting circuits in commission and auxiliary power. The forward engine room auxiliaries were started by taking steam from the No. 4 main steam line. The cross-connection between Nos. 1 and 4 main steam lines was secured when it was noted that the steam pressure dropped. By this time, the heat in the forward engine room (from the escaping superheated steam) had become so intense that this space was abandoned. In approximately two hours the blowers were put back into operation and this space reentered and the forward main engines started.

66. Emergency cables were rigged in order to supply power to portable submersible pumps forward and amidships. Suction was taken in the following spaces: No. 4 fireroom with the fire and bilge pumps; B-206-E on the second deck with a special gasoline-driven (4-inch suction) salvage pump; and three electrical pumps. The gasoline handy billy was used to unwater A-107-L. Two electric submersible pumps took

suction from the 1"1 ammunition hoist and another submersible pump was used in A-405-M. C-201-L was unwatered by bucket brigade.

67. To improve the list and trim, 96 tons of fuel oil was pumped overboard from four port fuel tanks. Twenty-nine tons of ballast water were removed from B-932-F and B-934-F. Ten tons of fuel oil were transferred from port to starboard tanks. During this period MINNEAPOLIS was heading for Tulagi where she arrived at about 0900 on 1 December. By the time she arrived the list had been reduced to two degrees. At Tulagi BOBOLINK came alongside and assisted pumping with a 6" suction line. Eight-inch projectiles and powder for No. 1 turret were jettisoned. The shoring of bulkheads and hatches was started and effectively completed. Topside weights were removed including port anchors and some eight fathoms of chain. All store rooms in the A section of the vessel were emptied and the stores were moved aft. Fire main jumpers were rigged to provide pressure on all forward plugs. At 1500 on 5 December, after considerable progress had been made toward improving trim and list, and while the bow wreckage was being cut away with a oxy-acetylene torch, a heavy vapor explosion occurred in compartment A-204-L. The watertight doors on the second deck in bulkheads 20 and 28 were blown off. Bulkhead 20-1/2 on the second deck was torn loose and split at the side. All furniture and equipment in A-204-L and A-206-L were badly wrecked. A-206-L was opened to the sea forward and A-307-L was flooded by water pouring down a damaged hatch. A-405-M, B-202-L, B-206-E, B-201-L, B-204-L and three drying rooms on the second deck, all previously emptied at great effort, were reflooded. Draft forward had been reduced to some 28 or 29 feet. After the explosion it was 36 feet, and from the standpoint of flooding and loss of buoyancy MINNEAPOLIS was in the worst condition since she had been torpedoed.

68. Salvage work was continued. ORTOLAN was called in to assist BOBOLINK and the second unwatering of flooded spaces undertaken in an expeditious manner.

69. Divers installed a temporary plate over missing door No. 2-28-2 and this made bulkhead No. 28 on the second deck sufficiently tight to permit pumping of A-206-L and A-307-L.

70. Additional chain (18 shots) was roused out from the chain locker; two shots were moved to D-308-L, two shots were moved to the fantail and the remainder was thrown over the side.

71. A four-foot coaming was welded around the starboard hatch to No. 1 fireroom. Welding of temporary plates and other repairs were continued to make compartments watertight. Considerable shoring was done. Empty 5-inch and 8-inch powder cans were stowed in A-204-L to maintain buoyancy in the event it reflooded. A cofferdam was constructed along the inboard bulkhead of B-202-L. A log breakwater (photo 16) of palm tree trunks was constructed between the main and upper decks at frame 20.

72. By 12 December, sufficient temporary repair and salvage work had been completed to allow MINNEAPOLIS to get under way for Espiritu Santo accompanied by NAVAJO and two destroyers. During the voyage to Espiritu Santo all shored bulkheads and decks held satisfactorily until about 1700 on 13 December when the action of the ship in the seaway caused the armored deck above No. 2 fireroom, port side, to commence working vertically. This resulted in excessive leakage along seams and around rivets. Additional shoring of this deck corrected the difficulty.

73. At about 1815 on 16 December MINNEAPOLIS moored alongside RIGEL at Espiritu Santo.

74. A large portable gasoline-driven centrifugal pump which had been originally intended for firefighting purposes proved invaluable. During the early stages of the damage control operations when power for the electric submersible pumps was often interrupted and before the arrival of BOBOLINK, this pump (1200 G.P.M. at a 20 foot lift) aided materially in controlling the flooding of the second deck compartments on the port side.

75. At Espiritu Santo repair units from BOBOLINK, ORTOLAN, RIGEL, VESTAL and DIXIE with a Construction Battalion assisted in making temporary repairs. The log bulkhead was removed and a new temporary bow structure (photo 17) was built of I-beams and channel bars, plated over from the upper deck to about three feet below the second deck. Above the waterline, this structure including the plating was welded and below the waterline it was bolted. Bolted plating and stiffeners were carried all the way to the keel. Power velocity tools were used for installing bolts below the waterline. A new bulkhead was constructed at frame 20-1/2. Wooden shoring in the second deck area (B-202-L) was replaced with metal I-beams. Doors to the uptake spaces were blanked off. Doubling plates were built along both the inboard and outboard bulkheads of B-202-L The inboard cofferdam which had been built by the ship's company at Tulagi was replaced by a stronger one, using heavier metal and more cement. Wooden shoring on the forward bulkhead of No. 4 fireroom was also replaced with metal shores. Cable ends on bulkhead 74 were boxed in.

76. By 4 January, 1943 MINNEAPOLIS was ready to proceed to Pearl Harbor but was held up to await corresponding readiness of PENSACOLA*. On 7 January, in company with PENSACOLA, VIREO and other escorts, MINNEAPOLIS departed Espiritu Santo for Pearl Harbor. Boiler tube failures caused by salting up forced the ship to drop out when about 185 miles out and return to Espiritu Santo in tow of VIREO.

77. Additional repair work including reconditioning and partial retubing of Nos. 7 and 8 boilers was done and on 10 February MINNEAPOLIS departed Espiritu Santo in company with two destroyers and the chartered tanker GULF QUEEN.

78. Navy Yard, Pearl Harbor was reached on 2 March and MINNEAPOLIS was drydocked on 8 March.

79. In general, the temporary repair work held up reasonably well during the passage to Pearl Harbor. The temporary stem remained in place although it buckled. The bolted plates

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* BuShips War Damage Report No. 35.

were lost, probably because of insufficient bolts and also because of the small size bolts used.

80. After permanent structural repairs were completed, MINNEAPOLIS proceeded to the Navy Yard, Puget Sound where No. I turret was removed for installation on NEW ORLEANS. She then proceeded to Navy Yard, Mare Island where the new bow section installed at Pearl Harbor was completely fitted out, firerooms Nos. 1, 2 and 3 were re-boilered and a new turret was installed. She returned to service on 9 September, 1943.

SECTION IV - DISCUSSION

A. Types of Torpedoes

81. The torpedo which struck CHESTER was undoubtedly fired from a submarine inasmuch as the firing vessel was not detected visually nor by radar. It struck at mid-depth some 10 to 12 feet below the waterline and below the armor belt. It is known that Japanese submarines of the larger size have employed two types of 21-inch torpedoes. The newer one of these has a warhead charge of 660 pounds of hexa while the older type contains only 450 pounds of explosive. Damage to CHESTER appears somewhat small for the larger type and therefore it is believed that the damage was inflicted by the smaller or 450 pound type of warhead.

82. Although the source of the torpedoes which struck MINNEAPOLIS has never been established definitely, most of the evidence points to the probability that these were fired by destroyers. Probably the torpedoes which struck MINNEAPOLIS were part of a salvo which also resulted in one hit on NEW ORLEANS*.

83. Damage to MINNEAPOLIS was somewhat greater than on CHESTER. Japanese destroyers are known to use both 21-inch and 24-inch torpedoes of which the former has a warhead charge of 660 pounds of hexa and the latter has a charge estimated to be in excess of 900 pounds. Judging by the damage it is probable that the 21-inch torpedo was used against MINNEAPOLIS.

B. Structural Damage

84. It will be noted from plate I that the rupture to the inner hull on CHESTER was larger than the rupture in the outer hull. This is somewhat unusual and has not been noted in other cases of similar damage to the middle body of cruisers. On MINNEAPOLIS, for example, rupture of inner and outer hulls was approximately equal in extent. The large hole in CHESTER's inner hull thus appears to have been an isolated case and one for which no explanation is readily apparent.

85. It is noted that both vessels lost an armor plate from the main belt directly above the point of impact, although the point of impact was some three or four feet deeper on MINNEAPOLIS than on CHESTER. A loss of one or two armor

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*BuShips War Damage Report No. 38.

plates from vessels with light armor in the event of torpedo damage is to be expected and is by no means an uncommon occurrence.

86. The second armored deck on both vessels was effective in restricting blast although the second deck on CHESTER is only 40-pound (1-inch) STS while that on MINNEAPOLIS is 90-pound (2-1/4-inch)STS. The armored decks on both vessels unquestionably prevented extensive topside damage. The depth of the hits on both vessels was an important factor in their ability to absorb the damage. In contrast, there was extensive topside damage to both PENSACOLA* and PORTLAND* because of the shallowness of the hits on these two vessels.

87. It is noted that liquid layer on both CHESTER and MINNEAPOLIS was effective in preventing fragment damage inasmuch as but one fragment, and that on CHESTER, was reported to have caused damage. In the case of CHESTER the engine room was inspected by representatives of the Bureau and the Norfolk Yard with the particular objective of searching for evidence of fragment attack on machinery and piping as well as structure. In cases where there is no liquid layer fragment attack is extensive. In view of the fact that the inspection revealed no evidence of general fragment attack, the one isolated fragment very probably came from the inner bottom rather than the shell and quite possibly resulted from the inner bottom striking some heavy object such as the reduction gear, and thus breaking off a fragment. A similar inspection was made in the firerooms of MINNEAPOLIS but after the boilers and other equipment had been removed. While wing tanks on vessels with no torpedo defense systems are to be kept filled to the waterline at all times, primarily for the purpose of reducing heel after damage, war experience and tests have demonstrated that a liquid layer four feet in thickness or greater will have a marked effect in reducing the velocity of fragments resulting from contact torpedo detonations against the shell.

88. The damage to the bow of MINNEAPOLIS is but one of several similar cases of torpedo damage to U.S. cruisers. On high-speed vessels with fine lines forward the beam and depth of girder are such that a torpedo detonation in the area adjacent to or forward of No. I turret will almost always result in the complete loss of the bow. Structural destruction will almost always so reduce the sectional modulus that the remaining effective structure will be inadequate to prevent loss of the portion forward of the region of damage.

89. Reduction of sectional modulus in way of the damage amidships on both vessels approached 30%. The remaining structure provided adequate longitudinal strength under the conditions of flooding, speed and weather subsequently encountered by both vessels.

90. It does not appear that damage from flexural vibration following the torpedo detonations was very serious in either case. This parallels other war experience of U.S. cruisers.

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*BuShips War Damage Report No. 35.

C. Machinery Notes

91. CHESTER's forward engine room and No. 3 fireroom were made useless by damage and flooding. Main steam lines were broken at the slip joints at bulkhead 76 thus preventing the after engine room from obtaining steam from Nos. 1 and 2 fire-rooms although the latter received no material damage. The main steam lines on this ship are straight and are provided with slip joints to take care of expansion. The main steam lines on MINNEAPOLIS are provided with long bends instead of slip joints to take care of expansion and probably for this reason they withstood the extensive distortion which occurred without rupture.

92. It is interesting to note that CHESTER's No. 5 boiler was practically demolished but No. 6 boiler remained intact and was found with a vacuum existing when it was inspected some days later.

93. The use of only one feed pump on CHESTER (it was not reported which was in operation) is open to question when steaming in waters where there is some possibility of under-water damage. Although the reason for the use of only one feed pump was not reported it appears improbable that this was done for reasons of economy inasmuch as the supply of fuel oil was about 73 percent of capacity. In this case immediately after damage the hotwell in the after engine room overflowed because of the open feed heater drain and the equalizing lines between the two hotwells in the two engine rooms. This permitted considerable flooding into the after engine room. In addition, open fresh water and salt water funnel drains also allowed some minor flooding into the after engine room bilges. The fresh water funnel drains could have been collapsed to shut off this source of leakage by crimping the piping inasmuch as it is copper.

94. In analyzing the damage to CHESTER it was found that the 4-1/2-inch feed heater drain line between the forward and after plants was not provided with bulkhead valves. A valve for damage control purposes has since been installed in this line abaft bulkhead 83 in No. 4 fireroom. It can be operated from each side of the bulkhead as desired. The fresh water funnel drains have been so altered that they will empty into double bottom tanks in each fireroom. It was found that some of these drain lines already had stop valves installed at bulkheads and these were not removed in performing the above alteration. Further, the salt water funnel drains have been blanked off so that they discharge into the bilges of the respective spaces. In order to provide an emergency source of fuel oil in the event of damage, the fuel oil booster pumps have been fitted with plug connections and suction lines in each fireroom. In addition, hand-operated fuel oil pumps have been installed. These alterations were completed on CHESTER and have been authorized for other vessels of the class as required.

95. At the time of the casualty CHESTER had no auxiliary source of electrical power except that from storage batteries located forward and aft of the machinery spaces. Shorted leads in the flooded spaces prevented utilization of power from the batteries. Hand lanterns were invaluable during the short time that CHESTER was without power. Since this action, two 100 KW diesel generators have been installed one forward and one aft of the machinery spaces, on all vessels of this class. Emergency leads and additional fuze boxes have been provided for these auxiliary units. Other

damage control improvements made to vessels of this class include a diesel-driven 1000 g.p.m. pump forward and two 300 g.p.m. electric-driven pumps, one forward and one aft. The number of portable electric submersible pumps of an improved type has been increased to 12. The fire main system has been altered and now forms a horizontal loop in the machinery spaces with a vertical loop both forward and aft of these spaces. Similar improvements have been authorized on other vessels of the class.

96. As is evident from the plans, the arrangement of machinery spaces of MINNEAPOLIS differs considerably from that on CHESTER. At the time of damage on MINNEAPOLIS Nos. 7 and 8 boilers in No. 4 fireroom were in use. The temporary loss of power, noted in paragraph 61, then occurred and lasted until full pressure could be regained in No. 4 fireroom. As in the case of CHESTER, drains from the forward fireroom into the engine rooms contaminated feed tanks. It was necessary to use sea water in the two remaining boilers. To reduce priming, boiler compound was injected into each boiler at 15-minute intervals. Considerable operational difficulty from the use of salt water feed was encountered as a matter of course. While at Tulagi steam was supplied first from tugs and finally from a destroyer's shore connection line via two 1-1/2-inch lines connected to the saturated steam line for No. 7 boiler. It was found that by careful operation steam at 290 pounds pressure could be made available to MINNEAPOLIS, using 400 pounds pressure on the destroyer. By doing this MINNEAPOLIS was able to gain an appreciable amount of feed water in addition to receiving 60% of the steam required to operate one main generator. No. 7 boiler was also furnishing steam during this interval.

97. Immediately after MINNEAPOLIS was struck amidships and before the main steam line stop to No. 2 fireroom could be closed, sea water entered No. 4 high pressure turbine (all pressure was off of this boiler) and caused it to stop. The auxiliaries in the forward engine room, with the exception of the generators, were started up, taking steam from the No. 4 fireroom. An attempt was made to start up the forward engines by taking steam from the No. 4 fireroom, but the steam pressure dropped. It is apparent that the steam pressure in Nos. 7 and 8 boilers was not sufficient to handle this additional load. Nos. 7 and 8 boilers were having feed water difficulties also which may have contributed to this drop in pressure. The exhaust and supply blowers to the forward engine room stopped when the power temporarily failed. Before the forward generators could be started up the heat from the leak in the superheated steam line, noted in paragraph 62, made the forward engine room untenable and it was necessary to abandon this space.

98. Those alterations described for CHESTER have been applied to MINNEAPOLIS and vessels of the same class whereever applicable. Further, MINNEAPOLIS has received an additional 8000 gallons per day distilling plant for emergency use in order to provide a means for making feed water in the event of a casualty to the main evaporating plant.

99. The superiority of the arrangement of machinery spaces on CHESTER compared to the arrangement on MINNEAPOLIS was demonstrated. The arrangement on MINNEAPOLIS presents a vulnerable target for complete loss of power from one hit and it obviously was fortunate that the hit in way of No. 2 fireroom was not in way of either engine room or No. 4 fireroom, in which case the complete loss of all power would have been inevitable. If the hit had been in way of No. 3 fireroom there is a probability that all power would have been lost by damage to main steam lines.

D. Flooding and Stability

(Plates I and II)

100. Despite the fact that flooding was extensive on both vessels, GM never became negative although it was sharply reduced in both instances. Calculations indicate that for CHESTER GM was reduced from 4.3 feet to about 1.1 feet in the most critical condition when there was free surface in both No. 4 fireroom and the after engine room. Approximately 2200 tons of water were taken aboard CHESTER. For MINNEAPOLIS GM was reduced from 4.0 feet to about 1.3 feet. In this case some 3200 tons of water were taken aboard. The effect of free surface on the second deck was considerable and caused the major portion of the reduction. CHESTER suffered a greater loss of GM than MINNEAPOLIS principally because the area of free surface was greater than on MINNEAPOLIS.

101. These two cases are good examples of the benefits of adhering to the Bureau's liquid loading instructions. In both cases it is noted that large angles of heel did not develop as would have been the case if wing tanks in way of damage had been empty before damage. Moreover, it has been pointed out by the Bureau that it is necessary to keep liquids in certain tanks in addition to wing tanks for the purpose of maintaining adequate stability. Cruisers of both of these classes had good stability characteristics with some margin, as originally designed, but alterations since commissioning have caused some reductions in stability which must be compensated by retaining certain amounts of liquids low in the ship. Fortunately this was apparently done in both cases as the stability was adequate for the rather extensive flooding incurred. Every effort is made in new designs to provide adequate stability to cover cases of reasonably severe damage with some margin remaining. Retaining liquids in wing tanks however, will always be required to minimize the angle of heel after damage, and some bottom tanks may have to be kept filled, even in new ships, to meet stability requirements. Alterations during the life of the ship may reduce design margins to a dangerous point. Introduction of liquid ballast for stability compensation further increases the average operating displacement with many attendant disadvantages. It is much better, therefore, to adhere to the original design conditions as to fixed installations and consumable loads, except in cases of urgent military necessity.

E. Damage Control

102. The means taken on both vessels to correct list by pumping liquid overboard and transferring other liquids, rather than counterflooding, not only brought the vessels upright but also increased the reserve buoyancy. CHESTER's engineering personnel proved equal to the task of keeping steam up in No. 4 fireroom by ingenious and promptly applied

methods. MINNEAPOLIS' performance in regaining power and re-orienting the machinery plant was equally outstanding.

103. The fortuitous use of a special gasoline-driven pump by MINNEAPOLIS is noted. This type of pump is heavy and unwieldy and inefficient for its weight. Present cruiser allowances of 12 portable submersible electric pumps and of 6 gasoline handy billys of an improved type plus the installation, noted in paragraph 95, of diesel pumps and diesel generators with electric pumps should be more than adequate for any situation in which a heavy unwieldy pump would be of value.

104. The records of both vessels are indicative of the great improvement in damage control technique which occurred in the fleet during the first year of the war. The installation of modern equipment and facilities in all vessels should result in ships with even more ability to control damage, and continued training should result in maintaining high standards of performance by operating personnel.