

U.S.S. MARBLEHEAD (CL12)

Bomb Damage

Java Sea

4 February 1942

Class.....Light Cruiser(CL12)	Length (O.A.).....555'-6"
Launched.....9 October 1923	Beam (W.L.).....55'
Displacement.....7050 tons (standard)	Draft (Std.).....13'-6"

References:

- (a) C.O. MARBLEHEAD ltr. CL12/A16-3(003) of 17 February 1942 - (Action Report).
- (b) C.O. MARBLEHEAD ltr. CL12/L9-3, Serial 010, of 4 May 1942 - (Damage Control Report)

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PLATE

I - Bomb Damage

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  4. C.P.O. quarters D-304 port side.
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  12. Bomb hole upper deck under motor launch.
  13. Under side of upper deck showing hole where bomb pierced deck.
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  16. Flare of shield of No. 1 stack, showing deflection. Normal space between shield and deck is 12 inches.
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  18. Six-inch powder magazine A-108-M, looking aft.
  19. Magazine A-110-M looking aft.
  20. .50 caliber magazine A-112-M looking forward.
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## SECTION I - SUMMARY

1. On 4 February 1942 MARBLEHEAD, a unit of a combined striking force consisting of United States and Dutch cruisers and destroyers, was attacked by enemy planes. The attack resulted in two direct bomb hits and one near miss.

2. One bomb penetrated the main deck about seven feet to port of the centerline at frame 126, passed through the first platform deck and detonated just below the latter in the hand steering compartment. In addition to considerable structural damage resulting in this area the steering gear compartment flooded and the rudder jammed at an angle of left 30 degrees thus causing the ship to turn in circles. After some difficulty the rudder was brought amidships and the ship steered by the engines.

3. A second bomb struck and pierced the upper deck about 12 feet from the starboard deck edge at frame 45 and detonated just above the main deck. A hole was blown in the main deck and fragments penetrated the first platform deck. Partition bulkheads on the main and first platform decks were badly damaged.

4. The near-miss bomb detonated very close to the shell on the port side abreast frame 24. The shell was ruptured and bulged inward which resulted in extensive flooding.

5. Fires were caused by both direct hits but extinguished within a few hours.

6. After temporary repairs at Tjilatjap MARBLEHEAD made her way to Ceylon, successfully eluding the Japanese. She then crossed the Indian Ocean to Durban and passed down the east coast of Africa to Simon's Town with a short stop at Port Elizabeth. At Simon's Town MARBLEHEAD was placed in drydock and underwater repairs were effected preparatory to the transatlantic crossing. When these were complete MARBLEHEAD crossed to Pernambuco, Brazil and then sailed north to New York. At the Navy Yard permanent repairs and many alterations were accomplished upon the completion of which she returned to active service.

7. MARBLEHEAD is an old cruiser. By modern standards her stability characteristics are poor. By virtue of age and riveted construction, her watertight subdivision is considerably less effective than that of newer vessels. She was damaged in three separate areas and extensive flooding occurred both forward and aft of the machinery spaces. Two major fires added to the difficulty. Despite all these unfavorable circumstances, MARBLEHEAD's officers and crew were able, by persistent and determined effort, to keep the ship in action and to bring her home.

## SECTION II - NARRATIVE

(Plate I, Photos 1 to 20 inclusive)

8. This report is based on data contained in the references. Photographs were furnished by the Commanding Officer and the Navy Yard, New York. The plate was prepared by the Bureau from plans submitted by the Navy Yard, New York.

9. On the night of 3 February 1942 MARBLEHEAD, together with other ships of a combined striking force consisting of two U.S. cruisers, two Dutch cruisers, four U.S. destroyers and three Dutch destroyers, put to sea after having been scouted by enemy planes while at anchor at Soerabaya, N.E.I. Cruisers were in column - distance 700 to 800 yards with destroyers forming an anti-submarine screen. Speed was 15 knots on a zig-zagging course.

10. Wind velocity was about 14 knots, the sea was moderate, visibility was fair with the sky overcast varying from 80% cloud covering in the morning to 40% in the afternoon. General quarters stations were manned with material condition YOKE in effect. Boiler power for 27 knots was available.

11. At 0949, 4 February, enemy planes were sighted approaching at an altitude of approximately 17,000 feet. Material condition Zed was set immediately and the remaining boilers lighted off. At 0954 the attacking plane formation divided and nine planes approached MARBLEHEAD which was maneuvered to keep the anti-aircraft guns bearing and to reduce the probability of bomb hits. At 1027, after several unsuccessful bombing runs, a stick of approximately seven bombs straddled MARBLEHEAD resulting in two direct hits and one very near miss. Bombs were estimated to have been approximately 10 inches in diameter and 60 inches long, thin walled and with comparatively large explosive charges.

12. One bomb (A on plate I) struck the main deck about seven feet to port of the centerline between frames 125 and 126, just missing the after port corner of the after twin mount. It penetrated the main and first platform decks detonating in the hand steering station compartment (D-204) just below the first platform deck at the centerline.

13. While the hole (photos 1 to 4 inclusive) made by the penetration of the bomb was relatively small, the force of the detonation, diverted upward and somewhat aft, ruptured the main deck abaft the after twin mount. Sections of the deck plating were torn away from the stringer angle at the shell, port and starboard, and were split and blown up as much as six feet.

14. A hole (photos 5 and 7) approximately 8 by 10 feet was blown in the first platform deck over the hand steering station. On the first platform bulkhead 124 extends from the cylindrical stool for the after twin mount to the shell on both sides. This bulkhead was bulged forward on the port side and the door leading into the C.P.O. mess (D-303) was blown out. On the starboard side bulkhead 124 was bulged aft. The force of the blast apparently went through the door

and then around the cylindrical stool. Bulkhead 117 was deflected forward and both doors leading into D-302 were blown from their hinges. Sections of the deck plating surrounding the hole were forced upward, while in D-303 the deck was deflected downward as much as seven inches in places. Doors in bulkhead 109 showed signs of strain but held intact. Bulkhead 135 separating the C.P.O. quarters (D-304) and the storeroom (D-305) was deflected forward.

15. A hole, approximately five by six feet, was blown in the second platform deck over the after peak tank at the centerline between frames 126 and 128. The hole extended both forward and aft of armored bulkhead 127 between the first and second platforms. This armored bulkhead was deflected aft and ruptured at the center near the bottom. Bulkhead 124 was deflected forward a maximum of eight inches. Stanchions in compartment D-203 were bent due to the downward deflection of the deck above. The longitudinal bulkhead separating the hand steering space from the battery locker was ruptured and blown outboard. Beams, frames and stanchions were badly damaged between frames 124 and 127.

16. In the hold, floors, frames, deck gratings and bulkheads were considerably distorted.

17. The shell plating was pushed outboard at the main deck connection port and starboard between frames 124 and 135. Several rivets were missing in the port shell near the stern. This permitted minor flooding from the sea into the after peak tank. On the port side at frame 125 several weeps were noted around rivets approximately two feet up from the keel. There was also a small fragment hole in the shell at this point.

18. Practically all machinery and gear in way of the blast and subsequent fire were wrecked. The after twin mount jammed in train. The gun foundation was canted and the roller path damaged. The elevating screw was bent and the elevating bracket twisted.

19. Almost immediately following the explosion, fires started in several places, advancing through compartments aft of frame 117 on the first platform deck and above. Fire in compartment D-305 apparently caused a subsequent minor explosion which may have caused the forward deflection of bulkhead 135. Fires were promptly brought under control and extinguished with water from hose lines.

20. The after twin mount gun room was sprinkled immediately. Ready service powder and the lower handling room were also sprinkled. The sprinkling system to group V magazines was turned on for a short period and then secured.

21. Compartments in the damaged area flooded to within one foot of the first platform deck. Flooding was from the sea through the small fragment hole in the shell and seams and rivet holes and from firefighting water from within the ship.

22. Flooding of the steering gear compartment caused the steering motors to stop, locking the rudder at left 30 degrees through the action of the hydraulic system. This caused the

ship to turn in circles until the rudder was freed by loosening flanges and plugs in the hydraulic system and bleeding off the oil.

23. The second direct hit (B on plate I) ripped the hull of the motor launch stowed on the starboard side of the upper deck and penetrated at frame 45 about 12 feet from the deck edge. It detonated just above the main deck.

24. The upper deck was bowed upward a maximum of 12 inches over an area extending almost the breadth of the ship between frames 39 and 52. Fragments pierced the deck in numerous places.

25. The detonation blew a hole (photo 14) approximately four feet in diameter in the main deck and wrecked light metal bulkheads in the wardroom country forward to frame 17 and other compartments aft to frame 64. Piping, electrical circuits and equipment were badly damaged. Passageways, port and starboard of the uptakes structure, were also wrecked. Bulkheads bounding the No. 1 fireroom uptakes and No. 1 blower room were practically demolished. The forward casings for the No. 1 uptakes were bent aft between the upper and main decks. This pulled the stack (photo 16) downward and forward about one foot thus damaging the inner casing beyond repair. Smoke and heat pulled into firerooms 1 and 2 made them untenable and necessitated securing the six boilers in these spaces.

26. The force of the blast passed downward to the first platform deck and into the sick bay through the hole in the main deck (photo 15). Fragments penetrated the first platform deck which forms the top of fuel oil tanks. Bulkheads and sheathing were distorted. Ventilation ducts and some drain lines were ruptured. Fires spread up and through compartments on the main deck. These were extinguished in about two hours.

27. Compartments on the first platform deck between frames 25 and 47 flooded to a depth of two feet with water from leaking mains and firefighting and with oil from the tanks below coming up through fragment holes in the first platform. Some additional flooding probably occurred through damaged decks and bulkheads from flooding forward.

28. The near miss (C on plate I - photos 17 to 20 incl) detonated slightly below the turn of the bilge close to the shell abreast frame 24 port. The "A", "B" and "C" strakes were pushed in a maximum of six feet and ruptured, resulting in two irregular openings in the shell each of which was approximately two by nine feet. The keel was distorted and bent upward about 10 inches over a length of eight feet but remained intact. Seams and rivets were loosened between frames 16 and 29.

29. Bulkheads, frames, decks and shell plates were either badly buckled or demolished from the keel to the first platform deck. Above the first platform deck the shell plating was indented to a depth of about six inches between frames 20 and 26. Well forward and aft of the distorted area there were many leaky seams and rivets.

30. The forward bulkhead and deck of the I.C. room at frame 26 in the hold were buckled and torn, and this space was flooded immediately. Slow leakage through the inboard bulkhead and deck above the I.C. room caused gradual flooding of central station and storerooms above.

31. Immediately forward of the I.C. room the .50 caliber magazine A-112-M (photo 20) was opened to the sea and belted ammunition hung out through the rupture. The inboard longitudinal bulkheads and decks were ruptured causing immediate flooding of compartments A-113-M and A-114-M.

32. Immediately inboard of compartment A-112-M, destruction of bottom plating and longitudinal bulkheads resulted in the instant flooding of group II magazines. Compartments A-108-M and A-110-M were opened to the sea. Both watertight doors leading to handling room A-109 were blown from their hinges causing flooding of that compartment. All magazines on the starboard side of this group were flooded through open seams and damaged bulkheads.

33. Between frames 9 and 20 all compartments in the hold were flooded through open seams and loose rivets. Forward peak tank A-101 was flooded through a leak near the stem. Peak tank A-102 remained dry. The hatch cover for the hatch in compartment A-204 was distorted and the deck around the hatch coaming was split, resulting in flooding of A-204. The deck in A-204 was bulged upward a maximum of six inches on the port side. Compartment A-203 flooded to a depth of six inches and A-205 had a few inches of water on the deck. Flooding to a depth of from two to eight feet on the first platform deck occurred in all compartments between frames 14 and 47. This flooding resulted largely from water being forced up from below through ruptured decks, hatches and piping. Water used to combat fires also contributed to the flooding of these spaces.

34. The large concavity and ruptures in the shell formed a scoop through which water entered under considerable pressure and was forced up through the ship. This effect was particularly noticeable when the speed was 25 knots. Oil in considerable quantity was present throughout the forward flooded section due to the rupture of fuel oil tanks A-1, A-2 and A-118.

35. Shock from the near miss disabled the forward director, three 6-inch guns, ruined the forward range finder and radio room batteries and wrecked the gyro-compass.

36. Immediately after the attack a 10 degree list to starboard developed with draft forward reaching a maximum of 30 feet.

37. At 1255 the force was ordered to retire westward. The ship was steered by the engines. The rudder was secured finally with about 4 degrees right rudder. Throughout the rest of the day and night and the next day MARBLEHEAD was underway to Tjilatjap, arriving there at 0730, 6 February. Draft had been reduced to 20 feet forward and 19 feet aft by pumping 300,000 gallons of fuel oil over the side and

unwatering flooded spaces. As the floating drydock at Tjilatjap was not long enough to take the entire ship, MARBLEHEAD was partially docked twice, first raising the bow to patch ruptures in the shell and second, raising the stern to plug and caulk rivet holes and seams in that area. After these temporary repairs, MARBLEHEAD proceeded to Trincolamee, Ceylon, thence to Durban, Port Elizabeth and Simon's Town, Union of South Africa. During the first 3600 miles of this 9,300 mile voyage, steering was by the engines. The crew finally managed to put one steering motor in operation by using additional parts from the other. The ship was then steered using the trick wheel in the steering gear room. At Simon's Town MARBLEHEAD was drydocked and extensive temporary repairs were made. On 15 April 1942 she proceeded to Navy Yard, New York via Pernambuco, Brazil.

### SECTION III - DISCUSSION

#### A. Size of Bombs

38. In reference (a) it was estimated that the bombs were 10 inches in diameter and 60 inches long. It is probable that they were the 100 Kg. general purpose type known to have been used at various times by the Japanese Army and Navy and which are 9.4 inches in diameter and 53 inches long. This type was extensively used by the Japanese in the early stages of the war apparently because of their anti-personnel characteristics.

39. Height of bomb release was approximately 14,000 feet. The angle of impact was about 70 degrees. The bomb which struck the fantail penetrated the main and first platform decks, traveling approximately 12 feet from the point of impact to the point of detonation. The bomb which struck amidships was deflected off the side of the motor launch stowed on the upper deck. The motor launch apparently initiated the fuse action as only the upper deck was penetrated prior to detonation. The length of travel from point of impact on the motor launch to the point of detonation was also about 12 feet.

#### B. Material Damage

40. The bomb which struck the fantail detonated close to the centerline approximately 12 inches forward of the 120 pound STS bulkhead of the steering motor room and just below the first platform deck. The force of the explosion caused this bulkhead to split at the butt joint and deflect as shown on plate I. While this bulkhead failed, it unquestionably reduced blast and fragment damage to the steering gear.

41. It is interesting to note the circumstances which caused the steering gear space to flood. As shown on plate I, this space is protected by 3" STS transverse bulkheads at each end, a total thickness of three inches of STS on the shell and a total thickness of 1-1/2 inches of STS and



nickle steel on the deck above. It will be noted that there is no armor on the deck under the steering gear room. The bomb detonated just forward and near the top of the armored bulkhead at frame 127, forcing the butt joint at the centerline to deflect aft and split at the bottom. It also blew a hole in the deck which extended forward and aft of this bulkhead. This permitted oil and water to enter from the punctured fuel oil and peak tanks below.

42. The second bomb detonated just forward of and above the 120 pound STS bulkhead at frame 47 which terminates at the main deck and forms the forward bulkhead of No. 1 fireroom. This armored bulkhead, which apparently was undamaged, effectively prevented blast and fragment damage in No. 1 fireroom. Damage to the bulkheads bounding the uptakes to No. 1 stack and No. 1 blower room permitted smoke and heat to be pulled into Nos. 1 and 2 firerooms. This made it necessary to secure the six boilers in these spaces.

43. Damage from the detonations was thus extensive but is not considered unusual for bombs of this size. Each detonation was of high order. Fragment and blast damage was restricted by adjacent armored bulkheads and heavy decks.

44. Damage resulting from the near miss was among the most severe cases of this character which any U.S. vessels have yet reported. Detonation was approximately 16 feet below water. Angle of impact with the surface of the water was estimated to have been about 70 degrees. The bomb thus seems to have passed close to the hull and detonated slightly below the turn of the bilge, possibly three or four feet from the shell abreast the seam between "B" and "C" strakes. The resulting local structural damage to the shell and ship's structures was extensive. The shock effects of this near miss were more severe than from the direct hits. On the basis of tests and other war experiences, shock from close near misses well underwater is apt to be more severe than from direct hits.

### C. Fires

45. Fires broke out immediately following each bomb hit. While flooding of lower compartments reduced the volume susceptible to fire, it actually increased the fire hazard by pushing oil upward on the surface of the water. Fire resulting from the hit abaft the after twin mount was most severe in the C.P.O. quarters, (D-303 and D-304) on the first platform.

46. Fires between frames 25 and 48 were more difficult to control, although it was reported that except for the wreckage which hindered reaching the various burning areas, all fires could have been controlled with portable CO<sub>2</sub> extinguishers. The unavoidable delay in reaching the scene permitted fires to gain such headway that it required about two hours and a considerable volume of water

to finally extinguish them. Several auxiliary steam lines in way of the damage were ruptured and when it was found that the escaping steam was aiding in preventing the spread of fires, they were not isolated until after the fires were extinguished.

47. Although numerous pipe lines were ruptured in way of the damaged areas, all fire mains remained intact.

#### D. Flooding

48. Flooding in the after section of the ship was caused by sea water entering through one small fragment hole, rivet holes and leaky seams plus water from firefighting.

49. Flooding from the hit at frame 45 was caused principally by water from firefighting. Some additional flooding in this area resulting from water entering through damaged decks and bulkheads from the flooded area forward.

50. Flooding forward through ruptures in the shell (which resulted from the near miss) was extensive. Draft forward increased to 30 feet but was reduced to approximately 20 feet during the next day by pumping fuel oil from the forward tanks and unwatering flooding spaces. The scoop effect of the ruptures in the shell forced water up and into the ship under considerable pressure.

51. Flooding of the I.C. room destroyed all internal communications (including all fire control circuits) with the exception of sound powered phone circuits which remained intact.

#### E. Damage Control Measures

52. In preparing for action, all gasoline, kerosene, alcohol, acids and paint were dumped overboard. CO<sub>2</sub> was used to fill the empty gas tanks and pipe lines. This was, of course, a wise precaution although the rapidity with which CO<sub>2</sub> dissipates when released to the atmosphere makes it of little value in preventing gasoline fires or vapor explosions once the boundaries of the tanks or the pipes are ruptured. Blanketing with CO<sub>2</sub> is intended primarily as a safety precaution for the normal operation of an intact system.

53. Immediately after damage, drainage pumps were put into operation; however, drainage lines had been ruptured in a number of the flooded areas. Two electric submersible pumps were operated forward. Bucket brigades were effective in removing considerable water from spaces accessible by this method. Two fire and bilge pumps were removed from machinery spaces and temporarily installed, one in the C.P.O. quarters aft and one on the first platform deck forward. These pumps were very effective in unwatering flooded spaces through improvised suction and discharge lines.

54. Approximately 300,000 gallons of fuel oil was pumped overboard from forward tanks to correct list and trim. At a later date an additional 15,000 gallons of fuel oil was pumped overboard.

55. Flooding of the steering gear compartment caused the steering motors to stop with left 30 degrees on the rudder. It was with considerable difficulty that the rudder was finally brought amidships by removing flanges from the hydraulic system, bleeding off the oil and then using chain falls (rigged to the yoke) to overcome the torque on the stock at small rudder angles (vessels of this class have balanced rudders). While flooding of this space was gradual, fire on the deck above prevented entering this space immediately, and by the time men could enter, liquid was five feet deep.

56. All forward magazines were flooded rapidly from the sea through ruptures in the shell, bulkheads and decks. Ready service powder tanks in the handling room for the after twin mount were sprinkled for a short period. Information is lacking as to how long this sprinkling was continued, but apparently the sprinkling system was secured after a few minutes as it was reported that the handling room was entered and 18 bags of 6-inch powder were taken from their cases and thrown overboard. The sprinkling system to group V magazines (D-110-1/2-M and D-109-1/2-M) was turned on for a short period and then secured when it was determined that further sprinkling was not necessary. Information in reference (a) regarding the length of time group V was sprinkled is conflicting. It was reported in one paragraph that these magazines were sprinkled for 30 minutes, while again it was stated that they were sprinkled for a short period. Probably the sprinkling was of short duration inasmuch as it was reported after examination that the powder was found dry and in good condition. If sprinkling of group V had been continued as long as 30 minutes, the magazines would have been completely flooded as of the two magazines comprising this group, D-110-1/2-M requires only 21 and D-109-1/2-M but 27 minutes to flood. It was determined that it was not necessary to sprinkle group IV magazines (D-106-M, D-105-M, D-105-1/2-M, D-202-1/2-M) and in these the crew remained at their stations.

57. It is noted that in general the after magazines were sprinkled just sufficiently to obtain a cooling effect. Complete flooding would have added a considerable and unnecessary volume of water to the ship. This is one of the few cases on file where correct sprinkling procedure has been employed.

#### F. Stability Analysis

58. At the time of damage, MARBLEHEAD was making 15 knots. Immediately after the bombing occurred, speed was increased to 25 knots. This speed was maintained for long periods of time during the subsequent air attacks. Only at intervals between the attacks was speed reduced. About three hours after damage was received, the rudder was freed and secured with about four degrees right rudder. During the three-hour period MARBLEHEAD steamed in circles.

59. In analyzing the starboard list of 10 degrees reported by the Commanding Officer, it is necessary to take this continuous port turn at high speeds into account. Reference (a), in describing the effects of the near miss, stated that the detonation gave the ship a 10 degree starboard list and that she quickly changed trim down by the bow, ultimately reaching a draft forward of about 30 feet. Since both of the hits and the near miss came from bombs dropped in the same stick, damage caused by each occurred almost simultaneously and it is difficult to isolate the effects. The only off center flooding reported was between frames 26 and 34 in the hold. A-116 on the port side was flooded, whereas A-117 on the starboard side remained dry. This normally would have caused a  $3-1/2^{\circ}$  port list, yet a  $10^{\circ}$  starboard list actually occurred. By reference to plate I it will be noted that there was a large amount of free surface in the forward section of the vessel. The drafts and condition of loading before damage were not reported, but assuming that MARBLEHEAD was in normal load condition, the transverse metacentric height would have been about two feet. The free surface reported and shown on Plate I was sufficient to cause a reduction in GM of about 1.5 feet. GM after flooding would then have been about 0.5 feet. The centrifugal force involved when a ship makes a high speed turn almost always results in outboard heel. In this case the small transverse stability with consequent small transverse moment of resistance undoubtedly resulted in an abnormally large heel during the turn. When the rudder was finally freed and brought amidships (ultimately secured with 4 degrees right rudder) the list was not reported; however if it had been large, it probably would have been noticed. It is thus probable that once MARBLEHEAD was on a straight course, the list was small.

60. Because of the probable danger from air attacks, it was imperative that the large trim by the bow be removed in order to improve the maneuverability. This was done by pumping overboard approximately 1000 tons of fuel oil from the forward tanks. The exact location of the oil removed and the time when this was done are not reported in the references. It is probable, however, that the oil came from the forwardmost group of tanks and that several hours were required to remove such a large quantity. As the oil was removed, the resulting effects were first, to improve the trim forward and second, to further reduce the transverse metacentric height. The reduction in transverse metacentric height was caused by the removal of weight (liquid) from below the center of gravity and the effect of transient free surface as the tanks were emptied. If the tanks were emptied one at a time, the effect of transient free surface would have been negligible. The correction of trim was desirable but the reduction in GM might have been serious. This quantity of oil from low in the ship would have resulted in a further decrease (by the removal of low weight alone) of approximately 0.5 feet in GM. If no other action had been taken the ship would have been in a precarious condition insofar as transverse stability was

concerned. Actually, it appears that in addition to removing the oil from the low tanks, unwatering of the flooded compartments forward was also started. This probably prevented creating a condition of dangerously low or negative stability. No circumstances were reported which would indicate that MARBLEHEAD did not have positive initial stability at all times.

61. Nonetheless, it is important to recognize that removal of weight below the center of gravity is always dangerous and particularly so after damage has been incurred and stability reduced by impairment of waterplane area and free surface. In this case possibly it would have been a better procedure to have concentrated efforts on removing free surface and damage water from the upper forward compartments, and thus insured positive stability prior to unwatering low compartments. It is appreciated that the efforts which were made probably were about all that could have been done under the circumstances of high speed, damaged drain lines and extensive flooding.

#### G. Conclusions

62. This ship is one of a class of 10 which are the oldest cruisers now in service in the U.S. Navy. They were designed originally in 1916 as scout cruisers with large minelaying capacity. Prior to completion in 1923 the design was modified primarily by the augmentation of the main battery. In 1940 their anti-aircraft armament was radically increased and a comparatively large amount of splinter protection was installed. The cumulative effects of these changes, together with the original design characteristics, have resulted in a GM of about two feet in the full load condition. Because of the original requirement for laying mines, the freeboard to the main deck at the stern is only seven feet in the same condition. There is no watertight subdivision above the main deck and the after bulkheads on the main deck are non-watertight. Thus, the reserve buoyancy is only about 50% of the intact displacement. The new CL's have a GM of between four and six feet and reserve buoyancy is about 105% of the intact displacement. Thus, by modern standards MARBLEHEAD is deficient in both stability and reserve buoyancy.

63. Severe damage occurred simultaneously in three separate areas and extensive flooding resulted forward and aft of the machinery spaces. It was fortunate that no damage occurred in the main machinery compartments. The combination of this circumstance and prompt and effective damage control measures enabled MARBLEHEAD to continue in action. After retirement, persistent effort insured her survival.

64. It is apparent that the vessel was in a condition of proper closure prior to action and that damage control personnel were well trained. The effort and thought so evidently placed on damage control matters paid dividends when action

was joined. MARBLEHEAD, as did her sister RALEIGH \*, survived extensive damage which could have been fatal without the determined and effective efforts of her personnel.

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\* BuShips War Damage Report No. 9.