U.S.S. YORKTOWN

Loss in Action

June 4-7,1942

Midway

Class.....Aircraft Carrier(CV5)	Length (W.L.).....770'
Launched.....April 4, 1936	Beam (W.L.).....82'-3"
Displacement.....20,000 Tons (Standard)	Draft (prior to damage) .....26'-3" (mean)

References:

(a) C.O. YORKTOWN ltr. CV5/A16-3(CCR-10-per) of 18 June, 1942 (War Damage Report).
(b) C.O. YORKTOWN ltr. CV5/A16-3(CCR-10-oah) of 18 June, 1942 (War Action Report).
(c) C.O. YORKTOWN ltr. of 17 June, 1942 endorsed by Cincpac ltr. A16/Midway, Serial 01982, of 7 July, 1942 (Loss of YORKTOWN).

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SECTION I - FOREWORD

1. U.S.S. YORKTOWN was hit by three bombs and two aircraft torpedoes on the afternoon of June 4, 1942. Numerous fires were started by the bombs. These were brought under control in one hour. The two torpedoes produced extensive flooding which resulted in a list of about 23° to port at the time the ship was abandoned. Later the same afternoon a salvage crew was organized and returned on June 6. Two degrees of the list had been removed when a submarine torpedo attack occurred. The first torpedo from this attack struck HAMMANN which was alongside assisting in salvage operations. Almost immediately thereafter two torpedoes hit YORKTOWN on the starboard side. This reduced the list to 17° but internal flooding caused the ship to go deeper in the water. Finally, on the morning of June 7 YORKTOWN capsized to port and sank.

2. This report is based on references (a), (b) and (c) submitted by the Commanding Officer who compiled them entirely from the memory of the officers on the ship who had knowledge of the various events as they took place. Under the conditions, many technical details are of necessity lacking. The Commander-in-Chief, Pacific Fleet, in an endorsement on reference (c) gave an account of major events from the time YORKTOWN was first attacked until she sank.

SECTION II - NARRATIVE

(Plates I & II, Photos 1 to 12 inclusive)

3. On the afternoon of June 4, 1942, YORKTOWN was operating 150 miles northeast of Midway as a part of a task force. Just one week earlier temporary repairs had been completed at Navy Yard, Pearl Harbor for damage sustained in the Coral Sea Battle, May 8 (see Buships Damage Report No. 22). Enemy action during the day was expected and the ship was at General Quarters with material condition "Afirm" set before and during the attack. The weather was clear with unlimited visibility. The sea was calm.

4. At 1359, while fueling the fighters which had returned from combat air patrol, radar contact was made with the enemy. Immediately the fueling of planes was discontinued and the sixteen VSB planes of YORKTOWN Attack Group, which were then in the landing circle, were directed to form a combat air patrol. The auxiliary gasoline tank on the stern, containing about 800 gallons of clear aviation gasoline, was dropped over the side. Fuel lines were drained and filled with CO_2 at 20 pounds pressure. The gasoline tank compartments had been previously filled with CO_2.

5. As the enemy approached, speed was increased from 25 to 30.5 knots. Radical turns were made to avoid bombs. At 1414 three hits and one near miss were made by dive bombers. The first bomb tumbled in flight because the plane went out of control just as the bomb was released. This bomb exploded upon contact blowing a 12-ft. hole in the flight deck abaft No. 2 elevator on the starboard side. This hole was repaired within about 25 minutes. Fragments from this hit pierced the hangar deck. Fires were started in three planes on the hangar deck from bomb fragments. The sprinkler system and water curtains in the two after bays quickly extinguished the fire.

6. The second bomb, released at 500 ft., came from the port quarter, pierced the flight deck and exploded in the uptakes just below the second deck starting fires in the uptakes, in the photographic laboratory, Executive Officer's Office, and First Lieutenant's Office. Fire parties fought the fires and extinguished them in 30 minutes.

7. The most serious effects of this bomb hit were the rupturing of the uptakes from boilers 1, 2, 3, 4, 5, and 6, completely disabling boilers 2 and 3, and the extinguishing of fires in boilers 2, 3, 4, 5, and 6. Speed immediately dropped to about 6 knots, and at 1440, about 26 minutes after the bomb had hit, all engines were stopped.

8. The third bomb, released at 500 ft., from the starboard side, pierced the starboard side of No. 1 elevator platform and exploded on the third deck. Persistent fires were started in the rag stowage and the aviation storeroom which was located immediately below. These compartments are forward of and above the forward gasoline stowage and No. 1 magazine group. The magazine group was flooded. The void spaces around the gas tanks had been previously filled with CO_2 , but the fire did not approach sufficiently close to the gasoline tanks to endanger them.

9. Flooding from a ruptured fire main extinguished the fire in the aviation storeroom. Repair parties extinguished the fire in the rag stowage in about one hour except for some baled rags that smoldered until the return of the salvage party June 6.

10. At about 1540, one hour and sixteen minutes after the bomb explosion in the uptakes, sufficient repairs had been effected to the uptakes to enable boilers 4, 5, and 6 to be cut in. At 1550 the engine room reported ready to make 20 knots or slightly better.

11. The fueling of fighters on deck was underway when at 1627 radar contact was again made with the enemy. Fueling of airplanes was stopped, the gasoline system was again drained and secured with CO_2. At 1627 YORKTOWN went ahead emergency full speed which under these conditions was only 20 knots. By radical maneuvering at least two torpedoes were avoided. At 1645 an aircraft torpedo hit on the port side at approximately frame 92, resulting in a list of about 6° to port. Thirty seconds later a second torpedo hit at approximately frame 80 immediately increasing the list to 17° to port. As a result of these two hits all power was lost, steam dropped immediately and electric power failed completely. The rudder was jammed at about 15° left. The ship became dead in the water.

12. Damage control measures could not be taken because of loss of all power, both steam and electrical. The after emergency diesel generator cut in and started, but circuit breakers on the switchboard failed to hold, evidently due to short circuit. At 1702, seventeen minutes after the two aircraft torpedoes hit, word was passed to abandon ship. The list was 23° at this time. By 1918 all survivors were rescued and YORKTOWN was left under the surveillance of HUGHES.

13. At noon on June 5 VIREO joined company with YORKTOWN and HUGHES. Preparations were made to tow YORKTOWN. At 1636 VIREO commenced towing at 2 knots. (Although YORKTOWN appeared to be riding easily, she was yawing quite badly and appeared to be down farther by the bow than when first abandoned.) Later in the afternoon a rescue party was sent aboard YORKTOWN to jettison loose gear.

14. On the morning of June 6 a salvage party composed of ship's officers and crew returned aboard YORKTOWN. They found that the list had increased to 24° and the fire in the rag stowage was still smoldering. The Commanding Officer, in reference (b), reported that a careful inspection was made below decks to determine the extent of damage. Details of this inspection, however, are not available in the ~~Bureau.~~ It was decided to reduce the list by removing topside weights on the port side and by pumping and counter flooding, utilizing power from the destroyer HAMMANN until salvage tugs could arrive.

15. At 1536 considerable progress had been made, and the list had been reduced 2° , when a salvo of four submarine torpedoes was sighted approaching the ship on the starboard beam. The alarm was immediately passed by word of mouth. HAMMANN went to General Quarters. The first torpedo hit HAMMANN approximately amidships. Two torpedoes then hit YORKTOWN probably at the turn of the bilge about frame 85. HAMMANN sank very rapidly, and shortly after her stern sank, a heavy explosion occurred, apparently from her depth charges. The damage from the submarine torpedoes and the shock from HAMMANN's depth charges were very severe. The list was reduced to 17° but the ship settled deeper in the water. There was no noticeable change in trim.

16. The salvage party abandoned ship prior to dark, after closing as many watertight closures as possible on main deck and below. The Commanding Officer, during his final inspection, noted a heavy pounding of water through the torpdeo hole on the starboard side. This may have led to rupture of some internal bulkheads during the night. About 0530 on June 7 the list of YORKTOWN was noticed to be increasing to port. At 0701 YORKTOWN turned over on her port side and sank in 3000 fathoms of water.

SECTION III - STRUCTURAL DAMAGE FROM BOMBS

(Plate III, Photos 11 & 12)

A. Bomb Hit, Frame 36

17. The bomb which hit at frame 36 was released from 500 ft. The angle of release was about 70°. It struck the flight deck at frame 36 about 17 ft. to starboard of the centerline. It penetrated No. 1 elevator on the flight deck traveling forward and inboard through the elevator trunk. It pierced the elevator pit on the second deck and exploded on the third deck, centerline frame 32 in A-305-A (rag and cleaner stowage). Total travel after striking the flight deck to point of detonation was 47 ft. The detonation was of high order. The size of most of the fragments was about one inch in diameter.

18. The impact on the elevator platform caused a hole approximately 14 inches in diameter. On penetrating the second deck a large oblong hole was left indicating that the bomb had probably tumbled after penetrating the elevator. It exploded in A-305-A, rupturing bulkheads at frames 26 and 38. Fragments traveled upward piercing the second deck in No. 1 elevator pit in many places, and others traveled aft piercing the bulkhead at frame 35 in A-405-A and further aft through A-406-A to pierce bulkhead at frame 43, the forward bulkhead of A-410-A. The starboard fire main riser in A-406-A was ruptured, causing complete flooding of A-405-A, A-406-A, and A-410-A through fragment holes in the transverse bulkheads. The reach rods at frame 40 to cut-outs on the third deck were jammed due to the force of the explosion on the surrounding structure. Cut-outs in the port and starboard fire mains were then closed at frame 82 to prevent further flooding.

19. The Commanding Officer, in reference (a), reported that fragments "pierced the overhead in A-506-M and A-510-M." In the light of war experience it seems improbable that fragments pierced an armored deck of 60# S.T.S. at a point so far removed from the explosion.

B. Bomb Hit, Frame 95

20. The bomb which hit at frame 95 hit the flight deck 10 ft. inboard of the Island. It penetrated the flight deck traveling outboard and forward through the port side of the uptakes in the hangar, down through the uptakes and detonated just below the second deck about frame 88.

21. The detonation was of high order, blowing a 15 ft. hole in the second deck and completely wrecking the Executive Officer's Office, C & R Office, oil and water testing laboratory, and intakes to firerooms 2, 3, 4, 5, and 6. On the third deck the laundry was completely wrecked. The uptakes from boilers 1, 2, and 3 were badly ruptured. Boilers 2 and 3 were completely disabled. Casings and tubes were ruptured, and brick work torn loose and dropped into fire boxes. The damage to firerooms 4, 5, and 6 was considerably less. However, fragment holes in the intakes permitted smoke to fill these three firerooms.

22. The explosion damaged the following systems: (A) The general lighting on the second deck in the immediate vicinity of the hit. (B) Ventilation in the "B" section of the ship. (C) The firemain riser, frame 95 starboard, which was isolated by closing the starboard cut-outs in firerooms 3 and 9.

C. Bomb Hit, Frame 132

23. The bomb which hit at frame 132 tumbled in flight. It hit the flight deck about 10 ft. to starboard of the centerline and exploded upon contact blowing a 12 ft. hole in the flight deck. The fragments from the hit were about equally divided between the flight deck and the hangar deck. In the hangar, bomb fragments pierced the Engine Overhaul Shop, Torpedo Shop, and Sheet Metal Shop, rupturing the fire main riser in the latter shop.

fragments also pierced the main deck traveling below into compartments D-201-L and D-202-L. Some of these fragments pierced the second deck into compartment D-301-1LM. Fragments that pierced the main and second deck traveled as far as 42 ft. through as much as 25.5 lbs. of mild steel.

D. Near Miss, Close Astern

24. The near miss close astern on the port side tumbled in flight and exploded upon contact with the water. Fragments hit the port corner of the flight deck and the first superstructure deck. Several small fires were started by fragments but were quickly extinguished.

SECTION IV - STRUCTURAL DAMAGE FROM TORPEDOES ON 4 JUNE 1942

(Plate IV)

25. The two torpedo hits on the afternoon of June 4 hit within 30 seconds of each other. The damage caused by each torpedo individually is almost impossible to reconstruct, therefore the probable combined effects of both torpedoes will be considered.

26. Both torpedoes hit the port side at the same depth, estimated to be about 11 ft. above the keel or about 15 ft. below the water line. The first torpedo is reported in reference (a) to have hit at frame 92; however, fuel tanks, as far aft as frame 105, were reported damaged with flooding extending to frame 107. The comparison of this damage with that suffered by other ships is quite interesting. Ships damaged by Japanese aircraft torpedoes at Pearl Harbor* in no case had damage extending farther than 36 ft. from the point of explosion, whereas the reported damage on YORKTOWN extended about 52 ft. from the point of explosion. This damage appears to be unusually extensive for an aircraft torpedo. A study of photos 4 and 9 indicates that the port gallery walkway from about frames 84 to 100 was carried away by the geyser from this explosion. The center of damage is about frame 92, verifying the location. The second torpedo was reported to have hit at frame 80. This is consistent with the flooding reported. The ship shook from the heavy dull explosions but no general flexural vibration of the ship was noted. No flash or flame was noted from the explosion, nor were any fires started.

27. The probable extent of damage is shown on Plate IV. This class of ships has a torpedo defense system which varies from four layers in way of the engine rooms to three layers elsewhere. The extreme inboard layer of tanks was empty. The two outboard layers of tanks were filled completely with fuel oil, in accordance with the latest liquid loading practice as recommended by the Bureau. There are no previous cases of damage to this type of system in the records of the Bureau. However, records of other torpedo damage indicate that it is quite probable that the skin was destroyed for about 20 ft. vertically and 20 to 30 ft.horizontally;

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* See U.S.S. CALIFORNIA, War Damage Report No. 21.
See U.S.S. NEVADA, War Damage Report No. 17.

that No. 1 bulkhead was destroyed in way of the explosion; that No. 2 bulkhead was ruptured and pushed inboard; and that No. 3, the holding bulkhead, was deflected inboard and its connections broken at the top and bottom. This would permit rapid flooding of the port firerooms and the forward generator room.

28. The force of the two torpedo explosions blew the fourth deck up into compartments A-432-L, B-402-L, B-414-L, and C-404-L completely flooding these fourth deck living spaces. The quick-acting doors in bulkheads 82, 90, 98, 106, 112, and 130 on the third deck, port side, were reported sufficiently warped to be non-watertight.

SECTION V - FIRES, FLOODING AND DAMAGE CONTROL 4 JUNE 1942

(Photo 12)

A. Bombs

29. The bomb hit on the No. 1 elevator that exploded in A-305-A started a fire in the rags stowed in this compartment and in the aviation stores in A-405-A immediately below. This consisted mainly of a persistent rag fire emitting a great deal of smoke. The heat was transmitted to surrounding bulkheads of A-305-A and A-405-A causing the paint to blister and bake; however, the paint did not catch on fire.

30. Steps to control the fire were immediately taken by using CO_2 and fire hoses leading aft to plugs abaft frame 82. To facilitate access to the fire, holes were cut in the deck of No. 1 elevator pit using oxy-acetylene torch, and fire nozzles were aimed below on the fire. Although the fire was very persistent, it was extinguished, except for smoldering rags, in about an hour.

31. The rupturing of the starboard fire main riser (caused by bomb fragments) in A-406-A resulted in the flooding of A-405-A, A-406-A, and A-410-A through splinter holes in the transverse bulkheads. This flooding extinguished the fire in the aviation storeroom, A-405-A. Some water also leaked into the forward 5" handling room, A-507-M, through the reach rod stuffing box before this space was deliberately flooded to prevent a magazine explosion. Since reach rods to cut-outs at frame 40 were jammed, cut-outs in the port and starboard fire main were closed at frame 82 using third deck reach rods. Thus, further flooding from the ruptured fire main was prevented. It was this cutting out of fire mains forward of frame 82 which necessitated the leading forward of all fire hoses.

32. Magazine group No. 1, located directly abaft and one deck below the burning aviation storeroom, was flooded to prevent a magazine explosion. The gasoline tanks just abaft and three decks below the aviation storeroom were surrounded by CO_2.

33. The bomb hit in the uptakes started a heavy fire on the second deck in the Photographic Laboratory where films caught fire, in the Executive Officer's Office and First Lieutenant's Office where papers caught fire. Small fires started on the third deck

in the laundry and in the Mess Attendant's living space, but they were quickly extinguished. Smoke from the fire filled second deck wardroom country, third deck forward mess compartment, and third deck "B" section of the ship. The stack was pierced and bulged in several places from fragments and from the force of the explosion. Heavy smoke from the fires and from the boilers filtered into the control spaces in the Island. The fires that resulted from the explosion were effectively extinguished in about thirty minutes by the use of CO_2 and fire hoses from fire plugs abaft frame 106; however, heavy smoke persisted, undoubtedly from the No. 1 fireroom uptake.

34. Firerooms 1, 2, 3, 4, 5, and 6 were filled with dense black smoke and gases; fires in boilers 2, 3, 4, 5, and 6 were extinguished by concussion and damage. Although the casing in boiler room No. 1 was red hot and ruptured, this boiler continued to operate using two burners and was able to maintain the auxiliary steam pressure at 200 lbs/in^2. Although uptakes and intakes to firerooms 4, 5, and 6 (group II) were not nearly as badly damaged as those to 1, 2, and 3, they filled with heavy smoke and gas because No. 1 boiler was discharging through the bomb hole into Group II intakes, thence to firerooms 4, 5, and 6. This group had to be secured. With only No. 1 boiler furnishing auxiliary steam, the forward generators were secured and the electrical load shifted to the after generators. No. 1 boiler continued to operate with two burners furnishing steam to auxiliary machinery by frequently changing personnel. A crew was sent into No. 4 fireroom with gas masks (the Commanding Officer reported, in reference (a), that these were more effective than rescue breathing apparatus) and lighted fires under No. 4 boiler. Speeding up No. 1 blower slightly alleviated heavy smoke condition. One hour after the bomb explosion No. 4 boiler was cut in. Crews with gas masks then lighted off No. 5 and 6 boilers. No. 1 boiler was then secured to eliminate discharge of flue gas into Group II intakes. Together with superheat boilers 7, 8 and 9, which had not been damaged, there were then 6 boilers, 3 saturated and 3 superheat, on the line about one hour and twenty minutes after the attack. During this whole period, repair parties were blanking off bomb holes in the uptakes of firerooms 4, 5 and 6.

35. Fragments from the bomb hit at frame 132 set airplanes abaft No. 2 elevator on fire. Flames were quickly extinguished, however, when hangar sprinklers were turned on the water curtains released by remote push-button control.

36. The hole in the flight deck from bomb hit at frame 132 was repaired sufficiently in twenty-five minutes to permit the operation of planes. It was repaired by securing wooden beams to the remaining steel transverse beams bordering the hole. Ten-pound plates were laid over the supporting wooden beams. Five large square ten-pound plates were then placed to cover the entire hole. The plates were held in place by spikes driven into the wooden flight deck around the edge of the plates (see Photo No.12).

B. Torpedoes

37. The flooding from the two torpedo hits during the second air attack was quite extensive. The port side fuel tanks from frame 69 to frame 107 were reported either destroyed or in free communication with the sea. Firerooms 2, 6 and 8 and the forward generator room were flooded. The ruptured fourth deck,

as stated before, resulted in the immediate flooding of the port fourth deck spaces from frame 71 to frame 106. According to the Commanding Officer's report, the third deck was flooded to a depth of 8 ft. in the lower port corner between frames 71 and 144, and the forward and after engine rooms were flooded to the level of the first platform deck at the lower port corner. Apparently the third deck was flooded by water entering through fragment holes in the uptakes of No. 2 boiler (see Par. 20). The extensive flooding fore and aft on the third deck may have resulted from improper closure of the quick-acting W.T. doors as the crew abandoned these spaces. As stated in paragraph 28, the Commanding Officer reported these doors warped by the force of the explosion. Watertight doors that are warped remain tight only until undogged. They cannot be dogged down again and expected to be watertight. Doors more than 30 ft. from the point of explosion usually are not warped or, if so, only to such a slight degree that they can be dogged down again to maintain their watertight characteristics. Therefore, it appears improbable that doors in bulkheads 106, 112, and 130 were warped sufficiently to be non-watertight. The Commanding Officer gave no reason for the flooding in the forward and after engine rooms. This flooding may have taken place through damaged piping or around cable stuffing boxes.

38. The Commanding Officer, in reference (b), reported that no electrical power was available for damage control measures because the after switchboard was "destroyed", although the emergency diesel generator was intact. Questioning of a survivor from this space and the report of the engineering officer both indicate that the after switchboard was intact but short-circuited. It appears that it was standard practice on this ship to cruise with both plants running and both boards paralleled. Damage and flooding in the forward portion of the ship shorted out a large number of leads. Men on watch in the forward switchboard room were apparently killed before they could isolate the board. After all steam was lost the after emergency generator cut in automatically and tried to energize the after board. Since this board was shorted through damaged leads forward, the breakers repeatedly kicked out. It is not clear why the breakers on the after board connected to the damaged leads were not opened to permit the use of the board for intact circuits.

SECTION VI - FINAL SALVAGE EFFORTS - 6 JUNE 1942

39. Upon the return aboard of the salvage party June 6, the fire in the rag stowage was still smoldering. It was extinguished by fire hoses led from HAMMANN when she came alongside. Steps were taken to correct the list and to maintain buoyancy. The port anchor was cast loose and dropped overboard, five port side 20mm gun mounts were dropped overboard, and airplanes in hangar overhead forward were lowered and dropped overboard. Power was obtained from HAMMANN and suction was taken by three submersible pumps on the low side of third deck frame 125 and discharged to empty tanks starboard through fourth deck manholes starboard side frames 130 to 150. One submersible pump took suction in after engine room and led to discharge overboard. The discharge from HAMMANN's fire and bilge pumps was led through fourth deck manholes to empty fuel tanks starboard side frames 130 to 150.

40. On the morning of June 6 the draft and list of the ship did not appear to be appreciably greater than on the evening of June 4. During the entire day of salvage operations the flooding in the ship did not increase, and the water on the third deck aft had been reduced three feet in depth. The list was reduced by 2° resulting in a list to port of 22° just before the ship was attacked by a submarine.

SECTION VII - PROBABLE DAMAGE FROM SUBMARINE TORPEDOES

6 JUNE 1942

(Plate V)

41. The Commanding Officer, in reference (a), estimated that two submarine torpedoes hit about frame 85. In view of the flooding reported it appears that one of the torpedoes hit further aft, probably in the vicinity of frame 94. A survivor of the salvage party, who was questioned, stated that he noted one hole in the bottom of YORKTOWN just below the turn of the bilge when she capsized to port. In light of the above it appears that two torpedoes passed under HAMMANN and hit YORKTOWN below the turn of the bilge at frame 85 and frame 94.

42. The Commanding Officer reported that three starboard firerooms, interior communication room, switchboard room and central stations were flooded. Calculations made by the Bureau indicate that this flooding would reduce the list to about 17° to port, which was what the Commanding Officer reported. This flooding was not particularly dangerous to the ship as the reserve stability was probably reduced very little. The explosion of the HAMMANN's depth charges, combined with the torpedo explosions, undoubtedly weakened many bulkheads, piping and fittings which permitted progressive flooding to take place throughout the night. As a result of this slow flooding, it appears that the ship acquired negative stability because of the large free surface losses in flooded compartments. This fact, in combination with the fact that the original flooding on the port side still gave a heeling moment to port, caused her on the morning of June 7 to capsize to port and sink.

SECTION VIII - DISCUSSION

A. Size of Bombs

43. The Commanding Officer, in reference (a), estimated the bomb that hit No. 1 elevator to be a delayed-action projectile type bomb, weighing about 800 lbs. and measuring approximately 12 inches in diameter. This description does not fit any of the currently available data on Japanese bombs. The distance of travel and the extent of damage corresponds with that observed on this ship in the Coral Sea Battle of May 8, 1942. The bomb performance also corresponds closely to that of the bombs which struck CALIFORNIA and CURTISS. Damage in the above three cases was concluded to have been caused by a 250 Kg. (550 lbs.) "semi-armor piercing" bomb with delayed action fuses of the type recovered at Schofield Barracks after the raid of Dec. 7, 1941.

44. The bomb which exploded in the uptakes traveled through less plating; however, its distance of travel was comparable to that of the hit in No. 1 elevator. Damage was more extensive because the bomb exploded in a more confined space. However, it is quite probable that this bomb was also a 250 Kg. "semi-armor piercing" bomb.

45. The size of the bomb that exploded on the flight deck was not estimated by the Commanding Officer. By comparison with the damage suffered by CHESTER at the Marshall Islands raid on February 1, 1942 to that suffered by YORKTOWN, it is estimated that the latter was struck by a 100 Kg. "general purpose" bomb with instantaneous fuse.* CHESTER received a 6-ft. hole in a deck composed of 2 inches of teak layed on 10-lb. plating. This was concluded to be a 60 Kg. "general purpose" bomb. YORKTOWN, on the other hand, received a 12-ft. hole in a deck composed of 3-1/2 inches of teak over 5-lb. plating.

B. Types of Torpedoes

46. The weight of charge in torpedoes used against YORKTOWN cannot be definitely established. There is some specific information as to three types of Japanese submarine torpedoes which have been recovered, but the information on Japanese aircraft torpedoes is less definite. Further, the information on structural damage caused by torpedoes on YORKTOWN is too indefinite to permit any accurate estimate of the size of charges used.

47. The Japanese are estimated to have three aircraft torpedoes: type 91 with 337.5 lbs. of hexa, type 92 with 452 lbs. of hexa, and the "new Kure" with 661 lbs. of hexa. However, no case so far studied in the Bureau has indicated the use of the "new Kure". Therefore, it is quite probable in the light of previous damage, particularly at Pearl Harbor, that the aerial torpedoes contained less than 500 lbs. of explosive.

48. In addition to the large torpedo recovered at Pearl Harbor from a Japanese midget submarine, two types of torpedoes from regular Japanese submarines have been recovered. The larger of these two types has not had the explosive charge weighed, but it is estimated from the size of the warhead to contain about 550 lbs. of hexa. The smaller type contains only 385 lbs. of hexa. It appears to the Bureau that the larger of these two types was probably used against YORKTOWN.

C. Comments on Equipment

49. The Commanding Officer, in reference (a), furnished some notes and recommendations of which some are briefly discussed below.

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* The Japanese are reported by Army Intelligence and Chinese Intelligence to have a 100 Kg. G.P. bomb. War Damage Reports studied by the Bureau have not indicated the use of this type of bomb; however, the damage reported on YORKTOWN is more extensive than that usually resulting from a 60 Kg. G.P. bomb.

(a) "The new type 'A' Rescue Breather proved unsatisfactory in several instances because contact of the rubber bag against any object forced air out of the bag, and vigorous movements of head or body pinched soft breathing tubes restricting the air supply and exhaust. The bags should have a relief valve set for greater pressure and firmer rubber tubing should be installed."

The criticism of the ease and rapidity with which the breathing bag can be deflated has been voiced many times. The Bureau has issued a rubber cap to be placed over the escape valve. This rubber cap has one small air escape. If at any time the rubber bag should be deflated, the wearer need only to rest for a minute or two and the oxygen generated in the canister will fill the lung. A modified Rescue Breather "A-1" is now being issued to the service. Its operation is similar to the old "A" Rescue Breather but it is simpler in design and less susceptible to derangement.

A "patrol type" rescue breather has now been designed. Its principle of operation is similar to the type "A". However, the respirable air reservoir of the "patrol type" apparatus is in the form of a vest. This provides a slightly larger reserve of respirable air than does the type "A" apparatus and at the same time permits passage through hatches approximately 18" in diameter.

(b) "Compartments should be so assigned and stowed that no two adjacent compartments contain inflammable stores."

The advantage of stowing inflammables as recommended by the Commanding Officer has long been recognized by the Bureau. However, the arrangement of stowages on a ship in operation is to a certain extent within the discretion of the Commanding Officer. The Bureau, realizing that stowage spaces are changed to suit the convenience of operating personnel, has instructed all navy yards and building yards to install in all old and new carriers a "fixed fog nozzle sprinkling system". This outfitting is being done as rapidly as possible in all compartments on and below the forecastle deck except spaces already provided with CO_2 protection, steam smothering or other sprinkling systems and cold storage spaces and voids. In this way the Commanding Officer can choose any space for inflammable stowage and still receive protection from fire.

This system permits sprinkling to be carried on progressively from one compartment to another, starting with an enterable compartment and working toward the root of the fire cooling and quenching otherwise untenable compartments en route. This system is divided into independent units each serving a compartment bounded by structural bulkheads and decks. In the latest design each unit consists of a fixed run of dry piping capable of being fed from two separated locations so that a fire can be fought from either of two locations separated by W.T. bulkheads. In general, this will permit fighting the fire from either forward or aft of the compartment in which there is a fire. Each of the two terminal ends is located on the other side of the compartment

bulkhead boundary and on the deck level above the compartment in question. The terminal is fed by a hose led from a fire main riser.

> (d) "Diesel drive should be installed on main damage control pumps so that stability can be controlled even though electrical power and steam fail."

In new carrier construction sufficient standby pumps have been provided to preclude the necessity of carrying out this recommendation.

> (e) "Provide adequate gasoline or diesel portable pumps."

The allowance list of all carriers provides for 6 gasoline portable pumps.

> (f) "It is necessary to have lamps that automatically turn on when general lighting fails."

All carriers have installed an automatic emergency lighting system which cuts in when the main power supply fails. This system draws power from the emergency diesel generator. JR-1S relay control hand lanterns are also provided on both new and old carriers. These hand lanterns are fitted in important control spaces. They cut in automatically through relay boxes upon the failure of the general lighting system. These hand lanterns are powered by two dry cells and may be removed from the bulkhead by unfastening the connection to the relay box.

D. Organization of Salvage Parties

50. As battle damage data from the forces afloat accumulates, the importance of having an organized salvage party to commence salvage operations immediately after the ship has been incapacitated becomes more clearly emphasized. As a result of the experiences of YORKTOWN, the Commander-in-Chief, Pacific Fleet, issued instructions that all ships will organize a salvage party composed of the key personnel of the repair parties. This party will proceed with the salvage of the ship if the tactical situation will permit. In all cases this party is to be the last to abandon ship.

E. Discussion of Design Features

51. YORKTOWN was designed during 1931 and 1932 while RANGER (the first carrier designed and built as such) was still under construction. The size of the YORKTOWN class was determined by the Navy Department to meet the requirements for aircraft carriers insofar as practicable within the limitations imposed by the Naval Treaties then in force. It was recognized, of course, that aircraft carriers of this size could not be given the same degree of protection against gunfire and torpedoes as the heavier battleships. Within the limitations imposed by size, however, it was intended to provide the best degree of torpedo protection attainable. Penetration of the thinner parts of the torpedo system

was to be expected, particularly in case of attack from large torpedoes. Accordingly some longitudinal bulkheads were provided inboard of the torpedo protection system to limit the extent of flooding after damage. Adequate metacentric height was provided in the design to limit the angle of heel in case of unsymmetrical flooding in these parts of the ship to an acceptable degree.

52. One of the most important design principles in providing against war damage is to subdivide the machinery into as many units as possible and so arrange the spaces that damage from one torpedo hit will incapacitate the smallest practicable fraction of the machinery plant. This principle was well recognized before the present war and was applied in some ships. In the YORKTOWN class an important consideration in locating the boilers in one group of compartments directly below the island was to reduce the length of uptake leads to the island. The weight and space thus saved were devoted to other military features. It was felt at that time that the subdivision of the boiler spaces into nine separate compartments and the machinery spaces into two compartments would prevent complete loss of power from any one hit. This assumption was probably correct, except that the steam lines from the boilers were so arranged that a break any place in the main steam line would make it very difficult to supply power to either engine room depending on the accessibility of the valves after damage. In other words, it was not feasible to divide the boilers into four groups each independently supplying one turbine.

53. In YORKTOWN, however, the loss of power was due to damage from more than one hit, and it is difficult to attribute this loss of power to any one factor. It is not clear in just what manner steam was lost after the two torpedo hits on June 4. Possibly the bomb hit in the uptakes had so damaged boilers No.1 to No.3 inclusive (the three forward boilers) that the shock damage from the torpedo was sufficient to end their usefulness. Flooding, of course, put all the port boiler rooms out of action, and possibly also the centerline boiler rooms. The starboard boilers should have been available, however, except for possible shock damage, unless the main steam line were broken somewhere. No break in the steam line was reported.

54. Even if steam had been available, the question arises as to whether any main engine could have been used. It is not at all clear just how leakage into the after engine room occurred. Bulkhead 118 between the two machinery spaces was so far from the nearest torpedo explosion that it would not have received important structural damage. There is no question but what flooding occurred in the after engine room. Very probably most of this leakage was through piping and fittings. It is difficult to understand, however, why this leakage stopped. Both engine rooms were reported flooded only to the first platform in the lower corner on June 4, and, as previously noted, the ship did not increase her draft appreciably between June 4 and June 6. If both engine rooms had flooded to the new water line, the draft and trim would have changed appreciably. The salvage party reported pumping with a submersible pump from the after engine room on June 6, but did not report any increase in the water level in that engine room between June 4 and June 6. It can only be assumed that the leaks, at least into the after engine room, came primarily from pipe lines which drained completely or were shut off before the engine room was abandoned. If that is the case, the loss of propulsion power must be attributed primarily to the loss of steam and electric power rather than to engine room flooding.

55. British experience in the present war, before our own entry, emphasized the importance of arrangement and subdivision of machinery units to minimize loss of power from underwater damage. In ESSEX (CV9 class) the machinery arrangement, starting from forward is boiler room, boiler room, engine room, boiler room, boiler room, engine room. The steam lines are so arranged that the plant can be operated as four independent units. In the CV41 class still further improvement is accomplished by providing four main engine rooms, with three boiler rooms for each. Including main turbo generator rooms, etc., there are 26 machinery compartments.

F. Conclusion

56. In view of the recognized inadequacy of the torpedo protection system in YORKTOWN, it is remarkable that that ship remained afloat as long as she did after such extensive underwater damage. In spite of leakage which occurred through some transverse bulkheads which should have remained tight, the watertight integrity and subdivision, and the initial stability of the ship were sufficient to give her an excellent power of survival. If the machinery arrangement had been such that all power would not have been lost as a result of one bomb hit plus the two closely spaced hits on the port side, it is very probable that the ship could have made port under her own power, after the attacks on June 4 if no further damage had occurred. It may be argued that if she had left the area under her own power she might have been able to avoid further attack. Although this argument is somewhat conjectural, it is certainly true that she would have had a better chance of avoiding attack if underway under her own power than when lying dead in the water. Insofar as hull damage is concerned she might even have survived the June 6 attack, but this second attack might have caused complete loss of power even with a better machinery arrangement.