Technical Report

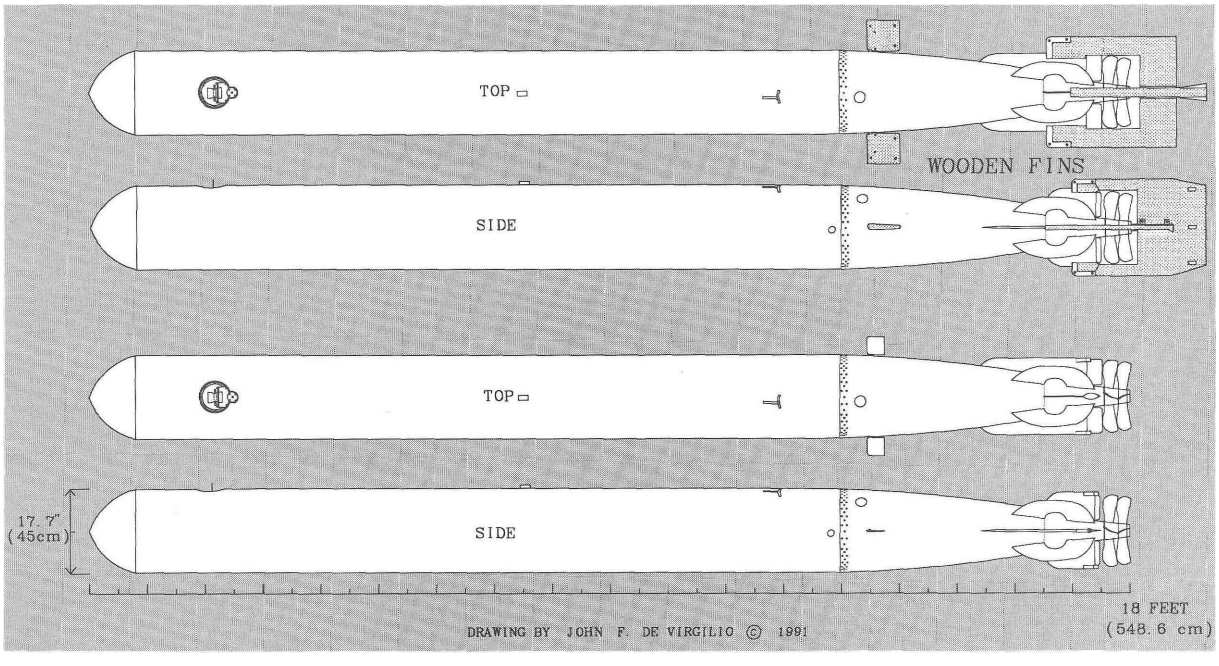
Japanese Thunderfish

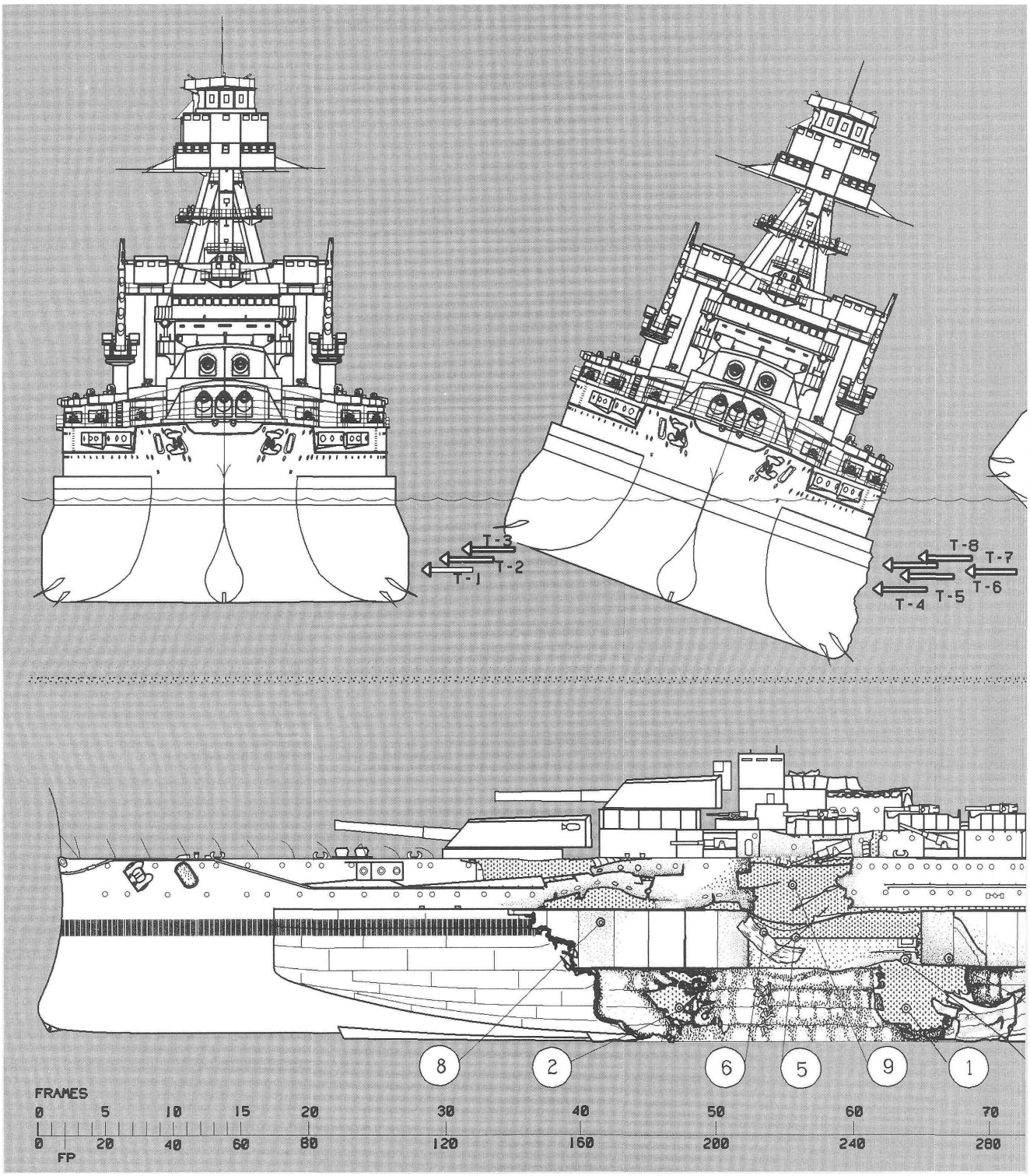
By John F. De Virgilio

A key to the planning for the raid on the U.S. Pacific Fleet at Hawaii was the question of whether aerial torpedoes could be used in shallow water. Only 40-45 feet deep, Pearl Harbor presented a formidable technical obstacle. In September of 1941, late in the operational planning for the attack on Pearl Harbor, Japanese technicians finally met the requirement for a drop in 40-foot water.[1] By mid-October, a new torpedo was ready for service. This new weapon was designated the Type 91, Modification 2, and was Japan's latest in a series of upgrades. However, these new torpedoes were slow in reaching the fleet. The Japanese Navy's striking force waited until 18 November to receive an adequate quantity for use at Pearl Harbor.[2]

This weapon had several new features, which included a warhead 121 pounds larger than its predecessor (for a total of 452 pounds) and separate anti-roll stabilizers mounted directly on the aft body of the torpedo. The anti-roll stabilizers were an important addition because these appendages increased the chances of the torpedo running true to drop direction. In addition, the shallow-water drop altitude doubled, from 33 feet for the older torpedo to 66 for the new one, with drop

Illus. A: The shaded portions are the wooden fins that came off on entering the water.

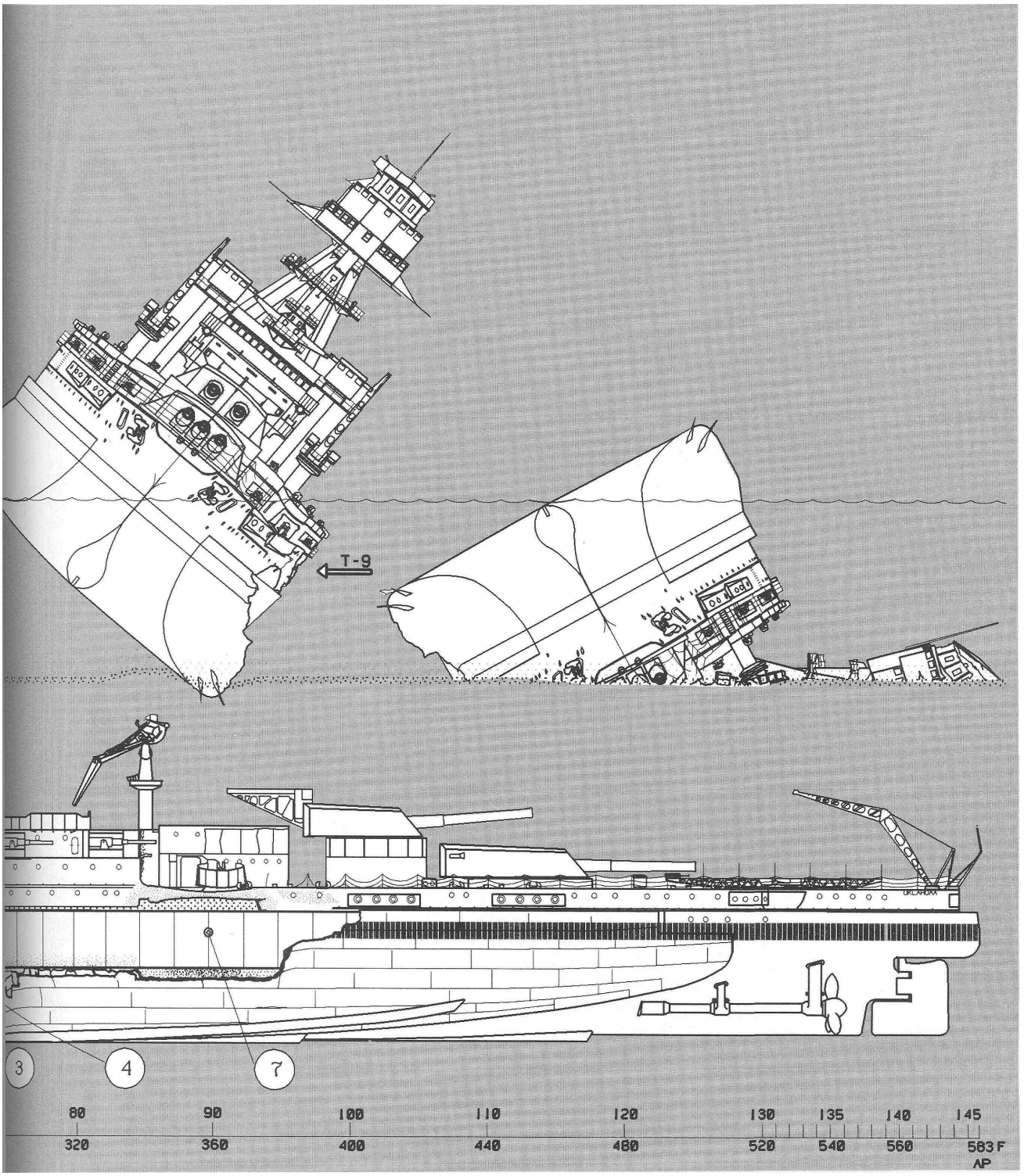




Illus. B: As more and more torpedoes hit her port side, the *Oklahoma* rolled farther over and then capsized. Each group of torpedoes thus hit higher on the **hull.**

speeds at or below 160 knots.[3]

The Japanese considered their torpedoes to be highly reliable. They were superbly constructed and maintained. The arming pistol was easily accessible and was mounted into a dorsal cavity of the warhead when being readied for use. The minimum arming run for this arming pistol was about 650 feet and could be adjusted quickly for longer arming distances. The depth mechanism had ten settings with each increasing the depth by



two-meter increments. Japanese noted the margin of error for the torpedo run depth as being plus or minus half a meter (about 20 inches).[4]

Torpedoes had to be specially prepped for use at Pearl Harbor. Among other things, wooden extension fins were attached to the metal horizontal and vertical tail fins of the torpedo. Smaller wooden fin attachments were added to the anti-roll stabilizers located on both sides and several feet forward of the torpedo's metal horizontal tail fin (see Illustration A). These fins served to stabilize the torpedo in its aerial flight and came off upon entering the water.[5] The large steel horizontal variable-depth control rudders located on the very tail end of the fin as-

sembly were placed in an up position. This position helped the torpedo to hook upward after water entry.

Other factors centered on the pilot and his training. Air speed and drop height were critical to ensure that the torpedo would enter the water at an angle of 17–20 degrees. When the torpedo was dropped from too high, the steep angle of entry caused it to dive into the harbor's bottom. On the other hand, if the torpedo was dropped at a low altitude and at too fast a speed, it would strike the water's surface at a shallow angle, skip on the surface, and break up.

Determining the drop height was purely by pilot's estimation, for aircraft altimeters did not function when within a few dozen feet of the water. The pilot had to bear the burden of simultaneously finding the correct drop height, drop speed, target selection, target range, and target approach. A simple error in estimating minimum range to target might cause the torpedo to run too short a distance and thus not activate the warhead before impact. There is little doubt that the torpedo pilot had the most arduous undertaking of the attack.

The Japanese assigned a total of 40 Type 97 Nakajima (Kate) torpedo planes to attack Pearl Harbor. This group was comprised of 12 aircraft from the carrier *Akagi,* 12 from the *Kaga,* 8 from the *Hiryu,* and 8 from the *Soryu*. Each aircraft carried a three-man crew and one aerial torpedo. The Val dive bombers were assigned to attack the airfields. Twenty-four torpedo aircraft from the *Akagi* and *Kaga* were assigned to attack the outboard American battleships on the southeast side of Ford Island. The inboard battleships were the primary targets for the Kate high-level bombers with their 1,760-pound armor-piercing bombs. The remaining 16 torpedo aircraft from the *Hiryu* and *Soryu* were assigned to attack the American aircraft carriers' mooring areas on the opposite side of Ford Island.[6]

The first wave approached the island of Oahu from the north. A lone scout plane from the heavy cruiser *Chikuma* was already circling over the Pearl Harbor area and reported on the American ships in port. The scout plane radioed back that no aircraft carriers were in the harbor.[7] This was not good news to the *Hiryu* and *Soryu* torpedo groups, whose pilots hoped that the American aircraft carriers had entered port during the previous night.

After the initial attacks by dive bombers, the Japanese torpedo groups approached from the flanks. Kates from the *Hiryu,* followed those from the *Soryu,* were the first torpedo planes to arrive over Pearl Harbor's Middle Loch mooring. After confirming that there were no American carriers present, the *Hiryu* group leader, and all in his group, veered toward the harbor's mouth. Two of the eight *Soryu* torpedo aircraft group followed the *Hiryu*'s lead. The other six *Soryu* torpedo planes dropped their torpedoes on the ships moored on the northwest side of Ford Island.[8]

The first torpedo detonations of the attack were hits on the light cruiser *Raleigh* (CL-9) and the target ship *Utah* (AG-16). Despite popular belief, the Japanese did not mistake the *Utah* for an American aircraft carrier. Of the ten remaining *Hiryu* and *Soryu* aircraft, five released their torpedoes against the cruiser *Helena* (CL-50) at the long Ten-Ten Dock. The last five aircraft dropped their torpedoes on Battleship Row. All torpedo planes from those two carriers returned to their ships without loss.

At the southeastern side of Ford Island lay the most worthy prizes of the attack that morning. Seven of eight American battleships were moored either singly or in side-by-side formations. The *Akagi*'s torpedo group attacked first. This attack was followed a few minutes later by the more loosely spread line of planes from the *Kaga.* Mixed partly through the tail end of the *Akagi* group and throughout the *Kaga* group were the four *Hiryu* and one *Soryu* aircraft looking for battleship target opportunities.

Torpedo drops made by the planes enumerated were as follows: 3 on the USS *California* (BB-44), 12 on the USS *Oklahoma* (BB-37), 9 on the USS *West Virginia* (BB-48), and 1 on the USS *Nevada* (BB-36). No pilot dropped on the USS *Arizona* (BB-39).[9] In the short span of approximately 10-12 minutes, the torpedo attack ended. Of the original 40 Type 97 torpedo planes assigned to the attack, only five failed to return. All five losses were from the carrier *Kaga* and were in the tail end of the aerial torpedo assault.

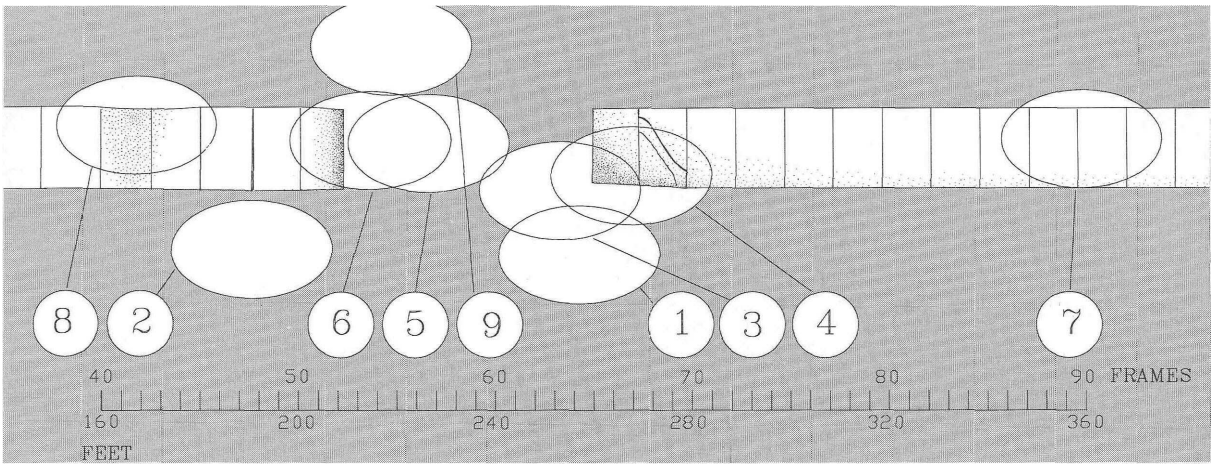
Battleships faced the brunt of the torpedo attack and consequently suffered far more serious damage than did most other ships except the *Utah.* Bureau of Ships reports on torpedo damage for the *California, Nevada, Raleigh, Helena, Utah,* and *Oglala* (CM-4) are accurate and well documented.[10] However, little has been written about torpedo damage on the *Oklahoma* and *West Virginia*.[11] What little exists has never been satisfactorily compiled and in some instances is inaccurate. Despite the shortage of written documentation, there is an abundance of photographic information. This material and the sparse written information have now been compiled to provide a clearer depiction of torpedo damage to American battleships at Pearl Harbor than previously available.

With the inclusion of two additional pieces of data, a far more conclusive picture can be painted than before. Japanese information on the number of ships targeted and the number of drops made have helped to determine the maximum ceiling on possible hits. The most important added information has been the cross-section examination that measured the differences in armor belt displacement for each known torpedo hit. The differences helped to distinguish areas of multiple hits that were originally counted as only single hits.

On the northwestern side of Ford island, the Japanese scored three torpedo hits out of six drops. Two torpedoes struck the *Utah* and caused her to capsize. Two large holes and one smaller hole were reported by underwater salvagers in March 1942. The first hole covered the area of frames 55–61, and a second torpedo hole covered the area of frames 77-82. A smaller 12-foot hole (at frames 69-72) was too small for torpedo detonation and was probably the result of structural failure caused by the torpedo hits on either side.

Another torpedo running at the 13-foot depth struck the *Raleigh* just above the turn of the bilge. The explosion did not gouge out the hull. The hull was smashed upward and inward. The arc-shaped damage covered the area of frames 50-60. The *Raleigh* miraculously managed to stay afloat. Three other torpedoes missed, passed between ships, and lodged in the mud off Ford Island.

At the Ten-Ten Dock, located on the other side of the harbor near dry docks one and two, the Japanese made five drops. The difficulty for the aircraft that attacked there was reflection and glare from the sun directly ahead. The Japanese attackers managed only one hit. That torpedo, running at 20-foot depth, passed under the minelayer *Oglala* and detonated against the *Helena,* which was moored inboard. The torpedo struck well below the armor belt, some 20 feet below the waterline on the starboard side. The resulting blast smashed the hull inward and upward to form an arc-shaped damage area. The damage area to the *Helena*'s hull covered the area of frames 69.5-80.5. The back blast from this detonation also smashed in the thin metal hull of the *Oglala,* which later sank. Struggling to stay afloat, the *Helena*



Illus. C: The numbered hits on the *Oklahoma*'s armor belt correspond to the arrows on Illus. B.

made it to dry dock two on 10 December.

Three other torpedoes are believed to have missed astern of the *Helena* and are probably still sitting in the mud under the old Ten-Ten Dock. There were no apparent detonations by these torpedoes. The remaining torpedo was reported by its dropping plane's crew to be a no-run malfunction and mired in the harbor's bottom.[12]

The battleship closest to the harbor's exit channel was the *California,* which was struck by two of the three torpedoes dropped against her. Both torpedoes, running at the 20-foot depth, detonated on the thin shell plating just below the 13.5-inch armor belt. The first torpedo struck slightly aft at frame 97.5, tearing a hole that measured approximately 30 by 18 feet. This hit ruptured the internal fuel bunkers in this area. The second torpedo struck forward at frame 53 and tore a hole approximately 32 by 18 feet. The blast ruptured the internal fuel bunker.

The *California* sank despite the fact that both torpedo detonations failed to penetrate deeply into the ship's underwater protection. The Bureau of Ships concluded that the battleship should have been saved despite the torpedo damage. The sinking was a result of poor watertight integrity and human oversight. Water penetrated deeply into the ship through numerous unclosed manholes and pipe passageways. The *California* sank slowly and settled finally on the harbor's bottom three days after the attack.[13] One torpedo dropped on this ship is unaccounted for and remains a mystery to this day.

Evidence is fairly conclusive that both the *Oklahoma* and *West Virginia* were struck by more torpedoes than previously thought. The following narrative will cover the torpedo hits on these ships.

The massive amount of torpedo damage to the *Oklahoma* is fully illustrated in the enclosed composite drawing (see Illustration B).[14] The *Oklahoma* received nine hits and capsized within 15 minutes. Initial torpedo strikes occurred at frames 64 and 47.5, about 20 feet below the water line. These early hits tore away major portions of the outside blister shell and gouged the internal hull plating, which immediately caused a heavy list to port (see points 1 and 2 on Illustration B).

Following closely behind the first couple of hits, a third torpedo struck at frame 63, very near the lower edge of the armor belt (see point 3 on Illustrations B and C). The fourth torpedo hit near frame 67, close to the lower edge of the armor belt. The resulting explosion smashed the lower half of the armor belt inward several feet and caused a 5-inch-wide crack in the armor belt between frames 67 and 70 (see point 4 on Illustrations B and C). As a result of the excessive amount of armor belt distortion (inward several feet) in this area, there is a strong possibility that another torpedo may have struck between the third and fourth hits (points 3 and 4).

Because of the increasing port list, the remaining five hits on the *Oklahoma* occurred quite high on the hull. Four torpedoes detonated high on the armor belt with the last exploding above the armor belt at the level of the main deck.

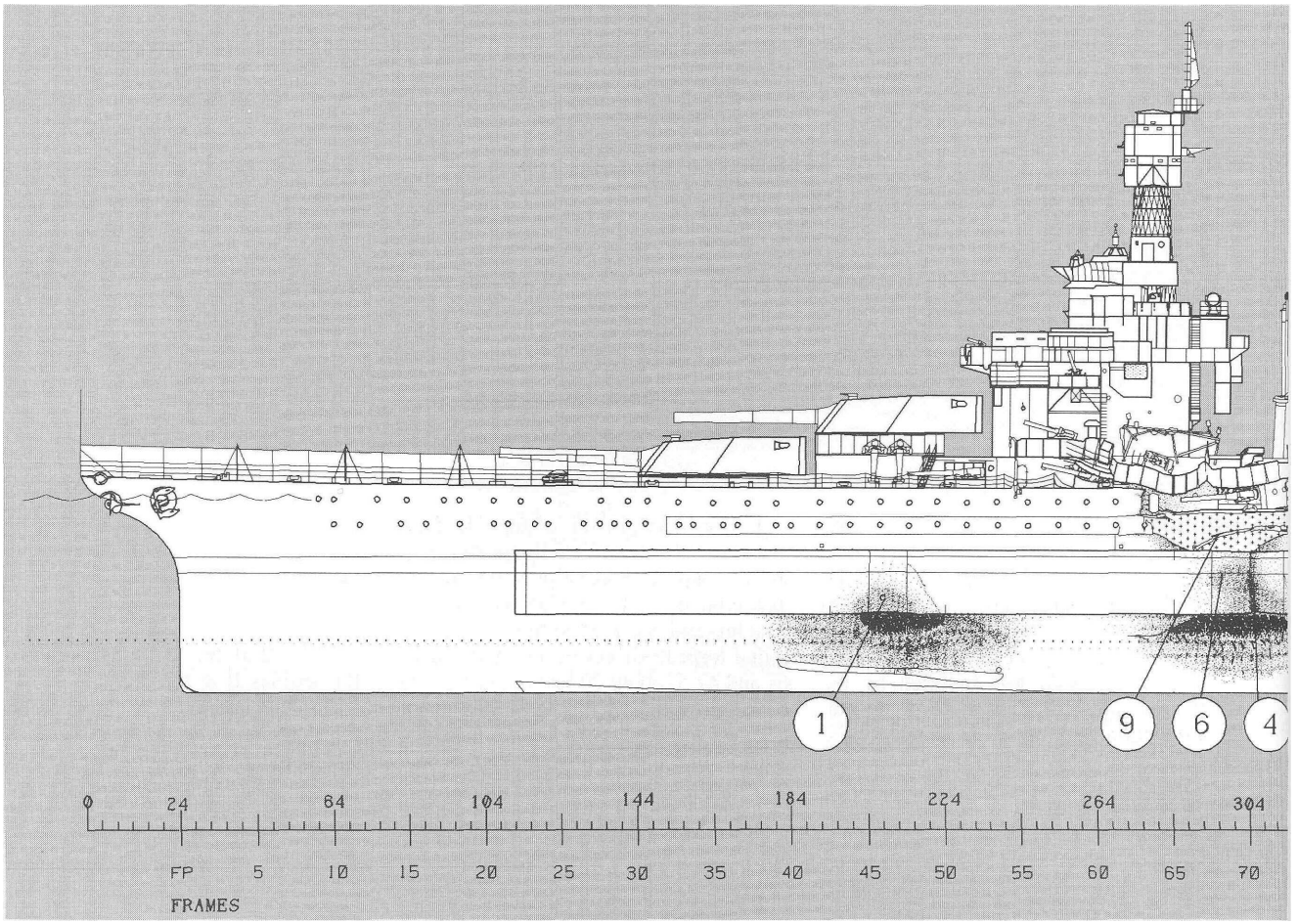
A torpedo struck the upper half of the armor belt near frame 56 about 5-6 feet down from the upper edge of the armor belt (see point 5 on Illustration B). The closest intact piece of armor belt in this area was at frame 52 and was smashed inward almost 2 feet. This large amount of inward armor belt displacement seems to indicate that a further torpedo detonated just above the mid-point on the armor belt at frame 53 (see point 6 on Illustrations B & C).

Another late torpedo exploded below the mainmast area on the blister shell plating outside the armor belt near frame 89. The resulting explosion tore a hole 46 by 34 feet. This hole included much of the shell plating above the armor belt as well as the upper half of the blister (see point 7 on Illustration B). The blister apparently detonated the warhead far enough away so that there was little or no recognizable armor belt distortion in this area.

A very late torpedo exploded on the upper half of the armor belt at frame 42. The blast tore through the light shell plating above the armor belt area and caused an upward arc-shaped distortion that measured approximately 38 by 18 feet. The armor belt itself was distorted inward several inches (point 8 on Illustration B).

The last and most destructive torpedo hit was at frame 55. This hit was well up on the side shell plating at the main deck level as the *Oklahoma* listed 35-40 degrees to port. This detonation tore a 38-foot-diameter hole in the shell plating and caused considerable damage to the internal and upper hull areas (see point 9 on Illustration B).

This last torpedo hit is worth further investigation. There is some well-founded speculation that this last hit caused two major events. First, it is reasonable that the explosion from this hit at such an odd angle was responsible for the peeling away of the 50 feet of missing armor belt. Secondly, the most important factor of this hit is the water wedge that



Illus. D: The *West Virginia* was **heavily damaged by torpedoes but did not capsize because of timely counterflooding and better armor protection than the** *Oklahoma's.*

was created by this particular warhead detonation. Calculating the *Oklahoma*'s maximum draft at about 32 feet, she should have touched bottom and pushed 8–10 feet into the harbor's muddy bottom with a list of 35-40 degrees. It is reasonable to believe that the *Oklahoma* had some chance of stabilizing or even correcting her list at this point. Then, consider the moving qualities of an extremely high pressured liquid wedge pushing itself between the *Oklahoma*'s hull and harbor's bottom. With little doubt, this water wedge acted as a giant lever. The *Oklahoma* capsized in a tumbling manner. She did not roll in place. Her final resting angle was 151.5 degrees and nearly 100 feet away from the inboard USS *Maryland* (BB-46).

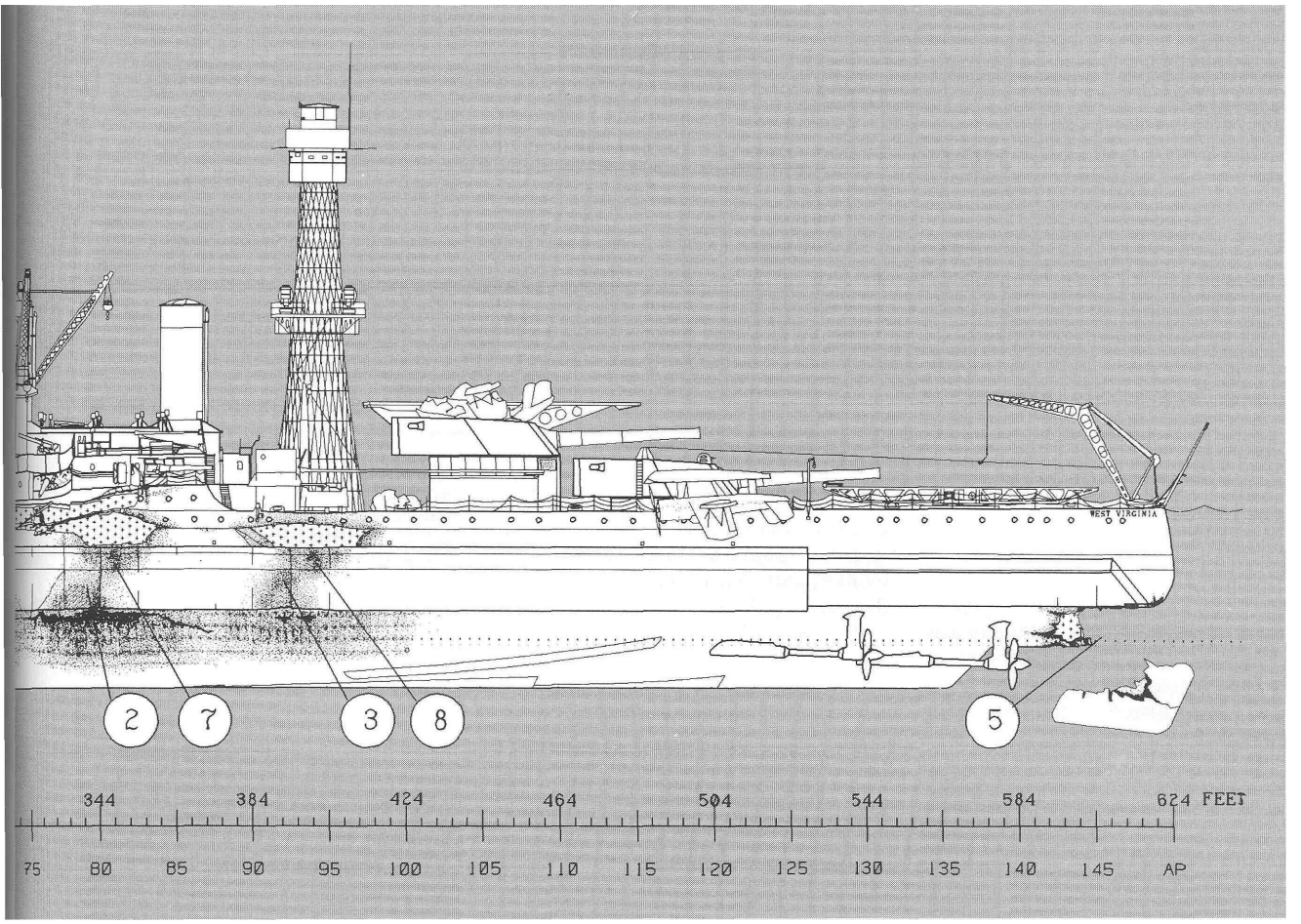
Three other torpedoes dropped on the *Oklahoma* were unaccounted for until May 1991. At that time, a large dredge bucket, working the area outside of the old salvage site, pulled up a completely intact Japanese aerial torpedo. This torpedo was with little doubt one of the three missing torpedoes targeted against the *Oklahoma.* This particular torpedo was jettisoned too high and late by an *Akagi* plane that was badly damaged by nearby antiaircraft fire. With this find, there are now only two *Oklahoma* torpedoes unaccounted for.

Next in line was the *West Virginia.* Unlike the *Oklahoma,* the *West Virginia's* damage is, in many ways, easier to assess. She was also struck by nine torpedoes (see Illustration D).[15] Seven of the nine hits detonated on the armor belt itself. Four torpedoes exploded on the lower half of the armor belt, and three detonated on the upper half of the armor belt itself. The inward armor belt displacement ranged from about eight inches to approximately 22 inches. There were no hits on the shell plating below the armor belt.

The shell plating below the armor belt in the areas of frames 41-53 and frames 60-100 was smashed inward and downward but did not disintegrate (see Illustration D). This indicates that there were no torpedo detonations below the armor belt in these areas.[16] Damage in these areas was caused instead by torpedo detonations above these particular sites on the lower half of the armor belt itself.

The first hit on the *West Virginia* occurred at frame 46 by a torpedo running about 13 feet deep. The torpedo struck the armor belt itself, about 3 feet above the lower edge of the belt. The blast pushed in the 13.5-inch armor belt about 8 inches and left a circular warhead impact groove in the armor (see point 1 on Illustrations D & E). The thin hull plating below the armor belt was smashed inward and downward. Although the shell plating was badly crushed, it was still present to indicate no hit below the belt.

Another torpedo hit the armor belt between frames 79 and 80. The warhead exploded about 5 feet up from the lower edge of the armor belt. The resulting water hammer smashed in the shell plat-



ing below the belt (see point 2 on Illustrations D & E). A further torpedo also struck the lower portion of the armor belt at frame 92. The impact point of this hit was approximately 7 feet up from the armor belt's lower edge at frame 92. The blast pushed in the lower half of the armor belt plate approximately 10 inches and smashed in the shell plating below the belt (see point 3 on Illustrations D & E).

Similarly, another torpedo hit on the lower half of the armor belt at the armor belt joint of frame 70. This torpedo left a circular scar about 5 feet up from the lower edge of the 13.5-inch armor belt. Again, the thinner shell plating below the armor belt was smashed inward and downward (see point 4 on Illustrations D & E).

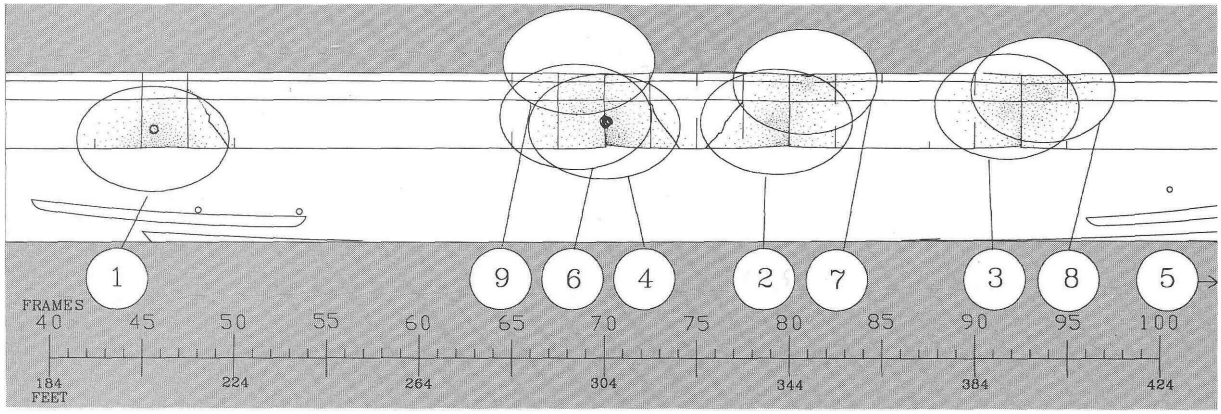
The only deep-running torpedo (approximately 20 feet) hit the rudder at frame 145. The blast gouged out the rudder housing area and damaged the steering machinery in the area (see point 5 on Illustration D). The badly mangled rudder broke off and was later recovered in two pieces.[17] The last group of four torpedoes struck the *West Virginia* late. Three torpedoes hit the upper half of the armor belt, and the final torpedo apparently passed through a damaged opening in the shell plate above the belt and exploded inside the ship.

The largest armor belt depression was between frames 67 and 72. The lower 13.5-inch armor belt at frame 70 was displaced inward nearly 2 feet while the top area, at frame 68, less than a third of this. The large inward displacement was, with little doubt, caused by an added torpedo detonation a short distance above the mid-point of the armor belt near frame 68 (see point 6 on Illustrations D & E). This hit, added to the previous lower hit (point 4) on frame 70, accounts for the amount and depth of the armor depression. This hit also accounts for the damage just above the belt between frames 63-71 and the entrance of the last torpedo.

A late torpedo struck just below the armor belt's upper edge at frame 81. The blast pushed the armor belt inward approximately 7-8 inches and formed an arc-shaped damage area on the shell plating above the belt itself (see point 7 on Illustration D & E). Similarly, a late torpedo struck high on the armor belt at frame 94. The armor belt depression is similar to the hit at frame 81 (point 7). However, the damage to the shell plating above the armor belt is lengthier (see point 8 on Illustration D & E).

The last torpedo to strike the *West Virginia* hit the ship as she listed to port approximately 28-30 degrees. The torpedo entered through an arc-shaped damage hole in the shell plating above the belt area at frame 68. This torpedo detonated on or just above the armored second deck (see point 9 on Illustration E). The armored deck was smashed down approximately 3 feet. Exploding 5-inch ammunition also contributed to a large amount of internal structural damage in the vicinity of this detonation.

The next battleship in line was the USS *Arizona.* A number of reports state that the Arizona was hit by a torpedo. These reports originated from the repair ship USS *Vestal* (AR-4), moored to port of the



Illus. E: The numbered hits on the *West Virginia*'s armor belt match those on Illus. D.

Arizona. The fact is that the *Arizona* was not hit by a torpedo. In 1943, the Navy used high-pressure hoses to pull mud away from the *Arizona's* hull. Navy divers searched the entire port forward section of the hull to a point 10 feet under the turn of the bilge and found no torpedo damage.[18] This particular splash seen outboard and just forward of the *Arizona*'s turret number one and mistakenly reported by various witnesses as a torpedo hit was, in all probability, a near miss by a 1,760-pound bomb.

The last battleship in line was the *Nevada.* She was struck by a single torpedo running at the 20-foot setting at frame 41. The resulting detonation tore an ugly gash that measured approximately 48 feet long and 33 feet high. This hit, plus a substantially smaller amount of underwater bomb damage later, was the primary cause of the beaching of the *Nevada.*

The Japanese aerial torpedo caused the most widespread damage to the American ships at Pearl Harbor. One contributing factor to the success of the Japanese torpedo attack on the capital warships at Pearl Harbor is often overlooked: the overweight condition of the battleships. All the battleships at Pearl Harbor were grossly over their original displacements. Despite the deep internal battleship torpedo defense, ships were so deep in the water that partial penetration and flooding could and did jeopardize the ships.

The Japanese claimed 36 drops out of the 40 torpedoes carried to Pearl Harbor. They scored 25 hits; 11 torpedoes missed, malfunctioned, or plunged into the mud. There are only sketchy accounts for the remaining four torpedoes. One torpedo, still attached to a plane, blew up. Another crashed on the ground in the Navy Yard. A third torpedo was reported as lost by its mother craft. No explanation exists for the last torpedo not dropped on a target.

The successful dropping of a torpedo in 40 feet of water is now recorded in the annals of naval history as a first. The number of capital ships sunk as a direct result of this aerial torpedo raid has never been matched. The type 91 Gyorai or Thunderfish has earned its place as the premier weapon of the Pearl Harbor attack.

Despite the success of the Japanese torpedo, the weapon was not perfect. Unaccounted-for torpedoes are still resting in the muddy bottom of Pearl Harbor. How many of the torpedo failures were due to mechanical causes, human error, or war damage is unclear. The Pearl Harbor aerial torpedo investigation is still unfinished.

[1]Gordon Prange, *At Dawn We Slept* (New York: McGraw-Hill, 1981), p. 321.
[2]Masanori Ito with Roger Pineau, *The End of The Imperial Japanese Navy* (New York: W. W. Norton & Company, Inc., 1962), p. 35.
[3]*Hawaii Sakusen* (Hawaii Operation—Japanese text), p. 622.
[4]Sadao Yamamoto, letter to author, 16 July 1991. *Soryu* type 97 bomber pilot, Mr. Yamamoto, was kind enough to get Mr. Shigeo Motoki, the surviving *Soryu* torpedo ordnance specialist, to respond to a list of torpedo questions left with Yamamoto in the author's 3 June 1991 interview.
[5]U.S. Naval Technical Mission to Japan, 1945-1946, No.O-O1-2, part I.
[6]Hirata Matsumura, *Hiryu* torpedo group leader, interview with author, 24 May 1991.
[7]*Ibid.*
[8]*Ibid.*
[9]*Hawai Sakusen,* p. 355.
[10]Bureau of Ships War Damage reports for the *Raleigh, Helena, Oglala, California,* and *Nevada* can be found in the Vice Admiral Homer Wallin papers in the Operational Archives of the Naval Historical Center, Washington Navy Yard. A much larger collection of Bureau of Ships damage reports can be found in the western regional National Archives in San Bruno, California. Salvage reports are the best source of damage information for the *Utah.* The salvage dive survey report of 15 March 1942 on the *Arizona, Oklahoma,* and *Utah* was used as the best source on damage to the *Utah.*
[11]No comprehensive Bureau of Ships war damage reports for these two battleships have been found. However, several damage reports can be found in the Admiral Wallin papers in the Naval Historical Center and at the National Archives, Suitland Branch, Military Section, Bureau of Ships, BB37, BB48. Also the oversize collection under the same BB numbers at Suitland was most useful.
[12]Hirata Matsumura, interview with author, 24 May 1991.
[13]Bureau of Ships War Damage Report Number 21, USS *California.*
[14]This composite drawing of torpedo damage is based on an official Navy damage blueprint drawing stored in the *Arizona* Museum at Pearl Harbor and on numerous torpedo damage photographs. Photographic information on the *Oklahoma* can be found in the Admiral Wallin collection in the Naval Historical Center. There are also a number of *Oklahoma* battle damage photographs in the Bureau of Ships records, under BB 37, at the National Archives, Suitland Branch, Military Section. This drawing illustrates the torpedo damage without the added salvage holes and other damage that resulted as the ship capsized.
[15]The *West Virginia* composite drawing of torpedo damage is based on photographs found in the Admiral Wallin papers in the Naval Historical Center. A number of rare and excellent damage photographs can be found in the Bureau of Ships records, under BB48, at the National Archives, Suitland Branch, Military Section. Also, a number of rare Bureau of Ships battle damage photographs of the *West Virginia* can be found at the western regional branch of the National Archives in San Bruno, California.
[16]Vice Admiral Homer N. Wallin, USN (Ret.), *Pearl Harbor: Why, How, Fleet Salvage and Final Appraisal* (Washington, D.C.: U.S. Government Printing Office, 1968), p. 350. Admiral Wallin noted that no torpedo detonated directly on the shell plating below the armor belt.
[17]*Ibid.,* p. 351.
[18]USS *Arizona,* War Damage Report, 7 October 1943.

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