Hits 16, 17 and 18 – Damage to Second Deck Superstructure

From the BuShips damage report:

> 28. Three hits were made on the starboard bulkhead between frames 83 and 85 about 3 feet above the second superstructure deck. From the size of the entry holes, it is estimated that these were one 8-inch and two 6-inch AP projectiles. The 8-inch projectile ripped through five structural bulkheads and was stopped by the shield of 5-inch mount No. 2, knocking off the rear door of this mount without detonating. When the projectile was discovered after the battle, it was quickly thrown overboard. In staterooms 0202, 0203, 0205, the unassigned space under the starboard signal locker, and B-103-L through which the projectiles passed, furniture, ventilation ducts, metal joiner doors and aluminum division bulkheads were demolished. Less extensive shock and fragment damage was sustained in staterooms 0204, 0206, 0207, and B-0201-L. One fragment pierced the starboard signal flag locker and started a minor fire.[68]

South Dakota's time line in her action report describes this hit as follows:

> [From "Chronological Log of the Battle" section of Action Report]
>
> 0104 More hits felt. Secondary battery is still firing.
> No communication with sky control.
> Shell hit, glancing off mount 5, through signal storeroom, across superstructure, and into after end of mount 4. Shell did not explode, later found on deck, 8-inch disposed of by throwing overboard.[69]

In *South Dakota*'s action report the damage is described as follows:

> WRSR 0205. Salvo of 3 projectiles (belived [sic] to be 6") entered longitudinal bulkhead at frame 84, approximately 3' above 2nd superstructure deck resulting in the following damage:
> Entire transverse aluminum divisional bulkhead between WRSR 0205 and locker used for stowage of forms completely blown out.
> Inboard longitudinal structural bulkhead has 30" diameter hole approximately 3' above deck level.
> Secretary desk completely demolished.
> Confidential safe demolished.
> Wash basin and cabinet demolished.
> Overhead supporting deck beam frame 82 torn open 4" x 6".
> Ventilation duct demolished.
> Hot and cold water piping and drains completely demolished.
> Metal joiner door to passage demolished.
> Metal enclosure and binding strips of berth torn and distorted by shrapnel.
> 10" hole approximately 32" above deck plate in outboard longitudinal structural bulkhead.
> Unassigned compartment under starboard signal flag bag used for stowage of XO office forms.
> All shelving completely demolished by shrapnel.
> Bottom of starboard signal bag blown open at seam approximately 4' x 2'.

[68] BuShips War Damage Report # 57, page 8

[69] USS *South Dakota* Action Report, page 8 [Ed's note: This paragraph seems to be conflating Hit 24, which glanced off Mount #5 but did not penetrate into the superstructure, together with Hit 17 which did not hit any of the starboard side 5-inch twin mountings but which did pass through the superstructure and struck the rear of Mount #2. According to both the BuShips report and the "Gunnery Damage" section of Enclosure D, Mount #4 did not suffer any damage at all in this battle.]

3 outboard bulkhead stiffeners on after transverse bulkhead pierced by shell fragments, holes approximately 3" in diameter.
Welded seams torn.
Outboard longitudinal bulkhead pierced by shell fragments approximately 8" in diameter, frame 85, 4' above deck level.
30" hole in inboard structural bulkhead.
2" drainage line on inboard and outboard ends of signal bag torn out.
Deck plating dished over 3' square area, 8' inboard of longitudinal structural bulkhead.
Non-watertight door pierced by shrapnel and is unserviceable.
6" aluminum ventilation duct demolished.
Ventilation terminal of supply ventilation system demolished.

WRSR 0207.
Frame 87½ battle port 2" hole.
Metal Joiner door to passage distorted.
Door frame pierced by shrapnel.
After transverse structural bulkhead pierced by fragments ranging from ¾" to 3" in diameter.

Passage B-0201L.
Door frame of metal joiner door access to B-103L pierced by fragments.
Drain line for upper level stateroom pierced by 3 fragments approximately 5' above deck level.
Exhaust ventilation system duct torn and blown open.
2" fresh water supply lines to 2nd and 3rd superstructure deck staterooms severed 2' above deck level.

WRSR 0204.
Metal joiner door and frame blown out and distorted. Inboard longitudinal panel bulkhead blown out.

WRSR0206.
Inboard longitudinal panel bulkhead demolished.
Metal joiner door and frame broken.

B-103L.
2nd superstructure deck. 25" by 8" T bars bulkhead stiffeners on starboard longitudinal structural bulkhead at frame 83 severed 2' above deck level.
Access ladder and fittings to 3rd superstructure deck demolished.
Hot water tank (supply to system on 2nd superstructure deck) demolished.
Topping lift and big falls for starboard boat crane damaged.
Three 4" fuel hoses damaged. #1 MWB[70] damaged. (26 small shrapnel holes).
Electrical booster pump and all connections completely demolished.
Steam line supply and drain to hot water tank completely demolished.
Longitudinal centerline structural bulkhead demolished at frame 84.
Ventilation supply and exhaust lines severed and demolished at frame 82½ port.
1 ¼" compressed air line severed at frame 82.
First aid box and supports demolished.

[70] MWB = Motor Whale Boat

Intake and exhaust ventilation ducts demolished, starboard.
Port longitudinal structural 30 pound bulkhead and stiffeners completely demolished.
Seams to fresh water gravity tanks leaking.
Stanchions on access ladder cut and broken.
Combing of access hatch to first superstructure deck bent and distorted.

WRSR 0202
Metal joiner door and frame demolished.
Large ship's confidential safe demolished.
Secretarial desk demolished. Built in metal berth demolished. Wardrobe locker demolished. Chiffonier locker demolished. Sheathing and insulation torn out over entire area. Wash basin and connections torn from fastenings.
Shaving cabinet broken.[71]

- - -

Secondary Battery Group #2

. . . Mount #2 was struck by 6.1" projectile which had passed through superstructure from starboard side. This projectile did not explode. The projectile struck door to left hit case chute, then up rear of shield. The rear armor plate is pushed in and broken loose from top, sides, and bottom plates. The angle beam is cut. Oil reservoir tank of left shell hoist punctured.[72]

[71] USS *South Dakota* Action Report, Enclosure D, pages 3-5
[72] USS *South Dakota* Action Report, Enclosure D, page 15

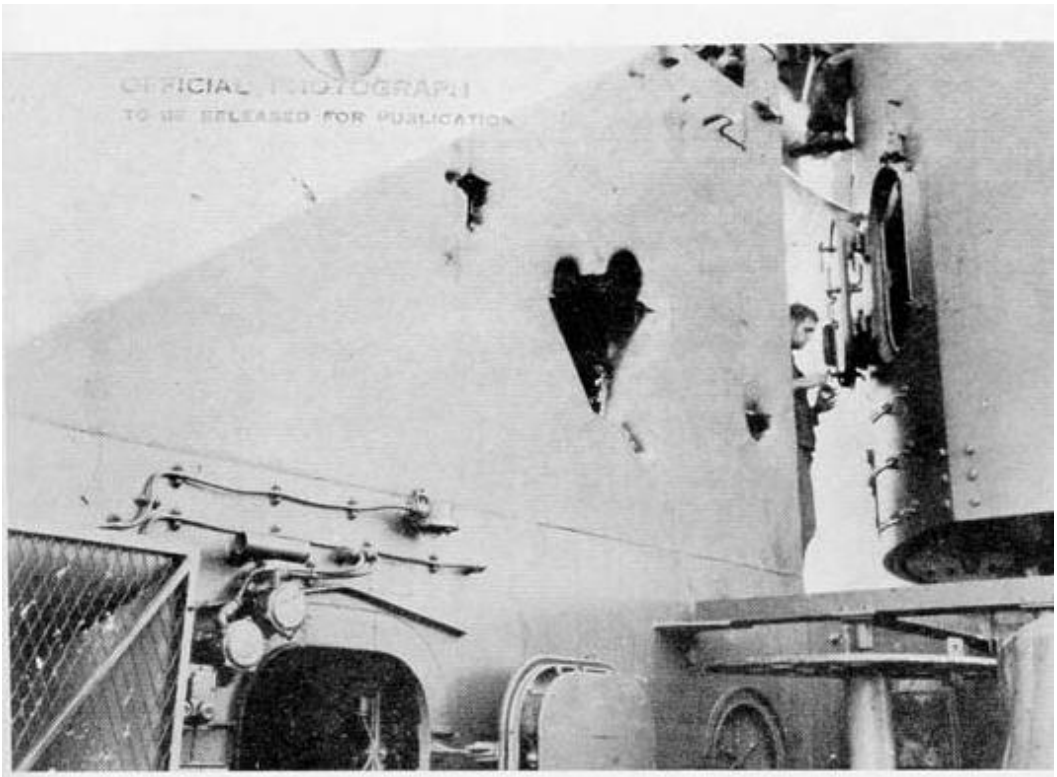

Photo 24: Hits Nos. 16, 17 and 18 on starboard side of W.R.S.R. 0203.

Figure 54 – Hits 16, 17 and 18 – Entry Holes

Figure 55 – Hit 17 – Reverse View of Entry Hole

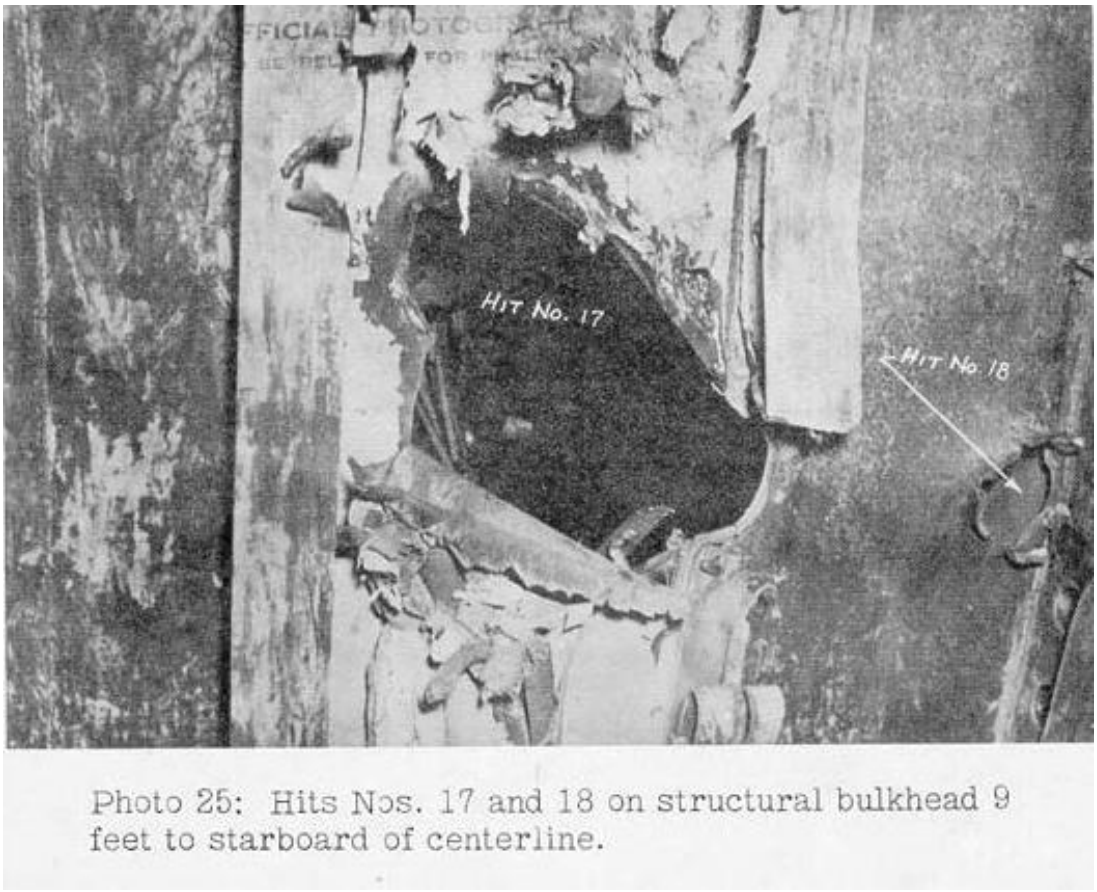

Photo 25: Hits Nos. 17 and 18 on structural bulkhead 9 feet to starboard of centerline.

Figure 56 – Hits 17 and 18 – Strikes on Internal Bulkhead

Figure 57 – Hit 17 – Damage to Internal Bulkhead of Staff State Room – View A

This photograph also shows the damage to the safe, the front of which seems to be badly wrecked but "demolished" appears to be a bit of an overstatement. The word "demolished" is used many times in Enclosure D as something of a synonym for "needing to be replaced."

Figure 58 – Hit 17 – Damage to Internal Bulkhead of Staff State Room – View B

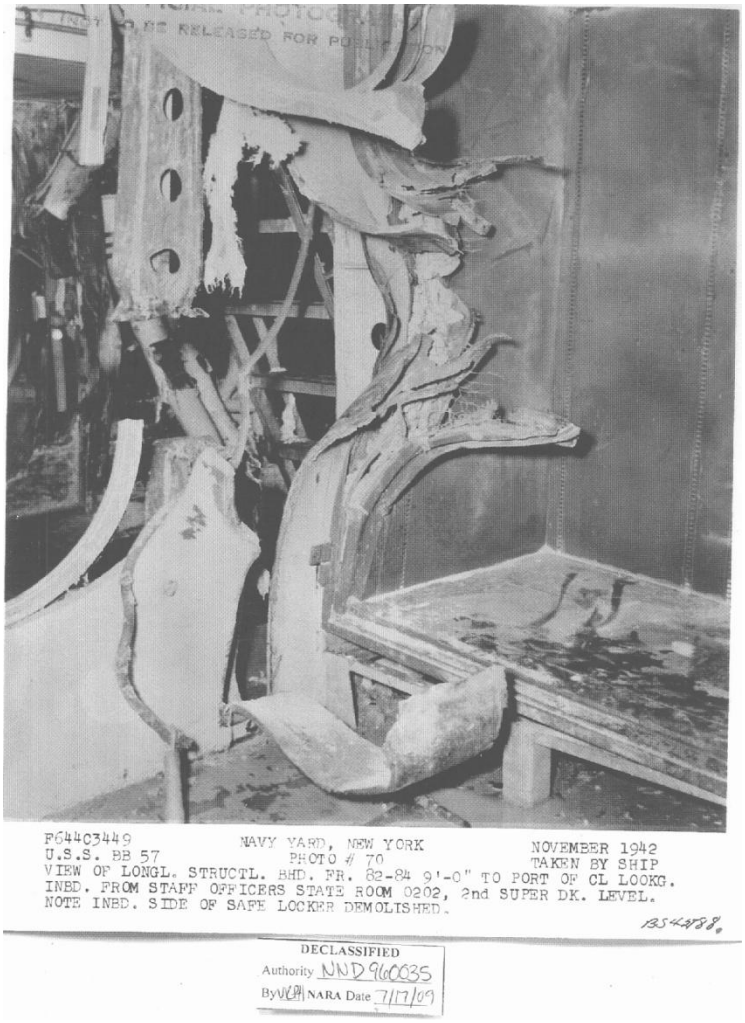

Figure 59 – Hit 17 – Damage to Internal Bulkhead of Staff State Room – View C

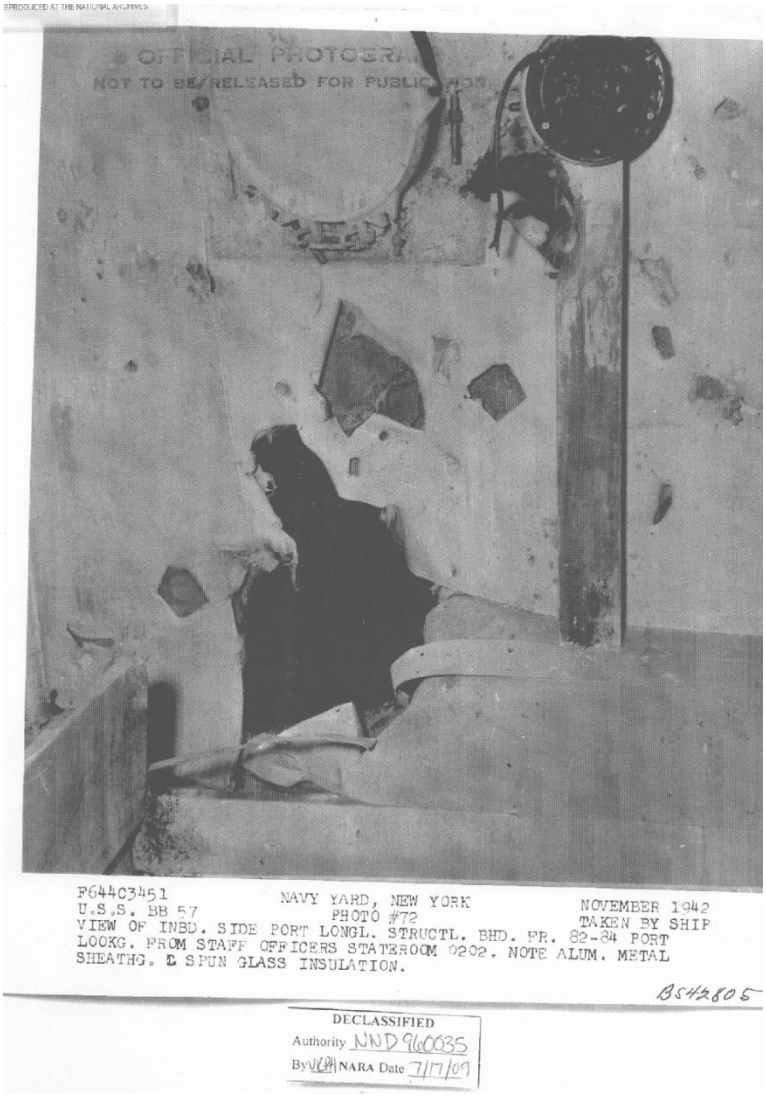

Figure 60 – Hit 17 – Damage to Port Longitudinal Structural Bulkhead in Staff State Room

Figure 61 – Hit 17 – Damage to External Bulkhead and to 5-inch Mount #2

The small hole below and to the left of the blown out porthole shown in Figure 61 is either from the cap head paralleling the path of the 8-inch AP projectile body or is from a chunk of something in the superstructure that was knocked out so hard that it tore its own hole through the outer bulkhead just above the 8-inch projectile body slot. It does not seem to have hit the back of the gun mount with enough force to make any noticeable dent or perhaps it went through the punched-out doorway in the mount rear and ended up inside the mount, although the damage report does not state that any part of the projectile was found inside the mount.

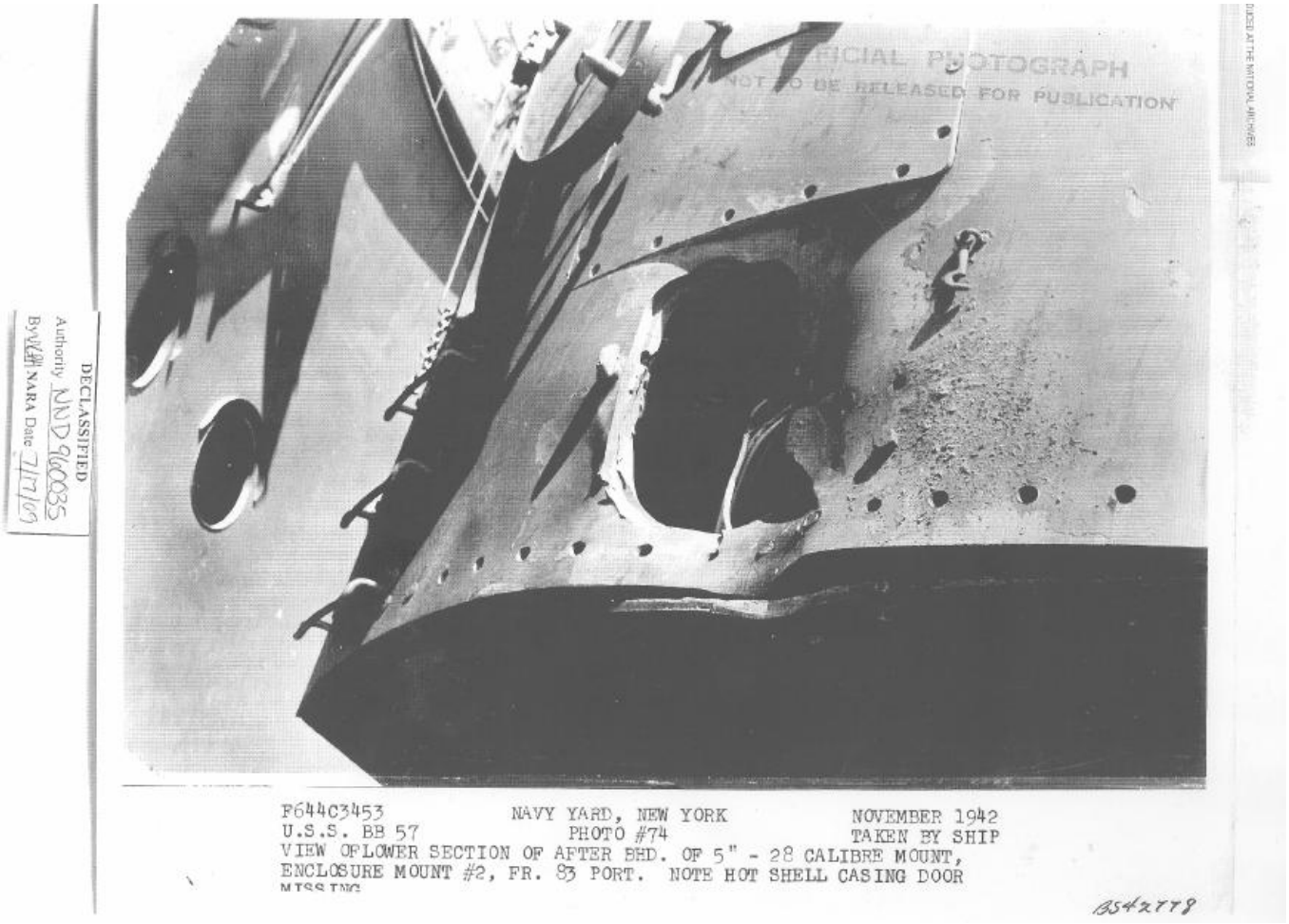

Figure 62 – Hit 17 – Damage to 5-inch Mount #2

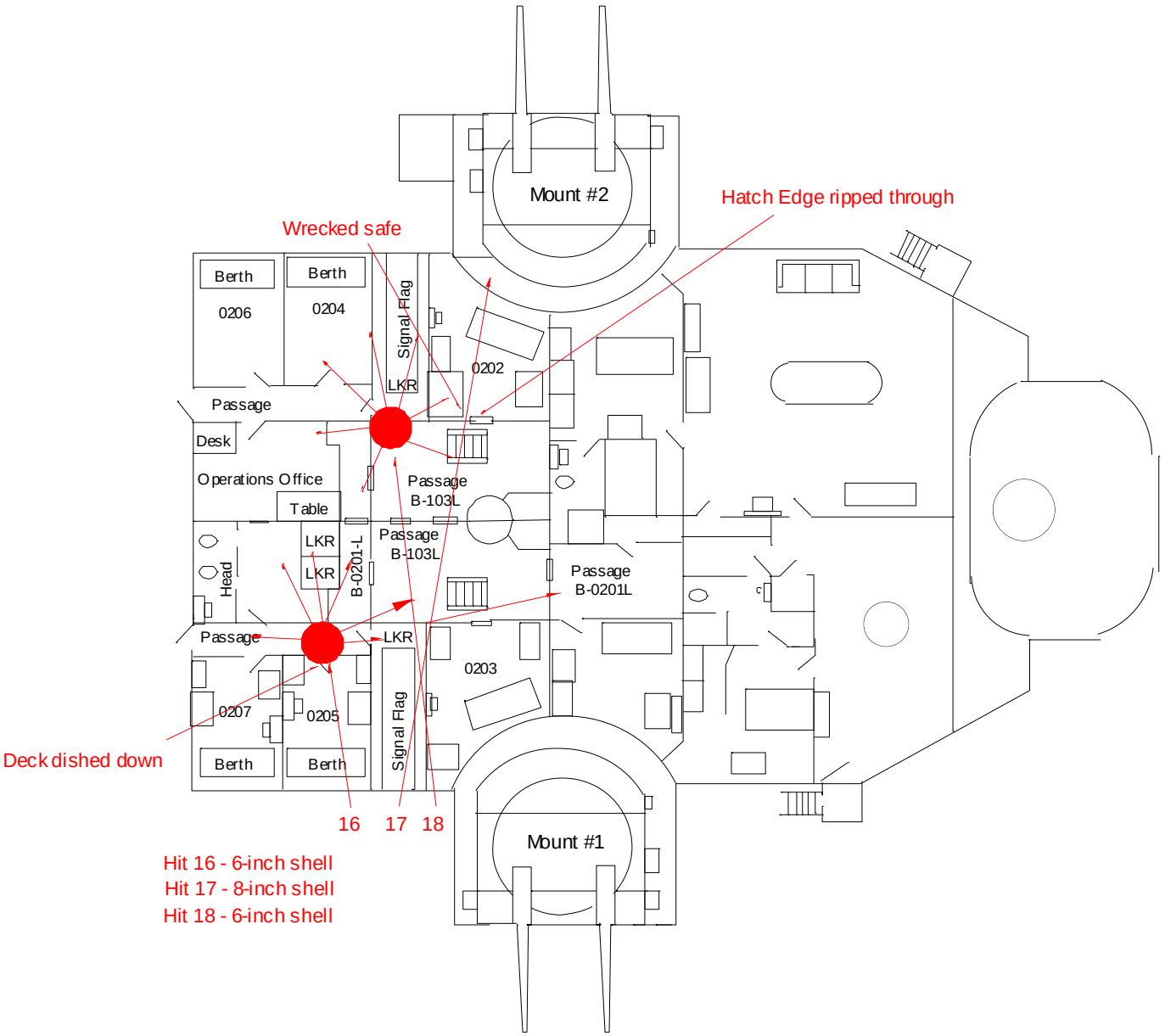

Figure 63 – Hits 16, 17 and 18 – Paths of the Shells and Splinters

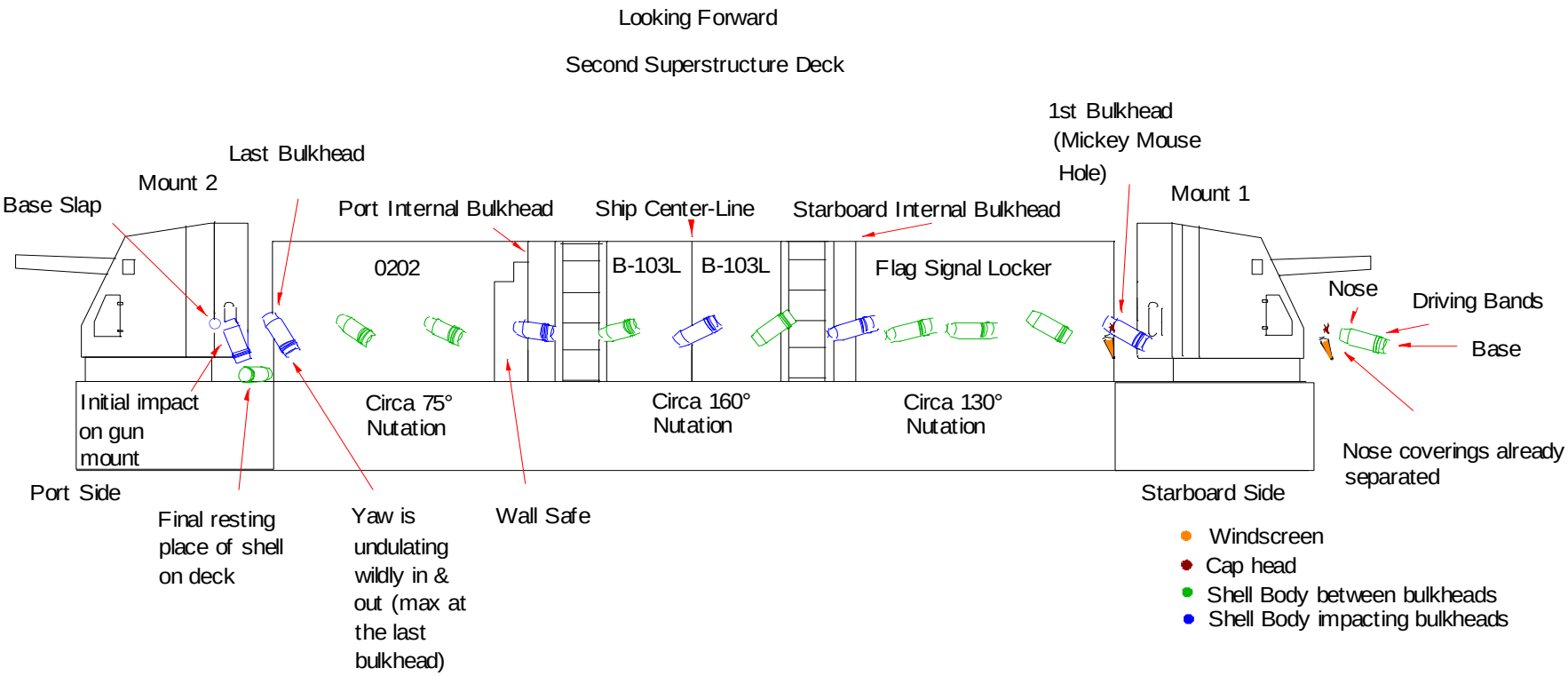

Figure 64 – Hit 17 – Path of the Shell

Analysis of impact

The documentation on these three hits is very inconsistent, but in the end the estimate of two 6-inch and one 8-inch projectiles appears to be correct. First, the photograph labeling the entry hits at WRSR 0203 (Figure 54) is misleading in that two of the shells actually entered WRSR 0205 and into the starboard Signal Flag Locker room and only Hit 18 actually entered via WRSR 0203. Secondly, the shells were not part of a single salvo as the shell trajectories of the two 6-inch shells (Hits 16 and 18) are from forward moving aft while the 8-inch shell (Hit 17) must have came from aft moving forward or else it would have completely missed mount two. This can be seen in Figure 56 where Hit 17 came through a bulkhead moving right to left while Hit 18 was moving left to right. The two 6-inch shells appear to have detonated, causing blast and fragment damage to the staterooms. The relatively small 10-inch entry holes seen for these hits appear to be more consistent with 6-inch shells.

Hit 16 appears to have detonated on the inboard side of compartment WRSR 0205 as the deck plating was dished down over a 3 foot square area, 8 feet inboard of longitudinal structural bulkhead. The entire transverse aluminum divisional bulkhead between WRSR 0205 and the locker used for stowage of forms was completely blown out. This inboard longitudinal structural bulkhead also had a 30-inch diameter hole knocked in it approximately 3 feet above deck level. Plate 1 of BuShip's original report (shown as Figure 118 in this essay) has a notation that implies that none of these three projectiles detonated, but *South Dakota*'s action report makes it clear that the two 6-inch projectiles did indeed detonate within the superstructure.

The holes in the bulkheads for Hit 17 appear too large for a 6-inch shell and, contrary to South Dakota's action report, there were no guns present at this battle that fired a 6.1-inch shell. The only 6.1-inch guns in the vicinity were part of the battleship Yamato's secondary battery and she was anchored miles away at Truk.

Based on the photographs, it appears that the entry hole caused by the shell passing through to hit mount 2 is significantly larger than 10 inches. The first clue to its identity is the shape of the entry hole shown in Figure 54 and Figure 55. Examining these two photographs show that Hit 17 made a "V" shaped entry hole along with two circular holes at the top giving it "Mickey Mouse" ears. This is an odd shape for an entry hole, as can be seen comparing it with the round holes made by Hit 16 and Hit 18.

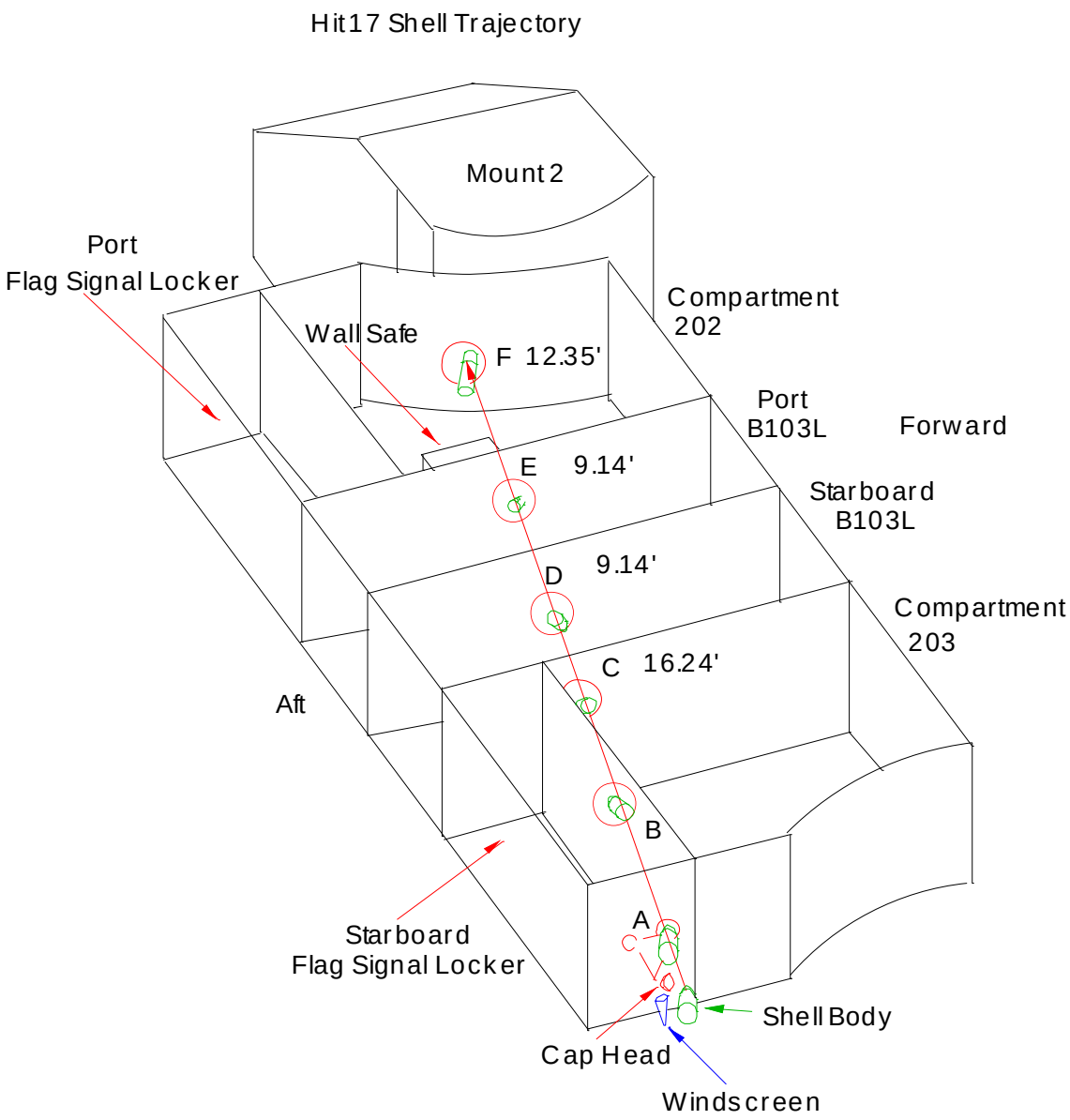

Figure 65 – Hit 17 – Path of the Shell – 3D View

What could have caused this oddly-shaped entry hole? A possibility is that the shell components separated before reaching the bulkhead. If we think of an 8-inch AP projectile as having a windscreen, a cap head and a shell body, then the bottom of the "V" may have been caused by the windscreen (point down) with the left and smaller circular entry hole being from the cap head and the larger circular hole on the right being caused by the shell body.

To have broken up like this, the projectile must have already hit something hard enough to dislodge its nose coverings prior to impacting this exterior bulkhead. This could only have been the water short of the

ship, which would have also slowed it down considerably in the process. So, this hit could have struck at too shallow an angle to "bite" into the water and instead it ricocheted up to hit the superstructure, shedding its nose-coverings as it went.[73]

After hitting the water, the windscreen and cap head of the 8-inch AP shell were knocked off and the projectile slowed down considerably before ricocheting upward at a very shallow angle, slamming into the starboard bulkhead to form the Mickey Mouse Hole. In the water ricochet process, the nose acquired a significant "yaw" angle, which is the tilt of the nose away from the direction of motion of the projectile caused by the water impact pushing on the upper end of the projectile with a different force than on the base end. The projectile thus began to move forward like a surfboard, cocked off at an angle to the direction it was moving, in this case about 20-30 degrees, as shown by the oval hole in Figure 56. Since the projectile was still spinning at a high rate, however, this yaw started to "nutate"[74] as soon as it left the water so that the nose punched through the superstructure bulkheads with the yaw angle pointed in progressively different directions, as shown in Figure 64.

While the direction of the yaw changed due to the nutation, the amount of yaw stayed more-or-less at the same 20-30 degrees it had when it initially made part of the Mickey Mouse Hole over most of its path through the superstructure, as shown in Figure 56 (the picture here is from the exit side of the hole, so it is a mirror image of the actual direction that the yaw was pointing when it punched through the bulkhead toward the camera).

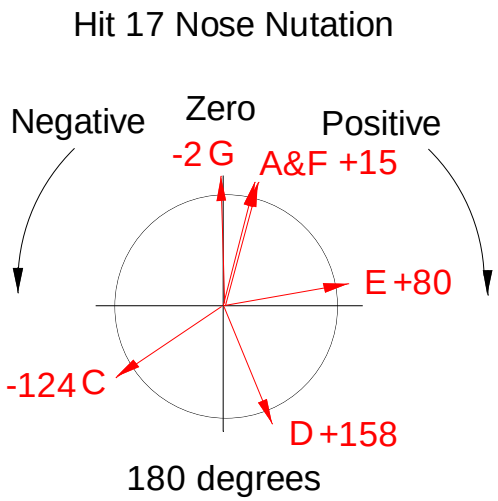

Figure 66 – Hit 17 – Nose Nutation

[73] The heavy cruisers only scored hits between 0102 and 0106 and during this time their range to *South Dakota* was between 5,600 yards and 4,700 yards. For Type 88, Type 91, Type 1 and any other similar tapered, flat-nose shell-body design, only those striking calm water at angles over 7 degrees were able to reliably dive and avoid skipping. John Campbell in *Naval Weapons of World War Two*, page 186, states that the angle of fall for an 8-inch Type 91 AP projectile was 3.0 degrees at 5,470 yards (5,000 m). This implies that any 8-inch round that landed short of *South Dakota* during this phase of the battle had a high probability of skipping.

[74] Nutation – A "spiral", "corkscrew", or "helical" motion of the tip of the projectile nose as it moves forward such that the yaw angle is tilting in different directions as the projectile moves forward – like the tip of a propeller on a fast-moving ship.

Figure 66 shows how the nutation angles are used in this document. Zero degrees nutation is directly on top. Positive degree nutation angles are in a clockwise direction while negative degree nutation angles are in a counter-clockwise direction from the zero point. Negative angles may also be referred to as a Positive angle by measuring in the clockwise direction. For example: -124 degrees is equivalent to a Positive Angle of +236 degrees. The letters shown in Figure 66 refer to the nutation angles as the shell body impacted the bulkheads as it traveled through the superstructure as labeled in Figure 65.

For Hit 17, when this shell entered the exterior starboard bulkhead of the Flag Signal Locker, the shell nose was at a nutation angle of +15 degrees (Refer to Figure 65 Point A). The shell was nutating in a counter-clockwise direction.

The shell then ripped through a thin transverse bulkhead to exit the Flag Signal Locker (Refer to Figure 65 Point B) and entered Compartment 203 at a highly oblique angle, but very close to its inboard end, so the bulkhead has little deflection effect as the projectile tears through it. Since the projectile body has a flat nose and such a small yaw, the forces generated are still very close to directly down the centerline of the shell, so any added yawing effect (increasing or decreasing) by penetrating this transverse bulkhead was minimal.

The projectile then hit the longitude inboard bulkhead of compartment 203 (Refer to Figure 65 Point C). The nutation angle at this point had progressed to -124 degrees based upon Figure 56. The yaw angle remained at about 20-30 degrees. The distance from the exterior bulkhead to this inboard bulkhead is 16.0 feet and taking into account that the trajectory is on an approximate 10 degree composite angle, this changes the actual distance traveled to 16.24 feet [16 feet x 1/cos (10 degrees) = 16 feet x 1.015 = 16.24 feet]. There has been a total of 139 degrees change in nutation (-15 degrees + -124 degrees = -139 degrees), so -139 degrees/16.24 feet = -8.5 degree change per foot of travel.

The next bulkhead is the centerline bulkhead of the ship in Compartment B103L (Refer to Figure 65 Point D). This bulkhead is 9.0 feet from the inboard bulkhead of compartment 203. The 10 degree angle for the shell trajectory adjusts the actual distance traveled to 9.14 feet [9 feet x 1/cos (10) = 9 feet x 1.015 = 9.14 feet]. Maintaining the same nutation rate of -8.5 degrees per foot, an additional -78 degrees (9.14 feet x -8.5 degrees = -78 degrees) will result with the shell impacting this bulkhead with a nutation angle of +158 degrees (-124 degrees + -78 degrees = -202 degrees = Equivalent Positive Angle +158 degrees) with the yaw remaining constant.

The next bulkhead is the inboard side of compartment 202 (Refer to Figure 65 Point E). This bulkhead is also 9.0 feet away from the ship's centerline. The distance and nutation rate remains the same as for the previous bulkhead, so the projectile's nose impacted this bulkhead with a nutation of +80 degrees (+158 degrees + -78 degrees = +80 degrees).

However, there was a wall safe on the other side of this bulkhead inside compartment 202. The now-nearly-horizontal projectile's lower body broad-sided the 2-inch-thick left side of the large double-door safe, as shown in Figure 59 (also shown in Figure 57 and Figure 58, but not as clearly).[75] That violent middle-body impact with the safe caused the yaw angle to begin swinging wildly in and out, to angles well above the original 20-30 degrees, perhaps up to 60 degrees away from directly along the flight path,

[75] As shown in Figure 59, this shell made a huge gouge into the side of the safe, knocked off the left-side door, snapped open the right-side door, and partially pulled the safe from its heavily-reinforced foundation, tossing the left door and the safe's contents all over the room. This safe was made of metal similar to homogeneous armor steel, so its effect on the projectile's motion thereafter was considerable.

and the nutation rate also changed to approximately -5.3 degrees per foot, although the shell would still be nutating in the counter-clockwise direction. This is to be expected since the larger yaw angle acts like a rapidly-spinning ice-skater spreading her arms out and slowing her spin rate down due to conservation of angular momentum.

The distance from the wall safe to the curved exterior bulkhead of compartment 202 (Refer to Figure 65 Point F), is 12.35 feet. With the new nutation rate, the projectile nutated an additional -65 degrees (12.35 feet x -5.3 degrees = -65 degrees), so that the shell on impact with the port exterior bulkhead had a nutation of +15 degrees (+80 degrees + -65 degrees = +15 degrees). As shown in Figure 61, the projectile then "belly-flopped" through this bulkhead and made that long slot that was almost identical, though longer, to the initial slot (mostly masked by the long windscreen hole) it made on the starboard bulkhead. The projectile nose had thus spiraled through one complete circle during its passage through the superstructure (see Figure 64).

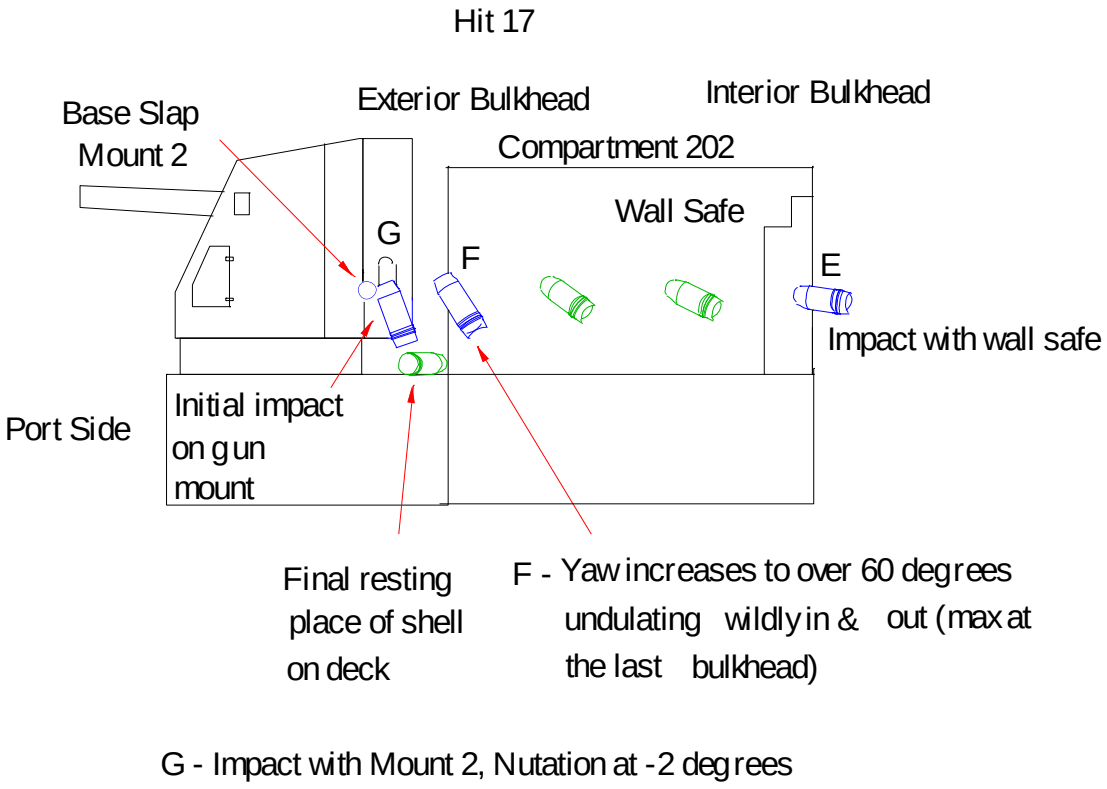

Figure 67 – Hit 17 – Path End

As shown in Figure 61 and Figure 62, the projectile kept that high yaw angle in the gap between the port bulkhead and the back of the 5-inch gun mount (Refer to Figure 65 Point G). The gap distance is 3.25 feet and, using the nutation rate of -5.3 degrees per foot; -5.3 degrees x 3.25 feet = -17 degrees change in nutation angle), the shell impacted the gun mount at a nutation angle of -2 degrees (+15 degrees + -17 degrees = -2 degrees), angled almost exactly vertical, nose up, at the point where its forward motion was finally stopped.

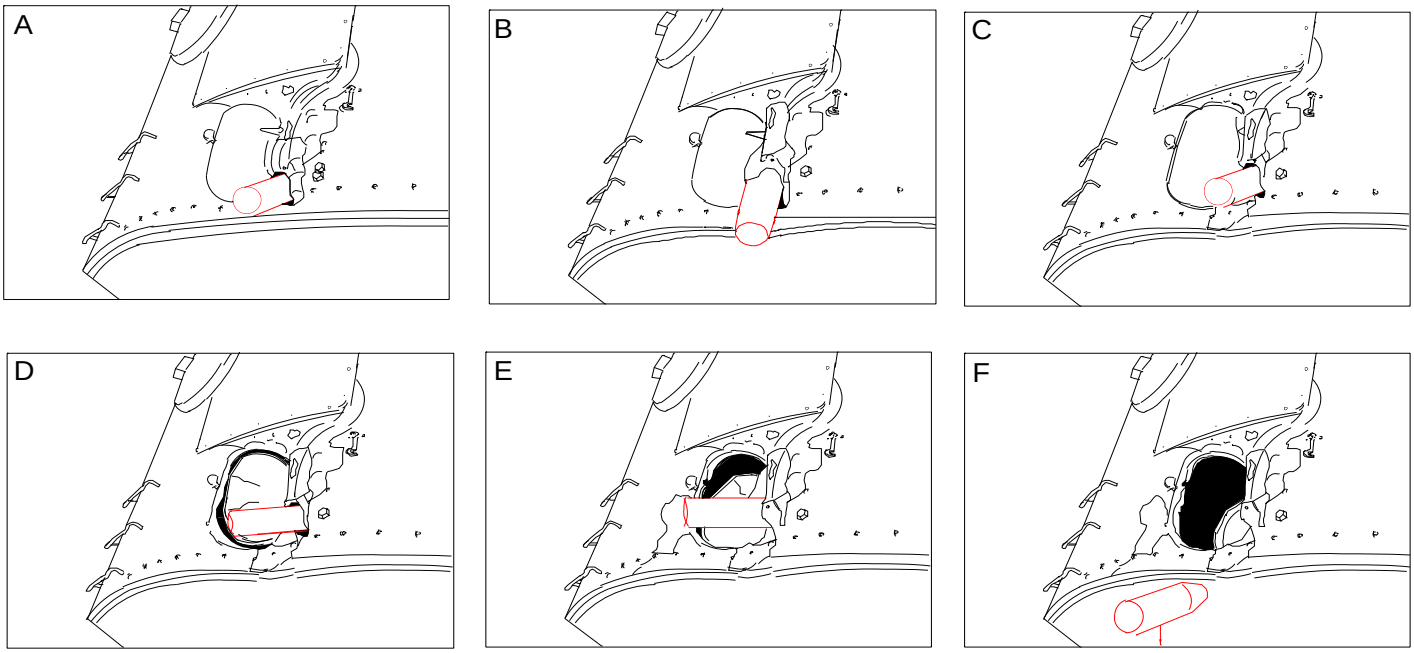

Figure 68 – Hit 17 – Impact on 5-inch Gun Mount 2

Referencing Figure 68, the nose hit the 5-inch mount at the lower-right-hand corner of the left-side-gun's shell casing ejection hatch (A) and punched a deep pit and hole, but did not completely penetrate. The tapered flat nose was jammed into that hole and could not move while the base continued forward, slamming vertically nose-up into the rear of the gun mount (90 degrees yaw angle and -2 degrees nutation angle), as noted by the curved dent in the lower edge of the rear armor and the gash in the edge of the armor floor plate below that (B). As the nose was jammed into the deep dent and hole, this rotation pulled out the armor just above the nose hole, since it is now shallower than the dent higher up on the right edge of the case-ejection hole. The projectile body hit the lower-edge armor sideways at a high nutation rate, as shown by the depth of the dent, and then rebounded outward, pivoting on the jammed nose (C). The nutation inertia was still in force, however, so the rotation of the lower projectile body toward the horizontal, reducing the 90 degrees yaw angle toward zero, was accompanied by the nutation of the projectile base to the left, counter-clockwise, just as before the armor impact, but now pivoting on the nose tip, not the shell center-of gravity about halfway down the shell length (D). This caused the base to move in a curve like a question mark without the bottom dot and end up slamming horizontally on the far left side of the case-ejection opening from the nose hole (90 degrees yaw angle and a 90 degrees nutation angle), as shown by the rectangular dent there (E). This cross-wise slam across the closed hatch covering the case-ejection opening rammed the hatch cover through the opening into the gun mount, tearing out the edge hinges and locking clamps and causing deep tears/dents all around the edge of the opening. In the process, the nose pulled out more of the armor trapping it, pulling up the raised torn area to the right and below the nose hole.

After this second horizontal base impact, the projectile no longer had any energy and the base fell downward, so the weight of the shell finally twisted the nose free of the hole in the mount. The projectile then fell to the deck, still spinning for a few minutes in a circle, but not moving very far (F). It was found right there by crewmen after the battle and thrown over the side.

This shell did not explode on impact with the safe or gun mount because it was moving so slowly (at the range of the gun which fired it, a shell with no yaw that was not slowed down considerably by the water impact would have easily punched entirely through that 5-inch mount); hit rather soft, thin (compared to the shell diameter, that is), and easily dented steel (the force on the fuze firing pin was reduced because it was spread over a longer time than a sharp penetrating-impact shock); and hit at such a high yaw angle that the firing pin was probably jammed sideways and could not move in the fuze, even with a stronger force than actually occurred (such fuzes are not designed for such yawed impacts). This form of base-slap for this projectile will be seen to be similar to the one that struck Turret III barbette, as will be discussed later. Both of these impacts had rotations along two planes; one along the direction of flight (the base moving forward to hit the same plate the nose had previously hit) and one at right angles to that direction rotating from a nose-down vertical yaw to a horizontal yaw parallel to the deck using a counter-clockwise one-quarter-circle turn with the projectile nose tip as the pivot point.

Hit 18 probably detonated on the inboard, port side and aft close to compartments WRSR 0204 and 0206. In WRSR 0204 the metal joiner door and frame were blown out and distorted and the inboard longitudinal panel bulkhead was blown out. In WRSR 0206, the inboard longitudinal panel bulkhead was demolished and the metal joiner door and frame broken. Fragments damaged the Operations office, B-0201L, and B-103L as well.

We believe that Hit 17 was from the 8-inch AP shell that was later found on deck and that the correct shell size was indeed 8-inches, even though South Dakota's logs confuse which gun mount was hit. The heavy cruisers opened fire late, at which time they were abreast and then aft of *South Dakota* during their firing passes. The shell trajectory and timing of the 8-inch shell matches the heavy cruisers position while the trajectories of the 6-inch shells match *Kirishima'*s position (see Figure 69) at 0104 when this damage was listed as occurring in *South Dakota'*s time logs. This also eliminates the possibility of the shell being a larger caliber one as at the time this hit was made *Kirishima* was still forward of *South Dakota* and not aft. For Hits 16 and 18, the best estimate is that they were base-fuzed 6-inch Type 4 Common projectiles, as these shells did not explode on impact with the outer bulkhead but were able to penetrate inside the ship before they detonated.

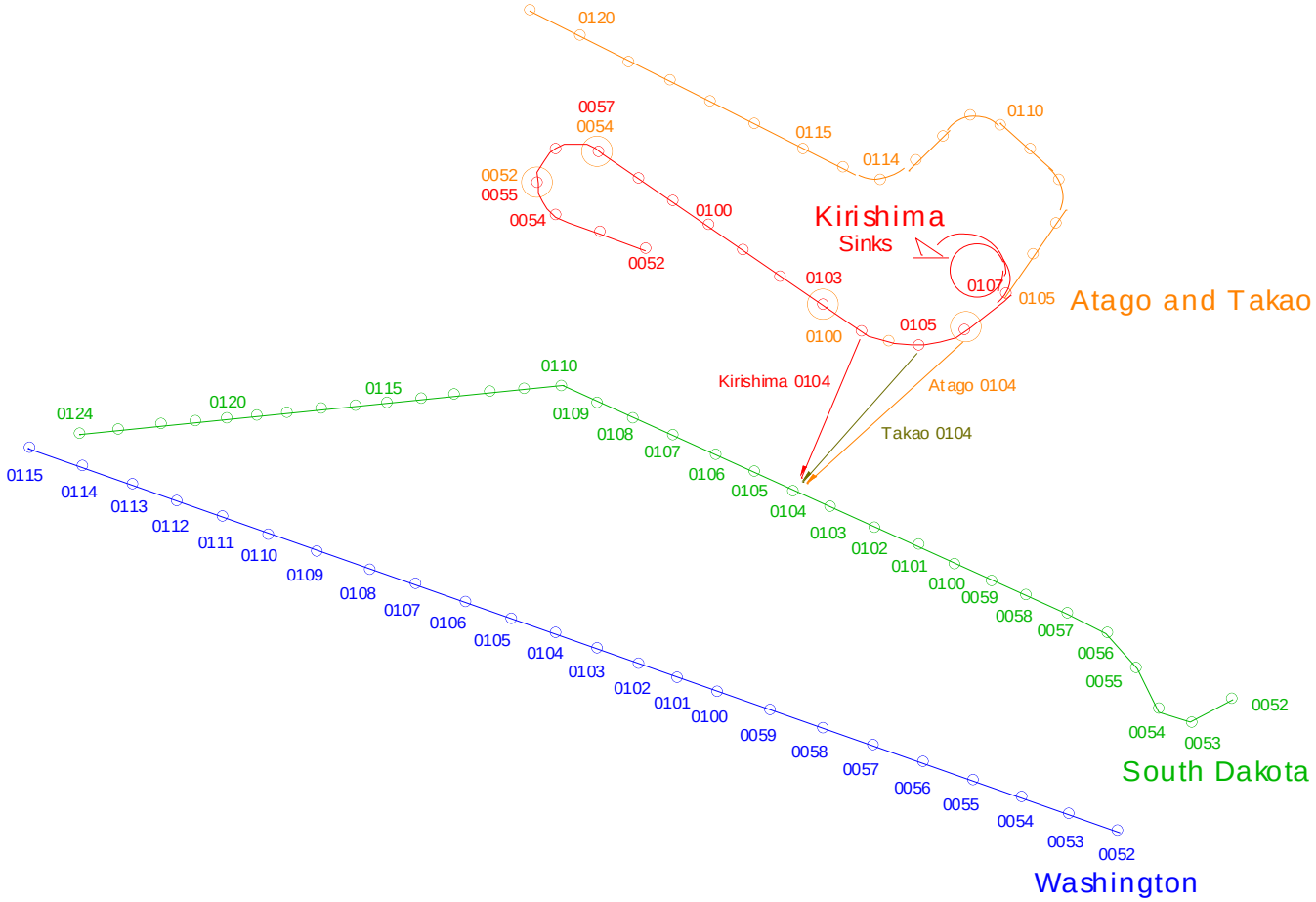

Figure 69 – Hits 16, 17 and 18 – Ship Locations at time Projectiles Struck[76]

[76] Track Chart from *The Battleship Action 14-15 November 1942* and is based upon the track charts given in Enclosure A of USS *Washington*'s Action Report