The Last Log of the Titanic

by David G. Brown

ET Research

Wednesday 31 January 2001

A reevaluation of the fatal collision.

The Last Log Of The Titanic is not intended for readers who believe in impossible shipboard romances or giant blue gems. Nor is it for anyone seeking to rewrite history with lurid flights of imagination. The Last Log Of The Titanic is a serious attempt to unravel the events on Titanic's bridge and in its engine rooms that led to the accident and the ship's eventual foundering. To do that, I spent four years researching original sources--mostly the 1912 testimony of the crew who survived. There are no new "discoveries" in this book. The facts it contains were put into the public record in 1912. However, what I discovered is that the real story of Titanic is totally different from the official myths pushed onto a gullible public nearly 90 years ago. As usual, the truth is far more compelling than myth and legend.

This project started out as part of a article on boat handling for Boating World magazine. My intention was to use the scene from the then-popular movie which showed Titanic's starboard bow grazing the iceberg to illustrate how boats do NOT maneuver. It is impossible for a rudder-steered vessel to damage only its starboard bow as depicted in the movie during a left turn. This is because of the location of the pivot point around which the hull rotates during a turn. If Titanic had struck the berg as shown on the movie screen, damage would have occurred to its entire starboard side, not just the bow.

Murdoch's "Port Around"

We know that after Lookout Fleet's final iceberg warning, Second Officer William Murdoch initially ordered the ship to turn to its left (starboard helm in 1912). Titanic undoubtedly turned slightly faster to the left than to the right because it was driven by three propellers. Every propeller delivers both forward thrust and sideways pressure. A propeller that rotates to the left in forward also pushes the stern to the left. Conversely, a propeller that rotates to the right pushes the stern to the right when the ship is moving forward. Two of Titanic's propellers rotated to the right, giving the ship a slight tendency to swing its stern to the right (turning the bow to the left) when steaming forward. This meant the ship turned a bit faster to the left (starboard helm in 1912) than to the right. By ordering a left turn, Murdoch took advantage of the ship's natural tendency.

Virtually every report, book, TV documentary and motion picture has depicted Titanic sideswiping its starboard bow on the iceberg while turning left, away from danger. Not only did this not happen, but it could not have happened under any circumstances. A starboard bow sideswipe "collision" while turning left was impossible for a conventional ship in 1912. (Nor can it be done today.) The manner in which rudder-steered ships pivot in the water does not allow the actual damage received by Titanic's bow to have occurred during a left turn. Iceberg damage to the starboard bow while turning to the left absolutely would have necessitated bumping and grinding of the ice along the ship's starboard side all the way to its stern.

Every conventional power-driven vessel has a "pivot point" located on its centerline roughly one-third of its length aft from the bow. The vessel rotates around this point when its rudder is put over. Because the pivot point is not amidships but is offset toward the bow, the vessel's stern swings a larger arc than the bow.[1] Turning only to the left (or right) avoid a close-aboard object swings the vessel's stern toward that object even though the bow points clear. A side-on impact cannot be avoided. The object then bumps and grinds along the side of the ship doing damage along the entire length of the hull from the initial point of impact to the stern.

The impossible "left turn only" scenario would have caused damage to the majority of the ship's 16 primary watertight compartments. The truth is, Titanic did not receive ice damage aft of Boiler Room #5 which was approximately below the bridge. This is proof the ship was turning to the right at the time of the accident, turning toward the iceberg.

Immediately following the accident, Murdoch told Captain Smith that he attempted to "port around" the deadly berg. This maneuver for dodging an obsticle is familiar to every mariner. The bow is first turned away from the object, then the helm is shifted (turned the other way) to clear the stern. That is exactly what Murdoch must have done, because the ship did not suffer any ice damage aft of boiler room #5. In truth, the bow was clear of the ice until Murdoch executed his second turn, back toward the berg. This second turn was not a mistake. Even though the bow had been pointed away from the ice, Titanic's stern was sliding dangerously toward the berg when Murdoch shifted the helm. Only when he initiated a turn to the right did the fragile stern swing away from the iceberg and certain disaster.

Murdoch's "port around" maneuver required the ship to be extremely close to the berg before initiating the second turn. As a result, the iceberg would have appeared to be off the starboard bow when Murdoch called for port helm to turn the ship to the right. Quartermaster Olliver apparently was fooled by the angle of the ship to berg when he said Murdoch's port helm order came after the berg passed the bridge. "The iceberg was away up astern," he told Senator Burton at the U.S. hearings.

If Titanic had been turning left (starboard helm in 1912) at the moment of contact, ice and metal should have met roughly in the way of the bulkhead between Boiler Rooms #5 and #6. In reality, this is about the location on the hull where damage from the ice ended. In the mythical left turn, the berg would have bumped and crashed along the ship's entire starboard side starting at Boiler Room #5 and continuing aft into Boiler Rooms #4, #3, #2, #1 and the two engine rooms. Compartments forward of Boiler Room #5 would have remained undamaged and free of water. Titanic still would have foundered, but stern first. Of course, the pattern of damage to be expected during a left turn collision is exactly the opposite to what actually occurred.

The timing of Murdoch's second turn in his "port around" maneuver, the one back toward the danger, was critical. Unfortunately, he started his turn a bit too soon and the bow came a few yards too close to the berg. Actual damage received by the starboard bow during the accident is irrefutable proof that Titanic was under port helm and turning to the right (starboard) at the moment of impact. Murdoch did, in fact, "port around" the portion of the berg above the water.

One witness at the British proceedings knew the impossibility of explaining Titanic's starboard bow damage with only a single left turn. Edward Wilding, an employee of Harland and Wolff and one of the ship's designers, appeared to recognize that the lack of damage to compartments aft of Boiler Room #5 did not fit the left-turn-only scenario. His testimony gives the impression that Wilding was struggling to accept the conventional version of the accident. He was troubled by the left-turn-only theory because it required damage to parts of the hull that were not involved in the real accident.

MR. WILDING: ...after the ship had finished tearing herself at the forward end of No. 5, she would tend to push herself against the iceberg a little, or push herself up the iceberg, and there would be a certain tendency, as the stern came round to aft under the helm, to bang against the iceberg again further aft.

-- British Board of Trade
Wreck Commission Hearing
June, 1912

Having found the conventional story of the accident is physically impossible, I began a quest to learn if any other commonly-believed details of the accident were wrong. That took me on a nearly four-year adventure through testimony from hearings on both sides of the Atlantic as well as into the dusty archives of libraries. What I uncovered astounded me because, at the time, I still believed the conventional story of the isolated iceberg, the failed left turn, the engines pounding in reverse, and the ship remaining stopped until it sank.

All of that turned out to be myth and legend.

Late at night I often found myself too excited to sleep as Titanic's crew spoke to me through their 1912 testimony. Time after time I would suspect a quartermaster, fireman or lookout of lying -- only to find overwhelming evidence supporting those claims. It became obvious to me that the events experienced by the crew were not those etched into history by either the U.S. Senate or the British Board of Trade inquiry.

No "Crash Stop"

According to Fourth Officer Boxhall, First Officer Murdoch changed the orders to the two outboard propellers from AHEAD FULL to ASTERN FULL, requesting what sailors call a "crash stop." This is a violent maneuver that can damage the ship's engines, drive shafts, or propellers. For that reason, it is reserved only for the worst of emergencies. Testifying in London, Boxhall said the engine order telegraphs read "full speed astern" when he stepped into the enclosed section of the bridge.

Unfortunately Boxhall's recollection seems faulty. Titanic never attempted the crash stop that people on land still believe was the obvious way to prevent the ship from slamming into the iceberg. Reverse thrust from the propellers would have eliminated the ability of the single rudder to steer the ship. Murdoch knew this. Under full reverse power the ship could not have pivoted to the right, but would have begun a sideways slide into the iceberg[2].

The toil of those sweaty men feeding the fires in the ship's boiler rooms was by red warning lights and clanging bells moments before the accident. "Shut the dampers," sang out Leading Stoker Frederick Barrett. He and Second Engineer James H. Hesketh had been talking in Boiler Room #6 when the alarms clanged and the lights on the stoking indicators changed from white to red. Chatter among the men stopped in mid-sentence as they turned to this unexpected work. Closing the dampers on the furnaces was an ordinary precaution to reduce the fires to prevent generating excess steam pressure while the engineers stopped the engines. There were safety valves, of course, but these were not foolproof and had been known to stick on occasion. Nobody wanted to risk building up excessive steam pressure.

The command to close the dampers came just prior to impact when Titanic was perhaps 700 feet from the berg. Closing the furnace dampers is yet another indication that a crash stop was never performed. Full reverse power would have required as much steam as possible from the boilers. Shutting the dampers would have been the worst possible thing to do during a crash stop. Instead, stokers would have been asked to rake the coals in their furnaces to increase steam output from the boilers in order to get maximum power out of the engines.

Titanic's engines and associated drive shafts and propeller blades were designed to withstand an instant shift from forward into reverse at harbor speeds. They might have had strength enough to withstand the strain of instant reversal at 22.5 knots, but only if every part from cylinder to tail shaft was totally free of defects. Ships have been known to snap shafts and propeller blades during crash stops. If nothing broke on Titanic, a crash stop would have caused a rumbling shudder to convulse through the after third of the hull.

In 1951, the U.S. Navy aircraft carrier Tarawa was passing through the Straits of Messena. A passenger ferry suddenly cut across the warship's bow. "All back emergency!" was the instant commande and the carrier's engines began pounding in reverse. The stern of the ship began jumping up and down, some of the crew later said the jumps were six feet or more. The collision was avoided. Next morning, dozens of the carrier's crew were sporting slings, casts and neck braces from being flung to the deck by their ship's successful "crash stop." So much china was broken by the maneuver that it was necessary to put into port to buy more in order to feed the crew. Within a few weeks, the ship itself was drydocked to repair damage done to the at least one propeller shaft.

Since none of the seven-hundred Titanic survivors described such a memorable event, and because the firebox dampers were ordered shut, the engineers could not have performed a crash stop[3]. They just closed the throttles to the engines to stop them from pushing the liner forward. In sailor terms, Titanic was "shooting," or coasting forward without power when it contacted the iceberg.

Fatal Contact

Where was the fatal ice damage done to the ship? "To the side," history has answered for 88 years--despite both the physical impossibility of such damage and the direct testimony to the contrary by members of the crew. Scenes in the movies show the starboard bow of the giant liner slamming against a wall of ice much like an automobile sideswiping a highway bridge abutment. Nothing could be further from the truth. If the ship had collided with the berg in that manner, the impact would have been devastating. Men sleeping in the bow would have been thrown out of their bunks to the hard steel decks. Anyone standing in the grand First Class entrance likely would have had their feet knocked from beneath them. Certainly there would have been dozens (if not scores) of injuries: broken arms, legs and even skulls. More than a few people would have been killed outright as the steel bow collapsed around them.

None of that happened.

With full right rudder (port helm in 1912) Titanic was turning to the right as it contacted the ice. There had been those few quick seconds when it appeared the daring S-curve would succeed. However, as every child learns in school, the bulk of an iceberg lies beneath the water. Murdoch knew it, too. He fully expected what happened next. Titanic's fragile underbelly scraped across an underwater shelf called an "ice ram." These shelves are common enough to warrant special attention in Bowditch. "It is dangerous to approach close to an iceberg of any size because of the possibility of encountering underwater extensions," the navigation text cautions. The great danger of icebergs is "underwater extensions, called rams, which are usually formed due to the more intensive melting or erosion of the unsubmerged portion."[4]

Physical evidence and eyewitness accounts point to the accident being a grounding, not a collision. Titanic did not run into an iceberg; it ran over an iceberg. The initial pattern of flooding and testimony from surviving crew members are consistent on one point: the bottom of the ship--not the side--made solid contact with the ice. Survivors unanimously described the sound and vibration of a ship running aground. There was no sharp jolt of a ship slamming horizontally into an immovable object. Instead, the slight tremble was barely enough to rattle silverware set out for breakfast in the First Class dining saloon.

The difference between a grounding and a collision is far more significant than it appears. Head-on impact with the berg would have sent all of Titanic's 52,310 displacement tons[5] smashing into the ice at a speed of almost 36 feet per second[6]. In the crunch of a head-on impact, the ship's speed would have effectively dropped to zero. Everything inside the bow that was not tied down--people, chairs, bottles of wine, soup tureens--everything would have continued moving. Sleeping immigrant men near the bow would have been sent flying out of their bunks. Farther aft, the impact would have been less, but still substantial. Women could have been hurled down the grand staircase in First Class to land twisted and broken in a pile of taffeta. In the Second Class smoking room behind the fourth funnel men might have felt their chairs move beneath them.

Edward Wilding, one of the naval architects who designed Titanic, testified in London about the effect of a head-on collision. "If she struck a fair blow I think we should have heard a great deal more about the severity of it, and probably the ship would have come into harbor," he said. "I am afraid she would have killed every firemen down in the firemen's quarters, but I feel sure the ship would come in." At the U.S. Senate hearings Captain John J. Knapp, the U.S. Navy's hydrographer, tried to imagine such an impact for Senator Smith:

MR. KNAPP: ...an idea may be formed as to the possible blow by using the accepted formula, the weight multiplied by the square of the velocity divided by twice the gravity. Multiplying...will give the blow that would have been struck if she had kept straight on her course against this apparently solid mass of ice, which, at a speed of 21 knots, would have been equal to 1,173,200 foot tons, or energy enough to lift 14 monuments the size of the Washington Monument in one second of time.

-- U.S. Senate Hearings
May 18, 1912

Naval architect Wilding raised an interesting point about a head-on accident involving an extremely large ship. The bow of Titanic would have crumpled much like the "crumple zone" of a modern automobile. Crumpling would have absorbed much of the force of the blow by spreading it out over time. According to Wilding, telescoping of the ship in this manner would have reduced injuries among the passengers and crew who were lucky enough not to have been trapped in crumpled sections of the bow.

While less dramatic, the more often invoked "glancing blow" at 22.5 knots would have created its own kind of havoc. At impact, the deck would have jumped sideways relative to anything not rivetted to it. This "rebound effect" should have been as disruptive to people living in the forward third of the ship as a major earthquake in a large hotel ashore: sleeping Third Class passengers tossed to the hard steel decks; personal items tumbled off shelves; people thrown down. There would have been fewer injuries and less spilled drinks than during a head-on collision, but some deaths and broken bones. Either type of horizontal impact--head-on or glancing blow--would have been unforgettable from the point of view of a passenger. None of the more than 700 survivors remembered as dramatic as either a head-on or "glancing blow" impact that happening.

What a sailor calls "rebound" is known scientifically as "impulse and momentum." These are the words naval architect Bill Garzke used to explain the traditional bow sideswipe to the Discovery Channel. He envisioned the hull striking the ice, then rebounding to strike again...and again...for nearly 300 feet along the bow[7]. Garzke's description of events may have been inspired by Lightoller who described essentially the same type of accident in his autobiography.

The impact flung her bow off, but only by the whip or spring of the ship. Again she struck, this time a little further aft. Each blow stove in a plate, below the water line, as the ship had not the inherent strength to resist.

-- Charles H. Lightoller
Titanic And Other Ships, 1935

Lightoller and Garzke undoubtedly got their Newtonian physics correct. In theory, Titanic could have been so unlucky that it pushed its side against an underwater ram with exactly enough force to crack its steel shell plating, but not enough to throw people out of bed. A single light bump or two against the berg could have accomplished that if the ship came to a stop against the ice in the same manner as a hard landing against a pier when docking. A few light taps seem highly unlikely considering the ship was making more than 22 knots at impact and continued moving throughout the encounter with the ice.

Alternatively, a single hard sideswipe of the iceberg might have caused enough crumpling of the ship's hull to have cushioned the blow. In this impact the bending, twisting and shattering of steel would have produced a single huge hole at the point of contact with no damage anywhere else. Of course, Titanic did not receive damage to only one spot on the bow. Damage extended over a distance of nearly 250 feet from the forepeak all the way into Boiler Room #5. It is the extended nature of this damage that argues most effectively against the "impulse and momentum" type of rebounding impact.

More to the point, the theory of multiple impacts does not fit the experiences described by survivors. Each impulse and rebound would have whipped the deck sideways beneath the feet of passengers and crew. That is not the type of impact anyone reported. The universal description of the accident was a rumbling or vibration, not side-to-side motion of the deck.

Rapid horizontal motion of a deck knocks people off their feet much quicker than large a large roll of the ship. This is because friction keeps the person's feet in place on the deck when it jerks sideways. The victim's torso has inertia which resists sideways movement, with the result that the feet move out from beneath the individual's body. The person's center of gravity is suddenly and unexpectedly no longer supported in a straight line by the legs. A fall is almost inevitable.

If the Lightoller/Garzke horizontal impact took place, an indelible memory of a large percentage of surviving Third Class men who happened to be standing upright in their cabins near the bow would have been an unexpected tumble to the deck. Crew members in their quarters at the very front of the ship would have had the same disquieting experience. Instead, except for one man, they universally recalled only a slight trembling as the ship passed over the ice.

When a ship "strikes the ground," the action can be quite stately. Speed often drops gradually, so gradually that the first moments of a grounding go unnoticed even by professional seamen[8]. Sliding onto mud or sand may produce almost no sound or vibration. Striking on a hard surface can sound like pouring marbles over sheet metal. Neither type of grounding is the smashing impact of iron against an immovable object. Soft or hard, a grounding is exactly what passengers and crew aboard Titanic experienced during the seven seconds when the ship was in contact with the ice[9].

Author Lawrence Beesley, a teacher on his way to America for holiday, was in Cabin D-56 just aft of the Second Class dining saloon when the ship slid over the ice. His personal experience is a perfect illustration of a ship going aground, not colliding head-on:

...there came what seemed to me nothing more than an extra heave of the engines and a more than usually obvious dancing motion of the mattress on which I sat. Nothing more than that--no sound of a crash or anything else: no sense of shock, no jar that felt like one heavy body meeting another.

-- Lawrence Beesley, The Loss of The S.S. Titanic, Its Story and Its Lessons, Houghton Mifflin, 1912

A grounding such as Beesley described is soft because it does not take place in an instant. Only a small portion of the vessel's displacement weight is involved at the beginning. That increases as the ship slides onto the ground, but this increase is spread over time. The event is not instantaneous like a head-on collision, but takes several seconds from first touch until the ship either stops or breaks free.

Ice On The Deck

A full-size iceberg[10] has hundreds of times more mass than Titanic. Each cubic yard of berg is roughly a ton of solid ice. The ship was a hollow metal structure filled mostly with air. In a head-on collision, there would not have been enough time for the energy of Titanic to overcome the inertia of the ice and push the berg sideways. But, the ship didn't hit the berg. It spent those seven seconds grinding across the top of an underwater ice shelf. There was plenty of time for the berg to move a bit under the ship's weight. Ice felt the ship as much as the ship felt the ice, and the berg rolled ever so slightly toward Titanic.

It rolled because icebergs are notoriously unstable. Just as Captain Smith told his New York friends, the upper part extending into the atmosphere melts at a different rate from the underwater portions. This upsets the equilibrium of a berg, which often compensates by suddenly capsizing. "Icebergs that are in the process of disintegrating may suddenly capsize or readjust their masses," warns Bowditch. When the ship rode onto the shelf, the berg was forced to support increasing tons of steel, rivets and passengers well outboard of its center of gravity. Like any other floating object, the berg tipped toward this extra weight.

As it tipped, the upper portions of the berg brushed against the ship's topsides at the forward end of the well deck. This contact precipitated the famous mini-avalanche of ice. Brushing against the top of the berg probably didn't scratch the liner's fresh paint. During the middle 1990s, scientists studied the impact of icebergs against iron or steel objects.[11] This research was aimed at developing offshore oil rigs for use on the Grand Banks near the spot where Titanic now lies. Experiments have shown that ice above a berg's waterline can be relatively soft and often crumbles upon impact. Crumbling produced the broken pieces of ice that littered the ship's forward well deck.

"There was quite a lot of ice on the starboard part of the ship," 26-year-old Olaus Abelseth told the U.S. investigation. The young Norwegian was sleeping in the Third Class open berthing area on Lower Deck G near the bow of the ship. Also near the bow was Frank O. Evans, a 27-year-old Able Seaman. "I was sitting at the table reading a book, and all of a sudden I felt a slight jar," he testified in New York. "I did not take any notice of it for a few minutes until one of the other able seamen came down with a big lump of ice in his hands."

Fatal Damage

Although passengers were largely unaffected by the brush with the iceberg, the black gang in the boiler rooms was not so lucky. After seven seconds of screaming metal, they now found themselves in a fiery twilight caused by a temporary electric blackout. A few men were dispatched from each stokehold to make the long climb to E Deck in search of portable lights. That turned out to be unnecessary as the main electric power came back on after a few dark minutes and the stokeholds were flooded with light again.

Stokers and trimmers probably feared for their lives as water poured into Boiler Room #6. Most likely, however, everyone survived the initial scramble to escape the freezing water. "We heard a crash," Fireman Frederick Barrett recalled. "The engineer and I jumped to the next section (Boiler Room #5)." Barrett became one of the few people to survive after seeing first-hand the damage done to Titanic by the iceberg. He told the U.S. Senate that a horizontal opening:

...ran past the bulkhead between sections 5 and 6, [Boiler Rooms #5 and #6] and it was a hole two feet into the coal bunkers. She was torn through Number 6 and also through two feet abaft of the bulkhead at the forward head of Number 5 section.

-- Frederick Barrett, U.S. Senate Hearings, May 25, 1912

In London, Barrett told essentially the same tale. "Water came pouring in two feet above the stokehold plate; the ship's side was torn from the third stokehold to the forward end," he testified[12]. (The "third stokehold" in Barrett's testimony was the forward end of Boiler Room #5.) The fireman's experience was as frightening as his testimony is illuminating. He did not mention Boiler Room #6 as suffering any great structural damage despite the tremendous noise and sudden deluge of freezing sea water. Most important, he did not report that mythical dagger of ice ripping open the side of the ship.

Barrett placed the open seam at "two feet above the floor plates." Those plates were light metal decking to give stokers easier access to the furnace openings. The stokers actually worked standing a few feet above the tank top deck, the upper side of Titanic's watertight double bottom. This means the open seam was about four feet above the tank top. On the outside of the ship it would have been in the single-thickness vertical side plating just above the turn of the bilge. Barrett's observation confirms that the opening in the side was confined to the very lowest portion of the hull, no more than ten feet above the keel.

Sprung seams also must have occurred in the four compartments forward of Barrett's position. Recent dives to the wreck have brought back evidence of six or more horizontal openings in the ship's side in the area from Boiler Room #6 to the bow.

Unfortunately for the hypotheses of modern researchers, however, the ship's crew did not believe the open seams in the side of Titanic allowed significant amounts of water into the hull. Surviving crew members knew the more exact location of their vessel's mortal wounds: the bottom beneath their feet. Seaman Edward J. Buley was precise about where the fatal water entered the hull. It was not coming through the side, but up through the bottom. When the interrogator made a mistake on this, Buley pointedly corrected him.

MR. BULEY: ...down where we were there was a hatchway, right down below, and there was a tarpaulin across it, with an iron batten. You could hear the water rushing in, and the pressure of air underneath it was such that you could see this bending. In the finish I was told it blew off.

SENATOR FLETCHER: What part of the ship would you call that?

MR. BULEY: The forecastle head.

SENATOR FLETCHER: How far was that from the bow?

MR. BULEY: About 20 yards, I should think.

SENATOR FLETCHER: That condition could not have obtained unless the steel plates had been torn off the side of the ship?

MR. BULEY: From the bottom of the ship. It was well underneath the water line.

U.S. Senate Hearings, Thursday, April 25, 1912

The ice was cruel. Rivets must have been stretched and even ripped out of the plating. Seams would have been forced open and butt joints misaligned. Damage on the outside undoubtedly was random. Although horrible to look at (if that could have been done), it is unlikely that this exterior ice damage was life-threatening to the ship. The most immediate result of damage to the exterior was flooding of the starboard side tankage located beneath the tank top deck.

There is one place where there was evidence of direct internal damage from the ice. This is at the forward end of Hold #2 directly above the spot on the keel where the ship would have first felt full grounding pressure on the ice shelf. According to the report of the British inquiry, the impact smashed a metal enclosure around the foot of the double spiral staircase used by firemen to go from their quarters on D, E, and F Decks to the stokeholds. This damage was followed by substantial flooding of the Holds #2 and #3, and the passageway. Hold #3 filled rapidly to the vessel's waterline.

Ice damage to the shell plating of the bottom forced the ship to rely on its double bottom to stay afloat. Rending of steel plates on the outside of the outer bottom did not allow significant amounts of water to enter the inside of the hull because the tank top deck was there to stop it. If that deck had remained totally watertight, Titanic might have stayed afloat just as QE II did eight decades later when it ran arground off the U.S. Atlantic coast. Unfortunately for more than 2,200 people aboard Titanic, (most still warm in their beds) the tank top deck was no longer watertight after the ship came off the ice. The Atlantic Ocean was boiling up in the forward cargo holds. It was also rising in Boiler Room #6, but at a markedly slower rate.

Rents in the horizontal tank top deck would be expected as a result of upward deflection of longitudinal girders running parallel to the keel within the double bottom. These longitudinals acted much like snow skis carrying the ship over the ice. And, just as skis flex over moguls, Titanic's hull flexed upward as it passed across the ice ram. Upward movement may have created random strained rivets, sprung seams, or cracked plates in the overlying tank top deck. This movement of the ship's structure was greatest at the point where the keel reached its full depth at the base of the spiral staircase. Damage to the metal around this staircase and the rapid flooding of Holds #2 and #3 likely resulted from upward displacement.

Seventy-seven years after Titanic, the oil tanker Exxon Valdeze struck Bligh Reef in Alaska's Prince William Sound. The resulting oil spill continues to make headlines. Shipyard workers who repaired the tanker's hull found numerous bent web frames and displaced longitudinals. Similar damage must have occurred to the framework of the passenger liner as a result of crossing the ice shelf.

Although Titanic was not cut open by a knife of ice, Barrett's eyewitness account has often been cited as proof of a long slice in the ship's side. The importance of what he saw was misunderstood. When the seam opened, it released the stress created by the ship squirming off the ice. This release prevented rivets from popping any higher on the ship's side. Plates in the side above this single horizontal seam remained undamaged and watertight. Barrett's description of a horizontal opening has distorted nearly every discussion of Titanic's demise. Based on what he saw, it has generally been assumed the berg tore a horizontal gash the length of the first four compartments and into the fifth. Crew members on duty that night did not think that was what happened.

MR. BULEY: ...according to where the water was, I should say the bottom was really ripped open altogether.
SENATOR SMITH: The steel bottom?
MR. BULEY: Yes, sir.

-- U.S. Senate Hearings, April 25, 1912

The pattern of flooding during the first ten minutes after the accident shows how the upward curve of the keel toward the bow influenced where damage occurred. Titanic's keel ran straight for most of the ship's length, but swept upward in a gentle curve beneath Hold #1 and the forepeak. This upward curve protected these first two compartments from the full force of the grounding on ice. The brunt of the impact was reserved for the after portion of Hold #2, particularly beneath the double spiral staircase, and the forward portion of Hold #3 where the keel first reached full depth.

The report of the British inquiry found that following the accident the forepeak was dry above the orlop for more than an hour. Hold #1 was awash to seven feet, but Holds #2 and #3 were quickly flooded[13]. Water rose 24 feet within the first ten minutes in Hold #3, indicating it received considerable damage.

Boiler Room #6 was protected by Holds #2 and #3. While flooding here was immediate, water does not seem to have driven out the majority of stokers and trimmers until they had raked their fires and vented the 215 pounds of steam pressure from their four double-ended boilers. Boiler Room #5 remained nearly dry despite a high-pressure fan of water cascading through a sprung seam at its forward end[14]. Significantly, the space beneath #5 was apparently dry enough for engineers to open a manhole into the tankage below. There are no reports of ice damage to compartments aft of Boiler Room #5.

Depending upon the point of measurement, Titanic's tank top was six to eight feet above the keel in the area of the ice damage. The British report noted that damage reported by men in the boiler rooms did not appear more than a few feet above this deck. This means that the observed damage was low on the hull.

The Crow's Nest Heels

Titanic's steel bottom absorbed just a few ounces of the ship's weight during the first split second of the accident. This weight continuously increased to pounds, and finally to hundreds of tons while the hull was fully on the shelf. However, steel plates in contact with the berg did not carry the total mass of Titanic even when the maximum amount of ship was on the ice. The bottom would have supported only that portion of the hull extending deeper than the top of the shelf. Grounding pressure on the vessel's structure may not have exceeded a minor percentage of the ship's mass. This, too, contributed to the soft impact.

Men standing watch on Titanic's bridge knew they had gone across a submerged ice shelf and had not run into the iceberg. "During the time she was crushing the ice, we could hear a grinding noise along the ship's bottom," Quartermaster Hitchens confirmed during the U.S. Senate hearings. Note that he stated "along the ship's bottom," and not "along the ship's side." Hitchens believed the damage was located on the underside of Titanic's bottom, and he said so. He also used the phrase "crushing ice," an unlikely way to describe a glancing blow against the side of the bow. "Crushing ice," however, is a perfect description for what happened as the ship slid over top of the underwater ice shelf.

Sliding across the underwater ice ram would have lifted the starboard side of the ship to a small extent. This lifting would have been virtually unnoticeable inside the hull on the lower passenger decks. The men on the bridge might have noticed it that except their attention was focused on dodging the berg and closing the watertight doors. There were two men, however, who were perfectly positioned to observe the lifting of the starboard bow: lookouts Fleet and Lee. The 90-foot height of the crow's nest would have magnified this small roll, which is just what Lee experienced.

"The ship seemed to heel slightly over to port as she struck the berg," Lee recalled in London. "Very slightly to port as she struck along the starboard side."

Eerily, Captain Smith appears to have predicted Titanic's accident to some American friends, Mr. and Mrs. W.P. Willis and a Dr. Williams. His prediction was made about 1910 while he was in command of the White Star Line's Adriatic prior to taking command of Olympic. "The big icebergs that drift into warmer water melt much more rapidly under water than on the surface, and sometimes a sharp, low reef extending two or three hundred feet beneath the sea is formed," Smith explained after a meal in the doctor's Flushing, New York home. "If a vessel should run on one of these reefs half her bottom might be torn away." Should that happen, the Captain said, "Some of us would go to the bottom with the ship."[15] [16]

Below The Tank Top

As designed, Olympic-class ships had double bottoms and single sides above their tank top decks. A double bottom is nothing more than a box girder the width and length of the vessel. This is the simplest and strongest way to build a steel ship. Titanic's flat plate keel was the first piece of steel laid down in Harland and Wolff's yard. This was followed by a vertical keel and another flat plate, creating an "I" beam that became the ship's backbone the length of the hull.

Horizontal frames (called "floors") were placed at right angles to the keel. These were later joined to vertical frames, forming a steel rib cage defining the hull's shape. The horizontal and vertical frames met in a radius known as the turn of the bilge, or simply, the bilge. The ship's outer skin, called the shell plating, was installed on the outside of the floors and up the vertical frames. Another layer of slightly thinner steel plating was installed on top of the floors, creating an enclosed space more than six feet deep. Much of this space was used for tankage, so the layer of plating over the floors was logically called the tank top deck. All of the boilers and engines were mounted on this watertight deck.

The inside of the double bottom was further divided by longitudinals running fore-and-aft through the tank space. They helped the keel support the length of the vessel. Some of these longitudinals, like the vertical keel, were watertight and subdivided the tankage into smaller watertight compartments. Beneath the two engine rooms the tankage was divided into four watertight cells between each primary bulkhead. Forward and aft of the engine rooms, tank spaces between the bulkheads were divided into two cells along the keel. The forepeak and afterpeak were not divided. Cells near the bow and stern were void spaces kept empty. Some under the engine rooms served as tanks for non-potable fresh water destined for the boilers. Others could be filled with sea water for ballast.

Immediate listing was the logical result of extensive damage to the outer double bottom on the starboard side forward[17]. Empty tank spaces ("voids") inside the double bottom on the right side of the ship flooded instantly. Port side voids were protected by a watertight longitudinal along the keel, so stayed dry. This unbalanced condition gave the ship more buoyancy on its port (left) side, resulting in an immediate starboard list.

Loss of buoyancy in the starboard tankage would not have caused the bow to tip downward significantly because the ship was about ten times longer than it was wide. Titanic lost buoyancy for half its 92.5-foot breadth beneath the first five compartments, but for less than a third of its 852.5-foot length. This disparity resulted in the ship listing quickly, but not tipping down by the bow to the same degree. It took several minutes longer for the weight of water above the tankage to cause the bow to sag deeply into the water. Once the bow did tip, Titanic straightened its starboard lean and then listed to port. This change occurred when flooding of the larger main compartments above the tank top became the deciding factor in transverse stability.

Damage to the outer plating of the bottom and to the tank spaces inside the double bottom must have been severe, but it did not flood the any of the cargo holds or boiler rooms. Titanic immediately began floating on its inner bottom, the tank top deck. This was exactly what Wilding and the other naval architects at Harland and Wolff intended should happen in just such an emergency. The tank top deck in Titanic can be thought of as a "back-up bottom" put there specifically to prevent the ship from flooding if its real bottom was ever torn apart by a grounding on rocks or ice.

The Fatal Damage

Unfortunately, damage from scraping across the iceberg was not confined to the exterior plating. The vital inner bottom suffered openings as well, probably caused by stretching and cracking resulting from displacement of longitudinal framing within the double bottom. This upward movement must have stretched or sheared rivets holding the steel plates of the tank top together. Damage already referred to at the foot of the spiral staircase inside the ship was minor compared to what occurred to the outer bottom, but it was sufficient to create substantial flooding in the three holds and allow significant water into Boiler Room #6.

An aggregate opening equal in area to twelve square feet could not have resulted from the sprung seam described by Stoker Barrett. Water entering through that seam did not cause significant flooding of Boiler Room #5, so the actual opening must have been quite narrow. In reality, the sprung seam proved to be only a nuisance that did not cause serious flooding of the space. This indicates that while open seams above the tank top undoubtedly played a role in the flooding, they were not the fatal wounds. Naval architect Wilding calculated that the openings in Titanic's hull were equal in aggregate to about 12 square feet. If the fatal damage did not arise from sprung seams in the side, the only other logical place to look for openings equal to Wilding's 12 square feet is in the double bottom, the tank top deck.

Fatal damage to Titanic most likely resulted from a combination of the initial force of the grounding coupled with inability of the vessel's structure to accept the twisting and flexing caused by running over an underwater shelf of ice. The box girder structure of the bottom had been subjected to increasing strain as more of the ship's weight came on the ice. This strain caused the starboard side of the forward third of the hull to lift and flex. The portion grinding over the ice was higher than those sections ahead or behind that were not supported by the berg. An upward flex traveled along the forward third of the ship like a wave. (This was the upward lifting of the starboard side noted by lookout Lee.)

Under Way For Halifax

Fatal damage did not necessarily mean sudden death for Titanic as the British report implied. There is evidence from the ship's Chief Engineer that the pumps were successful in slowing the flooding of Boiler Room #6 during the first ten minutes after the accident. Pumping definitely was able to keep even with the inrush of water into Boiler Room #5. This is not to suggest that the ship would have floated indefinitely, only that Titanic might have floated as long as there was bunker coal to keep its pumps running. The ship could not founder until Boiler Room #6 was lost. That does not appear to have been imminent as late as 11:50 pm, thanks to the pumps.

A basic precept of safe navigation is to never make assumptions, especially assumptions based on scanty information[18]. Ismay and Smith assumed their ship was safe to steam again based on Boxhall's visit to the Third Class berths and scanty information about the extent of damage and the ability of the pumps to cope with the flooding. Titanic was more seriously damaged than its two commanders assumed when they started it moving under its own power again. Smith and Ismay should have waited another quarter hour or so while the man who supervised building the ship made a thorough damage inspection. Ismay was not noted for his patience.

Life in stokeholds aft of flooding Boiler Room #6 was dry but confused during the first ten minutes after the vessel struck on the iceberg. This confusion was the natural result of the accident and flooding. It was compounded by orders from the engine room which seemed to conflict with the damaged condition of the ship. Fireman Thomas "Paddy" Dillon was still struggling to shut the firebox dampers and draw the fires when the lights and bells on the Kilroy electric stoking indicators flashed and rang. The engine room was telling the black gang to "keep up the steam" despite obvious flooding. The men around Dillon shrugged and then began stoking the fires again.

Greaser Scott recalled the same unexpected orders in his testimony. Unlike Dillon, however, Scott's work placed him in contact with the ship's engines where he could see why it became necessary to keep up steam pressure in the dry boiler rooms. Scott remembered the engines rolling again at AHEAD SLOW for at least ten minutes. His memory was supported by Dillon who recalled the engines re-start and then run for several minutes.

Quartermaster Olliver saw orders to re-start the engines sent down by the telegraphs from the bridge. "The Titanic went half speed ahead. The Captain telegraphed half speed ahead," Olliver testified to the U.S. Senate hearing. He did not recall if the engines were stopped at the time of that order, or if they were working slowly astern. He was certain Titanic was almost dead in the water when it started moving for the last time.

In the wheelhouse, Quartermaster Hitchens must have been told to "steady up" on the ship's heading of just east of north. Otherwise, Titanic would have steamed in a giant circle with full right rudder given by Murdoch as he "ported around" the iceberg. Hitchens was kept at the wheel for more than 40 minutes after the accident, a job which would have accomplished nothing if the ship had not been moving. No amount of rudder movement has any effect on the heading of a stopped ship. Yet, Hitchens was kept at his usual post instead of being sent to help uncover lifeboats or fire distress rockets. The only logical reason Hitchens remained at the wheel was to steer the ship after it resumed making way following the accident.

It has been suggested that Captain Smith resumed steaming in an attempt to reach the twinkling lights of Californian. If this had been true, Ismay would surely have claimed the ship sank itself during a desperate race to save the passengers' lives. Such a race would have transformed a blatant example of bad seamanship into a failed act of courage. Unfortunately, Californian does not appear to have been the destination. The small freighter had not been noticed from the crippled Titanic when the liner started moving again. Captain Smith was making for Halifax because it was the closest port for a large ship. The freighter just happened to be along the way.

Halifax was the only possible destination. In addition to being closer than New York, this Nova Scotia port had other attractions for Ismay. It was a major port with facilities that could be stretched to handle the sudden influx of people from the crippled liner. Rail connections would make it possible to get passengers to their final destinations. Also, Halifax was not a major city with a sophisticated network of reporters and wire services. In Halifax it would be much easier to control the flow of news about the ship than in the media center of New York.

Titanic's fatal decision made, the two men who commanded the ship parted company. Captain Smith left the bridge for the wireless office, a visit which opens another of the mysteries surrounding the sinking. It is most unusual that any captain would leave the command center of his damaged ship simply to "alert" the radio operators to a "possibility" that some message requesting help would be necessary. This was particularly true in 1912 when wireless was still considered more of a commercial novelty to amuse passengers than a useful tool. Preparing the operators for a possible eventuality was an errand too trivial for the Captain's personal attention. It should have been done by relief Quartermaster Olliver who would shortly return from his second errand of taking that note to Chief Engineer Bell. Sixth Officer Moody was also on the bridge and could have been sent as he had no other pressing duties at that moment.

Smith must have had a compelling reason for making that trip personally. There is intriguing evidence that the Captain's real motivation was to dictate a message to the White Star office in New York. It appears he wirelessed that Titanic had struck an iceberg; that everyone was safe; and they were steaming for Halifax. (All of this was true at 11:53 pm.) Another ship from the Allen Line (probably Virginian) reportedly transcribed just such a message and forwarded it to the White Star office in Boston via a Canadian ground station. From Boston it went by land telegraph to the company's New York office[19].

Carpenter Hutchinson rushed into the bridge enclosure only to find Captain Smith had departed for the Marconi room. His short conversation on the stairway with Fourth Officer Boxhall delayed him from reaching the Captain before the engines were re-started. There is no way to know for sure, but perhaps Hutchinson's report of the flooding mail room would have prevented Captain Smith from bowing to Ismay's demand to resume making way. Unfortunately, the engine room telegraphs were clanging while the Carpenter and Boxhall spoke on the stairway. By the time Hutchinson reached the bridge, the fatal mistake had been made and Captain Smith was on his way to the radio room.

Not Sinking?

While the Captain was visiting the Marconi office, Bruce Ismay went "down below" (his words) to confer with Chief Engineer Bell. Ismay knew the route to the engine rooms. He had visited Bell previously and allegedly had his own set of engineer's coveralls. His earlier visit had been to discuss the ship's speed and tonight's visit probably had a similar goal. Ismay appears to have been attempting to circumvent the Captain's authority again, if that could be done under the current circumstances. First he had to know the damage. Was the ship sound enough to increase speed, or to resume course for New York?

MR. ISMAY: I asked if he [Bell] thought the ship was seriously damaged, and he said he thought she was. But [he] was satisfied the pumps would keep her afloat.

U.S. Senate Hearings, April 19, 1912

Ismay's recollection of this short conversation may be the single most important piece of testimony given during either the British or American investigation. Without this particular information, the decision to re-start the ship's engines is unbelievable. Why would anyone try to steam for Halifax in a sinking ship? Ismay gives us the answer: Titanic wasn't sinking when the engines began beating again. According to Ismay, the Chief Engineer believed the pumps were effective against the flooding as late as 11:54 pm. That was a dozen minutes after the accident. If Ismay was correct, Bell did not did not think the giant liner was foundering for several minutes after the engines began rolling again.

It is hard to imagine that an experienced engineer such as Bell would have overlooked something so important as his ship sinking. Accepting what Bell said at face value is much easier: Titanic was seriously wounded but not foundering almost fifteen minutes after the accident, even during the first few moments after it resumed making way. Put another way, it was not the ice that sank Titanic, but the actions of its captain and owner.

Bell had good reason for optimism during his conversation with Ismay. Almost immediately after the accident he had asked Captain Smith to release the watertight doors to allow his engineers to pass between Boiler Rooms #4 and #5 to rig a 10-inch suction hose. This door would not have been opened if Boiler Room #5 had been rapidly filling with water. Watertight doors are opened on a sinking ship only if compartments on either side of the bulkhead are thought safe from immediate flooding. Opening this door is evidence that Barrett's sprung seam was more of an annoyance than a major leak[20]. If the incoming water had been thought dangerous, the door to Boiler Room #4 would have remained tightly closed[21].

In any case, the British report said the new 10-inch line was enough to handle water spurting through the two feet of open seam in Boiler Room #5. More likely, however, this line was part of a apparently successful effort to slow the flooding in Boiler Room #6. The British report's claim of water eight feet deep at 11:51 pm is put into doubt by the Ismay/Smith decision to resume steaming. A flooded stokehold should have sufficiently alarmed even Bruce Ismay about the condition of the ship to delay making way again.

Confidence in the pumps that night was based on their performance during the quite moments after the accident. Prior to steaming again at 11:50 pm, Titanic's pumps and bulkheads were doing a good job of controlling the flooding. Put simply, the ship was floating on its pumps. This was a precarious situation, to be sure, but far from the immediate disaster that ensued after

Smith and Ismay resumed making way. Ten minutes after the ship started for Halifax, the pumps were being overwhelmed in Boiler Room #6. Once that happened, the system of watertight bulkheads was rendered meaningless. Titanic was condemned to a quick end.

What changed?

Certainly not the pumps. If there was a change in the pumps, they would have become more effective as additional suction lines were connected. Surviving stokers and trimmers witnessed engineers rigging more lines to improve the discharge of water. As minutes ticked by, the pumping improved. This means that if the pumps were overwhelmed, there must have been an increase in the rate of flooding. The inescapable conclusion is that Titanic's pumps were swamped by massive amounts of water pushed into the ship by its own forward motion. Water surged to eight feet deep in Boiler Room #6 within a few minutes of the engines turning again. Titanic appears to have steamed itself into a watery North Atlantic grave.

Captain Smith Investigates

Thomas Andrews, Titanic's builder, already knew that the situation was precarious. He learned that much on his personal tour of the bow prior to going to the bridge. Andrews probably was incredulous that the ship started moving again before being thoroughly sounded for damage. His appearance on the bridge must have been an attempt to convince Captain Smith to stop the engines. Suddenly, Boxhall popped up the stairway and gasped that the mail room was filling with water. This confirmed earlier reports of serious flooding from the mail clerk and Carpenter Hutchinson.

Andrews must have pointed out that the fourth compartment aft from the bow was now filled nearly to the ship's normal waterline. That flooding had taken less than twenty minutes. He must have quickly determined that Titanic was sinking, but he does not seem to have argued strongly to stop the ship. Common sense suggests that before leaving the bridge Captain Smith should have prudently ordered the ship stopped. However, the weight of evidence is to the contrary. Titanic apparently continued steaming slowly while Captain Smith, Andrews, Chief Officer Wilde and the Carpenter trooped off the bridge at virtually the stroke of midnight.

The Captain's inspection party went down the various stairways to the forward well deck where they walked past the crumbled ice. They hurried through the crew's quarters before descending deeper into the bow. Sailors described incoming water as under more pressure than might be expected during a quiet sinking. Samuel S. Hemming, a 43-year-old seaman, was awakened by the accident. About 12:05 am, he heard an unusual sound and decided to investigate.

...I went forward under the forecastle head to see where the hissing noise came from. I found it was the air escaping out of the exhaust of the (forepeak) tank. At that time the Chief Officer, Mr. Wilde, put his head around the hawse pipe and says, "What is that, Hemming?" I said, "The air escaping from the forepeak tank. She is making water in the forepeak tank, but the storeroom is quite dry."

-- Samuel S. Hemming, U.S. Senate Hearing, April 25, 1912

Hemming spoke to Wilde while the Chief Officer was touring the flooding spaces with Captain Smith. This incident seems to prove the ship was still steaming northward several minutes after midnight. Nearby, Seaman Frederick Clench had a similar experience. After looking at broken ice on the well deck, Clench went inside to be warm. Another crew member called to him a few minutes later.

...Someone said to me, "did you hear the rush of water?" I said, "No." They said, "Look down under the hatchway." I looked down under the hatchway and I saw the tarpaulin belly out as if there was a lot of wind under it, and I heard the rush of water coming through.

-- Frederick Clench, U.S. Senate Hearing, April 25, 1912

Such eyewitness accounts are not absolute proof that the ship scooped up water as it steamed forward. Incoming water could have forced air to hiss out of the forepeak tank or to balloon a canvas hatch cover even if Titanic had been sitting perfectly still. However, what the two men described seems to be more than quiet flooding through relatively small holes in the bottom. Both descriptions give the impression of rapid flooding under pressure, exactly what would have happened if the damaged ship were moving forward under its own power. The Captain's inspection of the bow was short22. It was obvious that Titanic was sinking.

Unavoidable Consequences

Forward motion during the approximately 20 minutes that the ship was making way must have created enormous hydraulic force on the underside of the tank top deck. This pressure should have caused weakened seams and other damage to open wider, increasing the flood of water through missing rivet holes and between the deck plates. As mentioned earlier, there is some evidence of increased flooding while the ship was steaming for Halifax. Crew members in the bow of the ship reported hissing air and other apparent signs of rapid flooding during that period of time.

Following the Captain's order to stop the engines for the last time, there seems to have been a slight reduction in primary flooding. Andrews reportedly gave the ship an hour to live when, in fact, it lasted almost two. The only possible explanation for even a small reduction of flooding is that less water entered the hull. The only cause for less water would have been the loss of headway after the ship glided to a halt. Nothing else changed except Titanic's forward momentum.

Stopping the engines not stop the ship's compounding problems. Every additional ton of water inside the hull caused the bow to tip downward. An often-overlooked consequence of this tipping is that it pushed damaged areas deeper under water where pressure increases with depth. Increasing pressure forced more water through the existing holes and must have caused other, lightly-damaged areas in the bottom to begin leaking. Water begot water in much the same way compound interest produces ever-increasing income from a single investment.

The effect of steaming is clearly seen in the pattern of flooding. At 11:50 pm, Titanic had lost buoyancy in all three forward holds, but the pumps were keeping down the level in Boiler Room #6. Water spraying into Boiler Room #5 was more of a nuisance than a threat. According to Lord Mersey's final report, the ship should have been able to float in this condition:

Even if the four forward compartments had been flooded the water would not have got into any of the compartments abaft of them though it would have been above the top of some of the forward bulkheads. But the ship, even with these four compartments flooded would have remained afloat....

Things changed quickly as the ship gained forward momentum after re-starting. Water was forced into all of the first five compartments. More water made no difference in the three holds which were already flooded beyond pumping. However, forward motion seems to have caused Boiler Room #6 to flood much faster than the pumps could remove it. The sea rose quickly to a depth of eight feet and more. This was Titanic's death blow: the loss of Boiler Room #6.

...But she could not remain afloat with the four forward compartments and the forward boiler room (No. 6) also flooded.

The flooding of these five compartments alone would have sunk the ship sufficiently deeply to have caused the water to rise above the bulkhead at the after end of the forward boiler room (No. 6) and to flow over into the next boiler room (No.5), and to fill it up until in turn its after bulkhead would be overwhelmed and the water would thereby flow over and fill No. 4 boiler room, and so on in succession to the other boiler rooms til the ship would ultimately fill and sink.

-- Report of the Court, July 30, 1912

Titanic was beginning to tear itself apart even as the engines were turning their last revolutions. This destruction was the result of a condition called "hogging" by sailors. The hull was being bent by the weight of water in the bow. Although made of steel an inch or more thick, Titanic was essentially a hollow metal tube supported by buoyancy along its entire length. Water flooding into the bow put tons of force on the ship's structure, force it was not designed to support. The bow bent down in a manner called "hogging." These bending forces were enormous[23]. Strain concentrated on the riveted seams, caused many to lose watertight integrity, allowing water into in areas not damaged by direct contact with the ice.

Additional flooding the apparent result of hogging occurred in the forward end of Boiler Room #4. This compartment remained dry until about 1:20 am when water in small quantities began coming in from "underneath the floor." Trimmer Cavell had not quite completed drawing the fires (pulling the hot coals out of the fireboxes) in Boiler Room #4 when this water began creeping upward. "Water started coming up over the stokehold plates. It came gradually," Cavell said in London, confirming that water came up from the bottom and not through the side of the ship. By the time he left the stokehold, Boiler Room #4 was knee-deep.

Abandon Ship, But Quietly

Titanic's 59-year-old Master gave out the assignments for abandoning the ship. Lightoller was detailed to launch the port side lifeboats; Murdoch the starboard boats. The memory of the French liner La Bourgogne must have flashed through everyone's minds. A horrible panic broke out when that ship went down 14 years earlier. None of the officers wanted anything similar to happen on Titanic. They all knew the horrible truth: there were seats in the lifeboats for about half the people on board. It would have been extremely dangerous to send people trooping up to the boats. Panic certainly would have resulted when more than half the passengers found out they could not get into a lifeboat.

Preventing panic was paramount. The maximum number of lives could be saved by loading only those people smart or lucky enough to reach the boat deck. No one would be told to go to the boats. In this way, the boat deck would remain free of panic for as long as possible. Those who remained in the warmth and false security of the ship's public rooms would have to fend for themselves after the boats were gone.

In 1911, when Titanic was launched, maritime experts openly spoke about large passenger ships being their own lifeboats. The belief was that multi-compartment vessels should remain afloat despite any imaginable accident. Today, the public considers this logic specious because of the great ship's maiden voyage tragedy. It is ironic that Titanic may have had history's best opportunity to prove a self-rescuing passenger vessel is possible. Even though mortally wounded from the outset, the huge liner was capable of saving all on board by floating into mid-morning until the rescue ship Carpathia arrived on the scene. Unfortunately, this did not happen. Titanic failed to be its own lifeboat because of the foolish decision to make way again.

By 12:19 am, only the ship's insufficient supply of wooden lifeboats represented any hope of survival. Captain Smith told Murdoch and Lightoller to swing out the boats. "Swinging out" meant moving the 14 lapstrake boats outboard from their chocks on the boat deck until they hung in their falls over the side. (Titanic's two "emergency boats" were kept swung out for immediate use. The four collapsibles could not be readied until the regular boats were launched.) In 1912 swinging out had to be done before passengers could be loaded in the boats. This order was as near as Smith came to giving a classic "abandon ship" command. There was no general alarm, no siren blaring; just a quiet "swing out the boats."

Titanic was coasting to its final stop, its life ebbing like the steam from its boilers. Beesley's thin white line of foam disappeared from around the cutwater. Without forward motion, the rudder was now useless and there was no longer any need for a quartermaster at the wheel. First Officer Murdoch, who remained as officer of the watch while the ship steamed toward Halifax, had one remaining job to do before attending to his lifeboat duties. It fell to him to issue the last navigation order given on Titanic. "That will do at the wheel," he told Quartermaster Hitchens, "it's time to get the boats out." Their dying ship was almost dead in the water. The world's largest liner was as near to its intended destination as it will ever get.

This is the moment when the story of the sinking began for those passengers who slept through the actual iceberg accident. Because they were asleep, most passengers had no knowledge of the slight shuddering as the ship ran over the ice shelf or of the engines stopping and re-starting. Sleepy passengers naturally assumed that the ship was gliding to a stop for the first time when they were awakened by stewards.

Procrastination in launching the first boats cannot be attributed to either problems with equipment or a lack of skilled manpower. The elite group of skilled seamen who helped Lightoller perform boat drills for the Board of Trade inspector was still on board. The Welin davits were of the very latest design. Third Officer Herbert J. Pitman actually bragged about the ease of launching boats that night, thanks to Welin's innovative equipment.

MR. PITMAN: ...it struck me at the time the easy way the boats went out, the great improvement the modern davits were on the old-fashioned davits. I had about five or six men there, and the boat was out in about two minutes.

SENATOR SMITH: You are referring now to No. 5 Boat?

MR. PITMAN: No. 5 boat.

SENATOR SMITH: The boat at your station?

MR. PITMAN: At my station; yes. The boat went out in two or three minutes. I thought what a jolly fine idea they were, because with the old-fashioned davits it would require about a dozen men to lift her, a dozen men at each end. I got her overboard all right and lowered level with the rail.

-- U.S. Senate Hearings, April 23, 1912

Moving any damaged ship in which the bulkheads have been weakened (as Titanic) is risky enough to warrant special attention in U.S. Navy training manuals. A major danger noted by that Navy is "panting" or a wobbling movement of weakened bulkheads. One possible cause for panting can be the "sloshing" of water inside a compartment resulting from movement of the ship.

...loose rivets, cracked seams and panting of bulkheads are indications of the need for shoring. Panting is a dangerous condition because it causes metal fatigue which in time will result in cracking and splitting...

-- Boatswain's Mate 2 & 3, U.S. Navy Bureau of Naval Personnel, NAVPERS 10121-C

The situation described by this military training manual sounds much like what happened to the bulkhead between Boiler Rooms #6 and #5. For almost an hour after the accident, there was no significant water above the tank top in #5. Then, at 12:40 am, a sudden rush of water burst out of the coal bunker attached to this bulkhead. This forced the abandonment of Boiler Room #5.

Slightly more than an hour had passed since the ship ran over the ice. Looking down 60 feet to the water alongside the hull, Murdoch finally felt the situation safe enough to order boat #7 lowered to the sea. Titanic's momentum had kept the ship sliding forward through the water for several minutes after the engines were stopped for the last time. Even though the ship was moving too slowly for the rudder to function, it still would have been foolhardy to attempt lowering lifeboats filled with passengers. Boats skillfully handled by professional sailors might still have been swamped[24].

Delay in launching the first boat from 12:10 am to 12:45 am has no other apparent cause except that the officers in charge felt the situation was still too dangerous. Perhaps they deliberately procrastinated another few minutes, hoping that taking way off the ship would slow the flooding and allow the pumps to catch up. (How foolish would Captain Smith have appeared in the morning if he had put people into small boats and the ship had not foundered?) It was a forlorn hope, but men who were not yet fully convinced the ship would sink might have needed the failure of that bulkhead to convince them that their "unsinkable" ship was really foundering. As Murdoch sent the first lifeboat down to the sea, Boxhall sent up the first distress rocket upward into the heavens. The symbolism of these almost simultaneous acts was not lost on the crew launching the boats.

Those Empty Seats

Often glossed over in the Titanic story are claims of ignorance by the ship's officers concerning the improved capabilities of their ship's davits and lifeboats. All said they feared loading the boats to capacity with passengers because prior to 1911 the davits, tackles, and wooden lifeboats were not strong enough to carry a full load of people. On older ships it had been necessary to lower boats with only a small crew of sailors aboard. Passengers formerly were loaded after the boats were in the water.

Titanic's newer lifeboat/davit combinations were capable of lowering boats fully laden with passengers. Surviving officers claimed they were never told this vital information. These claims are dubious at best. Titanic's officers must have seen the advertisements in marine publications placed by the Welin Davit Company touting the new davits, tackle and boats installed on Olympic-class ships. Some of Titanic's officers must have participated in the weight test conducted aboard Olympic in 1911. This test involved lowering boats filled with weights equal to a full passenger load. Axel Welin's equipment and the newly-designed wooden lifeboats (built by Harland and Wolff specially for the Olympic-class ships) easily passed the test.

The supposed lack of knowledge on the part of the officers came to light during the U.S. Senate probe when Lightoller was questioned about launching a half-full lifeboat.

SENATOR SMITH: How did it happen you did not put more people into that boat?

MR. LIGHTOLLER: Because I did not consider it safe.

SENATOR SMITH: In a great emergency like that, where there were limited facilities, could you not have afforded to try to put more people into the boat?

MR. LIGHTOLLER: I did not know it was urgent then. I had no idea it was urgent.

SENATOR SMITH: Did you not know it was urgent?

MR. LIGHTOLLER: Nothing like it.

SENATOR SMITH: Supposing you had know it was urgent, what would you have done?

MR. LIGHTOLLER: I would have acted to the best of my judgement, then.

SENATOR SMITH: Tell me what you would have thought wise...

MR. LIGHTOLLER (interrupting) I would have taken more risks. I should not have considered it wise to put more in, but I might have taken more risks.

SENATOR SMITH: As a matter of fact, are not these lifeboats so constructed as to accommodate 40 people?

MR. LIGHTOLLER: 65 in the water, sir, in the water.

SENATOR SMITH: 65 in the water and about 40 as they are being put into the water.

MR. LIGHTOLLER: No, sir.

SENATOR SMITH: How?

MR. LIGHTOLLER: No sir, it all depends on your gears. If it were an old ship you would barely dare to put 25 in.

SENATOR SMITH: But, this was a new one.

MR. LIGHTOLLER: And, therefore, I took more chances with her afterwards.

-- U.S. Senate Hearings, April 19, 1912

Although passengers were awakened and told to don lifebelts25, they were not systematically herded to the boat deck as would be done today. There wasn't even a suggestion that they should go to the lifeboats. Instead, confused passengers were encouraged to mill about in the warmth of the public rooms, waiting and wondering what was happening. At first, only a few lucky Titanic passengers found their way to the boat deck and the frigid night air. These hardy explorers found small groups of officers and sailors working on the davits. Women and children who appeared on deck were quickly shuffled into the lifeboats. However, there were so few women and even fewer children that the first lifeboats could only be partially filled. The officers allowed a few men and boys to board when no one else was about, Murdoch being more lenient with the male passengers than Lightoller. History has asked why so many of the early boats left virtually half empty. The answer is obvious: it was the inevitable result of not calling people to the boats.

SENATOR SMITH: How did it happen that you did not put more people into lifeboat No. 3 than forty-five?

MR. LOWE: There did not seem to be any people there.

SENATOR SMITH: You did not find anybody that wanted to go?

MR. LOWE: These that were there did not seem to want to go. I hollered out, "Who's next for the boat?" and there was no response.

-- U.S. Senate Hearings, April 24, 1912

One of the ship's barbers, A.H. Weikman, told a similar story in an affidavit. "I helped to launch the lifeboats," he said in his statement to the U.S. Senate hearings. "There seemed to be a shortage of women." This strange situation was confirmed in London by another member of the crew, seaman William Lucas, "...there was not anybody handy. No women. I was singing out for women myself." Lucas helped load boats all along the port side. "They were not all filled," he said, "because there were no women knocking about."

Third Class passengers were never intended to have direct access to the Boat Deck or any of the other upper decks reserved for First and Second Class passengers. Segregating immigrants in Steerage was U.S. policy in 1912. American immigration regulations specified that immigrant ships keep Third Class physically separate from First and Second Class for "health reasons." Titanic's interior architecture was designed to accomplish this separation with a minimum of doors, gates or cage-like bars.

Steerage passengers were forced to invent routes to the lifeboats on a night when a minute or two of hesitation separated those who got a seat in a lifeboat from those who saw only empty davits. Some Steerage passengers trying to make the climb ran into direct resistance from Titanic crew members who were absurdly still enforcing U.S. immigration regulations.

Bureaucrats in Washington and Ellis Island who ordered the segregation of immigrants did not take into account that ships are subject to sinking on occasion. Keeping Titanic's Steerage passengers away from First Class territory also kept them away from the Boat Deck. Completely forgotten was a plan to provide the immigrants open access to the lifeboats in an emergency. This oversight did not have criminal intent. Rather, it was the logical consequence of thinking that the multi-compartment Olympic-class ships were virtually unsinkable.

There was no special evil in the fact the crew did not have a plan for evacuating Third Class (steerage) passengers. The lack of planning on White Star's part was egalitarian. There were no plans for the orderly evacuation of the millionaires in First Class, either. Assistant second steward Wheat hinted at the lack of an organized plan to evacuate the ship during his testimony in London. He was questioned about this by the solicitor representing Third Class passengers, W.D. Harbinson:

MR. HARBINSON: Was there any system of organization among the stewards?

MR. WHEAT: No, only among the heads of departments. It was left to them.

MR. HARBINSON: There was no general system which had been established, was there, and positions allotted to the stewards in case of danger?

MR. WHEAT: Yes, all the stewards were allotted to boats. Every man had his boat.

MR. HARBINSON: Then there is no general system or instruction given them as to taking charge of the different classes and the different sections of the passengers?

MR. WHEAT: No, that is understood with regard to then First, Second, and Third. They are each in charge of their own departments.

-- British Board of Trade, Wreck Commission Hearing, May, 1912

Preparing an evacuation plan for Olympic-class ships in April of 1912 was simply impossible. They did not carry enough lifeboats. White Star planned to put only enough boats aboard the combined trio of Olympics to save the number people who could be carried aboard just one of the three ships. On the night of the disaster, only if Olympic had rushed to the side of its sinking sister would there have been enough lifeboats for everyone aboard Titanic. Of course, Olympic was well beyond rescue range and Britannic was not yet built.

The End Comes

Even before it's ill-fated maiden voyage, Titanic had captured the public's imagination. Everything about it was spectacular from its immense size to the sumptuous appointments of its two "millionaire's suites." In death, the ship lived up to the reputation it had created during its short life. The final moments were spectacular with the stern upended, pointing to the sky like the warning finger of a pagan sea god. There was the crashing sound of tearing metal prior to this final display, but that wasn't the sound most survivors remembered. As the taffrail disappeared, a great keening arose from those poor souls the ship had left behind. This wail continued until the last of more than 1,500 victims succumbed to the freezing water. Now, Titanic belonged not to the ages, but to the politicians, lawyers and tabloid journalists who would create great self-serving myths about the ship's demise.

One of those myths was that it sank intact, as perfect as the day it was launched. Thanks to Dr. Ballard, we know the ship broke apart either at or near the surface just as witnesses in the lifeboats claimed. After breaking apart, Dr. Ballard's photographs show the two major sections (bow and stern) suffered far different fates. The bow planed away to the north with comparatively little damage caused by its plunge until it slammed into the bottom. The stern appears to have been heavily damaged by implosions as air-filled compartments were crushed as the section of hull plunged into the depths.

Mostly because of testimony from the surviving officers, the myth grew that Titanic plunged intact to the murky depths of the Atlantic. The sounds of the ship tearing itself apart were ascribed to boilers exploding or falling through the bulkheads. "It sank in one piece," the myth proclaimed and nobody, not even eyewitnesses to the breakup, successfully challenged that version of the story for nearly 90 years. Survivors who witnessed the breakup and who described it in detail to investigators were simply ignored.

After she got to a certain angle she exploded, broke in halve[sic], and it seemed to me as if all the engines and everything that was in the after part slid out into the forward part, and the after part came up right again, and as soon as it came up right, down it went again.

-- Frank Osman, Seaman, U.S. Senate Hearings, April 25, 1912

She went down as far as the after funnel, and then there was a little roar, as though the engines had rushed forward, and she snapped in two, and the bow part went down and the after part came up and stayed up five minutes before it went down.

She parted at the last, because the afterpart of her settled out of the water horizontally after the other part went down. First of all you could see her propellers and everything. Her rudder was clear out of the water. You could hear the rush of the machinery, and she parted in two, and the afterpart settled down again, and we thought the afterpart would float altogether.

She uprighted herself for about five minutes, and then tipped over and disappeared.

-- Edward John Buley, Seaman, U.S. Senate Hearings, April 25, 1912

...and she almost stood up perpendicular, and her lights went dim, and presently she broke clean in two, probably two-thirds of the length of the ship.

She broke, and the after part floated back. Then there was an explosion, and the aft part turned on end and sank.

-- George Frederick Crowe, Steward, U.S. Senate Hearings, April 25, 1912

The tearing apart of the hull described in 1912 by these men, as well as other members of the crew and passengers, remains visible in the wreckage on the bottom today. There never should have been any doubt: Titanic broke apart either at or very near the surface of the sea and sank in pieces26.

The amalgam of steel, wood and paint that had been the world's largest moving object began its descent to the bottom of the Atlantic Ocean at 2:20 am on April 15, 1912. What rests there now is not Titanic, but the broken remnants of what was once a magnificent liner. Even as the real ship was disappearing into the dark waters, a new Titanic of myth and legend was being launched onto an ocean of public curiosity. It is this mythical ship, not the one of steel launched by Harland and Wolff, that still sails through the public imagination.

These two Titanics share histories filled with mistakes, deliberate untruths and human errors. The real ship failed to follow the Rule of Good Seamanship with regard to lookout, speed, and prudence. The mythical one fails to follow the rules of physics with regard to turning, impact and even the method of flooding. And, while the two ships provide material for an unending stream of sea stories, the harsh reality is that the tragedy underlying them should not have occurred. Posting another lookout, choosing a more southerly course, reducing to a safe speed, or remaining stopped after the accident--any of these actions of ordinary seamen could have prevented the needless loss of life. But, history is not a record of what might have been.

...the loss of the said ship was due to a collision with an iceberg, brought about by the excessive speed at which the ship was being navigated.

Dated this 30th day of July, 1912. MERSEY,

Wreck Commissioner.

Notes

1. Night's Modern Seamanship 17th Edition John V. Noel, Jr. Pg 214

2. Knight's Modern Seamanship, 17th ed. Captain John V. Noel, USN (Ret.) Van Nostrand Reinhold Co., 1984 ISBN 0-442-26863-7 Page 238

"The steering effect of the rudder is the only force turning the ship... The effect of the rudder is reduced as the headway is lost until there is no steering control when the ship is stationary."

3. Strictly speaking one person did report a crash stop, seaman Joseph Scarrott in his magazine article for The Sphere in April, 1912.

4. Bowditch, American Practical Navigator H.O. Pub. No.9 Defense Mapping Hydrographic Center 1977 ed. Page 808

5. Titanic's displacement weight is given variously at between 48,000 and 64,000 tons. This estimate of 52,310 tons at a draft of 34 feet 7 inches comes from testimony by naval architect Edward Wilding to the London proceedings. It should be remembered that displacement tonnage is actual weight, as compared to registered tonnage which measures cubic volume.

6. A nautical mile is 6,076.1 feet long. At 22.5 knots, Titanic was traveling 135,000 feet per hour, which is the equivalent of 37.9 feet per second.

7. The Discovery Channel Online field report by Jim Boyer, "Day 16." Available at http://www.discovery.com/area/science/titanic/dispatch16.html.

8. From the author's personal experience operating a passenger vessel in a shallow river.

9. This time can be calculated by dividing the distance over which the ship was damaged (249 feet) by its speed in feet per second (37.8). The result is 6.58 seconds. As friction between the hull and the ice would have slowed Titanic to some extent, it can safely be assumed that contact lasted a bit longer, probably in excess of seven seconds.

10. There are many different forms of floating ice on the ocean. Icebergs are, by definition the largest. These definitions are adapted from the report of the British inquiry:

Iceberg -- a detached portion of a Polar glacier carried out to sea. It is made of fresh water. Only about one-eighth of its mass floats above the surface of sea water.

Growler -- a colloquial term applied to icebergs of smaller mass. It is not infrequently a berg which has turned over, and is therefore showing what has been termed "black ice," or more correctly dark blue ice.

Pack Ice -- floating ice which covers wide areas of the Polar seas, broken into large pieces, which are driven ("packed") together by wind and current so as to form a practically continuous sheet. Such ice is generally frozen from sea water and not derived from glaciers.

Field Ice -- a term usually applied to frozen sea water floating in much looser form than pack ice.

Icefloe -- field ice, but in a smaller quantity.

Floe Berg -- stratified mass of floe ice.

11. Assignment Discovery: Icebergs The Discovery Channel TV Classroom Documentary

12. Barrett's "third stokehold" refers to the forward half of Boiler Room #5. Each end of the ship's double-ended boilers was considered as a separate stokehold by the crew. In Barrett's reference, the first two stokeholds would have been in Boiler Room #6. His third stokehold was the forward side of the boilers in Boiler Room #5. There was no common system of counting boiler rooms and stokeholds on Titanic. Boiler rooms were counted from the engine rooms forward, just the opposite of the way Barrett counted stokeholds.

13. Shipping Casualties Loss Of The Steamship "Titanic" Report of a Formal Investigation July 30, 1912 Page 32

14. Shipping Casualties Loss of the Steamship "Titanic" Report of Formal Investigation Lord Mersey, Wreck Commissioner 30 July 1912 Page 32, "The flooding in first 10 minutes"

15. New York Times April 18, 1912 Newspaper article from George Behe's Titanic Tidbits web site at http://infor-s.com/titanic.html.

16. Essentially this same story was carried by The Denver Post on Thursday, April 18, 1912 in conjunction with stories about Carpathia's arrival in New York.

17. Naval architect Edward Wilding advanced another theory for the immediate starboard list during testimony before the British proceedings. In questions 20242 through 20250 he proposes the starboard list may have been created by water coming up the stairway in the post office and flooding the starboard side of G Deck.

18. The International Regulations for Preventing Collisions at Sea (COLREGS) are specific on this point. Rule 7(c) specifically states, "Assumptions shall not be made on the basis of scanty information..."

19. This information was brought to light in a written statement to the U.S. Senate investigation by Maurice I. Farrell, managing editor of the Dow Jones News Service. He confirmed it in testimony on May 9, 1912.

20. Opening the automatic watertight doors also indicates there was telephone communication between Captain Smith and Chief Engineer Bell. Once closed from the bridge, the automatic doors were designed so they could not be re-opened unless the electric current was shut off from the bridge. Bell and Smith must have discussed the situation before the Captain permitted the current to be shut off so Bell could have the doors raised. This discussion may have reinforced the Captain's overconfidence in the ability of the ship to float despite major damage.

21. The Bluejacket's Manual, 14th Ed. The United States Naval Institute, 1950 Pg 527

"Watertight doors...should be opened only after making sure that the compartment is dry or so little flooded that no further flooding will be produced by opening the closure."

"Extreme caution is always necessary in opening compartments below the waterline in the vicinity of any damage."

22. In the aftermath, survivors reported seeing Captain Smith looking for damage as far aft as the second grand stairway and in a variety of passenger accommodations. Many people claimed to have been told privately "by the Captain" that the ship was sinking. These stories seem to be embellishments designed to enhance the teller's credibility. There was no reason for Smith to have visited any other portion of the ship than the bow. That's where he knew his ship was damaged.

23. Naval Architecture By Brian Baxter The English Universities Press, Ltd., 1959 Hodder and Stoughton, Ltd., 1976 ISBN 0-340-17883-3

Chapter 6 -- Flooding and Watertight Subdivision Chapter 10 -- The Strength of Ships

24. Boatswain's Mate 3 & 2 United States Navy NAVPERS 10121-C Chapter 7,

Boats The most dangerous time in hooking out a boat is THE MOMENT IT BECOMES WATERBORNE. (Emphasis in original.)

25. Although called "lifebelts" under British regulations, these were more like short, cork-filled serapes open at the sides with a hole for the wearer's head.

26. The Discovery Channel claims the two halves of the ship remained joined at the keel for a short time after the hulk disappeared from the surface. http://www.discovery.com.

Excerpted with the author's permission from *The Last Log Of The Titanic*, by David G. Brown, copyright 2001.

Courtesy of David G. Brown