TITANIC'S INITIAL LIST TO STARBOARD

by Samuel Halpern

The contributors to an initial list to starboard when *Titanic* struck the iceberg on her starboard side was due to asymmetrical flooding in various compartments. (See Figures 01 and 02 below.)

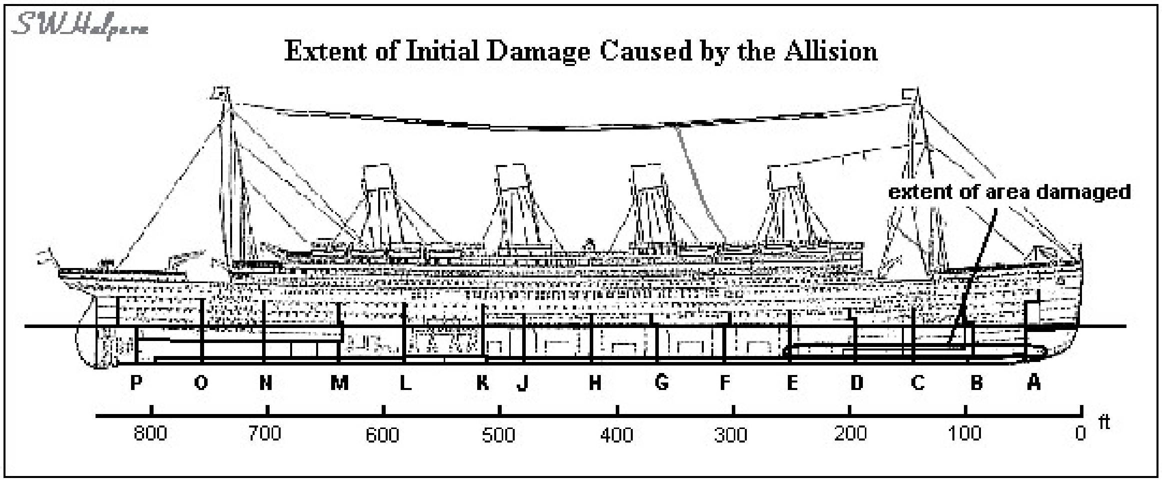

Fig. 01 – Profile view indicating the extent of known damaged areas on *Titanic*.

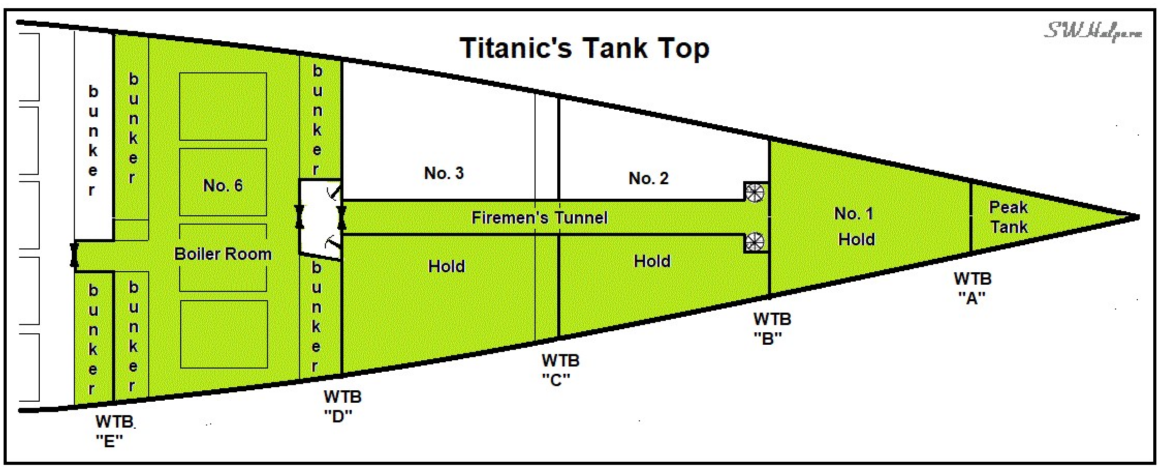

Fig. 02 – Initial flooding on the tank top level.

When we look at all six forward compartments what we see is No. 2 Hold and No. 3 Hold having an effective longitudinal watertight bulkhead in the way of the firemen's tunnel down on the tank top (Figure 02). This would tend to confine the floodwater initially to the starboard side until water overflowed the height of the tunnel and began to fill the port side as well. The flooding of the emptied forward bunker in No. 5 Boiler Room on the starboard side aft of watertight bulkhead (WTB) "E" also contributed a little bit to the starboard list. Since the Peak Tank was on the ship's centerline, there would be no heeling moment there. No. 1 Hold and No. 6 Boiler Room have nothing to stop the water from moving across the compartment transversely, and so they could be ignored initially in trying to estimate the initial angle of heel due asymmetrical flooding. Water flooding into the Firemen's Tunnel, which was also reported early on, would not contribute to the heeling moment since it too was on the ship's centerline.

In estimating the contribution from the bunker in BR 5, I assumed that the rate of flooding was from an equivalent fire hose opening of 3 inches diameter with a pressure head of 25 feet located 4.5 feet above the tank top (2 feet above the stokehold plates) as reported by fireman Frederick Barrett. I found it would take about 12 minutes to fill the bunker to that level with 41.5 tons of water in there. The center of the bunker from the centerline of the ship worked out to be about 27 feet. This contributes a heeling moment of 1120.5 ft-tons.

Now we have to look at the contributions of No. 2 and 3 Holds. To do that I had to estimate the volume that would be flooded on the starboard side of the ship between the hull and the starboard side of the Fireman's Tunnel. With reference to the Figure 03, the firemen's tunnel reaches a height of 10.5 feet above the tank top. The next thing was to measure the distances from the starboard side of the tunnel to the starboard side of the hull in three places: first was aft of bulkhead B, then at bulkhead C, then at bulkhead D; and also at two heights: at the level of the top of the double bottom, and 10.5 feet above that, the height of the tunnel. For this I used detailed bulkhead plans from H&W. I then took the average distance to the side for the tank top level and at the 10.5 foot level above it. Summing these two numbers together and dividing by 2 gets the average width of the volume we are looking for.

For No. 2 Hold this came out to be about 12 feet, and for No. 3 Hold it came out to be 25.2 feet. (Think of this as the average width at half the height of the Firemen's tunnel in those two cargo holds.) The next thing I did was to multiply these average widths by the height of tunnel (10.5 ft) to get their mean cross sectional areas. The next step was to multiply those mean cross sectional areas by 50 feet, the approximate length of each hold, to get the volumes we are looking for. I then added 10% to these values to account for the small volume between the double bottom margin plates and the hull that is below the level of the tank top that would also fill up.

Finally, the next step was to divide these calculated volumes by 35 long tons per cubic foot to get the tons of seawater that would take up those spaces. The results are, No. 2 Hold takes on about 198 tons and No. 3 Hold takes on about 416 tons on starboard side to the height of the firemen's tunnel. Keep in mind that this is not the total quantity of water entering these compartments, but only the amount that entered that would cause the ship to take on an initial list to starboard. Any water spilling over the top of the tunnel would add to a corrective moment tending to reduce the list as these compartments continued to flood. Thus what I did was to look for the worst case initial list, which is what we are really interested in.

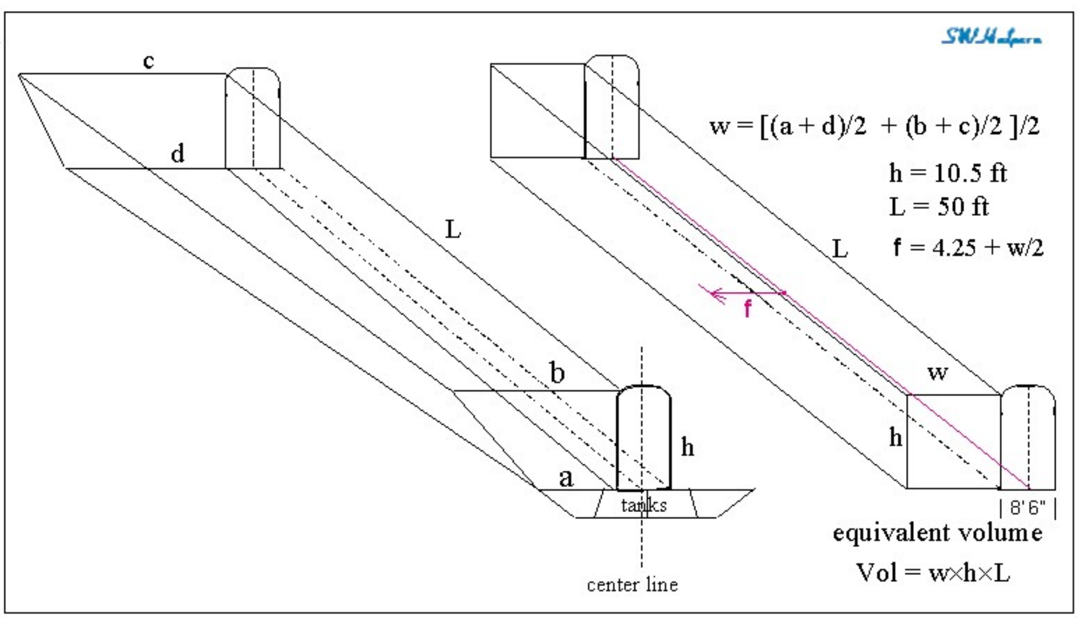

Fig. 03 – Calculating the flooded volumes for No. 2 and No. 3 Holds.

To get the heeling moments for No. 2 and No. 3 Holds we have to find the distances of the centers of the flooded areas from ship's centerline. That would equal 1/2 the average width of the volumes taken from above, plus another 4.25 feet which is one-half the width of the Firemen's tunnel (also shown in Figure 03). The results were a moment arm for No. 2 Hold that came out to be about 10.3 feet, and for No. 3 Hold that came out to almost 16.9 feet. When these are multiplied by the weight of water in each volume we get 2039 ft-tons for No. 2 Hold, and 7036 ft-tons for No. 3 Hold. These numbers assume that those spaces were empty.

If we now then take a permeability of 75%, as assumed by H&W naval architect Edward Wilding for these two holds, then the two moments become 1529 ft-tons for No. 2 Hold, and 5277 ft-tons for No. 3 Hold. If we then add all three moments together, No. 2 Hold, No. 3 Hold, and the starboard bunker space in No. 5 Boiler Room, we get a total of 7926.5 ft-tons acting on the ship.

Now once a list starts to develop it would also cause water in the compartments that have free, unconstrained movement, to slosh towards the starboard side, thus changing the location of the water's center of mass in those compartments. The contributions of these various compartments however would differ. For example, the peak tank and No. 1 Hold would not be major contributors since they are relatively narrow and their moment arms would be quite short. The major contributor, however, would be No. 6 Boiler Room which is quite wide. The unsymmetrical wedge in water that is created in that compartment by the list of the ship can easily be calculated for a given angle of list, and initially, is not dependent of the depth of water in that compartment. When we do this we find a moment of 3492 ft-tons is produced based on the dimensions of that boiler room and a permeability of 65% for flooding that does not yet get above the height of the double-ended boilers there. All of this is based on the dimensions of the boiler room, the double-ended boiler volumes, and a list of 5° which was obtained through an iteration process. Thus the total heeling moment caused primarily from the flooding in No. 2 and 3 Holds, No. 6 Boiler Room, and the starboard bunker in No. 5 Boiler Room, equal 11,418.5 ft-tons.

To get the angle of list in radians we divide the total heeling moment by the ship's displacement on the night of April 14, and then divide that result by the metacentric height (the GM) of the ship. Both the ship's displacement (48300 tons) and the metacentric height (2.63 ft) come from work of Hackett and Bedford. The result that is obtained is an angle of list of 0.090 radians, which equals **5.15-degrees**, a result that agrees very well with the observation of QM Hichens. (See Figure 04.)

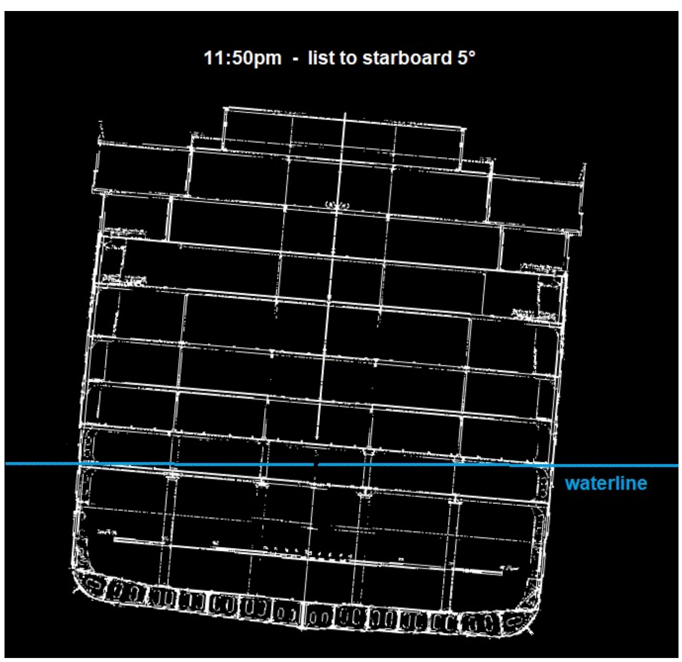

Fig. 04 – Cross-sectional view of Titanic showing a 5° list to starboard looking forward.

The results in this analysis, as in any other, are subject to the approximations and assumptions that were made. It says that one would expect to see a list close to 5 degrees on an inclinometer about 10 minutes or so after contact with the iceberg. As water would start to fill the spaces on the port side of No. 2 and 3 Holds after going over the top of the Firemen's tunnel (via the hatchways for example) one would expect the list to starboard to begin to lessen over time despite the bunker in No. 5 Boiler Room continuing to fill because of the differences in flooding rates. The bunker itself would continue to fill until one of the bunker doors gives way, which is the real weak point on the bunker bulkhead. My guess is that it was a bunker door that gave way when Leading Fireman Frederick Barrett saw that rush of water come from the passage between the boilers when he was in No. 5 Boiler Room later on that night, and not the collapse of a watertight bulkhead as some others have assumed.