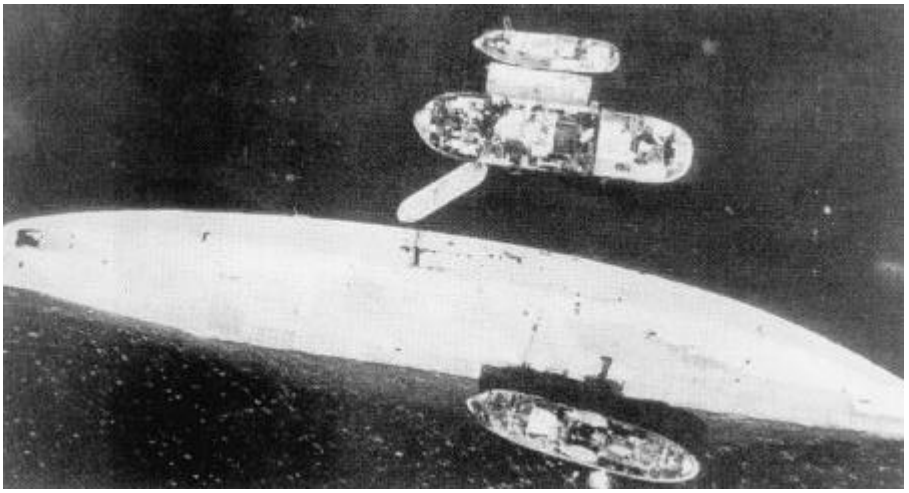
The Armor of German Warships 1920 – 1945

Edited by Siegfried Breyer

Marine-Arsenal

Special Volume 6



The Battleship TIRPITZ ranked – even more so than its sister-ship BISMARCK – as the best protected ship that ever sailed under the German flag. Its misfortune made it clear just how vulnerable warships are to air attacks when they are attacked with very heavy bombs.

The Armor of German Warships

Edited by Siegfried Breyer

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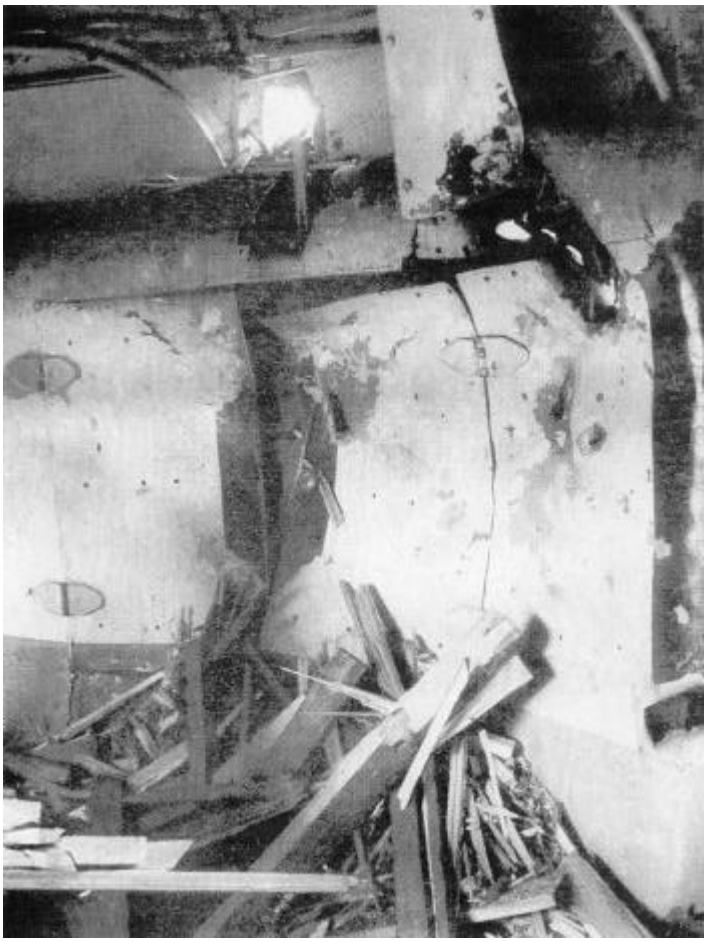


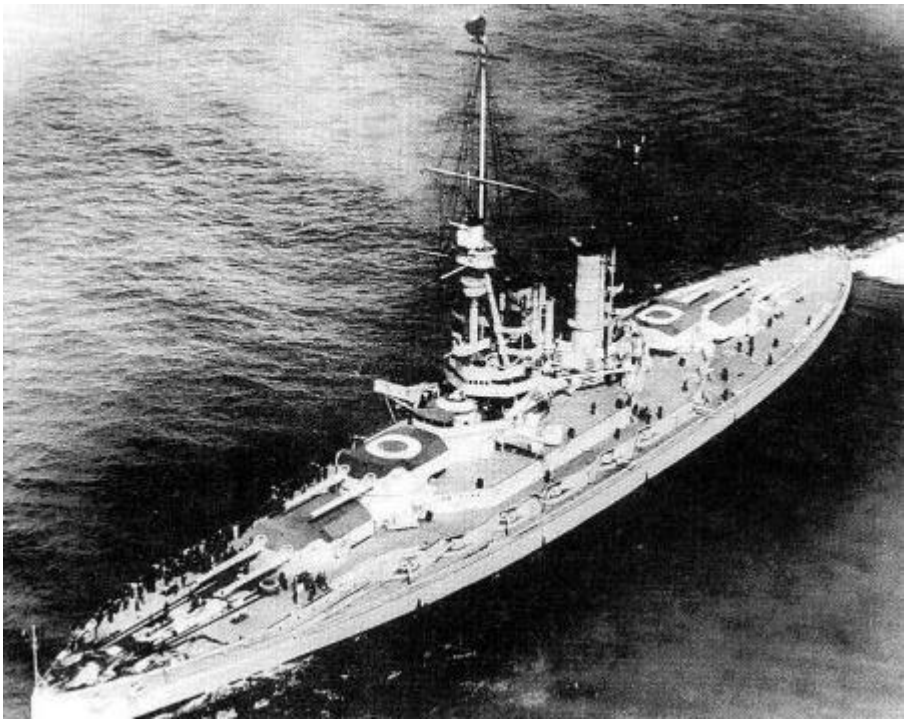
The design conditions for the most advantageous configuration of armor and protection below the waterline were determined, in Germany, by systematically executed blasting experiments. Based on these experiments, the fundamental doctrine evolved that the prime battle factor of "steadfastness" [staying power, modern naval term 'survivability'] must receive absolute priority among other factors – including striking power and speed. Therefore, the Kriegsmarine also adhered with an iron will [to this doctrine of the Imperial Navy and the Reichsmarine]. Consequently, German capital ships exhibited extreme resistance [to battle damage] and proved to be virtually unsinkable during both world wars. This did not change until the opponent employed increasingly heavier bombs, against which even the heaviest ship could not ultimately be immune. This illustration shows the effect of a blasting experiment aboard a ship of the Kaiser's Navy.

PRELIMINARY REMARKS

Shortly after the war's [WWII] end the victorious powers began a systematic investigation and evaluation of the German "war machine", and for this purpose they conscripted surviving German technicians and scientists. The naval establishment was also obliged [to cooperate]. Most importantly, the new German U boats (Types XXI and XXIII) were given high priority, but other areas were also of interest to the victors. One concern was the armor and protective measures of German warships built from 1919–1945. By order of the Soviet Military Administration in Berlin-Karlshorst, a team under the direction of the former Naval Chief Construction Inspector, Engineer Többicke, reported regarding the subject [of armor]. Official documents and files were not made readily available to the editors or were made virtually inaccessible; and thus, essentially, they had to depend on what they retained in their memory. Therefore, this resulted in uncertainties, especially in the designation of armor thickness, although this should not detract from the factual content of the document they wrote. These reports soon made their way via the former German Democratic Republic to West Germany, and there they "slumbered" for several decades. But now they can be made accessible to an interested readership.

This following report was left just as it was written, although – particularly in view of the comparative designs of foreign warship types - it is based on a past state of knowledge which was revised a long time ago (the editors could not be better informed due to the inefficiency of foreign intelligence). Thus, [this being the case,] it demonstrates and elucidates how, long ago, one thought and acted during the demise of the "age of naval gunnery", and what a large role armor protection played.

Siegfried Breyer



The best-protected and most heavily armored battleships that entered service into the Kaisers Navy were the units of the BAYERN-class (here, the BADEN) that were completed at the beginning of the First World War. The Kriegsmarine, with iron determination, embraced the basic tenets of her standard defensive design.

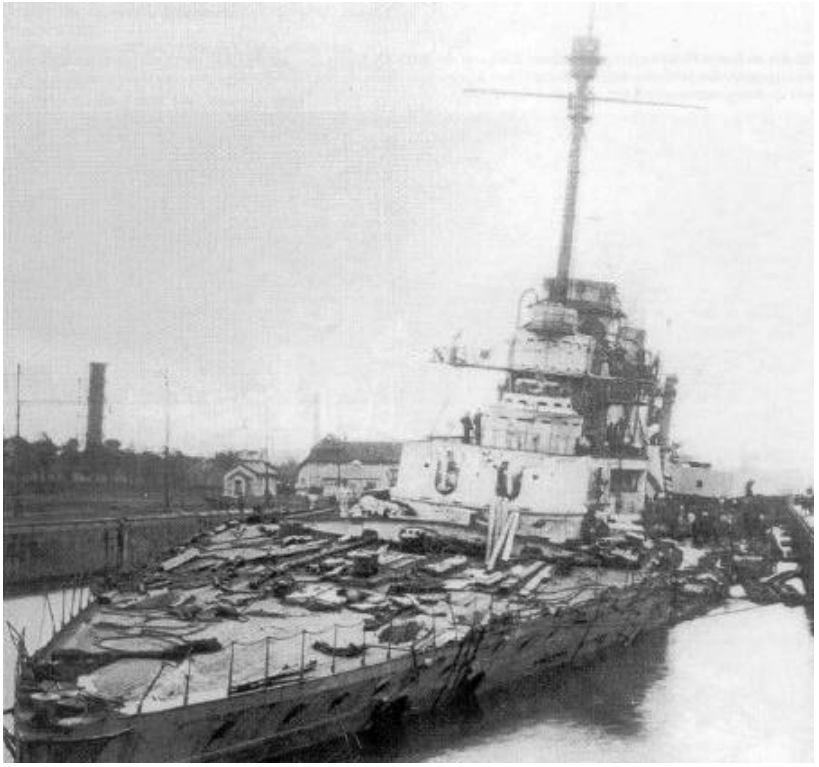
A. INTRODUCTION

During the war of 1914/18, the "steadfastness" [strength, durability, survivability] of German warships of various types was proven in numerous battles. The reasons for this survivability, which was never reached by foreign navies, were:

1. An armoring system, in connection with the coal bunkers' protection, with its thickness and extent matched to the type of ship and its other combat assets; however, with speed somewhat compromised.
2. A watertight subdivision that encompassed most of the ship's hull.
3. A well-organized damage control unit with extremely well trained personnel.

The Treaty of Versailles, with its limitations on ship weights, and the transition to oil-firing on the other hand, i.e., propulsion by Diesel motors, made it necessary to search for new ways of protecting ships, because oil-firing made the combination of armor and coal bunker protection obsolete.

Attempts on how to solve this problem are especially well demonstrated by describing the armor plating of individual ship types because it can be readily seen which experiments were made to arrive at final solutions. Before we can discuss the armor of individual ship types, we must first deal with some general questions that apply to all ship types.



The German capital ships of the First World War repeatedly proved their high degree of staying power. An exceptionally poignant example was presented by the battle cruiser SEYDLITZ. Severely shot up and burning, and having shipped 5,000 t of water, she returned to her homeport under her own power, her armor having largely withstood most hits. Here the SEYDLITZ is seen shortly after entering one of the locks at Wilhelmshaven.

B. MAIN PART

1. GENERAL COMMENTS.

a) Armor material.

Normally, the most important type of armor material, the cemented armor of great thickness that is attached to the outer skin, produced according to the Krupp method (abbreviation KC), could not be installed on any ship of the German Navy before 1933 because of weight considerations. Whether the headwalls, i.e., barbettes, of the 28 cm guns of the armored ship DEUTSCHLAND (later LÜTZOW) or the command posts of this ship and of the cruisers were made from this material is unknown, but it is entirely possible [This was indeed the case].

The probable composition of KC armor that was used starting with GNEISENAU is approximately as follows, and the usual former composition is also given:

Material	Abbreviation	Old (A)	New (N)
Carbon	C	0.37%	0.34%
Nickel	Ni	4.1%	3.78%
Manganese	Mn	0.3%	0.31%
Chromium	Cr	1.89%	2.06%

The increase in additional manganese and chromium was possible due to improvements in the manufacturing process. Specifics about how this was done are not known. The normal production process is presumed to be common knowledge.

The KnC armor, which was a material of identical composition as KC, although it was not cemented (which was formerly utilized in severely or doubly bent [reheated/bent again] plates of more than 80 mm thickness), as well as the nickel armor used up to and including the K cruisers, has been displaced by the newly developed armor materials WhnA and WwnA. These abbreviations mean “Wotan hard new type” and “Wotan soft new type”, whereby “Wotan” should be regarded as a camouflage name [secret code] [nA = neue Art = new type]. I do not know the compositions of these materials, but the tensile strength properties were:

Tensile Strength	Elasticity	Stretch Yield Point
Wh 85 to 95 kp/mm^2	20%	50 to 55 kp/mm^2
Ww 65 to 75 kp/mm^2	25%	38 to 40 kp/mm^2

Whereas the approximately 4% nickel steel used until then could not be welded, Ww as well as Wh could be welded very well with a special electrode. Because of the scarcity of raw materials this electrode had to be used very sparingly even before the war. Thus, a new electrode was developed, Böhler Fox A 7, which did not contain materials that where scarce in Germany, but with which almost similar results could be achieved.

In the sketches presented here and in the following narrative, Wh, i.e., Ww material, is recommended for use was in thicknesses from 10 to 150 mm. Later, it was produced in greater thicknesses, although I don’t recall any specifics. The advantages of using such material are obvious, even for armor belts, since they avoid the very expensive and tedious production times of KC armor. However, it is assumed that the material must

have been tempered in order to achieve, at equal or lesser thickness, the same protective effect as the KC-plate.

The acceptance of armor materials of all types was administered with special care. Even the production process was continuously monitored by [naval] officials who were detached to Krupp. KC-armor was produced exclusively by Krupp; Wh and Ww was produced by the Witkowitz Iron Works. [Perhaps initially W meant Witkowitz, instead of Wotan]. Several plates were selected from each armor lot delivery for submission to ballistic tests at the firing range in Meppen.

b) Basic Principle for Armor Construction.

When considering the armoring system of German warships the descriptions made above must be taken into account, especially those concerning the materials, because it is well known for its superior characteristics over that material used by other navies. In fact, there was the additional basic tenet that the individual parts of the armor system, such as belts, decks, splinter hatches, etc., are not to be viewed as independent from one another. Instead, they were to be arranged and matched in their thickness so that they complemented each other in their protective effects.

This is apparent on all ships that have a relatively narrow armor belt width, i.e., the waterline bulwarks made of armor material. The reason for the weight limitation in cruisers was based on the Versailles Dictate. The need for large machinery output in battleships required so much weight that not much was left to accommodate the weight of armor. Furthermore, it was based on the assumption that equipped for combat and with appropriate fuel stores, the ship's draft would considerably exceed the designed draft. Therefore, the lower edge of the belt in case of battle would be deep enough that even at high speed (drop in the water's level amidships) or during applying the rudder, i.e., heeling for some other reason, a hit below the belt could be avoided. These considerations presuppose a high-positioned armored deck, which, categorically, in all cases, was to lie [only] 1 meter above the floating waterline.

Many publications are available that describe the installation of the armor belt, so further details are superfluous. But it should be mentioned that the lateral edges of the SCHARNHORST and BISMARCK classes' side plates were ground so perfectly smooth that they could be installed on the outer skin without any further connection and without showing discernable joint grooves. The outer skin, in contrast to foreign navies, was formed according to the depth of the belt's backside, while formerly it showed a recess that was the thickness of the belt.

Two versions of armored deck were produced:
1. normal with sloping scarp, 2. without scarp.

Construction "with scarp" prevailed among light and heavy cruisers, whereas the further development of the SCHARNHORST class design (battleships of similar size with Diesel motor propulsion and even higher speed) were to have an armored deck "without scarps". It was planned to have all bulwark [ways] bunkers under armor protection and to make these bunkers as large as feasible. Therefore, this construction method [without scarps] was primarily used for ships with rather extensive cruising deployment [ranges], e.g., to provide vessels employed for disrupting merchant

shipping with enough space for sufficient fuel. It could not be anticipated during the design stage that the war's development would have necessitated the deployment of such ships that were not originally configured for this purpose. The horizontal protection configuration of all ships, including the Tirpitz-class, did not fully factor in dangers from the air, which became decisive during the progression of the war, into the armored deck thickness calculations by making appropriate increases in the dimensions and expanse of horizontal armor. The first case of this [prioritization of horizontal protection] was the further development of the planned ships H to M (see there). Further important items in horizontal armor construction are armored gratings, i.e., on openings in the armored deck that cannot be sealed with ordinary hatch covers [due to the need to transfer air and exhaust gases to and from compartments below the armor deck]. Aboard First World War ships these openings (for funnels and air shafts) were covered with gratings made from rods of armor material. The newer version consisted of armor plate (20% thicker than the deck) made from the same material as the deck, through which 35 to 40 mm diameter holes were drilled. These gratings were countersunk conically at the bottom of funnels and at the top of air intakes. Their total cross-sectional diameter had to be calculated to deal with the potential decrease of airflow volume to the funnels, i.e., air-shafts. Despite the necessary enlargements of the armored through-deck scarps, which were obviously unavoidable, the weakening of horizontal resistance was within tolerable limits since the gratings still provided good protection.

When it was at all feasible from the standpoint of weight reduction, a portion of the compartments' transverse bulkheads between the outer skin and the longitudinal torpedo bulkhead was constructed from Wh material. In addition, the oil bunkers between the compartment bulkheads were further subdivided with Wh material in order to prevent too many oil bunkers from becoming involved during penetration of the armored deck [by shells], as well as containing collateral damage from torpedo and mine hits.

For underwater protection the following guidelines were in effect: In order to diminish the splinter effect from torpedo and mine hits, the outer skin, which was attached without strong connectors, was made only as thick as required to guarantee structural soundness (during mine or torpedo hits in 1914/18 pieces were torn away from the outer skin as large as 75 kg that penetrated inboard bulkheads and decks, thereby inflicting heavier damage than from the actual explosion pressure itself). Since the most effective measure for dissipating the energy inherent in the expansion of detonation gasses is an expansion space, the interval distance between the outer skin and the longitudinal torpedo bulkhead was made as large as possible. Even on armored cruisers it measured 4 meters [wide], and was about 5 meters on the TIRPITZ. This space was further subdivided by a thin longitudinal bulkhead, whose purpose it was to markedly reduce the energy of the explosion to the extent that it could be absorbed by the torpedo bulkhead without causing leakage.

c) Tests

Explosion experiments were conducted on a full-sized model in order to test the proposed construction of a particular torpedo protection system for battleships. A 60-meter long amidships' section of an old KAISER WILHELM II class ship-of-the-line was used for this purpose. New construction designs were installed between two

transverse bulkheads within this section, with the last being tested in November 1936, and, if my memory serves me right, a torpedo head with a 300 kg explosive charge was detonated. It was to be determined if the state of the art in welding techniques with Ww material [was sufficiently advanced so that] a transition could be made in the SCHARNHORST class from a [traditional] riveted longitudinal torpedo bulkhead to a welded bulkhead. The experiment showed tearing of the plate adjacent to the welded suture [seam] despite flawless welding. Therefore, even the TIRPITZ class has riveted T bulkheads. The tearing was caused by the heating of the Ww material during welding, which resulted in the loss of ductile [elastic] properties and consequent brittleness. Later, welding techniques became much improved so that the material no longer suffered deterioration during welding; this was determined by explosion tests of welded Ww materials.

Additionally, acceleration [dynamic load] measurements were to be carried out during the last large explosion test, but their results are unknown. The maximum values were not recorded because the measurement instruments came to grief due to the excessive conditions.

In 1938 the old and devastated ship of the line HANNOVER was used, which had previously been heavily damaged by artillery ballistic tests, for investigating the effects of sea floor mines. A bottom mine was detonated under it at a depth of 15 to 20 meters, if I remember correctly. An older freight steamer sank immediately, while the HANNOVER remained afloat, but could be brought into Kiel only with the assistance of 4 pump steamers. The experiment verified the value of good, watertight compartmentalization, although they were not as extensively utilized in these old ship types as they are in newer ones.

In addition to the old ship of the line HANNOVER, the target ship HESSEN also served to determine the effects of artillery fire. In contrast to the ZÄHRINGEN, it had no cork filler within its hull compartments. However, it was armored to the extent that one would expect even heavy hits to spare the ship's internal installations. Based on initial [ballistic trial] experiences, the outer skin of the ship's bow area [HESSEN] was replaced with 30 to 40 mm Wh material from above the waterline armor to the upper deck in 1938. Direct hits with 28 cm target practice shells of about 150 kg and with highly sensitive impact fuzes failed to penetrate the armor from distances of 150 to 200 hm and beyond, and caused only dents. The entire armor arrangement aboard HESSEN was of such high quality that during target practice in the year 1941 she tolerated nine direct hits from 38 cm caliber shells without failures and, the following day, 7 more hits from 28 cm caliber shells in addition to numerous 15 cm hits. About half of the heavy shells penetrated the forward section and the upper deck armor; however, not the underlying armored deck. This result was primarily related to the use of Wh material for the outer skin, which dissipated so much of the shells' energy that they were unable to cause very much damage to the internal parts of the ship. Both firings occurred at a distance of 250 hm; and although the use of these 38 cm shells was more or less forbidden for target ship firing practice, they were used in this instance anyway. Both types of shells that were fired had highly sensitive fuzes (impact). The ship's armor belt, made from 225 mm KC armor of the old type, sustained various direct hits, but it was not penetrated in any case. The effect was merely a pushing back of the entire plate for a few centimeters into the ship's interior, which demonstrated the need for an effective rigid structural support of the outer skin behind the KC armor.

2. LIGHT CRUISERS

a) Construction after the Dictates of Versailles.

The first new German warship construction after the First World War was the cruiser EMDEN. Based on the arrangement and thickness of the armor, as well as the overall design, it was merely a replica of the last light cruisers of the old Imperial Navy. Originally, 4 of the 10 boilers were supposed to be coal-fired, and this meant that the coal's safety protection could not be completely dismissed. But the boilers were subsequently switched to oil-firing. It also became necessary to use a lesser thickness for the waterline bulwark ways, 50 instead of 60 mm, in order to accommodate the weight of greater fuel stores needed to allow multi-purpose use of the ship on distant foreign deployments. For the first time [in a German cruiser], the EMDEN employed an armor deck above the munition holds that was reinforced, from 20 to 30 mm, in other words, to the thickness of the inclined scarp. This reinforcement used part of the weight savings accrued in reducing the vertical armor. Otherwise, there is nothing remarkable about the construction.

The armoring system, as well as the overall construction of the three subsequent so-called K-cruisers, was intended to be of a novel design. They had, first of all, an armor deck without sloped scarps, and they were equipped with plain oil-fired boilers and cruising Diesel engines. The basic intent was to have [internal] armored boxes along the waterline on both sides of the ship that would prevent excessive listing and, which would be especially dangerous for this ship class because of their high aspect length/beam ratio. The bottom of this armored box consisted of a 10 mm thick scarp. The design intent was to keep this air chamber as watertight as possible, even after torpedo hits. Criticism of this construction must take into account that it originated in 1925 and that calculations concerning the explosive effects of torpedoes were based on the war of 1914/18. These armored air chambers did not prove themselves in WWII because they did not prevent the KÖNIGSBERG from capsizing after a bomb hit in Bergen, Norway. Nor did they prevent the sinking of KARLSRUHE after a torpedo hit. Above the munition holds, the armored deck was reinforced, as on EMDEN, with the armor material being similar.

All three ships [K-class, also KÖLN] were to be rebuilt as well as widened without incurring a loss in speed. This reconstruction was done only on KARLSRUHE since the war prevented it on the other two ships. The main reasons for reconstruction were stability and strength considerations because the ships were unable to measure up to the demands of handling multiple additional installations of artillery equipment. The "bending [flexing] moment" had become so large that fissures appeared at the major joints. In addition, the center of gravity had risen so high that fuel consumption had to be reduced in order to preserve stability.

The hull widening that encompassed nearly two thirds of the ship's length not only removed these weaknesses, but it also, in addition with the complete overhaul and rerouting of power cables, improved protection by replacing the outer skin with Wh material. Thus, a thin under-water external armor was placed over the waterline protection of the ship's hull, which was no protection against high explosive shells, but at least could induce the external detonation of high explosive shells with impact fuzes of up to 15 cm caliber. Therefore, this would prevent serious damage inside the ship. In

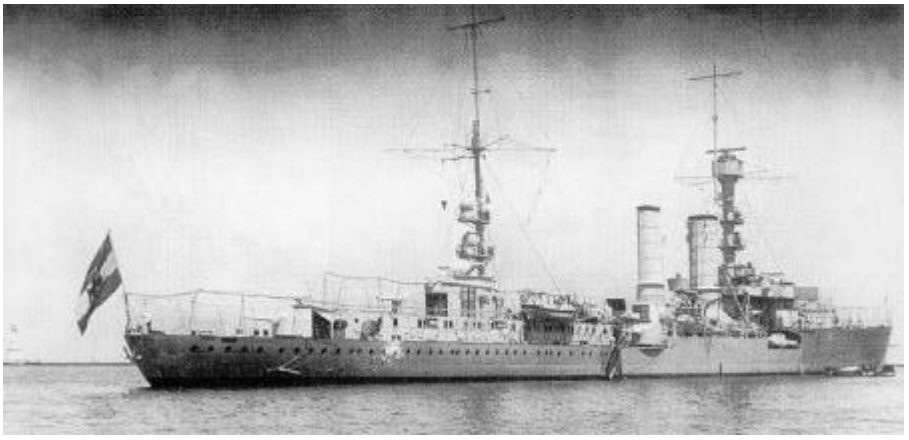
addition, this external layer was extended upward and thus provided an exterior/interior protective combination between the outer skin above the armored deck and the armored deck itself for about half the ship's length. Proof of this armor arrangement's value was not observed since the ships' duties during the occupation of Norway were accomplished without encountering artillery fire. However, during the return cruise to Kiel [KARLSRUHE] was lost due to a torpedo hit.

The cross-sections of LEIPZIG and NÜRNBERG demonstrate a return to normal, basic armor principles. Conspicuous is the unusual rounding of the armor deck's scarp. This was done to gain room in the ship's interior for the machinery necessary for high speed despite using the scarp. The use of Wh material in both ships for the deck and waterline passage way [wing tanks] was basically novel. Despite the general utilization of welding in the ship's hull construction, the armor plates, as well as the outer skin and even the deck plates, were riveted.

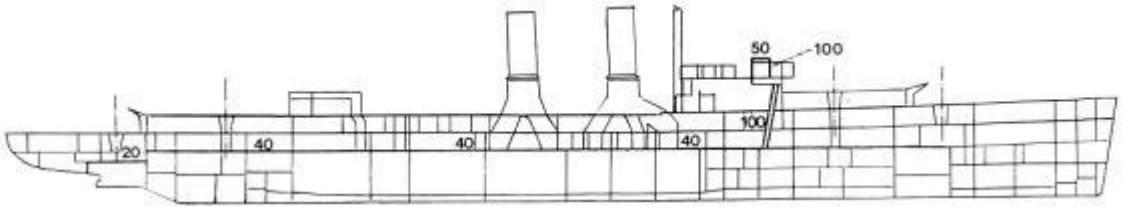
The reconstruction of both cruisers was not carried out. It would have followed the same aims as that for the K cruisers, and would have substantially improved protection against artillery fire.

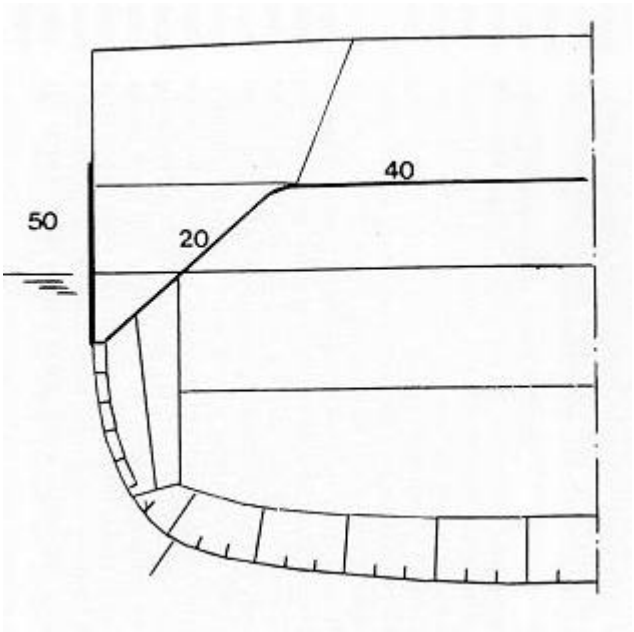
All the light cruisers were well protected against torpedo and mine hits by internal longitudinal bulwark bulkheads and by their good watertight compartmentalization.

In conclusion, it is to be noted that a stronger protection against artillery hits among all these ships could not expected in view of the weight restraints. Nevertheless, the actual installed armor thickness was astonishingly heavy in comparison with foreign ships of equal size, as will be shown in the following comparison with English, American, and French type-specific counterparts.



The EMDEN relied heavily on the technical standards of the last cruisers of the Kaiser's Navy: this was applicable in a particular way to the ship's hull and its armor.





Side view and cross-sectional profile of the first post-war cruiser EMDEN of the German Reichsmarine. The numbers show the armor's thickness in millimeters.

The EMDEN was more or less comparable to the British cruisers of the ENTERPRISE class. According to the available publications, these ships had a 25 mm thick armored deck and 76 mm of waterline protection. The deck thickness is similar to that of EMDEN, while the belt is considerably thicker and, in particular, it is broader and it extends all the way up to the forecastle deck. This armoring method is based on English experience gained in WWI, being employed first in the RALEIGH class. Because of more extensive protection and a 4-knot speed increase, the ships became about 50% larger [than EMDEN], although they mounted one less 15 cm rapid-loading cannon. One could afford this only in England, since speed reductions were not in effect [by treaty-mandated weight restrictions].

Subsequent classes from LEANDER to BELFAST clearly reveal the following tendencies: an armored deck that is as thick as feasible (LEANDER still 25 to 32 mm, later ships 51 mm) joined to an ever increasingly thicker waterline belt. According to the presently available documents, this amounted to 114 mm in the areas of the Belfast class' boiler rooms.

A peculiarity in English cruiser construction theory is that protection in the LEANDER and ARETHUSA classes covers only the machinery areas and boiler rooms by external means, while foreward and aft only the amidships ammunition chambers are armor-protected below the waterline. The basic idea appears to have been to maintain an [internal] air chamber capable of [flotation] support in case of heavy damage fore-and aft. This could have been precipitated by publications about the Battle of the Skagerrak [Jutland], wherein the sinking of the SEYDLITZ was prevented by an air-blister

trapped in the amidships' passageways. The advantage of this arrangement is in armor weight savings, although this is more or less balanced by the fact that hits from light caliber shells during combat could raise havoc with the unprotected fore and aft sections. This, in any case, would reduce speed dramatically unless even more serious consequences surfaced. This armoring system did not prove itself during WWII, since even the protected spaces of the ship's fore and aft sections were insufficient to keep ships of the NEPTUN [sic] class afloat following torpedo hits. As a consequence, modern British cruisers once again employed extensive [external] waterline protection.

A further fundamental difference between German and British cruiser construction methods is the strong outer skin behind the waterline belt, while the German Navy, due to weight-saving reasons, used the waterline bulwarks simultaneously as both the outer skin [and main armor belt]. The reason may be related to the materials that were used. While the German side assumed that no armor splinters would be torn loose from the backside [of its bulwark/belt armor] by a hit, the English apparently expected this [to happen], and counteracted it by considering the outer skin as additional protection for the ship.

The comparable French cruiser types are the DUGUAY and the TROIN class. They are equal in size to EMERALD and have the same weaponry as EMDEN; however, they have no hull protection. In comparison to EMDEN, their additional 1,800 t weight appears to be exclusively devoted to the power plant, since one can surmise that 108,000 WPS [shaft HP. In Anglo-American 1 HP is slightly larger than metric 1 HP: 745.7 W vs. 735.5 W] as opposed to 80,000 in EMERALD should reach more than 33 knots. The inappropriateness of totally unprotected ships of this size does not require a special discussion. The French Navy paid attention to this, and they [subsequently] reinforced their upper decks to 30 mm.

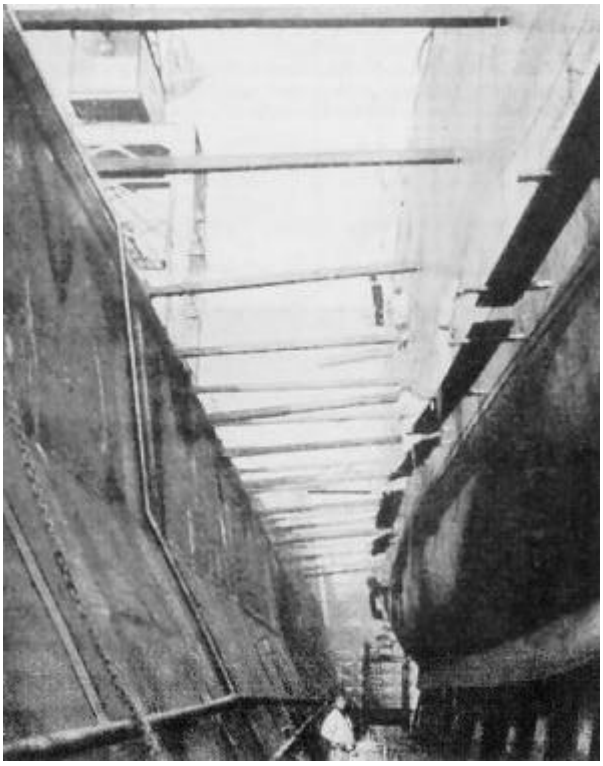
Further French developments proceeded similarly to that in England. The one-of–a-kind constructions JEANNE D'ARC and EMILE BERTIN did not yet receive waterline protection, but already had armored decks of 76, i.e., 50 mm thickness. The fleet-cruisers of the LA GALISSONIERE class had decks of 38 mm (above the rudder room 26 mm, according to other sources 70 mm), a belt from 105 or 120 mm, a torpedo bulkhead (?) of 20 mm, and as closure to the belt, 30 mm thick armor bulkheads. But overall, these ships are thought to be well protected.

Among the Italian ships, an escalating improvement form class to class is observed with regard to the lateral side protection. In addition, the ships of the COLLEONI class were given a 20 mm torpedo bulkhead; therefore, similar torpedo bulkheads would be predictable for the later ships. In parallel with protection improvement is the increase in size and drop in the high speeds that were seen in earlier ships. It is not known if the armor deck thickness was later increased by an additional 20 mm; although it must be assumed since 20 mm does not qualify for minimal horizontal protection requirements.

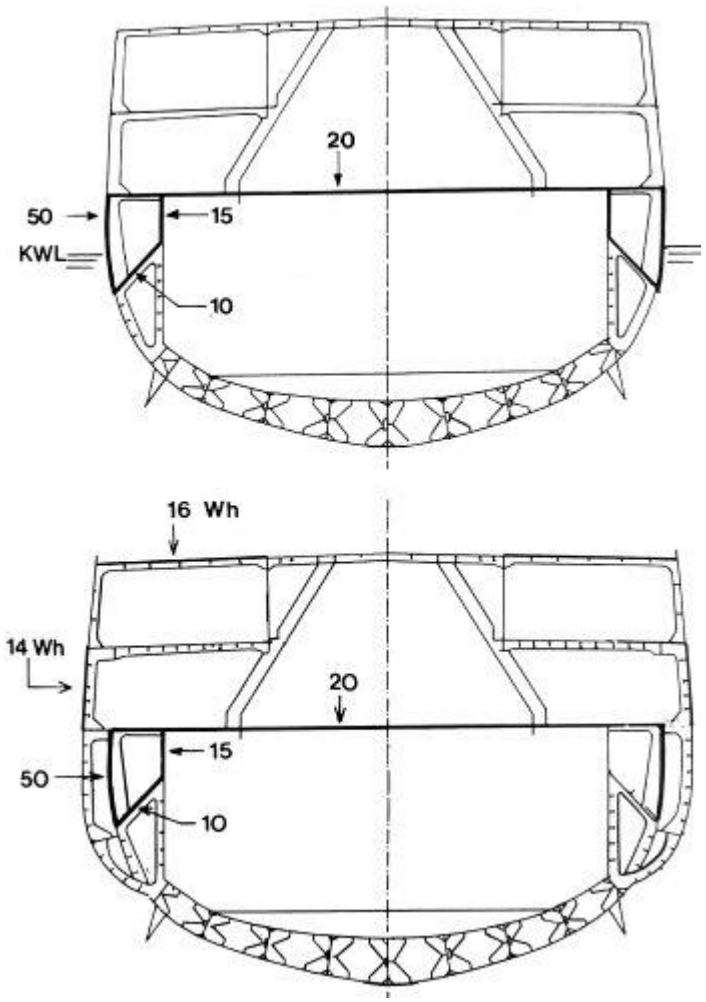
The US OMAHA class cruisers did have a short waterline protection of 76 mm and an armored deck of 38 mm thickness. However, they did not even have a double bottom (?? [sic]) and, therefore, these ships were inadequate in all ways for modern [combat] requirements. The US Navy resumed the construction of light cruisers only after a long pause, but the experience of other navies was thoroughly incorporated. Although excessive speed and an increase in ship size were disregarded, an extremely good

protection for these ships was provided. The data are quite conflicting, but an armored deck of 127 mm [was employed] with an equally thick belt – other sources states this to be 200 mm! – This appears to be an acceptable fact. [This is grossly exaggerated. The average main armor deck thickness of *Brooklyn* Class cruisers was 50 mm, while the belt was 82.5-127 mm]. Data are unavailable for the armor arrangement, although cross-sections for the heavy cruisers have been published, more about this later.

In concluding this section, it can be said that: the German cruisers, under the limitations of the Versailles Dictate, relied fundamentally on the protection principles proven in 1914/18 of employing armored deck and waterline protection: both as thick as possible; whereas other navies first made a detour via very fast and poorly protected cruisers [and then] back to a well protected cruiser. Only the British navy actualized thought processes similar to the German navy. The experiences of the last war have shown that the adopted direction was correct. But this [thinking] also showed that careful watertight compartmentalization is the only effective protection against torpedo hits. Due to space and weight constraints, adequate torpedo belt protection cannot be accommodated in ships of such size. The torpedo attack on the cruiser LEIPZIG in December 1939 serves as proof of the correctness of this view. The ship continued to make headway despite two of three boiler rooms having been completely flooded. She could be repaired, while numerous English cruisers were lost after torpedo hits.

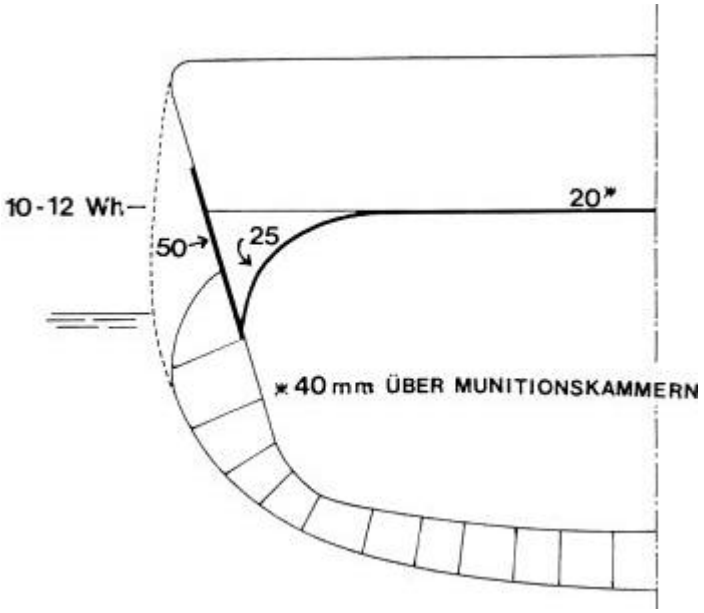


The cruisers of the KÖNIGSBERG class (also called "K-cruisers") were built extremely lightly to stay within the limits prescribed by the Versailles Limits (for cruisers the maximum [standard] displacement was 6000 t). Consequently, armor in the waterline region was particularly weak. Here is a view of the dry-docked cruiser KÖNIGSBERG.



KWL = *Konstructionswasserlinie* = construction [design] waterline

Cross-sectional profile of “K cruisers” in the original configuration (top) and after the reconstruction that was done only on the KARLSRUHE (bottom).



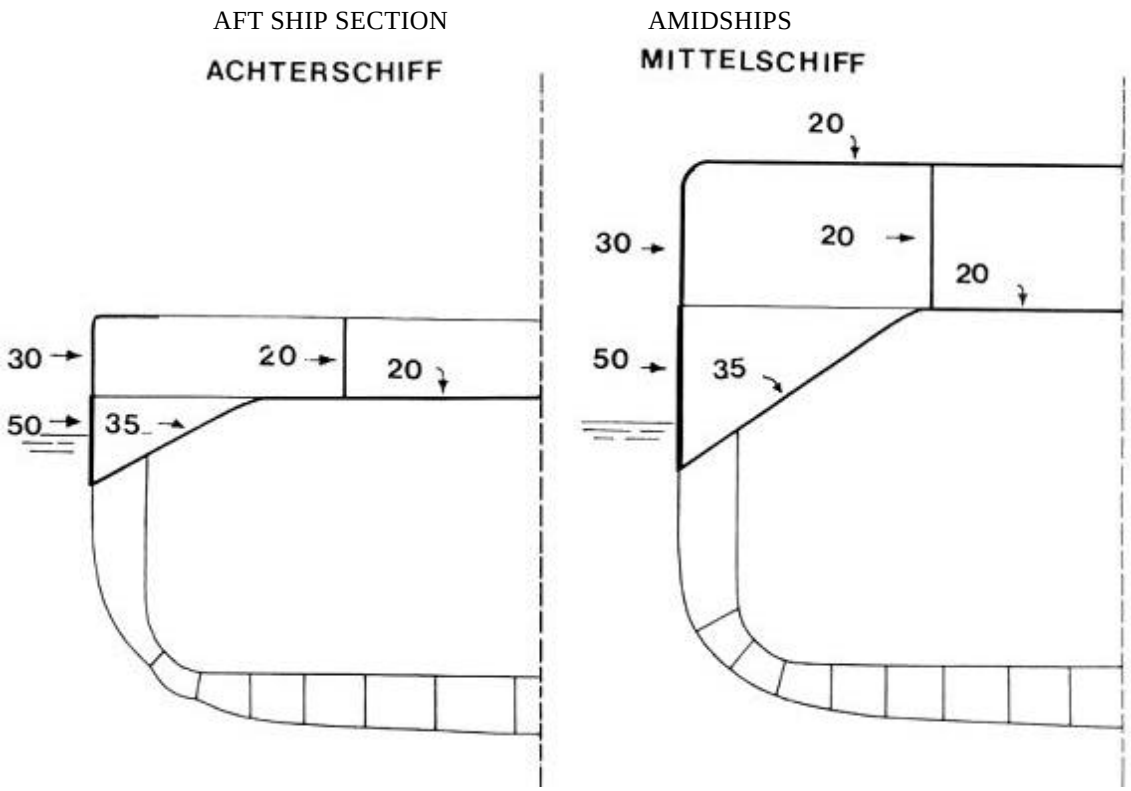
*40 mm ABOVE THE AMMUNITION CHAMBERS

Cross-sectional profile of the cruisers LEIPZIG and NÜRNBERG with the pinched-in side bulge. The dashed line indicates the cross-sectional profile after the proposed, but no longer accomplished, reconstruction.

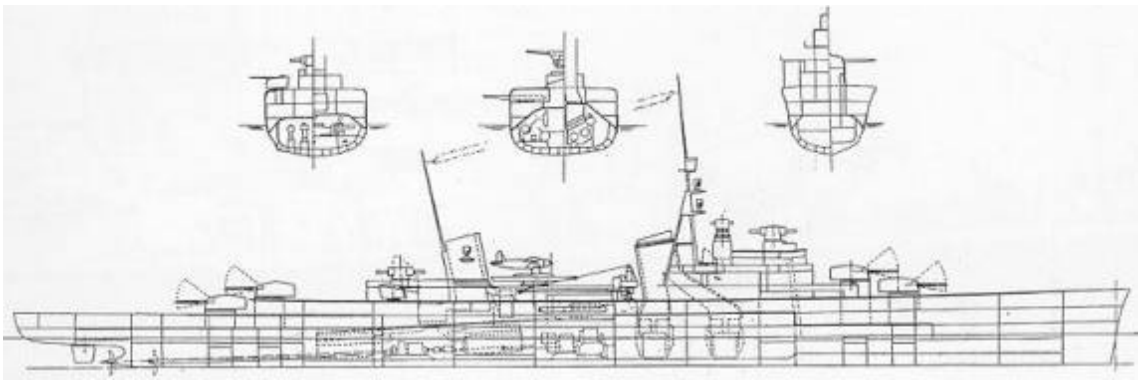
Despite the extremely light construction, the ship's hull of the cruiser LEIPZIG withstood the ramming of the heavy cruiser PRINZ EUGEN in October 1944. The picture shows both cruisers wedged together.

b) Planned constructions

NÜRNBERG was the last cruiser to be built according to the edicts of the Versailles Treaty. After her construction, a pause commenced that was to be lifted with the [proposed] cruisers M to P. The design of these ships was based on extravagant demands by the military, and must be viewed as a failure in construction design [terms]. The armor thickness has not been revealed. The armored deck had a normal scarp, but it was not laid out in a single contour sweep and had multiple shifts that resulted in structural discontinuities. However, the armor thickness could not have been considerable because, in view of the ships' other heavy combat assets, there would not have been sufficient room to accommodate the necessary weight.



Cross-sectional profile of the "M" type cruisers.



Side view sketch and cross-sections of the light cruisers of the "M" type.

3. ARMORED SHIPS AND HEAVY CRUISERS

So much has been already written about the German armored ship types that an in-depth report can be dispensed with. Individual characteristics are noted in the sketches. The waterline protection was fixed at 80 mm to provide protection against the artillery of the probable opponents, the so-called "Washington cruisers".

The protective effect is enhanced by the belt's outward inclination, and completed by the 20 mm thick inboard longitudinal splinter bulkhead between the foredeck and the armor deck. It was a disadvantage that, due to weight considerations, the armor deck of DEUTSCHLAND and ADMIRAL SCHEER could not be extended over the entire ship's width. Such protection to the bulwark bunkers was no bnger denied to the somewhat larger SPEE.

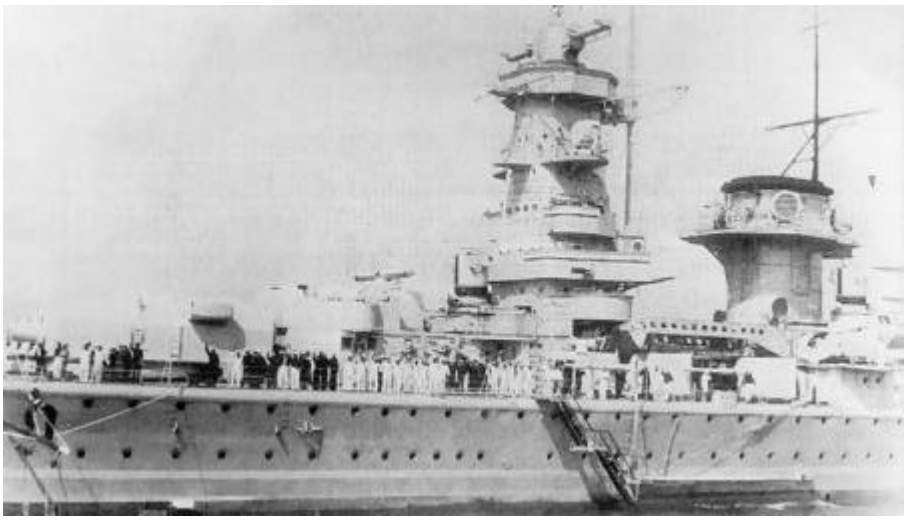
The thickness of the armor deck was 40 mm = half of the waterline belt's thickness. This follows remarkably good modern design theory, but it is inadequate against modern bombs.

The construction already proved its value during the attack by Red-Spanish bombers on the DEUTSCHLAND off Ibiza, since the armor deck was not penetrated and the splinter bulkheads limited detonation effects in the longitudinal direction.

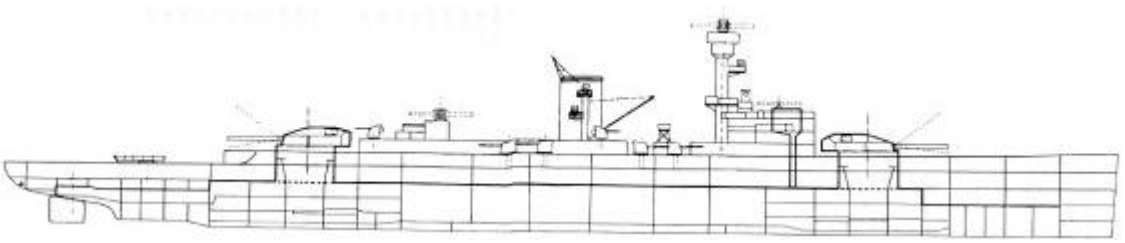
Also, the fire effects of 20.3 cm shells from the cruiser EXETER had no effect on the armor [belt] of the SPEE during the battle off the La Plata estuary [mouth, delta], while 15 cm shell hits against the other armored parts of the ship were especially ineffective.

Nevertheless, during this battle there was the recurring experience of the Battle of the Skagerrack, with this experience subsequently also becoming decisive for the BISMARCK; namely, that the protection of the ship's ends, particularly the forward parts of the ship, should be a considerable factor in the determination of its total protection (see also discussion of the LEANDER class). The evaluation of this fact will be considered in the discussion of battleships. The armored ships had a torpedo protection that consisted of a 30 mm thick, slanted longitudinal bulkhead. In DEUTSCHLAND and SCHEER it reached only to the double bottom, while in SPEE it led all the way to the outer skin. This was undoubtedly much better, since even the inner bottom was protected against torpedo hits. The version used in both initial ships was a consequence of weight restriction. The slanted position of the torpedo bulkhead, which initially originates at the middle height of the ship, is advantageous because it can be extended for a further distance downward without causing recessed areas [nooks, bays]. This method also allows [bulkhead] placement adjacent to the outer skin in fore and aft areas where frames are slanted [due to hull contours], without having to move the bulkhead farther inward. Further armor protection against underwater hits was not provided, and it was achieved by filling the outer and inner spaces of the bulwark [wing tanks with fuel oil], since experiments, of which we know no specifics, demonstrated that an underwater explosion is most severe on a wall behind which is located an empty space. Based on this protective effect, it is possible that the acceleration of a quantity [mass] of fuel absorbs energy that cannot be transferred to a posterior wall. Therefore, the breadth of the protective bunker is more important than is its volume.

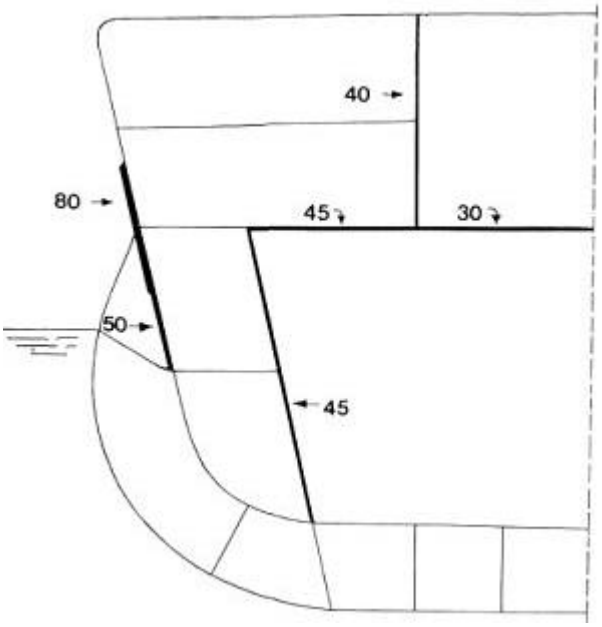
Observations regarding the efficacy of this underwater protection are not available, since only one ship – LÜTZOW – received a hit, but this one was in the stern section. Since no other navy has ever built this kind of ship, no comparisons are possible.



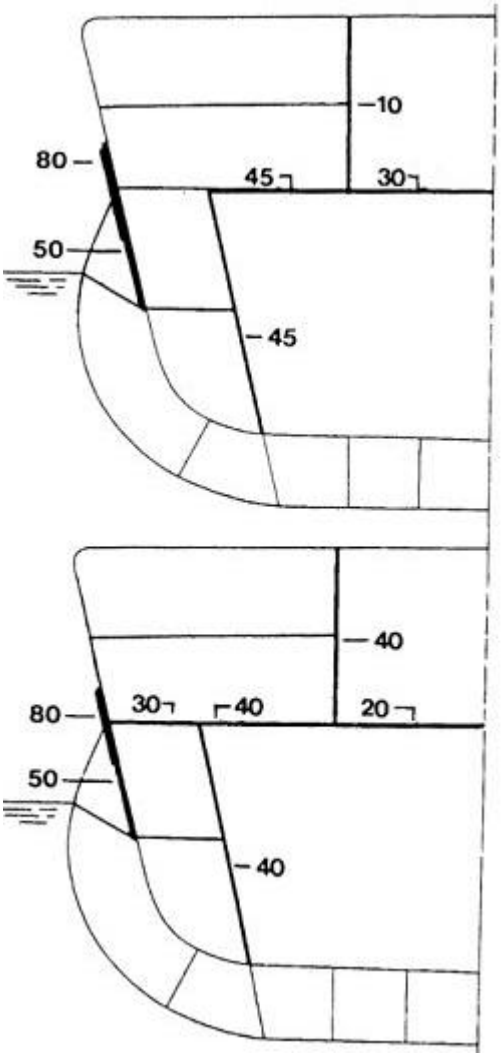
Armored ship ADMIRAL GRAF SPEE. Here the upper edge of the side armor is clearly visible.



Longitudinal section of the armored ship DEUTSCHLAND. The thicker lines indicate the extent of the armor protection.



Armored ship DEUTSCHLAND, schematic cross-section through the main frame level indicating armor thickness.



Schematic cross-sectional views at the level of the main frame of the armored ships ADMIRAL SCHEER (above) and ADMIRAL GRAF SPEE (below). The incrementally instituted improvements of the armor protection, which began with the armored ship DEUTSCHLAND, are clearly visible.

The German heavy cruisers of the HIPPER class are the first ships that were built without the limitations of the Versailles [Treaty], and therefore, it can be clearly compared with foreign constructions. Although these ships are considered well protected against artillery fire, their underwater protection is no better than that of the small cruisers because weight had to be freed up for the machinery plant. There was, however, a bulwark bulkhead that was 20 mm thick, but no heavy torpedo bulkhead. Furthermore, the inclined orientation of the longitudinal bulkheads was again discarded.

The correctness of this assertion [concerning the heavy cruisers' poor underwater protection] is verified by the sinking of the BLÜCHER, whereby it was demonstrated that the ship was not compromised in its floatation ability by artillery fire, but that hits from a land-based torpedo battery brought about her swift sinking. It would have been effective for ships of this size to forego some speed (trial speed 33.8 knots) and to request torpedo bulkheads, such as were in the armored ships. This way a good "Washington Cruiser" would have evolved, although this shall not, in any way, be construed as an approval of this type of ship.

In addition to the loss of the BLÜCHER, the following combat damage assessment of heavy cruisers during the war has been recorded:

1. Outer hull skin on HIPPER was ripped open from the ramming by GLOWWORM [sic], although no conclusions can be drawn from that.
2. Torpedo hit aboard PRINZ EUGEN. Explosion under the stern. Here again there are no conclusions concerning the efficacy of protection.
3. Bomb hit aboard PRINZ EUGEN in Brest. Here, a 500 kg bomb penetrated the decks and the armor deck scarp, was deflected by the slanted longitudinal bulkhead, and diverted into the ship's interior where it detonated. The floatation ability of the ship and structural integrity of its joints were not adversely affected; however, the interior installations of the impacted spaces were totally destroyed (command and weapons centers). This hit was renewed proof for the correctness of the assumption that modern ships need horizontal armor as thick as it can be made.

The "Washington Cruisers" of other navies also suffered from this same deficiency in sufficient horizontal protection, although the English Navy, based on its wartime experience, had proposed in its last war designs of WWI very extensive armor protection (RALEIGH class). This was again ignored during the post-war design of English heavy cruisers, which received no waterline protection, but only an armored deck. Its thickness measured 76 mm, except for the AUSTRALIA class which received a 100 mm deck. The defect in this construction was later recognized, since the entire ship type received 76 mm thick waterline belt protection during the course an extensive reconstruction, although the belt had to remain narrow so that the ships would not become too disadvantaged weight-wise [top-heavy]. Special measures for underwater protection are not apparent.

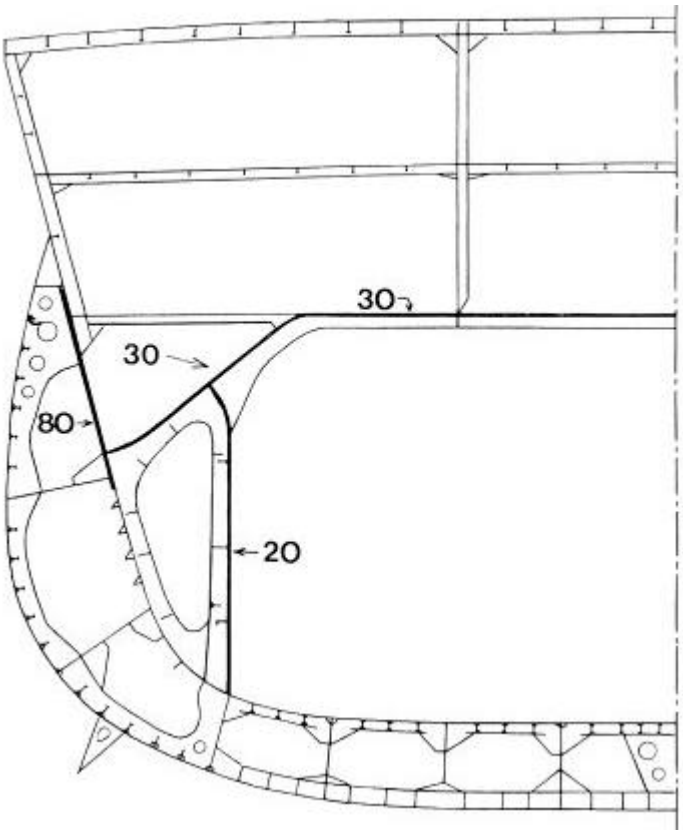
Even more disastrous are the initial French constructions of 10,000 t cruisers that possessed neither horizontal nor vertical protection. But already the next class of cruisers received a waterline protection of 60 mm that was strengthened to 110 mm in the last construction: ALGERIE. This ship's armored deck was 80 mm thick, while data

on the deck thickness of the preceding ships is missing. Only ALGERIE should be viewed as an acceptable construction that is comparable to German ships. The armor thickness can be approximated to those of German ships, taking into account the poor [quality of] French materials. For underwater protection, the French construction may also have had no weight [allotment] at their discretion.

The Italian navy had already chosen an alternate course for their first heavy cruisers, since they initially gave the TRENTO class a waterline protection of 70 mm and an armored deck of 30 mm. In the POLA class, the speed was dropped from 35 to 32 knots, but for that [loss in speed] the protection was much improved: WL 150 mm, deck 70 mm. However, in the BOLZANO class, with increases in speed required, the lesser [armor] thickness of the TRENTO class were again utilized. The appropriateness of stronger protection for the heavy cruisers is self evident, although the Italian navy, in fact, demonstrated that their better protected heavy cruisers, based on size, were still too poorly protected; because, in point of fact, three of these were lost to artillery fire at the battle off Cape Matapan.

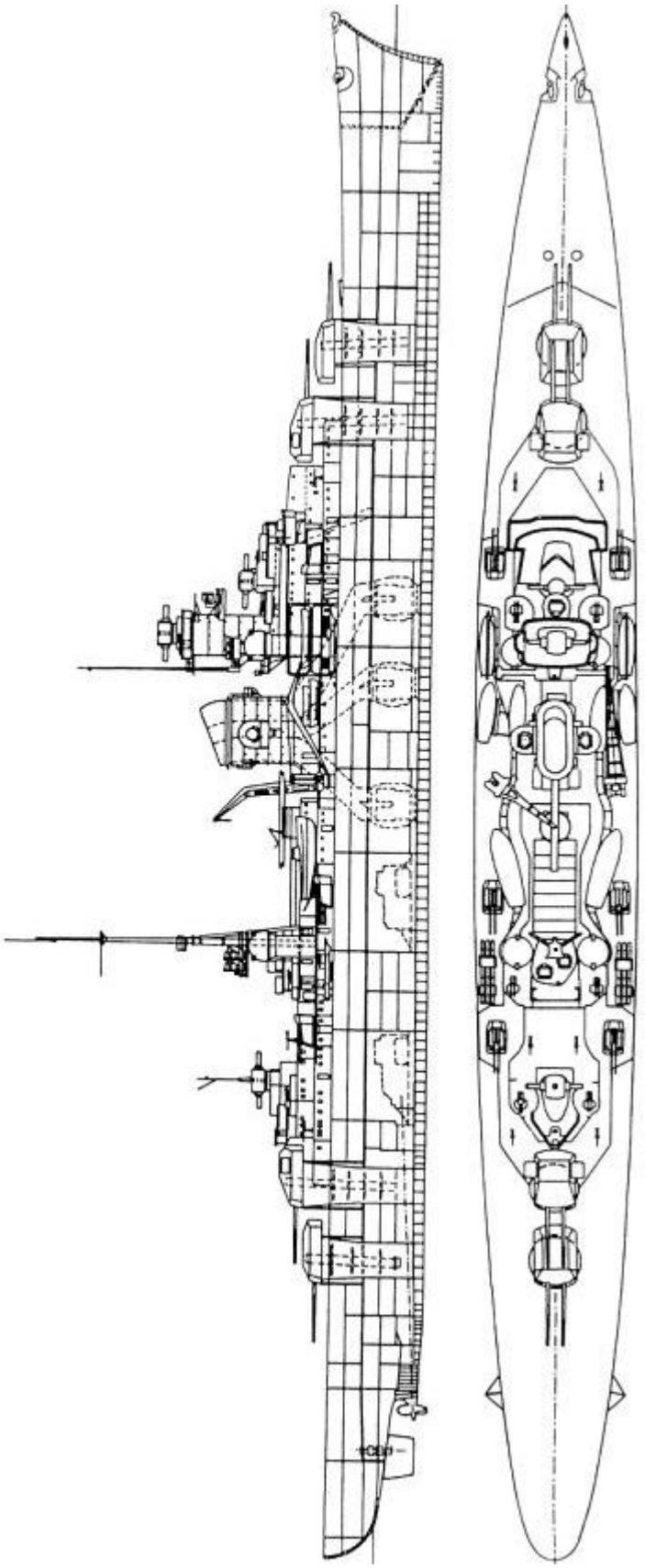
The US navy refused to accept poorly built armored ships in their initial construction phase, just as did the Italian navy. They already equipped their first heavy cruisers with an armored deck of 76 mm with an equally thick armor belt. The thicknesses were increased to 102 mm in PORTLAND and further to 127 mm in WICHITA. [The actual deck thickness was 25-52 mm in the first two classes of US "Treaty" heavy cruisers. It was increased to 63.5 mm in the *Portland* and was 57.1 mm in the *Wichita*]. The further reinforcement of protection could no longer be supported by the displacement [to armor weight ratio]. Thus, the BALTIMORE class, at 13,000 t standard displacement, was to receive a WL protection of 178 mm [This was actually 102-152 mm]. The underwater protection of the ship, as far as is known, was of no special configuration. However, the double bottom extends in greater intervals all the way to the upper deck. Thus, the ship at least had the underwater protection of the bulwark ways and longitudinal bulkheads. It is likely that during the time some of the 13,000 t ships were converted to carriers the additional available weight was utilized to improve the underwater protection, and that consequently a torpedo bulkhead would have been installed.

In conclusion, it can be said that the heavy cruiser of 10,000 t standard displacement represented a ship's genus whose size and combat assets would have required a protection system that could not be achieved within the available weight [distribution]. Indeed, the enlargements in displacement to 13,000 t and more (and beyond 16,000 t by the Germans!) are valuable, but they emerge as rather poorly protected ships which are useful only for cruiser duty, and they are utterly useless as battleships. (see BLÜCHER and Italian cruisers)!



Cross-section through the main frame of the heavy cruiser of the ADMIRAL HIPPER class

Heavy Cruiser ADMIRAL HIPPER. The welt-like strengthening of the ship's hull is especially apparent.



Heavy cruiser SEYDLITZ and LÜTZOW. Length-wise section and birds-eye view.

4. BATTLESHIPS

The first German battleships that were designed under the restrictive directives of Versailles were SCHARNHORST and GNEISENAU. Their size, however, was measured as no larger than the French battleships of the DUNKERQUE class for foreign policy reasons. Thus, these ships were built under coercive dictates in order to produce a ship of a submissive [inferior] type.

Thickness of the protection aboard SCHARNHORST and GNEISENAU

Belt 350 mm KC, up above reduced to 270 mm, and tapered below to 170 mm.

Outer skin	foreships	30 mm Wh riveted
	aftships	29 mm Wh riveted
Splinter protection between armored deck and upper deck		20 mm Wh riveted
Torpedo longitudinal bulkhead		45 mm Wh riveted
Armored deck		50 mm Wh riveted
Armored deck scarp		95 mm Wh riveted
Armored deck forecastle		20 mm Wh riveted
Upper deck		50 mm Wh riveted
Barbettes of the 28 cm turrets		320 mm KC riveted
Armored longitudinal bulkhead		no data available

When considering the numerical values, it becomes apparent that the design of these ships adhered to the preferred and proven tenet of the German Navy: to rely on heavy armor, even at the loss of some other combat assets. The necessary reduction in weight was obtained by installing nine relatively minor caliber 28 cm guns, although the final main battery configuration was planned for 38 cm guns.

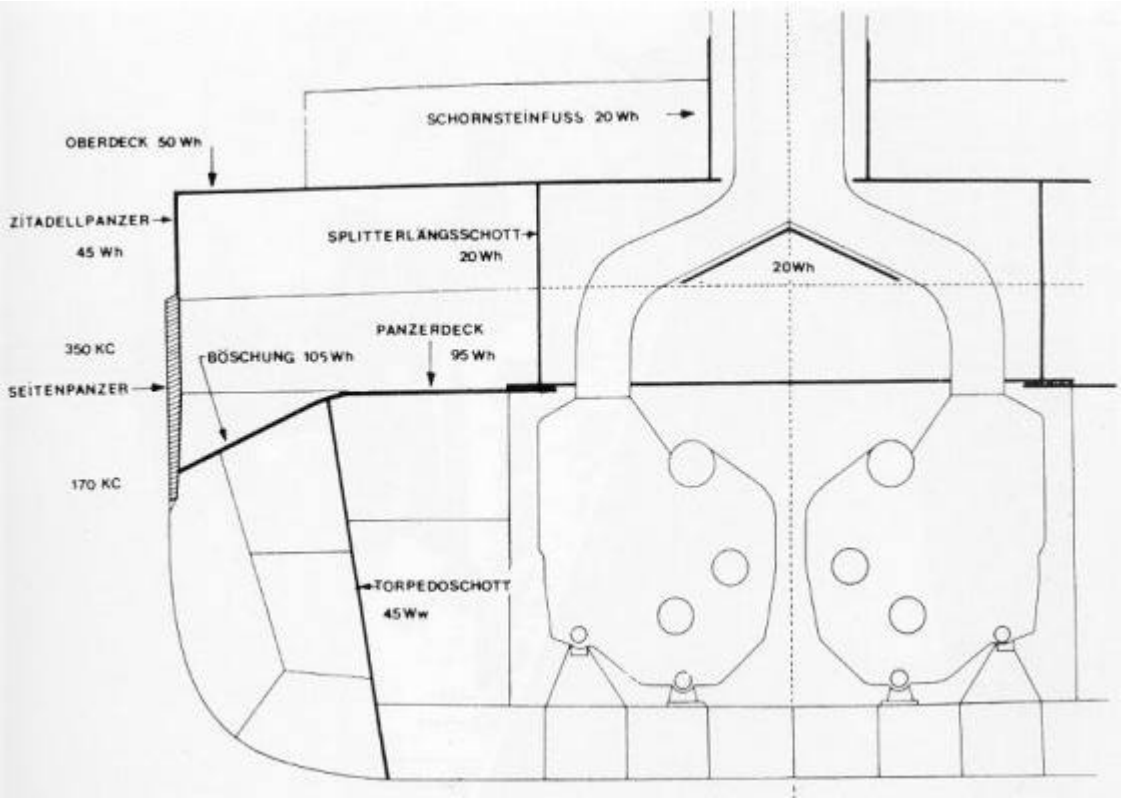
The sketch illustrates the arrangement of the armor. The weak spot is the unprotected outer skin forming the upper edge of the belt to the upper deck. Thus, the armored deck can be exposed to direct hits by armor-piercing shells. Although they hit at a poor angle for penetration, they are more likely to be dangerous to the interior of the ship. The assumption is that the first decisive combat hit, which led to the sinking of the SCHARNHORST, would have occurred in the manner described above; since the 50 mm Wh upper deck will reduce the effect [velocity] of a 35.6 cm shell enough so that the shell will detonate above the low-lying armor deck, i.e., will not penetrate the armored deck. The inboard longitudinal bulkheads behind the side armor are arranged like those in the armored ships, and they protect the ship's upper-middle portion in combination with the upper deck armor. During the timeframe of their construction design, the total deck armor thickness could be considered as adequate. A thin [armored weather] deck was planned for the region above the main armor deck because a thicker deck so high up would have been disadvantageous for stability reasons and it would not have prevented bomb penetrations anyway. In addition, without an upper armored citadel the belt's placement necessitated positioning the thicker deck in a lower location. The upper deck was made sufficiently strong to detonate steeply falling shells and to absorb a sufficient amount of energy from heavy bombs to prevent the armor deck below from being penetrated. The destruction of the spaces between the armor deck and the upper deck was considered acceptable because these compartments were limited to quarters that were insignificant to the ship's fighting power.

This construction [design] fully proved itself during the aerial bombing attack in Brest, i.e., La Pallice, when, aboard SCHARNHORST, two 500 kg bombs broke through the upper deck and exploded on the armor deck without penetrating it. The three other bombs that hit the vessel were evidently special bombs without explosive load that penetrated the ship from the upper deck down to the bottom without detonation, although the incline of the impact angle was unfavorable. In Brest, GNEISENAU received three bomb hits, all of which detonated on the armor deck after penetrating the upper deck.

Ultimately, the deck armor proved to be too weak when bomb weights increased. This was obviously apparent at the sinking of the SCHARNHORST; since the battle was conducted at a distance of approximately 350 hm where the angle of fall of 35.6 cm shells from British battleships is very steep and thus these shells must have resembled the effects of aerial bombs [The range assumptions are incorrect here. The main action took place at 12,000-16,500 meters]. Also, hits during a night attack by English bombers on GNEISENAU, while in Kiel harbor after the Channel Breakthrough, demonstrated the weakness of her deck armoring. During these hits, bombs detonated the munitions chamber of the foreward turret and incinerated it after they had penetrated the decks, i.e., the turret's armor. The ship was thus removed from combat for the war's remaining duration since the dockyard's repair capacity no longer existed.

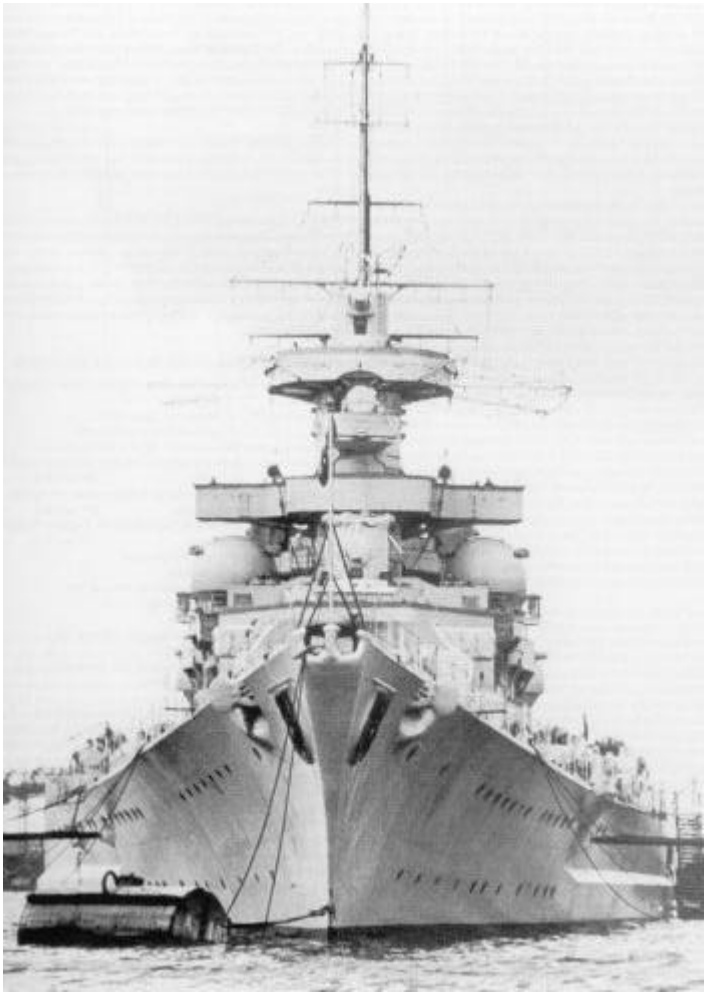
The underwater protection consisted of a slanted torpedo bulkhead made from 45 mm Ww material that ran parallel to the outer skin. The interval from the outer skin to the bulkhead averaged 4.50 m. The space between the outer skin and torpedo bulkhead was subdivided through the center by an additional longitudinal bulkhead. This construction method proved itself off Brest, when GNEISENAU received a torpedo hit which ripped open the outer skin, but did not even deform the torpedo bulkhead. A comparison of the effect of Japanese aerial torpedoes on English ships highlights the superiority of the German construction.

The ship's bottom was not especially protected against mine explosions. The thickness of the joint plates and hull plating was limited to the required values for structural integrity; however, the watertight underbody and external portion of the joint plates was particularly sound in the double bottom construction. That this type of bottom protection was sufficient against the mines then in use against large ships of 1942 vintage was shown when SCHARNHORST received two hits from ground [sea floor] mines during the Channel Breakthrough. Both were in the foreship area, and dented only the external bottom skin and unfolded some longitudinal plaits [seams]. The inner floor remained nearly watertight despite some slight buckling. In any case, the available flood control contained the incoming water without difficulty. Not even the ship's speed was substantially diminished.

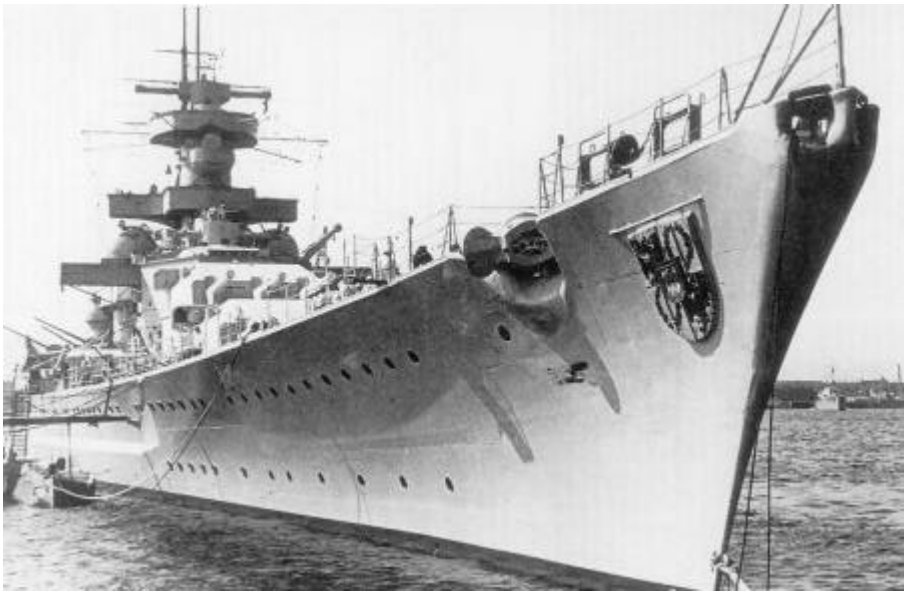


Battleship SCHARNHORST Class: Transverse section at the level of the main frame showing armor arrangement and thickness.

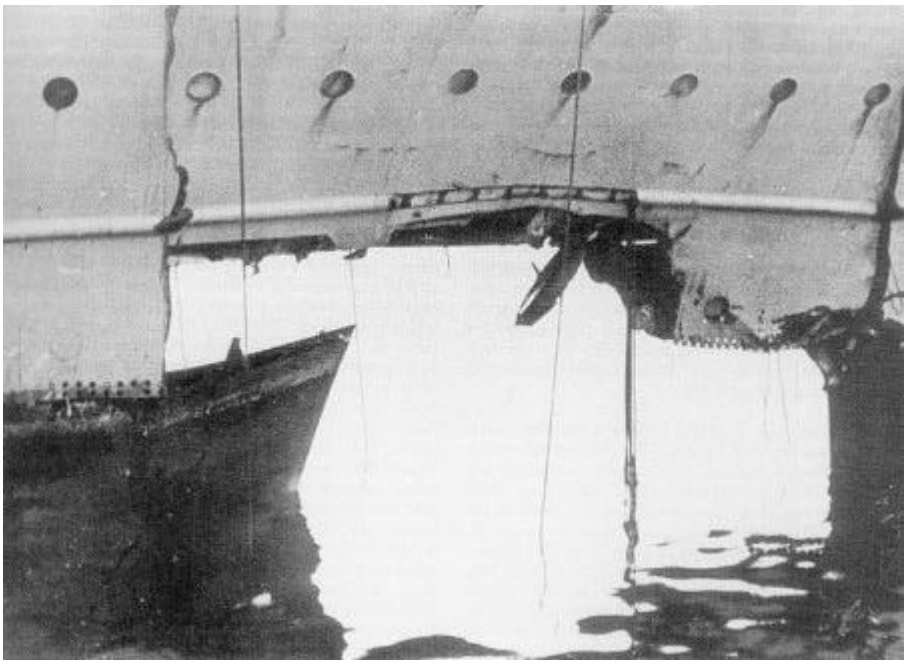
Oberdeck	50 Wh	Upper deck	50 mm Wh
Zitadellpanzer	45 Wh	Citadel armor	45 mm Wh
Seitenpanzer	350 KC	Side armor	350 mm KC
	170 KC		170 mm KC
Schornsteinfuss	20 Wh	Funnel base	20 mm Wh
Splitterlängschott	20 Wh	Longitudinal splinter bulkhead	20 mm Wh
Böschung	105 Wh	Scarp slant	105 mm Wh
Panzerdeck	95 Wh	Armor deck	95 mm Wh
Torpedoschott	45 Ww	Torpedo bulkhead	45 mm Ww
	20 Wh	[funnel base deflector]	20mm Wh



Battleship SCHARNHORST exact frontal view. Here, the heavy side armor is well depicted. He [sic] had, at 350 mm, a greater thickness than the BISMARCK class (320 mm). But the point is, that commensurately strong citadel armor was lacking.



The bow view of the battleship GNEISENAU (peace-time photo)



The GNEISENAU after a torpedo hit in the bow section. There was an absence of any armor protection in this area, but due to the especially extensive interior subdivisions, floatation was preserved.

The installation of more and more weapons and instruments diminished the freeboard of SCHARNHORST class battleships in a precarious manner; finally, the upper edge of the side armor was not far from the waterline, as is seen on this picture taken of GNEISENAU in 1941.

The British ships of the REPULSE class cannot be considered in this comparison since they are not equivalent to modern [ships]; however, it was attempted to improve their protection through reconstruction. The only really modern ships for comparisons sake are the French DUNKERQUE class. The French Navy went their own ways in their choice of gun caliber as well as armor system. In contrast to German and British construction, the belt was relocated to the ship's interior. From the upper edge [of the belt], i.e., 1.2 m above the construction [standard displacement] waterline [The belt's upper edge was actually 2.5 meters above the DWL], down to the bottom extended a thick layer of ebonite foam, which is 0.50 m thick above the construction waterline and 1.20 m below it.

The protection against artillery fire is herewith not improved. However, it is possible that the protective effect against torpedo hits is substantially improved by ebonite foam because the filling may act similarly to filled oil tanks, with the additional advantage that this material is flame resistant. Behind the interior bulkhead that demarks the limits of this filling are three torpedo bulkheads connected to a protective space. The literature is unclear about the thickness of these bulkheads. The statement that "the" thickness is 40 mm may indicate the sum of all three bulkheads or, alternatively, it may mean that one was that thickness and the others were lighter. The first assumption seems more likely, since this is in agreement with the English-American understanding that the inner limit of the explosion's expansion space and torpedo protection belt was not to be composed of a thick longitudinal bulkhead made of material with great ductile strength, but that there instead be several, mostly three, bulkheads of somewhat lesser total thickness. It seems that the reliance on the ebonite foam filling's thickness was less pronounced. Since the ships did not engage in actual combat, nothing can be said about the system's efficacy. The sinking in Oran was caused by the explosion of a munitions barge lying alongside whose entire load of 33 cm shells was ignited by an artillery or torpedo hit. This caused the entire side of the ship to burst open. Such serious damage could not have been stopped by better construction methods.

The vertical protection is subdivided into an internal and external belt. The outer belt is slanted outward and is bordered above by the upper armor deck and below by the scarp of the lower armor deck. The retaining bulkhead for the ebonite foam filling forms the continuation of the scarp to the areas below. The inner belt is positioned above the outermost of the three torpedo bulkheads [There was no inner belt in the actual design, with the lower armor deck scarp providing some modest reinforcement]. The total thickness of the waterline armor is given as 275 mm. It is not known how the thickness of the two belts is apportioned. This armoring method is considered to be unfavorable for the following serious disadvantages: 1.) Splinters from short shots or hits from smaller calibers could damage the outer hull skin adjacent to the armor and cause speed reduction. 2.) A single layer belt of 275 mm will be harder to penetrated than two layers of 140 mm thickness each. Furthermore, faults can be found with the belt's narrow width. The guiding thought appears to have been to interpose the resistance of a cemented surface to a shell twice. The armor's arrangement is similar to the American concept of having an armored floatation device in the vicinity of the waterline that, in any case, will secure the necessary floatation ability after a ship is injured [This device may refers to the internal raft-body of the South Dakota class, which is akin to an armored box surrounded by a relatively lightly built hull]. In any event, the protective combination of belt/armored deck against artillery fire would have been deleted, and the armored deck would have been exposed to direct hits by armor piercing shells at the

present day [sic] battle distances of 30 to 40 km, and consequently, to shells with steep angles of fall [plunging fire].

A horizontal armor of 175 mm thickness has been published. According to supporting data at hand, an upper deck of 125 mm and an underlying armor deck of 50 mm thickness should encompass it [the horizontal armor]. The disadvantages of such an arrangement are the same as those already mentioned during the SCHARNHORST's discussion [e.g., insufficient thickness to stop heavy shells & excessive top weight]. The incorporation of the internal floatation hull system leaves the entire ship's thwart area [external hull sides] totally unprotected. This design was proven to be useless during WWII.

Overall, the protection of French ships was entirely inferior to German ships. Only their protection against underwater explosions may have been comparable.

Orders for battleships of the TIRPITZ class explicitly dictated the creation of ships that would be *superior* to any existing battleships. The only limit was the treaty-imposed size restriction of 35,000 tons type [standard] displacement, which made it imperative to carefully compare the weights of the individual combat assets [The writer is being disingenuous here, for it was well known in German design circles that the battleship's operational displacement was over 50,000]. The basic tenet, to use the greatest possible armor thickness, was adhered to also in these ships.

<u>Armor thicknesses of the battleships BISMARCK and TIRPITZ</u>

Belt: 300 mm KC [should be 320 mm], upper at 270 mm, lower at 170 mm tapered
Citadel: 145 mm KC
Outer skin forward: 60 mm Wh welded,
Aft 80 mm welded
Splinter longitudinal bulkheads in the upper ship: 25 mm Wh welded [This was 30 mm]
Armor transverse bulkheads below the armor deck between the torpedo bulkhead: 200 mm Wh [This was 220 mm]
Armor transverse bulkheads up to the upper platform deck from the outer skin to the torpedo bulkhead: 100 mm Wh
The same below the upper platform deck: Between torpedo bulkhead and outer skin: 20 mm Wh

Torpedo longitudinal bulkhead:	45 mm Wh riveted
Armored deck:	80 mm Wh riveted
Armored deck above munition chambers:	100 mm Wh
Armored deck in forward:	30 mm Wh
Armored deck aft:	80 mm Wh
Armored deck above rudder machinery compartment:	100 mm Wh
Upper deck:	50 mm Wh welded
Upper deck next to heavy turrets:	80 mm welded
Barbettes of the 38's turrets:	340 mm KC

While examining these values, the relatively small magnitude of the belt becomes obvious. This apparently served to free up weight for the modern construction design of a new type of citadel. Thus, it was planned to protect as much of the upper ship as possible by sacrificing the ship's underwater protection against artillery fire by

relinquishing excessive belt armor thickness [The author fails to note here that the deck scarp reinforcing the belt was increased by a larger factor than the belt thickness was decreased]. The generally great battle distances that are common today in conjunction with consequently steep angles of shell fall make it acceptable to reduce the requirements for thick vertical armor in lieu of extensive overall armored surfaces.

The citadel armor system obviates the serious weak point exposed on SCHARNHORST. Moving the [internal] longitudinal splinter bulkhead, increased in thickness to 25 mm [30 mm], closer to the outer skin is an especially valuable improvement of the upper ship's protection.

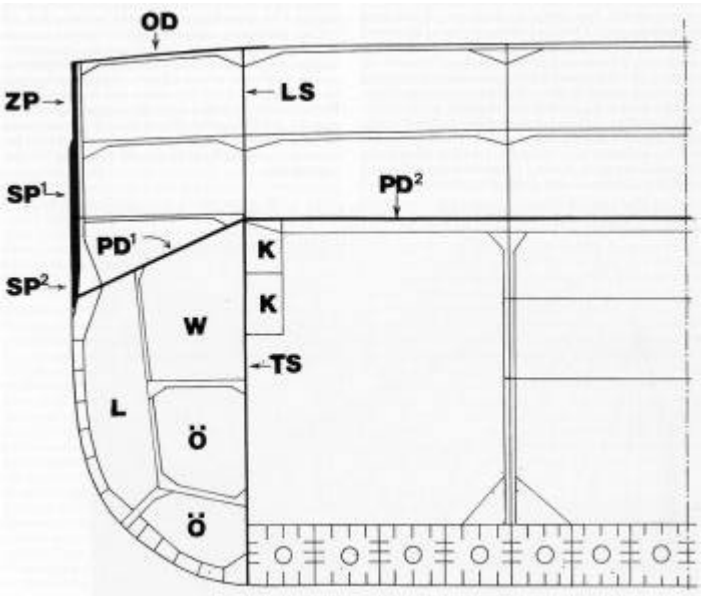
Its position above the perpendicularly positioned torpedo bulkhead is, moreover, very suitable for the ship's longitudinal stiffness.

The armor of the outer skin, fore-and aftships with 60 mm, i.e., 80 mm Wh, was commensurate with standards during the design's time.

The horizontal armor had a nominal total thickness of 130 mm [50 mm + 80 mm]. Therefore, it was at the time of the design quite sufficient, since it totaled 155 mm in the area of the scarp above the munitions chambers [Actual figure is 170 mm (50 mm + 120 mm)] and reached 160 mm, i.e., 185 mm, next to the turrets [The minimum figure is 180 mm (80 mm + 100 mm)]. The terminations of the areas protected by the belt are protected below the armor deck by 200 mm [220 mm] thick transverse bulkheads, with their thickness towards the sides and towards below being tapered. With this overall layout, the machinery installations, fire control center, and munitions chambers in the ship's interior were considered extremely well protected against artillery fire. The protection against torpedoes is built up as on all German [ship] construction by a longitudinal bulkhead of 45 mm Ww material. Its distance from the outer skin is 5.40 m, and approximately 3 m of material cannot be ignored. In addition, these ships run a thin longitudinal bulkhead outboard from this torpedo bulkhead. Overall, these ships were well-done construction designs, and they had excellent protection. Even though the armor thickness of ships of other nations was greater, the considerably better quality of German armor demonstrated a staying power [steadfastness] that equaled the famous steadfastness of ships of the German Imperial Navy, and they may have even exceeded that. During the undertaking that led to the sinking of the BISMARCK the ship was hit during the battle with HOOD and PRINCE OF WALES by a 35.6 cm shell in the bow section.

Naturally, the 60 mm armored outer skin did not measure up to this hit. Although the penetration of the outer skin did not cause considerable damage to the ship's interior, it became decisive for the further conduct of the mission because the ragged edges of the penetration hole made repair difficult and the burying of the bow [caused by subsequent flooding] reduced speed. Thus, the maintenance and reestablishment of contact was more or less facilitated. Moreover, the loss of oil forced the shortening of the cruise. When the English battleship squadron finally cornered BISMARCK, the ship had already sustained three torpedo hits in addition to the one that led to the loss of steering. Despite this, the entire artillery was in no way compromised in its combat readiness and was able to inflict damage on the English battleships that required months of repair time. Following hours of hits from 40.6 and 35.6 cm caliber guns, as well as fire from two heavy cruisers, at distances of 120 to 160 hm against this virtually immobile target,

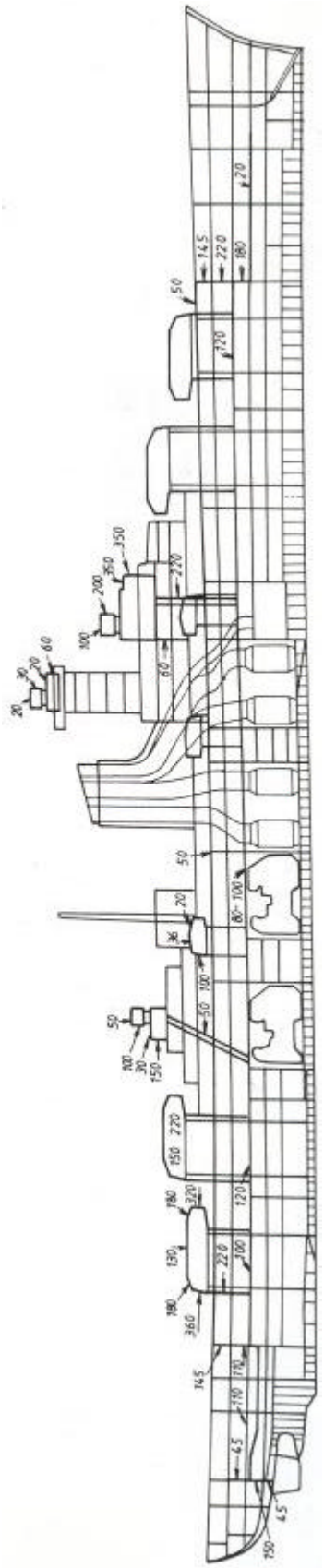
according to British news agencies, the artillery was totally torn apart and blown over the side, but the ship itself could not be forced to sink [the range actually decreased to under 5,000 meters at some points]. Only after three further torpedo hits, with the ship thus having sustained a total of nine torpedo hits, was the BISMARCK induced to sink [There is no knowledge being shown here about the scuttling charges]. The proceeding of the battle proves beyond all else the value of the German protective directive [arrangement]. Until this battle proved the opposite, the general opinion had been advocated that in the dispute between armor versus artillery, the latter had resoundingly won. The construction of BISMARCK had demonstrated that even in battleships of 35,000 tons, armor arrangements are feasible which can resist the heaviest modern artillery fire. The underwater protection's ability to resist underwater hits was also outstanding.



Schematic transverse section of the BISMARCK class battleships.

Designations:

OD	=	upper deck (50 mm Wh, welded)
LS	=	side longitudinal bulkhead (30 mm Wh)
ZP	=	citadel armor (145 mm KCnA, riveted)
SP^1	=	side armor (320 KCnA, riveted)
SP^2	=	tapered portion of the side armor (170 mm KCnA in the middle)
PD^1	=	armor deck level [scarp] (110 mm Wh, riveted)
PD^2	=	horizontal portion of the armor deck (80 mm Wh, riveted)
TS	=	torpedo bulkhead (45 mm Ww, riveted)
W	=	water filled
Ö	=	oil filled
L	=	empty spaces
K	=	cable conduits [tunnels]



Battleship BISMARCK class. Longitudinal sketch of the armor thickness.

The [Bismarck's] sistership TIRPITZ had amply demonstrated its ability to resist bombs and mines. During multiple attacks on the ship while moored in Bogen Fjord near Narvik, several hits by British bombs penetrated the upper deck but in no case did they also penetrate the armor deck. The explosion of mines, i.e., magnetic charges that were attached to the ship by mini-submarines, destroyed the outer bottom. However, the inner bottom was only heavily arched upward towards the interior and affected chambers could be kept watertight.

Based on what is presently known, the sinking of the TIRPITZ was caused by a direct hit from a special 10-ton bomb. Furthermore, additional bombs of this weight hit the water in the ship's close proximity. No battleship planned for construction in the foreseeable future will be able to withstand a weapon of such weight. It must also be taken into account that the drop was made on an immobile ship. The delivery of such heavy bombs against battleships on the high seas, which normally cruise at high speed, would require large aircraft because of the attack distances and probable searching times. Such aircraft do not exist at the present time. As far as is known, the bomb hit the ship between the outer skin and the splinter bulkhead and detonated after penetrating the armor deck. Not only the outer skin, but also the torpedo bulkhead was destroyed over an extensive distance. This destruction was effectively enhanced by the water pressure [shock wave] of explosions from bombs that fell alongside the ship.

Comparison of German ships with those of other navies results in the following picture; with the reconstruction of battleships also being briefly mentioned.

Already in 1933, the British fleet staff recognized the necessity of improving the protection of existing battleships. All battleships from NELSON and RODNEY to HOOD underwent major reconstructions. These covered the addition of protective bulges along the waterline as well as other improvements in underwater protection. The German Navy anticipated defeating this heavily improved underwater protection by developing a torpedo with a magnetic fuze, whose first success was the sinking of ROYAL OAK in Scapa Flow. However, the sinking of BARHAM in the Mediterranean by a conventional torpedo showed that the lateral bulges of older constructions do not offer viable protection.

As a typical example of a reconstructed older battleship, let us consider a transverse section of the ROYAL OAK. After the ship's [1922/23] reconstruction, the vessel had a torpedo protection belt width [thickness] of about 5.60 m This consisted of a double outer skin that had about a 1 m interval separating it from the original hull wall. A 37 mm torpedo bulkhead was positioned behind this at a distance of about 3.40 m [and it served] as the outer border of the ca. 1.20 m wide oil bunker, which had an interior border consisting of a 25 mm thick longitudinal bulkhead. After the attachment of the 1.95 m wide protective bulges the torpedo protection belt width [thickness] was increased to 7.70 m [This was presumably done during the major 1934/36 refit]. The principle of this arrangement was to provide a substantial expansion zone before explosion shock forces actually affect the internal protective bulkheads. This protection arrangement usually consists of two bulkheads in British battleships, while in American ships this methodology is resolved with three longitudinal walls of 19 mm each. The width of the torpedo protection belt in the newly constructed KING GEORGE class is reduced to 4.11 m and divided into three equally wide chambers by longitudinal bulkheads. Obviously, these protective bunkers are either for oil storage or they may be

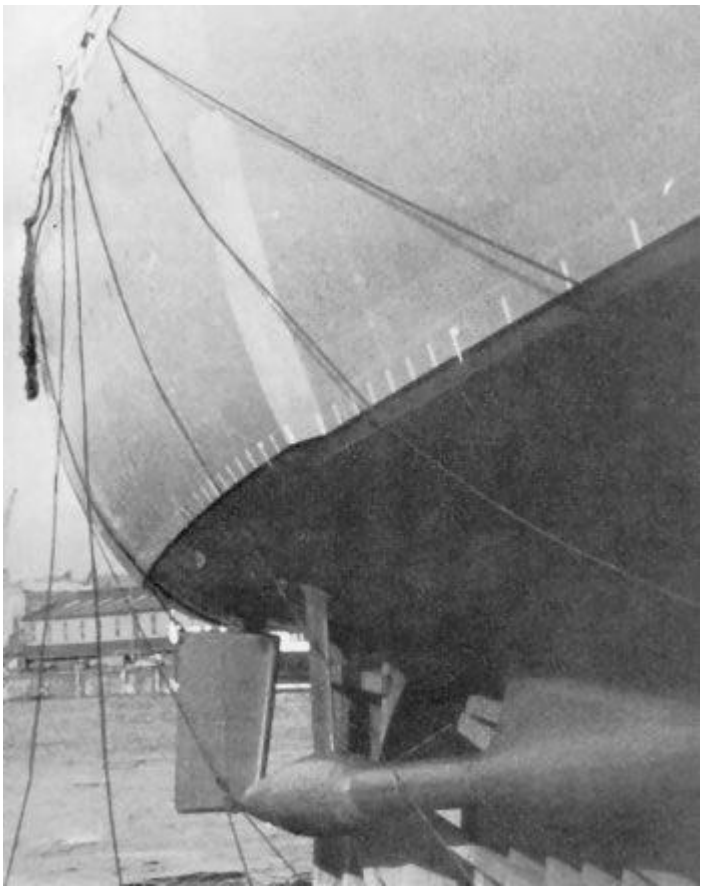
used, as on HOOD, for a protective filling of [sealed] steel pipes. However, during the sinking of PRINCE OF WALES by Japanese aircraft this construction demonstrated that it is not superior to German construction design and that it is only a means of effective protection against aerial torpedoes. Nothing was altered on the side protection during the older battleships' reconstruction, although the horizontal protection was substantially reinforced. In ROYAL OAK, this strengthening consisted of four armor decks with an overall thickness of 126 mm after rebuilding, and it was subdivided from above to below [as follows]: 25 m, 37 mm, 51 mm, and 13 mm. The main armor deck was probably the 51 mm deck. This was positioned 2.50 m above the construction [standard] waterline, and it had a very steep scarp that led to the lower edge of the belt. This arrangement is insufficient for modern demands, since the 51 mm deck is tapered [weakened] to 25 mm in the interior portion. This construction design must remain a makeshift solution that is meant to improve still valuable ships according to most recent basic technical understanding.

We have already dealt with the underwater protection of modern British design. The vertical protection of these ships consists of a very wide belt of 356 mm maximum thickness. According to other sources, the belt could be as much as 406 mm thick, and is, reportedly, planned for future construction of this class.

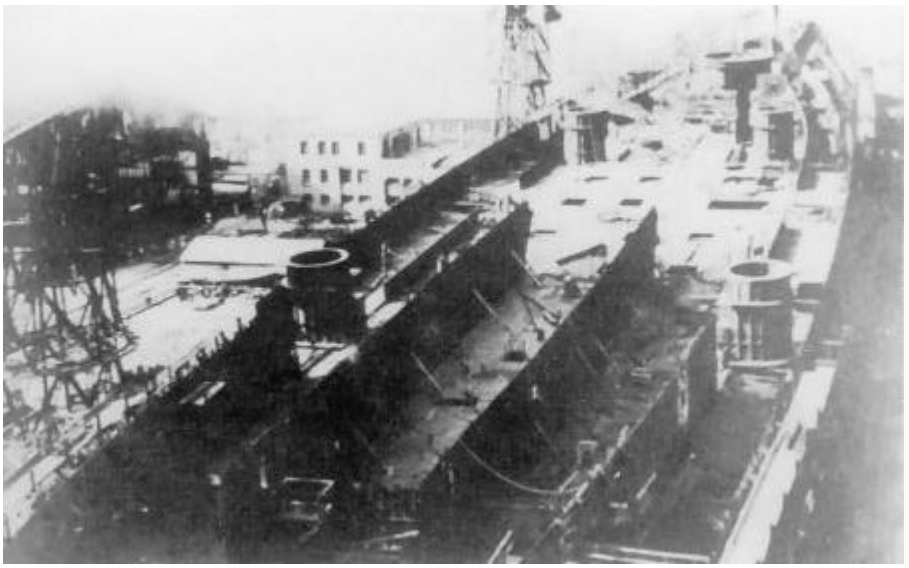
The upper limit of this belt forms the upper [reach] of both armor decks, the second [armor deck] being positioned only one deck lower, in about the middle of the belt. [This arrangement is incorrect. It may assume a scarp from the supposed lower armor deck that ascended to the main armor deck.] How the impact forces are absorbed of hits on the lower edge of this belt is not very clear. It appears that a weakness of the construction design lies herein, since these forces are difficult to dissipate with the chosen arrangement. One source gives the armor deck thickness as 200 mm, while another reports a thickness of only 150 mm. According to the recent revelations of sketches, the latter is probably incorrect. Combining both reports, it can probably be assumed that, after release of the sketches, that the upper armor deck was 150 and the lower was 50 mm thick [In fact, there was no lower armor deck. Instead, the weather deck served as a thin bomb deck, and it was situated well above the armor deck.]. This arrangement is similar to that of the DUNKERQUE class, which was also used in RICHELIEU and JEAN BART. The English landing at Casablanca could have tested the efficacy [of the vertical protection], but JEAN BART's damage assessment from artillery fire has not been published. The vertical armor of these ships appears to have been similar to DUNKERQUE, according to the published pictures; except the armor's total thickness was increased to 400 mm [This was actually 330 mm]. The same is true for the underwater protection.

The data for the armor thickness of the 35,000-ton Italian ships' main belt fluctuate between 230 and 300 mm [It was 350 mm, divided into 70 mm and 280 mm thick layers]. One source even states 380 mm. Nothing has been released about the arrangement of the vertical armor. Regarding the horizontal protection of these ships, the only available data reveal that several ships were to have armored decks with a total thickness of 178 mm. Regarding the underwater protection, it has become known that the Italian Navy also had a strong penchant to use ebonite foam filler in protective bunkers [This is incorrect]. If such a protective filling was actually used in new ships, or if such a protective system was installed as advocated by Pugliese, is also not verifiable by us. Basic advantages of the Italian underwater protective system are not

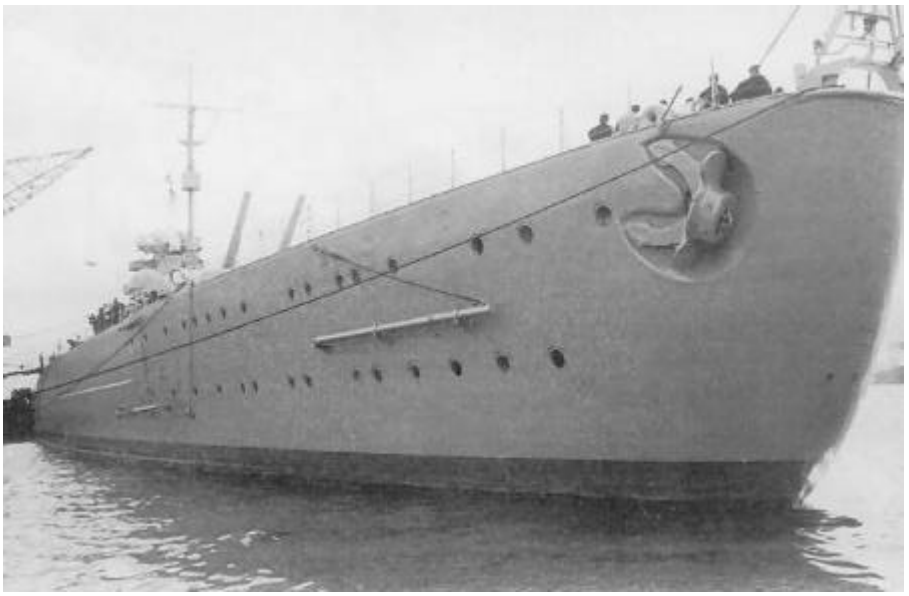
really obvious. This was shown in the Battle of Cape Matapan, as well as by air attacks by British torpedo aircraft, wherein aerial torpedo hits led to serious damage in these modern ships. The nominally strongest armor thickness is displayed by the US battleships of the NORTH CAROLINA class amounting to 406 mm of belt thickness and two armor decks of a total of 254 mm [The belt was actually 305 mm, while the upper and lower deck totaled 164-177 mm. The deck was divided into three layers (37 mm + 91-104 mm over a 36 mm base)]. In these designs, the upper deck is also thicker (at 152 mm) than the lower deck (at 102 mm) [The upper deck was 37 mm, while the lower armor deck totaled 128-140mm]. The entire armor arrangement and underwater protection is probably similar to the American system of sponsons [blisters] and triple torpedo bulkheads. It is innovative in that in the area of the machinery and boiler rooms a triple bottom was provided as protection against mine explosions. The utility of these designs' underwater protection against proximity explosions [magnetic fuzes] will be considered in detail during the discussion of German "H" class battleship designs.



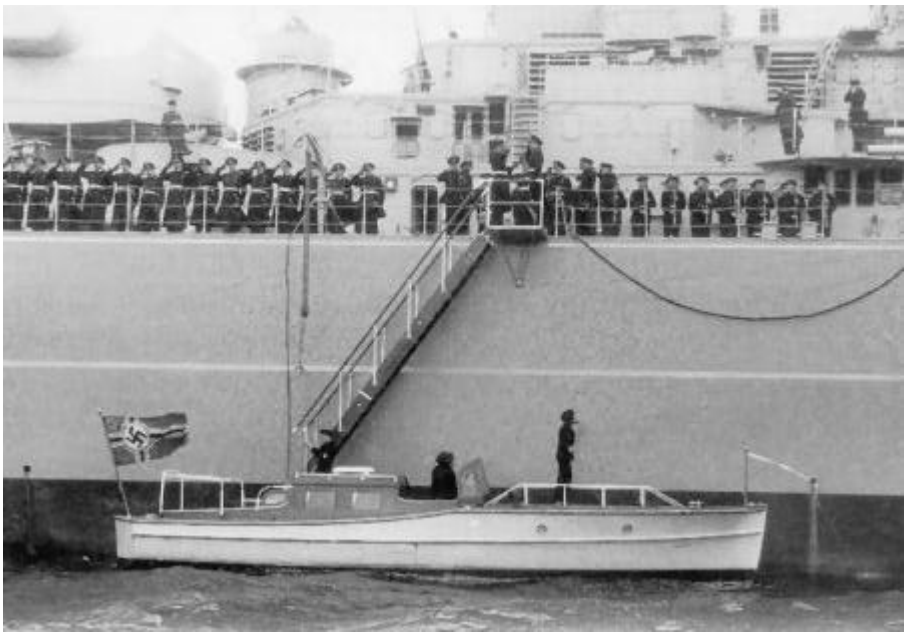
Battleship BISMARCK Stern section with the propeller shafts and rudders; the recessed area in the ship hull's freeboard marks the aft limit of the heavy side armor which is still missing.



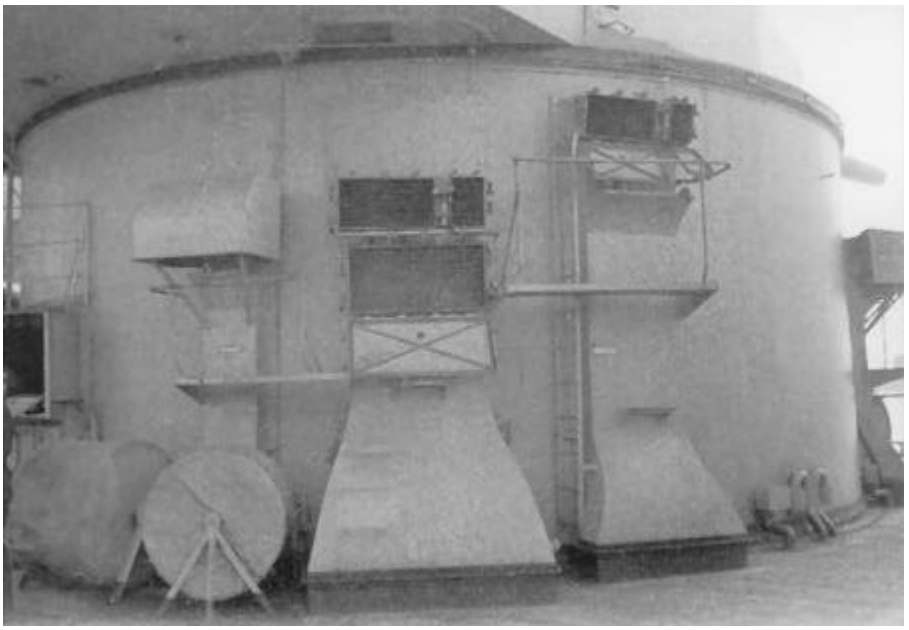
Battleship TIRPITZ under construction. The longitudinal bulkhead above the already closed armor deck is clearly visible; the upper deck is still missing.



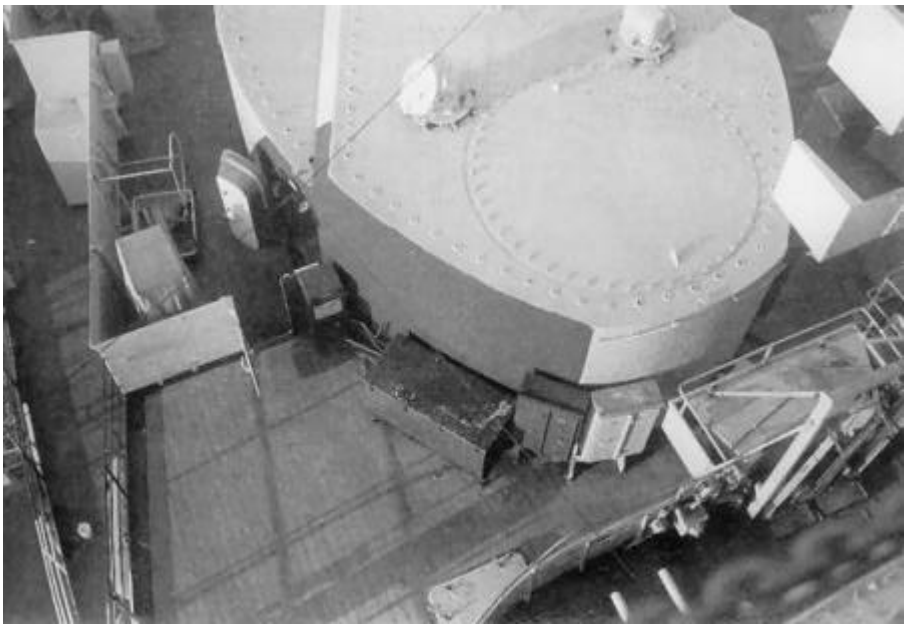
The aft section and stern of BISMARCK with his Achilles heel hidden below the waterline.



Battleship BISMARCK. View of the terminating edge of the heavy side armor.



The barbette of a 38 cm twin turret aboard BISMARCK: its armor thickness amounted to 340 mm above and 220 mm beneath the upper deck.



View of the BISMARCK's heavily armored command stand. The vertical armor thickness was approximately 350 mm, the horizontal was approximately 220 mm.

The BISMARCK defied opposing superior fire power during the final battle, and it became clear to the British that she simply could not be sunk by gunfire and torpedo hits alone. Only after a prolonged agonal struggle, did she begin to capsize [broach] and sink into the deep sea. This moment was immortalized in a painting by the German marine artist Walter Zeeden.

After the TIRPITZ had become combat-ready, the British put everything at their disposal at stake to shut her down. They continuously attacked from the air as well as from below the water, but they could achieve only single successes that naturally where of no long-term debilitating consequences. Time and again, repairs were accomplished to prepare her fit for combat. During the raid of 3 April 1944, TIRPITZ was hit by 15 bombs; she lost 122 men from her crew and had, furthermore, 316 who were wounded. Despite this, she was again able to withstand even this disaster.

Since the British could not accomplish the permanent shutdown of TIRPITZ with conventional bombs, they deployed one of their new super-bombs against her: the heavy, 5.4 t, "Tall Boy"; one of these is shown here.

TIRPITZ could not measure up to the "Tall Boy" bombs: Sustaining multiple hits, she capsized and came to rest keel-up [turtled].

b) Planned Ships

Both types of German battleships continued to be developed independently [divergently]: The SCHARNHORST class was represented by the so-called battle cruisers “O” to “Q” and the TIRPITZ class was represented by the battleships “H” to “N”.

<u>The protection of design “H” to “N” consisted of:</u>

Belt	300 mm KC throughout
Citadel	150 mm KC
Outer skin foreward	150 mm Wh, dropping downward to 60 mm
aft	90 mm Wh, dropping downward to 30 mm
Splinter bulkhead in the superstructure	30 mm Wh
Transverse bulkhead in the superstructure	25 mm Wh
Armor bulkheads from the armor deck	
up to the upper platform deck	220 mm Wh
between torpedo bulkhead and outer skin	150 mm Wh
Ditto below the platform deck:	
a) between the torpedo bulkhead	150 mm Wh
b) between the torpedo bulkhead and outer skin	150 mm Wh
Torpedo bulkhead	45 mm Ww
Interior floor	20 mm Ww
Armor deck	100 mm Wh
(above munition chambers)	120 mm Wh
Armor deck scarp	120 mm Wh
(next to munition chambers)	150 mm Wh
In the bow sections	50 mm Wh
Aft	110 mm Wh
Upper deck	50 mm Wh
Upper deck next to the turrets	80 mm Wh
Barbettes of 40 cm turrets (above decks)	360 mm KC
beneath decks	240 mm KC

These numbers reflect the total war experience of the German Navy regarding the protection of large ships. As was already done on BISMARCK, considerations of the belt thickness dimensions were to favor surface extent [area] over thickness; particularly so in the “H” class because an armored citadel was intended. Dropping the taper of the belt was done to avoid vulnerability during heeling and exposure of the lower belt along parts of the waterline due to the depression of water levels [caused by wave-form effects] during full speed runs, since these factors would not expose the severely tapered portions of the belt to artillery fire as had been the case until now. Thus, the belt’s protective effect is constant over its entire height. For these reasons; therefore, the thickness is only slightly increased over that of BISMARCK [and in some places even decreased as in the 300 mm maim belt]. Thus, comparisons of nominal thickness with American and British ships are not possible.

Due to evaluations of the forward hits on BISMARCK, it was proposed to extend from the belt forward a 150 mm thick outer skin that would be tapered to 60 mm at the stem. The greatest thickness was planned for areas around the oil cells, while in the other areas 60 mm was considered sufficient. All plates were to be joined by electric welding. Similar considerations led to extensive reinforcements of the aft outer skin.

The reinforcement of the longitudinal bulkheads in the upper deck is undoubtedly appropriate for strength reasons, if weight allowance is available for it. Entirely new is the provision for five transverse bulkheads of 25 mm Wh material in the upper ship [area above the main armor deck]. They are there to restrain the longitudinal expansion of gas pressure effects caused by shells and bombs that penetrate the upper deck. The armored transverse bulkheads below the armor deck are simply remarkable because their great thickness resembles the belt thickness. It was also planned to weld these bulkheads. The torpedo bulkhead has the same thickness as before because combat experience provides proof of the correctness of German underwater protection design. The welding of [torpedo bulkheads in] "H" class ships was a novelty. However, also for the first time, this German construction design incorporated an armored bottom. Indeed, the interior floor was to be made from 20 mm Ww material since combat experiences indicated the need for stronger protection of the ship's bottom. These construction plans followed the design of underwater protection requirements, while other navies also pursued the use of triple bottoms in their prototypes, and therefore, split the final protective wall of bottom protection into several layers. Theoretically, the following is evident: two bottoms weigh more than one. This is related to the requirement for greater longitudinal stiffness and the storage of oil and water in the resulting cells, and the fact that bottom plate thickness in large ships cannot be reduced to less than 12 to 14 mm for structural reasons. The total bottom plate thickness of the lower two layers thus comes to about 25 mm, and the weight is multiplied by the further duplication of braces and longitudinal frames, etc.. The thickness of the inner floor can perhaps be lessened, if the cells are shipped as empty spaces, although that would result in valuable wasted space.

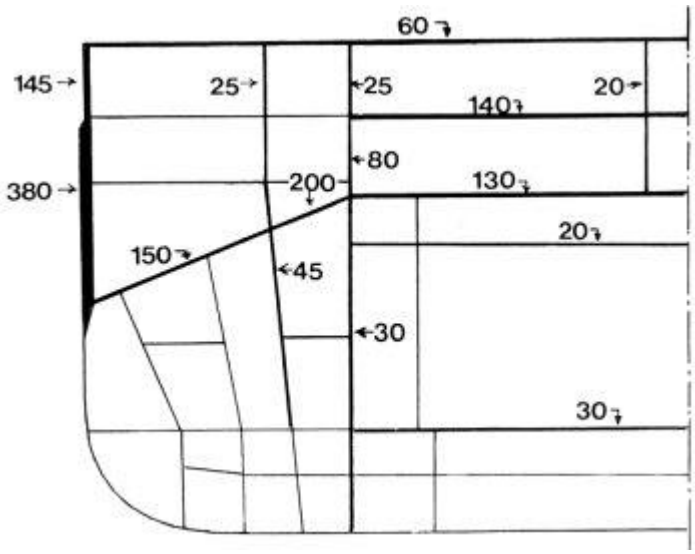
The German construction design avoids these disadvantages. An additionally greater expanse of [inboard] armor is allowed based on the [external bottoms] reduced plate thickness. However, [this design] presupposes a greater than normal height of the double bottom in order to obtain a real protective effect [from the additional explosion expansion space]. Whether the planned thickness would have met all requirements remains unanswered, although, based on the mine hit on SCHARNHORST and TIRPITZ, it can be assumed [to have been effective]. It must, however, be emphasized that this form of protection presupposes the construction is made with Ww material.

The reinforcement of the armor deck to 100 mm of Wh, with commensurate reinforcements of the ammunition chambers [horizontal protection], is also based on war experiences in order to counteract the growing penetrative forces of bombs and those related to shells due to increasing battle ranges. It is novel that the armor deck scarps were to be significantly thickened near the ammunition chambers. In the bow section, the armor deck was obviously strengthened in order to provide better protection for the oil bunkers, and it was planned to not make the strongly armored outer skin an illusory item that lacked appropriate horizontal protection.

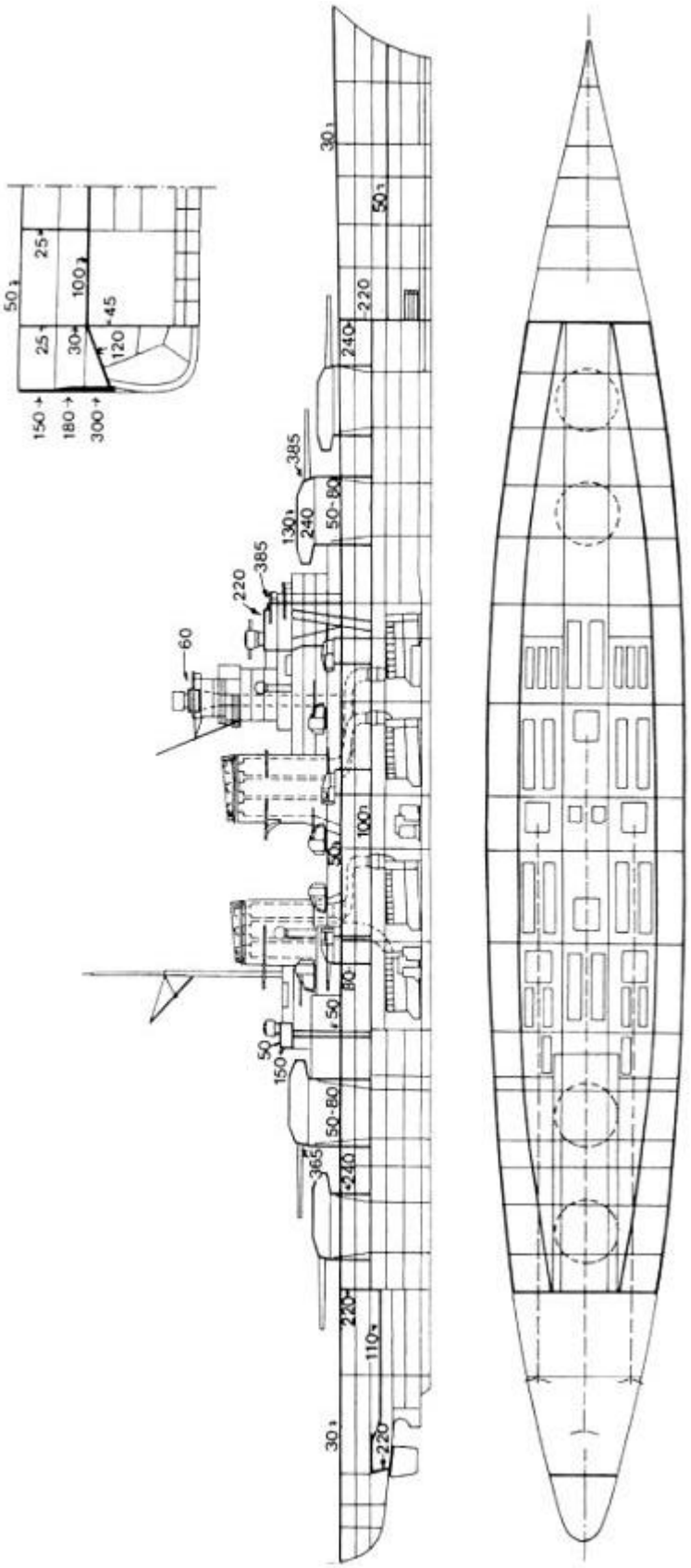
The chosen combination offers very good protection outside the citadels. The armor deck is not considerably improved in the aft area, but even there it is now thicker than normal. This seems to be justified since the combination of belt, citadels, and armor deck does not reach that far aft. However, 90 mm to 30mm of outer skin plating cannot replace the protective effect of the belt. Since the upper deck is made as thick as BISMARCK's, it is assumed that the thickness chosen by war experiences is sufficient.

The above descriptions indicate that the design of "H" would have produced a construction that, with relatively weak main weaponry (8/40.6 cm) and modest speed (29.5 knots), possessed good armor protection, whereby it was attempted to avoid all the apparent weaknesses that occurred during the war.

It is of interest, that the displacement of the planned new constructions was about 62,500 tons versus the 58,000 tons of the newest US battleships [Iowa class], meaning both navies had practically arrived at the same size.



The purpose of battleship research project "H 1944" was to ascertain how far one would have had to venture, in order make a battleship that would be invulnerable against the effects of the most recent weapons. The solution led to the discovery that the effective armor surfaces and thicknesses would require such an immense expenditure [of material] tha the displacement would grow to more than 120,000 tons.



Battleship “H” showing longitudinal sagittal section and coronal exposure beneath the armor deck.

The battleships of the SCHARNHORST class were to be further developed in the "O" to "Q" ships. These were to be equipped with Diesel propulsion and were also to have great speed and cruising range. For these ships, the following protection was proposed:

Belt	180 mm KC not tapered
Citadels	80 mm Wh
Splinter bulkhead in the upper ship	24 mm Wh
Transverse bulkheads in the upper ship	30 and 24 mm Wh
Armored transverse bulkheads below the armor deck up to the upper platform deck:	
a) between the torpedo bulkheads	110 mm Wh
b) between torpedo bulkhead and outer skin	80 mm Wh
Torpedo bulkhead	45 mm Wh
Armor deck	60 mm Wh without scarp
Upper deck	30 mm Wh
Upper deck forward	20 mm Wh
Upper deck aft	20 mm Wh
Barbettes of 38 cm turrets [topside]	180 mm KC
below	145 mm KC

Obviously, an initiative was proposed with these ship designs that the German Navy had previously declined: to build weakly armored battle cruisers. The decision for such a type was precipitated when progress in engine construction permitted the production of [Diesel] motors that could endow a battleship of such size (30,500 tons type displacement), while mounting sufficient main gunnery (6/38 cm), with a maximum sustained cruising speed of nearly 34 knots. Therefore, it was expected that the ships could escape from any available battleship or break off any engagement at will, while its protection was adequate against the fire of any ship of equal speed. The former battle cruisers displayed a weakness against battleships by having insufficient speed and cruising range, a mistake that was to be now avoided. Only these assumptions may explain the designated armor thicknesses.

The largest caliber guns of ships with similar superior speed were 20.3 cm, which the new ships were securely protected against with their 180 mm belts and, probably, also with their 80 mm Wh citadels. The latter thickness coincides with that of the armored ships' belts [*Panzerschiffe*], which were demonstrably protected against 20.3 cm shells (battle of GRAF SPEE off the La Plata delta). The splinter-, longitudinal-, and transverse bulkheads in the upper ship have virtually the same thickness as those used in "H" class ships, and they are sufficient for isolating gas pressure effects [from shell and bomb explosions]. The thickness of the armored transverse bulkheads below the armor deck is in accordance with routine protection.

The ships' underwater protection is provided by a 45 mm Wh torpedo bulkhead, similar to other battleships. Special bottom protection such as on "H" class was not proposed.

The horizontal protection of 90 mm does not meet our approval because it ignores pertinent combat experience [data]. The proposal of two decks is the same as was [mounted] on SCHARNHORST and BISMARCK, but the upper deck is only 30 mm

thick. Likewise, the lack of fore- and aft protection in the vessels is objectionable since the ship's ends are virtually unprotected because the forward and aft armor deck only measures 20 mm in thickness. This deviation from standard basic [armoring] principles is supposedly explained by the fact that these ships were to pursue war on merchant ships and cruiser chases on the open ocean. Furthermore, this was to be facilitated by the company of an aircraft carrier and accompanying battle group. The anticipated area of operations and fighter cover by their own carrier-based aircraft would naturally have diminished the danger of aerial bomb hits, and torpedo aircraft launched by a likely opponent from an hostile carrier had to take into account the retention of the proven underwater protection system.

Basically, we advocate the view that the supposition relating to previous considerations of 80 to 100 mm thick vertical armor for these battlecruisers would have been sufficient at the standard displacement waterline. The weight liberated by this change could have been used to improve horizontal protection or used in light fore ship armor.

5. OTHER SHIP'S TYPES

a) Cannon boat design

This type [of vessel] was not built, but it was planned for service as an escort gun boat and as a ship stationed on duty in foreign waters. Thus, its speed was limited to 20 knots with commensurate cruising range. Armament was to be eight 15 cm [guns]. The protection was to be formed by a 20 mm thick armor deck without scarp and a 40 mm thick torpedo bulkhead. A waterline protection was not proposed, but the outer skin from the waterline up to the foredeck was to be made of Wh material. The torpedo bulkhead was to be closed fore and aft with 40 mm armored bulkheads. Partial armored bulkheads were proposed for the oil bunkers. The design is noteworthy because, just as in the discussion of the design of the battlecruisers "O", the waterline protection was dismissed. However, a torpedo protection of virtually the same width as in a battleship was proposed, although the ship's size would have been a mere $1/7^{th}$ of the "O" [class].

b) Wartime improvements of auxiliary armor for command bridges against aircraft fire

These measures proved to be necessary during the war in order to stop heavy losses of personnel due to aircraft fire. As long as Wh material was still available, it was utilized, in particular, in the steering station of all forward-deployed forces; such as destroyers, torpedo boats, mine detection and sweep boats, and even S boats were protected with thin armor sheet metal. Ships that did not have weight and stability limitations, e.g., blockade breakers, received bridge protection of thick slake [cinder] or concrete walls up to 1 m that were encased between wooden boards. Of course, this was only a temporary relief measure. Basically, the weight [apportionment] for an armored stand for the bridge personnel was to be provided in future constructions.

c) U Boats

In order to complete the description of German warship armor it must be mentioned that the pressure bodies [bladders] of approximately the first 12 Type VII C U-boats built in Wilhelmshaven were made from from [Wh] material. The material delivered for the planned battleship and cruiser was not needed, but since it had already been delivered the pressure compartments were built with it. This assembly was only possible in Wilhelmshaven since here there were enough good welders available who were proficient in armor welding techniques. According to reports from commanders, these "armored' boats were highly effective against fire from heavy aircraft guns. In addition, the pressurized compartment made from Wh material exerted a greater resistance against depth charges. Furthermore, the pressure resistant upper part to the tower of all Type XXI U boats was built up with Wh material near the AA guns to provide protection for the operating personnel of these weapons.

SUMMARY

This report regarding the armor of German warships deals first of all with the armor material utilized by the German Navy and the basic principles of armor application for all the ship types concerned. After consideration of experimental tests dealing with proposed armor constructions, reports are made concerning the armor's arrangement and the material's thickness in the completed and planned German warships during the timeframe from 1919 to 1945. Especially intensive investigations are made into the experiences of the last war, and in particular, as these experiences concerned the basic armoring principles of the planned battleships. During the discussions of individual ship types, similar ship types from the English, French, Italian and American navies were brought up for comparison as far as data were available.

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