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The Fate of the Russian Ships at Tsushima from a naval constructors Point of View
Proposed New Type of Conning Tower for large Battleships.
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THE FATE OF THE RUSSIAN SHIPS AT TSUSHIMA,

FROM A NAVAL CONSTRUCTOR'S POINT OF VIEW.

By Commander WILLIAM HOVGAARD, Royal Danish Navy.

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In attempting an analysis, from a naval constructor's point of view, of the causes of the destruction and particularly the sinking of the Russian ships at Tsushima, it is expedient to deal with each type of vessel separately, and to leave out of consideration all questions relating to tactics, gunnery, training of personnel, etc. In other words, we take for granted certain injuries, which the ships, according to the most reliable reports, have received during the battle, and based on what we know of the ships, it is attempted to explain how these injuries could lead to the rapid sinking of the ships.

The Osliabia.

The *Osliabia* was of distinctly French type, not unlike the *Suffren*, characterised by relatively small beam (71.5 ft.), considerable tumble home and high freeboard with towering superstructions. The protection of the stability at even moderate angles of heel was imperfect, much more so than in the *Suffren*, because the heavy armour belt was not complete and not carried to so great a height above the water as in the French ship (about 1¾ feet against 3·6 ft.)

As a consequence of the small beam, the initial metacentric height was low; judging from comparison with other ships, it can hardly have been much more than 2½ feet in normal condition.

It has been stated (M. Lockroy) that when the Russian ships left the Saddle Islands, on the 25th of May, they had an excess of coal on board, stowed partly on armour deck, partly on upper decks. This is corroborated by a Japanese source, according to which the captured ships were found to have very large quantities of coal stowed in their upper works.* During the voyage from the Saddle Islands to the Strait of Tsushima, about 400 miles at slow speed, the consumption of coal in the large ships can hardly have exceeded about 200 tons, and this coal appears to have been taken chiefly from the lower bunkers. It is therefore likely that the Russian ships were very nearly in their fully loaded condition during the battle, and that their metacentric height was smaller than in their normal condition.

Thus the belt in the *Osliabia* was probably less than 1 ft. above the water—perhaps nearly immersed—and the metacentric height hardly reached 2½ ft.

The heavy belt was 9 in. thick amidships, and was surmounted by a strake of 5 in. armour extending up to the gun deck, which in fully loaded condition was about 8 ft. above the water. The sills of the 12 pdr. gun ports on gun deck were about 11 ft. above water. The 5 in. strake extended only for about half the length of the ship, leaving the ends above the belt, *i.e.*, practically down to the waterline, entirely unprotected. Thus any form of attack by gunfire was liable to produce wounds in the side near the waterline, and it is likely that the high explosive shell fire to which the Russian ships were exposed during the earliest stage of the battle opened breaches in the sides outside the high side armour which materially reduced the stability already at small angles of heel.

Due to the great tumble home, the curve of stability must, even in intact condition, have been weak, *i.e.*, the righting arms must have been small, and although the high freeboard secured a great range of stability, this advantage was in time of battle illusory, because the freeboard was so poorly protected. Finally the *Osliabia* possessed the undesirable feature of a centre-line bulkhead between her boiler rooms.

Early in the battle the ship received two serious wounds in the region of the waterline, apparently from large armour-piercing projectiles. The first projectile entered the orlop deck near the bow and caused the flooding of several compartments; on the orlop deck the water reached the third bulkhead from the bow, and in the hold it reached the 6 inch ammunition room and the dynamo room. It is possible that this extensive flooding was due to an imperfect service of the watertight doors. The case brings to mind that of the *Victoria*, for as in that ship the water in the *Osliabia* reached the compartments under the turret.

Another projectile entered on the port side into the tenth coal bunker. It is probable that hereby also a boiler room was flooded, and in such case the centre-line bulkhead would contribute much to the heeling effect of the water. The ship took a heavy heel to port and settled by the bow. The starboard magazine was flooded in order to right the ship, but insufficient size of the valves made the operation too slow. At the same time the ship was on fire and the masts were carried away. The attempts to stop the leaks failed, due to the heavy sea which was running at the time, and due to the movements of the ship. Such were the facts as reported, and we have now no difficulty in imagining what next took place and how the ship finally capsized.

The water began to enter through holes in the port side above the belt, the heel increased and soon became so serious that the sills of the 3 inch gun ports became intermittently immersed by the movements of the ship and the sea. The gun ports were partly demolished and could not be closed. At a heel of about 16°-18° the sills of the gun ports became permanently immersed, the ship then rapidly lost her stability completely, capsized and sank. This happened within one hour after the beginning of the battle, and was entirely the result of gunfire.

It appears that in regulating the stability of this ship, as also of many French battleships prior to the *Republique*, the leading idea of the designers has been to secure easy movements in a seaway. This result has probably been attained; thus in the *Suffren* the period of oscillation exceeds 10 seconds, and also the *Osliabia* was noted for her steadiness; but the fate of this latter ship has shown conclusively that if this quality is to be secured by small stiffness and great tumble home, it can only be had at the expense of safety in action. The smaller the beam and the greater the tumble home, the higher must be the freeboard in order to secure a proper range of stability, but the more difficult it becomes to give this freeboard an adequate protection. Also the target exposed to the enemy's fire will be greater, and the large unprotected superstructures will increase the liability to fires.

The Borodino Class.

Four ships of this class took part in the battle: *Borodino*, *Souvaroff*, *Alexander III* and *Orel*. These ships are likewise of French type, being derived from the *Tsesarevitch* and not unlike the *République*. The French in designing the *République* appear to have recognised the dangers of previous types, for not only has the tumble home been much reduced, compared with that of the *Suffren*, but the beam has been increased from 72.2 ft. to 78.7 ft., while the draught has been kept unaltered. The metacentric height thus attained is 3.6 ft. This metacentric height in a ship like the *République* may give a curve of stability, which for peace service may be perfectly satisfactory, but when the unprotected parts are damaged, the curve of stability shrinks, and if the ship is then struck by a torpedo, the stability is liable to become inadequate. This

* See also Admiral Nebogatoff's article in the book.

small metacentric height is indeed a feature which the *République* has in common with most modern battleships, as for instance the English, but in the French type it is combined with a system of side protection, which seems somewhat less rational than that of the English type; while in the *République* the belt is of uniform height from end to end, 7½ ft. above water, it is in English ships generally lower at the ends, but rises all along the broadest part of the ship to the upper deck. It is, however, effective as far as stability is concerned only to a height of about 11 to 12 ft. above water, where the integrity is broken by the gun ports of the secondary battery (*King Edward*, *Triumph*).

Returning to the *Borodino* class, we find that the Russians have here followed the French tendency to an increase in beam, evidenced in the *République*. Compared with the *Osliabia*, the beam has been increased from 71.5 ft. to 75.5 ft., while the draught has been reduced from 27½ ft. to 26 ft. The metacentric height has, however, hardly reached 3½ ft.

Like the *Osliabia*, these vessels have considerable tumble home, and the freeboard is very high with enormous, towering, unprotected superstructures, forming a large and prominent target for the enemy's shell fire. The side armour is arranged according to the French system, but the upper part of it is much lighter than in the *République*.

The side armour consists of two complete strakes: the lower (maximum: 10 in.) is in fully loaded condition less than 1 ft. above water; the upper (maximum: 6 in.) is covered on its top by a 4 in. armour deck, which is less than 7 ft. above water in fully loaded condition. A splinter deck, 1½ in. thick, is placed 6½ ft. below the principal armour deck, curving down at the sides to form a lateral armour bulkhead, intended to serve as protection against torpedoes.

A battery of 12 pounders is placed amidships on the principal armour deck. The sills of the gun ports are only about 9 ft. above water in fully loaded condition.

In a calm sea the heavy belt would be immersed at a heel of about 1°, the top of the upper armour strake at 10°, and the 12 pounder gun port sills at about 14°.

It has been stated that the vessels of the *Borodino* class rolled violently during the battle on the 27th.

The *Borodino* suffered much from gunfire at the beginning of the battle, and several serious fires broke out on board her during the afternoon. Fifty minutes after the fight began she was put out of action, but was, however, near four o'clock able to take the place of the *Souvaroff* at the head of the line and continue the fight. Later in the afternoon she again had a serious fire on board, and at about a quarter past seven she heeled over to starboard, capsized and sank. Admiral Togo reports that a ship, which, according to the evidence of Russian prisoners of war was the *Borodino*, was seen to become suddenly enveloped in the smoke of a violent explosion, and to sink immediately after. Presumably the fire had reached the magazines, although it is possible that the ship was struck by a torpedo.

The *Souvaroff* was soon after the beginning of the fight put out of action and had to leave the line with a great fire; at half past two the staff had to be transferred to the communication room. She lost both masts and funnels and was quite enveloped in smoke. She was subject to two torpedo attacks in the afternoon, of which it is known that the last one, at a quarter to five, was successful. A torpedo struck the ship under the port quarter and caused a heel of some 10°. In the evening she was again attacked by torpedo destroyers and sank at 7-20 p.m., after being hit by three torpedoes. The last torpedo is said to have struck at the engine rooms, after which she sank in a few minutes. It is stated by an observer in the *Aurora*, that the *Borodino* was on her beam ends for fifteen minutes before she sank, and that he could see down her smoke stacks. However this may be, the *Souvaroff* showed considerable power of resisting torpedo attacks, which seems to prove that she had a very efficient system of watertight subdivision (probably the same as that of the *Tsesarevitch*), a feature to which the French naval architects have always given great prominence. Possibly the armoured lateral bulkheads proved useful against the torpedo explosions. The success of the torpedo attacks was made possible only by the crippled condition in which the ship was left by the gunfire.

The *Alexander III* had several serious fires on board, and suffered much from gunfire. After six p.m. she had to leave the line, she gradually took a great heel and capsized at seven minutes past seven p.m. We do not know the exact nature of the damage sustained by this ship, but it appears that she was sunk entirely by gunfire.

Orel. Although the upper works were wrecked as in the other ships of this class, the *Orel* preserved her vitality throughout the engagement. The heavy armour was unpierced, no hits were found below the waterline, and no torpedo hits occurred.

* * *

Summing up, it is seen that four modern first-class battleships were sunk in the engagement, two by gunfire, one by torpedoes and one by the fire reaching the magazines. Also in the two latter cases gunfire was however primarily responsible for the result. These ships were of the earlier French type, and all suffered more or less from the defects inherent in this type; a too small initial stability, an inadequate protection of the freeboard, a great tumble home, and large towering superstructures. Even the carefully designed French system of watertight subdivision could not outweigh these defects.

The French type of battleship cannot be said to have stood the test of battle, but it is only just to add that it was tested much more severely than was the English type.

The Smaller Russian Armoured Ships.

The *Navarin* (10,000 tons), was a reduced *Trafalgar*. She was well protected up to upper deck and had no excess of unprotected superstructures. It appears that she stood gunfire well, but she succumbed to torpedo attack on the morning of the 28th, being struck by a torpedo on each side.

Sissoi Veliki (9000 tons), had much resemblance to the *Royal Sovereign*. During the artillery fight she was struck twelve times by projectiles of large calibre, she suffered much from fire, and towards evening she had settled somewhat by the bow. During the night she was attacked by torpedo boats and was hit at least once. On the next day, in the forenoon, she heeled over to starboard and sank. Bearing in mind the small displacement of this ship, she showed considerable power of resistance.

Admiral Nachimoff (8000 tons), was in point of distribution of armour very similar to the *Amiral Duperré*, only the armour deck joined the lower edge of the belt. The belt was narrow and no armour was found above the belt, which was surmounted by an upper unprotected hull of two deckheights and a superstructure. Like the *Duperré*, the *Nachimoff* was liable to great loss of stability by damage to the unprotected side. She was struck by a torpedo on the evening of the 27th, and with the damage sustained by gunfire during the day, we can readily understand that she was found the next morning in a sinking condition. The Japanese tried to take her in tow, but after the crew had been removed she went down, capsizing. Possibly the valves were opened by the crew.

Admiral Oushakoff (4100 tons), although built as late as 1893, was of the same type as the English "Admiral class," a type which had then been abandoned for several years by the English. It was characterised by a low central belt and an underwater armour deck at the ends, covered by a cellular layer. This type was like the *Amiral Duperré*, open to the objection that damage to the unprotected parts would in a seaway endanger the stability. Both types originated during the eighties as a result of the incompatible claims to heavy guns and heavy armour on one hand and a restricted displacement on the other; but both in England and France the designers evolved what was probably the best compromises under the circumstances. Due to the great development of rapid firing guns and shellfire which took place during the latter half of the eighties and the following years, both types soon became obsolete. For service on an expedition like the one in question, ships of the Admiral class of so small displacement were entirely unsuited.

The *Admiral Oushakoff* was attacked by the Japanese armoured cruisers *Iwate* and *Yakumo*, armed with 8 in. and 6 in. guns, on the afternoon of the 28th. At the end of about half-an hour she was completely wrecked and sank.

The two old belted ships, *Dmitri Donskoi* and *Vladimir Monomach* fell as an easy prey to torpedoes.

General Remarks and Conclusions.

The first-class battleships that were sunk in this fight were in point of STABILITY somewhat inferior to most existing modern battleships. Considering, however, the way in which these ships were sunk, as also the way in which battleships of other and better type were destroyed earlier in the war, we cannot remain satisfied with even the best of existing types. If we are to continue to build large battleships, it appears absolutely necessary that some radical change should be made in their design. A mere increase in size, if unaccompanied by a still greater increase in stability, is likely to lead to disappointment in time of war.

Hence, battleships should be given a much greater initial stiffness than has hitherto generally been given to ships of this class. The stability at moderate angles of heel should be better protected by carrying the side armour, unimpaired by the presence of gun ports, up to the upper deck all along the vitals. The tumble home should be very small. The watertight subdivision should be designed with more particular regard to torpedo attack; lateral, eventually armoured bulkheads should be carried along the vitals some 18 ft. from the sides, and the engine rooms should be reduced in size by the use of three or more propellors. Finally, compensating tanks, with a special and powerful flooding system, should be provided for righting the ship when it takes a heel.*

The advantages of a steady gun platform, so indispensable to a battleship, should be attained, not by sacificing the safety in action, but by increasing the resistance to rolling.

While in existing battleships of 14-16,000 tons we find a metacentric height of 3½-4 ft.; future battleships of about 18,000 tons should not have less than 6-8 ft. metacentric height, even although this feature, involving great beam, as well as the fitting of very large bilge keels may be somewhat prejudicial to speed. With a proper system of subdivision and protection, the passive power of resistance of such battleships against attack on their stability would thus be more than twice that of existing battleships.

* The questions here touched upon are dealt with more fully by the author of this article in two papers read before the American Society of Naval Architects and Marine Engineers in 1903 and 1904, entitled, *Watertight Subdivision of Warships* and *The Seagoing Battleship*.

In order to avoid the complete destruction of the *anti-torpedo-boat guns* during an artillery fight, these guns, and eventually their stands, should be made portable, as far as their weight and location permit, and should be capable of being housed under shelter of armour and readily mounted again. Rapid-firers of greater calibre, especially those above 3 in., which cannot be made portable without too great difficulties, should be given a protection corresponding to their importance.

The high explosive shell of the Japanese caused SERIOUS FIRES in all of the Russian battleships and widespread DESTRUCTION OF THE SUPERSTRUCTURES and all that was found in and about them. The confusion and interference with the service of ship and guns which was caused hereby can easily be imagined: communication was made difficult, the working of the guns was impeded by the debris of falling masts, funnels, ventilators, etc., as well as by the fire and smoke, the draught in the furnaces was obstructed, and the men who had to fight the fires must have been exposed in the unprotected parts of the ship to the gunfire of the enemy with consequent great number of casualities.

These numerous and violent fires came as a surprise to many, for probably the Russians had taken as complete precautions in this respect as other nations. Evidently we have still something to learn in this respect.*

In and on the unprotected superstructures of these ships were probably found a great number of inflammable objects such as furniture, hammocks, hawsers, effects of officers and crew, deck covering of wood or linoleum, etc., but these objects and materials could hardly by themselves account for the violent fires that occurred. It appears that one of the main causes of the fires were the boats, of which it is said that the Russians carried the full complement during the battle. It is worth noting that the Japanese had only a few boats on board each ship.

* See Admiral Nebogatoff's article in this issue.

It has been stated that also the paint took fire; this is probably a novel idea to many, but it is a fact that even after paint is dry, the inflammable substances contained in the linseed oil are not completely oxidised, and will burn readily. It seems therefore quite likely, if the paint has been allowed to accumulate into thick layers, that it may have contributed materially to the fire and to the smoke. It may be added also that linoleum will burn freely, and is in fact much more inflammable than paint.

If the statement is correct, that the Russians during the battle carried coal in the upper parts of the ships, this coal may have contributed considerably to the seriousness of the fires.

Finally, the high explosive shells had a very great incendiary power on account of the extremely high temperature attained by the explosion.

The fate of these ships shows the necessity of reducing the extent of unprotected structures to the smallest minimum, and of avoiding more scrupulously than hitherto the use or stowage of any kind of inflammable materials in these parts of the ships.

The boats carried during action should be of steel, and should be stowed on gun deck behind armour.

In order, on the other hand, to secure the most effective offensive power, it appears premature entirely to abandon the secondary battery. The attack on lightly protected or unprotected parts, which proved so effective at Tsushima, can be better performed by a greater number of 9 in. or 10 in. guns, than by a smaller number of 12 in. guns.

W. Hovgaard.

A PROPOSED NEW TYPE OF CONNING-TOWER FOR LARGE BATTLESHIPS.

A PROPOSED NEW TYPE OF CONNING-TOWER FOR LARGE BATTLESHIPS.

By Commander Hovgaard, Royal Danish Navy.

It is the object of this article to discuss the location and construction of conning-towers, and to propose a design of a conning-tower suitable for a large battleship.

Since a rational design of the structure, from which the ship is controlled in action, must be based on a certain organization of the service, it has been necessary in this article also to touch on this question, and to explain what the assumed organization is.

The defects of existing conning-towers, and the fatal consequences which these defects entail in war are now well known, and had indeed been foreseen and foretold years before the recent war. It is a fact, however, that even now the necessity for immediate action in this matter is not generally realized; for although improvements have been introduced in later ships of certain navies, many, if not most of existing battleships are in this respect unfit to send into action, and little or nothing is being done to remedy the defects.

It is therefore necessary, as a basis for this discussion, to commence with a review of recent war experiences and firing experiments, exposing and emphasizing the facts which bear upon this subject. By a study of these facts, the vital importance of the conning-tower as the central organ of a warship is brought out, its present imperfections are impressed upon our minds, and we are brought to realize the necessity of greater sacrifices of weight for this purpose in future ships. Space does not here permit to give more than a brief and fragmentary review.

RECENT WAR EXPERIENCES AND FIRING EXPERIMENTS.*

1. Action off Asan, 1894.

The Chinese cruiser, *Tsi Yuen*, had a conning-tower protected by 1 inch plating. A shell from the Japanese cruiser *Naniwa* struck the deck; glancing upwards it exploded under the conning-tower, and killed two officers stationed inside the tower and a midshipman stationed outside. The head of one of the officers was left hanging on one of the voice pipes, whilst steering gear, telegraphs and voice pipes were completely wrecked. The fore-bridge was demolished.

2. Battle of Yalu, 1894.

When the battleship *Ting Yuen* fired the first shot from the 12 in. guns. the concussion caused all who were on the bridge, which ran just above the barbettes, to be thrown down, and Admiral Ting, the commander of the fleet, was so much shaken that he had to be taken below. Also the chief of staff, Major von Hanneken, was much injured.

3. "Belleisle" Experiments, 1900.

It appears that the conning-tower was not hit, but the dummies inside it were broken by the concussion of exploding shells striking the bridge structure and boats in its vicinity. The shells used were 12 in. common and 6 in. common and lyddite.

4. The "Variag" at Chemulpo, 1904.

Inside the conning-tower were the gunnery, torpedo and navigating officers, the helmsman and a man at the engine telegraphs. Outside the conning-tower were the captain with a bugler and an orderly. A shell killed these two latter and bruised the captain, but none inside the conning-tower were hurt. Both bridges were demolished, the forward bridge took fire, and for five minutes the gunfire was suspended, while all hands on deck were engaged in extinguishing the fire. The range was taken by an officer on the forecastle and given to the guns by an instrument in the top, but both men in the top were severely wounded. Here, as later on board the *Rossia* and *Gromoboi* (Aug. 14th, 1904), the losses among the unprotected personnel were enormous, and the necessity for giving protection to all personnel, even the most unimportant, was clearly shown.

5. Battle of Round Island, August 10th, 1904.

The conning-tower of the *Cesarewitch* was of the mushroom-shaped type, with an open all-round slit of about 16 in. height; it was struck on the starboard side by a 12 in. full point shell which broke. The point glanced upward, was deflected into the conning-tower by the roof, and left the tower through the slit on the other side. On its passage through the tower the point of the shell killed the navigator, an ensign, the helmsman, and two or three other men, literally tearing their heads off their bodies, while two officers were made unconscious. By the falling men the rudder was laid hard aport, but the steering lead remained intact. The compass was destroyed, and the connection with the engines broken. The ship sheered out of the line which was thus brought in confusion.

Another 12 in. shell struck the foremast on the starboard side between upper and lower bridge, and burst inside the mast. The mast which was just aft the conning-tower was badly damaged, but remained in position, being supported by the bridge structure. This shell killed Admiral Witthöft, the fleet navigator and 15 men, while the chief of staff and the captain of the ship were wounded. All these officers and men were stationed on the bridge outside the conning-tower, probably on the port side behind the tower.

These two shells practically decided the issue of the battle, which up to that time had been undetermined.

The chart house, which was placed aft of the foremast was destroyed by another 12 in. shell.

On board the *Askold*, the first hit on the ship was made by a 12 in. shell, which tore away the range-finder on the bridge and killed the observer.

The *Mikasa* was struck by a shell at the bridge, whereby a number of officers and men were killed and wounded, but the Admiral was not hurt.

6. Battle of Tsushima, May 27th & 28th, 1905.

The *Souvaroff*. The conning-tower of this ship was imbedded between inflammable bridges carrying several light guns and numerous fittings. A charthouse and the foremast were placed close to it.

Little more than one hour after the commencement of the battle, the conditions inside the conning-tower were as follows:—Admiral Rodjestvensky, the flag captain and the navigator were all wounded by shell fragments, which entered in large quantities under the mushroom-shaped roof. The admiral was in fact wounded in the head, back and right leg, besides several small splinter wounds. Five or six dead bodies were lying in a heap on the floor, and several men who had been wounded in the conning-tower were now in the hospital. Excepting the telegraph to one of the engine rooms and a voice pipe to the other, all the instruments including the compass were destroyed. The bridges, boat deck and charthouse were demolished and on fire, the forward funnel was carried away. The heat in the conning-tower now became unbearable, and on account of the thick smoke look-out was impossible. It became therefore necessary to steer from the fighting position below the armour deck and to abandon the conning-tower for a place where one could see. Since the bridges were burning and the ladders destroyed, the only passage left was the armoured tube, through which, therefore, the wounded officers and men let themselves down with great difficulty, after having cleared away the dead bodies that covered the hatch.

This great destruction was wrought chiefly by the Japanese sensitive high-explosive 12 in. shell. The great incendiary power of these projectiles set on fire everything inflammable; the innumerable fragments into which they were shattered, rendered any stay in the unprotected parts of the ship fatal and penetrated into the protected parts through all openings in the armour; the great blasting effect demolished the unarmoured structures.

The conditions in the conning-tower and on the bridges of the other Russian battleships were probably similar to those existing on board the *Souvaroff*.

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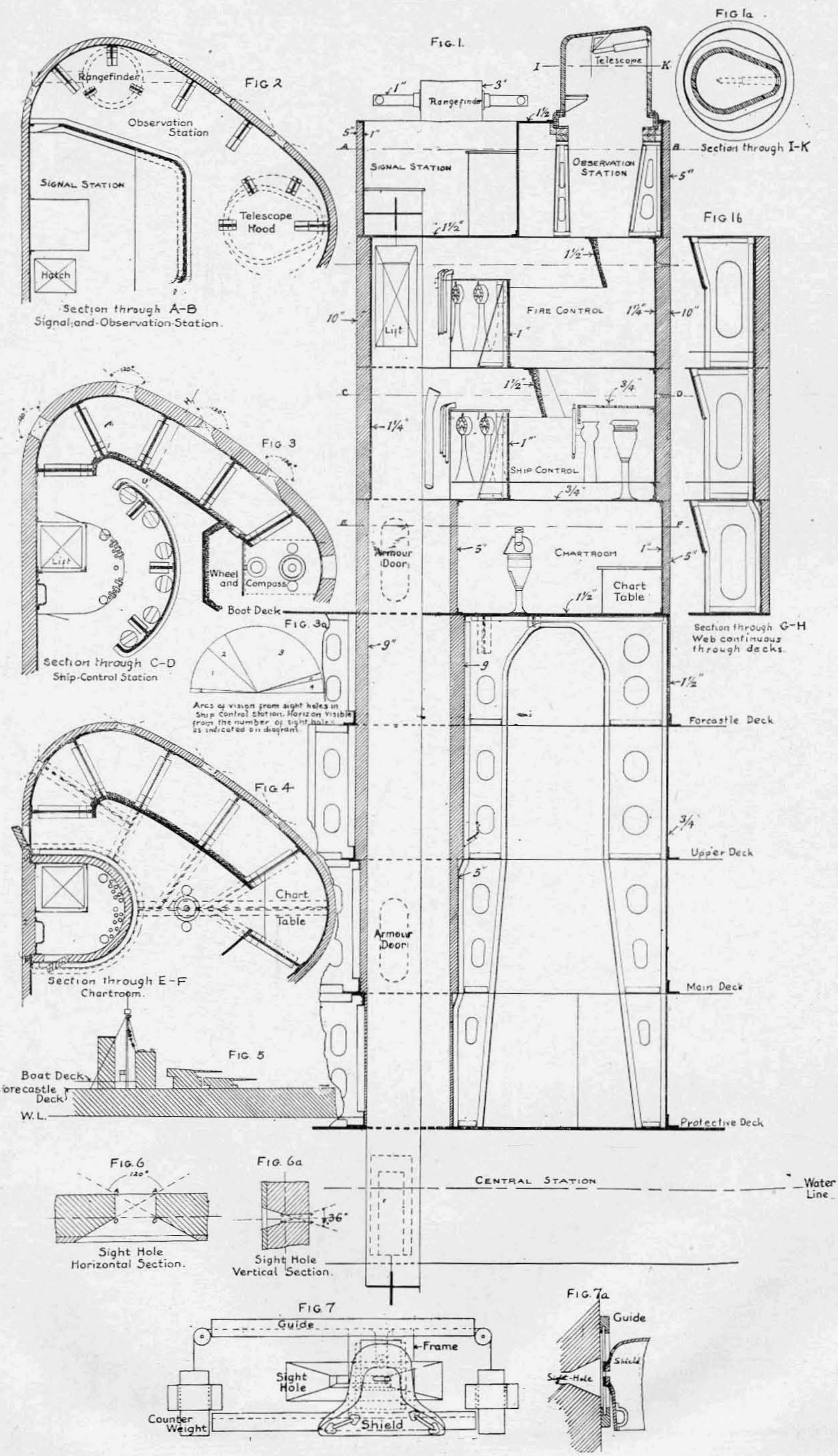
*H. W. Wilson:—"Ironclads in Action."
Captain V. Semenoff:—"The Battle of Tsushima."
Various Transactions and Periodicals.

Proposed Conning-Tower

Scale: about 1/8" = 1' (for Fig. 1 to 4)



Note.—U. S. Navy terms for the different decks are used in this diagram.

Thus in the *Orel* the occupants of the conning-tower were twice driven away by the smoke from burning hammocks and hawsers; several shells struck the conning tower, dislocating the armour plates and causing most of the voice pipes to be cut.

It has been stated that the Japanese commanders who were at first inclined to stay outside the conning towers, found it necessary early in the battle to take station inside.

7. Hero Experiments, 1907.

From the somewhat uncertain accounts of these experiments, it appears that the fire control station, which was placed unprotected in an improvised top on the mast, was destroyed at the very beginning of the test.

PRESENT STANDPOINT OF CONNING TOWERS.

At the time of the early armourclads the shell-fire was not so overwhelming or destructive as it now is. On the other hand, the ships were smaller and could not well carry the weight of a large, well-protected conning-tower. Further, the means for transmitting orders and communications were very imperfect, so that the conning-tower could not be made a really efficient central organ. It was therefore neither possible nor justifiable to bring great sacrifices in weight for this purpose, and this explains why conning-towers were at that time small, inefficient, and often poorly protected.

Since the introduction of high-explosive shell, and the increased rate of fire in all classes of guns, shell fire has become exceedingly destructive to all unprotected structures, and the effects of fragments and splinters as well as the danger of fire has greatly increased. Moreover, the modern claim to accurate gun practice on long ranges has necessitated a more efficient and contralized fire control. In spite of these changes in the means and methods of warfare, and in spite of the general technical development and the increase in size of ships, the conning-tower has been improved but little during the last forty years. Its present defects, apparent from the above historical notes, may be summarized as follows:

Location:—In most navies the conning-tower is placed essentially as in the *Souvaroff*, described above, being surrounded and surmounted by bridges, guns, searchlights, and numerous fittings. Often the bridges are inflammable as in the *Souvaroff*, and in addition, we frequently find a charthouse or even the foremast mounted directly on top of the tower. The forward funnel is often too near the conning tower. These defects are well illustrated in "Fighting Ships," by the pictures given of the bridges, etc., of the *Suffren*, (page 233,) *Charles Martel*, (page 237,) *Maine*, (page 118,) *Virginia*, (page 117,) and other ships. The defects are however by no means confined to these vessels or to the navies to which they belong, they appear to be found in various degrees in ships of all navies, although it is possible that in some ships the bridges are intended to be removed in war time.

Internal arrangement:—The space inside the conning-tower is very restricted; generally only one compartment is found, from which ships, artillery and torpedoes are all to be controlled, and in flagships also, the admiral with his staff are supposed to be stationed in that compartment. It is clear that under these circumstances mutual interference and disturbance are unavoidable. This restriction in space has led to a scattered and unprotected installation of several stations, which ought properly to be placed inside the conning-tower. Thus the range finding station is generally placed unprotected outside the conning-tower, and even the fire control and the signal stations are often so placed. All these important stations are thus liable to be destroyed early in an engagement.

Protection:—No attempt has been made to protect the men and instruments inside the conning-tower against the effects of fragments or projectiles entering the sight holes. In many ships of the French and certain other navies, the conning-tower has the mushroom-shaped overhanging hood, which proved so fatal in the *Cesarewitch*. The conning-tower now used in the British navy, mushroom-shaped roof without overhang, but with continuous all-round slit, is subject to the objection that the opening is very large.

As shown above, the conning-towers have, due to these defects, generally proved unsatisfactory in action, and in some cases they have proved veritable death traps. The issue of battles, not only between single ships, but even between fleets, has in several cases been largely influenced by the defective design of the conning-tower.

Hence the conning-tower has with good reason come to be regarded with considerable distrust by naval officers. It has been argued by many, that since the protection obtained in the conning-tower is so imperfect, it is better to take position outside the tower, where at least a good view is obtained. This has been done in many cases, and often without fatal consequences, but while it may be justifiable in light engagements, especially with the present defective conning-tower, it cannot be considered a rule on which to base a design.

To design a ship to-day, after the experiences of the Russo-Japanese war, on the basis of a plan by which the captain and his staff must be stationed outside the conning-tower, appears indeed as irrational as to place the brain outside the skull.

The design of the conning-tower as of all other important parts of a battleship should be based on the conditions of a long continued serious fight.

The ships are now so much larger than formerly, that a far greater weight can without detriment to other qualities be sacrificed to the construction of this vital organ. Great improvements have taken place in the means of transmission of orders and communications, for by the use of electricity the same transmitter may without difficulty be used to communicate with a great number of stations; and telephones although by no means perfect, permit a more intimate connection between the different parts of a ship.

Hence there is not only a necessity, but also a possibility for a radical improvement in the design of conning-towers, and it is indeed time that we should completely change our conception of what a conning-tower should be.

GENERAL PRINCIPLES GOVERNING THE DESIGN OF CONNING-TOWERS.

It will probably be admitted that the conning-tower of a warship may be likened to the head of a man; the armour being analogous to the skull, the captain and his staff together with the instruments and appliances inside the conning-tower being analogous to the brain.

The brain is the seat of intelligence and volition, and controls the external actions of the body, guided by the impressions which it receives through the senses. It comprises a number of nervous centers placed close together inside the protecting cranium. Although separate, each having its particular function, these centers are intimately connected with one another and with the various parts of the body.

Admitting the fitness of this arrangement, we may by analogy conclude that the groups of men and instruments, which under the leadership of the captain govern *the external activities* on which the fighting power of a ship directly depends, should, for perfect efficiency, be placed separately, but close together and interconnected, inside one well-protected structure. The activities referred to are: observation, motive power, steering, navigation, communication with other ships, and the use of the armament.

The proximity of these groups to each other and to the captain makes communication between them simple and certain, and facilitates unity of action; the different groups should therefore be separated only to the extent which is necessary to prevent mutual disturbance and interference.

By such contralization a more complete protection may be obtained on the same weight than where, as has been proposed by some, the controlling agencies are distributed in several separate structures, placed widely apart.

If then the centralization of all the controlling organs in one conning-tower is accepted, the question arises, whether *a reserve conning-tower* should be fitted, for it is a general principle in ship construction that all vitals should be duplicated or multiplied so as to reduce the chances of total disablement. Now it is possible without loss in power or efficiency to have two or more separate sets of boilers, engines, dynamos, etc., since the different sets of each plant can all be used at the same time, thus increasing the power proportionately, but with conning-towers the case is different. Only one conning-tower can be used at a time, and there is a great probability that when the main conning-tower is put out of action, the reserve conning-tower is at least seriously damaged.

Thus a reserve tower will ordinarily mean a dead weight of doubtful utility, and since it must be at least as heavily protected as the main conning-tower if it is to have any chance of survival in battle, this dead weight will be very considerable. In fact, the requirements to be fulfilled by an efficient conning-tower are to-day such, that it will hardly be possible to spare the weight for a reserve tower even in the largest ships.

Moreover, as will be shown later, only one really satisfactory position for the conning-tower can be found in a ship, and a reserve tower will for this reason always be less efficient.

Finally, a reserve tower does not supply a reserve for the most important part of the central organ: the captain and his staff.

We are thus led to follow the example of nature also in this respect, as a man has only one head, so *should the ship have only one conning-tower*.

Turning now to *the internal activities* of the ship, these should normally be carried on automatically, *i.e.*, independent of the conning-tower, being, as far as the ordinary routine service is concerned, controlled from certain secondary centers, placed in different parts of the ship, subject, however, to ultimate control from the conning-tower. Such activities are for instance the internal service of engine and boiler rooms, which is generally controlled from the engine room platforms, the supply and distribution of electricity, controlled from the dynamo room, the transport of ammunition, controlled from the handling rooms or from the turrets, etc.

There are, however, other activities which on account of their sporadic and scattered nature have not generally, as far as the author is aware, been sufficiently centralized. The activities referred to are: extinction of fires, clearing of wreckage, the use of the drainage and flooding systems, of watertight doors and of leak mats, re-organization of personnel when disorganized, distribution of reserves, and the maintenance of discipline and morale under the various incidents of battle, as for instance, when groups of men are left without a leader, or without materiel with which to work.

It is here proposed to establish a central organ for all these activities, and to place it in charge of the executive officer, and since such a station must have connection with all parts of the ship, it is proposed at the same time to make it a central for all telephone and voice pipe connections, and to merge it with what is generally called *the central station* (often called "communication" station). This station, which is also to form a reserve for the conning-tower, is conveniently placed vertically below the conning-tower under the armour deck. It may well be compared to certain semi-automatic and co-ordinating centers of the brain, which, although normally acting independently, are always subject to the control of volition.

If the central station and other secondary centers perform their duties efficiently, it becomes possible for the captain and his staff to concentrate their attention on the more decisive external functions of the ship.

Although the analogy between the conning-tower of a ship and the head of a man is generally recognized, it has been thought useful here to dwell on it, because the logical consequences of this analogy and its underlying principles have so far not been fully acted upon, and the conning-tower as it is to-day does but very imperfectly fulfil its functions as the central organ of the ship.

PROPOSED LOCATION AND CONSTRUCTION OF CONNING-TOWERS.

[See accompanying diagrams.]

1. Location.

The conning-tower should be placed in the centre line forward of the foremast and the funnels, and aft of the forward heavy gun-turrets (see Fig. 5). By giving the conning-tower a sufficient height, a perfectly free view may here be obtained in directions forward, and by giving it a breadth greater than that of the funnels, a free view right aft can be obtained on each side, although the funnels and masts will always obscure a certain arc of the aft quadrants of the horizon. No other position in the ship offers as favourable conditions in this respect, for in the corresponding position just forward of aft turrets the funnels and masts will obscure part of the forward quadrants, which it is of primary importance to keep clear. All other positions will obviously be inferior to these two. The position of the conning-tower should be absolutely isolated, and as far from mast, gun-turret, funnels, bridges, etc. as possible, so as to reduce to a minimum the effects of shell bursting on impact against neighbouring structures and fittings. The bridges should be reduced to their simplest form and smallest practicable size, and may probably with advantage be connected with the foremast, entirely clear of and well aft of the conning-tower. The upper (flying) bridge should preferably be constructed so as to be readily rigged down in war time. The position of the conning-tower relative to the heavy gun-turrets should be such that firing of the heavy guns will in no case cause any serious inconvenience to the occupants of the tower, and no small guns should be placed in its immediate vicinity.

It is of special importance that no inflammable materials of any description should be found near the conning-tower. Thus for instance deck coverings of wood or linoleum on bridges and superstructures are entirely impermissible, as are also the stowage of hammocks, hawsers, wooden boats, etc., in the unprotected parts of the ship.

2. General Arrangement.

The conning-tower here proposed is an armoured vertical cylinder, which projects above the forecastle (eventually upper) deck to a considerable height. This cylinder is sub-divided by platforms into several compartments, each of which serves as centre for some important activity as explained below. The main line of communication runs along the middle of the rear wall of the conning-tower, comprising a lift, a ladder, and all the leads and voice-pipes which connect the various parts of the conning-tower with the ship. It extends from the top of the conning-tower to the central station, and being armoured the greater part of its length, it shall be hereafter referred to as *the armoured tube*.

In the conning-tower should be found stations for the following activities:

Ship Control and eventually Fleet Control.

Fire Control.

Observation.

Signalling.

Directly below the conning-tower the central station should be found as stated above.

Ship Control Station (see Fig. 3):—This is the most important station, since it presides directly over the movements and indirectly over all other functions of the ship. It should be placed at such a height that a free view is obtained over the forward gun turrets, but this height should not be exceeded on account of the heavy armour protection which must be given to this station. In the accompanying sketch design the freeboard abreast of the conning-tower is assumed to be 27 ft., and there are supposed to be two forward 12 in. gun-turrets in the centre line as shown on Fig. 5. Under these conditions it is estimated that the requisite height of the sight-holes in this station will be about 48 ft. above the water-line.

Personnel:—Captain, navigator, aide, orderly, helmsman, and the men necessary to work telegraphs, voice pipes, etc.

The navigator should normally be in charge of this station, subject of course to the orders of the captain, who may at any time assume direct control of ship and engines. The captain should ordinarily be stationed here, but may, should he so desire, lead the ship from the fire control station, or, in less serious actions, from the signal station.

Appliances and Instruments:—Steering wheel and compass, engine room telegraphs, steering telegraph, rudder indicator, revolution counters, voice-pipes, telephones, etc. Eventually the main engines should be governed directly from this station, as by the arrangement now patented by Mr. Chas. de Grave Sells for turbine machinery.

Direct connection by voice-pipe should exist with engine rooms, steering room, fire control, observation, signal and central stations. Direct telephone connection to central station, engine and steering rooms.

Grated openings in the platforms which separate this station from the fire-control station directly above, and the chartroom directly below, permit direct communication between the stations.

The steering wheel and compass should be placed in the forward part of the compartment, the helmsman having outlook through a sight-hole in the centre line and through the two adjacent sight-holes.

Telegraphs and indicators to be placed in a circle round the armoured tube, behind a splinter-screen, voice-pipes to be fitted on a light screen round the front of the tube. These screens to serve also for attachment of switches and other fixtures.

Fleet Control Station:—In a flag-ship, a separate compartment of the conning-tower should be assigned to the admiral and his staff. In order to avoid separation of ship and fire-control, it is proposed to place the fleet control station below these stations in the position, which in ordinary ships is occupied by the ship control. Thus the height of the conning-tower in a flagship would be increased by about seven feet.

Personnel:—Admiral with staff.

Appliances and Instruments:—Compass, helm indicator, revolution counters, chart table and dumb compasses. Voice pipes to ship control, observation and signal stations. Telephone to central station. Grated holes in platform connecting with ship control station.

Fire Control Station:—The function of this station is to control and direct the fire of the battery on the basis of observations taken partly in the station itself, but chiefly in the observation station, which should be placed directly above. Orders to commence and cease firing, and orders regarding target, sight-bar ranges, lateral compensation and the kind of ammunition to be used are from this station given to the battery.

Also the torpedo service should be controlled and directed from this station.

No sectional view is given of this station since the general plan is quite similar to that of the ship control station, with the exception that there is no steering position.

Personnel: —Ordnance and torpedo officers with the requisite number of assistants.

Appliances and Instruments :—Telegraphs, indicators and directors as required by the system, adopted for the control of guns and torpedoes.

Voice pipes to ship control and central stations, to the important gun stations and handling rooms, to range finders, telescope and spotters, and to torpedo rooms. Telephone to central station.

Observation Station (see Fig. 2):—The introduction of long range firing has rendered it necessary to develop this station to a higher degree of perfection than formerly, and with its increased importance follows a necessity for better protection. It is moreover essential that this station should be in direct and certain connection with the fire control station, and it is therefore proposed to place it directly on top of this latter as an integral part of the conning-tower. The station has three distinct functions:—

(a) *Simple Observation:*—At long ranges the usual binoculars and long distance glasses are entirely inadequate for the observation of details on the enemy's ships, on shore batteries, etc. It is therefore proposed to mount a powerful telescope, 4 in. or more, such as that designed by Commander B. A. Fiske, U.S.N.* (see Fig. 1 and 1a), in an armoured revolving dome, projecting above the top of the conning-tower. This dome to be turned by electric power and to be provided with a divided circle, by means of which an accurate bearing of any object relative to the center line of the ship can be found.

(b) *Range-finding:*—The new Barr and Stroud range-finder with 9 ft. base is here supposed to be used. The probable error of this instrument as given by the makers is only 20 yards on 5,000 yards, and 85 yards on 10,000 yards, but even larger and more accurate instruments might be mounted without difficulty. Two range-finders should be mounted, one in each of the outboard corners of the station, and fitted, like the telescope, in revolving armoured hoods. Those parts of the instruments which project outside the hoods should be protected by heavy steel tubing. The range-finders should be mounted so as to be easily replaceable by reserve instruments. The ranges to be given to the fire control station by means of telegraphs.

Other instruments such as sextants and stadimeters to be found in the station.

(c) *Spotting:*—The spotters should be stationed at the sight-holes, which are about 62 feet above the water line.

Personnel:—One observer at the telescope, two observers at the range-finders and a spotting party.

Connections as already described. Holes with gratings in the floor. It may, perhaps, be of advantage to fit a periscope, similar to that used in submarine boats, on top of the conning-tower.

Signalling:—It is proposed to place the signal station on the same level as the observation station, and to let it occupy the central rear portion of the compartment.

While the observation station is roofed over, the signal station is left open, but the height of the surrounding armour wall being some seven feet, the signalmen are fairly sheltered.

Look-out to be kept from raised platforms in the signal station or from the sight-holes of the observation station.

Signal halyards to connect the station with the arms of a yard on the foremast.

Semaphores, signal lights, etc., to be controllable from this station.

Personnel:—Signal officer and signalmen.

Direct connection by voice-pipe and by telephone to central station, besides connections already mentioned.

Chartroom (see Fig. 4):—The compartment immediately below the ship (fleet) control station, which, as explained below, must be given considerable protection, is here proposed to be used as chartroom and record office.

Personnel: — Navigator (occasionally), with assistants.

Compass, dumb compasses and other instruments necessary for navigation to be found in this station.

Central Station:—As already explained, this station should serve three different purposes:

(a) It should form the telephone and voice-pipe central for the entire ship, and as such, connect with all important parts of the ship, including all the compartments of the conning-tower.

(b) It should, under the command of the executive officer be a centre for certain important branches of the internal service. Thus, outbreak of fires, bilging, and any other incident endangering the safety of the ship or causing serious disturbance in the internal functions of the ship or in the service of the crew should at once be reported to the central station, whereupon the executive officer should take action in the matter.

(c) It should form a reserve for the conning-tower in case this is partly or entirely put out of action.

If, for instance, certain appliances or instruments are damaged in the conning-tower, the orders are given to the central station by voice-pipe or telephone from the ship control or other station, and thence transmitted to their destination. If the conning-tower can not be used at all, the ship may be controlled from some other point, where a free view can be obtained and from which communication with the central station can be established.

Besides the executive officer, a younger officer should be stationed here in order to take command of the station in his absence. Other personnel as required for the service of telephones, voice-pipes, etc. Eventually reserves for orderlies, signalmen and spotters.

Appliances and Instruments:—Steering wheel, engine and steering telegraphs, rudder indicator, water alarms, etc.

The telephone and voice-pipe central to be in a compartment well isolated against noise.

The voice-pipes to ship control and signal station to be very large.

3. Protection.

The stations for ship, fleet, and fire control should be protected by armour of same thickness as the water line belt, which in the sketch is assumed to be 10 in., and the observation station should be protected by armour of at least half this thickness. Armour of similar reduced thickness should be fitted outside the compartment which is found directly below the ship control station, and which it has been proposed to utilize as chartroom, the primary object of this armour being to prevent shell from exploding immediately below the floor of the ship (fleet) control station. The armoured tube should, below the ship (fleet) control station be protected by armour of such thickness, that taken together with all external armour, the total thickness aggregates about that on the ship control station.

The substructure of the conning-tower between forecastle deck and chartroom to have a protection of $1\frac{1}{2}$ in. plating.

The platforms in the conning-tower to be of $\frac{3}{4}$ in. plating, excepting the top of the observation station and the floor of the chartroom, which should be of $1\frac{1}{2}$ in. thickness.

Since there is nothing to prevent fragments from entering the sight-holes, a certain exposure of the observers is unavoidable. It is, however possible to localize and reduce the effects of entering fragments, and to this end it is proposed to adopt the following measures:—

A hanging armour screen to run continuously behind the sight-holes about three feet from the outer wall. As shown on the sectional views, this screen should be inclined so as to deflect fragments upwards and thus prevent their direct entrance into the central part of the conning-tower. The screen should be of sufficient depth to catch all fragments which enter directly, i.e., without rebound, through the sight-holes. If, as designed on the sketch, Fig. 6a, the limiting direction for direct entrance forms an angle of 18° with the horizon, the lower edge of the screen will be about four feet above the floor. The proposed thickness of the screen is $1\frac{1}{2}$ in.

In order to prevent or deaden the rebound of fragments, the screen might be coated with a thick layer of some plastic material. What this material should be can only be determined by experiments, possibly it may consist of lead or some other plastic metal, covered with a thick layer of a tough cement.

Since fragments might still find their way into the interior of the conning-tower, a semi-circular, vertical, 1 in. screen, a little more than four feet high, is fitted just outside of the telegraphs and indicators in the ship and fire control stations.

The deep, radial frames of heavy plating, which are fitted between the sight-holes, will assist in localizing the effects of entering fragments, and will form a kind of stall for each sight-hole. In order to facilitate passage from one stall to the other, lightning holes may eventually be cut in these frames of a size sufficient to permit such passage. (see Fig. 1b.)

In order further to protect the personnel using the sight-holes, especially against the numerous

*Proceedings of U.S. Naval Institute 1903, (page 699).

minute fragments from high explosive shell, a sliding shutter carrying a shield might be fitted inside each sight-hole as indicated on fig 7, which must, however, be considered only as a preliminary sketch. The shutter to slide vertically in a frame, which is capable of horizontal motion in two guides, this double motion permitting the look-out hole in the shutter to be brought before any point of the inner opening of the sight-hole. The weight of the shield and shutter to be taken by counterweights. The shield to be of a shape suitable for protecting the face and breast of the observer.

The helsman with wheel and compass to be stationed in a deep stall formed by a radial frame and a screen on each side. He should wear a mask or helmet, and a breast plate of some non-magnetic metal.

A portable protective cover of $\frac{3}{4}$ in. thickness to be fitted over the compass and wheel mechanism, provided with a hole over the compass card.

All material surrounding the compass, excepting the outside armour, to be of non-magnetic metal.

4. Sight-Holes.

The sight-holes should be so designed that for a given *horizontal angle of sight*, the material removed, i.e., the weakening of the armour will be a minimum. It is easy to prove that in a plane wall this condition is fulfilled by the design shown on fig 6 and 6a, where the limiting lines of sight pass through the points O, O on half thickness, and the points AA at the outer corners of the sight-hole. In a curved wall the design must be somewhat modified in order to fulfil this condition. The recesses should be found on the inside and not on the outside of the armour, where they might deflect fragments into the conning-tower.

The total angle of sight obtained in a sight-hole should not generally exceed 120°, as beyond this angle the amount of material to be removed for a given increase in angle increases very rapidly. With 11 in. thickness of wall this gives a width of sight-hole of about 10 in. The number of sight-holes and their location may be determined by the claim that each point of the horizon shall be visible from a certain number of sight-holes. Dividing the horizon on each side of the ship into three nearly equal arcs, it appears a reasonable claim that each point in the forward arc shall be visible from at least two sight-holes, each point in the athwartships arc from three sight-holes, and each point in the aft arc from at least one sight-hole. These conditions are amply fulfilled in the given sketch design (fig. 3a.)

The vertical angle of vision in the sight-holes of the ship (fleet) control station should be of such magnitude that even in extreme cases of heel or roll the horizon may be seen from both sides of the conning-tower. If we consider a total angle of 36° sufficient, this will with 11 in. thickness of wall give a height of sight-hole of $1\frac{3}{4}$ in.

In the fire control station, the chartroom and observation station, the holes may eventually be made larger as required for the use of the instruments.

In spite of all possible care in the design of sight-holes, the view from a conning-tower will always be restricted, but it is a matter of experience that this drawback is largely overcome by practice. It is therefore of extreme importance to train the personnel in the use of the conning-tower in time of peace.

5. Access and Communication.

Access to the conning-tower is obtained through the armoured tube, which may be entered either from the central station or through armour doors on main deck and in the chartroom. The chartroom may be entered directly through a door in the rear.

Inside the conning-tower the lift and the steps fitted on the rear wall in the armoured tube serve to connect the different compartments. Above the floor of the ship (fleet) control station, the tube is continued in an open trunk, terminating in the fire control station.

Leads, voice-pipes, ducts for ventilation, etc., are carried along the forward part of the armoured tube.

6. Structural Strength and Weight.

Since the conning-tower projects as an independent structure above the forecastle deck, it will by the movements of the ship and by impact of projectiles be subject to great upsetting and dislocating forces.

The conning-tower should therefore be intimately connected with the decks through which it passes, and its internal structure should possess great strength and stiffness. In the present design, the upper part of this structure consists of deep radial frames (fig. 1b) fitted inside a cylindrical shell of heavy plating, $1\frac{1}{4}$ in. behind 10 in. armour and 1 in. behind 5 in. armour, to which the armour is fixed by means of screws as in French gun turrets. The armour plates to have keys at their edges.

The lower part of the conning-tower, i.e., below the floor of the chartroom (level of boat deck), form the substructure for the conning-tower proper. It is of same general construction and form as the upper part, consisting of a shell of $\frac{3}{4}$ in. plating stiffened by deep radial frames extending down to the protective deck. Special web frames are fitted round the armoured tube, both longitudinally and transversely.

The weight of the conning tower here proposed will be about 500 tons, or probably about 300 tons more than the total weight of conning and signal towers as now fitted in large battleships. This extra load will necessitate an increase in displacement of about 1000 tons if all other qualities of a design are to be preserved.

The addition of a fleet control station, would augment the weight of the conning-tower by about 100 tons.

Concluding Remarks.

It will probably be objected by some that the conning-tower here proposed presents too great a target, but it must be remembered that this target, although large, is probably smaller than that presented by the controlling groups of men and instruments, which in existing ships are scattered inside and outside of conning and signal towers on bridges, superstructures and in tops, and that these stations are in this design much better protected. It will perhaps also be objected that the *weight* is too great, but it has to be considered that an increase of 1,000 tons in a ship of 20,000 tons displacement amounts to only 5 per cent, and that with this small increase the efficiency of the ship as a fighting machine is very materially increased.

Whatever may be said in defence of former apathy in this matter, there is now no excuse for repeating *in new designs* the defects which have been brought out during the recent war. Nor can there be any excuse for not promptly remedying these defects *in existing ships* as far as this is possible, since these are the ships that are to fight the eventual battles of the near future.

Bridges, charthouses, masts, etc., should be reconstructed where necessary in order to isolate the conning-towers; all inflammable materials in the vicinity of the conning-towers should be removed, and as far as conditions of weight and space permit, the conning-towers themselves should be replaced by larger, better protected structures of improved design.

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