§ 1. Technician-history analysis of ship seakeeping

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(Russian original)

Contents

The beginning of XX centuries can be characterized by intensive development of trade navigation, which demanded a great number of new sea vessels, built in conditions of technical revolution. It is epoch of iron shipbuilding development and general transition to operation of independent power installations, epoch described by application of the most comprehensive science technologies into sea practice. An independent shipbuilding science began to engage in realization of all these achievements but unfortunately in time they has weakened connections with real navigation practice

It is known that ancient ships were under construction by navigators and the designing of a new ship was always done, taking into account future mode and area of navigation. It is possible to make the assumption that if the certain design decisions on the hull's form and ship architecture were kept by centuries and were duplicated simultaneously in several countries, it is possible to consider the appropriate ships quite seaworthy or optimum on navigation conditions and good sea practice.

The ancient seafarer-shipbuilders had to give the much greater attention to safety of storm navigating, because rowing paddles are not suitable as movers even at temperate wave roughness, and the squall heavy wind the sail arms become into a source of serious danger. A modern vessel, under condition of maintenance of serviceability of the main engine and steering device, is in a condition to oppose to sea elements capacity of the machines, thus reducing the requirements to storm seaworthiness provided with the form of the hull and superstructures.

The historical evolution of ship architecture is explained by changes in principles of keeping a motion and only partly by condition of shipbuilding technology. Last thesis is convenient for application to analyze seaworthiness of ship's hull from the most ancient times till the beginning of XX centuries. In naval architecture of modern vessels or ships of identical purpose, we can find essential differences in their form of the hull and superstructures, therefore there is interesting realization of the comparative analysis of seaworthy qualities caused by contours of the hull and architecture of superstructures. The urgency of such question is connected with fast changes of ideas about the best form of the hull last decades, but for this period there were no changes in principles of maintenance of seaworthiness or in a way of movement maintenance.

- *What did the modern evolution of the hull's form of a vessel cause?*
- *Are the seaworthy qualities of the naval ships of the Second Pacific Squadron of admiral Rozhdestvensky's better than modern ships of the same displacement?*
- *Is ocean navigation onboard the liner "United States" is more comfortable and safe than on the liner "Konstantin Simonov", built in 1982?*

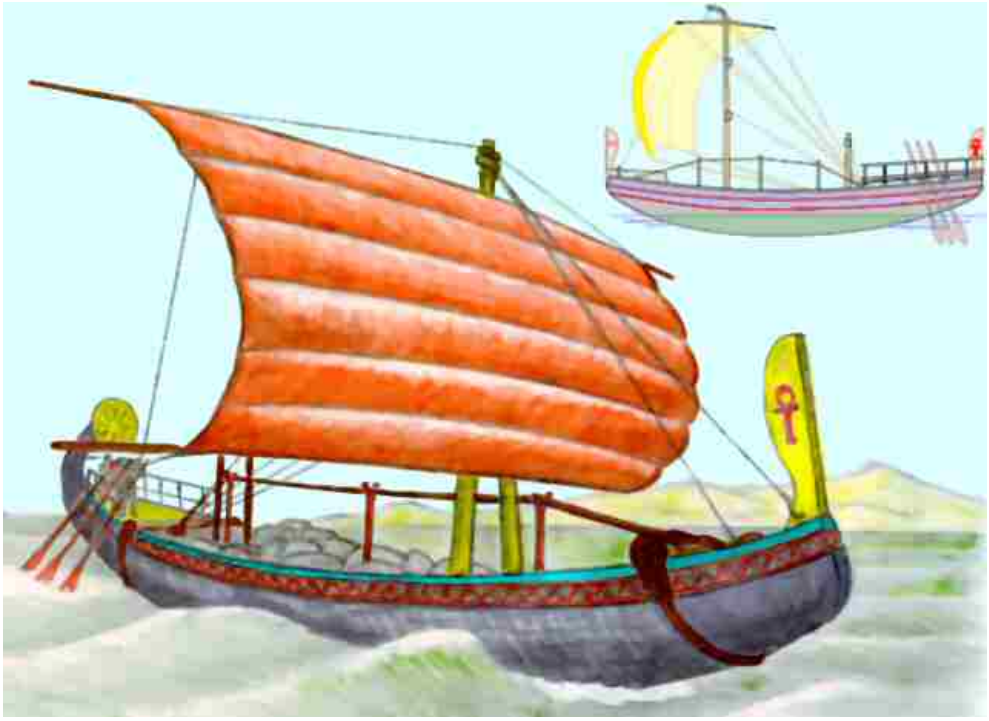
We can suppose, that the coherent history of development of representations about the most seaworthy ship was determined by practical experience of navigating, which was formalized in system heuristic and, apparently, unwritten rules. These rules have lost determining significance with arrival to practical designing of the "professional engineer's generation" - which not familiar with practical navigation. This boundary is marked by appearance and triumph of the project of a destroyer of the type of "Novik". In that period the aspiration to the maximal saturation of the ship by the weapon has prevailed over care of good navigation.

Thomas Gillmer said [Gillmer C. Thomas, 1984]: "Ships designing is frequently considered as an art...", he continues: "...The significance of it as an art is underestimated by those designers whose imagination and creative idea is limited...". We think that at designing ship contours this will be urgent till the appearance of computing optimization methods which are taking into account not only salability of the ship on calm water, but also all complex of questions of storm navigation on the rough surface of the sea. In present moment there are no appropriate optimal decisions in problem of salability and navigation. There are no such decisions and

for verifications of accounts under the given form of the hull, and not only in case of navigation on rough and even on calm water.

1.1 Ancient engineering decisions on seaworthiness of a vessel

Chronologically connected history of shipbuilding begins from Egyptian papyrus boats dated 5000-3000гг BC. But Egypt of those times was not glorified by voyages, its fleet intended for navigation on Nile, and from the hull of vessels in the greater degree the convenience was required at the approach to a flat coast, than maintenance of navigation on the rough sea. I think that the choice of the specific form of the hull, with the almost flat bottom and smooth rises of stems is connected with absence of the comfortable ports and trigger stocks in Egypt. It could be explained by often changes of Nile's high water.



Pic.1. Egyptian papyrus vessel
The hull of a vessel is well adapted for river sailing, with the often approaches to the non-equipped flat coast.

Pharaoh Neho (612-576гг. up to AD) is known as a man who addressed to services of Phoenicians to organize foreign trade and navigation, which state was on a rich wood territory of modern Lebanon and Syria. Flourish of shipbuilding and sea glory Phoenicia continued from 1200-700 up to AD.

It were of large trade vessel with decks, under the form of the hull and seaworthy qualities similar on Viking's boats, and also navy ships with bulbous bow (not only ram) and even, two banks of oars. They can be judged as the great seafarers because Phoenicians had colonies on all coast of the Mediterranean Sea and they were known far outside Gibraltar strait, including English Islands and even behind cape of Kind Hope. [Kurti O., 1977].

The sea glory Phoenicians shows a good seaworthiness of their trade vessels. The principles of designing of the form of the hull of such vessels longly were kept in boats of Vikings. For the analysis of experience of storm navigation it is possible will address to practice of use of self-made wooden boats, which confidently go on the roughed surface of Volga reservoirs, keeping a course "along to a wave".

Pic.2. Phoenician's sea trade vessel
Similarly to vessels of Vikings, such vessel is in a condition and can be kept along to a storm wave. In this mode of navigation the pitching is dumping by disorder of frames in extremities, and large cross stability of the hull allows to trace surfaces of a wave, than is provided non sweep of deck.

The hull of these vessels is most vivid example of adaptability to properties of wind roughness. Here shipbuilders pursue the purpose of minimization of power interaction of the hull with roughness, stipulating maintenance of non-sweeping of a deck.

Storm navigating along of sea wave

The basic features of contours of the hull, which provided storm non sweep of the top deck are following:

- *Lowsurface board that is not perceiving careening pressure of a wind, and wide hull ensuring good rolling stability;*
- *Rounding form of a middle ship frames provides abrupt branches of static rolling stability diagram, and in aggregate with a lowcenter of gravity allows the hull easily to be kept on an inclined surface of a wave. It is necessary for maintenance non-sweeping of the middle top deck;*
- *The narrowed and high V-figurative frames near of stem and astern promote dumping of pitching. During pitching these frame pushes the water aside, creating dynamic conditions non sweeping on the bowand back decks;*
- *The vessel is made symmetric concerning a bowand stern, that is a main condition of non-resistance of sea wave phenomena. For keeping of a rate along of wave (i.e. along wave fronts - when the hull do not cross-wave ridges), it appear by sufficient effort of oarsmen on oars. If strengthening of roughness and loss of a speed, only one of helmsman's steering oar can perform this work.*

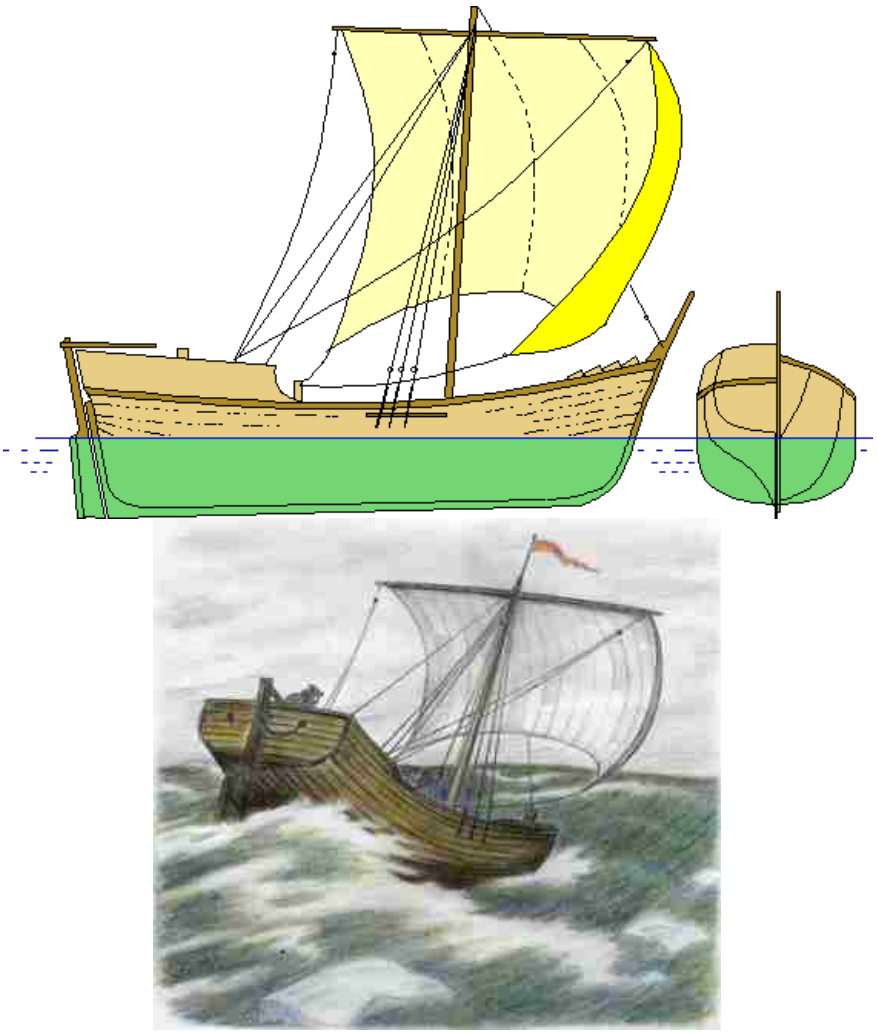
Such form of the hull well uses properties of wind excitement at small length of dispersal of free waves. (The long storm at ocean derivatives excitement in the form of a superposition of swell waves and active young wind waves, that from positions of the helmsman, makes the unpredictable approach of a wave to the hull and complicates maneuvering with the purpose of evasion from a wave). Group character of wind excitement causes occurrence large "crest of the tenth wave", which always have precisely expressed longitudinal lie stretching, and on dynamic properties these waves are similar to standing waves, that is the top of the wave does not carry on the hull of a vessel breaking surge of a flow. It is necessary for helmsman to see to the hull of a vessel to be kept by along to a wave, further vessel freely heels, keeping a deck parallel of wave surface. Non-sweep of deck in this mode of navigation is provided, even if height "of the tenth wave" in some times exceeds height of the hull of a vessel (or river boat). It is a fascinating and beautiful navigation, when it is visible on the part as the vessel is completely immersed in abyss, then for an instant appears at top of a wave perfectly safe!

But the seaworthiness of such vessel is not boundless, and in case of infringement of character of rolling at the expense of unguided turn of a vessel, or at strengthening storm, the first pernicious wave gets to the hull in area of a forepeak or stem bowl.

Active storm sailing with before wind course

New - daring storm navigating has come on fleet with introduction of sailing arms. It is a storm course on a down wave, which can be used by modern sports yachts. As ancient analogues of such sailing vessels were Arabian sailing vessels, Chinese sailing ones and fishing vessels of Russian north coast-dweller. Such navigation modes are proved by strengthening of northern wind in the Barents Sea, for example, it is necessary for fishermen to move to a coast and to be covered in coastal skerries. It is necessary also therefore

[Badigin K.S., 1956] their vessels are adapted for fishing and sailing in ice, but cannot sustain real northern storm, and have not sufficient autonomy for long navigation in ice fields in northern part of the Barents Sea.



Pic.3. Fishing vessel of Russian coast-dwellers
The sample of the hull admitting active maneuvering in the storm sea, that is necessary for a leaving (care) in shelter from real storm danger. Thus the contours of the hull take into account features of storm navigation on a wave, under the control of storm sails and stern rudder.

The vessel should have complete aft contours, with deeply put of a rudder blade. Thus the surface part of stern should not hang above water, that is necessary for exception of capture of the hull by a quickly driven crest of a passing wave. The rudder is desirable for having deep rudder so, that its blade was at a level of a sole of a wave, as the flowof water in a crest is gone in a passing direction and even faster than self vessel going.

The storm sail should provide moving of the center of sails in a bow, that in aggregate with complete stern and streamline by bowcontours will make possible deduction of a rate on a wave and on a wind. Here, the bowextremity should not have pointed and keel bottom, as last will move the center of dynamic board resistance to a bowand by that to break stability on a storm course.

As against Phoenician vessel, such hull demands continuous and active management of a movement with the help of a stern aft rudder. In case the hull nevertheless is grasped and is put along of sea waves to deduce (remove) a vessel on an initial rate it is possible only with the help of management of a sail, as the vessel at once loses a course.

Certainly sweeping at such mode of navigation is not excluded, but the destructive force of a passing wave is weakened by a course of a vessel forward and consequently water on a deck does not represent serious difficulties on management of a rudder and sail.

Considered above two such as the hull represent two projects, in which: the first vessel is best for navigation on the oars, second for navigation under sails. Both hulls were kept about our days: first is used at manufacturing saving boats and tows; second - at manufacturing sports yachts and again - tows of the salvers - if to take in attention architecture of superstructures. It is of good small vessels (boats), which are capable to keep activity (course and maneuvering) at a movement in conditions of amplifying storm excitement. But it is modes of navigation, in which the hull of a vessel is exposed to large overloads caused by storm rolling, therefore contours of such hulls cannot be used at designing large vessels, for two reasons:

- *Limited safety of storm navigation - as at increasing of storm waves, unpredictability of occurrence of waves and swell near to the hull will exceed experience and art of the helmsman, or energy of waves and wind will exceed opportunities of crewon management of sailing arms;*
- *Such is natural that a vessel, if necessary of maintenance of a course and maneuvering, will assume an intensive exchange*

of energy between the hull and storm waves. It is inadmissible for a large vessel, because the proportional increase strength of the hull is not sold, also, and for technical reasons.

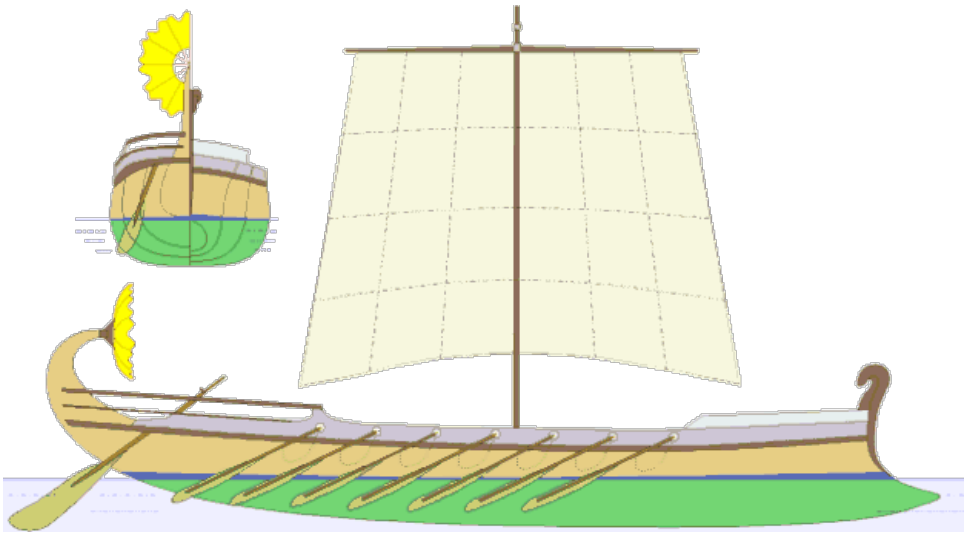
Here it is necessary to recollect that, both demand the project large initial static rolling stability, that is reached at the expense of essential increase of the area of the top deck and as the consequence conducts to destructive wave of storm water on this deck.

And again, addressing to Phoenicia, we find the third decision - as a prototype of the future all-weather ship. It is the ancient navy ship - galley.

Storm sailing into the wind and bow waves

As against trade vessels, the navy ships of Phoenicians were not symmetric as the middle-ship frame. One-sided opinion is that bulbous bow of galley carry out a role only of battle ram and such device complicates maneuvering very much but this fact is not taken in account. If speak about maneuvering and reduction of wave resistance then bulbous bow exert its negative influence on the motion speed of galley by increasing of the moistened surface of the hull. Bulb also prevents normal navigation with the sails because of displacement of lateral resistance center of the hull to a bow, it makes the ship very unstable on a course. This device can be determined as the revolutionary decision in shipbuilding and It cancelled the major property for ships of coastal navigation are an opportunity of the approach to a flat coast. So - Phoenician military fleet was under construction for long sea voyages, which corresponded to colonial policy of this country.

Let's recollect, that it is difficult to cope with oars of the small boat on the roughness sea and the conclusion is that galley should be adapted to safe storm navigation without a speed.



Pic.4. Ancient navy ship
The "ship of Argonautes " is represented " which has inherited seaworthy qualities of Phoenician warships. Such asymmetric hull concerning to middle-ship frame allows to keep a course of storm navigation by a bowon a wave.

Let it will be storm navigation without a going course and with keeping of a course by a bow on a wave, in the teeth of the wind. Features of the form of the hull ensuring such mode are:

- *Infringement of symmetry of the hull, concerning a middle ship frame with significant displacement of the center of size and center of board resistance in a bowof hull. Established with this purpose bulb favorably has a favorable effect for movement stability on roughness and stabilization of pitching. Thus the dynamic center of pitching about yawis close to stem;*
- *The smooth rise of the bottom in stern and hanging over stern extremity high above water liberate yaw. It is possible to explain necessity of use just of the helmsman oars, which can execute a role very effective at maneuvering of fin (flipper) mover and, perhaps, unique mover in fresh weather, direction of the appendix of force at such mover, besides, can be any.*
- *The displacement of the center of sail surface at the expense of an aft superstructure and volumetric stern figures also serves as a good means for use of wind force at putting of the ship by a bowon a wave. Here also pertinently to pay attention to a lowbowdeck is means, that the seafarers were not afraid of hit of water on a deck through stem. Curious details of the hull are, also, galun and forecastle, which are capable to destroy solidity of front falling on a bowdeck of a wave.*

Such galleys existed up to the new era. Greek and Roman shipbuilders built them.

On an example of three above-stated projects of the ancient ships and vessels, all engineering decisions, known in shipbuilding for maintenance of the given seaworthiness of the hull were shown almost.

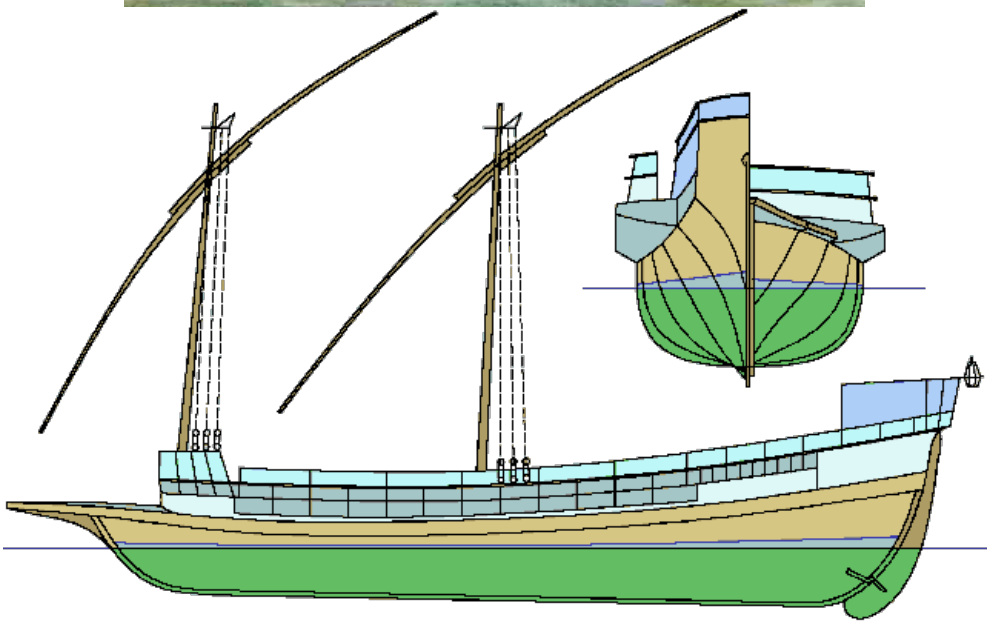
1.2 Medieval shipbuilding

Roman shipbuilding has achieved the flourish in 30th years up to AD. During some centuries Rome had not contenders in the Mediterranean Sea.

For protection of trade vessels against pirates, Saxon in north, and Illirian in the south, were created easy and high-speed sailing-oar ships, - librunes. Librune is considered to be the prototype of Mediterranean galleys, existed up to XVIII centuries. The purpose of this project put achievement of the maximal speed, and as a consequence new operational requirement force seriously to reconsider the

conception of seaworthiness and safety of navigation.

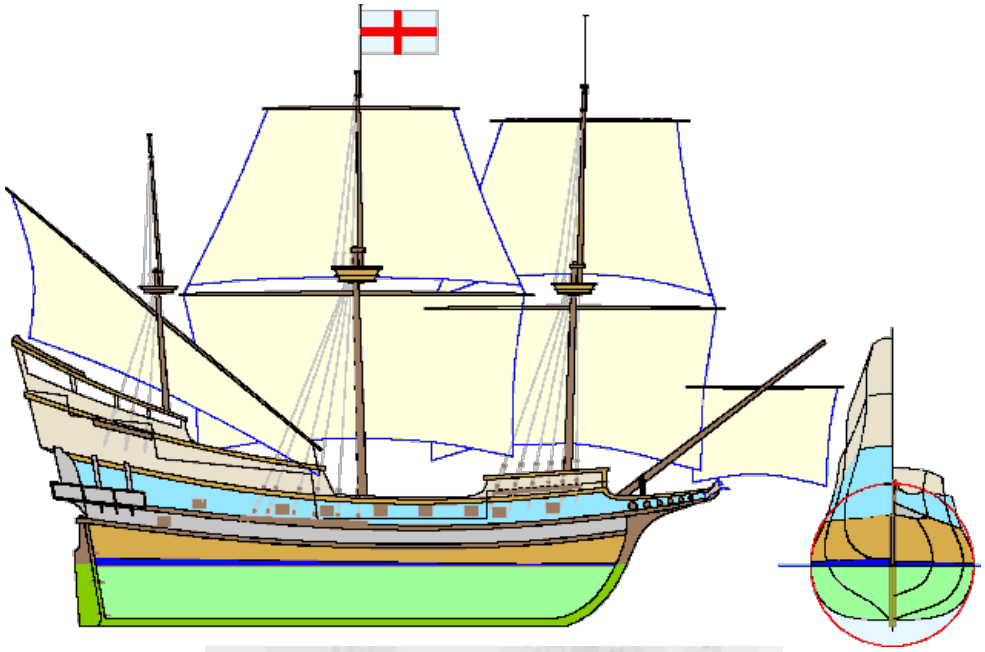
- *On Mediterranean galley bulb is already not present, as it obviously, did not maintain test on propulsive quality and maneuverability of ship.*
- *In bowpart of the hull the large completeness of contours is kept, and is being made larger galune, as the absence of bulb essentially reduces stabilization of bowextremity on counter roughness and results in increase wave sweeping.*
- *Nevertheless, the ship builders reduce height of a bowdeck and essentially increase sail surface of quarterdeck and the aft superstructure. Thus, the opportunity of storming by a bowon a wave is kept*
- *Trim the hull by the stern, installation of sternpost and small completeness of concave branches of stern frames, allowto result the center of board resistance of the hull on one vertical with the center of sail surface of Latin sails. It is necessary for achievement of stability in a movement under sails, and also makes effective work of stern rudder.*



Pic.5. Mediterranean galley

In architecture of the given ship the requirement of the maximal speed is realized. This newquality reduces safety of storm navigation. But for Mediterranean galley the maintenance of storm navigation is not the determining requirement, as it is intended for coastal navigation with small autonomy.

During 15 centuries shipbuilders basically, adhered to the above-described design decisions concerning contours of the hull. Actually, for this time the essential changes can be noted only in a design of sailing arms. In my opinion, approach of epoch of great opening - the XVth century, can be again characterized by construction of the ships in the best way adapted to long ocean navigation under sails. Taking into account the small tonnage of the ships Coulomb and Magellan, it is necessary to recognize true perfection of a ship science of that time, to note a harmonically in a combination of the architectural and fluid-mechanics decisions; and also accuracy in laying-out of sailing arms and its complete conformity to features of hydrodynamics of the hull in conditions of navigation on roughness.



Pic.6. Galleon "Golden Hint"
The ideal ship for ocean navigation. The storm modes of navigation are provided with the extremely special form of the hull. At strengthening of a storm wind, the crewtakes in all sails, and the vessel similarly to a weather vane leaves by a bowon a wave.

Certainly, the crew of these small vessels cannot completely rely on active use of sailing arms in an opposition with storm elements. Therefore determining role in maintenance of safe navigation again is played with the special form of the hull, where the contours and surface architecture provide a mode of the minimal interaction with energy of the storm sea. Again we shall formulate main components of the design decisions for medieval caravels and galleons. Let's note just, the design decisions can be submitted of rather figurative logic basis, where in time - existence and space - phenomenon the design decisions on the form of the ship hull will be analyzed.

1. The time - here is a science of management of the ship in various conditions of operation;
2. Space - or ability of active existence of the ship in the given physical environment;
3. Project - or engineering decisions incorporated in a design of the ship with the purpose of maintenance of its basic applicability.

Probably for the historical analysis of a particular class of vessels, the application of figurative basis looks little bit artificial. But this matrix can explain a variety of the design decisions accepted by shipbuilders of the various countries, especially if to accept in consideration the basic applicability (3) and condition of navigation (2) fleet of the particular country.

The ship interesting for us was under construction in the countries of Europe having coast of Atlantic Ocean. So, accepting the purpose of designing an opportunity beyond all bounds - long ocean navigation, we formulate the new thesises:

- *The advanced aft superstructure displaces the center of sail surface to aft, and large width and completeness of bowframes replaces a center of gravity and center of displacement in the bowpart of the hull. Thus, on a wind the hull behaves similarly to "weather vane", providing storming by a bowon a wave without a going;*
- *Equipment of sternpost and small completeness of stern frames has allowed putting the center of board hydrodynamic*

resistance on one vertical with the center of sails. It is necessary for achievement of a steady movement under sails, and also raises an overall performance stern blade of a rudder;

- *For achievement stability the ratio of length of the hull to width (L/B - 3-4) considerably decreases. Nevertheless, for the sailing ship there is no necessity in wide and continuous on length to a deck. Use the push-off-waves boards and the division of a deck by superstructures, rising in an aft, excludes hit on a deck large on weight of amount of water, providing preservation storm stability. The same inside tilt of boards reduces risk of sweep of a deck at a course of the ship under sails and with a large rolling, and reduces forces of yaw, as the hull gets vertical symmetry of a rather longitudinal axis which is taking place along a waterline;*
- *If at a sight in a stern part, medieval ship is soaring above water, allowing a wind to twist it without the special efforts, the bow part of the hull sees heavy and deeply pressed in water. As against the modern ships - the bowof ancient sailer is very low- that shipbuilders of those times did not care at all about non-sweeping on going bowto waves. The unique protection is bowsprit, bowcastle and galun, which by first perceive a counter wave and deform its front, a little not allowing concentrating impact on bowdeck.*

1.3 Prime of sailing fleet and evolutionary transition to a mechanical movement

Russian fleet formed under influence of Dutch ship school, in a period of flourish of European sailing navigation. Even the first ships of Peter the First had not the any more not advanced aft superstructure and were enough high-sided in bow part ("Orel", " Peter and Paul ").

In XVIII century the sailing arms reaches absolute perfection, already there is no necessity to solve a task of safe storm navigation only by designing the special form of the hull. For an opposition to a storm wind the sailing arms is actively used. The seafarers also need maintenance of the given rate and maximal speed of a course even in conditions of a storm wind, when small displacement caravels for a long time send to a storming mode without a speed. The deck of the sailing ship straightening, also becomes continuous and even almost horizontal (frigate "Pallada"). For improvement of a maneuverability various slanting sailing arms now is widely used, yard of direct sails are extended for installation Studding-sails, and in storm weather are exposed or special storm sails, or is used reeves for reduction of the area of the basic sails.

Well and, if the force of hurricane exceeds opportunities of crew on management of sails, there is a radical emergency means: a fore-mast - for a board, as a floating anchor, that transforms storming high-speed sailer in its historical prototype with sails, displaced in an aft, at the expense of the stayed mast and bow, pressed to water by force of a towed mast. Unfortunately, modern vessel with the mechanical engine have not similar emergency means, thus it is obvious, that the main engine and especially steering machine in storm weather work with large overloads.

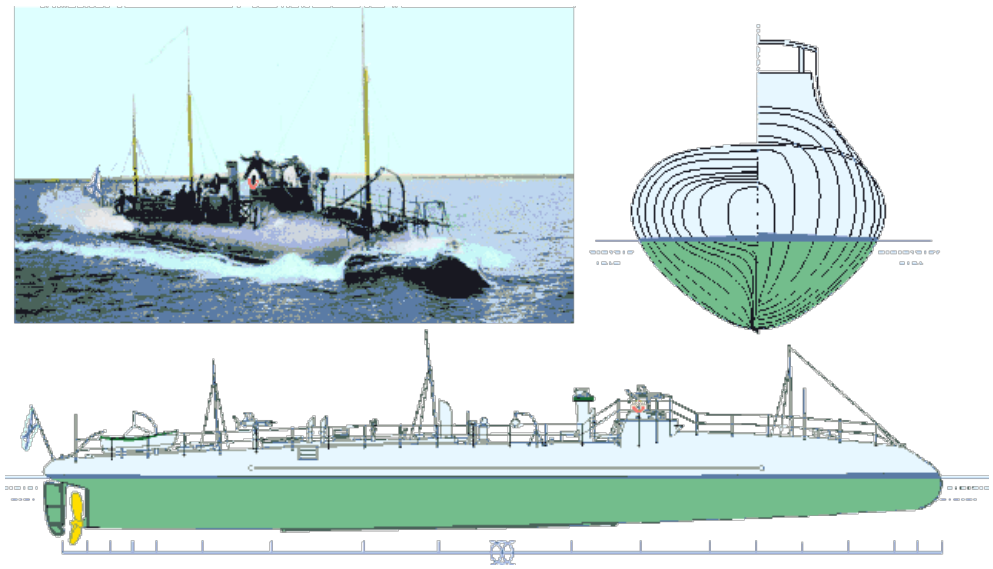
The beginning XIX centuries is marked by construction of the first vessels with steam machines. In 1815 the first wheel steamship in Russia was constructed which St. Petersburg - Kronstadt went on a line. In 1819 "Savanna" has made transition through Atlantic from New York in Liverpool for 24 days.

The mechanical drive enables of significant increase of seaworthy qualities of the ship, as now it can support a course and to keep an any speed concerning a wind.

The wheel steamships had all lacks oar vessel:

- *Wide deck;*
- *Vulnerability of a rowing wheel;*
- *Impossibility of an opposition to storm excitement.*

The first large vessel equipped with rowing screw: ***Great Britain*** was constructed in 1843. Subsequent 50 years the form of the hull of the high-speed all-weather ship undergoes consecutive evolutionary changes, which always took into account the best properties of the form of the hull rowing and sailing ships.



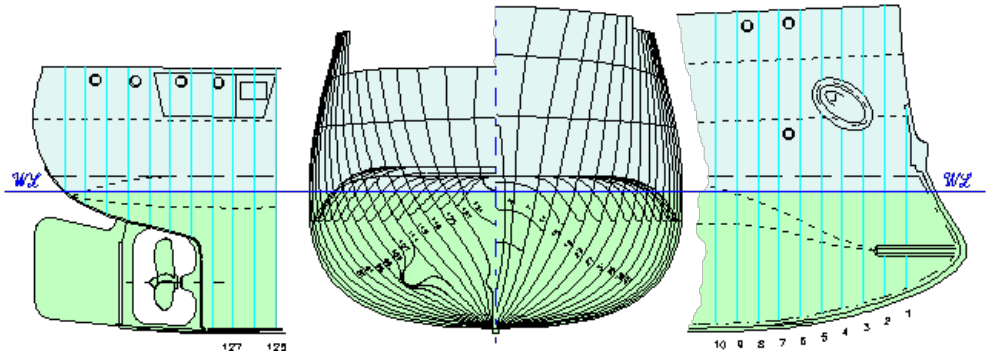
Pic.7. Destroyer of type "Izmail"

The ship used a storm course in a mode " cut through" of waves. It is know, that in 1887 there were the seakeeping experiment for destroyer on 6 ball roughness, where went towards to a wave and burying (going too far) on running cabin, showed 15.5 units, and 17 units at a course on a wave [9]. According for the theoretical drawing it is clear that the bowhas not property climb on a wave, at the same time - disorder of frames in area of count, it provides pressing of the hull to a surface of a wave on the ship motion. Last is necessary for stabilization of work of rowing screws in conditions of large roughness.

It is doubtless, that in contours of the ship constructed in the beginning of century is possible to read of the conciliatory proposals between submission and an opposition before sea phenomena:

- *Bulbous bowhas continued to serve for stabilization of the hull and preservation of stability on a course in conditions of roughnesst. Especially it is important for high speed of a motion, in comparison with galley with oars, this bulb favorably has an effect for reduction of wave resistance on calm water;*
- *Sharpening of extremities and small completeness of surface volumes in a bowand aft promote fastness on roughness and favorably have an effect for reduction of pitching and prevention of slamming;*
- *The narrowhulls of the ships are under construction for achievement of high speed of motion as Mediterranean galleys are;*
- *Narrowed width of a deck serves to the purposes of preservation storm stability in the sweeps conditions. The inside tilt of boards also reduces yawduring rolling that provides preservation of the given course and speed in conditions of storm roughness.*
- *Rather lowboard and small sails surface of superstructures gives the possibility to conduct the ship even in conditions of strong winds.*

Ideal architecture of the hull by all named criteria had cruisers and destroyers constructed at the end of XIX is beginning XX centuries. Not smaller seaworthiness had linear ships of that time, which had low and pointed a bow and quarter-deck, which basic surface volumes were going in an average part of the hull. It provided a steady movement on roughness in conditions increased sweeps of extremities.



Pic.8. Cruiser "Aurora"

Cruiser Aurora have international form of hull, and your seakeeping quality is very similar to above mentioned destroyer. Their essence is non-resistance of storm phenomena. The inside tilt of boards and absence of the large continuous areas on the top deck is well seen. There is obvious technological complexity of the hull, in contours of which there is no direct line. It is interesting howin those times people would project the hull of the ship, if the internal volumes were not determined. The seaworthy qualities similar to contours cumbrousity of ship engines are realized in the hull of a cruiser?

The special requirements of propulsive quality of ship at storm ocean to transport steam vessels were no made because of cumbrousity and low power of the main engine. The vessel had pointed vertical stem and rounded hanging above water to an aft. In case of storm weather the vessel should take a course by a bow to a wave and to be kept on it with the help of engines before improvement of weather.

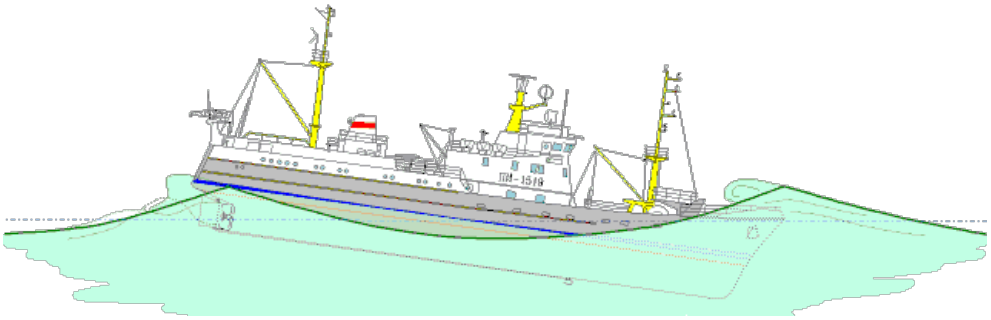
1.4 About the modern project decisions

At the 1st of August of 1910, on the basis of the competitive project, was incorporated destroyer "Novik", the hull form of which has received the broadest distribution in soviet shipbuilding, and unfortunately some negative elements of the form of the hull are excessively amplified nowadays.

"Novik" is under construction with a high and long bow deck, that has allowed to improve non-sweeping at navigation in the Baltic sea (more precisely in a Finnish gulf), and at the expense of increase of surface volumes of the hull, onboard a destroyer the unprecedented quantity of the various weapon was established.

Unfortunately, it is necessary to mark and other achievement of modern "independent ship science". In the beginning of XX centuries transport vessel were equipped by hold hatch with a sailcloth closings. The danger for storming was represented as a result of failure of such closing by wave flood on a deck. This problem successfully was solved by creation metal self-opening hatches of type "Mark-Gregory".

The same task had been solved independently by the scientists from independent shipbuilder's designers, by supplying with good capacity of the hull on a wave. Stem of a vessel or ship now has become inclined forward, and above it the wide deck of a bow settles down, that has by a consequence large aliform disorder of bow frames. Wide transom stern is easily picked up by a wave, aggravating the rolling and yawing.



Pic.9. Trawler on slowest ahead, fidgety helm and waves on bow deck
This mode is only allowable for storming for this fishing vessel, as the movement is impossible for a counter wave because of impacts of waves on spreading bowboards. Trawler supports a course necessary for preservation maneuvering, it strengthens destructive force of a wave, falling on a bowdeck. In the following moment of time between a high bowdeck and superstructure the lake of meter depth will be formed, the vessel loses stability and fast heeling dumps this lake through the deck board. Wide transom stern is slamming and the heaviest pitching an course up or down wave is always, but "the sea wolves" should love to give here course down a waves (it's need only strength of hull).

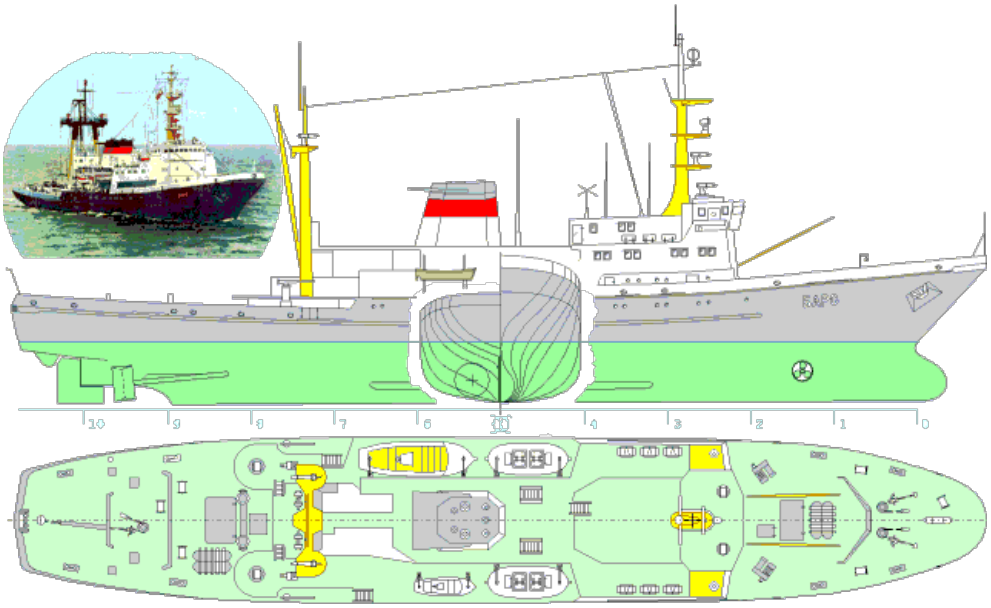
Unfortunately, the achievement good ascend to peak of wave has resulted in necessity of longitudinal durability strengthening of the hull (hulls of crisis of hulls squadron destroyers) here mean. My supervisions during storm running watches persuaded, that the task of maintenance non sweeping was solved to within on the contrary, because as a result of pitching strengthening the vertical acceleration in bow hold sometimes exceeded acceleration of free fall g, and the vessel, falling with a crest of one wave accepted on the wide deck a new wave in the most destructive phase.

The ship owners, certainly, have reacted by interdictions of navigation in storm weather, organizing a service of the storm warnings. The captains now frequently use a new way of storming: to a counter wave is means a movement minimally by possible course, with a course of corner approximately 30 degrees from a passer to a wave. Such navigation is accompanied by very strong overloads of the main engine and steering machine, as for deduction of the minimal course it is necessary to change loading for the main engine and it is not seldom that hulls expose up surface water the screw, in this mode of navigation of the helmsman frequently helm put out not less than from a board aboard.

Storming on close the wind and wave course is the combined method, in which the deviation from a rate «by a bow on a wave», allows the hull partially to trace a wave surface - keeping a mode of active navigation, at which by the helmsman does not give back a vessel completely in authority of a wave. But also this method of navigation was cancelled as a result of installation of bulbous bow, - because as a result of fluid-dynamic inertia of a bulbous stem, on this rate can be received the heaviest impact of a wave on a on spreading bow boards.

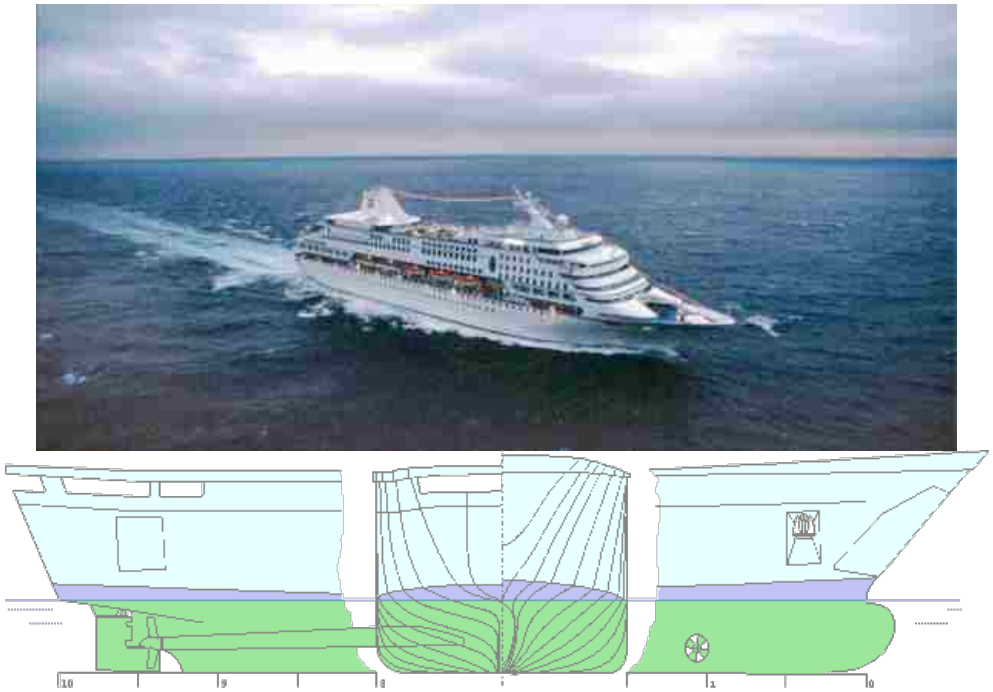
Impacts on a bow board are a new kind of slamming, dynamic interaction, caused by strengthening of the hull and roughness. If trawler, for example, following a storm ahead by a bow on a wave, will exceed slightly speed, the impacts of a wave attack on the bow deck will be received. In the basic course of trawler sailing - sample of trawl on a course down-wave, even in case of moderate excitement it is possible regularly to feel impacts of slamming under wide transom stern, which, besides, are accompanied by longitudinal vibration of the hull.

Main feature of fishing vessels is the necessity of work of crew on the top deck, in storm weather including. In this hull, the achievement non-sweeping of a bow deck, which has by a consequence increasing all kinds of rolling and pitching, comes in the obvious contradiction with a safety of work on the aft trawl deck.



Pic.10. Oceanic salvage ship and passenger liner

From the historical analysis these ships can be compared with coast-dweller's boats (pic.3) and boats of Vikings (pic.2) if to exclude a ratio of durability and sizes of the hull. Their hull configuration are justified for small vessels, which are capable to be kept on a surface of a wave despite of huge acceleration in process of tossing (theoretically is g on a crest of the tenth wave), and before which the task of preservation of a course, serviceability of the equipment, inhabitable, comfortable, etc is not put. It is necessary to hope, that such form of the hull is top of absurdities of struggle for non sweeping of the top deck.



Huge surface volume in bowpart of the hull should cause navigation with free yawon a course, but it does not admit by bulb. The wide aft deck essentially limits opportunities of a choice of a storm rate. As a whole the storm safety contacts to reliability of engines and experience of helm's watch. To me is thought, that here not good sea practice, and fashionable industrial art with set architectural direct, and half-sleepy associations of rest on river speed-boat participated in designing the ship hull.

But nevertheless stabilization of the hull especially is important for the ships with hydro-acoustic and radar-tracking equipment. For example: the English destroyer "Sheffield" has the hull steadier on excitement, than any of the Russian ships of the same class. As is known, during storm, "Sheffield" has appeared defenseless even in front of the out-of-date air rocket weapon.

The research of seaworthy qualities of modern fleet is separate and very interesting task. Unfortunately, till now, in Russia is not adjusted of constant interaction of a shipbuilding science with captain's experience of real navigation. The materials about seaworthiness available in watch books of 2-nd Pacific squadron are not published the experience of naval on the tests mile is not taken into account which in the beginning of XX century, were carried even in conditions of storm excitement. My attempts of use of a richest material from a watch books of ship, nor have enough for bureaucrat time waiting.

It is necessary to base on own sea experience, on slang of coastal meetings with messmate on Navigation College, yes on an art narration of the captains-writers. The upper deck - emotional, critical perception of modern art of designing of the form of the hull turns out. The ship is a complex, but uniform system. If at its designing there is a necessity to strengthen one of the requirements to seaworthiness, from this should not follow of an absurd consequence, which, if it is not keel seaworthiness quality, that, at least, removes a urgency of the requirement - reason. Just it has taken place as a result of irrepressible desire will cope with non-sweeping of a bow deck.

1.5 Preliminary offers to ship architecture designing

The designing of the ship, as engineering structure, should provide a combination of properties of non-resistance of elements with opportunities of active management of a vessel in the storm sea, according to its assignment.

Let's make attempt to formulate the basic requirements to seaworthy qualities of a vessel and on their basis to construct hypothetical model of the form of the hull and of common-ship architecture:

- *For the Navy ships, research and fishing vessels are necessary:*
    a. *Stabilization of the hull (as platforms for the equipment);*
    b. *The maintenance of an active movement in any weather conditions (means the given course and speed);*
- *Of vessel of a saving and patrol service should have an opportunity not only to move, but also actively to maneuver in any weather conditions;*
- *If to a transport vessel the requirement all-weather is not showed, the maintenance of an effective course on large excitement is purely economic requirement. The preservation of a course as is necessary for evasion or detour of cyclones, under the storm warnings.*

- *Certainly, it is important for everything, and for passenger and fish-processing vessels it is important as well on ethical norms (here there are no problems with maintenance of high speed of transportation of cargoes, with maintenance of battle-worthy). This requirement of safety of storm navigation without a course, which should be supplied with designing of the special form of the hull and superstructures.*

Really it is three interdependent of a problem:

1. Propulsive quality of ship;
2. Stabilization of the hull;
3. Safety of navigation,

which should be solved with reference to real navigation, including in conditions of storm excitement. Following the above described design decisions received from the historical analysis of properties of ship architecture, in the prospective project of the new ship the following 6 interdependency rules should be included:

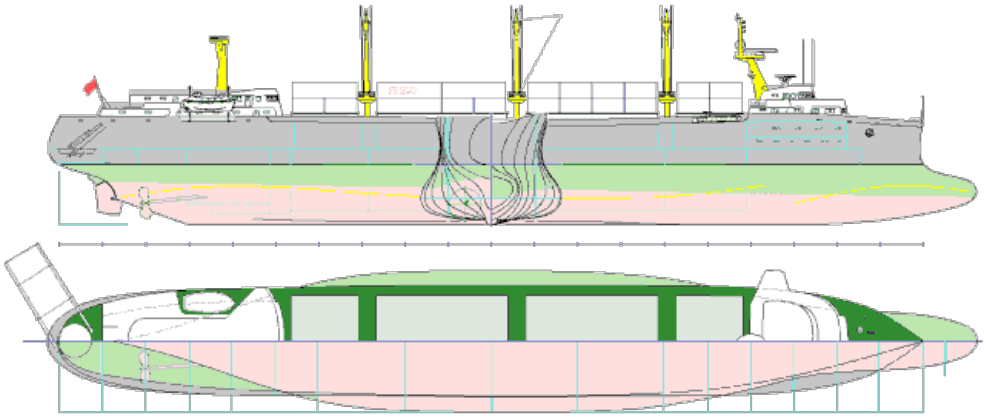
1. Displacement of the center of size in a bow, before reduction on one vertical or even advancing of the dynamic center of lateral resistance. It will provide stabilization of tossing at a movement on excitement, and without a course will create the preconditions for safe storming;
2. Essential reduction of the area, and also cross and longitudinal moments of inertia of a waterline surface, and sharpening of stem and stern posts it in extremities. For reduction of power(force) influence of moderate excitement and preservation of fastness in conditions of real ocean navigation;
3. Exception of boards flares, wide and continuous top deck (and also inclination forward of surface part stem). During storm navigation it will remove a problem of excessive tossing and impacts of waves both on the hull, and on a deck, and also will create conditions for active management of a course of a vessel;
4. Essential reduction of volumes of the hull in extremities. If the surface center of sails surface to adduce in an average part of the hull, it will improve storm maneuvering if to supply a inside tilt of a board at a level of a working waterline, it stabilizes a course on excitement without strengthening of pitching and yaw, as the hull will pass in a mode "cut throw" of waves;
5. Last does not contradict carry of the basic surface volumes to a stern part of the hull (certainly, without formation wide transom and flat stern-part of hull), by a rule: the bow is loaded in a underwater part, and aft volume hangs above water, including behind a stern perpendicular. Thus, the requirements of safe storming will be executed. Such decision takes into account properties of real storm roughness and does not work in conditions of unpredictability of wave creating at the center of a cyclone, but also does not prevent preservation of a course and maneuvering, because accelerated by mover the flow "presses" stern-part to a surface of a wave.

Essential reduction of wind sails surface and height of superstructures, with carry of the appropriate cabins and rooms inside of the fluid-mechanics reasonable hull. It already good sea sign: "the Beauty of the ship is defined by absence on board of unnecessary things". Restrictions on a choice of a storm course caused sweeping in passing are removed; and also the problem of a wind roll and as a consequence is solved, at the expense of reduction initial metacentric height, the hull can become passive in relation to heel to influence of waves; and certainly is the basic and unique(sole) decision of a task on struggle with an icing.

Is thought that the specified rules do not contradict other seaworthy qualities, as that:

- *Propulsive quality of ship on quiet water caused by bulbous bowcontours and rounded frames, containing greatest volume in the minimal surface of the ship plating;*
- *The exception of separation of a boundary layer in area of a rudder and movers is reached by smoothness of the longitudinal forming form of the hull;*
- *The passableness in ice can be achieved in a mode "break under" of ice from below, that also solves a problem of ice protection of movers.*

In the described rules mention a inside tilt of a board in area of a working waterline (4). It is a new element of the form of the hull removed from a principle non-resistance of sea elements. Most likely, shipbuilders of the last century widely would use such inside tilt of a board at hulls of warships, if the form middle ship frame was not determined by cumbrous of steam machines used in that time as main engines.



Pic.11. Draft of universal vessel

In the project of a universal vessel is shown, that the realization of the form of the hull satisfying to all set forth above requirements to seaworthiness, is possible even for the most complex universal vessel.

With the help of calculations under the Mitchell's formulas it is possible to show, that bulbous bow has an effect for decrease of wave resistance on relative speed: Fn=0.3, the inside tilt of a board at a level of a working waterline reduces wave resistance on critical speed: Fn=0.5. If to take advantage of the reference of strong influence, it is possible to tell: if the hull of the ship in a movement on various speeds radiates large ship waves, this hull will be subject t strong influence on the part of free sea waves, driven him(it). Such assumption is possible to take for a basis at a choice of the optimum form of the hull from a series of tests or calculations of wave resistance.