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WILLIAM HOVGAARD

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A Biographical Memoir by

WILLIAM FRANCIS GIBBS

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WILLIAM HOVGAARD was one of the foremost authorities on ship design in his generation, especially on the general and structural design of warships. His contribution to the shipbuilding art in this country, and particularly to the education of the officers of the Corps of Naval Constructors of the United States Navy, is incalculable. The scope and method of his teaching were such as to have constituted substantially the creation of a new art, and the breadth and depth of his intellectual interests stamped him as a man of genius.

His interest in ships was in his Viking blood. In addition, as he said in later life, he was attracted as a youngster by the bright brass buttons of his older brother, who was already an officer in the Danish Navy, and an explorer. This brother was a member of the "Nordenskjoeld" Expedition, the first ship to circumnavigate Europe and Asia. It sailed from Finland, through the Baltic, north of Norway, along the entire coast of Siberia, and back through the Bering Strait, Pacific and Indian Oceans, Mediterranean Sea, through the Suez Canal, and back to Denmark. It is small wonder, therefore, that he inspired hero-worship in his younger brother. Neither did the younger brother ever lose a thirst for adventure, although it was intellectual rather than geographical.

William Hovgaard was born in Aarhus, Denmark, the son of Ole Anton and Louise Charlotte (Munch) Hovgaard. His father, a scholar, a teacher, and a writer of history, was graduated from

Copenhagen University with distinction in philology, and during William Hovgaard's childhood, taught at the Aarhus Cathedral School, a Government institution. On graduation from grammar school in 1868, William Hovgaard entered the school in which his father was teaching. The school was divided into two classes, corresponding respectively to our fine arts and humanities on the one hand, and to scientific and mathematical studies on the other. Perhaps because of his father's interest in philology, William Hovgaard began in the fine-arts section, where his success was not notable. In consequence, he was transferred to the "real" or scientific section. From that time on, he stood at or near the top of his class, both in that school and later in the Danish Naval Academy at Copenhagen, where he was awarded the Gerner medal. This medal was named after a famous Danish naval architect and was awarded each year to the student receiving the highest marks in scientific subjects.

In 1879 he was graduated from the Danish Naval Academy with the rank of Sub-Lieutenant. In December, 1880 he became a First Lieutenant. In 1897 he was promoted to the rank of Commander. In 1905 he resigned from the Danish Navy with the rank of Captain.

Immediately following his graduation from the Naval Academy, he performed surveying service, and, in the winter of 1881–82, studied astronomy at the Observatory in Copenhagen in preparation for an expedition to be sent out by the Danish Government to observe the transit of Venus. As a member of this expedition, he proceeded in December, 1882 to St. Croix, Virgin Islands, accompanied by the Royal Astronomer, Dr. Pechule.

In 1883 he enrolled in the course in naval construction at the Royal Naval College, Greenwich, England, from which he was graduated in 1886. Here, in addition to advanced professional subjects, he made an intensive study of higher mathematics, covering substantially the courses given in preparation for the mathematical tripos of Cambridge University.

From 1886 to 1894 he was on technical duty at the Royal Dockyard in Copenhagen, with occasional sea duty. He also acted as Instructor

at the Dockyard School of Naval Architecture and Marine Engineering.

From 1895 to 1897 he was General Manager of the shipyard of Burmeister & Wain, Copenhagen. During this period the Imperial yacht "Standart" and numerous other vessels of importance were built at the yard, and a great deal of repair work was also carried out. His reputation in the Royal Danish Navy must already have been outstanding, for upon completion of this service with Burmeister & Wain, which really amounted to complete detachment from Naval service, he was permitted to rejoin the Danish Navy without loss of seniority.

He was married in Copenhagen on September 19, 1896 to Marie Ludolphine Elisabeth, daughter of Mogens Nielsen, of that city, an Army officer. Two children, Ole Mogens and Annette, were born of that marriage.

From 1898 to 1901 he performed technical and administrative duties in the Royal Dockyard and in the Admiralty in Copenhagen, with occasional tours of sea duty. He also prepared a complete design for a submarine, at a time when submarines were not generally considered feasible.

When in 1901 it was decided that members of the Corps of Naval Constructors of the United States Navy should pursue their postgraduate studies at home, rather than abroad, the United States Navy Department selected Hovgaard to organize and teach an advanced three-year course in Naval Architecture and Warship Design at the Massachusetts Institute of Technology.

The genesis of Hovgaard's selection to teach warship construction in the United States is interesting. The original impetus for advanced studies by graduates of the Naval Academy seems to have come from Richard Gatewood and Francis Tiffany Bowles, Cadet Engineer graduates of the Academy. They appear to have sensed the need for scientific training in naval architecture, and to have perceived the advantages to those who should enter the Corps of Naval Constructors with a background of scientific knowledge that had not

been possessed by their predecessors in the profession. Accordingly, in October, 1879, Gatewood and Bowles were sent to the Royal Naval College, Greenwich, England, to take the course in naval architecture there, and to get a view of the major problems confronting the profession in Europe. After completing the three-year course, they returned to duty in the Bureau of Construction and Repair in the summer of 1882. They were followed by a fairly steady stream of selected graduates from each class at Annapolis, who spent from two to three years abroad. Some went to Greenwich, others to the École d'Application du Génie Maritime in Paris, or to the University of Glasgow.

Sometime late in the nineties, the British Admiralty decided not to permit foreigners to study at its Naval College. This decision was probably made because Japan was already emerging as a potential rival, and Britain, with her far-flung interests in the Pacific, did not wish to have Japanese students at Greenwich. Hence the exclusion of all foreigners. Following this decision, the United States Navy sent selected Annapolis graduates to the University of Glasgow, to the École d'Application du Génie Maritime, or for one period to a technical school in Berlin. This foreign instruction had certain disadvantages. Among others, we could not shape the courses to suit our particular needs.

Consequently, a postgraduate course in naval architecture was established at Annapolis, with Naval Constructor Richard P. Hobson in charge. This course was soon interrupted by his assignment to active duty in the Spanish War. Later, Naval Constructor Lawrence Y. Spear took over the work for a short period. Due to the expansion of the Navy following the Spanish War, the attention of most Naval Constructors was absorbed in the actual work of building ships, leaving insufficient qualified officers for teaching. Hence it was decided to develop an advanced course in warship design either at Massachusetts Institute of Technology or at Cornell.

In 1901, Hovgaard was sent to this country by the Royal Danish Navy to study the Holland submarine, and John D. Long, then Sec-

retary of the Navy, offered Hovgaard the task of developing and conducting the proposed course in warship design. Instrumental in his selection was Admiral David Taylor, for whom the United States Navy Model Basin was named, and in whose name the Society of Naval Architects gives its most coveted award for distinguished accomplishment in the Society's field. Admiral Taylor had been Hovgaard's classmate at Greenwich. Hovgaard accepted the offer and the choice between M.I.T. and Cornell was left to him. He chose M.I.T. The Navy arranged with M.I.T. to appoint Hovgaard to its faculty in October, 1901. After a survey of universities in Europe, Hovgaard returned to this country and began his classes in January of 1902. His title was Professor of Naval Design and Construction.

When Hovgaard assumed this professorship, there was not much usable material available. At first, his lectures were given from his own notes, until, after years of research and constant revisions, he was able to publish in 1915 *Structural Design of Warships,* and in 1920 *General Design of Warships* and *Modern History of Warships.* The latter title was not Hovgaard's, but the publisher's. Hovgaard considered it misleading, preferring "Evolution of Warship Design and Its Analysis," which he had originally proposed. These books were the first of their kind and they became standard textbooks elsewhere.

Professor Hovgaard had an original and inquiring mind. When he began teaching at Massachusetts Institute of Technology, he asked himself the question, "Why are warships designed exactly as they are, with definite specific features in respect to subdivision, protection, and stability?" He asked himself why these features were not varied, and why many different solutions were not acceptable. He then proceeded to consider warship design as related to advancing technology, and also to the changing requirements of service, especially as dictated by war experience.

He sought to combine in naval design a full knowledge of the state of the art of shipbuilding and engineering in general with a careful study of war experience, including performance and damage suffered.

This made necessary a careful examination of all reliable accounts of ships in actual war service, as well as the checking of such reports against new designs. Hovgaard understood how easy it is for ideas and practices to become fixed or jelled, and to be accepted merely because they have been long in being. He set forth his ideas in this connection in the introduction to *Structural Design of Warships* as follows:

"In the study of current practice it was often found difficult to discover the reasons why certain features were adopted and in some cases why they differed in different navies. The explanation is in general that once a certain mode of construction has been introduced in one of the leading navies and found satisfactory, it becomes a standard. Gradually the reason for its adoption may be forgotten, and the construction is used as a matter of routine. It may even happen that the conditions which called forth the construction change or cease to exist, and that it survives simply because there is a vague feeling that something will go wrong if it is changed or abolished."

On the other hand, he was far from belittling the importance of studying everything that had gone before, because he goes on to say:

"A study of such questions cannot fail to be fruitful, because it leads naturally to suggestions for improvements. Moreover, in a work of this nature, it is desirable fully to state and explain the reasons for the adoption of the various structural features, inasmuch as such information will be of value, not only to the inexperienced student of the present time, but also as a matter of record for the future."

Indeed, he began his course with an historical analysis of warships previously constructed. He then proceeded to a consideration of the technical aspects of warship construction. He often expressed the idea that a naval constructor must, of course, acquire all the information that he can about the most recent technical progress in design. This, however, must be supplemented by a knowledge of what he

described as "war experiences." He wrote in the Preface to his *Modern History of Warships:*

"A naval constructor must possess an intimate knowledge and full understanding of the military as well as the purely technical requirements of warships. He should carefully study the strategic, tactical, and nautical conditions under which such vessels operate in time of war, note their behaviour, and analyze the damage which they suffer in action. From the point of view of the constructor, naval actions, submarine attacks, and naval operations may be regarded as gigantic full-scale experiments, which, if rightly interpreted, afford the safest basis for new departures in design. Hence this work, which is intended to supply the material for such a study, comes to lie on the borderland between naval construction and naval military science. Although written primarily as an introduction to the science of design and construction of warships, it should be useful not only to constructors, but also to naval officers."

He considered that in normal circumstances neither the designer in the drafting room nor the officer on the bridge or in a gun turret or in an engine room was qualified by himself to judge expertly in matters which involve both the technical and military points of view. To judge such matters expertly and to evaluate them intelligently from the design point of view requires access to the facts, and theoretical as well as practical competence. Insofar as access is concerned, he felt that only a naval officer would have an opportunity to observe damage suffered by ships as a result of ordinary service and action and to discuss both damage and performance with line officers. In view of this, it was his opinion that a small group of naval officers must be trained to have both the necessary theoretical and practical competence.

In the preface to his book *Structural Design of Warships,* he pointed out that, since the work was written primarily for American naval students, the practice of the United States Navy was given the most prominent place. He wrote that this was desirable because, for the United States Navy, the construction of armored ships had com-

menced scarcely twenty-five years before (around 1890), and was unhampered by tradition or by too-close financial restrictions. It had been possible therefore, to adopt the best practice of other navies and to add many original features.

Professor Hovgaard's classes were always small, and his instruction was intensely personal and intimate. A student was assigned a design problem and a drafting table. After some time for collecting data, consulting published references, etc., the design began to take form. Professor Hovgaard spent long hours over the drafting board with the student, criticizing, suggesting alternatives, and, in general, showing the student the breadth of his opportunity and of his responsibility.

One student was assigned to design a Yangtse River gunboat able to run the famous Gorges. This required geographical investigations, reading accounts of early navigators, and some knowledge of what United States interests would require. Furthermore, the habitability of the ship for extended periods away from base had to be judged. Finally, Professor Hovgaard suggested looking into legal and treaty limits to efforts to protect American life and property in a foreign country.

Professor Hovgaard's forte was structural design. This means calculations of strength to achieve minimum weight and maximum efficiency. Limiting conditions include loading, protection against underwater explosion, and penetration of armor. The majority of the theses which he assigned to his students at M.I.T. were on the subject of strength.

As a teacher he placed technical skills in perspective as elements of professional competence, to be built upon continuously as the art advanced. Responsibility for a project, in his view, had no limits. Professional responsibility for design included consideration of the interests both of the shipbuilder and of those who would go to sea in the ship. Safety of life at sea was always uppermost in his mind. Warships are not inherently safe, but their design and construction must, in Hovgaard's teaching, allow for damage from enemy action

and take every means to allow a margin for survival. Hovgaard stamped his students with his own high ethical and professional standards.

Although he was untiring in his endeavors to help a student with a problem he was nevertheless a stern taskmaster, with a pronounced aversion to the perpetuation of error. To this end, his corrections were frequently made with a very, very soft pencil, which so blurred the paper, that the student was obliged to discard the drawing in which any important error occurred, and to begin anew, in order finally to present a drawing with no mark of heresy.

In 1933 Professor Hovgaard retired from his professorship at Massachusetts Institute of Technology, but continued to lecture during the academic year 1933–34 with the title of Professor Emeritus. The extent of Professor Hovgaard's influence is illustrated by the fact that at the time of his retirement, the University Club of New York honored him at a testimonial dinner, at which it was revealed that every vessel of the Navy's great fleet, which then happened to be at anchor in New York Harbor, was constructed under the supervision of former students of Professor Hovgaard. For thirty-three years he had given the course in Naval Architecture and Warship Design, in which hundreds of officers of the United States Navy and many foreign officers had been enrolled. Many of his M.I.T. students were subsequently to become Chief of the Bureau of Construction and Repair. The first of these was Emory Scott Land, Vice Admiral, U.S.N. (Ret.), who studied under Professor Hovgaard from 1904 to 1907.

When he ended his teaching career at M.I.T., he was seventy-seven years old. He then moved to Brooklyn, New York, where he engaged in engineering consultation. During the Second World War, much of his time was occupied in a consulting capacity for the Navy and for Gibbs & Cox, Inc., who prepared many designs for the Navy. He did some of his most important work during this period. He continued scientific investigations up to the time of his death at the age of ninety-two.

Professor Hovgaard's intellectual interests were so varied, and his researches covered so many fields, that it is difficult to set them forth within any single framework. Beginning with surface ships, it might be said that his primary interest lay in the study of the stresses to which such a ship or any of its components might be subjected.

He was a man with a thirst for knowledge and truth. He never left a problem without stating conclusions and, where pertinent, making recommendations on which to base further research or positive action. He simplified procedures for solving problems connected with the bending of beams. He presented new methods for the calculation of stresses in welded and riveted structures. For the Navy's Bureau of Construction and Repair he made an extensive study of the effects of underwater explosions, stresses in gun turrets, stresses in riveted joints, stresses in docking blocks, and their distribution. He made original contributions to the understanding of stability and turning of destroyers, stresses in steam piping, and, in theoretical research and experiments connected with expansion bends in steam pipes. It is interesting to note that this achievement was accomplished after his retirement from M.I.T. at the age of seventy-seven, and, as indicated above, while he was acting as consultant for Gibbs & Cox, Inc. during their cooperation with the Navy in the expansion of the Navy's program, which began to bear fruit around 1936.

He was interested also in submarines. As has been noted, it was that interest which first brought him to this country. For a paper entitled "Buoyancy and Stability of Submarines," he was awarded a gold medal by the Institution of Naval Architects (London), in 1917.

In addition, he was interested in airships and in naval airplanes. In an article which appeared in the *New York Times* of July 3, 1927, Hovgaard prophesied transatlantic commercial service by aircraft. Among other things, he suggested the possibility of a gigantic ship with a flying deck, motive power, and with special moorings, to constitute a way station for use by transatlantic planes.

The independence of his mind and his broad vision are shown by

the manner in which he trained naval constructors. Among other subjects which he considered germane to his work at M.I.T. was that of naval strategy. So, following his usual custom, he set about making himself master of this subject also. His analysis of the position in which this country would find itself in case of war was almost devastatingly accurate. He suffered the fate of Cassandra, however, because nobody believed him; at least nothing was done about it.

In 1911, he foretold the date of the First World War. In the March issue of the *Proceedings of the U. S. Naval Institute* of that year, he wrote a paper entitled "Naval Strategy in a War between England and Germany." In that article, he explained that the Germans were deepening the Kaiser Wilhelm (Kiel) Canal from 30 to 36 feet, so that large battleships could pass through it. He noted that this work would cost 55 million dollars and would probably be completed by the end of 1914. He predicted that Germany would be ready to go to war as soon as that canal was completed. In the *Proceedings of the U. S. Naval Institute* for September, 1935, in an article entitled "The Strategic Situation in the Baltic," Hovgaard mentioned his 1911 prediction regarding work on the canal, explaining that that was why no major operation in the Baltic was attempted by the Allies during the First World War.

In the same publication, in the issue of February, 1917, he wrote an article entitled "Some Strategical Sketches." The objectivity with which he approached all problems is well illustrated by the introduction to this article, where he wrote:

"It may perhaps be considered by some inappropriate to assume and discuss a state of war between countries actually at peace and unlikely to enter into conflict, but it is obviously impossible to form a clear idea of the problems that the Navy of a given country has to solve without making definite assumptions as to the enemies with whom the country may be involved in war. All cases that are reasonably possible must be considered, and too much weight must not be attached to the political conditions existing at the moment. . . .

"If the general public is to judge intelligently the requirements of

the Navy and the coast defenses, it must be informed as to the probable course of events in wartime."

In this article it is particularly interesting to note what he wrote about what might happen in case of war between the United States and Japan. He did not anticipate Pearl Harbor. He assumed rather that the war would begin with a surprise attack on the Philippines. Otherwise his prophecy is so accurate that it is perhaps worth quoting somewhat at length.

"The United States Navy would in this case be decidedly superior to that of the enemy in battleships, but would lack the element of speed which the Japanese Navy possesses in a squadron of battle cruisers. The Japanese Navy would be somewhat stronger also in older armored cruisers and scouts.

"The Panama Canal would again be of utmost strategic value to the United States, and Pearl Harbor would form an excellent base in the Pacific, but, being about 3400 miles from Japan, it could serve only as an intermediary station in offensive operations against that country. The Philippine Islands are in this respect more favorably situated, but are yet too remote from Japan to serve as a base for a blockading fleet, Manila being about 1300 miles from the southern Japanese Islands. Japan, moreover, flanks the line of communication between the Philippines and Hawaii, which line is about 5000 miles in length.

"Guam Island, which is about 1700 miles nearer to Hawaii and Panama than is Manila, and which is no farther from Japan, is at present merely a coaling station, practically without any defenses. Yet this little island is much easier to defend than stations which, like Manila, are situated on larger islands where landings are difficult to prevent. It has a commodious natural harbor which with proper improvements can be rendered serviceable for a large fleet. If the United States is to maintain a strategic position in the East, a strong naval base at Guam appears to be indispensable. In the hands of Japan it would absolutely destroy the security of the line of communication with the Philippines.

"As matters stand, the United States is without a base in the Pacific suitable for offensive operations against Japan, and it does not seem likely, therefore, that the American fleet at the opening of hostilities would be advanced beyond Hawaii. Possibly a minor squadron would be detached to the Philippines, and we shall suppose these islands to be garrisoned as at present, with some 13,000 United States troops.

"We assume therefore that the Japanese, eventually using the Naval Station at Takow on Formosa as an advanced base, would open war with a surprise attack on the Philippines. The American squadron would be blockaded or destroyed by a superior Japanese fleet and an army would be landed. The positions at Manila and Olangapo would fall, and all important strategic points on the islands would be occupied. These operations would probably be completed before succor could be rendered, and once the Japanese were firmly established, they would not be driven out of the islands until after their fleet was defeated or closely blockaded, and the sea cleared of their cruisers; but this task the American fleet as now constituted could hardly hope to accomplish under the given disadvantageous strategic conditions.

"Having thus secured control of the western part of the Pacific, Japan would presumably follow a defensive policy, the battle fleet being kept in home quarters for protection of the coasts and engagements with superior forces of the enemy being avoided. The older cruisers might be detailed for protection of commerce in Asiatic waters and the fast modern cruisers, including the battle cruisers, might carry out raiding operations in the eastern part of the Pacific, threatening in particular the communications of Hawaii. Eventually, important points in Alaska would be seized.

"It is difficult to see how under these circumstances the American fleet could force the Japanese to a decision against their will. Offensive operations of importance could not be undertaken in these days of submarine dangers without the possession of an advanced base in the vicinity of the enemy's coast; but no such advanced base is

known to be available near the littoral of the Japanese islands. . . .

"It is likely therefore that the American fleet would remain at Hawaii, where it would be strategically in the best position for protecting the Pacific coast and the Canal, at the same time preventing the Hawaiian Islands from falling into the hands of the enemy. In fact, serious attacks by the Japanese fleet on points on the American continent or on Hawaii would hardly be attempted, and the Japanese would probably be content to seek opportunities of overwhelming weaker divisions of the American fleet. The war would be essentially a cruiser war, in which the Japanese would have the advantage of a more modern and powerful material, but by using battleships as convoys, the American Navy should be able to protect its lines of communication.

"In order that the United States should be capable of carrying out an offensive war against Japan with any chance of success, it would need to possess a suitable advanced base and a fleet decidedly superior to that of the Japanese in all the various classes of warships. On account of the vastness of the Pacific Ocean, the ships of all classes must be endowed with the highest seagoing qualities and steaming capability, and since they must also possess at least the same military qualities as the ships of the same class in other navies, they must be of very large size."

To our sorrow, Hovgaard's advice regarding Guam was disregarded.

His versatility knew no bounds. Somewhere around 1913 a controversy was raging as to where the Vikings landed in this country in the year 1000; in other words, where was the Vineland to which an early Icelandic saga refers. The *Boston Transcript* asked Professor Hovgaard to write an article seeking to clarify the matter. His resulting researches were so thorough, however, that they led to a book instead, *The Voyages of the Norsemen to America,* published in 1914.

In conducting this research, incidentally, Professor Hovgaard obtained access to the original Icelandic saga reporting the event. In

the process, he taught himself enough Icelandic to read it. Perhaps this was not so difficult as it sounds, since he had been in Iceland as a young Naval Officer, and during that tour of duty had learned some Icelandic. Because of the isolation of Iceland, contemporary Icelandic is not essentially different from the language spoken there a thousand years ago.

It is interesting to note that Hovgaard knew Danish, German, English, French, some Italian, and some Russian. He studied Russian without the aid of an instructor, but was able to understand what the Russians were saying among themselves during negotiations for the design and construction of a Russian battleship. In 1937 Hovgaard acted in this matter as consultant for Gibbs & Cox, Inc.

He was able to use English almost as if it had been his native tongue. He was never satisfied, however, and always carried a notebook in which he jotted down any word which he heard and which was not already a part of his active vocabulary. At one time he was voted by the M.I.T. faculty as the member of the faculty who spoke and wrote the best English.

When Professor Hovgaard came to this country in 1901, his children were young and had only a smattering of school English. Every evening, therefore, he required his children to take turns reading to him. His son Ole says that he still doesn't understand how his father had the patience to do it.

He never denied help to his children with their schoolwork. On the other hand, he refused consistently to tell them how to go about the solution of a problem. He had two rules. First, the child must attack the problem himself and work diligently at it until he felt unable to proceed further toward its solution. Second, he was obliged to write out for his father a description of the problem; how far he had proceeded toward its solution; and what, in his opinion, was acting as a bar to further progress. His son says that in nine cases out of ten the formulation of the problem pointed the way to its solution.

Aside from his early experience in the Burmeister & Wain Ship-

yard, Hovgaard never accepted any managerial or business position. His vocation was clear to him: to teach young men and to advise them on professional problems when they were older. Thus he continued for his entire life in this country as a teacher and professional consultant. He never organized a group of associates for his consulting practice. His services were individual and professional, like those of an expert surgeon.

Professor Hovgaard, whose major life work was connected with the design of warships, hated war, and gave much thought to its cause and possible prevention. He considered that, internationally, fear is the dominant emotion, as among the animals in the jungle. He reasoned from this that war is a biological phenomenon, being part of the struggle for existence in the wild state of nature. He stated that so long as man refuses to apply his intelligence and reason to economic appeasement, and so long as he refuses to establish some form of strong international government, war must follow sooner or later, since inequalities in economic development must go on increasing. He concluded that meanwhile no nation can afford to neglect its national defenses, "which are the only means left by which it can hope to preserve its neutrality, dignity, and independence. Even a country so favorably situated as the United States must have a powerful armament, whether for the purpose of keeping out of war or for the purpose of intervening where justice or its own vital interests render it necessary to use armed forces."

These ideas are set forth in an article entitled "Is War Inevitable?" published in the *Proceedings of the U.S. Naval Institute,* issue of October, 1937.

"War is like a sickness which nature inflicts when man disobeys her laws, but in its train is developed a loathing of war and a wholesome fear of its recurrence, which is the psychological antibody provided by nature. For a time it may render man immune to war, and will drive him in the direction of a more stable political order, but so long as wars are local, they produce only local results and are soon forgotten. It seems that world wars are required before large

international or world-wide organizations can be established."

He went on to quote Kant as saying that there is no remedy against the perils of war except "a system of international right founded upon public law, combined with power to which each state must submit."

On the humanitarian side, we have Professor Hovgaard's booklet on the subject, "The United World," published in 1944. This is a splendid example of his clear understanding of world politics and the problems that existed or that would arise during the process of making effective peace. His ideas concerning peace and how to secure it read like a prophecy of events that are now taking place. While his professional abilities had been utilized to create instruments of warfare, he sought to prevent war, knowing well its horrors, by creating a better intellectual understanding among nations.

It is clear that he had an extraordinary power of intellectual concentration and great tenacity in pursuing to its solution any problem which he undertook. He was one of the most articulate of men. When he had arrived at the solution of an extremely complicated problem, he was able to present his solution in such a simple and clear manner as to give little idea of the amount of effort which had gone into that solution. His extraordinary physical and mental powers may be illustrated by the fact that in 1940, at the age of eighty-three, he completely revised by himself his *Structural Design of Warships.*

At his death he had for some years been working on a new theory of cosmology. This is the only known instance in which he left uncompleted any task which he had undertaken; and it was only death which stopped him.

Professor Hovgaard did not need to await death in order to have his genius recognized. He was internationally famous, and found himself often in famous company.

In the *Transactions of the Institution of Naval Architects* (London) for 1946, for example, we find his name listed among the eight honorary members. The other seven are: The King of the Belgians,

The King of Norway, The Ex-King of Roumania, The King of Sweden, The Right Honorable Winston S. Churchill, R. W. Dana, and Professor T. H. Havelock.

He was a member of a special committee appointed by the National Advisory Committee for Aeronautics which made a report on the designs of the United States Navy airship ZR-1 ("Shenandoah") and the United States Army semirigid airship RS-1 during 1922–24. In 1925 he was technical advisor to the judge advocate of the court of inquiry investigating the destruction of the naval airship "Shenandoah." He was a member of a special committee on airship design and construction for the United States Navy in 1935, and a member of its advisory board on battleship plans in 1937–38. From 1935 to 1938 he was consulting naval architect for the Bureau of Yards and Docks, Navy Department.

In 1912 he helped organize the American Scandinavian Foundation, New York City, and was a Trustee and Vice-President until his death. He was a member of the American Academy of Arts and Sciences, American Geographical Society, Institute of the Aeronautical Sciences, National Academy of Sciences (elected in 1929), Institution of Naval Architects (London), American Society of Naval Architects and Marine Engineers, United States Naval Institute, American Mathematical Society, American Association of University Professors, Society for the Advancement of Scandinavian Studies, American Society of Danish Engineers, and the Massachusetts Historical Society.

In 1948 the American Scandinavian Foundation presented him with its gold medal for distinguished service to America and Scandinavia. The British Institution of Naval Architects awarded him a gold medal in 1917 for a paper on submarine boats, and in 1943 he was awarded the David W. Taylor Medal of the American Society of Naval Architects and Marine Engineers for his contributions to naval architecture. He was awarded the Order of the Savior of Greece in 1889, the Order of Francis Joseph of Austria in 1890, the Order of St. Anna and the Order of St. Stanislaus of Russia in 1901, and the

Naval Order of Spain in 1936; in 1927 the Danish Government made him a Commander of the Order of Dannebrog. Honorary Doctor of Engineering degrees were conferred on him by the Copenhagen Polytechnic Institute in 1929 and by Stevens Institute of Technology in 1934.

KEY TO ABBREVIATIONS

Geograph. Rev.=Geographical Review
Geograph. Tidsskr.=Geographisk Tidsskrift
J. Appl. Mech.=Journal of Applied Mechanics
J. Math. Phys.=Journal of Mathematics and Physics
Proc. Nat. Acad. Sci.=Proceedings of the National Academy of Sciences
Proc. U. S. Naval Inst.=Proceedings of the United States Naval Institute
Tech Eng. News=Tech Engineering News
Tidsskr. Sovaes.=Tidsskrift for Sovaesen
Trans. Am. Soc. Mech. Eng.=Transactions of the American Society of Mechanical Engineers
Trans. Inst. Naval Archit. (London)=Transactions of the Institution of Naval Architects, London
Trans. Soc. Naval Archit.=Transactions of the Society of Naval Architects and Marine Engineers
Z. angew. Math. Mech.=Zeitschrift für angewandte Mathematik und Mechanik

BIBLIOGRAPHY

BOOKS

1887

Submarine Boats. London, E. & F. N. Spon. 98 pp.
Sundhed eller Kundskaber (Health or knowledge). Copenhagen, Emil Bergman. 80 pp.

1888

Sport. Copenhagen, Emil Bergman. 174 pp.

1891

Lectures on Technology. Copenhagen, Royal Dockyard. 195 pp.

1914

The Voyages of the Norsemen to America. N. Y., American-Scandinavian Foundation. 304 pp.

1915

Structural Design of Warships. London, E. & F. N. Spon. 384 pp.

1920

Modern History of Warships. London, E. & F. N. Spon. 514 pp.
General Design of Warships. London, E. & F. N. Spon. 307 pp.

1940

Structural Design of Warships, 2nd ed. Annapolis, Md., U. S. Naval Institute. 410 pp.

PAPERS, ARTICLES, AND PAMPHLETS

1882

Venuspassagen (The transit of Venus). Geograph. Tidsskr.
Lord Cochrane. Dannebrog, April 15.
The Transit of Venus. St. Croix Avis, December 2.

1888

Proposed Designs for Surface Boats and Diving Boats. Trans. Inst. Naval Archit. (London).

1889

Vore Torpedobaades Södygtighed (Sea performance of Danish torpedo boats). Tidsskr. Sovaes.

1893

Om ot befästet Stöttepunkt for vor Flaade i Store Baelt (Protected base for Danish Fleet). Tidsskr. Sovaes.
Agersöstillingen (Naval strength). Tidsskr. Sovaes.
Die Verteidigung des Grossen Belts (The defense of the great belt). Marine Rundschau, Berlin, December.

1894

Den nye Ordning af det franske Söminevaesen (The new French rules regarding sea mines). Tidsskr. Sovaes.
Torpedokanonbaaden og Torpedojageren (Torpedo gun boats and torpedo destroyers). Tidsskr. Sovaes.
Sökrigen i Östasien (Sea battles in East Asia). Tidsskr. Sovaes.

1899

Die Seetüchtigkeit der Torpedoboote (Seaworthiness of the torpedo boat).

Mitteilungen aus dem Gebiete des Seewesens, Pola, Austria (Communications from the Department of Naval Affairs, Pola, Austria).

Undervandsbaade (Submarines). Tidsskr. Sovaes.

The Seaworthiness of Torpedo Boats. Engineering (London), July 26.

The State of the Ice in the Arctic Seas. Translation into English for the Nautical Meteorological Annual, Danish Meteorological Institute.

1900

Styrken af elliptiske Sektioner under udvendigt Vadsketryk (The strength of elliptic sections under fluid pressure). Ingenioren, 32.

Strategi og Folkestemning (Strategy and public opinion). Tidsskr. Sovaes.

Wind Charts, North Atlantic and Davis Strait, by V. Garde. Translation into English for the Nautical Meteorological Annual, Danish Meteorological Institute.

The Strength of Elliptic Sections under Fluid Pressure. Trans. Inst. Naval Archit. (London).

The State of the Ice in the Arctic Seas. Translation into English for the Nautical Meteorological Annual, Danish Meteorological Institute.

1901

Some Investigations Relating to the Ocean Current in the Sea between Norway, Scotland and Greenland, by C. Ryder. Translation into English for the Nautical Meteorological Annual, Danish Meteorological Institute.

Motion of Submarine Boats in the Vertical Plane. Trans. Inst. Naval Archit. (London).

The State of the Ice in the Arctic Seas. Translation into English for the Nautical Meteorological Annual, Danish Meteorological Institute.

1902

Technical Training for Shipbuilders. Trans. Soc. Naval Archit., 10:11–12.

Remarks on the New Design of Naval Vessels. Trans. Soc. Naval Archit., 10:283–86.

Submarine Torpedo Boats—Past, Present and Future. Trans. Soc. Naval Archit., 10:343–45.

The State of the Ice in the Arctic Seas. Translation to English for the Nautical Meteorological Annual, Danish Meteorological Institute.

1903

Watertight Subdivision of Warships. Trans. Soc. Naval Archit., 11:67–113.

On Ships' Forms Derived by Formulae. Trans. Soc. Naval Archit., 11:264–65.

1904

Simple Methods in Warship Design a Necessity. Trans. Soc. Naval Archit., 12:31–33.
The Semi-globular Naval Battery. Trans. Soc. Naval Archit., 12:69.
The Sea-going Battleship. Trans. Soc. Naval Archit., 12:73–106.
Some Further Notes on the Performance of the Torpedo Vessels of the United States Navy at Sea. Trans. Soc. Naval Archit., 12:149–50.

1905

The Cruiser. Trans. Soc. Naval Archit., 13:103–44.
Notes on the Strength of Watertight Bulkheads for Battleships and Cruisers. Trans. Soc. Naval Archit., 13:229–33.

1906

On Battleships. Boston Evening Transcript, December 5.
The Fate of the Russian Ships at Tsushima. In: *Jane's Fighting Ships* (Portsmouth).
Model Basin Gleanings. Trans. Soc. Naval Archit., 14:99.
Recent Development in Armor and Armament. Trans. Soc. Naval Archit., 14:137–38.
A Modern Fleet. Trans. Soc. Naval Archit., 14:119–20.
Notes on the Development of Warship Design. Trans. Soc. Naval Archit., 14:213–17.

1907

An Experimental Investigation of Stream Lines Around Ships' Models. Trans. Soc. Naval Archit., 15:5.
Further Tactical Considerations Involved in Warship Design. Trans. Soc. Naval Archit., 15:26–30.
Submarines of Battleship Speed. Trans. Soc. Naval Archit., 15:63–64.
On the Speed of Battleships. Trans. Soc. Naval Archit., 15:213–42.

1908

Proposed New Type of Conning Tower for Large Battleships. In: *Jane's Fighting Ships* (Portsmouth).
An Analysis of the Resistance of Ships. Trans. Inst. Naval Archit. (London).

The Influence of Midship-section Shape upon the Resistance of Ships. Trans. Soc. Naval Archit., 16:26.

Deviation of the Compass Aboard Steel Ships—Its Avoidance and Correction. Trans. Soc. Naval Archit., 16:111.

The Influence of Free Water Ballast upon Ships and Floating Docks. Trans. Soc. Naval Archit., 16:138–41.

1909

Protection of Battleships against Submarine Attack. In: *Jane's Fighting Ships* (Portsmouth).

Who Invented the Monitor? Army & Navy Journal, November 27.

Diverging Waves. Trans. Inst. Naval Archit. (London).

The Loss of the S.S. "Republic" and the Strength of Bulkheads. Engineering (London), June 18.

The Effect of Parallel Middle Body upon Resistance. Trans. Soc. Naval Archit., 17:176.

Some Ship-shaped Stream Forms. Trans. Soc. Naval Archit., 17:191–93.

The Design of Submarines. Trans. Soc. Naval Archit., 17:250–51.

Strength of Watertight Bulkheads. Trans. Soc. Naval Archit., 17:385–439.

1910

De Skandinaviske Amerikanere og deres Forhold til Hjemlandene (The Scandinavian-Americans and their relation to the homelands). Den Danske Pioneer, November 24.

Americans and Their Home Countries. Scandinavian American, December.

Notes on the Armaments of Battleships. Trans. Soc. Naval Archit., 18:22–25.

An Analysis of Tests of Watertight Bulkheads with Practical Rules and Tables for Their Construction. Trans. Soc. Naval Archit., 18:83–124.

Warship Design and Construction. Tech Eng. News, April 30.

1911

De maritim-strategiske Forhold under en Krig mellem England og Tyskland (Maritime strategy during a war between England and Germany). Tidsskr. Sovaes.

Naval Strategy in a War between England and Germany. Proc. U.S. Naval Inst.

On the Maximum Dimensions of Ships. Trans. Soc. Naval Archit., 19:28–31.

The Effect of Waves upon a Taffrail Log. Trans. Soc. Naval Archit., 19: 132–33.
Ship Calculations; Derivation and Analysis of Methods. Trans. Soc. Naval Archit., 19:284–85.

1912

The Danish Isle St. Thomas. New York Evening Post, November 23.
Watertight Subdivision of Liners. Engineering (London), May 24.
Turning Circles. Trans. Inst. Naval Archit. (London).
Review of *Festigkeit der Schiffe* (Strength of ships), by F. Pietzker. Engineering News, February 15.
Experiments on the "Fulton" and the "Froude." Trans. Soc. Naval Archit., 20:14–15.
Rudder Trials. U.S.S. "Sterett." Trans. Soc. Naval Archit., 20:333–34.

1913

The Commercial Future of St. Thomas. American-Scandinavian Review, January.

1914

Some Experiments with Models Having Radical Variations of After Sections. Trans. Soc. Naval Archit., 22:64.
Den Dansk-Amerikanske Bevaegelses Historie (The history of the Danish-American movement). Scandinavian American.

1915

Present Status of Submarine Boats. Science Conspectus, 5(3).
Submarines vs. Battleships. Philadelphia Public Ledger, February 20.
A Consideration of the Technical Limitations and Military Requirements of Underseas Craft. Baltimore News, April 14
A Lesson from the "Lusitania" Disaster. Engineering (London), September 3.

1916

Military and Technical Considerations in Battleship Design. Trans. Soc. Naval Archit., 24:101–3.
On the Suitability of Current Design of Submarines to the Needs of the United States Navy. Trans. Soc. Naval Archit., 24:116–17.
Naval Stations and Naval Bases. Trans. Soc. Naval Archit., 24:146–48.
The Naval War and the Size of Battleships. Engineering (London), December 15, 22, 29.

1917

Buoyancy and Stability of Submarines. (Awarded Gold Medal.) Trans. Inst. Naval Archit. (London).

Some Strategical Sketches. Proc. U. S. Naval Inst.

1918

Experiments on Simplified Ship Forms. Trans. Soc. Naval Archit., 26: 169–70.

On Vibrations of Beams of Variable Cross-section. Trans. Soc. Naval Archit., 26:142.

1919

Buoyancy and Stability of Troop Transports. Trans. Soc. Naval Archit., 27:137–61.

Launching of Ships in Restricted Waters. Trans. Soc. Naval Archit., 27: 211–13.

1921

Calculation of the Transverse Strength of Submarines by Marbec's Method. Trans. Soc. Naval Archit., 29:257–65.

1922

Details of Naval Design from Jutland. Trans. Soc. Naval Archit., 30:70–71.

The Longitudinal Strength of Rigid Airships. Trans. Soc. Naval Archit., 30:143–77.

Standardization as Affecting the Shipbuilding Industry in the United States. Trans. Soc. Naval Archit., 30:214.

1923

A New Proof of the Theory of Ordinary Bending and Its Extension to Beams of Non-homogeneous Materials. J. Math. Phys., 2(4).

The Principle of Minimum Energy and the Motion of Fluids. Proc. Nat. Acad. Sci., 9:363–69.

The Theory of Bending. Trans. Inst. Naval Archit. (London).

Comments on Aviation—Naval and Commercial. Trans. Soc. Naval Archit., 31:26–28.

The Probable Effect on Ports of the Future Growth of Ships. Trans. Soc. Naval Archit., 31:118–22.

1924

Aeronautics in Naval Architecture. Trans. Soc. Naval Archit., 32:24–25.

1925

The Launch of the Airplane Carrier U.S.S. "Saratoga." Trans. Soc. Naval Archit., 33:156–57.

An Analysis of a Failure of Keel Blocks in a Drydock. Trans. Soc. Naval Archit., 33:181–83.

Determination of the Stresses in a Beam by Means of the Principle of Least Work. J. Math. Phys., 4(2).

Adjustment of the Elastic Properties of a Model Keel, United States Army Airship RS-1. J. Math. Phys., 5(1).

The Norsemen in Greenland: Recent Discoveries at Herjolfsnes. Geograph. Rev., October.

1926

The Elastic Deformation of Pipe Bends. J. Math. Phys., 6(2).

Comments upon the Historical Basis of Mrs. Clara Sharpe Hough's Novel: *Leif the Lucky*. Boston Evening Transcript, October 2.

Inclining Experiments with Ships of Small or Negative Stability. Trans. Inst. Naval Archit. (London).

The Arsenal in Piraeus and the Ancient Building Rules. Isis, 8(25). Brussels.

The Ten New Cruisers. Boston Evening Transcript, December 23.

Review of *The Discovery of North America Twenty Years before Columbus,* by Sofus Larsen. American-Scandinavian Review, January.

Where was Vinland? Review of *Eyktarstad—Problemet og Vinlandsrejserne.* (Eyktarstad—The problem of the voyage to Vinland), by M. M. Mjelde. American-Scandinavian Review, March.

An Investigation of the Behavior and of the Ultimate Strength of Riveted Joints under Load. Trans. Soc. Naval Archit., 34:70–74.

The Strength of Propeller Shaft Struts. Trans. Soc. Naval Archit., 34:135–36.

Launch of the Airplane Carrier U.S.S. "Lexington." Trans. Soc. Naval Archit., 34:158–59.

Some Considerations in Design of Ferryboats. Trans. Soc. Naval Archit., 34:241.

1927

Deformation and Stress Distribution in Rigid Airships. Trans. Inst. Naval Archit. (London).

An Airplane Station in Mid Atlantic. Engineering (London).

Airplane Station in Mid Ocean. New York Times, July 3.

Bending of a Quasi, Ellipsoidal Shell with Special Reference to Rigid Airships. Proc. Nat. Acad. Sci., 13:256–63.

1928

Review of *Grönland: Ihverdag og fest* (Greenland: In everyday and holiday mood), by Sophie Petersen. Geograph. Rev.

Efficiency vs. Safety. The Submarine Problem. Boston Evening Transcript, January 11.

Deformation of Plane Pipes. J. Math. Phys., 7(3).

Further Research on Pipe Bends. J. Math. Phys., 7(4).

Determination of the Stresses in a Beam by the Method of Variation. Proceedings of the International Congress of Mathematics, Bologna, 6.

Some Observations of the Design of Airplane Carriers and Notes on the "Saratoga" and "Lexington." Trans. Soc. Naval Archit., 36:70–71.

The Inclining Experiment. Trans. Soc. Naval Archit., 36:117–18.

1929

Article on Disarmament. Engineering (London), July 26.

Article on Disarmament. New York Times, July 28.

Article on Disarmament. Boston Evening Transcript, September 27.

Article on Disarmament. Technology Review, November.

Airplane Station in the Atlantic. Technology Review, April.

The Relation between Armament and Protection in the 10,000 Ton Cruisers and the Ersatz-Prussen. Trans. Inst. Naval Archit. (London).

The Stability of Ocean-going Passenger Ships. Engineering (London).

Tests of High-pressure Pipe Bends. J. Math. Phys., 8(4).

Deflections and Stresses in Pipe Bends. Proceedings of the World Engineering Congress, Tokyo, 3.

1930

The Stress Distribution in Welds. Proc. Nat. Acad. Sci., 16:667–73.

The Stress Distribution in Welded Overlapped Joints. Proc. Nat. Acad. Sci., 16:673–78.

Bending of Curved Pipes. Proceedings of the Third International Congress for Applied Mechanics, Stockholm, 2.

Theoretical Mechanics in Engineering Schools. Science, n.s., 71:347.

A Model of the Christianus Quintus, Nautical Museum, Massachusetts Institute of Technology. Science.

Bestimmung von Balkenspannungen mit Hilfe der Variationsrechnung (Determination of the stress on beams with the aid of differential calculus). Z. Angew. Math. Mech., 10.

1931

Die Spannungsverteilung in Schweissungen (Distribution of Stress in Welding). Z. Angew. Math. Mech., 11.

Review of *Leif Eriksson,* by E. F. Gray. American-Scandinavian Review, March.

The Distribution of Stresses in Welded and Riveted Connections. Proc. Nat. Acad. Sci., 17:351–59.

A New Theory of the Distribution of Shearing Stresses in Riveted and Welded Connections and Its Application to Discontinuities in the Structure of a Ship. Trans. Inst. Naval Archit. (London).

Review of *A History of the Vikings,* by T. D. Kendrick and *Leif Eriksson,* by E. F. Gray. Geograph. Rev., July.

Article on Disarmament. New York Times, December 6.

Determination of Stresses in Plating from Strain Measurements. Trans. Soc. Naval Archit., 39:25–33.

Some Features of a Modern Airship—U.S.S. "Akron." Trans. Soc. Naval Archit., 39:154–56.

1932

Review of *The Kensington Stone,* by H. R. Holand. Geograph. Rev., July.

Ritz's Electrodynamic Theory. J. Math. Phys., 11(4).

The Kensington Stone. American-Scandinavian Review, April.

1933

Theory of Elasticity, Solution of Problems by Trial. Trans. Soc. Naval Archit., 41:61–62.

1934

The Stress Distribution in Longitudinal Welds and Adjoining Structures. J. Math. Phys., 13(2).

An Investigation of Stresses in Longitudinal Welds. Proc. Nat. Acad. Sci., 20:17–23.
Ship Structural Design. Trans. Soc. Naval Archit., 42:56–57.
Ground Tackle. Trans. Soc. Naval Archit., 42:169.
The Battle Cruiser. Trans. Soc. Naval Archit., 42:270–72.

1935

Article on Disarmament. New York Times, February 24.
Engineering Education in England and Germany. Trans. Soc. Naval Archit., 43:99–100.
Determining Anchor Holding Power from Model Tests. Trans. Soc. Naval Archit., 43:114–15.
Strength of Plating in Compression. Trans. Soc. Naval Archit., 43:128.
Stresses in Three-dimensional Pipe Bends. Trans. Am. Soc. Mech. Eng., October.

1936

Discussion of last item listed in 1935. Trans. Am. Soc. Mech. Eng., July.
Torsion of Rectangular Tubes. Proc. Nat. Acad. Sci., 22:362–67.
Airships for Naval Service. Proc. U. S. Naval Inst.
Medium-Sized Fast Liners. Trans. Soc. Naval Archit., 44:252–53.

1937

Torsion of Rectangular Tubes. J. Appl. Mech., September.
Is War Inevitable? Proc. U. S. Naval Inst.
Alloys in Shipbuilding. Trans. Soc. Naval Archit., 45:197.
Design and Construction of Ship Interiors. Trans. Soc. Naval Archit., 45: 229.
Further Studies of Three-dimensional Pipe Bends. Trans. Am. Soc. Mech. Eng., November.

1938

Discussion of last item listed in 1937. Trans. Am. Soc. Mech. Eng., October.
Care of Cargo at Sea. Trans. Soc. Naval Archit., 46:153.
Bending Theory of Ship Bottom Structure. Trans. Soc. Naval Archit., 46: 191–92.

1939

Ship Plating under Compression and Hydrostatic Pressure. Trans. Soc. Naval Archit., 47:111.

Graphical Analysis of Pipe Stresses. Trans. Soc. Naval Archit., 47:152–54.

1940

Notes on Rolling and Lurching. Trans. Soc. Naval Archit., 48:88–89.

Calculation of Motion and Stresses of a Pitching and Heaving Ship. Trans. Soc. Naval Archit., 48:110

The Effect of an Added Weight on Longitudinal Strength. Trans. Soc. Naval Archit., 48:123.

Investigation of Structural Characteristics of Destroyers "Preston" and "Bruce." Trans. Soc. Naval Archit., 48:160–63.

Feed Systems for Naval Vessels. Trans. Soc. Naval Archit., 48:316–17.

1941

The Growing Importance of Small Models for Studies in Naval Architecture. Trans. Soc. Naval Archit., 49:109–10.

Precision in Naval Architectural Calculations. Trans. Soc. Naval Archit., 49:148–49.

Design Curves for Cross-stiffened Plating under Uniform Bending Load. Trans. Soc. Naval Archit., 49:179.

1942

Subdivision of Ships as a Protection against Foundering. Trans. Soc. Naval Archit., 50:260–61.

1943

The United World. American-Scandinavian Review, June.

1946

Aspects of Large Passenger Liner Design. Trans. Soc. Naval Archit., 54: 358–59.