The Science of Camouflage Explained

By Raymond Francis Yates

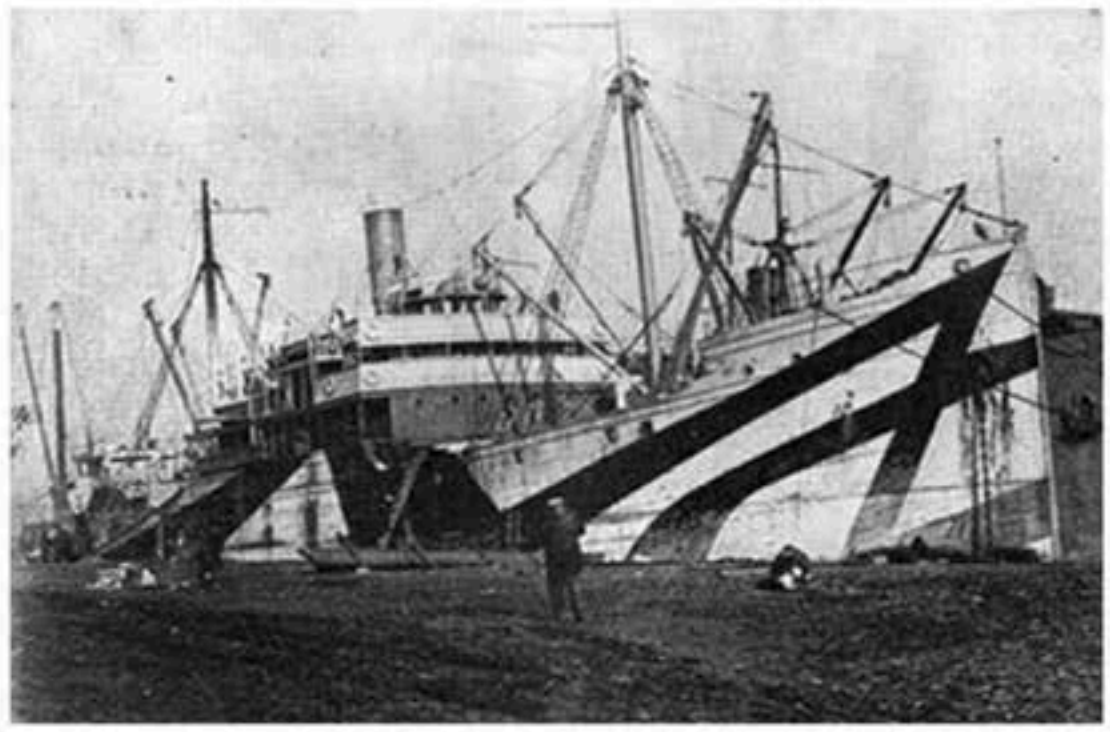
CAMOUFLAGE has been a much used and misused term during the past few months. The real science expressed by this word has been included with many other "war mysteries" about which the public received little information. We have seen many pictures of camouflaged vessels, and it is indeed difficult for the lay mind to connect optical science with a crazy-quilt, or, quoting an English authority, with what looks like "a cross between a boiler explosion and a railroad accident." True, we know that vessels were smeared with unsightly streaks of various colored paints to deceive German U-boat commanders, but as to the real basic facts behind these multi-colored freaks we knew little or nothing. A few daring newspaper and magazine correspondents made some desperate attempts to explain Camouflage, but their "startling" revelations were somewhat devoid of tangible information.

After the war clouds cleared away, the writer decided to gather some data on this interesting subject and present it to the readers of EVERYDAY ENGINEERING. The search for this material led him to an ordinary three-story brick building on the East Side of New York—a queer place indeed for one to seek information on such a subject. There was nothing about the building that would give a clue as to what was going on within—no signs or indications of any sort that would lead one to believe that it had such an important connection with war work. At the top of two flights of wooden stairs there was a door with "William Andrew Mackay" on it in modest lettering. With a certain feeling of awe the writer entered and asked to see Mr. Mackay. A very cordial "come in" echoed from the adjoining room, and the writer, with renewed courage, entered the mysterious sanctum of Camouflage; a place where men labored unceasingly to protect vessels from submarine attacks, not by means of an impenetrable armor, but with a thin crust of paint.

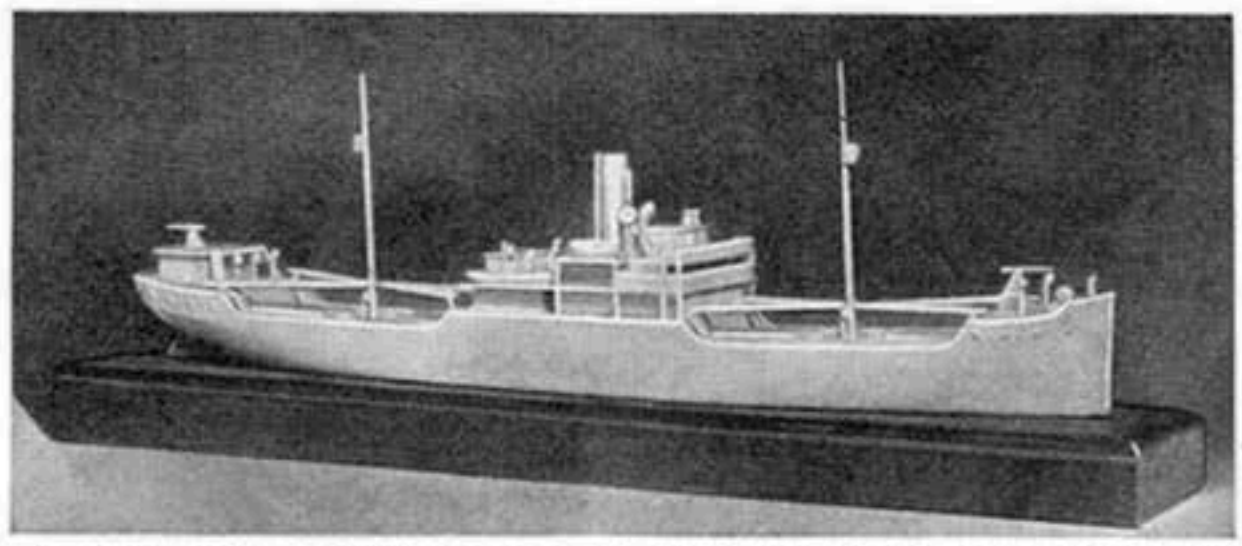
Upon learning my purpose, Mr. Mackay started to unravel his story—the Mysteries of Camouflage—a very absorbing revelation indeed. First came the history of the work, and with the history the name of William Andrew Mackay will always be closely connected. Mr. Mackay is America's pioneer camoufleur. Although a professional artist, he has busied himself with the problems of optical deception, through the medium of camouflage, since the year 1912. An effort to render submarine periscopes invisible through deceptive coloring caused Mr. Mackay to rivet his attention on this engrossing work. During the year 1914, in connection with the Navy Department, Mr. Mackay experimented with the camouflaging of submarine periscopes, this work being carried on at Pensacola, Fla. The results were very satisfactory. During the same year, Mr. Mackay brought the matter to the attention of the Secretary of the Navy and briefly outlined to him the possibilities of the work, giving some account of his experiments.

During the year 1915, these experiments were continued and the camouflage was extended to the superstructure and the hull. The sympathetic support and co-operation of Commander J. O. Fisher, then in command of the K-boats, was enlisted, and since that time he has been a staunch advocate of camouflage. Through his untiring efforts, as a devotee of Mr. Mackay's work, Camouflage has received great impetus in America.

In October, 1915, Commander Fisher was detached from the service at Pensacola and sent to Washington. This resulted in the work being turned over to Lieut. R. C. Grady, and a number of submarines were painted under his direction.



A camouflaged freighter. A camoufleur's model of this boat is shown below



A model of the freighter shown above. This model is used for experimental purposes in the camoufleur's laboratory

Mr. Mackay continued his work with great perseverance. He believed in the value of camouflage and was determined to carry on his work. Some time before the United States entered the world war, Mr. Mackay organized a camoufleurs' training school; the first institution of its kind in this country. As a matter of history, we will record the names of those men who became members of this unique institution, and who learned the fundamentals of camouflage first hand from its sponsor in America:

Harold Everitt Austin, Charles Bittinger, Henry Scott Bluhm, Thomas Casilear Cole, Maurice Lisso Freedman, Erie Gugler, W. S. Gephart, George Edgerly Harris, Kenneth S. MacIntire, Raymond J. Richardson, Frank Julius Spicker, Walter L. Ward, and Charles D. Bosisio.

These men became Mr. Mackay's thirteen disciples of camouflage, and through his untiring efforts they became thoroughly acquainted with the work that he held so close to his heart. Where they were going to use the knowledge thus attained under Mr. Mackay's guidance they did not know—definitely. Neither did their instructor know, but this did not dampen his enthusiasm.

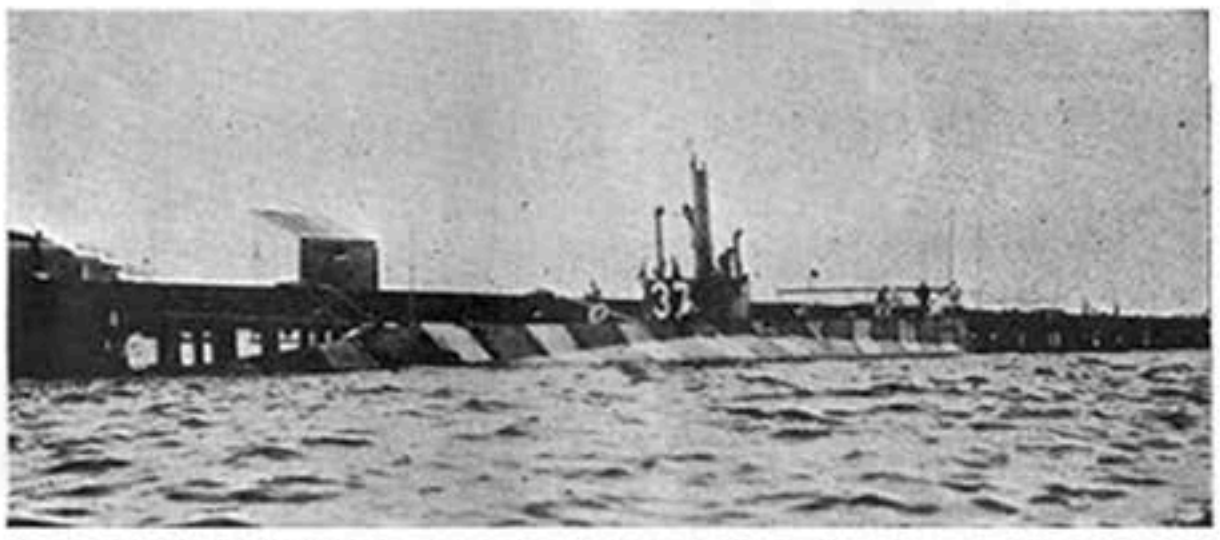
The United States was in the war for some time before the value of camouflage was officially recognized, and then came the call for camoufleurs. Camoufleurs? But who knew anything about camouflage, and where were such men to be found? At this point Mr. Mac-

kay's advice was sought, for, as he told the writer, he "had the only coop-full of camoufleurs in captivity." In a short time the members of his school became the nucleus from which our great body of camoufleurs grew. Many of Mr. Mackay's student camoufleurs were called to various parts of the country, while the remainder stayed with the Second District Division of Camoufleurs in New York City. So much for the history of camouflage in America. We will now proceed with our explanation of the real science involved in the work.

There are two distinct systems of marine camouflaging, i.e., "low visibility" and "dazzle." The former system, when applied to a vessel, has a tendency to render it more or less invisible at a distance. The colors used are of such combinations and values that they cause the vessel to melt away on the horizon. An ordinary vessel is silhouetted against the horizon because its color offers a distinct contrast to that which is back of it. In other words, it forms a patch on the horizon, and we can easily see that it is possible to paint out this patch by using colors that correspond to the background against which it is moving. This would cause a vessel to become quite invisible at a comparatively short distance. This is all good and true, but what compensation could be effected for changes in the color of the horizon? The answer is choosing a combination of colors that will meet general conditions. During the early part of his work, Mr. Mackay was a supporter of the low visibility school. Through the co-operation of a large American manufacturer, one of their sea-going vessels was camouflaged. This was the first large vessel that was camouflaged in this country. A report regarding observations on this vessel reads, "It was difficult to detect her approach, and I could only half close my eyes in looking at her to appreciate the difficulty of seeing her any great distance at sea."

The dazzle system of camouflage is of English origin. It was developed under the direction of Lieut. Commander Wilkinson, R.N.V.R. The dazzle system does not render a vessel invisible, in fact, it does just the opposite. The dazzle system was devised as a means of distorting the perspective of a vessel. This system has been very successful. When properly applied it plays havoc with the eyes; nature is indeed a victim of clever deception. The lines of a vessel are completely broken up into confusion, and it appears to be going in one direction when it is really going in another. As will be seen, it would be difficult to hide such a vessel from a submarine commander, but at the same time it is able to defy the submarine commander and to cause him great embarrassment in aiming his torpedo. He may fire a torpedo, after basing his calculations on the direction in which the boat is apparently traveling, but in reality the boat is taking an entirely different course, and therefore the shot will be ineffective. During the course of the war, the submarine commanders were alert to the shortcomings of their eyesight, and it was their practice to pick out a certain part of the superstructure of the vessel which was more or less weakly protected, and to use this as an aiming point. They would choose a corner of the cabin or some similar portion of the ship. They were later baffled, however, as the camoufleurs became more proficient in their work. The submarine commanders then used ray filters and in this too they met with failure.

Are these letters inverted or perpendicular?



A camouflaged submarine. This picture is of historic interest. It was taken at Pensacola, Fla., during the year 1913

An interesting story is told of a vessel that had a four-hour battle with a submarine. At comparatively close range, the submarine discharged three torpedoes, each one of them going wide of its mark. Upon the failure of these torpedo attacks, the submarine came to the surface and an open battle ensued. Of 240 shots fired at the vessel, by the submarine, but four were effective. It would seem that the gunners of the submarine had some trouble with their eyesight.

Each design used on a camouflaged vessel must be carefully developed in the camoufleurs' laboratory before it is finally accepted for use. The method of producing these designs and the routine of experimental work in determining their value is very interesting. First a tentative design is drawn on paper on a scale outline of the vessel to be camouflaged. The design is copied from this preliminary sketch upon a scale model of the vessel. Model boats are cast in plaster-of-paris from moulds, so in the event one design does not prove successful the work can be continued until satisfactory results are obtained. After the design is painted on the model, it is placed upon a small turntable. Back of this turntable is a curtain upon which the horizon is painted. (See cover of this issue.) This turntable is in a small compartment illuminated with a daylight lamp. A circular opening about 1½ ft. in diameter is cut in the partition, and a few feet in front of this a submarine periscope is placed. Looking through this periscope the "submarine commander" can see just how the vessel will appear upon the ocean. He can also vary the lighting effects and change the horizon as well as alter the direction of the boat, by changing the position of the turntable. After the design has been thoroughly tested in this way and found to be efficient, the camouflaging of the prototype is started. Experts mark off the design on the vessel, after which the paint is applied. When the painting is finished, the design is carefully inspected by officials before the final O. K. is given.

In the Camoufleurs Laboratory of the Second District, which is under the direction of Mr. Mackay, eight designs were developed every day, one each hour, and considering the work involved in the production of these designs, this is indeed a splendid record.

Mr. Mackay has devised a system of camouflage which he calls "disruptive coloration." It involves the use of both "low visibility" and "dazzle" systems, his object being to produce a happy medium that would fade away on the horizon, and if approached, would be deceptive. This particular system was recognized as being very efficient and just what was desired. Its development was brought to a close by

the official signing of the armistice.

As Mr. Mackay is an artist of no mean ability, he is very familiar with color and its application. A naval officer once asked him which was the better color for naval work, a light, warm gray or a darker blue gray. This query brought forth the following answer, which is important enough to record:

"The fact that the question shows there is a range from light to dark in the gray desired leads the writer to the conclusion that a battleship gray should be able to change, as the Captain suggests, in his question.

"Gray paint is made of pigments that, once ground together, are not able to change their tone. In light, gray is made up of red, green and violet. The air becomes warm and yellow in color when the sun shines through it, and when the sun is gone the air turns to the violet and cooler tones. It has been proved by practice and by observation that by placing the colors separately on a ship, say, red, of a luminosity of 51 degrees, white being 100 degrees, green of a luminosity of 51 degrees and violet 51 degrees, that a gray will be made in the same manner that the gray is made that surrounds the ship, but with this advantage; should the sun shine, the red part of the ship will warm and lighten the general tone of the gray. If the sun goes under, the red will go down again to its original position and the violet and green colors will affect the gray. These effects have been noted on ships painted in sections of red, green and violet, either in small dashes and dots or in large sections.

"The writer, in company with several scientists of a certain Society, visited the S.S. Olean. The S.S. Olean was the first large ship so painted. Previous to this experiments had been made in the Navy, at Brooklyn and at Pensacola."

"The S.S. Olean was carefully studied, and it was the opinion of one of the scientists when he first saw the ship that the masts should be black. After a half hour's study he said they should be painted white and then he decided that black and white in sections should be used. But neither of the scientists present would see any use for color. I told them that the spectroscope showed red, green and violet, and that by its use a vessel could change with the light that surrounded the ship and thus settle the question which is the best to use, light and warm or darker and blue."

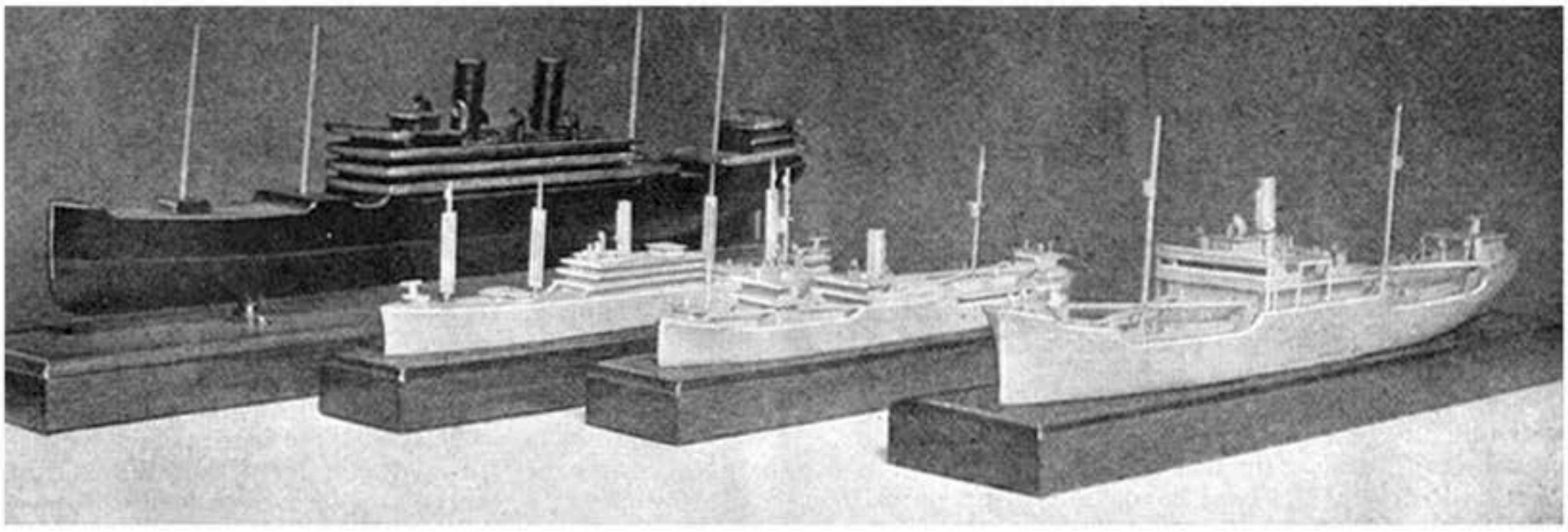
This brings forth the question: With whom will the development and perfection of camouflage rest, the scientist

A dazzle camouflage design

or the artist? At snap judgment we may decree the scientist, but upon further reflection we come to the conclusion that this work necessarily comes within the realm of the artist. The position of the scientist is like that of a dramatic critic who can criticise the performance of players upon the stage, but cannot act himself. The artist is a man thoroughly conversant with colors, their application, valuation and combination. The artist is the man best able to judge the practical effect of color, and we cannot deny him the important position which he must always hold in connection with the work of camouflage. When the artist paints a picture, he does so with the purpose of producing a certain effect, and, while the scientist thoroughly understands the colors that the artist is using, he cannot apply them. If he could apply them he would be an artist, not a scientist. The distinction is a clear one. This is just the position the scientist takes in regard to camouflage, and, although we cannot mitigate the importance of optical science in the perfection of camouflage we must confess that the future rôle of the scientist in this work will be somewhat unimportant.

What of the future of camouflage? Will it continue, and if so what form will it take? It is interesting to muse on this question, and incidentally we may drift into some important channels of thought.

The Peace Conference is considering the abolishment of the submarine, but it is a matter of conjecture whether or not this policy will ever be adopted. In this connection camouflaging today offers a peculiar suggestion. If we are trying to conceal boats by painting them, why not carry the work of concealment a step further and build our boats so they could be submerged? The submarine as a naval weapon would become somewhat useless under these conditions. At this point the airplane as a fighting unit is introduced, and in the war of the future, we can see the camouflaged aircraft soaring amid the clouds seeking its prey beneath the blue waters of the sea. Then the submarine must be camouflaged to protect itself, and it is interesting to know that experiments in the camouflaging of submarines are already being carried on. The writer was fortunate enough to see a model of a submarine painted to resemble a mackerel. And the airplane, that, too, is receiving the attention of the camoufleur. The fighting aircraft of the future will seek its protection by taking on a combination of colors similar to those possessed by a bird known as the prion. This particular bird is the object of scientific investigation at the present time, as it

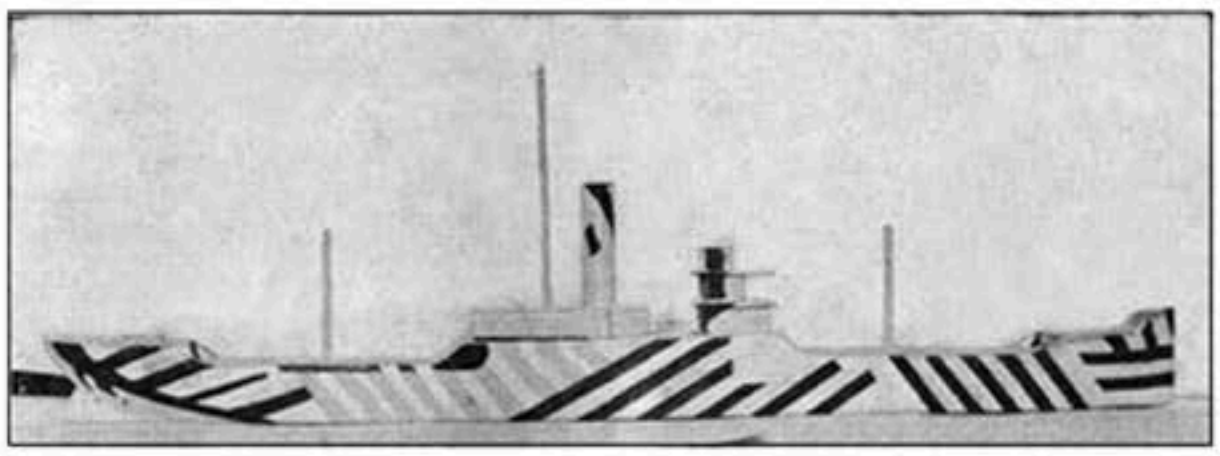


A fleet of models ready for the camoufleur

is one of nature's most perfect specimens of camouflage on the "low visibility" principle.

At the present time, Mr. Robert Cushman Murphy of the Brooklyn Museum is preparing a wonderful exhibit on camouflaging. This will be the first of its kind in America, and it will contain many interesting objects in connection with the history and development of the work. Mr. Murphy is to be congratulated upon his foresight in choosing this subject.

Aside from those mentioned, there are a number of other men who have made important contributions to the development of camouflage, and who labored indefatigably during the war. Herzog, Tosh, Bates, Warner, Emens, and Jones are names that will long be remembered in connection with the history of camouflaging. It is difficult to estimate the importance of these contributions to the war and we can only get a hint of their importance by recalling to mind the many lives saved by the use of deceptive coloration as a means of foiling the German U-boats.



A model freighter with a dazzle design

The camoufleur resorted to many clever ruses to deceive and embarass German U-boat commanders. In some instances the masts of the vessel were offset. This trick contributed greatly to the dillusion produced by the camouflaged. If there is anything that a submarine commander must know in firing a torpedo it is the direction that a boat is travelling in. If he does not have this information, the chances of scoring a hit are very remote. This is especially true in cases where the submarine cannot closely approach a vessel and it is necessary to discharge the torpedo at a great distance. This was usually necessary during the war, owing to the fact that most merchantmen carried light guns for submarine defense. It was a matter of strategy for the submarine commander to keep his U-boat out of sight. The introduction of camouflage greatly reduced the effectiveness of the submarine as a war weapon.

American technical writer **Raymond Francis Yates** (b 1895) was the author of popular books and magazine articles on science, engineering and technology, including several children's books. He also served as the editor of the **Everyday Engineering Magazine**, in which this article first appeared (Volume 6 Number 6, March 1919, pp. 253-256).