

SEA POWER

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Marine Camouflage

A preliminary account of the subject from the standpoint of a naturalist

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Low visibility in pelagic animals. Whalebirds photographed by the writer off the coast South Georgia, 54 south latitude. Several large black petrels, and one or more albatrosses, show up distinctly, but the hundreds of blue-gray Prions are difficult to distinguished from the background, notwithstanding the fact that many of them were within a few yards of of the camera.



WHEN JULIUS CAESAR sent his scout patrol boats (*speculatoria navigia*) along the coast of Britain, he first had them painted green and ordered their crews to wear clothing of the same color. This prophetic incident, referred to in the fourth book of his *Gallic Wars*, is, so far as I have been able to determine, the first record in history of marine camouflage. Changes in the color or painted patterns of ships, or sudden alterations of the superstructure and conspicuous parts of the hull for purposes of subterfuge have been familiar in many wars since medieval times, but the Roman emperor seems to have had definitely in mind one of the two main objects of modern ship camouflage—namely, low visibility—an object apparently not sought again for naval vessels until the period of the Spanish-American War.

Ship camouflage, as we know it today, is a more or less direct outgrowth of military or land camouflage, and the latter is in turn derived from a consideration of the concealing coloration of wild animals in their native environment. Exhaustive researches and voluminous speculations in the realm of this intricate and provocative subject were begun toward the close of the last century by various investigators, among whom the American artists and naturalists Abbott and Gerald Thayer, father and son, deserve first place because of their graphic demonstrations and their influence, notwithstanding the still problematical nature of some of their tenets. The work of the Thayers gave rise in the United States to a mass of controversial scientific literature, to which Colonel Theodore Roosevelt, among others, contributed at least one paper of 113 pages; but to European students, particularly to certain French strategists whose names I do



Edward Wadsworth (1919)

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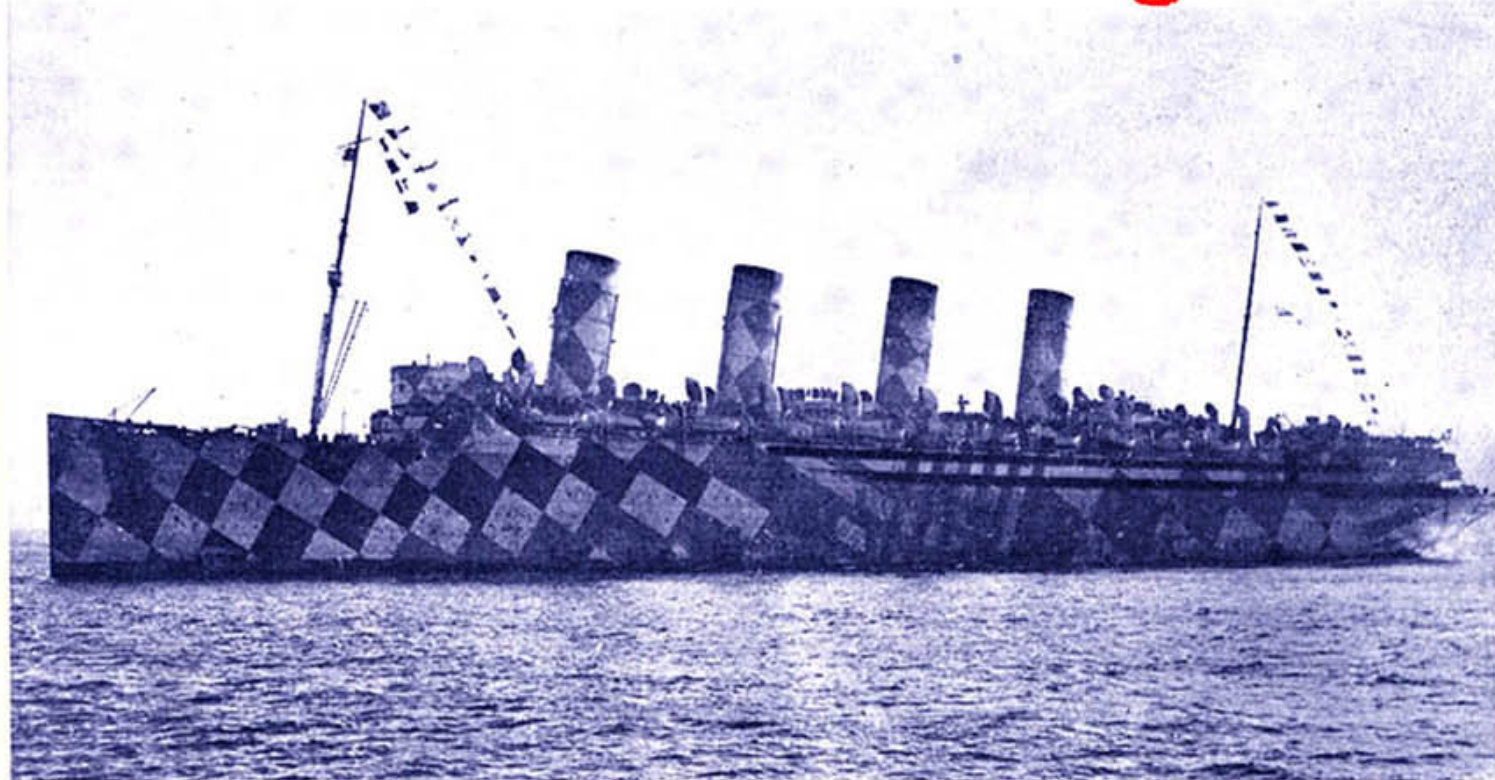


A whalebird (Prion) of the subantarctic Atlantic, a living example of low visibility over an ocean similar in meteorological features to that of the northern war zone. In the saturation, wavelength, and reflecting power of its dominant hue, the whalebird substantially agrees with "Omega-gray," the color especially devised for low visibility in high latitudes.

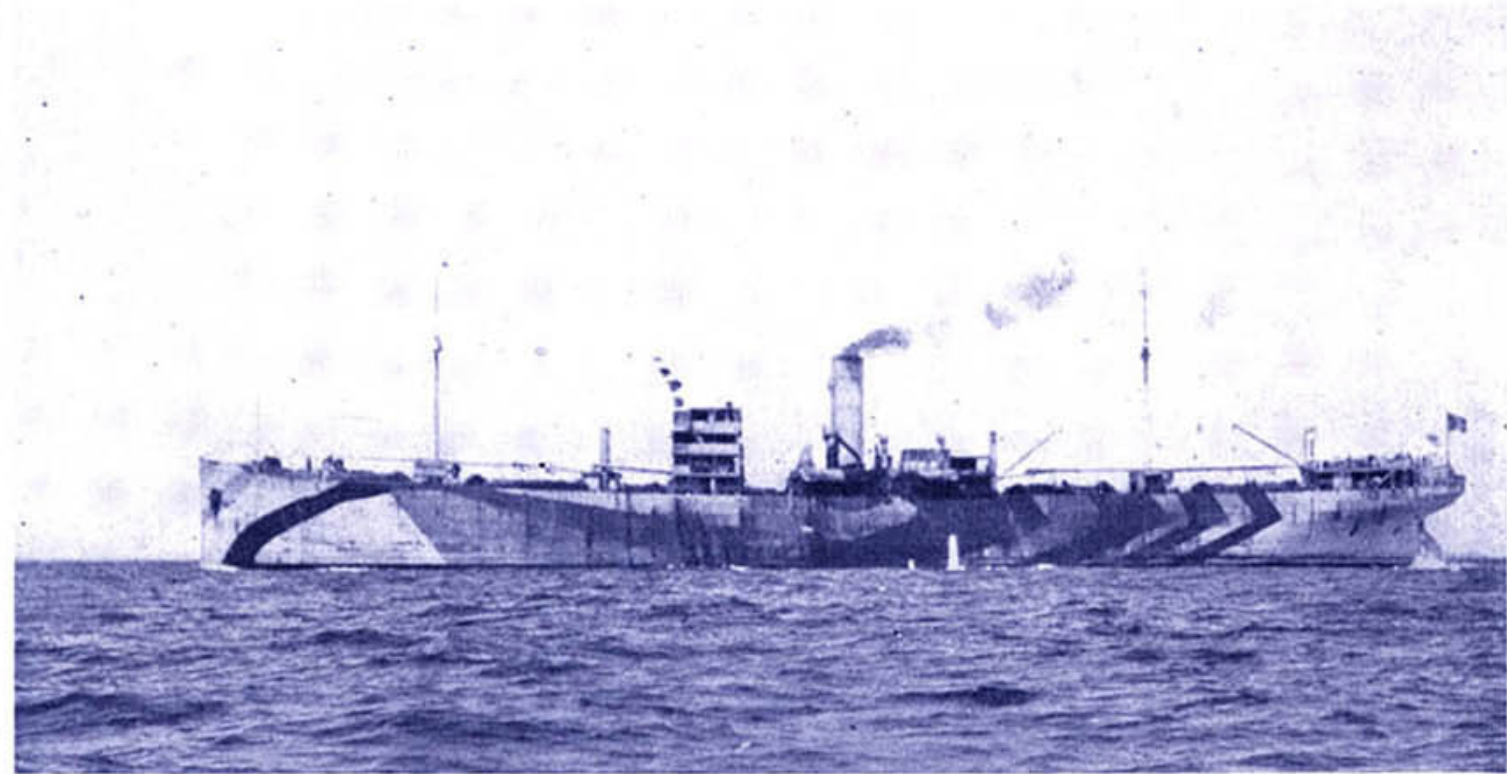
not know, belongs the credit of originally perceiving the applicability of obliterative coloration to the science of modern warfare. Abbott Thayer was, I believe, the first to point out the low visibility of white under a variety of conditions, especially in combination with colors, and it is noteworthy that the chief ground-colors and blend resultants used upon successfully camouflaged vessels during the present war have had a high "saturation," *i. e.*, percentage of white. Several years ago Thayer advanced the paradoxical idea that white by itself is of lower visibility than black or hues of low saturation when seen against the sky on a dark night. This received tragic confirmation when the *Titanic* sank, for the tall iceberg, which appeared gleaming white and snow-topped on the morning after the catastrophe, had escaped even the trained eyes of the lookout in the darkness. Early in 1914, before the outbreak in Europe, when war vessels painted experimentally with a pattern of alternating white and black polygons (similar to the present design on the transport *Mauretania*) were found to have an advantage, as regards visibility, over ships painted in monochrome, Mr. Abbott Thayer remarked to me that his basic discoveries had received an approbation of the highest possible worth.

Compared with the inherent difficulties of concealment on the open sea, the problems of land camouflage seem child's play. The military camoufleur, who in the United States Army belongs to a section of the Engineer Corps, deals with entities or situations in a heterogeneous environment where visibility is relatively low in the first place. A terrain broken by paths and rocks, hillocks and hollows, shell craters, buildings, vegetation, innumerable other topographic features, and, not least important, shadows, is well adapted to the exercise of his cunning; a large proportion of his craft is applied to objects that are at least temporarily stationary; he has at his command all the resources of the plastic and graphic arts and of structural accessories. More significant still is the fact that suggestive illustrations teem in the terrestrial cosmos about him; the mottled moth on the tree trunk, the brown partridge squatting invisibly among dead leaves, the sand-colored lizard on the desert floor, are his models. Hues of inherent low visibility,

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The transport *Mauretania*, bearing a checkerboard "dazzle" pattern, which has advantages also from the point of view of low visibility. Under favorable light conditions such a design serves well to blur outlines.



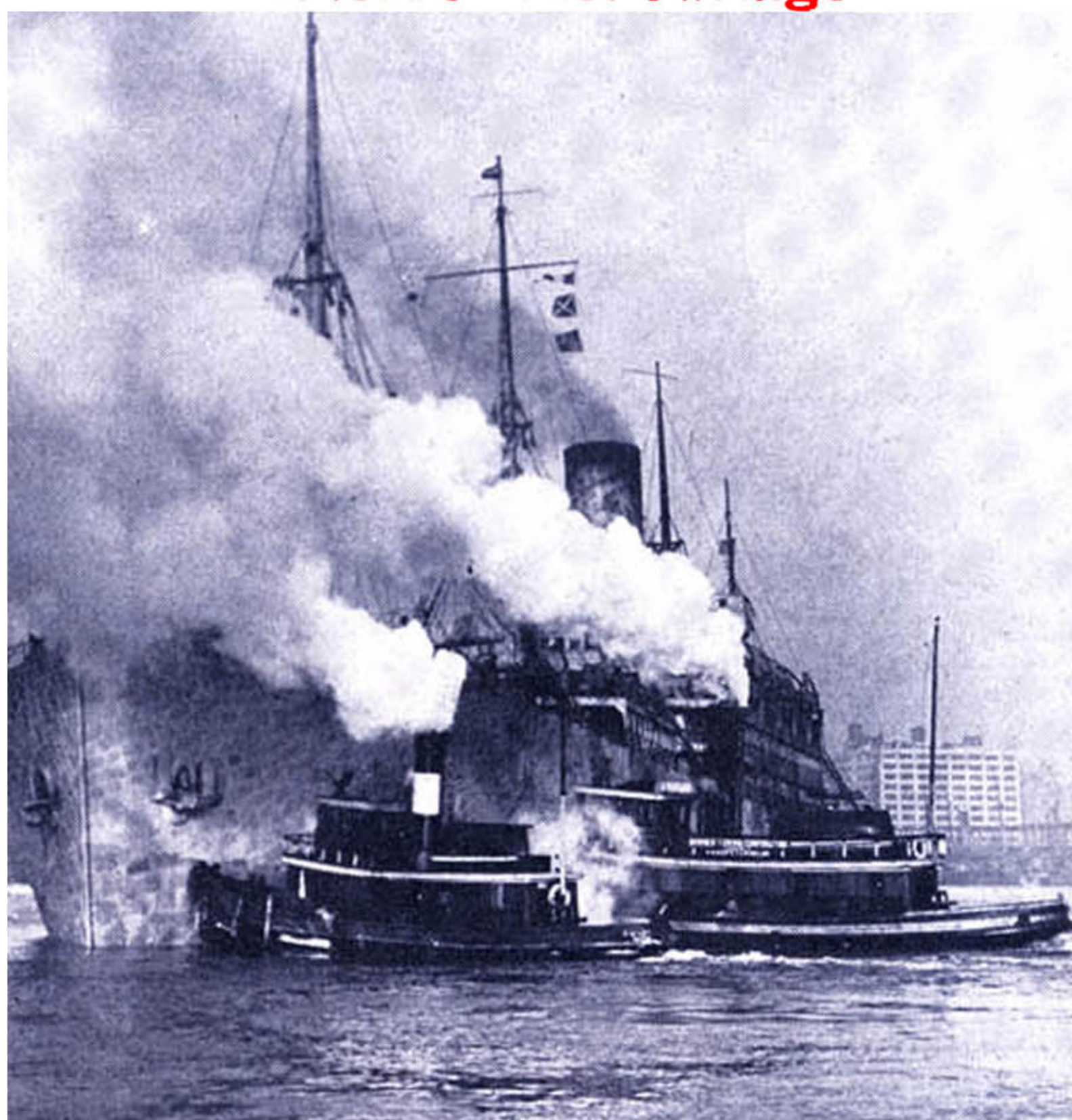
The steamer *Aden*, an example of the simple French designs; low visibility combined with "shortening up" and a false course effect. The illustration gives a poor idea of the colors, because two shades of blue, as well as a large gray patch, have photographed almost indistinguishably from the white areas.

counter shading, oblitative patterns, blurred outlines, disruptive contrasts, actual imitation of the surroundings—all these he draws directly from nature. The olive-drab of the Army uniform is itself a color that abounds in nature, but its visibility is lowest under tropical sunlight and in open country. The darker, less yellow shade worn by the Marines is better adapted to the latitude and atmospheric conditions of western Europe, and is, in fact, surpassed in approach to perfection only by the "feldgrau" of the Hun.

Turning now from the conditions of land camouflage to our specific subject, it is almost needless to refer to the contrast presented by the flat, illimitable expanse of the ocean, absolutely devoid of cover, across which the object to be rendered inconspicuous must travel at a rapid rate and without the advantage of any protective ruse save what it can carry with it. Not only is there no background possessing concealing features comparable with those of the land but, moreover, the camoufleur finds little aid in the field of natural history, for expressions of effective camouflage in animals that live on or above the surface of the sea are exceedingly rare. One such example was, however, pointed out by the writer early in the course of the war, namely the small subantarctic petrels or whalebirds of the genus *Prion*. These petrels are perhaps more gregarious than any other sea birds, and the outstanding characteristic of their enormous flocks is the extraordinarily low visibility of the individual birds. The color of *Prion* is a peculiarly beautiful blue-gray, not far different in tone from the "horizon blue" of the *poilu's* uniform, and likewise rather close to one or more of the grays which have been found by actual optical experiment to have the lowest general vis-

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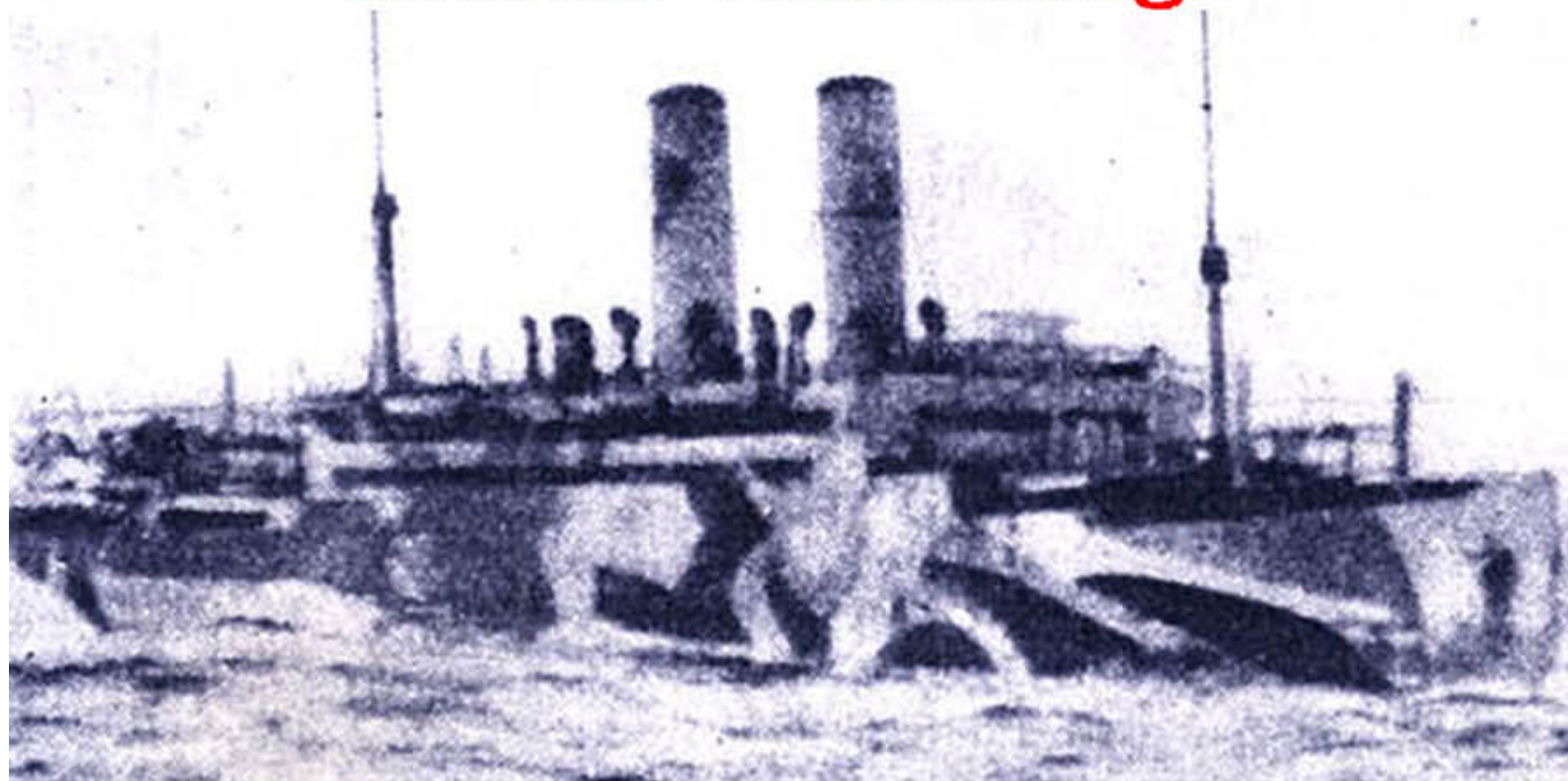
The Minnesota is here camouflaged with a dappled pattern of American conception, the intention being that the hues, applied separately, will blend at a distance to produce a tone of low visibility.

ibility under varying marine atmospheric conditions. It is worth mentioning that recent British experiments in camouflaging airplanes have resulted in favor of a pattern, which may not yet be described, but which is composed of colors almost identical with those revealed by an analysis of the blue-gray of *Prion*. The obliteration of the whalebird in its deep-sea environment is, of course, not due entirely to its prevailing color, but also to countershading and the presence of a slight pattern of both light and dark bands.

As regards concealing coloration within the water itself, we find innumerable instances, not only among oceanic invertebrates but among fishes as well. My friend Mr. John T. Nichols, of the American Museum of Natural History, has called attention to the fact that many pelagic free-swimming fishes (mackerel, dolphins, flying-fishes) with their greenish or bluish backs, silvery sides and white bellies forming a perfect scheme of countershading, are no less obliteratively colored than such notorious bottom-living fishes as the flounders. Mr. H. B. Tschudy, an artist and my colleague in the Brooklyn Museum, has collaborated with naval camoufleurs in a series of experiments on a miniature scale in which painted models of submarines were submerged in seawater, of varying color and clarity but uniformly illuminated from the sky, in the tanks of the New York Aquarium. His conclusions from these tests were that a submerged craft, white beneath, bearing a mackerel-like pattern upon its upper surface and countershaded by skillful blending on the flanks, might attain, when well below the surface, a close approach to invisibility to an aerial scout.

But these allusions are not wholly relevant, for practical marine camouflage in this war resolved itself into one clear cut, definite issue—protection of troopships and cargo carriers against submarines. Owing to the point of vantage of a periscope, in most instances within a few feet or even inches of sea level, a

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The transport *Tuscania*, photographed on the day before she was sent to the bottom by a German torpedo. This represents the British "dazzle" in its formative stage. The scheme has little or no practical effect in reducing visibility, even when the vessel is viewed at long range. The deceptive tricks, moreover, are far less misleading than others devised during later periods of the war.

further limitation was fixed in that a vessel endangered by a submarine was observed not against a background of water or even, as a rule, against a combination of water and sky, but rather as looming wholly above the horizon and against the pitiless sky, unless, indeed, she were at such long range that a *foreground* of water hid a portion of her hull. From the point of view of the camoufleur, the problem could not have been more clear and unified, nor more difficult of solution.

The first attempts at camouflage in the United States were aimed exclusively at low visibility but a second objective, commonly known as the "dazzle," soon came into prominence. The reason that camouflaged ships began so suddenly to dot the seas and fill our ports, to the wonder of wide-eyed landmen, is that on October 1, 1917, the Bureau of War Risk Insurance, recognizing the probable efficacy of protective painting, imposed a penalty of one-half of one per cent increase in premium upon all uncamouflaged merchant steamers in transatlantic service. In the same ruling, the Bureau limited the patterns for ships to a choice of one of the five "systems," devised by the same number of American students of the subject, which had up to that time received the approval of the Shipping Board.

Of the modification of superstructure, shortening of funnels, elimination of all but one mast, the use of painted screens such as were tried out on the ill-fated *Valeria*, the reduction of smoke issuing from the funnels, and the employment of dense, concealing clouds of smoke in emergencies, I shall speak only in passing. The unique feature of low-visibility camouflage consisted in painting vessels in such a manner that they would be least conspicuous at moderate ranges and altogether lost to vision at the shortest possible distance from an observer. Simple physical experiments determined that certain gray tones, differing slightly according to whether they were to be used in the generally overcast regions of the northern war zone or in the brighter, blue-sky-and-water latitudes of the southern or Mediterranean route, were best adapted for "painting ships off the ocean." It was also realized, however, that monochromes are seldom or never

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as inconspicuous as surfaces upon which the component hues of any desired mixture are applied separately in contiguous patches or bands, the resultant gray of lowest visibility being produced by the blending due to distance.

A ship standing above the horizon cuts off a silhouette of the light of the sky, and the camoufleur's problem is to paint her in such a way that she will transmit to an observer light equivalent to that which her opaque structure is interrupting. This involves the painting out of structural shadows with lighter colors so their reflection power will be raised to that of the more exposed surfaces. In practice, the eternal difficulty is that no combination of colors is equally well adapted to the changing light of sea and sky at different hours of the day and in different weathers and seasons. Here again, however, the separate application of component colors, one or more of which may harmonize with the background, gives a better result than a mixture of pigments. In the words of Mr. William A. Mackay, Camoufleur of the Second Naval District, pioneer and most successful exponent of the art in America, the Joseph's coat of a ship painted with correct proportions of red, green, and violet "will respond to light changes as no flat tone will. Battleship gray is made from pigments which have no color, black and white; the gray is made on the boat and carried to the eye in mixed paint. As it cannot change its color it will never quite fit its surroundings. The advantage of putting on separate sections of red, green and violet is that, if the source of illumination becomes warm, the red will count and the gray will be a warm gray. If the light becomes cool the red will go down and the green and violet will come up."

The so-called "dazzle" systems of camouflage—the piebald effect—make a vessel "unhittable" rather than invisible. The early British "dazzle" scheme was based frankly upon the assumption that "invisibility at sea being unattainable,

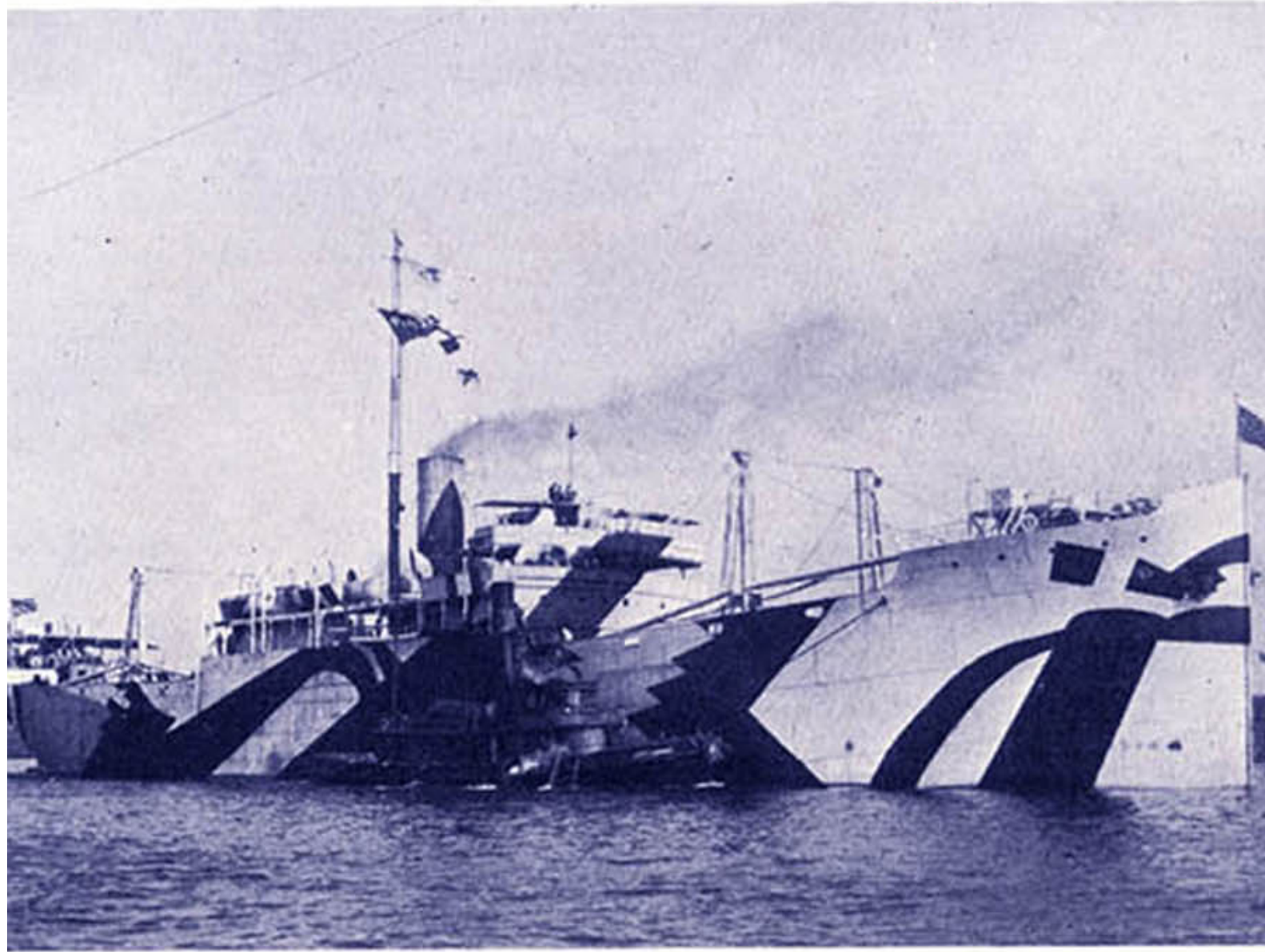
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some protection may be offered by painting the ships in such a way as to confuse the enemy and, by causing some doubt as to course, speed and distance, thus delay the discharge of the torpedo." Mr. Mackay, however, attempted several years ago to produce a "low visibility-dazzle," which would combine the advantages of both systems, and the more recent British applications, especially those involving the use of more or less upright, broken, dark and light banks (*e. g.*, the designs of the *Lapland*, the *Walmere Castle* and especially the American transport *Leviathan*), have tended toward a return to this principle. The chief criticism to be made of the pure "dazzle" theory is that the color patches are so huge and contrasting that they blend only at a distance at which invisibility or extremely low visibility might otherwise be obtained. A United States naval vessel used for purposes of experiment was rendered invisible, under slightly hazy weather conditions, at a range of less than three thousand yards. If it be considered that the periscope of a U-boat in action is commonly projected for only a few seconds at a time, and that the image inevitably loses a considerable proportion of its light through reflection and absorption, the importance of low visibility becomes apparent. Lieutenant Loyd A. Jones, of the United States Navy, inventor of the visibility-meter, has in fact demonstrated that reducing visibility by two-thirds would render a vessel nine times less liable to attack.

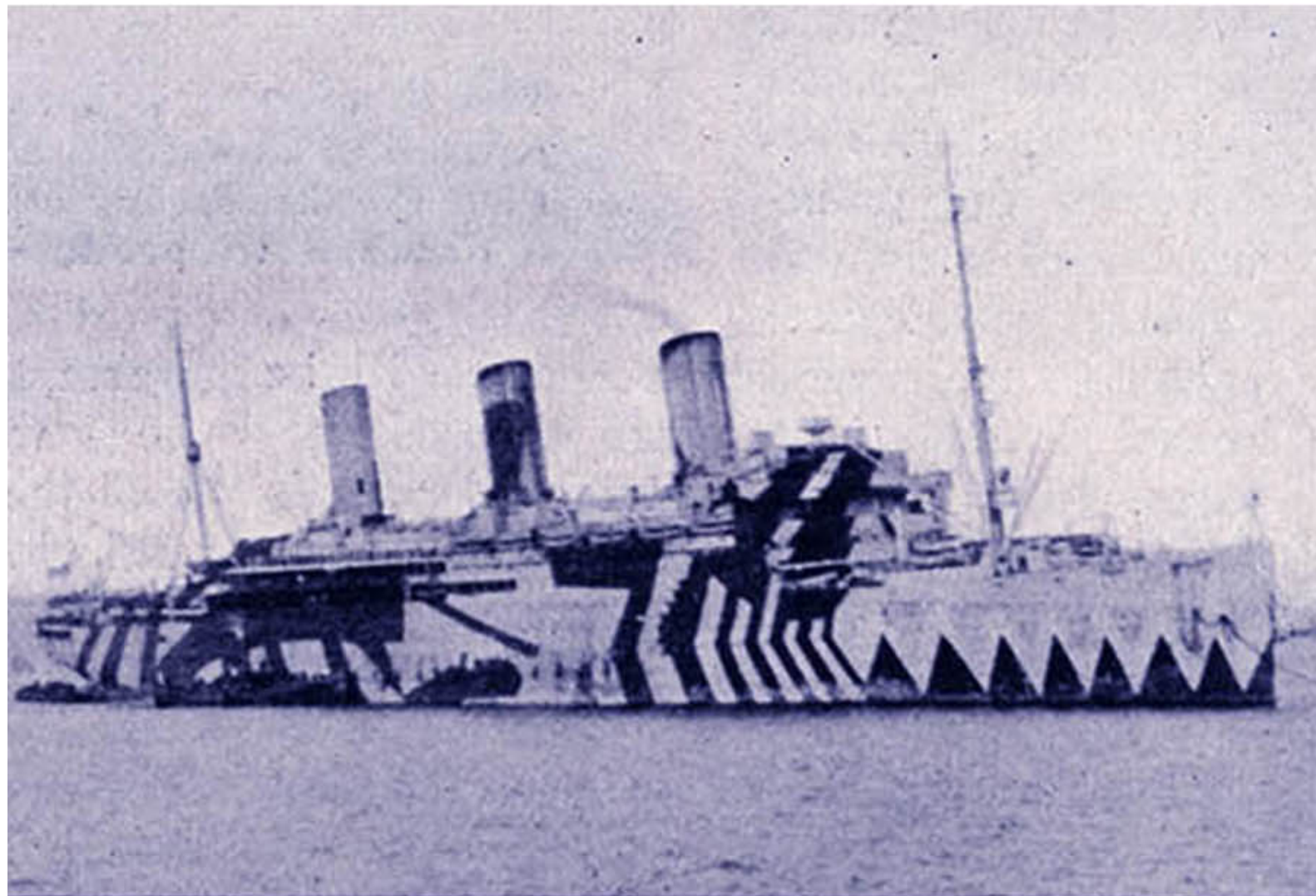
The French, who have been signally successful with their camouflaged steamers, have clung to the earlier principle of long-range defense, although the idea of deception as to size was by no means lost sight of in the application of prevailing low-toned pigments in juxtaposition with restricted areas of black and white. The French theory, which obviously differs from that of the British, assumed that one of their own protectively painted vessels, sighted at a distance of four thousand yards or more, might seem to be so unfavorable an objective as regards visibility, that the submarine observer would greatly overestimate her range, and, being furthermore without means of judging her speed and course, would lose hope and make no effort to pursue.

The "dazzle" systems, in their most comprehensive sense, include deception in all possible phases, with the object of causing an enemy observer to form in-

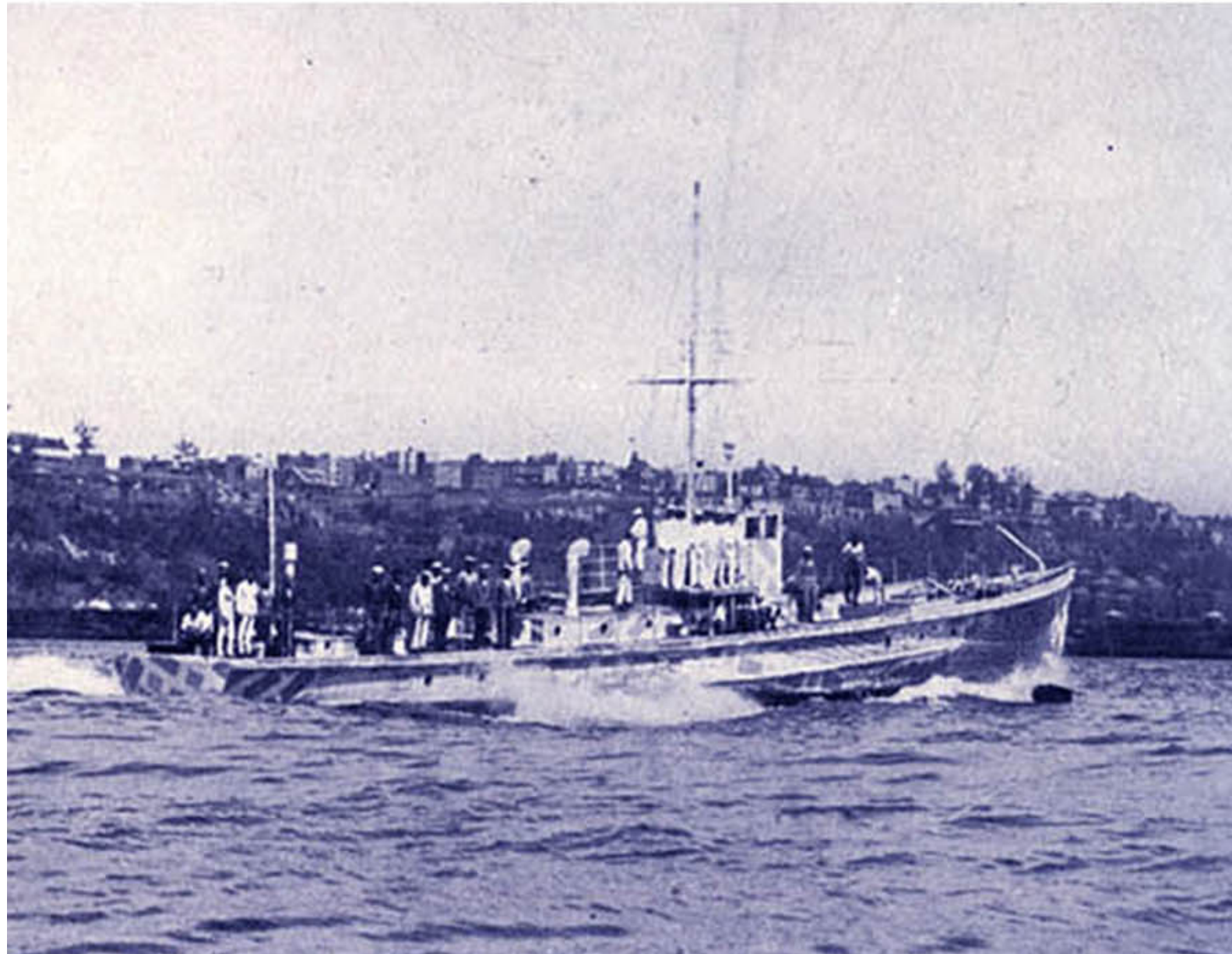
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An American "dazzle" camouflage. Such designs often involved the use of relatively bright colors, such as pink and high blues.



The Leviathan, greatest ship afloat and the latest word in camouflage. This war prize, which has been of tremendous value in ferrying American troops across the sea, has the most efficient "dazzle" thus far applied to any large steamer. So difficult has it been for accompanying destroyers to judge of her direction that she has been, as one naval officer expressed it, almost a menace to her convoy. On occasions, during her zig-zag coursing on the trans-Atlantic route, she has fooled the protecting destroyers altogether and has very nearly dodged out of their sight.



A submarine chaser with American low visibility camouflage.

correct judgments as to the size, range, speed and course of a ship. An artificial bow wave, an apparently shortened or reduced hull, distorted perspective, the elimination of all vertical lines and right angles, undoubtedly multiply the difficulties of a U-boat observer. Fearful and wonderful were some of the suggestions for marine camouflage submitted during the early stages of the

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work, for these included astounding combinations to imitate sunset effects, fluorescent colors, appearances of reversed direction of a ship, complicated arrangements of burnished mirrors to reflect water and sky, and many others. One odd conceit, which was tried out with apparent success, was the "painted convoy." Several transports, among them the *Von Steuben* (a former German liner), made the greater part of one or more return voyages across the Atlantic in charge of a destroyer *painted on her sides*. So realistically was this accomplished that many members of the crews of American scout patrols were completely deceived when such transports first passed them broadside on.

A common type of periscope range-finder contains a scale of cross-hairs upon which a ship of known length will measure a definite number of units at a certain distance from the instrument. A second type gives double images which are adjusted one above the other, after which the range of the vessel under observation is computed from the angle of shift. But both methods are alike in that either the length or the height of the target must be assumed. Now if these estimates, which offer at best a chance for error, can be made still more unreliable by means of painted designs, the "dazzle" will have served its purpose by leading to a greater or less misjudgment of the range of the ship. Likewise, by diverse treatment of the port and starboard sides, and especially by applying confusing, asymmetric patterns to bow and stern, it is possible to convey a false impression of a ship's course. An error of twelve degrees in course, two knots in speed, or a few hundred feet in range, may be ample to cause a torpedo to miss its mark, or even to prevent a submarine commander from ever reaching a suitable position for discharging his missile.

I have often been asked seriously whether many of the designs of marine camouflage do not represent the vagaries of

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vorticists and fantasists rather than the products of applied science. What I have written above may answer this in part, and it should be

stated besides that trained physicists and engineers, having at their disposal the best of laboratory equipment, have devoted months of research to the subject. The confidential report of the Submarine Defense Association contains scores of tables, technical diagrams, chromatic and optical formulae, etc., summarizing the results of efforts to reduce camouflage to an exact science. It is only fair to add, however, that in practice the art of the camoufleur has not passed the flexible and experimental stage, and there is no doubt that many of the details in the earlier painting had no specific theoretical basis and represented to some extent the whimsies of temperamental designers. These features, which were permitted because "they could do no harm and might do good," should by no means obscure the deadly seriousness and importance of the fundamental work accomplished by specialists of the American Society of Marine Camoufleurs, the Submarine Defense Association, the Shipping Board and the Navy. It is noteworthy, in this connection, that Columbia University and other educational institutions added courses to their war-time curricula.

As to the relative success of marine camouflage in accomplishing its purpose, there can be no question. Records tabulated by the British Admiralty, but not yet revealed, prove that the defensively painted ship has had a better assurance of life than her unprotected counterpart, and a gratifying proportion of the known attempts to torpedo camouflaged ships have resulted in failure. I have had the privilege of excellent opportunities to observe vessels painted in accordance with the various systems, particularly during one continuous period of eight days at sea in the path of the transports from New York. When examined at long and moderate ranges in the environment for which their painting was designed, ships often present a strange and baffling guise, quite unlike the absurd appearance that they sometimes make beside the dock. The time is not yet ripe for complete reports, but it is safe to predict that when each combatant nation, including the enemy, has bared its records, they will furnish data for an illuminating and absorbing story of an intricate subject which is here touched upon in only a casual way.