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Setting the Stage for Deception
Perspective Distortion in World War I Camouflage

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Near the end of the 15th century, Leonardo da Vinci described a discovery he had made while investigating perspective. He mentioned it in his *Treatise on Painting,* and elsewhere included two drawings. He had discovered what is known as *anamorphosis*, of which his two examples may be the oldest surviving attempts. One is a drawing of a baby's face, but laterally stretched and distorted, as if on a rubber sheet. The second, which represents a human eye, is also horizontally stretched (Baltrusaitis [1977]: 33; Leeman [1976]: 10-11). At the time he made these drawings, there was no way of predicting that, centuries later, this seemingly trivial finding, and its later applications, would be of substantial significance in World War I ship camouflage.

In linear perspective, an artist typically faces a perpendicular working surface, both while constructing an image and later in viewing the final result. In the case of Leonardo, it is apparent that his drawings were not made from that frontal position but from a surprising view from the side, at the extreme edge of the page. As a result, when the drawings are viewed head-on, they appear distorted. However, when viewed from the edge of the page – from the position from which they originated – they appear to be perfectly normal.

Anamorphosis was apparently little more than a curiosity for Leonardo, not something of evident practical use. He did not use it in any of his own paintings, in part because, as he explained, anyone wanting to interpret the image would have to view it from the side, and even, to experience it optimally, to observe it through a peephole with one eye only (Baltrusaitis [1977]: 33).

Anamorphic distortion, as is equally true of perspective, functions by way of adjustments between size and distance. As the size of an object decreases, its apparent distance from the eye appears to increase, and, in turn, as an object's size

increases, it appears to be nearer the viewer. By alternating trade-offs between size and distance, we can create visual phenomena that appear to be nearer or farther away and/or appear to be smaller or larger in size, to a degree that is often surprising.

Among the best-known examples of anamorphosis is a painting by Hans Holbein, completed in 1533, a couple of decades later than Leonardo's original note. A double portrait titled *The Ambassadors*, it depicts in astonishing detail two French emissaries to the court of King Henry VIII of England (Fig. 1a). In subject, it is assuredly complex enough that entire books have been written about its labyrinthine symbols. But for our purposes, of primary interest is a seemingly indecipherable shape that hovers above the carpeted floor at the bottom center of the painting (Baltrusaitis [1977]: 91-114; North [2004]).

That mysterious floating form has been reproduced and written about so often that it would not be surprising to find that most readers already realize that it represents a human skull. To the uninitiated, if that is at first not apparent, it is because the rest of the painting was designed to be viewed from a frontal observation point. In contrast, the skull is an anamorphic distortion and was designed to be seen (just as in Leonardo's examples) from an unconventional view from the side, with ones right cheek along the wall, at the right edge of the painting (Fig. 1b). When viewed from that unorthodox stance, that encrypted floating shape takes on the appearance of a precisely rendered human skull (Fig. 1c).

Holbein's *The Ambassadors* is perhaps the most admired of historic anamorphoses. While there is no shortage of others, mostly they consist of less remarkable artifacts, including encoded political sleights, hidden erotica, or optical puzzles for children. Magicians have toyed with anamorphosis, as have publishers, as shown by a

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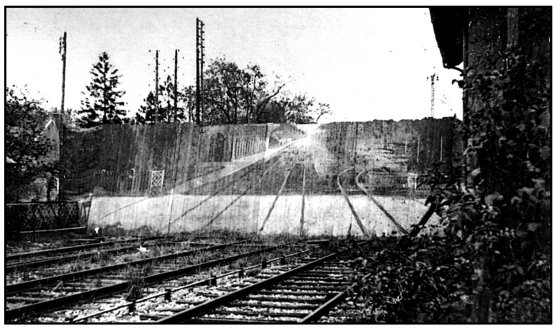
newspaper puzzle from the turn-of-the-century, which, viewed from the edge of the page, can easily be seen to read «A HAPPY BIRTHDAY» (Fig. 1d). Artists and architects have frequently made use of anamorphosis, as have stage set designers, special effects filmmakers, and hybrid artist-scientists who create wildlife displays (called habitat dioramas) for natural history museums. Today, anamorphosis is everywhere, as witnessed by the prevalence of illusion-based postings on the internet, such as chalk-drawn "street art" images that convincingly represent dimensional objects, but only if viewed or photographed from a static sideline point of view.

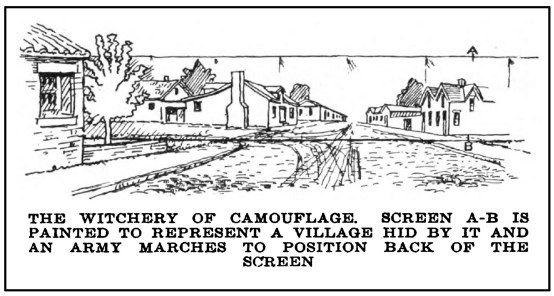
World War I began in Europe in the summer of 1914. By later that same year, it had become apparent to the French army that, because of advances in surveillance, there was an urgent, critical need for the skills of "vision specialists", those who as civilians had studied human vision and had mastered ingenious methods of «fooling the eye» of enemy observers (*tromper l'ennemi*) (Coutin [2012]). As a result, for the first time in history, a specialized camouflage unit was formed by the French Army. Soon the British did the same, as did (somewhat later) the American Army. The soldiers attached to these units, called *camoufleurs*, had typically worked before the war as architects, painters, sculptors, muralists, graphic designers, and theatre set designers. Also included were scientists who were expert in optics, lighting and color, while others were zoologists (or naturalists), since it was widely believed at the time that wartime camoufleurs could undoubtedly benefit from an understanding of protective coloration in nature.

A wide range of methods were tested in the development of field camouflage. Among the most common were: 1) *background matching*, in which figures (personnel, vehicles or equipment) were painted or otherwise covered in patterns that enabled them to blend in with their surroundings; 2) *disruptive patterning*, in which a figure was visually broken apart by covering its surface with a hodge-podge of discordant shapes (not unlike a harlequin's suit or a crazy quilt); and 3) *mimicry*, in which a figure's appearance was altered, causing it to be misidentified as a radically different kind of thing. To be sure, there were numerous other approaches as well.

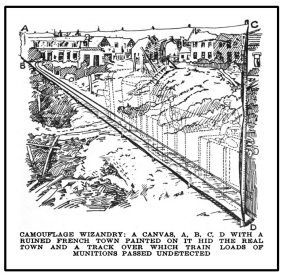
As for perspective illusions, it appears that their usefulness was limited in field camouflage, partly for the reason that Leonardo had anticipated. A perspective illusion works best if seen from the very same viewpoint from which it was made. For example, there is a photograph from WWI that records an attempt by American Army camoufleurs to create a perspective illusion (using a painted scenic background) in which several railroad tracks appear to continue into the distance (Fig. 2a). To

understand how this worked, it is instructive to look at three other images from the same time period. Two of these (Figs. 2b and 2c) are WWI-era drawings by American artist and camoufleur Joseph Minturn, in which he shows how he and other artists made large-scale outdoor backdrops that were based on perspective illusions (Minturn [1921]). The last is an editorial cartoon titled «Camouflage» (Fig. 2d) in which a comparable *forced perspective* ploy is used for political commentary.

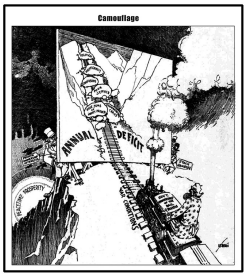




THE WITCHERY OF CAMOUFLAGE. SCREEN A-B IS PAINTED TO REPRESENT A VILLAGE HID BY IT AND AN ARMY MARCHES TO POSITION BACK OF THE SCREEN



CAMOUFLAGE WIZARDRY: A CANVAS, A, B, C, D WITH A RUINED FRENCH TOWN PAINTED ON IT HID THE REAL TOWN AND A TRACK OVER WHICH TRAIN LOADS OF MUNITIONS PASSED UNDETECTED

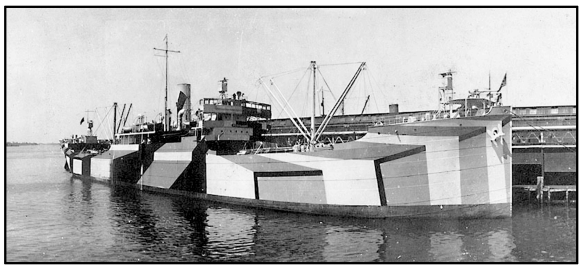


The problem with all these examples (which Minturn does not fully explain) is that they are only convincing (if at all) when the backdrop is viewed frontally, more or less. From an eccentric view from the side, they appear to be greatly distorted, just as the two ambassadors in Holbein's famous painting appear distorted when viewed from the edge of the painting, with the viewer's cheek along the wall (although the skull looks perfectly fine).

If perspective illusions were not ideally suited for WWI ground camouflage, they were of considerable value in naval camouflage. The circumstances came about early in the war, as the German Navy adopted a more stringent attack policy, increasingly using its submarines to engage in deadly torpedo assaults on non-military vessels, rightfully suspecting that supposedly blameless merchant ships were delivering weapons, ammunition and other wartime contraband to England. Among the consequences was the attack on the British ocean liner RMS *Lusitania*, off the coast of Ireland, in May 1915, in which nearly 1200 people died, including 128 Americans.

The phenomenal success of Germany's U-boat campaign (for example, in the last ten months of 1917, an average of 23 British ships were sunk each week) prompted a major assessment of Allied ship camouflage. It was a British seascape painter and naval

officer named Norman Wilkinson who called for a radical policy change. He urged the adoption of (what he and others called) *dazzle-painting*, a high difference brand of camouflage in which a ship was broken up (visually) by a profusion of contrasting colors and patterns. Unlike field camouflage, Wilkinson said, the primary goal of marine camouflage was not to conceal a ship – that was simply not possible, since its general presence was given away by its underwater engine noise (using hydrophones, a U-boat could detect a ship as far as ten or twelve miles away) and the emission of smoke from its smokestacks – but rather to decrease the odds of aiming at it accurately from the inevitably unreliable view of a U-boat periscope.



It is important to realize that a U-boat did not aim directly at a targeted enemy ship, nor did it "lead its target" in the straightforward, pedestrian manner of a duck hunter. Instead, complex calculations were made to determine where the ship would be by the time the discharged torpedo arrived. This was achieved in a roundabout way that relied on informed "guesses" about the range or distance of the ship, its speed, and the direction in which it was headed. To do this was far from easy (or safe), in part because a periscope could only be raised above the water for about thirty seconds at a time, because it left a telltale surface wake that announced the U-boat's location to submarine chasers.

On the Allies' side, all sorts of inventive methods were used to promote miscalculations. Ships were sometimes made to look as if they were traveling backwards, or false bow waves were painted on to throw off estimations of speed. Confusing structural changes were made to the stacks and masts. As for dazzle-painting, high contrast disruptive schemes were sometimes so bewildering (as reported by observers then) that a distant ship might seem to be two or three ships

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instead. There are scores of black and white photographs of camouflaged WWI ships (Fig. 3) (but unfortunately, no color photographs) that suggest just how baffling these patterns could be.

To further guarantee its success, ship camouflage was combined with other methods, such as traveling in convoys with escorts of submarine chasers, or steering not straight but in zigzags. During WWI, despite ongoing advances in periscope and torpedo design, it was claimed that captured documents showed that even the U-boat commanders believed that the range, course and speed of an Allied ship could be calculated with difficulty, if at all.

In 1917, when the US officially entered the war, it set up its own dedicated camouflage units, both land and sea. To address the needs of the navy, artist Norman Wilkinson was "loaned" by the British Admiralty to the US for one month, during which he shared his discoveries about ship camouflage in lectures to naval camoufleurs at various East Coast shipping ports. Throughout his visit, Wilkinson's primary escort was an American painter and naval reserve officer named Everett Longley Warner (Behrens [2002]).

Following Wilkinson's visit, as described by one journalist, «all our [US] merchant ships, our transports and many small naval craft were painted so that they looked, in the language of men in the convoys, cockeyed» (Sparkes [1935]: 82). To accomplish that, Warner was assigned to head a subsection of US Navy camoufleurs (mostly artists and architects), who were headquartered in Washington DC. But because of an on-going battle about whether artists, architects or scientists were better suited to be camouflage experts, a parallel science-based center (headed by optical physiologist Loyd Jones, who favored low visibility schemes) was established at Eastman Kodak Laboratories in Rochester NY. Harold Van Buskirk, an architect and Olympic fencing champion, was the officer who governed these twin sub-units of the Camouflage Section (for full accounts of all of this, see Behrens [2002, 2009, 2012]).

In discussing ship camouflage in relation to perspective, it makes sense to focus on Warner, in part because he, more than others, wrote detailed reports of the methods employed. Several of his articles appeared in popular magazines at the end of or shortly after the war (Warner [1919a and 1919b]). Others were never published, but have survived as scorched-edge typescripts after (posthumously) his painting studio caught fire in 1972. In those writings, Warner recalls that, as Wilkinson's influence faded, American naval camoufleurs relied increasingly on their own discoveries. In particular, they focused on (in Warner's words) «reverse perspective», which is also

variously known as *forced perspective*, *accelerated perspective* or (recalling Leonardo) *anamorphosis*. «Reverse perspective», Warner wrote, «was the most important aid to deception which we used at first, and perhaps in the larger sense it may be said to have governed all of our patterns» (Warner, in Behrens [2012]: 202-204).

To explain how such distortions work, Warner instructed his readers to suppose that the side of a ship had been

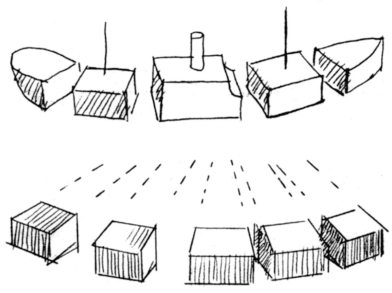
> painted with black squares, the largest toward the stern [the rear] and the others diminishing in size toward the bow [the front]. The human eye is so accustomed to the normal operation of perspective that if this vessel is viewed from some point off the bow we unconsciously assume that the squares are of similar size, and that, following the natural law of perspective, the smallest one is the farthest away from us. This gives us the idea that the bow is farther away from us than the stern, and that the vessel is heading away, when in reality it is steering in our direction (Warner, in Behrens [2012]: 204).

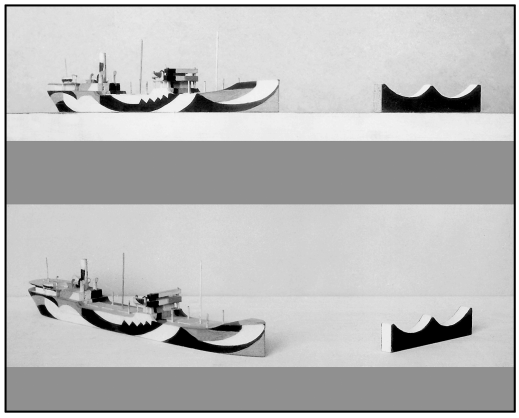
A journalist said it more simply: «Ships were made to have the appearance of turning when they were actually holding a straight course» (Sparkes [1935]: 82). Or, conversely, a ship might appear to be steering ahead when in fact it was actually turning. Obviously, misperceptions of this kind could be critical in subverting the calculations of the ship's future position. Indeed, according to Wilkinson, a course direction error of as little as eight degrees might enable a ship to avoid being hit, while others said fifteen or eighteen.

To grasp what Warner was trying to do, think back to Leonardo's drawings or to Holbein's floating skull. In Warner's approach, the side of the ship was equivalent to an artist's canvas. He then superimposed on that surface a second, contradictory plan – an anamorphic distortion – which was the camouflage pattern itself. Viewed in profile, the ship could be headed in a straight course, and yet the distortion could make it appear to be headed at an angle. Or, if the ship were viewed from off to the side, the distortion could make it appear to be steering ahead, when it was actually veering off at an angle.

In one of his published articles, Warner offered a vivid example of how this process operates (Warner [1919a]). He asked his readers to suppose that they were looking at a photograph of an empty room interior, the walls of which are covered with an all-over wallpaper pattern. Without any lines to indicate the walls or locations of corners, any viewer could nonetheless reconstruct that room from the clues that are provided by the changes in the size and shape of the over-all patterns – changes that are all but entirely due to our interpretations of perspective.

As Warner went on to explain, «a regular pattern [such as wallpaper] will not have the same appearance upon a curved surface as upon a flat surface, and if, upon the latter, we painted the pattern as it normally appears upon the curved surface we can give the illusion of a curving wall. This is exactly what was done on some of the [camouflaged] ships» (Warner, in Behrens [2012]: 226). To Warner, the use of perspective distortion was an all-important key to ship camouflage, and indeed, as he insisted, «when you have once thoroughly grasped this idea, marine camouflage hold no secrets for you» (Warner, in Behrens [2012]: 226).





The use of distorted perspective on flat surfaces, according to Warner, is as plain as plane geometry. But, while that in itself is useful, he believed that a greater achievement was made when he and his co-workers redefined the problem as a matter of solid geometry. In paraphrase, this is how that came about: Warner's navy camoufleurs were responsible for the design of all American marine camouflage, both military and merchant ships. However, there were additional teams of civilian camoufleurs (many of them artists) at about a dozen shipping yards around the country (New York, Boston, Philadelphia, Norfolk, Jacksonville and so on) whose chief responsibility was to apply those camouflage schemes to the actual ships. While these port-based camoufleurs were not authorized to devise their own camouflage plans (a restriction they resented), they were permitted to modify a design given to them, to make it fit a particular ship. The modifications were photographed and the results then shared with higher-ups.

At some point, Warner became dismayed by what he considered ineptness or errors in making these modifications. As a result, he began to hold training sessions for the civilian camoufleurs, «three of whom came down every week [to Washington DC] to become more familiar with our designs…» (Warner, in Behrens [2012]: 220). In

preparing for these workshops, Warner sliced up wooden ship models into smaller sections and applied contrasting patterns to each. One day, in the process of doing this, he arranged a selection of pieces on a tabletop, and placed behind them a monochrome gray ship model (Fig 4a). To everyone's surprise, when the model was placed at any angle in relation to the pieces, (in Warner's words) «it invariably appeared to take the same direction as the blocks» (Warner, in Behrens [2012]: 208). Unintentionally, Warner and his camouflage team had discovered a new, more expedient way to produce bewildering patterns, not by designing entire models, but by arranging dimensional sections in space, then transferring that, as a pattern, to the flat "canvas" of the ship (Fig. 4b).

In WWI newspapers, camouflage was ridiculed as looking like cubist and futurist art. At the time, Modern Art was a volatile topic, since it had recently premiered in the US at the controversial Armory Show in 1913. In countless wartime news reports, camouflaged ships were jokingly called «seagoing Easter eggs», «an intoxicated snake», «a Russian toy shop gone mad», «the delirium tremens» and so on. But Everett Warner and his co-workers were anything but cubists, and sadly, in the years that followed the war, many of them could no longer earn their living as artists, since their artwork was discredited as insufficiently «modern». To Warner and his team, it was both ironic and baffling «that it was precisely when our [camouflage] work was most firmly grounded on the book of Euclid that the uninitiated were the most positive that the ships were being painted by a group of crazy cubists» (Warner, in Behrens [2012]: 209).

To attempt to camouflage ships in any way other than routinely coating them in monochrome gray required extensive planning, substantial labor and great expense. To diehard navy personnel, the gaudy Jezebel dazzle designs were not only hideous, they were a blatant subversion of order and regularity in military tradition. The high visibility patterns of «dazzle-painting» (which artists claimed were contributive to camouflage) were counterintuitive, and, to their detractors, it was only a matter of common sense to see this as the latest case of the Emperor's Clothes.

Today there is still widespread public doubt about the effectiveness of WWI ship camouflage. As is often asked, how can we know if it actually worked if the only evidence we have is anecdotal, non-scientific speculation?

As it turns out, there was empirical confirmation of perspective distortion in camouflage in WWI, but regrettably it came too late. Near the end of the war, one of the original "observation theatres" for assessing the effectiveness of camouflaged ship

models was given (by Boston District camoufleurs) to the Department of Naval Architecture and Marine Engineering at the Massachusetts Institute of Technology. In charge of this equipment was Professor Cecil H. Peabody, who permitted it to be used for quantitative research of ship camouflage by Leo S. Blodgett, an MIT engineering student. The results of Blodgett's experiments were published in May 1919 as an academic thesis, a document that is still on file and accessible on the internet.

Blodgett's research procedures, as well as his conclusions, are too complex to recount in detail. But in brief, he proceeded as follows: He and his co-workers prepared wooden ship models at a scale of 1/32 inch = 1 foot. They designed and applied camouflage schemes (using the same colors that had been adopted by the US Navy), all of which were «based upon principles of distorted perspective» (Blodgett [1919]: 12). Each ship model was then viewed in the setting of the observation theatre (two photographs are reproduced in Blodgett [1919]: 5), a contrivance that included «all essential features of sea and sky illusion, light effects, and periscopic means of observation comparable with actual conditions» (Blodgett [1919]: 3). While being observed, each model was placed on an adjustable turntable, which included a compass device on which its actual angle was shown. At the opposite end of the theatre, from which position the ship was viewed through the periscope, was a second dial, where the observer recorded an estimate of the direction of the ship. The goal was to determine – by numerical measurement only – the degree of error that might result from observing any one model. Obviously, the greater the error, the more successful the camouflage.

Of particular interest is the range of people who were chosen as observers. There were three sets: The first was a single observer who was a European navy lieutenant, a person who (writes Blodgett) was «entirely familiar with ships, periscopes, range finders and conditions at sea in general». Not only that, but before the actual testing began, this same observer was allowed to «become familiar with each design, so that any errors made will be in spite of a previous knowledge of the ship» (Blodgett [1919]: 17). The second observer «had been very closely in touch with the evolution and application of each design», had «made repeated observations of them, [and] in fact [had] offered valuable suggestions in the progress of the work» (Blodgett [1919]: 18). Finally, the third set of observers consisted of four different people, none of whom were familiar with the painted models, «so that all were unbiased by a previous knowledge of what to expect from a design». Yet, a the same time, all four were

«entirely familiar with ship structures, with principles of perspective and optical illusions, as well as conditions of light and shadow at sea» (Blodgett [1919]: 18).

What is astonishing in this is the extent to which Blodgett's choice of observers appears to have increased the challenge of deceiving them. They were not only "experts" in various ways, but in the case of the first and second observers, they were also acquainted with what was being tested for. Yet, even under those conditions, when the results were tallied, in the most successful, perspective-based distortion schemes, Blodgett found course estimation errors as high as 58 degrees, when as little as eight (or 15 degrees) would suffice to avoid a torpedo.

Surely, the results of Blodgett's empirical tests go far to support the validity of the use of perspective distortion in WWI ship camouflage. At the same time, all this took place almost one hundred years ago, and given the growth of technologies in surveillance, targeting and attack, we cannot assume it is valid today.

Finally, once more thinking back to Leonardo's anamorphic drawings and to Holbein's eerie floating skull, what better confirmation is there of the value and long-term significance of Leonardo's finding in his pursuit of the laws of perspective?

Captions

Figure 1(a): Hans Holbein the Younger, *The Ambassadors* (1533). Public domain image from Wikimedia. The original painting is in the collection of the National Gallery, London.

Figure 1(b): Diagram showing the viewing position on the right side of the painting (where two diagonals intersect), from which position the skull is no longer distorted.

Figure 1(c): Corrected skull as seen from that position. Public domain image from Wikimedia.

Figure 1(d): Anon, typographic puzzle (c1900) which, from oblique viewpoints on the sides, reads A HAPPY BIRTHDAY. Public domain.

Figure 2(a): Anon, World War I US Army photograph (c1918) of a perspective-based spatial illusion, intended to be mistaken for a continuance of the railroad tracks. Public domain.

Figure 2(b) and (c): drawings by American camoufleur Joseph Allen Minturn (1921) of comparable painted backdrops. Public domain.

Figure 2(d): Artist's signature unreadable, cartoon on editorial page showing deceptive use of perspective, titled "Camouflage," from *Washington Times* (January 9, 1919). Public domain.

Figure 3(a): US Navy photograph of perspective distortion applied to the USS *West Shore* (1918). Courtesy Naval History and Heritage Command (NH 99395). Public domain.

Figure 3(b): Illusory geometric scheme applied to the USS *Congaree* (c1918), as reproduced in Warner [1919a]. Public domain.

Figure 4(a): Everett L. Warner (n.d.), pencil sketch of his method of slicing up wooden ship models, then repositioning the sections, as a way of producing a camouflage scheme. Public domain.

Figure 4(b): Two photographs of the same set-up, the top one from the point of view of a U-boat (giving the impression of a straight course ahead), the bottom one from a higher view, showing the ship model's actual direction. As reproduced in Warner [1919a]. Public domain.

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