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DATE 29 December 1938

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Report on

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Naval Camouflage,

Tests at Sea of '34, and June 1938

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NAVAL RESEARCH LABORATORY

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NAVY DEPARTMENT
BUREAU OF CONSTRUCTION AND REPAIR

Report on

Naval Camouflage
Tests at Sea of May and June 1938

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
Washington, D.C.

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CHAPTER 1

INTRODUCTION

1. Authorization. The present continuance of the investigation of ship camouflage was authorized by Bureau of Construction and Repair letter SS/S19-7(RM) of 30 December 1937.

2. References. References pertinent to the present report are given below:

- (a) "Handbook on Ship Camouflage", Bureau of Construction and Repair, February 1937, prepared by NRL.
- (b) NRL Report No. H-1409, 15 November 1937, "Low Visibility Camouflage of Submarines, Tests at Sea of June and July, 1937".
- (c) BuC&R letter to Cincus, 30 December 1937, S19-7(RM), "Camouflage Painting of Surface Ships."
- (d) Com.Des.Squadron THREE letter to BuC&R, 29 September 1938, S19(0246), "Camouflage Painting of Surface Ships", and endorsements thereto and enclosures thereof.
- (e) BuC&R letter to NRL, 16 December 1937, SS/S19-7(RM), "Low Visibility Camouflage of Submarines."
- (f) Com.Submarine Squadron SIX letter to C&R, 22 September 1938, FF4-7/S19, Serial C363, "Special Painting of Submarines."
- (g) Com.Cruiser Scofor letter, 3 February 1933, S70(S-558-15), "Experiments with paint for secret recognition system."
- (h) NRL letter to C&R, 15 April 1936, C-S19-7, "Investigation of Ship Camouflage."
- (i) Com.Battleships, Batfor, letter of 13 July 1938, S19/S28/(2533) "Special paint insignia on forward turrets of USS MARYLAND."

3. Historical. Recent investigation of various aspects of ship camouflage, initiated in 1935 by the Bureau of Construction and Repair and continued since that time, led to a number of conclusions summarized in references (a) and (b). Very briefly the more important of the conclusions were:

- (1) Horizontal surfaces of all ships, whether on the surface or submerged, should be black or very dark gray, for lowest visibility to surface and aerial observers.

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ABSTRACT

To substantiate and extend the results of camouflage experiments of 1935 to 1937 experiments were carried out in the San Diego area during May and June, 1938. In each experiment the observations extended over only a few hours of a single day or night. The following conclusions were reached by operating Fleet personnel:

1. Low visibility experiments with destroyers, Division Five, showed that in the daytime in sunny weather Ocean Gray was less visible than present standard Navy Gray and Graded Painting, the last two being about equal in visibility. At night under searchlight illumination Ocean Gray was less visible than standard Navy Gray.
2. Dazzle experiments with destroyers, Division Five, showed that dazzle painting caused some disturbance in course estimation and coincidence range finder observation, and had no effect on stereoscopic range finder observation.
3. All camouflage was ineffective when the ship was viewed against the sun.

Note: The above conclusions refer only to painting of vertical surfaces; horizontal surfaces, which are of importance viewed from the air, should be very dark for low visibility.

4. Experiments with submerged submarines, Squadron Six, showed that black was less visible than dark blue, in conflict with the conclusion from the Pearl Harbor experiments that dark blue was less visible than black. Whether the conflict is of importance is not known.
5. Preliminary tests on USS MARYLAND indicated some success in the use of concealed painted insignia for daylight identification of surface craft to aircraft.

Some further camouflage experiments are suggested with destroyers, submarines, and concealed insignia.

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- (2) Vertical surfaces of surface ships for lowest visibility in clear weather should be considerably darker than standard Navy Gray, and should be Ocean Gray or Graded; and in overcast, hazy or foggy weather should be standard Navy Gray.
- (3) At night under natural illumination there was little difference in the visibility of Navy Gray, Ocean Gray and Graded painting. At night under searchlight illumination the visibility increased in the order, black, Ocean Gray, Navy Gray.
- (4) Dazzle, or course distortion, camouflage was effective to a limited extent in disturbing course estimation and coincidence range finder observation, and then only when the painted ship was viewed away from the sun.
- (5) Low visibility and dazzle camouflage can probably not be combined successfully, because the contrasting colors of light and dark gray necessary for dazzle effects inherently increase visibility.

4. Scope of the Present Report. It appeared advisable, reference (c), to repeat certain of the experiments in order to substantiate the foregoing conclusions and to make further comparisons. The present report describes the results of observations of the relative visibility of destroyers painted standard Navy Gray, Ocean Gray and Graded, Chapter 2; the effectiveness of course distortion designs painted on destroyers, Chapter 3; the dark color for submarines, Chapter 4; and preliminary tests of the use of designs painted with invisible spectral difference for concealed daytime identification of ships to aircraft, Chapter 6.

5. Recording Color. All of the colors used in the present experiments were various shades of gray. Gray shades are designated by the diffuse reflectivity for white light. At the two ends of the scale are white, of reflectivity 100 percent, and black, of reflectivity 0 percent. It may be recalled that the reflectivity of Ocean Gray is about 18 percent, of Present standard Navy Gray is about 35 percent, and of white blotting paper is about 90 percent. In Plate 1 are illustrated various shades of gray which were used.

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CHAPTER 2

LOW VISIBILITY PAINTING OF DESTROYERS

6. Experiments. Four destroyers, Division Five, were used. The horizontal surfaces were not specially painted. The vertical surfaces were painted as follows:

- CASSIN, entire present standard Navy Gray, 35% reflectivity.
- CONYNGHAM, entire Ocean Gray, 18% reflectivity; except that a dark wave effect about 3 feet wide was painted at the waterline.
- REID, Graded, horizontal gray stripes, in order from waterline upward of reflectivity 6, 11, 18 and 35 percent.
- DOWNES, Graded, horizontal gray stripes, in order from waterline upward of reflectivity 6, 11, 18 and 25 percent. DOWNES differed from REID only in that the upper parts were slightly darker.

7. The approximate colors on the respective ships are illustrated in Plates 2, 3, 4 and 5. The ships were operated in the San Diego area and observed from the USS TUCKER. All of the observations were made during the course of one day and one night. Each of the five ships submitted a report of its observations of the other ships, reference (d). From the reports the following conclusions appear:

- (1) That all camouflage was ineffective when the camouflaged ship was between the observer and the sun.
- (2) That in the day with the sun behind the observers the CONYNGHAM, Ocean Gray, was the least visible; that the REID and DOWNES, Graded, and the CASSIN, Navy Gray, were all about equally visible and all more visible than the CONYNGHAM.
- (3) That when the ships were in line and at the same distance, 9000 yards, from the observing ship, the CASSIN, Navy Gray, appeared closer than the others, and that when the CASSIN drew out of line to a distance of 11,000 yards from the observing ship, it then appeared to be at the same range, 9000 yards, as the other ships. However, the camouflage effects in no way hampered the stereoscopic range finder in obtaining true ranges. The offset in apparent range of the camouflaged ships relative to the Navy Gray ship was due to their dark lower stripes near the water which made the determination of the waterline doubtful.

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(4) That at night under searchlight illumination Ocean Gray was less visible than Navy Gray. For example, at 5,000 yards the CASSIN, Navy Gray, was distinctly visible under the searchlight but great difficulty was experienced in making out the outline of the CONYNGHAM, Ocean Gray.

8. We quote a statement from reference (d) on which in part the above conclusions (3) and (2) were based: "As seen from the TUCKER, the CONYNGHAM was not visible to the naked eye at 8,600 yards when the other ships were clearly visible. CONYNGHAM could not be seen with glasses at a range of 14,000 yards when the other ships under observation were visible with the naked eye. It might be noted that at this range the wake of the CONYNGHAM could be seen although CONYNGHAM itself could not be seen through glasses. CONYNGHAM was making 15 knots. The condition of the sea, calm; sailing, unlimited; visibility, excellent. The sun was at 20° altitude."

9. Plate No. 7 is a painting of the Division as viewed from the TUCKER which illustrates the invisibility of CONYNGHAM and the apparent displacement into column of CASSIN when actually 2,000 yards beyond the column.

10. Discussion. The foregoing results, derived from observations during a single day and night in the San Diego area, substantiate the earlier conclusion that in sunny weather Ocean Gray is less visible than Navy Gray, and add one new fact, that the Graded painting is about as visible as Navy Gray. Actually the experiments were designed to ascertain this fact. The Graded painting was found to produce a slight illusion of range due to the dark stripe at the waterline. Whether the illusion is of any consequence is not entirely certain. If it is of no importance the Graded painting could appear to offer no camouflage benefits and therefore may be deleted from future camouflage consideration.

11. In reference (d) the importance was emphasized of low visibility of destroyers at night under searchlight illumination. In this case previous experiments have shown qualitatively that black is least visible, Ocean Gray next and Navy Gray the most visible. It would be of value to have quantitative data in this connection, that is, to know at what ranges destroyers painted black, Ocean Gray and Navy Gray can be picked up at night with searchlights. Further experimental tests are suggested in Chapter 5.

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DAZZLE PAINTING OF DESTROYERS

12. Experiments. Four dazzle camouflage designs to disturb course estimation and range finder observation were tested. Two of the designs were bold and contrasting; they were painted on the starboard sides of the DOWNES and REID. Two of the designs were of moderate boldness and contrast; they were painted on the port sides of the DOWNES and REID. Photographs of the ships are given in Plates 8 and 9. Three shades of gray were used, dark gray (nearly black), Ocean Gray and white, of respective reflectivity about 6, 18 and 55 percent.

13. Observations in the San Diego area were made during two days by observers on the CONYNGHAM, CASSIN and REID. The following verbatim extracts from the reports of the respective ships, reference (d), give the results.

CONYNGHAM "This vessel took station at a distance of about 9,000 yards from the vessels under observation and directed their maneuver in turn movements in an effort to determine the most effective design of the four applied to the sides of the DOWNES and REID."

"From the observations made at that time it is the opinion of the Commanding Officer that the designs painted on the starboard sides of both REID and DOWNES were the most effective of the four under test in concealing the turn movements of these vessels. The turn movements of the CASSIN which was painted a normal war color gray were almost immediately discernable upon their inception whereas the movements of the other two required a quite radical turn before becoming evident in direction and amount."

CASSIN "Commander Destroyer Division Five was present in the observing ship on one occasion only, namely, when the effect of the dazzle paint on judging target angle as the ships made simultaneous turns was under test. He believes that the effect of the dazzle painting does contribute to the difficulty of judging target angle when the sun is reflected from the camouflaged ships, i.e., when the observer's eye is between the sun and the ships observed."

REID "The designs (of the REID, Plate 9) were highly effective in changing the apparent target angle of the ship. At any distance greater than 3,000 yards it was difficult to determine the true target angle of the ship."

"None of these designs had much effect on ranging when using stereoscopic range finders, although coincidence rangefinders encountered increased

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difficulty in obtaining accurate ranges because of the broken up effect presented by the camouflaging paint."

"It was noticed that diagonal bands and streaks of black and white across the smokepipes did create the illusion of removing certain portions of these structures when at a distance of two miles or more."

14. Discussion. The conclusions that the dazzle patterns created a disturbance of course estimation and coincidence range finder observation, and that the bolder patterns gave the greater disturbance are in accord with the earlier experiments of reference (a). The earlier experiments also brought out the fact that the dazzle pattern increased the visibility of the ship and that the bolder the pattern the greater the augmentation of visibility. This effect was probably also true in the present experiments, although no specific mention of it was made.

15. Low Visibility Combined with Dazzle. In the report of the USS TUCKER, reference (d), the following suggestion was made:

"The Commanding Officer, USS TUCKER, predicated on his observations, desires to express the opinion that under the weather conditions existing at the time of observations, the optimum concealment of Division Five would have been obtained had all ships of the Division been painted with the paint similar to that used on the CONYNGHAM (Ocean Gray) and had there been superimposed on this paint camouflage designs of dull colors, the latter to dull sharp silhouettes and create shadows, thus preventing accurate estimates of target angles."

16. In response to this suggestion the dazzle pattern of Plate 10 has been prepared. It uses only black and Ocean Gray. The visibility in the day, and at night under searchlight illumination, should probably be about the same as a solid painting of Ocean Gray. Whether the design has any effectiveness in preventing accurate estimates of target angles can not be said with certainty; it is difficult to think that it would have much effectiveness. Only experiment can provide an answer; an experiment is outlined in Chapter 5.

17. In this connection it is hardly necessary to remark that structural changes, as offsetting a mast or stack, produce deceptive effects tremendously more effective than can possibly be achieved by any pattern of paint. However, structural changes for such a purpose may be regarded as beyond practicability.

LOW VISIBILITY PAINTING OF SUBMARINES

18. Experiments of 1937. As described in references (b) and (c), experiments were carried out in 1937 with submarines in the Pearl Harbor area to discover the best color for low visibility against aircraft. It was concluded that very dark blue, of reflectivity about 4 percent, was the least visible color for the submerged submarine. Quoting from reference (c),

"Blue has proven highly satisfactory in all submerged operations and is superior to black in operations in service."

19. Experiments of 1938. The present experiments, reference (f), were carried out during June and July 1938 by Submarine Squadron Six in the Tinian area. The experiments were for the purpose of testing the visibility of submarines painted with various colors, when on the surface and viewed from the surface, and when submerged and viewed from the air.

20. Four submarines were painted as follows:

PERCH	Entire light greenish gray (18% reflectivity).
PIKE	Entire black.
PORPOISE	Hull black, conning tower light greenish gray (reflectivity about 18%).
PERMIT	Entire Pearl Harbor Blue.

21. Complete details of the tests are given in reference (f). The following quotations give a glimpse of the data:

"Surface Tests.

"Range 12,000 yards. All ships harder to see. Binoculars used. Not much difference between ships except PERCH and PORPOISE conning towers harder to see. Ships backgrounded against clouds.

"Range 14,000 yards. Chiefly conning towers and occasional view of bow remaining in sight. PERCH and PORPOISE hardest to see, PERCH slightly less visible. PERMIT and PIKE about equally visible. Visibility conditions excellent, air clear, bright sun, ships backgrounded against clouds. No great difference between any of the four ships except light colored conning towers not as sharply defined."

"Submerged tests with Aircraft.

"At periscope depth the order of detection is as follows:

- (1) Green conning tower and black hull (PORPOISE). This color contrast made this submarine particularly easy to spot.

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- (2) 18% green (PERCH). Easy to spot.
- (3) Blue (PERMIT). Fairly difficult to spot.
- (4) Black (PIKE). Most difficult to spot."

21. Conclusions. Two conclusions were drawn from the tests:

First. There was not sufficient difference between the dark conning tower and the light conning tower on surface tests to warrant use of light paint particularly in view of the fact that the light surfaces tended to make submerged detection easier.

Second. For waters in these latitudes the black hull and conning tower afforded least chance of detection.

22. Discussion. It is seen that the San Diego area tests of 1938 and the Pearl Harbor tests of 1937 are in agreement in the conclusion that a dark colored paint, black or dark blue, yielded a lower visibility of the submerged submarine than a light colored paint. The two sets of tests disagree, however, in that the Pearl Harbor tests indicated that dark blue was better than black, whereas the San Diego tests indicated that black was better than dark blue. Assuming that the respective colors of the paints of the two tests were the same, it is possible that the disagreement was due to the difference in the color or optical purity of the waters of the Pearl Harbor and San Diego areas, the water near Pearl Harbor being much clearer than that off San Diego. On the whole it appears that the evidence available at present is not sufficiently definite to permit final conclusions regarding low visibility painting of submarines. Further tests would be valuable; these are outlined in Chapter 5.

SUGGESTED FURTHER CAMOUFLAGE EXPERIMENTS

23. Based on the results of Chapters 2, 3 and 4 the following suggestions for further camouflage experimentation are assembled below. Further suggestions of experiments with the concealed painted insignia of Chapter 6 are relegated to that chapter, for although concerned with paint they are in a totally different category from paint camouflage.

24. It can not be emphasized too strongly that the experiments should be carried out not for a few hours, but for many days or weeks, and that the observing ships make reports of their observations and conclusions.

25. Attention is invited to the recommendation in reference (d) that a special commissioned officer, familiar with camouflage and the requirements of the Bureau, be designated to act as liaison officer in coordinating tests and keeping records.

26. Destroyer Camouflage Experiments. Regarding low visibility camouflage of destroyers, three inter-related questions occur:

- (1) Is Ocean Gray the best compromise color for low visibility in all circumstances of weather, illumination and sea area?
- (2) What is the comparative visibility of Ocean Gray and Black at night under searchlight illumination?
- (3) To what extent is the dark dazzle pattern of Plate 10 effective in disturbing course estimation and coincident range-finder observation; what is its visibility compared with that of Ocean Gray?

27. The following experiments are suggested with the view of leading to the answers of the above questions:

Experiment 1. Paint the vertical surfaces of four destroyers as follows: one destroyer entire Standard Navy Gray, one destroyer entire Ocean Gray, one destroyer entire black, and one destroyer the dark dazzle pattern of Plate 10. These should cruise together and be observed by other surface ships, submarines and aircraft to determine their relative visibility in various areas of the sea and types of weather during the day, and at night under natural and searchlight illumination; observations should be made on them of course estimation and range-finder accuracy.

Experiment 2. Paint the vertical surfaces of the four destroyers of a Division entire Ocean Gray and observe them during operation in a Fleet problem.

Submarine Camouflage Experiments. It is suggested that four submarines be painted, two entire black and two entire Pearl Harbor blue. These should cruise together and be observed from the surface and from the air, when on the surface and submerged, in various areas of the Atlantic and Pacific Oceans.

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CHAPTER 6

CONCEALED PAINTED INSIGNIA

28. Introduction. It is possible to prepare two paints, apparently alike in color, which when viewed through a proper color filter do not appear alike, one being light and the other dark. This is the basis of a method of secret identification insignia for use on surface vessels in daylight. Experiments with the insignia in the form of circles and crosses painted on the sides of ships were carried out in 1933 by the Fleet, reference (g). Special red filters were used. The insignia were distinguishable only at moderate ranges, and this only when the side of the ship was in full sunshine; in shadow the range was only a few hundred yards. It was concluded that the method was of no utility between surface craft because of its lack of positiveness, and because better methods existed, but might be useful for identifying surface craft to aircraft.

29. In Plate 11 are shown photographs of insignia painted on the side of a Navy Gray destroyer near the bow. The photographs were taken with and without the special filter; with the filter the number 372 can be seen; without the filter the number can not be seen. The filter was a deep red, Wratten No. 70 of the Eastman Kodak Company.

30. Experiments of June 1938. In June 1938 preliminary tests, reference (i), were made to determine the effectiveness of the painted insignia in identifying surface craft to aircraft. The tops of Turrets One and Two of the USS MARYLAND were painted as follows:

Turret One was painted with apparently Navy Gray color which to the naked eye appeared to be the same color as the rest of the ship. When viewed through a purple filter two red circles about three feet in diameter appeared, one on each side of the top of the turret, one a blue background. When viewed through a red filter these circles stood out very distinctly as white on a dark gray background.

Turret Two was painted with an insignia which to the naked eye appeared as a reddish purple circle about eight feet in diameter with an inner, concentric, circle about three feet in diameter of light green. When viewed with the purple filter, a red cross appeared, each stripe of which was thirty-two inches wide and eight feet long. When viewed with the red filter the cross appeared white on a dark background.

When viewed from the air with the naked eye faint traces of the concealed design could be seen up to about 500 feet and became unnoticeable at greater distances. With the filters the concealed markings were apparent to about 5,000 feet; above this altitude they became blurred. It was thought that

the use of binoculars with the filters would probably extend the range. The red filter brought out the insignia with somewhat more distinctness (greater contrast) than did the purple filter. The red and purple filters were, respectively, Wratten Filters No. 70 and No. 35, of the Eastman Kodak Company.

Since the experiment was of a preliminary nature no further observations were made. Insignia of a larger size than those used would have been necessary to secure greater ranges.

31. It was remarked, reference (i), that the use of the secret painted insignia for identification of surface craft by aircraft might be valuable in war-time if the insignia were sufficiently positive. The suggestion was made that the most definite combination of paint and filter be worked out and experiments performed to determine the useful ranges under various light conditions.

32. Experimental Technique. The paint for the special insignia is mixed from the following palette.

Palette for Invisible Spectral Difference

+ Palette,
bright through filter

A⁺ Cobalt blue

B { White, any kind
Alizarin crimson
English vermillion
Chrome, light
medium
orange

- Palette,
dark through filter

A⁻ { Burnt sienna
Emerald green
Prussian blue

B { White, any kind
Alizarin crimson
English vermillion
Chrome, light
medium
orange

Use no black. + Palette is mixed from A⁺ and B; - Palette is mixed from A⁻ and B. The essential difference between + Palette and - Palette is that A⁺ has red and A⁻ has no red, the ingredients B being the same and merely added to give the desired apparent color. The paints are mixed until by test with the filter they give the desired effect.

33. This palette is useful only with a red filter, such as Wratten No. 70; it is the palette used in the USS MARYLAND insignia described above. The insignia were also visible with the purple filter Wratten No. 35. This was due to the fact that the filters No. 35 and No. 70 have similar transmission bands in the red. In addition to its red band, No. 35 filter has a blue band of transmission (hence it is a purple filter); but the blue band has either a negligible, or slightly deleterious, effect on the ability of the filter to reveal the insignia. This explanation is offered to avoid confusion. For it is true that since the No. 35 filter has a blue band in addition to its red band it transmits more daylight than does the No. 70

filter, which has only a red band. Therefore one can see a general scene, such as a ship at sea, better through No. 35 than through No. 70. And it might happen that an observer conclude that No. 35 is better than No. 70 on that account, whereas it may really be worse than No. 70 in respect to its prime function which is to reveal the concealed insignia.

34. It may be pointed out that the concealed painted insignia possess only moderate secrecy. If prepared for use with No. 70 red filter, the insignia can be seen with almost any deep red filter, as for example the red filters on some sextants. Further, it might be supposed that concealed insignia might be painted based on some color other than red, such as yellow, green, or blue. But not so, for due to the color curves of existing pigments and filters, it turns out that red is the only color which offers practical promise; for example, insignia based on concealed green and a green filter have but slight contrast and hence a short range, likewise for yellow and blue.

35. The Wratten filters of the Eastman Kodak Company are made of gelatin colored with dye and mounted between two plates of glass with Canada Balsam. Filters of this type may deteriorate and are troublesome to cut into desired sizes. Colored glass is much more convenient than the Wratten filters and is more permanent. It happens that glass of the Corning Glass Company called "Dark Red", No. 241 or 242, about 5 millimeters thick, is about the same color as the No. 70 Wratten filter. This glass is satisfactory for use with the concealed insignia.

36. To get the necessary best lighting the insignia must be painted on some horizontal surface of the ship free from shadows of superstructure. For identification of the ship to aircraft the insignia must be as large as possible, and hence as simple as possible, in order to secure a desirable range. The range probably depends more on the size of the insignia than on any other factor. If a space 20 feet square is available the insignia may be a solid circular spot 10 feet in diameter, or a cross with arms 7 feet wide, or two stripes 7 feet wide separated by 6 feet. Such insignia may be visible with the filter and unaided eye at 2 miles if the lighting is good and the range not too slant; with the filter and binoculars the range may be greater.

37. The background or base color of the portions of the ship immediately around the insignia is important. If the base color is Present Standard Navy Gray, it happens that the color seen through a red filter is of intermediate brightness, being neither very bright nor very dark. To get the best contrast in the concealed insignia it is necessary to prepare two paints each apparently Navy Gray, one of which, A, is fairly dark and the other, B, fairly light when viewed through the red filter. The insignia is then painted with B and the area surrounding it with A. If the base color is dark it probably appears dark through the red filter. In this case dark paint is prepared of apparently the same color as the base paint but which is as light as possible when viewed through the filter; this paint is used for the insignia.

38. Illustrations of concealed insignia painted on a moderate gray background and on a dark background are given in Plates 12 and 13, respectively. In order to see the insignia place the Plates in strong daylight, as near a window or better still in full sunlight, and look at them through the red or purple filter of Plate 14 held close to the eye. In Plate 12 the

insignia is the number 372; in Plate 13 there are stripes across the deck, and the top of turret No. 2 is different from the surrounding deck. Actually the red filter of Plate 14 is not quite as good as the Wratten No. 70 filter; however, it is provided merely for illustration and is sufficiently satisfactory for that purpose.

39. Suggested Experimental Procedure. The following procedure is suggested:

Select a ship and a suitable horizontal area of the ship free from shadows of superstructure on which to paint the concealed insignia. Determine the base color already on the area, or the base color desired on the area. Let the insignia paint be prepared in cooperation with the Naval Research Laboratory, or at the Naval Research Laboratory. Let the insignia be painted on the area in cooperation with the Naval Research Laboratory, as under the direction of a representative from the Laboratory.

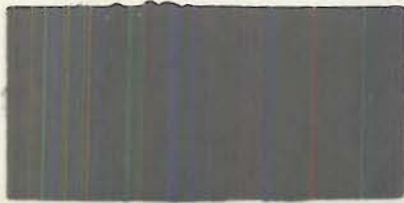
Prepare suitable filters either in rubber eye cups or in aviators' goggles. If desired equip a pair of aviators' binoculars with the filters -- all this in cooperation with the Naval Research Laboratory.

Carry out a program of test to determine the range at which the insignia can be seen from the air under various light conditions.

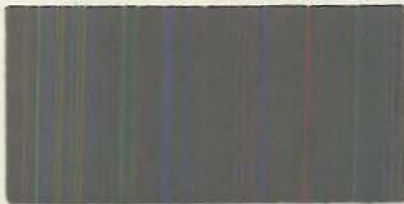
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Present Standard Navy
gray. Reflectivity 35%



gray. Reflectivity 25%



Ocean gray. Reflectivity 18%

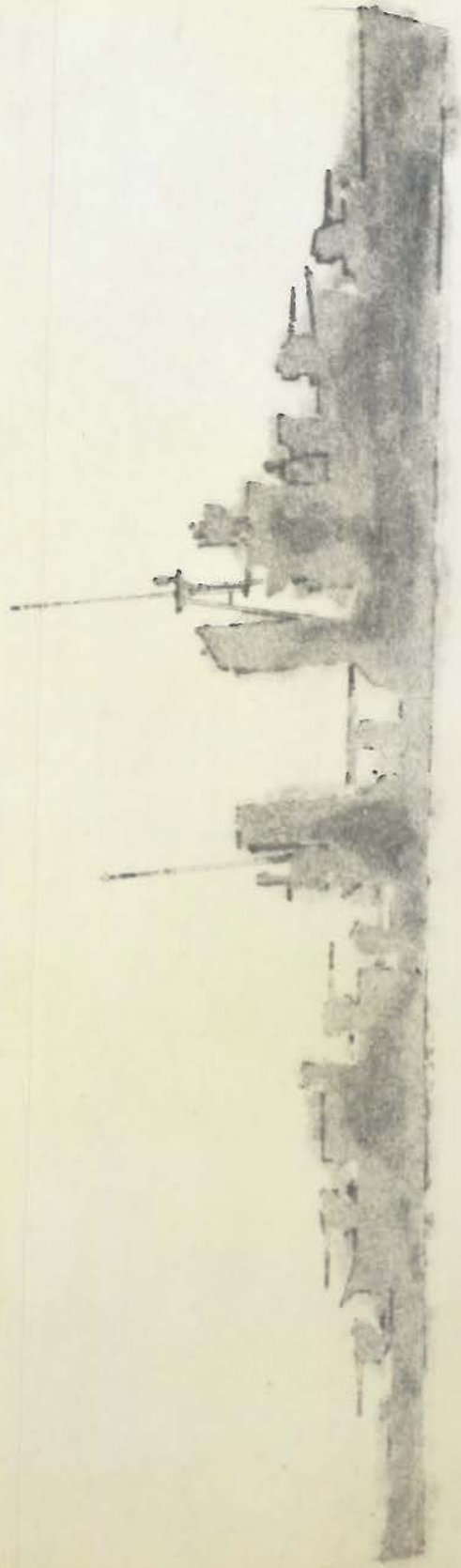


Dark gray. Reflectivity 6%

gray colors for low visibility camouflage.

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PLATE 1
DEC 13 1955



Handwritten text, possibly a signature or name, oriented vertically.

UNCLASSIFIED

DECLASSIFIED

plate 3

(No copy of this plate is available.
Only one copy was made and it was
sent along with original report to
Bu C&A).

U.S.S. REID. graded painting

DECLASSIFIED

PLATE 4

(No copy of this plate is available.
Only one copy was made and it was
sent along with original report to
Bu C&R).

U.S.S. DOWNES: graded painting

DECLASSIFIED

UNCLASSIFIED

PLATE 5



U. S. S. CONYNGHAM. OCEAN GRAY



U. S. S. DOWNES. GRADED PAINTING.

PLATE 6.

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Only one copy was made and it was
sent along with original report to
Bu CAR).

A painting by Bittinger

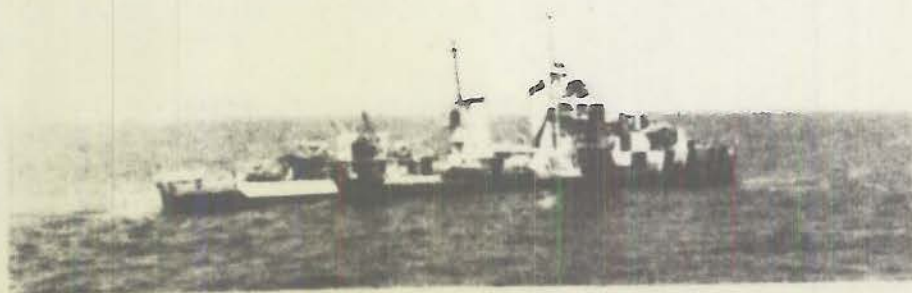
Looking east - Division Five as it appeared
from U.S.S. TUCKER

DECLASSIFIED

PLATE 7



U.S.S. DOWNES. DAZZLE CAMOUFLAGE, BOLD PATTERN.



U.S.S. REID. DAZZLE CAMOUFLAGE, BOLD PATTERN.

UNCLASSIFIED
DECLASSIFIED



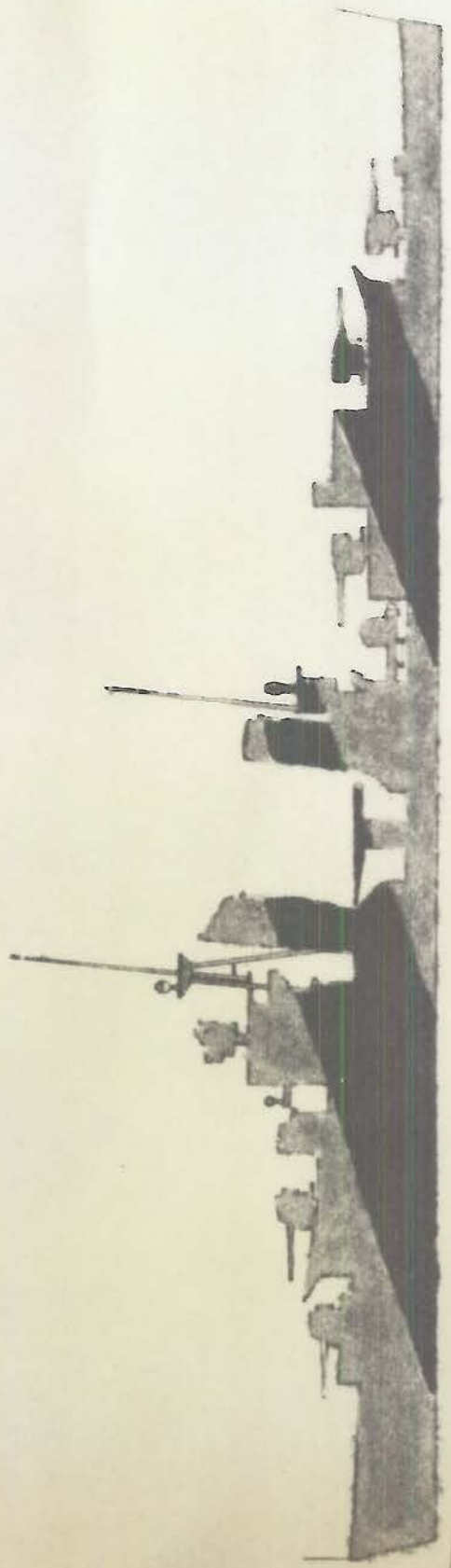
U.S.S. DOWNES. DAZZLE CAMOUFLAGE, PATTERN OF MODERATE BOLDNESS.



U.S.S. REID. DAZZLE CAMOUFLAGE, PATTERN OF MODERATE BOLDNESS.

DECLASSIFIED

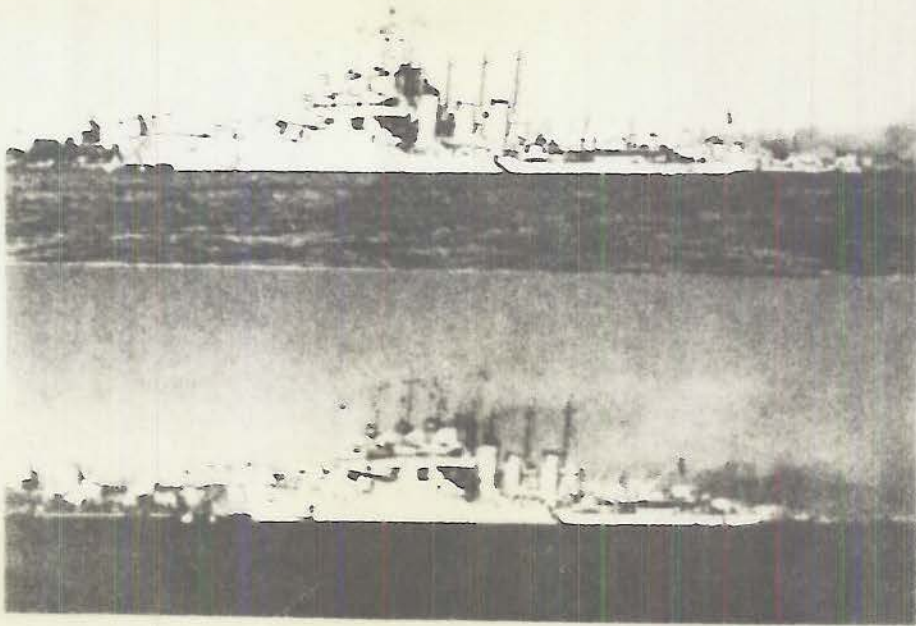
PLATE 9



Clark Macella's pattern, Black and Ocean Gray

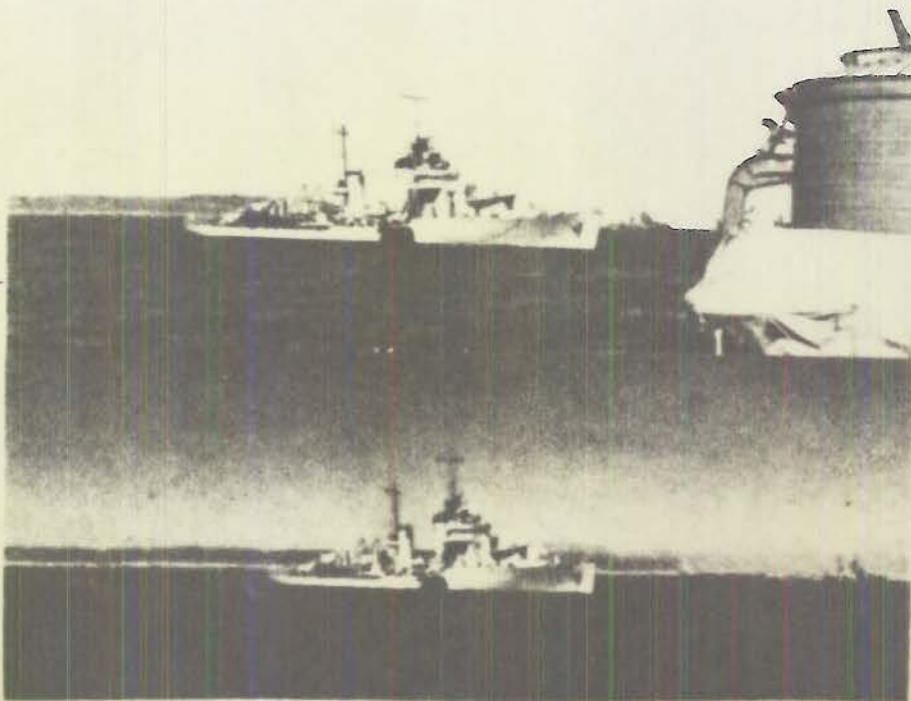
UNCLASSIFIED

DECLASSIFIED



WITHOUT
FILTER

WITH
FILTER



WITHOUT
FILTER

WITH
FILTER

U.S.S. CASSIN. CONCEALED INSIGNIA PAINTED ON
BOW. PHOTOGRAPHED WITH AND WITHOUT RED FILTER.

PLATE II.

DECLASSIFIED

UNCLASSIFIED

(No copy of this plate is available.
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sent along with original report to
Bu C&R).

a painting by Bittinger

Concealed insignia on side of ship

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UNCLASSIFIED

PLATE 12
DEC 13 1938

(No copy of this plate is available.
Only one copy was made and it was
sent along with original report to
Bu CAR).

a painting by Bittinger

concealed insignia on deck of ship

UNCLASSIFIED
DECLASSIFIED

DEC 13 1938
Plate 13

(No copy of this plate is available.
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sent along with original report to
Bu C&R).

Red and purple filters to reveal
concealed insignia of Plates 12 and
13. Place the plates in a good light
and look at them through the filter
held close to the eye.

DECLASSIFIED

Plate 14