FR-1079

REPORT NO. P-1079

DATE 8 October 1934

SUBJECT

Report on

Recognition Signals;

Visual Signals for Submerged Submarines

by

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Navy Department
Washington 25, D. C.

8 October 1934

NRL Report No.P-1079

S-SS/S70-1(13)

NAVY DEPARTMENT
BUREAU OF ENGINEERING

Report on

Recognition Signals;

Visual Signals for Submerged Submarines

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

Number of Pages: Text - 7 Plates - 6

Authorization: BuEng 4th end.S-S70-1(10-11-W9) of 5 Jan. 1933.

Date of Test: July - September 1934

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Distribution:
- Opnav
- BuEng (5)
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ABSTRACT

This report outlines work on the development of a visual daylight recognition signal suitable for use by submerged submarines in identifying themselves to known friendly vessels or aircraft. The signal depends on coloring an area of sea-water with a distinctively colored oil, metal powder, or dye. Means for ejecting the signalling agents from submerged submarines and preliminary tests of them are described.

AUTHORIZATION

SECRET

1. This problem was authorized by the Bureau of Engineering letter reference (a); other references pertinent to this problem are listed as references (b) to (f).

Ref. (a) Bu.Eng. 4th end.S-S70-1(10-11-W9) of 5 Jan. 1933 to ref.(e) below.

(b) Comsubron 4 Secret let. FF4-4/S70-1(9) of 7 Sept. 1932 to N.R.L.

(c) N.R.L. let.S-SS/S79-1 of 11 Oct. 1932 to Comsubron 4.

(d) Comsubron 4 let. FF4-4/S79-1(26) of 8 Nov. 1932 to N.R.L.

(e) N.R.L. let. S-S70-1(4) of 6 Dec. 1932 to Opnav via Eng. & Ord. with enclosure copies of references (b), (c) and (d) above.

(f) Opnav 3rd end. Op-20-Gs (SC) S70-1 of 3 Jan. 1933 to N.R.L. let. ref. (e).

STATEMENT OF PROBLEM

2. The present work is concerned with one specific aspect of the general problem of recognition signalling between Naval ships, namely the problem of a submarine's identifying itself during the day by a visual communication method to a friendly surface vessel or airplane. The best statement of the problem is that given by Commander Submarine Squadron 4 in reference (d):

"......it is desired to develop a positive system of recognition and identification signals whereby a submarine, which is forced to submerge by a known friendly surface vessel or aircraft, can make its friendly nature known to the attacking surface vessel or aircraft and thereby avoid being bombed. It has been considered that if a suitable dye material could be ejected from the submarine and color a fairly large area of water a positive means of identification could be obtained. Such a system could be made safe from imitation by employment of various colors and would also fail to disclose the submarine's position to other vessels or aircraft not in vicinity as would be the case using rockets or smoke bombs."

KNOWN FACTS BEARING ON THE PROBLEM

3. At present submarines depend upon the pyrotechnic smoke signals for a recognition signal. The objections to these are stated by the Chief of Naval Operations in his 3rd endorsement, ref.(f), which is quoted herewith:

"1. Due to the limited number of distinctive colors of smoke pyrotechnic signals which have been developed, these signals have less security than is desirable when used for emergency identification signals.

"2. As the inherent difficulties will probably prevent the development of smoke pyrotechnic signals with a large number of distinctive colors it appears that the only way additional security can be obtained is to use a greater number of distinctive systems.

"3. In order to develop a new system for use of submarines while submerged and thereby increase the security of submarine emergency identification signals, it is recommended that the Naval Research Laboratory undertake the development of colored water emergency identification signals."

THEORETICAL CONSIDERATIONS

4. The recognition method described herein is based on coloring a patch of the surface of the sea with suitable dyes and other coloring agents released from the submarine. Light from the sun or the sky is reflected from these coloring agents as colored light which is seen and recognized by the personnel on the aircraft or surface vessel in the vicinity.

5. All daylight visual signalling systems, such as flag-hoists, smoke signals, etc., and the present method, have the theoretical difficulty that their effectiveness depends on the position of the sun relative to the observer and to the signal; and experience proves that this difficulty is a practical as well as theoretical one. Thus, for example, parachute smoke signals cannot be recognized by an airplane pilot if the signal is on a line of bearing and between the airplane and the sun.

6. But if the deficiencies inherent in the present method are clearly recognized, some of the objections thereto can be overcome by careful indoctrination of the operating personnel in the best manner of using the system.

NARRATIVE OF ORIGINAL WORK DONE
AT THIS LABORATORY ON THE PROBLEM

7. This problem had its origin in a letter of the Commander Submarine Squadron Four, reference (b), requesting information on suitable dyes for coloring sea water as a recognition and identification signal by a submerged submarine. In reply, the Director Naval Research Laboratory requested the following further information, reference (c):

"(a) Probable depth at which submarine will release a recognition signal.

(b) Is it desired that the signal be seen by airplanes, surface ships, or both?

(c) Should the signal be incorporated in the parachute smoke signal or as a separate unit?

(d) Should the water be colored and thrown into the air or will a flat colored surface be satisfactory?"

8. In reference (d) the Commander Submarine Squadron Four replied as follows:

"(a) Submarine will release signal as it submerges and also up to maximum depths as it attempts to gain favorable position to avoid depth charges.

(b) The signal should be visible by both aircraft and surface vessels in near vicinity of submarine.

(c) Signal should be a separate unit.

(d) A flat colored surface would be satisfactory.

(e) The signal gun could be employed to eject the signal."

9. Following the authorization of the problem by the Bureau of Engineering, the first laboratory work was the study of suitable dye-colored oils to form an oil patch on the surface of the water. Petroleum oils being recognized as very unsatisfactory for use on submarines, vegetable oils were used in this work. Means for ejecting these oils from a submarine were developed. Next it was found that certain bronzing powders, such as aluminum and gold bronze, when spread on water gave a very satisfactory recognition signal and means were devised for ejecting these from submerged submarines. Finally, the Bureau of Ordnance projectile dyes were tried and found to give satisfactory coloration of water. It is desired here to make grateful acknowledgement of the kind cooperation of Lieutenant E.M. Crouch, U.S.N., Officer-in-Charge, Naval Ordnance Laboratory, and of Chief Gunner R.D. Carmichael, Officer-in-Charge, Naval Magazine, Bellevue, D.C., in this work.

EXPERIMENTAL METHODS

10. The experimental work on this problem divides itself naturally into three parts:

(a) The development of new recognition signalling agents.

(b) The testing of their visibility.

(c) The devising of means for ejecting the signalling agents from submerged submarines.

(a) Signalling Agents.

11. Oil-Dye Signal: The first type of signal depends on spraying a dye-colored oil on the surface of the sea to form a distinctively colored patch. The first experiments were to find a satisfactory oil. Experience of submarine officers shows conclusively that petroleum oils would be entirely unsuitable for this owing to the possibility that part of the oil might become trapped in the superstructure or the fairwater structure of the submarine and thereafter leave an oil slick which, for hours afterwards, would disclose the presence and position of the submarine. Hence, vegetable oils were tried in this work, corn oil, for example, proving satisfactory. Unfortunately, despite the enormous number of dyes known to chemistry, the

number of dyes soluble in oil is relatively small and some trouble was experienced in finding suitable dyes. Several were tried, but thus far only two -- yellow and red -- have proved satisfactory. The formulas for the final oil mixtures are as follows:

Red	Yellow
4 oz. Geigy oil-soluble red #7	3 oz. Geigy oil-soluble yellow #2
1/4 gal. Butyl Lactate	1/4 gal. Butyl Lactate
3/4 gal. Corn Oil	3/4 gal. Corn Oil

Dyes manufactured by the J.R. Geigy Company.

12. Powder Signals: As the oil patch recognition signal seemed to have undesirable limitations, other signalling means were sought. This led to the discovery of the second type of signalling agent, which comprises a distinctive colored powder which is scattered over water and floats for a period of time. A large number of materials were tried, of which the following were considered to show promise:

Bronze Powders		Other
Aluminum	(Aluminum Co. of America)	Fire Extinguishing Foam Powder.
Copper	(U.S.Bronze Powder Works)	Graphite.
Deep Copper	" " "	
Gold	" " "	
Light Blue	" " "	
New Green	" " "	

13. Dye Signals: The third type of signalling agent consists of a water-soluble dye in the form of dry powder which, when scattered over the surface of the sea, quickly dissolves and colors a body of water immediately beneath the surface. In principle this method is identical with the method of coloring the salvo-splashes of major-caliber projectiles. Two obsolete projectile dyes (blue and carmine) supplied by the Naval Ordnance Laboratory on authorization of the Bureau of Ordnance were tried and found to be suitable.

(b) Visibility of Signals.

14. The first experiments on the visibility of the above signalling agents were made as follows. On a sunny day, with the wind about force 2 on the Beaufort Scale, the various signals -- oil, powders and dyes -- were scattered from the stern of the Laboratory motorboat while she was underway at about 2 knots. Approximately one pound each of the various signals were used and scattered at intervals of about 200 feet along the course (Plate 1). When all signals had been put overboard, the course of the boat was reversed and the character of the various colored patches observed at various angles with respect to the sun. By steaming back and forth along the line of signals, a measure of the duration of visibility was determined. From these observations it was judged that the signalling agents were satisfactory in visibility and duration, most of them remaining visible for about half an hour.

15. Next, through the cooperation of Lieutenant E. M. Crouch, USN, of the Naval Ordnance Laboratory, visibility tests from the air were made.

In these the several signals were scattered over the Potomac River from the motorboat on a course 180° as described above, while Lieutenant Crouch observed them from a plane with Lieutenant (jg) J. H. Griffin, USN, piloting and also observing. The day was sunny with the sun bearing about 130° at altitude 50°, the wind about force 2 and the river slightly choppy and very muddy. The majority of the signals was found to be adequately seen from the airplane at altitudes up to 4,000 feet. The visibility of the signals varied greatly as the position of the airplane changed with respect to the sun. These visibility tests were not carried further because it was appreciated that conditions on the muddy Potomac River differed greatly from the conditions at sea and hence that visibility tests, to be of significance, could only be made in the open sea.

(c) Ejection Methods.

16. The remaining part of the work is concerned with devising suitable means for ejecting the above signalling substances from a submerged submarine.

17. Air Blow (for oil): In the first method, suggested by Lieutenant W.J. Holmes, USN, the oil is blown out a small pipe through the pressure hull in the submarine, coming out at as high a point as is possible in the submarine fairwater structure (Plate 2). Lieutenant Holmes visualized that in the final application of this method a number of small tanks containing the several oils (Plate 2a) would be provided, all manifolded to the common overboard pipe; the commanding officer would then be provided with means whereby he could at will blow one of the colored oils overboard (Plate 2b).

18. This suggestion was tested by constructing the tank-manifold system diagrammed in Plate 2a and using it from the Laboratory motorboat on the Potomac River, as diagrammed in Plate 3.

19. Projectiles (for oil): The second method of ejecting the oil signal was to devise a projectile suitable for use in the submarine emergency identification signal gun. In this, the oil is contained in a shell similar to the submerged emergency identification signal, Mark II. In the shells first tried, when the signal reached the surface air pressure forced the oil out as a spray which covered an area of water. But the air-pressure system proved so complicated and expensive in construction that a second type was devised in which nitrocellulose powder generated the pressure to eject the oil as a spray. In Plate 4 the final experimental model is shown in section.

20. Projectile (for powder): The method of ejecting the powder signals -- both the metal powder and the powdered dye -- is a simple modification of the emergency identification signal Mark II, Mod. 2, shown in Plate 5, in which a small charge of 3 grams of black powder scatters the signalling powder sufficiently to cover a wide area of the surface of the sea.

21. Tests of Ejection Methods: The final experimental recognition signal methods were tested by firing them from the submerged signal gun of the USS S-20 while she was submerged on the bottom of the Potomac River off Piney Point, Maryland, the operation of the signals and their visibility

being observed by personnel aboard the accompanying diving boat. These tests proved satisfactory.

CONCLUSIONS AND RECOMMENDATIONS

22. (a) Facts Established.

(1) Bearing on Problem: It is concluded that the work outlined above has shown that a recognition signal comprising a distinctively colored patch of sea-water -- the coloration being produced by dyed-oils, metal powders, or powdered dyes -- can be developed for use from submerged submarines. It is further concluded that tests of the method under practical conditions at sea will be necessary to decide definitely the merit of the method.

(2) Collateral Facts with Recommended Application: It is suggested that the metal powders used above should be tested for use as projectile dyes. It is believed that they would color projectile splashes in a manner so distinctive as to make them a valuable addition to the limited number of satisfactory projectile colors.

(b) Opinions.

23. It is considered that of the three types of signal agents tried, the powdered metal and powdered dye signals incorporated into projectiles, similar to that of Plate 5, offer the most promise. It is believed that the oil signals should be used only if further test shows the others to have unforeseen objections.

24. It is felt that further development of the work should be along the following lines. A number of the metal powder and powdered dye signals should be made up and tested under service conditions at sea by submarines, surface ships and airplanes operating in company under a variety of conditions of sun and weather. During these tests a tentative doctrine for the use of the signals should be set up. Then, if such tests show promise, the final signals could be designed with this background of service test and doctrine.

25. Another line of development would be to design a signal which would simulate the formation of a splash by a dye-loaded projectile, as projectile splashes are readily visible from planes for a considerable time. To do this, a projectile could be loaded with dye and a demolition charge (Plate 6a) such that when it exploded (Plate 6b) the dye was thrown into the water and a large colored splash result (Plate 6c).

(c) Recommendations.

26. Accordingly, it is recommended:

(1) That a number of submarine recognition signals incorporating the metal powder and powdered projectile dyes, similar to that shown on Plate 5, be manufactured by the Naval Magazine, Bellevue, D.C., for service test by the Fleet, the object of the tests being to ascertain the suitability of the suggested recognition signals and to develop a doctrine for their use.

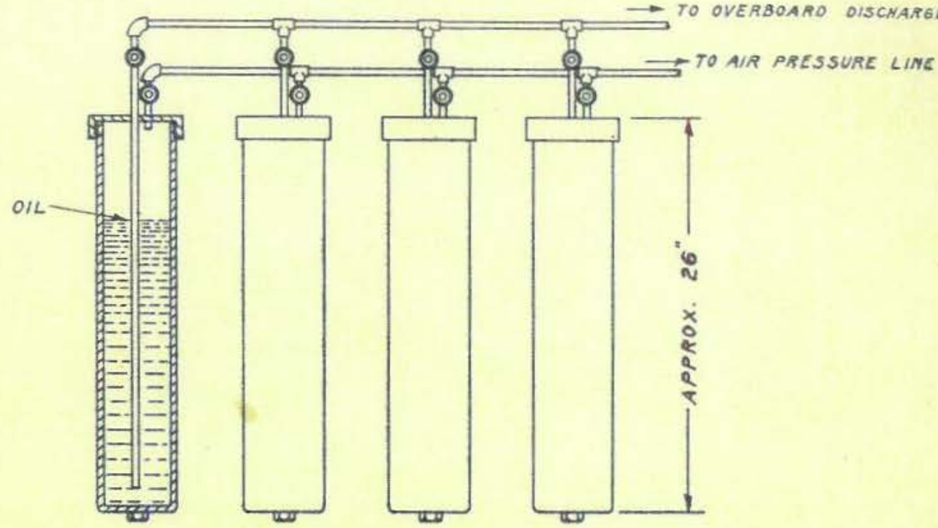
(2) That if the tests of (1) prove satisfactory, such further development work as appears desirable be carried out cooperatively by the Naval Ordnance Laboratory, the Naval Magazine, Bellevue, D.C., and the Naval Research Laboratory.

 [redacted]

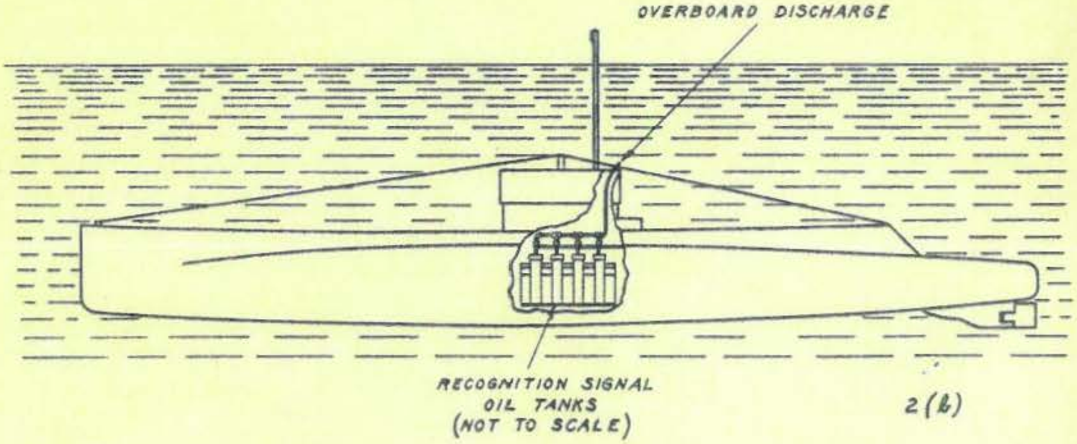
PLATE I

DECLASSIFIED

SECRET



2(a)



2(b)

PLATE 2

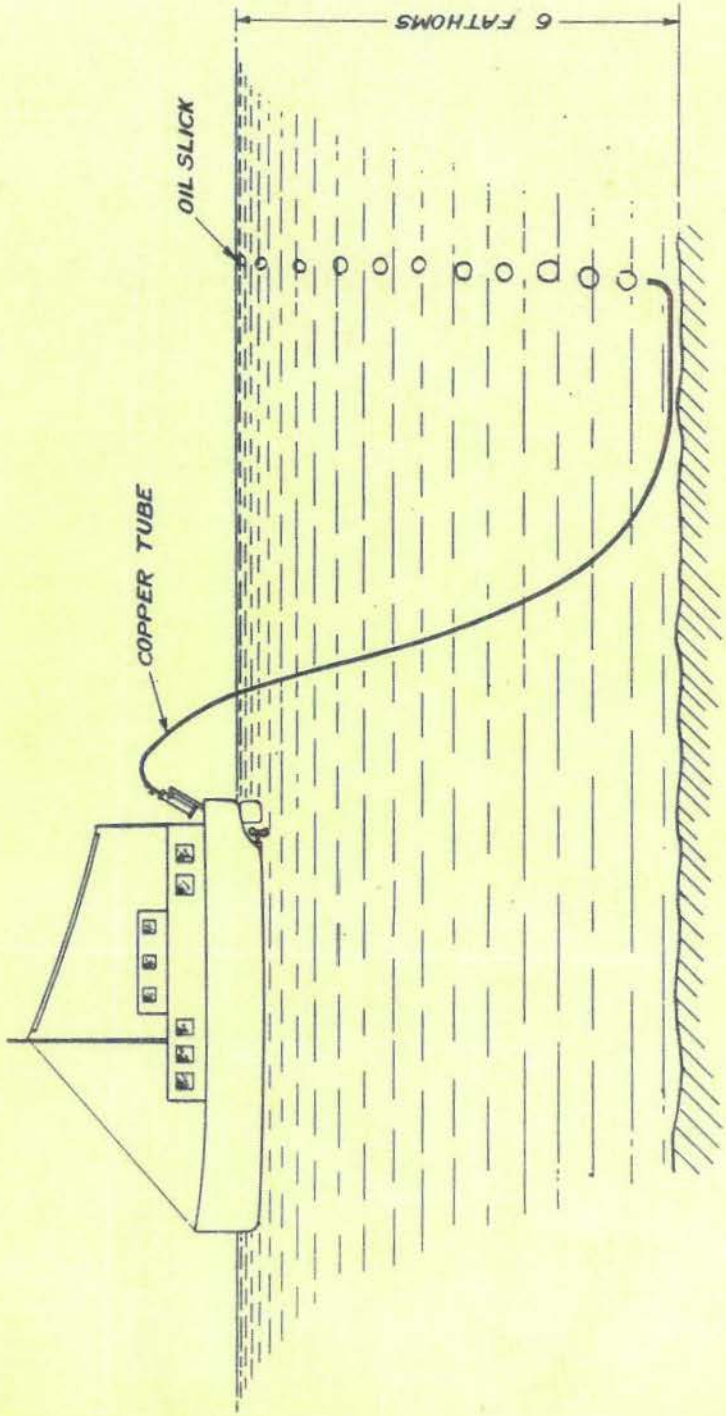
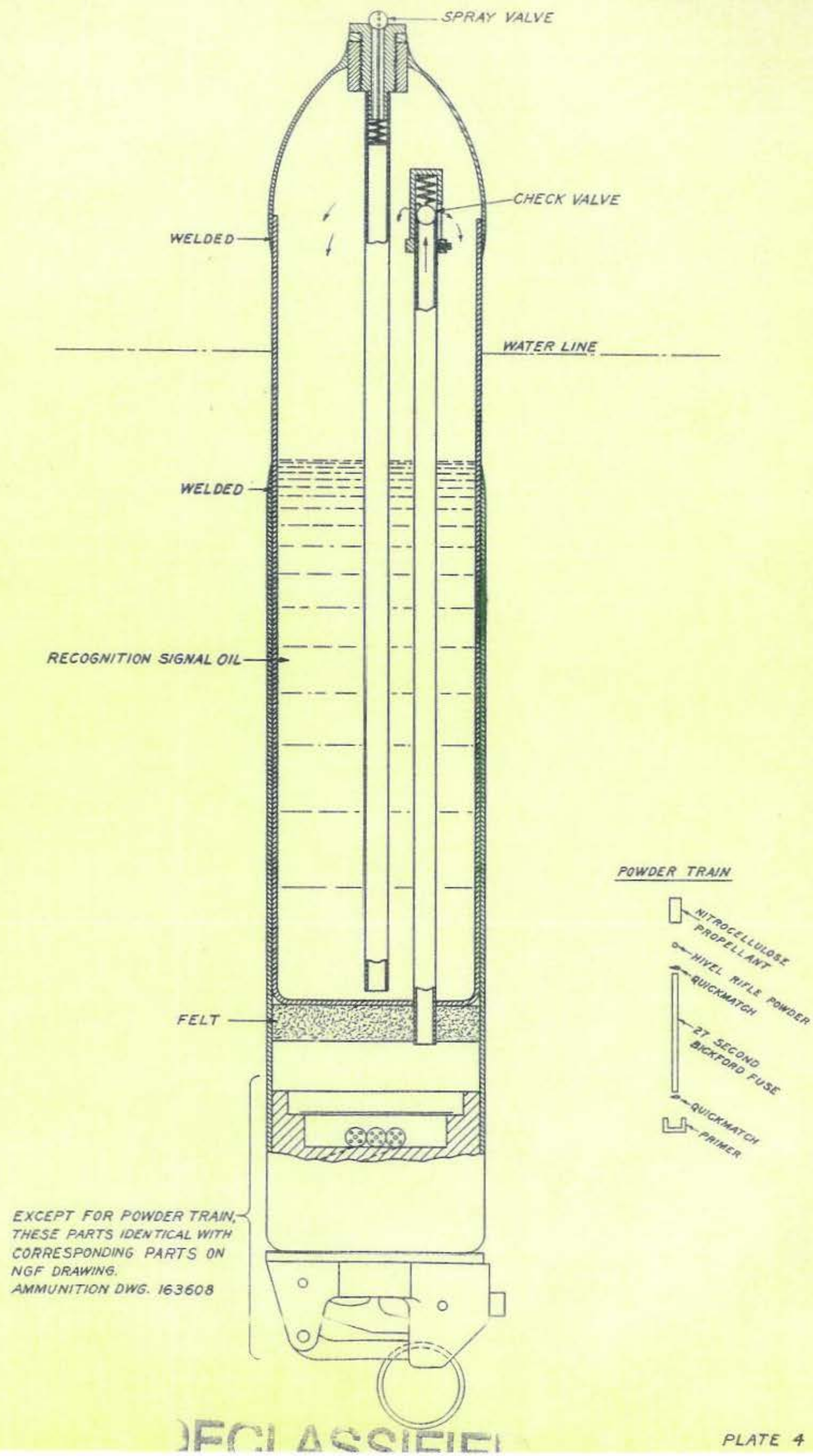


PLATE 3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CHECK VALVE
WELDED
WATER LINE
WELDED
RECOGNITION SIGNAL OIL
FELT
EXCEPT FOR POWDER TRAIN, THESE PARTS IDENTICAL WITH CORRESPONDING PARTS ON NGF DRAWING. AMMUNITION DWG. 163608
POWDER TRAIN
NITROCELLULOSE PROPELLANT
HIVEL RIFLE POWDER
QUICKMATCH
27 SECOND BICKFORD FUSE
QUICKMATCH
PRIMER

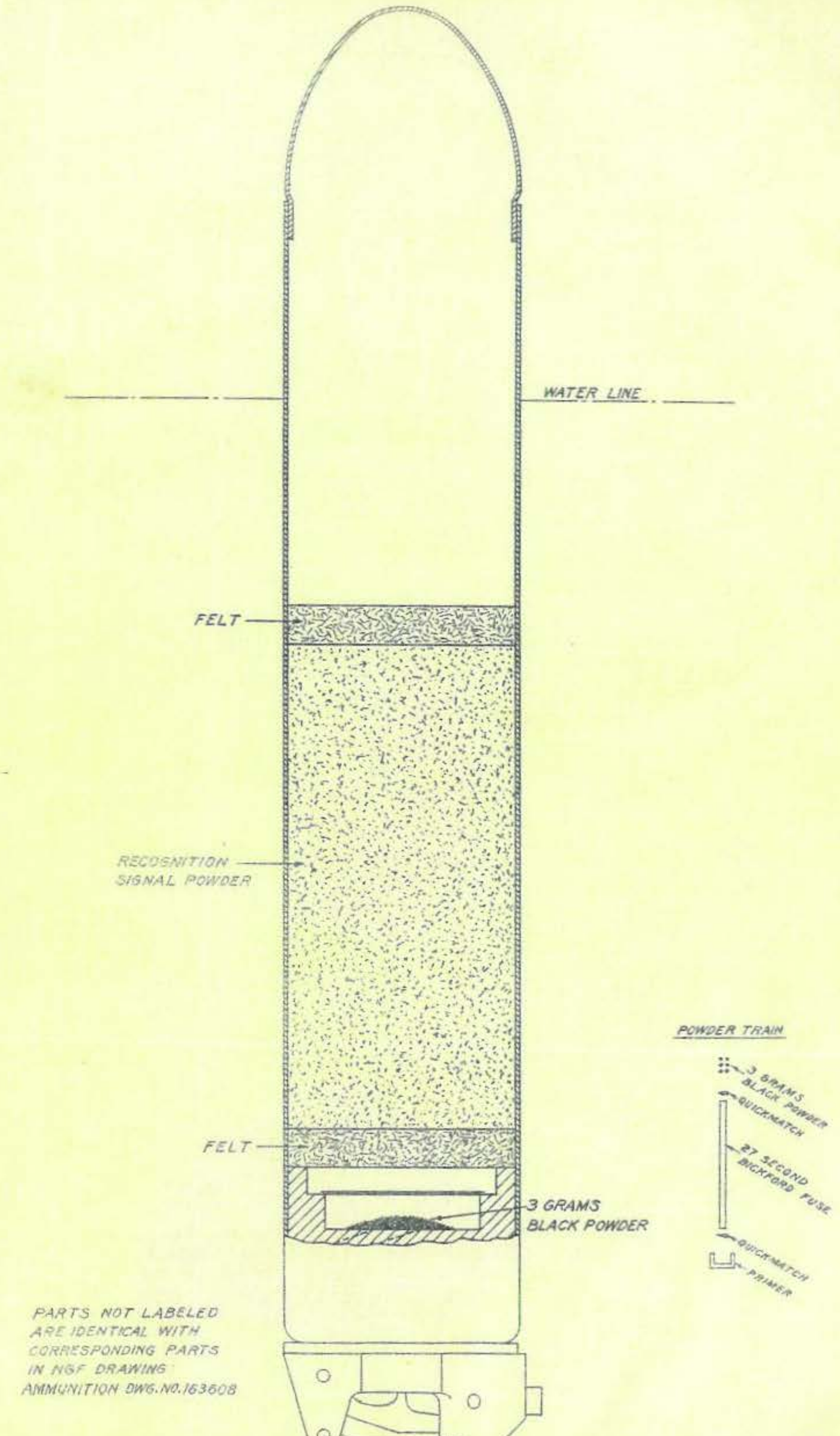
WATER LINE
FELT
RECOGNITION SIGNAL POWDER
FELT
3 GRAMS BLACK POWDER
POWDER TRAIN
3 GRAMS BLACK POWDER
QUICKMATCH
27 SECOND BICKFORD FUSE
QUICKMATCH
PRIMER
PARTS NOT LABELED ARE IDENTICAL WITH CORRESPONDING PARTS IN NGF DRAWING AMMUNITION DWG.NO.163608

PLATE 5

[redacted]

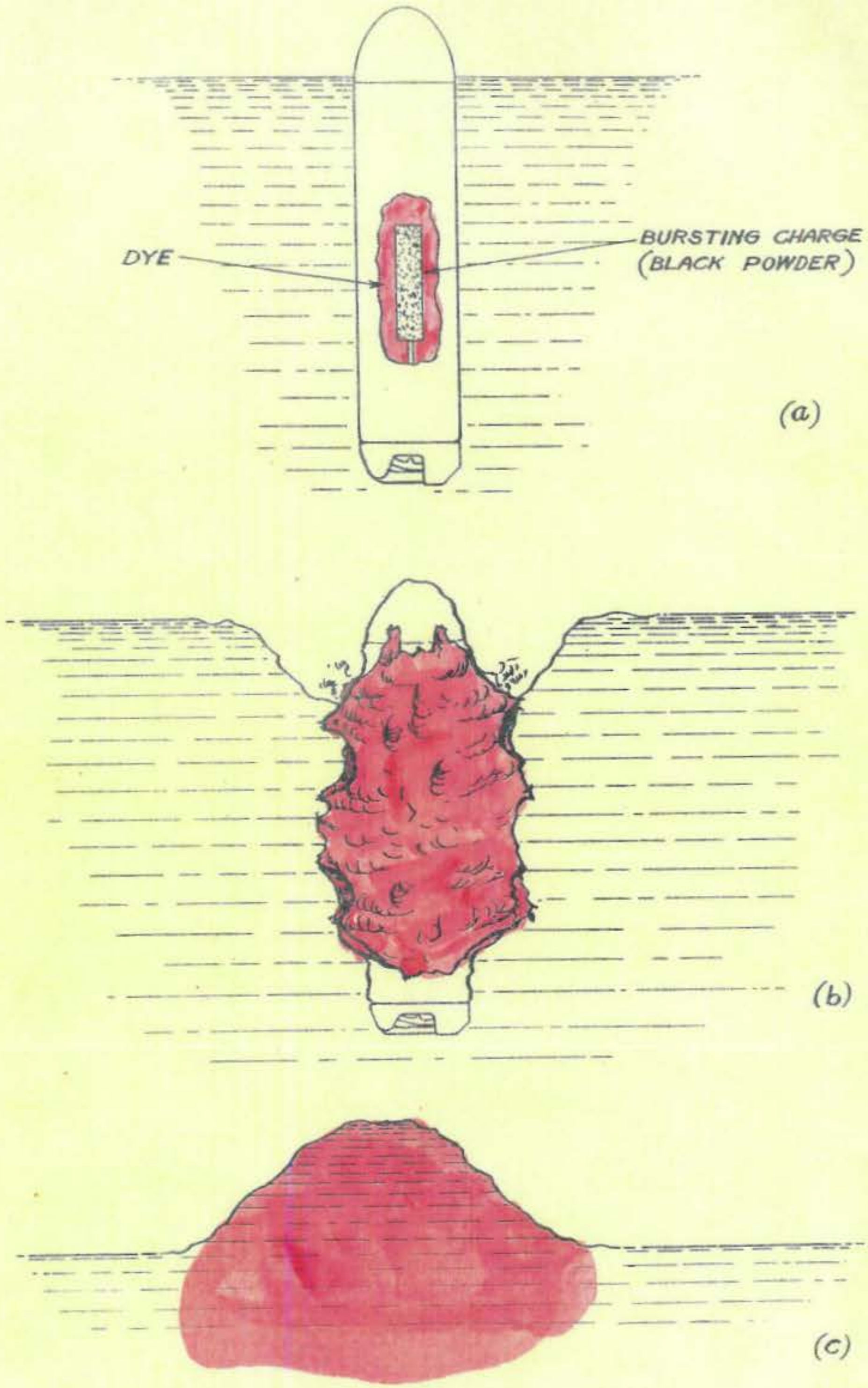

PLATE 6