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DEVELOPMENT OF FALSE TARGET
...LL MARK I - NRL Report No. R2058
30 June 1943

X-16666

Report No. R-2058

# REPORT NO.

DATE

SUBJECT

NAVAL RESEARCH LABORATORY

BELLEVUE, D. C.

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# CONFIDENTIAL

June 30, 1943 Report P-2086

NAVY DEPARTMENT

Report on
The Development of False Target Shell Mark I

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

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Date of Tests: October 1942 to May 5, 1943.

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8134

NAVY DEPARTMENT
BUREAU OF SHIPS
WASHINGTON, D.C.

S68/A16-3(349)

CONFIDENTIAL

30 AUG 1943

From: The Chief of the Bureau of Ships.
To: The Coordinator of Research and Development.

SUBJECT: False Target Shell - Naval Research Laboratory Report No. P-2086 on Development of.

References:
(a) NRL conf. ltr. C-368/S8(452) dated 31 July 1943 to BUSHIPS forwarding subject report.
(b) Vice CNO conf. ltr. Op-23C-1-VRJ 6/23/43(SC) A16-3/(23) Ser. 0259923 dated 24 June 1943 to BUORD and BUSHIPS.

Enclosure: (h.w.)
(A) Six copies of subject report.

1. Enclosure (A) is forwarded herewith.

2. Cognizance of procurement of FTS (False Target Shell) was assigned Bureau of Ordnance by reference (b). Information available to this Bureau indicates that initial stocks of FTS will probably be available shortly after 1 September 1943.

3. The Bureau of Ships is developing a silent airless plunger-operated ejector for installation on all Fleet submarines. This will accommodate the separate chemical-containing cans (FTC, False Target Cans) now housed in FTS. It is contemplated that FTC will be furnished in place of FTS as the new ejectors are installed.

Copy to: (with encl. (A)) 330
BUORD Atten. Re2, Re6, Pr6c. (4) 340
CO USS SEMMES (1) 352
USN Underwater Sound Lab. Ft. Trumbull, Conn. 515
USN Radio and Sound Lab., San Diego, Calif. 815
COMINCH (Readiness) (2) 940
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BAD (B. S. Smith) (2)
Director, Woods Hole Oceanographic Inst. (1)
Director, UCDWR at the USN, R&S Lab., San Diego, Calif. (1)
NRL

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## APPENDICES

## ABSTRACT

This report covers the experimental work and service tests performed in the development of the False Target Shell (FTS) Mark I. This device, on ejection from a submarine, is designed to generate a bubble cloud serving as a false target for submarine echo-ranging attack. It is suitable for training of sound operators as well as for submarine evasion.

Information from the Commanding Officer of the USS SEMMES concerning the deep water tests of the False Target Shell at Portsmouth, N. H. on April 17, 1943 arrived after publication of this report. This information (1. Bibliography) concurs with that given in the report.

Successful prosecution of this problem was made possible by the cooperation of officers and civilians of the Sound Division.

AUTHORIZATION

1. The problem was authorized by Bureau of Ships letter C-SS/A16-3(375) Serial 012-14-10 dated December 12, 1942 under Project Order 453/43. Other references are:

(a) Memorandum Chief of BuShips to COMINCH, C-S68/SS, dated Aug. 4, 1942, Orig. file C-SS/A16-3(340) Serial 085-13
(b) OpNav to BuShips, S-EF30, dated Aug. 7, 1942, Orig. file Op-16-F-9(SC)A8-2/EF30 Serial 01962316
(c) Plans of Submarine Emergency Identification Signal Ejector, E. B. Co. Dr. No. 1763-22 to 1763-25
(d) Ordnance Pamphlet No. 725, Ships Pyrotechnics, August, 1937
(e) Internal Report No. 100, Pillenwerfer Design, Orig. file C-EF13-(1) Serial 01203171. NAA London Report No. A929-42 of Nov. 16, 1942.
(f) Phil. Mag., 19, 1147-1151(1935)
(g) NDRC Report C4-sr20-326, dated 10/22/42, NRL file C-EZ1/6
(h) NDRC Report 6.1sr31-437, dated 2/18/42, NRL file C-EZ1/6.1
(i) BuOrd. ltr. to N.O.L. Nyd. Wash., Orig. file S73-1(9), Re2e Serial 02-3-9, dated 2/2/43, NRL file C-S68/SS
(j) BuShips ltr. to BuOrd., Orig. file C-SS/A16-3(330) dated 2/23/43, NRL file C-S68/SS

STATEMENT OF THE PROBLEM

2. The development of suitable materials to be discharged from a submerged submarine to generate a bubble screen creating a false target with echo ranging devices. The following requirements (Reference (a)) were considered essential to the bubble screen generator:

(a) Generation of a cloud of small bubbles rather than a vertical stream.
(b) A delay in bubble discharge of about three minutes.
(c) Safety in storage and handling while in readiness for discharging.
(d) Bubble screen should persist for three to five minutes.
(e) Discharged material evolving gas should have a slight negative buoyancy.
(f) Material must be commercially available.
(g) Device must be suitable for discharge from the "Submarine Emergency Identification Signal Ejector".

KNOWN FACTS ON THE PROBLEM

3. The Germans have successfully developed and put into active use a bubble screen generator technically known as "S-Gerat Vertilger" (Asdic obliterator) or more popularly as "Pillenwerfer" (Pillthrower). (See Plate 1.) The apparatus is essentially an ejector for discharging chemical pellets which generate a cloud of gas bubbles thereby giving false echoes to surface echo-ranging anti-submarine craft. The "Pillenwerfer" consists of a cylinder approximately 20" long and 3.2" in outside diameter with 0.6" wall thickness, containing a loose-fitting piston operated by a piston rod which passes through a packing gland in the breech of the cylinder. The outboard end of the cylinder projects a few inches from the hull and is covered by a pressure cap controlled by a handwheel. Water and air valves are provided for flooding and draining the tube. Operation of the "Pillenwerfer" is very simple:

> With the outer cap closed, the breech is opened and the bubble generating pellets inserted in the tube. The air release valve is then opened and water is admitted through the water inlet valve until it is seen to emerge from the air release valve, both valves are then closed, the outer cap is opened, and the pellets are discharged by pushing the ejector rod forward. The cap is then closed and the water drained from the tube in readiness for another loading.

The pellets are of unknown composition, cylindrical in shape and about 1-1/2" in diameter and 3-1/2" long. It is believed that the pills do not reach their full intensity of gas evolution until about two minutes after discharge and then last about six minutes. More complete information concerning this device may be found in Reference (b).

4. While the German pill ejector was especially designed for that purpose, any bubble screen generator developed at the Laboratory must be suitable for discharge from the Submarine Emergency Identification Signal Ejector. Plans of the ejector for submarines SS198 to 200 were obtained, Reference (c). This ejector is designed to fire by air pressure a signal shell. Unlike the German "Pillenwerfer" the barrel is built in two sections with a space in between the barrels for a muzzle closing mechanism of the swinging gate type. This gap between the barrels is 2-3/8" long and 4" in diameter. A pellet smaller than 2-3/8" might fall into this opening while one only slightly longer might jam in the barrel. The Mark II Mod. 2 Submarine Emergency Identification Signal (Reference (d)) used in this ejector is an ogival headed tube 18-1/2" long and 3" in diameter expelled in its entirety from the submarine. As the signal

leaves the ejector, a tripping lever is raised by contact with a lug in the ejector, thereby cocking and releasing a firing hammer which strikes and fires a primer igniting a time fuze. The fuze burns for approximately 25 seconds and ignites an expelling charge of black powder which ejects the signal from the case.

THEORETICAL CONSIDERATIONS

5. The study of bubble and wake phenomena is at present in progress at a number of laboratories. A complete picture of the quantitative relations involved has not as yet been attained. Information is here presented from outside reports merely to give an idea as to the order of magnitude of the factors involved and does not represent an attempt to evaluate or analyze the data. The reflection of sound by bubbles is critical with bubble size. In Table I (Reference (e)) are given volumes of gas at a hydrostatic pressure of one atmosphere required for various bubble sizes to simulate an equivalent spherical target of 100 meter diameter with an echo ranging frequency of 20 kilocycles/second.

Table I

| Diameter of each bubble | Total volume of gas required |
|---|---|
| 0.010 cm. | 9000 liters |
| 0.020 | 750 |
| 0.030 | 50 |
| 0.032 | 2.5 |
| 0.040 | 75 |
| 0.060 | 750 |
| 0.200 | 4000 |

The small volume of gas required for bubbles of diameter 0.032 cm. is accounted for by the fact that bubbles of this diameter resonate to a frequency of 20Kc/sec. Bubbles of diameter other than this resonating size require a much larger volume of gas to produce the same effect with a given frequency. The relation between bubble diameter and frequency for resonant conditions at a hydrostatic pressure of one atmosphere is given by

$$\text{Frequency} = \frac{640}{\text{Bubble diameter in cms.}} \qquad (1)$$

6. However, resonant frequency varies also with pressure or depth of water. Neglecting surface tension effects which are small with bubbles of the size under consideration, the variation of resonant frequency with pressure is shown by equation (2) Reference (f). Equation (1) was obtained from this expression by grouping of constants.

$$\text{Frequency} = \frac{1}{2\pi r}\sqrt{\frac{3KP}{d}} \qquad (2)$$

Where r is the radius of the bubble, K is the ratio of the specific heats of the gas at constant pressure and constant volume, P is the hydrostatic pressure on the bubble, and d is the density of the water. Assuming a frequency of 20 Kc/sec., the variation of resonant bubble size with pressure may be determined as listed in Table II.

Table II

| Diameter of Bubble | Depth of Water |
|---|---|
| 0.032 cm. | 0 feet |
| 0.072 | 50 |
| 0.089 | 100 |
| 0.101 | 150 |
| 0.112 | 200 |
| 0.130 | 300 |
| 0.145 | 400 |

To cover the frequency range of 18 to 32 Kc/sec. at atmospheric pressure, bubble sizes varying from 0.020 to 0.037 cm. would be required; to cover the same frequencies at a 400 ft. depth bubble diameters of 0.091 to 0.161 cm. would be necessary.

7. Persistence or duration of bubbles is dependent upon their rate of rise and initial depth and also upon their rate of solution. Rate of rise of air bubbles varies with bubble size as shown in Table III. The values given in the table below were taken from data given by Pekeris (Reference (g)).

Table III

| Bubble Diameter in Centimeters | Rate of Rise in cms/sec. |
|---|---|
| 0.010 | 0.4 |
| 0.020 | 1.2 |
| 0.030 | 2.3 |
| 0.040 | 3.6 |
| 0.060 | 6.6 |
| 0.100 | 13.0 |
| 0.200 | 27.0 |
| 0.300 | 27.0 |
| 1.000 | 24.0 |
| 2.000 | 31.0 |

It is readily seen that the velocity of the bubbles increases markedly with diameter until a diameter of 0.200 cms. is reached from which point the velocity is relatively constant at 27.0 centimeters per second.

8. A study of the solution rate of air bubbles in water at various pressures has been made by Wyman (Reference (h)). Except for a slightly faster initial rate, it was found that the rate of shrinkage of air bubbles in a given depth of water was linear with time within the size range of interest to this report. Further, the rate of solution was found to increase with hydrostatic pressure or depth until a limiting value was reached at 15-20 meters (50-65 feet) as shown in Table IV.

Table IV

| Depth of Water in Meters | Bubble Diameter Decrease in cms/sec. | Time to Decrease Bubble Diam. 0.01 cm. |
|---|---|---|
| 5 | $8 \times 10^{-5}$ | 125 seconds |
| 10 | 11 | 93 |
| 20 | 15 | 66 |
| 50 | 17 | 60 |
| 100 | 18 | 57 |
| 200 | 18 | 54 |

The rate of solution of bubbles in water is governed by the solubility of the gas, the thickness of the gas liquid shell boundary, rate of diffusion of the gas through this boundary, hydrostatic pressure, and partial pressure of the gas in the water. A rough idea of the order of magnitude of rates of solution may be obtained from the solubilities of gases in water as given in Table V. The solubilities are in unit volume of gas dissolved in unit volume of water at 25°C and atmospheric pressure.

Table V

| Gas | Vol/Volume |
|---|---|
| Nitrogen | 0.0143 |
| Air | 0.0171 |
| Hydrogen | 0.0175 |
| Oxygen | 0.0283 |
| Methane | 0.0301 |
| Phosphine | 0.20 |
| Carbon Dioxide | 0.759 |
| Acetylene | 0.93 |
| Ammonia | 630.0 |

9. Possible methods of generating bubbles considered were:

1. Mechanical
   - (a) Discharge of cylinders containing compressed gas.
   - (b) Discharge of fluid directly from submarine
     - (1) Spray gun and wetting agent
     - (2) Discharge of liquid solvent containing gas
     - (3) Compressed gas through porous plates

2. Chemical
   - (a) Discharge of a chemical to generate gas on water contact.

All of the above methods are feasible and the advantages and disadvantages of each were weighed.

10. Acting on the premise that 6 cu.ft. of bubbles of the proper size would give a good echo comparable to that of a submarine, this amount of gas could be compressed into an aluminum cylinder under 1800 lbs. pressure having a weight filled of approximately 1300 grams and an outside volume of 1950 cc. To have a slightly negative buoyancy with this volume the cylinder could weigh 2030 grams, or a difference of 730 grams. If added exterior parts were of aluminum or other material of similar density their weight could be 1180 grams (2.6 lbs.) and still maintain a density only slightly higher than sea water ( i.e. 1.04 g/cc.). From this 2.6 lbs. of aluminum would have to be designed, a discharge device, delay mechanism, hydrostatic pressure control, and either a porous plate or nozzle for producing small bubbles. In addition to this a special high pressure cylinder suitable for discharge from the submarine signal ejector would have to be made. In view of the difficulties involved and since by chemical methods the yield of gas with the same weight and volume restrictions could be improved by a factor of ten, the use of compressed cylinders was discarded pending work on chemical units.

11. The discharge of bubbles or bubble generating fluids from the submarine offers the easiest method of control, but lacks the important element of delay. Compressed gas from cylinders could be forced through a nozzle or a spray gun with water through a salvage connection on the submarine to generate bubbles. Possibly very fine bubbles of controlled size could be generated by the use of a spray gun with a wetting agent. The third fluid discharge type is the discharge of a liquid containing a large volume of dissolved gas which is less soluble in sea water than in the solvent liquid. For example, acetone at 15°C and atmospheric pressure will dissolve 25 times its volume of acetylene and at 180 lbs. pressure it will dissolve 300 times its own volume. These three methods were eliminated as they lacked the necessary requirement of delayed action.

## EXPERIMENTAL

12. Preliminary tests of a consultative nature before assignment of the problem to the Laboratory are summarized in Appendix X. From a review of the chemical literature the compounds listed in Table VI below were selected for a more detailed study.

Table VI

| Compound | Mol. Wt. | Gas Evolved | cc. of Gas/g. of Cmpd. | cu.ft. of Gas/lb.of Compound | Density g./cc. | Density lb/cu.ft. | cu.ft. of Gas/cu.ft. of Cmpd. |
|---|---|---|---|---|---|---|---|
| $CaC_2$ | 64.1 | $C_2H_2$ | 350 | 5.60 | 2.22 | 138.6 | 776 |
| $Al_4C_3$ | 143.9 | $3CH_4$ | 467 | 7.48 | 2.36 | 147.3 | 1102 |
| NaH | 24.0 | $H_2$ | 933 | 14.95 | 0.92 | 57.4 | 859 |
| $CaH_2$ | 42.1 | $2H_2$ | 1065 | 17.07 | 1.70 | 106.1 | 1810 |
| LiH | 8.0 | $H_2$ | 2819 | 45.10 | 0.82 | 51.2 | 2306 |
| $K_2O_4$ | 142.2 | 3/2 $O_2$ | 236 | 3.78 | 1.0 | 62.3 | 236 |

The compounds selected for investigation were chosen on the basis of volume of gas released, solubility of the gas in water, fire or other hazards incident to the chemical and gas generated and availability of the chemical. Laboratory tests were conducted on a number of other chemicals such as calcium phosphide and $CO_2$ producing mixtures of the "alka-seltzer" type, i.e. bicarbonate and a dry organic acid.

13. It will be noticed that no compounds liberating nitrogen are found in Table VI. Nitrogen would be an ideal gas to generate because of its safety and low solubility in water. However, compounds releasing nitrogen were unsuitable for the task due to their explosive nature or inability to evolve gas except under special conditions, for example, alkali azides or ammonium nitrite. Sodium hydride was discarded because of its high rate of reaction. Even with a coating of oil it had a tendency to ignite upon contact with water. Aluminum carbide was eliminated without a real test of its properties. A poor sample of aluminum carbide was obtained which gave only a feeble reaction with water and dilute acids. Attempts at purification did not improve its performance. The Aluminum Co. of America informed the Laboratory that there was no known manufacturer of aluminum carbide in the U. S., and that the compound was difficult and costly to prepare and had been made in laboratory quantities for research purposes only.

14. Preliminary testing of calcium hydride, lithium hydride, calcium carbide, and potassium tetroxide indicated that all of these materials would give fine bubbles of gas fairly efficiently if generated from small particles (4-30 mesh). Fine particles of these chemicals react in a matter of seconds and it was felt that the chemical should react as long as the duration of echo desired, i.e. three to five minutes. This premise was later substantiated by sound tests in the Potomac River of finely divided (30 mesh) LiH and $CaH_2$. These hydrides were released in 25 feet of water and reacted nearly instantaneously giving rise to a depth charge affect in that the bubbles collected and rose en masse to give a surface geyser. A very poor echo was obtained. This method of testing small particles was not the optimum since there was a limited amount of dispersion. Effective dispersion would be still another problem. However, a second requirement must be met in that the chemical should not come to the surface of the water. Particles of calcium carbide about 1/4" to 1/2" in diameter will bubble if submerged for approximately three minutes, but on release they will sink in water due to their high density (2.2g/cc) until the bubbling rate increases when they will rise at a rapid speed due to dynamic action of the bubbling. Calcium hydride rises at an even more rapid rate because of its lower density (1.7g/cc) and faster reaction velocity. Lithium hydride and potassium tetroxide have densities less than that of water, and will float on the surface and react, or if released submerged they will rise very rapidly. This meant that large pellets of material of controlled effective density (i.e. of slightly negative

buoyancy during the course of reaction) would have to be prepared in such a way that smaller particles would break off from the larger pellet and react. The effective density varies with each material depending on its density, surface area exposed, and rate of reaction. Rather than study these factors for each of the four chemicals it was decided to eliminate all but one material.

15. Sound tests (Appendix I) indicated that at this stage of development lithium hydride held more promise of successful results as far as echo response was concerned than calcium carbide or potassium tetroxide. With this fact in mind the advantage and disadvantages of each material were considered as compared with lithium hydride. Potassium tetroxide was the only one of the four materials generating a safe gas, oxygen. The potential danger of the free potassium tetroxide was considered as great as the possible premature release of acetylene or hydrogen from the other chemicals. Furthermore, potassium tetroxide presented real difficulties in that very few materials could be safely compounded with it to control its effective density. Some attempts were made along this line using pressed pellets of salt and potassium tetroxide and coating individual pellets with inert materials, but in view of the difficulties presented in this regard and the poor volume of gas produced by $K_2O_4$ relative to the other chemicals, it was decided to temporarily discard potassium tetroxide.

16. Finer bubbles are generated when only a single surface of a pellet is exposed to the action of water. If the pellet is completely exposed, bubbles generated from the bottom and sides tend to collect and form large bubbles rather than the desired fine bubbles. Calcium carbide gives an insufficient volume of bubbles under these conditions to counteract its high density and give the pellet effective density near that of sea water and still maintain bubbling for a three to five minute period. Calcium carbide has distinct advantage in its low cost of 6 cents per pound, but the small volume of acetylene generated per pound, the high solubility of acetylene in water and poor effective density characteristics of the chemical outweighed this advantage. It should be mentioned that if an ejector of the German Pillenwerfer type were available in which large quantities of bulk chemical without a special ejection container is used, calcium carbide would merit consideration because of its cheapness.

17. Both acetylene and hydrogen would be unsafe if released in large volume in a submarine. The inflammable limits of acetylene in air are 2.5 to 82% acetylene while the inflammable limits of hydrogen in air are 4.1 to 75% hydrogen. The use of hydrogen generating chemicals is relatively safe in that the volume generated by unit charge is small in comparison with the volume of the submarine. If conditions were such that one bubble charge completely reacted and liberated 60 cu. ft. of hydrogen the percentage of hydrogen in a submarine of 30,000 cu. ft. would only be 0.2%; it would take the complete reaction of twenty such charges to reach the lower limit of inflammability of hydrogen.

18. Lithium hydride was selected in preference to calcium hydride, since lithium hydride liberates a larger volume of gas, has a lower density (allowing more leeway for effective density adjustments) and is more stable under atmospheric conditions. Over short periods of time calcium hydride will completely decompose on exposure to the atmosphere while lithium hydride is stable under the same treatment. Lithium hydride cost the Laboratory $15.00 per pound while calcium hydride cost $10.00 per pound; this discrepancy in price is more than outweighed by the fact that per pound lithium hydride liberates over 2.5 times the volume of hydrogen liberated by calcium hydride.

19. Tests were performed on lithium hydride with the view of developing pellets of slightly negative buoyancy that would liberate fine bubbles for three to five minutes. Paraffin was found to be an ideal binder in that it was non-reactive and allowed particles of lithium hydride to leave the surface of the pellet and react. Natural waxes such as beeswax, carnauba, and ceresin were used but found later to react on storage with the lithium hydride. For laboratory tests visual observation was made of 1" x 1" cylindrical pellets made by a hydraulic pressing at various p.s.i. in a steel die. Paraffin was first tried as a binder for the lithium hydride, being mixed slightly above the melting point of the paraffin and allowed to cool before pressing. The effect of mesh size on time of reaction was measured to limit the number of variables involved. Using pellets of 70% lithium hydride and 30% paraffin of melting point 57°C, it was found that lithium hydride over the range of U. S. Standard mesh sizes 6-10, 10-20, 20-30, and smaller than 30 mesh, the speed of reaction varied by only 15%. Bubble size was about the same with the different mesh sizes. As a result of this test lithium hydride ground to the approximate mesh analysis given below was used in tests.

Mesh Analysis

| Mesh Size | Screen Opening in Inches | % of Total by Weight |
|---|---|---|
| 3 - 4 | 0.187 - 0.250 | 1.0 |
| 4 - 6 | 0.132 - 0.187 | 8.0 |
| 6 - 8 | 0.094 - 0.132 | 17.4 |
| 8 - 10 | 0.079 - 0.094 | 8.2 |
| 10 - 20 | 0.033 - 0.079 | 31.8 |
| 20 - 30 | 0.023 - 0.033 | 7.4 |
| 30 | 0.000 - 0.023 | 26.2 |

Seventy percent lithium hydride and thirty percent paraffin was selected as this mixture may be easily and uniformly made in small batches. Higher or lower paraffin content with this mesh size tends to produce non-uniform mixtures.

20. The effect of water temperature on the speed of reaction was found to be negligible for a pellet composed of 50% lithium hydride and 50% paraffin wax of melting point 135°F.

This high percentage of paraffin was used to accentuate any temperature differential in rates that might exist due to paraffin as lithium hydride alone reacted uniformly over the temperature range concerned. From an average of six determinations it was found that a 1" x 1" cylindrical pellet reacted 30% faster at 85°F than at 53°F. The mistaken assumption was made that in general the paraffin mixed pellets would react faster at high temperatures than at low temperatures. This was true for the particular case tried, a high percentage of low melting paraffin, but was not true for small percentages of paraffin. This erroneous assumption led to difficulties in later tests.

21. Larger pellets approximating the expected size for Service use were prepared by pressing material in a 2-7/8" diameter cylindrical die. Pellets were composed of 161 grams of lithium hydride and 60 grams of paraffin (M.P. 132°F) compounded while hot (90°C) and stirred until cool. This mixture pressed in the die at 3100 p.s.i. formed a pellet 2-7/8" in diameter and 2-13/16" high. The pellet was then sealed into a 28 gauge galvanized iron cup 2-29/32" inside diameter and 3" in body height containing 20 grams of hot paraffin and a 35 gram lead weight. Total weight was 375 grams with a volume of 325 cc giving a density of 1.15 grams per cc. With a density less than this the pellet will surface from 20 feet of water, the Potomac River depth used in testing. Through the cooperation of the Sound Division of the Laboratory two groups of six pellets each were tested and found to give echoes of good quality and intensity at a 400 yard range (Appendix II). Echoes were obtained over a thirteen minute period. Normally at the temperature of test, 59°F, each pellet would react for 7 minutes, but each pellet had a delay element of a single sheet of #41 Whitman Filter paper sealed to the edges of each pellet. These same pellets were tested in the Potomac River in 70 feet of water at Morgantown by the Sound Division. Good echoes were obtained at 1200 yards and fair echoes at 2000 yards using these pellets with the filter papers removed.

22. Originally, in conformity with the problem requirements, it was felt necessary to have each pellet delay its discharge about three minutes. Various methods of delay were tried - cloth and paper coverings of various types with and without impregnation with wetting agents, coatings of mixed water reactive and non-reactive chemicals, coating of fused and pressed water soluble salts. The delay time in paper coverings was governed not by the time of water diffusion but by the tensile strength of the material; water would diffuse through the paper and react with the chemical thereby generating gas which would balloon up the paper covering preventing entrance of more water. The pellet would only initiate action when a break in the paper occurred. Paper strength in the same lot varied too widely to make this method useful. The same effect occurred with cloth coverings the only difference being that action was initiated when the cloth left the surface of the pellet, that is when the gas pressure became sufficiently strong to break the binding edge between the pellet and cloth. Ordinarily with cloth coatings water was

admitted only sufficient to equalize the gas pressure underneath the cloth and the hydrostatic pressure of the water, then further action stopped. Reactive coatings varied too greatly over the temperature range involved. A layer of dried sodium chloride pressed over the exposed lithium hydride surface was found to be fairly satisfactory. The solubility of sodium chloride in water varies only slightly from 32°F to 90°F. Delay time could be controlled by variations in mesh size and pressure. A delay element of this type would be difficult to manufacture and control. With all types of delay the pellet would undergo a high rate of free fall in water until bubbling started to decrease its effective density, unless a float detachable on initiation of reaction were incorporated. However, sound tests of lithium hydride-paraffin pellets indicated approximately two minutes delay in developing the false target was inherent in the pellets. This delay was said to be sufficiently long and work was started on experimental units.

22. For commercial manufacture it would be cumbersome and time-consuming to press chemical pellets and then seal them into metal cups. For this reason, it was decided to use seamless drawn cups and make dies to accommodate cups and material and press the pellets directly into the cups. Can manufacturers were contracted and the standard size nearest the dimensions desired was selected. The American Can Co., 1834 Claybourne Ave., Chicago, Illinois, supplied seamless drawn cups (Plate 2 also Plate 1, Appendix III) of tin plated black iron 2-25/32" outside diameter and 1-7/8" body height and weighing 35 grams ± 2. Steel dies (Figure 1 of Appendix III) were made in the Laboratory machine shop to accommodate these cups and the material for the pressing operation. Paraffin of melting point 145°F was obtained from the Standard Oil Co. of New Jersey. The lithium hydride purchased from Maywood Chemical Co., Maywood, N. J., analyzed about 97% lithium hydride. Material previously used was furnished by the Lithalloy Co. of New York City and analyzed only 78% lithium hydride. Test pellets prepared by pressing 140 grams of 78% lithium hydride and 22% paraffin in a metal cup with a 40 gram lead weight added, reacted for 5-1/2 minutes at 34°F. Six of these chemical-containing cups were loaded into a Mark II Mod. 2 Submarine Emergency Identification Signal case with suitable packing as shown in Plate 1 of Appendix III. Three of these False Target Shells were tested by the Sound Division. The units were discharged from an open boat in the Potomac River at ranges 400 - 550 yards from the sound equipment. Each shell gave excellent echoes lasting 5 to 6 minutes.

23. Twenty-four signal cases were loaded with chemical pellets as above described with the exception that a 35 gram lead weight was used instead of a 40 gram lead weight. These "False Target Shells" were tested at Key West on Dec. 31, 1942, the submarine R-14 and destroyer NOA cooperating (Appendices IV and V). Echoes from the chemical pellets varied from test to test in quality and in intensity although in some cases excellent comparison echoes were obtained. Test results on the whole were

encouraging with certain modifications of the "False Target Shell" indicated as necessary. Reaction time of the pellet was too long as indicated by visual observation through the periscope. Size or time of expelling charge should be altered to reduce the noise volume. Possible surface observation of the air discharge of the signal ejector was noted as a disadvantage. This might possibly be remedied by water discharge from an auxiliary tank with air. In this connection it was noted that the "False Target Shell" barely cleared the muzzle of the ejector under 100 lb. air pressure. This shell had a volume of 1920 cc and weighed 2250 grams or a density of 1.17 g/cc. The overall weight should be dropped for this reason as well as to decrease the rate of fall during the 25 second period between ejection and time of pellet discharge.

24. Studies were initiated to overcome these disadvantages. The Bureau of Ordnance authorized the Naval Ordnance Laboratory, Washington Navy Yard to work on the development of expelling charges of lower noise level (Reference (i)). The most important factor brought to light was the length of time for reaction of the pellet. It was felt that this was the primary cause of not obtaining better echoes. Tests were made of the variation in reaction time of lithium hydride-paraffin pellets with percentage of paraffin, paraffins of different melting point, and hydraulic pressure used in pressing the material into the metal cup container. These results are shown in graphical form in Plates 3 and 4. It will be noticed that correspondence between similar points on different graphs is not too good. Although these points in most cases represent averages of two or more pellets individual variations due to mixing in small batches causes quite wide variations. However, these graphs indicated that 30% "Gulfwax", M.P. 125 - 127°F and 70% lithium hydride pressed at a pressure of 4400 p.s.i. would be suitable with a reaction time of about three to seven minutes dependent upon water temperature.

25. The modified chemical loading resulting in a weight saving of about 45 grams in the total weight of the shell. Further reductions in weight were effected by lightening the packing and by replacing the brass nut holding the base assembly to the tube by an aluminum nut. Shell weight was reduced from 2250 grams (4.96 lbs.) and a density of 1.17 g/cc to 2065 grams (4.55 lbs.) and a density of 1.075 g/cc. Effective weight in sea water of density 1.025 g/cc was 95 grams or approximately one fifth of a pound. Twenty-five FTS with the above modifications were prepared at the Laboratory and tested at New London, Conn. (Appendix VI and VII). Tests were conducted by the USS SEMMES (AG24) and the USS CACHALOT (USS170). Excellent echoes of the same quality and intensity as the submarine were obtained. Differentiation of the echoes could be made by a trained sound operator though the Doppler effect i.e. change in frequency of the echo due to the motion of the echo-ranged target, the bubbles having no motion gave no change in pitch to the echo.

In the particular case where the submarine target angle is 90° the submarine has no Doppler and bubble echo and submarines are indistinguishable. Evasion runs demonstrated that in the case where two or more FTS are fired it was possible to confuse the target trace recorder operator although the sound operator was not fooled. The shell was found to be still slightly heavy as evidenced by the fact that a few fired on the after deck after ejection from the submarine.

26. All preliminary tests indicated that the noise level of the black powder expelling charge in the FTS was too high. Mr. S. P. Lewis, Ordnance Engineer of the Naval Ordnance Laboratory, Washington Navy Yard, prepared a number of expelling charges of smokeless powder. These charges were sonically tested at New London, Conn. (Appendix VIII). The use of reduced charges of smokeless powder gave a marked reduction in sound intensity of the expelling explosion.

27. In accordance with References (i) and (j), the Naval Ordnance Laboratory furnished the Naval Research Laboratory with 50 shell cases and modified expelling charges for chemical loading. Twenty-five of these shell cases were loaded as previously and twenty-five were loaded with the chemical mixture to which 1% Aerosol OS by weight had been added. The addition of the wetting agent, Aerosol, was found to improve bubble size and in addition to give more uniform reaction time over a temperature range. A complete description of method of manufacture is given in Appendix III. These shells were tested in conjunction with the deep submergence dive of the USS BALAO (SS285) off Portsmouth, N. H. (Appendix IX). FTS fired at a depth of 300 feet gave excellent echoes persisting for ten minutes.

PRESENT STATUS OF THE PROBLEM

28. Because of the frequency of derangements reported for the present ejector, the Portsmouth Navy Yard, Portsmouth, N. H., has undertaken design of a new ejector. This gun will be of an airless ejection type.

29. The Bureau of Ordnance has agreed to handle manufacture of FTS. Specifications have been drawn up and a manufacturer contacted. It is expected to manufacture initially 3800 shells to be furnished to anti-submarine warfare units and sound schools for training purposes and to ammunition depots and submarine bases for those submarine commanders who wish to use them. A confidential supplement to Ordnance Pamphlet 725 "Ships Pyrotechnics" on use, method of firing, safety precautions, and storage of FTS has been prepared by the Laboratory.

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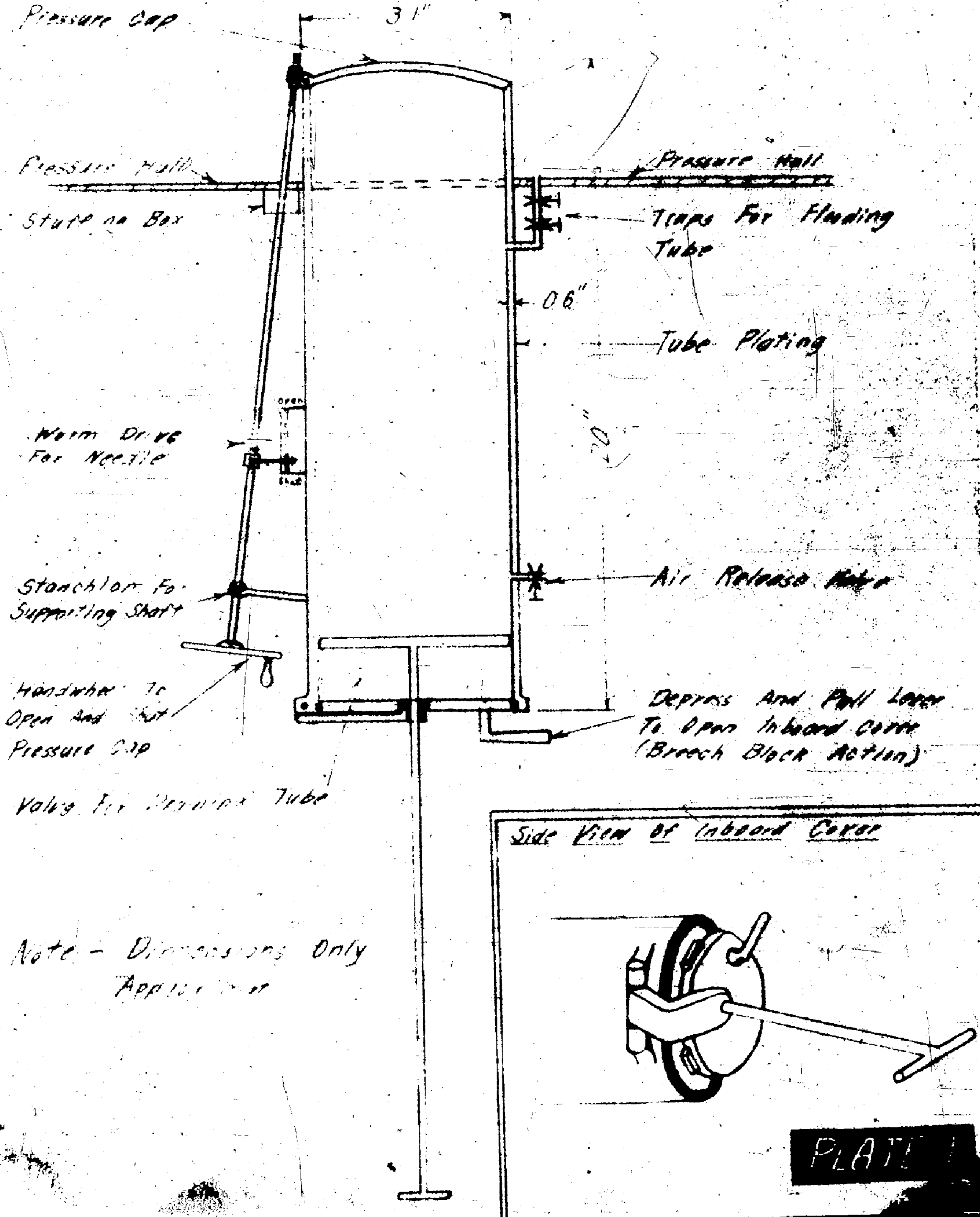
# Pillenwerfer Ejector




Note – Dimensions Only Approximate

PLATE 1

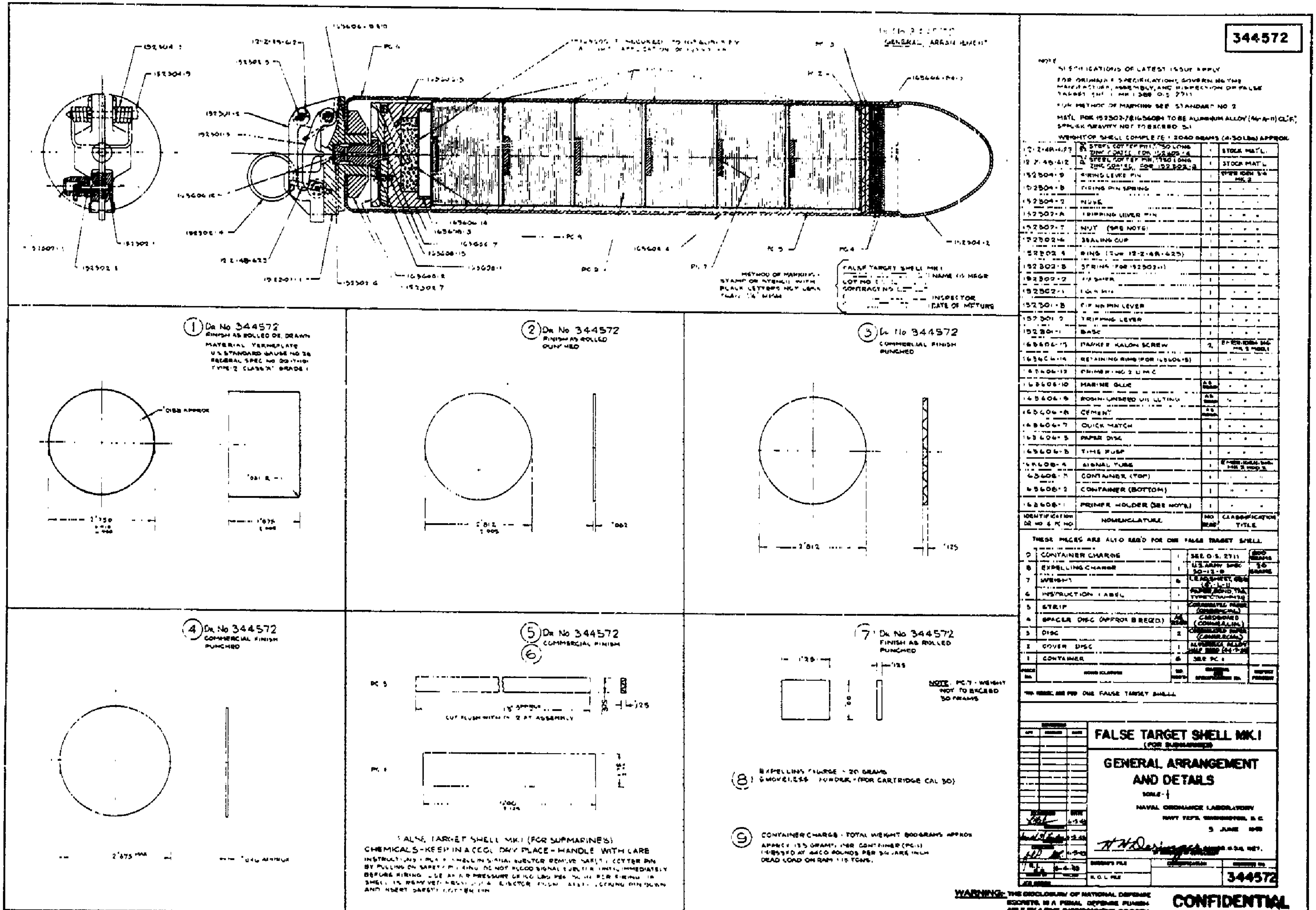
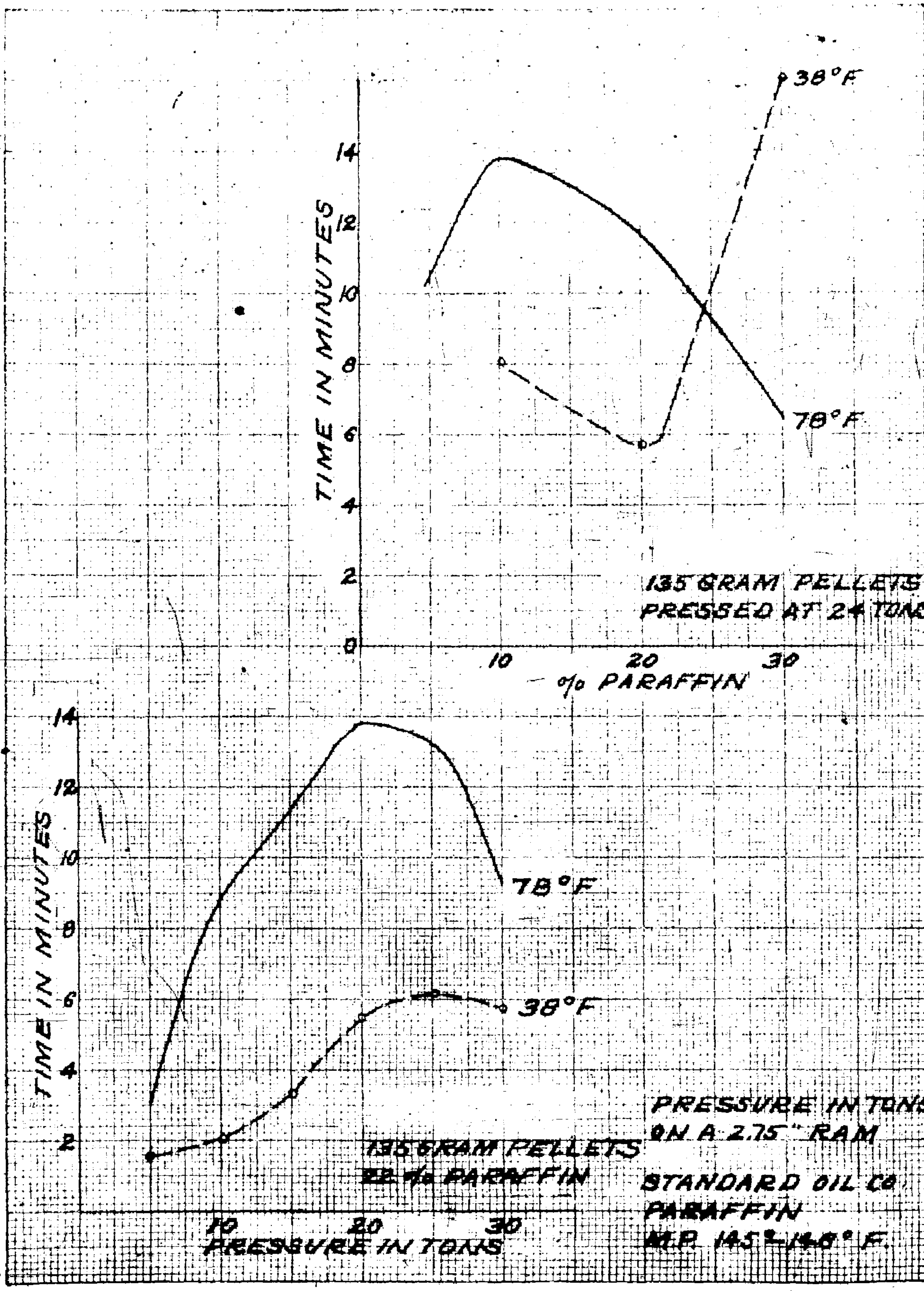

344572
GENERAL ARRANGEMENT
FALSE TARGET SHELL MK I
NAME OF MFGR
LOT NO
CONTRACT NO
INSPECTOR
DATE OF MFTURE
PC 4
PC 5
PC 7
PC 9
IDENTIFICATION OR NO & PC NO
NOMENCLATURE
NO REQD
CLASSIFICATION TITLE
CONTAINER (TOP)
CONTAINER (BOTTOM)
QUICK MATCH
PAPER DISC
TIME FUSE
SIGNAL TUBE
CEMENT
MARINE GLUE
SEALING CUP
BASE
TRIPPING LEVER
THESE PIECES ARE ALSO REQ'D FOR ONE FALSE TARGET SHELL
CONTAINER CHARGE
EXPELLING CHARGE
WEIGHT
INSTRUCTION LABEL
STRIP
SPACER DISC
DISC
COVER DISC
CONTAINER
1 Dr. No 344572
2 Dr. No 344572
3 Dr. No 344572
COMMERCIAL FINISH PUNCHED
4 Dr. No 344572
COMMERCIAL FINISH PUNCHED
5 Dr. No 344572
COMMERCIAL FINISH
6
7 Dr. No 344572
FINISH AS ROLLED PUNCHED
NOTE: PC 7 - WEIGHT NOT TO EXCEED 50 GRAMS
8 EXPELLING CHARGE - 20 GRAMS SMOKELESS POWDER (FOR CARTRIDGE CAL 30)
9 CONTAINER CHARGE
FALSE TARGET SHELL MK I (FOR SUBMARINES)
CHEMICALS - KEEP IN A COOL DRY PLACE - HANDLE WITH CARE
FALSE TARGET SHELL MK.I
GENERAL ARRANGEMENT
AND DETAILS
NAVAL ORDNANCE LABORATORY
5 JUNE
344572
WARNING:
CONFIDENTIAL

PLATE 2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78°F
TIME IN MINUTES
0
2
4
6
8
10
12
14
10
20
30
% PARAFFIN
135 GRAM PELLETS
PRESSED AT 24 TONS
TIME IN MINUTES
2
4
6
8
10
12
14
78°F
38°F
10
20
30
PRESSURE IN TONS
135 GRAM PELLETS
22 % PARAFFIN
PRESSURE IN TONS
ON A 2.75" RAM
STANDARD OIL Co
PARAFFIN
M.P. 145°-146° F.

PLATE 3

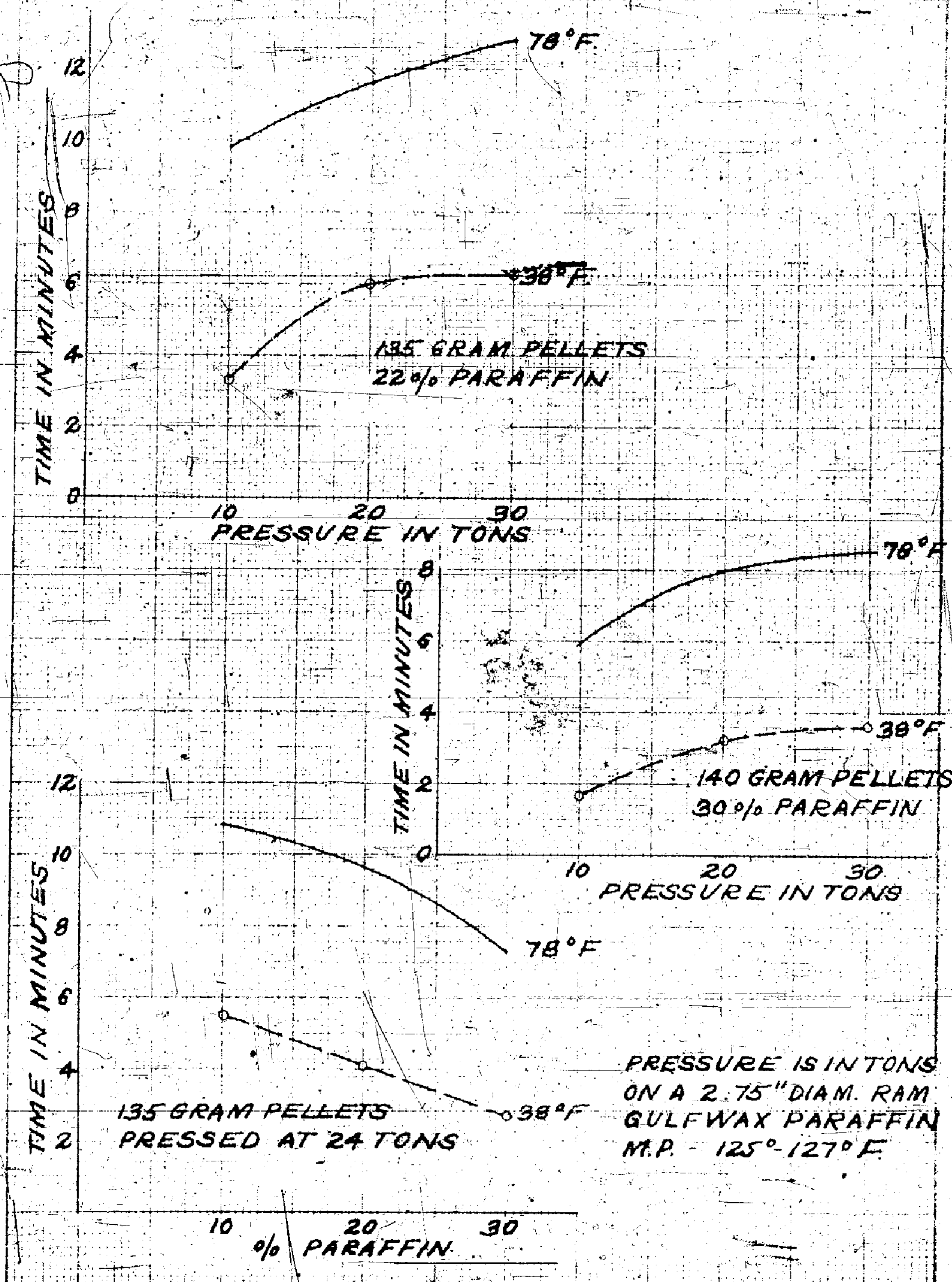

TIME IN MINUTES
PRESSURE IN TONS
78°F
38°F
135 GRAM PELLETS
22% PARAFFIN
TIME IN MINUTES
PRESSURE IN TONS
78°F
38°F
140 GRAM PELLETS
30% PARAFFIN
TIME IN MINUTES
% PARAFFIN
78°F
38°F
135 GRAM PELLETS
PRESSED AT 24 TONS
PRESSURE IS IN TONS
ON A 2.75" DIAM. RAM
GULFWAX PARAFFIN
M.P. - 125°-127°F.

PLATE 4

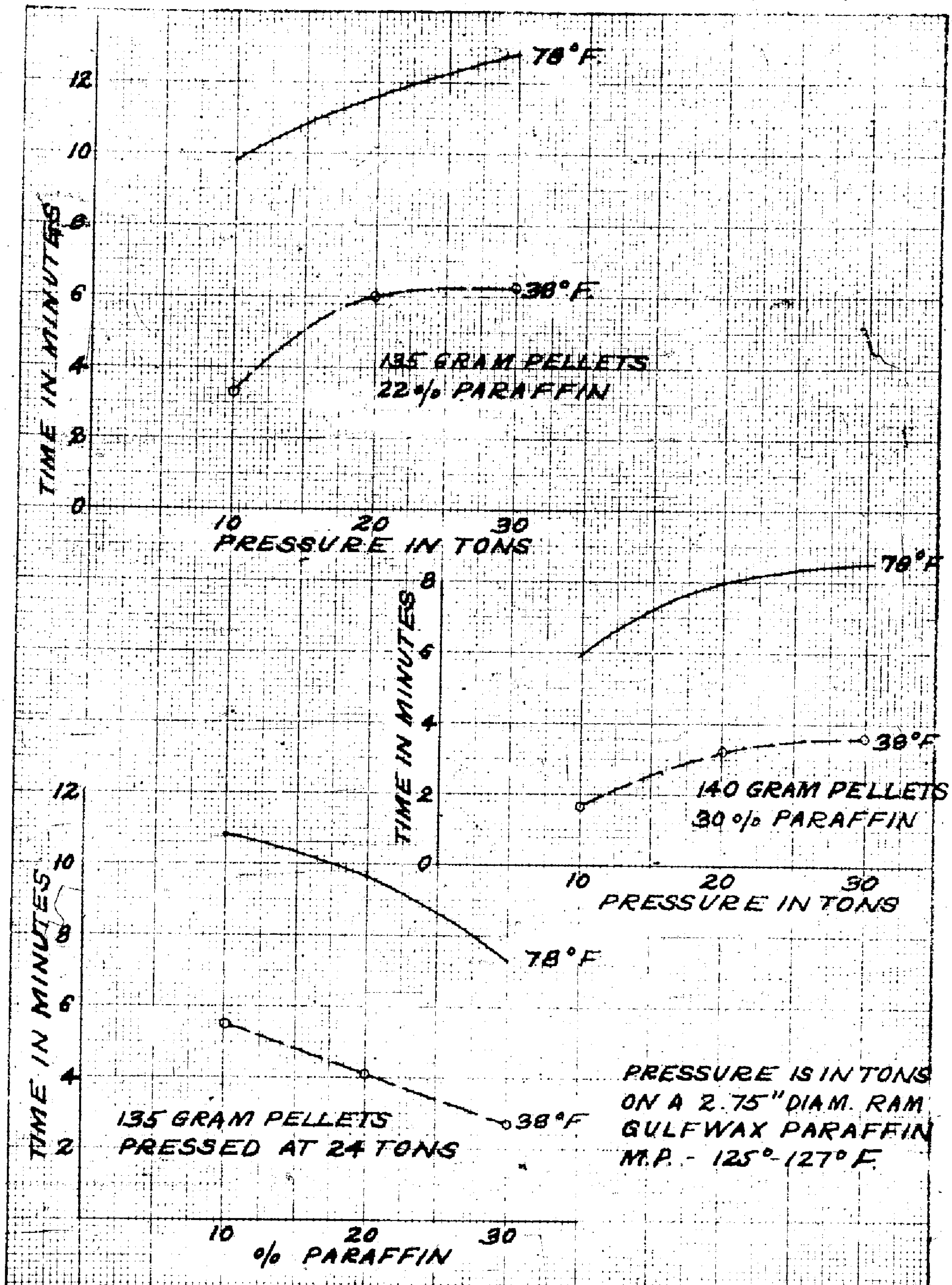

78°F
38°F
135 GRAM PELLETS
22% PARAFFIN
TIME IN MINUTES
PRESSURE IN TONS
78°F
38°F
140 GRAM PELLETS
30% PARAFFIN
TIME IN MINUTES
PRESSURE IN TONS
78°F
38°F
135 GRAM PELLETS
PRESSED AT 24 TONS
TIME IN MINUTES
% PARAFFIN
PRESSURE IS IN TONS
ON A 2.75" DIAM. RAM
GULFWAX PARAFFIN
M.P. - 125°-127° F.

PLATE 4

C-A16-3(452:DSB)hdr November 6, 1942

MEMORANDUM to the Director

Subject: Sound Test of Pellets for Making Bubble Screens.

A preliminary test of bubble producing agents was conducted in cooperation with the Sound Division on October 23. The compounds used included:

1. calcium carbide, generating 5 cu.ft. of acetylene per pound

2. mixed sodium and potassium peroxides yielding 3 cu.ft. of oxygen per pound

3. dry ice, yielding 10 cu.ft. of $CO_2$ per pound

4. lithium hydride, yielding 45 cu.ft. of hydrogen per pound.

The first three compounds were used in approximately the quantity that could be packed in a submarine signal ejector; only about a quarter pound of lithium hydride, however, was available for the test.

None of the echoes returned by these bubble screens could be considered satisfactory. Best results were obtained with lithium hydride, which in view of the small weight used, was considered most promising. With the arrival of ten pounds of this material on October 26, work was resumed on methods of processing with these ends in view -

1. production of many fine bubbles rather than of a few large ones.

2. retardation of reaction rate to 5-10 minutes per unit.

3. delay of initial reaction for about 3 minutes after immersion.

4. use of numerous small units of bubble-producing agent rather than of one large unit per charge.

A second test was made with the Sound Division on November 3. Two charges of 6 "pellets" each were used in this case. Each pellet consisted of a 70% LiH, 30% high M.P. Paraffin cake pressed at 2800 psi and paraffin-sealed in a 3" x 3" 28 gauge galvanized iron cup. A 7 cm. circle of filter paper was sealed to the pellet by pouring hot paraffin around the inside edge of the can. This served as a delay mechanism by retarding contact of water with the lithium hydride. Time-delay varied from a half minute to 15 minutes dependent upon the area of filter paper untouched by paraffin. Each pellet evolved 15 cu.ft. of hydrogen in a stream of fine bubbles over 6-7 minute period.

The first charge of 6 pellets was dropped into the river at a point 100 yards distant from the sound equipment. The pellets were spaced about 5 feet apart and probably reached bottom (25 ft. depth) in 30 seconds. First surface gas evolution was noticed in 2 minutes and all surface bubbling ceased at 15 minutes; this time agreed with the sound observations. The second charge was dropped in the same manner with the bubbles first sighted at 1-1/2 minutes. The sound apparatus showed time of evolution to be 20 minutes.

The Sound Division reported the echoes to be sharp and solid of approximately the same intensity as that of the concrete pier of the railroad bridge center span. In view of these encouraging results preparations are being made for a deep-water test. By this test it is hoped to definitely fix the optimum density of the pellets and also to test reproducibility of results with pellets made under probable manufacturing conditions.

R. R. Miller

D. S. Burgess

C-S68/SS(471)hk 3 November 1942

MEMORANDUM FOR DIRECTOR

Subject: Submarine Evasion of Detection Device - Bubble Screen Emitted by Submarine

Reference: (a) Memorandum on above subject of 23 October

1. Based on the experience gained in the tests described in reference (a), the Chemistry Department made up a set of twelve one-half pint cans containing Lithium Hydride, LiH. One face of the can was covered with one or more layers of filter paper which in turn was partially covered by a layer of paraffin leaving a circular area near the center through which the water could penetrate. This device determined the time delay after ejection before the cans would begin to emit bubbles.

2. The echo-ranging setup was essentially the same as that of 23 October except that the range to the boat was approximately 385 yards. Two tests were made. In the first test, six cans were dropped about five feet apart along the side of the boat which made an angle of about 30° with the axis of the sound beam. In the second test, the line on which the cans were dropped was perpendicular to the axis of the sound beam.

3. Excellent echoes were obtained during each test. The intensity of the bubble screen echoes were about two decibels below the intensity of the echo obtained from the center pier of the railroad bridge at a range of 600 yards. Allowing for the difference in range, the absolute difference in intensity was about five decibels. The width of the flash on the range indicator extended from 385 to approximately 410 yards being somewhat wider than the actual spacing of the cans because there was a fairly strong wind and current which caused the bubble screen to spread out. The cans, however, were weighted slightly so that they remained on the bottom. The bubbles came up and broke the surface and seemed to vary in size from generally small ones of a quarter inch or less in diameter to an occasional large one which might be two inches or more in diameter. The cans remained on the bottom because the initial range was very consistant at 385 yards. The cans did not start or stop at the same time, therefore, the echoes were obtained in the first test for approximately fifteen minutes and in the last test for nine minutes. The final echoes in the last test were evidently obtained from a single can because the echo narrowed down to a band about five yards wide at a range of 400 yards. In spite of the relatively narrow width, the intensity of the echo was within a decibel of that received when all the cans were bubbling. Of the two experiments, the first gave a

screen which had considerable depth with respect to the axis of the sound beam and the other one a greater width. This great width appeared to give a slightly better echo although the difference was not great.

4. Results of this test were so satisfactory and the echoes so strong that it is believed they would definitely confuse an attacking ship and if a screen could be laid down comparable in length to that of the submarine, it might well escape behind the screen. Unless the operator was thoroughly experienced, he would not be able to distinguish the bubble screen echo from the submarine hull echo. The writer was unable to determine any consistent difference in quality with either a CW or a frequency modulated CW screen.

5. It is proposed to repeat these tests in about two weeks in more open water near Piney Point, and if these tests are equally successful, to make up a batch of cans for a test on an actual submarine.

E. B. STEPHENSON

C-S68/SS(452:JAG)mep May 15, 1943

MEMORANDUM to the Director

Subject: Information on Preparation of "False Target Shells" at Naval Research Laboratory.

Enclosure: (A) One Figure
(B) One Plate

1. Since considerable interest has been shown in possible manufacture of "False Target Shells" for Service use, it was thought advisable to prepare a brief of the methods used at the Laboratory.

2. The device known as "False Target Shell" is essentially the same as the Mark 2 Mod. 2 Submarine Emergency Signal except as to contents and weight. Of slightly negative buoyancy it contains six metal cups of a lithium hydride-paraffin mixture designed to generate fine bubbles of hydrogen on ejection from the signal case. This bubble cloud serves as a false target for submarine echo-ranging attach approach.

METHOD OF PREPARATION OF CHEMICAL-CONTAINING CUPS

3. Lithium hydride (analyzed about 97% pure) as received from Maywood Chemical Co., Maywood, New Jersey, varies from 0.2 to 0.5 inch in particle size. The material used should analyze 95% or better, i.e. evolve at least 2680 cc. of hydrogen per gram. The lithium hydride was ground to approximately 10-14 mesh (U. S. Standard Sieve) by passing through a Brauns Sample Grinder (gyrating cone type). A typical particle size analysis is given below.

| U. S. Standard Sieve # | Sieve Opening In Inches | Grams of Material | % by Weight of Total |
|---|---|---|---|
| 3-4 | 0.187-0.250 | 10 | 1.0 |
| 4-6 | 0.132-0.187 | 84 | 8.0 |
| 6-8 | 0.094-0.132 | 181 | 17.4 |
| 8-10 | 0.079-0.094 | 86 | 8.2 |
| 10-20 | 0.033-0.079 | 331 | 31.8 |
| 20-30 | 0.023-0.033 | 77 | 7.4 |
| 30 | 0.00 -0.023 | 273 | 26.2 |

There should be no material larger than three mesh, and no more than 3% should be retained on a 4 mesh screen. A maximum of 30% is allowable on material passing a 30 mesh screen. Grinding as well as all other operations should be carried out in a dry room with all possible water and fire hazards removed.

4. Batches of 595 grams of the ground lithium hydride were weighed into half-gallon Mason jars and 8.5 grams of powdered Aerosol OS (American Cyanamid Co.) added and thoroughly mixed. The material was then placed in an oven at 90-95°C. and allowed to stand at least four hours. Each batch was then poured into a four liter Pyrex beaker containing 255 grams of molten "Gulfwax" paraffin (M.P. 125-127°F.) and vigorously stirred for a few minutes. While still warm sixteen such batches, each constituting a little more than a shell loading, were mixed in a wooden trough until thoroughly cool. The mixture of a 1.0% Aerosol, 69.3% of lithium hydride and 29.7% paraffin was weighed in units of 133 grams into quart Mason jars in readiness for the pressing operation.

5. A seamless drawn tinplate cup of 2-3/4 inches outside diameter by 1-7/8 inches body height, containing a 30 gram lead weight 1" x 1-1/4" x 1/8" centered in the bottom of the cup, was fitted into the bottom of a hardened steel die (Fig. 1). A 133 gram unit of chemical was poured in the top of the die and worked down with a spatula. The die was placed in a hydraulic press and the chemical pressed into the cup under a total static pressure of 13 tons (4400 lbs. per square inch). Each chemical-containing cup weighed 198 ± 3 grams. Six such cups were loaded into a Mark 2 Mod. 2 Submarine Emergency Identification Signal.

METHOD OF LOADING SUBMARINE SIGNAL CASE

6. The Mark 2 Mod. 2 Submarine Emergency Identification Signal without signal contents was used with two modifications: (1) the brass nut (Dr. No. 152302Pc7) holding the base to the signal tube was replaced by an aluminum nut (Sta-Hot Heater Corp., Brooklyn, N. Y.), (2) the 28 gram black powder charge (in bakelite container Dr. No. 163606) was replaced by a 20 gram smokeless powder charge (as modified by Mr. S. P. Lewis, Naval Ordnance Laboratory, Washington Navy Yard). Method of loading (see Plate 1) is as follows:

(1) Assemble signal cases and expelling charges in usual manner with modifications as noted above.
(2) Insert expelling charge block in signal tube with fuse end of the block toward the base of the tube and powder charge toward the open end of the signal tube.
(3) Place a 13" x 3/8" x 1/8" corrugated cardboard strip (common packing case cardboard) lengthwise in the signal tube as far as the powder charge block.
(4) Insert six chemical-containing cups, open end of cup toward open end of tube.
(5) Place aluminum disc 2-13/16" x 1/32" in tube flush with the top of the last chemical cup inserted.
(6) Cut the overhang of the cardboard strip flush with the aluminum disc.
(7) Insert 2 corrugated cardboard discs 2-13/16" x 1/8".
(8) Insert 8 to 10 cardboard discs 2-7/8" x 3/64", sufficient to make a tight fit when the nose of the signal is inserted.

(9) Seal nose with marine glue; nose may be heated but not the signal tube.
(10) Stencil in 1/2" red letters "FALSE TARGET SHELL" lengthwise along the signal tube.

COST OF MANUFACTURE

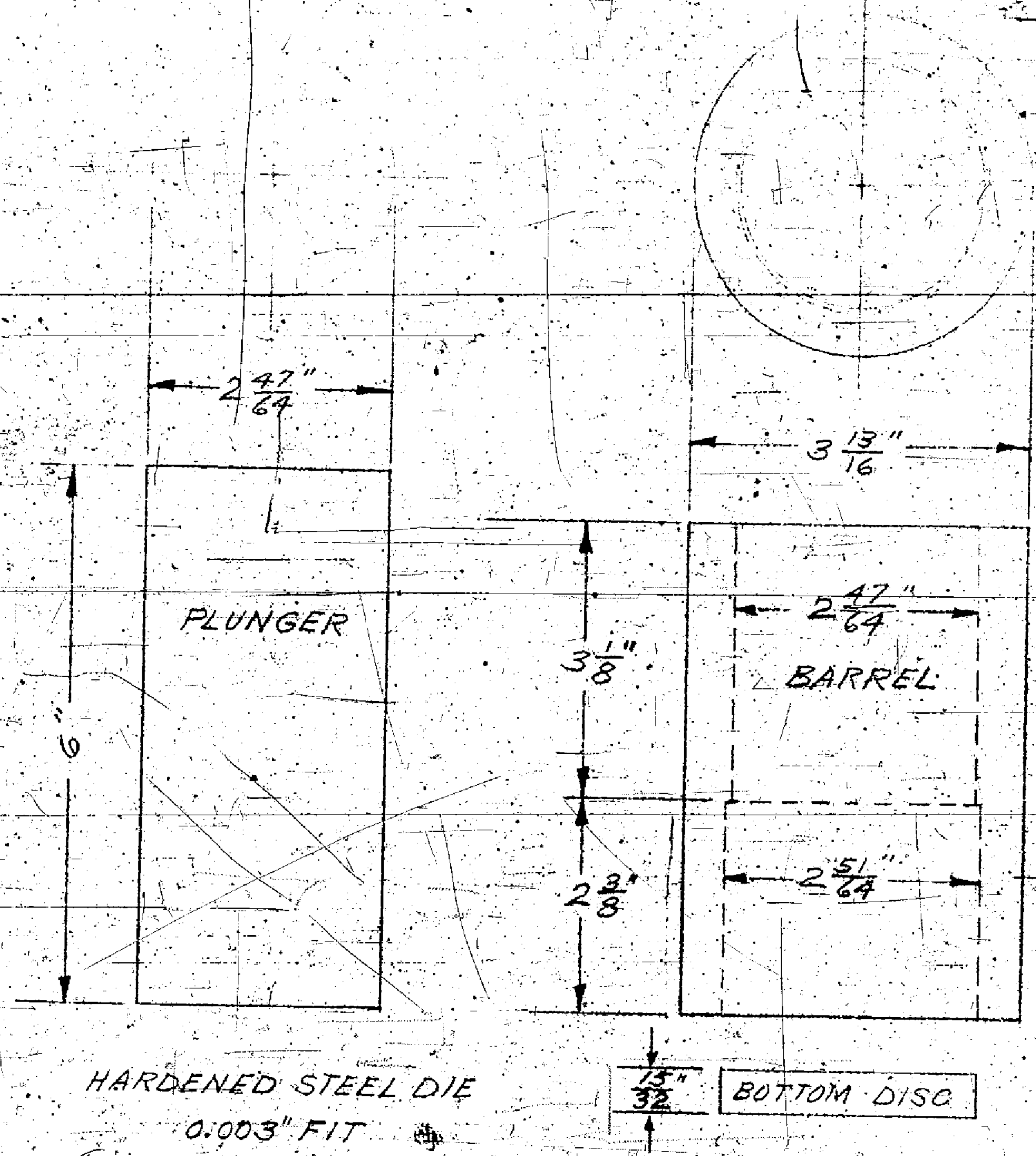
7. Lithium hydride as purchased from Maywood Chemical Co. by the Laboratory cost $15.00 per pound. "Gulfwax" paraffin was purchased for $0.15 per pound. Signal cases were obtained from the Bellevue Magazine at no cost to the Laboratory. The American Can Co. furnished the seamless drawn cups at $36.00 per thousand. At the present price, lithium hydride would more than equal all other costs in production of "False Target Shells".

8. No attempt is made here to estimate manufacturing costs. This information is for guidance purposes only. Cost of manufacture will depend in good measure on the number required and equipment used. Only 150 shells were made by the Laboratory method described using hand-mixing and a hand-operated press, while manufacture on any large scale would necessitate power-processing equipment.

Jos. A. Grand

## Legend for Plate I

1. Signal tube.
2. Nose.
3. Bakelite expelling charge block.
4. Chemical-containing cups.
5. Aluminum disc 1/32" thick.
6. Cardboard discs 1/8" thick.
7. Cardboard discs 3/64" thick.
8. Cardboard strip 13" x 3/8" x 1/8".


2 47/64"
3 13/16"
PLUNGER
6"
3 1/8"
2 47/64"
BARREL
2 3/8"
2 51/64"
15/32"
BOTTOM DISC
HARDENED STEEL DIE
0.003" FIT

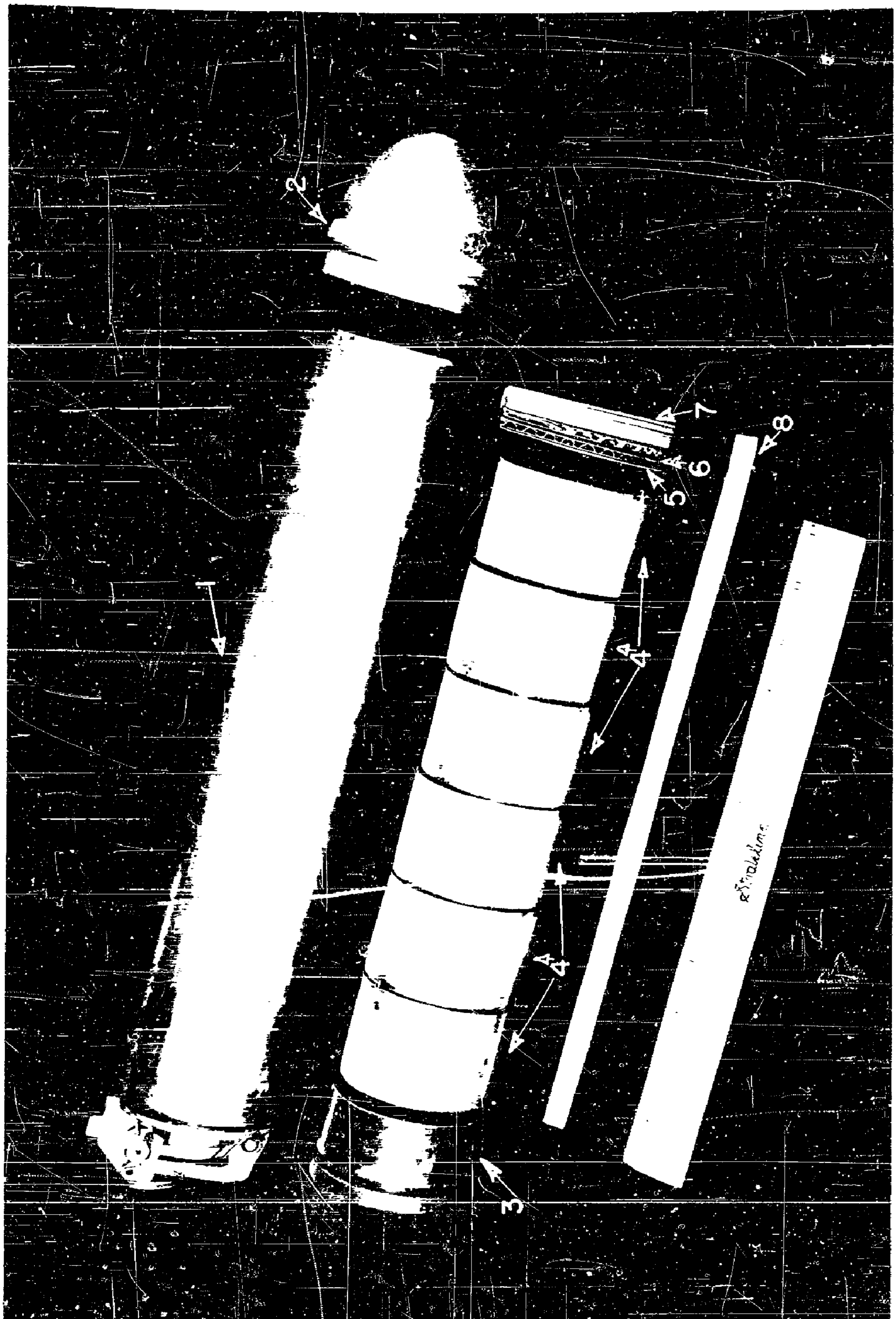



PLATE I

C-O-P-Y

SUBMARINE DIVISION TWELVE

A16-3/S68
Serial 07

Jan. 5, 1943

CONFIDENTIAL

From: The Commander Submarine Division Twelve.
To: The Chief of the Bureau of Ships.
Via: (1) Commander Service Squadron Nine.
(2) Commander Submarines, Atlantic Fleet.
(3) Naval Research Laboratory.

Subject: Tests of Device to Generate Bubble Cloud for Submarine Evasion Tactics; Report of.

Reference: (a) BuShips Conf. ltr. C-SS/A16-3(330) dated December 16, 1942.
(b) Comsublant conf. desp. 181850 of Dec. 1942.
(c) Comsublant conf. ltr. A16-3/(0945) dated December 13, 1942.

Enclosure: (A) Photograph taken during subject tests.
(B) Summary of best data for runs.
(C) Procedure.

1. In accordance with references (a), (b) and (c), tests of the subject device were conducted on December 31, 1942. Lt. Cdr. A. H. Bullard and Mr. J. A. Grand from N.R.L. and Mr. F.W. Varney of BuShips were present to assist in the conduct of these tests and to witness the results. The tests were made from various ranges with the submarine at predetermined submarine keel depths of 60 ft., 125 ft. and 150 ft. One device was released from periscope depth followed by standard Submarine Emergency Identification Signal in order to compare the sound made by the explosion of the signals and to compare the ejection impulse bubble with the generated bubble cloud. The procedure outlined in enclosure (C) was departed from in order to determine the effect of double and triple ejections and value in evasive tactics. Therefore, the number released at the deeper depths was reduced from that outlined in the procedure.

2. In order that this report may be understood more readily by readers to whom reference (a) is not available, the following is quoted therefrom:

"1. *****The device was intended to parallel or improve on the German 'Pillenwerfer', which is reported to have effectively confused inexperienced sound operators.

"2. To this end the Naval Research Laboratory has modified the Mark II-2 Submarine Emergency Identification Signal replacing its parachute and signal element with six cans of lithium hydride-paraffin mixture. This modified Identification Signal is intended to be handled and ejected from the submarine exactly as in the Identification Signal proper. The trigger-primer-fuse-and powder charge remains unchanged. Twenty-seven seconds after ejection the charge kicks the cans out into the

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water; after a few seconds the mixture begins to give off a mass of small bubbles and bubbling continues for three minutes. (In shallow water tests the bubble cloud has given good echoes from five to eight minutes). The unit as a whole sinks very slowly after it is ejected, and likewise the loaded cans when kicked out of the unit sink slowly during the bubbling."

3. The submarine was able to view the ejections through the periscope and reported that the majority of the signals, upon ejection, just cleared the gun and dropped on the deck. The case would then remain erect and would "walk" back to about the position of the after marker buoy, at which point it would explode and, in general, would throw the small canisters clear, or they would be immediately washed clear by the water flowing past the ship. However, in one case a small canister remained on deck and gave off gas for at least 30 minutes. The bubbles, as observed from the submarine, were fewer in number than had been expected and appeared quite small. The failure of the devices to clear the side of the submarine was a surprise to the personnel from Naval Research Laboratory but is explained by the fact that Mr. Grand, the development engineer, was under the impression that 200 p.s.i. is used in the ejector rather than 100 p.s.i. One of the 24 ejected signals was a dud and was recovered on deck when the submarine surfaced, when it was immediately thrown over the side. The Commanding Officer of the R-14 believes that the devices could be ejected from the signal gun at a maximum rate of one per minute. However, such rapidity of ejection was not attained during these tests. He suggested that a speed of at least 5 knots would be best when ejecting in order to insure that all of the small canisters are washed clear of the ship.

4. Enclosure (B) is a tabulated summary of results obtained on each of the 16 runs. The range, width of bubble, width of submarine and intensity of echo shown are those at the best point. Other readings obtained on the runs were less satisfactory than the ones given. The intensity of the bubble echo and the submarine echo are given for comparison purposes between these two echoes only. The time to "lost echo" is that from the ejection of the first shot of the run until all echoes from the bubble were lost. Sound conditions were very good throughout the day. The R-14 was making 3 knots during the tests. The explosion of the devices in such close proximity to the submarine resulted in a high intensity noise being heard in the submarine. In many cases the explosion of the device was heard by the surface ship in its sound equipment and this is considered a drawback since it makes known to the surface ship that a device of some kind has been actuated.

SUBMARINE DIVISION TWELVE

A16-3/S68
Serial 07

Jan. 5, 1947

CONFIDENTIAL

Subject: Test of Devices to Generate Bubble Cloud for Submarine Evasion Tactics; Report on.

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In view of the improvement of two shots over one it was decided to try a run of three shots on run No. 10. Due to delay in loading, shots No. 1 and 2 were fired as a double but the final effect of shot 3 was that it became a single shot with no connection between it and the first two; the latter are therefore reported as run 10a and the third shot as run 10b. On run No. 11, it was decided to have the Noa make an actual attack on the R-14 with the submarine using evasive tactics and using a double shot. This type of run was not included in the procedure and, as a result, a misunderstanding of the signals caused the submarine to fire the two devices too early in the attack and they were ineffective in misleading the attacking ship. Due to the limited number of devices, this run was not repeated. On run No. 13 the surface ship hovered over and slightly astern of the submarine in order to observe the effect of surface disturbances at close range. No explosion was heard but it was believed that some disturbance was noted aft of the surface vessel. This may have been the dud mentioned above. On run No. 14 run No. 13 was repeated except that the surface ship was farther aft along the track of the submarine. The explosion was heard and 1 minute 20 seconds later groups of bubbles approximately 4 inches in diameter rose to the surface. The main cloud could be seen while still quite deep. One minute later, that is 2 minutes 20 seconds after the explosion, a large cloud of bubbles surfaces in an area estimated as 10 yards by 4 yards. The entire phenomenon was similar on a smaller scale to that observed when a water slug is fired and was accompanied by apparent discoloration of water, due to presence of bubbles, and by a slight turbulence on the surface. It is to be emphasized that this surface disturbance caused by the bubble cloud was not as great in magnitude as is that of an ordinary water slug. The bubble cloud was visible to the personnel in the aircraft because the sea was calm but photographs were only successful in one picture, copy of which is enclosed, enclosure (A).

5. One immediately apparent drawback to this device is the fact that the gas liberated is hydrogen with the attending possibility of explosion, should any be liberated in a confined space as would happen were one of the devices damaged and then wetted. Each device releases 60 cubic feet of free hydrogen. It is, therefore, recommended that an attempt be made to utilize less dangerous gas or if no suitable substitute can be found, that careful consideration be given to this matter in order to evaluate the potential danger versus possible usefulness of the bubble cloud. The necessity for ejecting the device by air with the resultant impulse bubble should be noted.

C-O-P-Y



SUBMARINE DIVISION TWELVE

A16-3/S63
Serial 07

Jan. 5, 1943

CONFIDENTIAL

Subject: Tests of Devices to Generate Bubble Cloud for Submarine Evasion Tactics; Report on.

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6. It was the consensus that at the present state of development the bubble cloud is of little value because results indicated insufficient echo intensity and definition are obtained from the bubble cloud to seriously disturb any underwater sound operator. It is recommended that a form of shell be developed which functions without an explosion charge for reasons mentioned above. In addition, a need for a larger and possibly more compact bubble cloud is indicated and while the pellet which gassed for 30 minutes might have been an exception, it is quite possible that the others acted in the same manner. It is, therefore, further recommended that an attempt be made to design the pellets in such a fashion that the gas is more quickly liberated.

W. A. GORRY.

Copy to:
BuShips (Direct) (2)
Cominch (Readiness)
Coordinator, Res. & Devel.
Comsubron-7 (less Enc. (B))
Lantflt A.S.W. Unit.
West Coast Sound School.
U/W Sound Lab., NLC.
R-14 (less Enc. (B)).
Nom (less End. (B)).

CONFIDENTIAL

# RUN DATA SHEET - BUBBLE CLOUD TEST
## DECEMBER 31, 1942

| RUN NO. | RANGE | WIDTH CLD. | WIDTH SUB. | INTENSITY(ECHO) BUB. | INTENSITY(ECHO) SUB. | TIME TO LOST ECHO (minutes) | NO. OF SHOTS | DEPTH OF SUB. | COMMENTS; (Refers to echo from Bubble) |
|---|---|---|---|---|---|---|---|---|---|
| 1. | 640 | 7° | 18° | 62 | 71 | 7 | 1 | 60' | Echo very mushy. |
| 2. | 660 | 17° | 25° | -- | 69 | 5-1/4 | 1 | 60' | Echo fairly sharp; intensity equal to that from sub for short while. |
| 3. | 700 | 15° | 15° | 75 | 72 | 5-1/2 | 2 | 60' | Bub. echo excellent though that from sub had a more "metallic" quality; disappeared then reappeared; compared favorably with sub; echo of very short duration |
| 4. | 800 | 9° | 13° | 64 | 65 | 3-3/4 | 1 | 60' | Same as for Run No. 3 |
| 5. | 920 | 10° | 9° | 72 | 69 | 6-1/4 | 2 | 60' | Mushy after reaching peak; heard shell explode. |
| 6. | 880 | 10° | 13° | 50 | 67 | 5'50" | 1 | 60' | Mushy but with slight quality of tone behind the mush. |
| 7. | 1000 | 5° | 7° | 56 | 65 | 4-1/2 | 1 | 100' | Echoes intermittent; heard shells explode. |
| 8. | 860 | 8° | 12° | 68 | 68 | 3'40" | 1 | 100' | Good while lasted, but too short; heard shell explode. |
| 9. | 760 | 20° | 15° | 59 | 76 | 5 | 2 | 100' | Tone fair; heard second shell explode. |
| 10A. 1st | 1100 | 10° | 13° | 66 | 69 | ---- | 2 | 100' | Supposed to be 3 shells but long delay between 2nd and 3rd; mushy |
| 10B. 3rd | 110 | --- | 8° | -- | 62 | 10'40" | 1 | 100' | Scratch with echo; both 1st & 3rd bubble developed a distinct triple echo; both echoes mushy but difficult to distinguish between bubble & after end of sub; NOTE; Operator may have confused bubble and wakes of sub. |

| RUN NO. | RANGE | WIDTH CLD. | WIDTH SUB. | INTENSITY (ECHO) BUB. | INTENSITY (ECHO) SUB. | TIME TO LOST ECHO (Minutes) | NO. OF SHOTS | DEPTH OF SUB. | COMMENTS: (Refers to echo from BUBBLE) |
|---|---|---|---|---|---|---|---|---|---|
| 11. | 2000 yds to sub at start; poor echoes from sub, no interference by cloud. | | | | | | 2 | 100' | Evasive tactics; fired too soon; no results. |
| 12. | 910 | 12° | 14° | [illegible] | 66 | 6-1/4 | 2 | 125' | Heard explosion of shell; different sound (echo) from #1 & 2, harsh, 2nd harsh to mushy; neither echoes from sub or clouds very good. |
| 13. | --- | -- | -- | -- | -- | ---- | - | 125' | Fired underneath surface ship; no sight no sound. |
| 14. | --- | -- | -- | -- | -- | ---- | - | 125' | Fired underneath surface ship; sighted cloud, heard explosion. 1'20" after explosion saw group of large bubbles; 2'20" after explosion large cloud (approx. 10 yds. by 4 yds.) of bubbles surfaced. |
| 15. | 1200 | 17° | 14° | 79 | 33 | 7'48" | 2 | 150' | Heard both explosion echoes muffled but some tone; intensity from sub and cloud sound very much alike. |
| 16A | 460 | 15° | 40° wake? | 35 | 64 | 4'39" | 1 | Peris. | Shell fired at periscope depth and did not break the surface; echo quality of sub and cloud about the same |
| 16B | --- | -- | -- | -- | -- | ---- | - | Peris. | Fired black smoke bomb at periscope depth; resultant surface disturbance about same as for cloud shell (due to ejection air). |

C-S68/SS(452:JAG)hdr January 13, 1943

MEMORANDUM to the Director

Subject: Preliminary Test of Device to Generate Bubble Cloud for Submarine Evasion.

References: (a) BuShips ltr. C-SS/A16-3(330) of December 16, 1942.
(b) Comsublant Confidential Dispatch 181850 of December 1942.

Enclosures: (A) Suggested Program of Test by Dr. E. B. Stephenson, Sound Division, NRL.
(B) Copy of Submarine Division Twelve, Serial 0186, Program of Tests.

On December 31, 1942 Lt. Comdr. R. H. Bullard and Mr. J. A. Grand of the Laboratory witnessed preliminary tests at the Fleet Sound School, Key West, Florida of a bubble generating device developed at the Laboratory. This device known as a "False Target Shell" is essentially the same as the submarine emergency identification signal except as to contents and weight. In place of the flare in the submarine signal, the shell has six pellets of a lithium hydride-paraffin mixture designed to generate sixty cubic feet of hydrogen in fine bubbles.

The purpose of these tests was the determination of the quality and character of the echoes obtained from the "False Target Shell" in comparison with those obtained from a submarine under various service conditions. A suggested program /Enclosure (A)/ was obtained from Dr. E. B. Stephenson of the Sound Division. However, upon arrival at Key West it was found that an excellent program of tests /Enclosure (B)/ had already been formulated and with slight modification the latter program was followed through.

Test party aboard the Destroyer NOA comprised Lt. Comdr. W. Y. Allen, Commanding Officer of the NOA, Commander W. A. Gorry, Commander Submarine Division Twelve, Lt. Comdr. J. B. Swain, Materiel Officer of the Fleet Sound School, Radio Elect. S. Burdock and R.M.2/c J. H. Fink, School Instructors, Mr. F. M. Varney, Bureau of Ships representative, and Mr. Grand. Test party aboard the Submarine R-14 comprised Lt. Comdr. G. W. Kehl, Commanding Officer of the R-14, and Lt. Comdr. Bullard. Sixteen tests were conducted with twenty-four shells. The results are outlined in Table I.

At the conclusion of the tests Lt. Comdr. Kehl reported that "signals on ejection just cleared the gun and dropped on deck to about the position of the after marker buoy, at which point the burster charge set off and usually threw the small pellets clear or they would be washed clear by the forward motion of the vessel (3 knots). However, in one case a pellet remained on deck near the after stub mast and bubbled for at least 30 minutes. The bubbles were fewer in number than was expected and seemed quite small; so small that it was believed they would not be seen on the surface except in a glassy sea. It is believed that the signals could be ejected at a maximum rate of one per minute." Lt. Comdr. Kehl pointed out the following disadvantages of the shell.

1. The shell does not clear the submarine. Suggested making shell lighter. Stated that if required to use the shell in its present form he would proceed at 5-6 knots instead of 3 knots as in the test.

2. Explosive charge. The shell explosion sounded tremendous inside of the submarine. Expressed the fear that this noise might be heard by AS craft.

3. Impulse bubble. The air expelling charge might be seen on the surface.

Discussion of Results.

Of the 13 tests in which quality comparisons were made, seven tests, 2, 3, 4, 7, 8, 15 and 16, gave echoes whose sound qualities were comparable to those of the submarine. Five tests of twelve, namely 3, 4, 5, 8 and 15, gave echo intensities of the same magnitude as the submarine abeam. No indications were found of quality and intensity variations of bubble echoes with depth not also observable with the submarine. A fairly satisfactory width of bubble screen was obtained with the "False Target Shell" although not uniformly as great as that of a submarine abeam. Good comparison echoes were found at ranges of 600 to 1100 yards, however, at 420 yards and periscope depth the submarine was easily distinguished from the bubbles by an echo of much higher intensity. Delay of bubble generation was approximately one minute after discharge from the signal ejector; duration of the bubble screen was then about 3 minutes.

The mechanical drawbacks mentioned by Lt. Comdr. Kehl are points well taken. First and most serious of those mentioned is the fact that the shell did not clear the submarine but landed on the deck. Preparation of these shells was undertaken with the information that the shell was ejected from the signal gun with 200 lbs. air pressure as called for on the blue prints of the ejector for Submarines 198-200. The signal gun on the R-14 was designed to operate on 100 lbs. air pressure. The "False Target Shell" was undoubtedly too heavy for this gun. However, the shell may be lightened about 8% decreasing its density from 1.17 g/cc to 1.08 g/cc. It is a matter of conjecture whether a shell of this density would leave the gun with velocity sufficient to clear the deck or not under 100 lbs. air pressure.

By increasing the length of the shell (no manufacturer is at present set up to do this) it would be possible to adjust the density to any desired value. It must be borne in mind that a shell of too low density might surface on ejection.

The second objection raised by the Submarine Commander was the violence of explosion of the burster charge. The violence of the explosion is probably augmented by exploding on deck. A shell that cleared the submarine (test 16) gave very weak response inside of the submarine as compared with those that exploded on deck. Whether the same thing holds true for echo ranging response whould be a subject of further test before variations in quantity and type of bursting charge are tried.

Elimination of the third disadvantage, the impulse bubble, would entail modification of submarine equipment. By discharging water through the gun from an auxiliary water tank by air pressure no impulse bubble would be liberated.

Airplane photographs were not developed at the time of conclusion of the test so these results are unknown.

Conclusions and Recommendations.

The test results are, on the whole, encouraging. Some modifications at present are necessary, but even in its present form, given ideal conditions, it would mislead experienced operators. Mr. Burdock and Mr. Finck, the sound equipment operators for the test, are experts in their field and yet in test 7 there was some confusion as to differentiation of the bubbles and the submarine. However, this was the exception rather than the rule. It is recommended that in future testing the sound operators not be apprised as to the nature of the test at first until evasion runs are carried out. Work is proceeding on the remaining "False Target Shells" with the intention of dropping the density as low as can be safely permitted.

J. A. Grand
Chemistry Division

## TABLE I

| Test No. | Sub Depth (Ft.) | Range (Yds) | Min-Max Width in Degrees Bubbles | Min-Max Width in Degrees Sub | Min-Max Intensity in Decibels Bubbles | Min-Max Intensity in Decibels Sub | No. of Shells Fired | Bubble Echo Duration (Min) |
|---|---|---|---|---|---|---|---|---|
| 1 | 60 | 640 | 5°-7° | 15°-18° | 62 | 65-74 | 1 | 5 (?) |
| 2 | 60 | 610 | 10°-17° | 10°-25° | -- | 59-69 | 1 | 4 |
| 3 | 60 | 680 | 10°-15° | 15° | 75-75 | 71-72 | 2 | 4-3/4 |
| 4 | 60 | 790 | 5°-9° | 13° | 64 | 65 | 1 | 2-1/2 |
| 5 | 60 | 920 | 5°-10° | 9° | 56-72 | 69 | 2* | 4-1/2 |
| 6 | 60 | 830 | 8°-10° | 13° | 50 | 59-67 | 1 | 4-1/3 |
| 7 | 100 | 1000 | 5°-5°(?) | 7° | 56 | 63-65 | 1* | 3-1/2 |
| 8 | 100 | 860 | 5°-8° | 12° | 68 | 61-68 | 1* | 2-1/2 |
| 9** | 100 | 760 | 7°-20° | 15° | 46-59 | 76 | 2* | 4 |
| 10 | 100 | 1100 | 10°-10° | 13° | 50-62 | 62-69 | 3* | 10 |
| 11 | 100 | Evas. run sub fired 2 at start. Heard on NOA, disregarded. | | | | | | |
| 12 | 125 | 900 | 10°-12° | 14° | 47-48 | 56-66 | 2* | 2-2/3 |
| 13 | 125 | 0 | Nothing sighted. Heard shell fire. | | | | | |
| 14 | 125 | 0 | 1-1/3 min. after firing sighted some bubbles rising. 2-1/3 min. sighted cloud of bubbles. 30 x 12 feet. | | | | | |
| 15 | 150 | 1100 | 5°-17° | 11°-14° | 53-78 | 79-83 | 2* | 6-1/4 |
| 16 | 35 | 420 | 5°-15° | 35°-40°(?) | 32-38 | 64 | 1* | 3-1/2 |

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* Indicates explosion of burster charge of one shell heard over sound equipment.
** Number 2, a dud.

Note: Test 11 evasion run, no sound data taken. Tests 13 & 14 were shells fired directly beneath the destroyer to make surface observation of the bubbles.

1. Weather, sky overcast. Sea 0-1. Wind 2 mph N-NE.
2. Temp. of water, 75-77°F. Density of water 78°F=1.024 g/cc.
3. Water depth, 100 fathoms.

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Remarks

1. Very mushy echo.
2. Same pitch as sub, fairly sharp but long drawn out.
3. Good intensity and comparison echo. No. 2. Sub more metallic.
4. Very good echo but very short.
5. Mushy tone to echo.
6. Mushy, faint tone. Intermittent strength.
7. Intermittent (not readily distinguished on course plotter).
8. Good echo but too short a time.
9. Fair tone.
10. Mushy echoes. (Difficult to tell anything. Wakes ?)
11. Sub located 6-1/2 mins. later. Sub then thought run over.
12. Not very definite. Harsh to mushy.
14. 1/2 to 4" diameter. Cloud gave fine wake appearance.
15. Oscillating intensity. Sounds muffled. Tone through muffle. Good echoes. Sub and bubbles same.
16. Clear metallic echoes from bubbles but not as intense as sub.

## ENCLOSURE (A)

Suggested Program of Test
by Dr. Stephenson, Sound Division, NRL

No. 1 Submarine at 100 ft. on steady course, speed 3 Kts. Destroyer on same and paralled course abeam at 700 to 1000 yds.
When good echoes from submarine are obtained, destroyer signals submarine by supersonic to release 1 shell and destroyer tries to separate echoes from submarine and bubble screen. Noting intensity and quality of echoes from screen.

No. 2 Repeat, releasing 3 shells at 30 sec. intervals.

No. 3 Repeat, releasing 3 shells at 30 sec. Reduce time interval to 15 sec. if possible. Speed 7 Kts.

No. 4 Shoot 3 shells at short intervals. Speed 7 Kts. Make sharp turn to put submarine on far side of screen, then coast. Note loss of propeller noise.

No. 5 Shoot 3 shells at 20 sec. intervals. Speed 3 Kts. Turn and continue at 3 Kts. Submarine surface and compare notes for next tests.

No. 6 Destroyer makes depth charge from 1000 yds.

No. 7 Submarine uses any desired escape tactics.

No. 8 Repeat three times for statistical study.

No. 9 Release 2 shells for Range-intensity run.

ENCLOSURE (B)

S68
Serial 0186

SUBMARINE DIVISION TWELVE

CONFIDENTIAL December 26, 1942

## Tests of Device to Generate Bubble Cloud for Submarine Evasion Tactics

Reference: (a) BuShips ltr. C-SS/A16-3(330) of 12-16-42.
(b) Comsublant dispatch 181850 of December 1942.

Ships: R-14 and NOA

Aircraft: Aircraft equipped to photograph.

Area: Cast.

Test Party: Commander Gorry, Lieut-Comdr. Swain, Radio Elect. Burdock, school instructor, and Representatives of the Bureau of Ships.

Object of Tests: To determine the duration and character of echoes from a bubble cloud which is created by a device ejected from the submarine signal ejector. To determine whether or not bubble cloud can be seen or photographed from aircraft.

Procedure: Submarine and destroyer underway at 0730 and proceed to test area. Aircraft join group about 0830. Eight tests will be made at each submarine keel depth of 60, 100 and 150 feet.

Submarine dive on signalled base course with buoy streamed. Proceed at three knots speed. Report when ready. One minute after receiving letter "Q" over supersonic beam from destroyer, eject a bubble cloud making device and transmit letter "P" the instant the device is ejected. After the bubble cloud has disappeared, the destroyer will transmit the letter "L" twice as a stand by signal for the succeeding tests. Eight ejections will be made at intervals of ten to fifteen minutes, depending upon the persistence of the bubble cloud. The letter signals to the submarine from the destroyer will be paralleled by flashing light to the observing aircraft. After eight tests the submarine will be ordered to adjust depth to 100 feet submergence. Submarine report when ready and then repeat the same procedure as for 60 feet depth. After eight ejections, submarine will be ordered to change depth to 150 feet and procedure will be repeated for a 150 foot depth for eight more ejections.

The destroyer will take station 400 yards on the submarine's beam for the first ejection at each depth and will average three knots speed on the base course remaining abeam of the submarine. During succeeding ejections at each depth the destroyer will adjust position to be a distance from submarine of 500, 600, 700, 800, 900, 1000, 1100 yards. If results warrant, the distance may be increased by 200 yard intervals to observe results at greater ranges.

The destroyer will alternately obtain echoes from the bubble cloud and the submarine. The duration of time that echoes can be obtained will be recorded for each ejection. The quality of the echoes from the cloud for each ejection will be estimated and recorded. An attempt will be made to measure the width of the cloud. Destroyer observe any surface indication of bubble cloud. Submarine observe, if possible, bubble cloud through periscope and report results. Submit submarine bathythermograph records for each dive.

Aircraft: Arrangements have been made to have photographic or observing plane participate in the tests. If bubble cloud can be seen the aircraft is requested to photograph it as often as possible. Report on results obtained should be forwarded for inclusion in final report. Differentiate between results which were obtained under varying conditions of sea (if such exist) and times of day. Communicate with NOA on 4230 Kcs. Exercise call for plane GEW, Exercise call for NOA GAW.

Submitted:
(signed)

W. A. Gorry,
Commander, U. S. Navy,
Commander Submarine Division Twelve.

Approved:
(signed)

E. H. Jones,
Captain, U. S. Navy,
Commander Service Squadron Nine.

Distribution:
R-14
NOA
Each Representative Present from BuShips
Comdr. Fleet Air Wing Twelve (3)
Comservron-9
Comsubdiv-12

U.S.S.SEMMES

AG24/S68/(016)

CONFIDENTIAL

% Fleet Post Office,
New York, New York,
March 16, 1943.

From: Commanding Officer
To: Director, Naval Research Laboratory, Washington, D. C.
Via: Commanding Officer, Atlantic Fleet, Anti-Submarine Warfare Unit.
Comander Submarines, Atlantic Fleet.

Subject: Service test of Naval Research Laboratory Device to generate bubble clouds for submarine escape tactics.

References: (a) ComSubLant Conf. Ltr. A16-3/(0291) of February 24, 1943.
(b) NRL Conf. Ltr. C-S68/SS(220) of February 20, 1943.

Enclosures: (A) Recorder traces of attack and controlled runs.
(B) Plot of courses of SEMMES and CACHALOT during runs.
(C) Plot of bearings vs time for first controlled run (target angle 060 to 090).

1. The subject tests were conducted in the New London area during the period February 25 through March 10, 1943.

2. The procedure outlined in enclosure (A) of reference (b) was followed as closely as possible. The first tests consisted of six runs on the submarine, with the submarine using escape tactics, running at an eighty foot depth without a buoy. The next tests were made with the submarine towing a buoy. The first four runs with the buoy were definitely controlled in that the SEMMES positioned herself so as to have a target angle of first, ninety degrees, then zero, then two runs with a target angle of one hundred and eighty degrees. Three more runs were then made with the submarine using escape tactics but with the conning officer unable to see the buoy. The buoy was merely used to help analyze the results. The third set of tests consisted of static drop tests. These were curtailed as the results showed very little information was to be gained. Also the danger from a possible hangfire to the personnel in the small boat was very great. A special holder had to be used, and there was no way to cut loose a hangfire without losing the only holder.

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3. Enclosure (A) contains the recorder tracings for the various runs and enclosure (B) contains the plot of the course of the SEMMES and the CACHALOT during the runs plotted from data taken. For plotting the results, the buoy proved to be invaluable. Also it enabled the SEMMES to make a good estimate of the final success or failure of the attack. The conning was done by "seaman's eye" methods. No aids other than the Sangamo Chemical Recorder were used. The Bell telephone QBF sound gear was used. This is not equipped with S.L.C.

4. In all runs without the buoy the attack worked into either an astern or ahead attack except in the fifth run. In this type of an attack the "Doppler" effect was a complete giveaway to the experienced operators on the SEMMES and they found it quite easy to distinguish between the false echo and the target. In fact on the fifth run the operators were changed and the new operator was not even aware of the fact that anything out of the ordinary was happening. He reported the presence of the false echo but kept on the target because of its doppler. In the sixth run of this set the SEMMES ran directly over the submarine. This was definitely established by the strong SMSD indication. For the other attacks the results are estimated. The miss in the last case was due to the conning officer giving insufficient lead. In none of these runs was the operator or conning officer "fooled". It was noted, however, tha that there was a period of confusion when the bubble was strongest and it is felt that an inexperienced operator or one not trained to realize the value of the target's doppler could easily go astray at this stage of the attack.

5. Of the second day's runs, the first four were purely artificial. As was suspected from the first day's runs, the case in which the target angle was ninety degrees (condition in which the target had no doppler) proved the most confusing to the operator. Enclosure (C) shows on a plot of bearings vs time how badly an experienced operator was fooled even when he knew what was being done. It is hoped that more runs of this

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type analyzed by a plot can be made in the future as one run cannot be called conclusive. The other runs with zero and one hundred and eighty degree target angles merely verified the results of the day before, that the doppler is a dead giveaway. One peculiar occurrence happened. On the third run the SEMMES was dead in the water and the bubble cloud apparently drifted over the projector cutting out all signals. This is probably only of academic interest as even at slow speeds the ship is through the cloud very quickly.

6. The attack runs with the buoy appeared to be successful in the first two cases. However, on the second run, in which the CACHALOT stopped, the successful attack on the part of the SEMMES was largely luck. The recorder operator was confused by the two echoes on the paper. Both echoes were quite strong and the conning officer was also confused. This was a point that had not been previously realized, that where two or more distinct echo traces are present on the recorder, while the sound operator may know which is which, the recorder operator may not and he may fire on the wrong trace or give the wrong speed and range to the conning officer. On the last run two PILLENWERFER were released in such a position that three traces were visible on recorder and the attack was generally confused. The conning officer was heading in on the correct course until about five hundred yards from the target but at the very end he got bearings that apparently were taken from one of the bubbles and he turned hard left to cross the supposed target causing him to pass astern of the submarine.

7. The following drop tests were made with these results. (Times are measured from approximate instant of trigger pull. In most cases times are inaccurate as it was difficult to tell the instant trigger was pulled. The average time to fire was about twenty to twenty-five seconds.)

U.S.S. SEMMES

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| Run | Range (Yds) | Depth (Ft.) | Time of Explosion | Time of 1st Echo | Time of Max. Echo | Time of Last Echo | Echo Width | Character of Echo |
|---|---|---|---|---|---|---|---|---|
| 1) | 300 | 50 | 0-21 | 0-55 | 3-30 | 5-35 | 18° | Good strong echo not quite as clear as sub. |
| 2) | 440 | 50 | 0-19 | 0-33 | 3-00 | 5-43 | 6° | Good echo. |
| 3) | 700 | 50 | 0-20 | 0-53 | 7-00 | 10-00 | 15° | Poor echo. May have gotten on tide rip at end. |
| 4) | 1400 | 50 | 0-44 | 1-01 | 4-00 | 11-00 | 11° | Poor echo. May have gotten off at end. |
| 5) | 1500 | 150 | | | | | | Did not pick up echo or explosion. |
| 6) | 275 | 250 | 0-00 | 2-30 | 3-30 | 4-30 | | Echo difficult to pick up. |
| 7) | 150 | 150 | 0-10 | 0-46 | 2-50 | 3-45 | 35° | Good echo. May have lost due to short range. |
| 8) | 250 | 150 | 0-10 | 0-30 | 2-00 | 3-30 | 20° | Echo not very good. |
| 9) | 400 | 250 | 0-00 | 0-50 | 2-30 | 4-30 | 10° | Fair echo |
| 10) | 900 | 50 | 0-20 | | 3-10 | | | Tide rip obscured echo. |
| 11) | 700 | 150 | 0-25 | | | | | Faint echo only. |
| 12) | 900 | 250 | | | | | | Dud. |

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Roughly it is concluded that one minute after release an echo can be obtained and it is lost almost three minutes later. The bubble cloud was only seen once by boat releasing PILLENWERFER and then only briefly.

8. The following conclusions were reached as to the value of PILLENWERFER:

(a) If they are dropped in large enough quantities the attack would definitely be confused and probably would mislead the attacking ship in many cases.

(b) If they could be made of longer persistence, once the area is clouded with them attempts to regain contact with the submarine after an unsuccessful attack would be very difficult.

(c) The discharge of air when the projectile is fired from the submarine is plainly visible in the form of a surface bubble and confirms to the surface ship the presence of a submarine.

(d) The underwater detonation can be heard on the sound gear and should be very easily heard by any ship equipped with sonic listening.

(e) An experienced operator who can recognize "doppler effect" has no trouble distinguishing between the submarine and the echo, particularly on an astern or an ahead attack, although the sound of the echo is in general very much like that received from a submarine.

(f) The operator is most likely to be fooled when the submarine is crossing the course of the destroyer in which case the submarine also has no doppler.

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(g) A great many duds were experienced by the submarine but only on one out of the twelve drop tests, and that charge hit bottom and was damaged. It subsequently failed to fire. Many failed to fire the first time but in each case it was found the trigger had never been pulled. In some cases a very strong pull had been applied as the wire to the trigger had broken. This would seem to indicate that, when ejected by the submarine's gun, the trigger probably over-rode without being pulled as the projectile left the gun.

9. In general it is the opinion of this command that PILLENWERFER is very well suited for use against the type of attack which our destroyers employ but it is not suitable for use at present by our submarines as long as the enemy use sonic listening as their primary detection method rather than echo ranging. It is recommended that the program be carried out until more data is collected and the exact value of the PILLENWERFER more completely determined, by means of controlled attacks. Then the good and bad points may be presented to our submarines, so that when the day comes that they feel the need for such a device it will be developed and ready to be given to them. As a recommendation, the method of release should be changed so that no visible sign is given. Also the release should be made as silent as possible.

W. I. BULL

Copies to:

Naval Research Laboratory (Original)
Naval Research Laboratory (1 copy direct)
C.O. Atlantic Fleet A-S Warfare Unit*
Commander Submarine, Atlantic Fleet*
Cominch (Readiness Section)
Buships (Att: Comdr. Loomis)
ComSubRon ONE
C.O., U.S.S. CACHALOT
C.O., East Coast Sound School, Key West, Fla.
File
*Enclosure with original.
Note: Enclosure "A" with original only.

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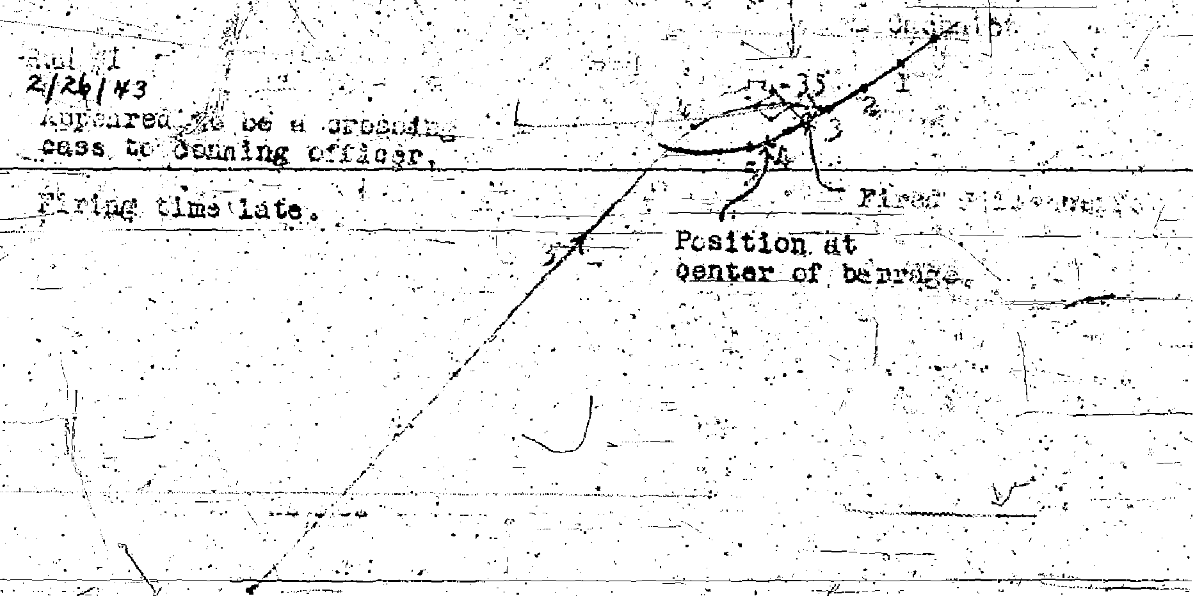
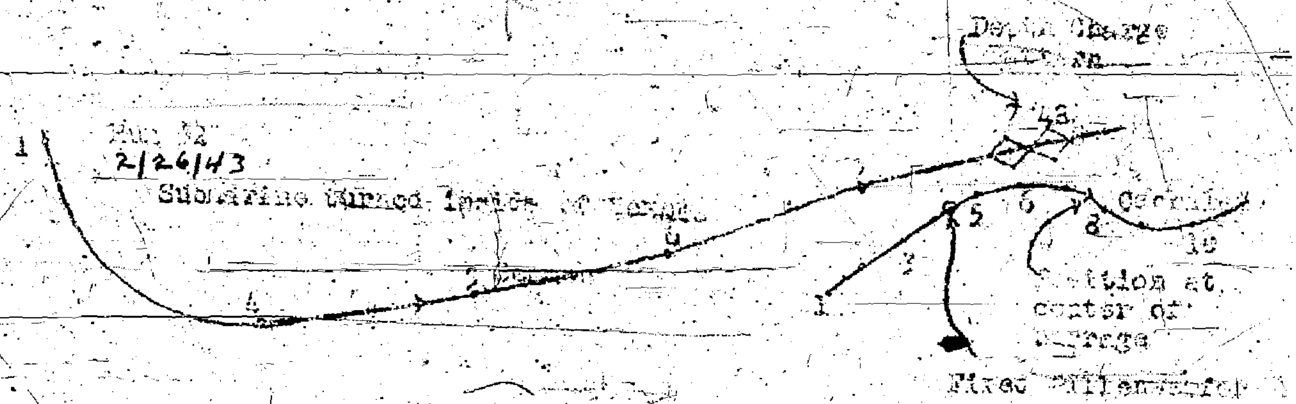
Enclosure (B1) To C.O.

USS Semmes ltr. dated 3/16/43

Serial AG24/S68/(016)



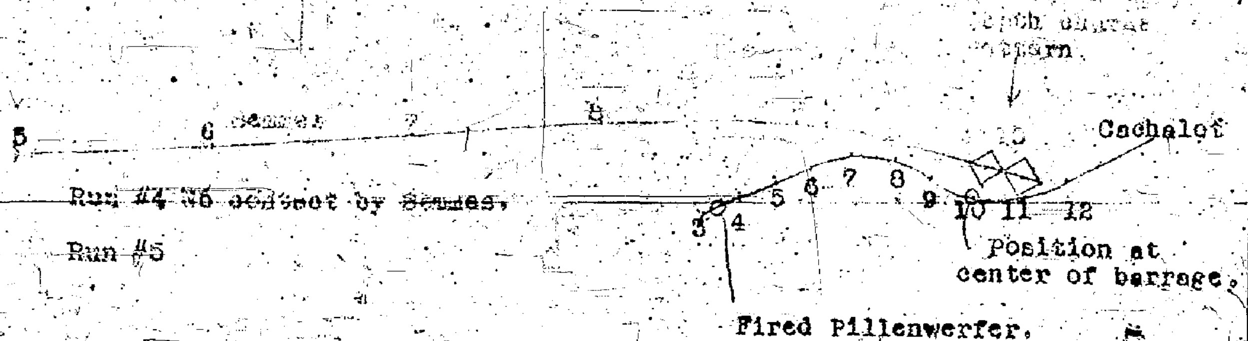

Scale: 1" 400 yds.
Numerals represent minutes from zero

CONFIDENTIAL

B2 ... O.

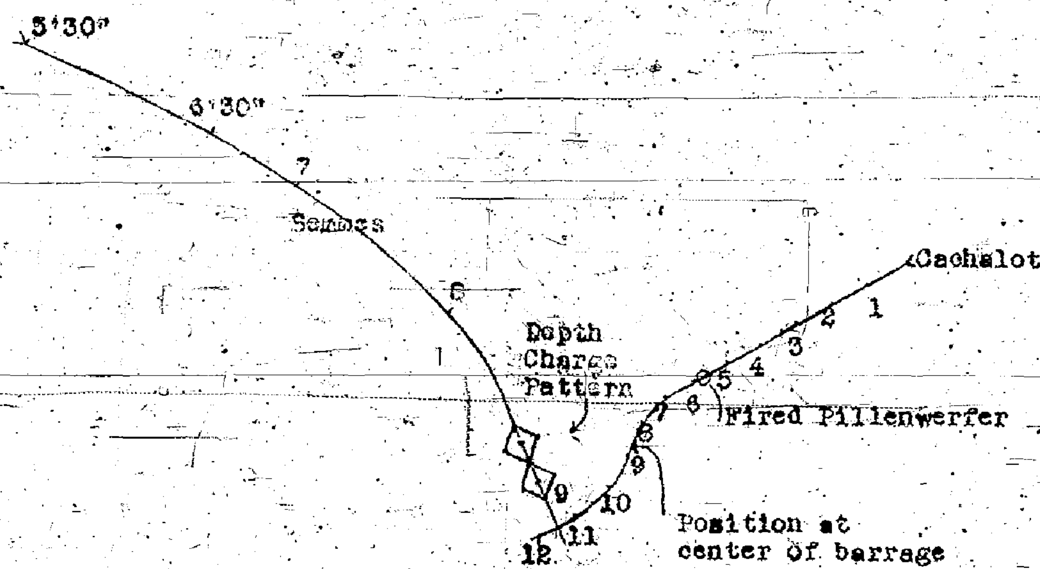
Run #3 2/26/43

... ltr. dated 3/16/43
Serial AG24/S68/(016)

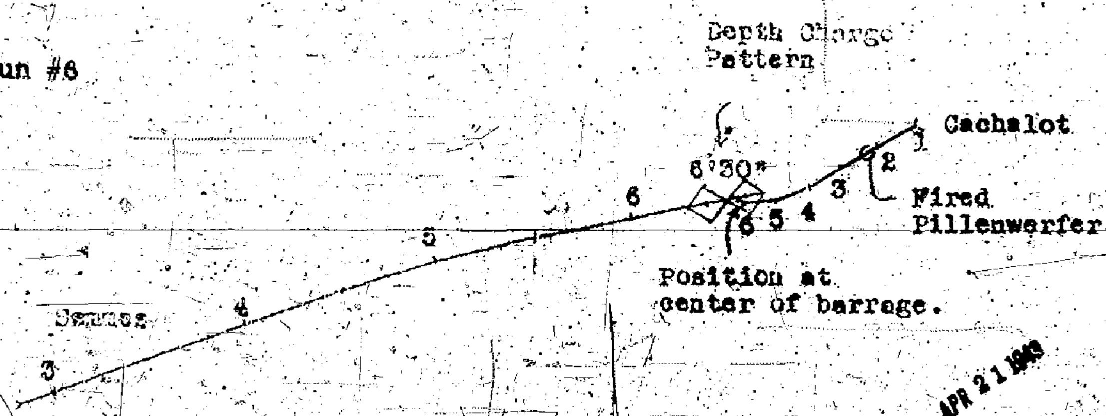



Run #4 No contact by Semmes.

Run #5




Run #6






Scale: 1" = 400 yds.
Numerals represent minutes from zero time.

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B3

Run #5
2/27/43
[illegible]

3/16/43
AG24/568/(016)

Runs #1, 2, [illegible] and 4 of this [illegible] were [illegible] runs and were not plotted.

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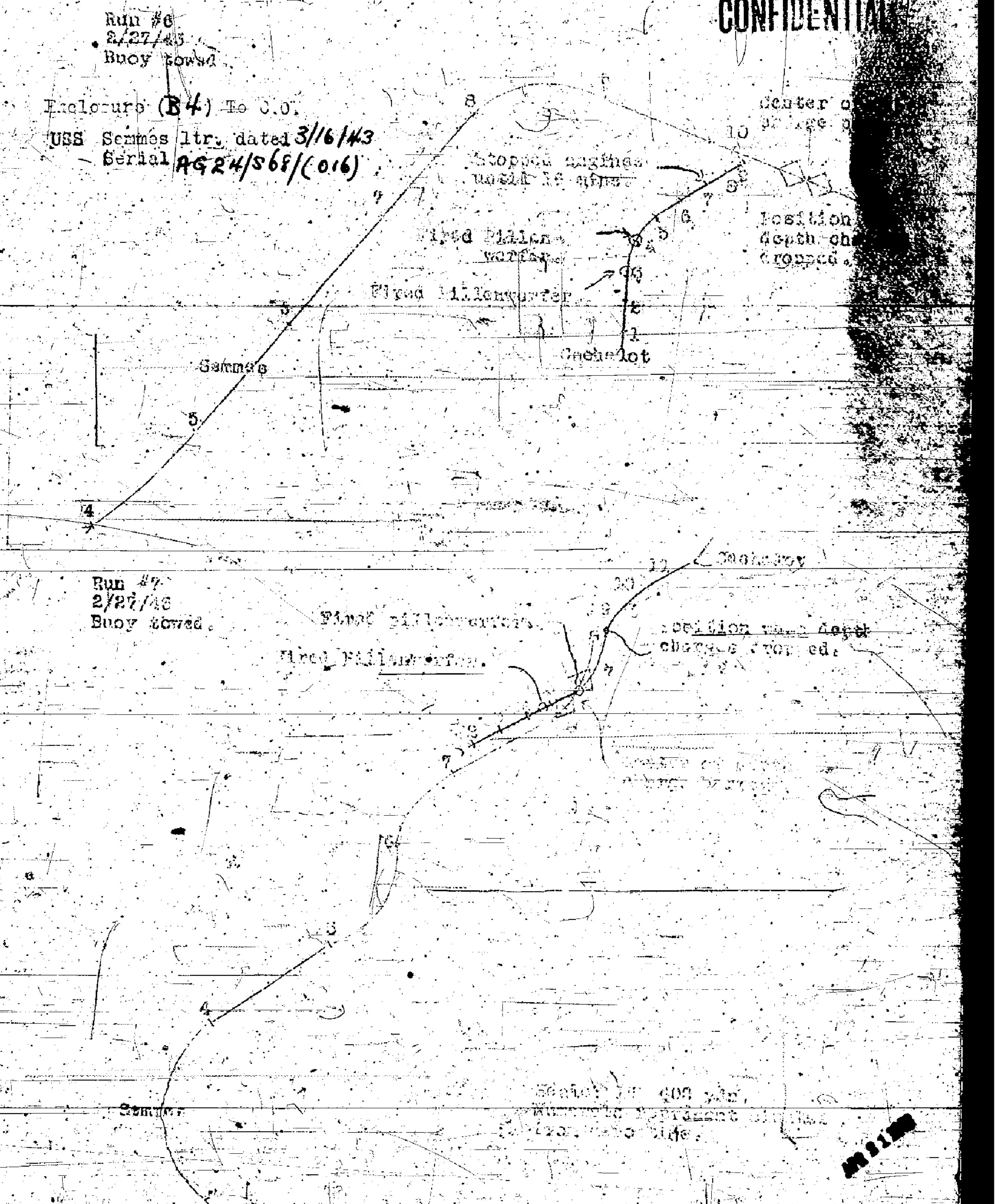
Enclosure (B4) to C.O.
USS Semmes ltr. dated 3/16/43
Serial AG24/S68/(016)

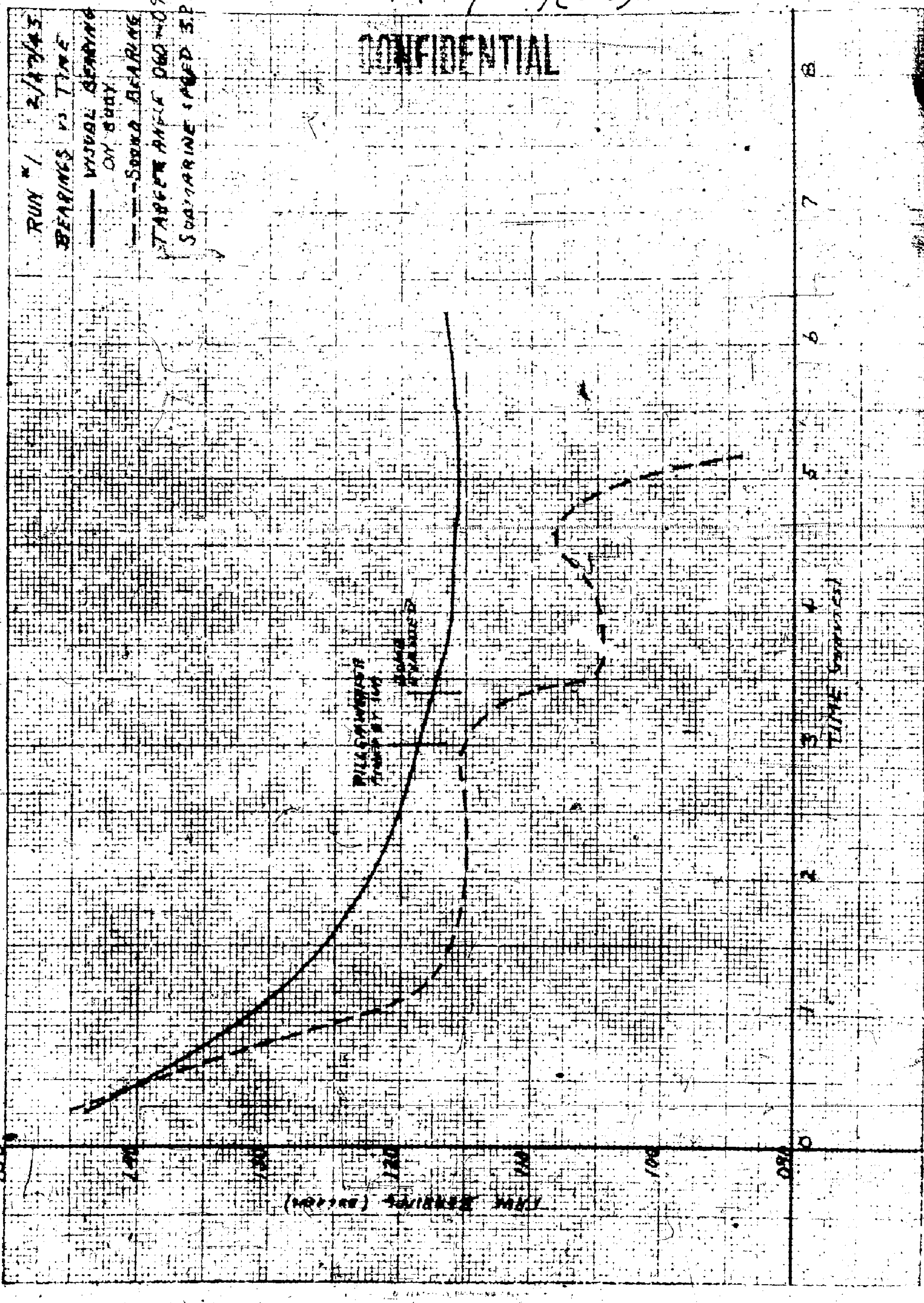


DEPARTMENT OF THE NAVY
BUREAU OF ENGINEERING

3/16/43
AG24/S68/(016)

DR. No.

CONFIDENTIAL



C-S68/SS(152:JAG)hdr March 10, 1943

MEMORANDUM to the Director

Subject: Service Tests of Naval Research Laboratory Device to Generate Bubble Cloud for Submarine Evasion Tactics.

Reference: (a) NRL Conf. Ltr. C-S68/SS(220) of February 20, 1943.
(b) Comsublant Conf. Ltr. A16-3(0261) of February 24, 1943.

1. Reference (a) is the proposed program of tests prepared by Commander W. L. Pryor, Jr., of the Laboratory. Reference (b) is Comsublant's approval of the program to be conducted by the U. S. Submarine CACHALOT and U. S. Destroyer SEMMES.

2. The subject device known as "False Target Shell" is essentially the same as the Submarine Emergency Identification Signal except as to contents and weight. Of slightly negative buoyancy it contains six cans 2-7/8" x 1-7/8" of a lithium hydride-paraffin mixture designed to generate fifty-three cubic feet of hydrogen in fine bubbles on ejection from the signal shell case. This bubble cloud serves as a false target for submarine echo-ranging attack approach.

3. In accordance with references (a) and (b) tests were conducted with the "False Target Shell" at New London on February 25-27, 1943. Commander F. K. Loomis, Lt. (j.g.) J. H. Curtiss and Mr. F. M. Varney of the Bureau of Ships, and Lt. C. L. D. Allen and Mr. J. A. Grand of the Laboratory were present to witness the tests. No tests were made on February 25 due to jamming of the submarine's signal ejection gun. On February 26, six evasion runs were carried out with the submarine Commanding Officer firing "False Target Shells" at his discretion. Throughout the conduct of the evasion operations the submarine maintained a depth of 80 feet. One shell only was fired in all runs except in one case where two shells were ejected. In two of the six runs the submarine heard the destroyer pass over head. The consensus of opinion

of the observer aboard the SEMMES was that although the bubbles gave an echo comparable in quality and intensity to that obtained from the CACHALOT the two echoes could be differentiated by the lack of Doppler from the bubbles.

4. Although some confusion resulted from the use of the "False Target Shell" its definite value in evasive tactics could not be ascertained from these tests. A series of controlled runs with the CACHALOT streaming a marker buoy were conducted the following day. Data from these observations of February 27 is summarized below. In all cases the submarine proceeded at a depth of 65-70 feet at 3.2 knots unless otherwise noted. During the first four runs the submarine followed a set base course while in the last three runs the submarine used evasive tactics. The destroyer in all runs except the first simulated attack conditions. All times given are in minutes and seconds with zero time as starting time.

Run #1. Destroyer followed parallel course slightly ahead of submarine abeam at a range of 800 yards. Under these conditions no Doppler is received from the sub and a slight Doppler from the bubbles. The submarine fired a shell at 3-00. Sound operator left the submarine and began to range on bubbles at 4-00. At 8-10 the run was concluded with the sound operator still ranging on the bubbles.

Run #2. Destroyer 1200 yards dead ahead of submarine. Submarine fired dud bubble shell at 3-00. Although sound operator became confused in the middle of the run a successful attack was made at 7-00.

Run #3. Destroyer approaching submarine's stern from an initial range of 600 yards. Shell fired at 3-00. Destroyer began receiving good double echo at 4-00. From 5-00 to 7-00 destroyer in bubble cloud which squelched all echo ranging. No bearings and ranges could be determined by echo-ranging while in this blanketed area. At 7-00 the submarine was momentarily ranged and lost again until 8-00 when contact was maintained until the conclusion of the run at 10-25. Destroyer not under way.

Run #4. Repeat test of run #3 with two shells to be fired instead of one. Initial range 500 yards. Shell fired at 3-00. Bubble echo first received at 4-00. From 4-30 to 9-00 at a range of 600-700 yards the bubbles gave a stronger echo than the submarine but no Doppler. Although the bubble echo was more intense than the submarine the Doppler from the latter was still distinguishable. At 9-15 the submarine fired a second shell which was first ranged by the destroyer at 10-00. From 11-30 to 12-30 the destroyer was passing through a bubble area; during this period no bearings could be taken. The operator of the range recorder was confused in this run because of the multiplicity of traces recorded.

Evasion Runs (different sound operator aboard SEMMES).

Run #5. Initial range 2400 yards. The submarine fired a shell at 5-29 and continued on base course until 7-00 when it began an 80° right turn completed at 11-06, the conclusion of the run. At 6-10 the destroyer had closed in to 1000 yard range, from which time the sound operator began to oscillate in taking bearings from bubbles to submarine and back. At 7-30 destroyer lost contact at 200 yard range.

Run #6. Initial range 2700 yards. Submarine fired shells at 3-00 and 4-05 and executed 60° right turn from 3-00 to 6-00; submarine stopped all engines from 7-00 to 17-00, the time of conclusion of the run. Destroyer closed in to 1500 yards at 6-30 when first double echo picked up. Although some confusion, destroyer apparently made a successful attack at 10-10.

Run #7. Initial range 2500 yards. Submarine fired shells at 4-39 and 5-44 and executed a 40° left turn from 6-00 to 8-00, returning to base course from 9-00 to 12-00. Destroyer first echo-ranged bubbles at 5-20 at a range of 1050 yards. Operator lost submarine and ranged bubbles from 6-00 to 7-00 when target trace operator called attention to this fact and sound operator relocated the submarine. At 8-10 simulated attack fired at 2nd set of bubbles instead of true target; this was due to confusion of the operator of the range recorder and not the sound operator.

5. Among the disadvantages of the "False Target Shell" is the use of an air slug for ejecting the shell. The resultant surface disturbance, although momentary, may be seen by surface craft several hundred yards away. This drawback could be eliminated by firing the shell with a water slug instead of air. Another handicap, probably more serious with sonic than with supersonic equipment, is the sound created by the black powder expellent charge. Both of the above mentioned difficulties would be removed by the use of an ejector like the German "Pillenwerfer" modified by the addition of a safety pop-off valve to the muzzle. Relatively little danger would

be involved in the use of an ejector of the piston type and further the chemical could be stored in cans instead of the more expensive signal cases.

6. The "False Target Shell" has in these tests demonstrated the possibility of:

(a) Confusing an experienced sound operator.
(b) Confusing the range recorder operator.
(c) Squelching momentarily all echo-ranging.

It is to be noted that in all individual tests a maximum number of two shells was used, while in actual service use a larger number could be used.

Jos. A. Grand

C-S68/SS(452:JAG)map March 29, 1943

MEMORANDUM to the Director

Subject: Sound Test at New London of Varied Expelling Charges in Device to Generate Bubble Cloud for Submarine Evasion Tactics (False Target Shell).

Reference: (a) BuOrd ltr. to Nyd Washington, No. S70-1(9), Serial No. 02-3-9, dated Feb. 2, 1942, requesting modification of expellent charge in false target shell.

Enclosure: (A) Program of Test Procedure.

1. Preliminary service tests demonstrated the necessity of reducing the expelling charge in the subject device because of the high order intensity noise produced by the explosion. In accordance with reference (a), Mr. S. P. Lewis of the Naval Ordnance Laboratory prepared four shells with an 18 gram smokeless powder charge and four shells with a 24 gram smokeless powder charge in place of the standard 8 gram black powder charge. These shells contained dummy pellets of wax in place of the chemical pellets.

2. Commander W. L. Pryor, Jr., Dr. H. L. Saxton, W.O. R. H. Whitehead, Mr. W. W. Stifler and Mr. J. A. Grand from the Laboratory and Mr. F. M. Varney of the Bureau of Ships witnessed sonic and supersonic listening tests of these shells as well as standard shells at New London on March 25th. The test procedure followed the program, Enclosure (A), with the exception that Run #6 of Part Two was omitted.

3. Sound recordings of the tests of Part One made aboard the AMADA & 1985 by Mr. D. P. Loye of the Underwater Sound Laboratory, demonstrate a marked reduction in sound intensity by the use of the 18 and 24 gram smokeless powder

charges. No "sonic scrambled egg effect", i.e. sounds produced by bubbles leaving the surface of the chemical, by the use of chemical shells could be noted. A condensed copy of these sound recordings will be sent to the Laboratory. The sounds heard over the QBF aboard the SEMMES were quite loud due to the fact that the shells exploded quite close to the sound dome. In all tests of Part One the pellets were ejected from the shell cases by the expelling charges.

4. The primary purpose of the tests of Part Two was to determine if the pellets would be ejected by the reduced explosive charges at the probable maximum depth of use. In all tests, except Run #2, the pellets were ejected from the shell cases. The shell used in Run #2 was a dud, probably caused by a primer misfire. Very feeble or no reports were heard over the QBF in the tests of Part Two.

5. While at New London, arrangements were made for the writer to visit the Electric Boat Co. in order to ascertain the possibilities of using salvage connections or other openings in a submarine for attachment of a "Pillenwerfer" type ejector. The salvage connection is the only opening available and that is not very suitable as it opens on the topside of the hull two to four feet from the deck, depending upon the compartment. Further, the salvage opening is only three inches at the weld which would permit only of using about a one-inch pill

Joseph A. Grand,
Chemistry Dept.

TENTATIVE PROGRAM OF FALSE TARGET SHELL TESTS MARCH 25, 1943

Part One (Semmes, Amada and 1985 participating)

The Semmes will take position about 1000 yards distant from the Amada and 1985 anchored off Fisher's Island at about 14:30. The Semmes will transmit by signal light the letter "P" when ready to proceed with the tests. The 1985 will answer if ready with the letter "P" or if not ready with the letter "H" for hold. If both craft are in readiness the Semmes will signal R1 for Readiness Run #1 and 1 minute later send a long dash for execute. At the moment the execute signal is sent the Semmes will trip the firing lever on the false target shell at a depth of 80 feet. Eight runs will be made as enumerated below using the same signalling procedure as above with shells of varying powder charge. The Semmes will note if the cans are ejected from the shell and also note over the OBF qualitatively the relative intensity of the sound made by the expellent charge. The first two runs will be used for sonic adjustment purposes by the 1985 and the Amada in order to record the sound made by the burster charge in runs #1 to 8 inclusive, as well as any "sonic scrambled egg effect" that might be found in runs #2, #7 and #8 with chemical shells.

| | | | | | | |
|---|---|---|---|---|---|---|
| Run #1 | 28 | gram | powder | charge. | Dummy pellets (Wax). | |
| Run #2 | " | " | " | " . | Chemical pellets (Standard False Target Shells) | |
| Run #3 | 24 | " | " | " . | Dummy pellets. | |
| Run #4 | " | " | " | " . | " | " |
| Run #5 | 18 | " | " | " . | " | " |
| Run #6 | " | " | " | " . | " | " |
| Run #7 | 28 | " | " | " . | Chemical pellets. | |
| Run #8 | " | " | " | " . | " | " |

Part Two (Semmes only)

The Semmes, on the conclusion of the tests of Part One will proceed to a point off Fisher's Island where a depth of 300 feet is available. The Semmes will trip six shells as noted below making the same observations as in Part One.

| | | | | | | |
|---|---|---|---|---|---|---|
| Run #1 | 18 | gram | powder | charge. | Dummy pellets. | |
| Run #2 | " | " | " | " . | " | " |
| Run #3 | 24 | " | " | " . | " | " |
| Run #4 | " | " | " | " . | " | " |
| Run #5 | 28 | " | " | " . | Chemical pellets. | |
| Run #6 | " | " | " | " . | " | " |

Copy to:
CO SEMMES
CPOinC 1985
CO AMADA
Mr. Varney
Mr. Grand
Signalman
Comdr. Pryor
Mr. Loye

C-S68/SS(452:JAG)map May 3, 1943

MEMORANDUM to the Director

Subject: Deep Water Sound Test at Portsmouth, N. H., of False Target Shell.

References: (a) Memo. to Director, C-S68/SS(452), dated March 29, 1943. Sound tests of varied expelling charges in False Target Shell.
(b) BuShips ltr. to BuOrd, C-SS/A16(330), dated Jan. 23, 1943, requesting that NOL(Wash.Nyd) be authorized to modify expelling charge and furnish NRL with 50 shell cases and modified charges for chemical loading.
(c) BuOrd ltr. to Nyd, Wash., 570-1(9)Re2e, Serial 02-3-9, dated Feb. 2, 1943, authorizing request of Reference (b).

1. The sound tests at New London of March 25 (Ref. (a)) indicated that a 20 gram smokeless powder expelling charge in place of the standard 28 gram black powder charge satisfactorily reduced the noise level of the expellent explosion. In accordance with References (b) and (c) the Naval Ordnance Laboratory supplied fifty modified expelling charges and fifty Mark 2 Mod. 2 Submarine Emergency Identification Signal cases. These cases were loaded with chemical pellets at the Bellevue Magazine under NRL supervision. Twenty-five of the False Target Shells were loaded with the normal chemical mixture, while the remaining twenty-five had 1% by weight of a wetting agent added to the chemical mixture. From laboratory experiments it is believed that more efficient bubbling is obtained by the addition of the wetting agent in that smaller bubbles are released.

2. Five of each of the two types of False Target Shell were sent to the Portsmouth Navy Yard, Portsmouth, N. H. for test in conjunction with the deep submergence run of the USS BALAO (SS285). Tests were conducted in deep water about 16 miles off Portsmouth on April 27th with the USS SEMMES (AG24) and USS MARTHA'S VINEYARD (IX97) cooperating. The False Target Shells were only a small part of the program as tests were also made by representatives of the Bureau of Ships, Portsmouth Navy Yard, David Taylor Model Basin, Underwater Sound Laboratory of New London and the Wood's Hole Oceanographic Institute. Information given here only concerns the bubble generation problem. Comdr. W. L. Pryor Jr., Lt. F. W. Kittler, Dr. P. N. Arnold and Mr. W. W. Stifler of the Naval Research Laboratory and Mr. F. M. Varney of the Bureau of Ships aboard the SEMMES and Mr. J. A. Grand of NRL aboard the BALAO witnessed the tests.

3. At a depth of 412 feet a green smoke bomb was ejected from the BALAO to determine if the ejector and signal would function properly at this depth. It is thought that this signal fired before reaching the surface and was drowned as the SEMMES reported no signal. Fuse time of the smoke bomb is 25 seconds, so it would be necessary for the signal to have an upward velocity of at least 16.5 feet per second to discharge on the surface. Two green smoke bombs were fired at a depth of 300 feet, both of which failed to function. At this depth, with submarine speed 1-1/2 knots, four False Target Shells were fired. Both types of False Target Shell were fired alternately at intervals of approximately three minutes beginning with the non-wetting agent type. The SEMMES recorded echo ranging on the submarine and bubbles, while the MARTHA'S VINEYARD recorded on sonic equipment the expelling charge noise. Observers aboard the SEMMES reported that echoes from the False Target Shells were of excellent intensity and quality. Recordings and data taken by the SEMMES, MARTHA'S VINEYARD, and the BALAO will be forwarded to the Laboratory. Before coming to periscope depth a green smoke bomb was fired at 200 feet which functioned correctly.

4. It was intended to fire a series of False Target Shells at periscope depth (62-64 feet) with submarine speed 6 knots with the MARTH'S VINEYARD directly astern of the BALAO to determine whether the bubbles had any sonic masking properties, but the gate valve on the muzzle of the signal ejector jammed after firing one False Target Shell. Unfortunately, the MARTHA'S VINEYARD was changing records at the time of firing of this shell.

5. The subject of a new type of signal ejector, better suited to the needs of the False Target Shell, was discussed with Captain A. I. McKee of the Portsmouth Navy Yard. The need for a new type of ejector had already been anticipated because of the frequency of derangements occurring in the Service with the present model. Captain McKee was of the opinion that an ejector suitable for the submarine signal and at the same time suitable for the False Target Shell could be designed.

Joseph A. Grand
Chemistry Division.

October 14, 1942

MEMORANDUM to the Director

On July 28, 1942, Comdr. Mallory, Bureau of Ships, informed the writer by telephone that Lieut. Raitz would visit the Laboratory for a conference on an urgent problem. On the same date Lieut. Raitz called at the Laboratory to discuss the use of chemical materials for forming a false target of submarines for the sounding apparatus aboard enemy ships. To date it appears that a ship's wake, a cloud of air bubbles, or temperature differences will give reflections similar to the hull of a submarine. The important condition apparently being a rather sharp change in density of the water, the exact mechanism of the reflection being under study in NDRC.

Lieut. Raitz, Dr. Burgess and the writer discussed various compounds which would decompose to give small bubbles in water to change the density by a controllable amount. These compounds were sodium peroxide, hydrogen peroxide, mixed oxide and KOX as $O_2$ producing compounds, carbon dioxide snow, alkali carbonates and bicarbonates with suitable dry acids (alka-seltzer types), as $CO_2$ producing compounds. Also various alkali metals as hydrogen producing compounds were discussed. The using of a fine air spray was discussed with Dr. Borgstrom.

On July 29th, Lieut. Raitz returned to the Laboratory to see some materials tried in a water bath. The bath used was 4 ft. high with glass windows giving good observation of the reactions.

Catalyzed mixed oxides gave a very vigorous reaction and large bubbles. Then NaCl was added as an inert material and pellets made with the mixed oxide. One sample contained NaCl 40%, MOX 60%, a second NaCl 60%, MOX 40%. A reasonably large volume of small bubbles formed in the tank which lasted for several minutes. The 60% MOX pellets reacted and descended more slowly than the 40% material. The reaction with the pellets (approx. aspirin pellet size) was over in from 1/2 to 1 minute time. Large pressed chunks, 2 to 3 cm. in diameter, reacted in approximately the same time and gave large bubbles which rose rapidly to the surface and disappeared.

Lieut. Raitz discussed the problem with Mr. R. L. Tuve who suggested calcium phosphide as a compound with suitable characteristics. The rate of gas production being easily controlled by the size of particles. The gas formed from the commercial calcium phosphide has an unpleasant odor which would be disagreeable if set free in a closed space. The odor is not due to phosphine, but probably to arsine from the arsenic present as the impurity in the phosphide. The phosphide reacted with the water slowly and regularly to give a well defined cloud of bubbles. The phosphine burned on contact with the oxygen in the air with a sharp crackling.

30% $H_2O_2$ was decomposed by pouring a solution of $KMnO_4$ and the peroxide each through a tube into a pocket or mixing chamber in a rubber stopper under the surface of the water. A cloud of small bubbles were dispersed which disappeared slowly. A dark brownish color was also present due to excess catalyst.

$CO_2$ snow in sizes that descended gave bubbles which were too large and smaller pieces rose to the surface.

Larger chunks of the 60% MOX mixture, 1-3/4 in. in diameter, weighing approximately 70 gm., were prepared and dropped into the river one at a time. Large bubbles came to the surface, but the water naturally was too muddy to observe any fine bubbles in the vicinity of the decomposing chunk.

DISCUSSION:

The phenomena of sound reflection from a location in an extent of water is found where there is a change in the density of the water. The change in density or the rate of change for a reasonable reflection is not known to the writer. However, density changes due to temperature differences are reported to produce a sound reflection.

The maximum temperature differences reported in sea water are around 40°F. (the highest reported around 80°F., the lowest around 40°F.) however, it would appear unreasonable if a difference of more than one-fourth this amount (10°F.) occurred in a short distance or boundary layer from which reflection could be obtained. On curve #1 the difference in density of sea water from 86°F. to 77°F. (9°F.) is 1.02425 - 1.02260 or 0.00165, while the difference from 41°F. to 50°F. (9°F.) is 1.02860 - 1.02785 or 0.000725.

Now choosing as the average density of sea water 1.02686 (value at 59° or 60°F.) the fraction of the volume in each cubic foot occupied by gas at the average density change would be $\frac{0.00120}{1.02686} = 0.00116$ or 0.116%. Where (a) and (b) are the major and minor semi axes respectively of an ellipse, the volume of the spheroid formed by rotation of the ellipse about its major axis is given by $V = 4/3\pi ab^2$. Considering that a suitable target elliptical in shape and equal in shape to the solid of rotation of the ellipse would be 150 feet in length and 20 feet in diameter at the center the volume would be in cu. ft.

$= 4/3\pi \cdot 150 \cdot (20)^2$

** $=$ Approx. $1 \cdot 150 \cdot 400$ cu.ft.

$=$ " 60,000 cu.ft.

60,000 x 0.00116 = 69.6 cu.ft. of gas to get the density change considered. Also this is the volume at the

** Correction:
This line should read $4(1 \cdot 150 \cdot 400)$ cu.ft. and should be carried through the calculation.

depth desired. Assuming 125 ft. to center where the pressure in the sea water would be $\frac{125 \cdot 62.5 \times 1.02686}{144} = 55.6$ lbs/sq.in. The gas volume is then $69.6 \cdot \frac{55.6}{14.7} = 263.$ ft³ at one atmosphere and the average temperature chosen 60°F. This figure does not take into account the weight of the gas or the solubility in sea water. Both of these values depend on the gas used. In case one foot thickness of gas filled water 150 ft. long and 20 feet high was satisfactory the volume would be 150 x 1 x 20 = 3000 cu. ft. or 1/20 of the calculated volume and only 1/20 of the gas volume would be required.

From the date of this visit to the present, work has been done on this problem at odd times.

During the week of October 5th, T. M. Varney, Bureau of Ships, visited the Laboratory three times on the problem and a confidential letter from the Bureau of Ships, C-SS/A16-3(340), has requested pellets for trial. They wish one hundred units. Men in the section on high flying and material testing have been put on this work to finish it quickly. In the meantime, Lieut. J. T. Burwell asked that I interview a Polish refugee in Baltimore. The data apparently is on German equipment for problems other than this one. The conference was reported in confidential memorandum to the Director of October 13th.

R. R. Miller,
Chemistry Division

UNITED STATES GOVERNMENT

# memorandum

7103/104

DATE: 24 September1996

FROM: James R. Griffith (Code 6107)
Burton G. Hurdle (Code 7103)

SUBJECT: REVIEW OF REF. (a) FOR DECLASSIFICATION

TO: Code 1221.1

VIA: Code 6100
Code 7100

AD - 310 181

REF: (a) NRL Confidential Report #P-2086 by J.A. Grand and D.S. Burgess, June 1943 (U)
(b) DoD Dir. 5200.9

1. Reference (a) is a report on the development and testing of an acoustic false target generator for U.S. submarines. Small air bubbles were generated and discharged from torpedo tubes. The report is the result of a joint effort between the Chemistry and Sound Divisions.

2. Both the chemical and acoustical technologies are widely known today.

3. Reference (a) was declassified by reference (b).

4. Based on the above, it is recommended that reference (a) be declassified with no restrictions.

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J.W.

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