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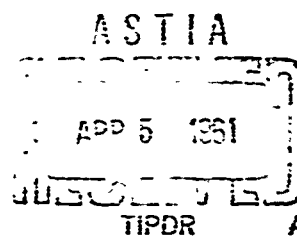
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Technical Report

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FIRE EXTINGUISHERS CONTAINING
INHIBITED LITHIUM CHLORIDE SOLUTION
FOR POLAR USE

27 March 1961



U. S. NAVAL CIVIL ENGINEERING LABORATORY

Port Hueneme, California

621000

**FIRE EXTINGUISHERS CONTAINING INHIBITED LITHIUM CHLORIDE SOLUTION FOR
POLAR USE**

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Type B Final Report

by

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OBJECT OF TASK

To determine suitable container materials and effective corrosion inhibitors compatible with water solutions of lithium chloride for use in fire extinguishers in polar climates.

ABSTRACT

Previous experiments under this task using small metal test panels resulted in the selection of a sodium dichromate-oxalic acid inhibitor for use in protecting stainless steel from corrosion by a 24-percent lithium chloride solution. Subsequent testing with unlined stainless steel extinguishers showed that the inhibitor did not prevent intergranular and crevice corrosion.

In this investigation, five different commercial extinguishers, fabricated of drawn brass or silicon bronze and lined with a lead alloy, were tested with the lithium chloride solution using either sodium dichromate-oxalic acid or sodium dichromate alone as an inhibitor. It was determined that 0.5 percent sodium dichromate satisfactorily inhibits corrosion by the water solution of lithium chloride when contained in an extinguisher of drawn brass.

INTRODUCTION

In 1955 a study on "Low-Temperature Fire Extinguishing Agents"¹ was reported. As a result of this investigation a 24-percent water solution of lithium chloride was selected for use in fighting Class A fires. A low eutectic made it satisfactory for use in extinguishers in polar climates. However, the solution was found to be very corrosive; a study was made at NCEL to find a corrosion inhibitor and/or a suitable container for use with this solution.

It was previously reported, from NCEL tests made on small panels, that when a mixture of sodium dichromate and oxalic acid was added to the 24-percent lithium chloride solution, corrosion of stainless steel was almost completely inhibited. Subsequent tests made with commercial 2-1/2-gallon stainless steel fire extinguishers showed, however, that although general corrosion was inhibited, severe corrosion occurred at welds and seams.² Further reference to the small panel tests indicated the possibility that brass or bronze extinguishers would prove satisfactory for use with an inhibited lithium chloride solution.

MATERIALS

Several brass or bronze extinguishers are manufactured for use with inhibited calcium chloride solutions. Since lithium chloride solutions are only slightly more corrosive than solutions of calcium chloride, it was decided to test these extinguishers with the lithium chloride solution. Ten were purchased, two from each of five manufacturers, and studies were made of their suitability as containers for inhibited 24-percent water solutions of lithium chloride. The extinguishers tested are listed below:

1. American-La France-Foamite Corporation, Elmira, New York; Model 3H-2 anti-freeze extinguisher, 2-1/2-gallon silicon bronze, 350-pound test.
2. Elkhart Brass Manufacturing Company, Inc., Elkhart, Indiana; No. X-A (for anti-freeze solutions) 2-1/2-gallon polished brass, 300-pound test.

3. Fyr-Fyter, Division of Fyr-Fyter Company, 221 Crane Street, Dayton, Ohio; anti-freeze extinguisher No. 94-11, 2-1/2-gallon drawn brass 500-pound test.
4. Walter Kidde and Company, Inc., Industrial and Marine Division, Belleville 9, New Jersey; Model KAM, anti-freeze extinguisher, 2-1/2-gallon silicon bronze, 350-pound test.
5. Pyrene C-O-TWO Division, The Fyr-Fyter Company, Newark 1, New Jersey; No. W-13 anti-freeze extinguisher, 2-1/2-gallon drawn brass, 500-pound test.

Spectrographic analysis of the lining material of all these extinguishers showed an alloy of lead and tin; these analyses are shown in Table I.

Table I. Container Material

No.	Extinguisher Mfr. and Model	Metal	Lining Material		Thickness* in inches
			% Tin	% Lead	
1	American-La Fr.	Silicon Bronze	40	60	0.004
2	Elkhart No. X-A	Drawn Brass	50	50	
3	Fyr-Fyter No. 94-11	Drawn Brass	50	50	0.005 minimum
4	Walter Kidde Model KAM	Silicon Bronze	40	60	
5	Pyrene C-O-TWO Model W-13	Drawn Brass	40	60	0.002-0.003

* Data from manufacturer

PROCEDURE

Test Conditions

Uhlig³ shows that anode-cathode relationships of metallic couples of lead and copper can be reversed by changing the pH. Both brass and bronze fire extinguishers were tested using lithium chloride solutions containing: (1) sodium chromate at pH 8.3, (2) sodium dichromate at pH 3.6, and (3) sodium dichromate and oxalic acid at pH 1.5.

The extinguishers were filled with the test lithium chloride solutions. In order to accelerate the corrosive action, they were kept at a constant temperature of 140 F for two months. At the end of this test period the clear supernatant solutions were decanted, and the residual liquids containing the insoluble corrosion products were filtered. The corrosion products adhering to the surfaces of the container were removed by brushing with a nylon-bristle brush. The residues were then combined, dried at 110 C for about 17 hours, and weighed. The corrosion which had occurred in each container was measured by the weight of the corrosion residue obtained at the end of each two-month test period.

Three separate two-month tests were conducted using ten fire extinguishers in all. Upon completion of all tests the extinguishers were cut in half vertically. The linings were examined visually to determine their condition, and photographs were taken of each.

Tests

Test No. 1. Five new extinguishers (one from each manufacturer) were cleaned with a nylon-bristle brush. After a careful rinsing, they were filled with a 24-percent lithium chloride solution containing the 0.5-percent sodium dichromate-0.2-percent oxalic acid inhibitor, and placed in a constant-temperature box at 140 F for a period of two months.

Test No. 2. After cleaning, the same extinguishers were used in Test No. 2. In this test, the lithium chloride solution contained only sodium dichromate (0.5%) as the corrosion inhibitor. The test conditions were identical with those in Test No. 1.

Test No. 3. The extinguishers used in the first two tests and the remaining five new extinguishers were employed in the final test. The interiors of the new extinguishers were cleaned as in Test No. 1. Each extinguisher was filled with a 24-percent lithium chloride solution containing corrosion inhibitors as listed in Table II. Test conditions remained unchanged.

Table II. Corrosion Inhibitors

Manufacturer	Material	Inhibitor	pH
American-La France	New/Bronze	None	7.3
Elkhart	New/Brass	0.5% Sodium dichromate	3.6
Fyr-Fyter	New/brass	0.5% Sodium dichromate - 0.2% oxalic acid	1.5
Kidde	New/Bronze	0.5% Sodium dichromate	3.6
Pyrene C-O-TWO	New/Brass	0.5% Sodium dichromate	3.6
American-La France	Used/Bronze	0.5% Sodium dichromate	3.6
Elkhart	Used/Brass	0.5% Sodium dichromate - 0.2% oxalic acid	1.5
Fyr-Fyter	Used/Brass	0.5% Sodium dichromate	3.6
Kidde	Used/Bronze	0.5% Sodium dichromate - 0.2% oxalic acid	1.5
Pyrene C-O-TWO	Used/Brass	0.5% Sodium chromate	8.3

TEST RESULTS

Previous Tests

Previous Laboratory tests of a large number of corrosion inhibitors showed that sodium dichromate, either alone or combined with oxalic acid, was the most suitable for use with the 24-percent lithium chloride solution.² During those tests both stainless steel and brass test panels had been given excellent protection. However, tests using 2-1/2-gallon stainless steel fire extinguishers showed severe attack by the inhibited lithium chloride solution along seams and welds, Figures 1 and 2 (figures taken from Reference 2). The attack by the inhibited lithium chloride solution at the seams and welds of the stainless steel extinguishers was so severe that the extinguishers did not survive a two-month test period, Figure 2 (arrows show locations of perforations).



Figure 1. Intergranular corrosion inside 2-1/2-gallon stainless steel extinguisher.



Figure 2. Crevice corrosion and intergranular corrosion of stainless steel.

Present Tests

When lithium chloride solutions were tested inside a lead-lined brass or bronze container, the addition of sodium dichromate inhibitor gave the best protection. Reference to Tables III and IV shows that in almost every instance the quantity of corrosion residue obtained at the end of each two-month test using sodium dichromate alone, at pH 3.6 was approximately one-tenth of that for sodium dichromate-oxalic acid at pH 1.5. At pH 8.3 sodium chromate (sodium dichromate-sodium hydroxide) the quantity of corrosion residue was also greater than that at pH 3.6. At pH 1.5 the corrosion was of the same magnitude as that obtained where no inhibitor was used.

When using either inhibitor (sodium dichromate or sodium dichromate-oxalic acid), the greatest amount of corrosion residue was obtained from the Elkhart and Pyrene C-O-TWO extinguishers, Table III.

Table III. Corrosion Residue, Tests 1 and 2

Extinguisher	Test 1* Residue***	pH	Test 2** Residue***	pH
Elkhart	3.93	1.5	0.50	3.6
Pyrene C-O-TWO	2.89	1.5	0.39	3.6
American-La France	2.17	1.5	0.27	3.6
Fyr-Fyter	1.78	1.5	0.22	3.6
Walter Kidde	1.67	1.5	0.13	3.6

* Inhibitor - 0.5% sodium dichromate - 0.2% oxalic acid

** Inhibitor - 0.5% sodium dichromate

*** Residue weight in grams

Table IV. Corrosion Residue, Test 3

Extinguisher	Inhibitor	pH	Residue (grams)
Elkhart†	0.5% sodium dichromate -0.2% oxalic acid	1.5	2.46
Pyrene C-O-Two†	0.5% sodium dichromate (plus NaOH)	8.3	1.17
American-La France†	0.5% sodium dichromate	3.6	0.27
Fyr-Fyter†	0.5% sodium dichromate	3.6	0.22
Walter Kidde†	0.5% sodium dichromate -0.2% oxalic acid	1.5	2.10
Elkhart‡	0.5% sodium dichromate	3.6	0.25
Pyrene C-O-TWO‡	0.5% sodium dichromate	3.6	1.3‡
American-La France‡	No inhibitor	7.3	2.32
Fyr-Fyter‡	0.5% sodium dichromate -0.2% oxalic acid	1.6	2.42
Walter Kidde‡	0.5% sodium dichromate	3.6	0.21

† Used in Tests 1 and 2

‡ New extinguisher

Visual inspection of the ten containers of Test 3 revealed severe losses of lining in several instances. It should be noted here that five of these had been used three times over a period of six months, and five had been tested for two months. Figures 3 through 7 show the relative condition of the inside of the containers. Pitting can be observed on the linings of all of the specimens exposed for six months. In Figures 4 and 7 the corrosion of the lining of the Elkhart and Pyrene C-O-TWO extinguishers has exposed large areas (see arrows) of brass. The attack appeared to have started at pin-hole breaks in the

lining and at the seam around the bottom of the container. The silicon bronze containers are of welded construction and contain seams vertically and around the top and bottom, as shown in Figures 3 and 6. Although seams are more susceptible to attack than plain surfaces, no failure of the lining had occurred at the seams in the silicon bronze extinguishers. Variations in the tin-lead ratio of the lining materials were not great and were not considered to be an important factor in the failure of these linings.

The stained area in the Kidde bronze container, as shown in outline in Figure 6, was caused by brass-corrosion products which originated in the area of the outlet at the top of the container. This same condition can be observed to a lesser degree in some of the other photographs.

When the cut edges of the containers were viewed through a 30-power lens, the lining in the Fyr-Fyter appeared to be the only one that was thick enough to afford much further protection. All others were very thin. The Elkhart and Pyrene C-O-TWO linings were perforated, and the linings on the Walter Kidde and American-La France containers were badly pitted. Perforation would soon have occurred in these had the test period been lengthened. The lining in the Fyr-Fyter showed the least evidence of attack, as can readily be seen in Figure 5. This extinguisher also produced the smallest amount of corrosion residue and had the greatest residual thickness when the test was completed.

Any container found suitable for use with the lithium chloride solution must also withstand an internal pressure near 500 psi. A slow-burning propellant was developed by the Naval Research Laboratory for use in the 2-1/2-gallon fire extinguishers. This propellant produces pressure in the neighborhood of 500 psi in the effluent hose or nozzle is clogged with ice or foreign matter. Brass and bronze lead-alloy lined containers tested to withstand this pressure are commercially available.

CONCLUSIONS

1. Sodium dichromate (0.5 percent by weight) at pH 3.6 will protect lead-alloy-lined drawn brass or silicon bronze fire extinguishers from the corrosive action of a 24-percent lithium chloride solution. A heavy lining of lead alloy (0.005-inch minimum) is necessary to protect the inside of the container.
2. Sodium dichromate (0.5 percent)-oxalic acid (0.2 percent) at pH 1.6 will protect stainless steel from attack by a 24-percent lithium chloride solution.

3. Sodium dichromate (0.5 percent)-oxalic acid (0.2 percent) will not protect welds or seams in stainless steel. (All current stainless steel 2-1/2-gallon fire extinguishers contain welds and seams.)

4. Welds and seams are areas of potential attack by corrosion.

RECOMMENDATIONS

1. That sodium dichromate at 0.5 percent by weight be used as the inhibitor for the 24-percent lithium chloride solution. The inhibited solution would contain 76 lb water, 24 lb lithium chloride and 0.5 lb of sodium dichromate.

2. That stainless steel extinguishers not be used as containers for lithium chloride solution.

3. That silicon bronze containers, because they are fabricated with welds and seams, not be used with lithium chloride solutions.

4. That the 2-1/2-gallon extinguishers be constructed of seamless drawn brass, lined with a minimum of 0.005 inches of a lead alloy and pressure-tested to 500 pounds per square inch.

5. Because sodium dichromate is a toxic material, it is recommended that contact with skin and eyes be avoided and that contaminated parts and clothing be thoroughly washed with soap and water.⁴

REFERENCES

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2. U. S. Naval Civil Engineering Laboratory. Technical Note N-328. Corrosion Inhibitors for Lithium Chloride Solutions, by C. V. Brouillette. 27 January 1958.

3. Uhlig, H. H. Corrosion Handbook, John Wiley and Sons, Inc., New York, 1948, p 213.

4. Sax, N. Irving. Handbook of Dangerous Materials, Reinhold Publishing Corporation, New York, 1951, pp 102-103.

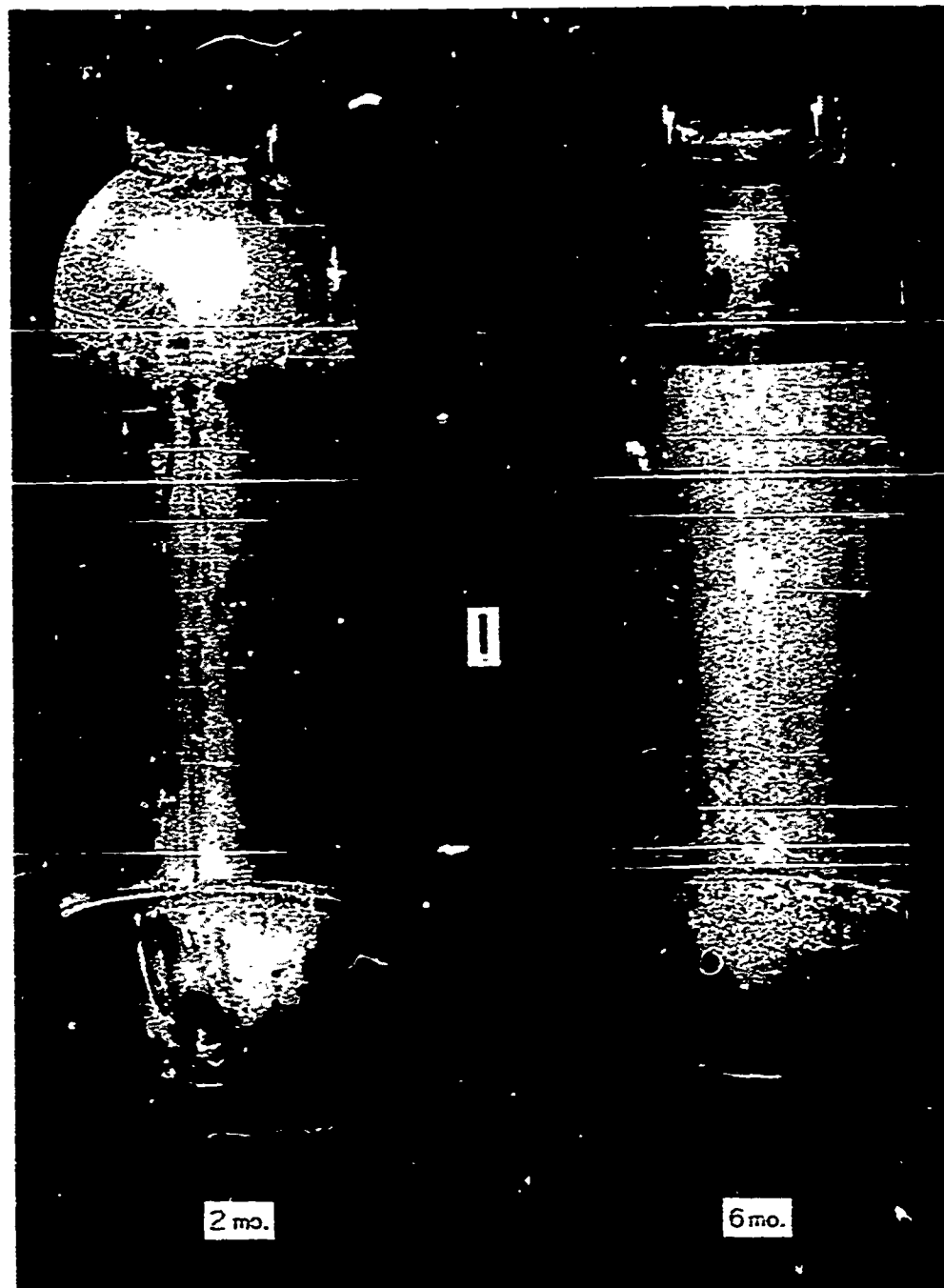


Figure 3. American-La France, Model 3H-2, Silicon Bronze.

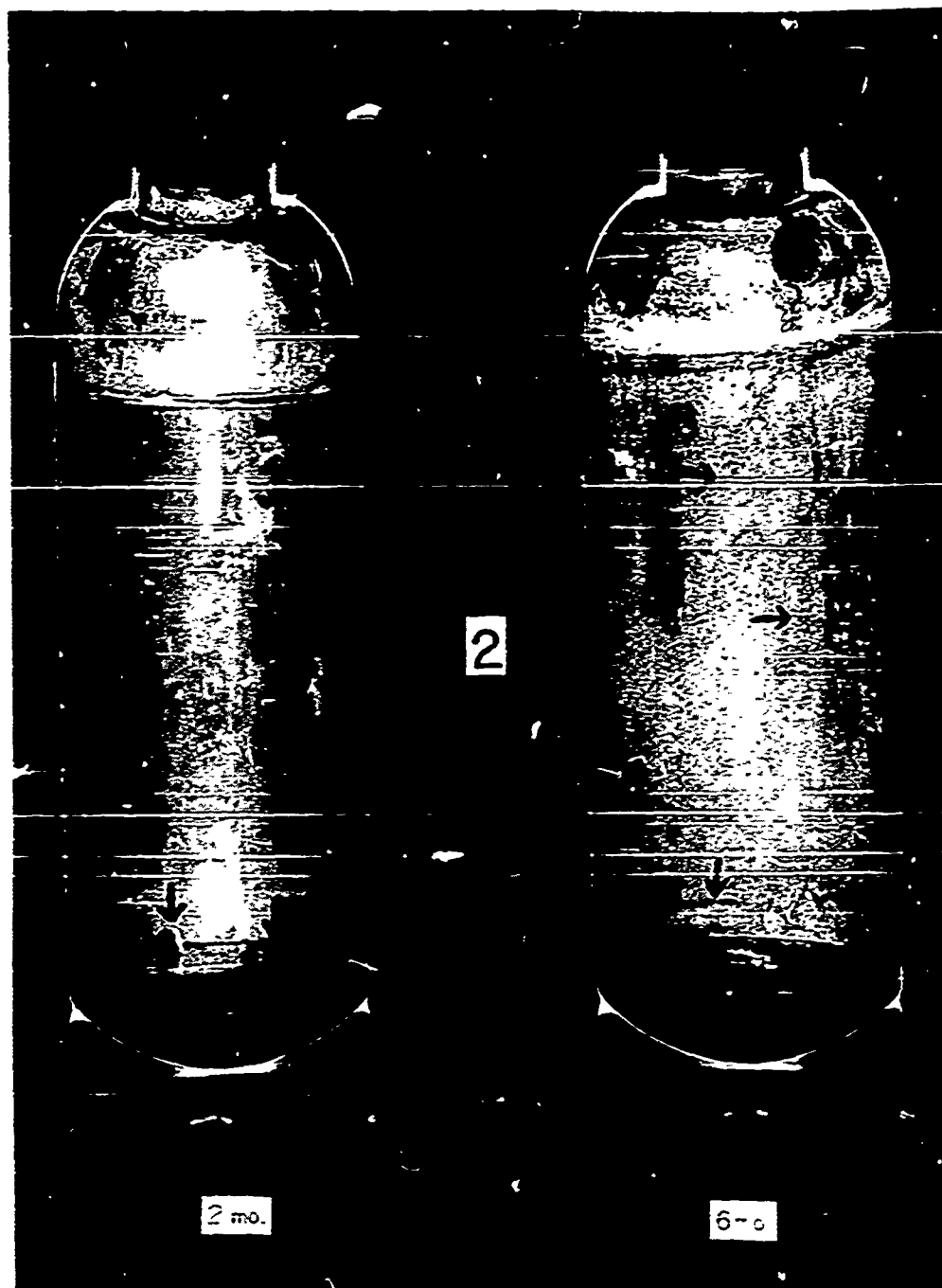


Figure 4. Elkhart, Model No. X-A, Drawn Brass.

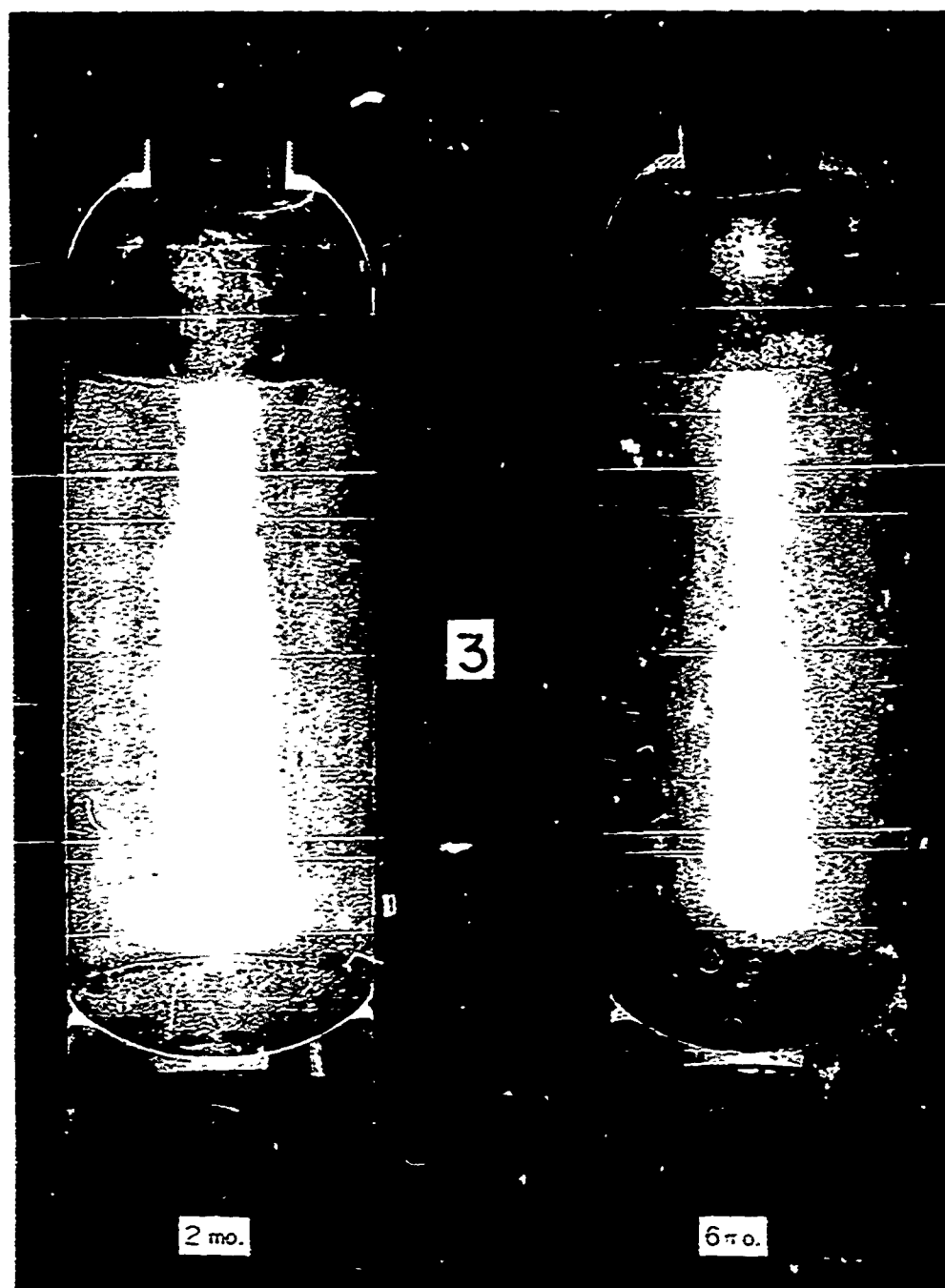


Figure 5. Fyr-Fyter, Model 94-11, Drawn Brass.

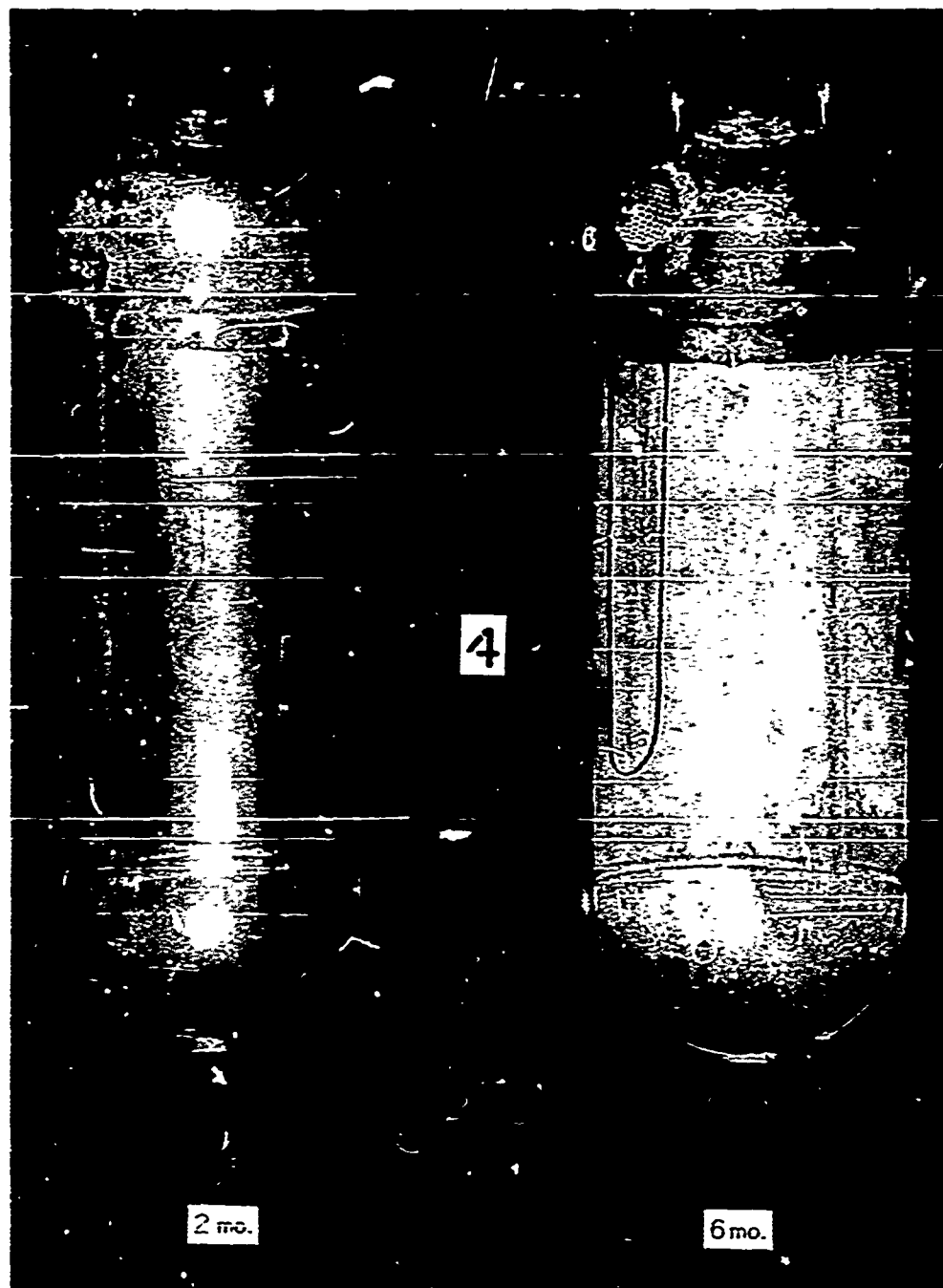


Figure 6. Kidde, Model KAM, Silicon Bronze.

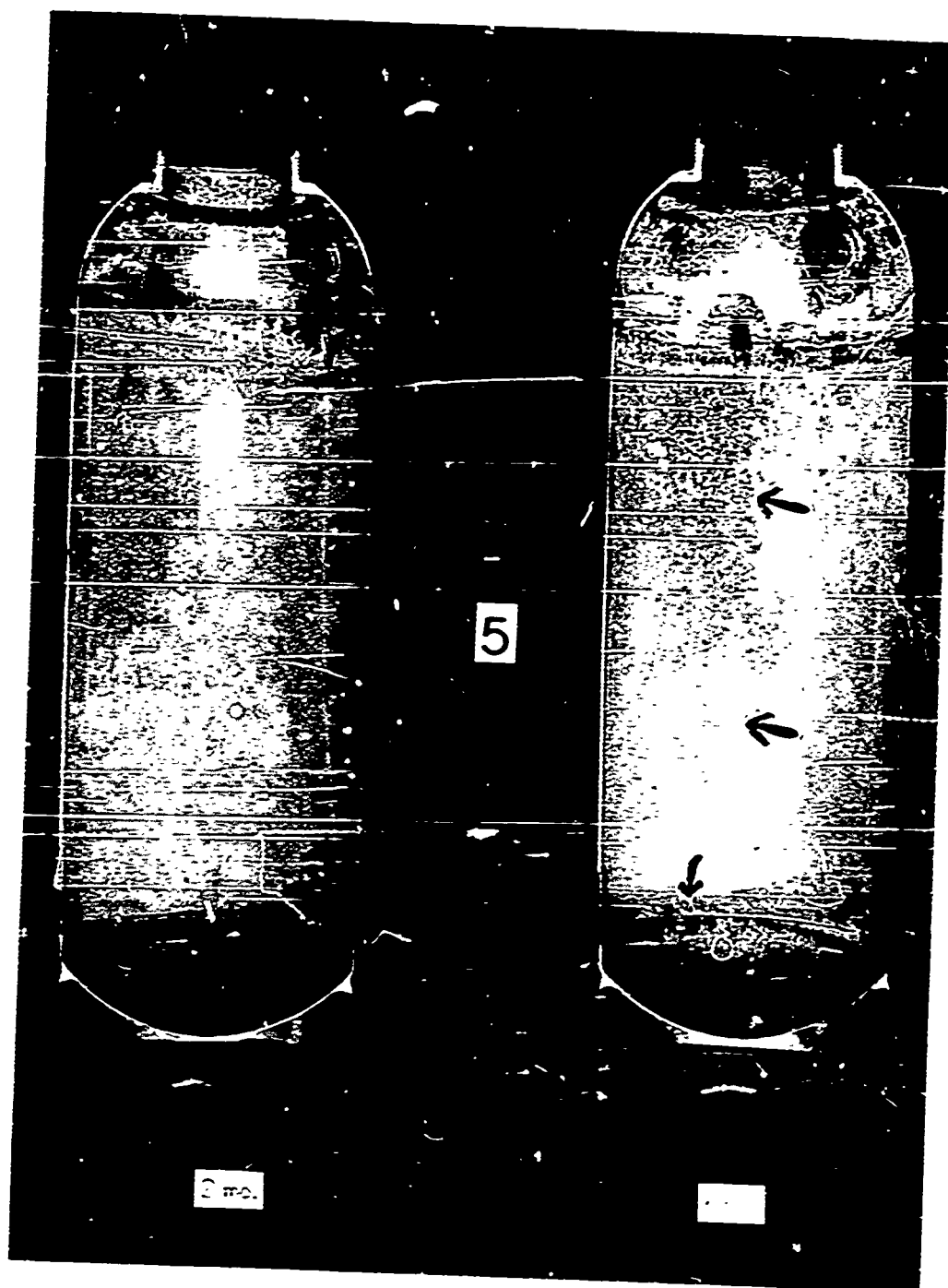


Figure 7. Pyrene C-O-TWO, Model W-13, Drawn Brass.

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