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PROTECTION OF FLOATING PONTOONS FROM CORROSION -- PART I. INSTALLATION AND INITIAL PERFORMANCE OF TEST FLOATS

by

Richard W. Drisko, Ph. D.

17 April 1967

INTERNAL WORKING PAPER

U. S. NAVAL CIVIL ENGINEERING LABORATORY
Port Hueneme, California

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Y-F015-11-04-632A

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ABSTRACT

A test program has been initiated that is aimed at reducing the maintenance costs associated with the recoating of deteriorated pontoon camel floats. Three 2-coat protective coating systems have been applied to pontoons on three test floats, and a material and labor cost analysis has been made on coating pontoons with each of these systems. A separate phase of the investigation is aimed at corrosion mitigation by cathodic protection. One of the test floats is currently being protected with zinc anodes, another with aluminum anodes, and the third float is serving as an unprotected control. After six months service to the fleet, the test pontoon camel floats were in good condition. No coating deterioration was noted, and the cathodic protection systems were providing electrical potentials that insure complete protection from corrosion to any exposed steel.

INTRODUCTION

Steel pontoons are one of the most widely used structural components in the Naval Shore Establishment. While they find many uses ashore, they are more commonly used in water to impart floatation to structures.

The Navy Public Works Center, San Diego, requested assistance from the Naval Facilities Engineering Command and the U. S. Naval Civil Engineering Laboratory in a program designed to reduce the cost of maintaining pontoon floats used as camels by ships of the fleet berthing at Navy docking facilities in San Diego Bay. This type of camel is widely used throughout the Naval Shore Establishment as a fender system to prevent abrasion damage to moored vessels. While thus serving the fleet, the protective coatings on these floats are subjected to extensive impact and abrasion damage in addition to their usual deterioration in an hostile marine environment.

BACKGROUND

The Navy utilizes about 450 pontoon camel floats of differing size and design in service to the fleet in San Diego Bay. They are secured to a centrally-located pier (Figure 1) from which they can be readily delivered to ships desiring their use. It has been the standard practice at PWC, San Diego, to protect the steel pontoons from corrosion with a protective coating of MIL-C-18480A, a cold-applied coal tar coating. Because of the deterioration of this coating by abrasion, fouling organisms, and other environmental factors (Figure 2), it has been necessary to recoat the floats annually.

The Navy Public Works Center, San Diego, desired that the maintenance cycle for camel floats be extended to at least three years. In order to further reduce maintenance costs, they desired that the coating be applied in no more than two coats. Accordingly, three two-coat protective coating systems were selected for testing on pontoon camel floats in San Diego Bay.

Much of the damage to camel floats occurs below the water line, causing them to sink. Thus cathodic protection was also investigated in this study as a means of extending the service time of the floats before required overhaul and thus further reducing maintenance costs.

TEST DESIGN

Three coating systems utilizing a corrosion-inhibiting primer and a compatible topcoat were selected for use in the test program. The selections were based on performance of the coatings on mooring buoys,[1-8] steel sheet piling,[9-13] and other steel specimens[14] located in a marine environment. The three systems are described below and their sources and analyses are given in Appendices A and B, respectively.

Paint System 1 consists of one coat of epoxy-polyamide primer (Devran 201) and one epoxy-polyamide topcoat (Devran 204). In previous work[1-14] polyamide-cured epoxies have been found to have good abrasion resistance and perform well in a marine environment.

Paint System 2 consists of one coat of an epoxy-polyamide primer (Proline 2001) and a coal tar epoxy topcoat (Proline 2002). The coal tar epoxy coating imparts good resistance to moisture penetration. Although some coal tar epoxies tend to become brittle when exposed to ultraviolet light, System 2 has performed well in San Diego Bay on a limited number of pontoon floats, as well as on the underwater portion of a test mooring buoy.

Paint System 3 consists of one coat of self-cured zinc inorganic silicate (Carbo-Zinc 11) and one coat of high-build polyamide-cured epoxy (Carboline 190 HB). Zinc inorganic silicates without a topcoating have provided good protection to steel in sea water for two or more years, and a topcoat should extend their service lives considerably. A self-cured rather than a post-cured zinc inorganic coating was used to reduce labor costs. Paint systems similar to System 3 have been used extensively to protect the atmospheric portions of off-shore drilling platforms.

Two different types of sacrificial anodes were utilized in the cathodic protection portion of the investigation. Both of these, zinc and aluminum, have previously been investigated by the Navy for other related work. In the test program, three pontoon camel floats were in-service tested. One of these floats was cathodically protected with zinc anodes, a second with aluminum anodes, and the third was not cathodically protected but served as a control.

Each test float consisted of three pontoons spaced a pontoon length apart and secured together with steel angle-iron bracing (Figure 3). They are commonly called 1x5's, because they have a width of one and a length of five pontoons. The test design for the three floats is shown in Figure 4. Each of three paint systems investigated was applied to one of the three pontoons in each test float. The pontoons in each float were arranged randomly as shown in Figure 4, so that each coating system would have the same magnitude of exposure to impact and abrasion damage. The design also permitted a study of the effect of each cathodic protection system on each of the three coating systems.

FABRICATION OF TEST FLOATS

The three test floats were fabricated along with other pontoon camel floats by PWC, San Diego, personnel as part of the regular work schedule. The pontoons were individually coated before the float was assembled (Figure 5). The sandblasting of the steel to white metal and the coating application were done by skilled workmen according to instructions provided by the NCEL project scientist and the coating suppliers. No difficulty was encountered in applying any of the coatings. There was some loss of the topcoat of System 1, however, because of high winds that arose during application of this coating. The thickness of each component of the three test coating systems is given in Table 1. Material and labor coats associated with coating application were determined for each coating system, so that the annual maintenance cost for coating of a pontoon camel float with each of the test coatings can be determined at the conclusion of the test.

COST ANALYSIS

An analysis of the costs (other than that for coating materials) for coating three pontoons is given in Table 2. It can be seen from this table that such costs totaled $56.84, regardless of which coating system was used. The coating material costs and coverages for three pontoons are given in Table 3. The relatively high cost of the primer of System 3 is related to the high cost of its zinc pigmentation. The overall cost for coating three pontoons with each of the test coating systems is given in Table 4. It can be seen from this table that the range of costs per square foot ($.22-.25) is so small that if one of the systems gave as little as 15% greater service life, it would be the most economical one to use.

The pontoons in the test floats have a draft of about 1½ feet (about 1/3 the height), as shown from the level of the fouling on Figure 2, and consequently require very little anode metal to protect them cathodically. Thus two small, flat sacrificial anodes were secured to each cathodically protected pontoon, one on each side near the bottom where they will be continually immersed in sea water. They were secured with nuts to steel studs welded to the pontoons for easy removal and replacement. The weights and costs of these anodes are given in Table 5. Although the initial cost of the aluminum is greater than that of zinc, its relative current output and efficiency are reported by the supplier to make aluminum competitive with zinc. In any case, a long service life at very low cost is expected from each type of anode.

PERFORMANCE TO DATE

The three test camel floats were placed in the storage area (Figure 6) along with other such floats available for fleet use. These floats are being used extensively by the fleet (Figure 7) receiving the type of service for which they were designed. In such use, they accumulate a film of oil at the water line from floating oil in the harbor and an accumulation of miscellaneous debris dumped over the side of the moored vessels (see Figure 7). Nevertheless, the three coating systems have provided excellent service with no apparent damage after six months of service to the fleet. The tops of the pontoons were cleaned with sea water and a stiff bristle brush before examining the coating.

The two cathodically protected floats are receiving excellent protection from their anodes. The pontoon-to-water potentials were measured with a portable field meter using a silver-silver chloride reference half-cell. The float protected by zinc anodes had a potential of -1.04 volts and the float protected by aluminum anodes had a potential of -1.00 volts. Both are well above the level of -0.85 volts considered to be necessary for complete protection. One obvious difference in the electrodes is that the zinc anodes are free of fouling while the aluminum anodes have much loose tunicate fouling on them. This has mistakenly caused workmen in the area to believe that the aluminum anodes were not functioning properly.

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Table 1. Descriptions of Coating Systems

System Number	Primer			Topcoat			Total Thickness (mils)
	Type	Proprietary Name	Thickness (mils)	Type	Proprietary Name	Thickness (mils)	
1	Epoxy-Polyamide	Devran 201	3	Epoxy-Polyamide	Devran 204	4	7
2	Epoxy-Polyamide	Proline 2001	4	Coal Tar Epoxy	Proline 2002	4	8
3	Zinc Inorganic	Carbo-Zinc 11	3	Epoxy-Polyamide	Carboline 190 HB	6	9

Table 2. Surface Preparation and Application Costs for Three Pontoons for Each Coating System[1/]

Laborer	Time (hours)	Hourly Rate	Cost per 3 Pontoons
Sandblaster	3	2.93[2/]	8.79
Sandblaster Helper	3	2.93[2/]	8.79
Painter	7[3/]	3.68[2/]	25.76
Total Labor Costs[4/]			$43.34
Cost of 1½ Tons of Sand			13.50
Total Costs			$56.84

1/ Each system required the same labor time.
2/ Includes additional increment for dirty work.
3/ Includes mixing and clean-up time.
4/ Labor was the same for applying topcoats as for applying primers.

Table 3. Coating Material Costs and Coverages for Three Pontoons

System Number	Coating Materials				Coverage (sq ft per gal)
	Type	Amount (gal)	Total Cost (dollars)	Cost (per sq ft)*	
1	Primer	3	27.30	0.05	200
	Topcoat	4	36.40	0.06	150
	Thinner	3½	11.73	0.02	
	Total		75.43	0.13	
2	Primer	5	39.50	0.07	120
	Topcoat	5	29.95	0.05	120
	Thinner	3	5.40	0.01	
	Total		74.85	0.13	
3	Primer	4	52.80	0.09	150
	Topcoat	4	33.00	0.06	150
	Thinner	2	7.20	0.01	
	Total		93.00	0.16	

* Assuming 600 sq ft total surface area for three pontoons, including hardware.

Table 4. Overall Cost in Dollars for Coating Pontoons

System Number	Material Costs				Labor Costs				Total Cost	Cost per Sq. Ft.
	Coatings		Sand		Coatings		Sandblasting			
	per 3 pontoons	per sq ft	per 3 pontoons	per sq ft	per 3 pontoons	per sq ft	per 3 pontoons	per sq ft		
1	75.43	0.13	13.50	0.02	25.76	0.04	17.58	0.03	132.57	0.22
2	74.85	0.13	13.50	0.02	25.76	0.04	17.58	0.03	131.69	0.22
3	93.00	0.16	13.50	0.02	25.76	0.04	17.58	0.03	149.84	0.25

Table 5. Description of Anodes

Anode Material	Weight (pounds)	Cost (dollars)	Cost per Pound of Anode Metal* (dollars)
Zinc	11	3.57	.32
Aluminum	9.6	7.00	.81

*Assuming the steel core of each anode to weigh 1.4 lbs.

APPENDIX A

Suppliers of Proprietary Coatings

Devran 201 and Devran 204:	Devoe and Raynolds Company, Inc. 2625 Durahart Street Riverside, California 92507
Proline 2001 and Proline 2002:	Pro-Line Paint Company 2545 Main Street San Diego, California 92113
Carbo-Zinc 11 and Carboline 190 HB:	Carboline Company 32 Hanley Industrial Court St. Louis, Missouri 63144

APPENDIX B Analyses of Test Paints

System Number	Test Paint	Weight Per Gal.	Nonvolatile (%)	Drying Time* (Min.)		Viscosity (KU)	Pigment (%)
				Set-To-Touch	Dry Hard		
1	Devran 201 (epoxy)	12.5	70.8	12	300	76	49.5
	Devran 201 (converter)	9.4	62.9			65	24.5
	Devran 204 (epoxy)	10.9	67.2	5	1,020	74	38.6
	Devran 204 (converter)	11.5	62.8			68	46.8
2	Proline 2001 (epoxy)	14.8	77.5	5	450	85	63.0
	Proline 2001 (converter)	7.6	54.3			54	
	Proline 2002 (epoxy)	11.3	83.0	10	480	110	47.4
	Proline 2002 (converter)	7.7	64.8			62	
3	Carbo-Zinc 11 (resin)	9.1	38.8	1	8	**	23.4
	Carboline 190 HB (comp.A)	9.3	83.6	6	480	82	51.0
	Carboline 190 HB (comp.B)	10.6	69.6			63	44.0

*For mixed components for two component systems
**Too thin for determination

Figure 1. Pontoon camel floats in storage ready for use by the fleet.

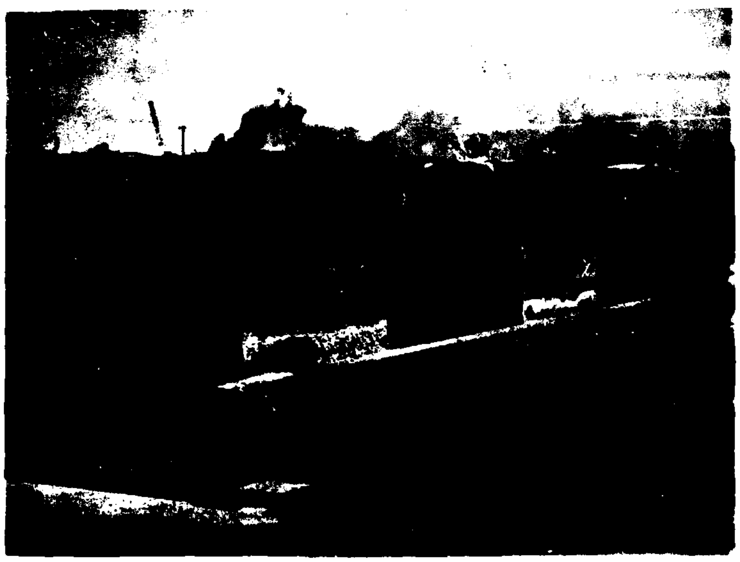

Figure 2. Deteriorated pontoon camel float.

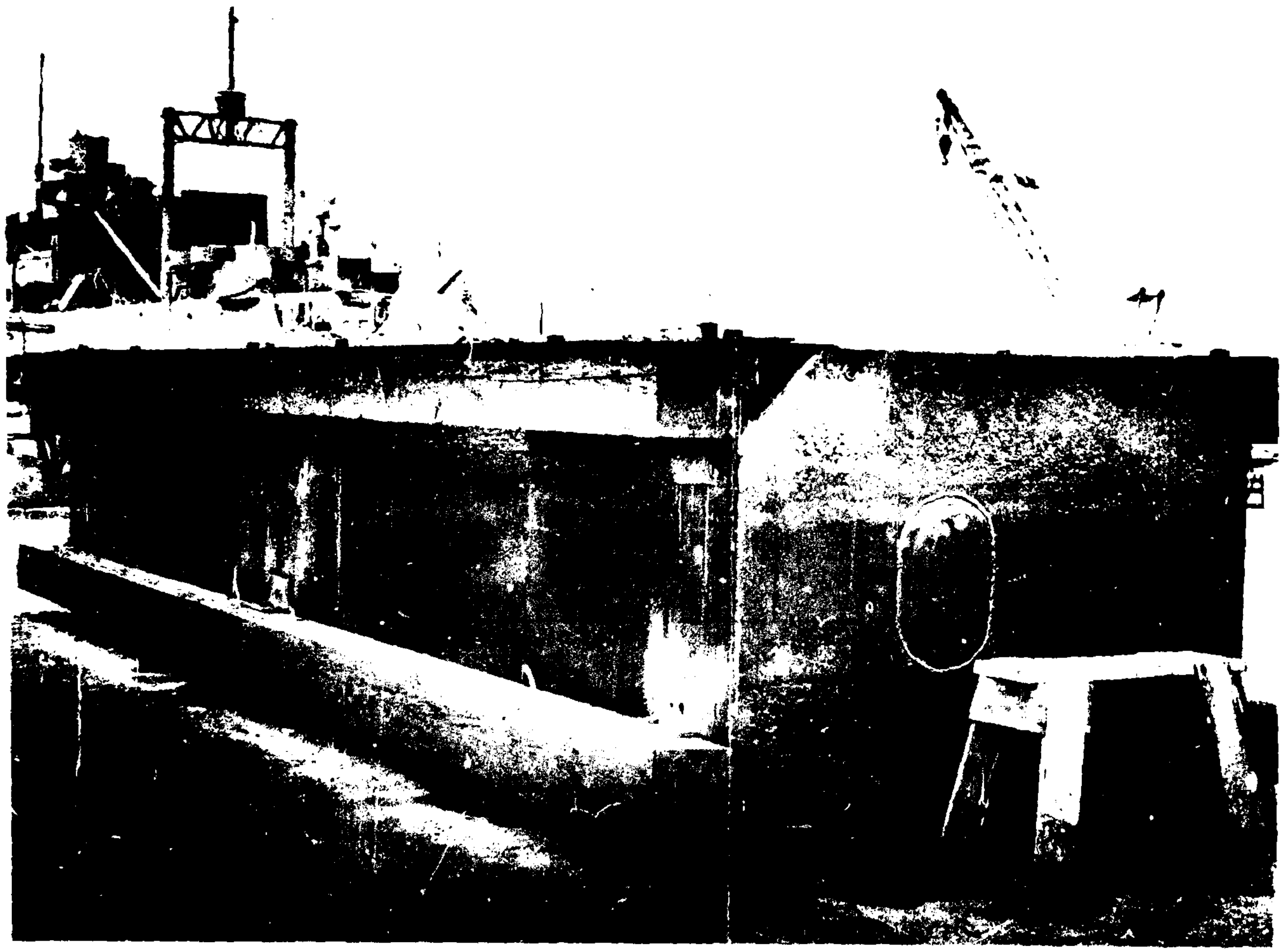

Figure 3. Completed pontoon camel float ready for service.

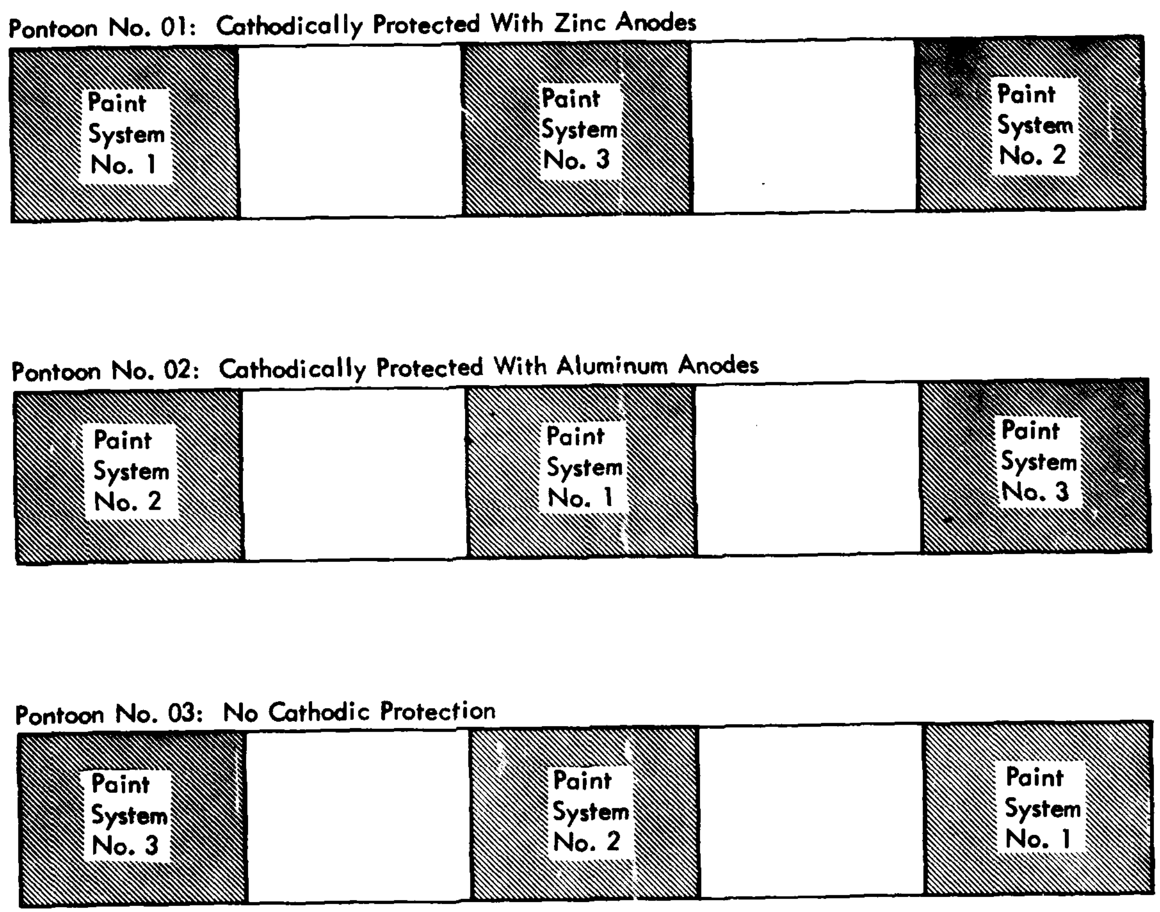

Figure 4. Design of Pontoon Float Test.

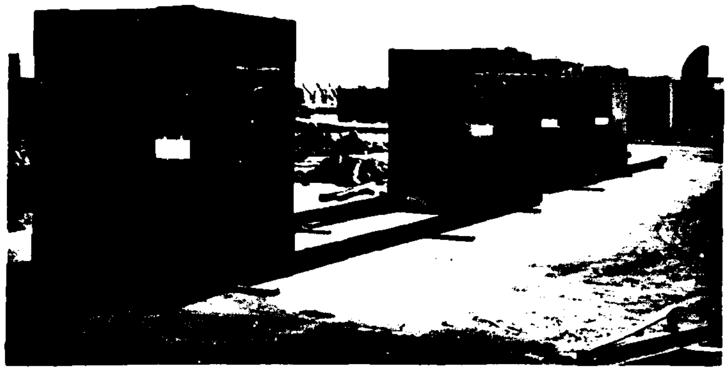

Figure 5. Partially fabricated test floats. Note the anode secured to each pontoon.

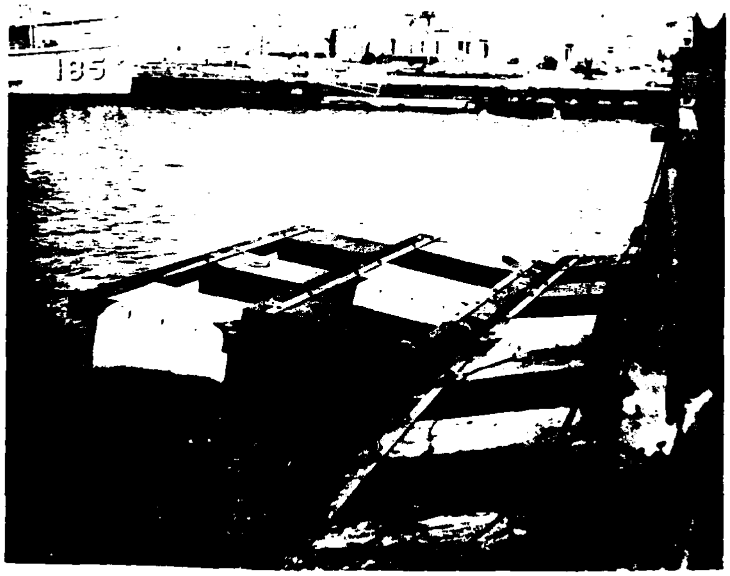

Figure 6. Test pontoon floats in storage available for use by the fleet.

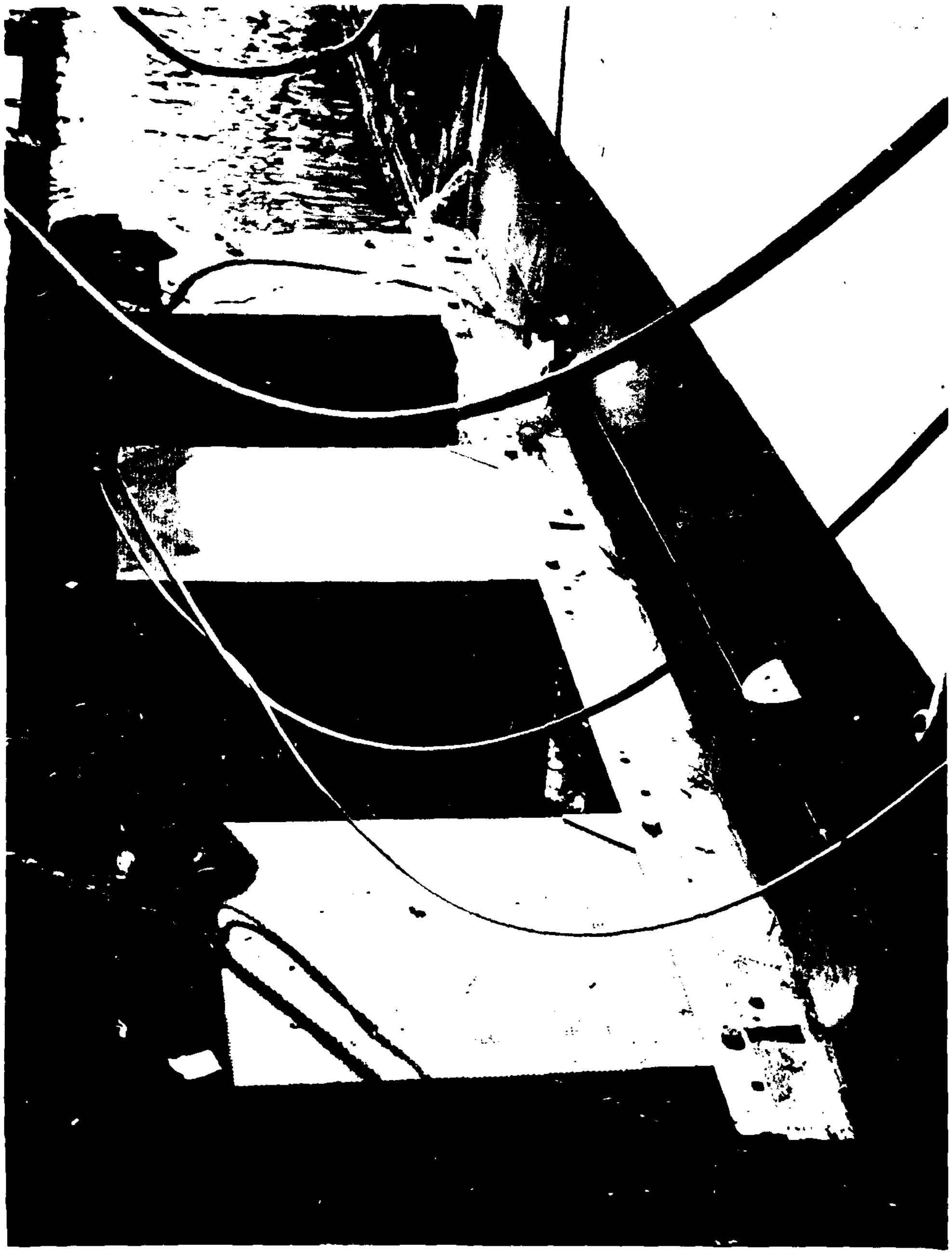

Figure 7. Test pontoon float serving the fleet.

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13. ABSTRACT

A test program has been initiated that is aimed at reducing the maintenance costs associated with the recoating of deteriorated pontoon camel floats. Three 2-coat protective coating systems have been applied to pontoons on three test floats, and a material and labor cost analysis has been made on coating pontoons with each of these systems. A separate phase of the investigation is aimed at corrosion mitigation by cathodic protection. One of the test floats is currently being protected with zinc anodes, another with aluminum anodes, and the third float is serving as an unprotected control. After six months service to the fleet, the test pontoon camel floats were in good condition. No coating deterioration was noted, and the cathodic protection systems were providing electrical potentials that insure complete protection from corrosion to any exposed steel.

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