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CHEMISTRY DIVISION - CORROSION AND DE-ICING SECTION

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A STUDY OF THE PERFORMANCE OF VARIOUS METALS AS IGNITER CONTACT RINGS ON THE FIVE INCH SSR ROCKET MOTOR

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Report P-2671

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NRL Problem P-121

ABSTRACT

Fourteen metals were examined with respect to the influence of exposure on their electrical contact resistances. None of these bare metals performs with satisfaction after exposure to high humidity and to salt spray.

Several organic coating materials were also investigated to determine whether they improve the performance of these metals. Rust inhibitive oils were of no value. Rust inhibitive greases of the paralketone type were moderately successful on silver plated metals only. Strippable lacquer films portected steel and silver well but were of little or no value on copper base alloys and zinc.

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INTRODUCTION

A. Authorization

1. This study was conducted under the authority of Bureau of Ordnance Project Order No. E-4795.

B. Statement of Problem

2. A number of failures of 5" SSR rockets has been experienced because of corrosion of the igniter contact rings made of cadmium or zinc plated steel. Corrosion had occurred during the period between packing in the factories and use during combat. This corrosion could have occurred while the rocket motor tubes were in their cases where conditions of high humidity sometimes existed or after unpacking when the rockets are placed in the launching racks and exposed to sea water spray until launched.

3. The products of corrosion deposit on the igniter contact ring in the areas where corrosion occurs. This product has a high electrical resistance and does not permit passage of sufficient current to fire the propellent charge.

4. This study was planned and carried out to determine the relative performance of a number of metals which conceivably could be substituted for the original, unsatisfactory metals. It was also an objective of this investigation to explore the possibility of using certain types of protective organic coatings.

METHODS

A. Materials

5. The metals examined for use as igniter contact rings are listed in Table I. An oil-type rust inhibitive material containing 2% zinc naphthenate in 10 W lubricating oil was investigated as were two grease-type rust inhibitors. The greases were, respectively, a proprietary compound, Alox-L-1200, made by the Alox Corporation and a sample conforming to Bureau of Ships specification 52-C-18. Protection of the igniter contact ring by use of a strippable lacquer was explored by use of a proprietary material, namely, DuPont Strippable Lacquer J200x7012.

B. Description of Experiments

6. Because of the considerable weight and size of the actual SSR rocket motor tubes and in order to reduce the number removed from production lines, a test unit was devised to simulate the actual design of the contact rings. To facilitate the preparation and evaluatioh of the materials, a flat specimen was designed as indicated in Plate 1 and Figure I. This may be compared with the actual igniter contact ring shown in place on a rocket motor tube in Plate 2. The steel motor tube is represented by the parts A-A, the bakelite insulator by B, and the igniter contact ring by C. Since in the actual rocket the ring is connected electrically to the tube through a low resistance igniter fuse, the simulated igniter contact ring is shorted to the steel part by the assembly bolts. This arrangement presented a galvanic couple established

by the tube and ring when salt water bridged over the insulator.

7. The component parts of these specimens were of the same length in the early specimens, as indicated in Plate 4, but in a later design the igniter contact band was made longer than the other parts to afford better electrical contact with the band. Plate 5 illustrates this type of specimen. Before all exposures the bolt heads were coated with a microcrystalline wax to prevent extraneous effects.

8. During exposure, all specimens were tipped at a very slight angle with the horizontal to permit adequate "bridging" by electrolyte over the bakelite insulator. This angle was not great enough to permit rapid drainage of the surface and therefore allowed the surfaces to remain wet the maximum length of time. As a result, maximum corrosion rates were obtained along with existing galvanic effects.

9. In addition to exposing these bare metal assemblies, some of the same metal systems were coated before exposure with the organic materials described earlier in this report.

10. Each metal system was exposed in duplicate to two different conditions. The first set was exposed for 100-200 hours in continuous, 20% salt spray at 95°F, an environment corresponding to the joint Army-Navy Specification AN-QQ-S-91 and Army Quartermaster Corps tentative specification OQMG No. 156A. The second set of each system was exposed at 95°F, to a cyclic humidity test of 100% R.H. with condensation for 8 hours and 80% R.H. for 16 hours. The specimens protected with the organic coatings were exposed only in the salt spray test. The exposures were terminated after 200 hours or earlier if the specimens became badly corroded; duration of exposures is indicated in the data presented in this report.

11. After exposure, the specimens were dried thoroughly and their electrical contact resistances were determined by use of the arrangement illustrated in Plate 3. A standard contact pin C was pressed against the specimen S by a force of 10 lbs. A potential of 2 volts was applied through the variable resistance R which was adjusted to permit a current of 1 ampere. The potential or IR drop across the contact was measured by means of the potentiometer P. Since the current was one ampere, the potentiometer reading was in ohms directly. The wiring diagram for this test circuit is given in Figure I. When evaluating the protective coatings, the strippable films were removed. No attempt was made to remove the oil or grease coatings since they were soft and easily penetrated by the firing pin.

RESULTS

A. Data Obtained

12. The condition of the exposed bare metal systems is illustrated by photograph in Plates 4-14, inclusive. In each plate, the specimen on the left was exposed to salt spray, the one on the right to high humidity. Photographs of the specimens with protective coatings are not presented.

13. In Tables II, III and IV are collected the contact resistances observed before and after exposure of the bare metal specimens. In column 1 is listed the metal used for contact resistance measurements; column 2 gives the history of the surface. The succeeding columns contain readings in ohms which were obtained at random points on the surfaces being measured.

14. Table V presents similar data obtained on several metals protected by rust inhibitive oil and grease. The data of Table VI is for exposed surfaces which had been protected by strippable lacquer films. All coated specimens were exposed to salt spray only. This was done because of the belief that their resistance to this environment is less than to high humidity and that satisfactory performance in the most severe conditions is necessary.

15. The samples were weathered in either the salt spray environment or in the high humidity for a maximum of 200 hours. However, several metals became so severely corroded, it was unnecessary to continue their exposure for the full 200-hour period. In the cases where this was done, it is indicated in the tables of resistance measurements.

B. Discussion of Results

16. In the humidity testing of bare metals, steel and zinc became seriously corroded in less than 20 hours. Cadmium showed some signs of corrosion in 150 hours. After drying, cadmium gave only fair electrical contact whereas zinc and steel exhibited very high contact resistances. Exposure to high humidity for 200 hours had negligible effects on the other metals tested.

17. The exposure to salt spray for 200 hours was sufficiently severe to cause all the metals to give poor contact performance. Steel, zinc, and aluminum gave by far the poorest performance; silver plate was probably the best but was not entirely satisfactory.

18. Since the performance of bare metals was not 100% satisfactory, attention was turned to several types of coatings. An oil-type rust preventive, two grease-type coatings, and one strippable lacquer were examined to determine whether they would be of any value and whether further studies would be desirable. The rust inhibitive oil showed no promise whatsoever on steel and zinc but did give good results on cadmium. Rust inhibitive greases performed satisfactorily on silver and cadmium. The greases were not satisfactory on steel, zinc and brass. The performance of grease-coated copper was erratic and therefore would not be dependable.

19. The strippable lacquer films failed to protect copper, brass and zinc; they were satisfactory on steel and silver. Cadmium was fairly well protected. The copper and brass became badly tarnished and blackened under the film with resultant high contact resistance.

CONCLUSIONS

20. None of the bare metals investigated give sufficiently low electrical contact resistance after exposure to salt spray.

21. Lubricating oil, grade 10W, containing 2% zinc naphthenate gives adequate protection to cadmium, electroplated on steel. It is of no value on steel and zinc.

22. Rust inhibitive grease, Alox L-1200, gives moderately good protection to silver, copper and brass but fails on steel and zinc.

23. Rust inhibitive grease, conforming to BuShips specifications 52C18 Type I, gives adequate protection to cadmium on steel but fails to protect steel, copper and zinc.

24. Strippable lacquer shows promise when used on mild steel, electroplated silver and cadmium. It fails on copper, brass, and zinc.

RECOMMENDATIONS

25. Bare metals should not be used as igniter contact rings on the 5" SSR rocket.

26. Cadmium, electroplated on steel, may be used if protected by a rust inhibitive oil or grease described in paragraphs 21 and 23.

27. Strippable lacquer of the type used in this investigation may be permitted on cadmium, mild steel, or silver.

TABLE I

METALS INVESTIGATED AS CONTACT RINGS

1. Cold Rolled Steel, SAE 1010
2. Stainless Steel, 18-8
3. Monel
4. Brass, 60-40
5. Copper
6. Aluminum, 2S
7. Zinc, electroplated on steel
8. Cadmium, electroplated on steel
9. Silver, electroplated on steel
10. Silver, electroplated on copper
11. Silver, electroplated on brass

TABLE II

Electrical Contact Resistances of Igniter Contact Rings

Contact Surface	Test[4]	RESISTANCE AT VARIOUS POINTS 1	2	3	4	5	6
Steel, 1010	A	.003	.004	.0027	.0039	.0027	.003
Steel, 1010	B-100	.91	.278[1]	.068	.72	---	---
Steel, 1010	C-150	.67[1]	NC[2]	NC[2]	NC[2]	NC[2]	1.28[1]
Stainless Steel, 18-8	A	.0095	.0093	.0089	.0084	---	---
Stainless Steel, 18-8	B-100	.60[1]	.174	.16	---	---	---
Stainless Steel, 18-8	C-200	.025	.015	.0115	.0115	---	---
Zinc on Steel	A	.0023	.0024	.0023	.0024	.003	.003
Zinc on Steel	B-100	NC[2]	NC[2]	NC[2]	NC[2]	NC[2]	NC[2]
Zinc on Steel	C-150	NC[2]	.328[3]	.53[1]	.35[1]	---	---
Cadmium on Steel	A	.005	.010	.0038	.003	.004	.0036
Cadmium on Steel	B-100	.035	.0395	.072	.21	.125	.089
Cadmium on Steel	B-200	NC	NC	NC	NC	---	---
Cadmium on Steel	C-150	.155	.061	.045	.036	---	---

Notes: -

1. IR drop unsteady; recorded value approximate
2. Contact on badly corroded area
3. Contact on area which seemed corroded the least
4. Test A was made on unexposed surface; B-100 after exposure to 20% salt spray for 100 hours; C-150 and C-200 after exposure to humidity test for 150 and 200 hours respectively.

TABLE III

Electrical Contact Resistances of Igniter Contact Rings

Contact Surface	Test**	Resistances at Various Points				
		1	2	3	4	5
Monel	A	.0066	.0064	.0058	.0068	---
Monel	B-100	.067	.245	.112	.03	.224*
Monel	C-200	.01	.0115	.0155	.011	.0095
Copper	A	.0028	.0025	.003	.0019	---
Copper	B-100	.04	.026	.0045	---	---
Copper	B-200	.105	NC	NC	NC	NC
Copper	C-200	.008	.0085	.0065	---	---
Brass 60-40	A	.0027	.0029	.0091	.0067	.0030
Brass 60-40	B-100	.255	.05	.625	.0067	.242
Brass 60-40	C-200	.023	.0085	.018	---	----
Aluminum, 2S	A	.0031	.0031	.002	.0884	---
Aluminum, 2S	B-100	NC	.06	NC	NC	NC
Aluminum, 2S	C-200	.007	.009	.0143	.0115	---

Notes: -

* IR value unsteady; recorded value approximate

** Test A was made on the unexposed surface; B-100 after exposure for 100 hours to salt spray; C-200 after exposure for 200 hours to humidity test.

TABLE IV

Electrical Contact Resistances of Silverplated Igniter Contact Rings

Contact Surface	Test[4]	Resistances at Various Points					
		1	2	3	4	5	6
Silver on steel	A	.015	.0083	.0081	---	---	---
Silver on steel	B-200	.0175	.0145	.034	.25[1]	1.37[1]	.205[1]
Silver on steel	C-200	.0075[2]	.0075[3]	.0075[3]	---	---	---
Silver on copper	A	.011	.017	.021	---	---	---
Silver on copper	B-200	.22[1]	.205	.23[1]	.165	.117	.243
Silver on copper	C-200	.006	.006	.006	---	---	---
Silver on brass	A	.0047	.0063	---	---	---	---
Silver on brass	B-200	.239	.337	NC[1]	.21[1]	.25	.057
Silver on brass	C-200	.0063	.0065	.0065	.0068	---	---

Notes: -

1. IR drop unsteady; recorded value approximate
2. Contact on badly corroded area
3. Contact on area which seemed corroded the least
4. Test A was made on unexposed surface; B-200 after exposure to 20% salt spray for 200 hours; C-200 after exposure for 200 hours to humidity test.

TABLE V

Effect of Rust-Inhibitive Films[1]
on the
Electrical Contact Resistances of Igniter Contact Rings

Contact Surface	Test[7]	Resistances at various points					
		1	2	3	4	5	6
Steel, SAE 1010	A	.022	.03[2]	.024[2]	.009	.0065	.0045
Steel, SAE 1010	B-150	.036	.21	.029	.021	.038	.315[3]
Steel, SAE 1010[5]	B-200	NC	NC	NC	.39	.465	.65[4]
Steel, SAE 1010[6]	B-200	NC[8]	.026	.037	NC[8]	.057	.019
Steel, SAE 1010[6]	B-200	.019	.015	NC[8]	.028	.247[9]	.015
Brass	A	.07	.035	.035	.017	.017	---
Brass	B-200	.145	.178[2]	NC	.133[2]	.148[2]	---
Copper	A	.049	.040	.028	.032	.042	---
Copper	B-200	.065	.095	.123	.056[2]	.073	---
Copper[6]	B-200	.105	.03	NC	.46	.303	---
Silver on steel	B-200	.026	.016	.012	.028	.026[4]	.07[4]
Silver on brass	B-200	.017	.068	.168	.025	.023	---
Silver on copper	A	.031	.019	.01	.011	.012	---
Silver on copper	B-200	.038	.26	.093	.042	.060	---
Cadmium on steel[5]	B-200	.041	.024	.036	.013	.039	---
Cadmium on steel[6]	B-200	NC	.025	.025	.031	.027	.025
Cadmium on Steel[6]	B-200	.017	.022	.023	.019	.019	.014
Zinc on steel[5]	B-200	NC	NC	NC	NC	---	---
Zinc on steel[6]	B-200	NC	NC	NC	NC	---	---

Notes: - 1. Rust inhibitor is Alox-L-1200 except where noted otherwise.

TABLE VI

Electrical Contact Resistances of Igniter Contact Rings

Protected by Strippable Lacquer Films*

Contact Surface	Test**	Resistances at Various points					
		1	2	3	4	5	6
Steel, 1010	B-200	.015	.024	.072	.042	.020	---
Silver on Copper	B-200	.018	.015	.018	.055	.028	---
Silver on Steel	B-200	.014	.014	.014	.016	.013	.02
Copper	B-200	.104	.199	.13	.3***	.24***	.178***
Brass	B-200	NC	.38***	.108	.28***	.35***	.27***
Cadmium on steel	B-200	.04	.049	.048	.12	.037	---
Zinc on steel	B-200	.183	.235	.238	.105	---	---

Notes: -

* DuPont Stripping Lacquer, J200x7012

** All resistances determined after exposure of specimen to 20% salt spray at 95°F for 200 hours.

*** IR drop unsteady; recorded value approximate

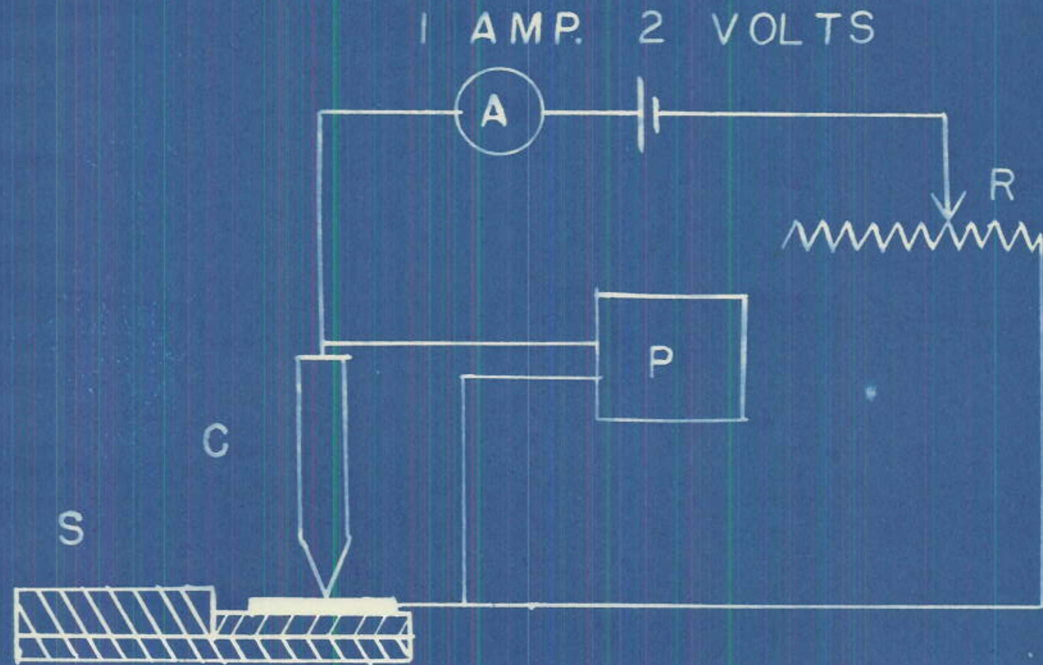
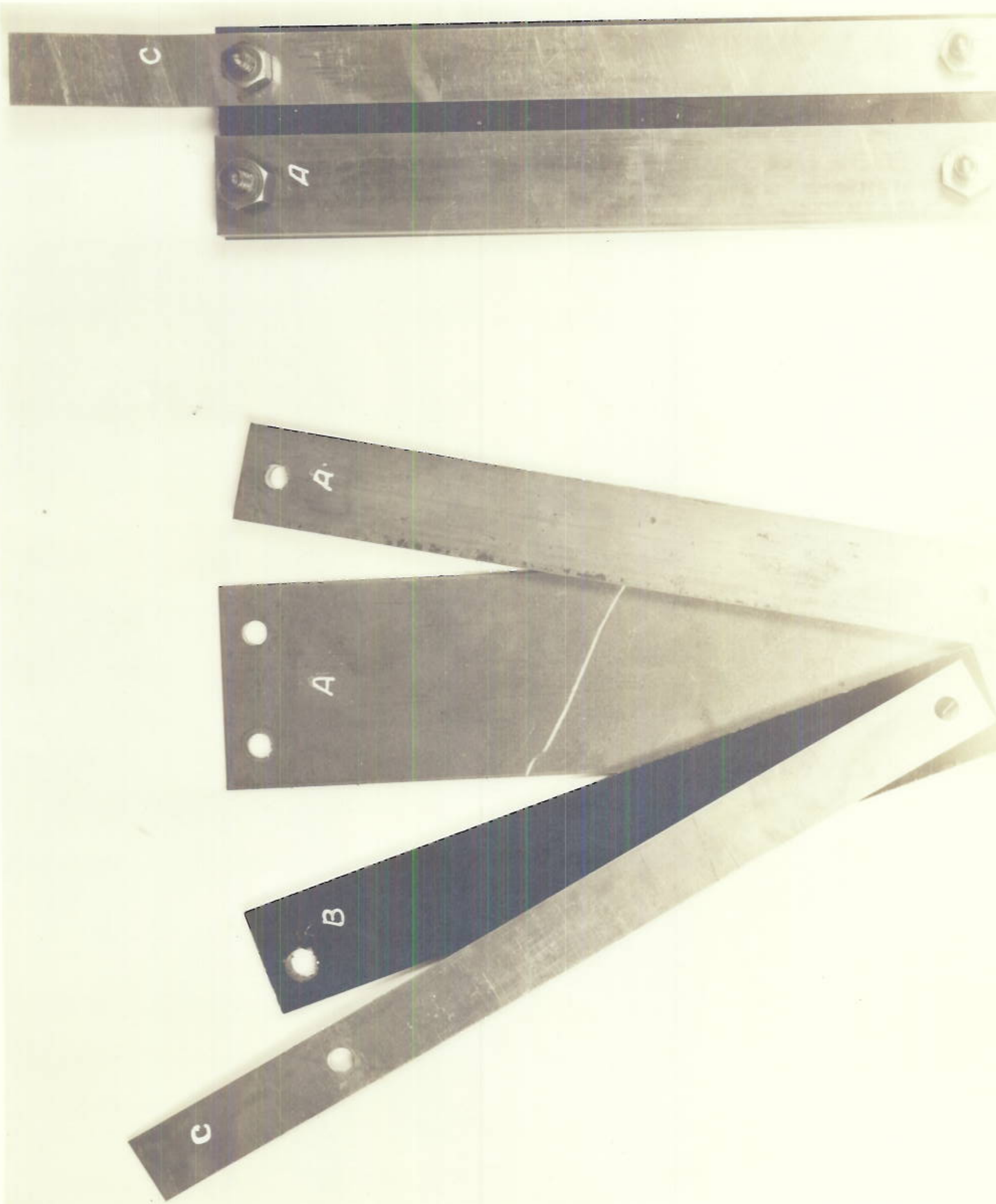


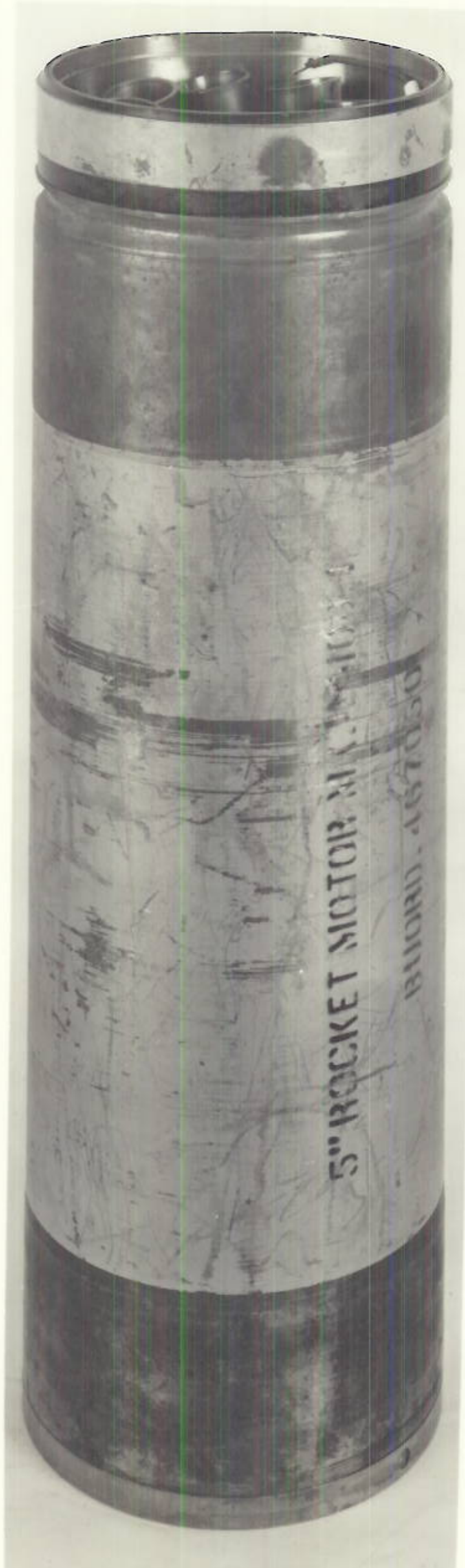
FIGURE 1

CIRCUIT FOR MEASURING
CONTACT RESISTANCES



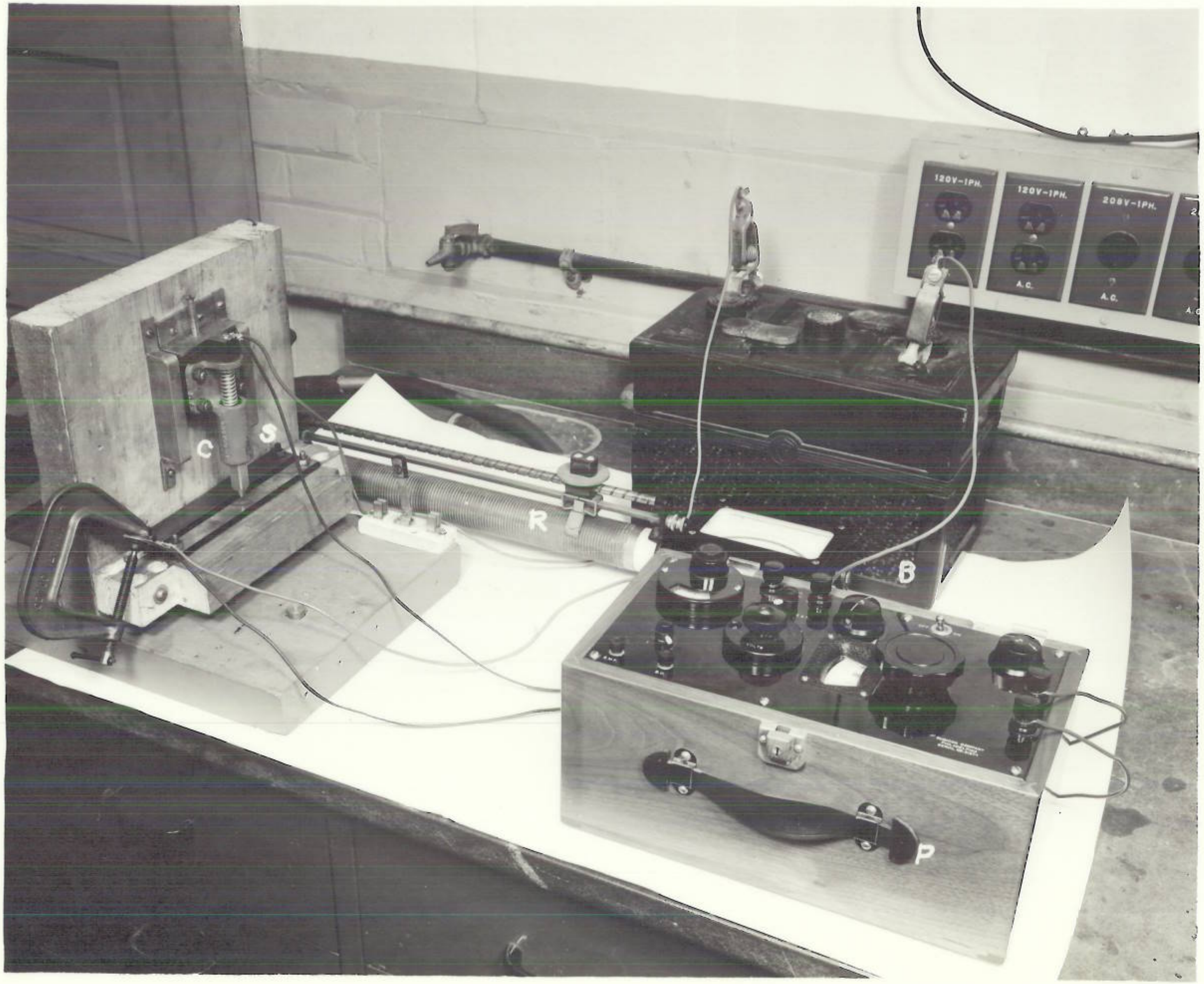
ASSEMBLY OF TEST SPECIMEN

PLATE I



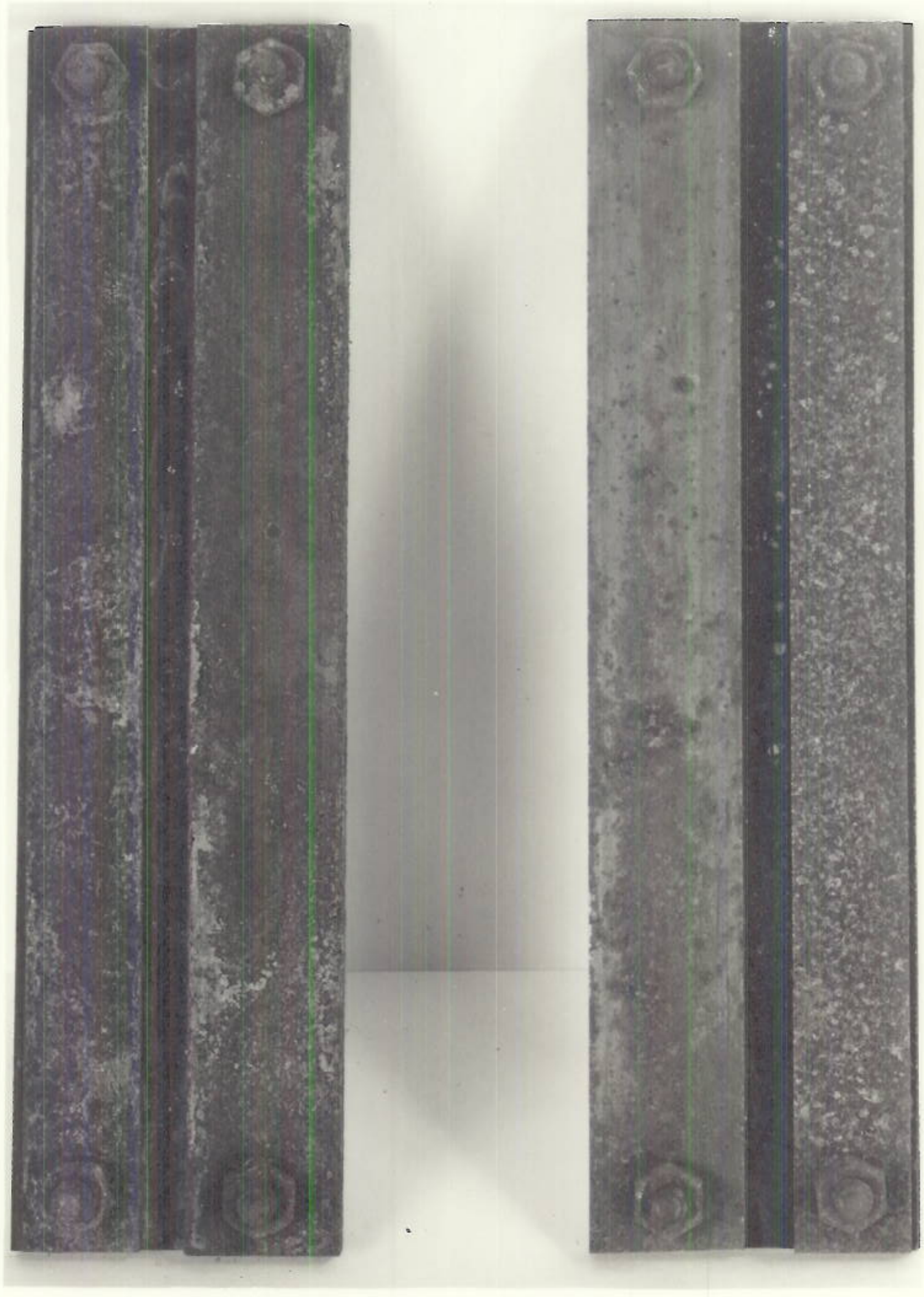
ACTUAL 5" ROCKET MOTOR
SHOWING
IGNITER CONTACT RING AND THREAD PROTECTOR

PLATE 2



ARRANGEMENT FOR MEASURING CONTACT RESISTANCES

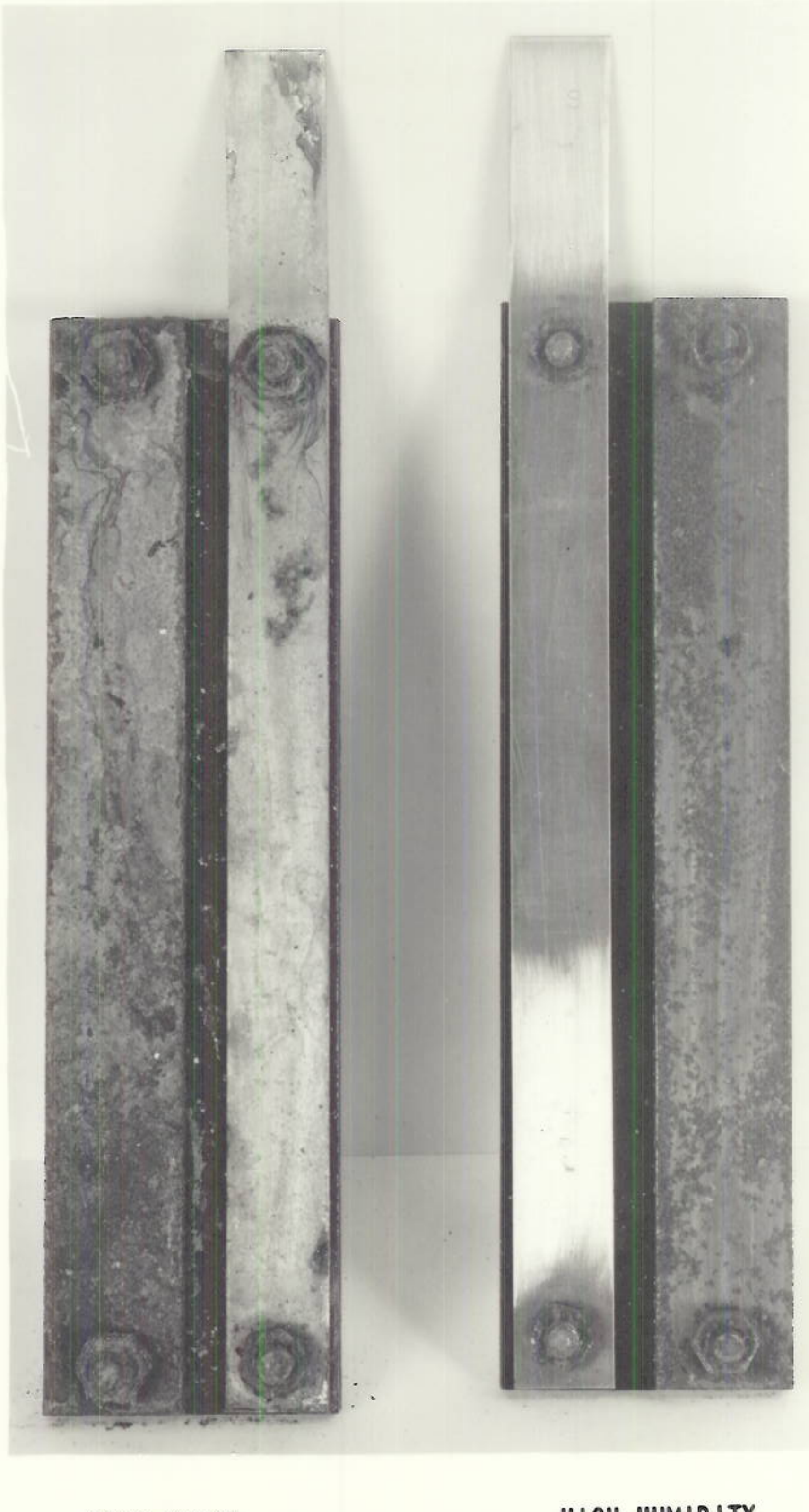
PLATE 3



SALT SPRAY HIGH HUMIDITY

STEEL, SAE 1010

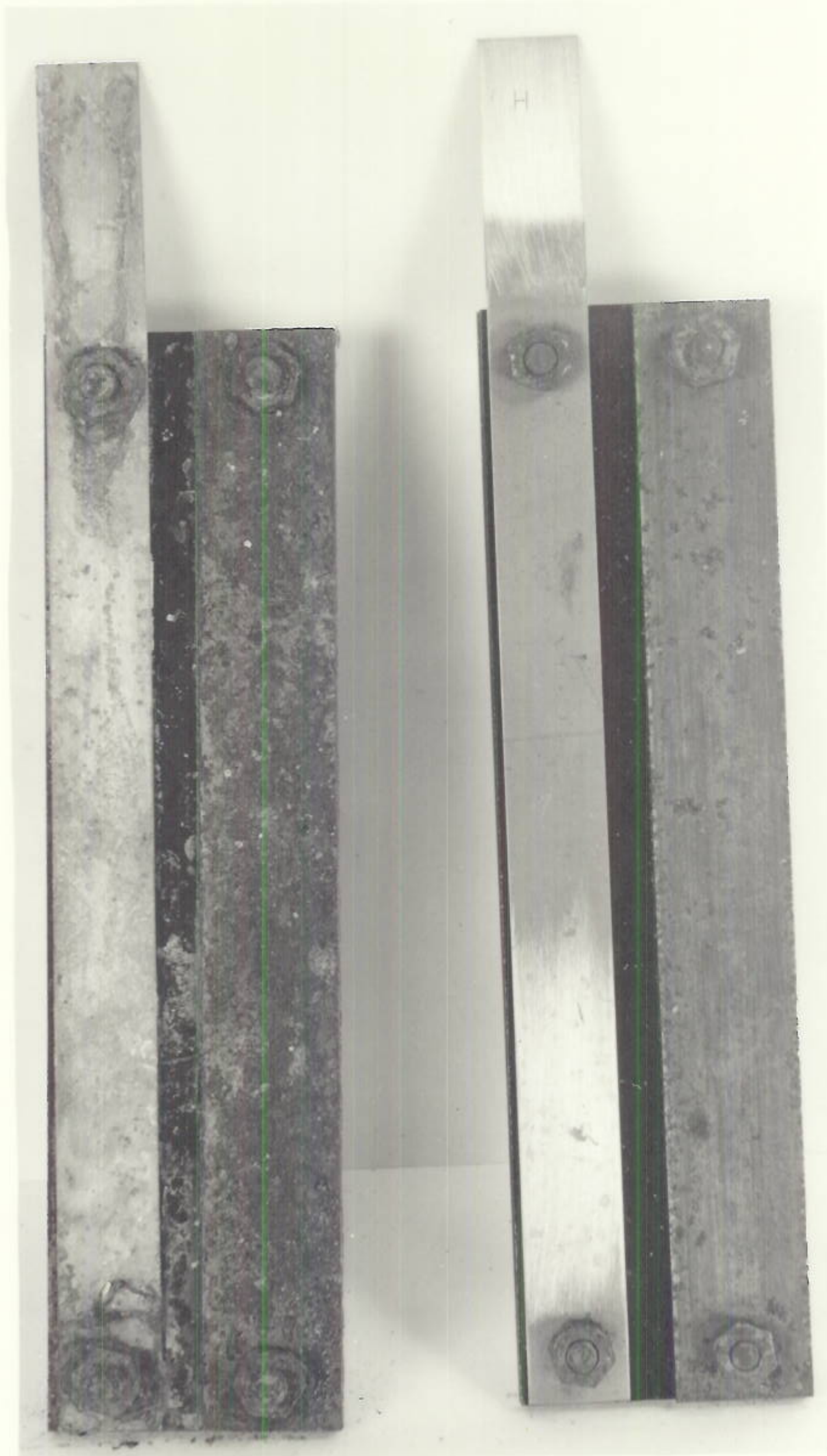
PLATE 4



SALT SPRAY . . HIGH HUMIDITY

STAINLESS STEEL - 18-8

PLATE 5

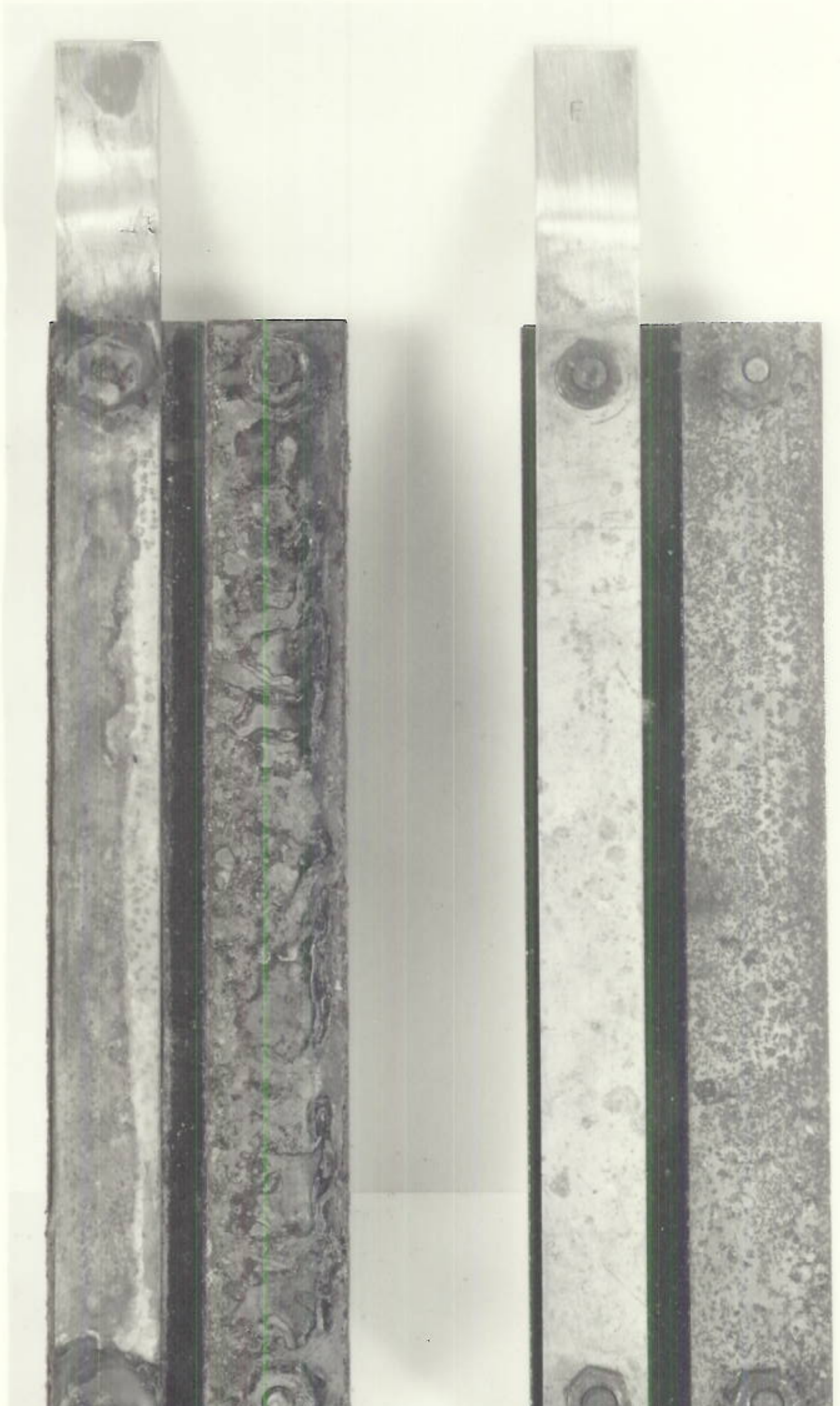


SALT SPRAY

HIGH HUMIDITY

MONEL

PLATE 6



SALT SPRAY HIGH HUMIDITY

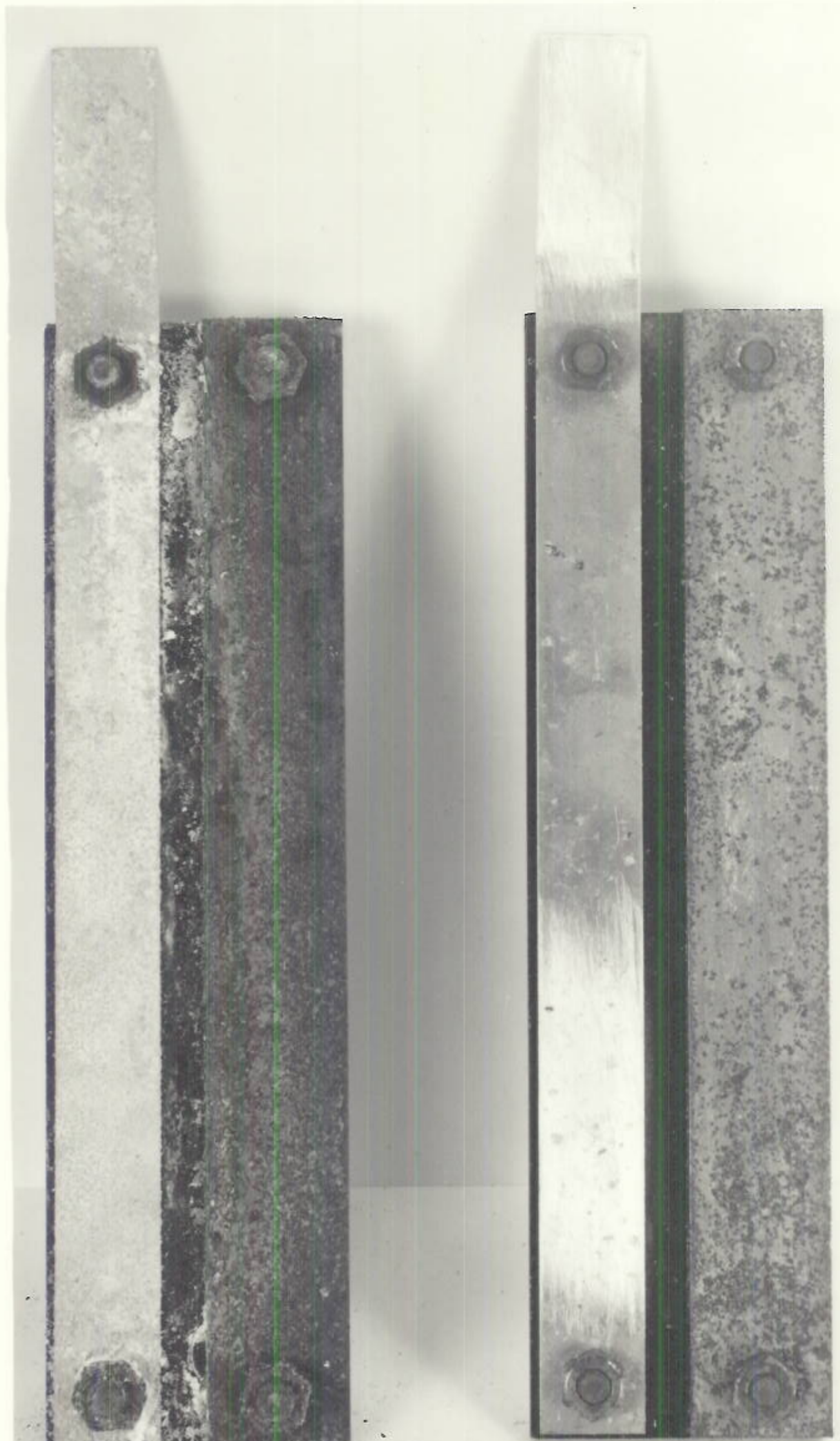
BRASS, 60 - 40

PLATE 7

SALT SPRAY HIGH HUMIDITY

COPPER

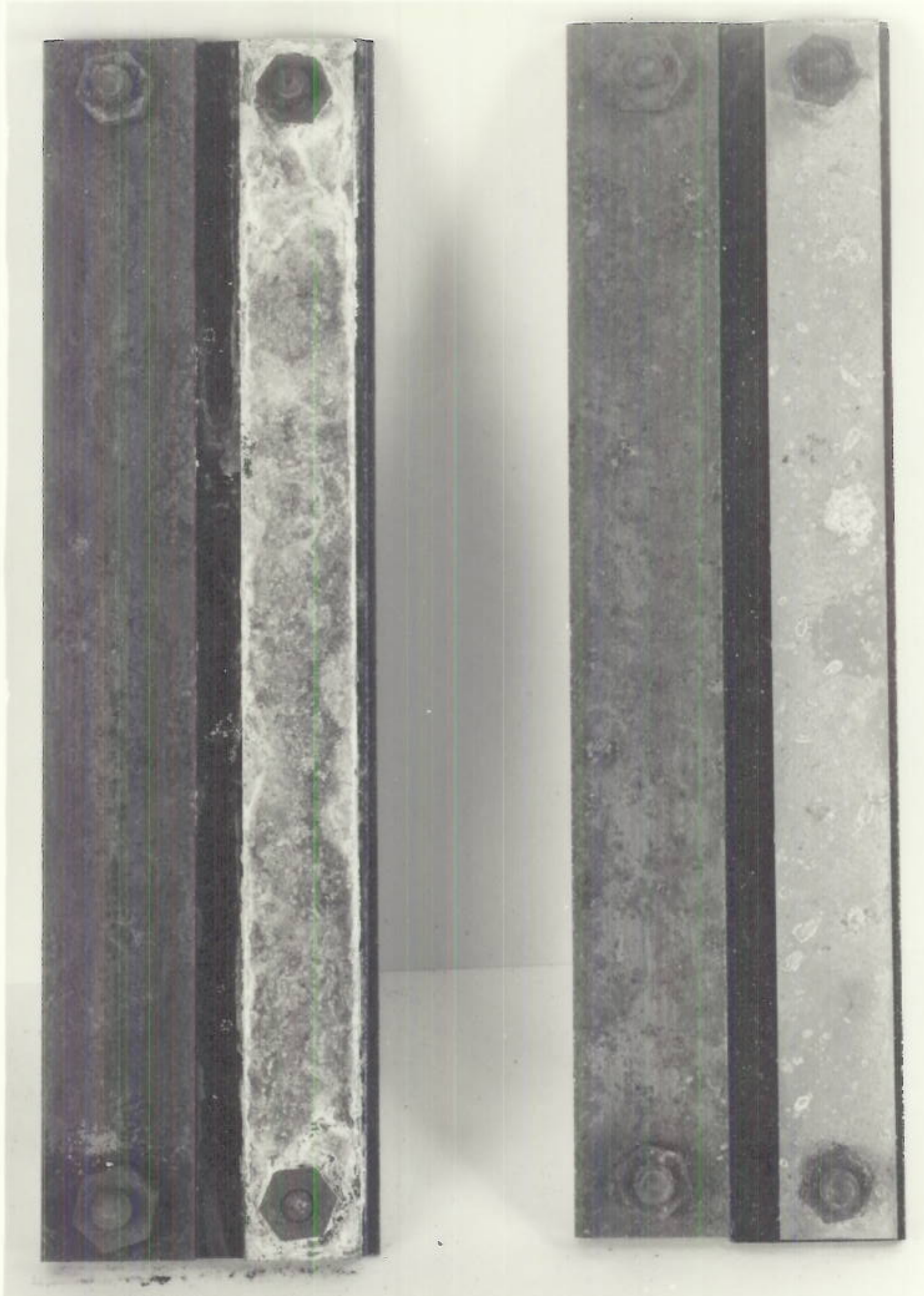
PLATE 8



SALT SPRAY HIGH HUMIDITY

ALUMINUM, 2S - 1/2H

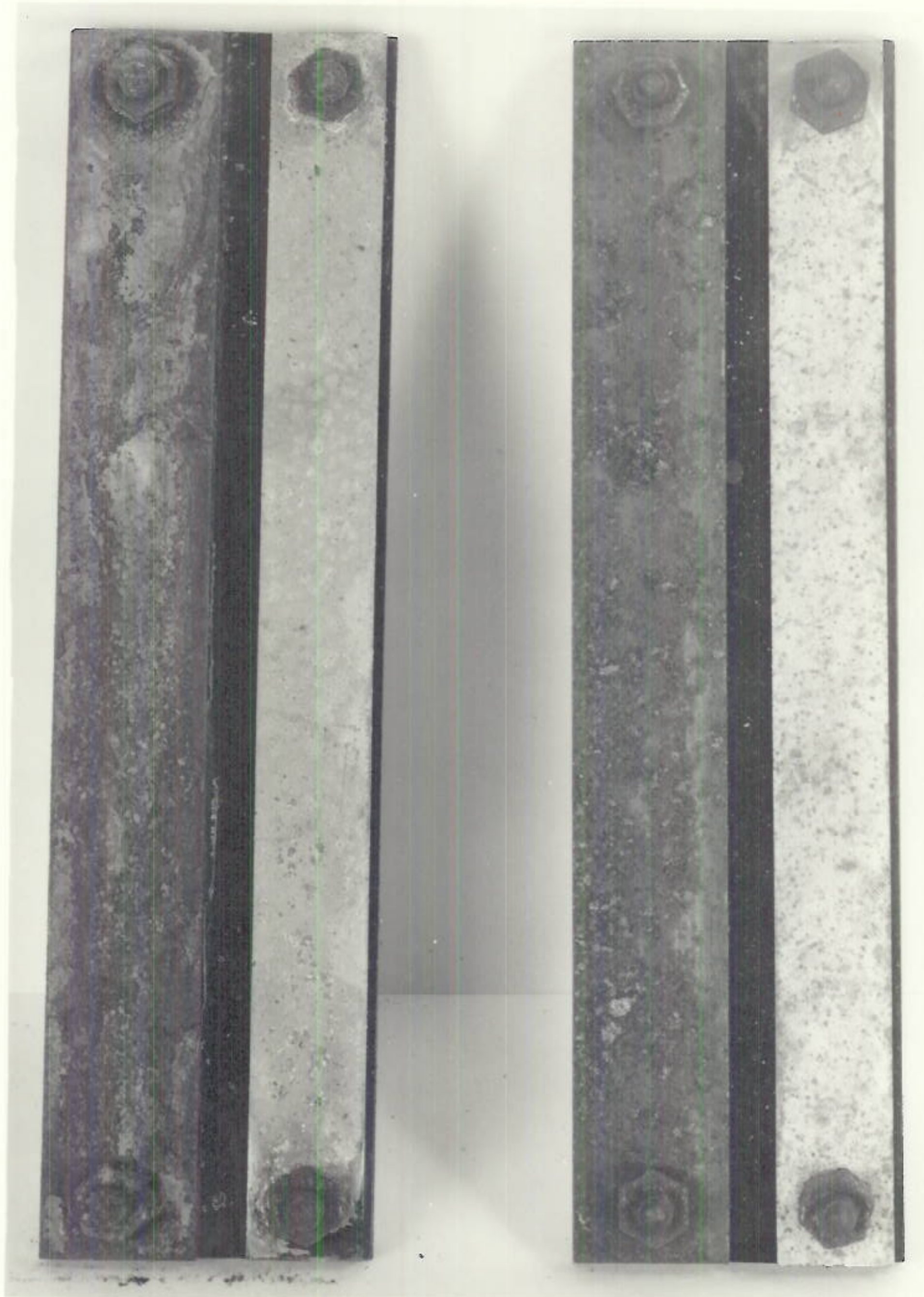
PLATE 9



SALT SPRAY HIGH HUMIDITY

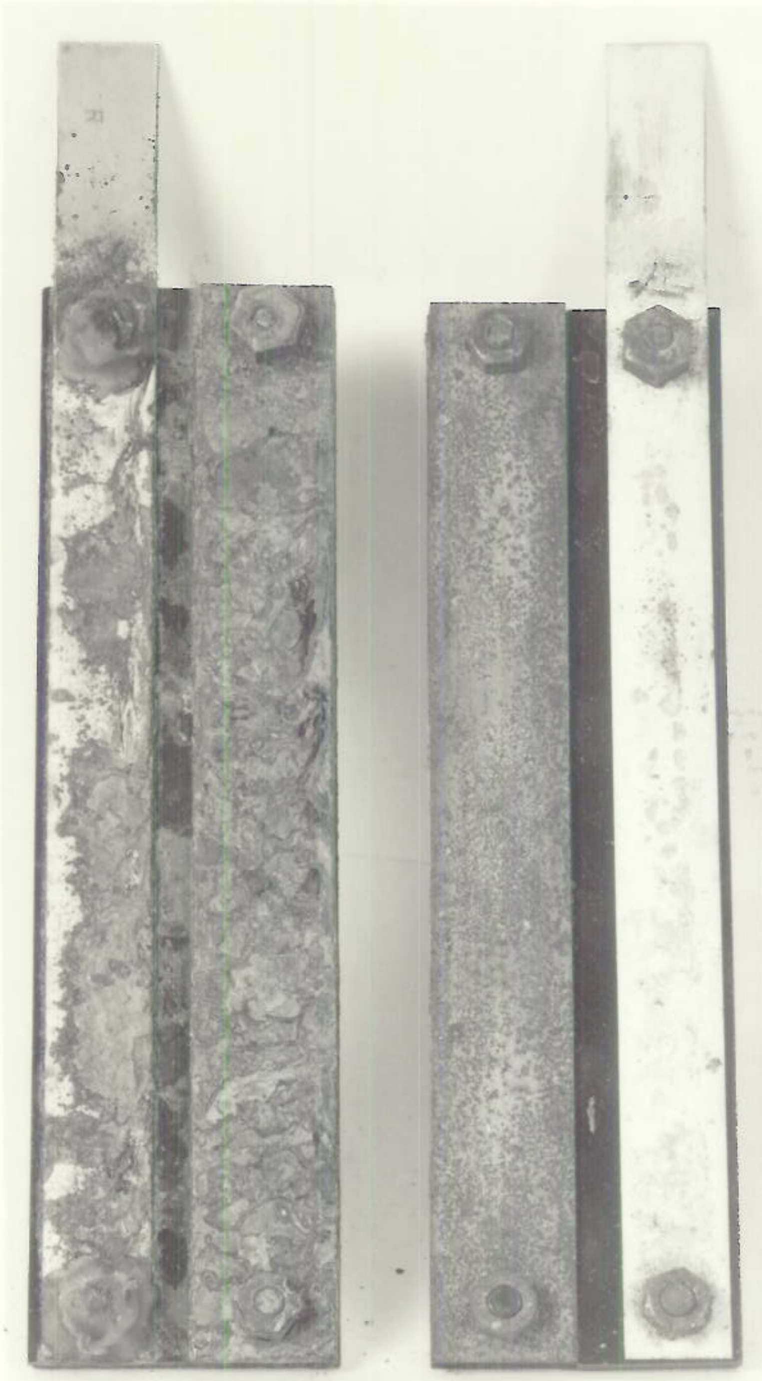
ZINC ON STEEL

PLATE 10



SALT SPRAY HIGH HUMIDITY

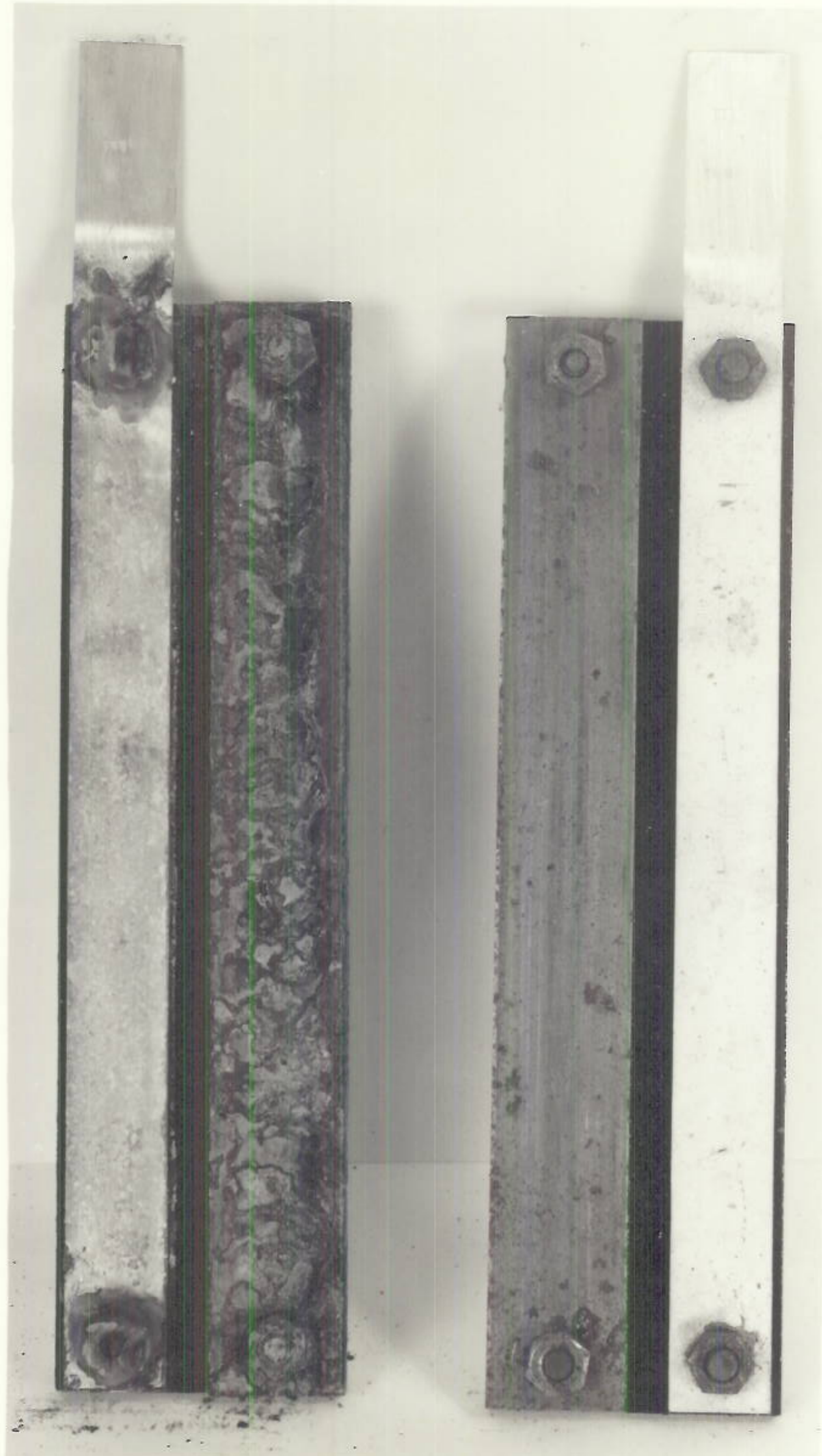
CADMIUM ON STEEL



SALT SPRAY HIGH HUMIDITY

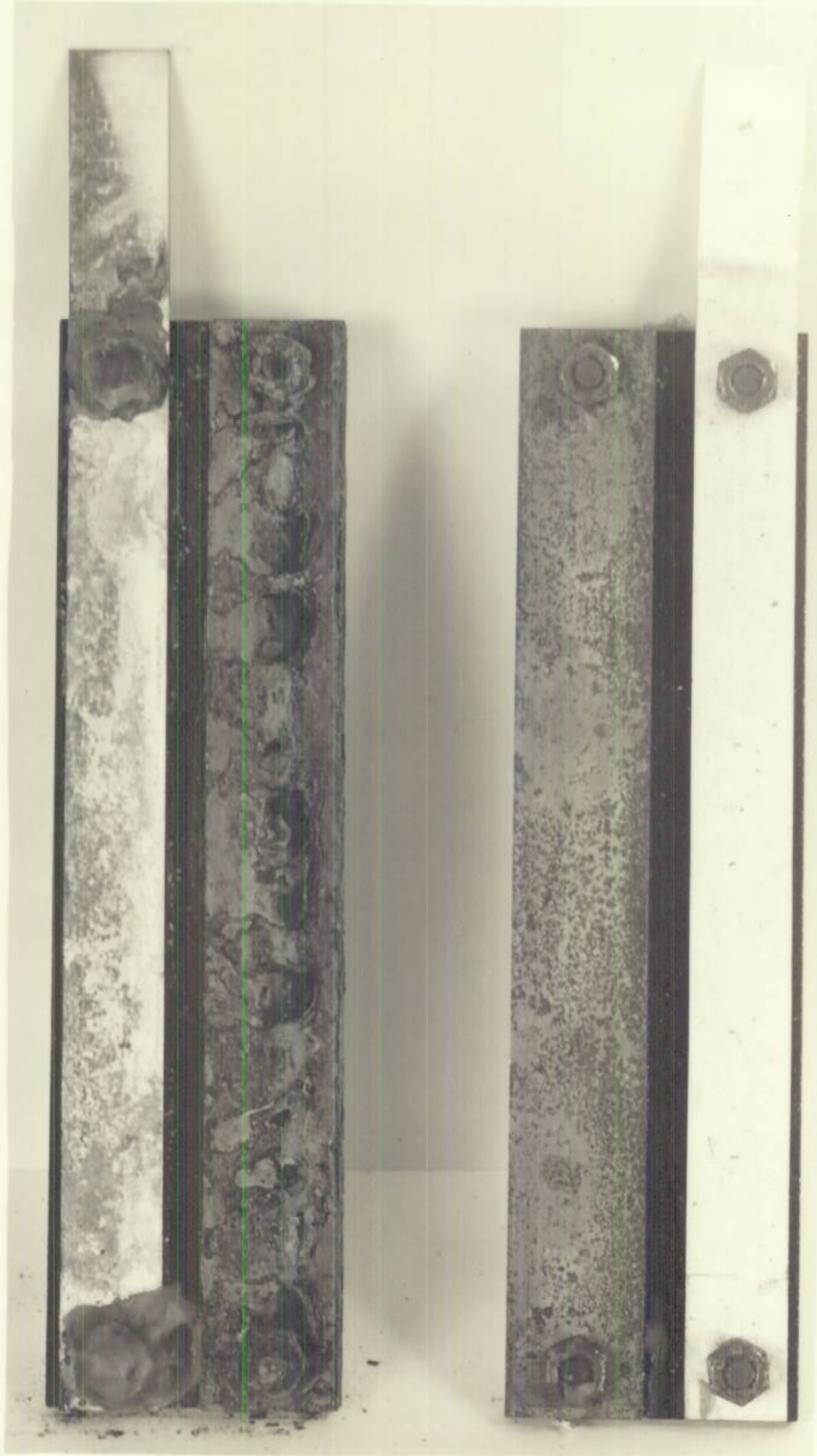
SILVER ON STEEL

PLATE 12



SALT SPRAY HIGH HUMIDITY

SILVER ON COPPER



SALT SPRAY HIGH HUMIDITY

SILVER ON BRASS

PLATE 14

DISTRIBUTION LIST

BuOrd	8
BuShips	2
BuAer	2
OR & I	2