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Technical Note N-910

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CONSTRUCTION AND PRELIMINARY EVALUATION OF AN
ENVIRONMENTAL TEST CHAMBER

by

Howard A. Porte, Ph. D.

July 1967

Internal Working Paper

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NAVAL CIVIL ENGINEERING LABORATORY
Port Hueneme, California

CONSTRUCTION AND PRELIMINARY EVALUATION OF AN ENVIRONMENTAL
TEST CHAMBER

Technical Note N-910

Z-R011-01-01-035

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Howard A. Porte, Ph. D.

ABSTRACT

Details of construction of an environmental wet test chamber are presented. Preliminary test results are reported for mild steel in a salt water environment. It is recommended that further tests be conducted to determine the feasibility of using this apparatus in accelerated tests for coatings.

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INTRODUCTION

The U. S. Naval Civil Engineering Laboratory is involved in the evaluation of coatings used by the Naval Shore Establishment. The Laboratory conducts a continuous program of testing coatings in service at field installations. However this type of testing often involves exposure of coatings over long periods of time, many years. It would be desirable to evaluate coatings in an accelerated test which could be performed in much shorter times. Although numerous accelerated test methods¹ are in use for predicting the performance of paints and coatings in atmospheric environments, as yet no completely satisfactory method has been developed. The main shortcoming of most accelerated methods is the unknown degree of correlation between the results of a laboratory test and the actual service life in a natural environment.

Recent U. S. Naval Air Engineering Center reports describe an environmental wet test chamber which gives good reliability and can be constructed at a relatively inexpensive cost.^{2,3} The test chamber was successfully used at NAEC to evaluate thin film compounds but it is conceivable that with slight modifications it could be used to evaluate the performance of paints or coatings on metals and alloys. This wet test chamber, slightly modified, was constructed and preliminary tests of uncoated steel specimens were performed.

CONSTRUCTION AND OPERATION OF APPARATUS

The apparatus can be assembled from relatively inexpensive parts and is shown in Figure 1. The essential parts are:

1. A glass jar, 12 inches in diameter by 12 inches high.
2. Drive motor. A synchronous one rpm AC motor was used with appropriate gears so that the drive shaft rotated at 1/3 rpm.
3. A spray nozzle. The nozzle consisted of 2 standard glass eye droppers mounted in rubber stoppers and held in position on a specially fabricated tripod stand. The distance between the tips of the droppers was varied experimentally until a suitable spray pattern was obtained.
4. A tripod stand. The stand was made of Lucite. The tripod stand and spray nozzle are shown in Figure 2. Air is forced down the medicine dropper held in the vertical position and the liquid which comprises the spray is pulled up into the horizontal dropper. The horizontal dropper is held by a bracket which is movable and can be adjusted to obtain the proper spray. The dimensions of the tripod stand are shown in Figure 3.
5. A turntable. The turntable was fabricated from 3/4 inch thick Lucite. It was made 10-1/2 inches in diameter and contained a hole in the

center for the drive shaft and 9 equally spaced holes around the edge to contain the specimen holders. The turntable is shown in Figure 4.

6. The specimen holders. These consisted of small glass jars with the bottoms sawed off and with holes cut in the plastic screw tops. The glass jars mounted in the turntable are shown in Figure 5. A specimen holder with its top removed and a specimen are shown in Figure 6.

In operation, two liters of salt water were placed in the jar and a Tygon tube extending from the horizontal eye dropper dipped into the reservoir of salt water. The air supply was the normal laboratory compressed air supply. A rubber hose was connected through a flow regulator to the vertical medicine dropper. An air flow of 20 liters per minute corresponds to a flow of fluid of about 1300 ml. per hour. This produced a fine spray which was suitable for the experiments.

The salt water used in these experiments was obtained from a well located approximately 100 yards from the Pacific Ocean at Port Hueneme, California. The analysis of this water is given in Table 1.

Table 1. Major Constituents of Salt Water

Ion	ppm
<u>Anion</u>	
Cl ⁻	18173
SO ₄ ⁻⁻	2751
HCO ₃ ⁻	211
F ⁻	1.3
NO ₃ ⁻	1
<u>Cation</u>	
Na ⁺	9890
Ca ⁺⁺	1411
Mg ⁺⁺	627
K ⁺	401
<u>Balance</u>	
B	3.5
SiO ₂	15
Total Solids	35654

EXPERIMENTAL

In order to check out the operation of the apparatus, preliminary tests were conducted on uncoated mild steel specimens. The material, SAE 1010 steel, was cut from Q-panels obtained from the Q-Panel Company, Cleveland, Ohio. The diameter of the specimens was 2.10 inches but with the specimen holders in place the diameter exposed was 1.62 inches with an area of 2.06 square inches. The specimens were exposed to a salt-spray environment and were withdrawn from the apparatus at hourly intervals. Upon removing a specimen from the apparatus a blank specimen holder was inserted in its place and the removed specimen was washed with deionized water and stored in a desiccator.

RESULTS

The effect of exposing mild steel to a salt-spray atmosphere in the experimental wet test chamber for periods from 1 to 7 hours is shown in Figure 7 and 8. Visible corrosion can be detected as early as after a 1 hour exposure and the amount of corrosion product on the surface increases with time of exposure so that after 7 hours exposure the surface is almost completely covered with corrosion products. A photomicrograph of a specimen which was removed after a 1 hour exposure is shown in Figure 9. It appears that corrosion begins at specific sites on the surface and the area of corrosion spreads from these sites. The sites of corrosion are seen to be of varying size indicating that certain sites are more active for corrosion to begin than others. It can be seen that the surface does not become covered uniformly with corrosion product but rather certain areas become corroded rapidly and the corrosion then spreads to other less affected areas.

FINDINGS

1. The observable advantages of the chamber over other commercially available tests are: (a) the specimens are easily accessible for observation or replacement during a test and it is not necessary to stop the apparatus or disturb other specimens, (b) any aqueous environment--salt water, plain tap water, etc.--can be used, and (c) the apparatus can be readily constructed from inexpensive material.
2. Uncoated mild steel showed visible signs of corrosion after one hour exposure to a salt spray atmosphere in the environmental wet test chamber.

RECOMMENDATIONS

1. It is recommended that additional tests be made on coated samples in this chamber in order to determine the feasibility of this apparatus as an accelerated test method for coatings.

ACKNOWLEDGMENTS

The assistance of M. Pacheco and C. Mathews in the assembly and preliminary operation of this apparatus is acknowledged.

REFERENCES

1. U. S. Naval Civil Engineering Laboratory Technical Note N-549: Accelerated testing of paints, by P. J. Hearst, Port Hueneme, California, December 1963.
2. U. S. Naval Air Engineering Center Report No. NAEC-AML-2090. The Development Thin Film Preservative Compounds, December 1964.
3. U. S. Naval Air Engineering Center, Report No. NAEC-AML-2436, Development of an Environmental Wet Test Chamber for Simulating Carrier Deck and Other Corrosive Environments, May 1966.



Figure 1. Environmental Test Apparatus.

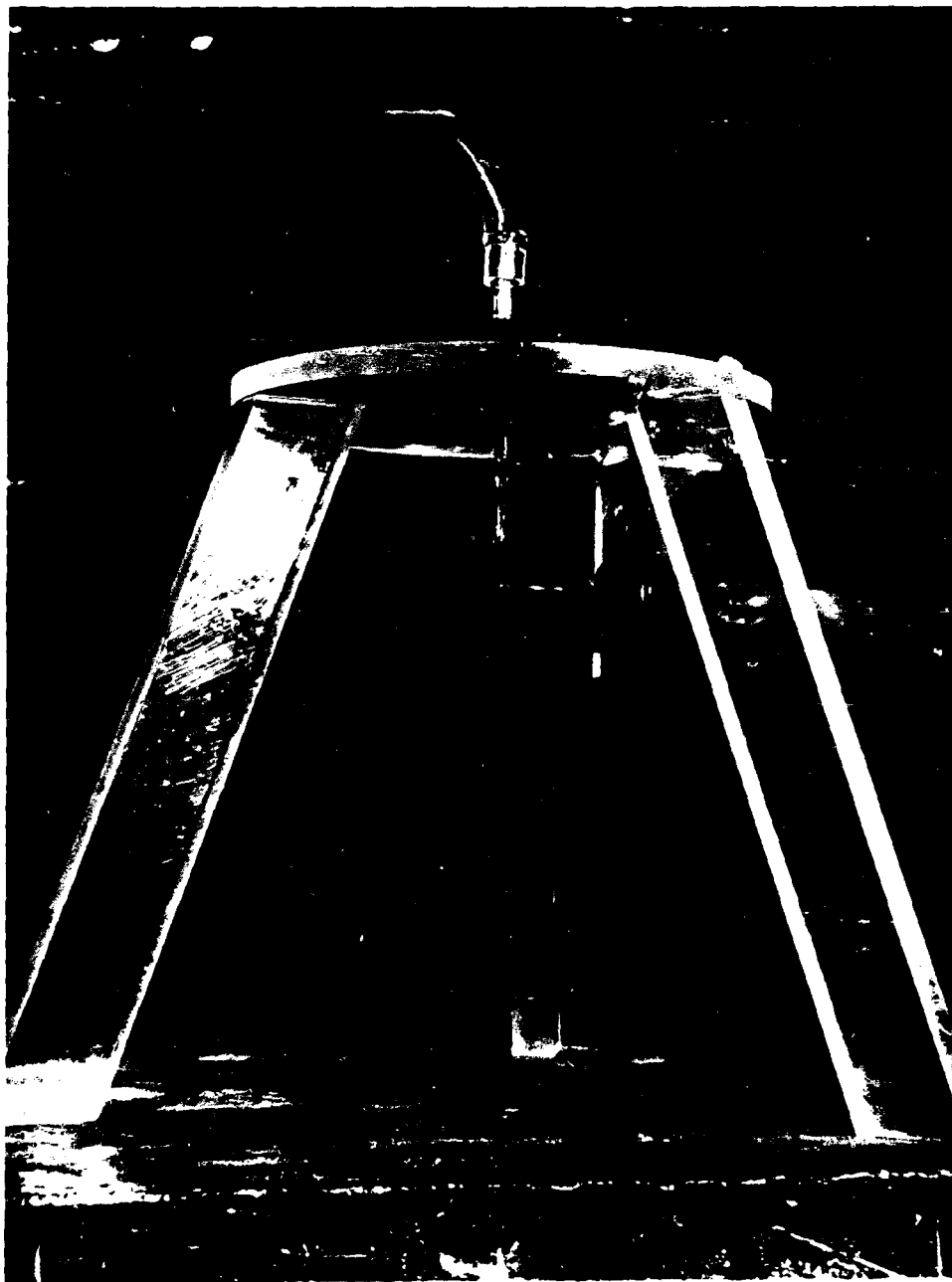


Figure 2. Tripod stand and spray nozzle.

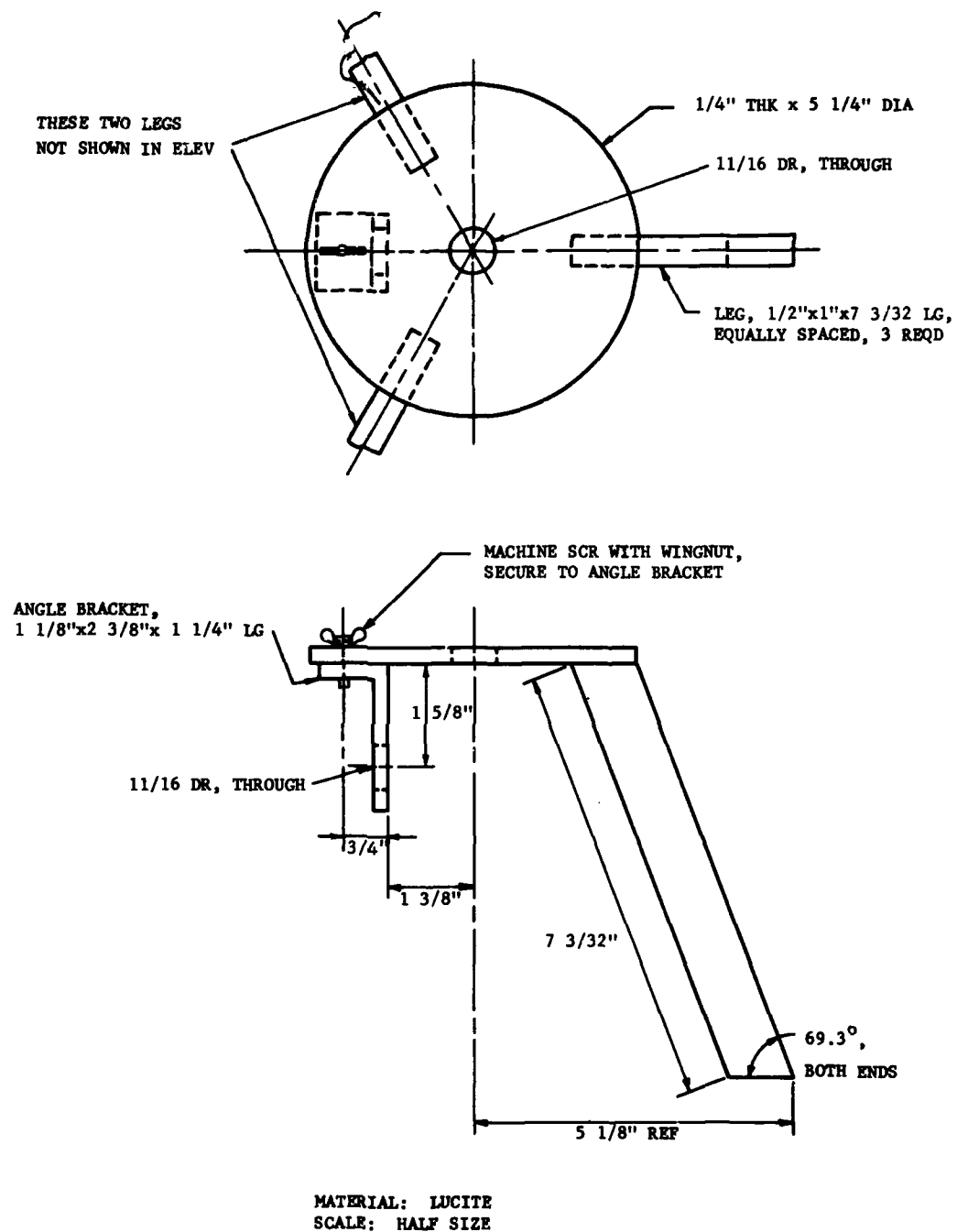


Figure 3. Dimensions of tripod stand.

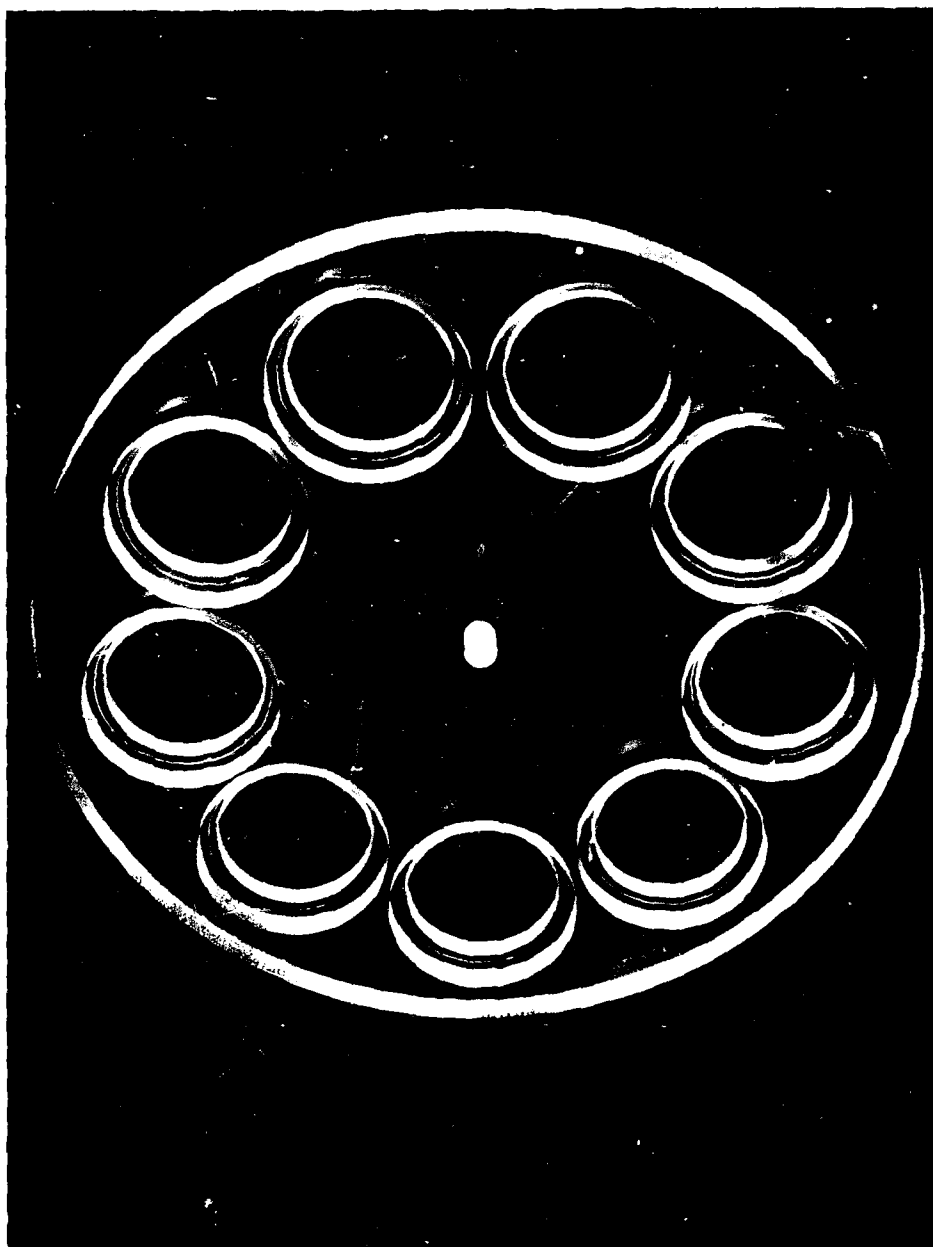


Figure 4. Turntable.



Figure 5. Specimen holders mounted in turntable.

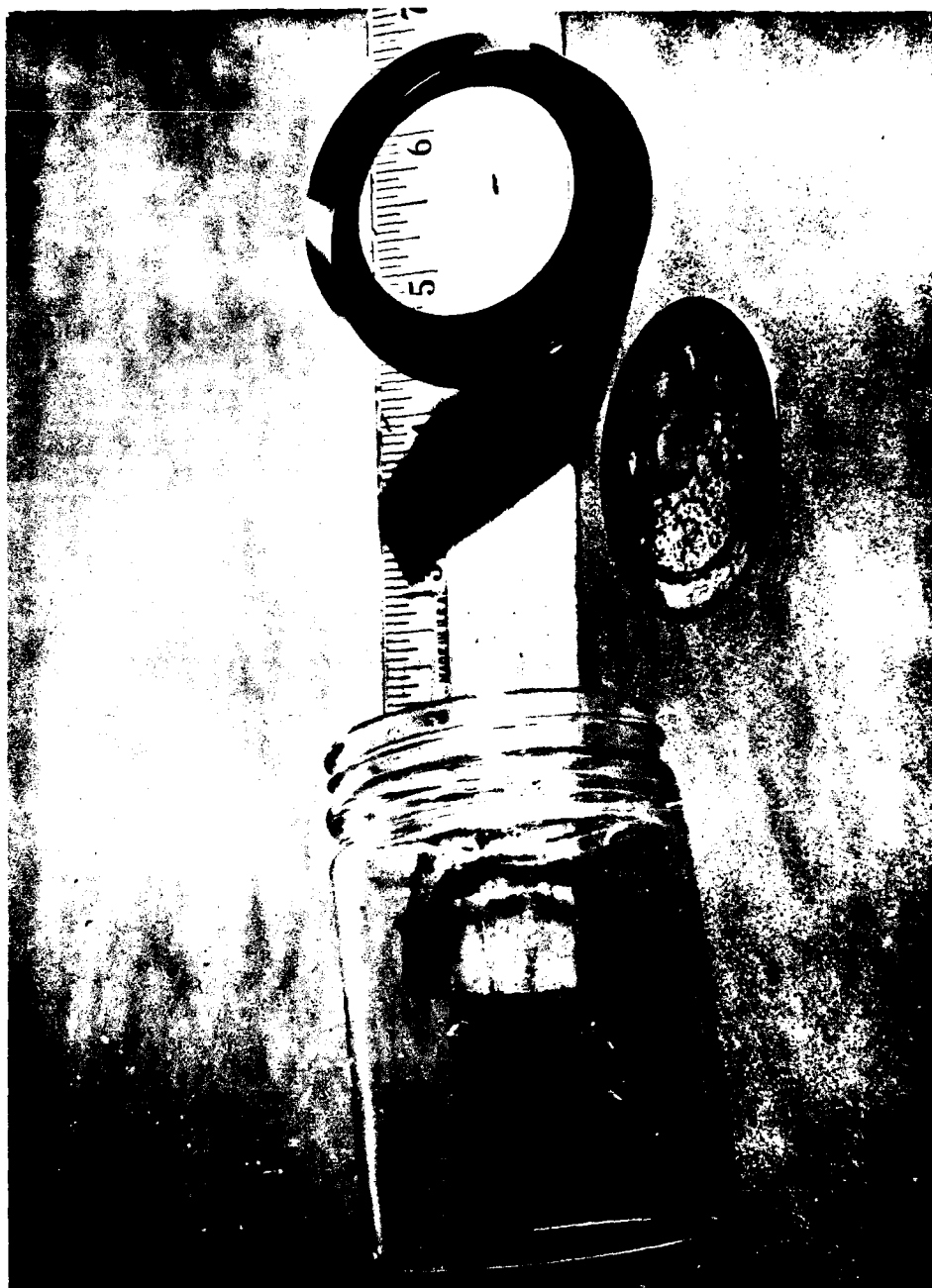


Figure 6. Specimen holder and a specimen.

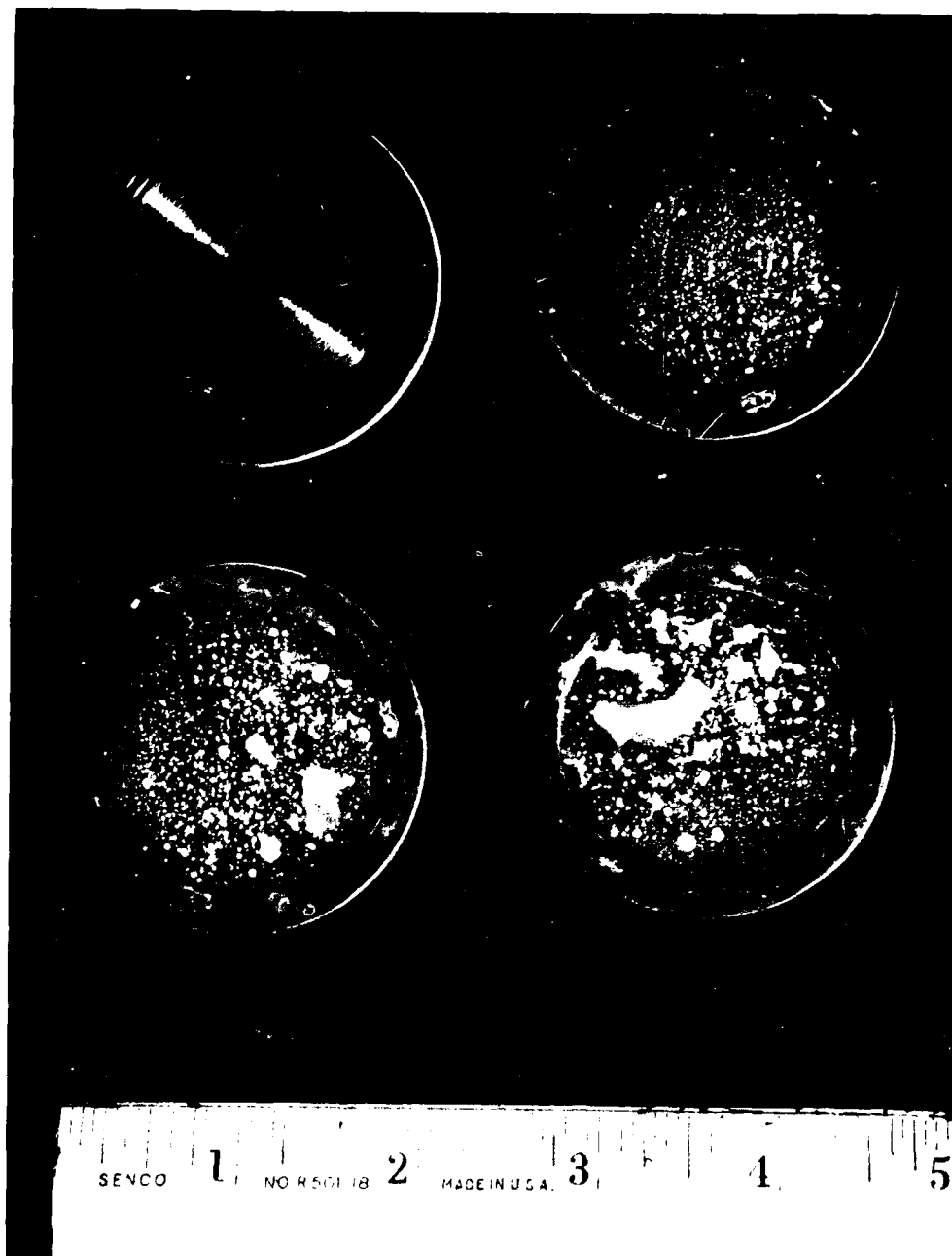


Figure 7. Mild steel specimens after exposure to a salt spray atmosphere - exposure times of 0, 1, 2, and 3 hours.

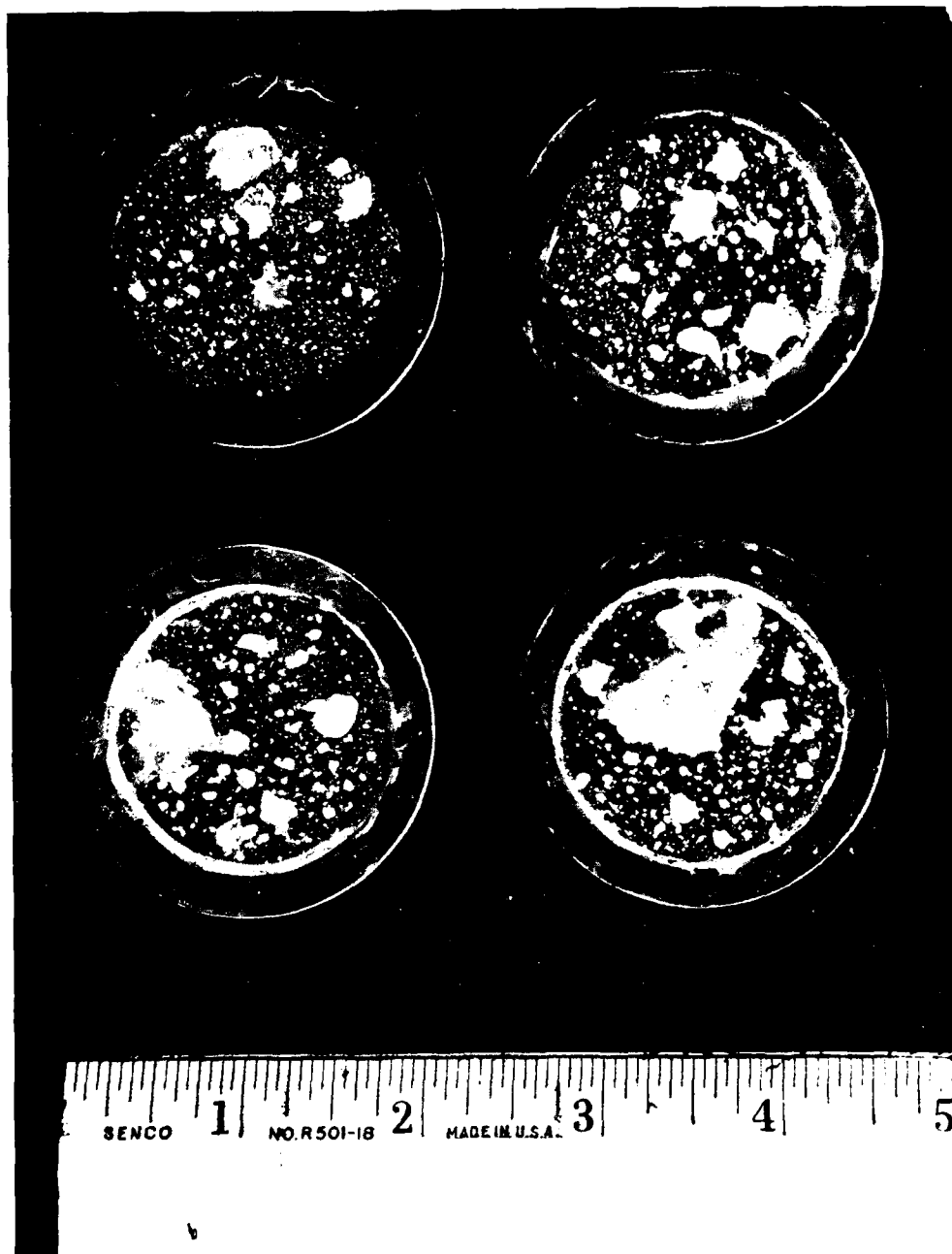


Figure 8. Mild steel specimens after exposure to a salt spray atmosphere - exposure times of 4, 5, 6, and 7 hours.

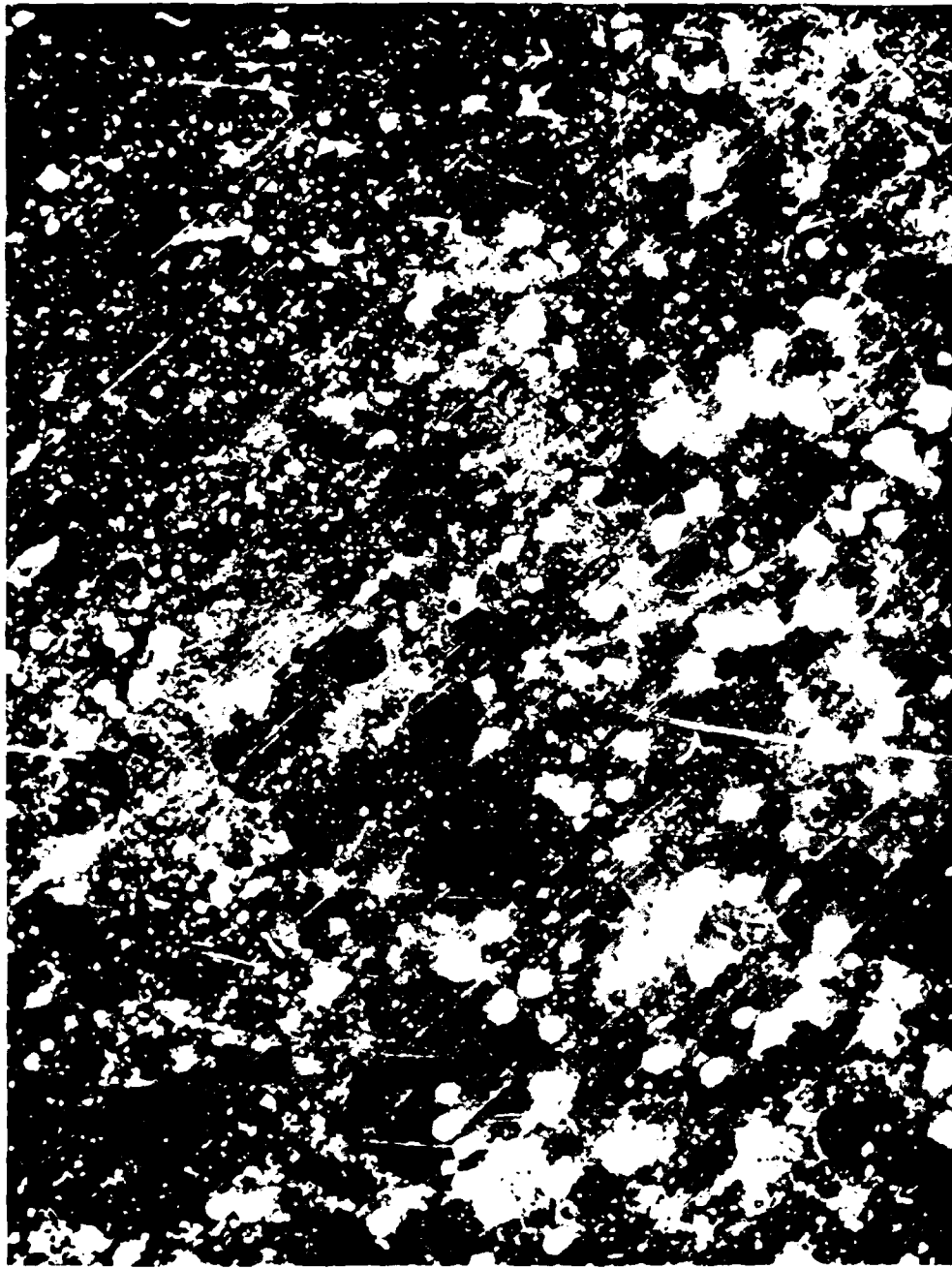


Figure 9. Photomicrograph of mild steel specimen after exposure to a salt spray atmosphere for 1 hour.
Magnification: 3X

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