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GROUND ROD METALS - FIELD TEST INSTALLATION

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U. S. NAVAL CIVIL ENGINEERING LABORATORY
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by

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ABSTRACT

The U. S. Naval Civil Engineering Laboratory was requested to investigate various metals now in use as ground rods, and metals which might be acceptable substitutes. NCEL cooperated with the National Association of Corrosion Engineers in the latter's "Driven Ground Rod Test Program" by installing a series of test rods at the Laboratory. A description of the site and details of the actual installation of the rods are given, along with similar information relative to a short term test being conducted at the Naval Air Station, Point Mugu, California. Results will be included in a forthcoming report.

INTRODUCTION

Power transformer stations, radar installations, and radio stations all require extensive buried grounding networks. The metal most commonly used for this purpose is bare copper as a solid rod or wire, or as a coating or cladding on a stronger base metal such as steel. A serious problem arises when extensive amounts of copper are buried in proximity to a less noble (less corrosion-resistant) metal: corrosion of the other metal is accelerated and the second metal eventually fails to perform its primary function. This is particularly true when the copper and the other metal are bonded electrically, as in the case of a steel-framed or steel-covered building where parts are buried in the earth. A second example exists where an inter-connection is made to both a copper ground and the water line.

The Bureau of Yards and Docks authorized the Naval Civil Engineering Laboratory (NCEL) to investigate several metals which might serve as ground rods. An economically acceptable substitute for copper would be desirable, if compatible with steels or other buried metals, as would alternates that might be used in emergency situations when copper is unavailable. The Laboratory then arranged to cooperate with the National Association of Corrosion Engineers (NACE) in its "Driven Ground Rod Test Program".

This report presents NCEL's test program, a description of the test sites, and installation details.

TEST PROGRAM

A. General

The NACE test program, modified to suit NCEL's needs, is as follows:

Rods of various metals are obtained, weighed, and driven into the ground in three groups. At intervals of one, three, and seven years after the initial installation the rods in one of the groups are to be removed, examined, and reweighed. The corrosion loss will be determined and the rate of corrosion calculated as grams per square centimeter per year.

Each group of rods consists of two sub-groups. The first sub-group consists of single rods of all the metals being considered. The second sub-group consists of a rod of each metal coupled to one or more mild steel rods. The coupled rods, by their dissimilarity, form the anodes and cathodes of galvanic cells; varying the number of steel rods coupled to the other metals provides a comparison of the effect of different anode-to-cathode area ratios for the same metal systems.

B. Test Rods

Thirty-one rods of eight different metal systems are included in each group. (Figure 1) The rods are nominally 5/8 inch in diameter by eight feet in length, pointed on one end to facilitate driving and chamfered on the other end to minimize mushrooming of the rod when driven. They are usually one continuous piece, not shorter pieces joined to form the desired length. The metal systems are mild steel, galvanized steel, Ni-Resist, Type 302 stainless steel, copper-clad steel, high-purity zinc, AZ31B magnesium alloy, and No. 6061-T6 aluminum alloy. Single rods of mild steel are coupled to single rods of the other seven metal systems; in addition, two mild steel rods are coupled to single rods of copper-clad steel, magnesium, and zinc, to provide the different anode-to-cathode area ratios mentioned previously.

C. Data

All rods are weighed prior to installation. When each group is removed from the ground, the individual rods will be freed of corrosion products, reweighed, and their corrosion losses determined. At the time of installation, each rod's potential to a copper-sulfate half-cell and its resistance to earth are determined. The same data is obtained for pairs of mild steel rods as soon as they are connected to each other. The potential to a copper-sulfate half-cell, the resistance to earth, and the current flow are determined for all couples as soon as they are formed. Subsequent data includes the resistance to earth of each rod or couple, the potential to a copper-sulfate half-cell of each rod or couple, and the current flow in each couple, to be obtained monthly or as dictated by weather conditions. The amount of rain that falls during the test period is to be determined, as will other data which may be considered pertinent as a result of further investigations

TEST SITES

A. NCEL

The NCEL test site is located in the southeast corner of the main Laboratory compound. (Figures 2 and 3) It is approximately 200 feet long and 20 feet wide, with two reference electrodes permanently installed at 50 and 100 feet from the nearest edge of the site and on a line perpendicular to the length of the site at the site's center. The site parallels the south boundary fence, with the first row of test rods six feet from the fence line. The soil consists of a three foot layer of crushed sandstone fill on top, followed by about five feet of sand and gravel hydraulic fill, and a natural deposit of sand and gravel of undetermined thickness. The resistivity of the soil to an eight-foot depth averages 1200 ohm-cm.

B. Mugu

The site at the Naval Air Station, Point Mugu, is located as shown in Figures 4 and 5. This location is sometimes covered by water at high tide and during the rainy season. The site is roughly 20 feet wide by 70 feet long; two reference electrodes are located at 50 and 100 feet from the nearest edge of the site, on a line perpendicular to the length of the site at the site's center. The top soil consists of a fine, silt-like material to a depth of 28 inches. At that level a sand is evident and is mixed with thin layers of silt or clay for two inches. The sand, light brown or tan in color, continues for six more inches. At a 36 inch depth the sand changes to a blue-grey color and becomes slightly finer in texture. Beyond four feet in depth the most obvious change is the appearance of at least two different types of sea shells. The resistivity of the soil to an eight foot depth averages 85 ohm-cm.

INSTALLATION DETAILS

A. NCEL

Rods were installed in a rectangular pattern on 6 foot centers as shown in Figure 3. An air hammer, with a special driving head, (Figure 6) was used to drive the rods after they had been started with a sledge hammer. A steel rod, 5/8 inch in diameter, was used to make pilot holes for the aluminum, magnesium, and Ni-Resist rods. The hardness of the soil surface, and the large stones known to be present could cause the Ni-Resist rods to fracture, and the other two materials to mushroom abnormally. A slightly larger rod was used for making pilot holes for the zinc rods, since they were so soft that other than minimum resistance could cause them to bend above ground level. Fine sand was poured into the holes after the rods were inserted to insure good contact between the rod and the earth.

B. Mugu

The same basic pattern was used at Mugu as at NCEL. The actual installation was much simpler, however, since the rods could be pushed into the ground until the sand layer was contacted. A light hammer was used to drive the rods the rest of the way into the ground (Figure 7), with a simple driving head used on the softer metals to minimize mushrooming. Pilot holes were not needed for any of the metals.

SUMMARY

No results are included in this report, since the two one-year groups of test rods were removed from the ground a short time ago. A report will be prepared which will include all test results obtained from those groups.

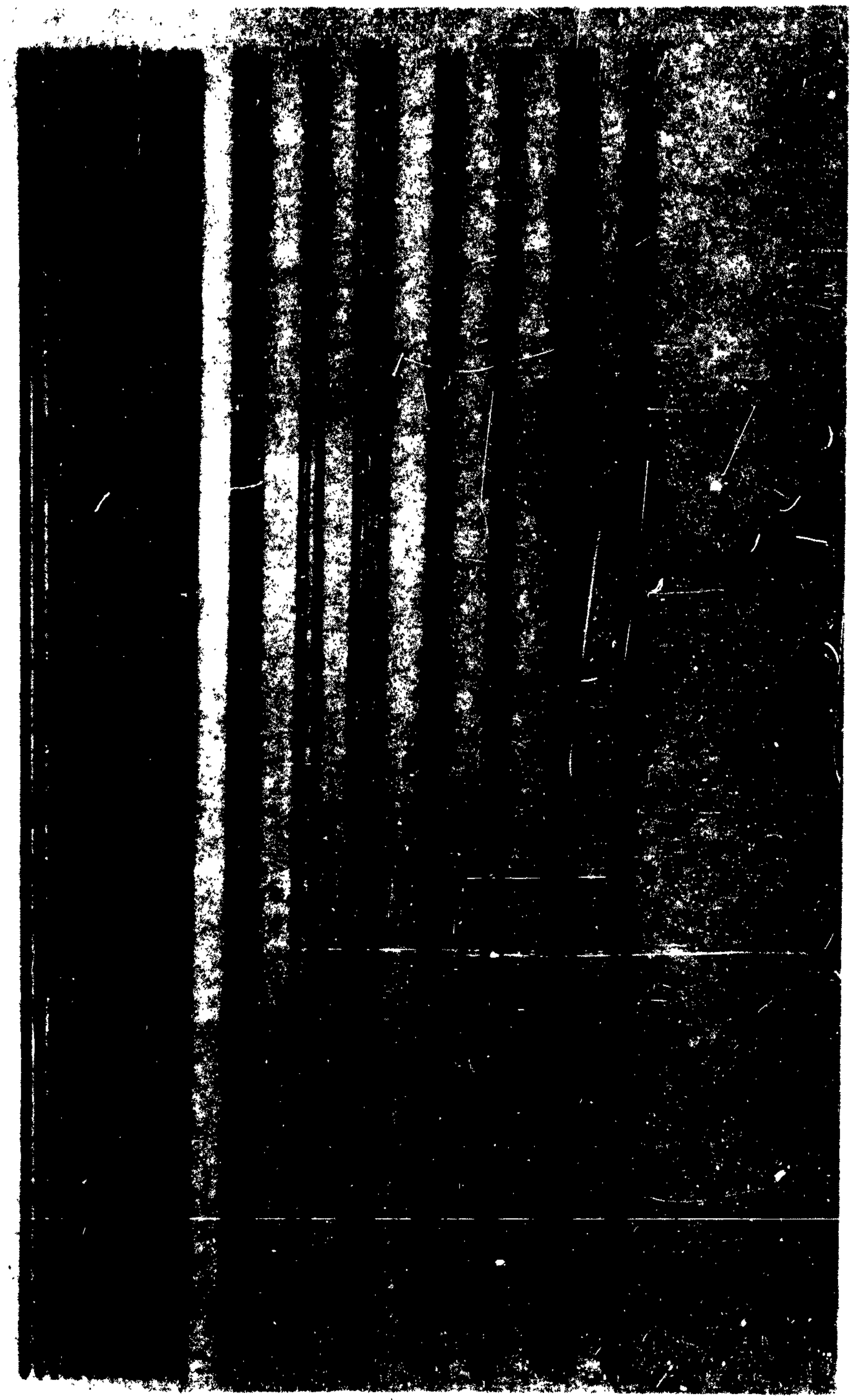

Figure 1. Typical group of ground rods. From left: mild steel, copper-clad steel, galvanized steel, zinc, Ni-Resist, stainless steel, magnesium, aluminum.

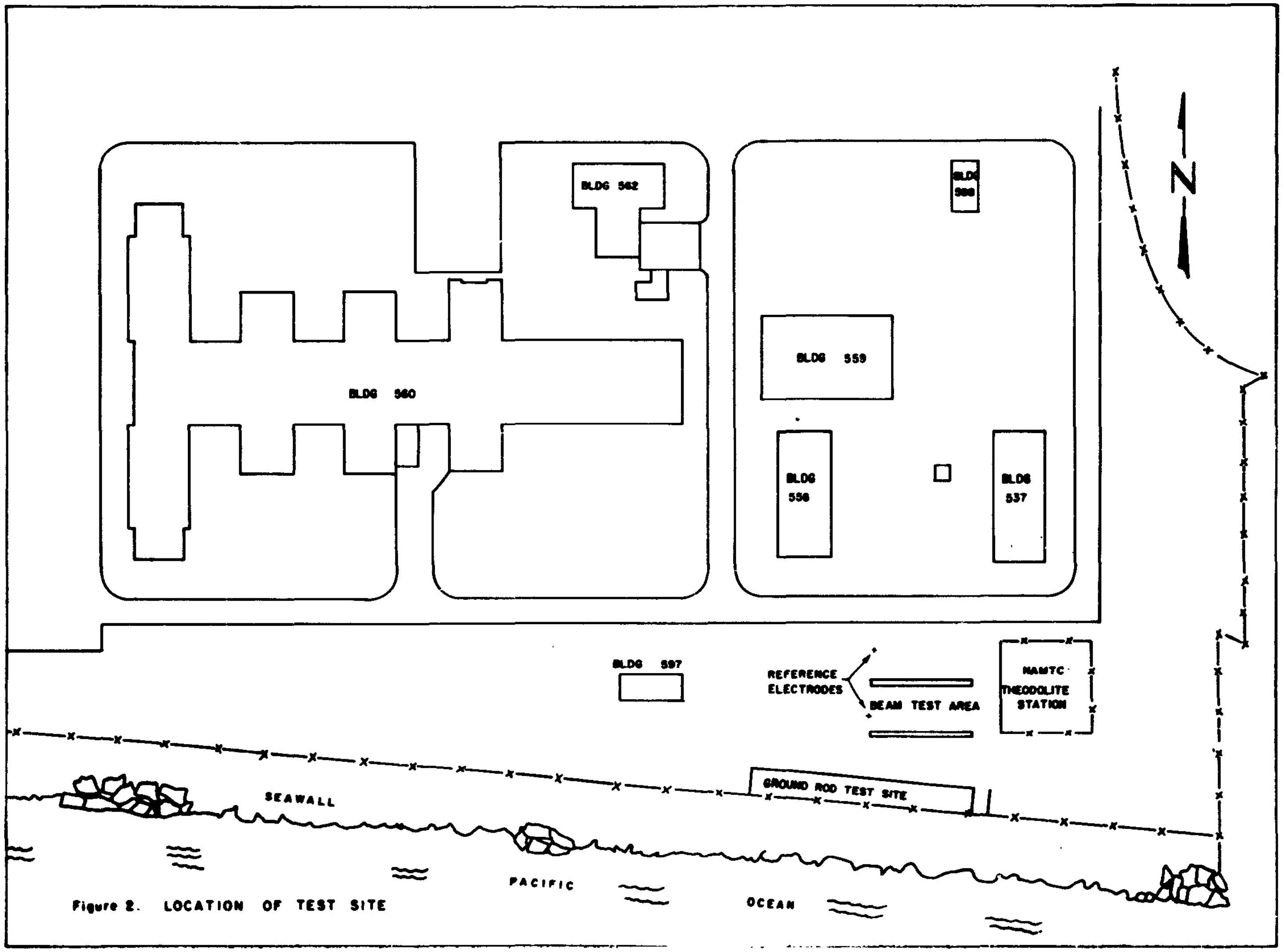

Figure 2. LOCATION OF TEST SITE

generator facility center rear, beam test site at right.

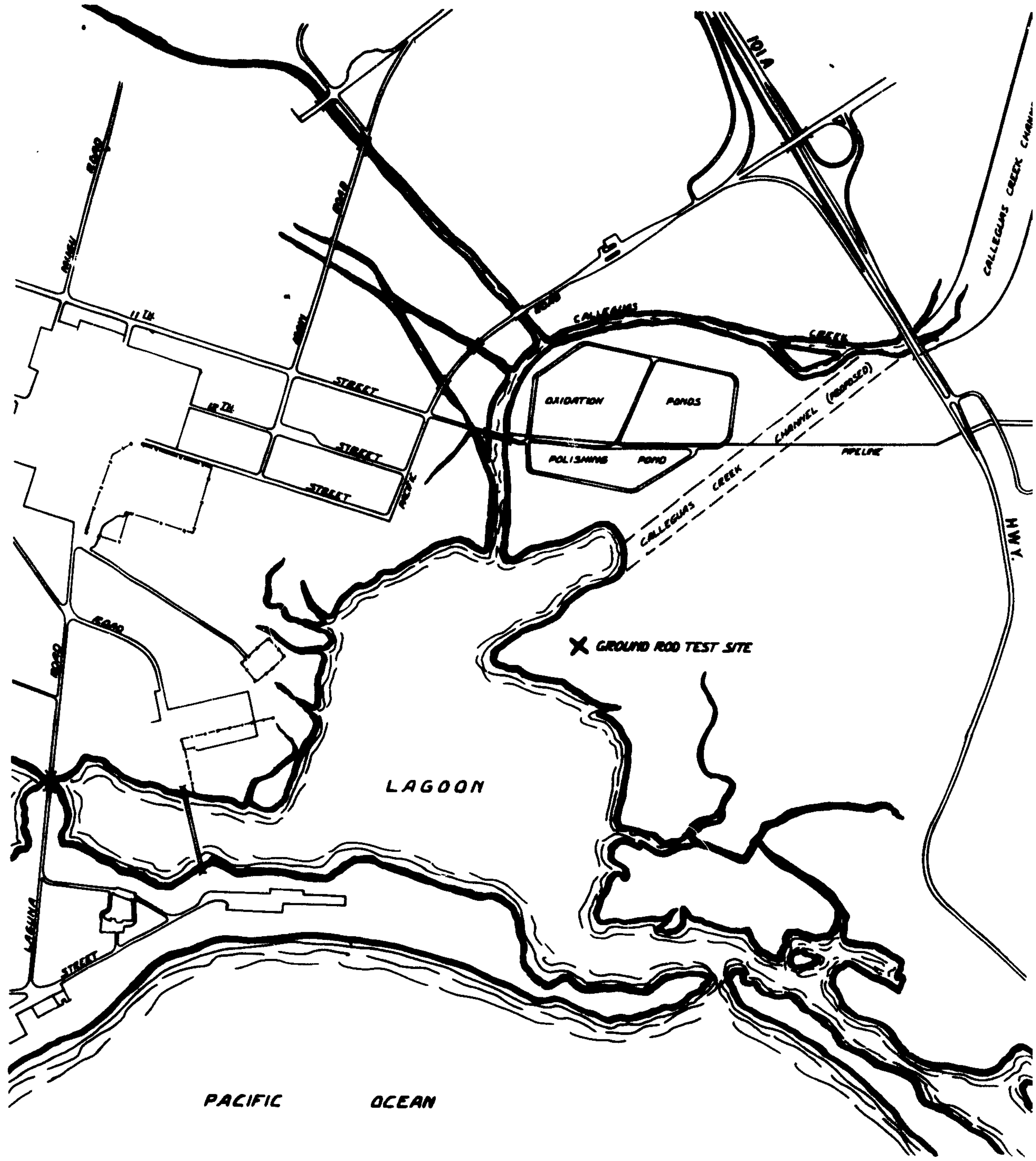

FIGURE 4 GROUND ROD TEST SITE — POINT MUGU

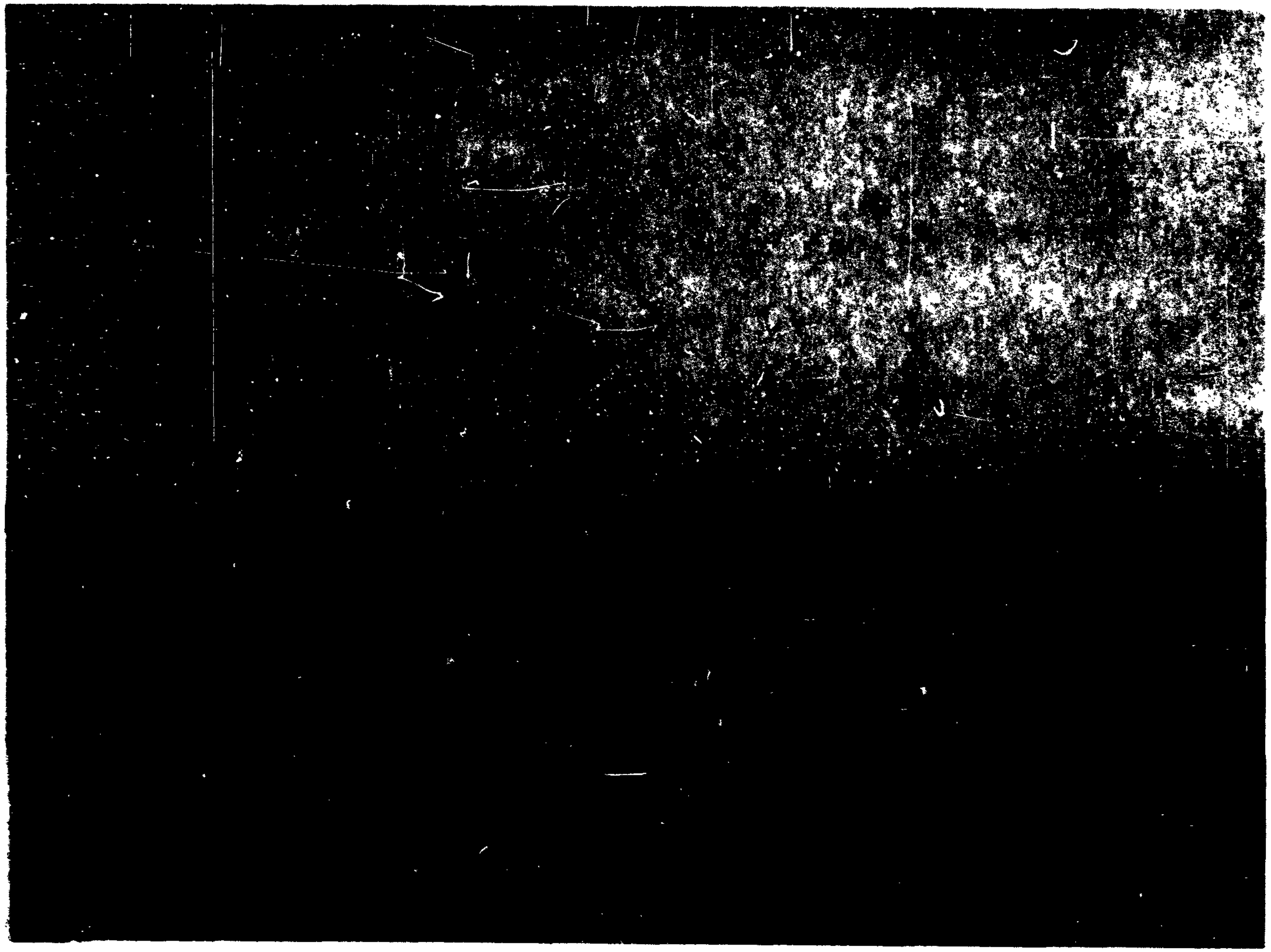

Figure 5. Ground rod test site, Point Mugu.

Figure 6. Installing rods with air hammer, NCEL.

Figure 7. Installing rods with light hammer, Point Mugu.