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TECHNICAL REPORT

SURVEY OF 603 TACTICAL COMMUNICATIONS SQUADRON (TCS) GROUNDING SYSTEM AT SEMBACH AIR FORCE BASE, GERMANY

ELECTRICAL/MECHANICAL BRANCH
1842 ELECTRONICS ENGINEERING GROUP
RICHARDS-GEBAUR AFB, MO. 64030

(1842nd)

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1842 ELECTRONICS ENGINEERING GROUP

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SURVEY OF THE 603 TACTICAL COMMUNICATIONS SQUADRON (TCS) ON-SITE GROUNDING SYSTEM LOCATED AT SEMBACH AFB, GERMANY BY REPRESENTATIVES OF THE 1842 EEG AND THE 1839 ELECTRONICS INSTALLATION GROUP IN ORDER TO INVESTIGATE AND RECOMMEND CORRECTIVE ACTION TO ELIMINATE THE SOURCE OF 400 HERTZ "HUM" ON COMMUNICATION CIRCUITS BETWEEN THE 603 TCS AND 2134 COMMUNICATIONS SQUADRON TECHNICAL CONTROL FACILITY.

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SUMMARY

A survey of the grounding system, located at the 603 Tactical Communications Squadron (TCS) at Sembach AFB, Germany, was performed by representatives of the 1839 Electronics Installation Group (EIG) and the 1842 Electronics Engineering Group (EEG). The purpose of the 1839 EIG survey was to investigate and identify the source of 400 Hertz (Hz) "hum" on communication circuits between the 603 TCS and the 2134 Communications Squadron (CS) Technical Control Facility (TCF) at Sembach AFB. The purpose of the 1842 EEG survey was to further investigate and attempt to correct the 400 Hz "hum" on the communication circuits. The results of the survey indicated: an inadequate low impedance ground at the 603 TCS site; incorrect electronic equipment van power wiring (in which the neutrals and green safety wires were connected together); the existence of various independent ground systems; excessive currents floating on the skin of equipment vans; and incorrectly wired semi-permanent buildings. Modifications in the power wiring of the semi-permanent buildings were made along with minor grounding system changes. As a result, a decrease in the 400 Hz "hum" was noted in the circuits between the 603 TCS and the 2134 CS TCF.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

1. INTRODUCTION.

1.1 The 2134 Communications Squadron (CS) had reported excessive 400 Hz "hum" noise problems on communications circuits from the 603 Tactical Control Squadron (TCS). Both units are located at Sembach AFB, Germany. The 1839 Electronics Installation Group (EIG) was tasked with dispatching a team to investigate and determine the source of the problem. This team surveyed the Sembach problem during the week of 18 Nov 75 and reported the source of "hum" was caused by power neutral currents flowing on site grounds. Because of the scheduled "Creek Swap" project at Sembach AFB, it was determined that further investigation and corrective action should be taken to eliminate the 400 Hz "hum" on the communication circuits under investigation. As a result, two 1842 EEG engineers, Mr. John Zych and Mr. Harold McRaney, were sent to Sembach AFB, Germany to investigate and take corrective action to eliminate the 400 Hz "hum" problem.

1.2 The information in this report reflects the findings, recommendations, and results of only the 1842 EEG survey. However, the results are similar to those of the 1839 EIG.

2. PROCEDURES.

2.1 The procedures used to obtain the data contained in this report are as follows:

a. Grounding drawings were developed with the aid of on-site personnel and through visual inspection. Site layout is shown in Figure 1 and existing grounding drawings are shown in Figure 2.

b. Resistance-to-earth measurements were made with an Associated Research Model 259 Vibro-ground Tester at important grounding rod locations throughout the 603 TCS complex. Earth resistance values are shown in Figure 2. The three-point method shown in Figure 3 was used for these tests.

c. Currents in the major grounding conductors were measured with a "clamp-on" ammeter. Results of current readings found on various ground cables are shown in Figure 2.

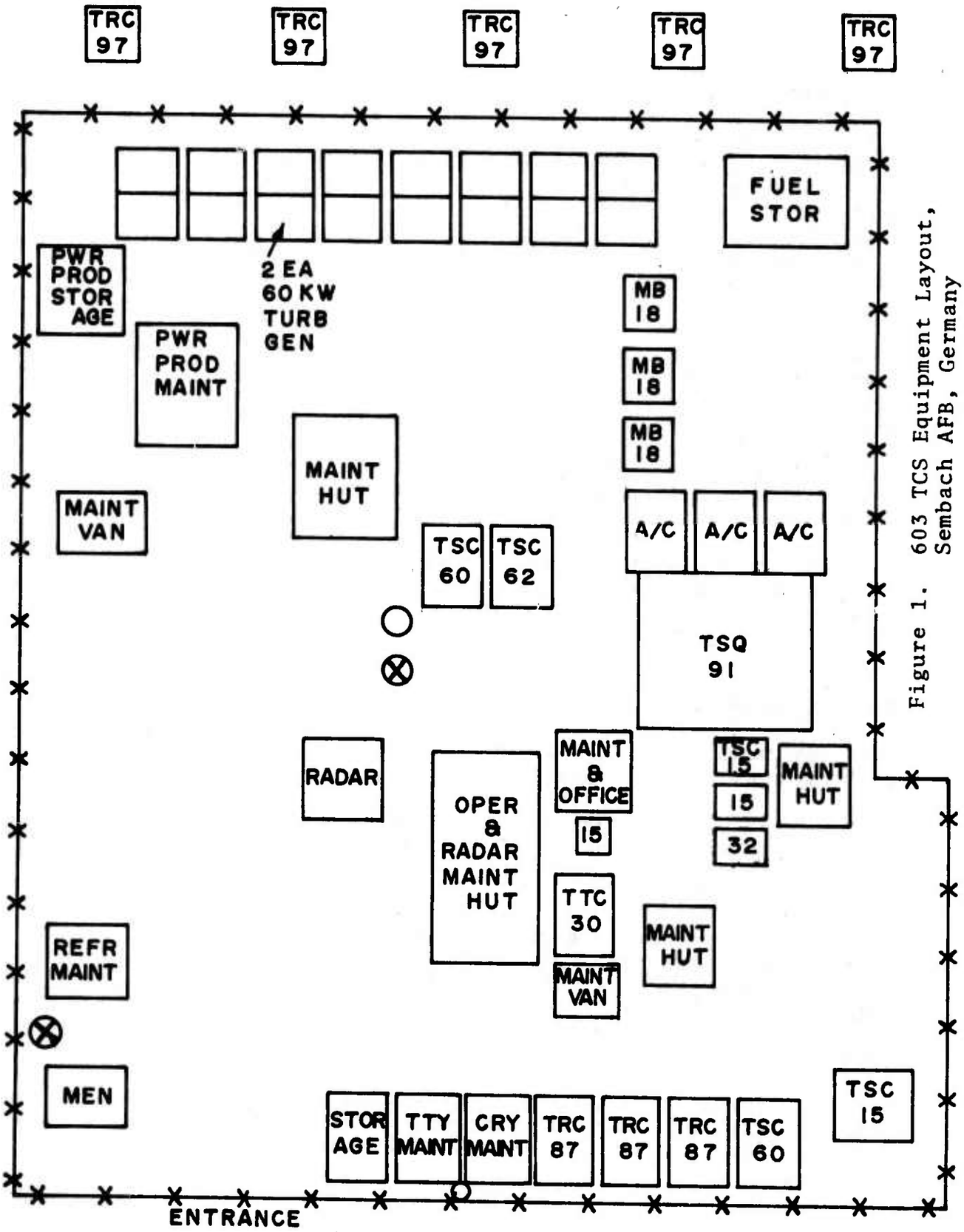

Figure 1. 603 TCS Equipment Layout, Sembach AFB, Germany

✕ ✕ ✕ EXISTING FENCE

⊠ - 50 HZ COM POWER DISTRIBUTION PANEL
O - 60 HZ GEN POWER DISTRIBUTION PANEL

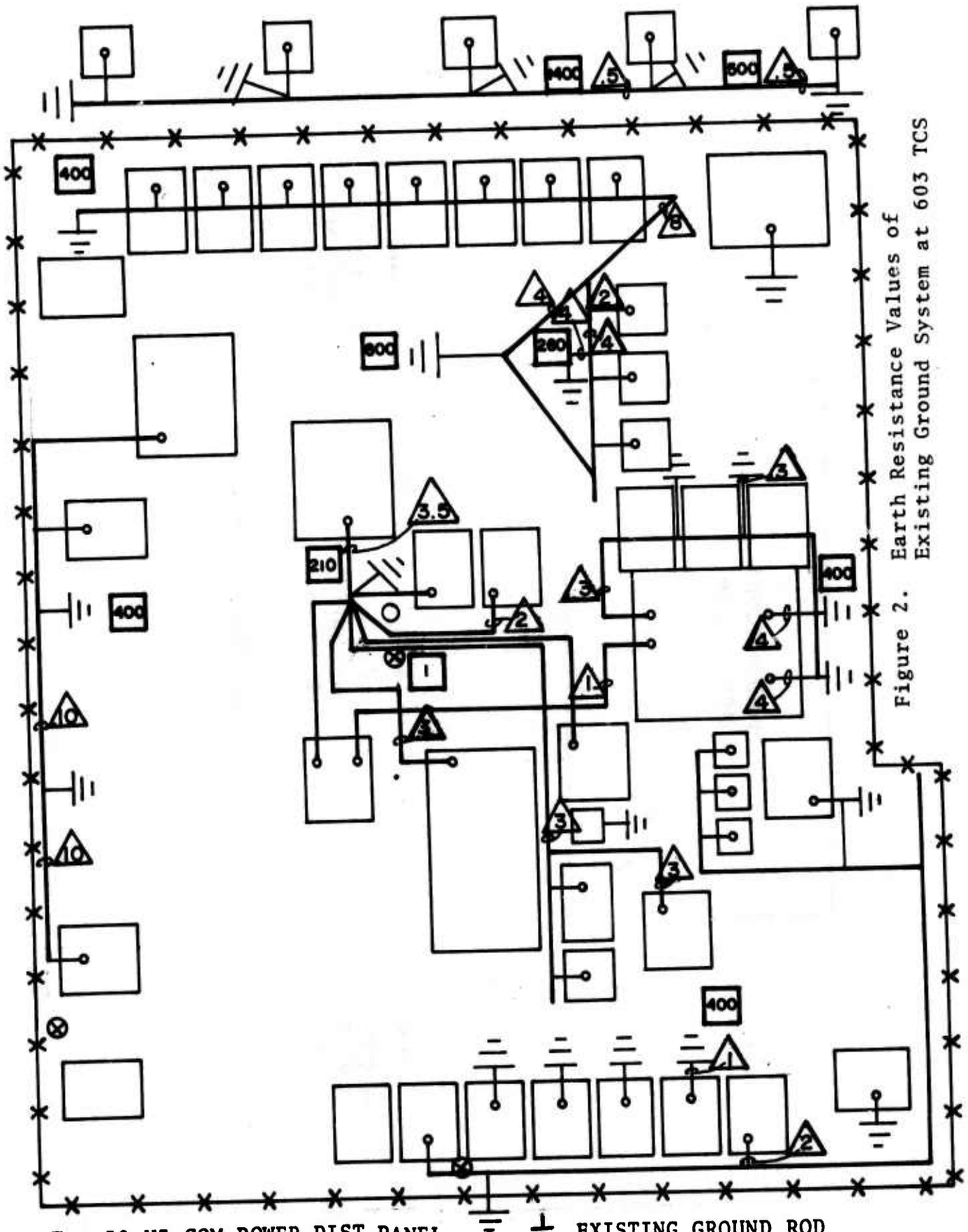

Figure 2. Earth Resistance Values of Existing Ground System at 603 TCS

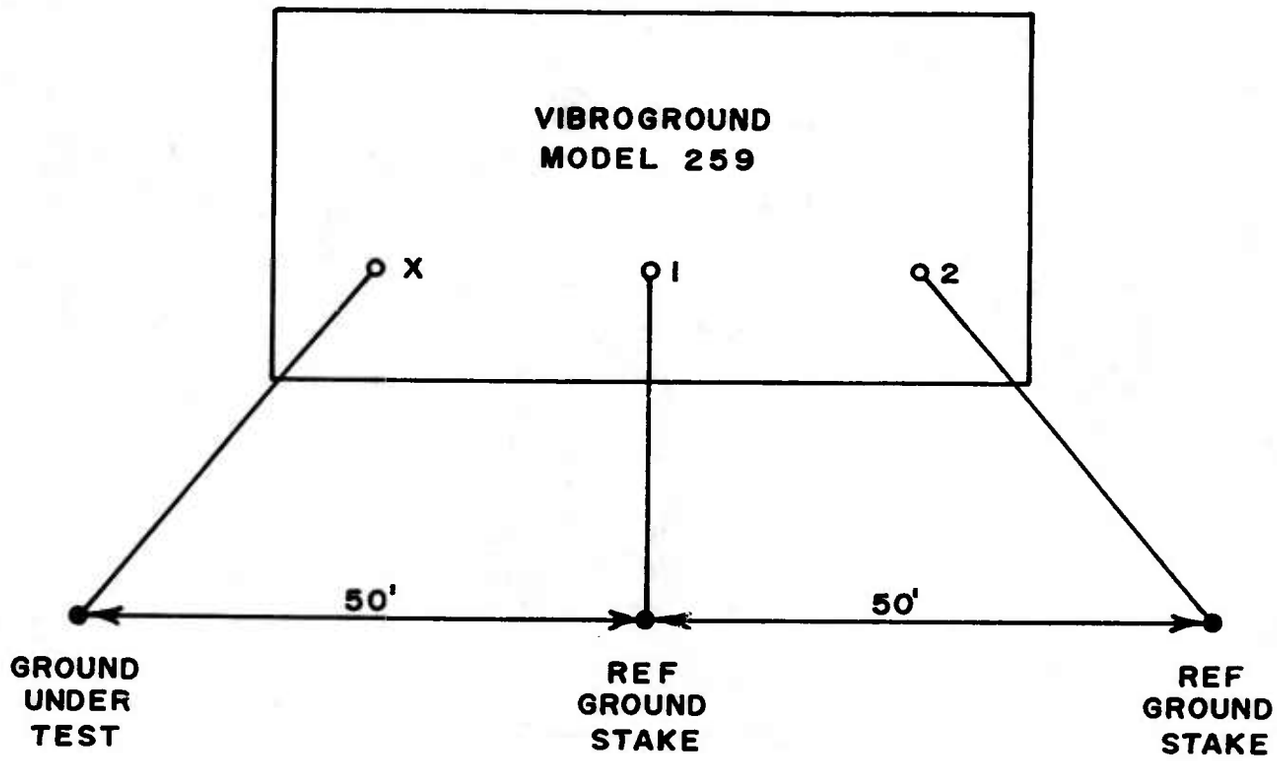

Figure 3. Test Equipment Setup for
Earth Resistance Measurements

d. A review of equipment schematics and a visual inspection of electrical wiring in various electronics vans was made to determine wiring configuration and to locate the green wire safety ground and neutral connected together at the wiring panels.

e. The level of the 400 Hz interference on the circuits was measured with an HP-3555 Transmission Test Set at the 2134 CS TCF and at the 603 Technical Control Van (AN/TCC-62). The measurements were made to determine the severity of the interference and to assess the results of modifications made to the site ground system during the survey.

3. RESULTS.

3.1 The results of the survey indicated a very poor site ground system. The measurements of ground rods showed the existence of a high earth resistance. The 603 TCS was unaware of this problem due to erroneous Base Civil Engineering (BCE) grounding measurements. The measurements had been made with all wires connected to the ground rods.

3.2 The TSQ-91, TSC-15, TSC-60, TRC-97, TPS-43, TSC-62 and TGC-28 vans are wired with all grounds tied together at the power distribution panels. The neutrals and green safety wires were connected together along with signal cable shields, signal reference grounds, and the skin of the shelter itself. This situation resulted in several amperes of current flowing in the various grounding conductors and the shelter skin which caused potential differences between the various equipments within the facility. The TRC-87 and TTC-30 have separate ground and neutral conductors as required.

3.3 The semi-permanent and permanent buildings on location all had power panels wired with the green safety wire and the neutral connected together. This situation introduced most of the current into the ground system. Current values of 10 amperes, 3 amperes, and 3.5 amperes were removed from the ground system when the green wires were isolated from the neutral.

3.4 Neutral wire conductors are being used as safety ground in the air conditioning (A/C) units on most of the vans. The A/C units operate at 3 phase, 208V, and use neutral as the safety equipment ground. This wiring introduces unnecessary current in the grounding system.

3.5 Neutrals and green safety wires are connected together at the utility outlets. This situation introduces current into the equipment's safety ground and is in violation of Section 210 of the National Electrical Code (NFPA No. 70).

3.6 The maintenance of ground systems is poor. Corroded and loose connections, many unnecessary taps, and frayed conductors were found throughout the grounding system.

3.7 Circuit measurements made during normal site operation indicated that high levels of 400 Hz interference (greater than -40 dBmo) existed on many of the 603 TCS circuits routed through the 2134 TCF. The level varied from circuit-to-circuit and changed during the day as different equipments were turned on and off within the 603 TCF facility. During periods when the level of interference was greatest, a high level near one volt RMS was found to exist between pair and ground on all 603 TCS circuits within the 2134 CS TCF. The major cause of the interference in the channels is the conversion of the common mode interference voltage to a differential signal within the channel. This is due to the impedance unbalance inherent in the cables and equipments both at the 2134 CS TCF and the 603 TCS communications facility. The problem is aggravated by the fact that the primary power frequency is within the passband of the circuits involved. Thus, for the same level of interference in the communication channels, the 400 Hz power system requires an additional 30 to 40 dB of rejection over that required by 50/60 Hz power systems.

3.8 The noise measurements were repeated during a period when the 603 TCF facility was down for testing. The results indicated a 30 dB decrease in the average interference level. After modifications were made to the 603 TCF ground system, which reduced the ground currents

(see paragraphs 3.2 and 3.3), additional measurements of the interference levels were made. The results of this test showed a 10 to 20 dB decrease in the average interference level compared to the results of the initial tests run on the operational facility prior to the modifications.

4. RECOMMENDATIONS.

4.1 Recommend that a new ground system be implemented at the 603 TCS. The ground system should be similar to the sketch in Figure 4. A low impedance (10 ohm or less) path-to-earth should be obtained, either by installing a new copper ground grid, or by using the existing 50 Hz ground system.

4.2 Recommend that 603 TCF obtain a Vibro-ground Tester and perform periodic ground resistance measurements on the ground systems. Ground resistance measurements should be made periodically on all permanent installations as well as at every temporary field installation. A goal of 10 ohms or less earth resistance should be obtained at all installations.

4.3 Recommend Unsatisfactory Report (UR) action be taken to have all neutrals and green protective grounds isolated within the vans. Neutral should be isolated from the equipment van shell and be grounded only at one lacation. This location should be at the power generation source. Only when the equipment vans are rewired can noise from the 400 Hz be completely eliminated. With a better grounding system, the quality of the circuits will be improved; however, some noise will still exist because of the neutral currents floating on the skins of the shelter.

4.4 Recommend that a complete analysis of site equipment configuration also be accomplished. Items such as common grounding, highest power consumers located near the power source, balancing of power loads to get neutral currents minimized, running power cables as short as possible, checking new equipment vans to insure neutral wire isolation grounding measurements, and maintenance of grounding system should be considered in the analysis.

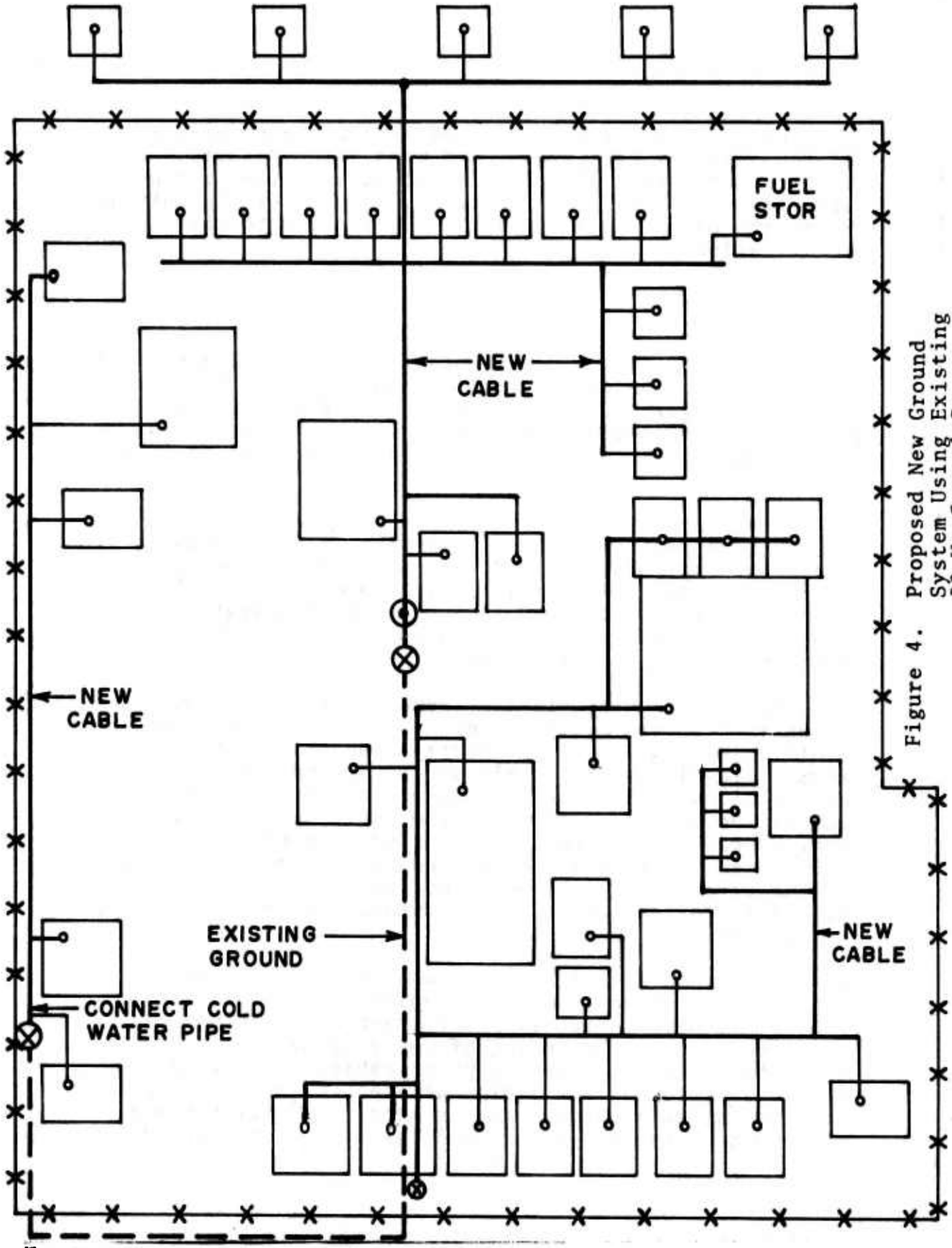

Figure 4. Proposed New Ground System Using Existing 50 Hz Ground System

4.5 Recommend larger cables be used for the 603 TCF grounding system. The braided cable presently being used does not have a high current capability. It also has a large voltage drop and a tendency to fray easily. A larger stranded copper cable, such as a #2/0 AWG cable, is recommended for installation use. For field application, a larger braided cable may be used.

4.6 Recommend that a longitudinal balance test be made a part of the routine system checks and trouble-shooting procedures for the equipment and cables associated with the 603 TCS facility. This test is required since the recommended improvements in the grounding system will not totally eliminate pair-to-ground 400 Hz voltage. Circuit longitudinal balance must be depended upon to further reduce the interference to an acceptable level. Methods and equipment for performing longitudinal balance tests are specified in DCAC-310-70-51, Sup 1, Chapter 9. The balance value should exceed 70 dB to insure satisfactory system operation.

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