INTERIM REPORT

9-13-79

Contract Program or Project Title:

Subject of this Document: "Nickel Contaminated Titanium Weld Wire Study"

Type of Document: LOFT Technical Report

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Date of Document: July 1979

Responsible NRC Individual and NRC Office or Division: G. D. McPherson

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Prepared for
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

NRC Fin #A6048

INTERIM REPORT

NRC Research and Technical Assistance Report

LOFT TECHNICAL REPORT LTR 141-93

JULY 18, 1979

USNRC P 394

NICKEL CONTAMINATED TITANIUM WELD WIRE STUDY

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EG&G Idaho, Inc.

IDAHO NATIONAL ENGINEERING LABORATORY

DEPARTMENT OF ENERGY

IDAHO OPERATIONS OFFICE UNDER CONTRACT DE-AC07-76IDO1570

EG&G Idaho, Inc.

LOFT TECHNICAL REPORT
LOFT PROGRAM

FORM EG&G-229
(Rev. 12-78)

TITLE	REPORT NO.
NICKEL CONTAMINATED TITANIUM WELD WIRE STUDY	141-93

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PERFORMING ORGANIZATION: Development and Evaluation Lab	DATE: July 18, 1979

LOFT Approval

LEMB Mgr. LEPD Mgr. PSB Mgr. P&CSB Mgr. RSB Mgr. FE&OB Mgr.

ABSTRACT

Attachment of thermocouples to fuel rod welding problems at Exxon Nuclear Company and INEL prompted an investigation study of the titanium filler wire material. It was found that the titanium filler wire was contaminated with nickel which was jacketed on the wire prior to the drawing process at the manufacturers. A method was developed to 100% inspect all filler wire for future welding application. This method not only indicates the presence of nickel contamination but indicates quantity of contamination. The process is capable of high speed inspection necessary for various high speed manufacturing processes.

DISPOSITION OF RECOMMENDATIONS

1. It is the practice of EG&G to inspect all weld wire before it is used.
2. All manufacturing procedures receive EG&G approval before a P.O. is issued.
3. It is a condition of all procurement packages for titanium weld wire that the material contain no nickel. (We are using ASTM and AWS specs and clarifying no nickel contamination.)

SUMMARY

The inspection probe and associated electronics are capable of inspecting and detecting nickel contamination of titanium and zircaloy wire at linear velocities in excess of 0.67 meter per second and cross sectional contamination percentages less than 0.65%. The tests were very successful and this inspection technique or equivalent should be implemented for all LOFT T/C to fuel rod welding filler wire.

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1.0 Introduction

The purpose of this report is to present the results of tests performed on nickel contaminated titanium weld wire used to laser weld thermocouples to LOFT fuel rods. This contamination is suspected to cause weld cracking, welds of decreased strength and reliability and in turn be cause for re-characterization tests on the survivability of the thermocouples in a LOFT type of environment. It is necessary to know the quality of the weld wire over the entire length. The inspection probe and associated electronics allows this to be accomplished in relatively short periods of time.

Test results, description of equipment, conclusions and recommendations are presented in this report.

2.0 Description of Test

Inspection equipment described in section 4.0 of this report was designed and built at EG&G Idaho-INEL to conduct this test. This equipment was calibrated by comparing electronic signal output versus known contamination percentages. These cross sectional area contamination percentages were determined by photo-micrographs and contamination maps which are included in Appendix A. It was shown that contamination percentages less than 0.65% could easily be detected. Contaminations denoted by location number C pinned the inspection equipment. The inspection system can be adjusted for greater gain if the contamination range is less than the mean shown by location G and by location C.

The test was conducted by pulling the wire through a selected ceramic brushing which holds the geometrical relationship of the wire to an eddy current coil. The results of the tests are presented in Section 3.0 of this report.

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3.0 Test Results

Inspection was conducted on 1902 meters of 0.381 mm (0.015 inch) diameter -CP itianium weld wire supplied by Astro Metallurgical Corp. (vendor lot number 76A3768R, CR-552 Heat Treat number 6081 under contract number S6572). The entire lot was rejected due to nickel contamination. This rejection overrides previously accepted material where only end point samples were visually inspected. The inspection equipment trace record is included in Appendix B of this report.

4.0 Test Equipment

The test equipment used to inspect for nickel contamination was an eddy-current displacement gage developed at INEL (see Appendix C). This instrument uses a one meg - hertz eddy current balance bridge. The instrument has capability of detecting either inductive or resistive component of bridge unbalance signal or any phase angle between the inductive or resistive components.

A special set of coils was developed for detecting nickel contamination of the titanium wire sample.

The eddy-current displacement gage was nulled on two known non-contaminated wire samples. The phase detection signal was adjusted for proper sensitivity. Then the wire sample to be inspected was pulled through the coil on one side of the bridge while a reference (non-comtaminated) wire was maintained in the other side of the bridge for comparison.

5.0 Conclusions and Recommendations

Recent nickel contaminated titanium weld wire problems have demonstrated the need for extreme controls on all raw materials, processes, and controls associated with the weldment of fuel rod thermocouples.

The following recommendations are made:

1. It is recommended that all weld wire be inspected 100% before use by the mentioned procedure or equivalent.

2. It is recommended that EG&G not normally issue a purchase order to any company that will not release an approved manufacturing procedure and meet the specifications of that procedure.

3. Add the requirement of no nickel contamination to the procurement specifications and control engineering blueprints where applicable.

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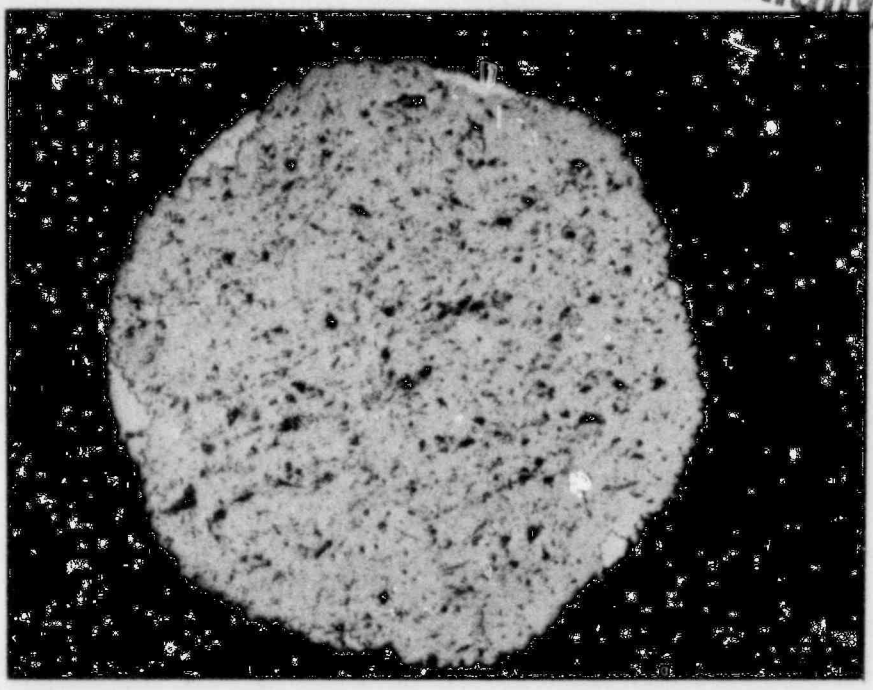
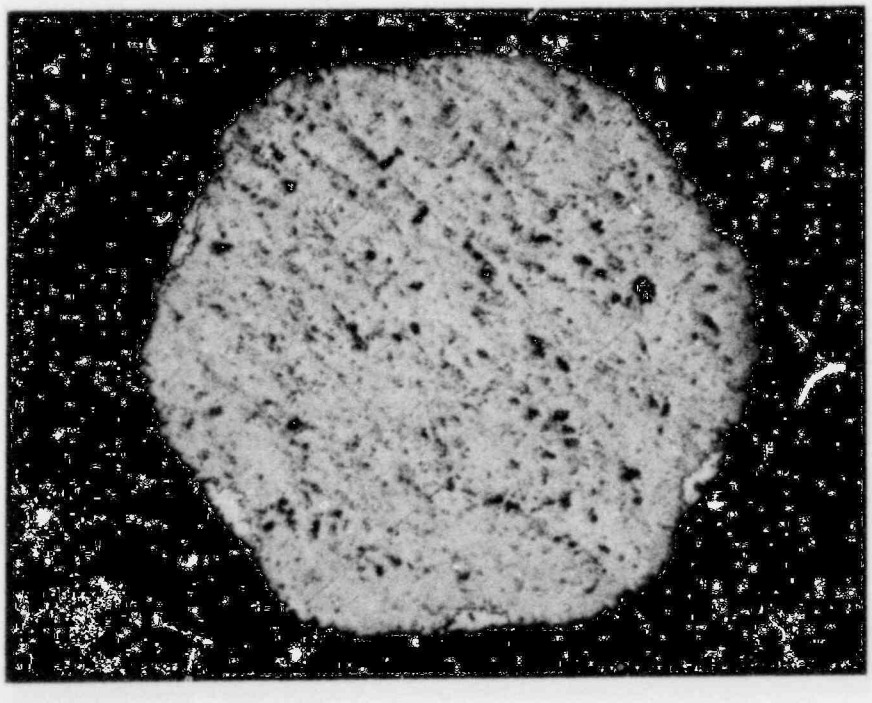
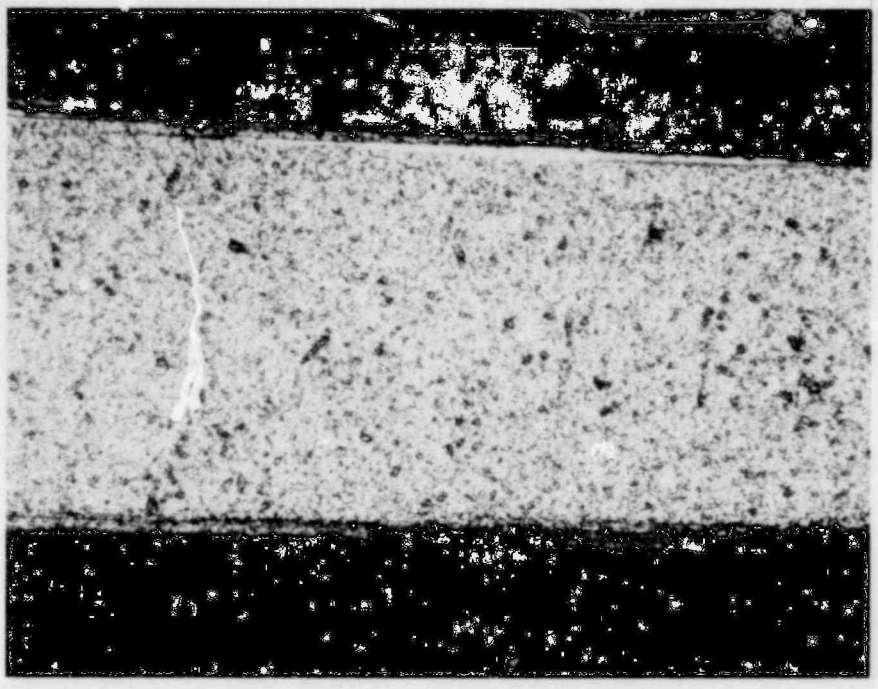
APPENDIX A



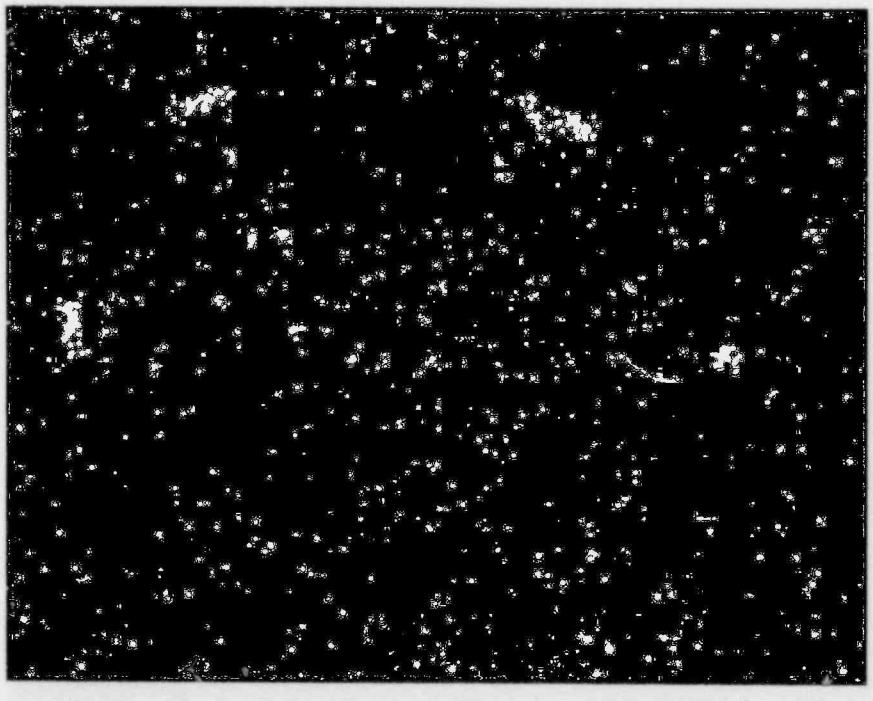
Optical photomicrograph at random transverse cross-section of nickel contaminated. 0.015 in diameter titanium weld wire.



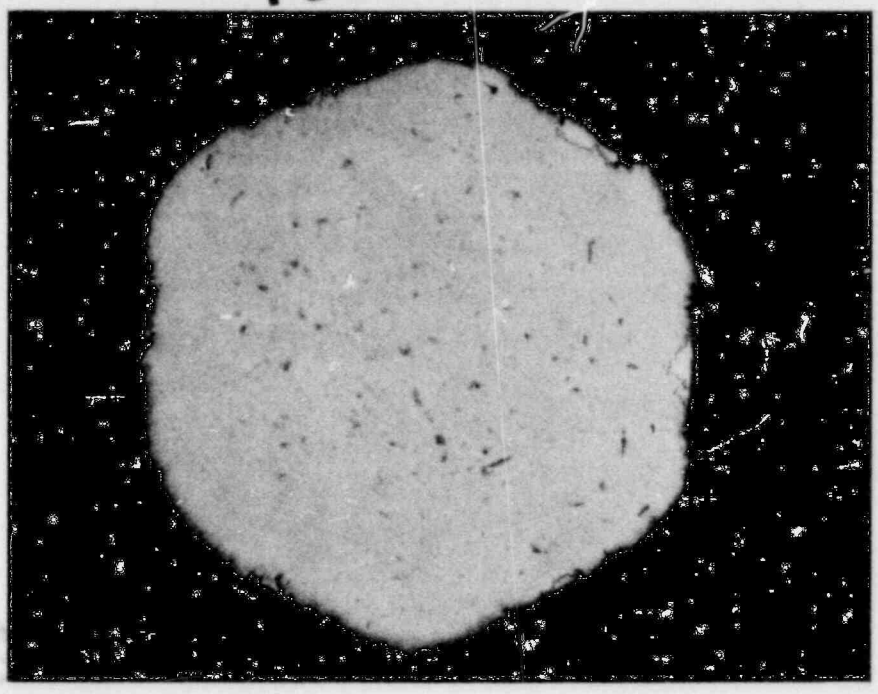
Optical photomicrograph at random transverse cross-section of nickel contaminated 0.015 in diameter titanium weld wire



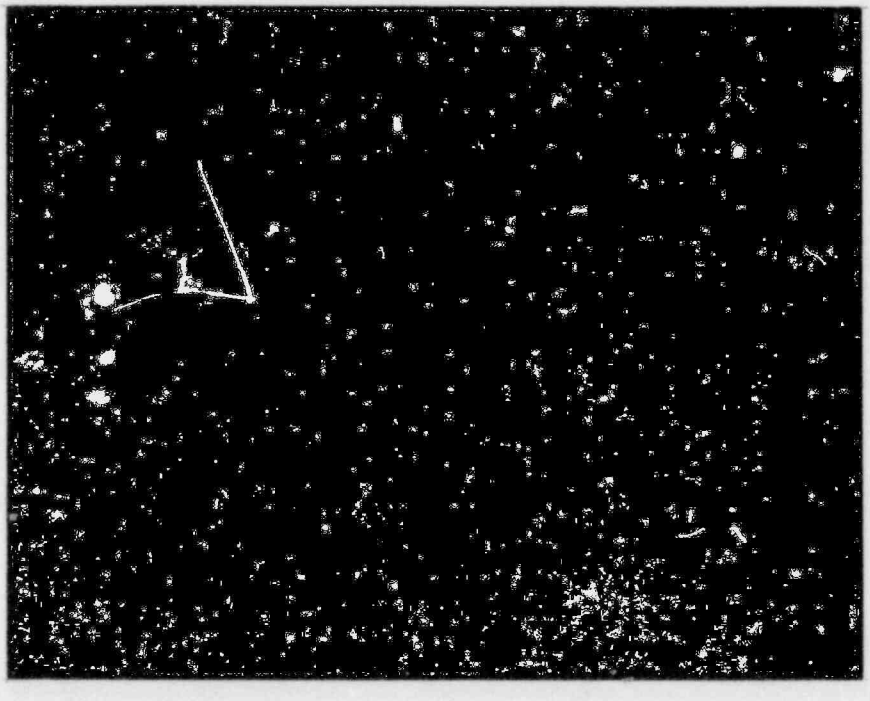
Wire #4 Longitudinal optical photomicrograph. Approximately 200X of nickel contaminated titanium weld wire.



Wire #4 transverse nickel contamination map. Approximately 250X of titanium weld wire.



Optical photomicrograph section at location A, approximately 200X



Nickel contamination Map section at location A. Approximately 210X

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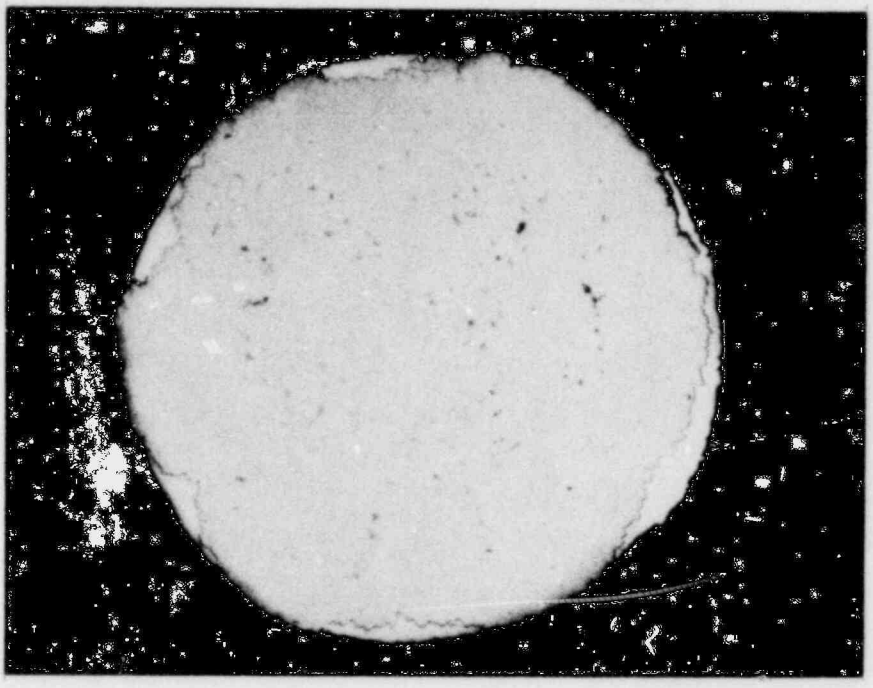
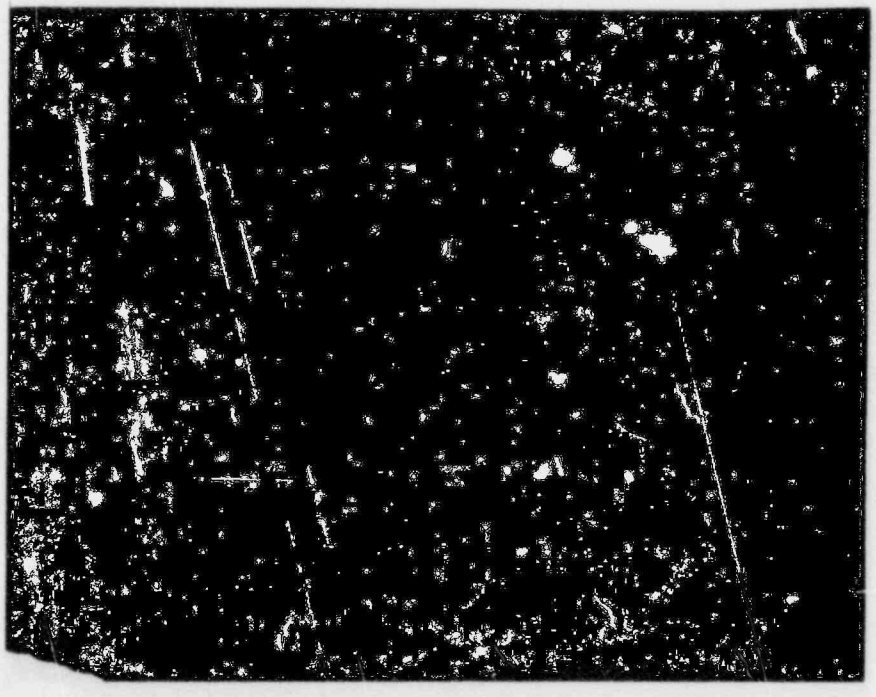
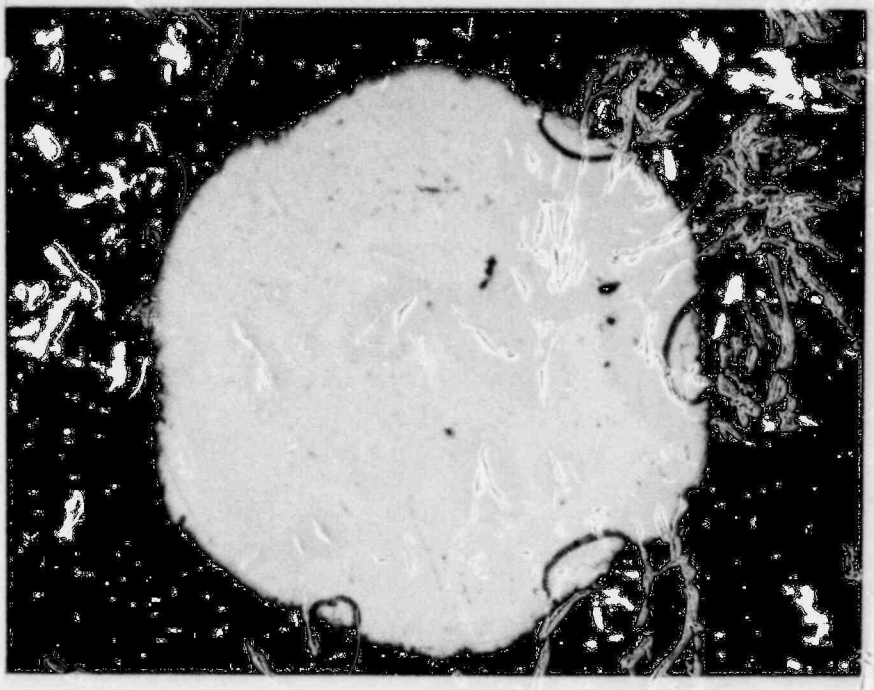


Optical photomicrograph section at location C Approximately 200X



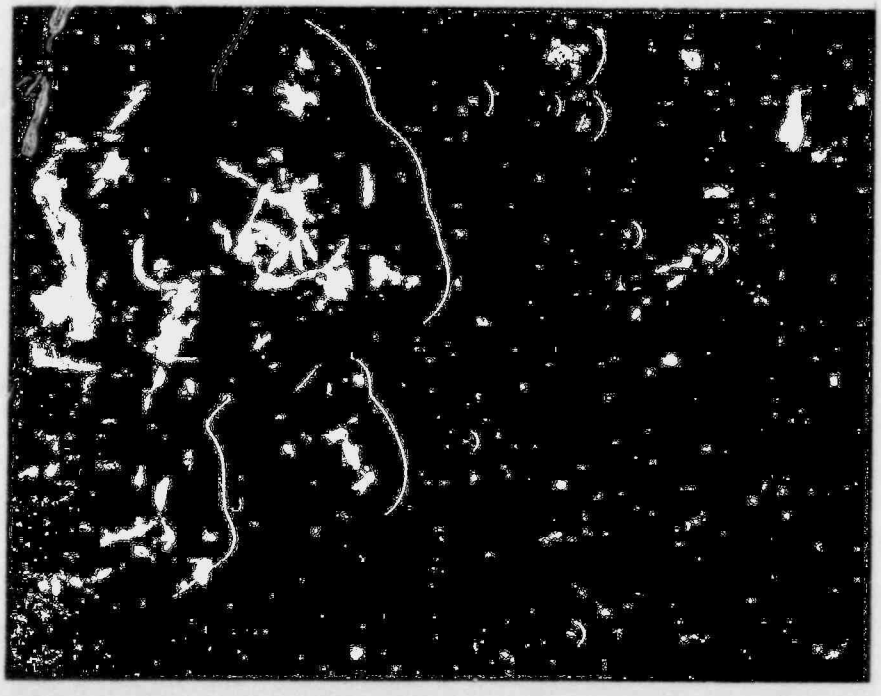
Nickel contamination map section at location C. Approximately 210X



Optical photomicrograph section at location G. Approximately 200X

Nickel contamination map section at location G. Approximately 210X

Optical photomicrograph section at location J. Approximately 200X



Nickel contamination map section at location J. Approximately 210X

APPENDIX B

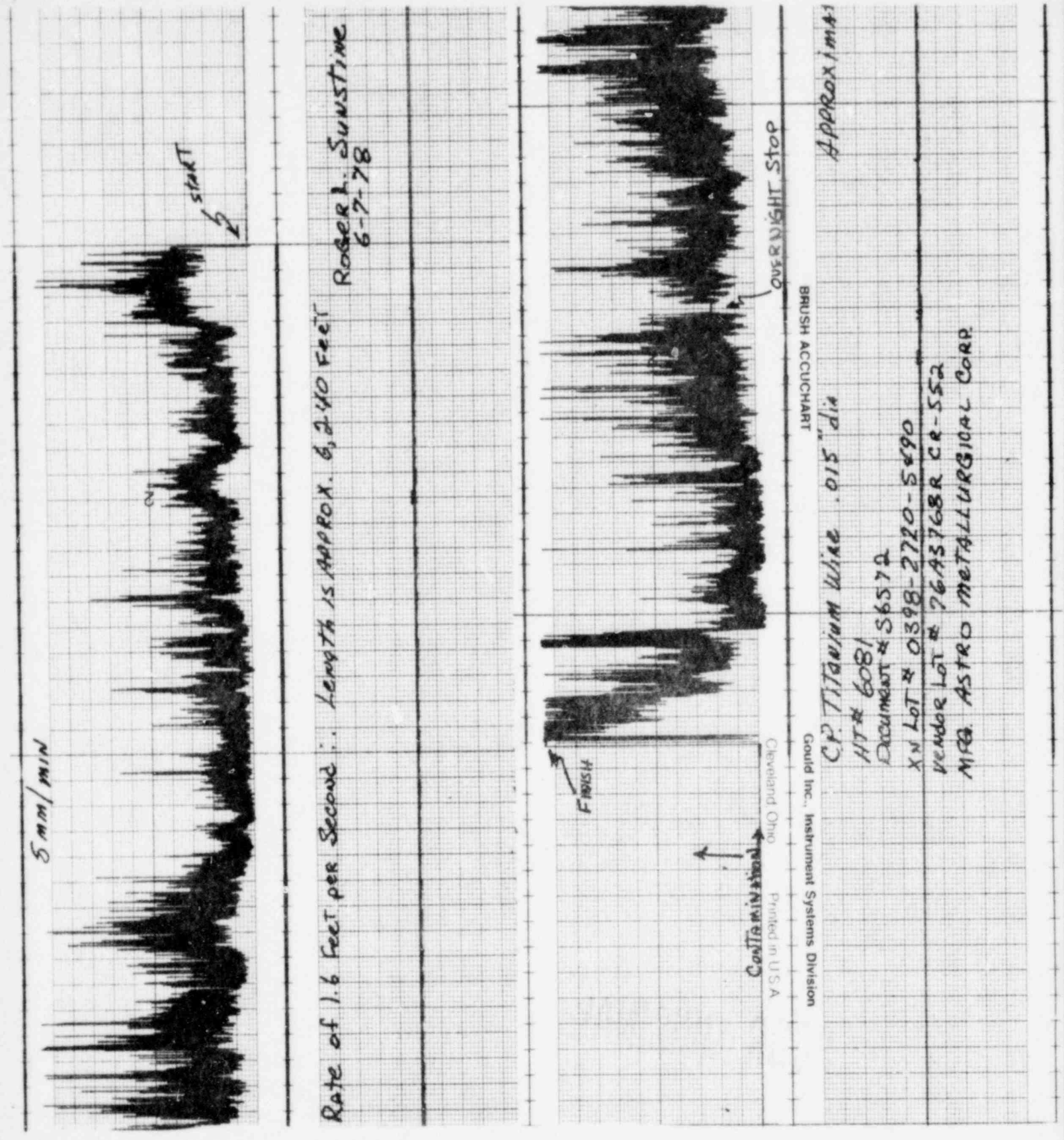


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Figure 1. Inspection trace records of Astro-Metallurgical Corp. Titanium weld wire lot number 76A3768R.

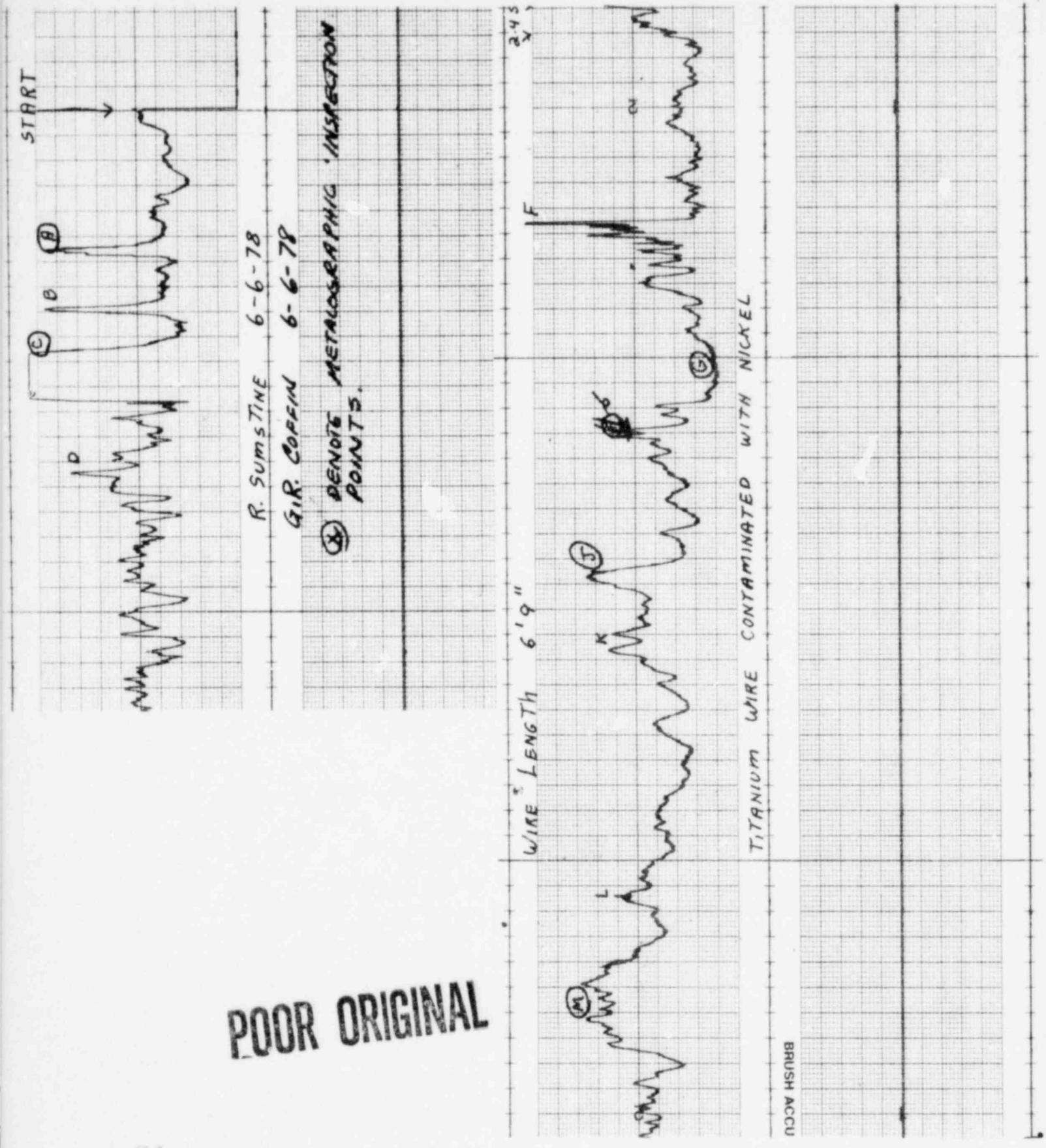

Figure 2. Calibration and qualification of Inspection system trace records—deflection vs. % contamination locations defined.

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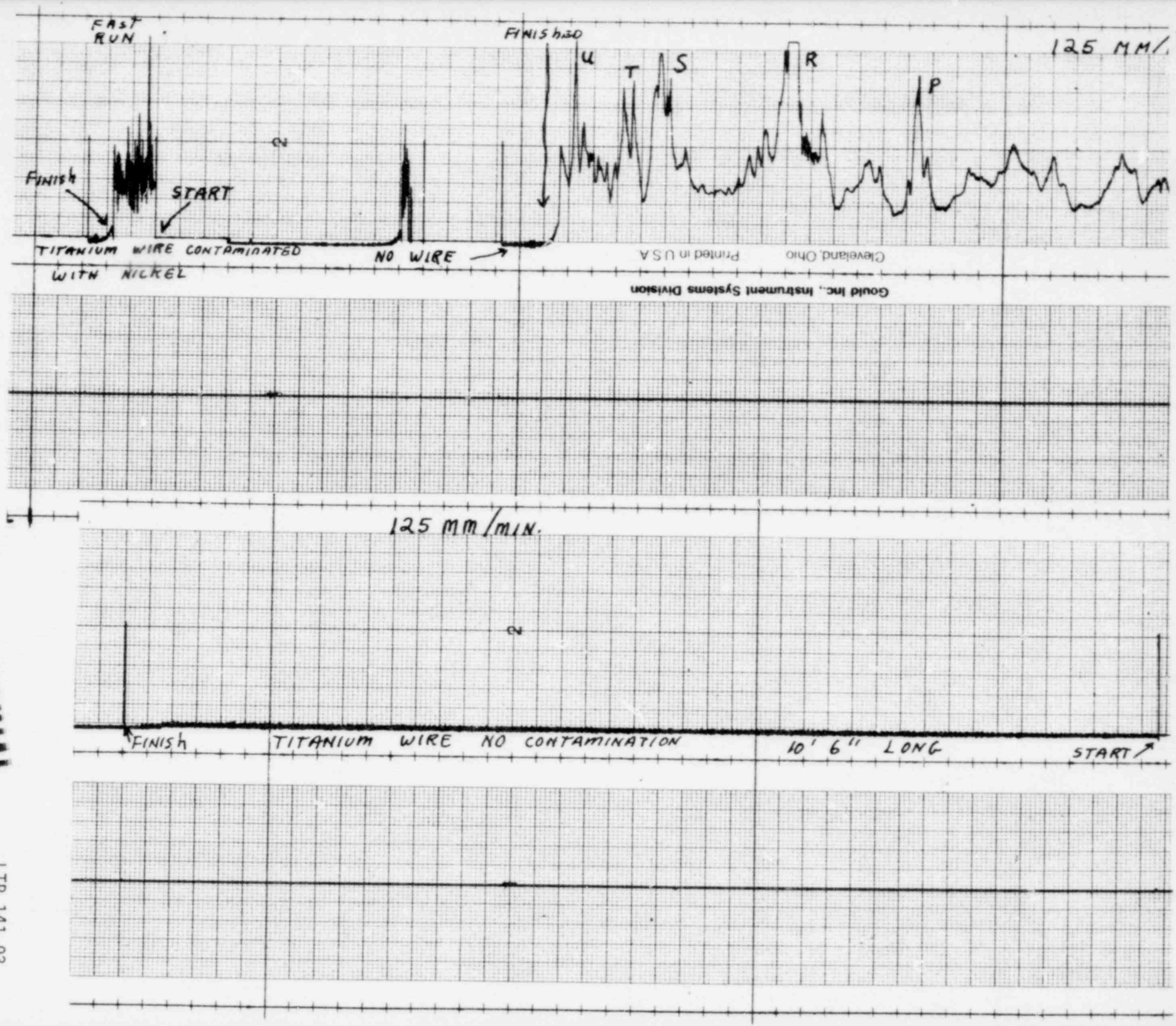

Continuation of Figure 2

APPENDIX C

Figure 3. Inspection Probe showing entry holes to eddy current coils.

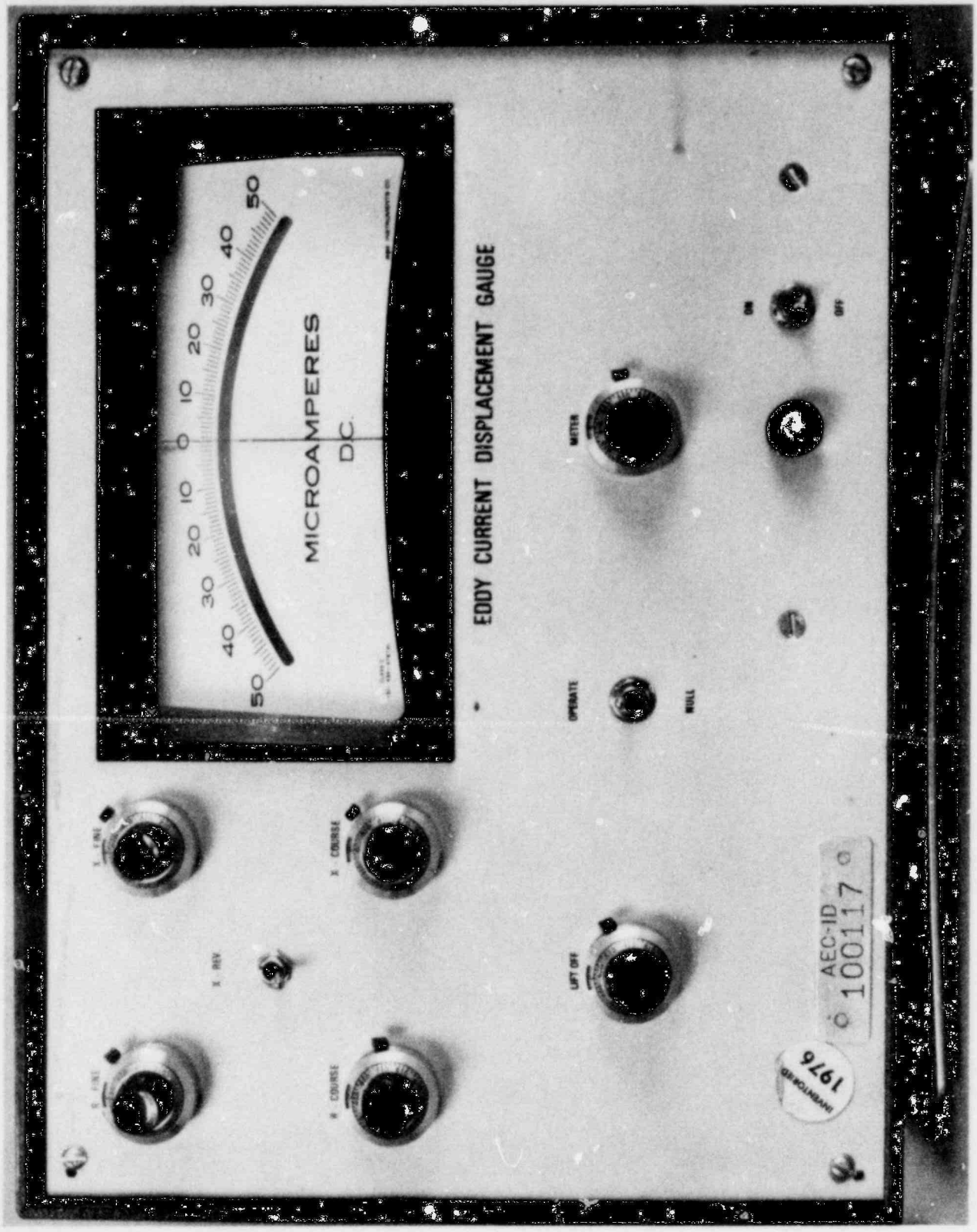

Figure 4. Electronics and Signal Conditioning equipment.