NON-INVASIVE CORROSION SENSOR

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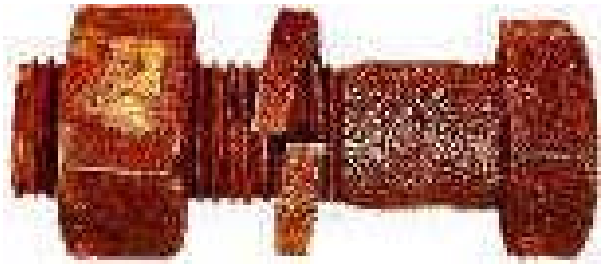
IRON + WATER

=

RUST!



$$4\ Fe^{+2}(aq) + O_{2\,(g)} + [\,4 + 2X]\ H_2O \rightarrow 2\ Fe_2O_3\ xH_2O + 8H^+\ (aq)$$

(ionic equation for Iron submerged on water)

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RUST GENERATES HEAT

HEAT OF FORMATION OF
IRON OXIDE (Fe_2O_3) = 197.0 kcal/mol
or
46.7 kj/mol

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HOW CAN WE RELIABLY AND ACCURATELY MEASURE HEAT PRODUCED DURING THE CORROSION PROCESS?

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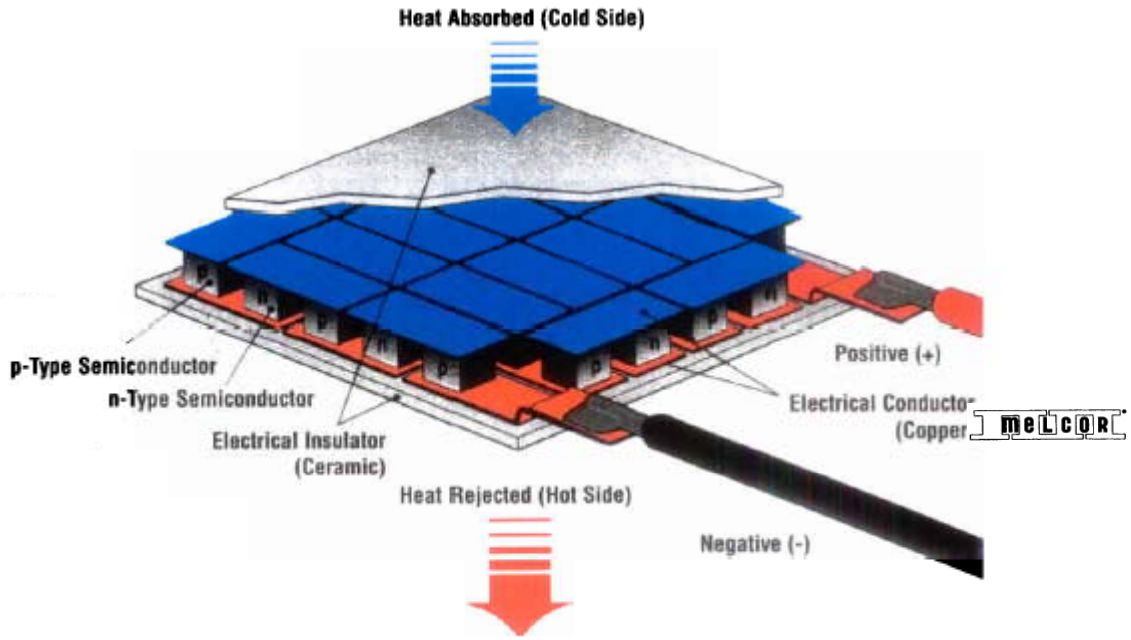
WITH THERMOELECTRIC MODULES



USING THE PELTIER EFFECT!

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WHAT IS THE PELTIER EFFECT?

CREATION OF A TEMPERATURE CHANGE BY PASSING A CURRENT THROUGH THE JUNCTION OF TWO DIFFERENT SEMI-CONDUCTORS

A DEVICE OPERATING IN THIS MODE WOULD BE KNOWN AS A THERMOELECTRIC COOLER OR TEC

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WHAT DOES THE PELTIER EFFECT HAVE TO DO WITH DETECTING CORROSION?

BECAUSE IT ALSO WORKS IN REVERSE!

EXPOSING EACH SIDE OF A THERMOELECTRIC MODULE TO A DIFFERENT TEMPERATURE PRODUCES A CURRENT

A DEVICE OPERATING IN THIS MODE WOULD BE KNOWN AS A THERMOELECTRIC GENERATOR OR TEG

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THE CORROSION PROCESS PRODUCES HEAT

THEREFORE

PLACING A THERMOELECTRIC MODULE WITH ONE SIDE IN CONTACT WITH A CORRODING SURFACE AND THE OTHER SIDE EXPOSED TO A CONSTANT TEMPERAURE SOURCE GENERATES A MEASURABLE CURRENT

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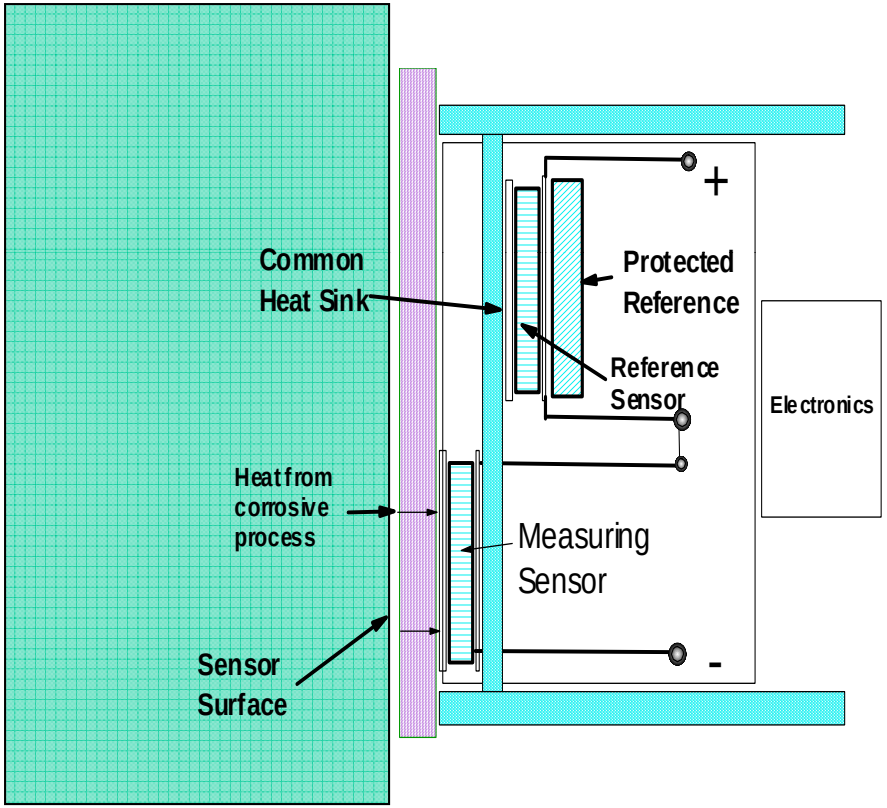
PROPOSED CORROSION SENSOR DESIGN



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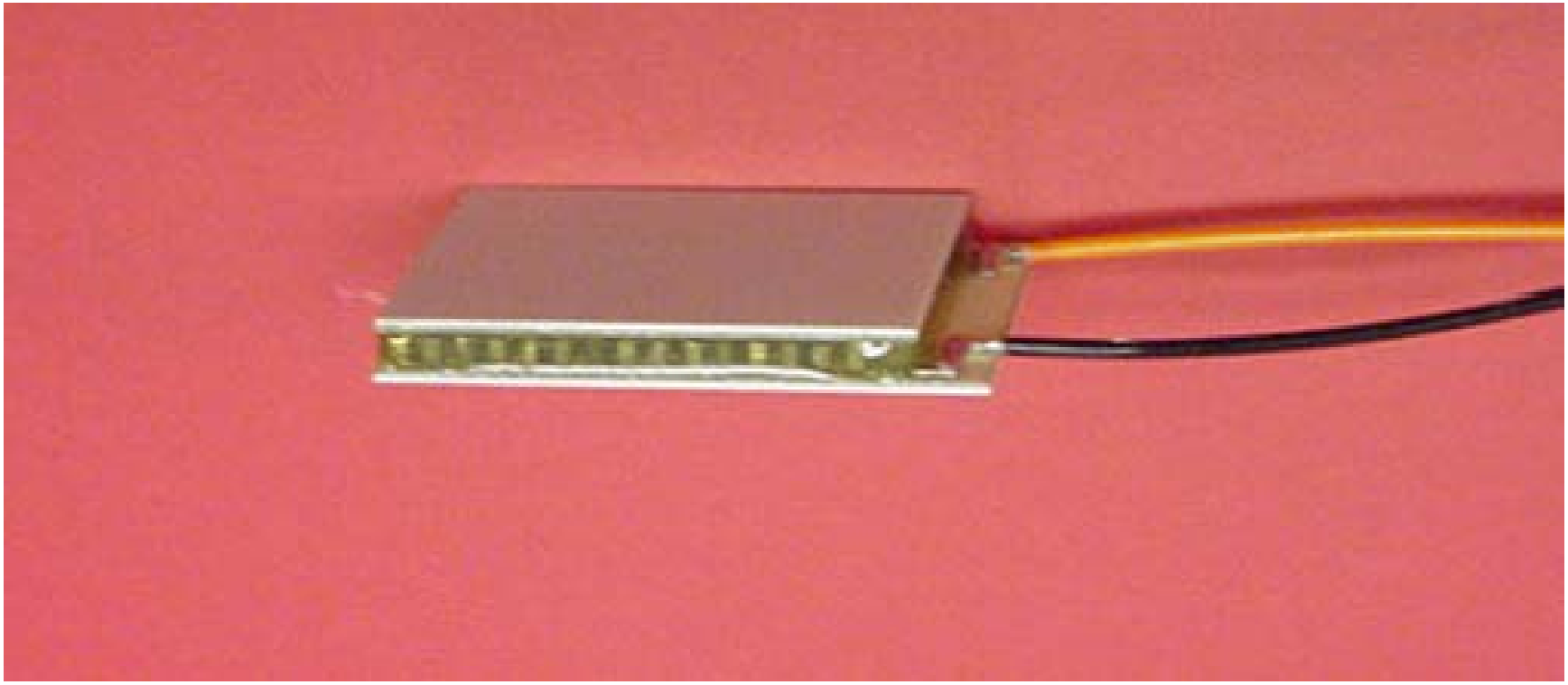
THERMOELECTRIC MODULE



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REFERENCE STANDARD

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HEAT SINK

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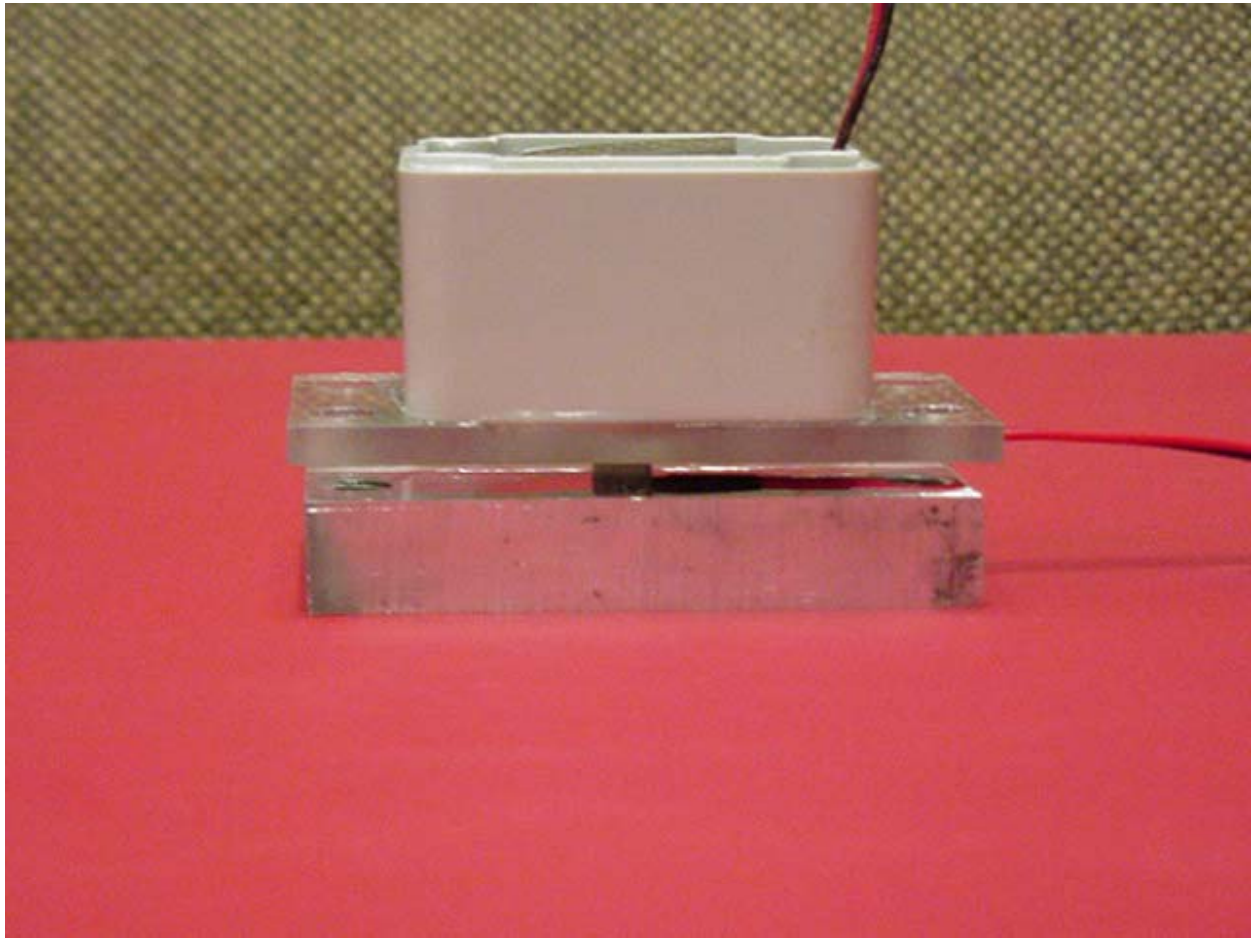
PROTOTYPE SENSOR
(Side View)



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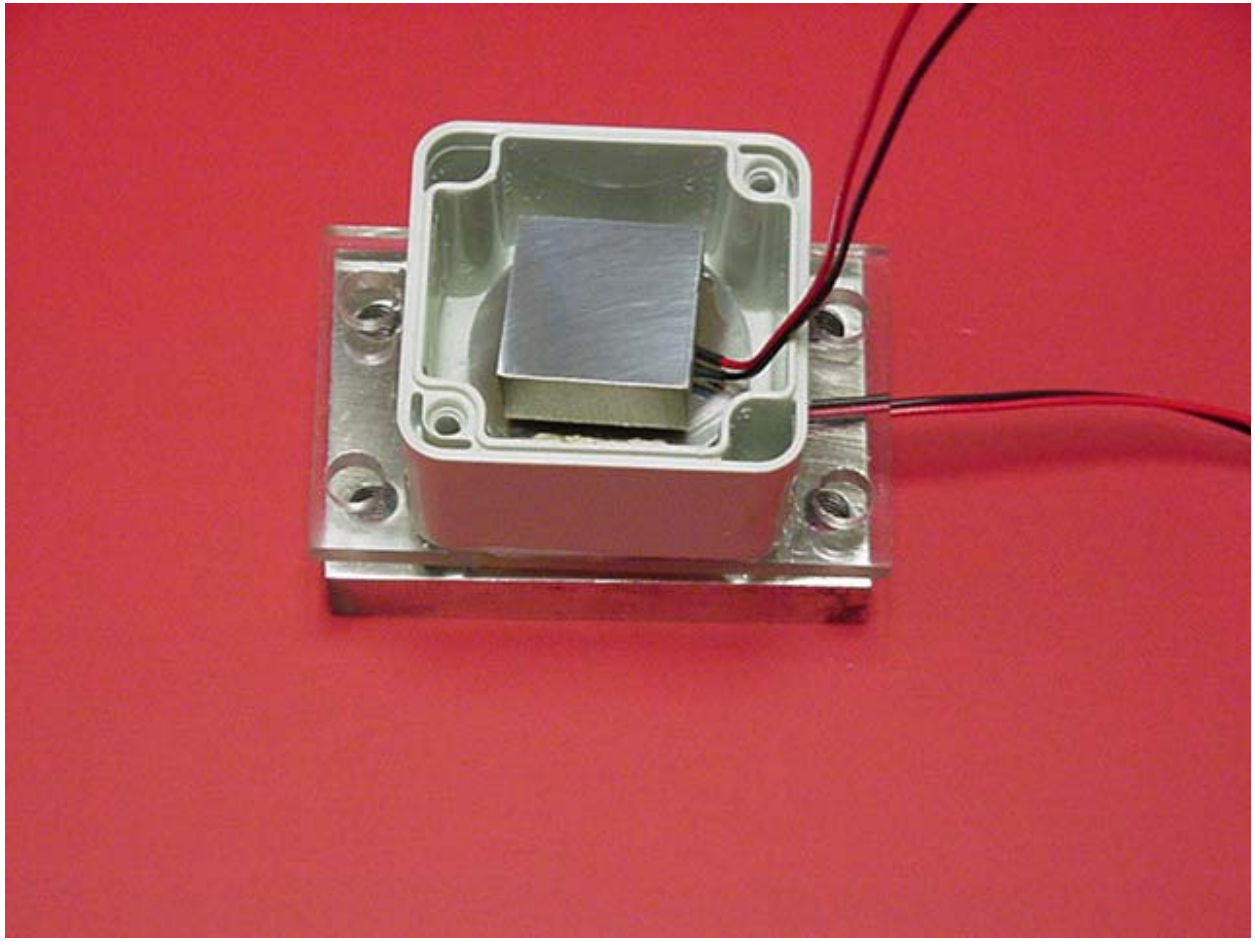
PROTOTYPE SENSOR
(Top View)



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PROTOTYPE SENSORS WERE MANUFACTURED TO BE TESTED WITH

Stainless Steel – 316L

Aluminum - 6061

Carbon Steel - 1040

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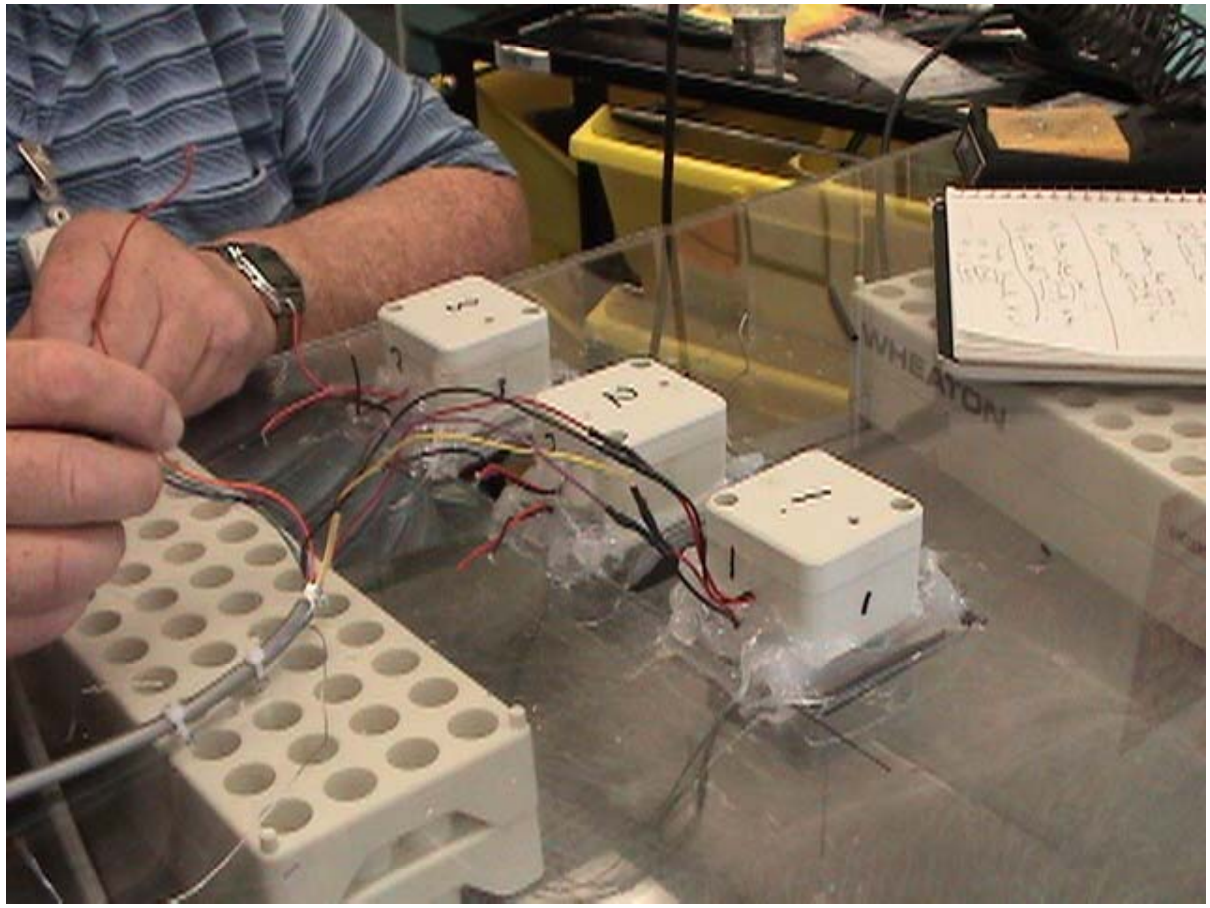
THE THREE SENSORS BEING WIRED FOR TESTING



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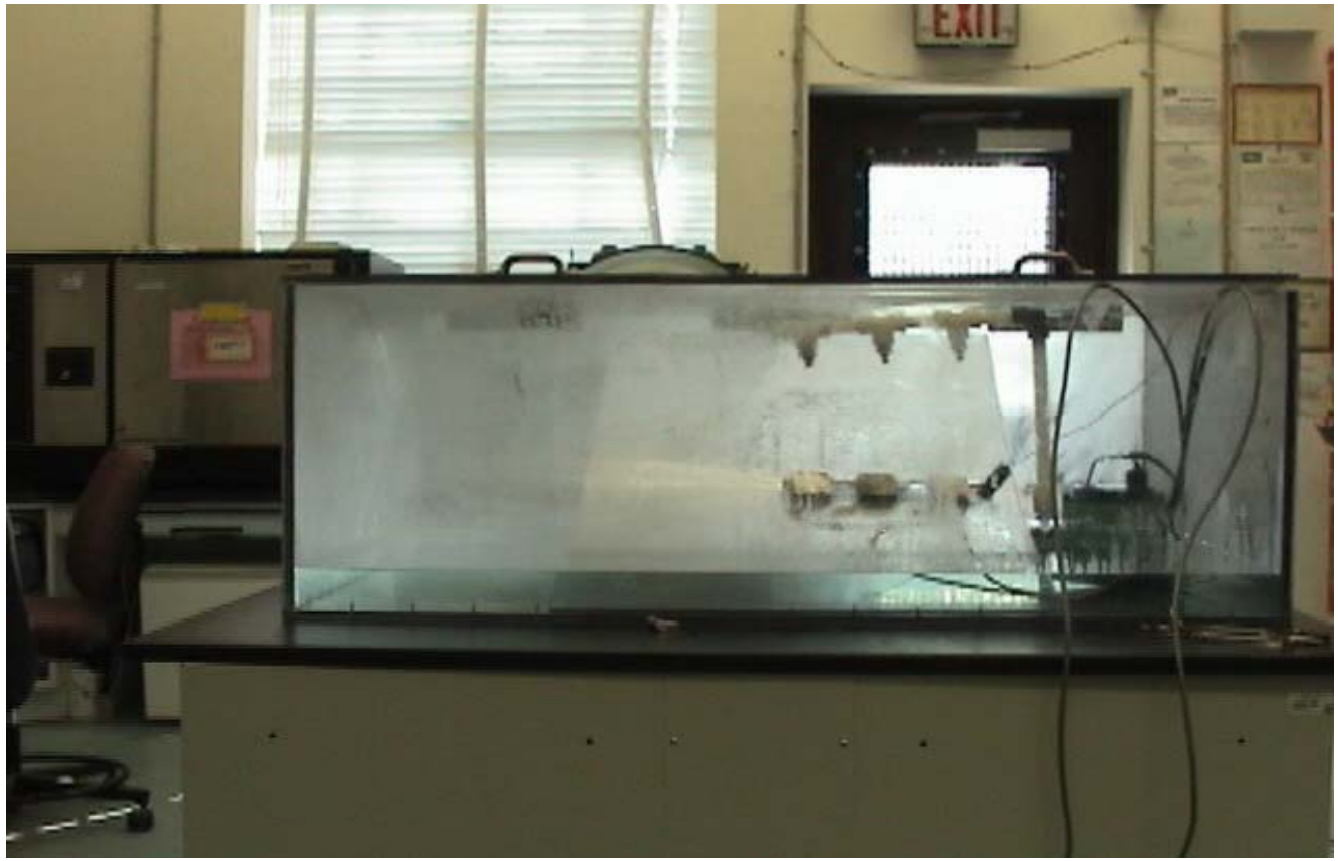
PROTOTYPE SENSORS IN TESTING CHAMBER



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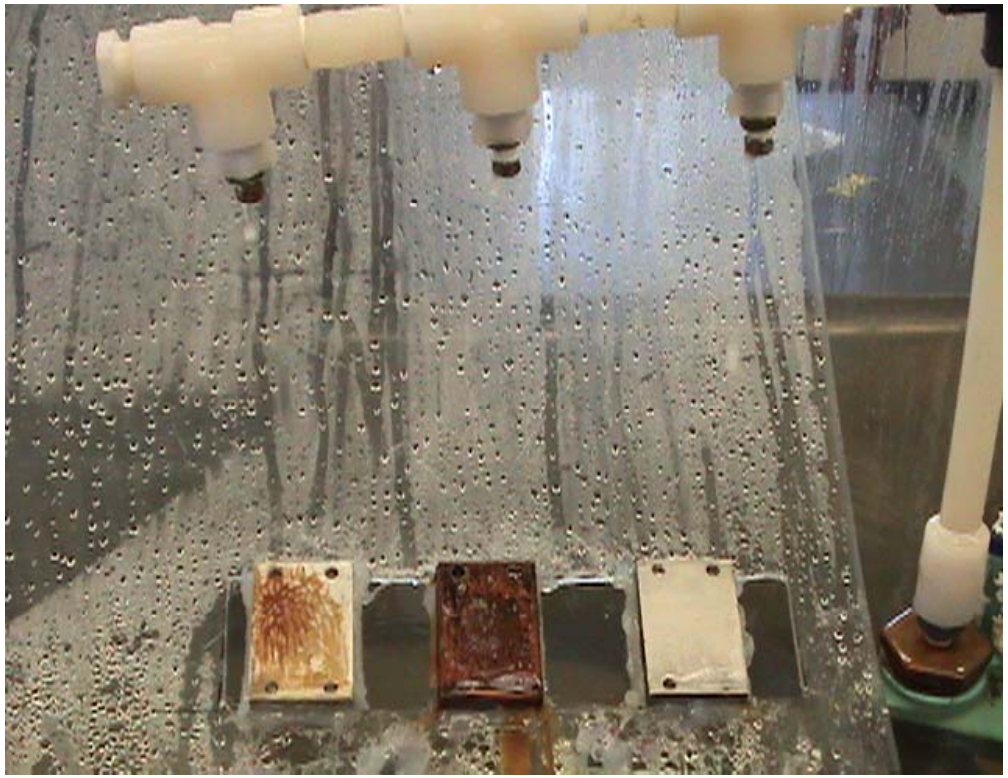
CORRODING PLATES DURING TEST



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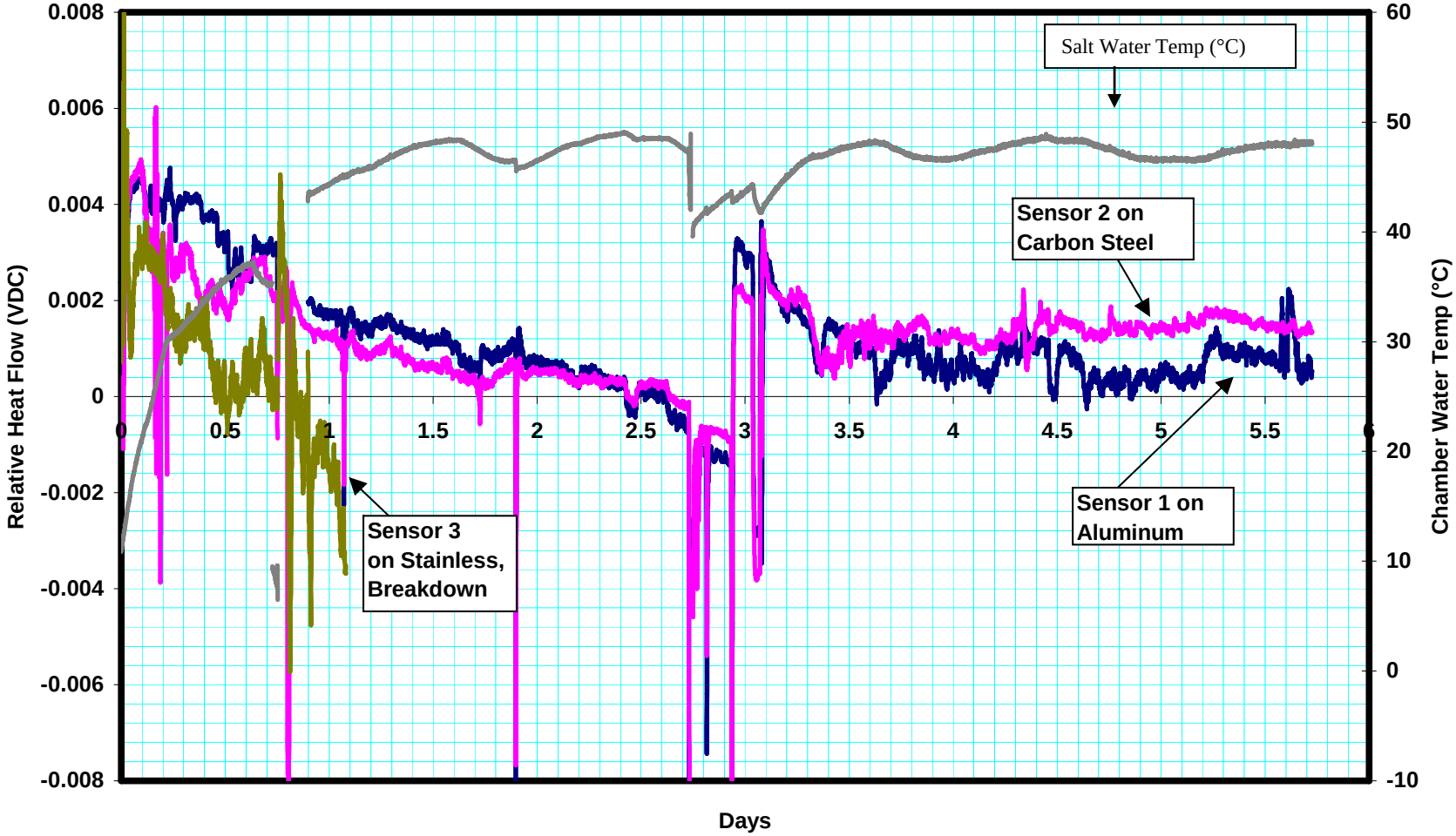
Overview of Corrosion Sensors 1, 2 and 3 on Test plates



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US006902316B1

(12) **United States Patent**
Pierce et al.

(10) **Patent No.: US 6,902,316 B1**
(45) **Date of Patent: Jun. 7, 2005**

(54) **NON-INVASIVE CORROSION SENSOR**

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(73) Assignee: **The United States of America as represented by the Secretary of the Navy**, Washington, DC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/774,649**

(22) Filed: **Feb. 5, 2004**

(51) **Int. Cl.**[7] **G01N 25/72**; G01N 17/00

(52) **U.S. Cl.** **374/7**; 374/4; 374/45; 374/57; 374/5; 374/1

(58) **Field of Search** 374/4, 7, 45, 57, 374/120, 129, 44, 1, 5

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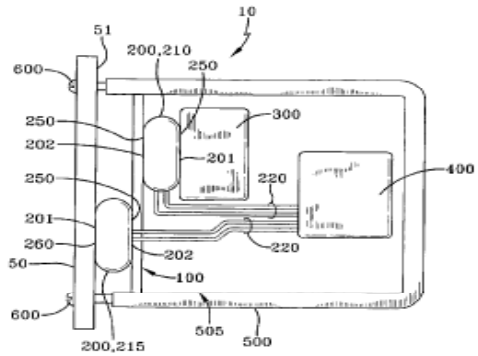
(57) **ABSTRACT**

The non-invasive corrosion sensor includes a heat sink, at least two peltiers, a reference standard and a data acquisition device. Each peltier has a negative side and a positive side, and each peltier communicates with the heat sink such that the negative side of each peltier is maintained at a common temperature. The reference standard communicates with the positive side of one of the peltiers while the test piece communicates with the positive side of the other peltier; and the data acquisition devise is able to record and compare the differences in temperatures between the test piece and the reference standard. A higher temperature in the test piece than in the reference standard indicates the presence of corrosion. The differences in temperatures of the test piece and the reference standard are obtained via electrical currents in the peltiers.

11 Claims, 2 Drawing Sheets



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