DP - 488

Instruments

AEC Research and Development Report

ACCURATE MICROMETER FOR CORROSION SAMPLES

by

W. J. Woodward
Applied Physics Division

June 1960

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INSTRUMENTS
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ABSTRACT

A diameter gage that utilizes eddy current techniques is described. The gage is capable of measuring nominal 0.5000-inch aluminum rods to an accuracy of ±0.00005 inch, and is unaffected by residual nonconductive surface films such as oxides or corrosion products.

CONTENTS

LIST OF FIGURES

ACCURATE MICROMETER FOR CORROSION SAMPLES

INTRODUCTION

It was desired to determine the amount of metal lost from a cylindrical aluminum rod subjected to a corrosive environment. Residual films of oxides and other corrosion products create errors in determination of weight loss and also reduce the precision with which volume measurements may be made. Removal of these films can only be accomplished at the risk of further attacking the metal. For this reason, the design and construction of an instrument were undertaken that would measure the diameter of the residual aluminum in the presence of nonconductive surface films.

SUMMARY

Eddy current techniques were used in an accurate gage that successfully measures the remaining diameter of aluminum corrosion test samples. The sample diameter is read directly from a meter calibrated in increments of 0.0001 inch with an accuracy of ±0.00005 inch. The measurement is not affected by the presence of nonconductive surface coatings.

DISCUSSION

In corrosion experiments with aluminum it is desirable to determine the amount of metal lost from a given sample during its exposure to the corrosive environment. This may be accomplished by measuring either weight or volume of the sample before and after its exposure. Residual films of oxides or other corrosion products adhering to the sample surface cause either of these measurements to be inaccurate, particularly when the metal loss is small.

A technique for measuring only the remaining metal of the sample is suggested in the literature[1,2]. This technique makes use of the coil-to-sample spacing effect of an eddy current instrument, and was readily adaptable to the specific needs of the existing problem.

The tuned grid - tuned plate (TGTP) oscillator has been employed successfully as a sensitive, self-generating eddy current detector[3,4]. Its characteristics are such that the grid tank coil may be used to induce eddy currents in a metal sample and at the same time act as a detector. Coil impedance changes, due to loading by the sample, are reflected in the output from the plate tank. By tuning the grid tank above or below the center frequency of the over-all response curve, one may obtain sensitivity to changes in either sample resistivity or coil-to-sample spacing. When the tuning is adjusted to maximize the one effect, the other is minimized.

A coil constructed so as to surround a cylindrical sample may be tuned to maximize the spacing effect, thus making the coil impedance a function of sample diameter. By making this coil the grid tank of a tuned grid - tuned plate oscillator, the output of the oscillator plate circuit becomes proportional to the sample diameter. This output voltage may be used to control whatever readout system is desired.

DESCRIPTION OF INSTRUMENT

The instrument uses the triode section of a 6AN8 tube in a TGTP oscillator circuit operating at approximately 100 kc. The plate tank coil is the primary of a modified 175-kc IF transformer that is retuned to the lower frequency. The grid tank coil consists of 100 turns of No. 30 wire inside a ferramic Q (General Ceramics Corp. Type F-269) core, as shown in Figure 1. Grid tuning is accomplished by means of variable capacitors.

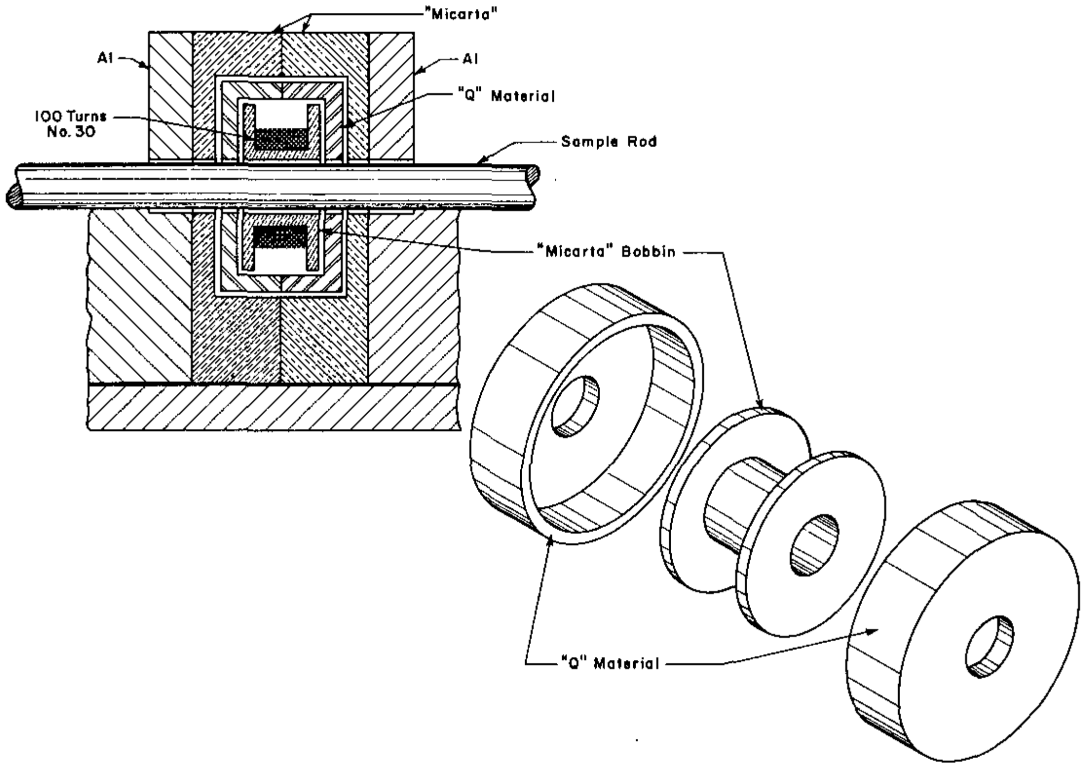

FIG. 1 SAMPLE COIL

Output voltage is taken from the secondary of the IF transformer, rectified and applied as positive DC to the grid of the 6AN8 pentode section. Positive bias is applied from a B+ voltage divider to the cathode of this tube through a shunted microammeter. This makes the cathode potential more positive than the grid, causing the tube to operate near cutoff. The bias is adjustable, as is the value of the meter shunt, giving control over the calibration reference point and the range. A remote cutoff pentode was chosen for this application in order to make use of its variable mu characteristic to oppose the nonlinear spacing-effect response, and therefore to produce a more linear readout.

The power supply is a conventional full-wave type, the DC being obtained from a 5Y3 rectifier and capacitor input filter. B+ potential is supplied to the oscillator and readout systems separately via two OA2 regulator tubes. The AC heater supply is grounded.

The instrument, except for the sample coil, is housed in a compact metal cabinet with operating controls and readout meter located on the front panel (Figure 2). Wiring connections and tuning adjustments are at the rear (Figure 3). Usual electronic construction practices were employed. A complete schematic diagram appears in Figure 4, and a chassis layout in Figure 5.

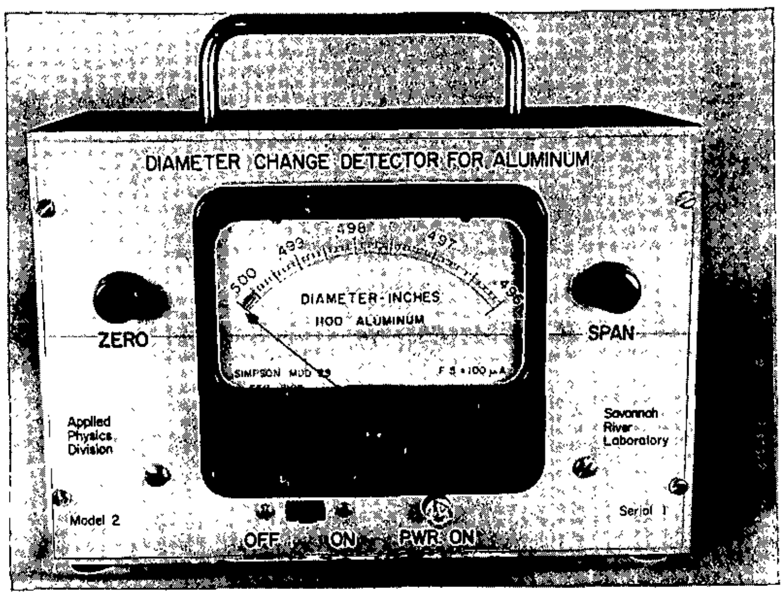

FIG. 2 FRONT VIEW OF INSTRUMENT

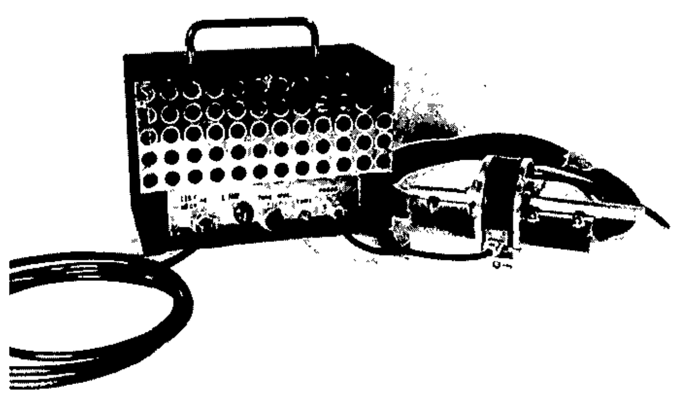

FIG. 3 REAR VIEW SHOWING SAMPLE COIL CONNECTED

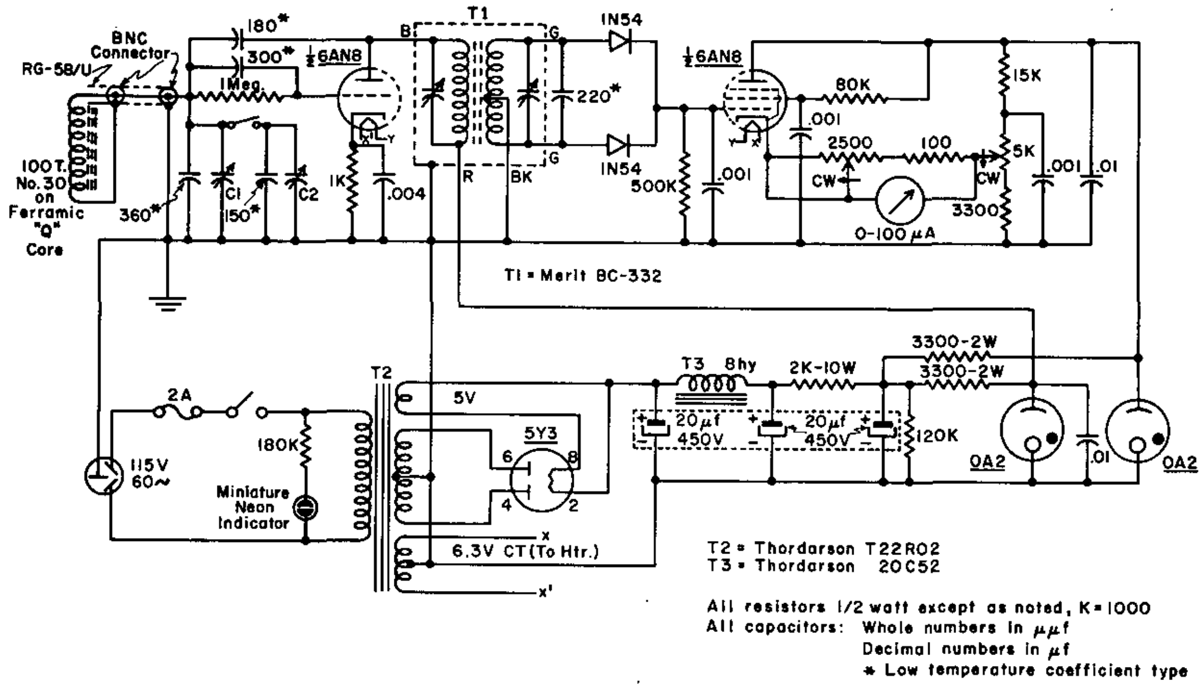

FIG. 4 SCHEMATIC DIAGRAM

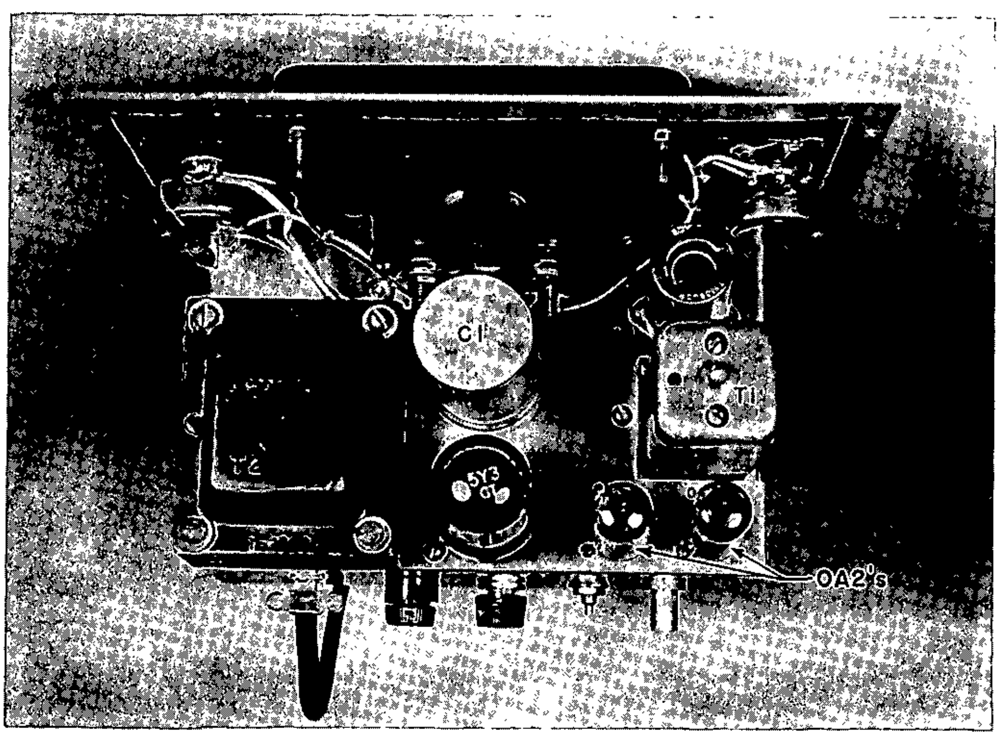

FIG. 5 CHASSIS LAYOUT

The sample coil is sandwiched between two phenolic resin blocks ("Micarta"), which are secured in an aluminum holder (Figure 6). The arrangement is such that nominal 0.5000-inch-diameter samples may be inserted from either side of the coil. A system of ball bearing rollers is provided to support the sample and maintain its position relative to the coil axis. The sample coil is connected to the rest of the instrument via RG-58/U coaxial cable through standard BNC connectors.

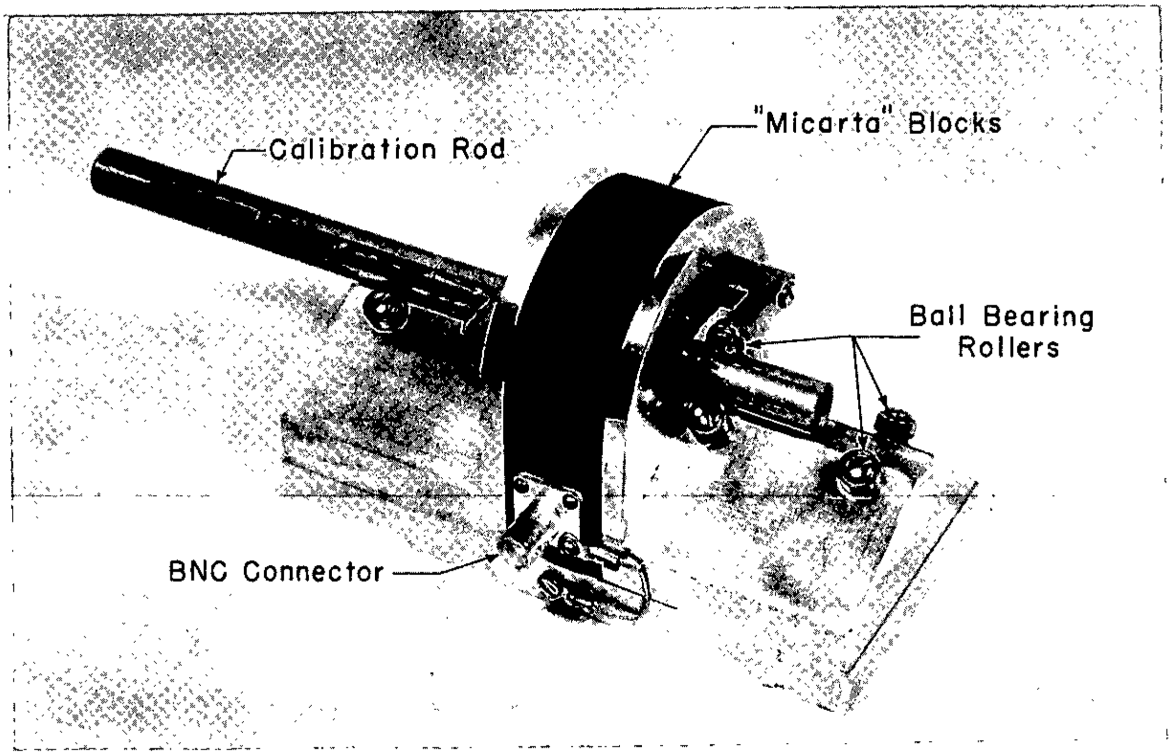

FIG. 6 SAMPLE COIL ASSEMBLY WITH CALIBRATION ROD INSERTED

The instrument is tuned initially so that maximum oscillator output is realized, as evidenced by maximum deflection of the readout meter. A switch (TUNE-OPERATE, Figures 3 and 4) is provided to reduce the capacity of the grid tank circuit by an amount that retunes the coil to the desired point on the response curve, thus simplifying the tuning procedure.

In operation, calibration rods of known diameter are used to establish correct meter readings at two widely separated points on the dial. These readings are adjusted by manipulation of the "ZERO" and "SPAN" knobs on the front panel, the former being set for a sample near 0.5000-inch diameter, and the latter for a sample near 0.4960-inch diameter. The temperature sensitivity and resultant drift of the instrument cause frequent recalibration to be necessary (in the order of once each 15 minutes), but the simplicity of this procedure is such that a calibration check may be included in the normal operating procedure without great inconvenience.

Although the instrument was designed for Type 1100 (2S) aluminum, it has been successfully calibrated for 63S and 24S alloys. The instrument is in daily use, and has been used to measure over 200 different samples. Many of these samples were measured more than once, at different times, and by different operators. All readings were reproduced exactly in the fourth decimal place, and within 40% in the estimated fifth place.

W. J. Woodward
Applied Physics Division

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