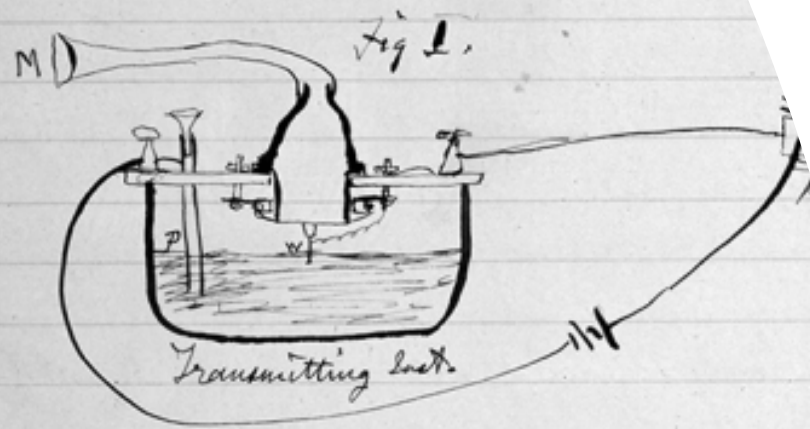


March 10th 1876



1. The improved instrument shown in Fig. constructed this morning and tried this eve. P is a brass pipe and W the platinum M the mouth piece and S the armature. The Receiving Instrument.

Mr. Watson was stationed in one room with the Receiving Instrument. He pressed his ear closely against S and closed his ear with his hand. The Transmitting was placed in another room and the doors of both rooms were closed.

I then shouted into M the sentence: "Mr. Watson - Come here -"

How to Keep a Good Lab Notebook

Based on slides courtesy Prof. Radenovic

The 1876 notebook of Alexander Graham Bell, who patented the first practical telephone.




Why is it Important to Keep a Good Laboratory Notebook?

- Keeping a complete and accurate record of experimental methods and data is a **vital part of science and engineering**. Your laboratory notebook is a **permanent record of what you did and what you observed in the laboratory**. Learning to keep a good notebook now will establish good habits that will serve you throughout your career. Your notebook should be like a **diary**, recording what you do, and why you did it.
- You should feel free to record your mistakes and difficulties performing the experiment - you will frequently learn more from these failures, and your attempts to correct them, than from an experiment that works perfectly the first time. It is extremely important that your notebook accurately record everything you did. A good test of your work is the following question: ***could someone else, with an equivalent technical background to your own, use your notebook to repeat your work, and obtain the same results?***
- For that matter, **could you come back six months later, read your notes, and make sense of them?** If you can answer yes to these two questions, you are keeping a **good notebook**.



Why is it Important to Keep a Good Laboratory Notebook?

- The laboratory notebook forms a permanent record that can be referred to while completing a disclosure report (often the first step in patent preparation) and later, provides accurate documentation of the work done. When an investigator makes an invention during the course of a research project, the dates of the conception and reduction to practice (turning an idea into a reality) become very important. Generally, a sketch and a brief written description are sufficient to establish conception. Reduction to practice is accomplished by actually constructing and successfully testing a material or device incorporating the invention.
- During prosecution of a patent application before the U.S. Patent Office, or even after issuance of a patent, the filing of another patent application may initiate an interference proceeding to determine which party was the first to invent. Each party has an opportunity to submit documentary proof of his or her dates of conception and reduction to practice. A laboratory notebook may be, and in several high-profile cases has been the crucial piece of evidence in this procedure.

A stack of spiral-bound notebooks is shown on the left side of the slide. The top notebook has a heart drawn on its cover. The notebooks are stacked on a dark surface.

Your lab notebook serves three important purposes:

- 1 A record of important procedures for experiments you have developed during your experimentation.
- 1 A record of the results of experiments that you have performed.
- 1 The means to reproduce the results of your experiments by following the procedures you have developed at another time or place

A good notebook is not simply a list of results of experiments but allows you to develop methods that you can use for further experimentation and would allow someone else to reproduce your results and understand why you did what you did in your experiments.

What goes into your notebook

- **Page numbers** – if your notebook doesn't already have them add them to the upper outside corner of each page. These are important so you can refer back to frequently used tables, procedures, or results. You can also be sure that there are no missing pages (leading to missing steps) if following a past procedure.
- **A table of contents** – The first few pages should be reserved for this, it allows you to quickly find the information you are looking for and makes the book a useful reference. Later on you will be able to find a particular experiment without having to read every page.
- **Dates** – Every entry, or at the very least every day that you record data should be dated, this allows you to find things more easily.
- **Unusual conditions during an experiment** – Sometimes things go differently than we plan and we have something unusual happen during our experiments some of the things you might want to look for and record are: Strong storms (ie. behavior of an observed animal may be atypical) Extremes in temperature or humidity (many instruments and materials are sensitive to temperature and humidity) Power failures (if your experiment requires power)

What goes into your notebook

- **Name of the corresponding files.**
- **Something went wrong or was unexpected** (ie. you notice that the apparatus is no longer working at some point during your experiment)
- **Experimenter fatigue** may impair your ability to make good observations
- **Reasons for decisions made during an experiment** – What we did isn't always good enough, why we did what we did is just as important to record. Make sure that you record the whys and not just the whats. Contact information for people that provided you with information or supplies – They may be able to provide you with some materials in the future or to give you more information later on should you need it. It is important to give credit where it is due as well. Any information that you might need to reproduce the results of an experiment – Your notebook alone should be sufficient *for someone* to reproduce your experiment. Aim to be as complete as possible!

Rules for Maintaining your Laboratory Notebook

TABLE OF CONTENTS	PAGES

Leave several pages blank at the beginning for a **Table of Contents** and **update it when** you start each new experiment or topic



Always use pen and write neatly and clearly



Date **every page on the top outside corner**

Start each new topic (experiment, notes, calculation, etc.) on a right-side (odd numbered) page

TITLE	DATE
Objectives and/or purpose of experiment	

Record the **TITLE and OBJECTIVES of each** experiment (or notes or calculations) at the top of the first page of the notebook dedicated to this topic.

Rules for Maintaining your Laboratory Notebook

~~$R = 3.256 \Omega$~~
3.526

$R = 3.256 \Omega$
3.526 *miswrote*

If you make a mistake, don't obliterate it! You may need to read your mistake later – perhaps you were right the first time! Use a single cross out and EXPLAIN why it was an error.



Data typed into the computer must be printed and taped into your lab notebook. Plots of data made in lab should also be printed and taped in your lab notebook.



When you record an observation in your notebook, include an explanation of what you were doing at the time. If appropriate, you may just record the step number in the instructions followed by your observation

Rules for Maintaining your Laboratory Notebook

Metric	Requirements	
Pen	Write in pen, not pencil	
Date	Date every page at the top	
Right Side	Begin each experiment on odd page	
Printouts	Attach printouts and plots of data as needed	
Legible	Obvious care taken to make it readable, even if you have bad handwriting	
Mistakes	Mistakes crossed out with one line and explained	
Organized	table of contents title of experiment on 1st page objectives of experiment clear from notebook what you were doing when	
Informative	All required data and information Descriptive comments of your observations	

Example: Complete Experiment

Experiment number
and title clearly stated

Clear statement of
purpose

Succinct description of
procedure.
The step number from
the instructions could
also be listed

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Experiment #3
Estimation of Internal Pressure within an Aluminium Soda Can

The purpose of this experiment is to measure the pressure inside an unopened soda can using strain gauges.

Procedure

The directions were read and a question selected:
e) How does an axial strain measurement compare to a hoop strain measurement for a given type of soda?

CEA-13-240UZ-120
CEA-13-240UZ-120
Gage Factor: 120.0 ± 0.3%
Resistance: 350 ± 0.5%
Gage Length: 0.125 in (3.175 mm)
Temperature Sensitivity: ± 0.01%/°F

MEM
Micro-Measurements
Division
**MEASUREMENTS
GROUP, INC.**
P.O. Box 1777
Raleigh, North Carolina 27611
(919) 385-3800

**GENERAL INFORMATION
SERIES CEA STRAIN GAGES**

GENERAL DESCRIPTION: CEA-Series Strain Gages are in a general purpose family of construction. They strain gages widely used in experimental stress analysis. Extremes: thin and flexible (0.0025 in (0.064mm)). CEA-Series gages feature: polyimide-encapsulated, grid and exposed, copper-coated integral carrier base to which "leadwires" may be attached directly. See Tech Note TN-508 for assistance in gage selection.

TEMPERATURE RANGE: Normal use temperature range for static strain measurement is -100°F to +300°F (-73°C to +149°C). For special or short-term exposure, an expanded range of -300°F to +400°F (-190°C to +204°C) may be used.

STRAIN LIMITS: Approximately 1% for 2-540 in (16 mm) gage length and approximately 2% for 0.125 in (3.175 mm) and 0.063 in (1.575 mm) gage lengths for single cycle use. See Tech Tip TT-605 for high elongation measurements.

FATIGUE LIFE: Dependent on gage length and method of cycling. 10⁶ cycles at a 2000psi (137.9 MPa) cyclic stress at 150Hz. Derate 10% for nonzero mean strains of same absolute (peak-to-peak) values. See Tech Note TN-508 for additional data.

ADHESIVES: M-Bond 200 is an excellent, general purpose adhesive for these gages. M-Bond 200 is an excellent, general purpose adhesive for these gages. M-Bond 200 is an excellent, general purpose adhesive for these gages. M-Bond 200 is an excellent, general purpose adhesive for these gages.

SOLDER: M-Line solder type 361 is recommended for leadwire attachment, when operating temperatures do not exceed +200°F (+93°C). See Catalog A-113 for higher temperature solders.

PROTECTIVE COATINGS: Because they have fully encapsulated grids, CEA-Series Strain Gages require no further protection under most laboratory conditions. When further protection is required, refer to Catalog A-113 for M-Coat protective coating information.

NOTE: The bonding of Strain Gages has been specifically treated for optimum bond formation with all appropriate gage adhesives. No further cleaning is necessary if contamination of the prepared surface is avoided. During handling, should contamination occur, clean with a cotton swab slightly moistened with a low residue solvent, such as isopropyl alcohol. Allow the gage to dry for several minutes before bonding.

Two cans of soda were selected (Seagram's Ginger Ale at room temperature).

The strain gauge was attached to the soda can as described in the instructions.

Spec sheet taped
into lab notebook

Example: Complete Experiment

Second page for Example 1

LabNotebookInstructions.doc

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However, one of the coils was dropped during preparation and was denied. In order to perform the experiment accurately, two new coils were selected (Diet Pepsi at room temperature).

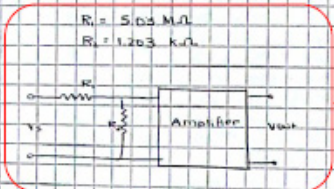
The strain gauges were then attached to these coils. I did the dual and Sam did the hoop.

While the glue adhered to the strain gauge, the lab amplifier was calibrated.

Serial Number of Lab Amplifier: NA7

Value of each resistor in the voltage divider constructed on the protoboard:

$R_1 = 5.03 \text{ M}\Omega$
 $R_2 = 1.203 \text{ k}\Omega$



Used HP 6300A as the power supply and set to 5V.

$V_{in} = 5.00 \text{ Volts}$
 $V_{out} = 0.010 \text{ Volts}$

V_R (voltage across R_2) = 1.20 mV

$V_{in} = \left(\frac{R_1}{R_1 + R_2} \right) V_s = \left(\frac{1.203 \times 10^3}{1.203 \times 10^3 + 5.03 \times 10^6} \right) 5.00 \text{ V} = 1.1955 \times 10^{-3} \text{ V}$

Percent error: $\frac{1.1955 - 1.20}{1.1955} = 0.373 \%$

Amplifier gain = $G = \frac{V_{out}}{V_{in}} = \frac{0.010 \text{ V}}{1.20 \times 10^{-3} \text{ V}} = 8.33 \text{ L}$ 552.85 550.8

$G = \frac{V_{out}}{V_{in}} = \frac{0.010 \text{ V}}{1.1955 \times 10^{-3} \text{ V}} = 8.36 \text{ L}$ 552.35

2/25/03 PHT

Computation:

- Intermediate steps shown
- Errors crossed out with a single line and an explanation ("calculator error").

$V_{in} = \left(\frac{R_2}{R_1 + R_2} \right) V_s = \left(\frac{1.203 \times 10^3}{1.203 \times 10^3 + 5.03 \times 10^6} \right) 5.00 \text{ V} = 1.1955 \times 10^{-3} \text{ V}$

Percent error: $\frac{1.1955 - 1.20}{1.1955} = 0.373 \%$

Amplifier gain = $G = \frac{V_{out}}{V_{in}} = \frac{0.010 \text{ V}}{1.20 \times 10^{-3} \text{ V}} = 8.33 \text{ L}$ 552.85 550.8

$G = \frac{V_{out}}{V_{in}} = \frac{0.010 \text{ V}}{1.1955 \times 10^{-3} \text{ V}} = 8.36 \text{ L}$ 552.35

Remaining pages for Example 1:

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deep strain can wall thickness: 0.105 mm
 outside diam: 0.121 mm (rounded)
 0.119 mm
 measured average: 0.104 mm

total strain can wall thickness: 0.129 mm
 0.125 mm
 0.104 mm

Analysis:
 deep strain: $\rho = \left(\frac{4F}{\pi} \right) \frac{L_e}{L - V} = \left(\frac{4(0.0015)(10^3)}{\pi(0.001)} \right) \left(\frac{0.001}{0.001 - 0.001} \right) = 2.51 \times 10^6 \text{ Pa}$

~~$\rho = \left(\frac{4F}{\pi} \right) \frac{L_e}{L - V} = 2.51 \times 10^6 \text{ Pa}$~~ wrong formula

$V_{cal} = \left(\frac{F_g}{k_g} \right) \frac{L_e}{L - V}$ $V_g = 10$ $F_g = 1.085$
 $C = \frac{V_{cal}}{F_g \cdot V_g} = \frac{0.001}{1.085 \cdot 10} = 0.0000922$
 $k = 557.9$

total strain: $\rho = \left(\frac{4F}{\pi} \right) \frac{L_e}{L - V} = \left(\frac{4(0.0015)(10^3)}{\pi(0.001)} \right) \left(\frac{0.001}{0.001 - 0.001} \right) = 2.51 \times 10^6 \text{ Pa}$

$C = \frac{V_{cal}}{F_g \cdot V_g} = \frac{0.001}{1.085 \cdot 10} = 0.0000922$
 $k = 557.9$

~~strain - does occur here?~~

Answer to the question posed by the experiment

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total resistance b/w leads: 0.01 Ω
 deep resistance b/w leads: 0.01 Ω

the resistance b/w the leads and the can include

deep strain:
 calibration resistance: 0.01 Ω
 measured output voltage: -3.08 V
 expected output voltage:
 $V_{cal} = \left(1 - \frac{R_{cal}}{R_{cal} + R_{leads}} \right) V_g = \left(1 - \frac{0.01}{0.01 + 0.01} \right) 10 = -6.374$
 R_{cal} strain gauge resistance

diameter: 0.119 mm
 0.121 mm
 0.119 mm
 average diameter: 0.119 mm

After all the corrections were checked, the amplified output voltage was recorded and the can opened.
 $V_{cal} (before) = -3.73 \text{ mV}$
 $V_{cal} (after) = 3.73 \text{ V}$

total strain:
 calibration resistance: 0.01 Ω
 measured output voltage: -3.9 V
 expected output voltage: $V_{cal} = \left(1 - \frac{R_{cal}}{R_{cal} + R_{leads}} \right) V_g = \left(1 - \frac{0.01}{0.01 + 0.01} \right) 10 = -6.374$

diameter: 0.119 mm
 0.121 mm
 0.119 mm
 average diameter: 0.119 mm

After the can:
 $V_{cal} (before) = -3.73 \text{ mV}$
 $V_{cal} (after) = 3.73 \text{ V}$



Key points in this example:

1. Neat and legible handwriting
2. Experiment title and purpose clearly stated
3. Procedure described clearly and succinctly, including errors and the steps taken to correct them
4. Computations performed neatly showing intermediate steps
5. Errors crossed out with a single line and explained
6. All pages dated at the top and signed by lab professor on the same