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AN ELECTRICAL STRAIN GAGE FOR THE TENSILE TESTING OF PAPER[1]

BY

Douglas M. Jewett, Physical Science Aid

Summary

A direct-reading strain gage has been developed at the U.S. Forest Products Laboratory that provides rapid and accurate measurement of the stress - strain properties of paper. The gage, which employs a differential transformer, is particularly suited to servo-operated x-y recorders.

Introduction

In order to obtain reliable load-elongation curves in paper testing, some sort of an extension gage must be employed because the crosshead movement of a testing machine is not a dependable measure of strain in the specimen. This was shown in Forest Products Laboratory Report No. 2066,[2] which also describes a lightweight optical-lever gage that was developed at the U.S. Forest Products Laboratory for the testing of paper. While this gage gives accurate results, it is time-consuming to use because the operator must watch the movement of a hairline of light on a scale and press a button to cause a mark on the chart for each increment of extension.

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[1] Acknowledgment is made to Ervin L. Burmeister of the U.S. Forest Products Laboratory for designing the spring -loaded clips and suspension system for the transformer.

[2] Setterholm, V., and Kuenzi, E. Method for Determining Tensile Properties of Paper. U.S. Forest Products Laboratory Report No. 2066. 1956.

The test must be run slowly enough so that the operator can accurately follow the hairline. The resulting graph is then replotted to obtain a load-strain curve. The work reported herein was undertaken to devise a faster-acting accurate strain gage.

Description of Gage

Several electro-mechanical devices were studied in the hope of developing an extensometer that could be wired into an x-y recorder, eliminating the need for "pipping" and replotting. The problem was to find a transducer sufficiently sensitive, yet delicate enough so as not to put excessive load on the specimen. The testing machine at the Laboratory was particularly suited to input from a differential transformer. It was equipped with a servo-mechanism that drove the chart in accordance with the movement of the transformer core. Experiments with a prototype gage in which the transformer was attached to the specimen by counterweighted levers showed that a satisfactory gage could be built.

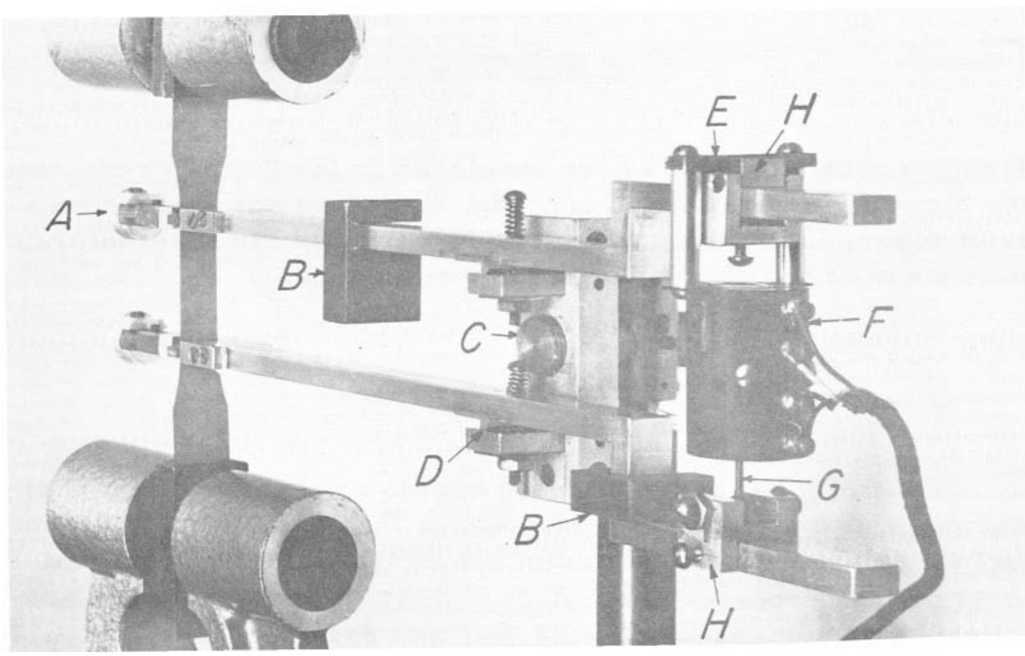

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Figure 1. --Direct-reading strain gage for testing of paper, which was designed at the U.S. Forest Products Laboratory. Spring-loaded knife-edged clamps (A) attach the gage firmly to the specimen. The weights (B) balance the system. The bearings (C, D, and E) allow the transformer core (G) to move in exact correspondence with the knife-edged clamps (A). The knife-edge bearings (D) are pinned to prevent lateral slippage, and springs are used to hold the knife edges in the grooves. This arrangement allows the lever arm to move freely, yet keeps the gage from flying apart when the specimen fails. The "cradles" (H) for the transformer (F) and core (G) can be moved laterally to provide the desired lever ratio.

The new gage (fig. 1) was designed to permit adjustment for magnification and sensitivity and, at the same time, to eliminate the need for frequent calibration and readjustment. It was also designed to make possible a complete and continuous load-elongation curve (fig. 2) over a wide range of crosshead speeds.

Calibration of the System

The accuracy of the measuring system using this gage was checked with a Boeckeler micrometer reading the distance between the knife-edged clamps to 0.0001 inch with the following results.

Extension from micrometer (Inch)	Extension from gage (Inch)	Deviation (Inch)
0.0250	0.0249	-0.0001
.0500	.0499	- .0001
.0750	.0749	- .0001
.1000	.1000	- .0000
.1250	.1246	- .0004
.1500	.1494	- .0006
.1750	.1741	- .0009
.2000	.1489	- .0011
.2250	.2237	- .0013
.2500	.2479	- .0021
.2750	.2724	- .0026
.3000	.2962	- .0038

If a gage separation of 1.5 inches is used, the table shows that up to 10 percent elongation (0, 1500 inch extension)--the range for most papers--the total deviation is less than 0.5 percent. Even at 20 percent elongation, it does not exceed 1.3 percent. The deviation is not random but systematic, so it can be corrected for when necessary.

Since development of this gage, several thousand tests have been made on a variety of papers, and there has been no need for adjustment or repairs.

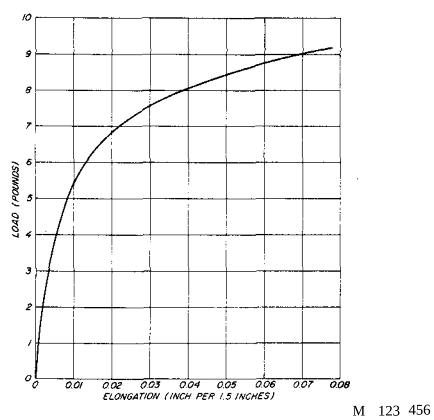

Figure 2. --Representative load-elongation curve obtained using new direct-reading strain gage.

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