N92-30282

An Automated System for Creep Testing

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KEY WORDS

Creep, Strain, Plastic Deformation, Potentiometer, A-D Converter, Automated Data Collection, Multiplex.

ABSTRACT

A completely automated data collection system has been devised to measure, analyze and graph creep versus time using a PC, a 16 channel multiplexed A-D converter and low friction potentiometers to measure length. The sampling rate for each experiment can be adjusted in the software to meet the needs of the material tested. Data is collected and stored on a diskette for permanent record and also for later data analysis on a different machine.

INTRODUCTION

Creep is the time dependent plastic deformation of a material under constant load or stress at elevated temperatures. For a given material, elevated temperature means at or above one half the absolute melting temperature. Structural materials typically creep at relatively high temperatures, rather large loads and typically over long periods of time.[1]

In this experiment 60/40 solder (Tin/Lead) is used because the solder will creep at room temperature, with small loads,and will break within a week. In fact in some specimens the solder will break within a day. This experiment requires that extension or strain be measured at regular time intervals until fracture, and lends itself to automated data collection. The following is a description of such a system. All the experiments were conducted on 60/40 solder, .079 and .158 cm diameter wire, at room temperature. Initial length of the solder ranged from 10 cm to 100 cm. Loads ranged from .250 to 2.00 kgm.[2]

EQUIPMENT AND SUPPLIES

		Cost
1.	A ten turn precision potentiometer.	$ 20.00
2.	Any PC/XT/AT IBM compatible computer with at least a 20 Mbyte hard disk.	600.00

3. A Data Translation DT2811 low cost Analog and Digital I/O board for IBM PC, PC XT and PC AT compatible computer systems (or the equivalent. The equivalent should have a 16 channel multiplexer leading to a 12 bit A to D converter. The convert time is not critical.) Source: Data Translation Inc., 100 Locke Dr. Marlboro, MA 01752-1192 tel. (508) 481-3700. 795.00

4. A 50 pin termination header Source: Industrial Computer Source, P.O. Box 23058, San Diego, CA 92193 tel. (619) 279-0084 part number 2M50FC. 59.00

AUTOMATED DATA COLLECTION SYSTEM

An automated data collection system was constructed using ten turn precision linear potentiometers as sensors (FIG.1), Data Translation DT2811 A to D converter board and a PC with 640K of memory and a 20 Mbyte hard disk (FIG.2). String was wrapped around the shaft of the ten turn precision linear potentiometer and connected to the weights at the end of the solder wire. Five volts were placed across the potentiometer. As the solder stretched, the potentiometer shaft rotated and the voltage at the wiper arm of the ten turn precision linear potentiometer changed. The change in the voltage for one centimeter stretch was measured in order to calibrate the ten turn precision linear potentiometer. This voltage was then measured with a 12 bit resolution A to D converter. The smallest voltage change that the ADC could measure was 2.44 millivolts corresponding to a smallest distance which could be measured of 0.037 cm. Any stretch of the wire greater than .037 cm can be detected with the system. The stretch is related to the voltage measured by the ADC (1 volt = 15.27 cm). Thus, by measuring the voltage periodically with the ADC we kept a time history of the change in length of the solder wire.

The DT2811 has 16 channels which are multiplexed to one 12 bit A to D converter. One channel from 0 to 15 is selected by software and A to D conversion is started again by software. A READY bit is checked in software and when the conversion is complete, the voltage at the wiper arm of the potentiometer is read as a 12 bit digital number. This number is recorded in a disk file along with the time that the reading was made. The program then selects the next channel and repeats the process until all channels are read for that time. This is repeated periodically until all of the solder wires break. The program is then terminated and the data in the disk file is analyzed. The time between readings varied, depending on how long it would take for the wire to break. For the thinner solder, readings were taken every 10 minutes.[3, 4, 5, 6, 7]

The data was analyzed using LOTUS 123. The raw data was imported into a LOTUS worksheet, scaled properly, converted to length and plotted all within LOTUS. No data was ever entered by hand, thus speeding up the operation and also avoiding transcribing errors. Data could also be conveniently archived on floppy disks in an easily accessed format.

The conversion from volts to strain from a given sample is:
$\epsilon = v/\ell_0 \cdot 15.27$ cm/volt, where ϵ = strain
v = voltage reading in volts
ℓ_0 = original length, and
15.27 cm/volt = conversion factor.

The strain rate can be determined by calculating the slope of the strain vs. time graph.
$\dot{\epsilon} = \epsilon_2 - \epsilon_1 / t_2 - t_1$, where $\dot{\epsilon}$ = strain rate
ϵ_1 = strain at time t_1
ϵ_2 = strain at time t_2.

Note that strain is dimensionless (sometimes reported as IN/IN or cm/cm) and strain rate is in the dimensions of reciprocal time.

RESULTS

Typical creep data is shown in graphs 1-4. Graph 1 is a plot of voltage vs. time and Graphs 2, 3, and 4 are plots of strain vs. time. Strain rates taken from the slopes of Graphs 2, 3, and 4 are 0.003, 0.0047, and 0.0025 cm/cm·min. The data is reproducible and has alleviated the problem of continual observation while the experiment is in progress. The data is consistent with other observations of the same wire which were monitored every hour, but this automated system of monitoring has the added advantage of catching very closely the time of fracture, and the onset of creep. Since solder is wrapped in a spool the kinks are not easily removed and the onset of deformation is delayed while the wire is straightened. The wire could be pre-straightened, but the duplication of the straightening technique is questionable. Future experiments will include several techniques for straightening the wire before testing to determine their effect.

ACKNOWLEDGEMENTS

The authors would like to thank Mr. Howard Moore, Technical Assistant of the Physics Department at Loyola College, for his assistance in assembling the apparatus; and Miss Margaret Davis, student of the Engineering Department at Loyola College, for her assistance in conducting the experiments. We also wish to thank Mary Spiegel for typing this manuscript.

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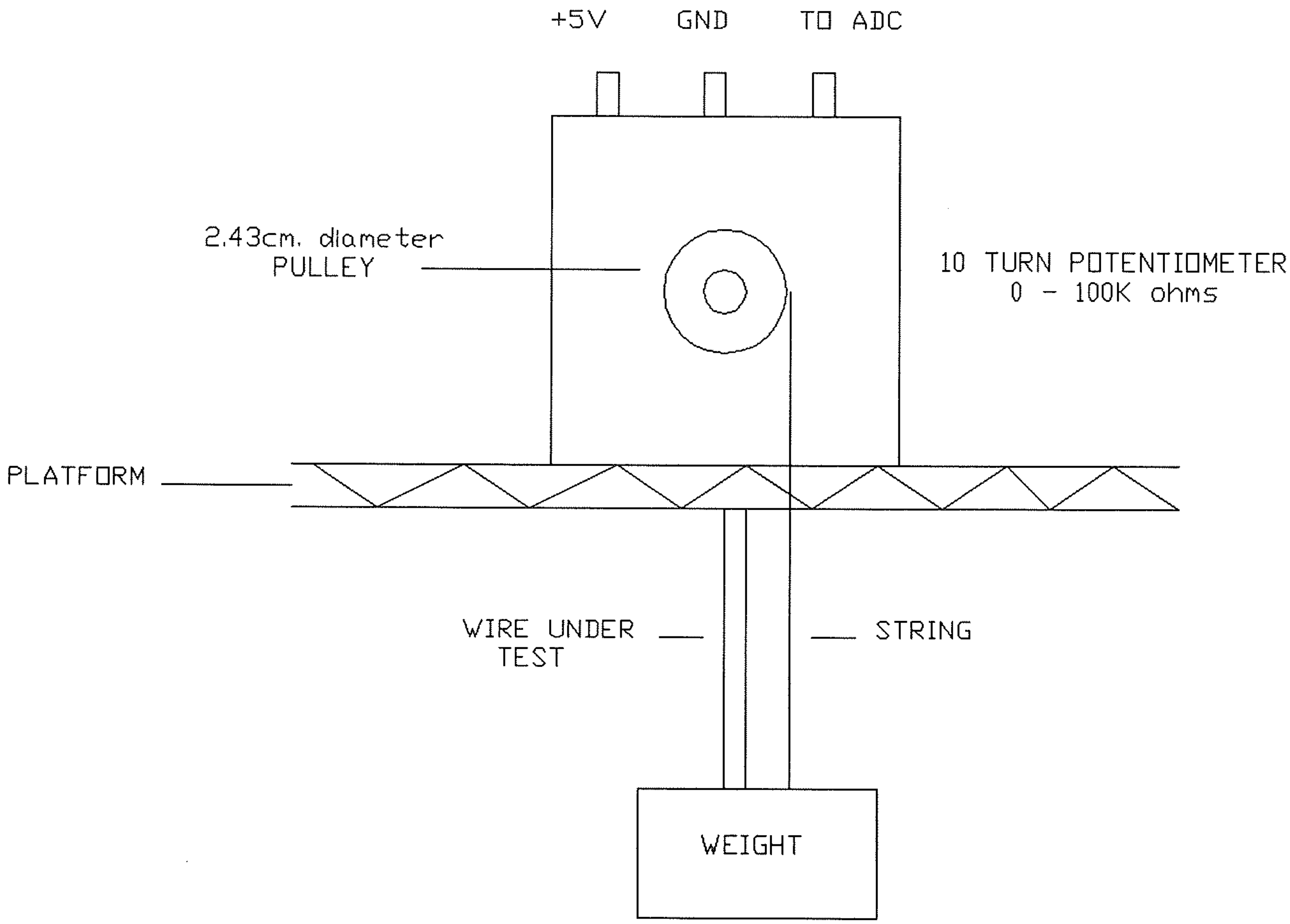


FIGURE 1

APPARATUS FOR MEASURING CREEP

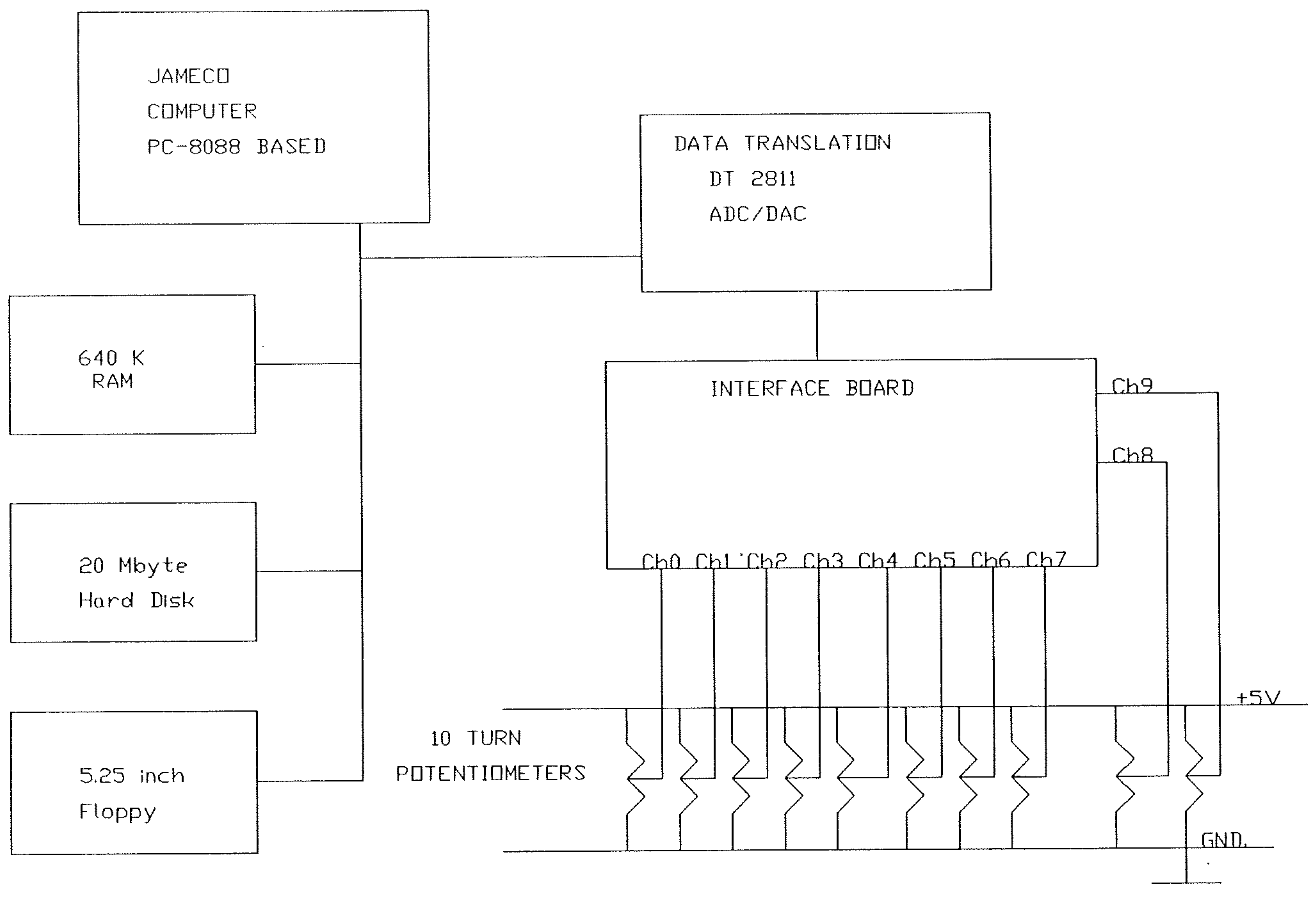
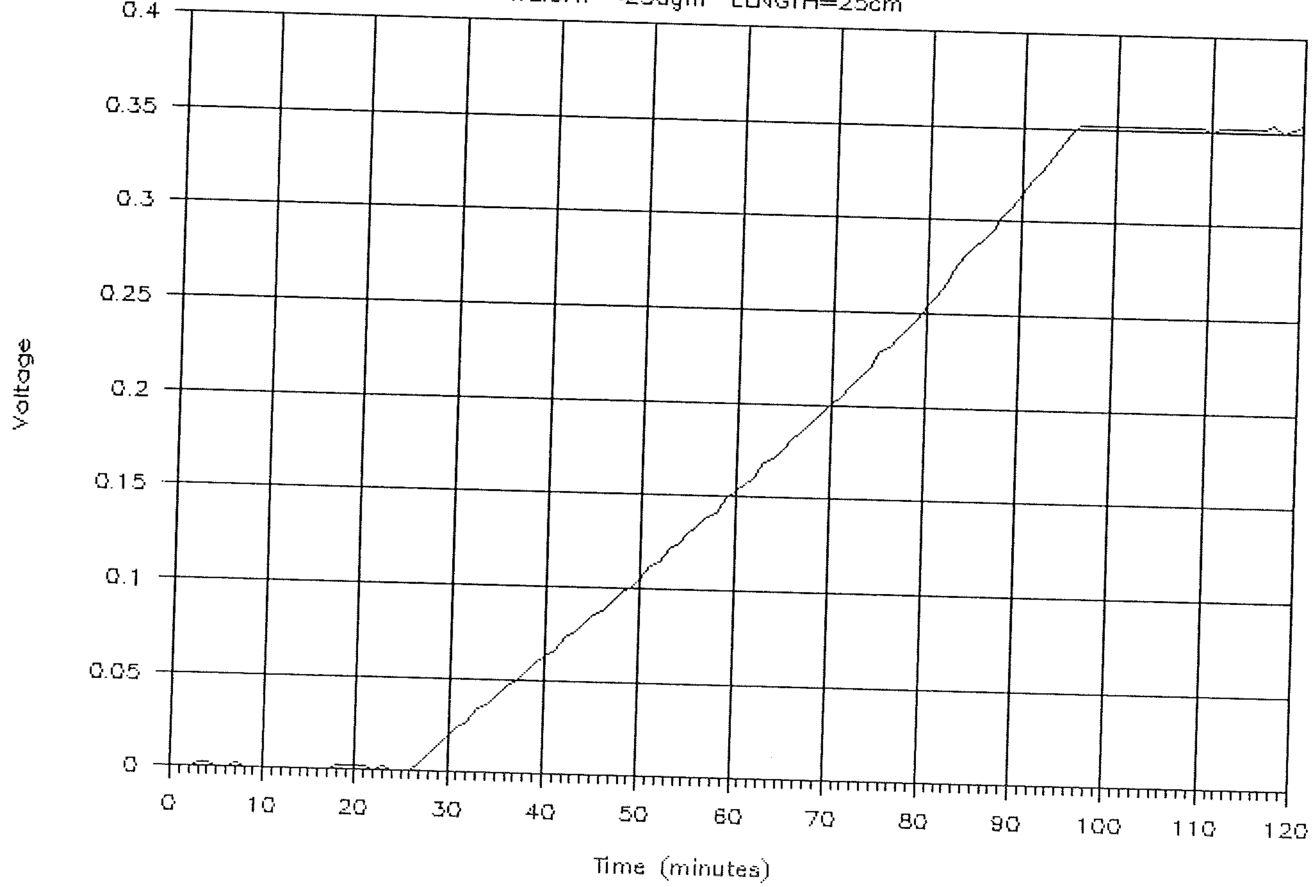


FIGURE 2

AUTOMATED DATA COLLECTION SYSTEM

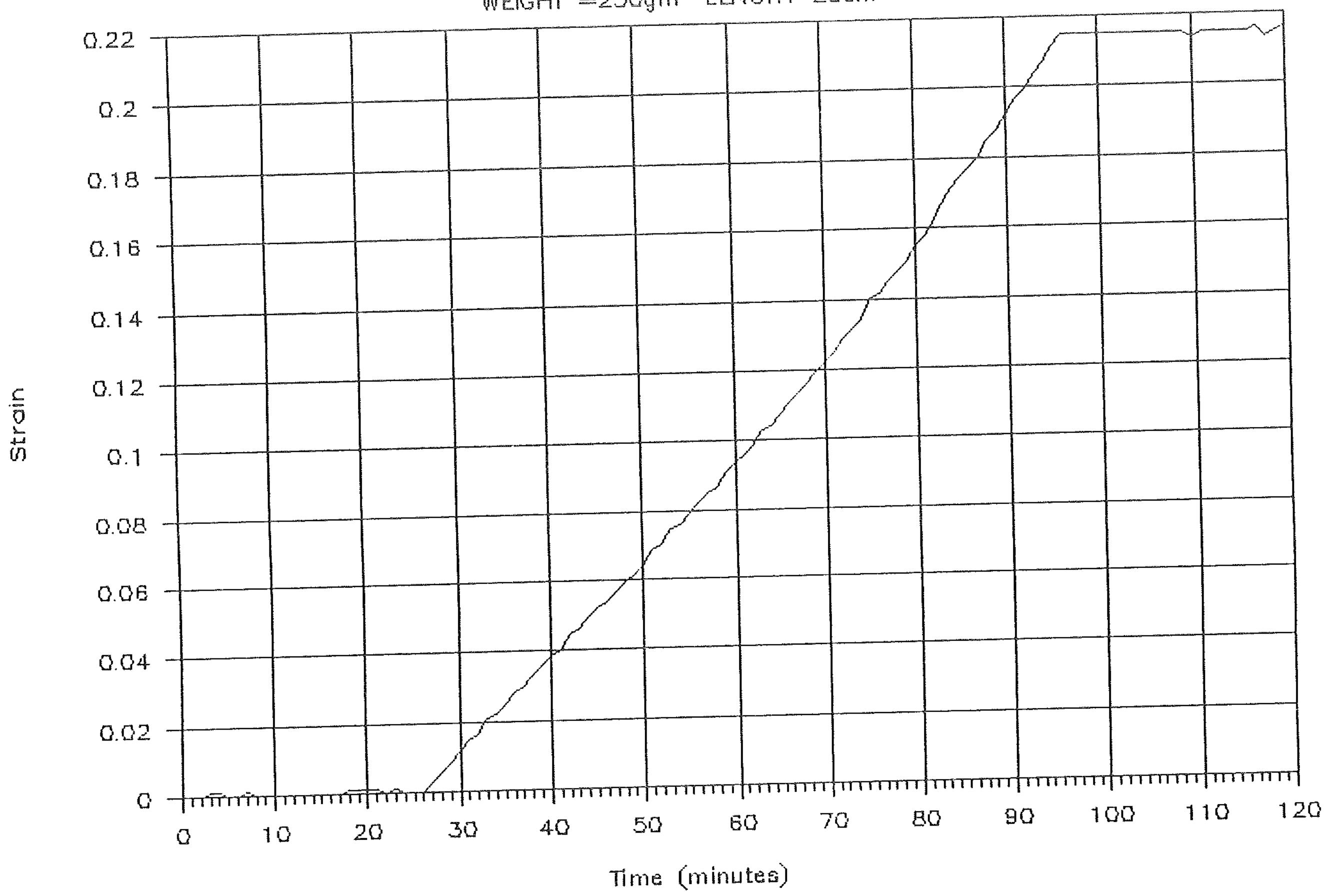
GRAPH 1 DIAMETER=0.079 cm

WEIGHT =250gm LENGTH=25cm



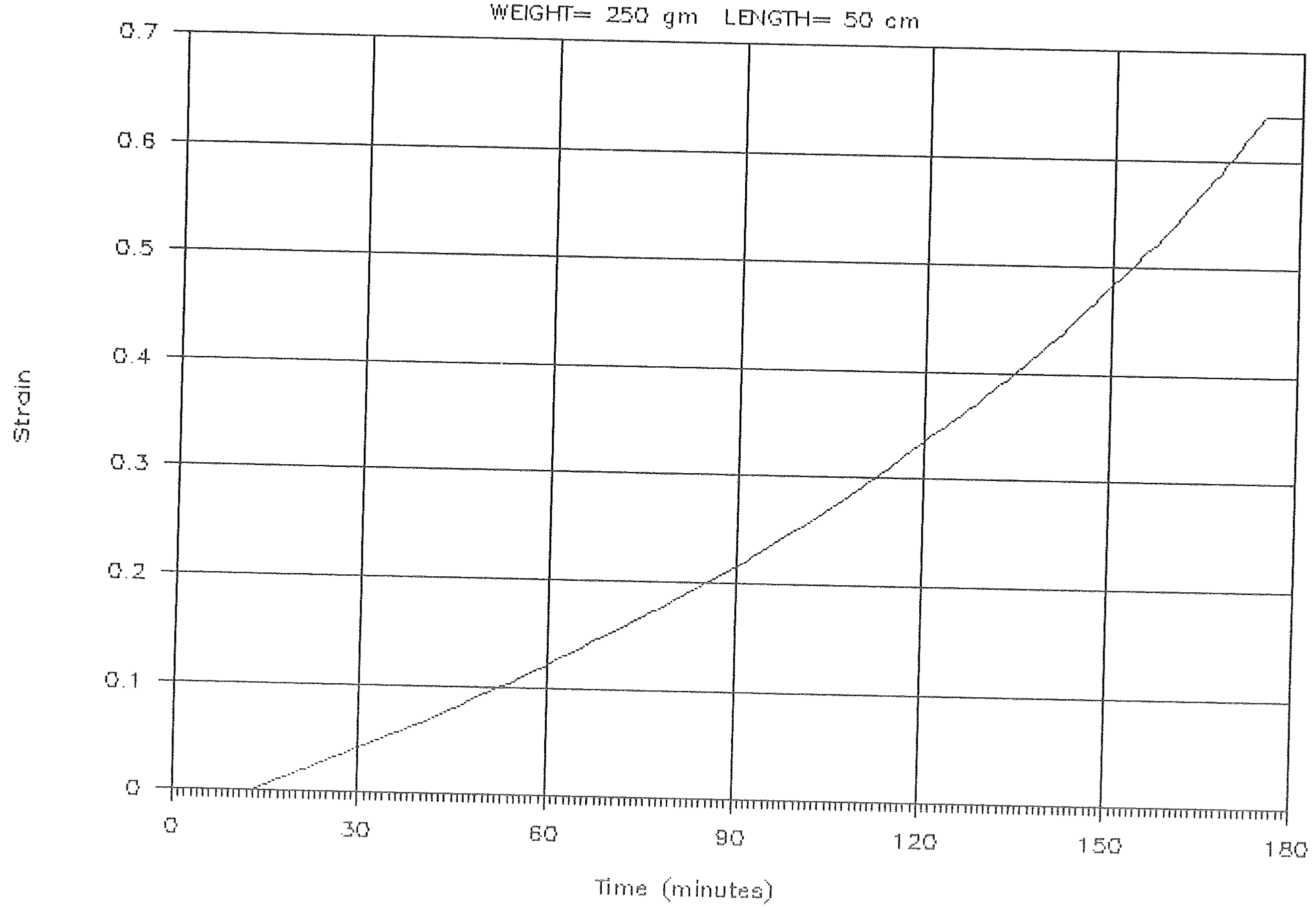
GRAPH 2 DIAMETER=0.079 cm

WEIGHT =250gm LENGTH=25cm



GRAPH 3 DIAMETER=0.079cm

WEIGHT= 250 gm LENGTH= 50 cm



GRAPH 4 DIAMETER =0.158cm

LENGTH=50 cm WEIGHT=750 gm