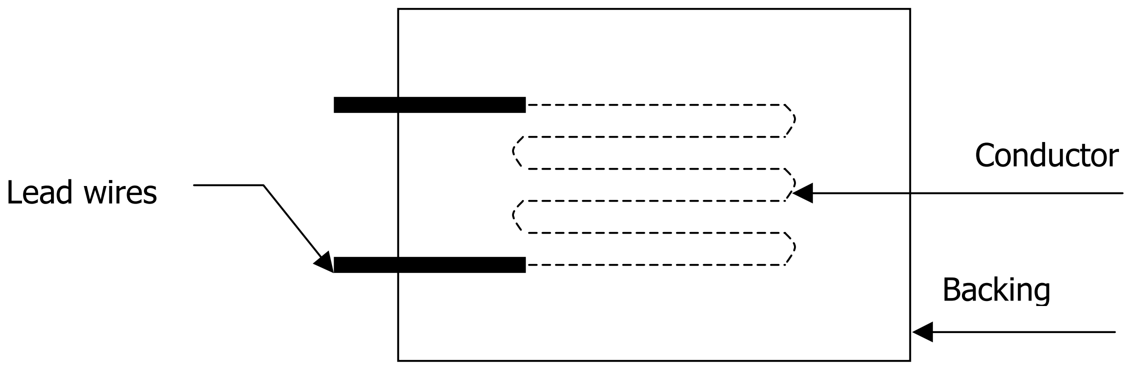
STRAIN GAUGE LOAD CELL

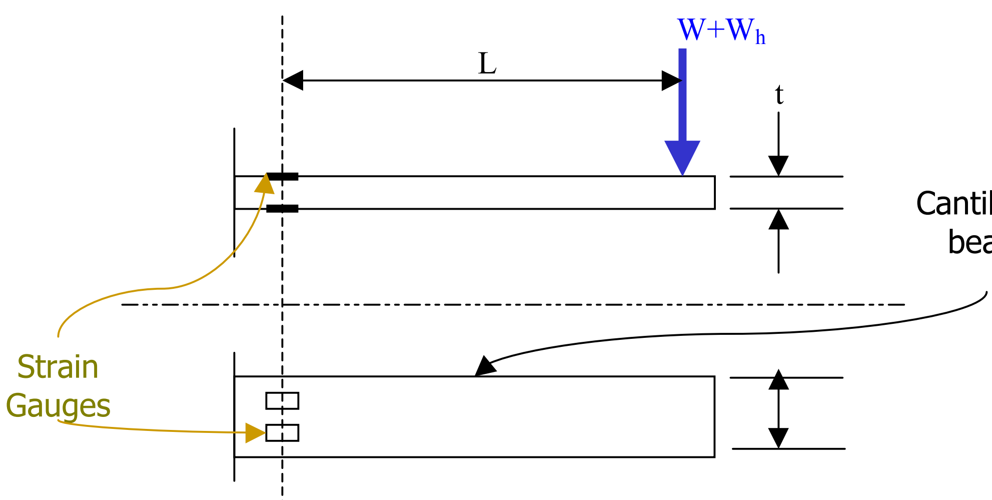
(Revised 18 Jan 2008)

Principle: The resistance of a conductor having uniform cross-sectional area A, length L, and made of material with electrical resistivity ρ is given by R= ρL/A. If the conductor is subjected to a normal stress along the axis of the wire, the cross sectional area and length will change, resulting in a change in resistance. This phenomenon can be used to sense strain and the device is called a Resistance strain gauge. In order to increase their sensitivity, the conductor is arranged so that several lengths of wire are oriented along the axis of the gauge. The strain gauge backing is bonded on to the surface where the strain is to be measured.

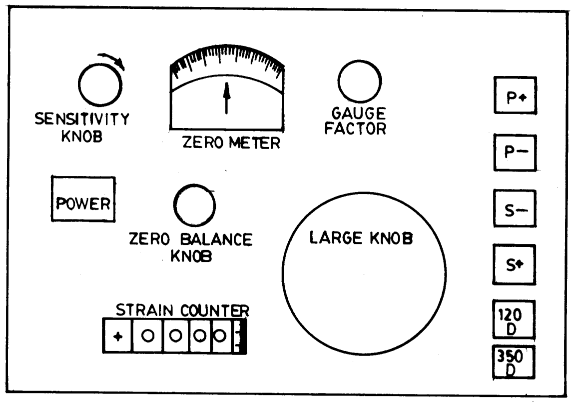


The Gauge factor is the ratio of change of resistance to the change of gauge length $GF = \frac{\delta R/R}{\delta L/L}$. Its value is provided by the manufacturer and is usually near 2.

The output from a bridge circuit can be increased by the appropriate use of more than one active strain gauge. This can also compensate for unwanted effects, such as temperature or specific strain components.



When a weight is added at the loading point of the cantilever, it produces a strain in the strain gauges fixed on the surfaces of the cantilever beam. The strain changes the resistance of the strain gauge ΔR and produces a voltage output for the bridge. This voltage is indicated by a deflection of the needle in the zerometer. This deflection can be nullified by rotating the large knob of the strain indicator, which results in an output reading of the strain counter.



Bending moment at a section taken at the center of the strain gauge = $(W+W_h) \times L$
Moment of inertia about the neutral axis = $bt^3/12$

Theory of bending suggests that the maximum stress at the surface of the strain gauge is given as

$$\sigma = \frac{(W+W_h)L\left(t/2\right)}{\left(bt^3/12\right)}$$

Strain corresponding to this stress is indicated by the strain indicator.

This apparatus is internally equipped with circuits, which form a wheatstone bridge (Fig. 3). Proper positioning of the leads from the strain gauges to the terminals P+, P-, S-, S+ & D results in three different bridge circuits namely:
Full-bridge
Half-bridge and
Quarter-bridge

Quarter Bridge

This bridge makes use of only one external strain gauge (Fig. 1 & Fig. 3). The bridge circuit diagram is given below in Fig.3 and 4. Three wires from the strain gauge are connected to the portable strain Indicator as given below.

Red wire connected to P+ terminal
Blue wire connected to S- terminal
White wire connected to 120 ohm dummy

The letter D stands for dummy gauge in arm 4. Simple 2- wire connection brings in errors due to changes in ambient temperature because copper has high temperature coefficient of resistance. Three lead wires connect the strain gauge to the bridge.

Length of red wire = Length of white wire

Change of resistance in the red and white wire is the same, for any change in the ambient temperature. Hence the errors get cancelled as given below.

$$\frac{R_1}{R_2} = \frac{R_4}{R_3} = \frac{120 + \delta Rt}{120 + \delta Rt}$$

Where δRT = Change in Resistance due to change in ambient temperature.

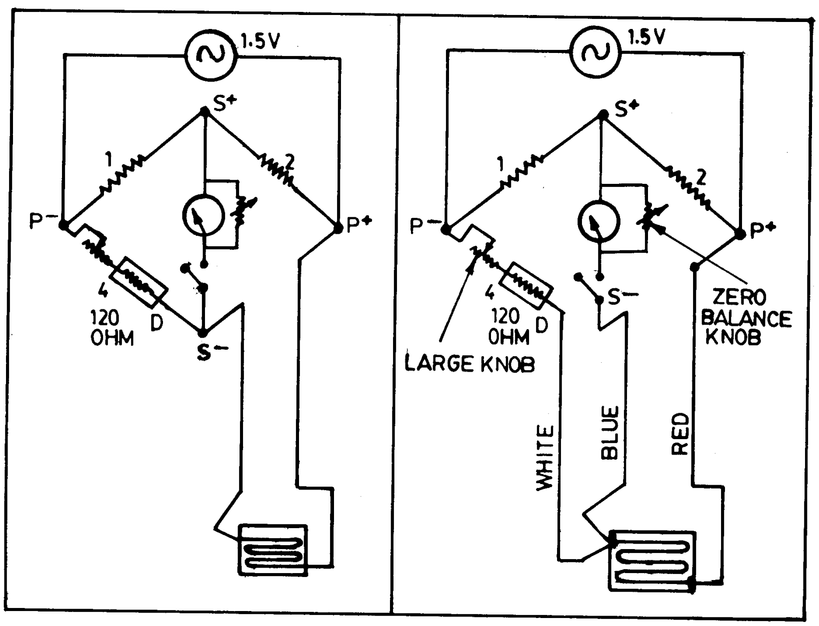


Fig. 3 & Fig. 4

Procedure:

Static Measurements are carried out using the null balance procedure.

1. Connect the gauges as shown on the plate inside the lid.
2. Select the proper position of the BRIDGE selector, FULL or HALF / QUARTER
3. Set the GAUGE FACTOR dial as desired for the particular gauge and/or application and lock.
4. Turn the SENSITIVITY knob fully clockwise to a strain counter reading of "0000".
5. Turn the RANGE EXTENDER knob to "+" (without digit).
6. Push the POWER switch to BAT or AC
7. Turn toggle switch above the BALANCE control to ON.
8. With a No-Load condition on the test specimen turn the BALANCE knob to null (zero) the Null Meter (clockwise to move the pointer to the right). Lock the knob.
9. Load the test specimen as desired.
10. Meter deflects left: Rotate the large Rebalance knob clockwise until the meter comes to null. Read the STRAIN counter and sign.

Meter deflects right: Turn the RANGE EXTENDER switch counterclockwise until the Meter pointer moves to the left. Then rotate the large Rebalance knob clockwise to obtain a Meter null. Read the STRAIN counter and sign.

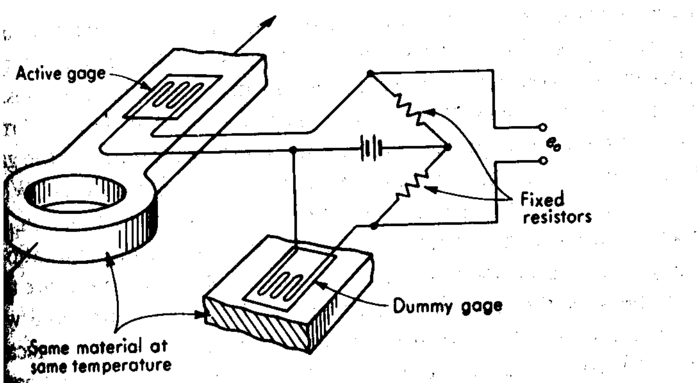
11. The STRAIN Counter reading (meter nulled) is the indicated strain. A "+" quantity indicates tension in the active gauges and "–" indicates compression.

Observations

Weight of the load hanger = Wh = 400 gms.
Bridge arrangement used =

Run Order	Load in g W	Input W+Wh (g)	Strain indicator reading	Strain	Stress
1					
2					
3					
.					
.					
.					
.					
.					
.					

Fit a straight line to the stress strain data using the method of least squares.
The modulus of elasticity of the material is the slope of the fitted stress-strain line.
Determine its uncertainty.



4.13 Strain-gage temperature compensation.