Strain Gauges

An essential component of many of the devices described in these sections is the device known as the *strain gauge* whose invention (at Caltech) in the 1930s revolutionized fluid flow instrumentation. The original invention utilized the property that the electrical resistance of a wire can change as the wire is stretched or strained. By gluing such a wire onto a solid surface one can then measure the strain in that solid by measuring the electrical resistance of the wire. While there are numerous variations on this strategy and a number of additional complicating factors, the basic principle of the strain gauge pressure transducer remains the same: the attaching strain gauges to the flexible diaphragm of a classical barometer or manometer one can measure the deflection of that diaphragm and consequently the pressure. Of course such a device would need to be calibrated using, for example, a classical mercury manometer. Following the development of the strain gauge pressure transducer, other methods were developed for measuring diaphragm deflection and the resulting variety of types of pressure transducers are described in the next section (Kddd).

Strain gauges are also used in fluid flow instrumentation for measuring the forces imposed on a object by the fluid flow, for example, the lift and drag on an airfoil. The design of such *force balances* constitutes another important part of fluid flow instrumentation and this is summarized in section (Kdde).

Modern strain gauges come in a variety of types. In addition to the original resistance-based strain gauges, semiconductor (or piezoresistive) strain gauges are now very common though they are typically more expensive and more fragile. Other, more modern and more esoteric strain gauges utilize nanotechnology techniques.

The sensitivity of a strain gauge is described by its *gauge factor*, GF, that relates the strain sensed by the gauge, ϵ, to the change in the electrical resistance, ΔR:

$$GF = \frac{\Delta R}{R_G \ \epsilon} \tag{Kddc1}$$

where R_G is the resistance of the undeformed gauge. For common metallic foil gauges, the gauge factor is usually a little over 2. These typically allow strains of up to 10% to be measured. To measure small strains, semiconductor strain gauges with substantially larger gauge factors are often preferable. These also have a faster response time and are therefore better for the measurement of unsteady strains. Almost all strain gauges are temperature sensitive and therefore require inbuilt temperature compensation.