ROUTINE LABORATORY INSTRUMENTS FOR THE MEASUREMENT OF THE MAIN FLUID MECHANICS QUANTITIES

In this section, the underlying principles, characteristics and operation of the most common fluid measuring devices used throughout the laboratory activity are described.

1. Liquid Level Measurement

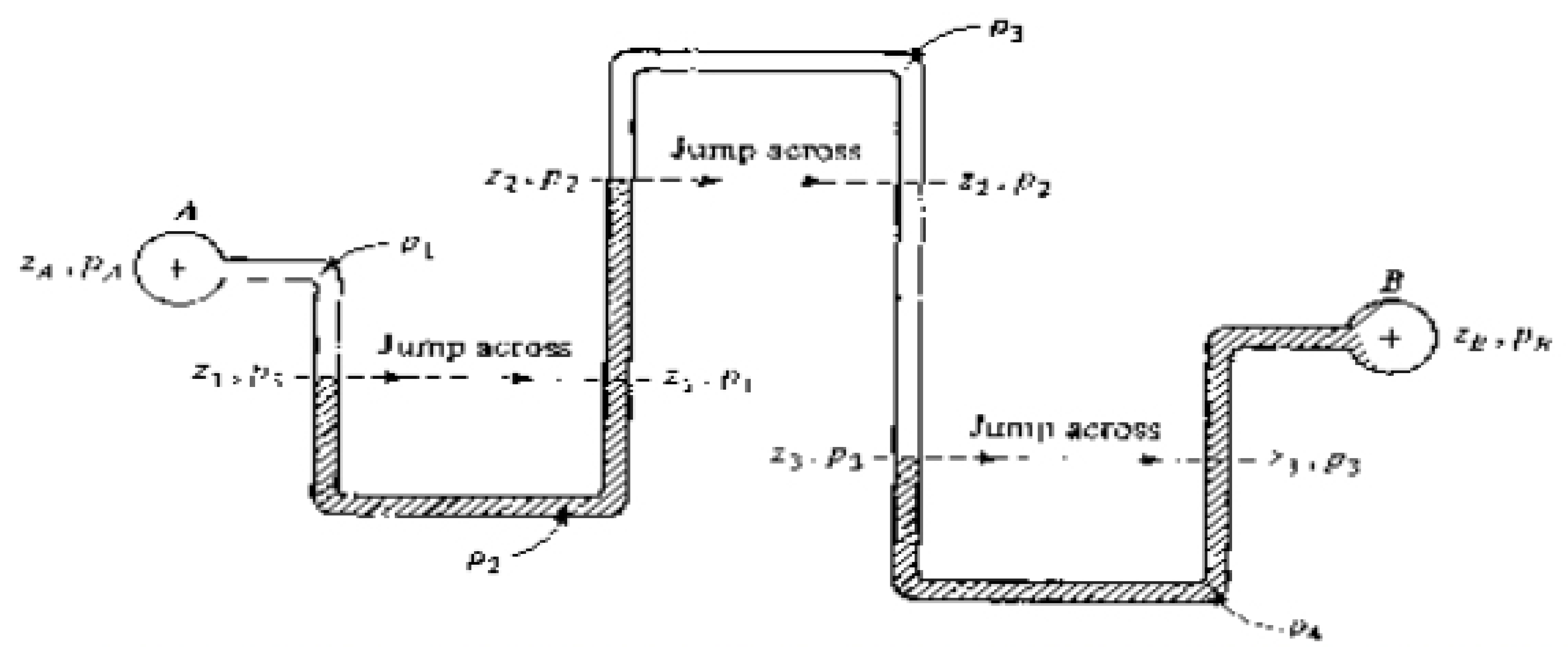
Usually these measurements are associated with free-surface or stationary flows. **Scales and tapes** for the measurement of length are readily available in a variety of forms.

A type of linear measurement peculiar to the fluids laboratory is the measurement of surface level in an open channel. This measurement is accomplished in general by means of a **point gage**. The gage is comprising a pointed shaft or hook mounted on a graduated rod which can be moved vertically relative to a zero line. Further precision can be gained by means of a vernier (see Figure 2) which allows to make readings with a precision of 0.001 ft. Contact with the surface is best observed in the reflection of light.

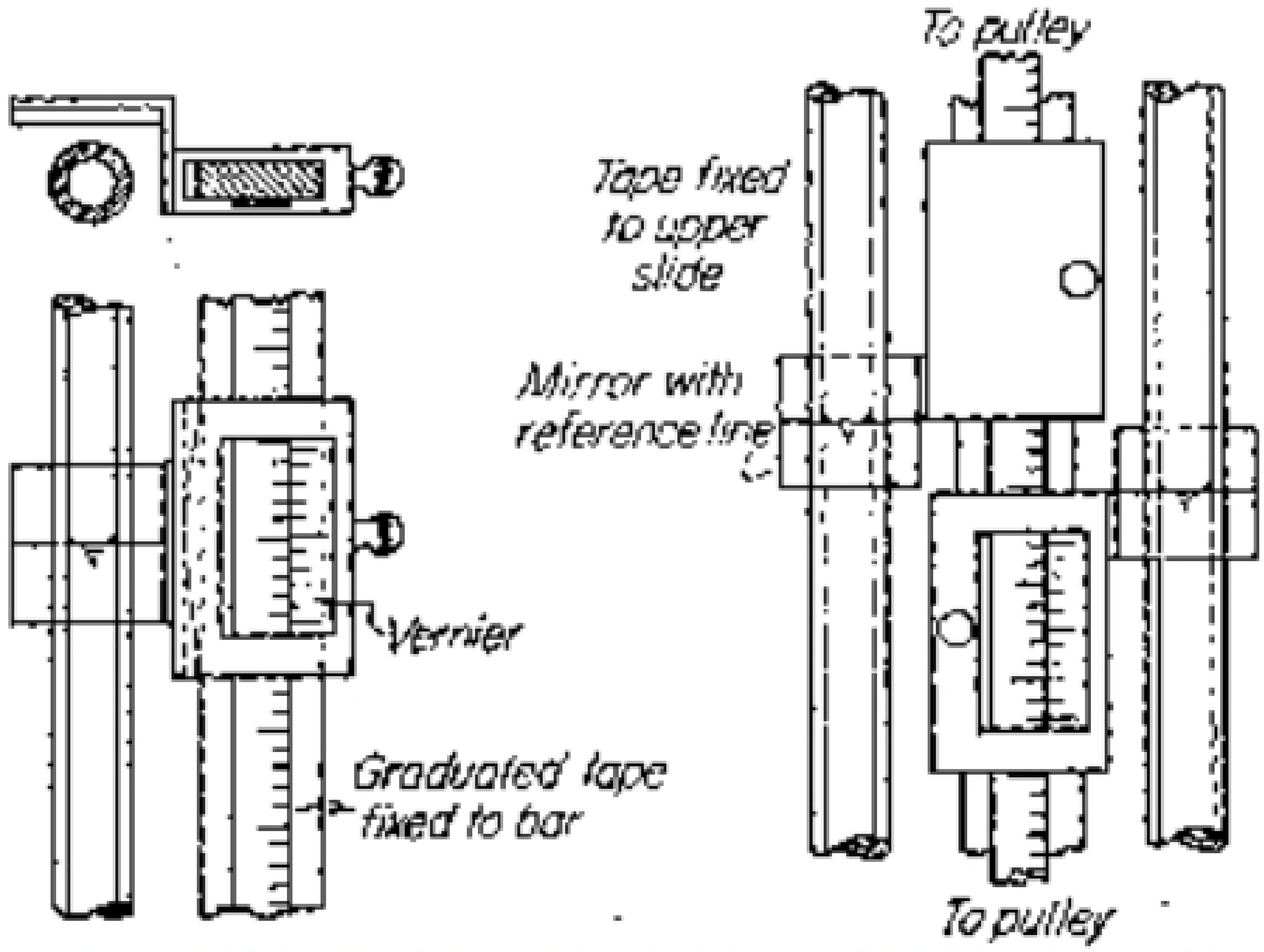
In zone of hydrostatic pressure, the liquid level can be determined by connecting a conveniently located **piezometer or open manometer** (open tubes for measurement of the pressure head of liquids) or a **stilling well** with point gage. Both methods remove difficulties associated with the waviness of the free surface.

2. Pressure Measurement

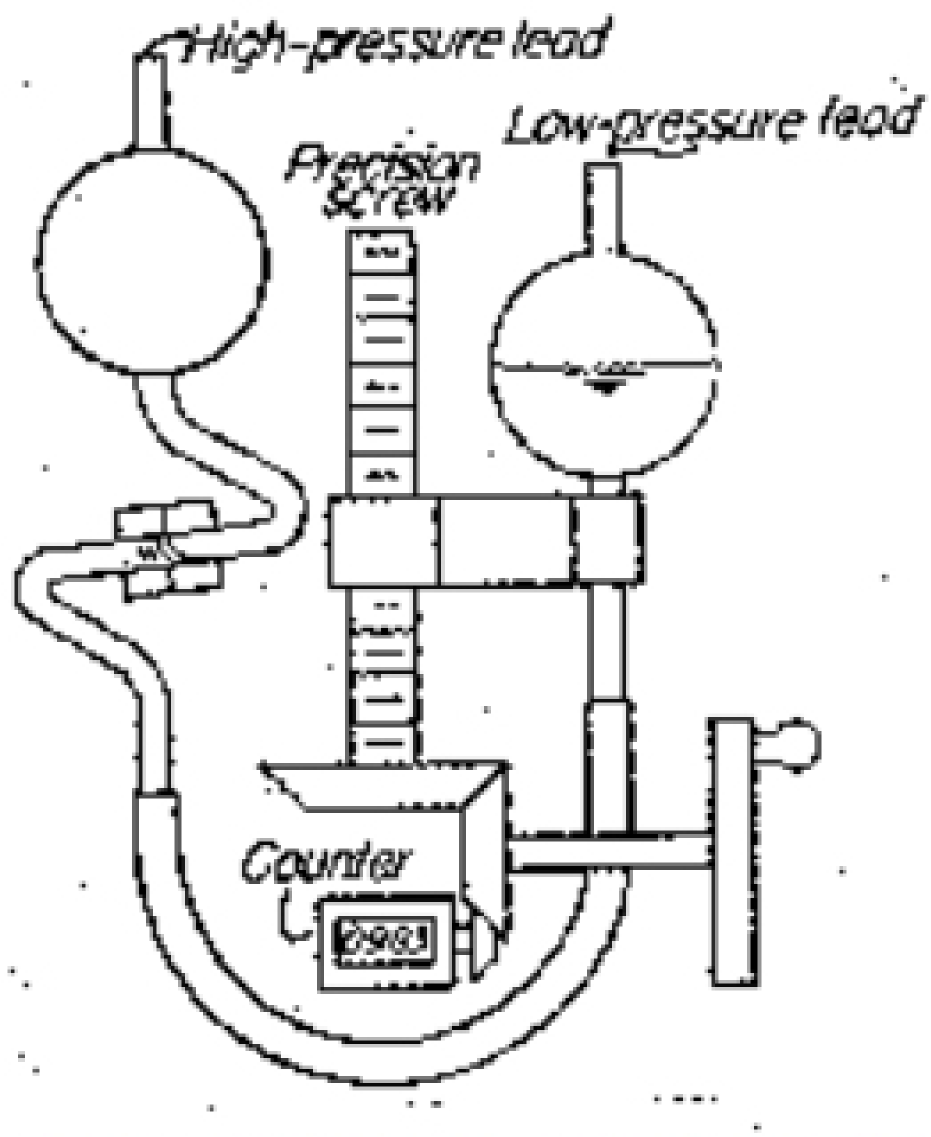
The simplest instruments for pressure measurement are the **single-column manometers**. They measure the pressure head relative to some arbitrary datum. Most often it is the difference between two levels or heads in a static or moving stream that is to be measured. Then rather to make two separate readings and subtract one from the other, we use the **differential manometer** which yield a single differential reading. Differential manometers relate a pressure difference to the densities and the elevations of liquid columns into a U-tube. The configuration of such a manometer is shown in Fig 1.



By repeated application of the hydrostatic formula we can relate the pressures p_A and p_B to the densities and the levels of the fluid levels in the tubes. Usually the central columns are placed on the sides of the same guide bar. Separate slides are provided for each column, and the graduated scale is fixed to one and read by the vernier on the other as shown in Figure 2.

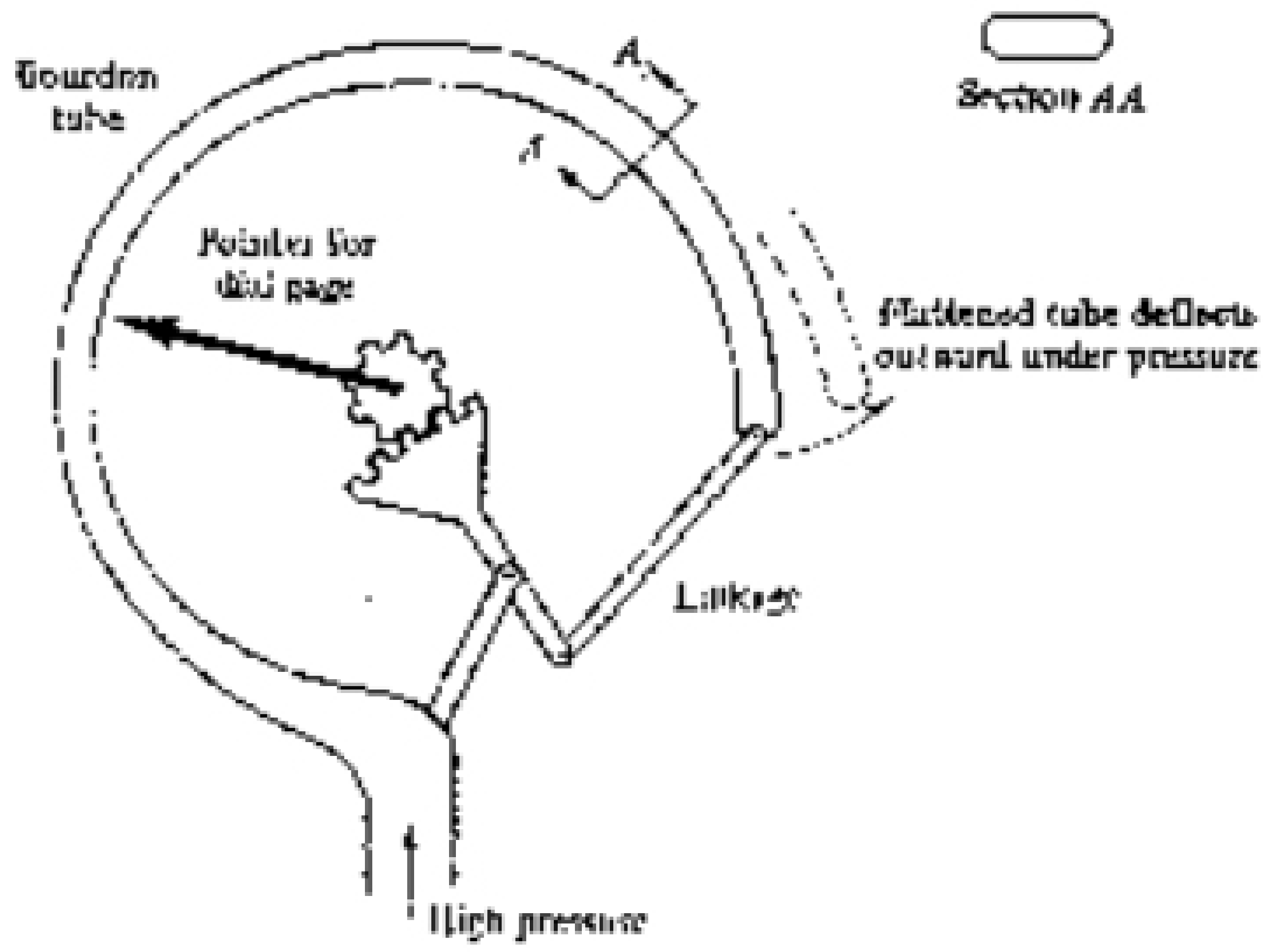


For small pressure differences (e.g., measurements in gas) the augmentation of the manometer sensitivity is accomplished by using a **sloping manometer** (inclined manometer) to magnify the displacement of the fluid meniscus. H. Rouse, former IIHR scientist, also designed a manometer from this category (see Figure 3).



For higher pressures, as is the case in pressure-driven flows (duct flows) **bourdon-tube pressure gages** are used. A curved tube, as shown in see Figure 4, with a flattened cross section will deflect outward when pressurized internally.

The deflection can be measured by a linkage attached to a calibrated dial-gage pointer. Extreme accuracy can be obtained through proper design, and commercial bourdon gages are available with an accuracy of ± 0.2 percent of full scale.



3. Velocity Measurement

Velocity, the magnitude of which is a simple combination of length and time scales, is sometimes **determined directly** as such. For example, by timing a **float** over a known distance the average rate of displacement at the free surface can be computed. More significantly, exposure of a camera for a short time interval will permit the measurement of streaks made on the film by surface floats or suspended particles in the flow (e.g., small neutrally buoyant spheres or hydrogen bubbles) to indicate local displacement in the given interval.

There are also various **indirect means** of velocity indication depending upon one or another of its effects. The simplest among them are the **mechanical rotating devices** and instruments employing Bernoulli relationship: **Pitot-tube and obstruction meters**. As the last mentioned instruments are usually used for metering the flow, they will be presented in the next section.

Rotating sensors, see Figure 5, can be used in either gases or liquids, and their rotation rate is approximately proportional to the flow velocity.