well. Such barometers are equipped with an adjustment to compensate for change in level of mercury in the well. The reading should be taken at the top of the meniscus and is obtained on a Vernier scale.

Correction for variation of the density of the mercury column and for expansion of the brass scale, which are usually calibrated for 32 F mercury and 62 F scale temperature, should be made by subtracting from the observed height in inches the value of $C$ determined by Equation 2.

$$C = \frac{h\,(t - 28.630)}{(1.1123\,t - 10978)} \qquad (2)$$

*where*

$C$ = correction to be subtracted, inches of mercury.
$h$ = observed height, inches of mercury.
$t$ = observed temperature of the barometer, Fahrenheit degrees.

Standard atmospheric pressure at sea level is 29.921 in. Hg. Since normal atmospheric pressure decreases about 0.01 in. Hg for each 10 ft increase in elevation, it is important to make a correction if the elevation of the barometer is not that of the test apparatus. In many cases the barometric reading may be obtained from a nearby Weather Bureau Station, in which case inquiry should be made as to whether the value is as observed or corrected to sea level.

Atmospheric pressure may also be measured by an aneroid barometer which is easily portable. In this type, variations in atmospheric pressure bend the thin surface of a sealed box or tube. The aneroid type is not as accurate as the mercurial and needs frequent calibration. Most of the pressure gages used in engineering work indicate the difference between the pressure being measured and the atmospheric pressure. Such pressures are called gage pressures. Absolute pressure may be obtained by adding barometric pressure and gage pressure algebraically.

## Pressure Gages

The Bourdon type gage is a widely used device for measuring pressures. The Bourdon tube is elliptical in cross-section and circular in form, and is connected by suitable linkage to a pointer which moves over a dial. An increase in pressure tends to straighten the tube and a decrease has the opposite effect. When used with high temperature steam, the tube must be protected by a water seal. When used with ammonia it must be made of steel or other material not attacked by this substance. When used for sub-atmospheric pressure, the gage is known as a vacuum gage, and is usually graduated in inches of mercury. For pressures above atmospheric, it is termed a pressure gage and is graduated usually in pounds per square inch.

Occasionally, gages are graduated in feet of water. Some, made to indicate either pressure or vacuum, are termed compound gages. Calibration is usually made by means of a dead weight tester, consisting of a platform and weights resting on a piston acting on oil in a cylinder. The pressure at all points in the fluid is determined from the area of the piston and the total weight resting on the oil. Adjustments are provided in the gage linkage to make necessary corrections. A correction chart may be used for accurate work.

## Manometers

For measuring low pressures or differences in pressure between two points as in a duct system, the vertical $U$ tube is a simple and accurate



gage and is used for test work with water or with various fluids such as mercury, kerosene, or alcohol. Readings are usually in inches of one of these fluids, and must be arithmetically converted into inches of water or other standard units. The glass tube used to form the manometer should be chemically clean and the bore should not be less than 3/16 in. A modified form of the $U$ tube manometer using mercury as the fluid, can be constructed to measure absolute pressures directly [7].

For measuring pressure differences of a few inches of water, or less, $U$ gages are often set at an angle for scale amplification. In commercial gages of this type, commonly termed *draft gages*, only one tube of small bore is used and the other leg is replaced by a reservoir. Although the

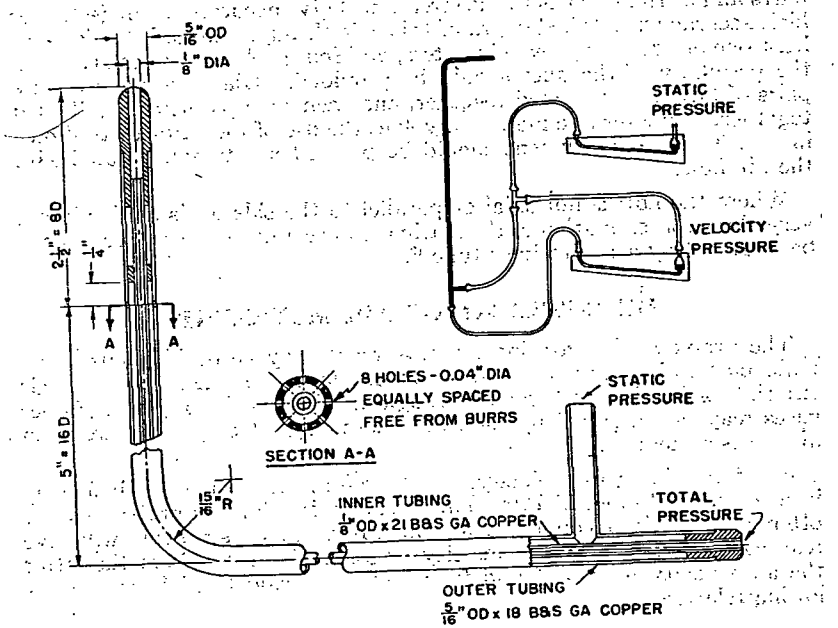


FIG. 3. STANDARD PITOT TUBE

scale is calibrated to read in inches of water, a fluid having the density and characteristics of kerosene is often used. It is necessary, in such a gage, to use a fluid having the same gravity as that for which the gage was originally calibrated, or to apply a correction if another fluid is used. Such gages may be checked one against another to detect errors in gravity of fluid. For more accurate calibration the gage may be checked against a micromanometer or a calibrating device known as a hook gage [8]. The accuracy of a draft gage is dependent on the slope of the tubes and consequently the base of the gage must be leveled carefully. It is not desirable to use a slope of less than 1 in 10.

Where pressures are read under extreme conditions of temperature and calibration is possible only at normal temperature it is necessary to correct for the change in density of the liquid in the manometer [9].

For measuring low pressure differences to within 0.001 in. of water very sensitive *micromanometers* are available, such as the Illinois or Wahlen;