tube, a metal tube of oval cross-section curved along its length to form almost a complete circle. One end is closed and the other is connected to the vessel in which the pressure is to be measured. With an increase of pressure, the tube tends to straighten, and vice versa. The resulting motion of the closed end is communicated by suitable linkages to a needle moving over a graduated dial. If the range is above about 20 psi, such gages are usually calibrated by means of a *dead weight tester*, whereby known pressures are produced in a fluid by imposing known weights on a piston of known area. Gages are commonly set to read accurately at or near the pressure of probable use. Gages of several different types or qualities are available on the market.[12] Suction gages and pressure gages with ranges below about 20 psi are ordinarily calibrated against mercury manometers.

Manometers

The manometer is a simple and useful means for measuring partial vacuum and low pressure. It is, moreover, a primary instrument; it does not require calibration, and it is often used as a standard for the calibration of other instruments. It is so universally used that both the inch of water and the inch of mercury have become accepted units of pressure measurement. In its simplest form, the manometer consists of a U-shaped glass tube partially filled with a liquid. A difference in height of the two fluid columns denotes a difference in pressure in the two legs, which is proportional to the difference in height.

For converting manometer readings into other pressure units, certain proposed standard factors are applicable for precise work. These are based on a standard gravitational acceleration of 32.1740 ft per (sec) (sec) and are as follows:

1 Standard Atmosphere = 14.696 lb per sq in. = 29.921 in. mercury at 32 F
= 33.96 ft water column at 68 F

For most ordinary purposes, the following figures are of ample accuracy:

1 Atmosphere = 14.7 lb per sq in. = 29.9 in. mercury
= 34.0 ft (408 in.) water column

Manometer tubes should be chemically clean. The bore is not important, except insofar as it affects the meniscus through wetting or surface tension. Bores of at least $\frac{3}{16}$ in. for rough, and $\frac{1}{2}$ in. for more precise, measurements are recommended. Liquids other than water are sometimes used for low pressure measurement and, when this is done, the readings must be corrected for the density of the fluid used.

For measuring pressure differences of a few inches of water, or less, U-gages are often set at an angle for scale amplification. In many gages of this type, commonly termed draft gages or inclined manometers, only one tube of small bore is used and the other leg is replaced by a reservoir. The scale is calibrated to read in inches of water, and it is necessary 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. For more accurate calibration the gage may be checked against a micromanometer or a calibrating device known as a hook gage.[13] The accuracy of a draft gage is dependent on the slope of the tube, 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.[14] For measuring low pressure differences to within 0.001 in. of water, very sensitive micromanometers are available, such as the Illinois or Wahlen, the Meriam, the Trimount, and the Emswiler.[15, 16]

When using a manometer or other pressure gage for measuring air flow, by means of orifices, the type of duct openings used for manometer connections and their location are important. Where velocities are low, as in some plenum chambers, or where the flow is free of large eddies and parallel to the walls of a duct, a drilled hole cleared of burrs and at right angles to the stream, is satisfactory.[17] For higher velocities, it is common practice to provide four holes or taps around the periphery of the duct. Diametrically opposite pairs of taps are connected together, and then such pairs are manifolded together.

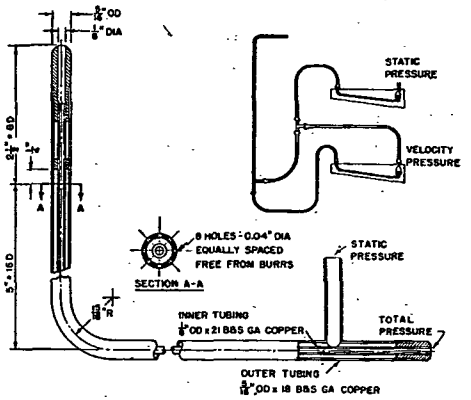

FIG. 3. STANDARD PITOT TUBE

An alternate method involves the use of the Pitot tube, shown in Fig. 3. This instrument should be pointed up-stream, parallel with the air flow. Where the flow is not axial or parallel to the side walls of the duct, a very close approximation of the static pressure and the flow direction can be obtained by a Fechheimer tube.[18]

Barometer

The simplest and earliest type of barometer consists of a glass tube somewhat more than 30 in. long filled with mercury, and inverted in a cup partially filled with mercury. The height of the mercury column in the tube above the mercury surface in the cup is a measure of the existing atmospheric pressure, except for the slight pressure of the mercury vapor in the space above the mercury in the tube. This can ordinarily be ignored.

Elaborate mercury barometers, fitted with vernier scales, are available. For precise work, corrections must be made for the thermal expansion of the mercury and of the scales.[19] The instruments are usually calibrated for 32 F mercury and 62 F scale temperature, and the correction