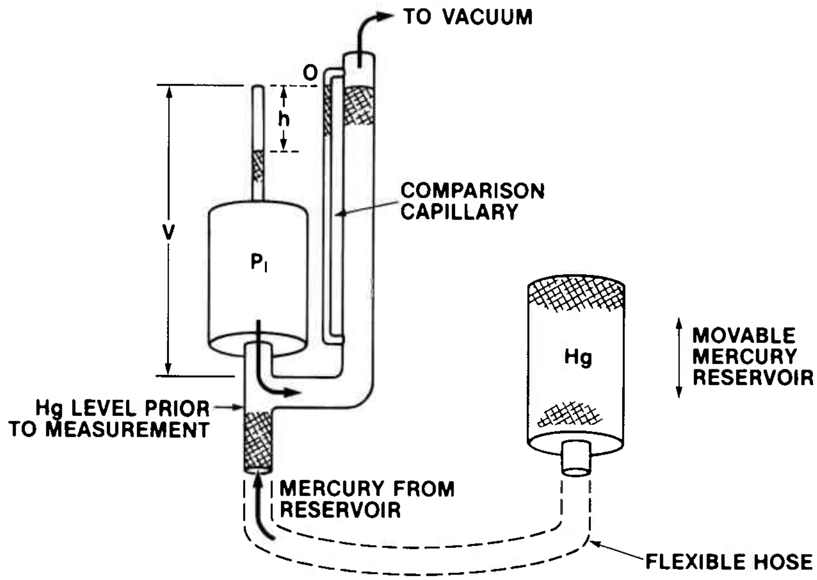
McLeod Gauge



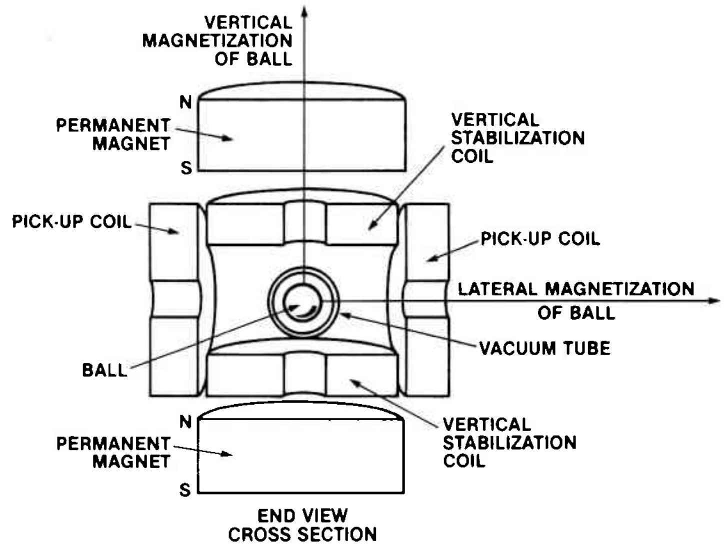
A McLeod gauge depends upon Boyle's Law for perfect gases. We use a large glass bulb and a small capillary tube with mercury to compress the gas at low pressure into a small volume at a higher pressure. A scale is attached so that we do not have to calculate the pressure from Boyle's Law each time. Because the gauge is made of glass and must use liquid mercury, it is rather fragile. If you had one on your production floor, it's broken by now! They are generally kept on a shelf in the "calibration lab" and used only there. The gauge suffers from several problems:

- It is fragile and is filled with mercury.
- It takes several minutes to get one reading.
- If the vacuum system contains a condensable gas (water vapor, for instance), the gas will condense during compression. The gauge reads incorrectly as a result. Therefore, drying filters must be used, and kept clean in order to get "correct" pressure readings for noncondensable gases.
- The mercury vapor is potentially toxic.
- It cannot measure rapidly changing pressures.

For many years, it has been the best "standard" gauge available, even with its problems.

To use the gauge, you connect it to your system and pump the gauge down. Be careful not to place the mercury bulb so that mercury can go into the vacuum system! When you think the gauge is pumped down (a problem), raise the mercury bulb slowly until it rises to the mark in the sidearm. Read the pressure on the scale. Lower the mercury to expose the gauge to the system pressure and try again.

Spinning Rotor Gauge



SPINNING ROTOR GAUGE

A newer gauge is now in the process of being accepted by the National Institute of Standards and Technology as a transfer standard gauge which they may certify. This is possible because the principle on which the gauge works can be related through calculation to basic laws of physics. Its name says exactly what it is— a spinning rotor.

You may recall from some experience that one of the problems with cars is the friction due to air. It's this property of air that is used in the gauge. A ball is magnetically suspended in a small chamber to eliminate all sources of friction except air friction. It is made to spin or rotate while suspended. If there are gases present in the chamber, the ball will slow down due to the impacts from molecules in the chamber. The rate at which it slows down is directly proportional to the gas pressure (number of impacts). All we need do then is to very accurately measure the rate at which the ball slows down, and calculate the pressure as a result. This calculation is, of course, done in the gauge control unit.

The manufacturer of this gauge states an accuracy of "1% of the reading plus or minus 3×10^{-8} torr from 10^{-2} to 5×10^{-7} torr." While you will not be using this gauge as a routine pressure gauge, your gauges may be calibrated using this gauge.

Other Calibration Gauges

The capacitance manometer may be used as a calibration gauge, generally in the rough vacuum range. It, in turn, could be calibrated using the spinning rotor gauge. You may keep one or more gauges in your tool box, just to replace a gauge on the system to see if they are about the same reading.

Summary

We have discussed various types of gauges used to measure pressure from the rough to ultrahigh vacuum ranges. You have learned what these gauges do, how they work, and how they are maintained.

Now that we've covered two major components of vacuum systems, pumps and gauges, let's move on to look at the hardware components and materials used in vacuum systems.

Notes

6 Vacuum Materials and Hardware

When you have completed this chapter, you will be able to:

1. Describe the basic materials used in vacuum work.
2. Understand the common joining techniques used in the construction of vacuum systems.
3. Describe the hardware components usually found in typical vacuum systems.

Introduction

Modern industrial vacuum equipment enables the manufacture of many different products. It enables processes such as vacuum skin packaging and vacuum drying. It also makes it possible to do many kinds of chemical processes, analytical work, and thin-film coating. These are only a few examples of the work done in vacuum systems. Of course, we must have the pumping mechanisms to produce high-purity vacuum environments. Let's now look at another key factor in vacuum equipment: the hardware components and materials used in vacuum systems.

Vacuum Purity Levels

It will help to have another look at what we are doing when we want to use a vacuum system. Here's a summary of some information about vacuum for you.

Pressure		Gas Density	Mean Free Path	
Torr	Pa	Molecules/cc	Meters	English
760	10^5	3×10^{19}	6×10^{-8}	2.5×10^{-6} in.
0.76	10^2	3×10^{16}	6×10^{-5}	2.5×10^{-3} in.
7.6×10^{-3}	1	3×10^{14}	6×10^{-3}	2.5×10^{-1} in.
7.6×10^{-6}	10^{-3}	3×10^{11}	6×10^{0}	21 ft
7.6×10^{-8}	10^{-5}	3×10^{9}	6×10^{2}	2100 ft
7.6×10^{-10}	10^{-7}	3×10^{7}	6×10^{4}	40 mi

Let's add two more numbers to compare to this table: About *10^{15} molecules* can cover *one square centimeter* (cm^2) of surface area only one layer (a *monolayer*) thick, when the molecules are at room temperature. At a pressure of 10^{-6} torr, it takes about 1 second to deposit one monolayer of molecules on the surface.

10^{15} molecules/cm^2 1 sec at 10^{-6} tor

Now, we can look at these facts and make some use of them. Let's suppose we want to put down a few layers of our own choosing on a surface. What pressure would we need to use in order to put down what we wanted– not just whatever was flying around in the chamber? Every second there will be another layer coating our surface at 10^{-6} torr. We better work fast. If we take a long time to lay down our layers, we will need to work at very low pressure.