Western Electric

D-79510 and D-79512 Ionization Manometer Tubes

IMPORTANT

STUDY THIS BOOKLET CAREFULLY
BEFORE PUTTING TUBE IN OPERATION

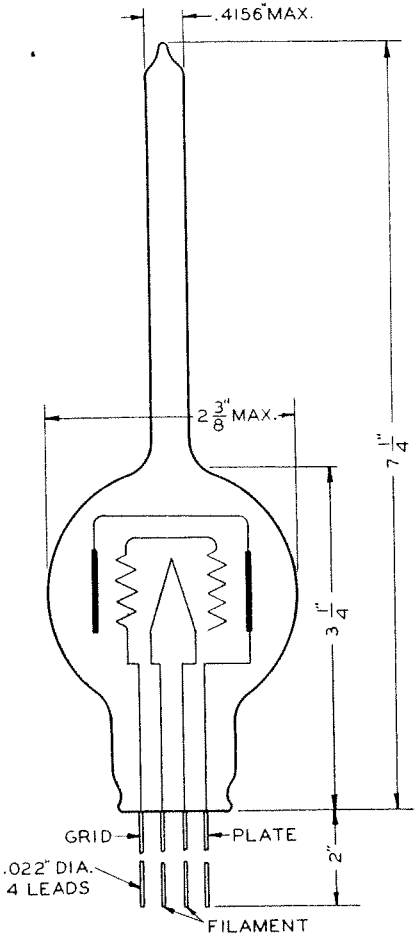


FIG. 1

Western Electric

D-79510 and D-79512

Ionization Manometer Tubes

Classification

The ionization manometer is a gauge for the measurement of low gas pressures. This booklet covers the use of the manometer especially with reference to the measurement of pressures of air, but with the proper conditions the gauge can be used with other gases.

The D-79510 manometer is a three-element tube in a spherical lead glass bulb with an elongated tubulation. The D-79512 is the same except that the bulb is pear shaped and of Nonex glass (corning 702P). The tubulation is used to facilitate sealing the manometer to the vacuum system.

Filament Characteristics

Nominal filament voltage	4.5 volts
Nominal filament current	1.6 amperes
Maximum filament current	2.5 amperes

Ordinary Operating Range

Plate Voltage	—2 to —10 volts, d.c.
Plate Current	3 milliamperes (max. d.c.)
Grid Voltage	100 to 125 volts, d.c.
Grid Current	5 to 25 milliamperes, d.c.
Pressure	Below 1×10^{-3} mm. of mercury

The calibration of the manometer is dependent upon the average grid current. Under the conditions given in Figure 2 the grid current is controlled by the adjustment of the relay which in turn controls the filament current. The manometer may be calibrated against a Knudsen, McLeod or similar gauge.

Theory

The filament of the ionization manometer is used as a source of electrons. The grid, which is maintained at a positive potential with respect to the filament, acts as an anode. If gas is present in the device, ionization occurs and positive ions flow to the plate which is maintained at a negative potential with respect to the filament.

This plate current depends upon the number of gas molecules within the tube, that is, upon the gas pressure and upon the number of electrons which flow to the grid. At fixed electrode potentials the plate current, I_p, is directly proportional to the product of the gas pressure, P, and the electron current to the grid, Ie; that is,

$$I_p \text{ or } PI_e \text{ or}$$

$$P = \frac{K}{I_e} I_p$$

where K is a proportionality constant depending upon the geometrical proportions of the system of electrodes, the character of the gas and the operating voltages. Provided $\frac{K}{I_e}$ is properly chosen, the values of the plate current may be made to correspond directly with the values of pressure, P, as expressed in any desired units, for example, in decimal fractions of a millimeter of mercury.

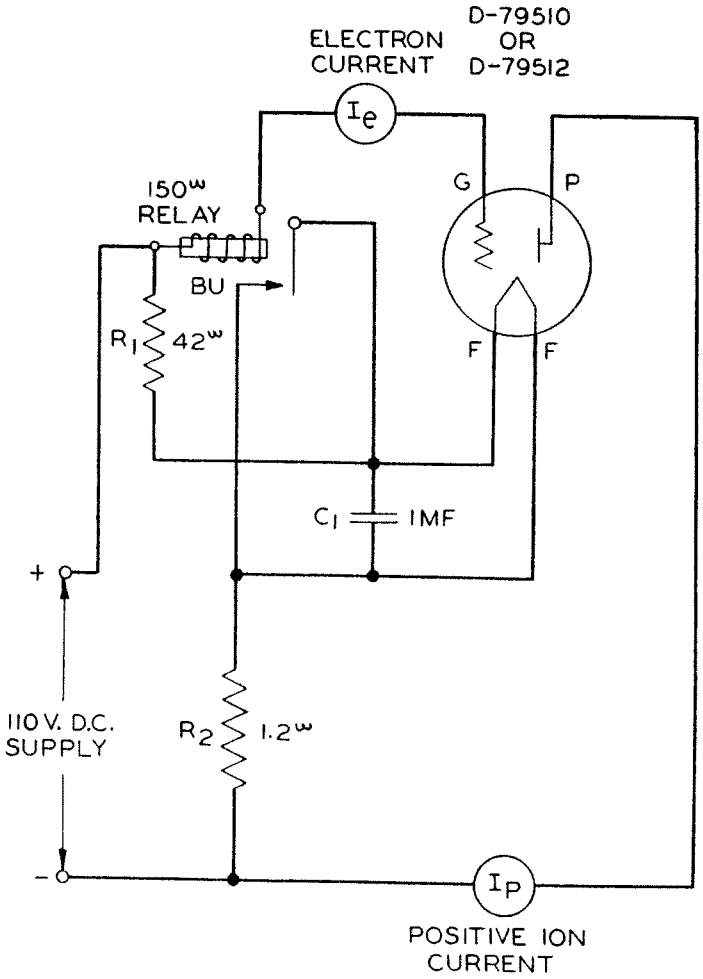
Operation

Figure 2 shows a schematic diagram of a circuit in which this type of ionization manometer operates directly from a 110 volt, d.c. supply. The value of the electron current is adjusted by means of the relay which places a low resistance shunt across the filament approximately ten times per second. With the electron current maintained at 21 milliamperes, experimental calibration shows the approximate value of the air pressure in mm. of mercury, to be five times the positive ion current in amperes, or $P = 5Ip$, approximately. For example, a current of 1 microampere to the plate corresponds to an air pressure of about 5×10^{-6} mm. of mercury.

The gauge is accurate only for pressures below 1×10^{-3} mm. of mercury. Pressures above this value should be avoided to prevent damage resulting from oxidation and the absorption of gas by the tube elements. In no case should the gauge be left in operation when the indicated pressure exceeds 1×10^{-2} mm. of mercury.

Bombardment of the Tube Prior to Operation

All the tubes are given a vacuum exhaust treatment and are sealed before they are shipped. However, during the time required to seal the manometer tube to the vacuum system, some gas will be absorbed by the bulb and electrodes. In the determination of pressures with this type of manometer, it is necessary to be sure that the positive ion current, Ip, is due solely to the ionization of the gas for which the pressure is to be determined and is not in part due to the ionization of gas evolved from the electrodes. To remove absorbed gas the following treatment should be given.



BU–BUNNELL NO. 536 COM. TEL. RELAY (150ᵂ)

CIRCUIT FOR CONTINUOUS AND AUTOMATIC OPERATION OF THE MANOMETER

FIG. 2

Seal the tube to the system to be measured and partially exhaust it. Connect the tube as shown in Figure 2. Before applying voltage safeguard the meters by shunting, since this bombardment causes abnormally high currents to flow. Block the relay armature to keep the contact open. Then apply voltage to the circuit. The filament will glow brightly due to a filament current of about 2.4 amperes. The grid will soon heat up to a dull red due to a grid current of the order of 150 milliamperes. The occluded gas driven off by this bombardment will be ionized and a blue glow will appear.

If the pressure is as low as 1×10^{-5} mm. of mercury, the blue glow will soon disappear and the discharge will be practically a pure electron discharge. The tube should be heated in this manner for about five minutes after the disappearance of the blue haze. If the blue haze does not disappear within a few minutes it is probable that the pumping system is not giving the required vacuum or that there is a leak in the apparatus. As a check on the effectiveness of the bombardment process, it is advisable to make a preliminary reading of the pressure and then to repeat the bombardment process for a short time. The pressure should then be observed again and the constancy of the indicated pressure may be taken as an indication of the reliability of the reading.

CAUTION: Starting the manometer before the system has been partially exhausted will cause oxidation of the tube elements, thereby impairing the accuracy of the measurements. The manometer should not be operated in a system containing an appreciable amount of water vapor, mercury vapor or any corrosive vapors. Whenever air has been admitted to a manometer, it is advisable to bombard the tube by the above method before using it again. When not in use the tube should be evacuated and kept sealed.

FILAMENT REACTIVATION

If the manometer tube has been left open to air and the filament has absorbed water vapor and carbon dioxide, it may not give the required 21 milliampere grid current when connected in the manometer circuit, even after the bombardment process described above. In this case it will be necessary to reactivate the filament by the following process.

When the system has been evacuated to approximately 5×10^{-4}mm. of mercury, a current of 2.5 amperes should be passed through the filament. A source of about 220 volts (a.c. or d.c.) should then be connected between the filament, and the plate and grid tied together, with a 400 ohm resistance and a meter capable of handling 600 milliamperes connected in series. If direct voltage is used, the plate and grid should be at the positive potential.

When the voltage is first applied there may be no current shown by the milliammeter, but in a short time current should increase to about 300 milliamperes and blue haze will appear. This amount of bombarding current will heat the grid and plate to a red color; and, if allowed to continue for several minutes, the blue haze should decrease until little or no haze can be observed in the tube. The tube should then be in a condition to function properly in the manometer circuit of Figure 2. This bombardment should be used only in cases when the grid current cannot be maintained as high as 21 milliamperes while connected in the manometer circuit or when a reading is wanted for low pressure such as 1×10^{-6} mm. of mercury or less. Since this process is deleterious to the filament, conditions that necessitate such severe treatment should be avoided.

A gentle heating of the manometer bulb during the early stages of bombardment will help to drive off any occluded gases. This may be done with a pale blue gas flame which has an excess of air, but care must be taken not to crack or soften the glass. The lead glass bulb should not be heated above 400° C. and the monex bulb should not be heated above 500° C.

Operation with A.C. Supply

The information herein contained covers direct current operation. However, the filament may be operated directly on alternating current and the grid and plate voltages supplied from a conventional rectifier. One method of a.c. operation is described in reference 3.

Calibration

This type of ionization manometer may be calibrated by connecting it to a vacuum system through a liquid air trap, the pressure of the system being determined by a standard mercury McLeod gauge and controlled by means of changing the height of mercury around a porous lavite cone leak, while the pump is kept in continuous operation. Since the pressure in the McLeod gauge will lag behind that in the ionization manometer, ten minutes or more should be allowed at each pressure for the system to stabilize.

Maintenance

The following paragraphs outline some of the various possible troubles which may be experienced in the use of the ionization manometer with suggestions to aid in their correction.

1. While bombarding the tube, the blue haze does not disappear within a reasonable time, ordinarily from 10 to 30 minutes:

   This is an indication that the pumping system is not operating properly or that there is a leak in the apparatus.

2. The milliammeter indicates no electron current to the grid with the filament glowing brightly:

   This is an indication that the polarity of the supply connections is reversed, that the grid lead is open, that the grid connection inside the tube is broken or that the filament is inactive.

3. The milliammeter indicates little or no electron current to the grid and the filament is a *very dull* red:

   This is an indication that the system has a very poor vacuum.

4. The microammeter in the plate circuit shows no reading while the filament glows in a normal manner and the milliammeter in the grid circuit indicates the proper electron current:

   This is an indication that the plate lead is open, that the plate connection inside the tube is broken or that the pressure is extremely low.

5. The milliammeter reads below 21 milliamperes regardless of relay adjustment, while otherwise the manometer apparently is functioning properly:

   This is an indication that a filament is inactive. In this case it will be necessary to reactivate the filament by the process outlined under "Filament Reactivation."

6. The microammeter in the plate circuit indicates positive ion current when the contact points of the relay are closed:

   This meter reading is due to leakage current in the tube or circuit. To remedy the trouble in the tube, disconnect leads from the manometer tube and burn off the conduction paths between each of the three elements with an induction spark coil.

References

1. Buckley, O. E. *Proc. Nat. Acad. of Sci.*, Vol. 2, 1916, pp 683-685.
2. Jaycox and Weinhart. *Rev. of Sci. Instr.*, Vol. 2, July 1931, pp 401-411.
3. Hoag and Smith, *Rev. of Sci. Instr.*, Vol. 7, Dec. 1936, pp 497-499.

Supersedes information in W.E. Instruction Bulletin No. 181.

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and D-79512}

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