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A BAKEABLE GLASS PIRANI GAUGE FOR MONITORING LOW VACUUM

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Abstract

A glass Pirani gauge of simple design has been made from thin diameter tungsten wire. The associated circuit has been simplified and made from indigenous components. The system is cheap, reliable and can be used in any glass system which requires baking upto about 300°C. It is in continuous use in the gas extraction system at the Stable Isotope Laboratory.

Introduction

In many applications involving vacuum systems a simple indication of pressure is very often all that is required rather than an accurate measurement of the vacuum. For example, to transfer gas from one part of the system to another; to see whether condensable gases have totally condensed when a trap is put, and to note whether baking pressure has been attained to switch on the diffusion pump, a rough indication of the vacuum is only required. In such cases, the gauge which finds wide application is the Pirani gauge.

The Pirani gauge is a thermal conductivity gauge. It is based on the approximate relation that at low pressures (below about 1 torr) the thermal conductivity of a gas is proportional to the pressure. If a resistive filament in a vacuum space is heated from a constant voltage source, the final temperature of the filament depends upon the rate at which heat is conducted away to the surroundings which in turn depends upon the thermal conductivity of the residual gas. Thus the temperature and hence the resistance of the filament depends upon the pressure of the gas in the space.

The change in resistance is not usually directly measured to determine the pressure. The filament is incorporated in the third arm of a Wheatstone bridge along with a compensating resistance in the fourth arm which is kept outside the vacuum and does not change. The change in resistance of the filament is measured by the out-of-balance current in the Wheatstone bridge and the meter reads the total pressure in nitrogen equivalent torr over the range 0.5 torr to 10^{-3} torr.

Design and construction

Pirani gauges with pyrex glass enclosures can be easily integrated in a glass vacuum system and can be made easily at a very nominal cost. Despite these advantages, glass Pirani gauges are not very common. The commercial gauges are usually enclosed in a metal envelope, which is not acceptable in some applications. For this reason we designed a simple gauge which can be easily made from the available materials.

The filament is a 25 μm dia tungsten wire which has a resistance of about 1 Ω/cm. Tungsten was chosen for its mechanical strength and high temperature coefficient of resistance (.0051). An alternative material would be platinum wire of 25 μm dia. Platinum has a higher resistance (about 2 Ω/cm) but a smaller temperature coefficient (0.0037). Two designs were tried as shown in Fig.1(a) and (b). The circuit was designed for a resistance of about 19Ω. The total length of tungsten wire required for this is about 18 cm and if used straight, can be accommodated in a 10 cm glass tube by looping it like a hair pin, see Fig. 1(a). The volume of the gauge can be made smaller by use of a spiral wire, see Fig.1(b).

The spiral was made from a straight wire as follows. A thin 1.2 mm dia copper wire (cable wire) was taken on which the tungsten wire was wound in spiral form by hand.Care shoud be taken to do it delicately as otherwise the wire will snap. The ends should be fixed by tying it or by the use of an adhesive. After winding, the wire was heated by a gas torch to dull red heat and then the copper was dissolved in nitric acid slowly to leave behind a spiral of 1.5 mm dia. This was cleaned with distilled water and alcohol and dried in an oven (at 100°C). The resulting spiral has a resistance of about 20 Ω/cm and an unstretched length of a few centimeters leading to a small gauge size. The spiral has a tendency to wind on itself and should therefore be handled gently. The wire can be either spotwelded to nickel support or simply crimped to the electrical leadthroughs. The housing of the gauge being made of pyrex glass, it can be joined to any glass system The Pirani gauges of this type are mechanically strong and can safely withstand baking cycles to a temperature of upto 300°C.

Pirani Gauge Controller

The gauge controller is very simple and is shown in in Fig. 2.

The secondary of the transformer T has an output of about 8V which is rectified and smoothed by a bridge rectifier and filter combination. This raw DC output is regulated by sampling a part of the final output voltage and comparing it with the reference voltage in the IC regulator CA3085. The output of the comparator in CA3085 drives the series transister 2N3054. Since the reference voltage in CA3085 is about 1.7V, the regulated output can be set as low as 2V. The circuit can deliver upto 300 mA. The output voltage is regulated against line and load variation to within 0.1%.

The operation of the control unit is as follows. The voltage regulator output of 2V is applied to the Wheatstone bridge formed by R1, R2, R3 and the Pirani filament. A 1 mA ammeter is connected as shown across the other ends of the bridge to measure the out-of-balance current.

With the gauge at atmospheric pressure, potentiometer P2 is adjusted until the meter reads zero. The gauge is then pumped to a vacuum of better than 10^{-4} torr. The temperature of the Pirani filament rises to an equilibrium value. The corresponding increase in the resistance of the Pirani filament will upset the balance of the bridge with the meter showing the out-of-balance current. The potentiometer P1 is now adjusted until the meter reads full scale corresponding to the low pressure limit of the gauge. The pressure in the gauge is then adjusted to intermediate values as monitored by a McClead gauge, and corresponding markings are made on the dial of the meter.

Performance

Many gauges of this simple design are in constant use in the Stable Isotope Laboratory of PRL in the vacuum system for combustion of cellulose nitrate to recover hydrogen gas for mass spectrometric analysis. They have given continuous and troublefree service.

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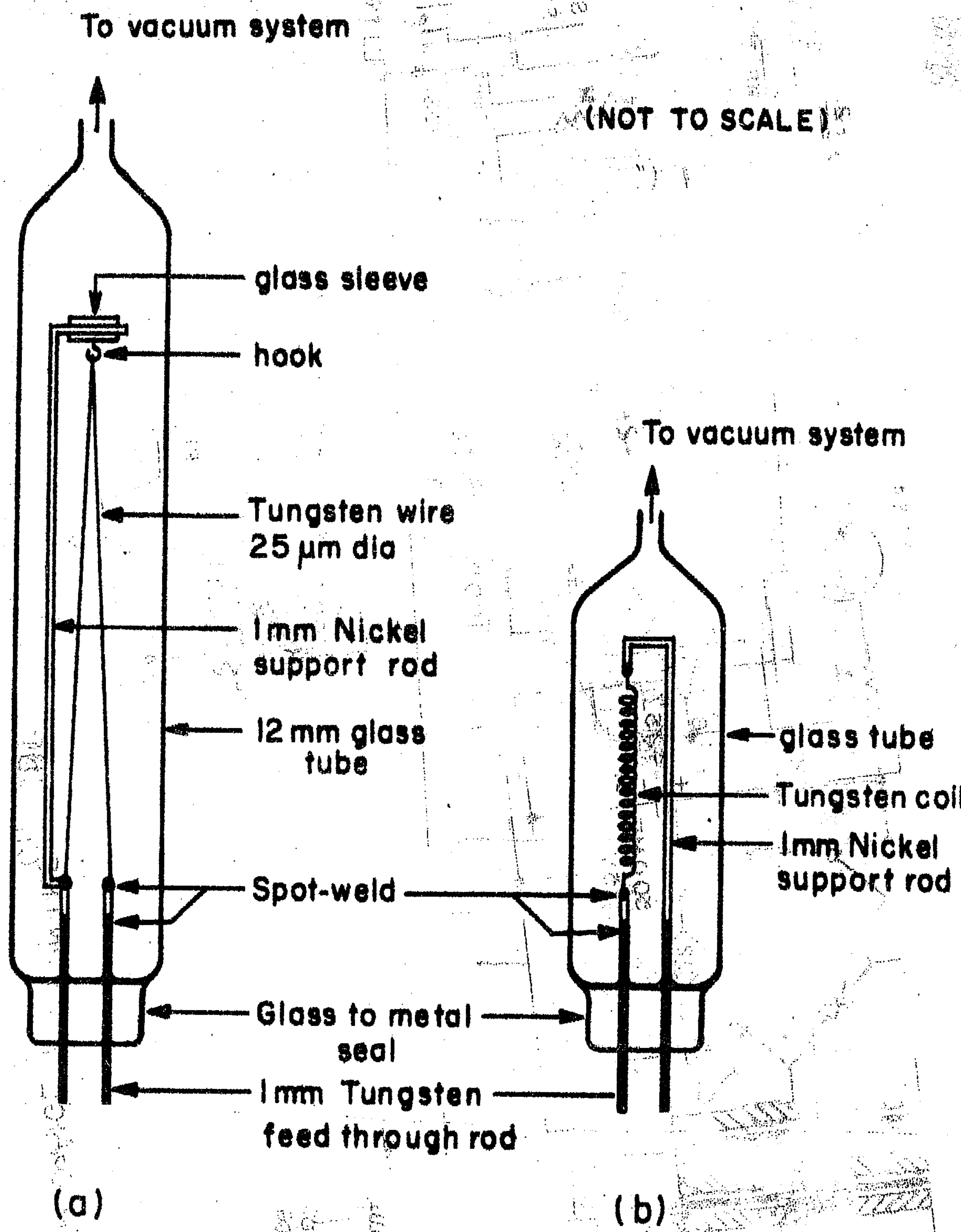

FIG. 1. PIRANI GAUGE HEADS

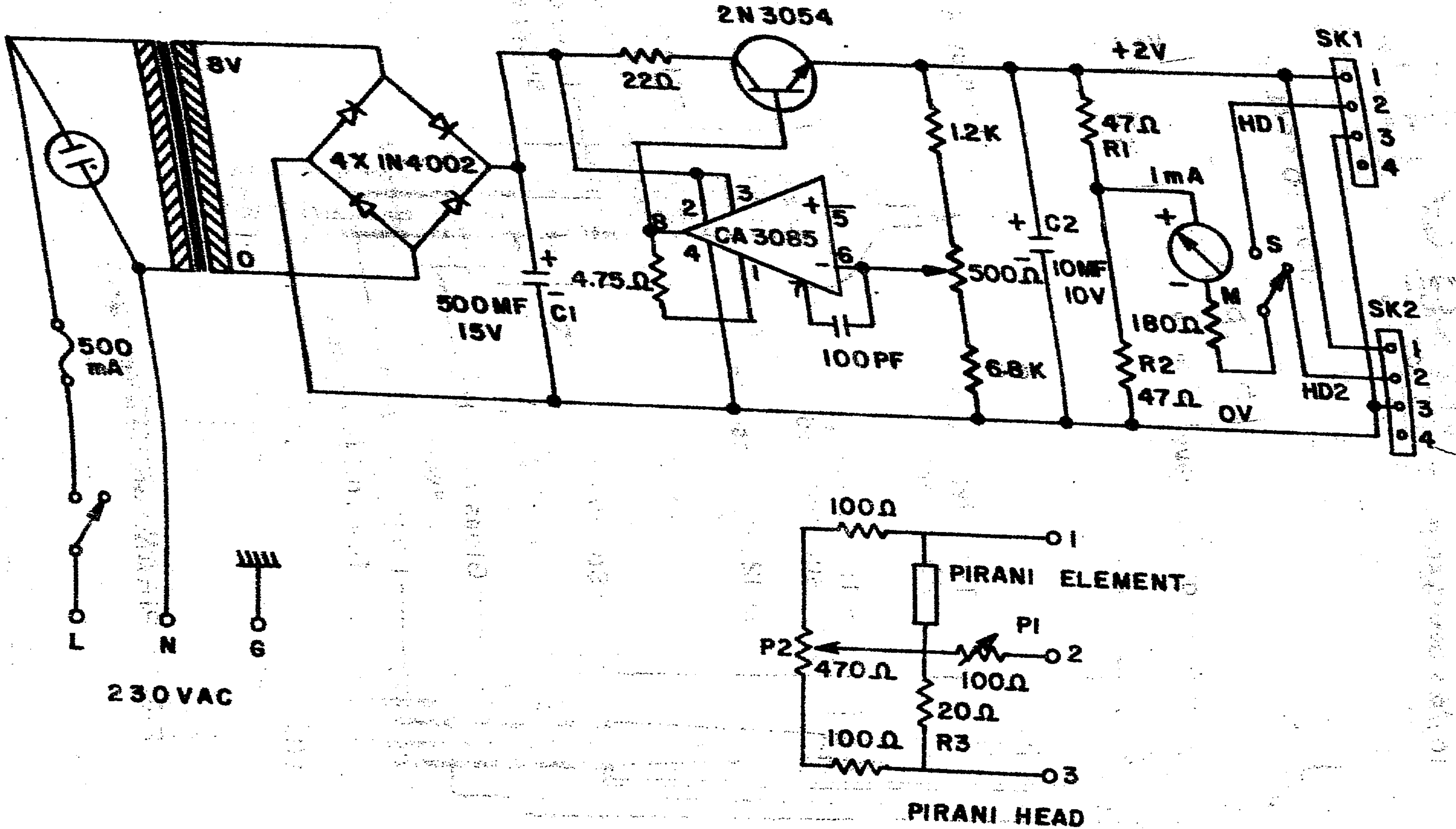

FIG. 2. PIRANI GAUGE CONTROL CIRCUIT