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Optical Servo Control for a Spoon Gauge

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A pressure gauge constructed of Pyrex glass is described which can be used for vapor pressure measurements of sulfur trioxide. The gauge automatically nulls pressure differentials across a spoon gauge by optically coupling to a servo control. Pressures up to 1 atm can be measured with an accuracy of ± 0.5 mm Hg.

INTRODUCTION

MANY ingenious pressure indicating devices have been described in the literature. Few, however, lend themselves to measurements over a wide range of pressures of corrosive vapors such as sulfur trioxide. Of the practical materials of construction only quartz and glass are inert to chemical attack by sulfur trioxide. The Bourdon tube, probably the earliest gauge constructed of quartz, cannot be constructed to give adequate sensitivity over a wide pressure range. The Bodenstein quartz spiral is more suitable from the standpoint of sensitivity but is difficult to fabricate without superior glass blowing technique. Other gauges such as the "click" gauge or vibrating quartz fiber are similarly unsuitable from the standpoint of either range or sensitivity. These types of gauges are not commercially available.

Recently Sanderson and MacWood[1] have described a spoon gauge which can be easily and inexpensively constructed from Pyrex glass tubing. This paper describes an adaptation of the spoon gauge which permits continuous measurement of vapor pressure over an extensive pressure range.

DESIGN AND CONSTRUCTION

The spoon gauge consists of an ellipsoid blown in a piece of glass tubing, indented on one side by heating to give the appearance of a spoon. In operation it is similar to the Bourdon tube in that a pressure differential across the walls of the spoon causes the gauge to distort. Sanderson[1] used a series of spoons (A as shown in Fig. 1) to increase the sensitivity of the gauge. The wall thickness governs the sensitivity, as well as the critical pressure differential, which if exceeded causes the spoon to break. Standard wall Pyrex tubing of 6 to 7 mm i.d. was found to be adequate for the construction of the spoons. Relatively little practice was required to produce a gauge consisting of four spoons which would withstand a pressure differential of about 50 mm Hg. The gauge as described here automatically compensates for pressure changes in the sample system, so that fairly rapid pressure changes can be followed.

As shown in Fig. 1, the spoon gauge A was enclosed in a housing formed from two 40/50 outer ground joints. The upper end of the spoon gauge was fused to a 40/50 inner ground joint by means of ring seal B. The lower end of the housing for the spoon gauge was closed with a second inner ground joint to which was fused the optically flat window C. A small depression G was made in the bottom of this joint. The bearing D and support E were prefabricated from cane and sealed to the wall of the joint, and aligned with the depression G. A small loop H was formed on one end of a thin shaft F, also drawn from cane, and bent at a right angle to form an arm 7–8 mm in length. The other end of the shaft was fire polished. Silicon

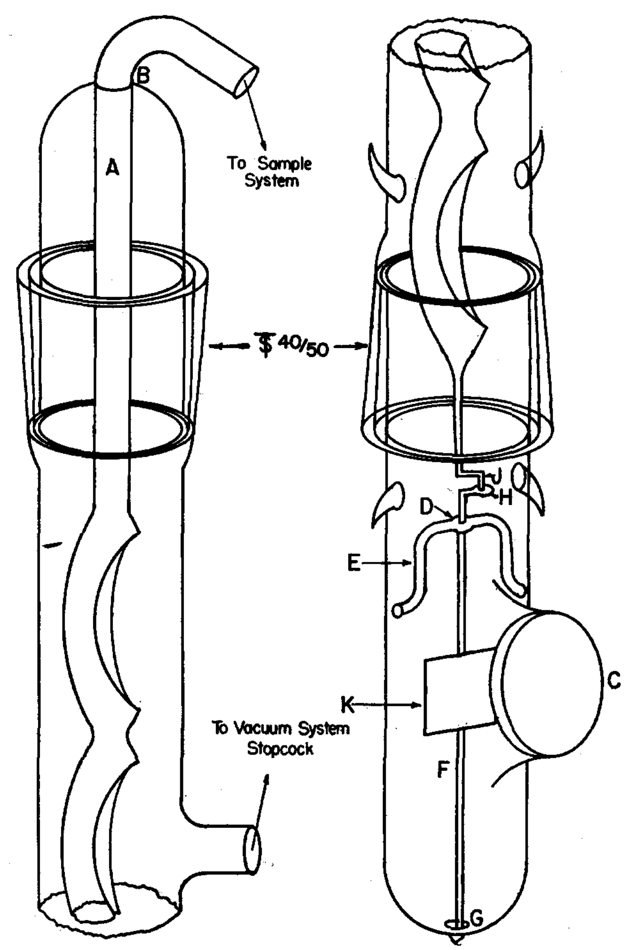

FIG. 1. Detail of spoon gauge assembly.

[1] B. S. Sanderson and G. E. MacWood, J. Phys. Chem. 60, 316 (1956).

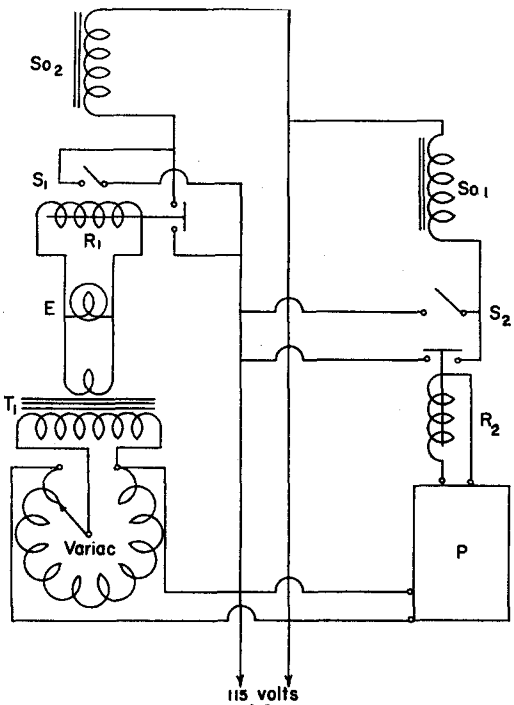

FIG. 2. Electrical schematic.

carbide and a piece of cane were used to enlarge the bearing diameter to just accept the shaft. The shaft, when mounted in the bearing D and seated in the pivot G is free to rotate. A mirror K was made by evaporating chromium onto a section of a microscope slide cover. This was cemented to the shaft in front of the window.

With the spoon gauge inserted in the upper ground joint, the pointer J protruded beyond the lower ground joint. The pointer was altered to align with the loop H and the end was rounded by fire polishing. It was fitted into the loop but not through it, when the lower section was put into place, to form a spherical ball joint. A very thin coating of Apiezon N high vacuum grease was used to obtain a vacuum seal at each ground joint. Any movement of the spoon gauge now resulted in a rotation of the mirror.

A light source, which produced a well defined rectangular beam of light, was placed 18 in. from the mirror and allowed the reflected beam to be focused on the window of a photocell unit, Springfield model K-40, mounted in the same plane and equidistant from the mirror. The photocell unit output relay (R_2 of Fig. 2) was electrically coupled to the solenoid So_1 of the normally closed valve V_1.

In the event that the lamp should fail, the control system would be evacuated which could result in breakage of the spoon gauge. As a protective device a normally open solenoid-actuated valve (V_2 of Fig. 3) was inserted in the vacuum line. A coil of relay R_1 which controls the solenoid So_2 was shunted across the lamp. The lamp, when operated at 80% of the rated input, appears as a short circuit to the relay and the relay remains open. Should the lamp fail, causing an open circuit, the relay would close, closing the valve in the vacuum line. The operating cycle is then halted at the existing pressure.

METHOD OF OPERATION

The sample whose pressure is to be measured is connected at T. All stopcocks are opened except the air throttling stopkcock Y, and the entire system is evacuated. The photocell window is covered and the light source and photocell unit are turned on. The beam should be centered on the photocell window since both sample and control systems are at the same pressure. This null position is marked as a reference. The isolation stopcock N is closed, and the seal-off P is collapsed, separating the two systems. The photocell window is uncovered, which opens the air valve V_1. The throttling stopcock Y is gradually opened until the light beam moves from the null position and the air valve closes. The vacuum pump immediately begins to remove the air, and the light beam begins to move back to the null position. By simultaneous manipulation of both throttling stopcocks Y and Z, the beam is adjusted to a swing of 5 to 6 in. and a frequency of 4 to 6 swings/min. The gauge is now ready for the measurement of pressures in the sample system. It is advisable as the pressure of the sample system changes to readjust the throttling stopcocks when the frequency reaches 30 to 40 swings/min.

Pressure readings are taken from a manometer L connected in the control system and are read to 0.5 mm. Although a slowly pulsating manometer can be read, more

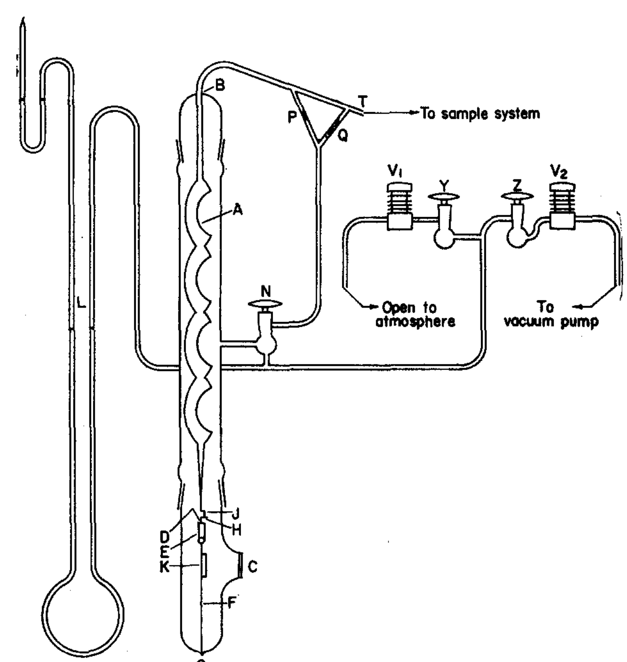

FIG. 3. Complete pressure gauge, showing manometer and control system.

accurate readings are obtained by holding the beam momentarily at the null position using the manual override switches S_1 and S_2. Re-entry into the sample system is made through the stopcock N and breakseal Q.

PERFORMANCE

The gauge described here has been operated for a period of three years. The original spoons are still in use as are the original components.

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Photo-Proton Spectrometer

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A detector system is described which can be used to observe protons in the energy range 2–10 Mev, with a discrimination factor against γ-ray background greater than 100 to 1 for γ-ray intensities less than 10^3/sec entering the scintillator. The instrumental linewidth of the detector is about 7% for 5-Mev protons.

INTRODUCTION

A PHOTO-PROTON spectrometer is needed to study certain photonuclear reactions. The investigation of these photonuclear reactions by scintillation counter techniques has long been limited by high backgrounds generally sasociated with the sources of γ rays used to produce such reactions. Since the cross sections for these reactions are small, bremsstrahlung machines capable of producing intense γ-ray beams are used to excite them. Although these machines have quite large yields in terms of roentgens per minute, the actual number of photons per second within a small energy range dE, suitable for exciting a particular state, is relatively small due to the continuous nature of the bremsstrahlung spectrum. Therefore most of the radiation goes into the production of unwanted background in the form of scattered γ rays and electrons. Another disadvantage is that the (γ,n) threshold in generally used shielding materials is often lower than the (γ,p) threshold in the material being studied, thereby producing more unwanted background in the form of neutrons and neutron-capture γ rays.

Thin scintillators, having a low response to this background, have been used to detect protons, but they have been moderately successful only in the higher energy ranges ($E_p > 10$ Mev). If the scintillator is made so thin that most of the electrons scatter out of the crystal before giving up an appreciable amount of energy, the crystal will then be too thin to stop a proton of more than a few million electron volts, and several different thicknesses of absorber must be placed in front of the crystal in order to obtain data on the energy of the proton.[1]

The basic method of approach presented here is to observe both dE/dx and the total energy of the particle entering the detector, and to accept the total energy observation only when dE/dx is greater than some predetermined value. The dE/dx observation can be made with a thin scintillator. This scintillator must be sufficiently thin to allow a very great fraction of the electrons produced by γ-ray background to be scattered out of it before giving up energy of the order of that given up by a 10-Mev proton passing through at normal incidence. This very thin scintillator is placed on top of a thicker scintillator (thick enough to stop a 10-Mev proton), whose light pulse has a very different shape in time. The sandwiching of two phosphors with different decay characteristics has been referred to as a "phoswich,"[2–4] however, this name

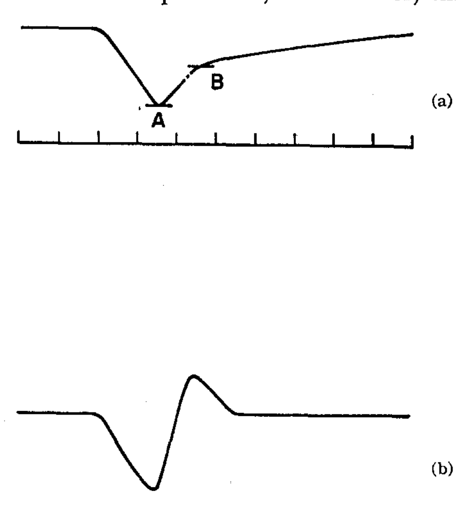

Fig. 1. (a) Sketch of the pulse at the anode due to a 4-Mev proton. The peak amplitude is approximately 1v, the time scale is 10 nsec/div (sweep speed). (b) The pulse shown in Fig. 1(a) is differentiated by a shorted stub. The time scale is the same.

[1] S. Penner and J. Leiss, Phys. Rev. **114**, 1101 (1959).

[2] D. Bodansky and S. F. Eccles, Rev. Sci. Instr. **28**, 464 (1957).
[3] A. Whetstone, *et al.*, Rev. Sci. Instr. **29**, 415 (1958).
[4] D. H. Wilkinson, Rev. Sci. Instr. **23**, 414 (1952).