

FIG. 1. Cross section of cold trap, with vacuum chamber above, and diffusion pump below. Cooling coil, internal baffles, and direction of flow of coolant are shown.

pulsating character; temperatures of about  $-70^{\circ}\text{C}$  are maintained at the baffles. The self-pumping action is thought to result as follows: (1) the acetone dissolves  $\text{CO}_2$ , (2) the  $\text{CO}_2$  is released as gas in the tubing, and (3) the pressure of the released gas pushes liquid out of the coil into the container.

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## An Automatic Liquid-Nitrogen Dispenser

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**A** PROBLEM which often arises in the laboratory is that of maintaining liquid nitrogen in vacuum system traps or other vessels over long periods of time. The device to be described accomplishes this in an especially simple manner and does not require an external source of compressed air.

It consists of a simple gas thermometer which measures the temperature at some point near the desired level of liquid nitrogen.

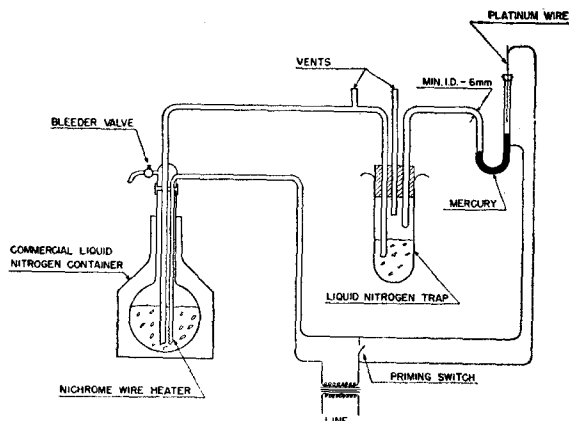


FIG. 1. Schematic diagram of liquid nitrogen dispenser.

If the level of nitrogen is below this point, the gas (air) in the thermometer expands and forces mercury to flow in a *U*-tube so that it completes an electrical circuit. This applies power (about 25 watts) to a nichrome heater at the bottom of the liquid nitrogen container. The ensuing evaporation generates gaseous nitrogen whose pressure is utilized to force liquid nitrogen through a connecting tube to the trap. As the level of liquid rises, the thermometer is cooled, the mercury flows so as to open the circuit, and the action stops.

As shown in Fig. 1, a vent should be provided in the delivery tube in such a position that the liquid nitrogen will continue past it. Its purpose is to prevent excessive bubbling of the liquid in the trap. The delivery tube must extend below the thermometer. A bleeder valve, whose adjustment is not critical, should be provided at the supply vessel to remove gaseous nitrogen generated by natural evaporation.

Only two adjustments need be made. When the dispenser is turned on, the platinum wire is pushed downwards until it contacts the mercury. After some liquid nitrogen has been introduced into the trap, the cooling will cause the mercury to break contact, but the level may be raised, if desired, by pushing the platinum wire downwards until it contacts the mercury again. The bleeder valve is set so that the liquid nitrogen does not stand above the container when the power is off, but is delivered when the power is on. The quantity of mercury in the thermometer is not critical but the *U*-tube should be sufficiently large to permit air to bubble past the mercury if necessary.

This device has functioned remarkably well in this laboratory for about 6 months and makes it possible to maintain liquid nitrogen in a vacuum system trap for about 3 days and nights, starting with a 50-liter can of liquid nitrogen. The only trouble so far experienced has been oxidation of the mercury at the point of contact with the wire. This could easily be remedied by use of a relay to control the power applied to the heater.

## On Plastic Scintillation Phosphors

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**P**LASTIC scintillation phosphors have been manufactured (1) by polymerization of scintillation phosphor-monomer liquid solutions,<sup>1,2</sup> (2) by mixing the phosphor in melted polymers,<sup>2</sup> and (3) by molding the phosphor and polystyrene-powder mixtures under heat and pressure.<sup>3</sup> We have used the first method to produce various plastic phosphors, each being a solid solution of 5 percent *p*-terphenyl, 10 percent stilbene, or 5 percent anthracene in polystyrene; the most efficient were the 5 percent *p*-terphenyl-polystyrene plastic phosphors. For these the technique used is essentially that of Koski except that for the larger masses much longer polymerization times are required as dictated by the requirements of a lower polymerization temperature. For ampoules up to  $1\frac{1}{2}$  inches in diameter the beginning polymerization temperature of the glycerine bath could be as high as  $125^{\circ}\text{C}$ , but for vials up to  $2\frac{1}{2}$  inches in diameter the bath temperature had to be reduced to  $110^{\circ}\text{C}$ . The monomer was Dow styrene N-99, used with the inhibitor not removed. Because the terphenyl increased the rate of polymerization, no catalyst was added; however,  $\frac{1}{2}$  percent tri-*o*-cresyl phosphate was added as a plasticizer.

At concentrations of terphenyl of 3 percent or more, the formation of bubbles became troublesome. Very complete dissolution by vigorous shaking during the first hours of polymerization usually eliminated this difficulty. Bubbles, entrapped in deep or long containers after polymerization had progressed slightly beyond the point where mixing was no longer possible, could usually be removed by heating the well-evacuated ampoule to about  $200^{\circ}\text{C}$  for a few hours; this produced no noticeable discoloration. Excessive heating resulted in the yellowing described

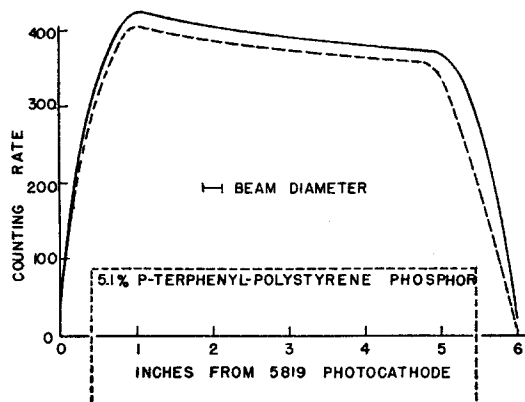


FIG. 1. Counting rate versus distance from the 5819 photocathode to the center of the incident gamma-ray beam, directed perpendicularly to the phosphor axis. The dashed curve is taken with the phosphor reversed.

by Koski. This method was not successful when applied to remove bubbles from well-polymerized plastic phosphors.

When the polymerization was about 70 to 90 percent complete, the bath temperature was raised to about 130°C and allowed to remain for 4 to 6 days. At the end of this time the temperature was lowered slowly over the course of a day to the annealing temperature (70 to 75°C) and allowed to remain for about 8 hours. Annealing was found essential for large masses of the plastic phosphor at the end of the polymerization time and after any appreciable machining. Incomplete polymerization is evidenced by a surface fogging after some months; Schorr and Farmer<sup>4</sup> report that the pulse size evidently increases with degree of polymerization.

Using this method we have produced rods up to 2½ inches in diameter and 5½ inches long; although we have not attempted to do so, presumably larger rods could be made. Our largest phosphor, weighing 650 grams, is approximately hemispherical (6 inches in diameter) with an axial hole, 1 inch in diameter.

Tests have been conducted to determine the uniformity of the phosphors and the absorption within them of the emission spectrum of the terphenyl-polystyrene system. Cs<sup>134</sup> gamma-rays were

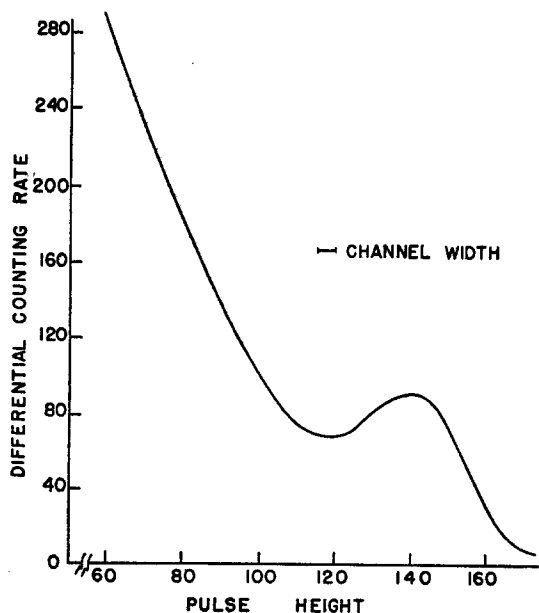


FIG. 2. Differential counting rate versus pulse height. Cs<sup>137</sup> internal conversion line as measured with a 5 percent *p*-terphenyl-polystyrene plastic scintillation phosphor on a 5819 photomultiplier tube.

collimated in a ¼-inch diameter beam perpendicularly to the axis of a cylinder of 5.1 percent *p*-terphenyl-polystyrene (1½ inches in diameter and 5½ inches long). The counting rate from a 5819 is plotted in Fig. 1 as a function of beam position along the axis; this procedure was then repeated with the ends of the plastic phosphor reversed. The identical shapes of the two curves, excluding the end regions, indicate the degree of phosphor uniformity. The fact that the two curves do not coincide is attributed to differences in light-coupling.

Koski<sup>1</sup> found slight shifts toward shorter wavelengths in the emission spectra of stilbene and anthracene when placed in phosphor-polystyrene systems. The emission spectrum of terphenyl is reported as 3900, 4050, and 4300Å, and one might assume the spectrum of a terphenyl-polystyrene system also to be somewhat shifted toward shorter wavelengths. Canada balsam in xylol has absorption coefficients of 6.7 per cm at 3900Å and 4.8 per cm at 4200Å. Mineral oil, on the other hand, is transparent in at least the range 3840 to 6000Å. Therefore, mineral oil (or silicone fluid for vacuum applications) is used between the plastic phosphor and the 5819, with a sodium silicate and Canada balsam seal around the edge.

Numerical efficiencies as determined by coincidence measurements of 23 to 28 percent for Co<sup>60</sup> gamma-rays and of 15 to 25 percent for Na<sup>22</sup> annihilation quanta for a 4-cm length of the phosphor are usual, depending somewhat on the sensitivity of the 5819.

The linearity of the response of a 5 percent *p*-terphenyl-polystyrene plastic phosphor on a 5819 to incident beta-energy has been examined by using Cs<sup>137</sup> betas (4π solid angle). The pulse-height distribution of the conversion line and gamma-rays as analyzed with a differential pulse-height discriminator is shown in Fig. 2.

<sup>1</sup> W. S. Koski, Phys. Rev. **82**, 230 (1951).

<sup>2</sup> M. G. Schorr and F. L. Torney, Phys. Rev. **80**, 474 (1950).

<sup>3</sup> J. L. Horwood and G. G. Eichholz, Phys. Rev. **83**, 886A (1951), and private communication.

<sup>4</sup> M. G. Schorr and E. C. Farmer, Phys. Rev. **81**, 891 (1951).

## A Precise Gas Manometer

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CONSTRUCTED for use with a gas interferometer at the Chemistry Department, University of Michigan, this manometer had to be reliable one decimal beyond the readings of the interferometer itself, in which, when working with air, a shift of 550 fringes was observed for a drop of the Hg column by 770 mm. Since the position of the fringes could be determined to  $\pm 0.03$  of their breadth, the required manometer precision was 0.004 mm Hg. Existing manometers, e.g., the McLeod, the differential manometers, or the ionization conductance manometers, detect pressures as low as  $10^{-6}$  or even  $10^{-8}$  mm Hg. However, none of them can be operated over the range of 770 mm. For the classical Hg column manometers, on the other hand, even for those equipped with telescopes and micrometers, the precision of 0.004 mm is not accessible. The problem can be solved relatively simply if, instead of determining pressures corresponding to counted numbers of fringes, one counts the number of fringes for given changes of pressures.

Figure 1 represents an apparatus in which a Hg column will close an electric circuit when it touches the end points of two rods. If the amount of Hg is adjusted to fill out exactly the space between the points of contact, the circuit will close only when the gas pressure equals  $D$  mm Hg. The accuracy of this instrument depends on the precise control of four factors: 1. Exact measurement of distance  $D$ , determined before introducing the rods into the manometer tubes. It was  $772.360 \pm 0.001$  mm at 23°C (Professor O. Boston, Engineering Department, University of