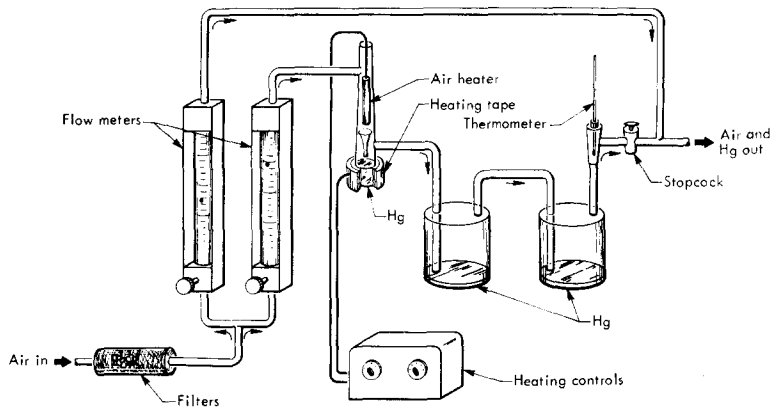

FIG. 1. Schematic view of calibration apparatus.

should not be handled and should be placed as far as possible from any of the heating equipment.

Concentrations in parts per million (ppm) by volume of the saturated air stream can be calculated from the following expressions:

$$C_{\text{ppm}} = \frac{(p_{\text{Hg}})(10^6)}{(P_A - p_{\text{Hg}})} = (w/V)\frac{(v_{\text{STP}})(T_m/T_{273})(P_{760}/P_A)}{(M_{\text{Hg}})}, \quad (1)$$

where C_{ppm} is the concentration by volume (ppm), p_{Hg} is the vapor pressure of mercury at T_m (Torr), w/V is the weight of mercury per unit volume of air (μg/liter, mg/m^3), T_m is the measured temperature of air saturated with mercury (K), T_{273} is the temperature of standard air (273 K), P_A is the atmospheric pressure (Torr), P_{760} is the pressure of standard air (760 Torr), v_{STP} is the volume occupied by 1 mole of air at 273 K and 760 Torr (22.4 liters/mole), and M_{Hg} is the molecular weight of mercury (200.6 g/mole).

Substituting in the known values, making the approximation that $P_A - p_{\text{Hg}} \approx P_A$ (because $P_A \gg p_{\text{Hg}}$), and solving for the concentration in mg/m^3, Eq. (1) reduces to

$$C_{\text{mg/m}^3} = \frac{(p_{\text{Hg}})(200.6\ \text{g/mole})(10^6)}{(P_A)(22.4\ \text{liters/mole})(T_m/273\ \text{K})(760\ \text{mm}/P_A)} = \frac{(p_{\text{Hg}})(3.22)(10^6)}{(T_m)}. \quad (2)$$

When air dilutes the saturated mercury vapor, Eq. (2) becomes

$$C_{\text{mg/m}^3} = \left[\frac{(V_{\text{Hg}})}{(V_{\text{Hg}} + V_A)}\right]\left[\frac{(p_{\text{Hg}})(3.22)(10^6)}{(T_m)}\right], \quad (3)$$

where V_{Hg} is the flow rate of air saturated with mercury (liters/min), and V_A is the flow rate of dilution air (liters/min).

The mercury vapor generator occupies only about $\frac{1}{10}$ m^2 of bench space and yields concentrations from 0.011 to 2.5 mg/m^3 at flow rates of 6 liters/min or greater. Other concentration ranges can be achieved if different flowmeters are substituted for the ones suggested. Concentration changes are made simply and easily by adjusting the needle valves. Equilibrium is reached almost instantaneously since there is no large mixing flask to equilibrate.

The author gratefully acknowledges the assistance of William A. Aceves and Emil Erbin in instrument construction and Harry F. Green and Melvin O. Bishop for their work in fabrication of the glass apparatus.

* Work performed under the auspices of the U. S. Atomic Energy Commission.

[1] "Syllabus for Short Courses for Industrial Hygiene Engineers and Chemists," Division of Occupational Health, U. S. P, H. S., Public Health Service Publication No. 614, D-9, Government Printing Office, Washington, D. C., 1958.

[2] G. O. Nelson, W. Van Sandt, and P. E. Barry, Amer. Ind. Hyg. Assoc. J. **26**, 388 (1965).

[3] P. Young, Analytical Systems Co., Pasadena, Calif. (private communications).

Time-of-Flight Test of a Slotted Disk Velocity Selector*

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THE performance of a slotted disk velocity selector[1] is usually checked by using it to measure the distribution of velocities in a beam of known chemical composition effusing from a source maintained at a known temperature. Agreement between such a measurement and the predicted (modified Maxwellian) distribution is then interpreted as evidence both for good construction of the selector and for its adequate alignment in the beam path. However, this procedure is neither a sensitive test for the absence of sideband transmission, nor does it directly confirm the design passband structure.

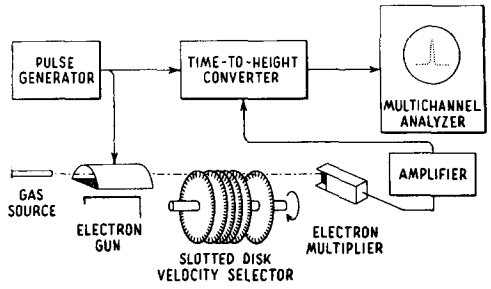

FIG. 1. Schematic diagram of the apparatus used for testing a slotted disk velocity selector by time-of-flight techniques.

We describe here, briefly, a method of testing the calibration and transmission characteristics of a high resolution velocity selector by time-of-flight analysis[2] of a pulsed beam of metastable atoms which was at the same time mechanically chopped by the velocity selector. The method is illustrated in Fig. 1.

A beam of ground state neon atoms was passed through a pulsed electron gun, and those atoms which were first metastabilized and subsequently transmitted by the velocity selector were detected with a windowless electron multiplier.[3] The prompt output pulses caused by the de-excitation of metastable atoms at the multiplier cathode were translated into a time-of-flight spectrum by a time-to-amplitude converter and a multichannel analyzer. Two spectra, obtained with and without the velocity selector in action, are shown in Fig. 2.

We observed the spectra of 14 velocity selected beams over the interval between 400 and 1100 m/sec. In each case the nominal transmission velocities computed from the design parameters of the selector agreed to better than 1% with the mean velocities determined from the corresponding time-of-flight spectra. We thus have an entirely independent check on the previous, more conventional calibration of our instrument. In addition, we are confident that there is no significant sideband transmission. We were also able to verify the design passband of the selector by analyzing the relative count rates of the time-of-flight channels which contributed to the various velocity selected spectra.

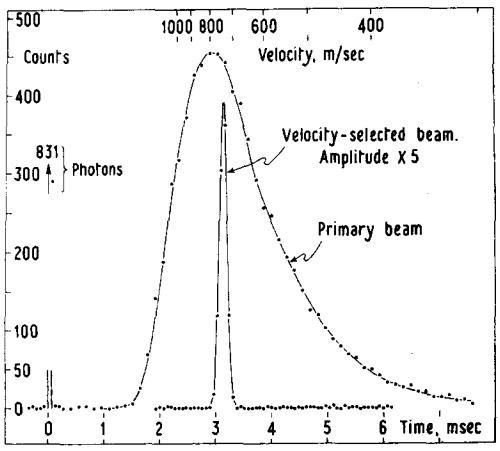

FIG. 2. Time-of-flight spectra of metastable neon atoms in a 2.3 m long molecular beam apparatus. The neon effuses from a source somewhat above room temperature. The gun pulse and channel widths were both 70 μsec and the pulse repetition rate was 100 Hz.

* Supported by the U. S. Atomic Energy Commission.

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[1] The design and performance of a modern slotted disk velocity selector are described by A. E. Grosser, Rev. Sci. Instrum. **38**, 257 (1967), who also gives references to much previous work. Our selector is very like that described by H. U. Hostettler and R. B. Bernstein, Rev. Sci. Instrum. **31**, 872 (1960).

[2] See, for example, J. B. French and J. W. Locke, in *Rarified Gas Dynamics*, C. L. Brundin, Ed. (Academic Press, Inc., New York, 1967), pp. 1461 ff.; and R. S. Freund and W. Klemperer, J. Chem. Phys. **47**, 2897 (1967).

[3] Model 306 magnetic electronic (strip) multiplier, Bendix Corp.

Wide-Range Controlled-Temperature Direct-Introduction Probe for Mass Spectrometer Samples*

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COMMERCIALLY available systems for the direct introduction and evaporation of a sample in the ion source of a mass spectrometer are not suited to highly volatile samples such as those usually isolated in gas chromatographic separation of mixtures. The sample temperature is uncertain, is affected by the ion source temperature, and cannot be decreased rapidly below ambient values.

A direct introduction probe which could be cooled was described by Haddon and co-workers[1] and found by them suitable for use with highly volatile or thermally unstable samples. In this laboratory, however, their design proved inconvenient because the vacuum seal through which the probe slid was unreliable when the probe was cold. Also, there was an uncertain and often large difference between the monitored probe temperature and the resulting sample temperature, apparently because of inefficient heat transfer.

A probe which can be cooled or heated and is free from the above mentioned disadvantages is shown in Fig. 1. This probe is compatible with the 21-086 direct sample introduction system available for use with the Bell & Howell/CEC 21-110B mass spectrometer. Nitrogen or helium chilled by passage through a heat exchanger (not shown) cooled by liquid nitrogen is supplied to the probe assembly.