electrometer as a detector, an ion current of 1.6×10^{-13} A can be measured into a solid angle of 2.2×10^{-4} sr for a source pressure of 2.7×10^{-5} Torr, an ion energy of 100 eV, an energy bandpass of 4 V, and a source electron current of 1 mA. Under identical conditions, a Bendix M-306 electron multiplier, used as an ion detector, yielded an ion count of 242 000 /sec. Thus, for this particular instance, the counting efficiency was 24%. For the Bendix detector, which has a dark current of less than one count/sec, this source allows the calibration of the current gain vs dynode voltages over a range of 10^5.

The broad energy spectrum output makes it possible to calibrate a tandem crossed-field velocity analyzer and an electrostatic energy analyzer under conditions corresponding to an actual plasma situation. Figure 3 shows the result of sweeping the voltage on the **E × B** velocity analyzer for a fixed ion energy. In addition to calibrating charge-to-mass ratios vs deflection plate voltage, the results yield the line shapes and instrument resolution. For this figure, the source was fed with a mixture of H_2, He, Ne, and Ar gases and the source pressure was about 2×10^{-5} Torr. The residual vacuum background spectrum is evident in the H_2O^+ and CO^+ lines. On Fig. 3, the strong H_2O^+ line masks the Ne^+ line.

This source has been successfully operated for ion energies as high as 3000 V. In the present instance there was no experimental requirement to test the device at higher voltages. Even with the simple pumping arrangement shown on Fig. 1, which used a 100 liter/sec diffusion pump, pressure in the test apparatus could be maintained below 10^{-5} Torr for a source pressure of 10^{-4} Torr.

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An Externally Triggered Relief Valve for High Temperatures and Pressures of Moderate Duration

P. M. Sherman and Pai Lien Lu

The University of Michigan, Ann Arbor, Michigan 48104

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In many systems employing high pressure burning or arc heating of gases, conditions need only be maintained for a fraction of a second, the time needed to make the measurements desired. It is therefore advantageous and often necessary to release the hot gas from the containing vessel quickly (after a given delay for measurement) before the vessel has time to heat up and become damaged. One way to accomplish this is with a timed externally triggered quick exhaust valve. A convenient and inexpensive design is one in which a double diaphragm system is used with the diaphragms separated by a solid section, which houses an ordinary electric blasting cap (see Fig. 1). The blasting cap is employed to rupture the outer diaphragm. The second diaphragm in the inner region is then ruptured by the pressure in the chamber. The two diaphragms combined this way act as one of a thickness equal to the two together. The thickness of the outer diaphragm which can easily be ruptured by the cap is designed to withstand considerably more than one-half the maximum chamber pressure itself. The second diaphragm can be thinner than that required to withstand one-half the chamber pressure so that there is surety of the diaphragm rupture and quick exhaust. The outer diaphragm should be scribed for clean breakage. The cap is placed in the mounting in an upside-down position so that it more effectively blows outward with the direction of the exhaust. For lower pressures a very thin inner diaphragm may be used.

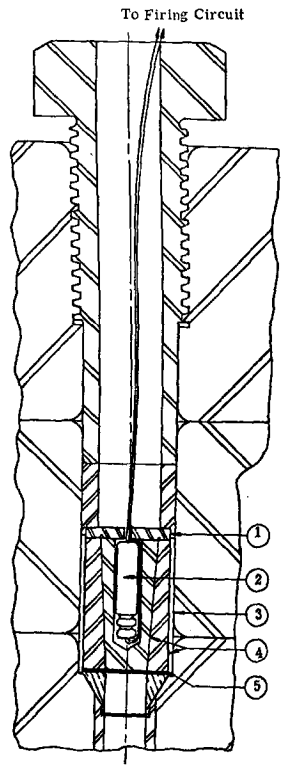

FIG. 1. Valve configuration. 1—Outer diaphragm (4340 R_c 30 steel); 2—No. 6 blasting cap; 3—1½ mm paper wrapping; 4— valve assembly (4340 R_c 30 steel) (taper~3½°, 3.81 cm long); 5—inner diaphragm (exposed to chamber gas).

This design has been used successfully over an extended period of time for pressures of 150–1500 atm at temperatures up to 5000 K. The exhaust was taken through a 15 cm diam pipe extended through the roof of the building with a deflecting plate and sand box to catch the exhaust debris.

It should be noted that while we have been using the No. 6 blasting cap for several years without accident, there is a safety hazard in such caps. A safer detonator can be employed. Exploding bridgewire caps are safer than the blasting cap and a number of safe caps are now com-

mercially available. The double diaphragm "tied together" by a solid detonator housing arrangement described here can be used with different detonators and in different valve sizes. In each case the thickness of the outer diaphragm would have to be checked for that easily ruptured by the detonator. Once this was determined, the design should be usable repeatably. For the design shown, the outer diaphragm (Fig. 1) was 2.59 mm thick with a 45° groove 19.05 mm in diameter, 0.508 mm deep. The hole at the center of the diaphragm for the detonator leads was made with a No. 44 drill.

Use of the ^{3}He Melting Curve for Low Temperature Thermometry*

R. A. Scribner† and E. D. Adams

Physics Department, University of Florida, Gainesville, Florida 32601

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In this note we describe in more detail a technique which was briefly mentioned in previous work[1] and in which substantial interest has been shown. Briefly stated, it was proposed that the melting pressure of pure ^{3}He could be used as a secondary thermometer to extend and improve cablibrations of cerium magnesium nitrate[2] (CMN) or nuclear magnetic resonance[3] (NMR) absolute thermometers. In recent ^{3}He melting curve measurements[1] extending below 0.02 K, the absolute temperature accuracy is 1–2% over the range from 0.7 to 0.04 K. Further measurements will no doubt extend the range[4] and improve the accuracy. The real merit of such a thermometer is its inherent sensitivity in the range below ~0.25 K (as well as in the range above 0.35 K) and its ease of calibration. Furthermore, there are the additional advantages[1,5] of easy sample density determination and simultaneous pressure measurement that are gained by incorporation of an *in situ* pressure gauge into experiments on bulk properties of ^{3}He and mixtures of ^{3}He and ^{4}He.

Calibration of CMN or NMR thermometers is generally against ^{3}He and ^{4}He vapor pressures in the region above ~0.4 K. Because of poor signal-to-noise conditions at these temperatures or limitations in the amount of material, the accuracy of the calibration may be low. Use of the ^{3}He melting curve for calibration in the region down to a few hundredths of a degree would improve the calibration accuracy. As is apparent in Fig. 1, the region of the melting curve above the minimum would be useful for checking the vapor pressure calibration and the low temperature region would be useful for extending and improving the calibration.

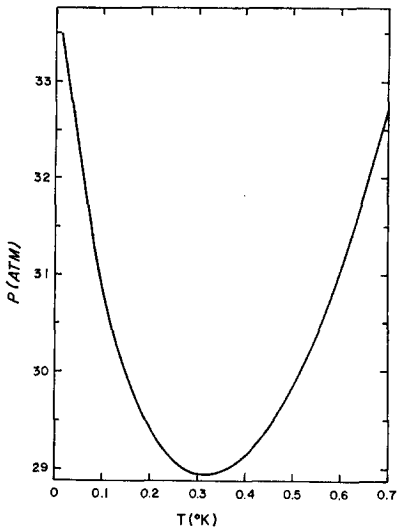

Fig. 1. The melting curve of pure ^{3}He below 0.7 K.

A capacitive pressure gauge can be constructed[1,5] to easily provide most of the desirable features of a secondary thermometer for very low temperature use. These features are (a) good sensitivity, (b) ease of calibration and measurement, (c) little heat input during measurement, (d) low heat capacity, and (e) small physical size. In addition, it is desirable that the thermal connection to the sample can be easily made. Here it should be kept in mind that a pressure gauge may be a separate entity in an experimental arrangement or it may be an integral part of the sample system.

Sensitivity of better than 1 μK may be obtained below 0.25 K. The magnitude of the melting curve slope at 0.25 K is about 4.0 atm/K and increases rapidly, as seen in Fig. 1, to about 40 atm/K at 0.02 K. Although the melting curve has an inflection point at ~7 mK, the magnitude of the slope should still be about 40 atm/K down to 2.5 mK.[1] Thus, with a pressure gauge sensitivity of 2×10^{-6} atm (see Ref. 5), a temperature resolution of better than 10^{-6} to 10^{-7} K may be obtained between 250 and 2.5 mK. Construction of less refined gauges permitting resolution of 10^{-4} to 10^{-5} K should present no problem.

On first consideration, it might be thought that the technique would require extensive equipment and an elaborate gas pressure system. However, this is not necessarily the case. The pressure system may be of the simple U-tube type[1] or it may employ, instead, an adsorbent bomb. Here, we are assuming that the primary use of melting curve thermometry would be in experiments on compressed ^{3}He so that most of the necessary equipment would be on hand already.

Calibration of the gauge is quite easy, involving only a few measurements of capacitance vs pressure over the range from ~29 to ~34 atm. In order to circumvent the need for highly accurate absolute calibration of the gauge, pressures may be measured relative to the melting curve