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Berkeley, California

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VACUUM MEASUREMENT TECHNIQUES
II. SECONDARY MICROTORR PRESSURE STANDARDS*

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Rothe has recently described how to avoid erroneous pressure readings in the μtorr range by the use of a refrigerated McLeod gauge.[1] While the McLeod gauge will probably remain as the primary pressure standard in this vacuum region for a considerable time, there is another device available for the accurate measurement of pressures between 0.05 and 35 mtorr: the electrostatically calibrated diaphragm micromanometer. Although the electrostatic-calibration technique is not new, recent advances in commercial electronics instrumentation and in the design of pressure transducers make it an increasingly desirable method.

There are several reasons why this calibration technique should be used: (a) once the electrostatic constant is known, it is simple to perform and can be done <u>in situ</u> without the use of special valves or tubing or an auxiliary McLeod gauge; (b) since it is applied directly at the transducer, it eliminates changes in the diaphragm tension, bridge constant, amplification factor, detector operation, or recorder calibration; (c) the linearity and accuracy for closed-loop, open-loop, or manual-null operation can be better than ± 0.5% and ± 2%, respectively; and (d) the electrostatic constant does not change in magnitude unless the diaphragm is physically deformed or the electrode-to-diaphragm spacing is changed; nonconducting dust particles or condensed vapors have little effect on its magnitude.

Any commercial differential micromanometer can be modified to permit electrostatic calibration by the addition of a low-impedance series capacitor in each of the lower bridge arms. The constant K in the simplified formula $\Delta P = K V^2$ is determined to ± 2% or better for each side of the transducer by a comparison between a known differential pressure (as measured with an accurate McLeod gauge) and a voltage of known magnitude. The results are linearly extrapolated to lower differential pressures. This process converts any commercial capacitive differential micromanometer into an excellent secondary pressure standard.

As an example, the nonlinear electrostatic calibration technique was used successfully with a homemade differential micromanometer (operated open loop) capable of measuring pressures between 0.05 and 35 mtorr.[2,3] After the electrostatic constants for the pressure transducer were determined to ± 2%, the system was calibrated daily by the stepwise application of a series of known voltages (Fig. 1). A plot of the recorder reading vs the square of the voltages gave the calibration curve (Figs. 2 and 3), which usually remained constant to better than ± 1% over an eight-hour interval and ± 5% over a month interval, providing that neither the electronics nor the transducer were disturbed. These two figures depended upon the stability of the amplifier and detector and not on the electrostatic calibration method.

The upper range of the electrostatic calibration technique can be extended to higher pressures in two ways: (a) coat the fixed electrodes and the diaphragm with an insulating layer to eliminate the possibility of electrical breakdown between the two surfaces and permit the use of higher voltages; (b) use larger fixed-electrode areas, smaller electrode-to-diaphragm spacings, and somewhat stiffer diaphragms. In this way, it should be possible to calibrate a transducer electrostatically to ± 2% accuracy or better, from 50 μtorr to 5 torr—a range of 10^5! This electrostatic technique may eventually supersede the McLeod gauge as the primary pressure standard in the μtorr region.

FOOTNOTES AND REFERENCES

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1. Erhard W. Rothe, J. Vac. Sci. Tech. 1, 66 (1964).
2. Kenneth W. Lamers, Lawrence Radiation Laboratory Report UCRL-11218, Pt. I, October 1964 (unpublished).
3. Peter R. Rony, Lawrence Radiation Laboratory Report UCRL-11218, Pt. II, April 1965 (unpublished).

FIGURE CAPTIONS

Fig. 1. Sample recorder calibration curves. Curves (a), (b), and (c) were made with different signal-attenuation settings within the amplifier.

Fig. 2. Computed calibration curve corresponding to curve (a) in Fig. 1.

Fig. 3. Computed calibration curve corresponding to curve (c) in Fig. 1.

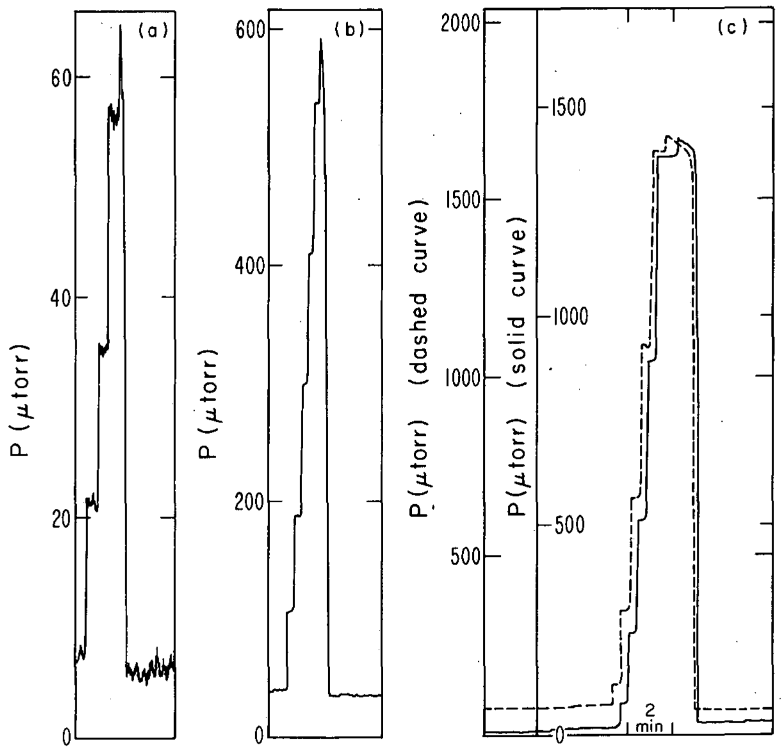

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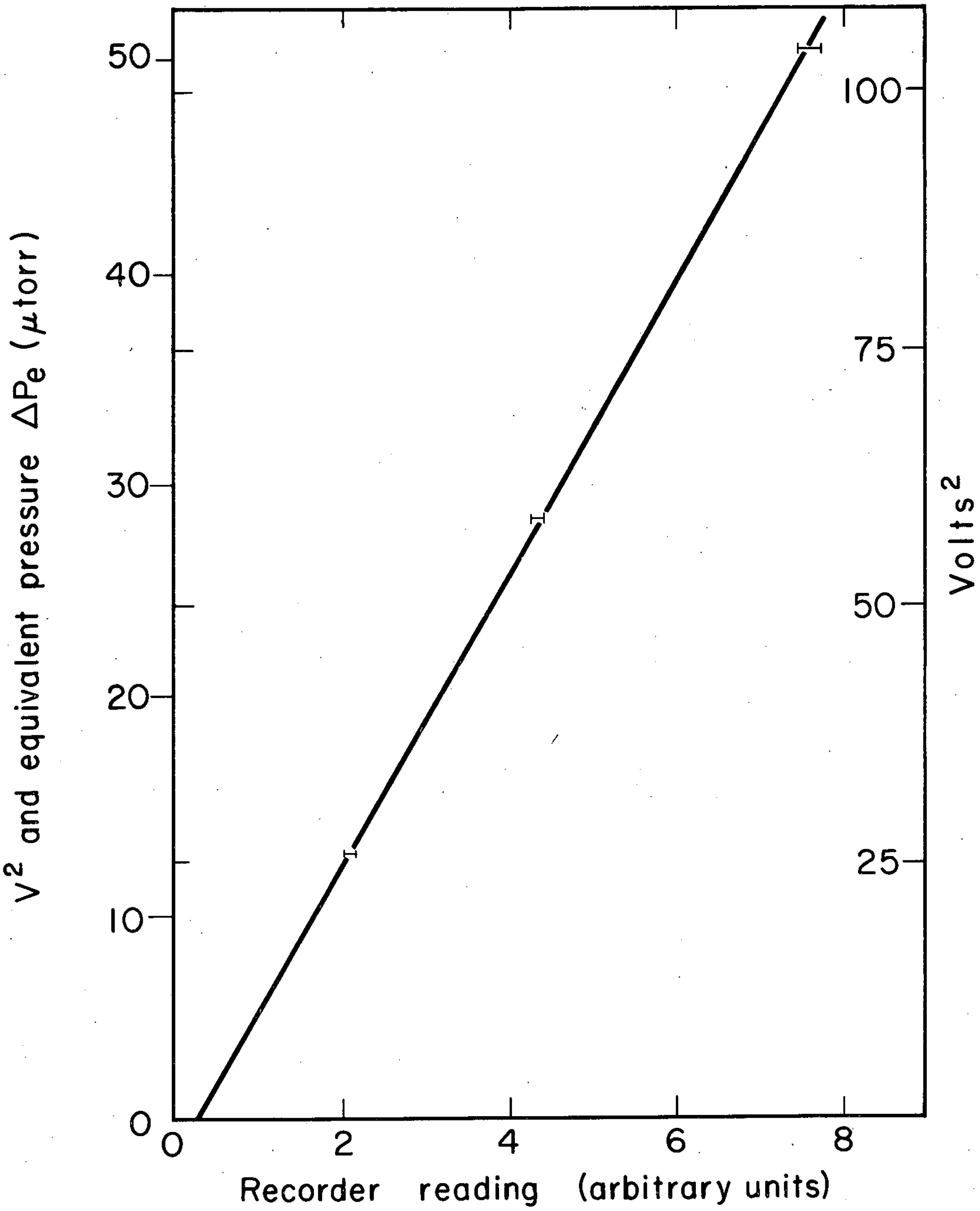
Fig. 1



MUB-4668-A

Fig. 2

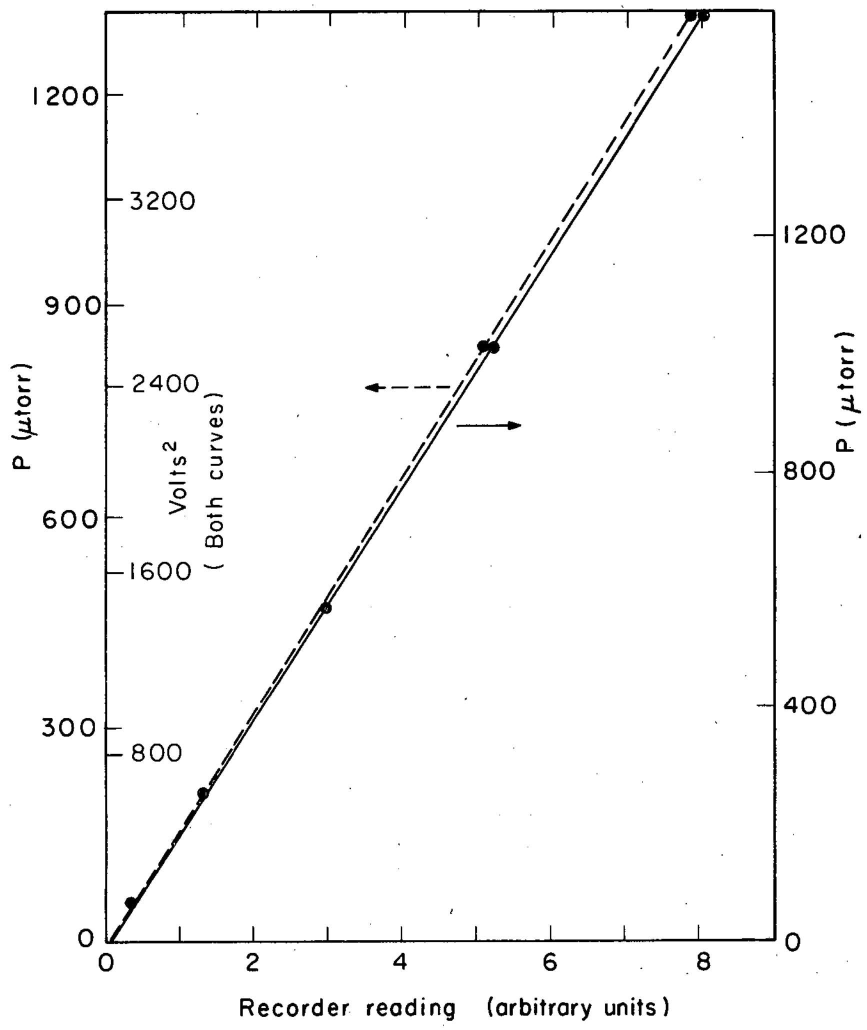


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Fig. 3