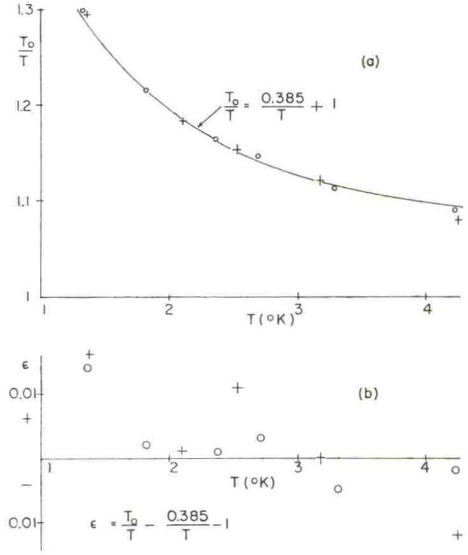

FIG. 3. (*a*) The experimental results at helium temperatures. T_0 is the noise temperature calculated from equation (5) and T the temperature determined from the 1958 helium vapor pressure scale.

(*b*) The deviation ϵ of T_0/T from the equation $A/T+1$ with $A = 0.385°$ K. ○ represents measurements with an integration time of 90 seconds and + with 67.5 seconds.

ment $I_1+I_2+I_3 = 3.7\times10^{-9}$ amperes. The measured grid current $I_1-(I_2+I_3)$ was approximately 2.6×10^{-9} amperes, which shows that shot noise due to the grid current is the main limitation of the thermometer. At 15 kc/s R_g was measured to be larger than 10^7 ohms, and because the noise temperature $T_g = \alpha T_1$ of R_g is unknown the contribution due to the second term is uncertain. If I_2 and I_3 are neglected compared with I_1 then one can conclude that $R_g/\alpha \simeq 47\times10^6$ ohms.

At helium temperatures equation (4*b*) applies, and over this temperature range a systematic error in adjusting τ_1 gives a fractional error in the noise–temperature which is essentially a constant. This means that b in the equation (9) is not unity. If $\tau_0\tau_2/\tau_1^2 = \text{constant} < 1$ for all the measured points between 1.3° K and 4.2° K, the curve in Fig. 3(*a*) will shift down.

In general it will be necessary to measure two known temperatures to calibrate a thermometer of the above kind. These measurements will determine A and b and when T_0 is measured the absolute temperature, T, can be calculated. However, if one is certain that no systematic error is made in balancing the τ's, or if $(\omega\tau_i)^2$ can be neglected with respect to unity then $b = 1$, and only one known temperature is necessary to calibrate the thermometer. Figure 3(*b*) shows the deviation ϵ of T_0/T from the equation $(A/T)+1$ with $A = 0.385°$ K plotted as a function of T. The calibrated thermometer measures temperatures accurately within ±1% between 1.3° K and 4.2° K.

This experiment makes use of the correlation of voltages from three independent noise sources at different temperatures to determine the temperature of one (or two) noise sources. This method has the advantage that it eliminates any switching device at the input of the amplifier. The requirements of this method are that for good absolute accuracy of the thermometer the amplifiers, the multiplier, and the integrator must be linear and that $T_1 > (T_0 + T_2)$. At present the main limitation of the absolute accuracy at low temperatures is shot noise generated at the grids of the first stages of the amplifiers. In principle, this method can also be used to measure high temperatures. R_1 could be a fixed resistor at the unknown temperature, and R_0 and R_2 could be kept at room temperature and one or preferably both of them be variable. At high temperatures errors due to shot noise can be neglected. When Z_1 is made infinite and R_0 and R_2 are replaced by two antennas which are located apart from each other, then one has in principle a radio interferometer of the kind developed by Brown and Twiss (1954).

In this experiment it was demonstrated that it is possible and feasible to measure low temperatures absolutely by making use of the thermal fluctuations of voltage across an impedance. Work will continue at this university to improve the accuracy of the noise thermometer, and to derive an absolute temperature scale in the liquid helium region.

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