

secondary galvanometer deflection, making it possible to resolve  $10^{-8}$  v. The sample current was 3 amp. The magnet was of laboratory design, with 7-in. pole pieces and a 2-in. gap. After initial checks on the linearity of Hall voltage vs magnetic field, all measurements were made by reversing a fixed field of 6310 gauss.

The samples were placed in a beryllium-copper bomb, which was connected by  $\frac{1}{8}$ -in. flexible stainless steel tubing to the piston and cylinder arrangement used to generate the pressure. The bomb has been described in detail elsewhere.<sup>14</sup> The electrical leads were brought out through a four terminal plug of beryllium copper. The pressure was determined by measuring the change of resistance of a manganin bridge which was calibrated by assuming the freezing pressure of Hg at  $0^{\circ}\text{C}$  to be  $7640\text{ kg/cm}^2$ . Pentane was used as the pressure transmitting fluid.

Sample preparation and handling presented some difficulty, since the alkali metals are highly reactive. The usual technique for making and preserving alkali metal samples for electrical measurements is to freeze the metal in glass capillaries or ampules. This is not suitable for measurements under pressure because the contraction of the glass is to generate nonhydrostatic strains in the sample. The sample holder finally developed, shown in Fig. 1, incorporates several compromises. In order to expose the metal to the pressure fluid we had to tolerate some surface oxidation. While it is desirable to have the sample completely free to contract under pressure, it was necessary to constrain it somewhat in order to make reliable contacts and to keep the sample presentation fixed. The relatively small hysteresis found in the curves of Hall voltage vs pressure, of the order of 1%, and the agreement of the pressure dependence of the resistance of rubidium with the data of Bridgman for free samples to at least 10%, indicates that the sample is behaving as if it were unconstrained.

The samples of lithium, sodium, and potassium were cleaned under Deo Base, a light mineral oil, by rolling a sheet of the metal to a thickness ranging from 0.007 to 0.050 in. and trimming it to the shape shown in Fig. 1 while it was on the sample holder. In the case of rubidium and cesium, it was necessary to cool the oil to approximately  $5^{\circ}\text{C}$  in order to reduce the oxidation and, in the case of cesium, to prevent melting. The Deo Base and the pentane pressure transmitting fluid were purified by reacting them with alkali chips and ampules of molten sodium-potassium alloy.

The lithium, from Fairmount Chemical Company, and the potassium from Mallinckrodt Chemical Company, were cleaned by heating to above the melting point under forepump vacuum. The sodium, from Rock and Company, was cleaned by melting under vacuum. The object of the cleaning process was to produce microscopically homogeneous specimens, not to remove

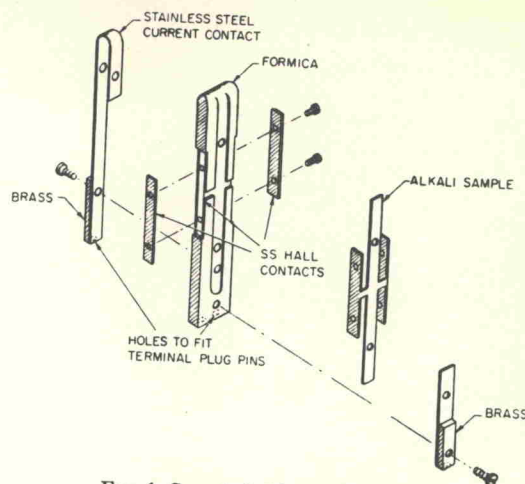


FIG. 1. Sample holder and sample.

impurities which were found not to be important in the lattice scattering range, as would be expected. The rubidium and cesium were obtained from MacKay and from Fairmount Chemical; they had already been distilled into glass vials and no attempt was made to clean them further.

Although the primary interest was in relative changes of the Hall constant, thickness measurements were made on lithium, sodium, and potassium using a 0.001-in. dial comparator with an accuracy of 0.001 in.

Temperature measurements on lithium were performed using a sample holder similar to that used in the pressure experiments. The sample holder and an associated heater were enclosed in a glass tube filled with helium exchange gas and the entire assembly was placed in a nitrogen Dewar; temperatures below  $77^{\circ}\text{K}$  were obtained by pumping on the liquid nitrogen and measured using a copper-constantan thermocouple. Rubidium and cesium were protected from accidental exposure to air by enclosing the sample holder in a formica tube filled with mineral oil.

## RESULTS

Figure 2 shows the results of the pressure measurements on typical samples of lithium, sodium, and rubidium, in terms of the normalized Hall voltage at fixed field  $V_H$  vs pressure. As an indication of the kind of reproducibility achieved, in a total of five runs on two different samples of rubidium the decrease in  $V_H$  in  $15\,000\text{ kg/cm}^2$  was between 12% and 13% for four of the runs and 9% in the fifth run.

In contrast to the pressure results on the other alkalis, the results for different potassium samples did not agree. Figure 3 indicates this difference and the approximate range of the value of  $V_H$  at  $15\,000\text{ kg/cm}^2$ . The resistance vs pressure curve for potassium was anomalous insofar as it consistently differed from the data of Bridgman.<sup>5</sup> Our value of 0.4 for the normalized resistance at  $15\,000\text{ kg/cm}^2$  is in sharp disagreement

W. Paul, G. B. Benedek, and D. M. Warschauer, Rev. Sci. Instrum. **30**, 874 (1959).