an electronic technique[2] over the temperature range from the λ-point to 0.75°K.

Earlier results[2] from this laboratory showed that the transport rate over machined copper is reasonably reproducible and for this reason, as well as for convenience, a copper surface was used in the present experiments. Temperatures below 1°K were obtained by adiabatic demagnetization of iron ammonium alum (Fig. 1, curve A) and of gadolinium sulfate octahydrate (Fig. 1, curve B) and were measured by means of the changes in self-inductance of a single layer coil which curronded the salt. The self-inductance was determined by the use of an Anderson bridge operated at 1000 cps. The sensitivity of balance was made independent of the temperature of the coil by placing a variable resistance in the inductive arm. It was possible at all temperatures to determine variations of 0.2 μh in a self-inductance of approximately 2.5 mh. The self-inductance was plotted against the reciprocal of the Kelvin temperature determined from equilibrium vapor pressure readings. The resultant straight line had a slope of approximately 180 μh per reciprocal degree for gadolinium sulfate and 85 μh per reciprocal degree for iron alum.

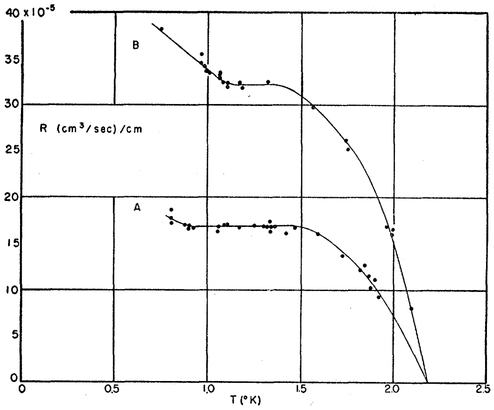

FIG. 1. Transport rate of the He II film as a function of temperature. (A) clean machined copper; (B) contaminated machine copper.

The electronic technique previously described[2] required a calibration based on visual observation of the helium level in the apparatus. In the present measurements this procedure was no longer necessary since convenient markers of the helium level were provided by grooves or shoulders (Fig. 2) which had been cut into the core of the cylindrical capacitor. This modification enabled the rate measurement to be made by noting the elapsed time required to empty the known annular volume of liquid helium from the region between the markers.

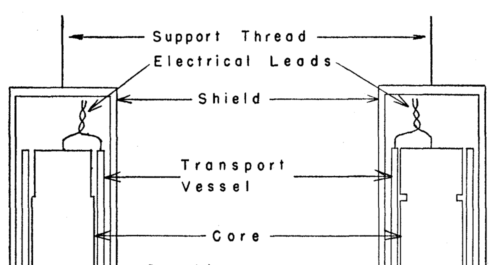

FIG. 2. Simplified sectional views of transport vessel and shield.

In all the experiments the salt and liquid helium were contained in a completely silvered glass vessel in which the temperature could be reduced to about 1°K by pumping on the liquid helium. The capacitor type transfer vessel was suspended in the helium-and-salt chamber by a thread attached at its upper end to a winch so that the vessel could be raised or lowered. Considerable difficulty was experienced in maintaining sufficient thermal isolation. Although temperatures as low as 0.4°K were obtained with the small magnet at our disposal, the initial rates of heating were too large to obtain reliable measurements below 0.75°K. It was expected that various modifications which were made from time to time would improve the isolation but this has not proved to be the case. Since the experiments are being temporarily discontinued, we are reporting the data thus far obtained.

The results are shown in Fig. 1. The data shown on curve A represent three experimental runs, the part below 1°K consisting mostly of results obtained in one of the runs (8/2/51). It is to be noted that these rates are approximately in agreement with those of Dash and Boorse for an uncontaminated machined copper surface. Curve B, on the other hand (data of 11/12/51), shows much higher rates than curve A. The high rates are believed to have been due to contamination.[3] Attention is directed to the fact that curve B shows a much more pronounced rise at the lower temperatures whereas curve A is essentially constant down to at least 0.9°K with perhaps the start of a rise at 0.8°K.

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α-Energy Systematics and Proton Shells for Heavier Nuclei

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THE variation of α-energies of different isotopes of a nuclei has been studied by a number of authors.[1–4] They have shown that E_α for different isotopes of an element decreases almost linearly with increasing neutron number. However, at certain points the relation is reversed and there is a very sudden increase in the α-energy. These reversals are associated with particularly stable neutron shells and consequent sudden drops in the binding energy of the neutrons. From the point of reversal we can easily determine the magic neutron number for which a completed shell exists.

Recent extension of the tab'e of known α-active nuclei[5] makes possible a similar study of the α-energies of different isotones. Great regularities are noticed if the α-energies for nuclei with the same number of neutrons are plotted against Z. In Fig. 1 such a plot is given for several neutron numbers. The data are all taken from Seaborg *et al.*[5] and Perlman *et al.*[4] E_α in the figure denotes the total decay energy. It is seen from the figure that the general trend here is an increase of E_α with Z. The curves are fairly well represented by approximately parallel straight lines. It is also clearly seen that at certain proton numbers there is a very sudden increase in E_α. These jumps are quite well marked and cannot be confused with the regular trend.

If $B_p(N,Z)$ be the binding energy of the last proton in the nucleus (N,Z), then it can easily be shown that

$$E_\alpha(N,Z)-E_\alpha(N,Z-1)=B_p(N-2,Z-2)-B_p(N,Z).$$

If we are proceeding from higher to lower Z, then a sudden drop in the value of $E_\alpha(N,Z-1)$ must be due to either a sudden increase of $B_p(N-2,Z-2)$ or a sudden decrease of $B_p(N,Z)$. The latter cannot be true since B_p values always increase with decreasing Z (see Fuchs[6]). Thus we conclude that, for decreasing Z, a sudden drop in E_α at (N,Z) is associated with a sudden increase in the proton binding energy at $(N-2,Z-2)$. Thus the proton number $Z-2$ must be regarded as a magic number giving rise to a closed proton shell.

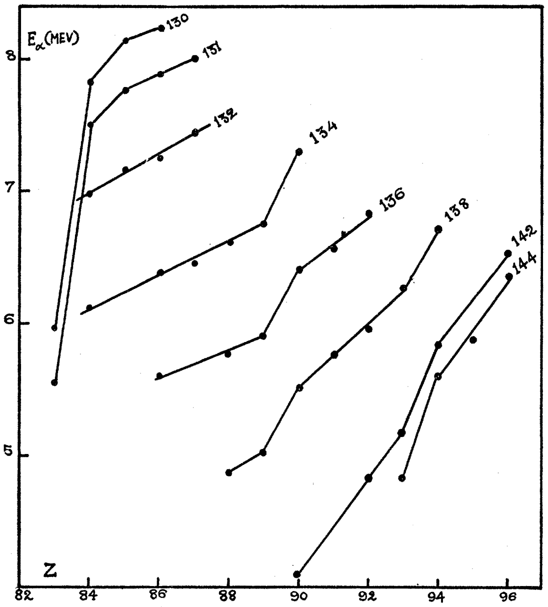

FIG. 1. Variation of E_α with Z. Constant neutron number is shown at the end of each curve.

In Fig. 1 we get a very sharp fall of E_α of about 2 Mev at $Z=84$, which obviously is due to the well-known proton shell at $Z=82$. In addition to this, however, we get two other less marked falls of about 0.7 and 0.5 Mev at $Z=94$ and 90, respectively. These probably correspond to proton subshells at $Z=92$ and 88. It may be noted that Stahelin and Preiswerk's[7] analysis of the energy of the first excited states of even-even nuclei has also revealed a magic number at $Z=92$.

According to Mayer's scheme[8] there ought to be a proton subshell at 92 due to the completion of the $1h_{9/2}$ level. However, this is not corroborated by the spin data, as has been shown by Dube and Jha.[9] According to the above scheme both $_{89}Ac^{227}$ and $_{91}Pa^{231}$ should have spin 9/2. Actually both are found to have a spin 3/2. These experimental values clearly indicate that from $Z=89$ to 92 the four protons must be filled in the $3p_{3/2}$ level. This at once gives us two subshells at $Z=88$ and 92, in agreement with what is found from our present investigation. The level order after $Z=82$ seems to be $2f_{5/2}$, $3p_{3/2}$, rather than $1h_{9/2}$, $2f_{7/2}$, as is given by the square well potential. But then the spin 9/2 of $_{83}Bi^{209}$ turns out to be anomalous.

A more detailed discussion of these and other related points will soon be published in a separate paper.

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Superconductivity below 1°K

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IN their study of superconductivity below 1°K, Daunt and Heer[1] observed an excess "paramagnetism" as the specimen of paramagnetic salt and superconducting metal warmed up in the presence of a finite applied magnetic field (Fig. 1).

The extrapolated dashed curve in Fig. 1 represents the paramagnetism of the salt alone. That portion (from C to B) of the full curve which lies below the dashed curve represents the situation when the metal has a diamagnetic susceptibility (in the superconducting state). From B to A the system exhibits a paramagnetic susceptibility in excess of that due to the salt alone.

It is the purpose of this note to suggest an explanation for the shape of this warm-up curve which is not restricted to multiply-connected superconductors.[1] Figure 2 shows typical isothermal (dashed lines, with $T_1<T_2<T_3\cdots$) and isentropic (solid lines, with $S_1<S_2<S_3\cdots$) magnetization curves for a large ideal super-

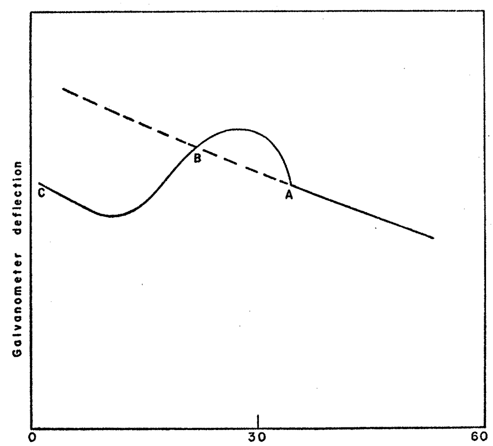

FIG. 1. Typical curve showing change of susceptibility with warm-up time in the presence of a small applied magnet field.

conducting sphere. The isentropic lines were obtained from the critical field and entropy data for tin. The other superconductors should give similar curves. The curves are plotted on a dimensionless basis with H_0, the critical field at $T=0$°K, as the normalizing factor. The vertical line in Fig. 2 represents the field h_1 in which the warm-up curve was observed. We seek the derivative $\partial\mu/\partial h$ (the differential susceptibility) of the magnetization curves at $h=h_1$. At this point we must distinguish between the isothermal and isentropic situations. In experiments such as carried out by Daunt

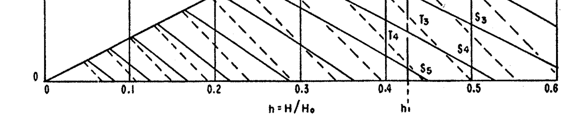

FIG. 2. Typical magnetization curves for an ideal large superconducting sphere.

and Heer[1] the process would be more nearly isentropic than isothermal. Hence, a plot of $(\partial\mu/\partial h)_S$ as a function of reduced temperature ($t=T/T_c$, T_c is the zero field transition temperature) is shown as the solid line in Fig. 3. For a real sphere the discontinuities shown in Fig. 3 would be replaced by smoothed curves.

Since increasing time in Fig. 1 corresponds to increasing temperature, it is clear that the essential features of the observed full curve can be obtained from a superposition of the dashed curve in Fig. 1 and a curve having the general shape shown in Fig. 3. If the