The data of Fig. 1 show that an increased tensile strength also occurs in thin films of silver. An explanation of this increased tensile strength may possibly be found in the greater ease with which the "dislocations" can move to the surface if the film is very thin.

The values of the adhesion A obtained from the data were independently checked by electro-depositing the silver only on regions of the rotor surface small enough to eliminate the "hoop" strength and then by determining the rotor speeds at which they were thrown off. Although the data so far obtained are not conclusive, there is an indication that the adhesion of the silver film increases when the thickness is reduced below 10^{-5} inch.

* Supported by the Navy Bureau of Ordnance.
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Difference in Viscosity of *Ortho-* and *Para*-Hydrogen at Low Temperatures

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THE cross section for the collision of two molecules depends, according to the quantum-mechanical theory of Massey and Mohr,[1] on whether or not the colliding particles are distinguishable. In the case of H_2, Halpern and Gwathmey[2] have defined two molecules to be distinguishable if, having the same electronic and vibrational eigenfunctions, they differ in their rotational or nuclear spin eigenfunctions. Under these assumptions Halpern and Gwathmey calculated the difference in viscosity at low temperatures for normal hydrogen (25 percent $p-H_2$ content) and hydrogen with another composition. For normal hydrogen and pure *para*-hydrogen, e.g., they predicted a relative difference of the order of several percent at 70°K. The gas with the lower $p-H_2$ content is expected to have the larger viscosity. The authors believe that it is possible to confirm their theoretical results from measurements of thermal conductivity made by Bonhoeffer, Harteck, and Farkas in a temperature region in which the rotational heat of the two modifications is still effective.

We have compared the viscosity of normal hydrogen (η_n) with that of hydrogen of variable $p-H_2$ content (η) using a bridge-arrangement. The results are given in Fig. 1. Our experimental viscosity-difference has the sign opposite to that predicted by Halpern and Gwathmey in the entire range of temperature and composition under consideration. The amount is smaller by about a factor of ten. Details will be given in the Zeitschrift für Physik.

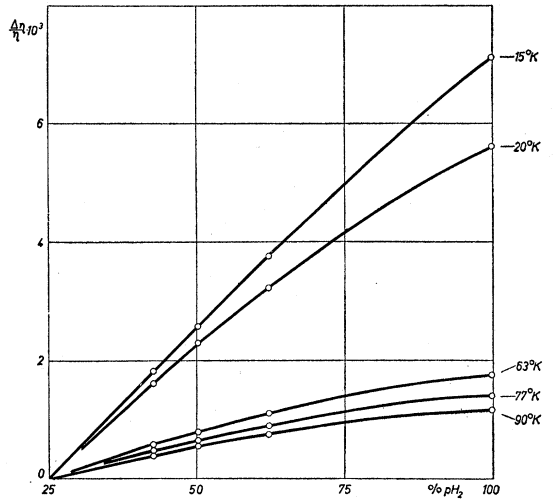

FIG. 1. Relative viscosity difference $\Delta\eta/\eta=\eta-\eta_n/\eta$ of hydrogen with variable $p-H_2$ content and normal hydrogen (25 percent $p-H_2$).

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Some Data on the Elastic Scattering of 18.3-Mev Protons*

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AN attempt has been made to measure the absolute differential cross section for elastic scattering of 18.3±0.1 Mev protons by Al, Fe, Ni, Cu, Ag, Sn and Pt. Burkig and Wright[1] have previously obtained relative cross sections for 18.6-Mev protons on Al, Ni, Pd and W.

The present scattering experiment was carried out in a 12-in. chamber which was constructed with exit ports at 30°, 60°, 90°, 120°, 150° and 165° to the incident beam. A NaI(Tl)-scintillation counter can be placed in front of these.[2] The solid angle is defined by a ground hole of $\frac{1}{4}$ in. in the glass reflector over the scintillator and its distance of 23.1 cm to the center of the chamber. A rotating and retractable foil holder also carries a fluorescent screen which enables one to align the chamber and to focus the beam. The beam spot is slightly over 1 cm wide and 3 mm high.

TABLE I. Elastic scattering cross section in millibarns/sterad for 18.3-Mev protons.

Lab angle	30°	60°	90°	120°	150°	165°
Al	187±20	47±4	8.7±0.7	8.7±0.7	4.5±0.5	4.9±0.5
Fe	310±30	28±3	11 ±2	2.5±0.3	3.2±0.4	2.5±0.6
Ni	390±30	30±3	15 ±2	2.8±0.3	3.9±0.4	3.6±0.6
Cu	480±30	21±2	18 ±2	4.3±0.4	3.8±0.4	3.5±1
Ag	1480±100	73±5	6.5±0.6	4.2±0.5	3.0±0.4	3.0±0.5
Sn	1800±150	91±10	11 ±0.6	4.5±0.6	3.5±0.5	3.2±1
Pt	4300±300	170±10	35 ±1	11.5±0.6	4.2±0.4	4.0±0.5

The protons are collected in a graphite Faraday cup which is connected with a polystyrene condenser on which the voltage is measured with a quadrant electrometer.

To record the scattered protons a technique had to be employed which separated the elastic line from the inelastic scattering. This was done by measuring the high energy end of the pulse spectrum with a ten-channel discriminator. The channel width was 2 volts and the maximum pulse height 80 volts. At 30° inelastic scattering is negligible relative to the elastic scattering. Hence, the shape of the measured 30° elastic peak was used to correct the large angle curves of which the shape is distorted by inelastic scattering. It is, of course, possible to separate the elastic scattering only so long as the low lying levels and the ground state have a separation comparable to or larger than the resolving power of the detector. The 30° peak had a width at half-maximum between 3 and 5 percent for different detectors.

The results of these measurements are presented in Tables I and II. For Al and Pt, measurements were also carried out with the energy of the protons reduced to 15.5±0.2 Mev.

TABLE II. Elastic scattering cross section in millibarns/sterad for 15.5-Mev protons.

	30°	60°	90°	120°	150°	165°
Al	225±20	37.8±4	10.5±1	9.5±1	9.6±1	9.3±1
Pt	7200±500	325 ±20	65 ±5	17.2±1	9.5±0.6	7.4±1

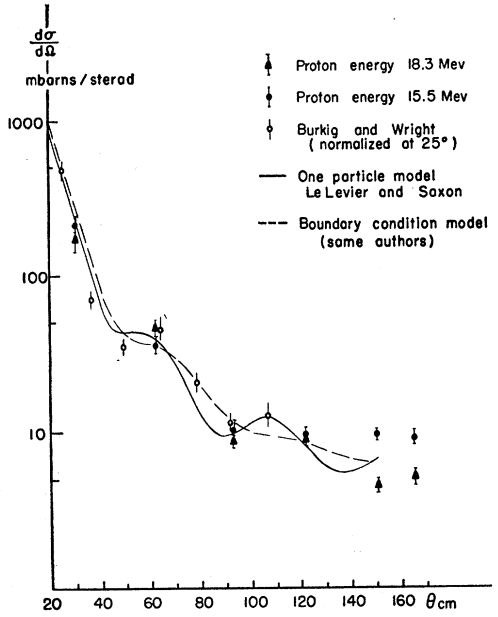

FIG. 1. Differential cross section for the elastic scattering of protons by Al

The errors were estimated on the basis of the fluctuations of the different measurements and of the following uncertainties. For the small angles the cross sections vary rapidly with the angle, and a misalignment of the beam spot of 0.5 cm causes a change in the measured cross section by as much as 17 percent. Such changes in alignment may occur because of fluctuations in the operation of the cyclotron. At the larger angles of observation the subtraction of the inelastic scattering introduces an uncertainty. Both effects are several times larger than the statistical error.

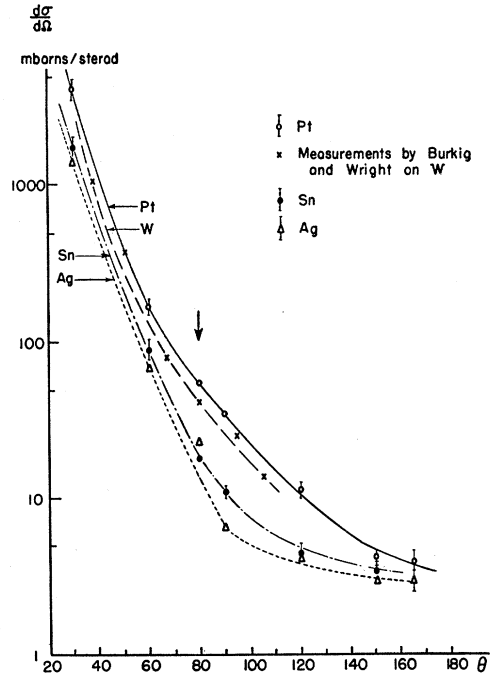

FIG. 2. Differential cross sections for the elastic scattering of protons by Pt, W, Sn and Ag. The points below the arrow are measured by Burkig and Wright and normalized for Pt.

Figure 1 represents the scattering cross section for Al. The measurements of Burkig and Wright are shown on the same graph. These are normalized at 25° on the cross-section curve calculated by Le Levier and Saxon[3] on the basis of a complex potential. These authors also calculate the scattering cross-section on the basis of a boundary condition model proposed by Feshbach and Weisskopf[4] as shown in Fig. 1.

The scattering cross sections of the medium heavy and heavy elements are difficult to analyze at the present since Coulomb wave functions up to $L=10$ have to be employed. Figure 2 shows the results obtained for the heavy elements.

The following results can be deduced from these measurements. The back scattering cross sections seem to be little dependent on the size of the scattering nucleus; their values being of the order of 3 millibarns/sterad for 18-Mev protons.

If the incoherent scattering leading to the ground state is as intense as the inelastic scattering leading to neighboring excited states, then the fraction of the incoherent scattering compared to the diffraction scattering may be as much as 30 percent for Cu and 5 percent for Pt for a scattering angle of 165°.

Another feature of the backward elastic scattering is its energy dependence. Britten[5] obtained a cross section of 0.6±0.1 millibarns/sterad for the elastic scattering of 31.5-Mev protons by Al at 161°. Comparing this value with the Al cross sections at the same angle for protons of 15.5 Mev and 18.3 Mev, one finds that the 161°-scattering cross section is inversely proportional to the third power of the proton energy. The same energy dependence is obtained by comparing the 155° Pb cross section for 31.5-Mev protons (0.8±0.2 milli-barns/sterad[7]) with the 155° cross sections of 15.5-Mev and 18.3-Mev protons on Pt.

* This work has been supported by the AEC and the Higgins Scientific Trust Fund.

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Copper as an Acceptor Element in Germanium

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THE experimental results reported below strongly suggest that copper is a surface impurity responsible for the familiar "thermal conversion" of germanium.[1] In a previous publication,[2] the solid solubilities of thermal acceptors[3] and their diffusion rate in germanium were given. In the present work, the solid solubility and the diffusion constant of copper have been determined with radioactive[4] Cu^{64}. The data for the thermal acceptor and for copper agree within the limit of error of the experiments.

The specimens (1.0×0.5×0.15 cm) cut from 9.6 ohm cm single crystal[5] germanium were treated by wetting the surface with 0.1 percent radioactive copper nitrate solution for two minutes. In one set of experiments, (Fig. 1) only one of the 1.0×0.5 cm faces was so treated on each of two specimens. Both specimens were heated together in helium at 1 atmos at a mean effective temperature[6] of 825°C for two minutes and rapidly quenched. One specimen (A) was analyzed for copper as a function of distance from the treated surface by recording the activity of grindings from successive layers. The other (B) was sectioned perpendicular to the treated surface so as to provide a prism, 0.25×0.125×0.15 cm. The variation of acceptor[3] concentration with distance was calculated from the incremental change in resistivity of the prism which was rendered p-type by the heat treatment. These data are plotted in Fig. 1, curves A and B, respectively. It is evident from the slopes of the two curves that the diffusion rates are identical within experimental error, the average value of the diffusion constant, 1.3×10^{-5} cm² per second is lower than, but in reasonable agree-