We bombarded the target with 1.22-Mev deuterons and used a linear amplifier to detect the protons. Long range protons were found and an absorption curve (Fig. 1) showed that they had a range of 55 cm, as expected. The ratio of the intensity of this group to the intensity of the group of 15-cm protons from the reaction $C^{12}+H^{2}\rightarrow C^{13}+H^{1}$ was found to be 0.11 percent. A target in which C^{13} was depleted was then bombarded and the ratio was only 0.029 percent. This showed that the C^{13} had been concentrated in the first target relative to the second by a factor of 3.8, whereas the separation factor had been calculated from the dimensions of the thermal diffusion apparatus as 3.7. The average of these two ratios (0.07 percent) is consequently the ratio of the yields from ordinary carbon at 1.22 Mev bombarding energy. This ratio would vary considerably with different bombarding voltages since the yield of protons from C^{12} shows resonances at 920 and 1220 kev.[3]

An excitation curve has also been obtained for this reaction and is shown in Fig. 2. The indicated error is the probable error increased by a factor of two, since it was necessary to make observations in two separate runs, which were joined at 1450 kev. The change in range of the protons with bombarding energy might be a source of systematic error in a curve of this type. To avoid this, the bias on the recording circuit was made low enough to count all the protons passing through the ionization chamber, and as an additional precaution absorbers were added as the bombarding voltage was increased to insure that the protons were always counted at the same distance from the end of their range.

The yield curve shows a maximum at about 1500 kev. This may be interpreted as a resonance in the yield, which would indicate an excited state in the intermediate nucleus (N^{15}) at 17.55 Mev. This is a surprisingly high energy at which to find isolated excited states, even in so light a nucleus. However, the experimental distribution might result from a resonance or a group of overlapping resonances of higher intensity than the neighboring overlapping levels which may appear as a continuum.

W. E. Bennett
T. W. Bonner
Emmett Hudspeth
Bob E. Watt

The Rice Institute,
Houston, Texas,
August 13, 1940.

[1] J. C. Bower and W. E. Burcham, Proc. Roy. Soc. **A173**, 379 (1939).
[2] E. Pollard, Phys. Rev. **56**, 1168 (1939).
[3] M. M. Rogers, W. E. Bennett, T. W. Bonner and Emmett Hudspeth, Phys. Rev. **58**, 186 (1940).

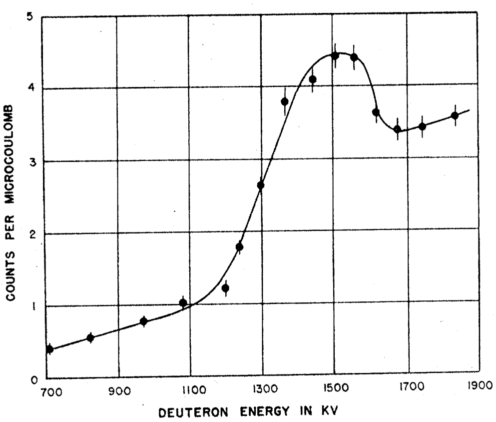

Fig. 2. Excitation curve for protons from the reaction $C^{13}+H^{2}\rightarrow C^{14}+H^{1}$. The maximum in the yield at 1500 kev indicates an excited state in N^{15} at 17.55 Mev.

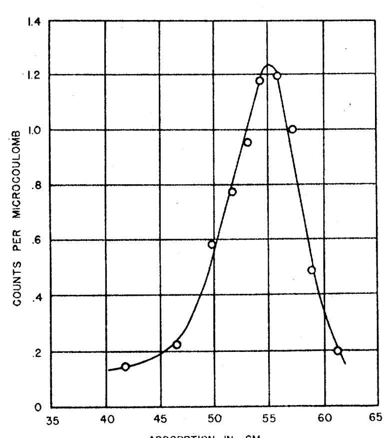

Fig. 1. Range-number curve for protons from $C^{13}+H^{2}$ at a bombarding energy of 1.22 Mev. The protons were observed with a linear amplifier biased so as to count particles near the end of their range.

Law of Magnus in Single-Crystal Aluminum Wires

By the traveling temperature gradient method of Andrade,[1] good single crystals up to 60 cm length have been produced in 1 mm diameter wires of pure aluminum. The wires were heated internally by a 15-ampere current, the traveling furnace was at 550°C, and moved at about 5 cm per hour along a 1-cm quartz tube evacuated to 0.01 mm Hg, containing the wire supported vertically.

While still unstrained the crystal wires were examined under asymmetrical temperature distributions (140°C peak) for the Benedicks e.m.f. Wires subsequently found by a study of their glide planes to have been uniformly crystallized, gave e.m.f.'s less than 0.02 microvolt, independent of position of the temperature distribution; wires found imperfectly crystallized gave e.m.f.'s greater than 2 microvolts, dependent upon position. Intermediate conditions were not found.

One specimen was deliberately made non-uniform at a selected place, P, by interrupting the motion of the furnace for several minutes when over P. Electromotive forces were produced in this crystal by a small symmetrical heater (110°C) placed at different places near P. On the side from which the traveling furnace had approached, there was a sharp peak of -10 microvolts close to P, on the other side a less sudden maximum +6 microvolts; e.m.f.'s reduced to zero for positions not near P. The overheated portion P behaved as a thermoelectrically different substance, and was found upon examination to be a hard polycrystalline section in an otherwise uniformly aligned single-crystal wire.

Since aluminum crystals are cubic, changes in orientation cannot cause contact e.m.f.'s, and since the wires were freed from internal strains by the heating processes, the usual causes of heterogeneity were absent.

Benedicks' e.m.f. in ordinary wires[2] is apparently due to electrical disturbances produced by positive emission of impurity nuclei from the wire. In the present work, the slow annealing should have baked out most of the impurity removable by positive emission, the remaining traces of impurity being effectively permanent.

It is suggested now that these permanent impurity nuclei are incorporated in the lattice of the single-crystal part of the wire, their thermoelectric effect being lost; in the polycrystalline section this solid solution does not occur, and the impurity atoms form the "cement" between the polycrystals, and change the thermoelectric properties of the aggregate.

If this interpretation is correct, it can be concluded that there is no contradiction with the law of Magnus in uniformly aligned single-crystal wires of aluminum.

C. Y. Ma
William Band

Department of Physics,
Yenching University,
Peiping, China,
July, 1940.

[1] E. N. Da C. Andrade, Proc. Roy. Soc. **A163**, 16 (1937).
[2] Ch'eng and Band, Proc. Camb. Phys. Soc. **35**, 622 (1939).