a final sample of 35 cc from an initial adsorption of 5025 cc. This revealed a three-fold enrichment of H^1H^2. A two stage desorption was then made in which, from 5715 cc adsorbed, an end desorption was secured amounting to 440 cc, which was then readsorbed and fractionally desorbed to give a final sample of 90 cc. This sample showed a five-fold enrichment of H^1H^2 over that present in the hydrogen after passing the purification train. While this enrichment may not be as large as that to be expected theoretically on the basis of zero-point energy and activated adsorption, it appears to be much larger than would be expected from a simple distillation process of separation. Since, theoretically, this method of separation by desorption involving zero-point energy will be enormously more efficient at the temperature of liquid hydrogen we are taking steps to extend our experiments to these lower temperature ranges.

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March 2, 1933.

[1] H. Eyring, Proc. Nat. Acad. Sci. **19**, 78 (1933).
[2] E. W. Washburn and H. C. Urey, Proc. Nat. Acad. Sci. **18**, 496 (1932).
[3] H. S. Taylor, J. Am. Chem. Soc. **53**, 578 (1931).
[4] H. S. Taylor and A. Sherman, Trans. Faraday Soc. **28**, 247 (1932).
[5] W. Bleakney, Phys. Rev. **41**, 32 (1932).

Scattering and Absorption of Neutrons

In these experiments the neutron source consisted of beryllium powder in one or more glass bulbs 4 mm diameter filled with radon, in amounts up to 1200 millicuries. Alpha-radiation equivalent to 3600 millicuries of polonium was thus utilized, making a much more powerful neutron source than hitherto reported, although de Broglie, le Prince-Ringuet, Thibaud and La Tour used a radon-beryllium source without stating the amount of radon.[1] Neutrons were ejected from the beryllium by the alpha-particles from radon, radium *A* and radium *C'*, to a number around 10^5 per second. To measure the intensity of the neutron stream a small ionization chamber was used, connected to an amplifier-oscillograph system described previously, which registered ionizations by single high-speed particles above the unavoidable background of gamma-radiation.[2] The ionizing particles were atoms projected from the paraffin front and the other materials of the chamber by neutron impact.

For the scattering measurements, annular ring scatterers were used, the direct beam being largely blocked out of the chamber by a cylinder of lead 19 cm long, and the scattering, measured by the increase in the number of neutrons registered with the scattering ring in place, was determined for positions giving several scattering angles.

TABLE I.

Material	*Angle of Scattering*				
	46±15	51±20	82±27	125±25	151±15
Paraffin	3.68	3.65	2.18	1.48	0.21
Water	3.59	3.45	2.50	1.48	0.56
Carbon	2.96	2.17	2.01	1.62	0.79
Lead	2.75	2.52	2.49	1.71	0.58

Table I shows the relative scattering by rings 15.5 cm mean radius and square cross section of 25 cm^2 in numbers of neutrons registering in ionization chamber per minute, the distance from source to chamber being 31.5 cm.

As might be expected, paraffin and water, containing much hydrogen, show small backward scattering, no more than would be indicated for the carbon or oxygen contained, while carbon and lead show more nearly uniform scattering.

The computation of the scattering coefficients requires approximations as to geometrical quantities and absorption. The following figures are probably relatively correct to within ±15 percent: fraction scattered (per unit volume of scatterer) from an incident beam of unit intensity into unit solid angle in the specified direction: lead 2.28×10^{-2} at 45°, 1.2×10^{-2} at 125°; carbon 2.12×10^{-2} at 45°, 0.96×10^{-2} at 125°.

Since the absorption of neutrons is largely scattering, the greatest absorption will be shown by an absorber just filling the geometrical path, because any material outside the direct beam scatters neutrons back into the chamber. For example, paraffin in the form of a cylinder 3 cm diameter and 4 cm long shows twice as much absorption as a large plate of paraffin 4 cm thick. Absorbers 3 cm in diameter were uniformly used in this work. Absorption curves were taken for carbon, lead, water and paraffin, the neutron beam having been filtered through 4 cm of lead to reduce the gamma-radiation. These curves are approximately exponential, and appear to approach a minimum which is probably the residual scattering from the room. A study was also made of the absorption by cylinders, 4 cm long, of various materials, as shown in Fig. 1. Copper has the highest absorption per cm of any material yet tested.

As to correlation of the atomic absorption with atomic weight, the simple hypothesis of elastic sphere collision between the neutron and the nucleus, with a definite radius for the neutron and a radius for the nucleus proportional to the cube root of its atomic weight, can be made to fit the absorption results very well, a radius of 4.6×10^{-13} cm being required for the neutron and one of 7.8×10^{-13} cm

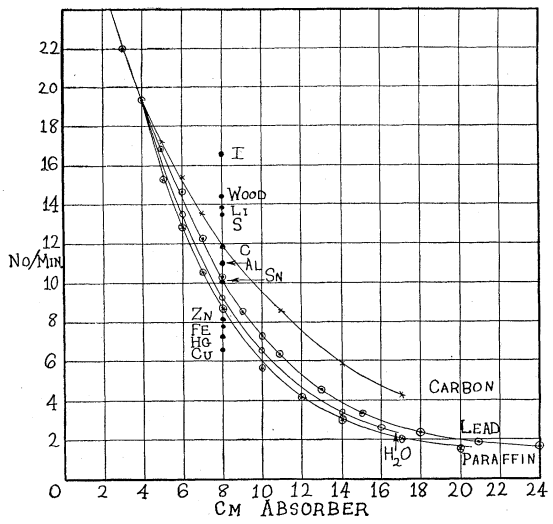

FIG. 1

for the lead nucleus. The size of the lead nucleus accords with radioactive disintegration theory, but the radius assigned to the neutron seems too large to permit it to fit into nuclei. If we introduce the hypothesis of an angle function for the scattering, such that small angle scattering is relatively greater for heavier atoms, the neutron radius will need to be smaller. Professor Rabi has kindly investigated the wave mechanics picture far enough to conclude that the scattering function for small angles is really of this type, and that our data lead to a more reasonable value, of the order of 1.2×10^{-13} cm, for the neutron collision radius.

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[1] de Broglie, le Prince-Ringuet, Thibaud and La Tour, Comptes Rendus **194** (1932).
[2] J. R. Dunning, Phys. Rev. **43**, 380A (1933).

Evaporation Technique for Aluminum

Mirrors made from aluminum by the evaporation technique are superior to silver in several respects as listed below. The reflectivity of aluminum is very nearly as high as silver for green light but is much higher for the ultraviolet[1] making possible the use of mirrors for ultraviolet optics where the lack of achromatism in a lens system is often objectionable.

The aluminum mirrors, now exposed for over six months, show no tarnish. The permanence of the high reflectivity definitely exceeds that of silver protected by an evaporated quartz layer.[2] The aluminum is inert toward corrosive agents because of a layer of oxide which forms on the aluminum upon contact to the air.

The aluminum adheres to glass more tenaciously than silver so that dust, etc., may be washed off with soap and water. One small glass grating coated with aluminum has been washed several times a week for a period of about three months without any harmful effect to the mirror and, furthermore, without introducing the small scratches which silver exhibits after being cleaned.

Other features, such as its apparent uniformity of reflectivity and transmission in the visible, may make of aluminum an important material for coating interferometer plates.

The evaporation of aluminum from a tungsten helix may be successfully effected when the proper size of tungsten wire and helix are chosen.

The technique of evaporation depends upon the fact that tungsten has a limited solubility in liquid aluminum. When the wire of the tungsten helix is large enough it is possible for the aluminum to become saturated with tungsten before the wire is dangerously reduced in diameter. For the successful evaporation of aluminum the helix may be 8 turns of 30 mil tungsten wire wound (in a Bunsen flame at red heat) on an 8 d. finishing nail to form a coil about one inch long. When the pitch of the helix is much less than 8 turns per inch the aluminum shorts the coil and is inefficiently heated by the electric current. When, however, the diameter of the helix is greater, the ratio of aluminum to tungsten is too great and the coil burns out. Furthermore, when a helix is made of wire of diameter larger than 30 mil the coil is excessively brittle.

The tungsten which is dissolved by the aluminum is deposited back on the helix as the evaporation proceeds. This may be sintered to the helix by a final heating of the empty coil and so approximately compensates for the dissolution of metal by the aluminum. Ordinarily one coil of tungsten lasts for some dozen charges of aluminum. The aluminum is cut in the form of a cylinder which fits easily into the helix. As the purest aluminum gives best results as regards tarnishing and adhesion, it is advisable to melt the aluminum to the helix to free it from gas and oxide before the mirror is uncovered. This may also be accomplished by a preliminary run to fuse the aluminum after which the apparatus is dismounted and the mirror introduced into the vacuum chamber. Other than this the technique is the same as has been described before[1] for the vacuum evaporation of metals.

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[1] W. W. Coblentz and R. Stair, Bur. Standards J. Research **4**, 189 (1930).
[2] C. Hawley Cartwright and John Strong, Rev. Sci. Inst. **2**, 189 (1931).