mirror-like surface. The glass was in the form of a ribbon 1.5 cm long, 1 mm wide and 25μ thick, fused to a glass plate at the ends in such a way that the ribbon bowed up slightly in the middle. Contacts were made by means of platinum wires sealed into the glass at the ends of the ribbon. This "receiver" was placed on a thin copper base-plate suspended on quartz fibers attached to a small heavy-walled copper vessel in which the liquid helium was made by the Simon expansion method. Our most sensitive film had a transition zone roughly 0.02° wide in which the resistance varied from 100 ohms (normal) to 10^{-3} ohm (superconducting). The estimated thickness of the film was 10 mμ. Other films studied varied in thickness up to 500 mμ and had correspondingly lower resistances. By means of a small electrical heating coil attached to the base-plate, the temperature of the film was maintained in the middle of the "steep" portion of the transition during the radiation measurement. Judging from the observed fluctuation in resistance of the lead film, the temperature was maintained effectively constant to within 10^{-6} degree.

The source of radiation was a blackened copper disk, electrically heated and with thermocouple attached. It was suspended about 5 cm above the receiver, with shutter and diaphragms in between so that measured amounts of energy could be transmitted.

The potential drop across the film was measured with a potentiometer circuit, the galvanometer beam having a deflection of 1 cm per μv. Radiation was flashed on the receiver from the radiator at a series of temperatures from 15°K to 150°K. The receiver was at a temperature of about 7°K and the shutter at 14°K.

The largest ratio of potential drop to input of radiant energy was obtained with the unblackened 10 mμ film. This receiver (glass+lead) had a heat capacity of about one erg deg.$^{-1}$. A beam of radiant energy, 6 erg sec.$^{-1}$, produced a galvanometer deflection corresponding to about 6 millivolts in less than 1 sec. This is equivalent to a sensitivity of 10^{-4} erg sec.$^{-1}$ per mm deflection. Blackening the lead surface with a thin layer of cobalt oxide produced no appreciable increase in sensitivity.

Because of temperature fluctuations in the receiver, this sensitivity of 10^{-4} erg sec.$^{-1}$ per mm deflection was too high to permit accurate measurements. The highest precision obtained was in an experiment with the radiator at 35°K. A beam of 2×10^{-4} erg sec.$^{-1}$ gave a deflection of 7 mm. The probable error corresponded to 1.5 mm, giving a precision of measurement of 4×10^{-3} erg sec.$^{-1}$.

It appears that the ratio of potential drop to radiant energy input is several orders of magnitude higher than in the other methods for measuring radiation in the infra-red region, and that the possibilities for sensitivity and precision are correspondingly high. It is probable that, with superconducting receivers of higher resistance, more sensitive galvanometer systems, and better temperature control, the precision can be improved considerably beyond the results reported here.

We wish to express our appreciation to Professor A. H. Pfund for helpful advice and suggestions. Grateful acknowledgment is made of a grant-in-aid from Research Corporation.

[1] D. H. Andrews, Am. Phil. Soc. Year Book (1938), p. 132.
[2] A. Goetz, Phys. Rev. **55**, 1270 (1939).
[3] W. F. Brucksch, Jr., W. T. Ziegler, E. R. Blanchard and D. H. Andrews, Phys. Rev. **59**, 688 (1941).

Production of Radioactive Hydrogen by Neutron Bombardment of Boron and Nitrogen

R. Cornog and W. F. Libby
Radiation Laboratory, Department of Chemistry, University of California, Berkeley, California
May 13, 1941

SATURATED water solutions containing an excess of boric acid crystals, or of ammonium nitrate crystals, were bombarded for several thousand microampere hours by fast neutrons produced by the $Be^9(d, n)B^{10}$ reaction, with 16.5-Mev deuterons. In all cases the water surrounding the crystals, when placed as water vapor in a Geiger-Müller counter, showed an activity of approximately 10^4 counts per mole per second. Control samples of distilled water had less than five percent as much activity.

The following reactions are energetically possible, with 20 Mev as the upper limit of the neutrons used:

$$_5B^{10}+{_0n^1}\rightarrow[_5B^{11}]^*\rightarrow{_4Be^8}+{_1H^3}+Q_1 \qquad (1)$$
$$_4Be^8\rightarrow 2\,{_2He^4}$$
$$_5B^{11}+{_0n^1}\rightarrow[_5B^{12}]^*\rightarrow{_4Be^9}+{_1H^3}+Q_2 \qquad (2)$$
$$_7N^{14}+{_0n^1}\rightarrow[_7N^{15}]^*\rightarrow{_6C^{12}}+{_1H^3}+Q_3 \qquad (3)$$
$$_7N^{14}+{_0n^1}\rightarrow[_7N^{15}]^*\rightarrow 3\,{_2He^4}+{_1H^3}+Q_5 \qquad (3a)$$
$$_7N^{15}+{_0n^1}\rightarrow[_7N^{16}]^*\rightarrow{_6C^{13}}+{_1H^3}+Q_4 \qquad (4)$$

where $Q_1=+0.2$ Mev; $Q_2=-9.6$ Mev; $Q_3=-4.3$ Mev; $Q_4=-10.1$ Mev; $Q_5=-11.5$ Mev.

Reaction (1) might be expected, since the compound nucleus formed has already been observed to yield radioactive hydrogen.[1]

Since only 0.38 percent of the bombarded nitrogen was N^{15}, it is not likely that reaction (4) was primarily responsible for the observed activity.

The total neutron output of the 60-inch cyclotron has been recently measured by Dr. Emilio Segrè and Mr. Hubert Yockey. Using their unpublished and preliminary result of one neutron per 200 deuterons, and 31 years as the half-life,[2] one may obtain a rough value for the reaction cross sections. Assuming that (1) and (2) are involved for boron, and (3) and (3a) are involved for the nitrogen, one obtains for both elements approximately 10^{-26} cm^2 as the fast neutron cross section for the production of hydrogen three. It is estimated that these values for both cross sections may be in error by a factor of five.

We wish to thank Professor E. O. Lawrence and the entire staff of the Radiation Laboratory for their interest and cooperation in all phases of this work.

[1] R. D. O'Neal and M. Goldhaber, Phys. Rev. **57**, 1086 (1940).
[2] R. D. O'Neal and M. Goldhaber, Phys. Rev. **58**, 574 (1940).