the water of crystallization of the magnitude suggested by the electrical properties should be much greater than the observed value.

These tests accordingly indicate that the unusually large dielectric constant of Rochelle salt crystals, especially in the *a* direction, is not due to the polarization of the water molecules. This makes it all the more probable that rotations of polarized water molecules or other parts of the tartrate molecule must account for the electrical effects. The corresponding changes in optical properties would then lie in the far infrared or Hertzian region of the spectrum.

The experimental work herein recorded was very efficiently performed by Mr. Alan Koerner.

JOSEPH VALASEK

University of Minnesota,
April 20, 1934.

H^3 in Heavy Hydrogen

A few months ago[1] Bleakney and Gould reported the results of a search for H^3 (hereafter designated by T) in heavy hydrogen. They found none although 1 in 10^5 could have been detected. Since then we have completed the construction of a much more sensitive apparatus with which we have subjected a sample of nearly pure deuterium to a careful test. In the meantime additional evidence for the existence of a third isotope of hydrogen has been offered by Oliphant, Harteck and Rutherford,[2] Tuve, Hafstad, and Dahl[3] and Allison.[4]

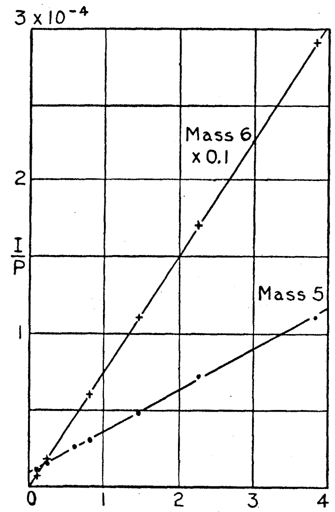


FIG. 1.

Our experimental data are represented by the curves in Fig. 1 where I as usual[1] is the intensity of a particular type of ion while the pressure p is measured by the number of D_2^+ ions. The curve for D_3^+ passes through the origin as expected since it is almost exclusively triatomic. The curve representing ions of mass 5 however has an appreciable intercept which we interpret as a measure of the ratio TD : DD. This gives for the abundance ratio T : D $= 5 : 10^6$ or one in two hundred thousand for this particular sample. This means that the ratio T : H in natural hydrogen is probably of the order of $1 : 10^9$ or smaller.

This result, we believe, confirms rather satisfactorily the existence of a third isotope of hydrogen from natural sources and gives a good measure of its abundance in this particular sample which was obtained by the electrolysis of heavy water and contained only about one percent light hydrogen.

We are indebted to Professor H. S. Taylor and his colleagues for the sample of deuterium.

W. WALLACE LOZIER
PHILIP T. SMITH*
WALKER BLEAKNEY

Palmer Physical Laboratory,
Princeton, New Jersey,
April 21, 1934.

---

[1] Bleakney and Gould, Phys. Rev. **45**, 281 (1934).

[2] Oliphant, Harteck and Rutherford, Nature **133**, 413 (1934).

[3] Tuve, Hafstad and Dahl, Washington Meeting, Am. Phys. Soc., April, 1934.

[4] Allison, Florida Meeting, Am. Chem. Soc., March, 1934.

* National Research Fellow.

The Production of $_1H^3$ by a Canal-Ray Discharge in Deuterium

Judging from the experiments recently reported by Oliphant, Harteck and Rutherford,[1] and by Dee,[2] the production of hydrogen of mass three may occur quite frequently as the result of collisions between deutons of high energy. Furthermore, the exact mass which they deduce from their measurements of range indicates that the $_1H^3$ should be stable.* Prompted by these results we have been running a high voltage discharge in deuterium at low pressure and passing the canal rays from it into deuterium at a higher pressure, hoping in this way to accumulate an appreciable amount of $_1H^3$. We believe we have succeeded in doing so.

The apparatus consists of a discharge tube some 70 cm long and 6 cm in diameter with heavy water-cooled iron electrodes sealed in either end with de Khotinsky cement. The cathode is pierced by a canal 3 mm in diameter and 19 cm long. This leads into a glass tube 150 cm long and 3 cm in diameter. Gas is continually pumped out of the

---

[1] Oliphant, Harteck and Rutherford, Nature **133**, 413, March 17, 1934.

[2] Dee, Nature **133**, 564, April 14, 1934.

* Some evidence for the existence of this isotope has apparently been found also by Tuve, Hafstad and Dahl [Bull. Am. Phys. Soc. **9**, No. 2, p. 13, April (1934) (Washington Meeting)].

discharge tube and into the lower tube. When the discharge is running properly a bright beam of canal rays may be seen extending almost the entire length of the lower tube. The discharge is run at a voltage of 50 to 80 kv and a current of about 15 m.a. The pressure in the discharge is of the order of 10^{-3} mm Hg, and in the canal-ray chamber of the order of 0.5 mm.

Starting with pure deuterium in the discharge we have drawn out samples after running different lengths of time under various conditions. The samples have then been turned over to Drs. Smith, Lozier and Bleakney for mass analysis in their new apparatus (see their letter in this issue). Three samples, each of which consisted of gas that had been treated about an hour, have been analyzed by them. The procedure was the same as that used in their study of ordinary deuterium. They conclude that ${}_1H^3$ (or T) is present to about one part in five thousand of D. This is in contrast to the one part in 200,000 present before treatment.

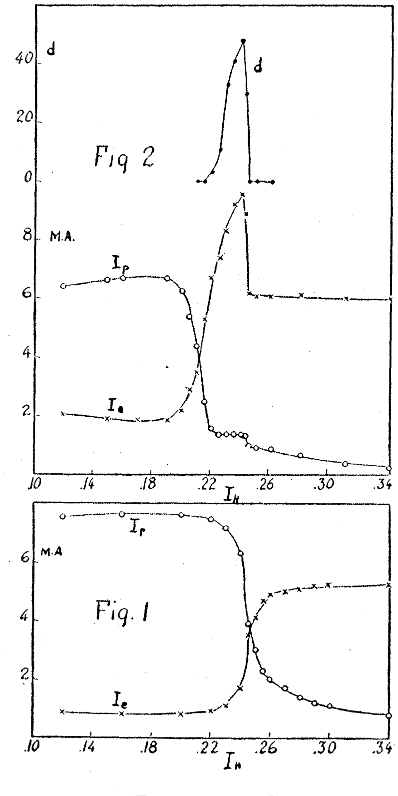
Obviously the experiment would have been impossible without the cooperation of the Department of Chemistry, which furnished the deuterium, and of our colleagues in the Department of Physics who analyzed the products.

G. P. HARNWELL
H. D. SMYTH
S. N. VAN VOORHIS
J. B. H. KUPER

Palmer Physical Laboratory,
Princeton University,
April 21, 1934.

Improved Magnetron Oscillator for the Generation of Microwaves

It has been observed[1] that to obtain maximum output from magnetron oscillators (both the split anode and the non-split anode types,[2,3] it is necessary to incline the axis of the anode with respect to the direction of the magnetic field. The angle is usually from 3° to 6°. The effect of this inclination is to give some of the electrons travelling between filament and plate, a component of velocity parallel to the anode axis. The electron trajectories in a magnetron consisting of a cylindrical anode and concentric filament, have been shown by Hull[4] and Langmuir to be cycloids when the magnetic field is parallel to the filament. Hollmann,[5] considering a simplified case, has shown that with tilting of the tube they become cycloidal spirals whose axes are parallel to the magnetic field. Without tilting, a similar effect can be obtained by electrostatic methods, for example, end plates may be placed near the ends of the cylindrical anode, and maintained at a potential such as to draw electrons towards them. Under these conditions, also, the electron paths will be spirals, and the behavior of the magnetron should be similar to that observed with tilting.



FIGS. 1 AND 2.

Numerous such magnetrons have been constructed and investigated by the writer at wave-lengths of from 7.5 to 12 cm. They show a distinct improvement over the older type, the efficiency being from two to three times greater. Outputs of about 2.5 watts at a wave-length of 9 cm have been obtained.

The static characteristic of a typical end plate magnetron is shown in Fig. 1. It will be observed that when the field magnet current I_H reaches the critical value the anode current I_P is cut off, as in the usual Hull type magnetron. Simultaneously, the end plate current I_e increases. As the critical point is passed through the electrons cease passing directly from filament to anode and describe longer, spiral paths to the end plates.

The effect of oscillations is shown in Fig. 2. The characteristic is essentially as before, except for peaks in the oscillation region. The increase in filament emission above the previous saturation value is apparently due to electron bombardment of the filament which causes additional heating and possibly some secondary emission.[6] Curve *d* indicates energy radiated from an antenna connected to the tube.

ERNEST G. LINDER

RCA Victor Company,
Camden, New Jersey,
April 16, 1934.

---

[1] Slutzkin and Steinberg, Ann. d. Physik **1**, 658 (1929); I. Ranzi, Nuovo Cimento **6**, 249 (1929); G. R. Kilgore, Proc. I. R. E. **20**, 1741 (1932).
[2] H. Yagi, Proc. I. R. E. **16**, 715 (1928).
[3] K. Okabi, Proc. I. R. E. **17**, 652 (1929).
[4] A. W. Hull, Phys. Rev. **18**, 31 (1921).
[5] H. E. Hollmann, Ann. d. Physik **8**, 956 (1931).
[6] E. C. S. Megaw, Nature **132**, 854 (1933).