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APPARATUS FOR RAPID ANALYSIS OF BORON 10

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APPARATUS FOR RAPID ANALYSIS OF BORON 10

by J. L. McKibben

ABSTRACT

An apparatus for rapid analysis of boron 10 or any strong slow-neutron-absorbing element is described. This was designed to be used by the boron 10 separation plant. A typical calibration curve is shown.

* * * * * * * * * * * * *

A rapid-analysis scheme for the B^{10} composition of the products of the separation plant at Whiting, Indiana, was needed in the summer of 1944. They had a mass spectrograph so could analyze samples, but it was too slow for rapid work. The author visited the plant in August, 1944, and determined that neutron absorption could be used to to measure the amount of B^{10} in a sample. They felt that they could analyze for total boron so this would still give abundance of B^{10}. Two methods appealed to the author, one consisted in straight absorption measurement, the second in counters being mounted at places on the plant where the vapor densities were high enough and well enought known so that the counters could use these as operating gas. This would give a more or less continuous record of the concentration of B^{10} in the methyether boron trifluoride complex. This later method seemed to be ideal but required too much development and was dropped.

Two requirements were placed upon the apparatus; that it take a small sample and that it be reliable. The first made it desirable to use a small chamber. The second made the use of an ionization chamber and simple D. C. amplifier or electroscope attractive, but had to be given up when it is found that the ionization from the gamma rays from a Ra-Be source was much greater than that due to the slow neutron reaction in boron trifluoride. This was true even for a great deal of lead shielding. Therefore a proportional counter, linear amplifier, scaler and high-voltage supply were needed.

A proportional counter had been used by R. Walker, LA-207, to measure B^{10} composition of B_4C. His counter was attached to the lid of a mason jar and the B_4C slurry was kept mixed with the water by stirring. It was decided to modify this design to make it more convenient to handle the many small samples. This was accomplished by placing the sample in a reentrant tube which set over the detector as shown in Fig. 1.

The counter was filled to about .5 atmosphere pressure of BF_3. Later this was changed to boron enriched BF_3. A .5 gram Ra-Be source left in its lead case, about 6" O.D., gave a counting rate of better than 100 per second so good statistics could be accumulated in 5 minutes. It was not necessary to shield the source to get a good plateau but it was desirable to do so to protect the operators. Water was used as the termalizing medium because of its convenience.

A soft glass absorption cell was first tried but the cell reduced the counting rate to nearly one-half. This reduces the sensitivity by even more due to selective absorption of neutrons so it was decided to also take along to the plant aluminum cells. These were coated with paraffin so the Bf_3 could be taken up by water from the ether polymer and placed in the cell for counting. The method proved fast and when I last visited the plant on October 21, 1944, it showed promise of being more reproducible than the mass spectrograph. It was necessary to use this measurement with a chemical measurement of total boron to get the concentration.

Fig. 2 shows a calibration curve determined by use of HBO_2 of known abundance and weight. This was dissolved in 60 cc of water. The abundance was checked by the

mass spectrograph. The ordinate is the logarithmic ratio of counts with boron solution in the cells to that with water alone. The abscissa is the concentration of B^{10} in millimols per milliliter. The method is seen to be quite sensitive and therefore requires small samples. If the sample covered all 4π of the solid angle of the counter and if the slow neutrons were all of a single energy then the points would fall on a straight line. This obviously is not the case so a calibration curve has to be determined for a number of concentrations of the sample in water.

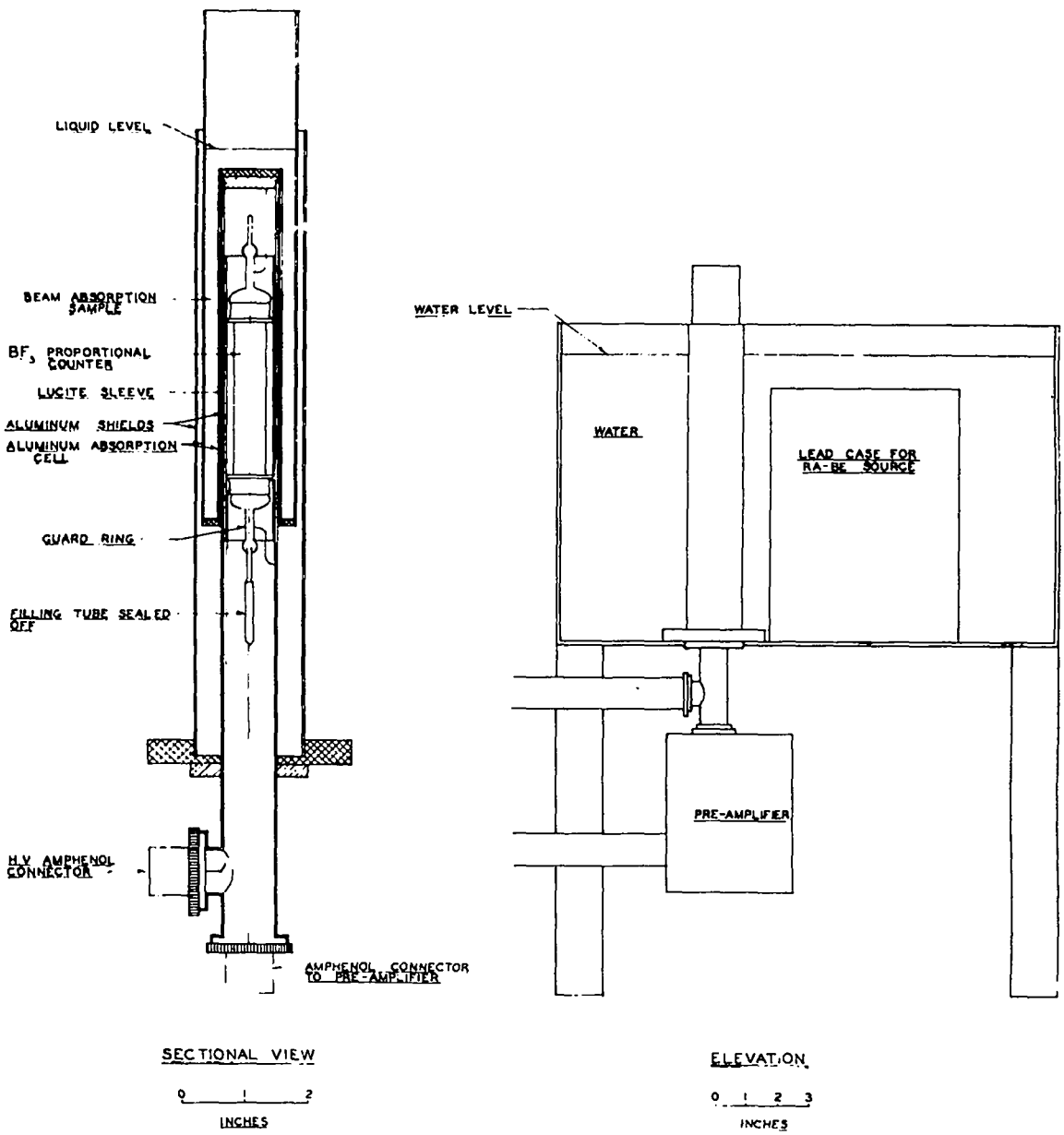
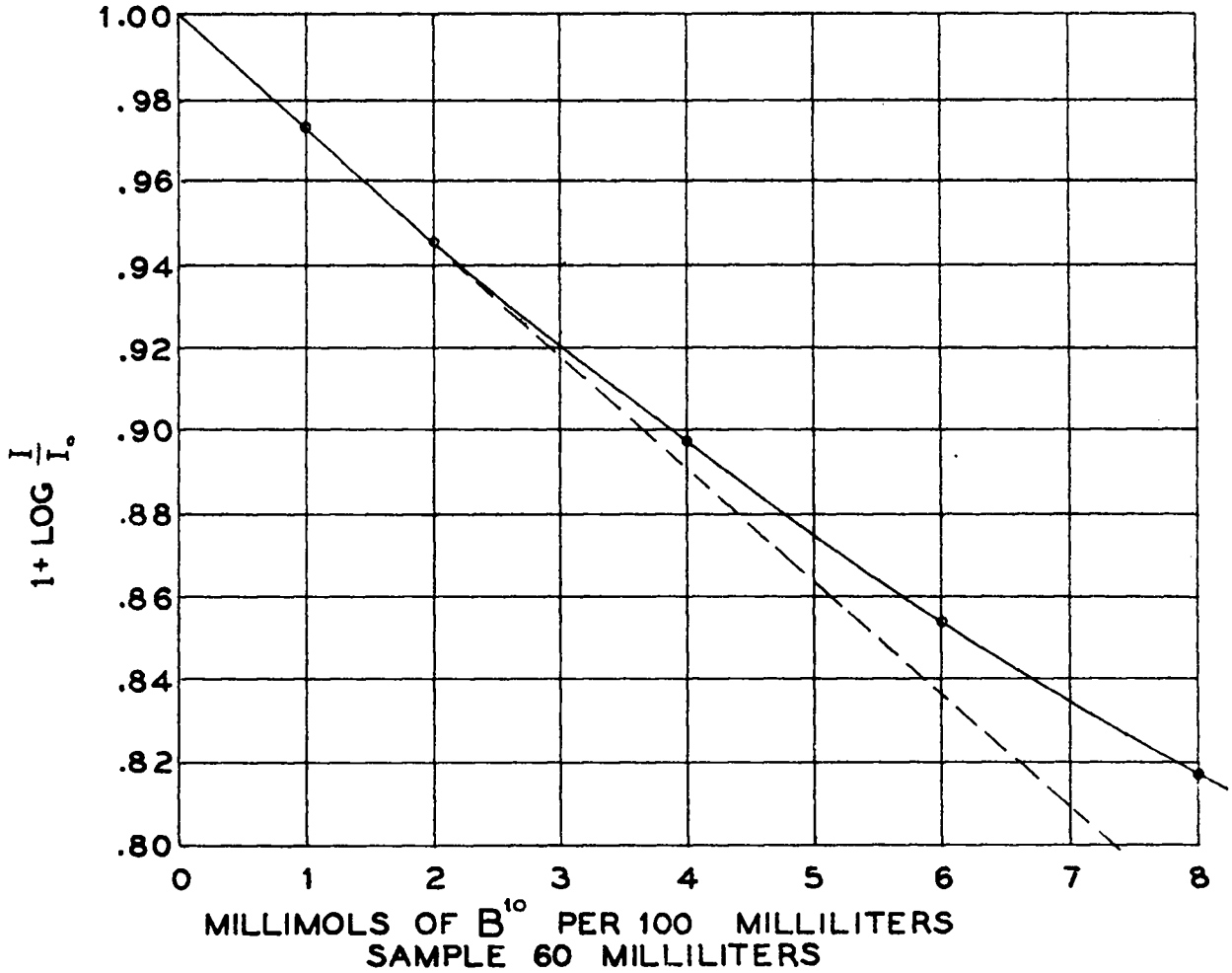


Figure 1. B^{10} analyser.



I_o = COUNTS WITH WATER IN CELL

I = COUNTS WITH WATER AND BORON IN CELL

Figure 2. Calibration curve for B^{10} analysis.

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