

Radiocarbon Concentration in Taiwan Wood

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(Received December 15, 1963)

Naturally occurring radiocarbon is measured using tree samples of Cypress grown in Taiwan. Acetylene gas is used as counting gas. The counter of effective volume of 1,034 ml is enclosed by a multianode gas flow counter which would supply the pulses of anti-coincidence. The whole counting system is shielded by iron sheets of 25 cm thickness. In this paper the results obtained with this apparatus are described.

1. INTRODUCTION

SINCE Libby *et al.*^{1), 2)} first discovered the existence of carbon-14 which has a half-life of 5,700 years, their method³⁾ for the measurement of carbon-14 has become a most important tool for dating the archaeological objects in various laboratories. But their technique for radiocarbon measurement has several disadvantages; (1) the preparation of pure carbon from the archaeological materials is somewhat troublesome, (2) the counter should be disassembled for each sample, and (3) poor efficiency.

In 1953, De Vries *et al.*⁴⁾ published the possibility of counting carbon as gaseous compound which can be easily brought into the counter. Then the carbon dioxide counting method has replaced the solid carbon method. However, it still has a defect, that is the CO₂ gas has only one atom of carbon per molecule, so that more gas sample must be taken into the counter to obtain good efficiency. Acetylene gas has good counter characteristics⁵⁾, has two atoms of carbon per molecule, and can be easily purified, though the preparation of the gas from the sample is slightly laborious. These properties, therefore, have conducted us to use the acetylene gas as counting gas in this experiment.

The present paper presents the results of the measurement on the radiocarbon concentration in tree rings of Cypress which gives an information of the annual average of the concentration of carbon-14 in the atmosphere. The measurements were done with an acetylene filled proportional counter enclosed by an anti-coincidence counter and shielded by iron plates.

- 1) E. C. Anderson, W. F. Libby, *et al.*, *Phys. Rev.* **72**, 1931 (1947)
- 2) E. C. Anderson and W. F. Libby, *Phys. Rev.* **81**, 64 (1951)
- 3) W. F. Libby, *Radiocarbon Dating* (University of Chicago Press, Chicago, 1952)
- 4) H. L. De Vries and G. W. Barendsen, *Physics*, **19**, 987 (1953).
- 5) K. Kigoshi and Y. Tomikuda, *Bull. Chem. Soc.* **33**, No. 11 (1960).

2. EXPERIMENTAL PROCEDURES

(a) Construction of Proportional Counter

A copper tube proportional counter (effective volume: 1034 ml) was placed in the middle of twenty propane gas-flow counters of 60cm length and the whole counting system was located at the center of an iron shield of 25cm thickness. The proportional counter used had the dimension of 3.5cm in diameter and 52cm length. For the center wire of the counter stainless wire of 0.05mm was used. The pulses from the proportional counter are delayed about three micro-seconds and are mixed with the pulses from the anti-coincidence counters. The background of the counter was 6.61 ± 0.08 counts per minute. Fig. 1 shows the whole counting system together with an iron shield used in this experiment.

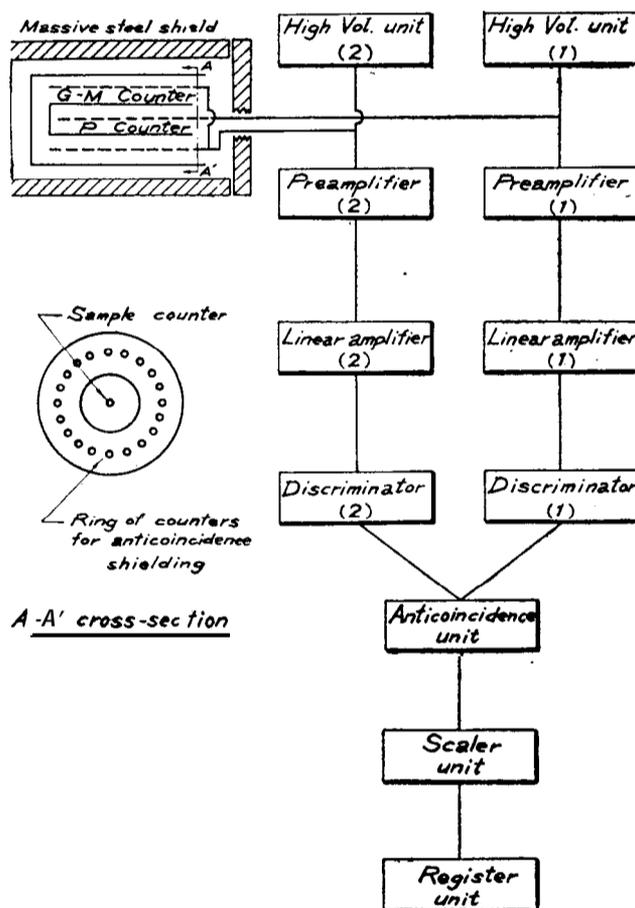


Fig. 1. Schematic arrangement of counting system

(b) Preparation of Acetylene From a Tree Samples

A tree sample was heated in metal container in order to remove the volatile organic substance. In this procedure the samples were changed to charcoal. The charcoal was

converted into strontium carbonate by the following procedures; combustion in a current of oxygen, absorption of carbon dioxide in 6N ammonia water, precipitation of calcium carbonate from an ammonium carbonate solution, evolution of carbon dioxide with hydrochloric acid from the calcium carbonate, absorption of carbon dioxide into ammonia water and precipitation of strontium carbonate (These aspects are shown in Fig. 2). Then, the preparation of strontium carbide from the strontium carbonate was done in stainless steel tube. That is, the mixture of strontium carbonate of 25g and magnesium

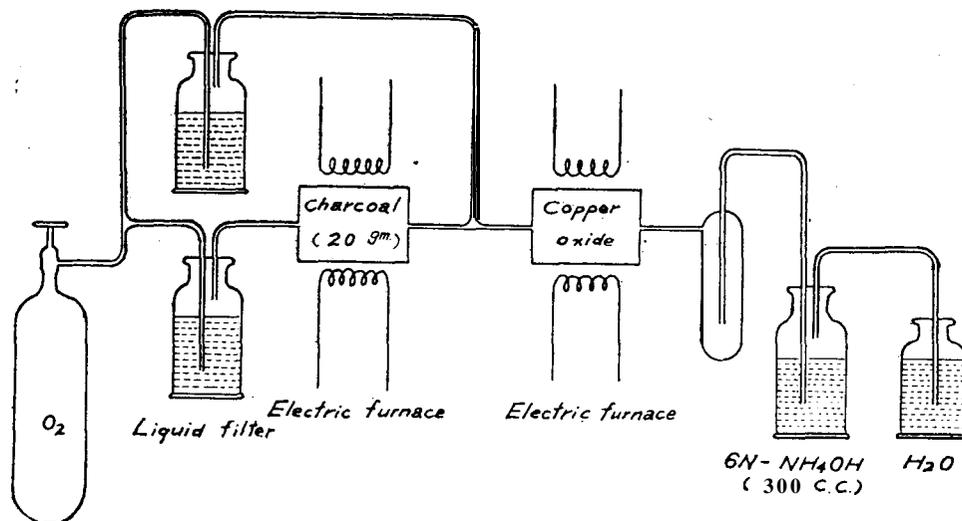


Fig. 2. Apparatus for Combustion

powder of 25g was heated in stainless steel tube (5.1 cm dia 105 cm length) (as shown in Fig. 3) connected to a vacuum line. When the temperature rose to $400^\circ C$ the pumping system was cut by the metal cock. The best way to get a good result was to heat the tube up to $850-900^\circ C$ for more than 4 hours, very often a kind of explosion was observed during the heating up to $700^\circ C$. It may be caused by the following processes;

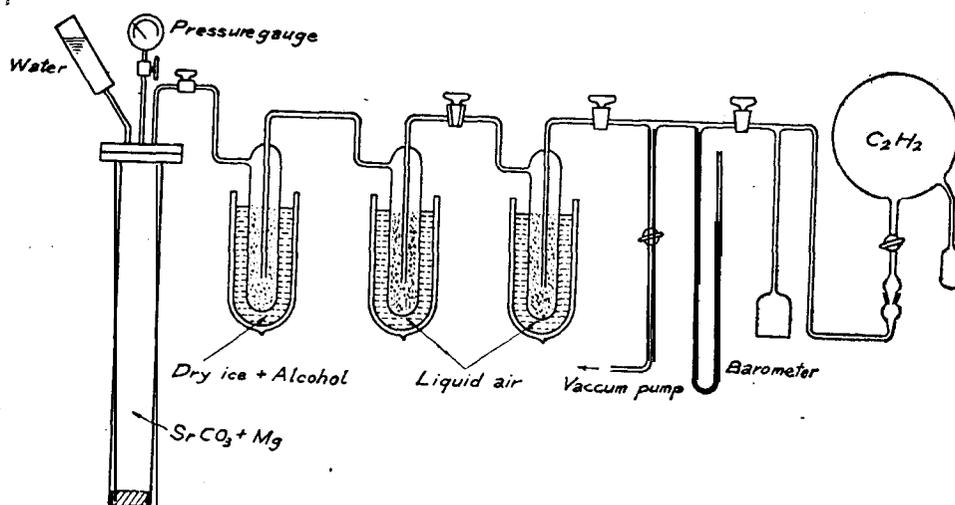
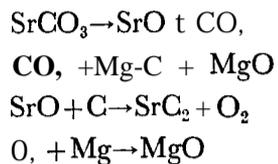


Fig. 3. Apparatus for Preparation of acetylene.



and the explosion may be chiefly due to oxygen, The pressure gage was set to be able to observe the inner pressure of tube. In most cases, it registered about 6kg/cm^2 on every explosion.

After the preparation of carbide, the stainless steel tube was connected to vacuum line with three cold traps for the purification of acetylene (as shown in Fig. 3). Acetylene was evolved by adding water through the side tube, dried with dry ice cold trap, and separated from the hydrogen by a trap cooled with liquid air. To remove effectively the contaminated radon from the acetylene, the acetylene had to be stored in a flask more than three weeks before the activity measurement was made.

(c) Counting Procedure

Acetylene gas stored more than three weeks was filled in the proportional counter after the purification by liquid air, and the characteristic curve was measured. According to the characteristic curve and the pressure in the counter on appropriate high voltage was applied to the counter. Through the whole experiment, the operating voltage was $V = 3P + 2300 \pm 50$ volts, where P is the pressure of acetylene in mm Hg and was in the range of 500 to 750 mmHg.

3. RESULTS

Table 1 summarizes the data of the measurements of radiocarbon concentration in tree samples which was obtained from the Rang Yang Area in Northern Taiwan. This tree has an age of about 750 years estimated from tree rings and was cut in July 1962.

The first column of Table 1 indicates the intervals in which the tree rings grew. The second column shows observed counts per minute for one gram carbon of each sample.

The third column gives the concentration of carbon-14 in tree rings at the year indicated in the first column. The concentrations are normalized to the value of measured concentration between 1891 and 1911. The fourth column shows the data obtained by K. Kigoshi et al.⁵⁾ There are a discrepancy between the two measurements, and may be explained by the local variation of meteorological factors.

TABLE 1

Table 1. Variation of C¹⁴ concentration in tree ring grown in 1491 and 1911

Intervals of grown of tree ring	Counts per min. per gram.	Carbon concentration	Data by K. Kigoshi Counts per min. per gram.
1491-1511	10.24 ± 0.19	0.843 ± 0.024	
1591-1611	9.49 ± 0.18	0.782 ± 0.024	
1691-1711	11.20 ± 0.16	0.922 ± 0.022	
1791-1811	11.21 ± 0.24	0.923 ± 0.024	12.02 ± 0.18
1891-1911	12.14 ± 0.24	1	12.47 ± 0.18

4. ACKNOWLEDGMENTS

The authors are much indebted to S. Y. Lin, Y. T. Hsu, F. L. Chen., C. K. Haung and L. Shieh for their valuable assistance at all stages of work. Also they wish to express their gratitude to the Forestry Bureau for presenting the tree samples of Cypress. This work was supported by the National Council on Science Development.