Cosmic-Ray Neutron Monitor at Syowa Base, Antarctica*

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水を利用した宇宙線中性子観測装置*

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要　　旨

当初，南極観測用に製作された宇宙線中性子観測装置は，IGY用として設計されたもので，全体の重量が 6 トンを超えるため，ヘリコプター輸送に適さない．そこで重量軽減化の方法として，

（1） ニュートロン減速剤として，パラフィンの代りに現地の海水を利用する．

（2） 真空管方式の増幅，計数装置をすべてトランジスター化する．

の 2 点から，新しい観測装置を製作した．この装置は重量約 500 kg で，第 4 次観測隊により無事基地へ空輸された．観測は 1960 年 3月3日より開始された．観測結果の一部として，日平均値の変化及び5月4日の宇宙線異常増加の結果を示した．

A small-sized, light-weighted neutron monitor was constructed for cosmic-ray observations at the Antarctic. Its construction and characteristics are described on comparing with the standard neutron monitor for the IGY. A part of the data obtained by using it, especially, the cosmic-ray unusual increase on May 4, 1960 is represented.

1. Introduction

The neutron monitor first constructed for the Antarctic observation was the same as that of the Simpson type for the IGY and its total weight amounted roughly to 5 tons including paraffin-lead pile and the electronic apparatus. It was, however, practically impossible to land such heavy apparatus at Syowa Base, Antarctica (69°00′S, 39°35′E). Because the condition of ice-sea in the neighbourhood of the Base was extremely bad for the navigation of an ice-breaker that she could not approach the Base except on the first expedition, 1956.

Since the third expedition, 1958, the transportation method of apparatus and goods from ship to the Base was changed from the land-carriage by snow-cars into the air-carriage by two helicopters. So it was necessary to reduce the weight of all research apparatus and consequently the weight of the neutron monitor was restricted within

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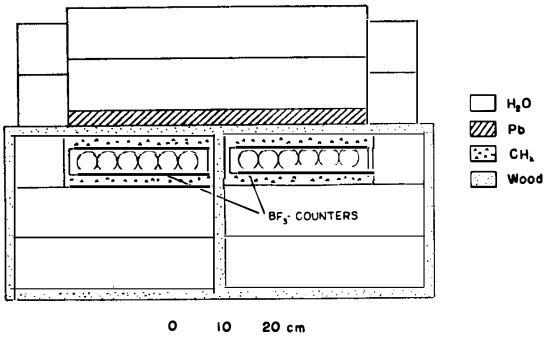
500 kg. Thus a new neutron monitor was made and set up at the Base on February, 1960. The present report gives the descriptions of it with a part of the data obtained by using it.

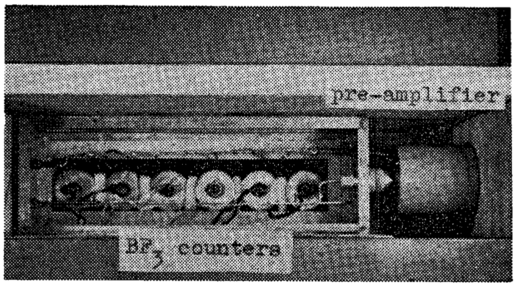
2. Neutron pile

As a slowing down material for neutrons, the utilization of paraffin can not be considered at all. For even if the standard neutron pile such as the IGY type might be used without lead, only one neutron counter[1] could be available under the condition of limited weight 500 kg. Such a monitor has poor statistical accuracy in counting rates and is not appropriate for cosmic-ray observations.

Fortunately, it is rather easy to draw up sea-water at Syowa Base in summer. So, sea-water was utilized as a neutron moderator in place of paraffin. The thickness of water is restricted by the weight of the water container made of iron. Although the size of the standard Simpson type pile is fairly large, the reduction of the number of neutron counters is unfavorable from the points of statistical accuracy. Therefore, the counters must be arranged so closely as in Fig. 1 in order to reduce the whole



(A) Geometry of neutron pile.



(B) Interior of half part of the pile.

Fig. 1.

pile size, or its total weight. Even in that case the thickness of water permitted from the limited weight is less than 20 cm.

The most serious problem is related to the heavy lead which is used as a local neutron producer. If twelve counters arranged as in Fig. 1 are covered by 5 cm thickness of lead as the standard pile, then the total weight of lead amounts to about 800 kg. Of course such a construction is out of question under the present severe conditions. Thus the utilization of lead was obliged to be restricted to the upper part of the counters. In that case, a preliminary experiment was carried out in order to decide the most efficient thickness of lead from the relationship between its weight and neutron counting rates. Results obtained are shown in Fig. 2, where solid and open circles correspond to piles of water and of paraffin, respectively. The ordinate is the efficiency of each pile against the standard pile of which efficiency is taken as 1 and the abscissa is the thickness of lead above the counters. Since it is clear from a

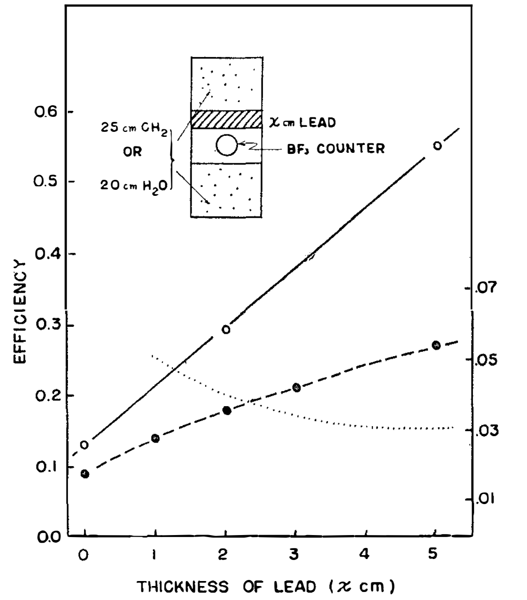


Fig. 2. Efficiencies of test piles against the thickness of lead. (Upper is thier arrangement.) Solid and open circles correspond to water pile and paraffin pile, respectively. Efficiency of the standard pile for the IGY is taken as 1. Dotted curve is differential of dashed curve (by right-hand scale).

dotted line in Fig. 2 that the first 1 cm thickness is most efficient, firstly many sheets of 1 cm lead were prepared and besides piled up to 3 cm in total thickness under the lucky condition at the Antarctic. The total weight of the final neutron pile is about 380 kg and its whole view is given in Fig. 3.

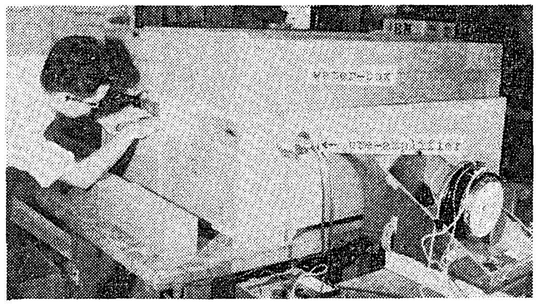


Fig. 3. The whole view of neutron pile.

3. Electronic apparatus

As the duplicate electronic apparatus[2)] prepared for the first expedition was about 600 kg in total weight including recorders, they had to be reconstructed in a lighter weight.

At first, all of the electronic equipments were altered from the vaccum tube system to the transistor system. New equipment includes both a linear amplifier probe and a scaler with high voltage supply. One piece of equipment is about 10 kg in weight. Next, the recorder used is the digital pen-writing type of which the mechanism is the same as the former recorder[2)]. The different points of the new recorder from the former are that its weight is one half and it has time mark every minute. The total weight of the duplicate equipment including recorders is about 40 kg and their whole view is seen in Fig. 4. Thus adding other necessaries of 80 kg, the present neutron monitor could be made within the limited weight, about 500 kg.

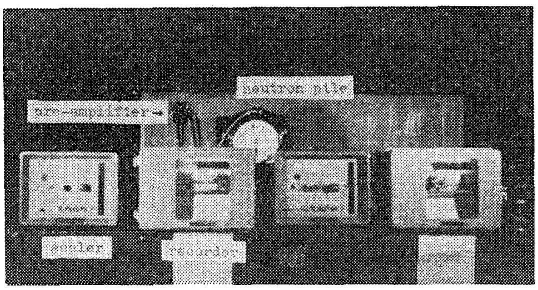


Fig. 4. The whole view of electronic apparatus.

4. Observational results

The neutron monitor mentioned above has been in operation since March 1960 at Syowa Base, where counting rates were about 2600 per hour. As the counting rates at the Antarctic estimated from the counting rates, 120,000 per hour, at Mt. Norikura station are about 4200, a significant difference is found between both numerical values. But the reason for this discrepancy is still open question.

The barometric coefficient, $-0.70\pm0.02\%/\mathrm{mb}$, was derived from the data of March 1960. The day-to-day variation of the intensity corrected for pressure is shown in Fig. 5 together with that obtained at Mt. Norikura, for comparison. In spite of in-

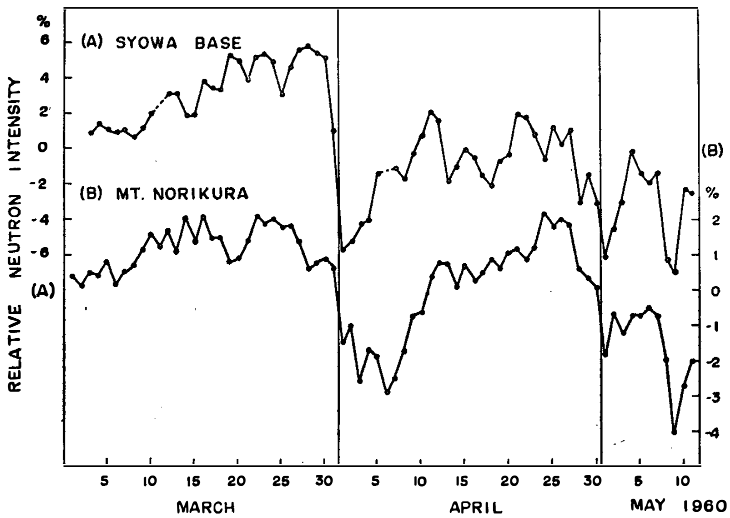


Fig. 5. Day-to-day variation in cosmic-ray neutron intensities. The upper curve is for Syowa Base and the lower for Mt. Norikura. (Note that scale (A) is twice scale (B).)

sufficient statistical accuracy, results obtained at the former are not so inferior to those at the latter because of their larger intensity variations. For example, in case of a Forbush decrease that occurred on March 30, the amount of the decrease at Syowa Base is about three times that at Mt. Norikura. This fact means that the statistical error at Syowa Base corresponds to one third of its practical value. Accordingly, it seems that the present neutron monitor is useful for study of the phenomena showing such a large variation as Forbush decrease or unusual increase.

On May 4, 1960, the sixth cosmic-ray unusual increase was observed in several stations[3)]. Neutron monitor at Syowa Base too detected it at that time. 15-minute values before and after the increase are shown in Fig. 6 and especially one-minute values from 1025 to 1050 in Fig. 7 are available to determine the starting time and the time of maximum intensity. It is clear from Fig. 7 that the intensity began to increase between 1031 and 1035 and then become the maximum at 1042, where accuracy in time is within 0.5 minute. The maximum was 44% for 15-minute values above the normal intensity. While, no increase was observed by meson monitor in operationt here. These data could be available for study of the solar cosmic radiation.

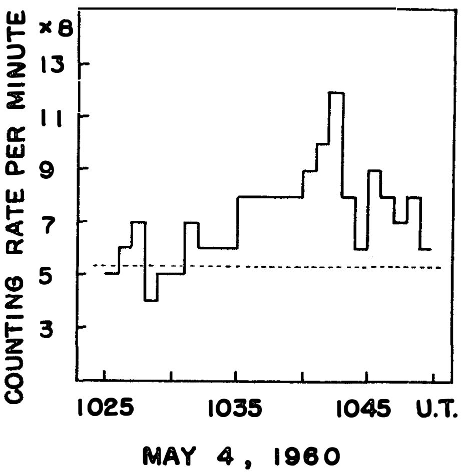


Fig. 6. Variations of 15-minute values in percent of cosmic-ray neutron intensities of May 4, 1960.

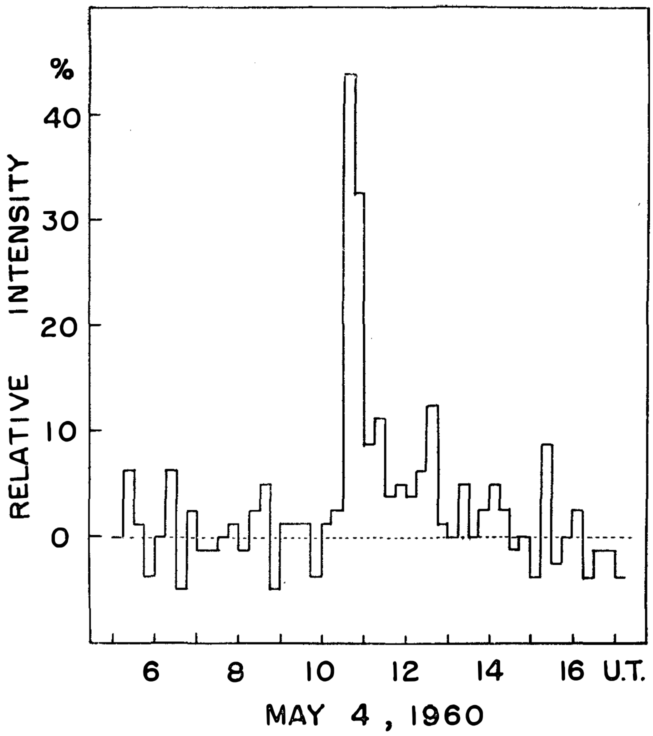


Fig. 7. Variations of one minute values in counting rates of cosmic-ray neutron intensities on May 4, 1960. Dotted line indicates the normal intensity level given in Fig. 6.

Table 1. Cosmic-ray intensity increase on May 4, 1960.

15-minute values, corrected for pressure, scaling factor-8.

Time (UT) beginning	Intensity	Time	Intensity	Time	Intensity	Time	Intensity
09 00	81	10 00	81	11 00	87	12 00	83
09 15	81	10 15	82	11 15	89	12 15	85
09 30	81	10 30	115	11 30	83	12 30	92
09 45	77	10 45	106	11 45	84	12 45	81

One minute values, corrected for pressure, scaling factor-8.

10 26	6	10 32	6	10 38	8	10 44	6
27	7	33	6	39	8	45	9
28	4	34	6	40	9	46	8
29	5	35	8	41	10	47	7
30	5	36	8	42	12	48	8
31	7	37	8	43	8	49	6

Notes added in the proof One of the authors, S. FUKUSHIMA, was lost in a fierce blizzard in the Antarctic on October 17th, 1960. The present paper is one of his posthumous works.

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