SHORT COMMUNICATIONS

COSMIC RAY INTENSITY INCREASE ON JANUARY 28, 1967*†

By L. V. Sud‡

During the present solar cycle, which started in October 1964, the ground-based cosmic ray detectors have so far recorded two increases in the intensity of cosmic rays. The first one was observed on July 7, 1966 and the other on January 28, 1967. Both these events were somewhat unusual in their characteristics.

The July 7, 1966 increase was the smallest ever recorded and was associated with a visible solar flare in the most northerly location so far known to produce an increase of cosmic ray intensity in ground-level detectors (Ahluwalia, Sud, and Schreier 1967).

The January 28, 1967 increase was a moderate one with a maximum amplitude of $\gtrsim 24\cdot1\%$ recorded at Sulphur Mt. and a minimum amplitude of $\sim 1\cdot4\%$ recorded at Dallas. The increase was isotropic throughout. The rigidity spectrum of the increase was rather flat with $\gamma = -1\cdot7$ and this value remained constant from the time of the maximum through the intensity decay. The decay was slow with a characteristic decay time of $\sim 5\cdot2$ hr.

In Figure 1 are plotted the pressure-corrected hourly data from 23 stations for January 28, 1967. Table 1 summarizes the information about the observing stations and their detectors, whose data have been used for this analysis. From Figure 1 the following features can be easily seen.

(1) The increase had a large rise time ($\sim$ 3–4 hr).

(2) Stations having a vertical cutoff rigidity of $> 4\cdot35$ GV did not observe the increase.

(3) The largest increase was recorded by the Sulphur Mt. super-neutron monitor and the smallest by the Dallas monitor.

(4) None of the meson monitors registered the increase.

In Figure 2 are plotted pressure-corrected 5 min neutron monitor data from Churchill, Alert, Resolute, Goose Bay, Inuvik, and Deep River. Onset times have been indicated by arrows at points O and are given in the caption to the figure. There is a spread of about 20 min in the onset times. In view of the fact that there are large statistical errors ($\sim 0\cdot4\%$) associated with these data, we are led to believe that the additional flux was isotropic even at the outset. The time at which

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maximum flux was recorded at different stations together with the magnitude of the increase, determined from hourly data (except for College), have also been listed in Table 1.

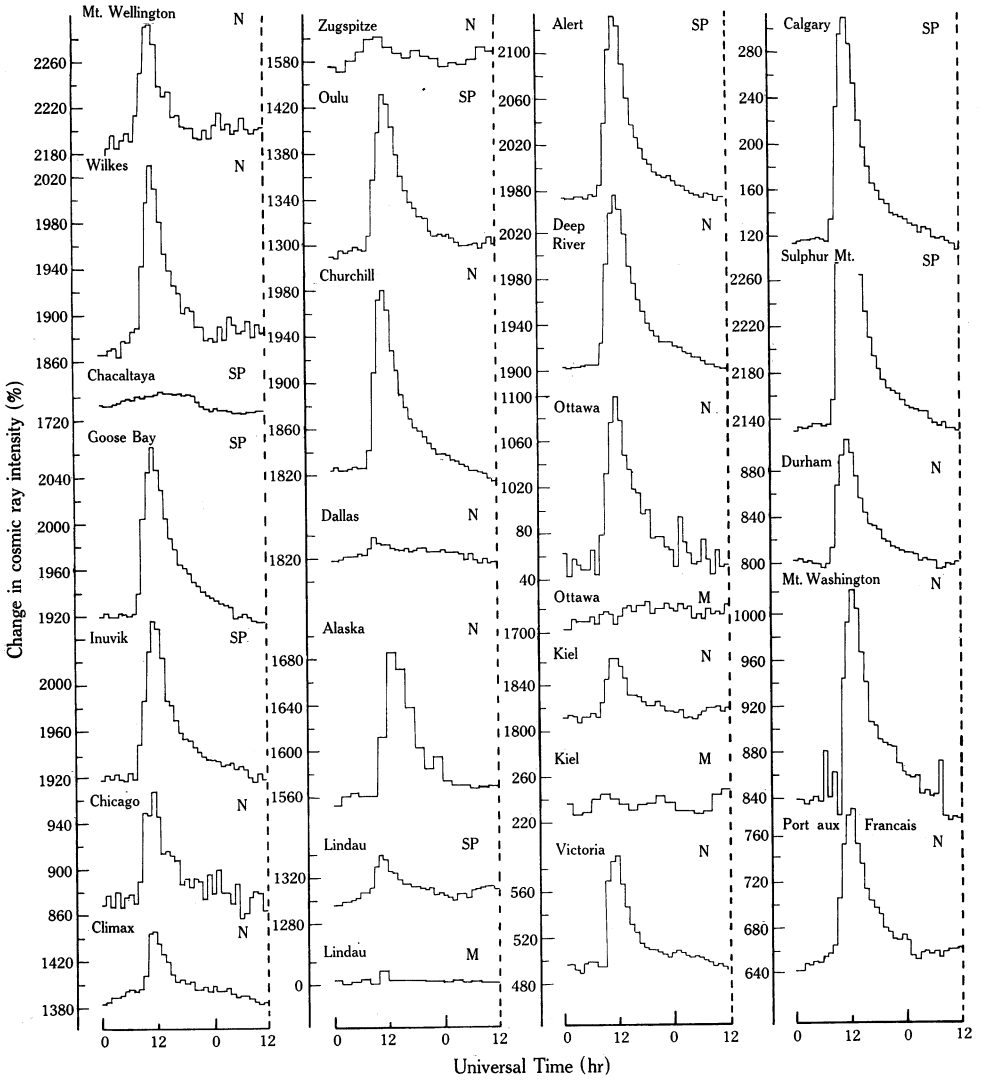

Fig. 1.—Pressure-corrected hourly data from 23 stations for the cosmic ray intensity increase on January 28, 1967 (N, neutron detector; M, meson detector; SP, super-neutron detector).

We find that the rigidity spectrum for the event, starting from the maximum phase, remains constant throughout the decay. The value of the exponents is $1{\cdot}7 \pm 0{\cdot}2$. Kodama (1967) has obtained a similar value for γ from the multiplicity measurements during the flare period. This value is very small compared with that

for other cosmic ray increases. Its constancy throughout the event suggests a complete isotropy of the additional flux.

Following McCracken (1962), Figure 3 shows the dependence of cosmic ray flux upon direction at 1400 U.T. on January 28, 1967. The distribution of points and the corresponding flux magnitudes around the position of the Sun confirm that there were no preferred directions of arrival for this event and that the flux was more or less isotropic.

TABLE 1

OBSERVING STATIONS AND COSMIC RAY INCREASE DATA

N = neutron monitor, M = meson monitor, n.o. = increase not observed

Station	Vertical Cutoff (GV)	Detector	Time of Increase (hr U.T.)		Magnitude of Increase* (%)	
			N	M	N	M
Calgary	1·09	N	11·5±0·5	—	19·4	—
Sulphur Mt.†	1·14	N		—	> 24·1	—
Churchill	0·21	N	11·5±0·5	—	15·4	—
Durham	1·41	N	11·5±0·5	—	11·2	—
Mt. Washington	1·24	N	12·5±0·5	—	18·2	—
Port aux Francais	1·19	N	12·5±0·5	—	13·4	—
Victoria	1·86	N	11·5±0·5	—	9·7	—
Ottawa	1·08	N, M	11·5±0·5	n.o.	15·6	n.o.
Lindau	3·00	N, M	10·5±0·5	n.o.	4·3	n.o.
Kiel	2·29	N, M	11·0±0·5	n.o.	5·1	n.o.
Deep River	1·02	N	11·5±0·5	—	14·9	—
College‡	0·54	N	11·0±1·0	—	12·3	—
Chacaltaya	13·10	N	n.o.	—	n.o.	n.o.
Alert	< 0·5	N	11·5±0·5	—	15·7	—
Goose Bay	0·52	N	11·5±0·5	—	14·7	—
Inuvik	< 0·18	N	11·5±0·5	—	13·8	—
Dallas	4·35	N	9·5±0·5	—	1·5	—
Chicago	1·72	N	11·5±0·5	—	9·7	—
Climax	3·03	N	11·5±0·5	—	5·2	—
Zugspitze	4·24	N	11·0±1·0	—	3·0	—
Oulu	0·81	N	11·5±0·5	—	13·2	—
Wilkes	< 0·05	N	11·5±0·5	—	15·3	—
Mt. Wellington	0·05	N	11·5±0·5	—	10·1	—

* Measured from the point where monotonic increase began.

† A break in the data from this station prevented determination of the time of increase.

‡ Only bihourly data were available from this station.

The decay of intensity followed an exponential law. Mathews and Wilson (1967) found that the characteristic decay time was $\sim 5 \cdot 2$ hr. This implies a somewhat slower decay than for most of the other increases.

Wilson, Mathews, and Johnson (1967) found the absorption length of the additional flux to be 103 ± 3 g cm^{-2}, which is in agreement with the value for solar flux and suggests that the additional flux was of solar origin.

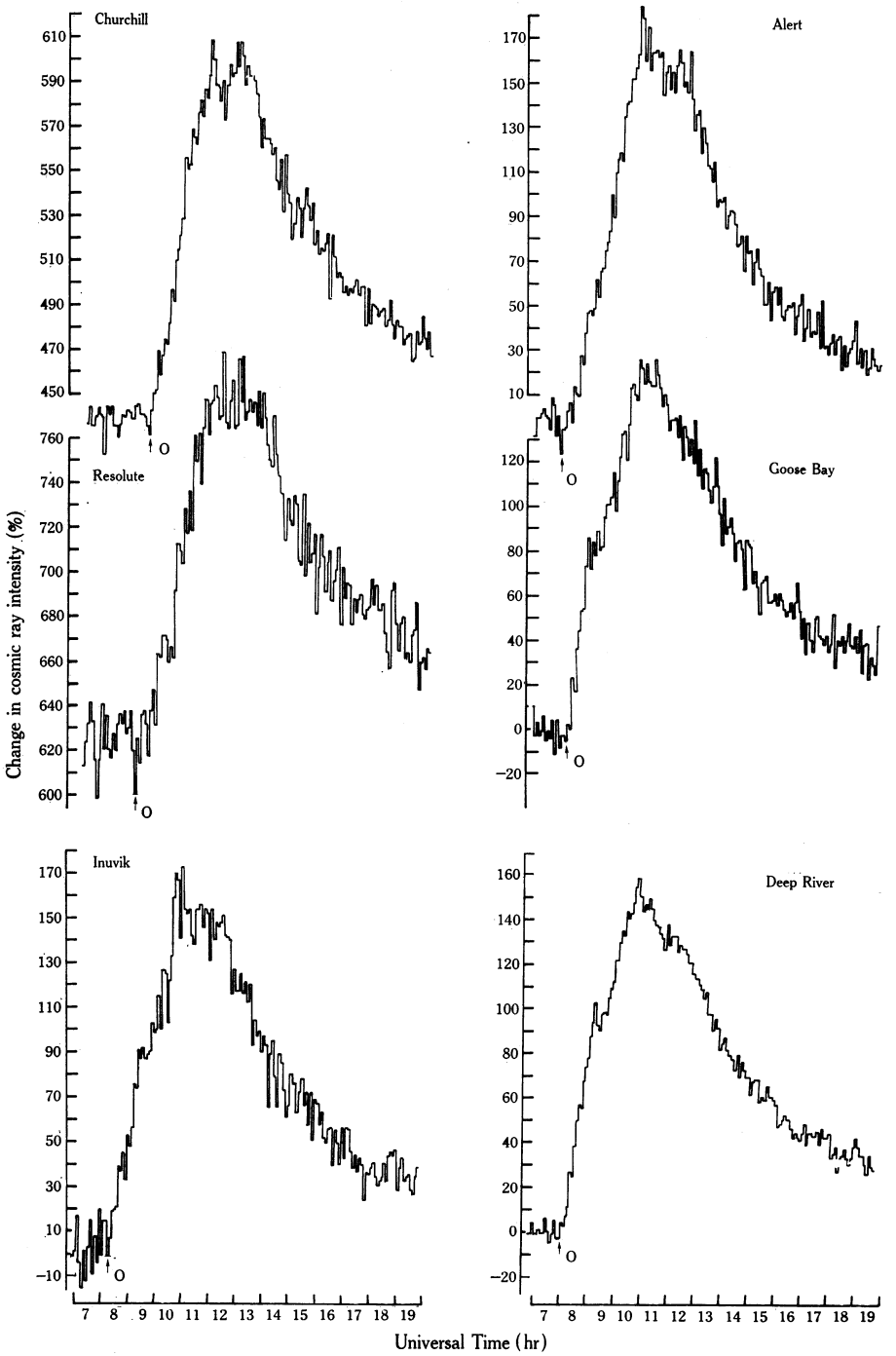

Fig. 2.—Pressure-corrected 5 min neutron data from 6 stations for the cosmic ray intensity increase on January 28, 1967. Arrows at the points O indicate the onset times: Churchill $8 \cdot 40 \pm 0 \cdot 04$, Alert $8 \cdot 08 \pm 0 \cdot 04$, Resolute $8 \cdot 40 \pm 0 \cdot 04$, Goose Bay $8 \cdot 33 \pm 0 \cdot 04$, Inuvik $8 \cdot 40 \pm 0 \cdot 04$, Deep River $8 \cdot 25 \pm 0 \cdot 04$ hr U.T.

The most unusual feature of the January 28, 1967 increase is that it is not possible to associate it with any flare on the visible side of the Sun. There is no magnetic storm a week before or after the event. The other associated phenomena, such as PCA or ionospheric disturbances, that are normally expected with an increase of this magnitude were not observed. This leads to the possibility that fairly large increases in intensity of cosmic rays, of solar origin, may occur without any association with a visible solar flare.

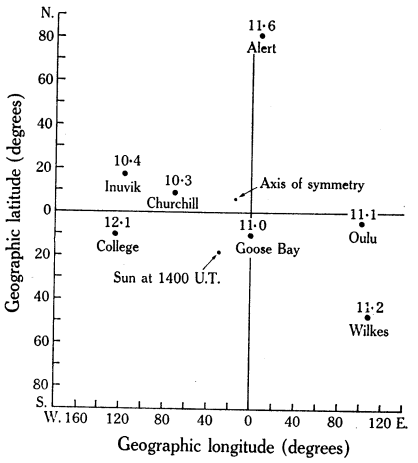

Fig. 3.—Dependence of cosmic ray flux of solar origin on direction at 1400 U.T. on January 28, 1967.

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