Discussion

Gold, T.: Another criterion than the suddenness of onset must be used to differentiate between auroral and P.C.A. effects: otherwise one will never recognize sharp changes in PCA. One is particularly interested whether at the time of SC there does occur a sharp change in the PCA. flux.

Beynon, W. J. G.: In the results for high latitude stations shown here I note that the occurrence of a Sudden Commencement during a period of Polar Cap Absorption is associated with an increase in ionosphere absorption. Any explanation of this must take account of the opposite effect which seems to occur at lower latitudes vir that under the same circumstances ionospheric absorption is actually decreased.

Sarabhai, V.A.: Ramanathan has shown that at Ahmedabad the absorber of 25 mc/S is greatly reduced after S.C.

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INTERNATIONAL CONFERENCE ON COSMIC RAYS AND THE EARTH STORM Part II

II-3B-9. The Solar Cosmic-Ray Increase of November 20, 1960

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Visual, radio, and neutron monitor observations indicate that a major solar flare situated some 20° behind the W limb of the sun occurred on Nov. 20, 1960, and produced high energy particles which reached the earth. A magnetic storm and a Forbush decrease may have been caused by this flare. The data from 30 neutron monitors and ten meson monitors for the whole month of Nov. 1960 are shown.

The solar longitude of the great flare of November 12, 1960, has been given by different observatories in the range 01 W to 08 W. Assuming a 27-day rotation period for the sun, this sunspot region (McMath 5925), eight days later, on November 20, 1960, must have been at solar longitude about 110 W, some 20 degrees past the limb on the far side of the sun.

At 2023 UT on November 20, there was a strong emission of 10.7 cm radio noise, illustrated in Fig. 1 (Covington and Harvey, 1961).

For some minute prior to this, elevated parts of a major solar flare behind the W limb and probably above the region McMath 5925 were visible. At 2023 UT a high-speed luminous cloud was explosively ejected, as illustrated in Fig. 2 (Hansen, 1961).

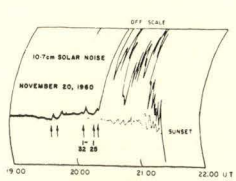

Fig. 1. The large increase in flux observed by Covington and Harvey, at Ottawa, started at 2023 UT and continued until the end of observations.

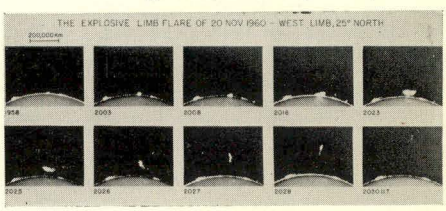

Fig. 2. Photographed at Climax by D. Keith Watson, Robert James, Herbert Richey and Robert Eddy. Reproduced courtesy Richard T. Hansen.

Reprint with larger figures is obtainable from the Authors on request.

Starting at 2055±10 UT on November 20, a solar cosmic-ray increase was observed (Carmichael, Steljes, Rose and Wilson, 1961). The shape of the increase at Deep River, and at Sulphur Mountain, Canada, is illustrated in Fig. 3. The onset appears to have been delayed about 30 minutes with respect to the radio noise and the visible indications. The rise to maximum took about one hour, which is relatively slow. The meson telescope at Sulphur Mountain was not affected.

Observations made by the world network of stations (received by direct mail) during the month of November 1960 are exhibited in the next four Figures. The great increases on Nov. 12 and 15 have been allowed to go off-scale on these plots. The increase of Nov. 20 can be seen clearly at all North American stations, Fig. 4, from Resolute in the Arctic, to Climax where the geomagnetic cutoff is 2.77 GV. At the polar stations, Resolute and Thule, the increase seems to be fully as large as, for example, at Deep River. This indicates that the solar particles on this occasion were essentially isotropic in the vicinity of the earth, which is consistent with the long delay of the onset of the increase and the slow rise to maximum.

The upper part of Fig. 5 shows the increase at southern stations, and the lower part of Fig. 5 the absence of any increase at equatorial stations. All the graphs have been adjusted so as to equalize the Forbush decreases of Nov. 12 and 13. About 2000 UT on Nov. 21, one day after the flare, there appears to have been a Forbush decrease which lasted for four days and ended very suddenly on Nov. 25. The end of the Forbush decrease on Nov. 25 is marked by the sudden onset of diurnal fluctuation which were particularly strong at the equatorial stations but almost completely absent at the polar stations. Resolute, and McMurdo. The longitude effect characteristic of diurnal fluctuations is well seen in Fig. 5.

Fig. 6 shows stations in Europe and Africa. Only at Leeds, where the cutoff rigidity is 1.71 GV, can the solar increase be seen. All

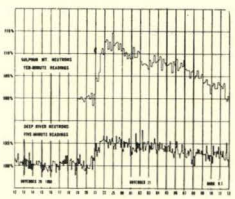

Fig. 3. Sulphur Mountain readings by Brian G. Wilson, reproduced courtesy D. C. Rose.

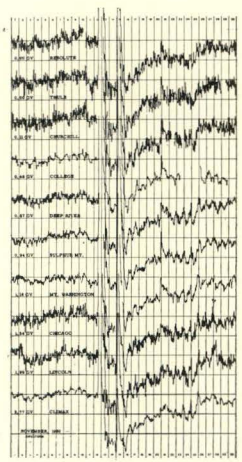

Fig. 4. The horizontal scale lines are spaced at intervals of 5% of the average counting rate during the first 11 days of the month for stations with cutoff smaller than 1 GV. The curves of all other stations have been expanded vertically with respect to the scale so as to equalize the sizes of the Forbush decreases (see, "The July 1959 Events," UGGI Monograph No. 7, 10 (1960)).

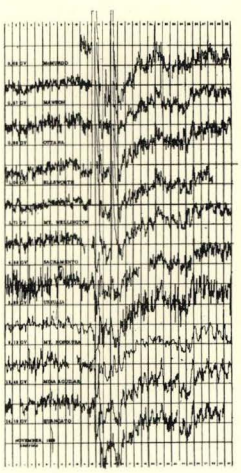

Fig. 5. As for Fig. 4.

these stations exhibit very clearly the Forbush effect and its sudden ending on Nov. 25 with onset of a strong diurnal effect of the galactic cosmic radiation. For completeness, we include in Fig. 7 the collected results from the meson telescopes, corrected for pressure only.

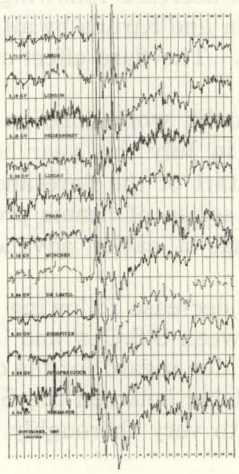

Fig. 6. As for Fig. 5.

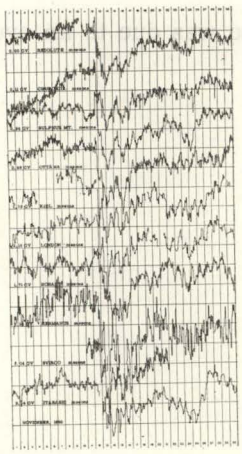

Fig. 7. As for Fig. 6.

Following the solar flare of Nov. 15 and the ensuing magnetic storm lasting until Nov. 17, geomagnetic activity subsided, and on Nov. 20 conditions were perfectly quiet. A magnetic storm began slowly at 0440 UT on Nov. 21, only eight hours after the solar flare. However, the Deep River magnetometer record for Nov. 21 and 22, Fig. 8, shows that a superposed sudden-commencement storm may have started at 1800 UT on

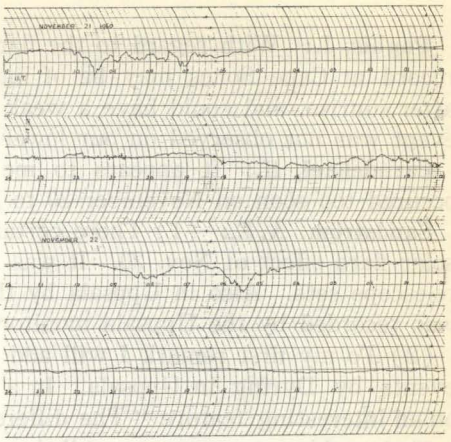

Fig. 8. The horizontal field H recorded at Deep River. Note reverse direction of time scale.

Nov. 21, 20 hours after the flare. The time of start of the Forbush decrease would be consistent with this later storm.

In summary, elevated parts of a solar flare 20 degrees behind the W limb of the sun were seen on Nov. 20, 1960, exhibiting the explosive ejection of a luminous cloud and strong 10.7 cm radio noise. Half-an-hour later, a small, slowly rising cosmic-ray increase occurred which seems to have been produced by solar particles of magnetic rigidities less than 3 GV and incident isotropically on the earth. The event was followed by magnetic storm activity and there was a Forbush decrease one day later which lasted for four days and ended very suddenly with onset of unusually strong diurnal fluctuations.

This is the first occasion on which radiation at ground level has been observed to originate from the far side of the sun. It is of interest to determine whether or not the ensuing magnetic and Forbush disturbances were in fact caused by this far-side flare. The long onset delay, slow rise time, and isotropy of the radiation at the earth are to be noted and can probably be explained only in terms of magnetic field guidance of the particles from the sun to the earth.

References

1) A. E. Covington and G. A. Harvey: Phys. Rev. Letters **6** (1961) 51.
2) R. T. Hansen: Phys. Rev. Letters **6** (1961) 260.
3) H. Carmichael, J. F. Steljes, D. C. Rose and B. G. Wilson: Phys. Rev. Letters **6** (1961) 49.

Discussion

Paghis, I.: With regard to the flare event of Nov. 20, 1960, the 30 mc, riometer record at Cape Sones may be of interest. A small absorption event started shortly after sunrise, and could have a weak P.C.A. The magnetic field was quiet, and this event was not observed on our lower latitude riometers.

Carmichael, H.: It appears to me that the absorption event seen on your slide occured too soon on November 20 to have been caused by the flare of 20, 23 U.T.

Sandström, A. E.: (1) There certainly was a Forbush decrease following upon the solar flare effect of Nov. 20. It was recorded in Uppsala and Kiruna by all six meson telescope sets. Also in Uppsala by the neutron monitor. The flare effect on the 20th was recorded by the Uppsala monitor.

(2) To my first remark I will add the following from the work done on the Nov. events by Dyring in Uppsala. In a report distributed in July this year he remarks on an interesting feature " The difference between the start of the flare and the connected sudden commencement " is decreasing in the series of beams produced by flares on the sun. This indicates that the plasma has a easier advance in the space when a earlier beam has prepared the way.

It is 12–19 hrs between the S.S.C. and the Forbush decrease following the event on Nov. 20th. This histograms of time differences between S.S.C'.s and associated F.d.s reveals this is not at all unbelievable. However with due regard for the decreasing time differences it is somewhat difficult to explain the delay between the S.S.C. and the Forbush decrease. I believe this has to be gone into very thoroughly before an answer can be given, if ever.

Carmichael: It was of your well known caution in this correlations, I wish to ask if you are prepared to say that this Forbush decrease was caused by the flare at 20 23 U.T.

Sandström: Yes, I believe that the Forbush decrease was due to an event in the same active region but it is very difficult to prove it.