‡ Now at CERN, Geneva, Switzerland.

[1] R. D. Sard and M. F. Crouch, in Progress in Cosmic-Ray Physics, edited by J. G. Wilson (North-Holland Publishing Company, Amsterdam, 1954), Vol. 2.

[2] J. C. Sens *et al.*, Phys. Rev. 107, 1464 (1957); J. C. Sens (to be published).

[3] C. E. Porter and H. Primakoff, Phys. Rev. 83, 849 (1951); T. Muto *et al.*, Progr. Theoret. Phys. Japan 8, 13 (1952); N. D. Khuri and A. S. Wightman (private communication).

[4] N. Campbell and R. A. Swanson (to be published).

[5] Reference 3, in particular Muto *et al.*

[6] J. C. Sens *et al.*, Bull. Am. Phys. Soc. Ser. II, 3, 198 (1958); recent preliminary results obtained at Liverpool also seem to indicate that $R > 1$ near $Z = 26$ [H. Muirhead (private communication)].

[7] Numerical calculations yielding such functions are now in progress at Los Alamos Scientific Laboratory.

[8] L. Lederman and M. Weinrich, Proceedings of the CERN Symposium on High-Energy Accelerators and Pion Physics, Geneva, 1956 (European Organization of Nuclear Research, Geneva, 1956), Vol. 2, p. 427.

COSMIC-RAY INCREASES PRODUCED BY SMALL SOLAR FLARES*

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This note reports the first observations of two unusually short-lived increases in the low-energy portion of cosmic rays. They appear to be produced by small solar flares. Some indications of effects of small solar flares have been previously reported,[1] but have not been widely accepted, possibly because the connection was only statistical and an isolated increase could not be discerned.

We therefore designed an experiment whose purpose it was to detect short-lived or small increases in the low-energy component of total cosmic-ray intensity, observe their structure and study their correlation in time with small solar flares. In order to improve the chances of detecting such events we constructed a detector with very large sensitive area so that the counting rate was high enough to be recorded directly through a ratemeter. Furthermore, since it seemed likely that the low-energy portion of cosmic rays would be most affected, we operated this detector at high latitudes (55° geomagnetic) and at high altitudes (up to 45 000 feet) in an aircraft operated by the Rome, New York, Air Force Base.

The detector was a cosmic-ray counter telescope 1 square meter in area. It consisted of two trays of geiger tubes spaced 1 inch apart. The trays were operated in coincidence. No absorber was used.

Flights were made at various altitudes on August 8th and 9th, 1957. No rapid fluctuations in the total cosmic-ray intensity were observed during the three hours the aircraft was at altitude on August 8th. On the 9th of August, however, two unusual events were observed.

The first event (see Fig. 1) occurred while the aircraft was flying straight and level at an altitude of 25 000 feet. It started at 1349 UT and lasted for nearly three minutes. During this time the intensity increased from its normal value by approximately 30%. The second event started at 1433 UT while the aircraft was still at an altitude of 25 000 feet. It lasted for almost

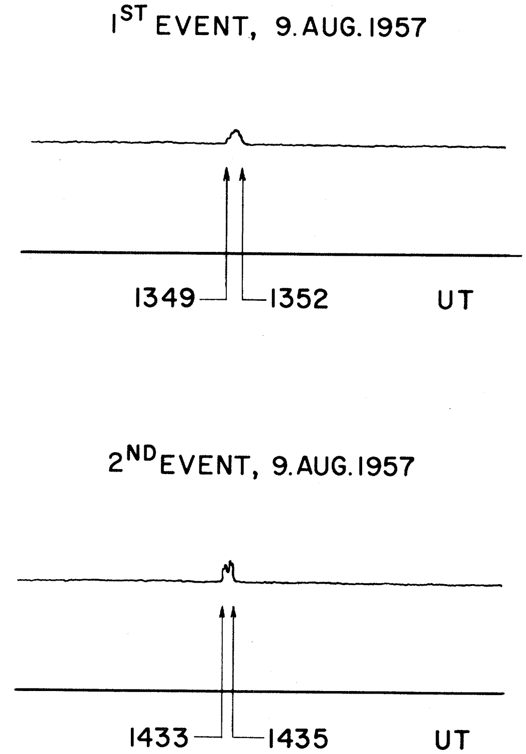

FIG. 1. Cosmic-ray increases observed on August 9, 1957 at $\lambda = 55°$ at altitude of 25 000 feet. A small solar flare was observed on the west limb of the sun starting at 1330 UT and reported by the High Altitude Observatory, Boulder, Colorado. Note the unusual "humped" shape of these increases, as well as their extremely short duration.

two minutes. The intensity increase was again approximately 30%. The average coincidence rate was about 1000 counts per second.

Reports of solar and other geophysical activity were obtained for the two days the flights were made. No solar flares were observed on the 8th of August during the time measurements were made. On August 9th, a solar flare of importance 1 was observed on the west limb of the sun at 1330 UT; the activity lasted for about one hour (High Altitude Observatory, Boulder). Thus the onset of the flare preceded the first cosmic-ray event by about 20 minutes. Other geophysical events were observed during the same period. A radio noise storm on 200 Mc was in progress when the flare started and during the first cosmic-ray increase (reported by National Bureau of Standards, Boulder). A sudden ionospheric disturbance with shortwave fadeout (importance +3) followed the flare (reported by Central Radio Propagation Laboratory of the National Bureau of Standards, Boulder). A distinctive magnetic event was observed (at Fredericksburg, Virginia, Station) just at the time of the first cosmic-ray increase.

Several conclusions can be drawn from the results of these flights. The results offer the first direct experimental evidence for a time correlation between a small solar flare and cosmic-ray intensity increases of short duration. The increases followed the appearance of the flare by 20 minutes. The same time interval has been found between large solar flares and large cosmic-ray increases. But the increases reported here were in the form of a hump instead of a sharp rise and exponential decrease to normal.[2] The absence of similar increases at other cosmic-ray stations is indicative of the association of low-energy cosmic-ray particles with small solar flares. Evidently most of the particles causing the intensity increases have low energies and could not have reached sea level.

It seems probable therefore that many, perhaps most, solar flares can accelerate particles to energies which may however be quite low.[3] Provisionally we would assume that the low-energy cutoff ("knee") observed for the general cosmic radiation does not exist for the solar-flare cosmic rays. No statement can as yet be made about their charge spectrum.

The present experiment clearly shows the need for operating high counting rate cosmic-ray detectors in conjunction with short resolving time count ratemeters at high altitudes and at auroral latitudes to detect low-energy cosmic-ray particles associated with small solar flares. Failure of other cosmic-ray experiments to meet these two conditions may be the reason why such events have not been detected in the past.

Equipments similar to the one flown at high altitudes are at present in operation at mountain altitudes at Climax, Colorado (altitude 3400 meters), and at Banff, Canada (altitude 2283 meters) as part of the International Geophysical Year effort. Balloon flights are planned for the near future.

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[1] Dolbear, Elliot, and Dawton, J. Atm. and Terrest. Phys. 1, 187 (1950); J. Firor, Phys. Rev. 94, 1017 (1954).

[2] See, e.g., S. F. Singer, in Progress in Elementary Particle and Cosmic-Ray Physics (Interscience Publishers, New York, 1958).

[3] S. F. Singer, International Union of Pure and Applied Physics Cosmic-Ray Congress, Varenna, June, 1957, Suppl. Nuovo cimento (to be published).

FREQUENCY OF CESIUM IN TERMS OF EPHEMERIS TIME

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The National Physical Laboratory, Teddington, and the U. S. Naval Observatory, Washington, have been cooperating in a joint program since June 1955 to determine ν_E, the frequency of cesium in terms of the second of Ephemeris Time.[1] In 1955 the International Astronomical Union recommended that the second of Ephemeris Time be adopted as the fundamental unit of time, and in 1956 the International Committee of Weights and Measures redefined the second so as to make it identical with the second of Ephemeris Time (E.T.), which is considered to be a constant unit of time. The second of Universal Time is thus no longer the fundamental unit of time.

Ephemeris Time is defined by the orbital mo-