SHORT COMMUNICATIONS

NUCLEAR EMULSION TECHNIQUE*

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Experiments on cosmic rays are being carried out using Ilford G.5 Nuclear Research emulsions, which are capable of recording particles at very low ionizing power. With careful development it is possible to record tracks of particles moving at velocities giving minimum ionization although it is still impossible to trace slow electron paths with certainty. In carrying out experiments with these emulsions in Australia, it is necessary to transport the plates from England by plane or ship and during transit the plates are affected by cosmic radiation and tropical conditions. Methods at present used for the eradication of background suffer from the disadvantage that the sensitivity of the emulsion is reduced in the process.

The background in the plates due to cosmic rays depends on the age of the emulsion and until the emulsions can be prepared in Australia it is preferable to transport them by plane. In this way emulsions two or three weeks old can be used for experiments. If the plates are transported by ship, the age of the plates is six or more weeks on arrival and the background density when finally developed is therefore heavy, making it more difficult to distinguish tracks of minimum ionizing particles. On development of plates transported by plane it was found that a dense surface blackening had occurred which was difficult to remove if left until the fixation and drying processes were completed. It was found that this surface layer could be removed by wiping the surface of the plate during the development process and plates treated in this way showed minimum ionizing tracks through the emulsion except for a layer a few microns thick near the surface. An example from an emulsion treated in this way is shown in Plate 1. The mosaic shows a π-meson coming to rest, disintegrating into a μ-meson which in turn comes to rest after a range of 600 μ and decays into an electron. The electron produces a track at minimum ionization and has in this case a grain density of approximately 24 grains/100 μ.

Development of 400 μ Thick Emulsion

For emulsions 400 μ thick on glass the following method was adopted.

Freshly made Agfa developer of 4 per cent. concentration was cooled below 4 °C. by placing the developing dish in an ice water mixture(1) and the plate allowed to soak in this for 2 hours. It was then placed in fresh developer

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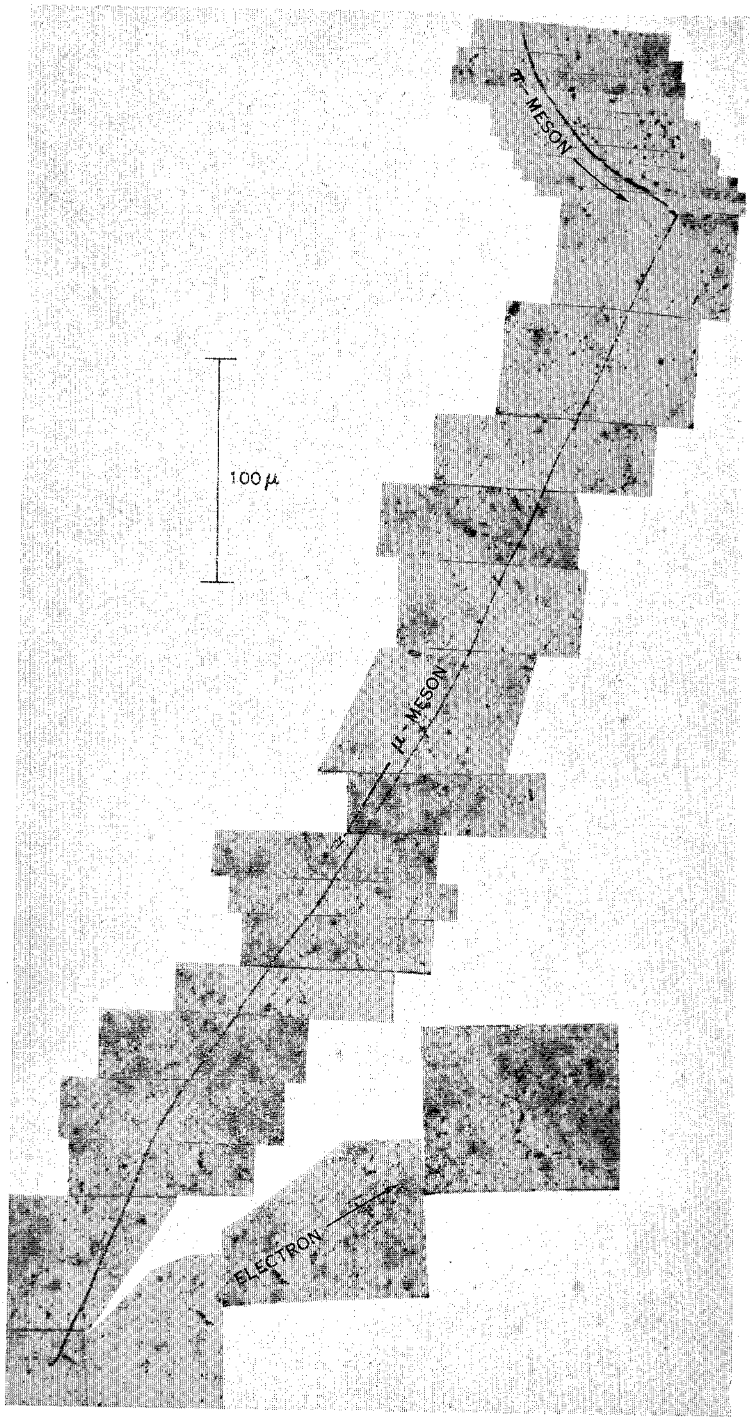

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at 18 °C. and allowed to develop for another 50 minutes. No stirring was employed during the development. It was rinsed and bathed for 1 hour in a 2 per cent. acetic acid stop bath. The plate was then placed in a hypo solution (400 g. of hypo in 1 litre of water) and stirred with an electrically operated rocker. After 15 minutes the surface was wiped with cotton wool to remove the dense black surface layer which had accumulated during the development process. The fixer was changed after 15 minutes, 30 minutes, 1 hour, 1 hour, 1 hour, 2 hours, 4 hours, and the plate left in the fixer for another 12 hours. At this stage a light source could be seen through the plate but the emulsion had a milky appearance. The milky background could be reduced by leaving the plate in the fixer for a much longer period but it has been found that this does not completely remove it. During the fixation process the rate of solution of silver halide was studied by slicing off thin sections of emulsion near the edge and observing these with a microscope, the cut of the section being at right angles to the optic axis of the microscope. The undissolved silver appeared opaque and in the remaining volume tracks of ionizing particles were visible.

The plate was next washed in running water for 4 hours and the milkiness of the emulsion diminished slightly. It was found possible to reduce this considerably by the following process but there is additional risk of emulsion distortion. The plate was placed in acid fixer and the temperature of the solution gradually raised to 30 °C. In less than 30 minutes the milkiness had practically disappeared and the solution was allowed to cool to room temperature. (The major distortion of the emulsion occurs during the cold water washing process following the acid fixer treatment and is due to the additional swelling of the emulsion in water. By reducing the concentration of the acid fixer gradually this danger of distortion can be removed.) The plate was dried vertically (drying time approximately 48 hours) and after drying the surface was cleaned by wiping it with a soft chamois leather damped with benzine.

Results

Table 1 gives a summary of data obtained from two plates. Plate No. 1 had been flown out by plane and had been kept at ground level whereas plate No. 2 had been flown out by plane but had been given an additional cosmic ray exposure on aircraft flights above 25,000 feet for approximately 7 hours.

These preliminary results indicate that a useful study can be made in Australia of cosmic rays at high altitudes using these plates. Exposures are

TABLE I

Plate No.	Area (cm.^{2})	Average Prongs/ Star	Age of Plate (days)	Number of Stars with following Number of Prongs : 3	4	5	6	7	8	9	10	11	12
1	30	3·83	42	10	6	3	1	2	1				
2	26	5·92	55	7	5	9	2	1	5	2	1	0	3

being made with the cooperation of the Department of Supply, the R.A.A.F., and the Meteorological Service. Mr. E. Matthaei assisted with the reproduction of the mosaic shown in Plate 1.

Reference

(1) DILWORTH, C. C., OCCHIALINI, G. P. S., and PAYNE, R. M.—*Nature* **162** : 102-3 (1948).

Explanation of Plate 1

Mosaic of π-meson coming to rest and disintegrating into a μ-meson which in turn comes to rest before disintegrating into an electron at minimum ionizing energy. Additional uncharged particles are emitted but these are not detected by the emulsion. Assuming that conservation of energy and momentum occurs and a single uncharged particle is emitted with the emission of the μ-meson the mass of the neutral particle at the π-μ transformation is less than 10 electron masses and it is generally assumed to be a neutrino.