ELECTRON BACKGROUND IN IMPORTED G5 EMULSIONS*

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Ilford G5 nuclear emulsions have been received by this department at regular fortnightly intervals during the last six months. They are sent by air mail and reach this laboratory approximately two weeks after the date of manufacture in England and are developed soon after arrival. Heavy electron backgrounds were observed in four batches of plates out of 12 successive fortnightly shipments. Possible causes of these variations have been investigated.

To compare the background in the plates two methods were used which gave closely similar results. In one method the number of sharply defined black grains in a (50 μ)^2 field using a 95 $\times$ objective was counted and an average obtained for a number of fields of view. Results are shown in Figure 1 (*a*). In the second method the number of electron tracks ending in the emulsion in the (100 μ)^2 field using a 45 $\times$ objective was counted and averaged for a number of fields of view (Fig. 1 (*b*)). Neither method is very accurate but the results were quite consistent up to exposures of about 150 milliröntgens. The second method could not be used for exposures above 150 mr as the electron tracks could not be resolved. A comparison was made of these results with plates exposed to a 4·6 c iridium source specified as giving 3 mr/hr at 1 m so as to obtain a measure in milliröntgens of the various backgrounds. The radiation 1 m from the source was checked using a radiation monitor and found to agree with the specified 3 mr/hr. Two Ilford G5 600 μ plates (manufactured May 3) of low background were placed on the surface of the container (i.e. about $\frac{1}{3}$ m from the source) and given exposures of 64 and 113 hr respectively, and two similar plates were placed 2 m from the source and given the same exposure times. The estimated dosages received by various batches are given in Table 1 and plotted in Figures 1 (*a*) and 1 (*b*) and photographs showing relative electron backgrounds of the plates manufactured on January 21 and February 7 are shown in Plate 1.

By considering only the cosmic ray background and general radiation from the Earth a rough estimate can be made of the radiation that one would expect in a plate imported to Australia by aircraft and developed one week after arrival, i.e. about a fortnight after manufacture. A typical time of flight in the height region 10,000–20,000 ft would be about 38 hr and the plates would be airborne for 46 hr. Assuming 1 mrep/day at 20,000 ft, the exposure due to cosmic radiation during flight would be of the order of 1·5 mrep. Radiation received at ground level mainly due to γ-rays is of the order of 0·5 mrep/day. Plates are normally stored under 2–3 in. of lead at this laboratory so the rate would be much less than this during storage. Thus the total radiation received

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by the plates at development would be expected to be about 10 mrep and it will be seen from Table 1 that some of the batches of plates show slow electron backgrounds corresponding to this.

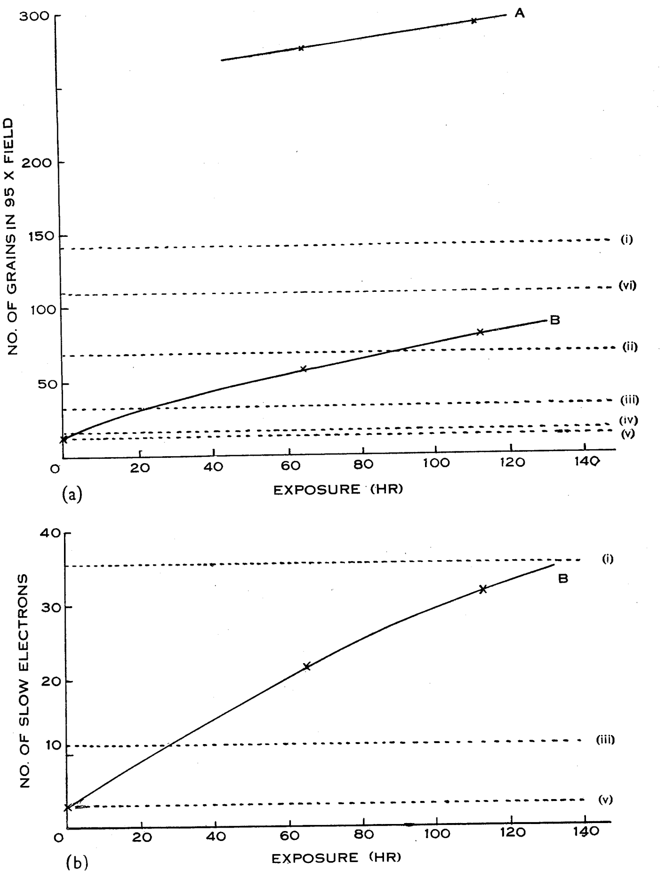

Fig. 1.—Electron background in plates. (*a*) Number of focused grains in 95 × objective field as a function of time of exposure of plates. *A*, Ilford G5 emulsion exposed $\frac{1}{3}$ m from ^{192}Ir source; *B*, Ilford G5 emulsion exposed 2 m from ^{192}Ir source. For comparison the level of the background in Ilford G5 plates manufactured: (i) Apr. 1, 1955; (ii) Jan. 21, 1955; (iii) Apr. 20, 1955; (iv) Feb. 7, 1955; (v) May 3, 1955; (vi) May 31, 1955, are shown.
(*b*) Number of slow electrons ending in 45 × field as a function of time of exposure.

Possible causes of the extra radiation background on some of the plates are:

(*a*) Irradiation at time of manufacture or during storage in this laboratory.

(*b*) Exposure to radiation from instrument panels and radioactive isotopes carried on the aircraft.

(*c*) X-ray examination by customs officials.

(*d*) Radiation from products of atomic explosion tests.

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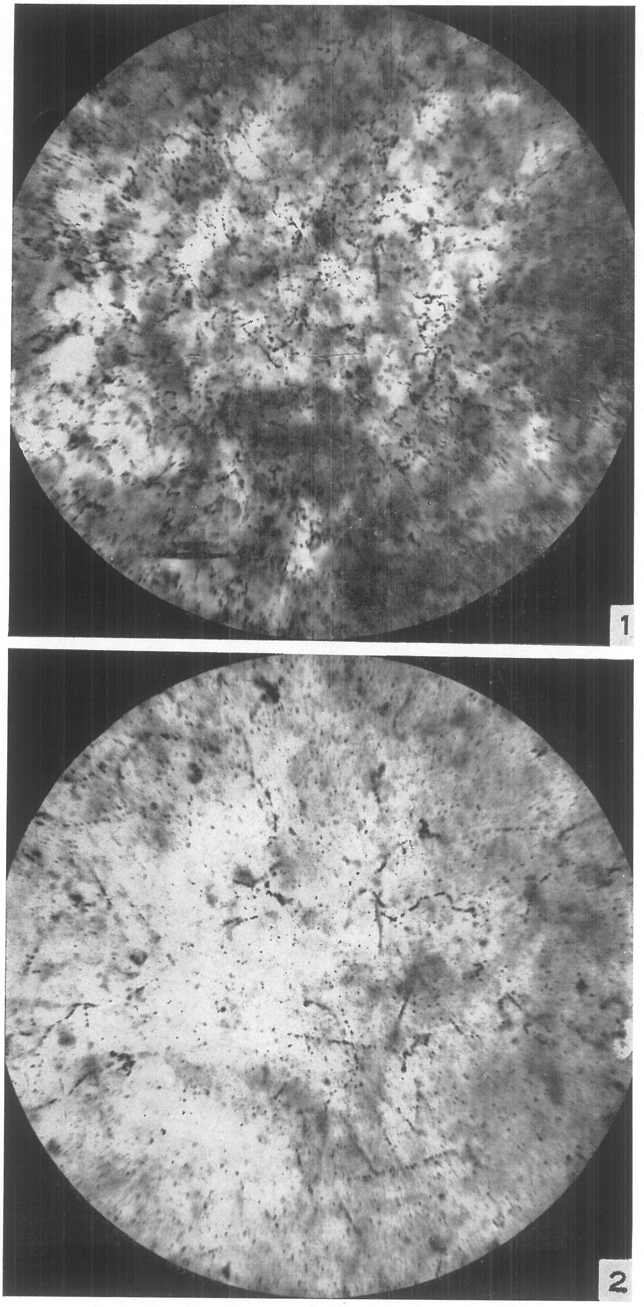

Photographs showing electron background in plates manufactured
(1) Jan. 21, 1955 ; (2) Feb. 7, 1955.

(*a*) *Irradiation at Manufacture or Storage*

It was stated by Ilford that there was no possibility of the emulsion being exposed before dispatch and that occasional complaints that had been received from America were attributed to customs activities or to emulsion travelling in close proximity to radioactive material. Regarding storage at this laboratory, the plates with high background had been stored alongside other plates and these showed no extra background.

TABLE 1

DOSAGE MEASUREMENTS ON PLATES OBTAINED BY COMPARING THEIR BACKGROUND WITH THAT PRODUCED BY γ-RADIATION FROM ^{192}Ir

Date of Manufacture 1955	Departure from London	Estimated Dose on Arrival (mr)
Jan. 21	Jan. 23	70
Feb. 7		15
Apr. 1	Apr. 6 (BOAC)	140
Apr. 20	Apr. 22 (KLM)	35
May 3		10
May 16		10
May 31, June 2	June 4 (KLM)	120
June 13		15
June 28		10

(*b*) *Contamination in Aircraft*

Instrument panels

A source of contamination in aircraft is the radioactive paint on instrument panels. Measurements were made by Morrison* in 1951 on the γ-radiation from instruments in a "Constellation" aircraft. From his figures it appears that radiation in the luggage compartments presumably well away from the instrument panels would be less than 2 mr per day. As the plates would be stored in the aircraft for the complete flight, the plates might conceivably receive a radiation dosage of 10 mr during the flight due to this cause alone, and it thus seems unlikely that radiation from instrument panels could be as high as the background observed in three of the batches received.

Imported isotopes

The background observed on the two most heavily exposed plates could have been produced if the plates had been stored 4–5 ft† from a 4·6 c ^{192}Ir

* MORRISON, A. (1951).—*J. Aviat. Med.* **22**: 350.

† Boxes of emulsions are labelled specifying that packets should be stored at least 10 ft from any radioactive material and parcels of radioactive isotopes are also labelled advising that photographic material be stored at least 10 ft from the container. Assurances have been received that these instructions are carried out. Ilford G5 emulsions having about 25 mr are usable for cosmic ray experiments but it is of course preferable to have a much lower background. To obtain a dosage less than 25 mr plates imported to Australia should, in fact, be stored at least 15 ft from an iridium source of 4·6 c.

source for four days (see Fig. 1). The Commonwealth X-ray and Radium Laboratory keeps a complete record of all isotopes entering Australia and γ-ray sources of highest activity arriving during the period in which the 12 batches

TABLE 2

RADIOACTIVITY OBSERVED AT VAL-JOYEUX BY MLLE. OLGA TANAEVSKY AND M. ETIENNE VASSY

Type of Precipitation	Date	Initial Activity (counts $m^{-1} l^{-1}$)
Rain	Jan. 11	61
Snow	Jan. 13	25
Snow	Feb. 15	50
Rain	Feb. 21	8
Rain	Night Feb. 23 to 24	14
Snow	Mar. 7	13
Rain	Night Mar. 20 to 21	88
Rain	Mar. 22	35
Rain	Mar. 28	90
Rain	Night Apr. 6 to 7	1596
Rain	Apr. 10	189
Rain	May 5	112
Rain	May 6	47
Rain	Night May 13 to 14	47
Rain	May 15	87
Rain	Night May 16 to 17	15
Rain	May 18	53
Rain	May 19	20
Rain	May 21*	24
Rain	May 26	69
Rain	June 3	192
Rain	June 6	154
Rain	June 9, 10 hr	87
Rain	18 hr	28
Rain	June 12	37
Rain	June 19	26
Rain	June 30	45
Rain	July 4	38
Rain	July 11	58
Rain	July 18	47
Rain	July 20	26
Rain	July 27	29
Rain	Aug. 10	37
Rain	Aug. 12	17
Rain	Aug. 14	38

* Data for May 21 and later were received in a further personal communication from Professor Vassy and have been added *in proof.*

of plates were received were in fact ^{192}Ir sources of 4·5–5·1 c. The nuclear emulsion plates that had excessive exposures were manufactured on January 21, April 1, April 20, and May 31 and the dates of departure of these batches are given in Table 1. From the records it was found that not one of these batches travelled to Australia on the same plane as an imported γ-ray isotope. There is, however, the possibility that the plates travelled in planes carrying isotopes dispatched to other countries en route but, if so, the plates would need to be stored even closer to the isotopes than $4 \cdot 5$ ft.

(*c*) *X-ray Examination at Customs Inspection*

All packets of plates are labelled as containing photographic material and the most heavily exposed was clearly marked advising that the plates should not be exposed to X-rays. Also all plates in packets are equally affected and, unless an exceptionally high energy X-ray or γ-ray source was used for customs examination, the background of high energy electron tracks would not be obtained.

(*d*) *Radioactive Products from Atomic Explosions*

The last possibility is that the contamination is due to by-products of atomic explosions. There is apparently no significant overall increase in the activity in the air due to the recent series of explosions as most packets of plates received during the period of analysis show low electron background. However, there may be isolated patches or clouds of radioactive contamination which could account for the intermittent appearance of the heavy background.

In a personal communication Professor Vassy, University of Paris, has supplied details of the radioactivity found in rain or snow at Val-Joyeux, near Paris, this year, and results, which are to be published in *Comptes rendus de l'Académie des Sciences*, are shown in Table 2.

It will be observed from Table 1 that the most heavily exposed batch of plates left England on April 6 and the radiation which produced the exposure may have been due to the radioactive cloud which produced the radioactive rain in Paris on the same evening. It will also be seen that there is a peak in the rainfall activity from June 3 to 6 which links with the high electron background observed on the plate which left London on June 4. Plates which arrived in July and August have backgrounds in agreement with the lower activity of rainfall in these months.

Japanese scientists under Dr. Miyake (personal communication) also found that ash and sand which fell in Japan in mid April was highly radioactive and attribute radioactivity of the ash as due to an atomic explosion. They also observed peaks of activity in January and at the end of May which appear to link with the emulsion data.

Conclusions

Using the present method for importing plates by air to Australia there is a chance of 1 in 3 batches having too high a background. The reason for the high background has not been determined with certainty but it could have been produced by storing the plates too close to imported γ-ray isotopes. The films did not arrive with isotopes entering Australia and would need to be placed well within $4 \cdot 5$ ft of a box containing a $5 \cdot 0$ c ^{192}Ir source to obtain the highest backgrounds observed. Ruling out the effect due to isotopes there must be some other very highly active source encountered by the plates en route. The date of departure from London of the most heavily affected packet agrees with the date of a highly radioactive downpour in France.

Whatever the cause of the anomalous backgrounds it is clear that before emulsions are used for experiments a test development is necessary to determine whether the plates are usable.

Beneficial discussions were had with Dr. C. E. Eddy, Mr. D. J. Stevens, and Mr. F. J. Richardson of the Commonwealth X-ray and Radium Laboratory.