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RANGE OF 25 FISSION FRAGMENTS IN PHOTOGRAPHIC EMULSION

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ABSTRACT

A fine-grain emulsion has been found which is sensitive only to the densely ionizing fission fragments. This emulsion has been soaked in uranyl acetate and exposed to slow neutrons. The ranges in the emulsion of about four-hundred fission fragments have been measured. The resulting distribution shows a sherp maximum at 23 microns of emulsion. No ternary fissions or large-angle scattering of fragments were observed. (auth)

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RANGE OF 25 FISSION FRAGMENTS IN PHOTOGRAPHIC EMULSION

Photographic emulsions which record protons and alpha particles, (e.g. Ilford Halftone Plates and Eastman Fine Grain Alpha Plates) are not suited for examination of fission fragments because there is not a sufficient differentiation between fission fragment tracks and the concomitant alpha tracks from the fissionable material. This lack of differentiation may seem surprising since the specific ionization along the two tracks is vastly different. Presumably the explanation is that the alpha particle already has a high-enough specific ionization to render developable every AgBr grain through which it passes.

In general the smaller the AgBr grain size, the "slower" is the emulsion. This "slowness" also corresponds to a higher threshold of ionization in the grain before the grain becomes developable. Hence the extremely fine-grain emulsions were examined in hopes of finding one which was sensitive only to the high specific ionization of the fission fragments. The Eastman 548-0 spectroscopic plate was the most satisfactory of any examined 1). The AgBr grains in this emulsion are so small that they are only visible under dark-field illumination. The linear grain density was high enough that the tracks were essentially continuous lines.

Since there were many background grains developable on an unexposed plate, it was necessary to remove these by the method which Liebermann and Barschall 2) have described. This method consists in developing the unexposed plate to reduce the developable AgBr grains to metallic silver. This metallic silver is then removed by a photographic "reducer" which dissolves the Ag without affecting the AgBr.

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1) Ilford R-1 plates are supposed to record alphas but not protons. The batch we received failed to give alpha tracks but did give fission fragment tracks but of rather poor quality. The linear grain density in particular was low compared to the Eastman 548-0 emulsion.

2) L.N. Liebermann and H.H. Barschall, Rev. Sci. Ins. 14, 89 (1943). [redacted]

IMPREGNATION WITH URANIUM AND EXPOSURE [redacted]

The plates were impregnated with uranium by soaking them for ten minutes in an alcoholic uranyl acetate solution (1.5 gm/100 cc of 50 percent ethyl alcohol) and then were exposed to slow neutrons by placing the plates in a paraffin block near one of the electrostatic generators.

RESULTS

The treated but unexposed plates showed no tracks while the plates exposed to slow neutrons showed tracks. The ranges of 400 of these were measured and the range distribution is shown in Fig. 1. Only those tracks were measured which were all in focus at one time. This requirement insured that the track made a negligibly small angle to the plane of the emulsion.

DISCUSSION AND CONCLUSION

One should be reminded that the range measured here is the sum of the two fission fragment ranges and hence should be a function of the total energy released. If the fission process always occurs in the same manner with the release of a definite quantity of energy we should expect the ranges (except for straggling) to be the same. One expects considerable range straggling of fission fragments because of the importance of nuclear collisions in the slowing-down process 3). However, there are reasons for believing that the width of the group in Fig. 1 is not the result of range straggling. In the first place Bohr, 3,4) has shown that almost all of the range straggling should originate very close to the end of the range. For the rest of the range the electrons are chiefly responsible for the slowing down and hence for this region, range straggling is practically

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3) N. Bohr, Phys. Rev. 58, 654 (1940).
4) N. Bohr, Phys. Rev. 59, 270 (1941).

[redacted]

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negligible. Bohr's predictions are verified experimentally in the cloud chamber pictures of Brostrom, Boggild and Lauritsen [5,6].

The photographic emulsions used in the present study are, however, insensitive to the fission fragments near the end of the range. This is attested by the lack of appreciable deflection of the tracks, the absence of the delta tracks which would be caused by the recoil C, Ag, Br, etc. nuclei struck by the fission fragments and by the fact that the equivalent air range of the peak of Fig. 1 is only about three centimeters, whereas the experimental observed sum for <u>two</u> fission fragments is between 4 and 5 centimeters. Hence we conclude that the distribution in range of Fig. 1 corresponds to a similar distribution in total energy of the fission process and while there is a most probable fission energy, perhaps 50 percent of the fissions show large deviations from this energy.

For the part of the range which the emulsion records the range is directly proportional to fragment velocity [3,4,5,6] and hence to the square root of the energy. Thus if we identify the peak of the range curve with 160 Mev as the average total energy (from ionization chamber measurements), [7,8,9] then the highest observed energy of fission would correspond to ∼195 Mev and the lowest to ∼115 Mev. These limits of the total energy of fission correspond quite closely to those observed in ionization chambers [7,8,9].

No ternary fissions were observed nor were any large-angle scatterings of the fragments observed.

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[5] K.J. Brostrom, J.K. Boggild and T. Lauritsen, Phys. Rev. <u>58</u>, 651 (1940).
[6] J.K. Boggild, K.J. Brostrom and T. Lauritsen, Phys. Rev. <u>59</u>, 275 (1941).
[7] M.H. Kanner and H.H. Barschall, Phys. Rev. <u>57</u>, 371 (1940).
[8] W. Jentschke and F. Pronkl, Zeit. f. Physik <u>119</u>, 696 (1942).
[9] Flammersfeld, Jensen and Gentner, Zeit. f. Physik, <u>120</u>, 450 (1943).

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It would be interesting to use this method to look at the total energy distribution from other fissionable materials, e.g., 02, 49, 23, 11, and 28. If a source of very high-energy neutrons were available, then the intermediate nucleus would be much more highly excited and one might expect that the fission might occur in a different manner. Ternary fission might be observed under such circumstances.

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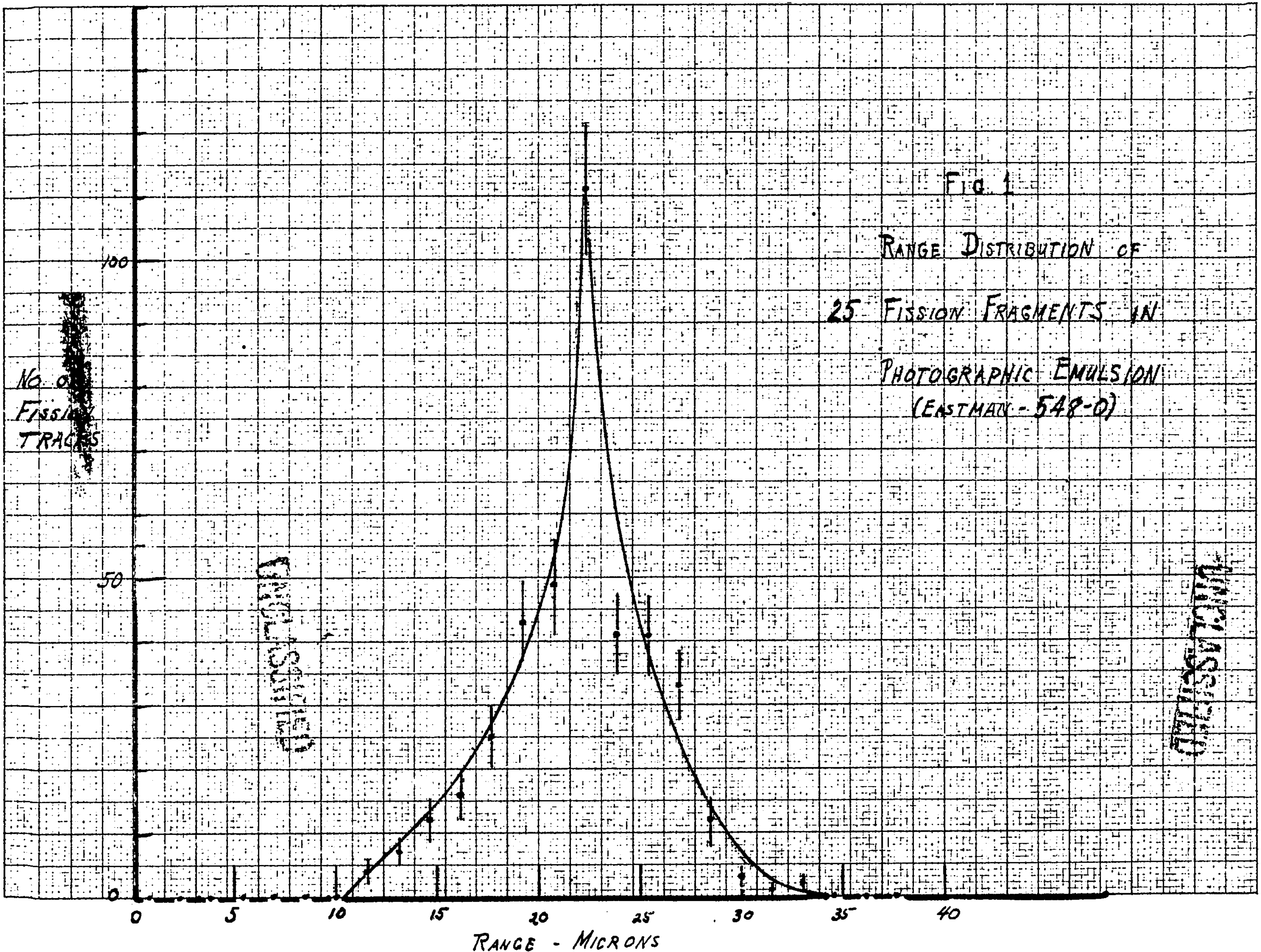

Fig. 1

Range Distribution of 25 Fission Fragments in Photographic Emulsion (Eastman - 548-0)

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