and were actually observed. If the 5^+ $v=4$ state is the 3.614 Mev state, the observed branching ratio of its decay to the two 4^+ levels would indicate that the upper 4^+ state is primarily a $v=2$ state, whereas, the lower 4^+ state has primarily $v=4$. However, the ratio of the observed transition strengths is only 3. This would indicate rather considerable admixtures or else the impossibility of an exact description of the effective $E2$ operator as a sum of single particle operators. The corresponding ratio of transition strengths from the 3.832 Mev level seems to be about 50, but the data here are only rough values. It is clear that no further conclusions can be reached before the experimental situation is clarified.

From the experimental evidence, it seems that the $f_{7/2}^n$ configurations of either protons or neutrons (while the other group is in closed shells) are rather pure. The level scheme of Cr^{52} with the seniority assignments made above agrees rather well with a $f_{7/2}^4$ configuration assignment. This nucleus may be very useful in testing the validity of the seniority as a good quantum number. The answer to this question will tell us whether the effective mutual interactions between nucleons can be really represented by two body forces, or that effective three and four body forces are also important. At the same time the transitions in Cr^{52} may furnish a sensitive test of the idea that the effective $E2$ operator is actually a sum of effective operators of the independent individual nucleons. In order to find out more about these problems more accurate experimental information must be available.

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Delayed Neutron Yields in the Photofission of U^{238} and Th^{232}†

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The delayed neutron yield per fission in the photofission of U^{238} and Th^{232} was measured with a 22-Mev betatron. The results are 0.036 and 0.030, respectively, and substantiate previous empirical predictions for these isotopes. No evidence was found of a dependence of this ratio as a function of energy.

THE absolute delayed neutron yield of several isotopes of Th, U, Pu and Cf has been known for some time and recent additional data were published by Cox[1]; in this paper, a systematic of the yield/fission is suggested.

Two additional nuclei, U^{238} and Th^{232}, were measured by us using the 22 Mev betatron of the University of São Paulo; photofission in these isotopes cannot be produced by particle-induced fission. In neutron-induced fission, the fissioning nucleus has one additional neutron over the target neutron number.

Measurements of delayed neutron yields are easy to carry out with betatrons which are pulsed machines with short x-ray pulses and high repetition rates. The fissionable target is irradiated inside a paraffin box in which are embedded two BF_3 counters.[2] The prompt neutrons are counted by the same system and decay with a half-life of 125 μsec characteristic of the paraffin moderator. After 3000 μsec, only the delayed neutrons are left, and the prompt neutron tail and background are negligible. No correction for the decay of the various periods of the delayed neutrons is necessary because counting is made after equilibrium is reached.

The ratio of delayed to prompt neutrons is obtained without any corrections due to counting of activities and absolute calibration of counters.

Measurements were made at maximum bremsstrahlung energies of 12 and 20 Mev.

TABLE I. Experimental results. The errors in columns 3 and 4 are statistical. The errors in column 5 represent extreme values using plausible estimates for $\sigma(\gamma,n)$ and $\sigma(\gamma,2n)$, and $\bar{\nu}$ from Gindler *et al.*[3] and Leachman.[4]

Element	Energy (Mev)	(Relative counts/pulse)/ monitor unit Prompt	Delayed	Delayed neutrons/fission
U^{238}	12	620±25	3.2 ±0.2	$0.036^{+0.008}_{-0.007}$
	20	2545±100	13.6 ±0.5	$0.036^{+0.010}_{-0.009}$
Th^{232}	12	223±12	0.55±0.04	$0.027^{+0.008}_{-0.007}$
	20	995±40	2.2 ±0.1	$0.030^{+0.012}_{-0.006}$

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[1] Samson A. Cox, Phys. Rev. 123, 1735 (1961).
[2] J. Halpern, A. K. Mann, and R. Nathans, Rev. Sci. Instr. 23, 678 (1952).

To obtain the number of delayed neutrons per fission, account has to be given to the fact that not all neutrons are originated in fission, such as those from (γ,n) and $(\gamma,2n)$. Data from Gindler, Huizenga, and Schmitt[3] and Leachman[4] were used for this purpose.

The results are included in Table I and Fig. 1 which includes the data summarized by Cox.[1] It can be seen that our results substantiate Cox's empirical predictions.

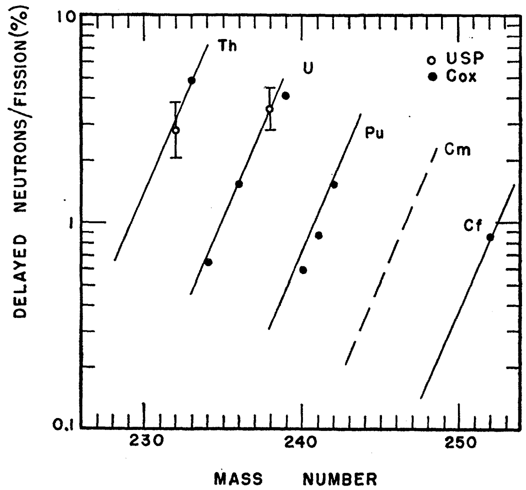

FIG. 1. Delayed neutrons per fission as a function of mass number. The lines are drawn parallel and equidistant to fit the points.

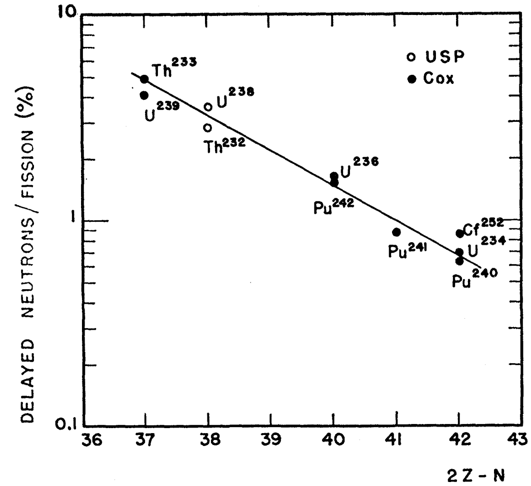

FIG. 2. Delayed neutron per fission as a function of $2Z-N$, which seems to be a significant parameter.

In Fig. 2, we plotted the delayed neutron yield per fission as a function of $(2Z-N)$ which seems to be a significant parameter.

We found no evidence of the dependence of delayed neutron yield per fission as a function of energy.

Measurements of the known individual half-lives which are present in the delayed neutrons are in progress. No evidence was found of the presence of half-lives between 1000 and 10 000 μsec.

[3] J. E. Gindler, J. R. Huizenga, and R. A. Schmitt, Phys. Rev. **104**, 425 (1956).

[4] R. B. Leachman, *Proceedings of the Second United Nations International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1958* (United Nations, Geneva, 1958), Paper P/2467, Vol. 15, p. 229.