in a distant collision. This effect[4] is obviously proportional to the local density of air and to the incident nucleon intensity:

$$I_3(x)=BxI_1(x). \quad (4)$$

Expressions $I_1(x)+I_3(x)$ and $I_2(x)$ are respresented in curves II and III respectively. Formula (1) or curve I is obtained by adding the two mentioned expressions.

The influence of the production of secondary particles in the mass of the rocket is approximately proportional to the total intensity of the incident particles and does not affect the given formula.

[1] J. A. Van Allen and H. E. Tatel, Phys. Rev. **73**, 245 (1948).
[2] H. L. Bradt and B. Peters, Phys. Rev. **77**, 50 (1950).
[3] B. Rossi and K. Greisen, Rev. Mod. Phys. **13**, 240 (1941).
[4] A. Wataghin, Anais de Academia Brasileira de Ciencias **21**, 353 (1949).

Rise Times of Voltage Pulses from Photo-Multipliers*

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A METHOD has been devised for measuring fast rise times of voltage pulses from photo-multiplier tubes without using high speed oscillographs.

1P21 tubes were operoted at voltages high enough (about 1600 v) to give 25-volt pulses from a radium source, when used in conjunction with a 6AG7 cathode follower. The time constant of the RC circuit on the last dynode from which the pulses are taken is $\sim 10^{-6}$ sec. The pulse is fed into a variable length of shorted RG63U cable, thus subtracting from it a delayed pulse of equal height. The maximum height reached by the resulting difference pulse is the height of the original pulse at a time after its start equal to the delay. The clipped pulse then is fed through a discriminator and scaler. By varying the length of the shorted delay line and adjusting the discriminator setting so that a constant counting rate is obtained from a given source, the shape of the pulse can be accurately plotted if the cathode follower and crystal diode responses are known (measurements showed them to be quite linear in the region used).

Plots of the rise of the pulses have been made for pulses from various organic phosphors, and for noise pulses (using both thermionically emitted electrons and those knocked out of the photo-cathode by gamma-rays). With slight deviations which are undoubtedly due to limiting or curvature of cathode follower or crystal diode characteristics, logarithmic plots of the curves in

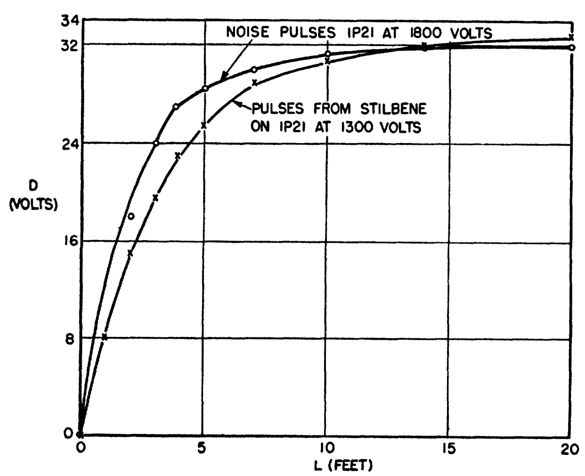

FIG. 1. Rise of noise pulses and pulses from stilbene. D is the discriminator reading corresponding to a constant counting rate. L is the length of shorted delay cable (4 feet of which correspond to a time delay of 10^{-8} sec.).

TABLE I. Rise time of voltage pulses from 1P21 at 1500 v.

Crystal	τ	Quality of crystal
Stilbene	$(0.85\pm0.05)\times10^{-8}$ sec.	Single crystal, colorless, transparent.
Phenanthrene	$(1.0\pm0.1)\times10^{-8}$ sec.	Microcrystalline, pale yellow.
Anthracene	$(2.1\pm0.2)\times10^{-8}$ sec.	Single crystal, colorless.
o-Phenylphenol*	0.9×10^{-8} sec.	Microcrystalline, pinkish
p-Phenylphenol*	2.0×10^{-8} sec.	Microcrystalline, colorless.
5-*sec*-butyl-2-hydroxy-α^1,α^3-xylenediol*	1.6×10^{-8} sec.	Microcrystalline, colorless.

* These rough measurements probably good to 0.4×10^{-8} sec., were taken with larger 1P21 voltages ($\sim$1700 v).

Fig. 1 show them to be of the form $V=V_0(1-e^{-t/\tau})$. The value of τ for the noise pulse is 5 to 6×10^{-9} sec., of which an unknown, but probably not the major, fraction is due to delay in the circuit following the photo-multiplier, and the remainder represents the spread of transit time through the photo-tube for the secondary electrons from a primary noise electron emitted at the photo-cathode.

Table I summarizes results on organic phosphors. The figures given are averages of a number of crystals, which show some variation in τ. For these experiments, the rise time of the voltage pulse differs from that of a noise pulse due to the decay time of the fluorescence of the phosphor.

These results show fair agreement with those of other investigators.[1] The three last ones have not been previously covered in the literature.

* We should like to thank the AEC which aided materially in this research.
[1] For example, Hofstadter, Liebson, and Elliot, Phys. Rev. **78**, 81 (1950); J. R. Bell, unpublished results.

Altitude Dependence of Neutron Production by Cosmic-Ray Particles*

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THE counters and circuits used in the cloud-chamber study of neutron coincidences[1] (carried out jointly with the Harvard cosmic-ray group) have been employed in a preliminary study of the changes in neutron coincidence rates between Climax, Colorado (3400 meters) and St. Louis, Missouri (170 meters). The experimental arrangement is shown in Fig. 1. The crossed fourfold G-M tube telescopes[2] are placed between a 10.16-cm Pb filter and a 10.16-cm Pb absorber. The double anticoincidence tray C more than covers the cone defined by the telescopes. Below C is a large paraffin thermalizer containing five thermal neutron counters, proportional counters filled with enriched BF_3.[3]

The following events were recorded: telescope coincidences (AB), anticoincidences ($AB-C$), neutron counts (N), and neutron counts in delayed coincidence (3 to 150 μsec.)[4] with AB events ($AB{:}N$) and $AB-C$ events ($AB-C{:}N$). The neutron counters were, in addition, in prompt anticoincidence (±1 μsec.) with the C tray; this feature discriminated against pulses due to showers.

TABLE I. Neutrons associated with stoppings (AB-$C{:}N$).

	Climax	St. Louis
With absorber (115 g/cm² Pb)	$7.02\pm0.48/h$	$1.16\pm0.09/h$
	Expected Casuals $\pm0.15/h$	Expected Casuals $\pm0.005/h$
	Corrected rate $6.87\pm0.48/h$	Corrected rate $1.15\pm0.09/h$
Sans absorber (0.69 g/cm² brass in counter walls)	$0.16\pm0.09/h$	$0.051\pm0.01/h$
	Expected Casuals $\pm0.19/h$	Expected Casuals $\pm0.002/h$