Letters to the Editor

Spatial Channel Theory

The concept of spatial channels as presented by Williams and Engle[1] appears to be a most useful tool in shield design. The idea of pseudo-particles called "*contributons*," with a flux (C) and an associated current ($\boldsymbol{D}$), provides a physical analogy that is quite illuminating.

The derivation of the theory and the definitions of the mathematical entities are carefully developed. The arguments, however, for considering the *contributon* flux at various points as indicators of the contribution to the detector response from the portions of the shield at the point concerned are not rigorous and are not very convincing, at least to this reader. I refer primarily to the two paragraphs following Eq. (18) of the Williams-Engle paper, starting out with "Intuitively . . . "

Some further physical analogies appear possible, which may improve one's insight into this question, and these are offered in an attempt to bolster the justification for use of the *contributon* flux field for shield design in the manner discussed in that paper.

The suggestions to be made are easily demonstrated with the help of Fig. 1, which depicts a small source and a small detector separated by a block-shaped shield. The *contributon* field is expressed by lines proceeding from the source and ending at the detector. The density of the lines at any point is proportional to the *contributon* flux at that point and the direction of the lines is along the directions of $\boldsymbol{D}$, the *contributon* current. Any surface, such as that shown by the dotted line in the figure, that intercepts all the lines will have the same number of lines passing through it, which is analogous to Eq. (17) of the basic paper and the remarks following it.

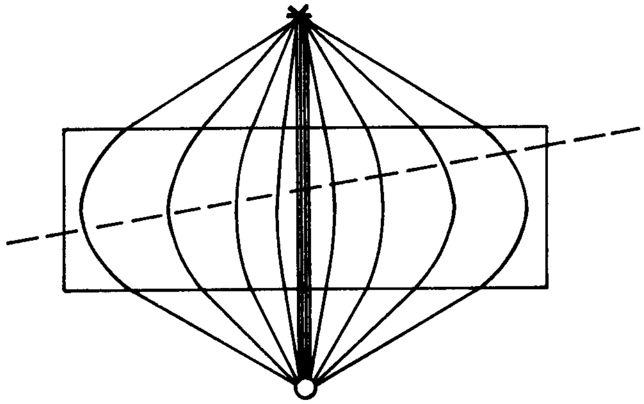

Fig. 1. Elementary shielding situation showing *contributon* lines.

So far, this is not a particularly significant insight. But one further idea may be of interest. It appears to this writer that these lines are typical, average tracks of those actual particles from the source that succeed in arriving at the detector. The fact that they are smooth curves rather than the erratic tracks, expected as a result of discrete collision processes, is the counterpart to the fact that the equations used for predictions of the forward and adjoint particle flux (ϕ and ϕ^+) predict only average values and submerge entirely the statistical variability related to the truly erratic nature of the physical process of radiation transport.

The bundle of lines between source and detector is put in the figure to represent the part of the *contributon* field related to the uncollided particle contribution to the detector response. Anywhere along this heavy line, the *contributon* line density is very large, and if the source and detectors were at true points, the *contributon* flux here would involve Dirac delta functions.

Where the *contributon* lines are crowded together is therefore a region through which a large proportion of the actual source particles that reach the detector pass.[2] This appears to be a good justification for adding shielding material that will intercept those lines that crowd together, most efficiently in the very regions where the crowding occurs. This is, of course, simply another way of saying one should do something about these regions where the *contributon* flux is the greatest. What such addition does is to thin out (eliminate some of) the lines in the crowded region. Of course, the lines can be thinned by putting shielding material anywhere that will intercept them, although more material would be needed if placed at locations other than where the lines are thickest. Thus, placing shielding material where the *contributon* flux is highest may be the most economical way, but is not the only way to prevent streaming.

The suggestion of this writer is that a calculation of the directional values of the *contributon* current, in addition to the flux values, may permit a designer to sketch out the *contributon* lines, at least for a two-dimensional situation, and further assist in the creative process of shield improvement.

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[1]M. L. WILLIAMS and W. W. ENGLE, Jr., *Nucl. Sci. Eng.*, **62**, 92 (1977).

[2]This is not to imply that the line density is consistent with the number of particles from the source reaching the detector. The presence of the lines is also affected by the relative response of the detector to the particle whose track it simulates (in a smoothed-out sense). For example, if the detector is for fast neutrons and will not be affected at all by neutrons below a cut-off energy, no neutron tracks that end up at the detector with low neutron energy would have any counterpart in the *contributon* lines.