Reply

CHARLES C. MEER AND BARCLAY G. JONES

Nuclear Engineering Program, University of Illinois at Urbana-Champaign, Urbana 61801

20 November 1973

The authors are grateful for the interest shown by Prof. Peskin in the fundamental aspects of this title problem and appreciate the considerable background which he has in the subject. However, in the paper it was the primary intent of the authors first to consider, from a somewhat different vantage point than had been used previously (Lumley, 1957; Peskin, 1960; Csanady, 1963), the problem of heavy particle transport in homogeneous fluid turbulence, and second to compare the resulting theory with the best available heavy particle data. No attempt was made to analyze initial transient particle behavior but rather only statistically stationary particle motion was studied. Such stationary behavior, however, is of prime importance since in most laboratory and field situations the response time of suspended particles can be shown to be small in comparison to times of measurement. Being able to utilize the concept of statistical stationarity additionally allows the appropriate definition of average quantities in the particle motion. As a consequence particle freefall velocity was treated as a uniform drift [e.g., Eq. (7)].

In the study it was reasoned that upon achieving stationary motion the particle (insofar as its average behavior was concerned) could be viewed as experiencing an average forcing function characteristic of the underlying homogeneous turbulence field and its response to this field. For a determination of the particle's time correlation the appropriate forcing function clearly would be identified with the particle's energy spectrum. Eq. (13) thus relates the underlying average fluid spectrum to that actually experienced by the particle and as such may be thought of as a defining equation for the particle's response function (see, for example, S00, 1967). The response function used in this study, Eq. (14), is appropriate to a solid particle-fluid particle Eulerian space-time correlation of unity, and for good reason. Particle dispersion is particularly sensitive to this correlation as it enters into the dispersion expression, Eq. (22), at least as a squared quantity. Should the correlation be significantly less than unity Eq. (22) would greatly overpredict the dispersion. However, as can be seen in Fig. 2 in the article in question, no overprediction occurs but rather excellent agreement between theory and experiment is obtained. Consequently, the authors must strongly disagree with the assertion that "it is the Eulerian space-time correlation which controls particle diffusivity." Such a sweeping generalization ignores the experimental realities of the situation. The importance of this space-time correlation to conditions of inhomogeneous turbulence is also recognized and is presently being extensively investigated experimentally in our laboratory with parameterization including particle size, shape, density, and free-fall velocity.

As noted in the article in question the results of the analysis are in broad agreement with earlier studies regarding the importance of the crossing trajectories effect. However, as shown in Fig. 3, the present work indicates that inertial effects can be quite significant for heavy particles, in marked contrast to the conclusions of earlier investigators (see Csanady, 1963, for example). Far from being dismayed by similarities between the present work and that done by earlier workers, the authors were gratified by these results which tend to validate the underlying analytical approach. Indeed, it is felt that the constancy of spatial scales and subsequent transformation from the spatial to the time domain concept introduced in the paper may be used with good effect in other related studies. As an example, such an approach predicts that for homogeneous fluid turbulence, the ratio of Eulerian to Lagrangian time scales will equal the turbulent intensity. Extension of the present study into the realm of lighter particle behavior (to coincide with experimental studies) is presently being undertaken.

REFERENCES

