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Introduction

For a brief period during the latter part of World War II, N. F. Mott, then professor of physics at the University of Bristol (later knighted and a Nobel laureate), undertook an effort to theoretically describe the statistical fragmentation of bodies subjected to intense impulsive loads. Specifically, he focused on fragmentation resulting from the explosive rupture of cylindrical bombs (referred to by Mott as H.E. shells or shell cases). Over a period of about six months in 1943, three internal UK Ministry of Supply reports emerged, which provided the core of his theoretical efforts (Mott and Linfoot, 1943; Mott, 1943a,b). In late 1943 through 1944 three further internal reports (Mott, 1943c; Mott, 1944; Mott et al., 1944) undertook critical examination and experimental testing of his seminal theory of fragmentation. Sometime later he more formally prepared selected portions of these efforts for open literature publication (Mott, 1947). Finally, apparently under stimulus from an earlier conference on fracture in metals held at Cambridge University, Mott (1948) published an extended note titled by him "Fracture of Metals: Some Theoretical Considerations." Some of his most forward-thinking thoughts on the micromechanical and molecular aspects of fracture are included in this last publication.

For scientists and engineers concerned with the dynamic fracture and fragmentation of solid bodies subject to the intense transient loads imparted by explosive detonation or high velocity impact, Mott's original publications contain the seminal theoretical concepts from which numerous later modeling efforts and engineering formulae emerged. The original physical ideas conceived by Mott and the accompanying mathematical analysis pursued are unique and fascinating. They clearly reflect the unusual insight and scientific accomplishment of this individual.

Mott's theoretical results, as put forth in the original internal reports and the later open literature publication have, unfortunately, not been fully appreciated in work by later authors and, in some cases, not fully understood. The presentation by Mott is terse, leaving much for the reader to fill in.

Considerable reflection, with pencil in hand, is required to begin to appreciate the richness and insight offered in these works.

The present book surveys the theoretical analysis put forth by Mott with particular focus on his efforts to characterize the size and distribution of fragments resulting from a dynamic fragmentation event. This book also pursues additional new theoretical analysis. The intent of this analysis, however, is to delve further into the physical ideas and unfinished analysis implicit in Mott's original study. The thesis being that with further time and inclination, those are avenues that Mott himself might have pursued. These additional efforts fall short of exhausting the fruitful thoughts put forth by Mott in his original reports.

Mott pursued several approaches, as his thoughts on the nature of statistical fragmentation matured. Early on he was influenced by the theoretical efforts of Lineau (1936) who, a few years before him, examined in depth the statistical distribution of fragment lengths resulting from the random partitioning of a one-dimensional body (a line). This Lineau distribution was intriguingly close in form to experimental fragment mass distribution data on exploding metal shells available to him at the time. This led Mott, along with Linfoot, in his first report to pursue in some detail the fragment size distributions resulting from the random geometric partitioning of two- and three-dimensional bodies. These efforts, in fact, led to the familiar Mott distribution in which the log of the cumulative fragment number is proportional to the square root of the fragment mass. This Mott distribution continues today as the most common means of representing fragmenting munitions data. Further, the geometric fragmentation problems explored early on by Mott have in the intervening years, provided the source for a large amount of analysis.

Mott became disenchanted with the random geometric approach to the dynamic fragmentation problem as his scientific investigation progressed. He noted the likelihood that both nonuniqueness of the statistical algorithms used, and the lack of statistical homogeneity in the experimental fragmentation event, could easily negate applicability of predicted distributions from the geometric theory. He then embarked on an entirely different, and more physically-based, theoretical study of the statistical fragmentation problem.

In this second exploration of dynamic fragmentation of rapidly expanding shells, concepts emerge concerning the statistical activation of fractures and the interplay among an ensemble of fractures as the propagation of stress release waves ensue. The instructive analysis in which an elementary momentum solution leads to the diffusive nature of tensile stress release from fracture sites is illustrative of this latter effort. This latter approach leads to a coupled physical and statistical theory of fragmentation in which the physical properties governing the fragment size and distribution length scales emerge.

Mott's approach to dynamic fragmentation has been objected to by some more recent workers in the field as too phenomenological in form. A closer look at Mott's efforts, however, reveal extraordinary and successful attempts by him to relate phenomenological parameters from his statistical theory to the underlying microscopic and atomic physics. Mott was, in fact, an advocate of multiscale physics long before this topic gained its current fashionability.

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