CHAPTER I

INTRODUCTION

Creation of an anisotropic ferromagnet by subjecting a ferromagnetic material to a planar shock wave produces the shock induced magnetic anisotropy effect. The resulting uniaxial strain establishes a magnetic anisotropy field which fundamentally affects the magnetic behavior of the material. A quantitative understanding of this shock induced magnetic behavior is necessary before a complete description of the response of magnetic materials to dynamic loading can be determined.

1.1 Background

The interdependence of magnetic and elastic behavior of ferromagnetic material was first established by Joule[1] in 1842 when he observed the change in length of a ferromagnetic bar upon magnetization. The inverse effect (Villari effect) or the change in magnetization with applied tension was reported in 1865.[2] There followed a rash of discoveries of magnetostrictive effects and related inverse effects which were finally incorporated into a coherent theory with the advent of conventional magnetoelastic theory in the early 1930's.[3] Intensive research in the 1940's and 1950's established the foundations of domain theory.[4] Finally, a consistent thermodynamic treatment of magnetoelastic interactions by Brown[5] (1963) refined the conventional theory to its fairly sound foundation of the present day.

The shock induced anisotropy effect is a specific form of the general piezomagnetic or inverse magnetostriction effect. Its contribution to the shock induced demagnetization problem was established by Royce[6] (1966) while investigating the magnetic response of nickel ferrite under shock loading. Subsequent work by Royce[7] and Shaner and Royce[8] in the plastic region of yttrium iron garnet and Seay et al.[9] in the elastic and plastic regions of manganese zinc ferrite confirmed this conclusion. The effect in single crystal and polycrystal ferrites has been considered theoretically by Bartel.[10,11] Wayne, Samara, and Lefever[12] have observed a form of this effect which occurs locally in porous ferromagnetic material subject to hydrostatic pressure.

There has been continuing interest in this magnetic effect peculiar to the realm of shock wave physics. The interest has recently been increased by attempts to understand the magnetic response of natural and meteoritic material under dynamic loading. This understanding is necessary to be confident in using magnetic techniques for investigation of the history and origin of such materials.

1.2. Objectives

The work cited in the previous section represents a significant contribution to the definition and understanding of the shock induced anisotropy effect. However, it is the belief of this author that the extension of this understanding to the prediction of the magnetic response of actual material subject to shock loading requires a firmer quantitative foundation than is now available. The intention of this work is to contribute theoretical and experimental groundwork toward this foundation.

The objectives undertaken in this work are as follows. The necessary thermodynamics for a systematic description of the induced anisotropic ferromagnet will be developed. The shock induced anisotropy effect in single