On Some Effects of Torsion 
on the Magnetization of Ferromagnetic Cubic Crystals.

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Summary. — It has been demonstrated that the domain theory of ferromagnetism, with the hypothesis of the isotropic magnetostriction and for monocrystals of cubic lattice structure, can explain Matteucci's effect which appears in ferromagnetic substances dipping in a longitudinal magnetic field, when they are submitted to a torque. The accord with experimental results for polycrystalline ferromagnetic wires is excellent. The theory provides also an electrical signal in the circular direction, due to the longitudinal magnetization by twisting only.

1. - Introduction.

If a torque is applied to a wire of ferromagnetic substance and the wire is dipping in a longitudinal periodic magnetic field, at its ends an electrical signal appears.

This effect, known as Matteucci's effect (1), is not a recent one, and many papers have been written to explain it. But, all previous papers have given only qualitative or semiqualitative interpretations (2-5). Recently this effect

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has been rediscovered by Skorsky \(^{(5,6)}\), but nowhere in this paper have we found a precise explanation and more lately Rothenstein and others \(^{(7)}\) have enriched only the amount of experimental data giving some information on Matteucci's effect obtained by means of periodic torsional oscillations of ferromagnetic wires in a uniform magnetic field.

The purpose of this work is to see if it is possible to find an interpretation of this effect in the outlines of ferromagnetic domains theory.

The calculations are done, for simplicity's sake for monocrystals of ferromagnetic substances of cubic lattice structure. Therefore the results are not completely comparable to the preliminary experimental ones which are concerned with ferromagnetic polycrystalline wires, but a partial accord has been found.

More rigorous experiments on ferromagnetic cubic monocrystals are in preparation, and their results will be detailed in a further paper.

2. - Calculation of the magnetoelastic energy density.

Following the classical theory of ferromagnetism we have to compute the magnetoelastic energy density, depending on the magnetization directions.

To do this, let us consider a ferromagnetic monocrystal of cubic lattice structure which we suppose to be a rectangular parallelepiped with a square base.

We call \(a\) the length of the edge of its base and \(l\) the height of the monocrystal.

As for our coordinate frame, let us take the \(z\) axis coincident with the axis of our monocrystal and the \(x\) and \(y\) axes parallel to the edges of the base.

Moreover we take the torsion and tension of the monocrystal as happening along or about the \(z\) axis.

If we suppose that there exists a periodic magnetic field \(H = H_0 \sin \omega t\) directed along the \(z\) axis, then we have for the energy density \(E\):

\[
E = E_K + E_{\tau} + E_{\tau_0} + E_M
\]

where the right hand terms are respectively the lattice, tension, torsion and magnetic energies depending on the magnetization directions.

For the lattice energy \(E_K\), we have \(^{(9)}\):

\[
E_K = K(x_1^2 x_2^2 + x_2^2 x_3^2 + x_3^2 x_1^2)
\]

where \(K\) is a constant and \(x_1, x_2, x_3\), are the direction cosines of the magnetization axis.

