1. INTRODUCTION

Electric and magnetic fields are our description of how fixed or moving charges exert forces on other electric charges. We describe these fields by lines of flux, or simply lines. We use the idea of field lines to describe how the influence of our fixed or moving charges is distributed in the surrounding space. Electric field lines start and stop on charged particles, or objects that contain charges. Magnetic field lines do not start or stop. They are all closed curves, and they encircle the path of the moving charges which give rise to them. They tend to concentrate in nearby objects which have certain atomic properties that make them receptive to the presence of these fields. The extent to which magnetic fields tend to concentrate in these materials (ferromagnetic materials) over free space or nonferromagnetic materials is called permeability. For electric fields the dielectric constant indicates in a corresponding manner the preference of an electric field for one kind of material over another.

Nothing has either an infinite dielectric constant or an infinite permeability. Some small numbers of the magnetic field lines surrounding the windings in a transformer will surround some or all of the conductors of the primary winding only, rather than reside in the core where they encircle both primary and secondary. Some magnetic field lines will loop outside of the core itself, and constitute the "stray" field of the transformer. These stray field lines are loops like all magnetic field lines, and they will therefore encircle nearby components or circuitry. Because they encircle a conductor, they can induce a current in the conductor, just as they encircled the current flow which gave rise to that field line.
The simple thing we call an inductive component, and which we design and construct so readily, is in reality a marvelous consequence of some of the most fundamental forces which make this physical universe behave as it does. The magnetic field is really a relativistic effect, arising out of a remarkable interplay between the electric field and the nature of this space. The interested reader is urged to obtain the three-volume set of the Feynman lectures on physics, and read in particular the second volume.

Since this is a book about magnetic components it might be helpful to define, or at least establish some agreement as to just what magnetic components are.

Magnetic components are those which store or transform energy by utilizing the magnetic fields associated with electric currents.

Electric currents are electrons or charged particles which are moving or caused to move, usually through conductors.

The actual velocity of an electron in a wire is perhaps a tenth of a millimeter per second, but when we push an electron in one end of a wire it repels nearby electrons which in turn repel further electrons, and a different electron pops out the other end of the wire very rapidly. The time it takes for the pushing in of the first electron and the popping out of the first electron is dependent on how fast the push propagates down the wire. That push is the electrostatic field of each electron nudging that of the next.

Something else happens here when we do this. We are in effect setting charges in motion, and when something is moving it usually has an energy associated with that motion, called kinetic energy. An ordinary piece of mass stores its energy of motion within itself, but charges behave a little differently. You can look at the situation as if the charge stores its energy of motion in the surrounding space, rather than within itself. The mass of the electron stores kinetic energy in its mass, but the charge, which is not mass, behaves differently.

It is this energy of motion of a charge which we call the magnetic field. A useful definition of a field is "a physical quantity which takes on different values at different points in space."

Even if we can't see the field we can measure the presence of it. Magnetic fields affect the behavior of charges in such a way as to bring about the behavior characteristics of transformers and inductors.

Physics is not an exact science, and we definitely do not know all the rules. If we set up a very simple, restricted experiment, we find that it behaves in a certain way, and we can say we understand the laws of physics that govern that experiment. The foregoing explanation of the nature of a magnetic field