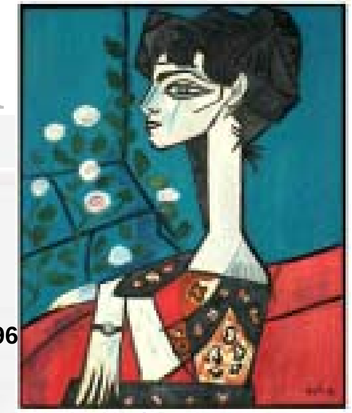
The World Leader in Electromagnetic Physics
www.Distinti.com



Classic Flux Anomaly

By Robert J Distinti B.S. E.E.

This material is copyright protected 1999-2003 and is solely the work/discovery of Robert J. Distinti. www.Distinti.com 46 Rutland Ave, Fairfield CT, 06825. (203) 331-9696 contact@distinti.com. The New Electromagnetic models are available at the above website.

Classic Flux Anomaly

ABSTRACT

It is asserted in classical electromagnetic theory that the magnetic field of a coil of wire, wrapped around a closed magnetic core (assume ideal permeability), is completely contained in the core. In the Annenberg CPB program "The Mechanical Universe" (episode 37--www.learner.org), Dr. David Goodstein uses an apparatus similar to Figure 1-1 to demonstrate electromagnetic induction. The experimenter goes to considerable length to show that there is absolutely no flux activity outside the core even when the current changes.

There is no doubt that this is a true assertion of classical electromagnetic field theory; however, is it true under all circumstances? If the flux from a constant current is completely contained in the core, then how are new flux lines "threaded" through the core when the current is increased?

This paper will detail a number of methods by which new flux lines could "thread" the core; however, the only method that does not violate Ampere's Circuital Law requires part of a newly created flux loop to pass outside the core and "cut" the secondary on its journey to "engage" the core. This new flux method (model) is not detectable by the methods used by Dr. Goodstein. Furthermore, it allows transformer theory (as demonstrated in Figure 1-1) to be explained by the Classical Motional Electric Law ($emf = (\mathbf{v} \times \mathbf{B}) \bullet \mathbf{L}$) in addition to Faraday's Law. In classical electromagnetic theory, only Faraday's Law was capable of explaining transformer theory.
Along with the improved flux model, this paper demonstrates that Faraday's Law ($emf = -N\frac{d\Phi}{dt}$) is only a special case of the Classical Motional Electric Law

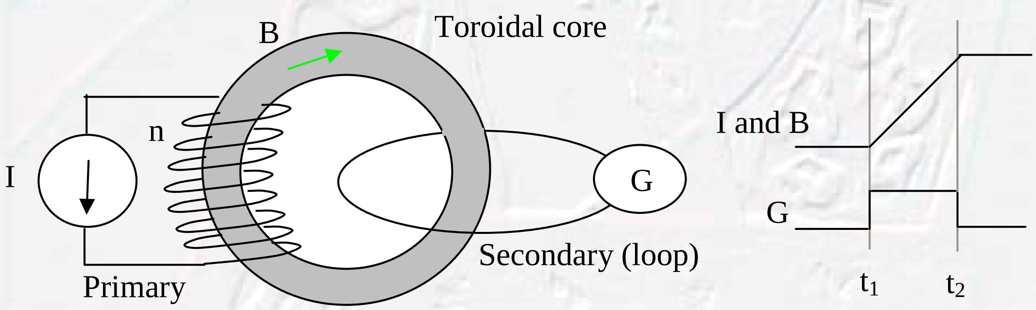


Figure 1-1

Copyright © 2003 Robert J Distinti.

1 Introduction

The experiment shown in Figure 1-1 is typically used to "prove" that Faraday's Law is the only explanation for transformer theory. This proof is based on the assertion of classical electromagnetism that all flux activity is contained in a perfectly permeable core. Since all flux is contained in the core, then there can be no flux activity at the actual wire which comprises the secondary (the wire). Since all flux activity passes through the area contained by the wire and no flux activity comes into "contact" with the wire, then alternate explanations (such as New Electromagnetism) which require actual flux contact with the wire seem unfeasible. This unfeasibility holds true for any degree of core permeability greater than free space (The paper New Induction provides an alternate explanation of transformer theory for free space which requires flux contact with the wire). If the classical assertion is true, then the only model able to explain this phenomenon (transformer theory) is indeed Faraday's Law.

This paper poses the following question: how do new flux lines (generated from an increase in primary current) "thread" through or "engage" the core? If the classical assertion is true, then it seems reasonable to conclude that new flux lines begin in the core; however, any method developed to model this assertion ends up violating Ampere's Circuital Law (shown in this paper) and the Rules of Nature.

This paper proposes an improved flux model that explains the manner in which flux lines "engage" a core without violating Ampere's Circuital Law. This new model ironically shows that new flux lines (loops) must start completely outside the core (near the primary). As the magnetic field expands, these new flux lines are then drawn into the core. In the process of being drawn into ("engaging") the core, the flux lines cut the secondary. Consequently, this improved flux model enables transformer theory to be modeled using the Classical Motional Electric Law (CMEL) ($emf = (\mathbf{v} \times \mathbf{B}) \bullet \mathbf{L}$) as well as Faraday's Law and New Induction. In fact, it is shown that Faraday's Law is just a special case of the CMEL and not a stand alone model of nature.

The derivation of this new flux method (or model) begins by considering many different ways that flux could thread a core.

Copyright © 2003 Robert J Distinti.

2 The Various Methods

This section details the various flux "threading" methods wherein newly created flux lines become "engaged" by the magnetic core.

In this section we consider only ideal core materials (perfectly permeable). In a later section it is demonstrated that the methods developed here are applicable to cores of different permeability to include free space.

The term "engaged" is used in this paper to denote a flux line that exists within the magnetic material of the core. If a magnetic flux line is entirely contained within the magnetic material, then the flux line is said to be "engaged" or "completely engaged". If part of the flux line exists outside of the magnetic material then the flux line is said to be "partially engaged". If the entire flux line exists outside the magnetic material, then the flux line is not "engaged."

In this paper, many possible flux threading methods (models) are considered. Some of the models (such as the first one shown in section 2.1) are outright illogical; however, by considering the faults of the illogical models, we learn about what characteristics a true model must posses. The faults of the illogical are the building blocks of the truth.

2.1 The Instantaneous Manifestation

Note: It is only logical that flux can not manifest instantaneously; the following argument is provided only for completeness.

The first possible method whereby new flux lines become "engaged" is though instantaneous manifestation within the core. In other words, when the current in the primary increases, new flux-lines appear or "materialize" instantaneously within the core.

The first objection to instantaneous manifestation is the fact that new magnetic flux-lines (Shown in red in Figure 2-1 and Figure 2-2) will appear in one place when a core is present and in a different place when a core is absent. How do flux-lines know where to materialize?

Copyright © 2003 Robert J Distinti.

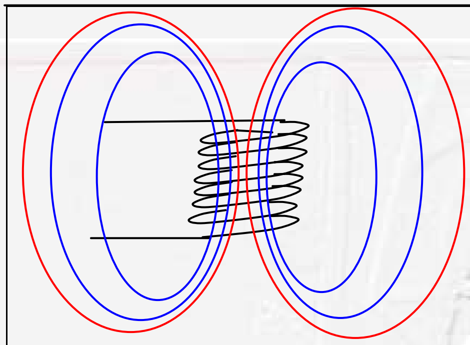


Figure 2-1: Magnetic field: No core

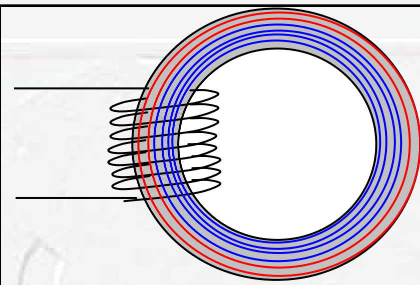


Figure 2-2: Magnetic field with core

Not only do new flux-lines have to manifest relative to the existence of a core, they have to manifest relative to the pre-existing flux-lines such that the proper spatial field distribution is maintained. This seems to require sentience somewhere in the process of creating new flux-lines.

Another fault with this method is demonstrated with the following thought experiment. Suppose we had a special “transporter” machine that would allow us to instantly insert a magnetic core in the empty coil shown in Figure 2-1. How would the pre-existing flux-lines engage the core? Would the flux-lines disappear then re-manifest within the core? This is not logical.

The simplest way to prove that flux-lines do not appear instantaneously is to propose a long distance communication system whereby magnetic core material is used in place of conductive wire. If magnetic flux-lines appear instantaneously about the magnetic core, then we would have a faster than light -- instantaneous communication system.

Thus it is reasonable to conclude that magnetic flux-lines are not created through instantaneous manifestation; therefore, our first building block of the truth requires us to conclude that a field must grow or expand from a point of origin. This growth then requires flux to have an actual velocity or motion through space (not a propagation velocity—this distinction covered in section 5). If flux lines must grow from a point of origin, then where is the point of origin?

2.2 The “Breakable” Flux method

Another possible method for flux-lines to engage the core requires that new flux-lines sprout from a “point of origin” as “broken” segments. These segments then thread a path around the core to form a closed ring. This concept is illustrated by the red arrow in the following two figures.

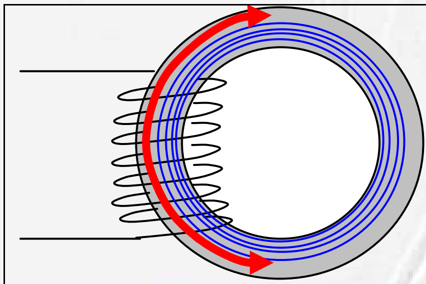


Figure 2-3 Newly created

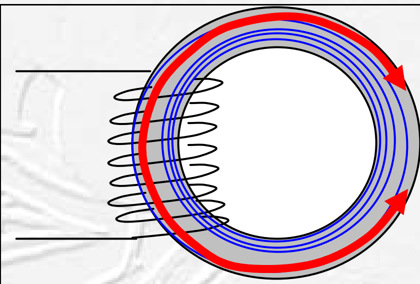


Figure 2-4 Almost closed

This method seems to provide an adequate mechanism; in fact, this model is almost correct. It will be shown in a later section that the magnetic molecules do in fact align in a fashion that propagates around the core; however, there are a number of faults with this method that must be addressed.

The first and simplest fault is demonstrated by considering an infinitely long strait filamentary conductor as shown in Figure 2-5 and Figure 2-6. When current is first applied to the filament, concentric flux-loops will form around the conductor. If a flux-loop begins life as a broken segment (Figure 2-5) then where does it begin? Any radial point from the conductor is as good as any other? This method violates the ambiguity rule.

Another objection is that this method violates Ampere's Circuital law:

$$I = \oint \mathbf{H} \bullet d\mathbf{L}$$

Equation 2-1 Ampere's Circuital Law

Copyright © 2003 Robert J Distinti.

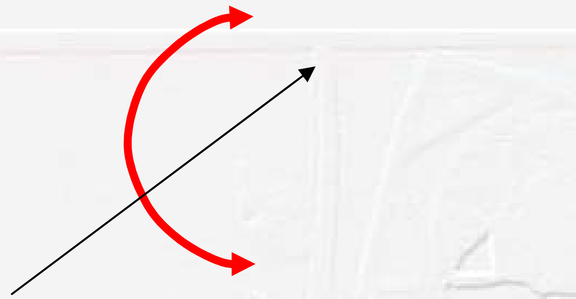


Figure 2-5

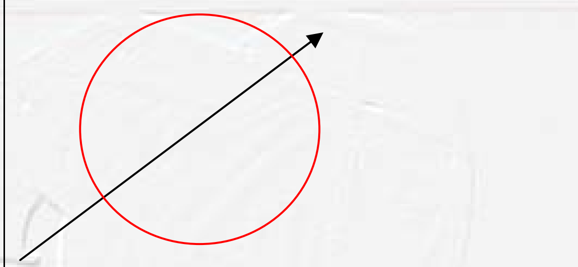


Figure 2-6

In order for Amperes Circuital Law to register the correct amount of current passing through the filament, the "broken" flux-loop in Figure 2-5 must be "thicker" until the loop is completed in Figure 2-6. This "thicker" flux-arc would make it possible to choose an arbitrary closed path, which excludes the filament and results in a non-zero current. This, of course, is a violation of Ampere's Circuital Law and wrongly suggests that electromagnetic fields in free space are not linear. This is obviously an unacceptable method.

Exploring Ampere's Circuital Law has provided another clue (building block) about what properties the correct model of flux should posses. The correct model should not violate Ampere's Circuital Law; as such, flux-lines must be treated in a manner similar to the contour lines on a topographical map. Like the contour lines on a topographical map, flux-lines are ALWAYS continuous closed (unbroken) loops. Also, like contour lines, flux-lines can NEVER intersect. To do otherwise would violate Ampere's Circuital Law.

Another building block arises from exploring the point-of-origin. We seek a non-ambiguous point-of-origin for a flux-loop. Referring to Figure 2-6, it is reasonable to conclude that the point-of-origin must exist somewhere in the plane that contains the flux-loop. The most logical and certainly non-ambiguous point is where the current carrying filament intersects the plane. Thus, the field "material" must expand from, or contract to, the current carrying filament. This is logical since the filament is the "source" of the effect.

2.3 The Expanding Field Method

By considering the building blocks from the previous discussions, we are left to consider that new a flux-line begins as an infinitesimal small loop

Copyright © 2003 Robert J Distinti.

around the primary-wire. Since loops can not overlap or cross, this new loop must physically displace pre-existing loops outward when it is created. Therefore magnetic fields must expand from, or contract to, the source wire.

This expanding field method is the only way that a magnetic field can expand (or contract) without violating Ampere's Circuital Law.

In classical electromagnetic theory, it is common to talk about expanding and collapsing magnetic fields; however, this phenomenon is only addressed in the following simplistic terms: When the current is large, the magnetic field is large; when the current is small, the field is small. Classical electromagnetism does not discuss the manner in which a field expands, or contracts. The mechanism of field expansion and collapse is one of the founding concepts of New Electromagnetism. New Electromagnetism shows that flux expands and contracts through free-space with an actual real velocity (see note 1 below) which depends upon a number of factors. The derivation of the free space flux velocity equation is contained in the paper titled "New Electromagnetism"—ne.pdf which is found at our website. This paper will use the same logic to derive a method for flux expansion/contraction with regard to a magnetic core.

Note 1: flux velocity is not the propagation velocity defined by the classical retarded time techniques. The distinction between actual flux velocity and flux propagation velocity is discussed in section 5.

To illustrate the expanding flux method, consider Figure 2-7 which is a larger view of the toroidal system at steady state. In this diagram, only one turn of the primary is shown for simplicity. The primary winding is shown relatively far away from the core for the purpose of examining the behavior of the flux near the primary. Since Ampere's Circuital Law must not be violated, there must be flux between the primary-wire and the core as represented by the violet/thick flux-loop.

Note 2: Each flux-loop is shown as a different color to aid the discussion.
Note 3: "Thicker" loops indicate higher magnetic field intensity (flux-lines/area).

The discussion begins by considering the system prior to the increase in primary current as shown in Figure 2-7. At this moment, there is a constant current in the primary which is responsible for the steady state magnetic field represented by flux-loops engaged by the core (blue/thin) and flux-loops near the primary which have not touched the core (violet/thick).

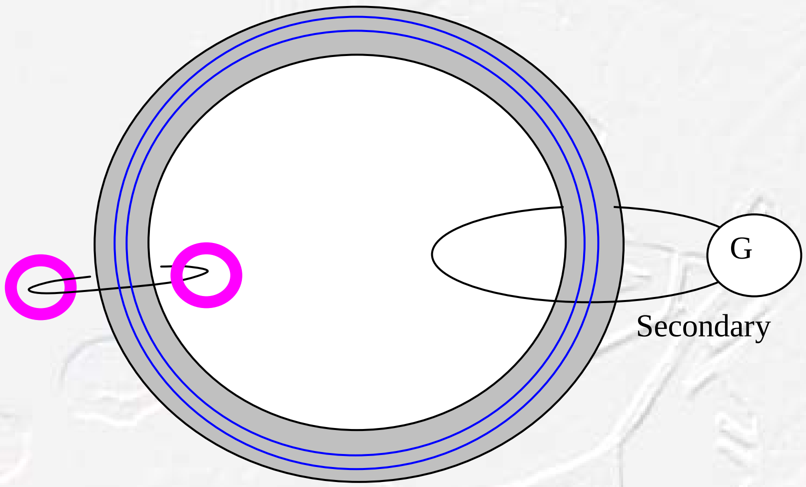


Figure 2-7 Steady state

When the primary current increases (Figure 2-8), new flux-loops (red/thick) are created near the primary-wire which then displace the violet flux-loops out. As the violet flux-lines displace, they expand in perimeter which causes their intensity to decrease (represented by the diminished line thickness of the violet loop). When the flux-line expands to the point where it touches the core, the “engagement” process begins. The “engagement” process continues as the remainder of the flux-loop is drawn into the core.

Note: The black arrows in the diagram represent the flux velocity.

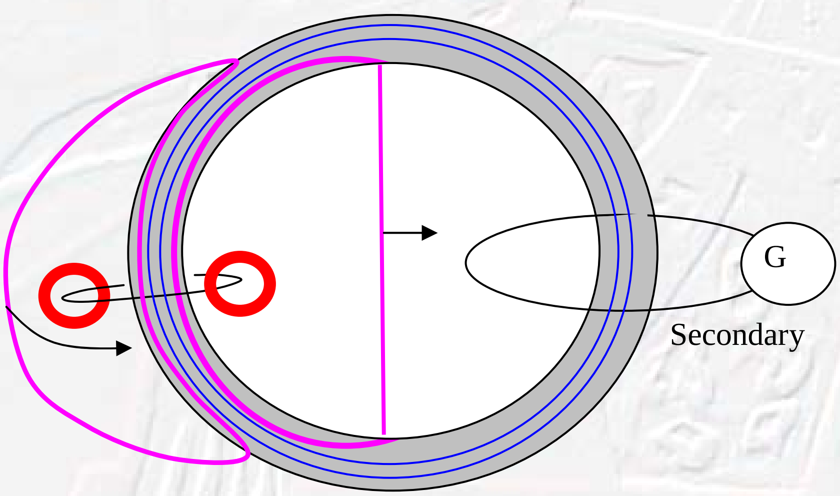


Figure 2-8 Current increased

Copyright © 2003 Robert J Distinti.

In the engagement process, the right violet loop (inside the core) simply expands across the center as shown in Figure 2-8. Since, the left violet loop can not pass through other loops, it must therefore swing around the primary to the left or right (like a door slamming shut). When steady state is achieved, the violet flux-loops are completely engaged by the core (we are assuming an ideal core).

This method preserves the integrity of the classical flux model and Ampere's Circuital Law; however, it shows that the flux-lines "cut" the secondary on their journey to engage the core.

Copyright © 2003 Robert J Distinti.

3 The Derivation

The method described in Section 2.3 shows that flux-lines are “cut” by the secondary when “engaging” the core. Since the Classical Motional Electric Law (CMEL) relates emf to flux-lines “cut” by a wire, then it should possible to derive the emf generated in the secondary using the Classical Motional Electric Law.

$$emf = (\mathbf{v} \times \mathbf{B}) \bullet \mathbf{L}$$

Equation 3-1 Classical Motional Electric Law (CMEL)

If the derivation is correct, then the results should be identical to the only accepted classical model for the transformer experiment; Faraday’s Law (Equation 3-2).

$$emf = -N \frac{d\Phi}{dt}$$

Equation 3-2: Faraday’s Law.

To determine the emf in the secondary using CMEL, the velocity (v) of the wire (secondary) relative to the flux lines is required. Since the velocity of the secondary is stationary, the question becomes: what is the velocity of the flux lines? Do the flux lines entering at different aspects have different velocities? This seems like a daunting task; however, by analyzing CMEL we find that the velocity of the flux lines can be abstracted out (for the closed loop case). The following diagram represents the relationship described by CMEL.

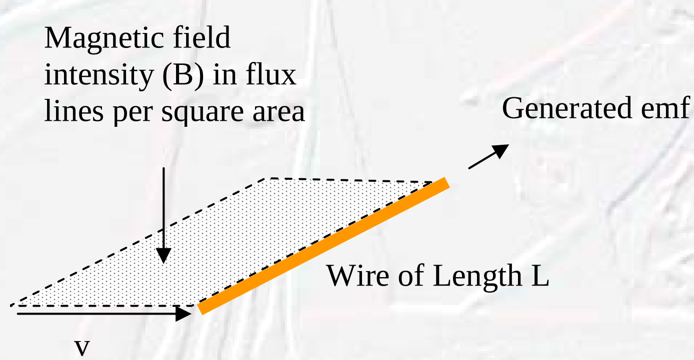


Figure 3-1 The emf generated by wire moving through magnetic field

Copyright © 2003 Robert J Distinti.

In our experiment, the wire is stationary and the flux is moving; therefore, we redraw the diagram as follows:

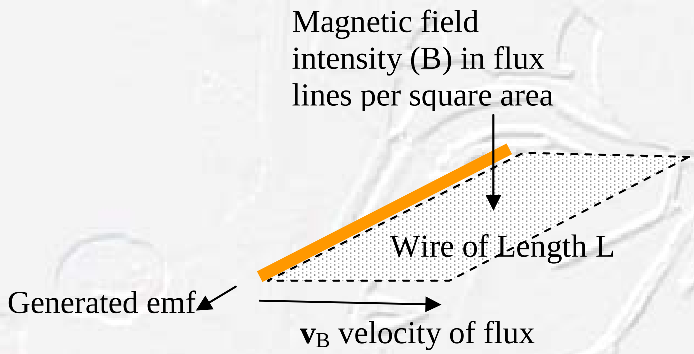


Figure 3-2 The emf generated by flux moving relative to wire

Then, restating the Classical Motional Electric Law (CMEL) as follows:

$$emf = ((\mathbf{v}_W - \mathbf{v}_B) \times \mathbf{B}) \bullet \mathbf{L}$$

Equation 3-3 A Modified version of CMEL

Careful observation of Figure 3-1 and Figure 3-2 show that a length of wire moving at relative velocity to the magnetic field sweeps out an effective area inside the magnetic field related by:

$$area/second = \mathbf{L} \times (\mathbf{v}_W - \mathbf{v}_B)$$

Equation 3-4

Since B represents the magnetic field intensity in flux-lines/area, then the total flux lines that are cut by the wire in each period of time is then:

$$\frac{d\Phi}{dt} = (\mathbf{L} \times (\mathbf{v}_W - \mathbf{v}_B)) \bullet \mathbf{B} \qquad \text{[(area/second)*(flux-lines/area)=flux-lines/second]}$$

Equation 3-5 derivation of flux lines per second

We observe that Equation 3-3 and Equation 3-5 are vector equivalents of each other therefore:

$$emf = \frac{d\Phi}{dt} = ((\mathbf{v}_W - \mathbf{v}_B) \times \mathbf{B}) \bullet \mathbf{L}$$

Copyright © 2003 Robert J Distinti.

Equation 3-6: The complete Modified Classical Motional Electric Law (MCMEL)

The above result shows that rate of flux crossing (being "cut" by) a wire length is related the emf generated along that length.

Equation 3-6 almost looks like Faraday's Law (for loops of one turn) except that Faraday's Law is negative with regard to $\frac{d\Phi}{dt}$ whereas the above equation is positive. This dilemma is easily reconciled by applying MCMEL to a loop where a single flux line exits to the right as shown in Figure 3-3.

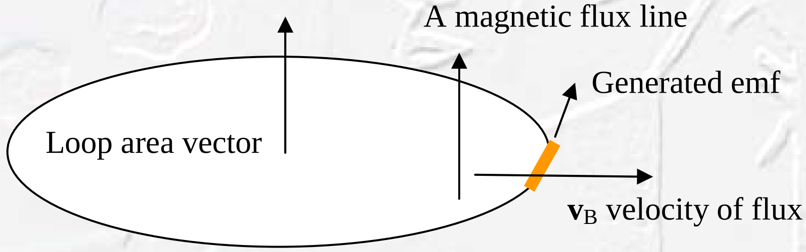


Figure 3-3 Applying MCMEL to flux exiting a loop

The application of Equation 3-6 to the above diagram yields a positive emf when flux exits the loop; consequently a negative emf is developed when flux enters.

Since the $\frac{d\Phi}{dt}$ in Faraday's Law is by definition the rate of change of flux in the loop, then a positive $\frac{d\Phi}{dt}$ indicates that flux is entering the loop. From this observation we restate Faraday's Law as follows:

$$emf = -N\frac{d\Phi(entering)}{dt} = N\frac{d\Phi(exiting)}{dt}.$$

From the above, we see that Faraday's Law, like Equation 3-6, yields negative emf for flux entering and positive emf for flux exiting.

Therefore the new flux method allows us derive Faraday's Law from the Classical Motional Electric Law.

Note: The N from Faraday's Law is set to one for our experiments since we are considering loops of one turn.

4 Consideration of core Permeability

Although the logic that led to the previous derivation considered an ideal (perfectly permeable) core, the derivation itself is applicable to any range of core from ideal to air core. The permeability of the core affects the number of flux lines that will pass into the space contained by the secondary when the primary current increases.

The following diagrams show (schematically) how core permeability affects the magnetic field generated by a constant current in the primary.

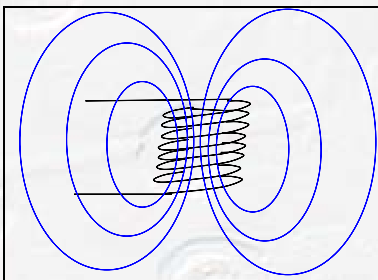


Figure 4-1 Air core

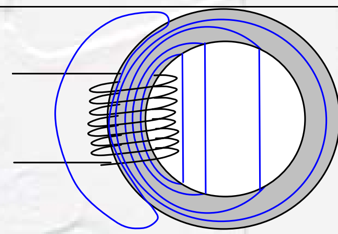


Figure 4-2: semi-permeable

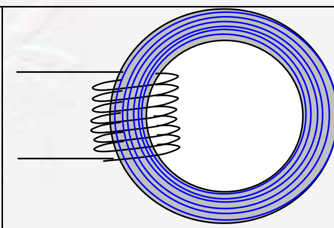


Figure 4-3 Perfectly permeable (ideal)

In each case the primary current is the same, therefore the same amount of flux is generated by the primary in each example. As the permeability (magnetic conductivity) of the core increases, the flux lines are more completely contained by the core.

In the next set of diagrams, the primary current is increased. This generates new flux-lines (red lines) which then displace the pre-existing field lines.

Copyright © 2003 Robert J Distinti.

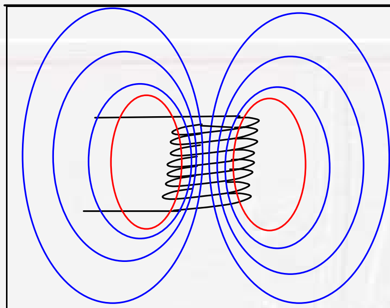


Figure 4-4 Air core

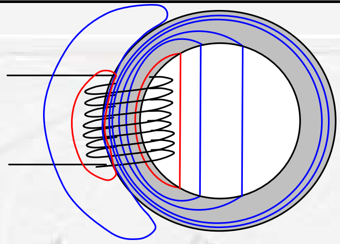


Figure 4-5: semi-permeable

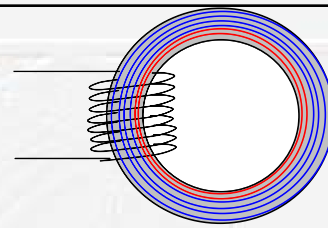


Figure 4-6 Perfectly permeable (ideal)

If a secondary were wrapped around the core as in Figure 1-1 (in a similar position for the air core), it is not hard to see that with increased core permeability, more flux-lines pass into the interior of the secondary for any given increase in primary current.

Copyright © 2003 Robert J Distinti.

5 Conclusion

This paper shows that the emf generated in the secondary of a transformer is the result of flux-lines that begin outside the core and "cut" the secondary on their journey to engage the core. This represents a new wrinkle to classical field theory which has traditionally asserted that no flux activity exists outside of an ideal core.

This new flux method enables transformer theory to be derived from a modified form of the classical Motional Electric Law (MCMEL). Prior to this development, only Faraday's Law was capable of explaining transformer theory with regard to permeable cores. This new flux method for classical electromagnetism is a byproduct of the New Magnetism models developed to explain magnetic materials in a fashion compliant with New Electromagnetic principles. Prior to the New Magnetism research, New Electromagnetism could only explain air core transformers (See "New Induction"--ni.pdf).

In order to derive a quantifiable value for emf, the MCMEL requires a relationship for the actual flux velocity. Due to the nature of a closed loop, it is possible to abstract out the flux velocity term. This is important since classical electromagnetic theory has no relationship or model for flux velocity. One might mistakenly say that the retarded time models (e.g. retarded potentials) infer a velocity; however, they only infer propagation velocity. The distinction between the two velocities is highlighted in the following paragraph.

The retarded time models of classical electromagnetism provide a time-delay mechanism to account for the propagation time between a change in current at one point in space and the corresponding change in flux density at another. The retarded time models relate the **propagation** of an effect, not the **velocity** of flux. It is easier to highlight this distinction with the following analogy: electrical signals **propagate** through a conductor at close to the speed of light; however, the actual electrons move at a **velocity** of only a few inches per second. Therefore, it is clear that an "effect" and the carrier of that "effect" do not necessarily move at the same velocity. Furthermore, **propagation** velocities are substantially constant whereas carrier **velocities** are variable. A derivation for free-space flux velocity is

Copyright © 2003 Robert J Distinti.

contained in the paper "New Electromagnetism"—ne.pdf; found at our website.

As stated previously, it is possible to derive Faraday's Law from MCMEL. Since the derivation is a special case of MCMEL for closed loops, then Faraday's Law is only a special case of the Motional Electric Law and not a stand-alone model as previously thought. Consequently, since Faraday's Law is used to derive Maxwell's Equations, then it is reasonable to conclude that Maxwell's Equations are only a special case of a more complete electromagnetic wave equation.

To reinforce the notion that MCMEL is a more general form of induction than Faraday's Law, we must show that the general form explains more about the phenomenon than the special form. This is demonstrated by realizing that the MCMEL allows us to determine in which direction the emf is generated in a small section of an arbitrary loop without regard to the rest of the structure. It also enables us to model the emf generated in wire constructs that are not closed (such as radio antennae); remember that a closed loop is a requirement of Faraday's Law. Furthermore, Faraday's Law only yields the NET emf from a closed loop; whereas, the MCMEL enables us to determine the emf contributed by each section of a wire construct.

Although www.Distinti.com is the Home of New Electromagnetism; we fully support the classical electromagnetic models as demonstrated by papers such as this.

The New Electromagnetic models are the most complete description of electromagnetic theory. The New Electromagnetic models are based on experimental data which show that magnetism is a completely spherical field phenomenon and not the donut shape as represented by the Biot-Savart flux model. The New Induction model provides a more sophisticated and detailed model for electromagnetic induction than that provided by MCMEL. In fact MCMEL is only represents half of the effects described by New Induction. The New Electromagnetic models (which include New Induction) enable the representation of time-dilation, mass, energy, inertia and gravity as purely electromagnetic phenomena. Most of this information is published freely at our website www.Distinti.com.

Copyright © 2003 Robert J Distinti.