DUAL DILEMMA FROM FARADAY'S LAW: CONSTRUCTIVE FRAUD AT THE FOUNDATION OF ELECTRODYNAMICS

S. I. Wells
P.O. Box 223, Truckee, CA 96160; cywels@gmail.com

Abstract
The original formulation of Faraday's Law (the motivation of an electric current in a conductor about a region of expanding magnetic flux), and its well-known expression in Maxwell's fourth equation (the generation of an actual electric field circulation about such a region of magnetic flux change) are examined in the context of energy and angular momentum conservation. It is shown that these formulations, especially Maxwell's equation, directly violate both conservation laws –i.e., the First Law of Thermodynamics and the Third Law of Motion. Several idealized descriptive arrangements of experimental apparatus are employed in demonstrating the persistent fallacies in the conceptions of electromagnetic relations from the very outset of their theoretical development: various systems of free charges, co-axial coils and rotating charged wheels display specific (though unintentional) conflicts with basic laws of mechanics –evidence of 'constructive fraud'— and point to the need for a thorough re-evaluation of the premises of electrodynamics. Several possible directions toward reformulation are briefly critiqued; more studied attention is then devoted to an Ether Traction-Compression Hypothesis to resolve the issues.

Introduction
The generation of an electric field circulation about a region of changing magnetic flux (as in Maxwell's statement of Faraday's Law) has long been regarded as one of the most fundamental and well-established phenomena in electromagnetism. However elegant its formulation may be, and however useful it may have proven in practical applications, certain features of this law, as customarily understood, radically conflict with other basic laws of physics: The Law of Energy Conservation (first law of thermodynamics) is violated in various simple laboratory idealizations to which theory is applied, and the Law of Angular Momentum Conservation (third law of motion) is also violated in similar situations. To demonstrate these conflicts in physical law conclusively, concrete examples of application of theory will be examined.

Induced Potential Dilemma
In electrostatics, the electrical potential between two points in a static field may be calculated by simply integrating $\overline{E}d\overline{s}$ over any pathway between the points. When a charge Q is moved from one point to the other, it either gains or loses a precise quantity Ψ of electrical potential energy according to the algebraic product of the charge polarity and field direction. Thus, work W is done *on* the charge when it is moved *against* the respective field direction, and work is done *by* the charge when it moves *along* the respective field direction, and energy is always conserved, since in all such cases

$$\Delta\Psi = -\Delta W \quad . \tag{1}$$

However, this simple relation does not hold in electrodynamics:

From Maxwell's fourth equation in integral form,

$$\oint \overline{E}d\overline{s} = -\frac{\partial}{\partial t}\Phi_m , \tag{2}$$

the amount of electric field circulation about a given closed path is equal to the rate of change of magnetic flux (Φ_m) within the enclosed area. Although practical considerations will eventually intercede, there is no theoretical limit to the duration that this rate of change may be sustained in the generating apparatus. Thus over a given finite time interval, the electric circulation may be treated as a static field, much as the analogous magnetic field circulation which exists about a steady electric current, such that while the induced electric field exists, work may be done on a charge placed anywhere within it --either by an external agency in moving the charge against the field, or by the field itself when moving the charge along with it.

In the magnetic circulation case, physicists quite innocently follow Ampere's Rule when integrating the quantity $\overline{B}d\overline{s}$ about a closed path surrounding the current --this is taken merely to quantify the 'amount of magnetic field' in the neighboring space, without any regard to a theoretical 'magnetic potential' which might exist for a hypothetical 'magnetic charge'. Thus no difficulty is encountered here with the conservation of energy.

However, with the electric circulation, there is a definite issue to be raised regarding the calculation of the electric potential. The analogous integral of $\overline{E}d\overline{s}$ about a single closed path might provide a similar quantification of the 'amount of electric field' in the neighboring field, but the termination of the calculation after precisely *one* circulatory path (returning to the original point of departure) is, if not naïve, wholly inadequate with respect to the assessment of *actual* electric potential [1]. Merely assigning the term 'non-conservative field' to the circulation does nothing to resolve the potential dilemma:
Let a unit test charge Q be placed in the circulating induced $\overline{E}$ field. Suppose the charge to be moved about one turn of a closed path against the direction of force $Q\overline{E}$ in the otherwise static $\overline{E}$ field. Work has definitely been done on the charge, but how is its potential distinguishable from another identical test charge, which merely remained in the original position throughout the effort? The answer is that it is NOT; and there is no accounting for the largess of energy consumed by the first test charge. Furthermore, when the electric field generation is itself curtailed, any potential possessed by either charge immediately vanishes, and all the work done on the one charge is irretrievable in the resulting situation: *the law of energy conservation is violated*. Conversely, we may immerse any desired magnitude of test charge in such a circulating field created by mere laboratory fiat, and instantly create an arbitrarily large potential --in fact, an *infinitely large* potential, since there is no reason to terminate the calculation after any finite number of courses about the field. Likewise, there is no theoretical limit to the quantity of work that could be done *by* the test charge in such a situation, since there is no apparent withdrawal of energy from the generating apparatus during the operation. Again, *a violation of the law of conservation of energy results from application of Faraday's Law.*

Angular Momentum Dilemma

Furthermore, equally serious problems arise from Faraday's Law with respect to the conservation of angular momentum:
If a free charged particle were placed within the electric field circulation around a region of changing magnetic flux, it would be impelled in an angular sense along the electric field pathway. Yet no mechanism is specified for acquisition of angular momentum in an opposite sense by the field source, as would be required by the third law of motion. The difficulty within this phenomenon may be accentuated by placing a uniformly charge-embedded disc within the circulating field.
In order to illustrate these theoretical difficulties more definitively, we shall examine the problems in the context of an ideally constructed laboratory apparatus:

Let a massive, electrically neutral wheel be mounted to permit free and frictionless rotation about the vertical axis. This shall serve as the 'ballast' platform against which to drive rotation of other co-axial wheels. Let another co-axial wheel, the 'primary', be set in rotation by mechanical action between it and the massive neutral wheel. If the primary is also neutral, angular momentum is perfectly conserved due to the balance of torques against the wheels. However, if the primary is densely positively charge-embedded (i.e., the numerous individual charges are 'frozen in' to the ponderable matrix of the wheel), a magnetic field will develop in the surrounding space similar in form to that produced by a current-carrying coil. Energy will exist in this field, in addition to the rotational kinetic energy of the primary wheel, and therefore greater torque will have been applied to produce a given angular acceleration over a given time interval. The necessarily greater counter-torque against the massive neutral wheel will have produced in it a greater angular momentum $\vec{L}_0$ (in the given time interval), yet there is no indication of additional angular momentum in the primary $\vec{L}_1$ at the conclusion of the operation (especially if the positive charge were created by *removal* of electrons), and there is certainly no discovery of angular momentum in the resulting magnetic field. The third law of motion has evidently been violated, as the angular momentum does not balance:

$$\Delta\vec{L}_0 \neq -\Delta\vec{L}_1 \qquad (3)$$

Further, let another charge-embedded co-axial wheel (the 'secondary) be placed near the primary, both so secured to prevent vertical displacement from mutual electrostatic repulsion [Figure 1]. If the secondary is also positively charged, it will begin to rotate in a sense *opposite* to the primary (due to the direction of the induced electric field circulation of the primary), thus adding to the gain in angular momentum of the neutral, *further compounding the defect in angular momentum conservation*. (If the secondary is sufficiently massive, its low acceleration rate will not produce any significant opposing fields.)

Limitless Energy Production?

Next suppose the massive secondary were initially set in rapid rotation, and suppose further, for simplicity, that the primary were also set in rotation, such that its initial magnetic field cancels that of the secondary. Then when the induced electric field is brought about through angular acceleration of the primary in the direction opposite the secondary (radius $\vec{r}_2$), the secondary now receives a continuous torque $\oint \vec{r}_2 \times \vec{E}_1 dQ_2$ in the direction of its own rotation. This torque manifests as a mechanical power input to the secondary:

$$P_2 = \frac{d}{dt}\frac{I_2 \omega_2^{\ 2}}{2} = L_2 \frac{d}{dt}\omega_2 , \tag{4}$$

where P_2 is the mechanical power input, or rate of acquisition of rotational kinetic energy $\frac{I_2 \omega_2^{\ 2}}{2}$ of the secondary, whose moment of inertia is I_2; P_2 is thus equal to its angular momentum L_2 times its angular acceleration $\frac{d}{dt}\omega_2$. If I_2 and ω_2 are large, considerable power may be applied to the secondary without any significant opposing electric field circulation developing from its low acceleration rate. Hence we would witness a seemingly unaccountable acquisition of kinetic energy– a violation of the law of energy conservation. In fact, a load may be placed upon the secondary, just sufficient to maintain a constant angular velocity ω_2 , whereby *theoretically limitless external work may be accomplished by the system.* "*Theoretically limitless*" of course ignores the very practical problem of maintaining a continual acceleration of the primary; nevertheless, there is no accounting for the work accomplished by the secondary over any given finite time period. Indeed, the possibility of a sufficiently ingenious arrangement of alternating rotations, separations, and charge concentrations to accomplish a perpetual generation of energy cannot altogether be dismissed in such context.

The above argument follows from the notable textbook omission [2] of any 'back-reaction' being communicated to the driver of the primary: this presumes that the quantity of energy expended in producing the induced electric field of the primary is unchanged by the presence of the charged secondary –no extra torque is required to establish the primary field exceeding that which would be required in the absence of the secondary. Not only is there a theoretical lack of mechanism for such a direct reaction against the primary— it would further disrupt the angular momentum balance of the system, since the neutral wheel must ultimately receive this torque *in the same direction as the secondary!* I.e., where $\overline{L}$ is the total angular momentum of the system (initially zero):

$$\Delta\overline{L} = \int_0^t \tau_O dt + \int_0^t \tau_1 dt + \int_0^t \tau_2 dt \neq 0 \tag{5}$$

with τ_O, τ_1, and τ_2 the respective torques experienced by the neutral, primary, and secondary wheels through time t . On the other hand, if the primary 'feels' the negative torque on the secondary in such way as to manifest in itself a positive counter-torque, *an unaccountable 'runaway' phenomenon results, whereby the primary gains limitless kinetic energy.* Thus the 'dual dilemma' is defined: Angular momentum conservation cannot be maintained without violating energy conservation, and energy conservation cannot be maintained without violating angular momentum conservation. In fact, without the introduction of additional hypotheses, Faraday's Law simultaneously violates *both* conservation laws.

Theoretical Reformulation Necessitated

Since the system as described allows for the theoretically unlimited production of energy without additional input, and contradicts the third law of motion as well, a close examination of the fundamental laws of electromagnetism is called for. Unless we can find a sufficient non-zero value for τ_1, such that eq. (5) sums to zero, and reason to discover an additional demand on the power source, to account for its generation by eq. (4), the dilemmas of angular momentum and energy non-conservation persist unanswered. Several hypotheses may be briefly critiqued before a more definitive solution is proposed.

The third law of motion is upheld through the occurrence of *field momentum* –induced or radiative.
It is conceivable that radiation emitted by the accelerating charges of the primary possesses a *moment* with respect to the system. Thus Poynting's vector could be responsible for carrying away the missing angular momentum (where A is the radiant surface area perpendicular to the linear acceleration at radius $\vec{r}$):

$$d\vec{L} = -\frac{1}{c} A(\vec{r} \times \vec{S})dt \tag{6}$$

this expression, when integrated, could supply the missing factor for $\Delta\vec{L}$ as per the defect in eq. (5). Although this formula might be valid for an angular momentum defect in the primary, it cannot account for the acquisition of angular momentum in the secondary, whose radiative angular momentum would only add to its already unaccountable gain. The same argument applies to any momentum that might be possessed by the induced fields, steady or changing, of the charged wheels themselves, especially since the magnetic field of a negatively charged wheel, in opposite rotation, is tacitly considered to be physically identical to that of the positively charged wheel.
[It might have been possible to attribute momentum conservation to a *literal* use of the original Faraday field, by which the expanding (and substantive) magnetic 'lines of force' are actually *repelled* in the opposite direction by their action against charged bodies; although this would constitute real 'field momentum', it does not account for the kinetic energy gain of the secondary (or of the lines of force themselves), and the notion of 'moving' lines of force has, for a variety of reasons, since been largely discredited.]

Momentum conservation is upheld through an appeal to Mach's Principle –in which distant mass participates.
Next, it might be presumed that the various accelerated charges and fields somehow induce motion in the distant surrounding matter of the universe –but this is extending Mach's Principle beyond its already conceptually difficult intent, especially as it requires neutral matter to 'know' about the operations of distant charged bodies. Neither is any such mechanism present, or even tacit, in Maxwell's equations, nor in any other widely recognized formulation of electrodynamics.

Energy and angular momentum conservation are imputed through velocity-dependence of the electric force.
A weakening of the actual electro-motive force of the circulating field as it is applied to ever greater charge velocities could supply a solution: however, no evidence, experimental or theoretical, suggests that the force would vanish at any charge velocity less than $\vec{c}$. Laboratory velocities, being inappreciably small in comparison, therefore could not succumb to such a phenomenon as described, and the unaccountable gains in angular momentum and energy persist.

Energy conservation is upheld through an increased *reactive* force.
An increased *reactive* force (or torque resistance), due to the presence of the charged secondary and felt against the primary, could explain the source of energy gain in the secondary, since the increased torque now required for the angular acceleration of the primary would necessarily draw *more* energy from somewhere in the system. This action, however, must presume a direct *communication* of this added torque resistance from the charge quantity carried by the secondary, *through* the induced electric circulation of the primary, which is ultimately expressed back against the neutral wheel. An explicit mechanism by which these effects are *seen* or *felt* by the charges and fields is again not presented by the customary exposition of Maxwell's equations--although recent work on this general problem brings out some of the right questions [3]. But even if energy conservation can be upheld by such mechanism, momentum conservation cannot be: the primary does not then receive sufficient acceleration to attain the angular velocity necessary for its moment of inertia to comply with the requisite gain imposed by the acquisition of opposing angular momentum in the neutral and secondary.

Energy conservation is upheld through an as yet undefined *potential* energy.
The postulation of such an uncharted potential, from which the necessary motive energy is mysteriously withdrawn, might spare traditional electrodynamics from violation of energy conservation. This 'potential', combined with a Machian-style angular momentum conservation, could conceivably reconcile the two branches of physics: mechanics and electrodynamics –but here we must accede to some rather awkward and artificial hypotheses. This postulated energy source, whose limits and mode of action remain inscrutable, is reminiscent of a principal difficulty encountered by Heaviside in the context of

gravitational field relations [4], where such a vague and phantom-like physical quantity was deemed necessary to complete the equation structure. The difficulty with invoking Mach's Principal has already been noted.

Ether Traction-Compression Hypothesis

A consistent resolution to the dilemma may be found in a simple and justifiable physical principle: the existence of a dense and elastic *ether*, which carries momentum through the mechanism of its own *longitudinal compression*, and also enables a *longitudinal traction* against electrified and magnetized bodies –through the fields it supports. An introduction to this concept has already been provided [5]. In the situation described herein, the phenomenon is extended to include the occurrence of the communication of a *moment of compression* against the ether by the tractive action of the electric field circulation when working against motile charge concentrations –whether these be free particles, or charges embedded in massive bodies. Thus the field not only impels the charge, it sustains a localized *traction* in the ether along the field direction. It is as though the field lines were laid down like tracks in a pliable matrix, and when acting against a charge, cause a transient compression in the matrix, or space-filling medium. Such compression, impressed upon the enormous surrounding ether mass, will easily account for the 'missing' momentum. The magnitude of this ether displacement, and the mechanical energy accrued thereby, will be relatively miniscule, owing again to the great collective ether mass.

When combined with the postulate of increased resistance (or electrodynamic inertia) against the primary from the induced motive power on the secondary (again communicated through ether traction), where

$$\vec{\tau}_1 \cdot \vec{\omega}_1 = -\oint \vec{E}_2 dQ_2 \cdot \vec{\omega}_2 \ , \tag{7}$$

energy is also conserved, in that the increased effort postulated as necessary for the action against the primary requires a proportionally greater draw upon the work supply. With the motive force on the primary anchored in the neutral, the action of the induced primary field against the moving charged secondary is postulated to retard the acceleration rate of the primary, which in turn results in a reduction in its final kinetic energy. The precise mechanism for this reaction remains obscure, although it may be postulated to lie within the opposing magnetic field magnitudes.

Thus, calling $d\vec{P}_e$ the momentum differential for a volume element of the ether compression (accrued during the given time interval), the total angular momentum balance of the system may be equated with the inclusion of this additional compression factor integrated over the entire volume V of the surrounding ether:

$$\Delta\vec{L} = \int_0^t \tau_O dt + \int_0^t \tau_1 dt + \int_0^t \tau_2 dt - \int_V \vec{r} \times d\vec{P}_e = 0 \, , \tag{8}$$

--thereby ensuring angular momentum conservation in the system.

And with W the work generated by the power source, the energy balance may be equated by including the greater work-load encountered in the effort of accelerating the primary (mechanical resistance resulting from action on the charged secondary):

$$\int (\vec{\tau} \cdot \vec{\omega}) \, dt = -\Delta W \, . \tag{9}$$

Thus the total energy of the system is constant: energy acquired by the secondary is withdrawn from the energy supply, which enables the reactively impeded acceleration of the primary. The precise mechanism by which the primary 'feels' the power input to the secondary, however, at this point remains undetermined. The conservation laws simply demand that the primary receives no reaction torque from the presence of the secondary charge (this being applied to the ether itself), but nevertheless encounters a definite *reactance* from the mechanical power input to the secondary. In this proposal, no attempt is made in describing any 'structure' of the ether, nor in quantifying its mechanistic properties (elasticity, density, rigidity etc.); neither is any precise function offered to account for its transmission and distribution of momentum. Although it might be postulated that the ether behaves as a perfect crystalline solid whose mass as a whole adjusts to local transient displacements of its substance, and that these adjustments are communicated at the speed of light c, at this stage of theory actual determination of these factors must await further empirical investigation.

Finally, returning to the 'Induced Potential Dilemma', an answer may be tacitly presumed from the field reaction mechanism just described: the phenomenon of increased work load imposed upon the induced field-generating apparatus effort when providing energy *to* the test charge is reversed, *mutatis mutandis,* when external work is done *on* the charge in driving *against* the field –a partial relief in the inductive reactance is experienced by the primary charged wheel or current-carrying coil.

Conclusion

Although 19th century scientists made admirable progress in formulating the laws of electromagnetism, we begin to see that their efforts were wholly inadequate. Neither Oersted nor Ampere, nor Faraday nor Maxwell, nor Gauss nor Weber, nor anyone else (including Einstein), had capably evaluated the phenomena under study --they simply failed to follow their own formulations through to their ultimate consequences. It is yet more reason why subsequent developments in electrodynamics, such as special relativity, are also necessarily faulty, since the foundation itself is faulty. It has been the purpose of this paper to bring out the flaws in existing theory, and lay sound foundations for new theory. The import of all the foregoing can be summarized in this: the traditional exposition of the basic relations of electromagnetism is fundamentally flawed, in that there is no observance of the law of conservation of momentum nor of the law of conservation of energy –inviolable laws inherited from the science of mechanics. This 'conflict of laws', as it were, constitutes a veritable 'constructive fraud' pertaining to the whole of electrodynamics. By this latter term is meant that in physics, as in civil or contract law, contradictory requirements have been *inadvertently* or *unintentionally* imposed upon a situation which are impossible to fulfill (e.g., angular momentum conservation must be ratified, yet must also be repealed) within the framework of traditional theory. A tentative hypothesis (Ether Traction-Compression) has been proposed to remedy the apparent defects. Its principal features, especially as applied to the system of wheels described previously, may be summarized as follows:

Electric and magnetic fields are sustained by a space-filling and elastic ether.
Though of considerable mass density itself, ether imposes no appreciable obstruction to the motion of matter through it.
The production of an electric field causes a tractive force to develop in the ether, which acts on the ether and charges in opposite directions, respectively, along the field lines, causing motion in the charges and a longitudinal compression throughout ether-filled space.
The electric circulation encountered in Faraday's law must then produce torque against the surrounding ether equal and opposite to that encountered by charges placed within the circulation.
The mechanical power input to the surrounding charges by action of the electric circulation communicates a reactance, through the fields, against the field-generating source, which demands a compensatory energy withdrawal from that source.
The magnitude and rate of the *longitudinal* compression are extremely minute, although its *lateral* distribution is propagated though the surrounding ether at the velocity of light.

The attribution to the ether of just those properties necessary to validate the Traction-Compression Hypothesis is admittedly *ad hoc* in character, and could be regarded as a weakness in development of theory, except that the alternative –a draconian repeal of the laws of momentum and energy conservation implied by the conventional construction of electrodynamics— is so anti-physical that the proposed attributions appear instead as comparative strengths. In conforming the relations of electromagnetism to the well-established laws of mechanics, the need for a thorough refiguring of the structure of electrodynamics has been demonstrated by the arguments presented: *Experimental verification* of hypotheses is hence of paramount importance.

References

[1] R. A. Serway, PHYSICS FOR SCIENTISTS AND ENGINEERS, Third Edition, (section 31.4) pp. 884-885 Saunders College Publishing. Philadelphia PA (1992)
[2] D. J. Griffiths, INTRODUCTION TO ELECTRODYNAMICS, (Faraday's Law, Example 7), pp. 261-262 Prentice Hall Inc., Englewood Cliffs NJ (1981)
[3] C. K. Whitney, "On What Electromagnetic Systems Can Feel", Proceedings of the Natural Philosophy Alliance, 13th Annual Conference (2006) vol. 3, no. 2 , p.310
[4] O. Heaviside, A Gravitational and Electromagnetic Analogy, Part I, The Electrician, **31**, pp. 281-282 (1893) [From Oleg D. Jefimenko, *Causality, Electromagnetic Induction, and Gravitation: A Different Approach to the Theory of Electromagnetic and Gravitational Fields*, 2nd ed., (Electret Scientific, Star City, 2000)]
[5] S. I. Wells, "The Dilemma of Radiant Momentum" 14th NPA Annual Conference (2007)

Addendum: Electrodynamic Self-Propulsion?

The preceding rendition of Faraday's Law does lead to one extraordinary consequence. Although induced angular momentum in a surrounding charged body is the most immediate effect, a considered modification in the charge distribution would bring about a most remarkable result: an 'auto-dynamic' induced linear momentum acquisition by the system as a whole. In other words, *if* the proposed traction-compression hypothesis is valid, a *materially reactionless propulsion becomes possible:*

Let the secondary carry two equal and opposite embedded charges, located on opposite sides of the wheel, respectively. If now an induced electric circulation were applied by the primary, the torques would cancel, but a net *linear force* would be expressed along the diameter separating the charges [Figure 1A]. This primitive arrangement may be significantly improved by replacing the primary with an induction coil, powered by an alternating current source. Let the frequency of the current be ω. Let the angular velocity of the secondary also be ω, synchronized with the current (and alternating induced field) such that the recurrent peak force is always in the same direction. A perpetuated linear acceleration of the entire system should be effected in the assigned direction, *without the customary 'reaction mass' ejected from it.* The appearance of a truly 'self-propelled' craft is rendered possible through the unseen traction against the ether –i.e., the Third Law of Motion is satisfied only through such reaction, which produces an ether compression of equal and opposite momentum.

From the basic relations of electrodynamics, the peak impulse may be calculated. Adjusting for the phase angle between applied voltage and resultant current, an induced electric field intensity may be expected of magnitude

$$E = \frac{1}{nS} N \frac{\partial i}{\partial t}, \tag{1A}$$

where N is the inductance of the coil, n is the number of turns, i is the magnitude of the current, and S is the line integral of dS in the vicinity of the circumference of the coil of radius r. When i is taken at peak magnitude, E will produce an approximate peak force magnitude

$$F \approx 4Q \frac{Ni\omega}{nS} \tag{2A}$$

where Q is the magnitude of each opposite charge concentration. For a concrete example, with Q at 1 Coulomb, r at 1 meter, ω at 1 cycle per second, i at 1 ampere, with n at 1 turn, and N at 1 Henry, F will then come out at a magnitude of roughly $\frac{4Q\,volt}{2\pi\, meter}$, or an *average* force on the order of $\frac{Q}{\pi}\frac{volt}{meter}$ --about one-third Newton.

A Coulomb is not a practicable charge concentration --but in a more ambitious design, a reduced charge quantity may be compensated with increased values of N, i, ω, especially as N is generally proportional to the square of n. The inclusion of a variable resistance in the circuit would allow for alteration of the resultant force direction through deliberative variation of the customary 'phase angle' between applied voltage and current.

Would the device actually work as described? Only experiment can settle the issue. The proposition is at this point purely speculative, for the argument is dependent on the ether traction hypothesis. A more conventional analysis might declare that the 'back reaction' occurs against the body of the inductor (causing it to spin opposite the secondary), and not against any ether; but this conclusion is not justified by close consideration of the relations as outlined. Just as the prescribed back reaction against the charged primary wheel would violate the conservation of energy in the more primitive situation (i.e. its resulting unaccountable acquisition of rotational kinetic energy and magnetic field energy, with a consequent *free* production of torque on the secondary), so would this law be violated in the modified situation (i.e., the effective *emf* on the motile charges in the coil would constitute an unwarranted power dividend in the circuit). Hence, the absence of such a counter-torque in the body of the inductor would affirm its presence in the substance of the surrounding ether; likewise, the resultant linear force in the apparatus in the situation described above is balanced by a reaction not within itself, but against the ether.