

# Electromagnetic propulsion via a vacuum-interactance push

## An electromagnetic inertial impulse drive system

CLEVELAND'S PAPER WON FIRST PLACE IN THE ELECTRIC SPACECRAFT COMPETITION FOR INNOVATIVE CONCEPTS IN ELECTRIC PROPULSION. IT ARGUES THAT THE LORENTZ FORCE EQUATION IS MISSING A FORCE TERM PROPORTIONAL TO THE RATE OF CHANGE OF ELECTROMAGNETIC MOMENTUM DENSITY CARRIED BY THE POYNTING VECTOR-FLUX,  $\mathbf{E} \times \mathbf{B}$ . AN ABRUPTLY PULSED CROSSED-FIELD DEVICE (NON-RADIATING) IS PROPOSED TO INTERACT WITH THE VACUUM MEDIUM, THEREBY CREATING AN ACTION-REACTION PROPULSIVE FORCE (PUSH) WHICH CAN BE UTILIZED FOR TRANSPORTATION MEANS.

### Nomenclature

<b>E</b>	electric field
<b>B</b>	magnetic field
<b>S</b>	Poynting vector
<b>G</b>	electromagnetic momentum density
<b>p</b>	momentum $\mathbf{p} = m \times \mathbf{v}$
<b>m</b>	total mass of a body
<b>mm</b>	mechanical mass
<b>em</b>	electromagnetic mass
<b>v</b>	velocity of an object
<b>c</b>	velocity of light
<b>U</b>	energy density
<b>q</b>	unit electric charge
<b>d/dt</b>	time rate of change
<b>dV</b>	volume element
<b>F</b>	action force
<b>F'</b>	reaction force
<b>d</b>	change in
<b>t</b>	time

### INTRODUCTION

Imagine, the possibility of propelling yourself through space using electric fields generated by your spacecraft, a method which would be quite different compared to conventional rocket technology. How could this electromagnetic propulsion be generated and could it really work?

This paper presents a thesis on how to create

propulsion using a novel approach to electrodynamics that does not require the ejection of mass, like a rocket, but, in effect, actually utilizes electromagnetic fields to push against the mass of space, the so-called vacuum medium. While this novel concept may seem absurd, the physics reviewed in this paper provides evidence that it could be achieved. By applying a few fundamental principles based on scientific peer reviewed literature and patents, electromagnetic propulsion may be possible.

A review of an important experiment performed at the University of Toronto (1980) is presented because it shows conclusively that a motional force of the Poynting vector for static fields in vacuum is real. Furthermore, electromagnetic fields have mass and can store momentum which can be used to generate inertial reaction forces if the correct principles are applied.

A unique radio antenna design, called a crossed-field antenna, is described. The antenna generates, by direct synthesis, a radio wave from separately stimulated electric and magnetic fields. More importantly, a cavity-mode resonator may be configured and pulsed in such a way as to optimize its capability for producing thrust, not electromagnetic radiation. Radiation, in this case, would be considered a loss of energy; the energy is needed to create a push in space!

An electromagnetic inertial impulse drive system

is described using a qualitative discussion and figure illustrations. The enclosed information presents a proposed test setup for testing the validity of the conjecture and is intended as an introductory treatment only. A full, detailed report is not covered here; the information presented is a work in progress and, therefore, will require further study and testing for proof of principles.

## THE STANDARD LORENTZ FORCE EQUATION...

### IS MISSING A FORCE TERM...

and how it interacts with the vacuum of space, is crucial to an understanding of the physics necessary for creating electromagnetic propulsion.

To understand the information to follow in the discussion section, a knowledge of college level physics will be necessary. Also, some constants of proportionality have been omitted from the equations so that the equations appear in a basic form to facilitate understanding. For the purpose of this paper, it will be necessary to limit the discussion to electromagnetic fields in free space, because a discussion which includes magnetized and polarized material is too complex.

Finally, it should be realized that the standard Lorentz force equation found in most physics texts is missing a force term. This missing force is a factor of the energy momentum stored in the electromagnetic field. How this force relates to the third law of motion, and how it interacts with the vacuum of space, is crucial to an understanding of the physics necessary for creating electromagnetic propulsion. It is hoped that the information offered here will come as a revelation to the readers of the *Electric Spacecraft Journal*; and that it may stimulate creative thinking and experimentation.

Force in its simplest sense is a push or a pull . . .  
It is an interaction between one object and another.

"For example, in walking across the floor, we push against the floor, and the floor in turn pushes against us. Forces always occur in pairs...The action and reaction

forces make up a pair of forces."<sup>1</sup> (Since they act on different bodies, action and reaction never cancel out.)

Newton believed nature to be symmetrical and discovered the third law of motion:

Whenever one body exerts a force on the second body, the second body exerts an equal and opposite force on the first.<sup>2</sup>

$$\mathbf{F} = -\mathbf{F}'$$

action equals reaction

(1)

Mass in motion is momentum, the product of the mass of an object and its velocity,  $\mathbf{p} = m \times \mathbf{v}$ . Exerting a force upon an object during a specific amount of time creates an impulse, and when a net external force is impressed upon an object, it will accelerate.

$$\mathbf{F}t = d\mathbf{p}$$

change in momentum

(2)

This force is needed to overcome the object's tendency to resist acceleration. Hence, objects possess inertia; the more mass an object has, the more inertia. Mass is a measure of the inertia of an object. Therefore, objects tend to conserve their momentum because of their tendency to resist a change in motion. Here, the third law can be viewed as a statement of the law of conservation of momentum.

$$m \times \mathbf{v} = m' \times \mathbf{v}'$$

a system of equal but oppositely directed momenta

(3)

The conservation law describes a system of momentum exchange between two bodies. No momentum is gained, and no momentum is lost. (The recoil of a rifle has just as much momentum as the speeding bullet.)

Momentum exchange is involved in the Lorentz force, a fundamental electrodynamic force of nature. The Lorentz force is active at the microscopic level inside current-carrying wires to make an electric motor spin,<sup>3</sup> and at the macroscopic level to form interstellar dust into planetary bodies via cosmic electrodynamics.<sup>4</sup>

$$\mathbf{F} = d\mathbf{p}/dt = q\mathbf{E} + q(\mathbf{v} \times \mathbf{B})$$

Lorentz force

(4)

This is the standard form of the Lorentz force equation (Eq. 4), and it will be shown later that it is missing a force term due to the interaction of the electromagnetic field with the vacuum medium of space.

However, for now, just consider the two terms on the right-hand side of the equation to discover their importance in electrodynamic phenomena. The  $q\mathbf{E}$  term is called the electric force, and the  $q(\mathbf{v} \times \mathbf{B})$  term is called the magnetic force. They both can affect the motion of a charged particle,  $q$ , in space.

The unique relationship these forces share in space was discovered by Faraday during his investigations into the electrodynamics of moving objects. In *Faraday's Diary*, he states,

The mutual relation of electricity, magnetism, and motion may be represented by three lines at right angles to each other, any one of which may represent any one of these points; and the other two lines, the other points. Then, if electricity be determined in one line and motion in another, magnetism will be developed in the third; or if electricity be determined in one line and magnetism in another, motion will occur in the third. Or, if magnetism be determined first, then motion will produce electricity; or electricity, motion. Or, if motion be the first point determined, magnetism will evolve electricity; or electricity, magnetism.<sup>5</sup>

From Faraday's words, a rectangular vector diagram

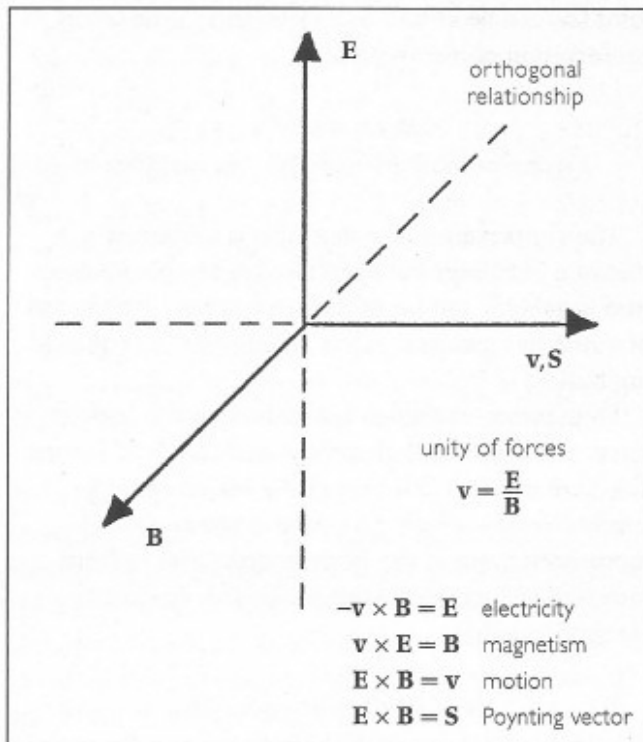


Fig. 1 Rectangular vector diagram for the electromagnetic field forces.

can be drawn (See Fig. 1.), and using the right-hand rule, three simple vector cross-products can be written.

$$-\mathbf{v} \times \mathbf{B} = \mathbf{E}$$

electricity

(5)

$$\mathbf{v} \times \mathbf{E} = \mathbf{B}$$

magnetism

(6)

$$\mathbf{E} \times \mathbf{B} = \mathbf{v}$$

motion

(7)

The spontaneous nature of these forces explains their tendency to coexist in a state of equilibrium, such that the following relationship is satisfied.

$$\mathbf{v} = \frac{\mathbf{E}}{\mathbf{B}}$$

unity of forces

(8)

Eqs. 5 and 6 describe the electromagnetic induction of moving media and will not be discussed here; although two definitive resources of information concerning this topic are references 6 and 7. The main focus will involve the nature of Eqs. 7 and 8.

What is odd about Eq. 7 is it says a motional force can be generated if an electric field is made to coexist in space perpendicular to a magnetic field, called a crossed field. Eq. 8 shows an interesting electrodynamic relationship for the case of a charged particle in transverse motion through a volume of space occupied by an  $\mathbf{E} \times \mathbf{B}$  crossed field. If a charged particle moves too slowly as it encounters the crossed field, it will experience mostly the Coulomb force  $q\mathbf{E}$  and be diverted from its original path. Similarly, if the particle moves too quickly it will experience mostly the magnetic force  $q(\mathbf{v} \times \mathbf{B})$  and, again, be diverted from its path. However, if the charged particle has just the right velocity and momentum, and enters normal to the plane of the  $\mathbf{E} \times \mathbf{B}$  zone, it will pass right through unaffected. Therefore, an  $\mathbf{E} \times \mathbf{B}$  vector can be thought of as a velocity filter or momentum selector.<sup>8</sup> An acceleration of the charged particle can occur if, during the moment the particle is in the crossed field, a uniform boost is given to the fields – a way to create a momentum booster.

Note that Eq. 7 mirrors the Poynting vector in electromagnetic theory, which describes the energy flow of the electromagnetic field. From Poynting's theorem,<sup>9</sup> the electromagnetic energy flow is expressed by the relation,



$$\mathbf{S} = \mathbf{E} \times \mathbf{B}$$

Poynting vector (power/area)

(9)

Furthermore, an electromagnetic momentum density is defined using the Poynting vector and can be used to map the flow of energy and momentum contained in the field.

$$\mathbf{G} = \frac{\mathbf{S}}{c^2}$$

electromagnetic momentum density (momentum/volume)

(10)

A review of the physics literature reveals many discussions concerning the Poynting vector and electromagnetic field momentum, a very powerful tool for understanding electromagnetism. (See references 10-26.) It will come as a surprise to learn that the Poynting vector is not zero for static field configurations. Pugh and Pugh<sup>27</sup> explain, "The use of  $\mathbf{S}$  in static fields has been objected to by some because it often has magnitude in static fields where no flow of energy can be detected. However, in all cases, it can be shown that  $\text{div } \mathbf{S} = 0$  everywhere."<sup>28</sup> (Flux entering equals flux exiting.)

Since power is transmitted by DC circuits, the Poynting vector can be used to map both sources of  $\mathbf{S}$  (dynamos) and sinks of  $\mathbf{S}$  (motors or resistors).

## THE MAIN CONCEPT TO GRASP IS THAT ELECTROMAGNETIC FIELDS HAVE MASS.

"We are all familiar with the fact that energy needed to actuate our radio and television sets is propagated through space from our broadcasting stations to our sets. We should not then be surprised to find that even with DC and low-frequency AC, the electromagnetic energy is propagated through space from the source to the sink, just as it is with the higher-frequency AC circuits."<sup>29</sup>

The main concept to grasp is that electromagnetic fields have mass. An electrically charged capacitor actually weighs more than its uncharged equivalent, a fact that has been confirmed by experiment. Woodward,<sup>30</sup> for example, performed weight measurements on a bank of capacitors, charging and discharging them, and used a resonant detector to observe a weight change in the apparatus. Woodward was able to cause mass fluctuations in his device. His published measure-

ments, which appear to have been done with considerable care, record mass changes of several milligrams.

Knowing that the total mass of a capacitor, for example, is comprised of the sum of two mass components, note the following relation:

$$M = mm + em$$

total mass = mechanical mass + electromagnetic mass

(11)

The electromagnetic mass is a function of the energy density of the fields and is an exact statement of the equivalence of mass and energy. It is the energy-derived mass of a system.

$$em = \frac{U}{c^2}$$

electromagnetic mass ( $U = \frac{1}{2}\mathbf{E}^2 + \frac{1}{2}\mathbf{B}^2$ )

(12)

In Booker's approach to electrical science, he states,

Consider an electronic wheel consisting of a circle of fixed conducting wire through which a current of electrons is flowing. Here the rim consists only of the electrons that constitute the current. This is an extremely light rim...

Consequently, the inertia of an electronic wheel, consisting of an electric current flowing round a circuit, is controlled by the electric charge of the electrons rather than by their mass.<sup>31</sup>

Two physicists, who helped communicate the physical significance of electromagnetic momentum, are Feynman<sup>32</sup> and Romer.<sup>33</sup> Feynman described a thought experiment in his famous lecture series that describes a paradox concerning the conservation of angular momentum and field momentum. The Feynman disc paradox introduces the concept of a real energy momentum stored in the magnetic field surrounding a charged plastic disc. If the disc is initially at rest, Feynman's question asks, will the disc begin to rotate if there is a change in the static-electromagnetic field surrounding this disc? He says, "When you figure it out, you will have discovered an important principle of electromagnetism!"<sup>34</sup> Later, in chapter 27 of Feynman's lecture series, the answer is revealed.

The answer is that if you have a magnetic field and some charges, there will be some angular momentum in the field. It must have been put there when the field was built up. When the field is turned off, the angular momentum is given back. So, the disc in the paradox would start rotating. This mystic circulating flow of energy, which at first seemed so ridiculous, is absolutely necessary. There is really a momentum flow. It is needed to maintain the conservation of angular momentum in the whole world.<sup>35</sup>

The earth, with its axial magnetic field, and radial electric field lines produced by its electrostatic charge, has a Poynting vector pointing west to east. This suggests a portion of the earth's angular momentum (spin) is stored as field momentum, electromagnetic energy endlessly flowing around the earth!

More importantly, Cullwick<sup>36</sup> makes clear the issue of Newton's third law and how an imbalance of forces will result if the energy and momentum contained in pure fields are not taken as real. He states, "The inertia of a system is not confined to the material bodies. In order that the force element

$$\mathbf{F}' = - \frac{d}{dt}(\mathbf{E} \times \mathbf{B}) \cdot dV$$

[reaction force density]

(13)

should have an equal and opposite reaction, the element  $dV$  of the electromagnetic field must contain a moving entity possessing inertia, and whose momentum is changing at a rate

$$\frac{d}{dt}(\mathbf{E} \times \mathbf{B}) \cdot dV$$

[vacuum-interactance term]."

(14)

Thus, the reaction  $\mathbf{F}'$  is caused by the electromagnetic mass of the field, alone, which is moving in the volume element  $dV$ . To include this mass of the field in the material system, the third law of motion, then, becomes completely valid for the whole system (charges and field).

Eq. 14 is the missing term that must supplement the Lorentz force equation (Eq. 4), discussed above. To preserve the third law of motion, the force term (Eq. 13) must be included in the standard Lorentz force equation, yielding:

$$\mathbf{F} = q\mathbf{E} + q(\mathbf{v} \times \mathbf{B}) - \frac{d}{dt}(\mathbf{E} \times \mathbf{B}) \cdot dV.$$

Lorentz force

(15)

In the vacuum of space, in the absence of  $q$  charges, the equation becomes simply an interaction between the electromagnetic mass of an electromagnetic field (crossed field) and the vacuum medium.

$$\mathbf{F} = - \frac{d}{dt}(\mathbf{E} \times \mathbf{B}) \cdot dV \text{ recall } \mathbf{F} = -\mathbf{F}'$$

(16)

Now, here is an action-reaction system based upon

the physics of crossed fields in vacuum, a way to exchange momentum with the vacuum medium of space, a push via a vacuum interactance!

Has the vacuum-interactance force ever been detected? Yes, it would seem to be so, based upon an experiment, performed in 1980 at the University of Toronto, by Graham and Lahoz.<sup>37</sup>

Our program of measurement of the forces related to electromagnetic momentum at low frequencies in matter has culminated in the first direct observation of electromagnetic angular momentum created by quasistatic and independent electromagnetic fields  $\mathbf{E}$  and  $\mathbf{B}$  in the vacuum gap of a cylindrical capacitor. A resonant suspension is used to detect its motion. The observed changes in angular momentum agree with the classical theory within ~20%. This implies that the vacuum is the seat of something in motion whenever static fields are set up with a nonvanishing Poynting vector, as Maxwell and Poynting foresaw.<sup>38</sup>

According to the Maxwell-Poynting ideas, the last term (Minkowski's) in [Eq. 13] can be interpreted as a local reaction force acting on charges and currents when the vacuum surrounding them is loaded with electromagnetic momentum.<sup>39</sup>

Graham and Lahoz performed three important experiments.<sup>37,40,41</sup> The first two experiments investigated the mechanical detection of a reaction force density in dielectric and magnetic materials subjected to a time-varying  $\mathbf{E} \times \mathbf{B}$  field. They succeeded in detecting the reaction force caused by changes in electromagnetic momentum density. However, their third experiment provided an amazing observation. When they eliminated the dielectric and magnetic materials from the volume of their detector, the reaction force was detected in the vacuum space remaining! Graham and Lahoz seem to have detected an interaction between the  $\mathbf{E} \times \mathbf{B}$  field and the vacuum. The field coupled this reaction force to the charges present in the mechanical detector via the Lorentz force.

The third Graham and Lahoz experiment<sup>37,42</sup> (See Fig. 2.), indicates the physical reality of the Poynting vector in vacuum, and in many ways validates Maxwell's classical theory and his idea of a real vacuum medium. Graham and Lahoz concluded,

It is remarkable that no known particle can be identified as the agent of the observed electromagnetic angular momentum exchange with the mechanical detector. However, this does not imply that a new entity has to be introduced, because the concept of energy momentum carried by the macroscopically quasistatic electromag-

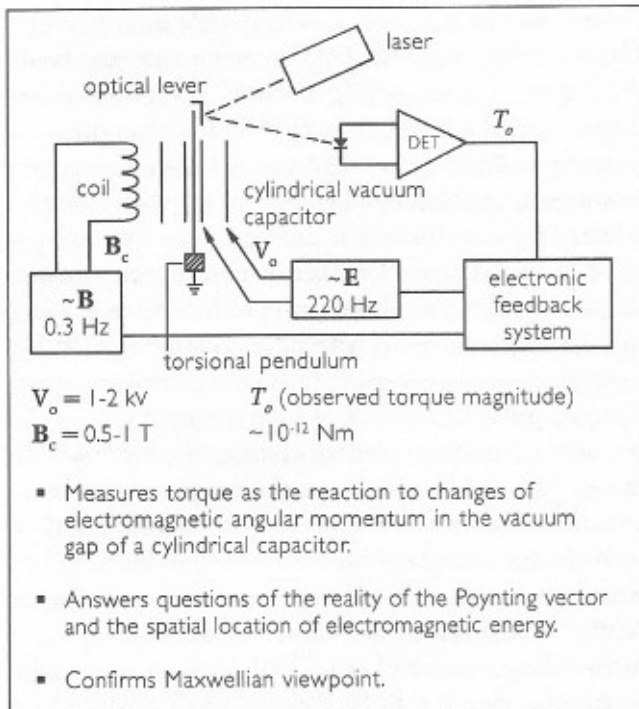


Fig. 2 Graham and Lahoz experiment illustration

netic field is already contained in Maxwell's equations. According to these, and directly implied by our experimental result, permanent magnets and electrets can be used to build a flywheel of electromagnetic energy steadily flowing in circles in the vacuum gap of a capacitor, as if Maxwell's medium were endowed with the property corresponding to superfluidity.<sup>43</sup>

hypothesis as magnetic polarization and electric polarization, or, according to a very probable hypothesis as the motion and the strain of one and the same medium.<sup>45</sup>

The present view held by most physicists today is that the vacuum medium contains field energy. The most striking feature of the vacuum state is that it contains an immense store of energy hidden away in randomly quantized electromagnetic fields of extremely high frequency. A survey of scientific literature discussing the physical reality of the vacuum state, called quantum vacuum fluctuations (QVF), is given in references.<sup>46-53</sup> What must be realized, however, based on the conjecture presented here, is that the QVF fields contain a storehouse of electromagnetic momentum of incredible volume density (*i.e.*, the entire universe). The vacuum of space is not empty, but completely full of electromagnetic energy and electromagnetic mass. The vacuum of space has hidden momentum!

In inflation cosmology, "the density of mass-energy in the universe is right on the borderline between expansion and collapse... Astronomers have only found between 10 and 20 percent of the required mass. So where is the rest?... An energy density is equivalent to a mass density, so vacuum energy could account for some — perhaps most — of the missing mass [the so-called dark matter]."<sup>54</sup>

What is proposed here is the possibility of exchanging momentum between the electromagnetic field generated by a spacecraft and the electromagnetic fields of the vacuum. One body (the spacecraft) interacting with

It is important to understand that the fields generated by this electromagnetic propulsion technique must not propagate away from their source.

They must interact with the vacuum in the immediate vicinity of the source, like pushing off from a wall.

#### Maxwell<sup>44</sup> stated in his "Dynamical Theory of the Electromagnetic Field,"

In speaking of the energy of the field, however, I wish to be understood literally. All energy is the same as mechanical energy, whether it exists in the form of motion or in that of elasticity, or in any other form. The energy in electromagnetic phenomena is mechanical energy. The only question is, where does it reside?... In our theory it resides in the electromagnetic field, in the space surrounding the electrified and magnetic bodies, as well as those bodies themselves, and is in two different forms, which may be described without

another body (the vacuum medium) creates a third law of motion push via a vacuum-interactance momentum exchange. The spacecraft dissipates energy to generate acceleration by producing an electromagnetic field which pushes against space (the action), and when the spacecraft's field interacts with the vacuum medium, space pushes back (the reaction). It is important to understand that the fields generated by this electromagnetic propulsion technique must not propagate away from their source. They must interact with the vacuum in the immediate vicinity of the source, like pushing off from a



wall. The technique can be described as a novel form of electromagnetic induction, where the propulsion fields are used to induce motion, not radiation. Radiation would be considered a loss of energy in the system. Electromagnetic radiation is like the ejection of mass. What is required, however, is the generation of a local inertial impulse to create a momentum change. The device is more like a force engine that generates a thrust vector that predominantly points in one direction; thus creating motion in the space of the vehicle along the thrust vector.

What has just been described is a novel form of electromagnetic propulsion which provides the basis for engineering an inertial impulse drive system. The components necessary to build such a system are as follows:

- a power source, or store of energy
- a unique crossed-field device for creating an intense thrust vector
- a high-energy pulse modulator (fast-rise time) circuit
- an impedance matching network to couple the energy into the device
- a mechanical support structure to couple mechanical impulses received by the device to the body of the craft, or the hull of the craft is an array of devices

The drive system requires a unique crossed-field structure for generating an intense momentum impulse. The best candidate may be a crossed-field antenna, an unusual type of antenna design that has received little recognition in the technical literature.<sup>55-57</sup> This revolutionary antenna synthesizes directly the Poynting vector ( $\mathbf{S} = \mathbf{E} \times \mathbf{B}$ ) from separately stimulated electric and magnetic fields in a volume of space. A fundamental feature of the structure is that the physical size of the antenna is independent of the radiated wavelength. This is a remarkable concept in comparison to conventional antenna design, because the radiation is not produced by current flow in wires. The crossed-field antenna generates the Poynting vector by using structures that are driven by time-varying electric fields.

Consider the basic form of the field-producing equations of time-varying electromagnetics (in vacuum):

$$\begin{aligned} \text{curl } \mathbf{E} &= -\frac{d\mathbf{B}}{dt} \\ &\text{Faraday's law} \end{aligned} \quad (17)$$

$$\begin{aligned} \text{curl } \mathbf{B} &= \frac{d\mathbf{E}}{dt} \\ &\text{Maxwell's law} \end{aligned} \quad (18)$$

The above relations contain valuable information: a time-varying magnetic field creates an electric field (Eq. 17), and a time-varying electric field creates a magnetic field (Eq. 18). For example, the physical meaning of Eq. 18 says that a parallel plate capacitor produces a magnetic field whenever its plate voltage is changing, because of the existence of a displacement current. Large, circular capacitor plates, when supplied with high voltage, will produce strong, circular magnetic fields within the volume enclosed by their plates. In addition, if the capacitor is abruptly pulsed, or driven at high frequency, it becomes a significant source of magnetic fields which can extend well outside the capacitor plates. Therefore, capacitor structures can be used as sources of both electric and magnetic fields. By suitable arrangement, two individual capacitor structures, independently voltage driven, can cross-stress the surrounding volume of space with inphase Poynting vector flux. (See Fig. 3.) Radiation is then produced through  $\mathbf{S} = \mathbf{E} \times \mathbf{B}$  and flows out to space as vertically polarized electromagnetic waves.

In the conjecture presented here, radiation must be minimized and propulsive thrust maximized; therefore, the crossed-field antenna design requires a curl-free Poynting vector asymmetry. The vector  $\mathbf{S}$  should point predominantly in the direction of the desired vacuum-interactance push, so the resultant thrust vector passes through the center-of-mass of the object to be accelerated. The crossed-field device must produce a Poynting vector flux that does not curl back

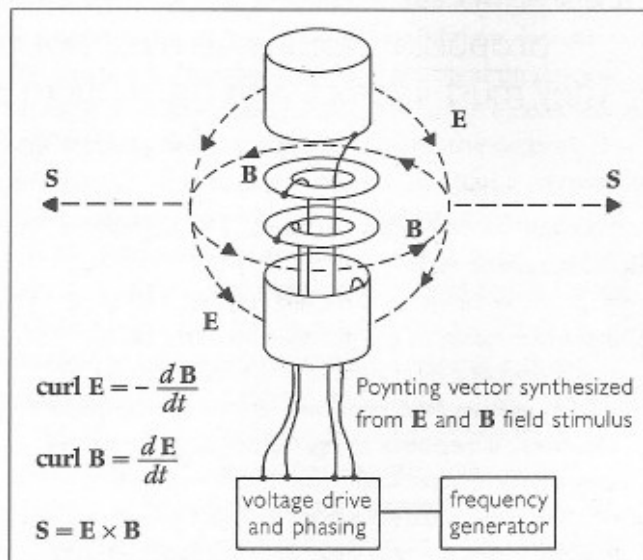


Fig. 3 Crossed-field antenna explanatory diagram.

onto the source because that would effectively cancel the thrust. Therefore, attention to the control of the device's fringe fields is crucial for creating curl-free Poynting vector flux (electromagnetic momentum).

Unfortunately, the crossed-field antenna shown in Fig. 3 will not satisfy the requirement and will have to be redesigned. Perhaps one design could be realized by applying microwave techniques to cavity resonators.<sup>58,59</sup> A given cavity can resonate in different modes to produce specific field patterns within the cavity. Most importantly, a cavity resonator does not radiate; it resonates electromagnetic field patterns inside its volume. Cavity resonators may be of various shapes and sizes: spherical, ellipsoidal, conical or cylindrical, for example. They may be considered most simply as parallel resonant circuits. Also, a cavity can be constructed of a hollow conductive

cavity, or of a solid dielectric body. Think of these cavities as containers that hold electromagnetic mass, and whose volume density can be controlled electrically, a way to control the mass and inertia of an object.

A cavity resonator (See Fig. 4.) may satisfy the basic requirement proposed in this paper: a device for generating cross-stressed, inphase, electric and magnetic fields for synthesizing the Poynting vector. The basic arrangement of components for an electromagnetic inertial impulse drive system are shown in the block diagram of Fig. 5, while a simple setup for testing such a system is illustrated in Fig. 6.

Two important U.S. patent disclosures are relevant to this discussion. The inventors, Brown<sup>60</sup> and Schlicher,<sup>61</sup> both describe electromagnetic propulsion techniques which parallel the conjecture introduced in this paper.

Brown discovered a way to produce propulsive thrust by applying very high voltages to capacitor structures. His electrokinetic apparatus was tested in vacuum. Brown states, "The propelling force, however, is not reduced to zero when all environment bodies are removed beyond the apparent effective range of the electrical field."<sup>62</sup> Concerning varying applied fields, he states, "It is another object of this invention to provide a device for producing modulated thrust in response to varying electrical signals, which device produces a greater effect than the prior devices mentioned above."<sup>63</sup> (See Fig. 7.)

Schlicher describes his invention as "an electromagnetic device whose geometry and energy conversion mechanisms are optimal for the production of propulsive thrust rather than radiation of electromagnetic

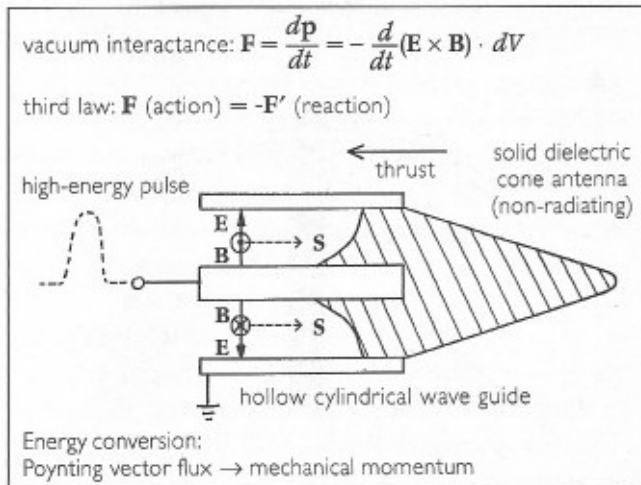


Fig. 4 Cavity-mode thruster.

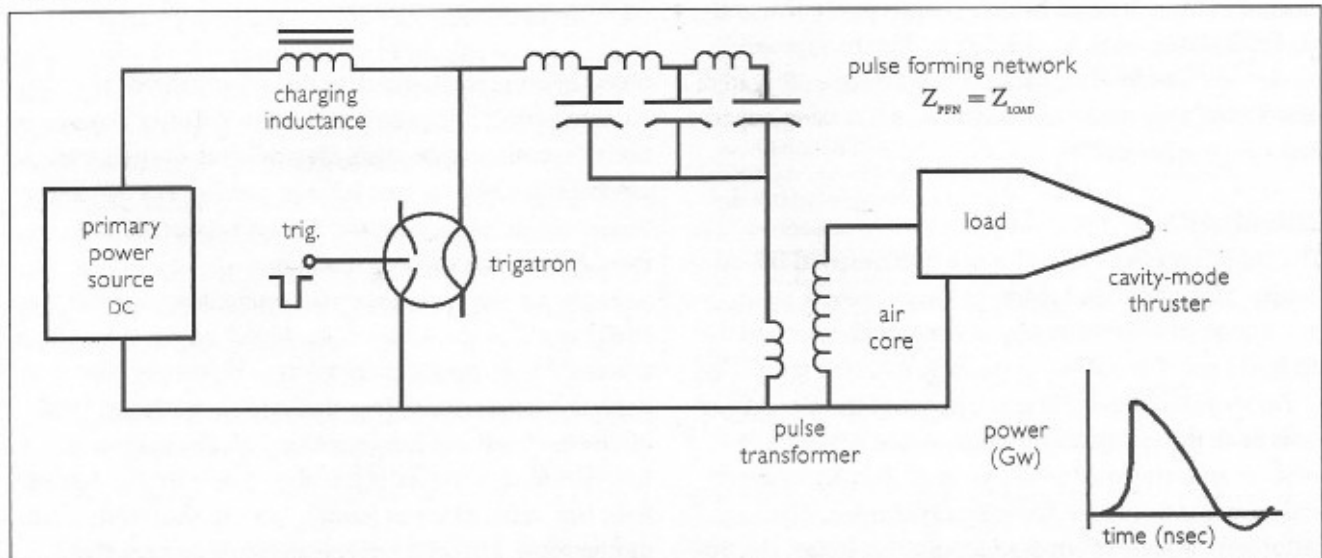


Fig. 5 Electromagnetic inertial impulse drive system diagram.



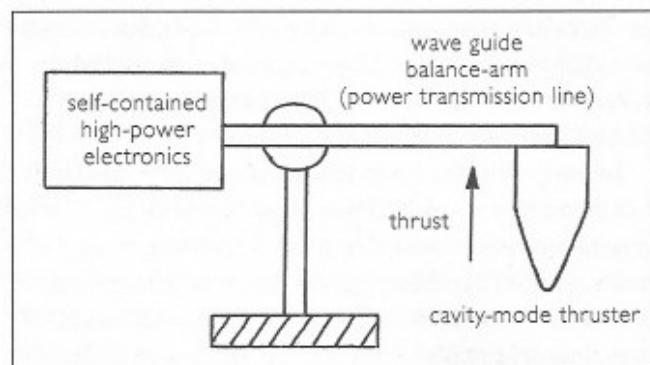


Fig. 6 Proposed system test setup.

energy into space."<sup>64</sup> The device uses an antenna structure pulsed at extremely low frequency to trap magnetic flux in a volume of space internal to the loop antenna geometry. Lorentz forces in the charges bound to the loop are generated, and the field, then, becomes converted to mechanical thrust.

Both Brown and Schlicher realize the mechanisms involved in their energy conversion devices are enhanced by the inclusion of materials of high dielectric permittivity and high magnetic permeability. Also, they both mention that the optimal design should incorporate multiple thrust device elements built up into arrays for purposes of generating large propulsive force densities.

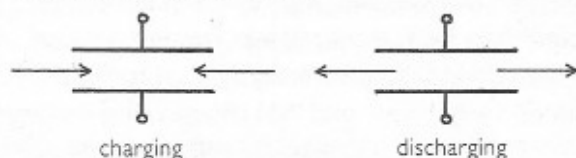
To conclude the discussion section, the words of Graham and Lahoz seem most fitting, "It would appear that a modest window has been opened into the structure of the vacuum; particles alone cannot monopolize the attention of the physicist, and quantum electrodynamics should pursue a treatment of the mechanics of induction fields...Whatever the theoretical implications may be, the fact is that, to approximately the 10% level, at least, the last outstanding item in Maxwell's vacuum electrodynamics has been experimentally confirmed."<sup>65</sup>

## CONCLUSIONS

The third law of motion affirms a fundamental law of nature. The action and reaction forces coexist in an interaction between one object and another, and make up a system of equal but oppositely directed momenta.

Faraday discovered the true essence of the electromagnetic field: the spontaneous nature of the field energy exists in an orthogonal relationship of electric, magnetic, and motional forces. He knew, by experiment, if he disturbed the state of equilibrium of these forces, electrodynamic effects occurred: an electric field appeared, the

### parallel circular plate capacitor



- Energy flow (Poynting vector flux) in a capacitor is represented with arrows ( $\rightarrow$ ).
- There is a nearly uniform  $\mathbf{E}$ -field inside the capacitor, which is changing with time.
- Remember that there is a  $\mathbf{B}$ -field that circles around the axis when the capacitor is charging or discharging.
- There is a mass flow proportional to  $\mathbf{E} \times \mathbf{B}$  that comes into and out of the capacitor volume between the edges of the plates.

Brown's electrokinetic apparatus, U.S. Patent #3,187,206, viewed using Poynting vector field momentum — a mass flow.

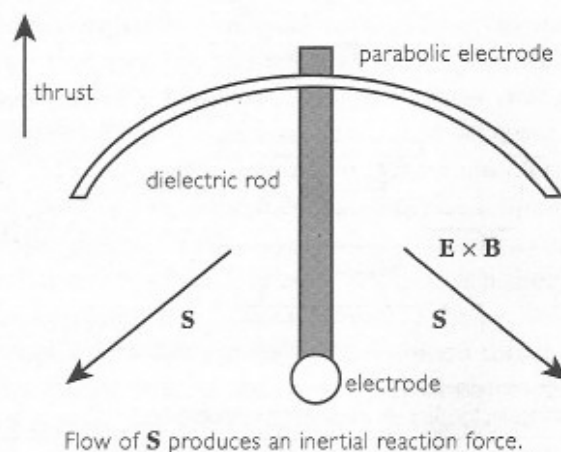


Fig. 7 Energy flow in a capacitor.

object became magnetized, or the object moved. The Lorentz force is a physical expression of nature's conservation of momentum because Maxwell said all energy is mechanical energy in one form or another. His dynamical theory of the electromagnetic field is a theory of the mechanics of the vacuum medium.

Is electromagnetic propulsion possible, and could it really work? It would seem so. Based on a review of scientific literature, experiments and patents, the conjecture presented does indicate that a novel form of electrodynamics for generating electromagnetic propulsion in vacuum is possible. The electromagnetic field has mass: mass in motion, called electromagnetic momentum. Therefore, if it is possible to vary the mass of an object electrically, and inertia is a measure

of how much mass is in an object, then it may be possible to control the inertia of an object. A sudden change in mass will produce an inertial reaction which, if directed properly, can change the momentum of the object. By creating a change in electromagnetic momentum density, the missing force of the Lorentz force equation could be used to induce motion. A motional force is produced by a momentum exchange between the induction  $\mathbf{E} \times \mathbf{B}$  fields of an object (the action mass) and the quantized fields of the vacuum medium (the reaction mass), a push via vacuum interactance! The induction field pushes on space, and space pushes back, an action-reaction system based on a vacuum Lorentz force.

An analogy may be made using one of nature's creatures. A jellyfish moves through an ocean of water by taking in some water into its body and then suddenly releasing the water. The jellyfish creates its motion by using a parcel of water to push against the water of the ocean. It does so by changing the volume of water in a cavity that is part of its body, a mass fluctuation. Think of the jellyfish as a spacecraft, the water as the vacuum medium, and the ocean of water as the universe. Imagine!

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ED. NOTE: Cleveland has recently informed *ESJ* that he doesn't believe that the cavity resonator will be able to generate the fields needed to synthesize a Poynting vector. Details will be published in an upcoming issue of *ESJ*.

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