Electromagnetic Propulsion using the Concepts of a Homopolar Motor

John R. Warfield
8250 N via Paseo Del Norte, Apt. E 102, Scottsdale, AZ 85258
e-mail: warf1002@aol.com

The intention of this article is to describe an electromagnetic propulsion demonstration proof of concept model, which will propel itself without a propellant, furthermore in apparent violation of Newton's Third Law.

1. Introduction

In order to appreciate this article, one can reference two previous articles. [1] [2] For the average individual, the electromagnetic propulsion principles presented would be very difficult to assemble into a working device, moreover expensive. In contrast, this article intends to use the physical concepts of homopolar motor to illustrate a proof of concept demonstration model, however difficult to assemble, nevertheless inexpensive, perhaps costing only a few hundred dollars or less.

This article will be divided into three sections:

Section 1 describes a simplified explanation of the underlying physics principles of a homopolar generator and motor

Section 2 uses the rudimentary concepts described in section 2 to discuss in much greater detail the physics of a homopolar generator/motor, along with how they interrelate with each other.

Section 3 utilizes the underlying principles and physics described in sections 1 and 2 as well as the concept of mirror image symmetry to illustrate a model that can propel itself without a propellant, nevertheless still complex and therefore difficult to construct.

2. Fundamental Physical Principles

A current by convention is a flow of positive charge, but the actual flow is of only electrons; a flow of negative charge. It is much easier to appreciate the concepts described in this paper if one envisions flowing electrons--- a negative charge. Nevertheless the concept of a flowing positive charge is so engrained in the minds of scientists, as well as most lay individual, that assuming a flow of negative charge was depicted, then many individuals would be confused. As a result, even though less than ideal, this paper will for the sake simplicity and ease of understanding define a current as a flow of positive charge. Nevertheless occasionally in order to illustrate the underlying principles, the Lorentz force exerted on only the electron will be described.

Even so, before proceeding, with reference to a positive current, the concepts as illustrated below need to be understood.

2.1. Left- and Right-Hand Rules [3]

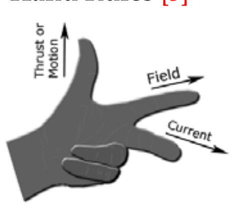


Fig. 1. Fleming's left hand rule (for motors)

Fleming's left hand rule (for electric motors) shows the direction of the thrust on a conductor carrying a current in a magnetic field. The left hand is held with the thumb, index finger and middle finger mutually at right angles. It can be recalled by remembering that "motors drive on the left, in Britain anyway.

- The first finger represents the direction of the *Field*.
- The second finger represents the direction of the *Current* [conventional current, positive(+) to negative(-)]
- The thumb represents the direction of *Thrust* or *Motion*.

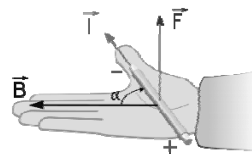


Fig. 2. The right-hand rule

Point the thumb of the right hand in the direction of the conventional current or moving positive charge and the fingers in the direction of the B-field the force on the current points out of the palm. The force is reversed for a negative charge.

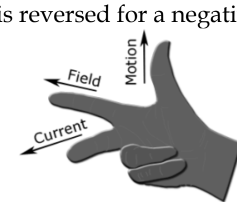


Fig. 3. Fleming's right hand rule (for generators)

Fleming's right hand rule (for generators) shows the direction of induced current flow when a conductor moves in a magnetic field. The right hand is held with the thumb, first finger and second finger mutually perpendicular to each other {at right angles}, as shown in Figure 3.

- The thumb represents the direction of conductor *Motion*.
- The first finger represents the direction of the *Field*.
- The second finger represents the direction of the induced or generated *Current* (classically from positive to negative).

2.2. General Properties of Magnetic Lines of Force

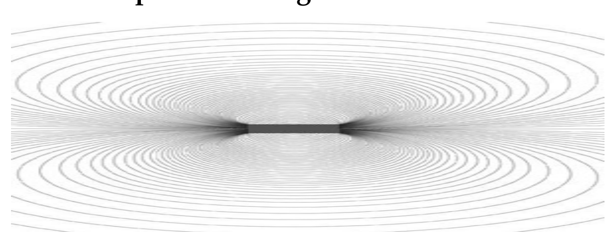


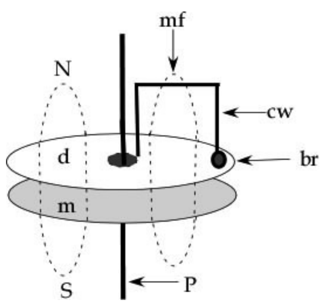
Fig. 4. Magnetic lines of force

Important properties of Magnetic lines of force include: [4]

- They seek the path of least resistance between opposite magnetic poles.
- In a single bar magnet as shown to the right, they attempt to form closed loops from pole to pole. They never cross one another.
- They all have the same strength. Their density decreases (they spread out) when they move from an area of higher permeability to an area of lower permeability.
- Their density decreases with increasing distance from the poles.
- They are considered to have direction as if flowing, though no actual movement occurs.
- They flow from the South Pole to the North Pole within a material and North Pole to South Pole in air.

Using the principles illustrated above, let us now discuss both a homopolar generator as well as a homopolar motor. A homopolar generator and motor are actually two interrelated devices invented by Faraday, the latter of which apparently violates Newton's Third Law; that for every action there is an equal and opposite reaction.

2.3. Homopolar Generator



d = disk conductor
m = permanent magnet
mf = magnetic field
cw = closing wire
br = brush
p = pole

Fig. 5. Homopolar Generator

Structure

- The South to North direction of the magnetic field within the magnet is from the bottom of the page to the top of the page.
- The disk [d] is a conductor [defined as disk], furthermore attached to a vertical pole [p].
- The disk can rotate independently from the pole.
- The magnet [m] is a permanent disk magnet [defined as magnet] with its South to North Pole magnetic axis aligned parallel with the vertical pole.
- The magnet is separated by a space apart from the disk.
- The magnet can independently rotate with respect to the pole as well as the disk. Alternatively the magnet and disk can co-rotate together.
- The stationary closing wire [cw] consists of a wire conductor that connects the center of the disk to its periphery. It can be open or closed. Furthermore it remains stationary relative to the magnet as well as disk, given that e it still maintains contact with the periphery of the disk by a brush [br].

Function

- Assume the closing wire [brush] is stationary.
- If the disk is rotated counter-clockwise by a torque relative to the stationary magnet, a current is induced through the disk and closing wire, moreover in the direction from the center of the disk to its periphery.
- If the magnet is rotated by torque relative to the stationary disk, no current is produced. This fact in conjunction with the above observation is apparently a violation of Einstein's relative motion concept.
- If both the disk and magnet are co-rotated counter-clockwise by torque in synchrony, a current is induced through the disk and closing wire in the direction from the center of the disk to its periphery. This function is again a violation of Einstein's relative motion concept, furthermore Faraday's induction theory, because a current should only be produced if there is relative motion between the disk and magnet.
- If the disk is rotated by torque with the closing wire open rather than closed there is no resistance to this torque, or in other words no back force.
- If the disk is initially rotated by a torque, and if simultaneously a current is withdrawn from the closing wire, there will be a reverse force produced on the disk resisting the initial torque, or in other words a back force.

2.4. Homopolar Motor

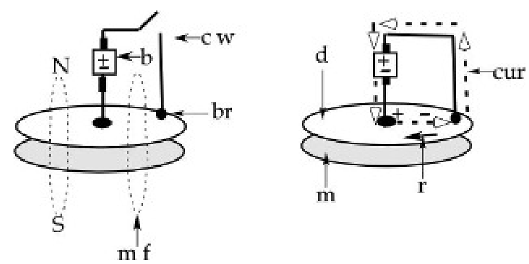


Fig. 6. Homopolar Motor

d = disk conductor	cur = direction of current
m = magnet	+ = positive charge
mf = magnetic field	- = negative charge
cw = closing wire	b = battery
br = brush	r = rotation direction

Structure

- South to North axis runs through the disk from the bottom of the page to the top of the page.
- On the left, the physical structure of the homopolar motor without a current.
- On the right, the disk rotates clockwise due to the Lorentz force exerted on the current.

Function

- Assume the closing wire is stationary.
- When a current travels through the disk from its center to its periphery, a Lorentz force is induced, this produces clockwise rotation of the disk. However, and this is extremely important, there is no back force exerted on the disk consistent with Newton's Third Law.

2.5. Co-Rotating Homopolar Motor

The above homopolar motor example is to some extent puzzling, since the disk is separated from the magnet by a space and because the magnet can rotate independently of the disk, consequently one can become confused. For that reason a more simplified model is illustrated as below, whereby the magnet and the disk are one and the same.

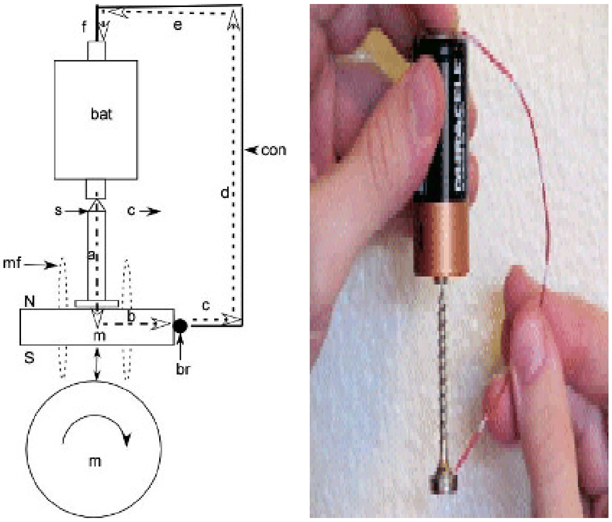


Fig. 7. Simplified Homopolar Motor [5]

bat = battery	s = metal screw
m = conductor disk magnet	con = conductor
c = current magnetic field	br = brush

a, b, c, d, e, f = different sections of the current

The device in Figure 7 consists of a battery, a metal screw, a permanent disk magnet, and a copper wire conductor. The magnetic field is oriented at right angle relative to the current passing through the magnet. The current traveling through the permanent magnet conductor is oriented at a right angle with respect to the direction of the magnetic field created by that same magnet. Note; the magnet and the conductor disk are one and the same. As a result, there is a sideways Lorentz force which produces clockwise rotation of the circular magnet disk and the screw. This is a co-rotating homopolar motor.

Structure

- The disk shaped magnet is attached to the base of the metal screw, which then magnetizes the screw.
- The tip of the magnetized screw is placed in contact with the battery's lower electrode; what's more, it is attracted to it, as it is now magnetized.
- The stationary copper wire conductor is attached to the battery's upper electrode, while the other end of the conductor gently touches the side of the magnet [like a brush], even so it still allows the magnet to freely rotate.

Function

- The current passes from the battery's lower electrode down through the screw vertically, and then turns horizontally as it traverses through the magnet.
- The current then enters the copper wire, through the brush, whereby it returns to the battery's upper electrode.
- With respect to this model, the only area where the Lorentz force exists, is in the region where the current travels horizontally through the permanent magnet (the magnet and conducting disk are one and the same). At this location, the current interacts with the vertical oriented magnetic field, consequently inducing a sideways Lorentz force, which causes causing both the magnet and screw to rotate clockwise. A brief movie of this homopolar motor can be found at [6].
- To recap, the current traveling through the permanent magnet is oriented at a right angle with respect to the direction of the magnetic field created by that same magnet. Note that the magnet and the conductor disk are one and the same. As a result, there is a sideways Lorentz force that produces rotation of the circular magnet disk as well as the screw.

Nonetheless this concept is considerably more complicated. There is still a current located within the vertical and horizontal portions of the closing wire conductor, as it returns to the upper electrode as illustrated in Figure 8 below. The screw is the pyramidal structure attach to the lower electrode of the battery.

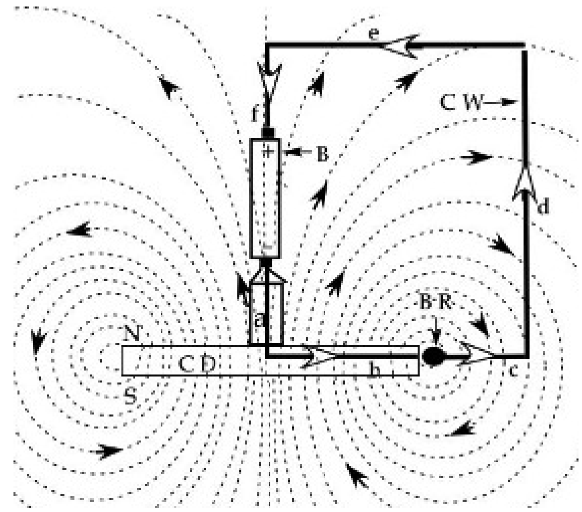


Fig. 8. Homopolar Motor Fields

B	= battery
CW	= closing wire
BR	= brush
CD	= permanent magnet conductor disk
a, b, c, d, e, f	= different sections of the current
Solid arrows	= direction of magnetic field
Hollow arrows	= direction of current

2.6. Lorentz Forces on the Different Sections

Note that one can visualize the direction of all of these forces by applying the right hand rule in Figure 2 to the currents in Figure 8. The directions of the Lorentz forces in each section are:

a = no force	d = into of page
b = out the page	e = into of page
c = into of page	f = no force

Section a. As the current passes downward through the screw into the disk, it is oriented parallel to the direction of the magnetic field, thus no force

Section b. As the current passes through the magnetic disk conductor it is oriented at a right angle with respect the axis of the magnetic field, consequently a Lorentz force is produced in the direction of; out of the page.

Sections c, d, and e. As this current within the closing wire interacts with the non-vertical portions of the magnetic field, as that field returns to the opposite magnetic pole, a Lorentz force is exerted on the wire. Moreover the direction of this force is oriented in the opposite direction compared to the Lorentz force exerted on the conductor disk magnet at [b].

Section f. As the current travels downward through f there is no force, since once again its orientation is parallel to the direction of the magnetic field.

So if the Lorentz force exerted on the magnet is equal to the Lorentz force exerted on the closing wire, then with respect to the closed system, there is no net linear force or overall linear motion—rotational motion, possible—translational motion, no.

Even so this idea is over simplified, because the interaction of the circular magnetic field with the closing wire is extremely complex. As a result, only a portion [or portions] of the closing wire experiences an opposing Lorentz force. Therefore the opposing Lorentz forces may or may not be equal. This potential asymmetry is as a function of both the position of the closing wire as well as the direction and the intensity of the magnetic field at that location.

Since this article is all about electromagnetic propulsion without a propellant, then the objective relative to this example is to design a structure that reduces the opposing Lorentz force exerted on the closing wire as is illustrated below.

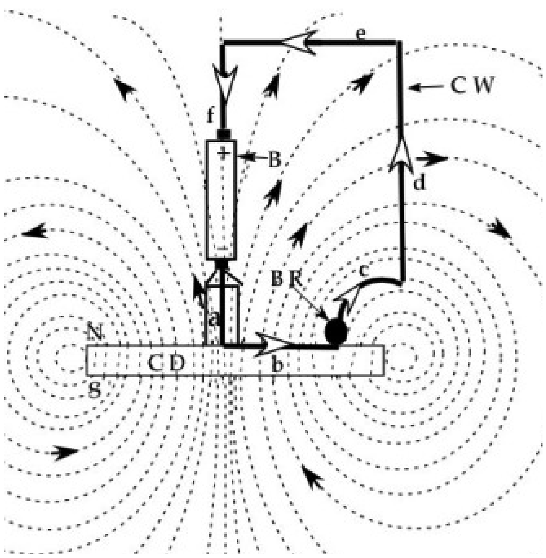


Fig. 9. Homopolar Fields with Forceless Path c

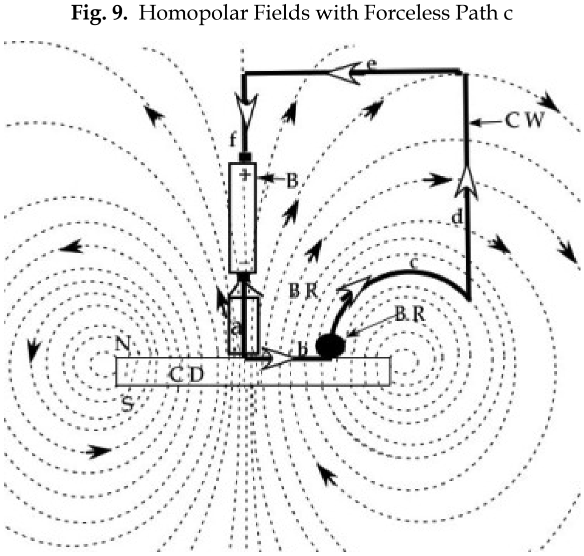


Fig. 10. Homopolar Fields with Forceless Path c (longer path)

The symbols and the direction of the Lorentz force in Figures 9 and 10 are identical with those in Figure 8, except along path c, where there is no force. Current flows force free along path c because the left hand rule in Figure 1 one generates no thrust.

Section a. There is no Lorentz force produced as the current travels vertically downward from the lower electrode through the screw and into the magnet, because at this location the current and magnetic field are parallel to each other, accordingly no force.

Section b. The current interacts with the right angled magnetic field to produce a Lorentz force oriented out of the page.

Section c. The current as it leaves the magnet within the exiting closing wire is oriented parallel to the magnetic field lines, in this case a curve towards the other pole, so again there is no force.

Sections d and e. Observe; in order to complete the circuit the closing wire must necessarily return to the upper electrode and not towards the other magnetic pole. Consequently to accomplish this feat the closing wire follows along parallel with the curvilinear magnetic field's path [c] until positioned at some significant distance from the magnet where the field is considerably reduced. At this point instead of following the field lines to the opposite pole, the conductor turns vertically [d] towards the top of the page, then horizontally [e] back to the upper electrode. Recall the strength of the magnetic field created by a magnet does not obey the inverse square law. This concept is unlike the electric force or the gravitational field. In essence, the strength of the magnetic field produced by a magnet decreases much more rapidly the further it is from the magnet, as compared to the inverse square law. Notice; the interaction of the current and the magnetic field, when located inside of the magnetic disk [b] is at a maximum, since they are oriented at right angles with respect to each other, moreover at the full strength of that magnetic field. In contrast, only when the exiting closing wire veers from the direction of the magnetic field, as it returns to the upper electrode [d and e], does it then experience a Lorentz force. Furthermore this force is oriented in the opposite direction compared to that force exerted on the magnet. What is more, the magnetic field in this region of [d and e] is relatively weak. Therefore the opposite Lorentz force exerted on the closing wire is significantly less than the Lorentz force exerted on the conductor magnet.

Section f. The current is again parallel to the direction of the magnetic field, so no force.

In summary, on one hand, the Lorentz force exerted on the current located within the conductor magnet is at a maximum, given that it experiences the full strength of the right angled vertically oriented magnetic field [a]. On the other hand the current of the closing wire interacts with the magnetic field only in the sections where it deviates from parallel to that field [d and e]. Take note of; this latter interaction is situated away from the magnet where the field is relatively weak. As a result the Lorentz exerted on the magnet producing rotation [a] is much greater than the opposing Lorentz exerted upon the upper sections of the closing wire [d and e]. In addition with respect to this example there are no other Lorentz forces. So here again there is a violation of Newton's Third Law.

Alternatively, it is arguable that the equal and opposite force, associated with the torque, is positioned where the tip of the screw touches the battery's lower electrode. Yet, if this apparatus was placed in outer space, there would be a forward net force exerted on that lower electrode, moreover not countered by an equal and opposite force (given that it is free floating), once more an infringement of Newton's Third Law. As an analogy, envision a wheel 'free floating' in outer space. If a Lorentz force is applied to the periphery of the wheel, relative to its plane, the wheel will rotate, but at the same time, there will also be forward translation movement of that entire wheel as depicted below.

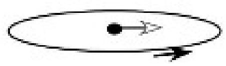


Fig. 11. Free Floating Wheel Analogy

The dark arrow represents a Lorentz force exerted on the periphery of the wheel resulting in rotation related to the inertia of the wheel.

The hollow arrow represents the forward concomitant translational motion of the entire wheel as a function the above Lorentz force.

3. Physics of a Homopolar Generator/Motor

The above descriptions [section 1] are very rudimentary explanations, presented so that one can without difficulty grasp the underlying physical principles of both the structure as well as function of a homopolar generator/motor. However as usual in life things are significantly more complicated. The following section will discuss these two devices but in much great detail, moreover the mechanism as to how they interrelate to one another. In essence it is much easier to understand the following complex descriptions, if one at first understands and comprehends the above uncomplicated explanations.

3.1. Homopolar Generator

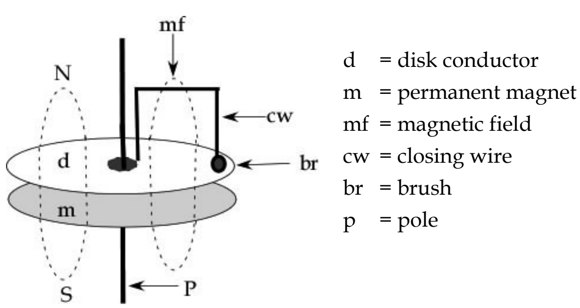


Fig. 12. Homopolar Generator (same as Fig. 5)

Structure

- The disk [d] is a conductor [defined as disk], furthermore attached to a vertical pole [p].
- The disk is capable of independent rotation with respect to the pole.
- The magnet [m] is a permanent disk magnet [defined as magnet] with its South to North Pole magnetic axis aligned parallel with the vertical pole.
- The magnet is separated by a space apart from the disk.
- The magnet can independently rotate with respect to the pole as well as the disk. Alternatively the magnet and disk can co-rotate together
- The closing wire consists of a wire conductor that connects the center of the disk to its outer side; by a brush located peripherally. This structure allows the disk to freely rotate independently of the closing wire. Furthermore the closing wire can either be open or else closed, what's more either stationary relative to the disk or else it can co- rotate with it.

Function

With the stationary closing wire closed

- If the conductor disk is rotated relative to the stationary magnet, current is produced in the disk as well as in the stationary closing wire.
- If only the magnet is rotated relative to the stationary conductor, no current is produced in either the disk or closing wire.
- If the conductor disk and magnet are co-rotated, a current is produced in the disk as well as the stationary closing wire, exactly as if the magnet were stationary. Essentially, if the conductor disk is rotating, then it makes no difference as to whether or not the magnet co rotates with it, for regardless a current is induced in the disk and stationary closing wire.

3.2. Faraday's Paradox

These observations are inconsistent with Einstein's notion of relative motion, although some may argue that this device involves accelerated motion, therefore the relative motion concept is not applicable. Likewise these observations are inconsistent with Faraday's idea that an electric current is produced only when a moving conductor crosses the lines of force of a magnetic field.

However Faraday's concept is incorrect, seeing as the lines of force of a magnetic field in fact do not exist. The lines of force theory is derived from placing metal filing on a piece of paper influenced by a magnetic field and then observing the results; the filings line up in supposed force lines.

But what is really happening? Essentially under the influence of the magnetic field the metal filings become magnetized, moreover in the opposite direction compared to the field. For this reason, they all align end on end in the same orientation, thus creating a line. Moreover these individual lines repel each other to form an overall picture; the lines of force of a magnetic field.

However, if smaller metal filings are used, then the force field lines become more numerous as well as narrower; what's more, the smaller the metal filings, then the more this effect. What this actually indicates is that there are no lines of force. Basically a magnetic field possesses a magnitude and direction for a given point is space. Therefore, as in our example, if a uniform disk like magnetic field is rotated, then with respect to any given point in space, there is no change in the magnitude and direction of this field. So it makes no difference as to whether or not the magnet is rotated, for this value remains the same. Nevertheless this still does not explain the relative motion paradox.

Incidentally, if no current is produced when both the disk and magnet are stationary, and if there is a current when they co-rotate, then this fact necessitates a third frame, perhaps a preferred frame or in other words the old discarded term; the Ether.

3.3. Voltage Produced by Rotation

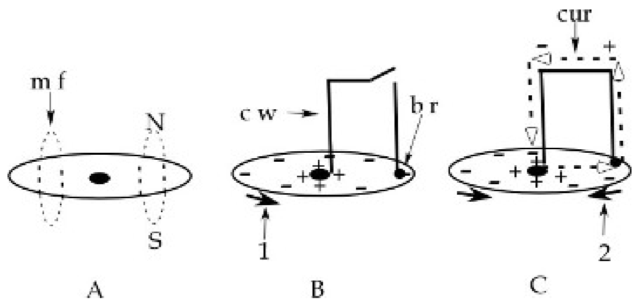


Fig. 13. Text?

mf = magnetic field cw = closing wire
br = brush N, S = magnetic poles

In Figure 13, Black arrow [1] represents the initiating force that drives the rotation of the disk counterclockwise. Black arrow [2] represents the clockwise back force resisting the driving force. The hollow arrows represent the direction of the current [cur].

Figure A. The physical structure of the device with the South to North magnetic field axis oriented through the disk from the bottom of the page to the top of the page

Figure B. The disk is rotated counter clockwise by force [1] with the closing wire open. Therefore due to the electromotive force the electrons accumulate at the periphery of the disk, thus producing a voltage across the radius of the disk

Figure C. The disk is rotated by force [1] with the closing wire closed. Therefore due to the voltage produced as depicted in B, a positive current is induced from the center of the disk to its periphery. Essentially this is a homopolar motor. Moreover the direction of the Lorentz force [2] of this motor is clockwise, thus resisting the counterclockwise force which initiated the rotation [1] This resisting force is the back force of a homopolar generator.

Assume the South to North direction of the magnetic field through the disk conductor is from the bottom of the page to the top of the page as depicted in Figure 9. In addition presume the closing wire is stationary, Furthermore for future reference the rotation of the disk refers to either the disk alone or the disk co-rotating with the magnet

The physical structure of the device is as depicted in A Now if the closing wire is open [B], there is no current. Consequently, if the conductor is rotated counterclockwise, a negative charge accumulates at the periphery of the disk, furthermore a positive charge will form at its center. This process is due to the Lorentz force [electromotive force]. Recall; generally although not exclusively, within this paper, a current is defined as a movement of positive charge. Nevertheless in this particular instance, in order to comprehend this concept, it will be necessary to discuss the movement of negative charges, or in other terms the movement of the electron by the Lorentz force. Note; this Lorentz force exerted on the electron is the mirror image of the classic Lorentz force associated with positive charge.

A conductor consists of atoms [e.g. copper] with unpaired outer shell electrons, furthermore loosely held within those outer shells. Moreover these unpaired electrons can move from the outer shell of one atom into the outer shell of an adjacent atom, and so on, and so forth, to form an electron current. In essence the electrons are free to move under the influence of the Lorentz force, whereas the protons are relatively fixed. So with respect to our specific model, when the disk is rotated counter-clockwise, a Lorentz force propels the electrons to the outer side of the disk. In contrast, the protons are relatively fixed so they cannot move. This leaves the negative charge located on the periphery of the disk and the positive charge positioned at the center; a voltage.

Conversely, if the rotation is in the opposite direction or else the magnetic field is reversed, then a negative charge will accumulate centrally and a positive charge peripherally. For future reference, moreover to avoid confusion, this form of the Lorentz force that drives the electron will be defined as the electromotive force.

3.4. Opposing Lorentz Force

On one hand, if one rotates the disk by force [labeled 1 in Figure 13], with an open closing wire, there is no resistance to that force. On the other hand, if the circuit is closed there is resistance [labeled 2 in Figure 13]. So what is happening here? Remember with respect to our example of the homopolar generator that during counter clockwise rotation, with an open closing wire, a negative charge forms on the periphery of the disk and a positive charge centrally, due to the electromotive force [B]; a voltage. Subsequently if the circuit is then closed, a positive current is created that travels from the center of the disk to its periphery [C], essentially this is a homopolar motor. Again with respect to our example, if a current travels from the center of the disk to its periphery [motor] then the Lorentz force induced drives the disk clockwise. As a result, with the closing wire closed, as one rotates the disk generator counterclockwise by force [1], then an opposing homopolar motor opposite Lorentz force [2] is created resisting the initiating force [1]. This is called a back torque but it is in fact a back Lorentz force.

3.5. The Closing Wire

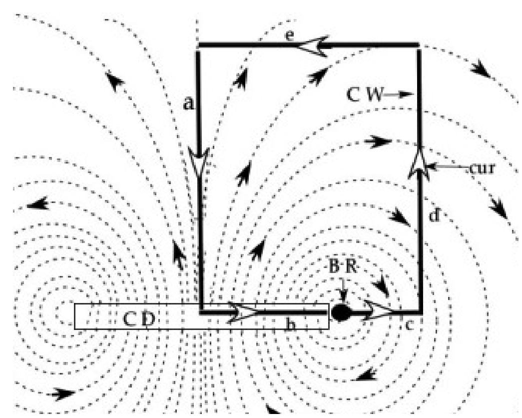


Fig. 14. Homopolar Motor Fields (Compare with Fig. 8)

CW = closing wire
BR = brush
CD = permanent magnet conductor disk
a, b, c, d, e, f = different sections of the current
Solid arrows = direction of magnetic field
Hollow arrows = direction of current
Pole is omitted

The closing wire is rotated within the magnetic field thus a voltage is created in the closing wire which opposes the voltage located within the conductor disk.

Most dissertations concerning homopolar motors either neglect or else deemphasize the closing wire. Nevertheless comprehending this component is very important, assuming one actually wants to understand a homopolar generator. Like the conductor disk, the conductor closing wire also exists within the magnetic field.

Nevertheless assuming it carries a current and is not moving relative to the magnetic field, there is no electromotive force. Remember it is the relative movement of the conductor with respect to the magnet that produces the electromotive force and not vice versa. So even though the magnet rotates, if the conductor closing wire is stationary there is no electromotive force.

However things change when the closing wire rotates along with the disk. In this scenario, because the closing wire rotates relative to the magnetic field, an electromotive force is created within the closing wire. But observe the magnetic field is a circular structure; furthermore it constantly changes its orientation as it travels from the North Pole to the South Pole outside of the magnet best illustrated the lower diagram of Figure 14. So the interaction of the field with the closing wire produces a voltage [from the electromotive force], what's more, and this is crucial, oriented in the opposite direction compared to the voltage driving the current within the conductor disk.

To recap; as the magnetic field interacts with the rotating closing wire, the voltage produced within the wire, by the electromotive force is oriented in the opposite direction compared to voltage driving the current in the conductor disk. So if the closing wire rotates along with the conductor disk, there will be either be a reduction of the current or else no current This is a function of the physical structure of the closing wire as well as the shape and magnitude of the interacting magnetic field. Furthermore if there is a reduction of the current or else no current, there will also be a diminution of, or else no back Lorentz force [resistance to rotation].

3.6. Homopolar Motor

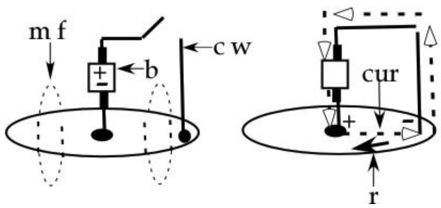


Fig. 15. Homopolar Motor (Compare with Fig. 6)

mf	= magnetic field	+	= positive charge
cw	= closing wire	-	= negative charge
br	= brush	b	= battery
cur	= direction of current	r	= rotation direction

3.7. Lorentz Force on the Disk

A homopolar motor has some of the reciprocal functions compared to that of a homopolar generator, nevertheless not that much reciprocity. Observe in Figure 15 the orientation of the current as well as the direction of the magnetic field. Furthermore recall the interaction of a positive current with a magnetic field produces a Lorentz force in the direction, shown in Figure 2.

Thus Figure 15 depicts two images of a homopolar motor, one without a current [left] and the other with a current [right]. When a current is applied to the disk as shown on the right, the disk rotates clockwise.

3.8. Electromotive Force on the Disk

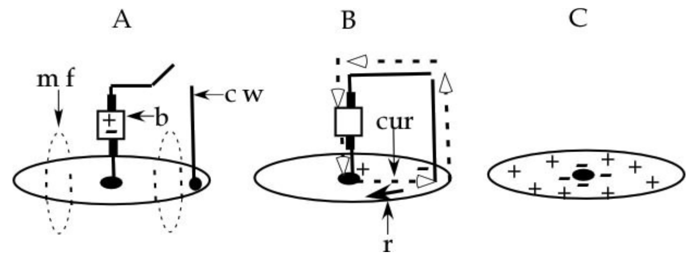


Fig. 17. Text?

Figure A. The physical structure of the homopolar motor with no current is shown.

Figure B. The disk rotates clockwise due to the Lorentz force exerted on the current from the battery.

Figure C. As the disk is rotated clockwise by the motor Lorentz force, then as a response, due to the electromotive force, a negative charge accumulates centrally and a positive charge peripherally. This latter voltage opposes the initial voltage of the battery that drives the current.

As a function of the Lorentz motor force, the disk rotates clockwise [r.] In response, the outer shell conductive electrons are propelled towards the central portion of the disk, as a function of the electromotive force [C]. This creates a voltage across the radius of the disk; moreover this voltage is in opposition to the voltage driving the current from the battery. For that reason, the current driving the disk diminishes. Furthermore the faster the rotation, the more this effect, until there is equilibrium. Note this example ignores friction.

In summary, the most import aspect with respect to this example moreover this article is that there is no back Lorentz force, rather only a back electromotive force [voltage], the latter of which resists the initial voltage produced by the battery that drives the current.

3.9. Lorentz Force exerted on the Closing Wire

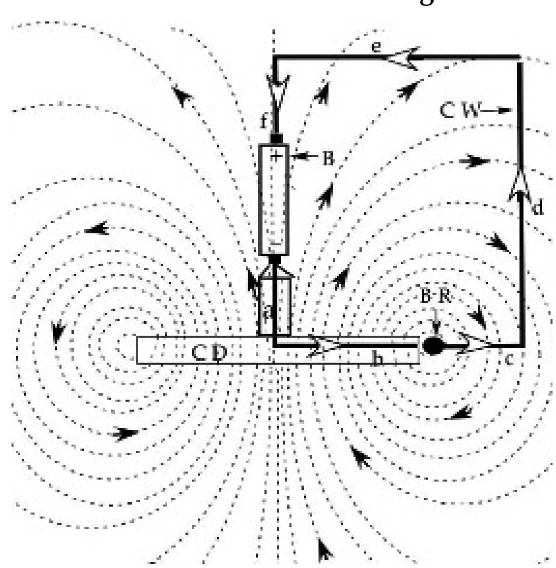


Fig. 18. Homopolar Motor Fields (compare with Fig. 8)

Symbols are the same as in Figure 8.

As in Sec. 2.6, the Lorentz forces in each section point:

a = no force	d = into of page
b = out the page	e = into of page
c = into of page	f = no force

The closing wire also possesses a current; in addition it also exists within the magnetic field produced by the magnet. Nevertheless, compared to when located within the disk, both the orientations of the magnetic field as well as the current are different. Basically because of this divergence, the direction of the Lorentz force exerted at the location of the closing wire is now oriented in the opposite direction compared to the Lorentz force exerted on the disk. If these two forces are equal then with respect to the entire apparatus there is no translation motion. In addition, if the opposing Lorentz force exerted on the closing wire is less than the force exerted on the disk, then this fact is a violation of Newton's Third Law.

As previously stated, the intention of this article is to use the underlying principles of a homopolar motor to create an electromagnetic propulsion apparatus that can propel itself without a propellant. This can be achieved if the Lorentz force on the closing wire is reduced.

3.10. Reducing the Lorentz Force on the Closing Wire

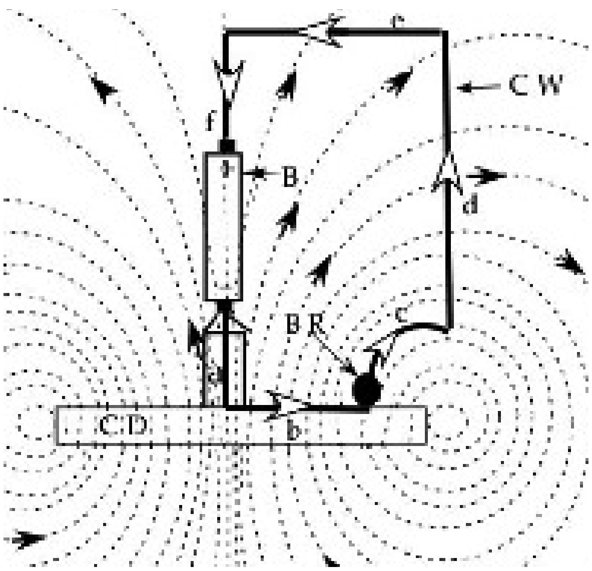


Fig. 19. Homopolar Fields with Forceless Path c (compare Fig. 9)

The forces are identical to the above, except along c, where now there is no force. Thus

Section a. The current traveling from the lower electrode, through the screw, and into the disk is parallel to the magnetic field, so no force.

Section b. The current within the disk is oriented at a right angle to the axis of the magnetic field, so there is force oriented out of the page

Section c. Now assume the current located within the exiting portion of the closing wire follows the magnetic field as it curves towards the opposite pole rather than as depicted in Figure 18. While it follows the field it is parallel to that field, so again no force.

Section d and e. However in order to complete the circuit, the closing wire cannot follow the field to the opposite pole. Therefore at some point it must veer from the direction of the field, and so in this case it travels vertically, then horizontally where it returns to the upper electrode. When it does veer from parallel to the field a Lorentz force is induced. What is more, its direction is in opposition to the Lorentz force exerted on the disk. [into the page] This veering portion of the closing wire is the only section of the closing wire that experiences this force. All other regions of the closing wire are parallel to the field, thus experience no force.

Section f. Again there is no Lorentz force, since the current is again parallel to the field.

3.11. Comparing Opposing Lorentz Forces

The Lorentz force exerted on the disk is at a maximum, since the right angled current interacts with the full intensity of the magnetic field.

The Lorentz forces exerted on the portions of the closing wire not parallel to the field are significantly less. This is because at these locations [d and e] the current exists where the magnetic field is much weaker. And, the current and the interacting field are not always oriented at right angles with respect to each other.

Recall the strength of the magnetic field created by a magnet does not obey the inverse square law. This concept is unlike the electric force or the gravitational field. In essence, the strength of the field of a magnet decreases much more rapidly the further it is from the magnet, as compared to the inverse square law.

If all this is true, then the Lorentz force exerted on the disk will be significantly greater than the opposing Lorentz force exerted on the closing wire.

This is a violation of Newton's Third Law.

4. Homopolar Self Propulsion

Before proceeding, this theory assumes that the Lorentz forces exerted on the disk and the closing wire consist of a force as opposed to a torque. There is a difference. A force is oriented in only one direction. A torque is two forces oriented in opposite directions, resulting in rotation.

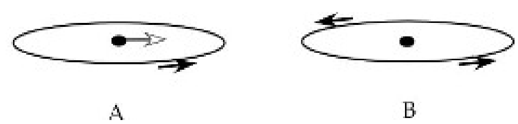


Fig. 20. Torque = Two Forces in Opposite Orientations

A force is different from a torque. As an analogy,

Figure A. Envisage a wheel "free floating" in outer space. Subsequently, if a Lorentz force is applied to the periphery of the wheel [relative to its plane], the wheel will rotate. But simultaneously there also will be net forward translational movement of that entire wheel.

Figure B. Imagine the same wheel in similar circumstances, but in this scenario a torque is used to rotate the wheel [equal but opposite forces applied to either side of the wheel]. There will still be rotation but no translational motion.

With reference to our homopolar example, moreover, assuming a force rather than a torque, then the overall motion produced by all of the asymmetrical opposing Lorentz forces is exceedingly complex, in fact too complex to describe here, because:

- The opposing Lorentz forces are unequal
- The opposing Lorentz forces are not oriented along the same axis, which results in rotation
- The Lorentz force exerted on the disc results in mainly rotation with some translational motion, while the Lorentz force exerted on the closing wire is linear.
- Rotation of the disk will result in a gyroscope effect.

There are numerous ways to describe this concept. So for ease and simplicity of understanding, I have chosen to present several figures depicting all of the fields, currents and forces. Then by using these figures, as well as the following discussions, it will be shown how mirror image symmetry can counteract all motion except for translational motion

4.1. Further Examples

Figure 21 demonstrates the physical structure of the device without the magnetic field. Figure 22 depicts this same structure, but now with a superimposed magnetic field. I have chosen to present section 3 in this way to avoid confusion, because if presented as only one figure it would, in terms of labeling, be very complex. Nevertheless if one refers to Figure 24, there is an integration of both Figures 21 and 22. Using Figures 21, 22 and 2, picture within your mind the Lorentz forces exerted upon each of the separate sections of the two closing wires.

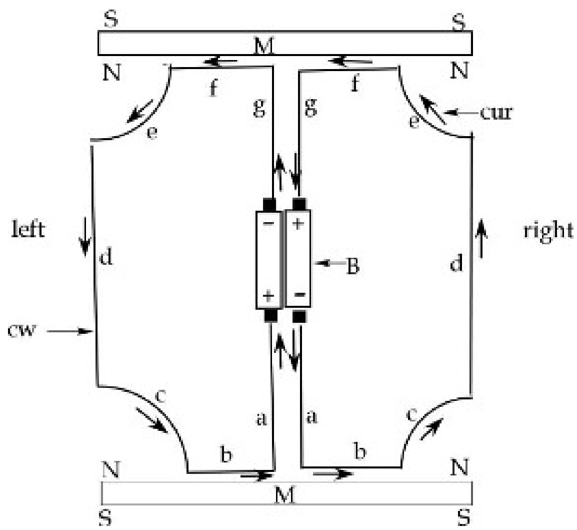


Fig. 21. Self-Propulsion Device

B	= battery
cur	= direction of current
M	= magnet, direction of magnetic field indicated
cw	= closing wire
a, b, c, d, e, f =	different sections of the current

Figure 21 depicts the physical structure of the device without the superimposed magnetic field.

- The physical components pictured in Figure 21 are attached, moreover fixed, to a flat wooden platform oriented vertically.
- The entire platform along with its components acts as single unit, which undergoes translation motion, since the individual components are fixed to the platform.
- The magnet is not a disk magnet, rather a bar magnet, furthermore as shown the direction of its magnetic field is oriented across its width instead of longitudinally.
- The two individual conductor wires are separate entities, apart from the magnets, although they are attached and fixed to the magnets.
- Figure 22 depicts the magnetic field superimposed upon Figure 21
- Figure 24 is an amalgamation of Figures 21 and 22.

In this section, it will be demonstrated, as a function of structural mirror image symmetry, as well as Lorentz force mirror of symmetry, that all forces counteract one another, except for those forces that propel the platform in the direction of; out the page. This is the rational for why the right and left sides are labeled as such. Even so, there is no mirror image symmetry involving the directions of the two opposing currents.

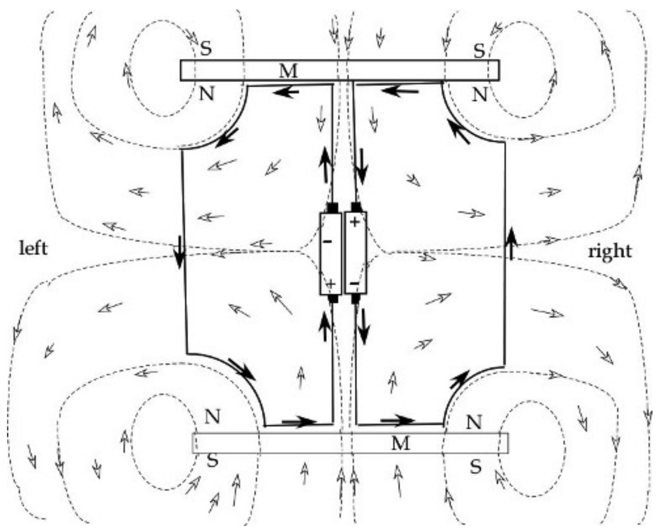


Fig. 22. Self-Propulsion Device with Magnetic Fields

First the Lorentz force exerted on each separate section of the closing wires as an independent entity will be discussed. Subsequently these independent units will be combined into one overall Lorentz force that propels the platform out the page with translational motion.

4.2. The Individual Components

a bilaterally. The current located within each wire conductor is oriented parallel to the magnetic field, therefore no force is generated on either side. Nevertheless this assumption is not entirely accurate as will be discussed later on within this article.

b bilaterally. The current located within each wire interacts with a right angled magnetic field, which then produces a Lorentz force oriented out of the page. Mirror image symmetry results in translation motion of the lower magnet out of the page.

c bilaterally. The current locate within each wire is oriented parallel to the magnetic field, so there is no force on either side.

d bilaterally. The current located within each wire interacts with the now non parallel magnetic field, as that field returns to the opposite pole. This interaction is very complex. Nevertheless if one envisions the forces [using the figures], then the resultant force exerted on each wire possess at least a component directed towards; into the page. Once again mirror image symmetry produces only translation motion, but in this case, in contrast to [b bilaterally], into the page. What is more, any component of the

Lorentz force directed laterally or else medially is counteracted, again by mirror image symmetry

e bilaterally. The current locate within each wire is oriented parallel to the magnetic field, so there is no force on either side.

f bilaterally. The current located within each wire interacts with the right angled magnetic field which produces a Lorentz force oriented out of the page. Mirror image symmetry results in translation motion of the upper magnet out the page.

g bilaterally. The current located within each wire conductor is oriented parallel to the magnetic field, so no force is produced on either side. This is not entirely correct as discussed below.

again a and g bilaterally. The currents are oriented parallel to the magnetic field so there is no force related to this specific factor. Nevertheless the two currents are traveling in opposing directions; consequently the wires repel one another. However recall, they are attached as well as fixed to the platform, thus there is no movement of the wires. What is more, given that there is mirror image symmetry, then with respect to this second factor, there is no translational or rotational motion of the platform.

The simplest way to demonstrate the amalgamation of all of the Lorentz forces into one general overall Lorentz force, moreover producing translational motion of the platform into the page is to use a synthesis of Figures 21 and 22, along with the following discussion. This complex and busy combined Figure 24 should now be more comprehensible, given the previous discussions

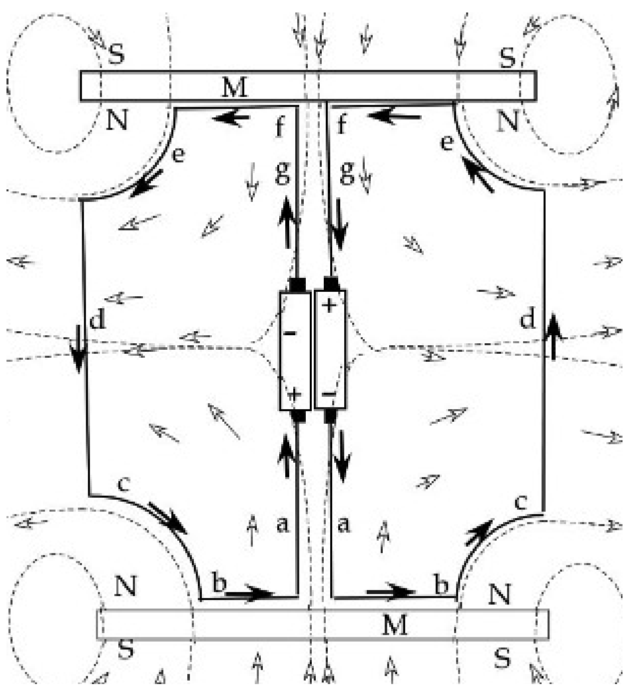


Fig. 24. Self-Propulsion Device (Synthesis of Figs. 21 and 22)

4.3. Discussion

a and g bilaterally. At these locations the conductor wires repel one another due to their opposing currents. However they are fixed to the platform, therefore the mirror image symmetry of repulsion prevents any translational or rotational motion of the platform.

b and f bilaterally. At these locations the direction of the forces are oriented out of the page. Consequently, mirror image symmetry results in an overall translational force exerted on the platform directed out of the page

c and e bilaterally. At these locations the currents are oriented parallel to the magnetic field, so there are no forces.

d bilaterally. At these locations the currents interact with the now non parallel magnetic field to produce forces oriented in the direction of; into the page. Mirror image symmetry produces translation motion of the platform; into the page. Even so, there still may be other forces oriented laterally or else medially, nevertheless mirror image symmetry prevents any translational or rotational motion of the platform with respect to these latter forces, leaving only the force oriented towards into the page.

The two regions associated with opposite translational motion [into and out of the page] are further discussed as below. All other forces counteract one another due to mirror image symmetry.

b and f bilaterally. The overall mirror image symmetry of the Lorentz forces produces translational motion of the platform directed out of the page.

d bilaterally. The overall mirror image symmetry of the Lorentz produces translation motion of the platform directed towards into the page.

If one assumes these two opposing forces are equal, there is no translational or rotational motion. But notice; on one hand with respect to locations [b and f bilaterally] the forces are at a maximum, since the currents interact with the maximum intensity of the magnetic field, moreover at a right angle. On the other hand, at positions [d bilaterally] the field is significantly weaker, as it is located further from the magnets compared to [b and f bilaterally]. Additionally, the interactions at [d bilaterally] are not always oriented at a right angle. As a consequence, the overall Lorentz force driving the platform into the page is significantly less compared to the overall Lorentz force driving the platform out of the page. If so, there exists translational electromagnetic propulsion without a propellant'.

5. Conclusion

If the assumption of this article are correct then one can propel an object through space without a propellant using a only a magnetic field and a current

References

[1] J. Warfield, "Electric Currents, Magnetic Fields, Magnetic Pulses and Electromagnetic Propulsion", Infinite Energy **14**(84) pp. 49-54 (Mar/Apr 2009).

[2] J. Warfield, "Electromagnetic Propulsion of Matter in Violation of Newton's Third Law", in this proceedings (2010).

[3] Wikipedia

[4] NDT resource center http://www.ndt-ed.org/EducationResources/CommunityCollege/MagParticle/Physics/MagneticFieldChar.ht.

[5] http://www.flickr.com/photos/oskay/208883275.

[6] http://www.youtube.com/watch?v=w2f6RD1hT6Q.