A Longitudinal Force
Motor Design

Horace Heffner January, 2006

BACKGROUND

This analysis was the result of a protracted discussion of electromagnetic longitudinal force issues between Frank Stenger, Scott Little, and Horace Heffner in May 2000.

COMBINED EQUATION FOR INFINITE STRAIGHT WIRE

```
                        Q2          <-- i
                   x    dx
---------------------|--|---------    (e-)  v-->
                |  theta /
                |       /
                |      /
          d     |     /          dF
  dFy           |    / r        /
   |            |   /          v
   v            |  /
                | /
                |/
               o Q1  v-->
```

Fig. 1 - Diagram of long straight wire and charge Q1

The initial objective here, in equations (1) through (10) below, is to explore the estimate of the y axis force Fy on a charge Q2 moving at velocity v at distance d from an infinitely long straight wire with current velocity v, by applying the incremental combined pancaking plus rho transformation force:

Fi = (3 sin^2 theta) v^2 Q1 Q2/(8 Pi c^2 e0 r^2) (1)

Looking at Q2, we see it is the product of linear charge density rho2 (in Coul/m) and the interval length dx, so for an incremental force dF from interval dx2,

dF = (3 sin^2 theta) v^2 Q1 rho2/(8 Pi c^2 e0 r^2) dx (1a)

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In order to simplify, assume this results in a force dF from a segment dx of:

$$dF = k\,(3 \sin^2 \theta - 2)/r^2\, dx \qquad (2)$$

giving the constant k:

$$k = v^2\, Q1\, \rho_2/(8\, \pi\, c^2\, e0) \qquad (2a)$$

Looking at Fig.1 we see the identities:

$$\sin \theta = d/r \qquad (3)$$

$$r = (x^2 + d^2)^{(1/2)} \qquad (4)$$

and the y axis portion dFy of the force is obtained by multiplying (2) by sin theta = d/r:

$$dFy = k\,(d/r)\,(3 \sin^2 \theta)/r^2\, dx \qquad (5)$$

and, subs (3) and (4) into (5):

$$dF = k\, d\, (3\, [(d^2)/(x^2 + d^2)])\ \ [(x^2 + d^2)^{(-3/2)}]\ \ dx \qquad (6)$$

$$dF = [3k\, d^3\, (x^2 + d^2)^{(-5/2)}\, dx] \qquad (7)$$

Integrating on x, 0 to +inf:

$$F+ = k/d\, [x\, (2\, x^2 + 3\, d^2)\, (x^2 + d^2)^{(-3/2)}] \qquad (8)$$

[eval x=0 to +inf]

and again noting that:

$$\lim (x \to +\text{inf})\, [x\, (2\, x^2 + 3\, d^2)\, (x^2 + d^2)^{(-3/2)}] = 2 \qquad (8a)$$

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F+ = (k/d [2]) - (k/d [0]) (9)

F+ = 2k/d (10)

Now, lets look at integrating a finite distance, say 1 meter, when d = 0.1 m. Integrating on x, 0 to 1 m:

F_1m = k/d [x (2 x^2 + 3 d^2) (x^2 + d^2)^(-3/2)] (11)

[eval x=0 to 1 m]

F_1m = (k/d [(1 m) (2 m^2 + 3 * (0.01 m^2))) (1 m^2 + 0.01 m^2)^(-3/2)]

- (k/d [0]) (12)

F_1m = (k/d [(2.03 m^3)/(1.01 m^2)^(3/2)] (13)

F_1m = k/d [1.99992623379 m^-1] (14)

F_1m = k * (0.199992623379 m^-1) (15)

But applying (1) for d = 0.1 m gives:

F = k * (0.2 m^-1) (16)

So there is only a very small difference, 7.3766x10^-5 m^-1, or 0.003688 percent between integrating to inf and to 1m when d = 0.1 m, but the difference is finite.

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LF FROM THE COMBINED EQUATION FOR INFINITE STRAIGHT WIRE

Now lets rexamine Fig. 1 to evaluate the sum of the longitudinal force on Q1. Looking at Fig.1 we see the identities:

cos theta = x/r (17)

r = (x^2 + d^2)^(1/2) (18)

and the x axis portion dFx of the force is obtained by multiplying (2) by cos theta = x/r:

dFx = k (x/r) (3 sin^2 theta)/r^2 dx (19)

and, subs (17) and (18) into (19):

dF = k x (3 [(d^2)/(x^2 + d^2)]) [(x^2 + d^2)^(-3/2)] dx (20)

dF = 3k d^2 [x (x^2 + d^2)^(-5/2) dx] (21)

Integrating (21) on x, 0 to +inf:

F_x = -k d^2 (x^2 + d^2)^(-3/2) (22)

[eval x=0 to +inf]

and noting that:

lim (x -> +inf) [(x^2 + d^2)^(-3/2)] = 0 (23)

F_x = (-k * d^2 * [0]) - (-k * d^2 * -abs[1/(d^3)]) (24)

$F_x = k/d$ (25)

as opposed to the Lorentz force in the same situation:

$F+ = F_y = 2k/d$ (10)

Suppose now we are looking at a partial circuit as shown in Fig. 2, and that the length d is 1 m. Anything that happens to the right beyond a few meters is clearly moot, an effect way less than 0.003688 percent.

```
     S3
     d2            S1
     ---|------------------------------ ... on for miles
     |
     |
     |
  d  |
     |          ^
 S2  |        y |
     |           --->
     |            x
     |
     |
     --|-|---------------------------- ... on for miles
        Q1

     d2
```

Fig. 2 - Corner Longitudial Force

Now the tricky part. The magnitude of the Lorentz force on Q1 from S1 remains fixed at $F_y(S1,d) = 2k/d$. Similarly the magnitude of LF on Q1 from S2 remains fixed at $F_x(S2,d) = k/d$.

Now the tricky part. The magnitude of the LF on Q1 from vertical segment S2 is

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F_x(S2,d2) >= k/d2, but lets say F_x(S2,d2) ~= k/d2. This is because the longitudinal and Lorentz forces on a current segment representing Q2 from a long nearby current line (S2) do not change very much as a function on the velocity of the current segment angle because it is a straight line force from segments of S2 towards Q2. What matters in the end is the very close proximity of S2 to Q1 compared the fixed and distant S1. This step is not rigorous proof, is the weak part of all this, so this integral (with the current flowing at the line) needs evaluation, but it is self evident that a straight line force all from one direction for each element will add up to a net force from that direction.

As d2 -> 0, the force (to the right) on Q1 from the vertical segment S2 increases as 1/d2. The LF to the right from the segment S3 of length d2 goes to zero. The LF on Q1 from the very long top segment S1 remains constant at 2k/d, since S2 and d remains constant. Therefore, as d2 -> 0, the longitudinal force on Q1 goes to infinity and is towards the right. In other words:

lim (d2->0) F_x(S2,d2) - F_x(S2,d) (26)

= lim (d2->0) k/d2 - k/d (27)

= inf + k/d = inf (28)

If there were no longitudinal force, i.e. if it balanced everywhere in a loop, then:

lim (d2->0) F_x(S2,d2) - F_x(S2,d) = 0 (not inf as shown) (29)

thus it is shown that the LF exists. SR+C denies Lorentz and vice versa.

It is reasonableat this point that the LF will emerge as a signifcant force in an FEA model, and that the LF motor will be predicted by the FEA model to work as proposed. There is not yet a quantitative handle on the effect of the radial velocity of the armature, or the magnitude of the back-EMF in either the armature or the stator coils, however. It is true though, that the back-EMF is expected to be energy conservative, because the Coulomb force, on which all is based, is momentum and energy conservative.

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LONGITUDINAL FORCE MOTOR DESIGN

Following is a LF motor design, which is one of the primary probelm areas for application of an SR+C FEA model.

The armature is a current carrying ring, denoted in Fig. 1 and Fig. 2 in "connect the dots" fashion. The Marinov motor "brush" area in this design looks like the configuration in Fig. 3:

```
  CCW       |
Rotation    v i
     o      |
       o  R |
        o   |
         o  |
          o |         2i
        ^ o |---------->-----
       i| o |
         o  |
        o   |
       o    ^ i
     o   A  |
            |
```

Fig. 3

Note that there is no brush in Fig. 3. Assume the armature ring is has it's own current supply, be it brushes or inductive plus electronic means mounted on the armature. It could actually consist of a coil with brushes on the central shaft though, possibly mercury brushes. Also, this motor can run on AC or DC provided the current in one of two phases is consistent with the drawing below. The SR+C formula yields a repulsive force (away from the stator coil) on the armature at R and an attractive force at A. This applies torque to the armature, which would obtain no torque under a BS-L scheme. So, how to realize a complete motor? Fig. 4 is an approximate picture of an idea to achieve this.

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```
-----------<-------------->-----------
|   \            |             /    |
|    \           ^            /     |
|     \          |           /      |
|      -----><-----------<-----      |
^      |   R   o  o  o  A    |      ^
|      V    o           o  R V      |
|      |A o              o  |       |
|      | o               ^ o |       |
--<---| o i|           i| o |-->---|
|      | o  v             o |       |
|      |  o              o  |       |
|      ^ R  o           o  A ^      |
|      |    A  o  o  o  R    |      V
|      ----><-----------<-----      |
|     /          |             \    |
|    /           V              \   |
|   /            |               \  |
-----------<-------------->-----------
```

Fig. 4

The outer stator coils can be wrapped around wooden dowel posts protruding from a flat plywood jig. The armature consists of a wire coil wrapped around a spool on an axle. The axle can be mounted in ball bearings. Current to the axle assembly, and thus to the armature coil, can be provided using two slip ring brushes. AC or DC can be used. *No commutation is required.* Alternatively, if AC is used, a brushless transformer arrangement can be made using part of the axle as one leg of a transformer and dovetailing a C shaped core to the armature portion. The secondary coil on the armature then feeds the armature coil. Alternatively, it may be possible to drive the armature coil directly by using a C core that couples to the armature on opposed (both) sides of the armature spool. To accomplish proper phase alignment between the stator and armature coils, however, the "rotational coupling" transformer would then have to be fed by yet another transformer to obtain an extra 90 degree phase shift.

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THE LONDON EQUATION AND THE MEISSNER EFFECT

If current in the LF motor stator induces a back-emf in the armature, then it can similarly induce a current in a superconducting ring placed where the armature coil is. It is speculative then that the London equation, which states that for SC's,

$$J = -k*A$$

may just simply be a result of the SR+C longitudinal force from electron current inside the magnet induced on the electron pairs in the SC. It is then a back-emf that prevents J from running away with itself. However, if energy can be pumped from the changing (London) current in the SC, i.e. as the London current builds, then cooling of the magnet may ensue. A violation of the Second Law may then be possible by converting the magnet electron speed into a macro effect, London current induction, which does not require a Maxwell's demon to tap. The magnet can lie outside the insulating envelope of the SC, thus can tap ambient heat. This was already the premise of the SC experiment planned, but the SR+C perspective gives another angle on the situation. It appears, however, that such logic can only apply to a permanent magnet created by aligning unmatched orbitals, as opposed to aligning spin.

This perspective indicates that the LF motor proposed may not work very well at all, because it may only work at a very very small rpm. However, if the LF motor works only slowly, due to the very slow electron drift speed, then it may make a very good DC generator, because the rotation speed of the armature is very high in comparison to the electron drift speed.

This is a very interesting place to be. Earlier a configuration was shown where the longitudinal force clearly emerges, and showed by integration that the longitudinal force from 1/2 an infinite wire (all in one direction) is about 1/2 the Lorentz force from that wire. The LF similarly emerges in any case where the Lorentz force emerges, regardless of whether the combined force rule is used, or just one of the two SR force components - rho contraction and/or field pancaking. Further, neither time dilation nor Doppler shifting can change the fact that the Coulomb force is straight-line, thus we have the fact that a net longitudinal force must emerge in at least some cases where a Lorentz force emerges. If a circuit is non-symmetric, then

summing around the loop does not eliminate the LF from every current segment in the circuit. What is interesting about this conclusion is that relativity was inspired by, and thought by Einstein to be fully consistent with Maxwell-Lorentz. However, SR applied to the Coulomb force in at least some or maybe all circumstances accounts for ALL the Lorentz force, and thus eliminates the possibility of the existence of magnetism in any real sense - merely relegating it to a secondary apparent effect, a computational manifestation of the only real effect, the Coulomb force. However, the existence of the longitudinal force is NOT part of Maxwell-Lorentz, and therein lies a problem. Only SR or Maxwell-Lorentz is correct, not both, if a real measurable LF is predicted. If such a force is predicted and found then SR is vindicated. If the predicted longitudinal force is not found, then Maxwell-Lorentz is vindicated, and there is either something wrong with SR, or SR has not been applied correctly to the EM problem.

MAGNETOHYDRODYNAMICS AND THE LONGITUDINAL FORCE

Becker on page 155 dealing with the "Inertia effects of electrons in metals" look at the problem from the opposite perspective from that of using the electron effect in a motor, i.e. he looks at the (small) current and/or voltage from the (large) inertial effect, vs using the inertial effect to produce motion and force, instead of vice versa.

At a given velocity, the inertia of an electron is about 1/1836th that of proton, and about 1/11,680th that of copper at a given velocity. This is really small. However, electrons accelerate very fast, so they can transfer their (mean) kinetic energy many times per second. This is the basis for the powerful MHD (magnetohydrodynamic) effect. In their path across a conducting fluid, the electron's direction is bent by the Lorentz force from an orthogonal magnetic field. In a vacuum this would result in a path with loops. However, if the mean free path is short, momentum is transferred, in the direction orthogonal to E and v, by the electrons to local fluid molecules before the loop directions can reverse (on average) followed by an acceleration due to and initially in the direction of E. Thereby a force is developed between the magnet and the fluid that is in the direction of fluid flow and orthogonal to E and B. This MHD force can be a large force with practical applications, including submarine propulsion, and plasma acceleration. The longitudinal force as applied to electrons should be similar in magnitude to an MHD force, only not orthogonal to the direction

of current flow. It is small at small field magnitudes, but possibly of practical use at large field strengths.

The big disadvantage to MHD is it takes a really big current to get a big effect. It is questionable that it can ever be very efficient. Also, it can't be done with superconductors because the electrons breeze on by the lattice without friction. However, if the LF turns out to exist, there may be an efficient means of application. The idea is to run the electrons in reverse to the direction of the LF, but initially rotate the armature in the direction of the LF as it is felt by the positive particles. In this manner, the positive lattice charges constitute the current experiencing the LF, and thus the LF moves the armature directly. If this approach of using the positive lattice charges as the current element works, then it could also work for a superconducting armature - even if the back emf on the electrons does require a potential to push the current through the armature coil so as to maintain the electrons at an angular velocity less than that of the armature. The use of SC's thus makes for the possibility of a very high efficiency high current DC motor/generator. This impiles that in future analyses it is important to look at the actual total force on both types of charges in the conductor, (or at least one) - not just the force difference.

SUMMARY

A motor similar to Marinov's motor has been designed using Coulombs law and relativistic effects. This motor is not predicted to work using only Lorentz, i.e. by applying Biot Savart. Marinov utilized longitudinal force in his designs as well, so this design may in some sense be a test of Marinov's thinking as well. The advantage to the proposed design is, provided the design principles are correct, that it can be engineered up to produce large torques. If the motor does not work, then, assuming no error in the theory (unlikely!), it brings into question special relativity. If it does work, it brings into question the Lorentz force. In any event, it should be a fun project for an amateur.