The Biefeld Brown Effect and the Global Electric Circuit

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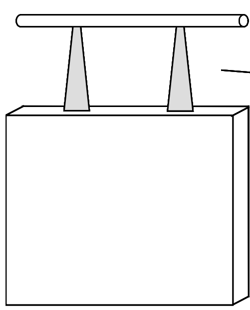
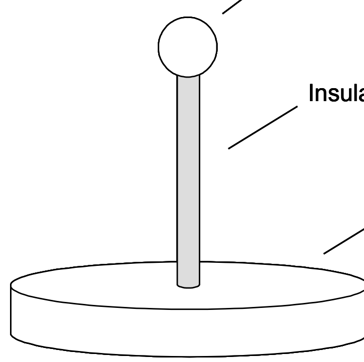
Abstract. A comparison of the measured Biefeld Brown Effect and the measured global circuit electric field shows several parallels. Both exhibit diurnal variations, and both show a dependence on thunderstorm activity. Based on an analysis of experimental data taken on the Biefeld Brown effect, a case is made for describing this effect as a secondary electrostatic effect related to the global electric field. It is concluded that: 1) the Biefeld Brown Effect is a real effect that is likely electrostatic in nature, and 2) its potential propulsion utility may therefore be limited to the volume between earth's surface and the ionosphere.

INTRODUCTION AND SCOPE

During a series of experiments at Denison University in Ohio in the 1920's, Thomas Townsend Brown and Dr. Paul Alfred Biefeld discovered that charged capacitors experience a net force, or thrust, in proportion to their charge. (Bahler, 2002) This effect has become known as the Biefeld Brown Effect. Since its discovery, a variety of experiments have been performed to test the Biefeld Brown Effect. T.T. Brown continued to experiment with the effect over the following 60 years, documenting his design efforts primarily through the patent process., most notably patents 2,949,550 and 3,187,206. (Brown, 1960, 1965) These patents represent two broad categories of experimental activity, and are contrasted in figure 1.



(a) Patent 2,949,550.



(b) Patent 3,187,206.

FIGURE 1. T.T. Brown's Primary Electrokinetic Patents (Brown, 1960, 1965).

Patent 2,949,550 has led to the development of a series of lightweight "lifters" which develop enough lift to exceed their weight such that they can become airborne. (Naudin, 2004; Ventura, 2004; Bahder, 2002; Campbell, 2001) Patent 3,187,206 has led to a series of static tests of heavier high voltage, high capacitance stationary capacitors that develop controlled, measurable thrust when charged. (Talley, 1991; Musha, 2002; Buehler, 2004) In the former case, possible ion drift effects complicate the measurement and interpretation of the effect, ruling out the use of this type of device as a method for quantification purposes. (Bahder, 2002; Tajmar, 2004) This version of the Biefeld Brown effect will therefore not be further addressed in this paper. However, in the latter "static" set of experiments it is a

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much more straightforward matter to isolate the effect to measure its strength. (Talley, 1991; Musha, 2002. Buehler 2004) It is the relationship of these experiments to yet a third set of experiments that is the topic of this paper.

The third set of experiments, named "petrovoltaic" experiments by Brown, (Bolland, 2004) were intended to characterize the alternating component of the Biefeld Brown Effect by measuring the changes in the self potential or forced potential of various capacitors or other charge carriers under test. The hypothesis advanced by this paper is that the variations measured by Brown and others (Brown, 1977,1978; Musha, 2002) in the Biefeld Brown Effect are due to diurnal variations in the Earth's global electric field. This is the scope of the present paper.

BIEFELD BROWN EFFECT BACKGROUND

Returning to the static tests, recent experimental results are summarized here to scale the Biefeld Brown Effect, before reviewing the petrovoltaic experiments in search of a possible cause. Talley (1991) has performed the most sensitive set of measurements yet published. Often cited as an example of a negative result, the published data sets do show a thrust effect as large as 33 μN. Talley seems to have concluded that the results were negative simply because no difference was observed between standard parallel plate capacitors and the asymmetric capacitors that Brown thought were a necessary condition of the effect. Since the same condition was present in parallel plate capacitors, Talley concluded that there was no Biefeld Brown Effect. It is therefore possible to completely agree with all of the data Talley collected, and still disagree with the conclusions. Focusing only on Talley's data, very repeatable thrusts, on the order of 30 μN for 19 KV of applied voltage, were demonstrated for geometries where at least one pole of the capacitor was a plate perpendicular to the axis of the dipole moment. For device #6, (Talley, 1991) the plate area was on the order of 50cm^2 with a dielectric air gap of 2 cm. This is the configuration outlined in Patent 3,187,206. The thrust dropped repeatedly to half that value, ~16 μN, where two charged spheres were used rather than one or two flat plates.

The next set of Biefeld Brown static tests to be documented comes from Japan (Musha, 2000). In the case of Musha's experiment #2, 12 KV was applied to a capacitor with a plate area of 78 cm^2, a dielectric constant of 2.3, and a dielectric thickness of 2.0 mm. Measured thrust varied from 0.75 to 2.0 mN. These unexplained variations, originally thought to be lunar, may actually be of a diurnal nature.

Finally, the most recent set of static tests to come to light were performed in Canada. (Buehler, 2004) A wide variety of monopoles (charged plates), dipoles (parallel plate capacitors), and higher order charge distributions (asymmetric capacitors) were tested to extremely high voltages. In one example (Buehler, 2004, figure 10) a thrust of better than 70 mN was recorded at an applied voltage of 200 KV using a capacitor with a plate area of 0.21 m^2 and a dielectric separation of 10 cm in air. Thrusts recorded in these particular examples are summarized in table 1, along with relevant experimental parameters.

TABLE 1. Biefeld Brown Static Test Measurement Examples.

Test Series	Applied Voltage	Plate Area	Dielectric Thickness	ε_r	Measured Thrust
Talley, 1991, device #6	19 KV	50 cm^2	2.0 cm	1.0	28-30 μN
Musha, 2000, exp. #2	12 KV	78 cm^2	2.0 mm	2.3	.75 - 2.0 mN
Buehler, 2004, fig. 10	200 KV	210 cm^2	10.0 cm	1.0	73 - 78 mN

It is clear from Table 1 that Biefeld Brown thrust increases when either applied voltage or capacitance increases, i.e. as charge increases. This strongly hints at an electrostatic effect. A quantitative analysis is provided in more detail in a later section.

GLOBAL CIRCUIT BACKGROUND

Before going into a summary and analysis of the petrovoltaic set of experiments, atmospheric electrodynamics considerations are reviewed briefly here to provide background. The standard atmospheric electrodynamics model is that of the global electric circuit. Components of the global circuit are the spherical conductor of the earth, the spherical conductor of the ionosphere, and the relatively low conductance, low carrier mobility troposphere that separates the two, which acts as an insulator. The circuit operates in a way that tends to charge the surface of the earth negative, charging the ionosphere positive, and setting up an electrostatic field between the two conductive layers in the atmosphere. How does the global circuit maintain its charge?

A model of global circuit operation was first put forth by C.T.R. Wilson in 1920 (Holzworth, 1995) who postulated that the sum of all thunderstorms acting as charge generators, operating in unison over the entire surface of the earth, can be measured in the fair weather electric field anywhere on earth. This theoretical model is supported by the experimental fact that statistically the field strength reaches minimums and maximums everywhere on earth according to UTC time, not local time. This statistical local maximum occurs everywhere at 1800 UTC, and was experimentally verified with data taken onboard the ship Carnegie in 1921. The characteristic diurnal curve is still often referred to as the “Carnegie curve” for this reason.

This diurnal cycle is accounted for by the following observations:

1) First, that thunderstorms are more likely over land masses than over water, and
2) Second, that thunderstorms are more likely in the late afternoon local time.

If these two observations are combined and integrated over the entire surface of the earth, it can readily be demonstrated that the thunderstorm charging should reach a minimum at 0600 UTC and a maximum at 1800 UTC, which matches the Carnegie curve. This is widely accepted as evidence that the fair weather electric field is created by thunderstorm activity. (Holzworth, 1995) A conceptual diagram of the Carnegie curve is presented in figure 2.

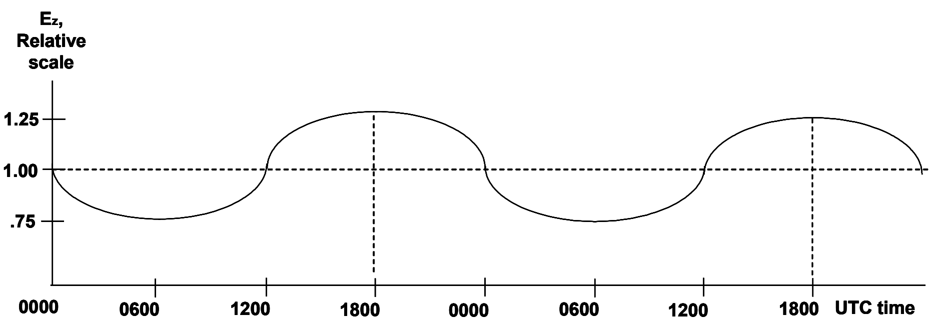
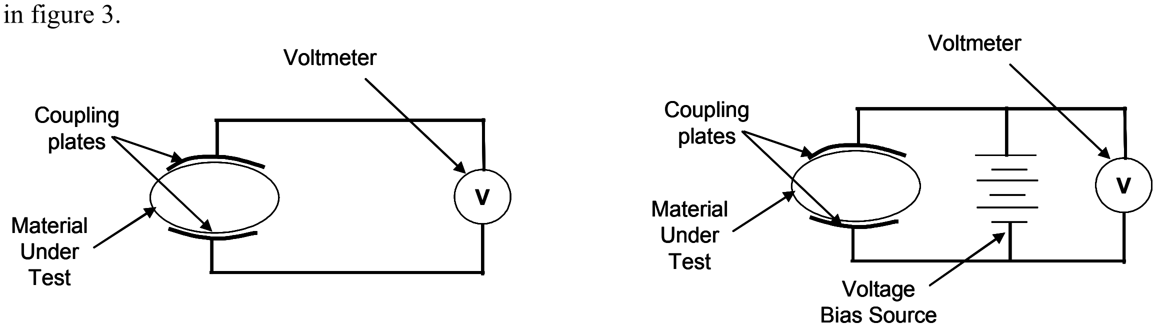


FIGURE 2. The Carnegie Curve: Vertical Electric Field Variations during Fair Weather (Holzworth, 1995).

ANALYSIS OF PETROVOLTAIC EXPERIMENTS

While investigating the Biefeld Brown Effect, T. Townsend Brown noticed that there was a diurnal variation embedded in the thrust signal. (Bolland, 2004) While this signal was present in the forced potential experiments where capacitors were biased, it was also present in capacitors and other materials without any imposed voltage. Brown named these measurements "self-potential" tests. The self-potential test configurations of Brown are shown in figure 3.



(a) Self-potential configuration. **(b)** Forced-potential configuration.

FIGURE 3. The Petrovoltaic Experimental Configurations of T.T. Brown, Circa 1977 (Brown, 1977; Bolland, 2004).

In the self potential experiments, a capacitor, often with a rock sample acting as the dielectric, is exposed to the background electric field to determine what self potential is induced. This was also known as the petrovoltaic or petroelectric effect in many of T.T. Brown's papers. The conducting plates were applied to the surface of a rock sample such that they were roughly parallel to each other, and were often perpendicular to nadir, the direction of the global circuit electric field. This is essentially a test capacitor exposed to the global field. It is the essence of the electric field strength meter. It is not unlikely that the global electric field was responsible for the self potential effect so often measured by T.T. Brown.

There are a number of data sets that support the hypothesis that self potential in this context is created by the global electric field, but the clearest is test #105, which shows a strong diurnal variation. (Brown, 1977; Bolland, 2004) Shown in figure 4, it was taken by T.T. Brown from June 18th to June 28th of 1977, in Sunnyvale, CA. This data period was checked against meteorological data published in the San Francisco Chronicle under the Santa Clara section. (San Francisco Chronicle, 1977) It was confirmed as a period of fair weather. Note also that the peaks in the self potential, which would correspond to peaks in the fair weather electric field, occur at roughly 1000 hours local time. Local time in this case corresponds to PDT, which is 8 hours from UTC time. In UTC time the peak would correspond to 1800 hours.

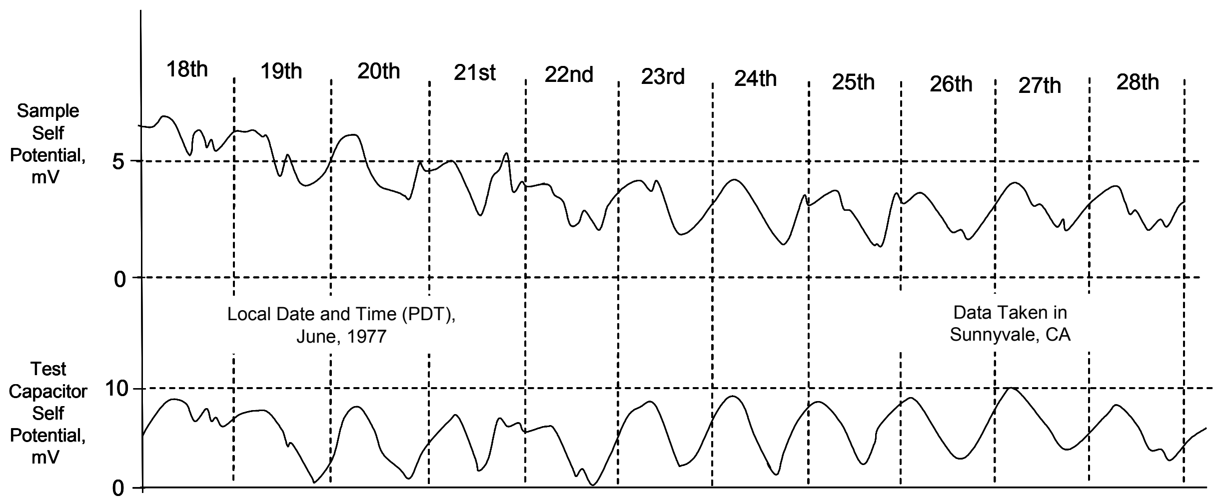


FIGURE 4. Measurements of the Diurnal Variations of Self-Potential, Fair Weather Case (Brown, 1977, Bolland, 2004).

This correspondence to the Carnegie curve is strong circumstantial evidence that the variations in self potential as measured by Brown are due to the variations in the fair weather electric field of the global circuit.

The data taken by Brown from August 6th to August 13th of 1978, labeled as test #110 , provides further supporting evidence. It was unseasonably hot that August in the San Francisco area. According to the San Francisco Chronicle the weather was fair and hot, with highs in the Santa Clara area ranging from the 90's to 105 F (32 - 41C). Note in figure 5 that the normal curve was reversed, with maximum field strengths occurring in the afternoons. The first hint of why was given in the forecast of August 8th 1978, with thunderstorms in the nearby mountains and desert.

The 100 F (38C) hot weather continued to hang over the bay area on August 8th and August 9th, with increasing scattered thunderstorms on August 9th. Finally, on August 10th, the weather broke, with scattered thunderstorms and showers, and the high was back down to the 90's (32 - 37C). On August 11th, the San Francisco Chronicle reported "a return to normal" with thunderstorms decreasing, and highs falling to the 80's (27 - 32C). Finally the weather returned to a fair pattern with continued cooling on both August 12th and August 13th, with highs in the 70's to 80's (21 - 32C).

The correlation of the meteorological data to the self potential data of figure 5 is obvious. A pattern of afternoon thunderstorms reversed the usual local diurnal variations, and the strength of the peak field each day corresponded to the number and proximity of thunderstorms in the greater test area. The highest peaks occur on August 9th and August 10th, 1978, the days with the highest degree of thunderstorm activity.

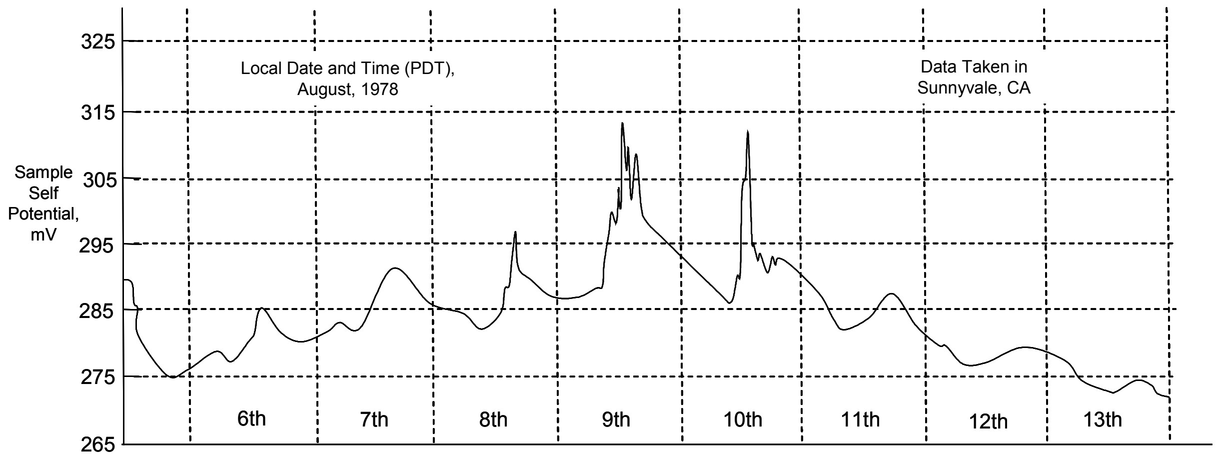


FIGURE 5. Measurements of the Diurnal Variations in Self Potential, Thunderstorms Case (Brown, 1978; Bolland 2004).

It is well known in atmospheric electrodynamics that the electric field strength increases due to thunderstorm activity (Holzworth, 1995). Data taken during a single thunderstorm is shown in figure 6. The vertical electric field is likely the one that would have affected T.T. Brown's test instrumentation. Notice that it peaks in a matter only an hour or so. A number of such storms moving in unison through an area would have the combined effect of the curve on the timescale of figure 5 – a series of very sharp peaks over several afternoon hours (Holzworth, 1995).

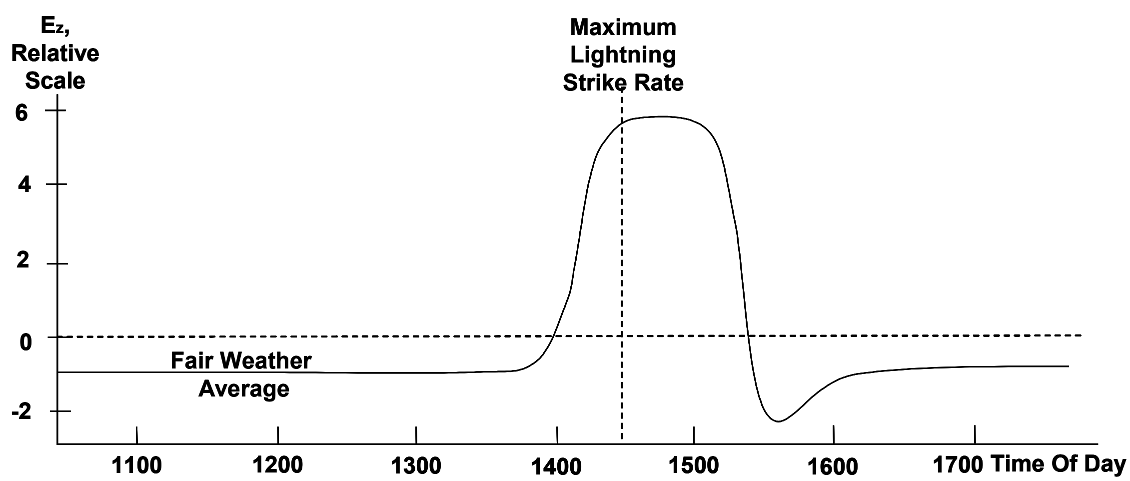


FIGURE 6. The Vertical Electric Field during a Single Thunderstorm Event (Holzworth, 1995).

The strong correlation between the global electric field and the measurement of self-potential associated with the Biefeld Brown Effect provides additional circumstantial evidence that suggests the Biefeld Brown Effect is electrostatic in nature.

BIEFELD BROWN EFFECT QUANTITATIVE ANALYSIS

A brief quantitative analysis of Biefeld Brown Effect is performed in this section to determine to what extent a purely electrostatic force may account for the effect. In the static forced potential experiments, a voltage is applied to a capacitor whose plates are, at best, parallel with the earth, and are therefore perpendicular to the vertical electric field of the global circuit. As the capacitor's plates are charged it will experience a force that corresponds to the strength of the externally applied electric field and the strength of its charge. So long as the capacitor is stationary and is not cutting through any lines of magnetic flux, the force experienced by the capacitor is $F = Q * E$, where Q is the charge in the capacitor and E is the strength of the electric field. (Lorrain, 1970)

Rough order of magnitude calculations may be made for each of the cases measured in table 1. If the capacitor plates are parallel with the Earth, they are perpendicular to the vertical global electric field, which is 100 V/m on average, near the ground, but can be higher. (Holzworth, 1995; Buehler, 2004) According to the equation for capacitance of a parallel plate capacitor, $C = \varepsilon_o \varepsilon_r A / h$, for a capacitor with an air gap where $\varepsilon_r = 1$, a plate area A of .05 m^2 and a dielectric thickness of h = .02 m, then the capacitance will be 22 pF. Since $Q = C*V$, a capacitance of 22 pF with an applied voltage of 19 KV will store a charge of Q = 0.42 µC. This charge, in a fair weather electric field of field strength E = 100V/m will experience a force on the order of 42 µN. The actual value as measured by Talley was 28 to 30 µN for this case. This same set of calculations when repeated for the other Biefeld Brown example test cases results in the values listed in Table 2.

TABLE 2. Predicted Versus Measured Biefeld Brown Static Test Examples.

Test Series	Capacitance	Predicted Charge	Predicted Thrust	Measured Thrust
Talley, 1991, device #6	22 pF	0.42 µC	42 µN	28-30 µN
Musha, 2000, exp. #2	.0008 µF	9.53 µC	.95 mN	.75 - 2.0 mN
Buehler, 2004, fig. 10	18.6 pF	3.7 µC	.4 mN	73 - 78 mN

Note that the correspondence between the theoretical electrostatic maximum thrust values and the measured thrusts is far from perfect. There are a number of mitigating effects that could cause correspondence to experimental values to be inexact and in some cases to break down altogether. Orientation, image charge formation, charge shielding and carrier mobility effects can all reduce the effect or cause a less than optimum result. In the case where the value is higher than predicted, it is possible during thunderstorms for the "fair weather" value of the vertical electric field to grow by several orders of magnitude. It is therefore important that care be taken to document the weather related vertical electric field component during future tests, and to carefully control capacitor orientation.

Of course, alternate explanations abound that fit the facts. First, it has been suggested (Buehler, 2004) that the Biefeld Brown Effect may be linear with charging energy versus charge. If this is true then the thrust would go as the square of the voltage, which would account for why measured thrusts are higher than predictions at higher voltages. An updated version of ether interaction is another proposed explanation. (Cameron, 2002) There is also the possibility that a unified field theory, such as has been advanced by Heim, (Droscher, 2004) may hold the key to finding the quantitative connection between the Biefeld Brown Effect and electromagnetics, but the simple explanations are usually the most correct.

CONCLUSIONS AND RECOMMENDATIONS

A comparison of the measured self potential variations in the Biefeld Brown Effect with the measured global circuit electric field has shown several parallels. Both exhibit diurnal variations, and both show a dependence on thunderstorm activity. Based on an analysis of experimental data taken on the Biefeld Brown Effect, a case has been made for describing this effect as a secondary electrostatic effect of some type, related to the global electric field, without resorting to electrogravitic or other unified field theory (UFT) formulations. It is concluded that:

(1) The Biefeld Brown Effect is a real effect that is likely electrostatic rather than electrogravitic in nature,
(2) Its potential propulsion utility may therefore be limited to the volume between earth's surface and the ionosphere.

It is recommended that the absence of the Biefeld Brown Effect above the ionosphere be demonstrated via spaceborne experimentation to verify that the effect is due purely to electrostatic atmospheric effects.

This area of inquiry would also benefit from further surface testing to determine what level of shielding is necessary to eliminate the observation of the Biefeld Brown effect. Previously documented attempts to shield this effect have been unsuccessful. (Brown, 1977; Talley, 1991) Future tests of the effect should also include careful measurement of the local atmospheric electric field.

If the Biefeld Brown Effect is ever to be used for propulsion, caution is advised in at least three areas:
(1) Launch areas should be good insulators to avoid the formation of an image charge that would negate lift.
(2) Care should be exercised to account for and compensate for the earth's magnetic field component of the overall force on the lifting body. Recall that once the lifting body experiences a velocity, the overall force F of a moving object is given by the Lorentz force $F = Q*E + Q*(V \times B)$, where Q = charge, E = electric field, V = vector velocity, and B = magnetic field. (Lorrain, 1970)
(3) Operation in the presence of thunderstorms should be avoided, as the regional electric field reversal would render any propulsion device depending on the field extremely unstable.

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