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Exploratory Research on the Phenomenon of the Movement of High Voltage Capacitors

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Abstract: Experiments performed with high voltage single and parallel plate electric capacitors indicated a net external force acting upon the capacitor mass. The observed tendency was that the charged capacitor consistently moved in an upward direction. However, the force could not be directly associated with the interaction of the electric and magnetic fields of the earth; the results were extremely anomalous. For the parallel plate capacitors, it was shown that the upward motion is proportional to the amount of electrical potential energy stored in the electrostatic field of the capacitor. A rigorous theoretical discussion is not presented since a complete understanding of the results was not attainable. Preliminary data analysis is presented. Comparisons are made with an ionic lifting grid to formulate a basic hypothesis for the capacitors' motion.

Keywords: high-voltage capacitors, nonlinear field effects, anomalous forces, electrogravitics, antigravity

1. INTRODUCTION

Experiments were performed to analyze the effects produced by a charged mass relative to the earth's electric, magnetic, and gravitational fields.

It was observed from numerous experiments that single and parallel plate capacitors are acted upon by an external force when charged. The force acts in such a way as to physically move the entire capacitor in an upward vertical direction.

The main area of concern with regard to the experiments was that this phenomenon did not have a "text-book" explanation; a satisfactory explanation for all aspects of the observed effects was apparently nonexistent.

When the specially constructed single and parallel plate capacitors (enlarged physical dimensions) were placed upon a sensitive scale and charged with 100-200 kV maximum they consistently proceeded to lose apparent weight. Although the total force was not a large quantity (enough to cause complete levitation of the capacitor), it still was a significant amount to warrant further investigation.

Additionally, the direction of the force apparently could not be attributed to Coulomb's Law in relation to a negatively charged earth and a positively or negatively charged capacitor. The magnitude of the force acting upon the capacitor was also several orders of magnitude stronger than that theorized by Coulomb's Law.

The unique feature of this force was its relation to motion and energy. It was revealed that the upward force was proportional to the amount of electrical energy that was stored between the capacitor plates. From this it was shown that the upward vertical motion was created by the direct use of potential energy and not from kinetic energy. According to this energy theory, the capaciforce could potentially work in a vacuum. Additionally, further extrapolation indicates that the capacitors could become self-levitating if sufficient energy is available.

No attempt has been made to explain the phenomenon or to present any particular theory as the explanation. The hypotheses to follow were proposed independent of the experiments. The main purpose of this paper is to present experimental facts representing an apparently inexplicable phenomenon in hopes that other researchers will take up the challenge to explain this capaciforce. Further research and experimentation will provide a definite base for a theory, or explanation, associated with the phenomenon.

2. BACKGROUND

It has been noted by other researchers experimenting with high voltages that a large charge will apparently produce anomalous results on masses. Some effects, claimed not to be associated with normal electrostatic forces, were observed. It should be noted that some of these results were not highly documented and so the validity of some of the claims is not known. It is left up to the reader to further interpret the results.

Erwin Saxl [1] of Harvard, who presented his findings in the highly respected journal *Nature*, charged a torque pendulum inside a Faraday cage. He observed that the period of swing could be changed by placing a charge on the pendulum mass. The conditions used to measure this effect were highly controlled; the pendulum timing was by a light beam and photoelectric cell with an accuracy of one part in 10 million in measuring the arc through which the pendulum swung. See Liu et al [2] and Wang et al [3] for similar experiments and comments regarding Saxl's measurements.

Thomas Townsend Brown [4] of Ohio developed a basic principle for inducing capacitor motion. The effect concerned the observed tendency of a highly charged capacitor to exhibit motion towards its positive pole. Brown was granted several United States and foreign patents on his devices. With further development, Brown constructed capacitors with specially shaped electrodes. These devices were capable of lifting more than their own weight.

Patrick Cornille [5] reviews various anomalous electromagnetic effects and apparent violations of Newton's third law.

3. APPARATUS AND EXPERIMENTAL SET-UP

It was noted that the experimental forces created were relatively small in magnitude. The effect created was only noticeable at extremely high voltages (normally above 15 kV) due to measurement limitations. The high voltages posed a major problem, such that dielectric breakdown was common (arc discharge between parallel plates) therefore special capacitors were constructed in an attempt to counteract the breakdown.

Initial experiments were performed with single charged plates with varying dimensions as described in Table 1. The plates were constructed of 24-gauge aluminum. The experiments were designed to measure directly the interaction of a charged plate with the surrounding environment – that being the earth's electric, magnetic, and gravitational fields.

Table 1: Single Plate Capacitor Specifications

	Plate Mass (g)	*Surface Area (m^2)*
Plate 1	186.9	0.068
Plate 2	38.4	0.013
Plate 3	11.9	0.004

Three parallel plate capacitors were also constructed with 24-gauge aluminum and other physical characteristics as outlined in Table 2. The capacitors all had a common plate area of approximately 324 cm^2. The first capacitor consisted of an air dielectric, the second also had an air dielectric; the third capacitor had a dielectric of wax to theoretically increase the capacitance. The capacitor plates were all physically separated by rigid insulating supports. The capacitance was calculated neglecting edge effects.

Table 2: Parallel Plate Capacitor Specifications

	Dielectric	*Plate Area (cm^2)*	*Separation (cm)*	*Capacitance (F)*
Capacitor 1	Air	324	5.08	5.6×10^{-12}
Capacitor 2	Air	324	7.62	3.8×10^{-12}
Capacitor 3	Wax	324	6.35	1.2×10^{-11}

In addition to the three parallel plate capacitors, two other devices were constructed for experimental use. An additional capacitor was constructed as non-uniform such that it incorporated a unique geometry. It consisted of a circular plane electrode with an area of 680 cm^2. Attached was a spherical ball electrode with a total surface area of 4.3 cm^2 (Figure 1). The two electrodes were then separated by a conical dielectric with a bottom surface area of 133 cm^2. The apex was attached directly to the sphere. The separation of the electrodes was 9.6 cm.

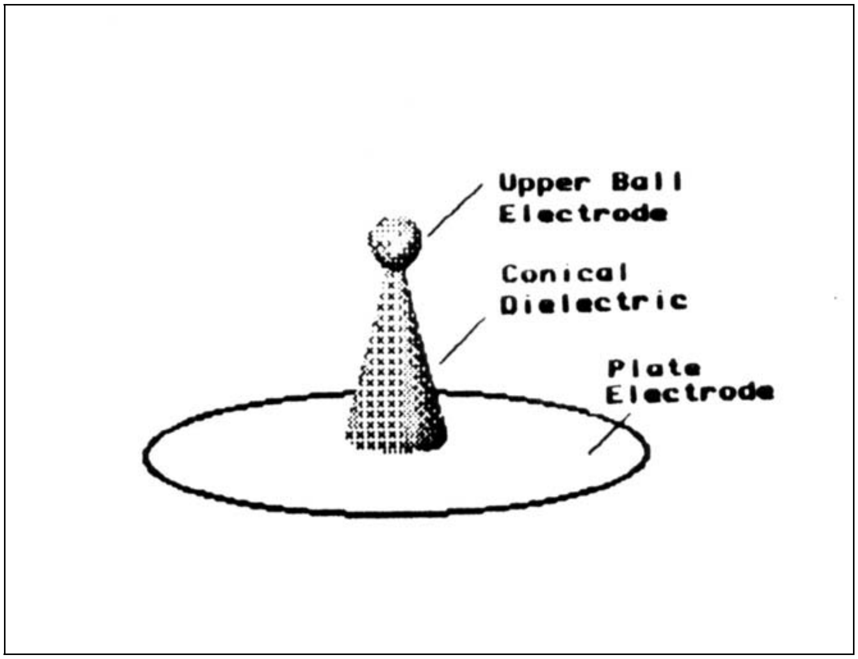

Figure 1: Non-Uniform Capacitor consisting of a circular planar electrode at the base of a conical dielectric with a solid spherical electrode at the top of the dielectric. (Note: *not drawn to scale*)

An additional device consisted of two parallel conductive grids with areas of 380 cm^2 and 754 cm^2 respectively (Figure 2). Insulating supports 5.3 cm long then separated the two grids. The direct purpose of this device was to be associated with ion momentum, which will be discussed later.

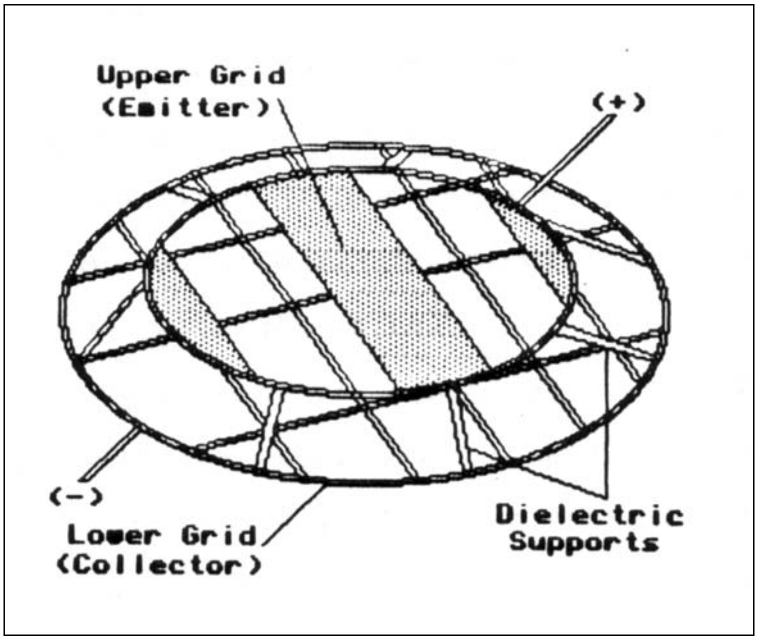

Figure 2: Ionic Grid Device used to measure the forces created by the acceleration of electrically charged particles through two oppositely charged grids (ion momentum transfer).

Voltages up to 100 kV direct current were used for the first experiments. The high voltage power supply was a solid state device with a Walton-Cockcroft type multiplier [6-7] that was variable between 25 and 100 kilovolts. Later an upgraded supply capable of output up to 200 kV DC was used. The supplies were capable of a positive or negative output. A survey of high voltage technology, safety, and techniques is given in the books by Alston [8], Haase [9], and Craggs [10]. ***Warning!*** Do not attempt to work with high voltages or reproduce these experiments unless you are familiar with the hazards involved and take appropriate safety precautions.

One of the difficulties associated with the high voltage was measuring the value of the voltage. It was not a calibrated power supply—voltages were based upon the design of the supply itself, as well as typical arc length based on a standard spark gap that I was using.

The experimental set-up was designed to measure the force vectors created. The various devices were placed on a digital analytical mass balance to record the weight change resulting from the various forces acting upon the apparatus. To clarify any possible confusion, it should be noted that in the experimental graphs presented on the following pages the vertical column is labeled as Δ mass (grams). The unit of grams was chosen because of the manner in which the experiments were performed. The reading on the scale was recording a force caused by the apparatus. For simplicity mass was used as this could then easily be calculated into a force.

The digital scale had a metal tray. The devices were insulated from this with a dielectric of wood, or in some cases glass. The capacitors were insulated as best as possible from the scale. The readings were taken at each voltage set-point; the power supply was not turned off or disconnected from the capacitors during the experiment nor the reading. Removing the wires during the experiment would have been too dangerous. The device was set up, voltage increased to set point, reading taken, voltage increased to next set point, new reading taken, etc. The plates were then grounded and completely discharged when the experiment was over and prior to starting a new series of experiments. The digital scale did not appear to be affected by the surrounding high voltages as readings were consistent with the qualitative data, as well as the fact that it did not build in any error in the display during the experiments. The scale zero remained stable and the scale did not need to be reset.

A few additional experiments were performed with a mechanical scale to see if the digital scale was being directly affected by the presence of high voltage. The digital and mechanical scales gave similar results. Further experiments were performed on a suspended equal arm balance with a horizontal non-conductive beam, which placed the apparatus in a "conductive-free" area. This scales led to similar results as the other two scales indicating the high voltage present for the experiments did not interfere with any of the measuring apparatus. All three scales indicated an upward capaciforce. (Results in section 5 are for the digital scales.)

The apparatus was charged by means of medium gauge high voltage wire to minimize any current losses through corona discharge (the charging effect of the nearby air). During experimentation, one plate of the capacitor was attached directly to the positive or negative output from the power supply; the other plate was grounded to earth (Figure 3). Both positive and negative voltages were used. The switching current was isolated from the capacitor system.

Initial experiments were performed at the Southern Alberta Institute of Technology, in Calgary, Canada, under the supervision of Ray Cullons, Technical Program Advisor, in the department of Chemical Engineering.

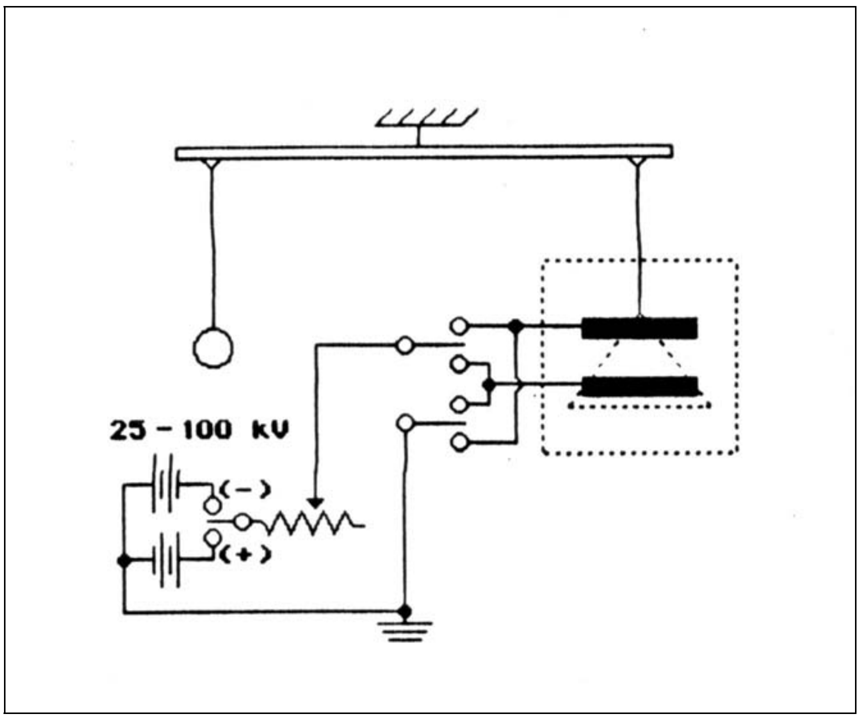

Figure 3: Schematic diagram of experimental set-up with suspended equal arm balance. The capacitor plates are suspended from the arm, isolated from the switching circuit.

To try to fully control the phenomenon, two major variables were associated with the experiments. The two variables were orientation and polarity as detailed within Figure 3 and Table 3. Polarity refers to whether the positive or negative terminal of the power supply was utilized. Orientation refers to which of the plates was connected to ground and which was connected to the power supply.

Another significant variable was the voltage. Increase in voltage was directly associated with increasing the charge, which in turn could theoretically increase the force acting upon the capacitors. Constant voltage was applied to the capacitors during measurements. However, there are current losses associated with increased potentials.

Even with carefully controlled environmental conditions, there are still electrical losses inherent with a charging capacitor. When the charging current flows for a sufficiently long time (as in the experiments – within several seconds, in some instances, of charging time), a situation is reached whereby the surface charge density of the capacitor becomes so large that the surrounding air becomes conductive through ionization. Discharge resistance is then reduced and a potential equilibrium is obtained (with the behavior of a straight horizontal line on a current versus time graph caused by the emission of charges into the air). If the breakdown voltage for air or any dielectric has been reached periodic spark-overs occur.

Table 3: Experimental Variables

	Polarity	*Orientation*
Single Plate	YES	N/A
Parallel Plate Capacitors	YES	YES
Non-Uniform Capacitor	YES	YES
Ionic Grids	YES	YES

To directly associate with experimental results, note on the following graphs that, as the capacitors were charged, a point would be reached when the force would not increase significantly with increasing voltage. Further voltage increase resulted in an arc discharge across the plates thus inhibiting final results at a maximum voltage (100 kV). The air dielectric of capacitor 1 broke down at 85kV. Capacitor 3, with a dielectric of wax broke down at an extremely low voltage of 31kV. The only parallel plate capacitor that was able to have a total potential difference of 100kV without breakdown was capacitor 2. This difference in maximum voltage should be noted as the results are further interpreted.

Table 4: Parallel Plate Capacitor Limits

	Maximum Voltage (kV)	*Maximum Energy (J)*	*Maximum Charge (C)*
Capacitor 1	85	0.020	4.8×10^{-7} C
Capacitor 2	100	0.019	3.8×10^{-7} C
Capacitor 3	31	0.006	3.7×10^{-7} C

4. THEORETICAL ANALYSIS

Since the experiments dealt with extremely high potentials, one of the prime suspects for the observed effects was the ionization of surrounding air. Under certain circumstances such charged particles could produce a propulsive force. This was proposed for a possible explanation of the phenomenon. Another possible explanation was attributed to the interaction of the earth's electric and/or magnetic field with the fields of the apparatus. Finally, the effects of induced charges in the environment were considered.

4.1 Ion Momentum Transfer

A distinction must first be made between the type of ionic lifting grids presented here [11-13] (a very basic concept) and propellant-injection type ion rockets (thrusters) which are significantly more complex.

Motion is produced by the acceleration of ions between two electrically charged grids. Ions from the emitter are attracted to the oppositely charged grid. They interact with air molecules along the way to produce elastic collisions (Figure 4). These collisions combine to create an upward or downward force on the entire mechanism. Lift is proportional to the area through which the large masses of air are accelerated downward from a discharge electrode to the collection electrodes. “The latter being a meshed screen, bars, strips or any other structure that provides maximum collecting electrode area with perforations slots or other types of opening to allow the air to pass through with minimum of drag.” (de Seversky 1964)

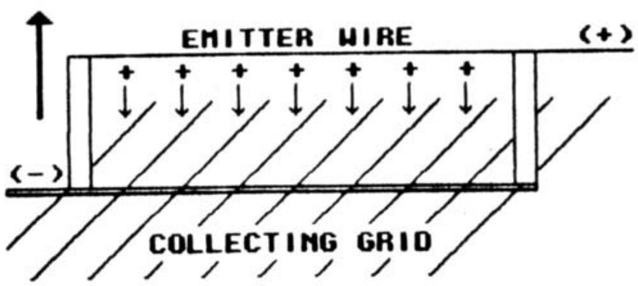

Figure 4: Schematic diagram of the acceleration of ions between emitter and collector grid to produce a reactive force against the medium, propelling the entire mass in a bi-directional motion dependent upon polarity.

A high D.C. voltage is applied between the emitting and collecting electrodes; one pole or terminal of the high voltage generator is connected to the emitting electrode and the opposite pole or terminal is connected to the collecting grid electrode. This creates a potential difference and electric field between the electrodes. The force is obtained from elastic molecular collisions of the air fluid particles resulting from ionic discharge. “… when apparatus of the character just described is immersed in a dielectric medium, as for example, the ordinary air of the atmosphere, there is produced a force tending to move the entire assembly through the medium …. This force produces relative motion between the apparatus and the surrounding fluid dielectric.” (Brown, Patent # 2949550)

It can also be stated that “if the apparatus is held in a fixed position, the dielectric medium is caused to move past the apparatus and to this extent the apparatus may by considered analogous to a pump or fan.” (Brown, Patent # 2949550) From this it is shown that the assembly receives the thrust from the momentum of air or other gas being propelled backward or downward. The actual thrust or lift that it receives can be considered as being momentum per unit time:

$$F = m\, v / t \qquad (1)$$

where m = mass of air molecules, v = velocity of air molecules, and t = time. The investment of power necessary to provide this momentum per unit time is

$$P = \frac{1}{2} m v^2 / t. \qquad (2)$$

Consequently, the ideal ratio of thrust or lift per unit of power is

$$F / P = 2 / v. \qquad (3)$$

From the foregoing expressions, the efficiency of the reaction is inversely proportional to the velocity of the propelled air. To achieve the highest efficiency possible, large masses of air should be moved at low velocity. One drawback of this concept is that by accelerating charged ions or particles (assuming that air molecules and ions are elastic), they will lose their elasticity upon impact at higher velocities. This is called molecular disassociation or secondary ionization. Secondary ionization causes a net decrease in thrust due to a reversal of direction of the now oppositely charged particles. Another loss through secondary ionization is that of corona discharge such that energy is lost through light and sound.

It should be stated that ion momentum would produce a force in any direction as long as there is an emitter and collecting grid such that the movement will always be towards the emitter wire. If the capacitors were to be accelerating ions to produce a force then the direction of force would be relatively the same for the capacitors and for the ionic grid under the same experimental conditions.

4.2 Coulombic Repulsion

The electric field of the earth was a greater concern in this avenue of research due to the fact that the earth has an extremely weak magnetic field relative to the earth's electric field. Additionally, past experiments indicated that the magnetic field was not the primary force affecting the apparatus.

Above an elevation of about 50 km, the earth's atmosphere becomes conducting. Therefore, to a first approximation, the earth can be treated as a spherical capacitor. This simple capacitor model consists of a conducting sphere the size of the earth surrounded by an air dielectric 50 km thick and a conducting outer shell. Near the earth's surface the electric field is typically about 100 V/m pointed downward. The field becomes weaker with increasing elevation, and the total potential difference between the earth's surface and the outer conducting layer is about 400 000 volts. The earth has a negative surface charge (Figure 5). Additionally, the earth's surface charge is about 3×10^5 Coulombs. [14-17]

The explanation perpetrated by Coulomb's Law [14,15] was that the electric fields of the capacitor would interact with the electric field of the earth, producing a force equal to

$$\underline{F} = q_{net} \underline{E} \qquad (4)$$

where q_{net} is the net charge on the capacitor and $\underline{E}$ is earth's electric field. If the interaction of earth's electric field were responsible for the observed effect, the direction of the force would change sign when q_{net} changed sign. Thus, the force exerted on a positively charged capacitor would be opposite in direction to the force exerted on a negatively charged capacitor. Furthermore, since the earth's electric field points downward, a positively charged capacitor would have an associated increase in apparent weight while a negatively charged capacitor would have an associated decrease in apparent weight.

This prediction stands in constrast to the observation that the force consistently caused the capacitor to lose apparent weight regardless of whether the capacitor was charged positive or negative. Thus, simple Coulomb interaction between the charged capacitor and the earth's charge can be ruled out as a cause of the force.

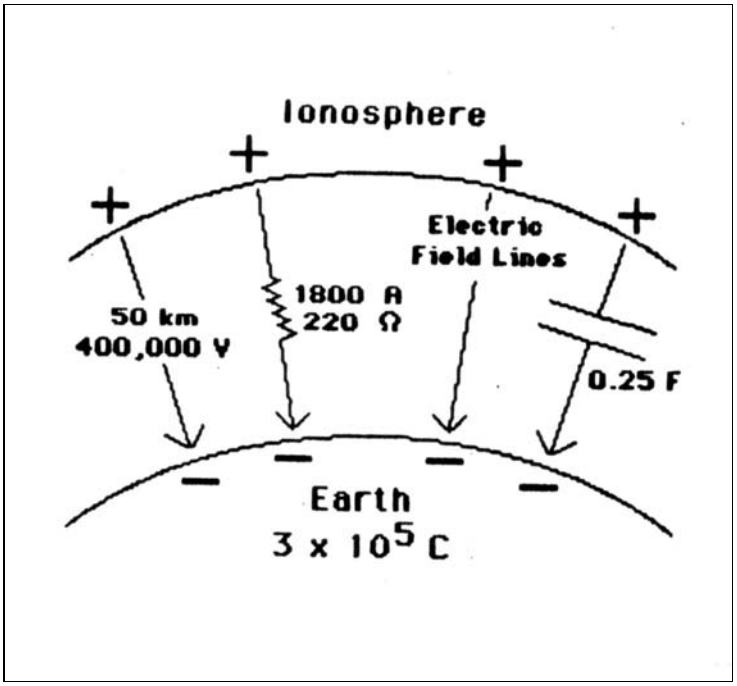

Figure 5: Electrical characteristics of the earth. Electric field lines run from the ionosphere, terminating at the earth, resulting in a negative surface charge.[1]

4.3 Induced Charges

One could also put forth the hypothesis that the force observed is due to the creation of induced charges. A common example of such an effect is that of a charged balloon sticking to a wall.

The force due to induced charges is always attractive. This can be understood as following. If you charge a balloon negative and then move it close to a neutral wall, an electric dipole will be generated in the wall due to the following principle. The negative charges in the wall (i.e. the electrons) will be repelled by the negative charge of the balloon. Thus as the electrons orbit atoms in the wall, the electron clouds are distorted and bent away from the balloon. This effect means the positive charges in the wall (i.e. the atom centers) are on average closer to the balloon than the negative charges in the wall (i.e. the electrons) are. Thus, the balloon gets attracted to the wall. This is always an attractive effect, never repulsive.

Also, the force between the wall and the balloon varies inversely with the distance between the balloon and the wall raised to some power. What this means is that the balloon has to be close to the wall in order for the inductive effect to be appreciable. Consequently, only matter which is close to the capacitor is significant when considering the force due to induced charges.

If the force exerted on the capacitor were due to induced charges, then the force direction would depend on mass in the vicinity of the capacitor. If the mass were located below the

[1] Approximate values only; reported values vary. [14-17] Note that the average electric field magnitude decreases with altitude so that the average electric field magnitude $E \approx 100 N/C$ near the Earth's surface is significantly greater than the average electric field $E \approx 10 N/C$ in the effective Earth capacitor. Additionally, the magnitude of Earth's surface charge exceeds what is predicted by q=CV in this simple model.

capacitor, the force direction would be down. If the mass were located above the capacitor, the force direction would be up.

If the interaction were due to induced charges between the capacitor and the scales, then scales below the capacitor (e.g. the digital scale) would produce a downward force while scales above the capacitor (e.g. suspended equal arm scale) would produce an upward force. However, these predictions are in opposition to the experimental results suggesting that induced charges between the capacitors and the scales did not produce the observed forces.

Induced charges between the capacitors and other materials in the environment apparently could not explain the observed forces.

5. EXPERIMENTAL RESULTS

5.1 Single Charged Plates

Each plate was charged either with a negative or positive voltage independent of each experiment (Table 5). With the largest plate (plate 1) charged positive, an attractive force was present, moving the plate closer to the earth. With plate 2 charged positively, a repulsive force was noted, moving the mass away from the earth. The smallest aluminum plate (plate 3) charged positive exhibited a repulsion – that being a stronger repulsion than plate 2. The next series of experiments consisted of charging each plate negative. This negative charge consistently caused the plates to move in a repulsive manner from the earth. The magnitude of the force caused by the smallest plate (plate 3) was in fact the largest repulsion. Graphic representation is presented in Figure 6.

Table 5: Single Charged Plate Force Vectors

	Plate Polarity	*Force (N)*	*Resultant Vector*
Plate 1	+	2.08×10^{-2}	↓
	-	3.90×10^{-3}	↑
Plate 2	+	1.45×10^{-2}	↑
	-	1.49×10^{-2}	↑
Plate 3	+	2.07×10^{-2}	↑
	-	1.46×10^{-2}	↑

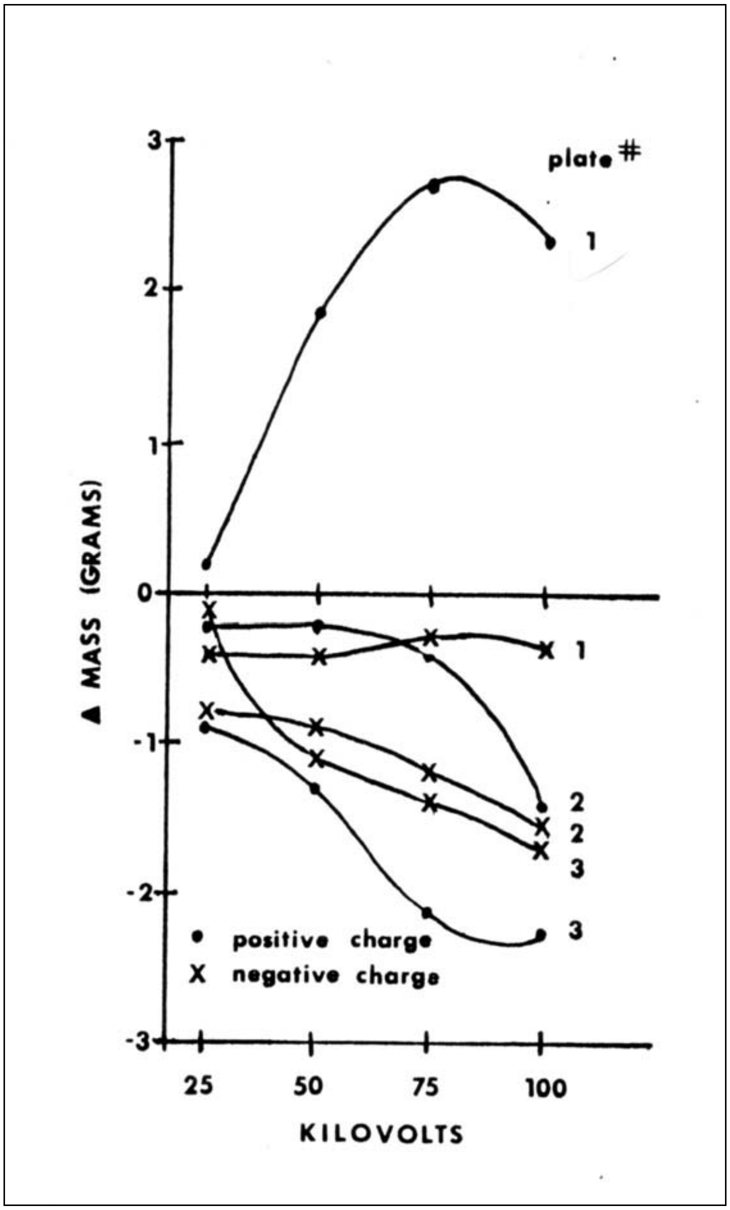

Figure 6: Graph of force produced by change in voltage for a single positive and negatively charged plate relative to the earth.

It should be noted that there was one extremely obvious anomalous result. With plate 1 charged positive, a downward motion (attractive force) was observed which was significantly contrary to the usual upward (repulsive) pattern of motion. In all other cases, the charged plate exhibited a repulsive force from the earth.

5.2 Parallel Plate Capacitors

These experiments, as mentioned earlier, were designed specifically to measure the effects of a charged capacitor interacting with the earth's electric field. All three capacitors were of equal physical dimensions (Table 2) with varying capacitance. The polarity and orientation of the capacitors were varied (Table 3).

Table 6: Parallel Plate Capacitor Force Vectors				
	Set	*Top Plate Polarity**	*Bottom Plate Polarity*	*Resultant Vector*
Capacitor 1	A	+	G	↑
	B	G	+	↑
	C	-	G	↑
	D	G	-	↑
Capacitor 2	A	+	G	↑
	B	G	+	↑
	C	-	G	↑
	D	G	-	↑
Capacitor 3	A	+	G	↑
	B	G	+	↑
	C	-	G	↑
	D	G	-	↑

* Positive (+), negative (-), or ground (G).

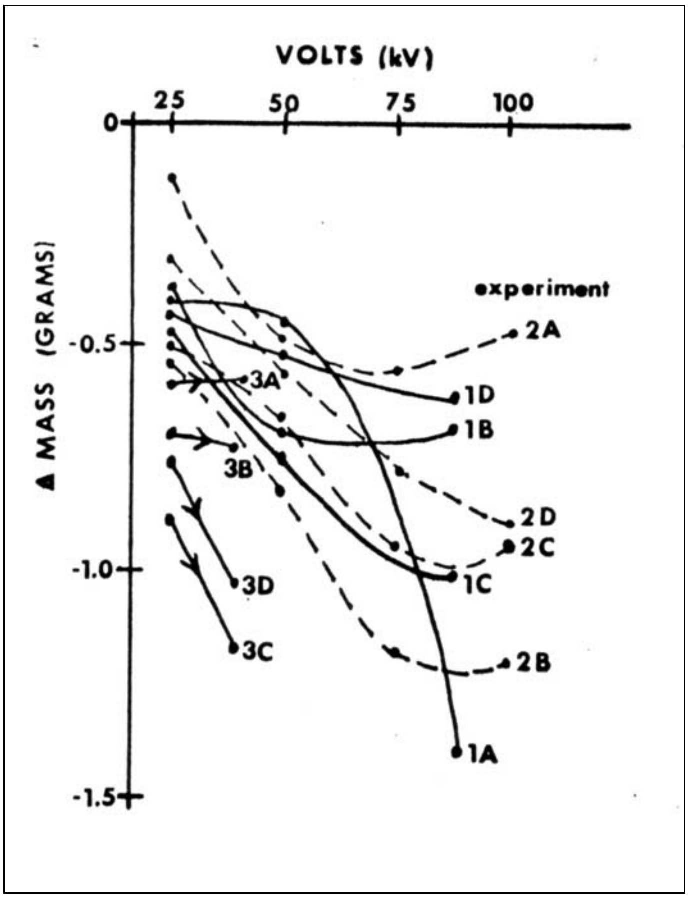

Figure 7: Graph of the unidirectional forces created by the change in voltage with a parallel plate capacitor relative to the earth. The graph indicates that the direction was constant, independent of polarity and orientation.

Experimental evidence clearly showed that the resultant vectors on the capacitors did not vary significantly with orientation or polarity. It was found that the forces created consistently moved the capacitor mass in an upward direction from the earth (Table 6). The graphic representation is presented in Figure 7.

It should be noted that the wax dielectric capacitor was totally enveloped in a layer of wax to minimize the ionization of surrounding air caused by charge leakage off the plates. Therefore if any motion was observed it could not be directly attributed to ion momentum (there was unidirectional motion with this capacitor as well). One difficulty that arose with the wax dielectric was the dielectric broke down at relatively low potentials thus inhibiting the final results at maximum voltage.

Additionally, there were differences noted in maximum voltage for each individual capacitor (Table 4), which affected the amount of charge on the capacitor as well as the final force.

The relation associated with the capacitors' upward motion was found to be proportional to the potential energy involved in the capacitor system. The resultant force could be directly attributed to the concentration of energy that could be stored between the plates of the capacitor.

The capacitor is utilized to represent the storage energy in the electric field associated with groups of positive and negative charges on the surface of the plates. The energy stored in a capacitor can be derived from the basic concept of the voltage as the potential energy associated with a unit charge. At any potential, the work required to charge the plates of the capacitor is

$$W = \tfrac{1}{2} C V^2 \qquad (5)$$

where W = energy (Joules), C = capacitance (Farads), and V = voltage.

The relation associated with the experimental data is such that the force created by the capacitor is directly proportional to the amount of electrical energy stored in the electric field of the capacitor (Figure 13), such that:

$$\text{Force}_{\text{Repulsion}} \ \alpha \ \text{Energy}_{\text{Capacitor}}. \qquad (6)$$

To a certain extent, the energy can be viewed as analogous to the potential energy of mechanical systems, in that energy is stored as a result of the location of the charges between the plates. Stated simply, the capacitor has the ability to do work in the electrostatic field between the plates. However, the capacitor seems to be using the energy of the internal electric field and directly converting it to energy to produce force or motion of an external nature.

5.3 Ion Grids

The third experiment had to deal directly with measuring the effects produced by the acceleration of electrically charged particles between two oppositely charged grids resulting in the motion of the body and surrounding medium.

Table 7: Ion Momentum Grid Force Vectors

Experiment	*Emmiter Polarity*	*Collector Polarity*	*Emitter Orientation*	*Force (N)*	*Resultant Vector*
1A	+	G	Top	2.31×10^{-2}	↑
1B	+	G	Bottom	2.20×10^{-2}	↓
2A	G	+	Top	7.30×10^{-3}	↑
2B	G	+	Bottom	1.76×10^{-2}	↓
3A	-	G	Top	1.54×10^{-2}	↑
3B	-	G	Bottom	1.28×10^{-2}	↓
4A	G	-	Top	1.84×10^{-2}	↑
4B	G	-	Bottom	2.96×10^{-2}	↓

The final results indicated that the ion device was dependent upon the variables associated with it (Table 7). The device was caused to move upward or downward relative to the earth by directly changing the polarity and orientation. It is speculative though whether its orientation relative to the earth actually affected the results. It was found that the motion was always in the direction of the smaller grid (emitter). (Note that runs of set A had the emitter on top and runs of set B had the emitter on bottom.) The graph is detailed in Figure 8.

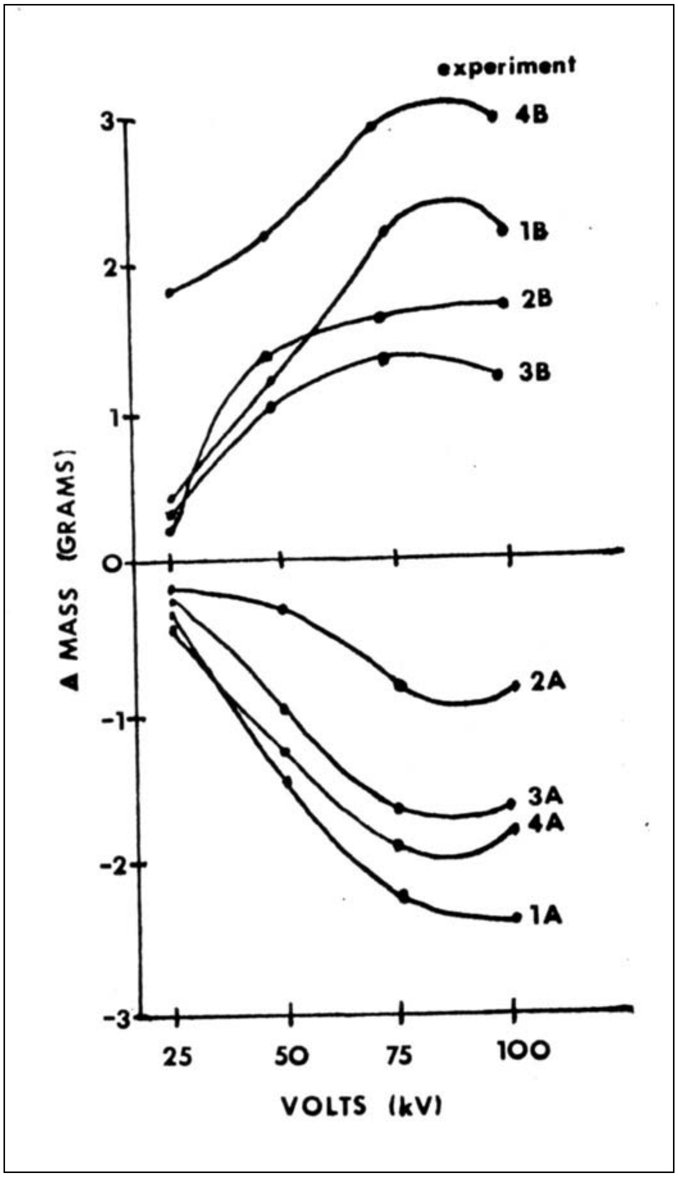

Figure 8: Bi-directional forces created by ionic grids. The direction of the movement of the apparatus could be changed by simply changing the associated variables.

5.4 Non-Uniform Capacitor

This device was built with a similar physical structure to the ionic grid model, with unequal plate areas (Figure 2). Use of unequal plate area was thought to emphasize the movement of charged particles whereby ion momentum could occur. One major difference between the ionic grid and the non-uniform capacitor was that of the dielectric inserted between the electrodes.

The resultant vectors for the Non-Uniform Capacitor were relatively the same as for the parallel plate capacitors. That is, the motion was always a repulsion away from the earth (Table 8), therefore being independent of all variables (orientation and polarity). The data is plotted in Figure 9.

Table 8: Non-Uniform Capacitor Force Vectors				
Experiment	*Ball Polarity*	*Plate Polarity*	*Ball Orientation*	*Resultant Vector*
1A	+	G	Top	↑
1B	+	G	Bottom	↑
2A	G	+	Top	↑
2B	G	+	Bottom	↑
3A	-	G	Top	↑
3B	-	G	Bottom	↑
4A	G	-	Top	↑
4B	G	-	Bottom	↑

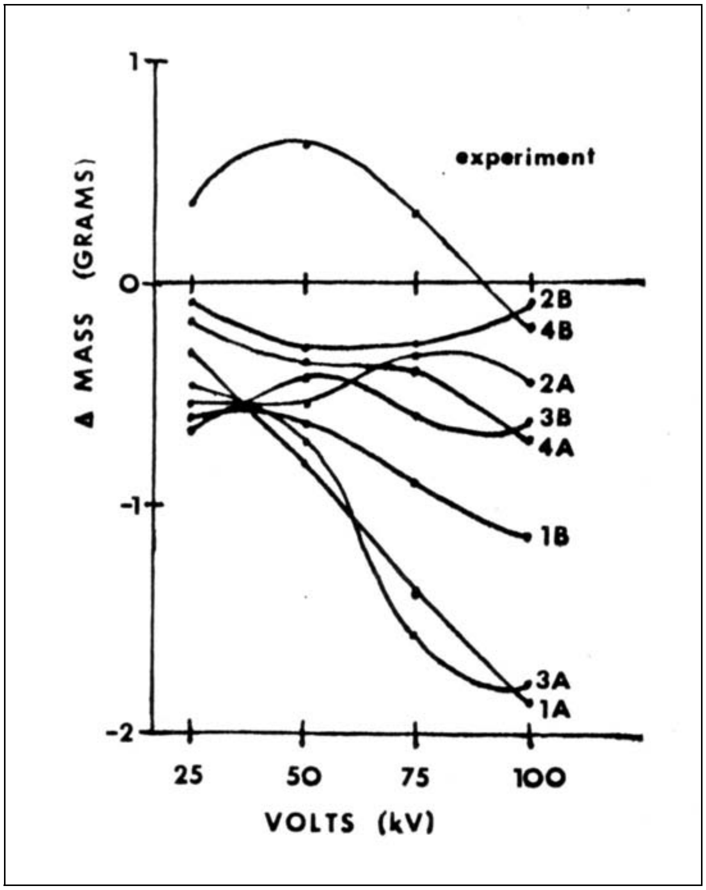

Figure 9: Non-uniform capacitor with unidirectional force. Force direction could not be altered by changing the associated variables, such as orientation and polarity.

The capacitance of the capacitor was not calculated (and therefore also the capacitance energy) due to design complications. It is not directly known if the energy law characteristics observed earlier is still valid.

However, there is other evidence that seems to support the Force/Energy relation. In experiment #4B the force started as an attraction to the earth. As the voltage was increased (which increased the energy of the capacitor), the force receded as an attraction and at maximum voltage (100 kV) the force resulted in repulsion.

The exact explanation for this is not known; neither is the fact that it occurred in only one example. From this it seems possible that two forces are acting upon the capacitor, trying to maintain equilibrium of forces. The geometry of the capacitor may also be an important factor. Due to the geometry of the capacitor it is assumed that the capacitance of this capacitor is smaller than the parallel plate capacitors, thus the non-uniform capacitor should have produced a smaller force according to the energy relation. It is also interesting to note the difference in force magnitude with respect to the different orientation and polarity (Figure 9).

5.5 Faraday Cage

One further experiment, which was performed, involved placing the entire apparatus (ionic grid and capacitors) inside a Faraday cage thus shielding it from the earth's electric field. The Faraday cage was made of solid galvanized sheet steel. (The cage was constructed of a magnetic permeable material, therefore the earth's magnetic field could interact with the apparatus.)

Ion theory states that ion momentum transfer would work in a shielded condition because it only requires a volume of gas to be accelerated between the grids to produce the force.

However, Coulomb theory states that the capacitor force will only occur when an external electric field is present. Thus the capacitor motion is dependent upon the electric field of the earth and the charge on the capacitor.

The results from these additional experiments were indeed conclusive. The ion model continued to exhibit the force characteristics observed earlier, while the capacitors did not exhibit motion of any kind. This strongly indicates that ion momentum was not the prime cause of the observed effects for the capacitors. (Capacitor 3, enveloped in a layer of wax, also indicated this conclusion). If the capacitors were accelerating ions for a propelling force, there would be motion inside the Faraday cage, which indeed there wasn't. This also implies that the force is not directly caused by the capacitor, but rather by an external field, such as the electrostatic field of the earth. Therefore, an interaction of the fields of the earth and of the capacitor seems to be occurring to produce the force. It is primarily an electric interaction due to the results in the Faraday cage experiment.

However, the force could not be explained in terms of Coulomb's Law. According to Coulomb's Law, outside of the Faraday cage a downward force should exist on a net positive capacitor, and an upward force should exist on a net negative capacitor. The observed results do not follow these predictions.

5.6 Air Dielectric with Improved Power Supply

Maximum voltages in the order of 200 kV were achieved using an upgraded power supply. Voltage was stepped up from 12 V to a high voltage transformer where the voltage was further rectified and multiplied. The voltage multiplier was based on a Walton-Cockcroft solid state DC generator. [6,7] The multiplier section had a total of 24 stages of rectifiers and capacitors to further increase the voltage. The entire HV multiplier section was immersed in high dielectric oil for greater efficiency and cooling of parts.

A large (0.21 m^2) circular parallel plate capacitor with air dielectric was utilized. The distance between the capacitor plates was variable from 2-4 inches. Figure 10 summarized the data for this experiment with a plate separation of 4 inches.

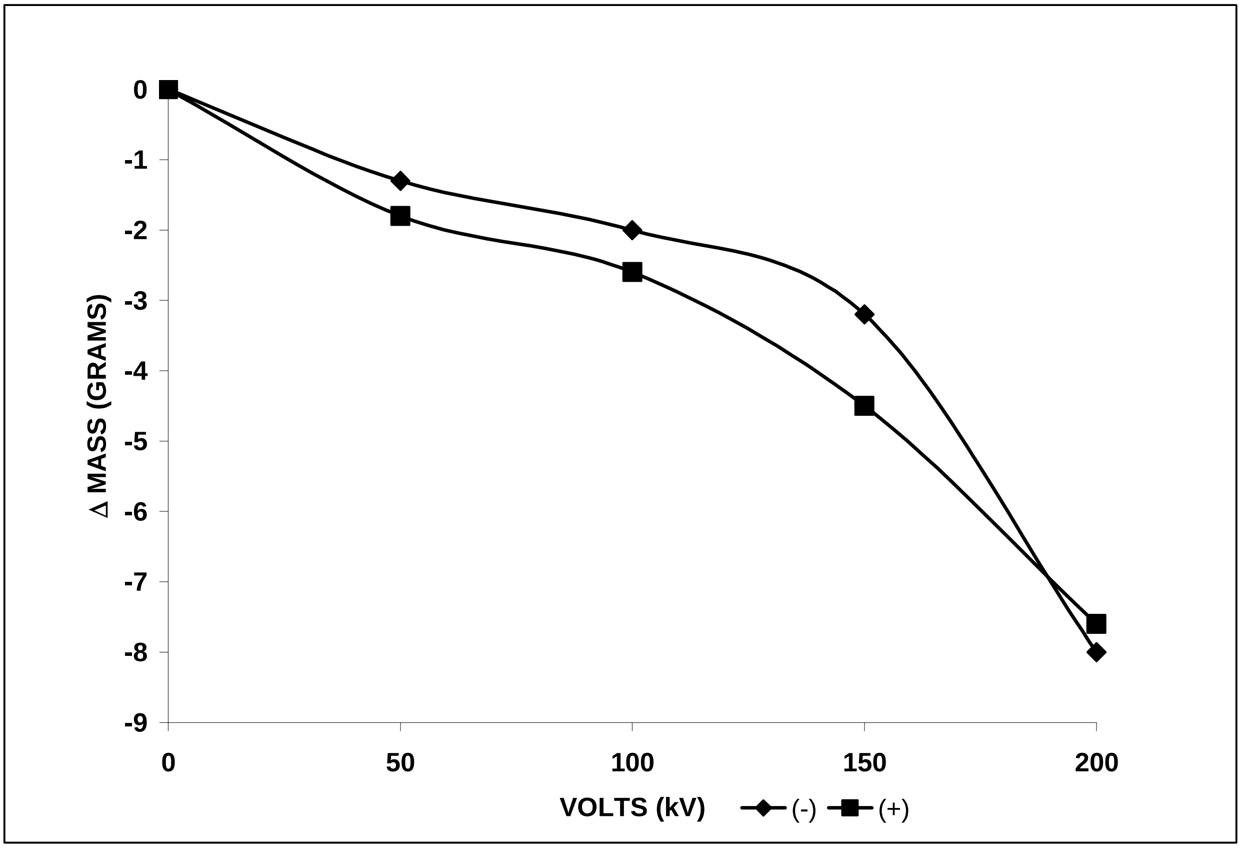

Figure 10: Air dielectric capacitor. The polarity of the bottom plate is indicated in parentheses.

In order to test the possible effects of electric field curvature (fringe field) at the edge of the capacitor, two additional experiments were conducted with a guard ring around the capacitor. The metal guard ring was suspended independently of the air dielectric capacitor and held at the same horizontal level. There was an air gap between the guard ring and the capacitor. Because the electrostatic field inside an ideal conductor is zero, the purpose of the guard ring was to reduce the vertical component of the electric field near the capacitor's edge.

Experiments using the guard ring were performed with plate separations (dielectric thickness) of 2 and 4 inches. The results are shown in Figure 11 below. Notice that the force was still apparent when the guard ring was used. Futhermore, the results for a dielectric thickness of 4 inches with the guard ring were found to be nearly the same as the results without the guard ring (Figure 10).

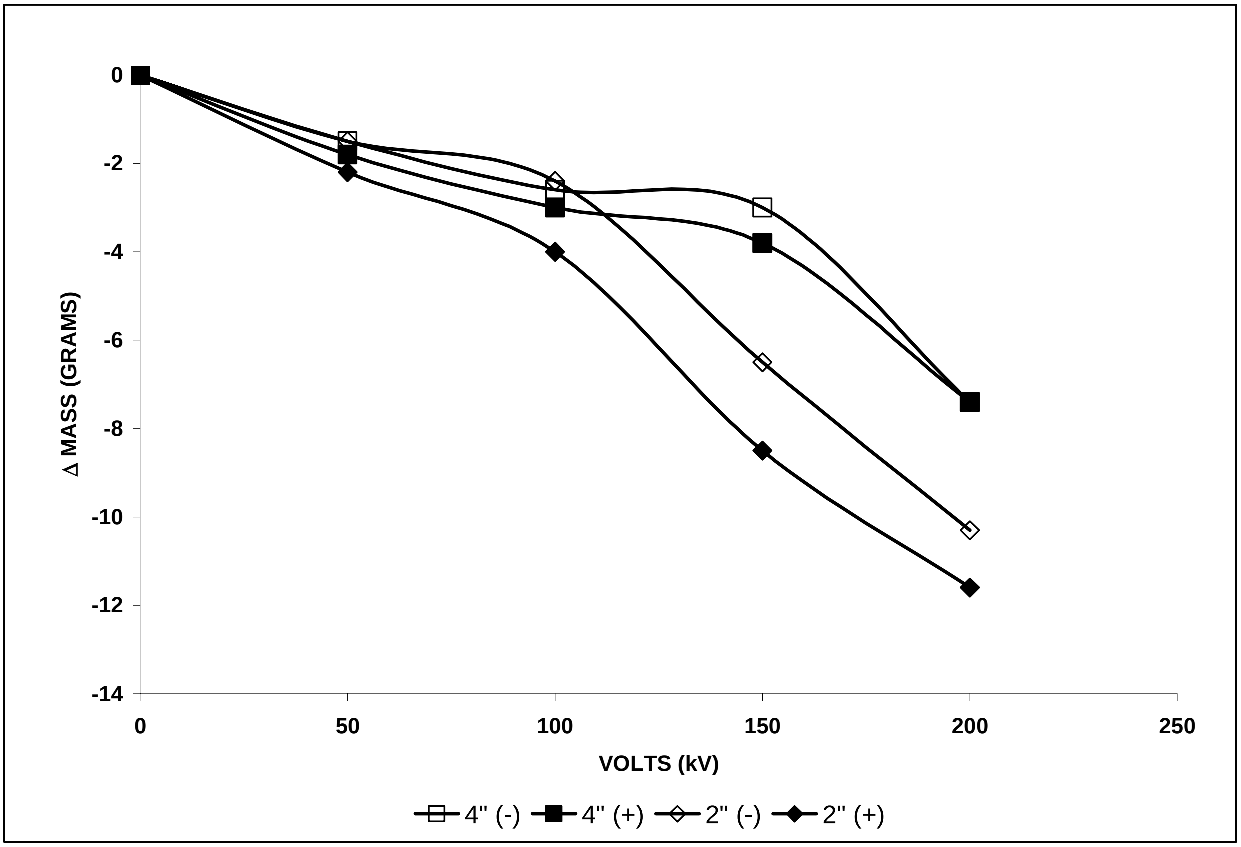

Figure 11: Air dielectric capacitor with guard ring. The polarity of the bottom plate is indicated in parentheses.

Additionally, it was apparent how the charge on the capacitor was a direct factor on the force magnitude. Observations were such that upon initial charging (charge buildup) the force would increase a certain amount. As voltage was increased to a certain amount, an arc discharge would occur across the plates. Upon close observation of the scale it was noted that the force dropped off significantly as soon as the discharge occurred. This seems to strongly indicate how greatly the internal mechanisms of the capacitor had an affect on the effect.

5.7 Glass Dielectric Capacitors

Two parallel plate capacitors were constructed with glass dielectrics having a dielectric thickness of 2 mm and a dielectric constant around 6 (estimated). The first capacitor had a plate area of 0.06 m^2 while the second had a plate area of 0.03 m^2. Each capacitor was constructed to achieve minimal electrical loss. This was achieved by putting an insulating compound with a very high voltage breakdown rating over the entire plate surfaces. This was done to minimize direct ionization of the surrounding air and hence loss of charge. Each plate was also sealed to the glass with epoxy to further minimize losses.

The improved power supply described above was utilized for these experiments. The observed tendency was as theorized. Both capacitors exhibited a force which caused them to reduce their weight. As expected, the larger capacitor created nearly exactly 2 times the force as the smaller capacitor.

The energy concentration stored in the capacitors was very large (comparatively). This was also reflected in the magnitude of the forces created. The maximum force created by the larger capacitor was almost 4 N, comparable to almost 380 grams of displacement of the total weight of the capacitor at 100 kV. Furthermore, this resulted in a weight loss of approximately 18 % of the total weight. The smaller capacitor created a force of close to 2 N, resulting in a maximum displacement of about 180 grams. The glass dielectric broke down at approximately 125 kV, therefore a maximum voltage of 100 kV was utilized.

The polarity had a very small effect on the force produced. A negative charge on the upper plate resulted in a slightly greater force than a negative charge on the bottom plate, although the differences in forces between the two polarities was less than 10 % at 100 kV. The force always resulted in a weight loss, regardless of the polarity. As would be expected from the energy relation, the force produced was observed to be proportional to the square of the voltage.

Figure 12 summarizes the experimental data for the glass dielectric capacitors.

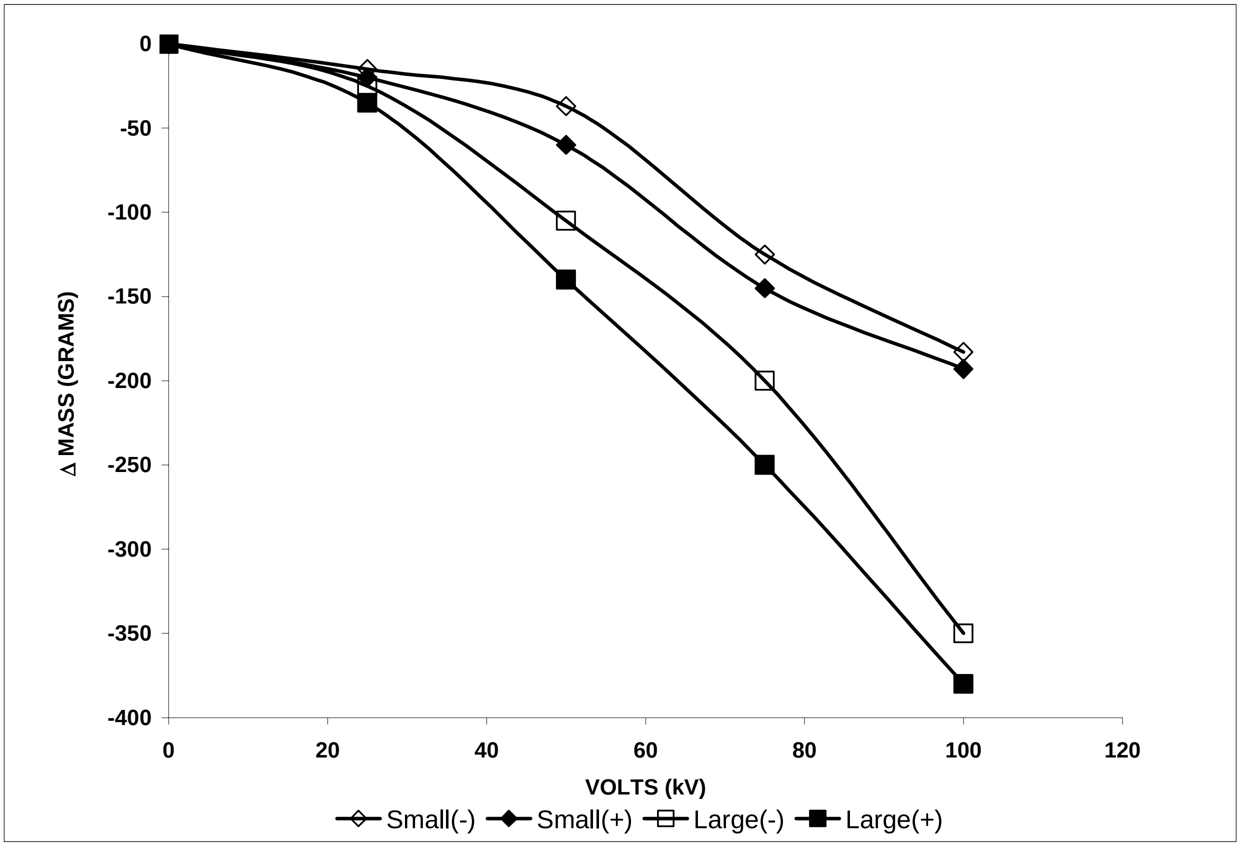

Figure 12: Glass dielectric capacitors. The small capacitor had one-half the area of the large capacitor, and the polarity of the bottom plate is indicated in parentheses.

5.8 Summary

Data for all of the parallel plate capacitors is summarized in Figure 13 below. Note that this graph includes data for (1) capacitors 1, 2, and 3 of section 5.2 at their maximum voltages (the data point for each capacitor is the average of sets A, B, C, and D), (2) the air dielectric capacitor of section 5.6 without guard ring (the data point for each voltage was the average of + and - polarity values), and (3) the two glass dielectric capacitors of section 5.7 (the data point for each voltage was the average of + and - polarity values).

This gave a combined total of 15 data points. The data points were for (a.) voltages from 25 to 200 kV, (b.) air, wax, and glass dielectrics (c.) dielectric constants from 1 to 6, (d.) plate areas from 0.03 to 0.21 m^2 (e.) dielectric thicknesses from 2 to 100 mm, and (f.) charging energies from 6 to 7965 mJ. Note that although each plotted point contains an average for positive and negative polarity, the difference in force for positive and negative polarity is typically a small quantity and may be neglected to first approximation.

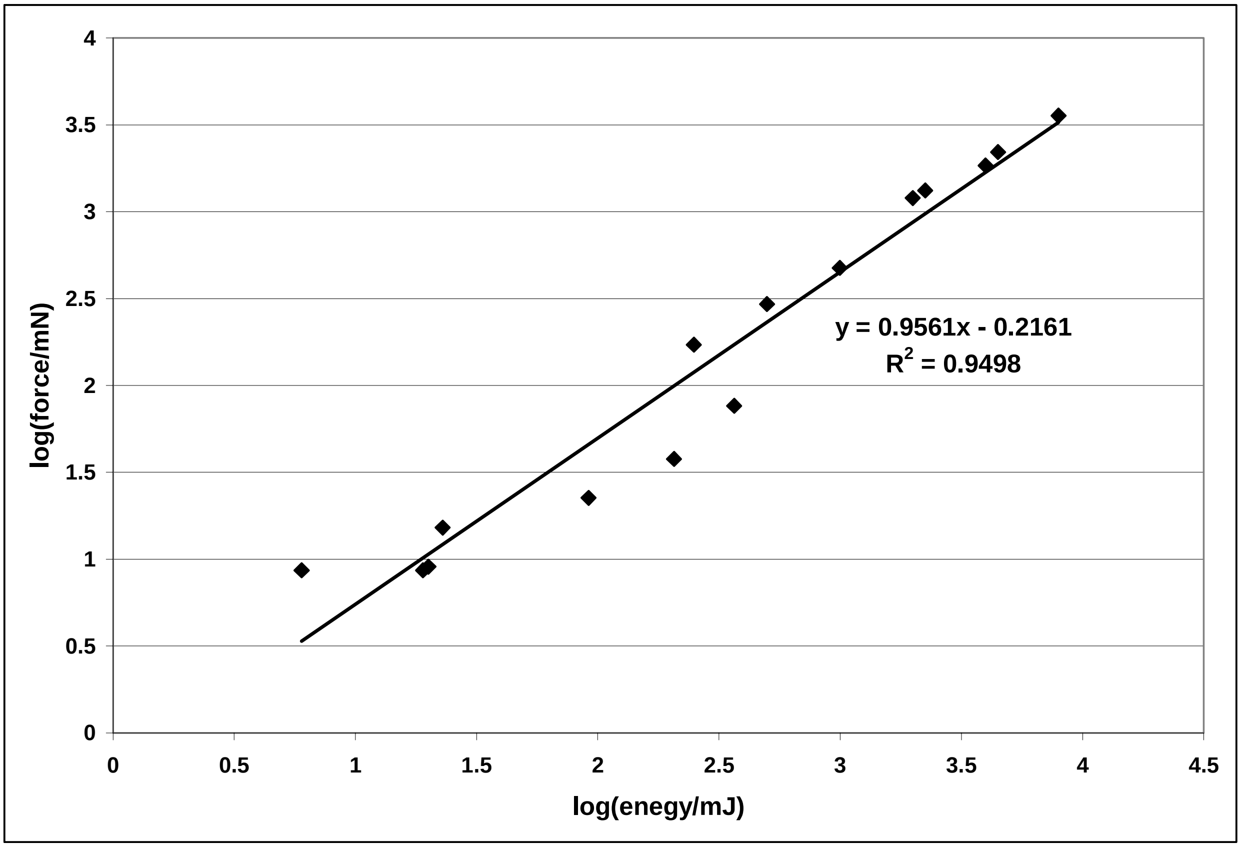

Figure 13: Force exerted on parallel plate capacitors as a function of energy.

The results indeed conclusively show a linear relationship between the charging energy and the force produced for the parallel plate capacitors. The fitted exponent was found to be 0.9561, which is close enough to the integer 1. Additionally, the R^2 value of 0.9498 indicates the linear fit was good. We thus have the following energy relationship for the parallel plate capacitors:

$$F \cong kU \qquad (7)$$

where

$$k \cong 0.47 N / J \,. \qquad (8)$$

Note, however, that the observed energy relationship holds only for the parallel plate capacitors. It does not hold for single plate capacitors, nonuniform capacitors, or ion grids.

6. CONCLUSIONS

A force is produced when single and parallel plate capacitors are charged to high voltages. This force was observed to consistently reduce the weight of the charged capacitors. For parallel plate capacitors, the effect is proportional to the amount of energy stored in the capacitors.

The force is associated with the interaction of fields, primarily the electric component, as demonstrated by the experiments performed in the Faraday cage. It seems to be a force caused by the electric field of the earth, although it is irrespective of polarity of charge on the capacitor (the plate adjacent). Results indicate a system directly dependent upon potential energy stored in the electric field of a capacitor for the creation of a vertical force.

The force was not caused by any induction charges from the earth or measurement apparatus. Additionally, electrostatic image charges proved ineffective in explaining the force.

The forces created by the capacitors and ion grid were comparable in magnitude. The difference arose between the direction of movement of the capacitors and ion grid. The ion grid could be made to move in any particular direction, which was directly caused by the change of polarity and orientation; the capacitors were not. The force exerted on the capacitors was consistently repulsion from the earth whereas the ion grid always moved towards the emitter.

These results clearly seem to indicate that ion momentum transfer is not wholly responsible for the movement of high voltage capacitors. The effect could not be explained on the basis of Coulomb's Law or current electromagnetic theory.

There is direct experimental evidence of an energy relation. This relationship strongly indicates that the phenomenon observed is controllable to some extent as well as being a non-random event. The energy relation found in the experimental results is quite simple. Thus the experiments do have a simple mathematical base supporting the observed effects, which will prove extremely beneficial for future reference.

As to the original problem regarding this phenomenon, we can conclude that current electromagnetic laws cannot effectively account for the movement and the force is not characteristic of normal electrostatic effects. The exact nature of the force cannot yet be explained. More experiments must be performed to provide more concrete evidence into the nature of the force. However, the force has been shown to be reproducible and follow an energy relationship.

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Doyle Robert Buehler has worked in the military, as well as in the aerospace industry, and is currently developing new retail business concepts with advanced manufacturing technologies as an entrepreneur. He has a Master of Business Administration, an Aeronautical Engineering Technology Diploma (Hons.), and a Mechanical Engineering Technology Diploma (Hons.). He is a Certified Engineering Technologist (CET). He first became interested in researching high voltages and corresponding capacitive effects in 1985. He pursued this interest through academic science competitions across Canada.
