# Flying Triangles:

# An Investigation of the So-Called “Lifter” Phenomenon

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## Abstract

A “lifter” is an electrically-charged asymmetrical capacitor built of a light wooden frame with one electrode of thin magnet wire, the other a strip of aluminum foil; its ability to lift itself off the ground through a propulsive force has in the past 12 months created much excitement in science-hobbyist circles. Many of these hobbyists claim the lifter’s propulsive force to be a manifestation of antigravity. This paper describes several procedures used to discredit this claim, and to discover the true mechanism behind the lifter’s thrust-production. Through thrust measurements, physically isolating a lifter, and probing for ions, this mechanism is found to be a form of ion-wind, created by the large electric field in the wire-skirt gap. A physical model of the lifter’s thrust production is considered. The lifter is a novelty, not a breakthrough technology; its performance in the tests described in this paper show that it is unsuited for practical propulsive applications.

## I. Introduction

Since October of 2001, a popular investigation among amateur scientists has focused on a small device commonly called a “lifter.” A simple structure usually made of balsa wood, magnet wire and aluminum foil, it responds to great excitation voltages by producing a thrust force along its central axis (see figure 1). As of August 2002, any mention of the lifter phenomenon was limited to amateur web-pages; no mention of any related study appeared in the scientific literature. As such, no rigorous theory had been developed to explain the behavior of the lifter under great excitation voltages; in fact, the majority of amateur investigators ascribed the lifter’s motive force to anti-gravity, or to the mysterious “Biefeld-Brown” effect, the same concept under a different name. Records of experiments given online were limited to videos of the lifters flying under their own motive force, with actual numbers being rare and, when available, either indecipherable and/or of dubious scientific value.

The project detailed in this report is an attempt to clear up the confusion surrounding the lifter phenomenon. The arguments for the lifter as an anti-gravity generation device are unconvincing at best, and this report primarily debunks that assertion; in doing so, the lifter’s true lifting mechanism is identified, and factors which affect its performance are categorized. The characteristics of the true lifting mechanism are used to produce a model of the system, and that model is shown to be consistent with the data. Results from this project enable an analysis to determine if the thrust from the lifter is of any practical significance, i.e., whether the science behind the lifter has any practical applications.

## II. Experimental Technique

### A. Searching For Antigravity

The first of several set-ups used in the course of this project was designed to observe the anti-gravitational effects mentioned by previous researchers. A lifter, created to the dimensions provided by American Antigravity[1], was a triangular configuration with square 1/8" basswood struts 11 cm tall and supports 20 cm long (a total perimeter of 60 cm) attached to the struts 4 cm above ground level; an aluminum foil skirt (standard store-bought, not heavy duty) 4 cm tall; and a corona wire of copper magnet wire, 30-gauge, wrapped about the struts with a sheath of plastic introduced between (to allow for easy movement up and down the struts), stripped of its enamel on the underside but not at the lifter's corners (stripping at corners caused unwanted arcing from the corona wire to the grounded skirt). The corona wire (after being wrapped about the top of the lifter) was attached to the power supply of a computer monitor (standard power supply of ~ 22.5 kV output); the foil skirt was grounded by affixing a length of the magnet wire to a corner of the skirt and connecting it to a ground strap in the monitor.

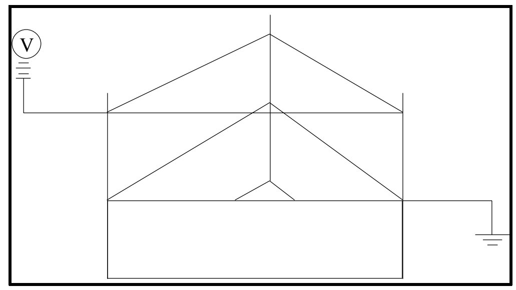

**Figure 1** — The lifter, first iteration

After verifying that this configuration would fly and function much as described by American Antigravity, the lifter was isolated from the environment by a thin plastic membrane stretched over the whole structure. The membrane allowed for no momentum transport into or out of the system; with the assumption that simple plastic is not an antigravitational inhibitor, this setup showed whether the lifter depended on some form of momentum transport.

### B. Characterizing the Flow

Given the results of § III.A, characterizing the flow of momentum was a step (performed simultaneously with that of § II.C) undertaken to enhance the investigation. Figure 2 shows a square lifter, turned on its side; this lifter was constructed for the purposes outlined in this section and the following two. To characterize the flow, a smoke wire was used to generate a line of smoke at the outlet of the lifter (figure 2, replacing the ammeter with a power supply feeding a voltage across the wire, rotated 90 degrees counter-clockwise, would summarize the setup). The smoke wire was a 0.0031" NiCr resistance heating wire with common motor oil brushed onto it. With a current of ~ 1.5A passed through, it heated rapidly and created a line of smoke. When the smoke appeared, the lifter was activated, and the effect of the lifter activation on the line of smoke was observed. These observations were used to verify the existence of a breeze exhausting from the skirt end of the lifter, and led to the development of the steps outlined in § II.C.

### C. Determining the Lifting Mechanism

The results presented in § III.A suggest that the lifter is reliant on momentum transport. Based on the reasoning given in that section, the mechanism is postulated to be a form of ion-wind. Verifying this required evidence of ions in the system. Largely as a result of the difficulties encountered in the process of § II.C ("Characterizing the Flow"), it was found that this could be done by "catching" ions on a probe and using the induced

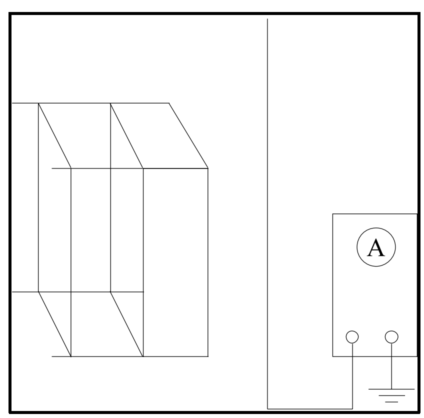

**Figure 2** — The ion-catching scheme

current in the probe to determine what type of ions these were. To this end, a simple ion probe (consisting of a single wire) was strung at the outlet of the lifter (not between the wire and skirt, as this would facilitate arcing in the high-voltage system) (see figure 2). The current read off the ammeter resolved what ion polarity was being observed.

### D. Measuring Performance

Having identified the lifting mechanism for the lifter, a thorough investigation demanded that the factors which affect the lifter's performance be identified as well. A simple thrust-stand was created to accomplish this purpose: a force-balance (realized in a spring of $k = (0.6654 \pm 0.037)\ g_f/cm$) was hung from a stand, and the lifter (now a square, to balance any problems caused by tension in the wires that connected it from opposing corners to the power supply) was hung upside-down from this force-balance (see figure 3). In this way any effects of the weight of the lifter and its connecting wires were taken out of the thrust measurements. As long as the force being measured remained within the spring's elastic region (which, for the purposes of this project, was not an issue), the thrust force could quite easily be read off from a graduated scale (realized in a simple ruler) hung alongside the spring, according to Hooke's law ($F = k \cdot x$)

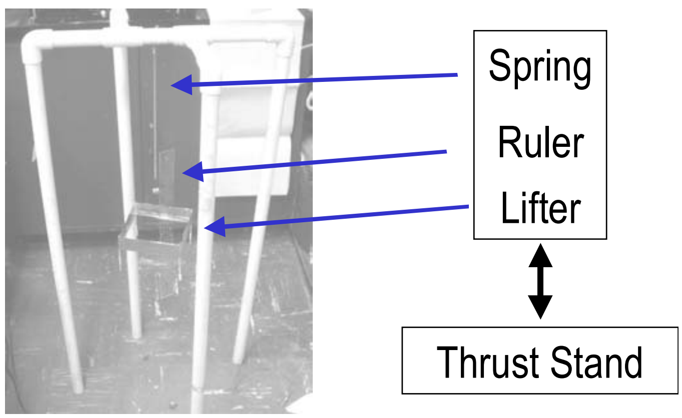

**Figure 3** — The force-balance used to measure lifter thrust

This portion of the project required control over several variables. Four lifters were used: the original triangle (Perimeter ($P$) = 60 cm); and three squares ($P$ = 30 cm, 60 cm, 120 cm). All were constructed according to the same material parameters given in § II.A. The monitor was replaced as a power supply by a variable-voltage, current-limited DC power supply with range 0 to 50kV. The lifters were made to enable easy alteration of the distance $s$ between the corona wire and the foil skirt. With the thrust stand and the capability of varying these several parameters, the parameters were sequentially altered to produce the data of § III.D. This data set was analyzed with an eye to defining more precisely the physical mechanisms that constitute the lifter's ability to produce thrust.

## III. Results and Discussion

### A. Eliminating Antigravity As a Thrust Mechanism

When a lifter was enclosed in plastic (isolating it from its surroundings, as described in § II.A), no difference was observed between the weight of the inactive lifter and that of the lifter with voltage applied across it (i.e., "turned on"). See figure 4 for a picture of the actual setup. Electric fields, magnetic fields, and any postulated antigravity fields were not inhibited by this plastic sheathe. Momentum transport alone was impeded by this setup—and the lifter's failure to produce any sort of lift in this configuration shows that it was entirely reliant on momentum transport as its source of thrust-production. The assertion that antigravity is in some way responsible for the lifter phenomenon was thereby shown to be untrue. From this point on, the

**Figure 4** — The enclosed lifter in this picture did not move the balance when it was activated.

investigation focused on identifying the source of the momentum transport and the factors affecting the lifter's momentum-generating effectiveness.

### B. Identifying a "Lifter Breeze"

The setup detailed in § II.B allowed for the verification of a breeze exiting the lifter from its skirt end. The smoke wire was activated, producing a line of smoke; when the lifter was activated, the smoke behaved as it would have if a known flow source was blowing air through it. At the same time, light threads above the lifter, used to tie pieces of the setup in place, flapped as though they were subject to a wind. These observations allow the momentum transport through the lifter to be identified as a flow of air (i.e., a wind). However, the smoke wire setup was unable to provide any further data; shortly after the lifter was activated (approximately one second), the oil which provided the smoke completely disappeared from the wire. Since the oil did not respond this way when other sources of breeze blew over it, this observation suggested that something about the lifter-produced breeze was anomalous. This observation led to the trial of § II.C and the results in the next section. These results suggest that the interaction of the oil with ions present in the breeze caused its rapid disappearance.

### C. Detecting Ion-Wind

With the setup described in § II.C, the breeze identified in the last section was identified as a manifestation of ion wind. When the lifter was activated, the ammeter read a negative current running between the ion probe and the grounded terminal. This current increased as the voltage applied across the lifter increased. This suggested that ions in the flow were depositing their extra negative charge on the wire when the two made contact, and that the number of ions exhausting from the lifter (and collecting on the probe) was dependent upon the applied voltage. These deposited electrons would move from the probe to ground, producing the negative current registered by the ammeter.

### D. Measuring Performance

The performance measurements which were conducted on the lifter are broken into four categories, each characterizing the lifter's response to the change of one variable. These four categories are discussed below.

#### 1) Lifter Shape

The thrust produced by the lifter was found to have no relation to the shape of the lifter producing the thrust. Figure 5 shows the thrust produced by both a square and triangle-shaped lifter. The plot shows that these two lifters produce equal amounts of thrust at several values of the applied voltage (60 cm perimeter, 3 cm wire-skirt separation distance). This result first shows that there is nothing special about triangles; the dominance of this shape among hobbyists comes from the need for least amounts of construction materials—and hence lightest configuration—which is important to those who wish to fly the lifters. This result also shows that the thrust is not dependent upon the area of the lifter; the two lifters used, though of equal perimeters, are of different areas.

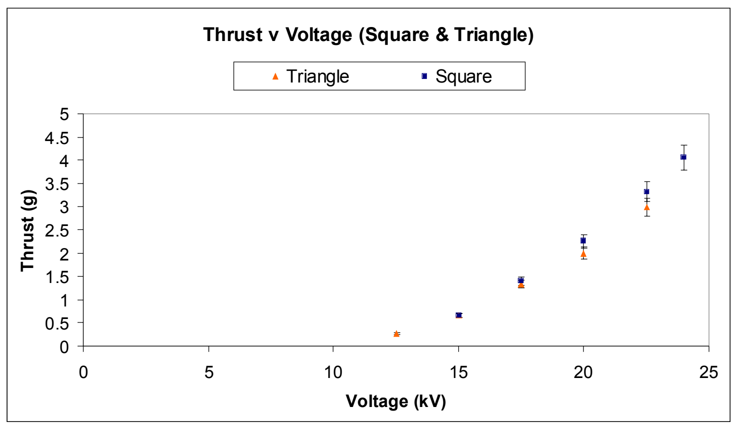


**Figure 5** — Square and Triangle lifters of equal perimeters produced equal amounts of thrust

This would indicate that the ion-wind generation is accomplished along the perimeter of the lifters; any future flow-visualization should show that most of the flow is concentrated at the lifters' borders.

**2) Lifter Perimeter**

The independence of performance on shape and internal area suggests that the lifter's performance may instead be dependent upon its perimeter length. As shown in figure 6, this is true. (Data shown is at a constant excitation voltage of 15 kV.) This result, coupled with the findings of part (1) of this discussion, show that the interactions which cause the lifter to produce thrust happen along the perimeter (i.e., between the corona wire and skirt), with the rest of the lifter's area being essentially inert.

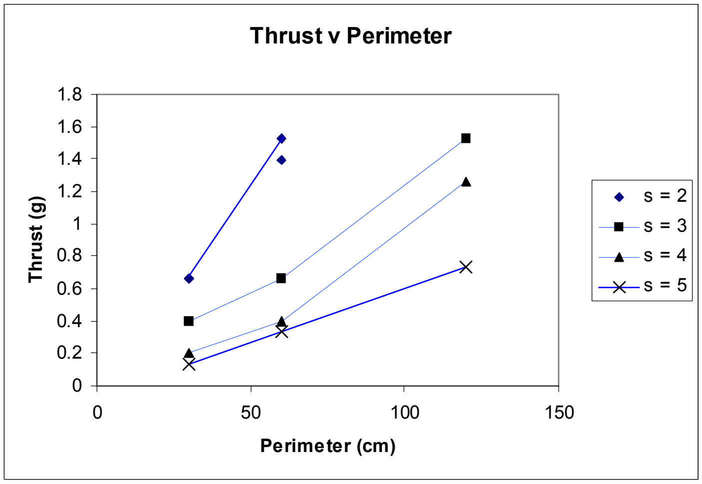


**Figure 6** — The lifters' thrust production is dependent on the perimeters, the one increasing as the other does.

**3) Corona wire – skirt separation distance**

Since the lift-producing interactions occur in the wire-skirt gap, it was expected that the thrust would vary as a function of the length of the gap (*s*). Figure 7 shows that this is the case (again at a constant excitation voltage of 15 kV). With a constant voltage across the

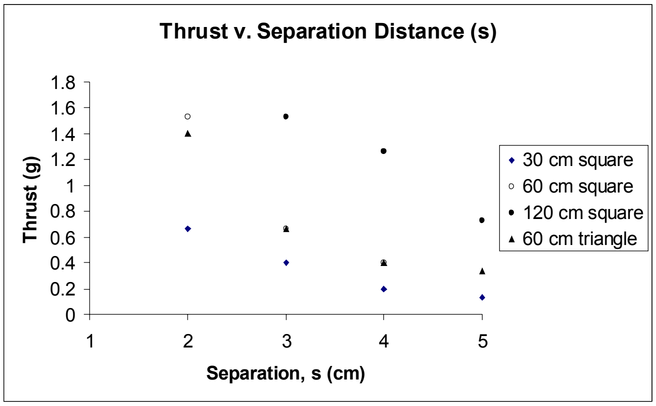


**Figure 7** — The lifter's thrust production is inversely dependent upon the separation distance between the corona wire and the skirt.

gap, decreasing the gap length will increase the strength of the electric field within the gap (in V/m). A summary of what this entails is contained in the discussion of § III.E.

**4) Excitation Voltage**

The final parameter varied was the lifter's excitation voltage. For each lifter in each configuration, the trend was the same, and is illustrated in figure 8: the thrust produced by the lifter (and, in the same way, the current moving through the system) was proportional to the square of the excitation voltage, in the following manner: $I\ (F_{th}) = C\ (V - V_o)^2$, where $C$ is a constant and $V_o$ is a threshold voltage. The curves in figure 8 are shown for the lifter of $P$ = 120 cm and $s$ = 5 cm; the polynomial fit equations given by Excel can be reduced to the forms $F_{th}$ and $I$. Altering the voltage across the gap, with all else remaining the same, changes the electric field strength within the gap (just as changing $s$ did). This is addressed further in § III.E.

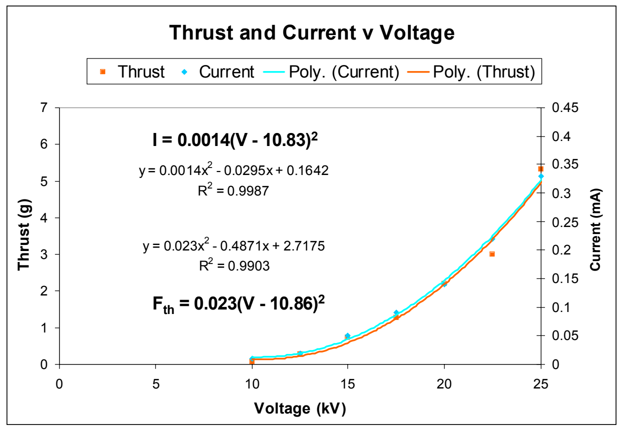


**Figure 8** — The thrust and current of the lifter in a particular configuration goes like the square of the excitation voltage.

Because there is no electrical contact in the lifter, current such as shown in figure 8 can only flow via charge carriers—ions—which is further evidence for the ion-induced momentum transfer theory. Greater thrust forces would therefore be expected from conditions that increased the current—such as greater ionization (more ions) and greater accelerations of those ions. Each of these can be obtained by varying the strength of the electric field in the wire-skirt gap, or by increasing the area of the atmospheric-electric field interaction (in this case, the lifter perimeter). The results of the past four parts of this section verify that the electric field strength is the key to lifter performance.

### E. A Physical Model

A description of the physical processes which occur to produce thrust when the lifter is activated can be summarized as follows. An electric field is generated between the negatively charged corona wire and the grounded skirt. The strength of this electric field is sufficient to ionize the surrounding atmosphere ($O_2$ and $N_2$, the major atmospheric gasses). Once ionized, the molecules are accelerated along the electric field lines by an electrostatic force according to the relation $F = q\,E$. The ions then impact the skirt (completing the circuit and creating the current measured in § III.D(4)), or they are expelled out the foil end of the lifter, having been forced off the electric field lines by collisions with atmospheric neutrals. The thrust force produced by the lifter emerges from the momentum flux it creates by forcing the ions along the electric field lines. The order-of-magnitude calculation in Appendix B demonstrates the consistency of this model with the predictions of physics. A complete and accurate model will take into account the variations in ionization levels with air temperature and humidity, the effect of ion collisions with neutrals while accelerating through the electric field, the variations in the nonhomogeneous electric field with charge density, and other related variables; the computational complexity involved in creating such a model is prohibitive, and is outside the scope of this project.

## IV. Conclusion

The lifter has been shown (§ III.A) to function not through a production of antigravity, as some among the amateur researchers will claim[1], but through a transport of momentum through the system. This momentum transport was identified as a production and subsequent acceleration of ions, and thereby a production of a wind out the skirt end of the lifter. A physical model of the system, focused on the electric field in the wire-skirt gap, was built based upon the data produced by this project. These were the objectives of the project.

The extremely high voltages needed to produce small amounts of lift (on the order of milliNewtons) by a lifter make the technology impractical for any applications. Operating at voltages lower by an order of magnitude, typical ion thrusters can produce the same amount of thrust. Other than ion-production (useful in some laser and air-filter applications), the lifter does nothing more useful than entertain the hobbyist. Further research should be left to the hobbyists—there is no foreseeable return on investment for more serious research into the phenomenon. The two components of the system—charge acceleration through electric fields, and corona-discharge ion production—are, respectively, well understood by physics and already being researched elsewhere.

This paper's firm denial of antigravity's existence (in the lifter) and of the usefulness of the lifter for practical applications refutes the more misguided of the claims given by the researchers on the internet. While the lifter can continue to be a fun (albeit dangerous) novelty item, it can now be approached as such and not as the revolutionary technology touted by Naudin[2], Ventura[1], et. al.

## References

1. http://www.americanantigravity.com

2. http://jnaudin.free.fr

3. Meek, J.M., and J.D. Craggs. Electrical Breakdown of Gasses. Wiley & Sons: New York. 1987. p. 336

## Appendix A: Summary of Data Collection

The data presented in § III.D was collected all in the same manner. One of the lifters was suspended from the thrust stand, and measurements of the displacement of the spring ware taken as the voltage from the variable-output power supply was varied (from 0 kV to the sparking potential—between 13 kV and 45 kV, depending upon the value of *s*). The gap length was then changed (from 2 cm up through 5 cm), and the data-taking process was repeated. When all gap lengths were tested, the lifter was switched out for another, and the operation was repeated. This happened for each of the four lifters. The data accumulated was transferred to Excel, the displacement values used to calculate thrust force (based on the empirical spring constant), and the data plotted. For the thrust- and current-v-voltage plots, the Excel polynomial fit was used to fit the data; its equations could be reduced to the form elaborated in § III.D(4). For the thrust-v-*s* and the thrust-v-*P* plots, the 15 kV data (chosen because it was a value common to all the data sets) was taken from each data set and plotted together to produce the plots in the corresponding parts of § III.D.

The first four plots on the following page are given as a demonstration of the continuity of the claim that performance-v-voltage goes like the form of the relation of § III.D(4). On the second half of the page are the force measurements for each lifter in each configuration; and on the page after, the current measurements for each configuration.

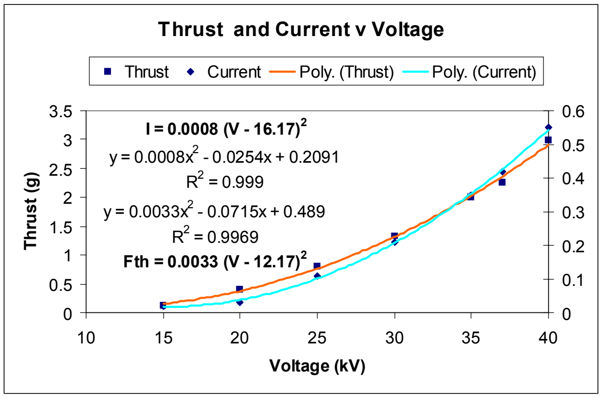


**Figure 9** — $P$ = 30cm, $s$ = 5cm; current (right-hand axis) in mA

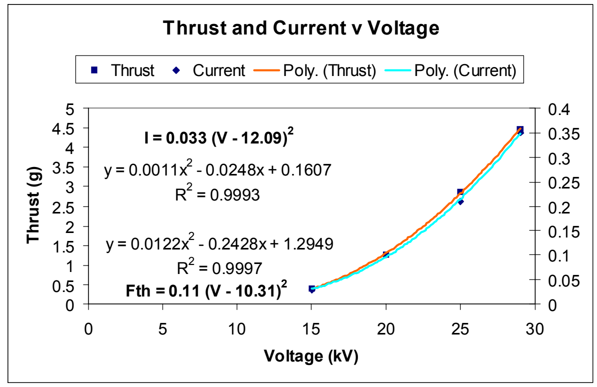


**Figure 10** — $P$ = 60 cm, $s$ = 4 cm; current (right-hand axis) in mA

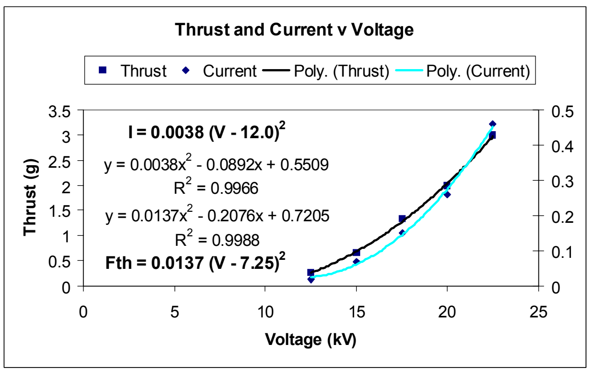


**Figure 11** — $P$ = 60 cm (triangle), $s$ = 3 cm; current (right-hand axis) in mA

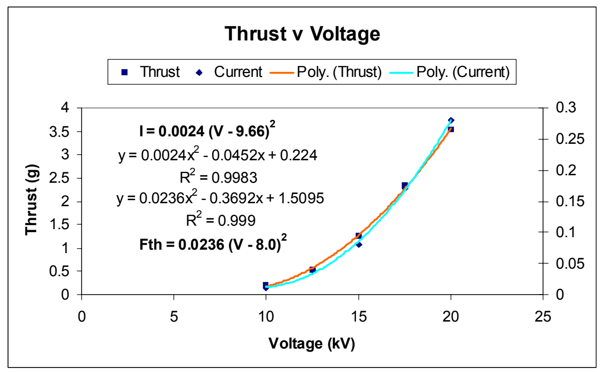


**Figure 12** — $P$ = 120 cm, $s$ = 3 cm; current (right-hand axis) in mA

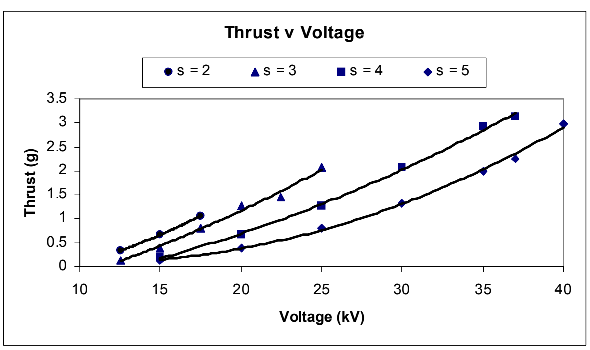


**Figure 13** — Thrust measurements for $P$ = 30cm

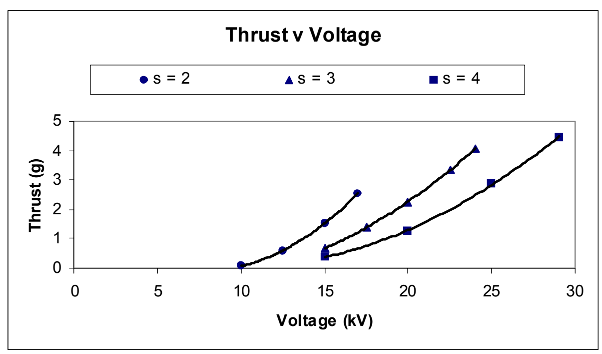


**Figure 14** — Thrust measurements for $P$ = 60cm

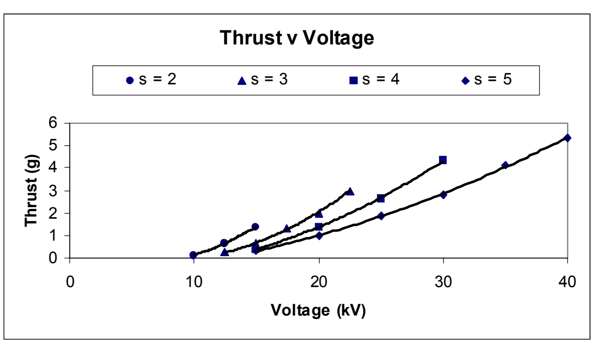


**Figure 15** — Thrust measurements for $P$ = 60cm (triangle)

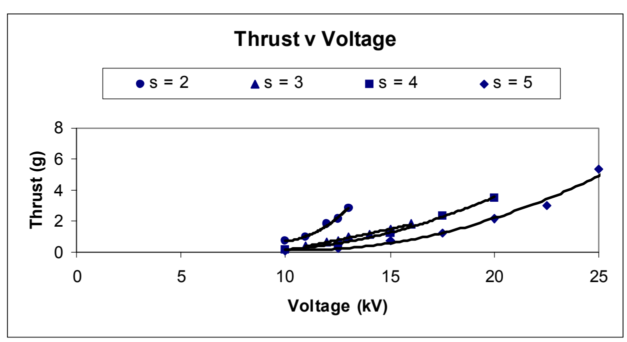


**Figure 16** — Thrust measurements for $P$ = 120cm

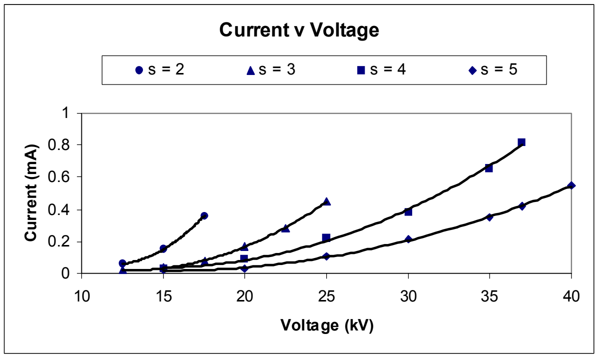


**Figure 17** — Current measurements for $P$ = 30cm

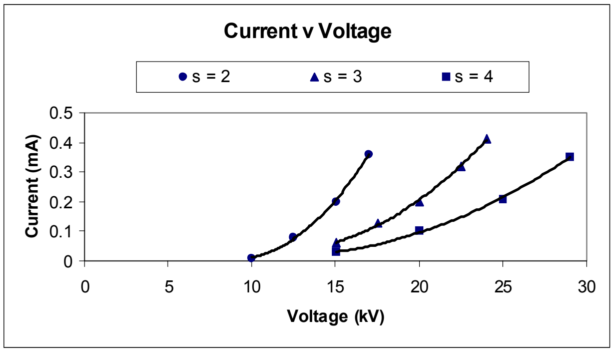


**Figure 18** — Current measurements for $P$ = 60cm

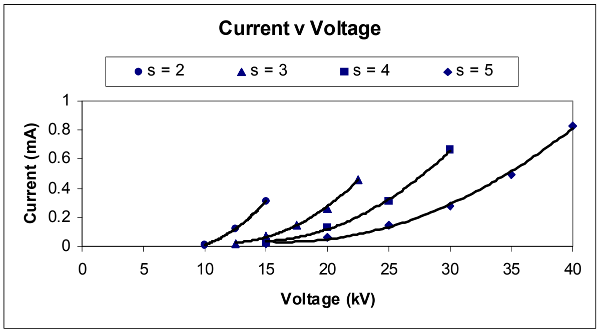


**Figure 19** — Current measurements for $P$ = 60cm (triangle)

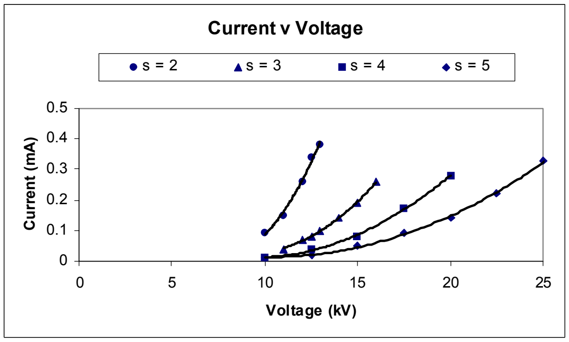


**Figure 20** — Current measurements for $P$ = 120cm

## Appendix B: A Thrust Estimate

The following thrust estimate demonstrates the veracity of the physical lifter model stated in § III.E. The force on a set of $N$ charged particles of charge $e$ in an electric field $E$ is

$$F = eNE = neEV_{ol} \tag{1}$$

where $n$ is the charge density between the skirt and corona wire and $V_{ol}$ is the corresponding volume. The equation can be reduced using the flat-plate approximation of $E = V/s$, where $s$ is the wire-skirt gap separation. The charge number density $n$ can be found from the lifter current, according to where

$$I = neuA \Rightarrow n = \frac{I}{euA} \tag{2}$$

$I$ is the charge-carried current, $u$ is the velocity of a charge carrier, and $A$ is the area through which the charges are carried (approximately the width of the top of the skirt ($w$) multiplied by the lifter perimeter ($P$)). The velocity $u$ can be found via the mobility of ions through air, according to where

$$u = E\mu = E\mu n/n \tag{3}$$

$\mu$ is the ion mobility, and $\mu n$ is given as a chart in Meek & Craggs[3]. Standard atmospheric number density is $2.7\times10^{25}m^{-3}$; $\mu n$ for this case is about $6.5\times10^{21}V^{-1}m^{-1}s^{-1}$. Standard values used in this investigation are $V$ = 20kV, $s$ = 4cm, $I$ = 0.5mA and the dimensions of the lifter were $w$ = 0.5cm, $P$ = 60cm (by way of example). Entering these numbers in equations 1–3, the force value returned is $F$ = 8.5g$_f$. This value is on the order of magnitude of the forces measured; it demonstrates consistency between the model of § III.E and the numbers provided by physics.

3 Meek, J.M., and

J.D. Craggs. Electrical Breakdown of Gasses. Wiley & Sons: New York. 1987. p. 336

1. http://www.americanantigravity.com

2. http://jnaudin.free.fr/