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The Electric Field Energy of an Electret

By Katsuo Sakai

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Therefore, a simple experiment that confirm this phenomenon was performed. As a result, the possibility was recognized by the experiment.

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The Electric Field Energy of an Electret

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1. INTRODUCTION

“Electrostatic generator” has long history and it had been greatly studied in 17th and 18th century, after that it has been almost forgotten because electromagnetic generators become very popular. Today, safety pollution-free and low cost energy is strongly required. Therefore, electrostatic generator must be reconsidered.

The idea behind an electrostatic generator has been defined by lifting the charge to a high potential by a mechanical force against the electric force that acts on this charge. It is impossible for the mechanical force to carry the charge directly. Therefore, the charge is packed into a suitable body. This body is called the charge carrier.

The most popular electrostatic generator that is driven by a mechanical force is the Van de Graaff type electrostatic generator [1].

On the contrary, a new electrostatic generator that is driven by an electrostatic force was recently invented by this author [2]. Even if it is said as a new electrostatic generator, the basic principle of the generation is the same as the former electrostatic generator. Namely, the generator picks up charges into a charge carrier at a low electric potential place and transports the charge carrier to a high electric potential place.

Usually, the magnitude of the electrostatic force is the same when the direction of the electric field is reversed. However. This is true only for a point charge or a charged spherical shape conductor. On the contrary, the magnitude of the electrostatic force that acts on a charged asymmetric shape conductor is different when the direction of the electric field is reversed.

This very interesting new phenomenon was found by a simulation [3] and was recently confirmed by a experiment [4] This phenomenon was named Asymmetric electrostatic force. The new electrostatic generator is driven by Asymmetric electrostatic force in place of a mechanical force.

A basic unit of the new electrostatic generator that is driven by Asymmetric electrostatic force is concretely shown in figure 1.

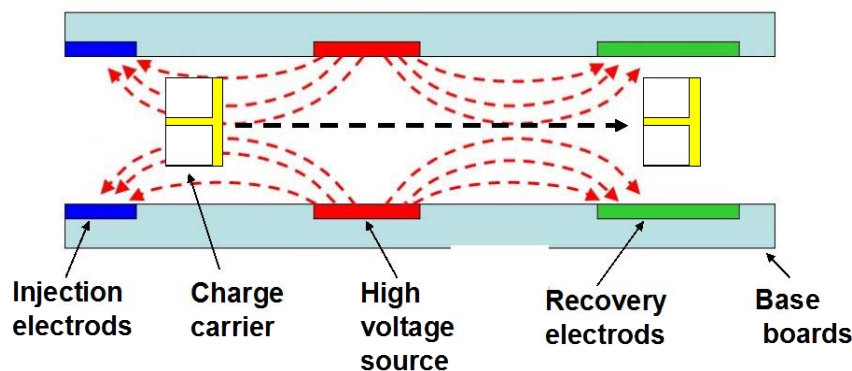


Figure 1 : Schematic layout of a basic unit of the new electrostatic generator

This generator mainly consists of charge injection electrodes, high voltage sources, charge recovery electrodes and charge carrier. Those electrode and the high voltage source are disposed on insulating base board.

The high voltage source give a positive high voltage. The injection electrodes are grounded. The recovery electrodes are kept at a negative low voltage. As a result, the high voltage source and the injection electrodes produce a forward electric field for a negative charge between them. The high voltage source and the recovery electrodes produce a backward electric field for a negative charge between them. The line of electric force is depicted as red arrow dotted lines in figure 1.

A "T" character shape conductor is used as a charge carrier that carries negative charge (electron) from the injection electrodes to the recovery electrodes through the high voltage source.

Asymmetric electrostatic phenomenon produces a large electrostatic force in the forward field and it produces a weak electrostatic force in the backward field. Therefore, the charge carrier gains large kinetic energy in the forward field. Then, it loses some of its kinetic energy in the backward field. As a result, the charge carrier maintains extra kinetic energy, when it arrives between the recovery electrodes. The carried charge can be lifted to a higher potential by this extra energy.

At the first step of the development of the new electrostatic generator, a experiment instrument confirmed that Asymmetric electrostatic force can work as a driving force of the new electrostatic generator. Namely, the charge carrier could reach at the recovery electrode [5]. If Asymmetric electrostatic force did not work, the charge carrier could not reach at the recovery electrode.

And at the second step, it was recently confirmed that charges were really carried from the

injection electrode to the recovery electrode [6]. However, this confirming experiment was performed with using a friction charged Teflon sheet as the high voltage source. And, the charges on the Teflon sheet leaks quickly. As a result, the charge carrier can be transported only one time from the injection electrode to the recovery electrode.

Therefore, at the third step, an electret will be used as the high voltage source, because the charges in the electret will be kept for a long time.

The lifetime of the electret is expected over 10 years at the room temperature.

An electret condenser microphone that was produced 40 years ago can be used today.

However, it is not yet confirmed by a real experiment that the same electret can transport a charge carrier repeatedly for a long time.

This is the subject of this experiment.

II. EXPERIMENT

a) Experimental instrument

Figure 2 shows a photograph of the main part of the experiment equipment and. figure 3 shows the front view of the experimental instrument

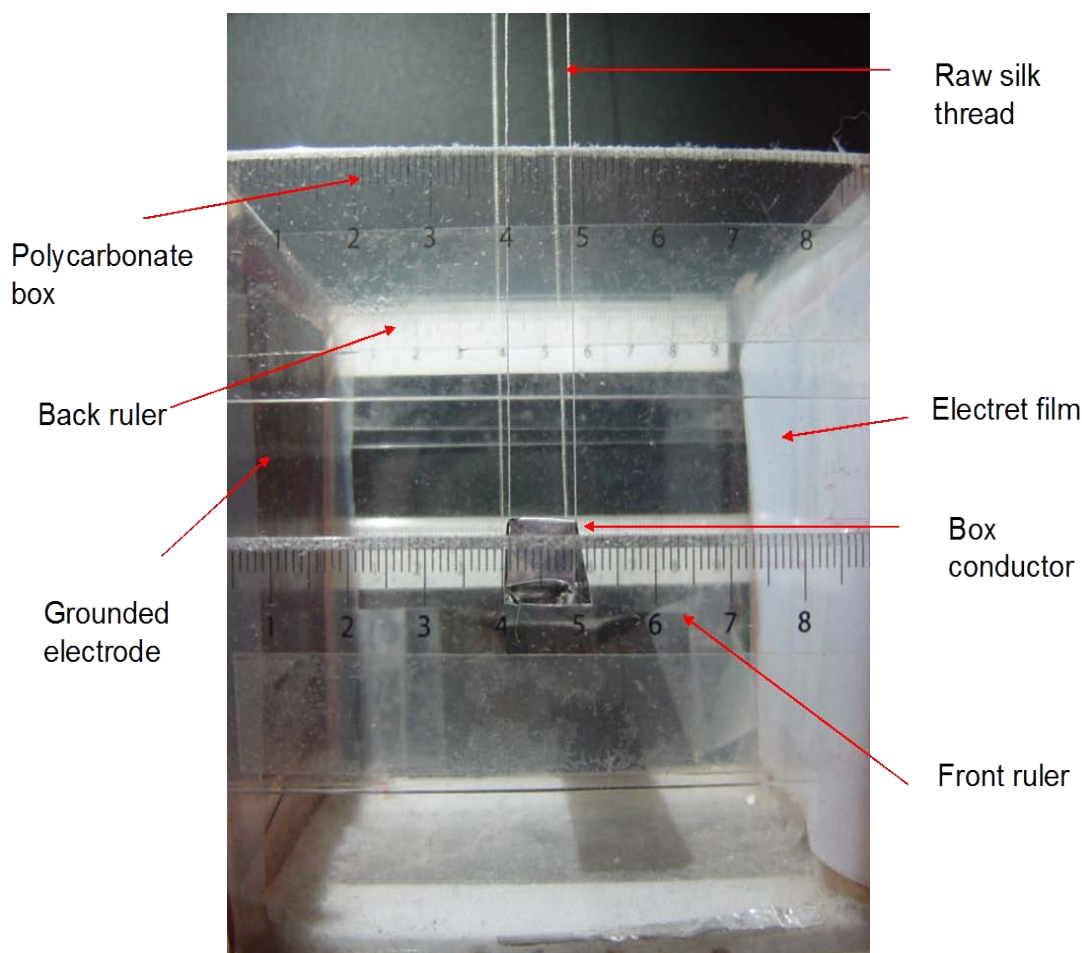


Figure 2 : A photograph of the experiment equipment

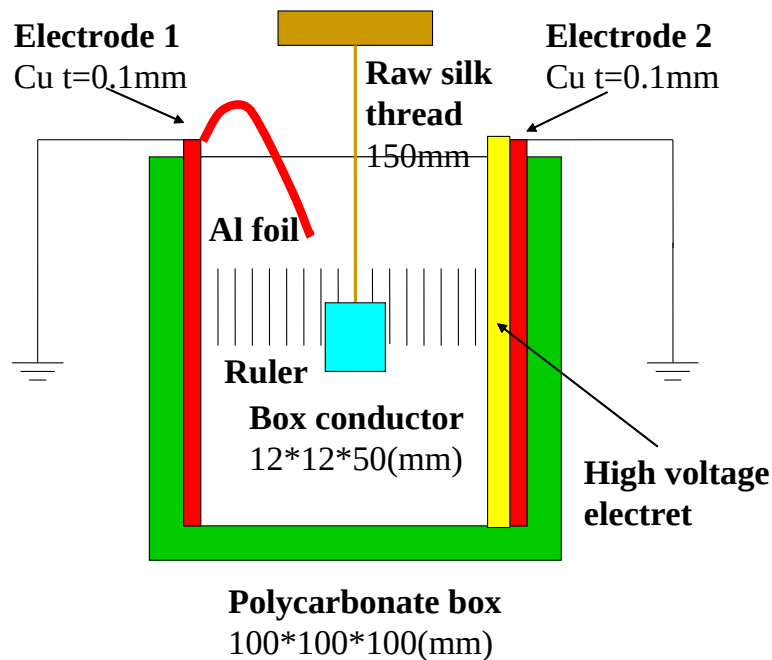


Figure 3 : The front view of the experimental instrument

This instrument consists of two parallel electrodes, an electret and a box conductor. They are arranged in a large box. A large transparent polycarbonate box was prepared. This box protects the small box conductor from wind that was blown from outside.

The thin copper plate 100mm*100mm with a thickness of 0.1mm was attached to the left and right wall of the large box as a left and right electrode. The distance between both electrodes was 100 mm. The both electrodes were grounded. A small box conductor was floated by an insulating raw silk thread with a length of 150mm at the center of both electrodes. The width, the height and the length of the conductor was about 12 mm, 12mm and 50mm respectively. The material of the

conductor was aluminum, and the thickness was 0.1mm.

An electret (TOHFLON ELT SHEET made by TOHO KASEI Co., Ltd. Japan) was attached on the right electrode. This special electret was used as high voltage power supply. The potential of this electret was 14kV. Usually, this high voltage can not gain by one sheet of electret. Therefore, 4 sheets were superimposed. Each sheet had 3.5kV. Charge density of the sheet was about 0.8mC/m^2 . Thickness of the sheet was 75 micron meter. Material of the sheet was fluorine resin.

b) Experimental procedure

Figure 4 shows an explanation drawing of the procedure of the experiment.

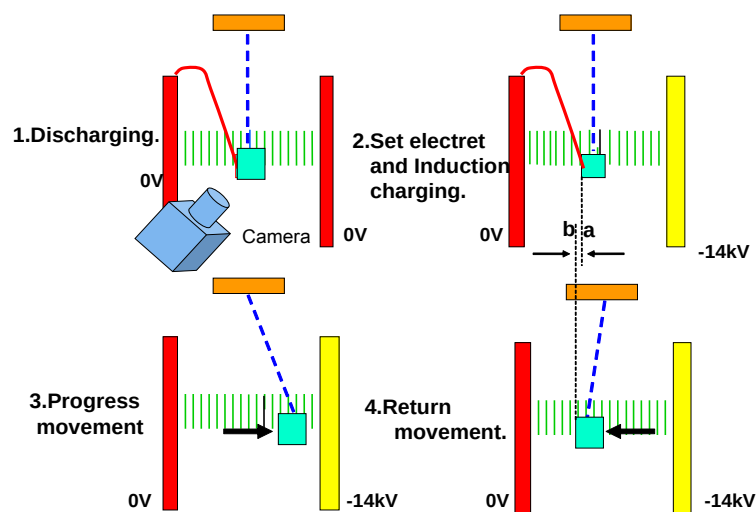


Figure 4 : A schematic of the experimental procedure

The experiment was performed using the following procedure:

- ①. The left and right electrodes were grounded, and the box conductor was touched to the grounded aluminum foil for discharging.
- ②. The electret was superimposed on the right electrode, and the box conductor was touched to the grounded aluminum foil again for induction charging. This position was defined as the start point "a" as shown in figure 4.
- ③. Then, the conductor was progressed toward the right side by the electrostatic force that acts on this charged box conductor.
- ④. Then, the conductor was returned toward the left side by the tension of the thread that acts on this

box conductor. The terminal of the return movement was defined as the return point "b" as shown in figure 4.

- ⑤. Finally, the distance between the start point "a" and the return point "b" was measured from the movie that recorded those movement. The distance a-b was named as the overrun distance.

This experiment was repeated 48 times. These experimental results and the following simulation results will be shown later in the same graph.

III. SIMULATION

Figure 5 shows four different forces that act on the charged box conductor.

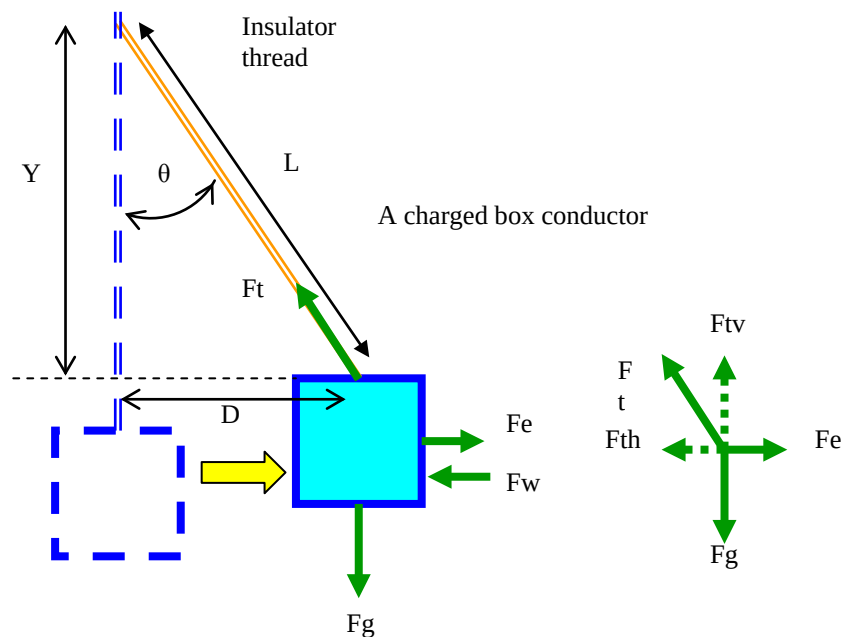


Figure 5 : Schematic diagram of the electrostatic force, the gravity force, the tension and the air resistance force that act on the charged box conductor on progress path

There are four different forces that act on the charged box conductor of moving.

Namely, they are the electrostatic force **fe**, the gravity force **fg**, the tension **ft** and the air resistance force **fw**. The direction of the electrostatic force is x-plus. The direction of the horizontal component of the tension, and the air resistance force is x-minus. The direction of the vertical component of the tension is y-plus and the direction of the gravity force is y-minus. The strength of the vertical component of the tension is the same as the strength of the gravity force always. As a result, there is no force that acts on the charged box conductor in y-direction. Therefore, the charged box conductor is moved by the total force of the electrostatic force, the horizontal component of the tension and the air resistance force horizontally.

The electrostatic force was simulated with two dimensions finite difference method. I learned this method from Dr. Matsubara's papers [7], [8], [9] and wrote a two-dimensional program by myself. The reliability of this handmade simulation program was confirmed by simulating a physics problem that can be solved analytically [4]. Therefore, only the final results of this simulations are represented in this report.

Quantity of charge that was induced in this box conductor was simulated as -6.72nC . Then, the strength of the electrostatic force that acts on this charged box conductor was simulated as 0.722mN .

The strength of the horizontal component of the tension **Fth** can be calculated by the following formula (1) from the moving distance *D*, the thread length *L* and the gravity force *Fg*.

$$F_{th} = F_g \times \tan \theta = F_g \times \frac{D}{Y} = F_g \times \frac{D}{\sqrt{L^2 - D^2}} \quad (1)$$

where $L=150\text{mm}$, and $F_g=10.22\text{mN}$, which was calculated using the measured weight of the box conductor (1.04 g).

The strength of the air resistance force can be calculated by the following formula(2):

$$F_w = \frac{C_d \times \rho \times S \times v^2}{2} \quad (2)$$

where C_d is air resistance constant, ρ is air density, S is the front space of the box conductor and v is velocity of the box conductor. Actually, $C_d = 1.0$, $\rho = 1.2\text{kg/m}^3$ and $S = 0.0006\text{m}^2$ was used in this calculation.

Figure 6 shows the simulated electrostatic force, the calculated horizontal component of the tension that was calculated from the formula (1) and the total force that acts on the charged box conductor. The air resistance force was not represented in this figure because the strength of it is very small.

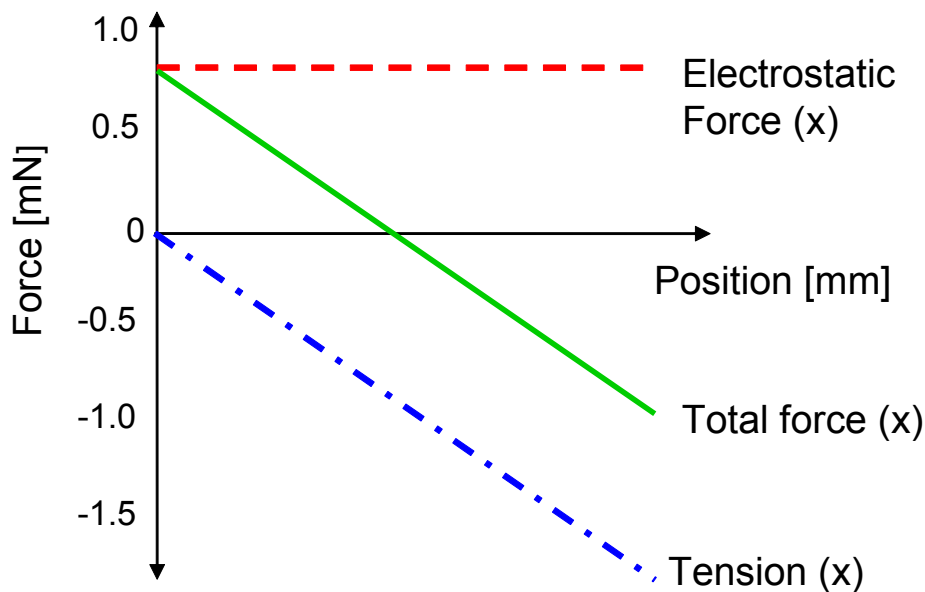


Figure 6 : The electrostatic force, the tension and the total force that acts on the charged box conductor

It is apparent from figure 6 that the charged box conductor was accelerated from 0mm to 11mm and decelerated from 11mm to 22mm. The velocity of this charged box conductor was calculated from the total

force that acts on this charged box conductor by solving a kinetic formula.

Figure 7 shows the calculated velocity of the charged box conductor.

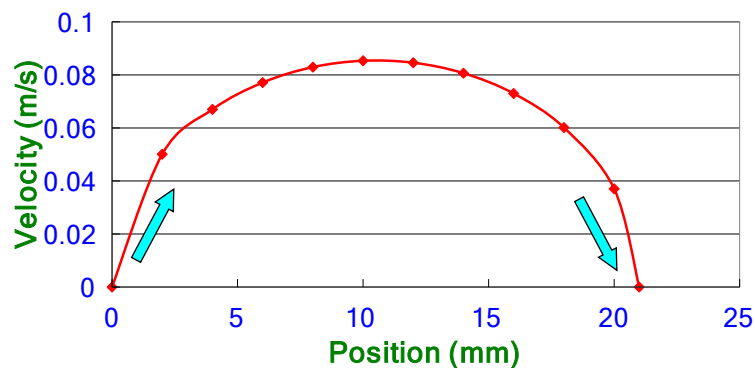


Figure 7 : The calculated velocity of the charged box conductor from the total force that acts on it by solving a kinetic formula

It is apparent from figure 7 that the velocity of the box conductor becomes maximum at 11mm and it decreases to zero at 22mm (This is a simulation result. Actually, the stop positions were less than 22mm or more than 22mm). At this position, the charged box conductor stops, and it starts return movement to left.

On this return path, does the energy of the electric field exist? The energy density W of the electric field can be calculated by the following formula (3) from the strength of the electric field E and the vacuum permittivity, ϵ_0 .

$$W = \frac{1}{2} \epsilon_0 \times E^2 \quad (3)$$

The potential of the electret is 14000 Volts and the distance between the grounded electrode and the electret film is 0.1 m. As a result, the strength of the electric field is 140000 V/m and the energy density W becomes 0.087 J/m^3 . The volume of the progress path of the box conductor is 0.0000132 m^3 . Then, the energy on this progress path becomes $1.15 \mu\text{J}$. However, the used energy w that transported the box conductor was

$15.88 \mu\text{J}$ that was calculated by the following formula (4) from the electrostatic force f and the transport distance s .

$$w = f \times s \quad (4)$$

where $f=0.72\text{mN}$, and $s=22\text{mm}$,

This result means that the box conductor was transported by the energy on the progress path and the around energy. Therefore, if the energy of the electric field is kept still, there is no energy not only in the progress path but also its around area. On the contrary, if the electric field consists of photons [10], energy will be reproduced rapidly.

Accordingly, the return movement of the box conductor was simulated with two different conditions, namely with energy and no energy.

Figure 8 shows the electrostatic forces that are corresponding for the two conditions, the calculated horizontal component of the tension that was calculated from the formula (1). The air resistance force was not represented in this figure because the strength of it is very small.

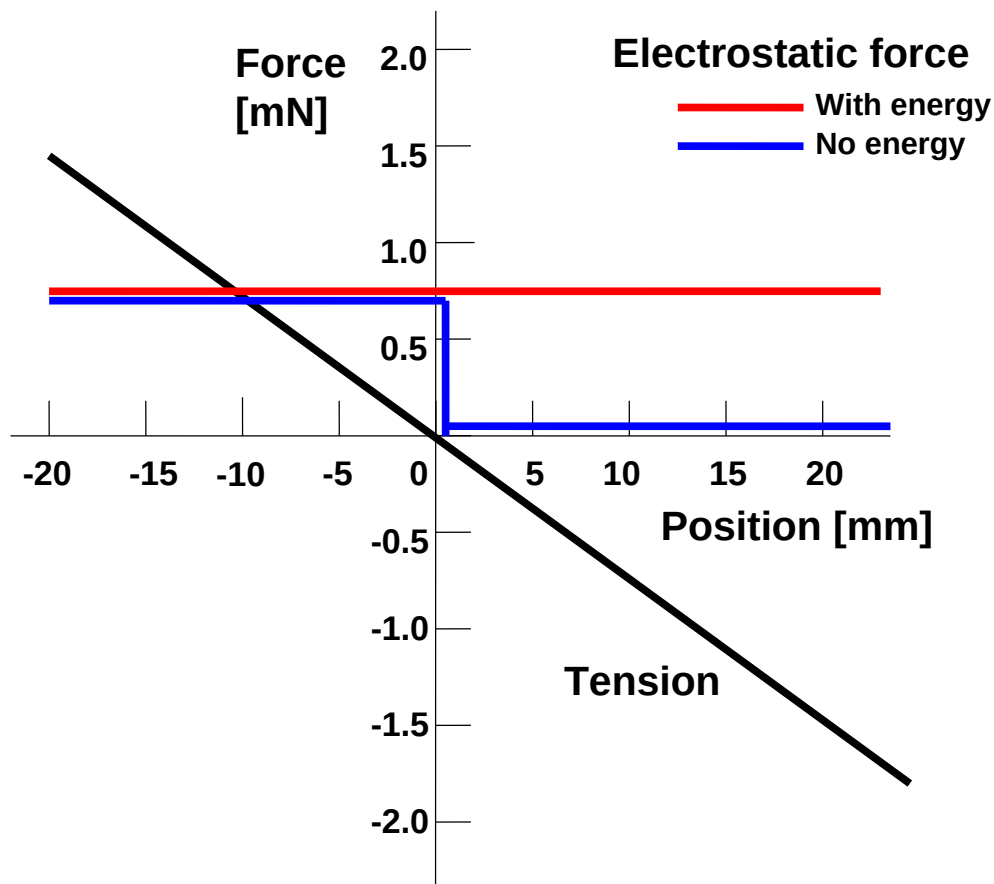


Figure 8 : The electrostatic forces that are corresponding for the two conditions, the calculated horizontal component of the tension that acts on the charged box conductor in the return path. The air resistance force was not represented in this figure because the strength of it is very small

Figure 9 shows the total forces that are corresponding for the two conditions.

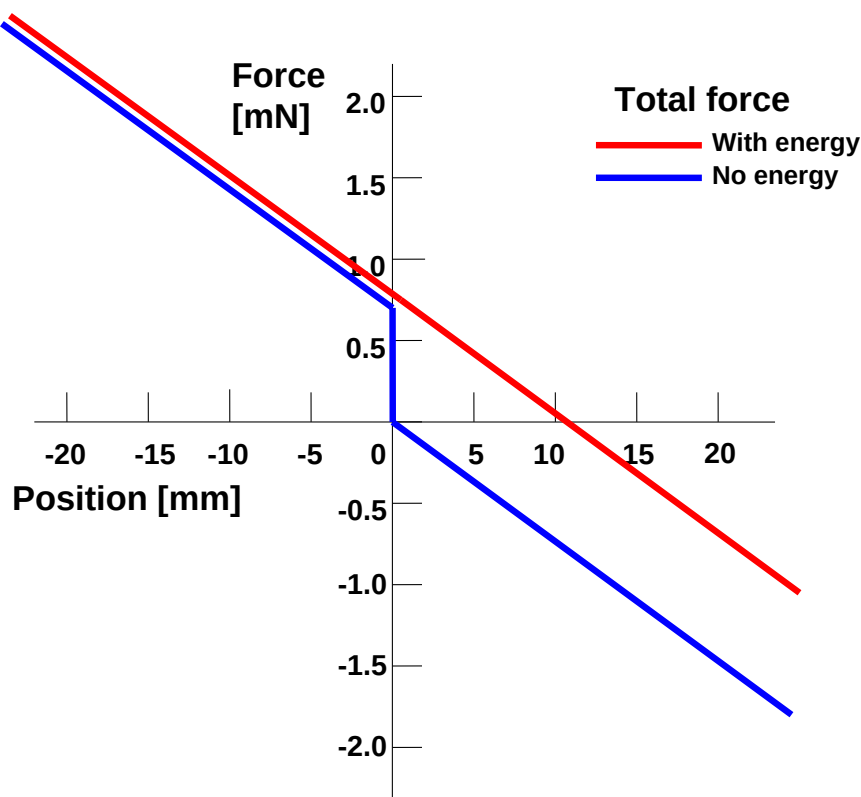


Figure 9 : The total forces that are corresponding for the two conditions. Those forces act on the charged box conductor in the return path

It is apparent from figure 9 that the charged box conductor will be accelerated from 22mm to 11mm and decelerated from 11mm to -22mm on the return path that has an electric field energy. On the contrary, it will be accelerated from 22mm to 0mm, and decelerated from 0mm to -22mm on the return path that has no

electric field energy from 22mm to 0mm. The velocity of this charged box conductor on the two conditions was calculated by solving a kinetic formula.

Figure 10 shows the calculated velocity of the charged box conductor in the two conditions.

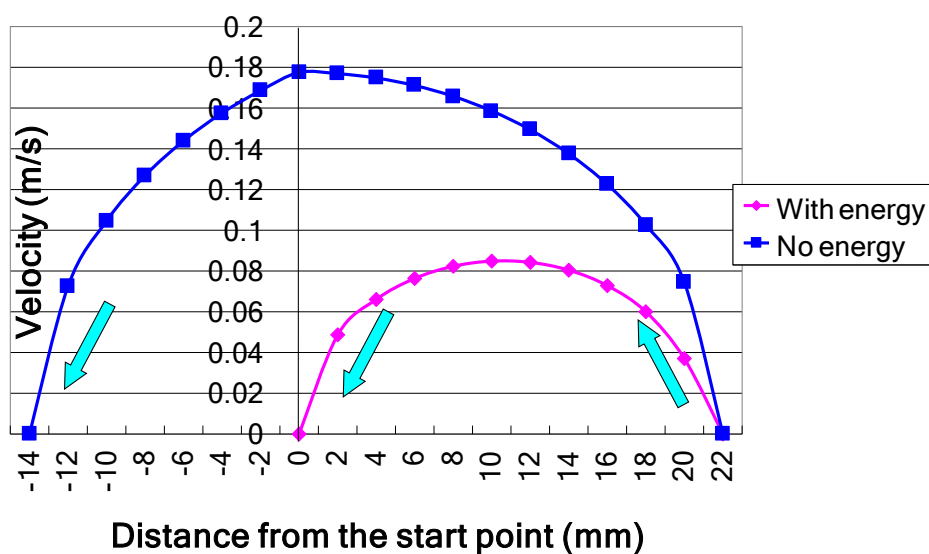


Figure 10 : The calculated velocity of the charged box conductor on the return path of the two conditions of the electric field

It is apparent from figure 10 that the charged box conductor returns to the starting point (0mm) when the electric field energy exists. On the contrary, it overruns the starting point when the electric field energy was lost. The simulated overrun distance is 14mm.

The actual overrun distances were measured by the simple experiment as described before. Figure 11 shows the simulated two overrun distances and the measured 48 overrun distances.

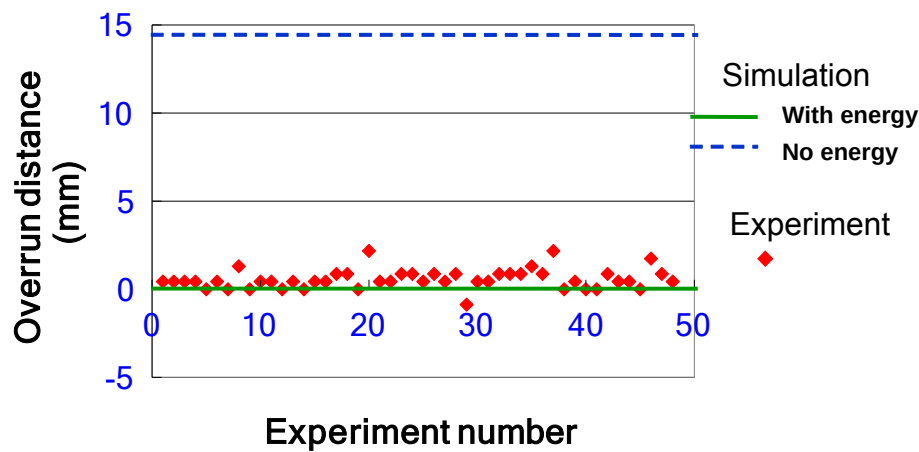


Figure 11 : The simulated overrun distances of the two conditions and the measured overrun distances by the simple experiment

IV. COSIDERATION

It is apparent from figure 11 that the 48 measured overrun distances almost agree with the overrun distance that was simulated with energy. On the contrary, the overrun distances that was simulated without energy, does not agree with the measured overrun distances. Therefore, it should be recognized that there is the same energy on the return path. Namely, the energy of the electric field was not changed even if the charged box conductor was moved by the electric force originated from the electric field.

Of course the measured overrun distance is not zero. The average of the 48 measured distances is 0.7mm.

This a few difference can be explained by a charge leak phenomenon. It is well known that charges on the surface of a conductor leak gradually into the air with time. The leak speed depends on the humidity. The experiment was performed in low humidity. It was 30%RH. This was not perfect condition for preventing the charge leak phenomenon. If 5% charge leaks on the progress path, the simulated overrun distance becomes 1mm or less. This result agrees well with the average of the 48 measured overrun distances.

V. CONCLUSION

It was confirmed by a simple experiment that there is the same energy on the return path even if the electric field energy of the electret on the progress path was used to transport the charged conductor.

This experiments were repeated with the same electret. The repeating were only 48 times. However, we

can expect that the new electrostatic generator that is driven by Asymmetric electrostatic force of the electret will produce electricity for a long time.

VI. ACKNOWLEDGEMENTS

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REFERENCES RÉFÉRENCES REFERENCIAS

1. Handbook of electrostatics (Japan) (1998) p.962.
2. K. Sakai, "Asymmetric Electrostatic Forces and a New Electrostatic Generator", first ed. Nova Science Publish, New York, 2010 p.41-p.54.
3. K. Sakai, "Asymmetric Electrostatic Forces and a New Electrostatic Generator", first ed. Nova Science Publish, New York, 2010 p.25-p.39.
4. K. Sakai, "Asymmetric electrostatic force", Journal of Electromagnetic Analysis and Applications 2014 on the Special Issue on Electromagnetic Field Theory, p.253-p.268.
5. K. Sakai, "A first trial for the new electrostatic generator that will solve the CO₂ problem", *Proceedings of 2014 ESA annual Conference (2014) B3*.
6. K. Sakai, "A New Electrostatic Generator that is Driven by Asymmetric Electrostatic Force", Global Journal of Science Frontier Research, A Volume 15 Issue 5 Version 1.0, 2015.
7. Yasuyuki Matsubara(1992), Improved Finite Difference Expression for Laplace's and Poisson's

Equations on the Surface of Dielectrics, *J. Electrostatics Japan* 16 (1992) 440-442.

8. Yasuyuki Matsubara(1992), A Guide to the Calculation of Electric Field Part III Application of the Finite Difference Method to Electric field in an Oil Tank, *J. Electrostatics Japan* 16 (1992) 530-538.
9. Yasuyuki Matsubara(1994), A Method to Calculate the Potential of Ungrounded Conductors, *Proceedings of the Institute of Electrostatics Japan* (1994) 181-184.
10. Kaoru Takeuchi, "What is the field? . Kodansha Ltd. 2000 in Japanese, pp. 93.



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