The second trial for the new electrostatic generator that is driven by asymmetric electrostatic force

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Abstract— **For a long time, Electrostatics generator has been driven by a mechanical force. On the contrary, a new electrostatic generator was proposed recently. It is driven by Asymmetric electrostatic force in place of a mechanical force. Usually, magnitude of an electrostatic force that acts on an charged sphere conductor does not change when the direction of electric field is reversed. But, if the shape of the conductor is asymmetric, the magnitude changes remarkably. This interesting phenomenon was named as Asymmetric electrostatic force. The new electrostatic generator uses a symmetric conductor as a charge carrier.**

First trial of this new generator was reported on ESA 2014. However, the result was poor, because of unstable movement of the charge carrier. Therefore, this time, an improved instrument was made. And, its performance was measured. Unfortunately, this second trial instrument failed to generate an electricity. The main reason of the failure is that this instrument needs 22kV to move a charge carrier from the injection electrode to the recovery electrode, however, electret can not produce this high voltage.

Therefore, the third trial instrument must be perfectly remade. It will produce electricity by 5kV electret.

I. INTRODUCTION

A. Asymmetric electrostatic force

For a long time, the main purposes of electrostatic research have been electrophotography and electrospray coating. Both technologies make use of fine charged powders, which are moved by electrostatic force. The magnitude of the electrostatic force has been calculated by the well-known Coulomb's formula (1). It is apparent from this formula that the magnitude of this electrostatic force doesn't change when the direction of the electric field turns over as shown in figure 1.

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where f: Electrostatic force that acts on the fine charged powder.

q: Quantity of charge on the fine powder.

E: Intensity of the electric field in which the fine powder is placed.

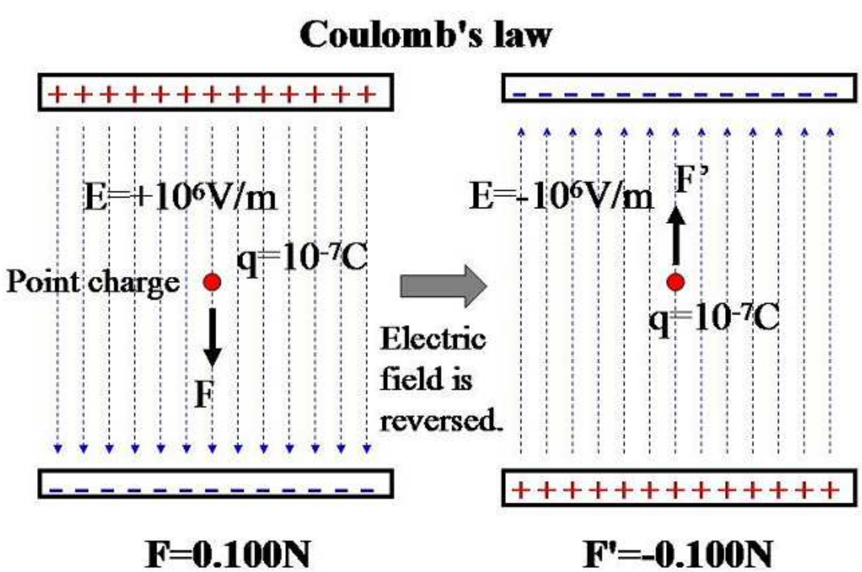

Fig. 1. Electrostatic force that acts on a point charge (Coulom's law)

The application of this formula is limited to point charges and sphere-shaped charge carriers [1]. The charge on a fine powder has commonly been treated as a point charge.

In contrast, a new electrostatic generator that uses a non-spherical charge carrier was presented recently [2], [3]. This generator uses an asymmetric shape conductor as its charge carrier. The electrostatic force that acts on this asymmetric shape charge carrier was both simulated and experimentally measured [4]. As a result, it has become clear that the magnitude of this electrostatic force reduces when the direction of the electric field is reversed as shown in figure 2.

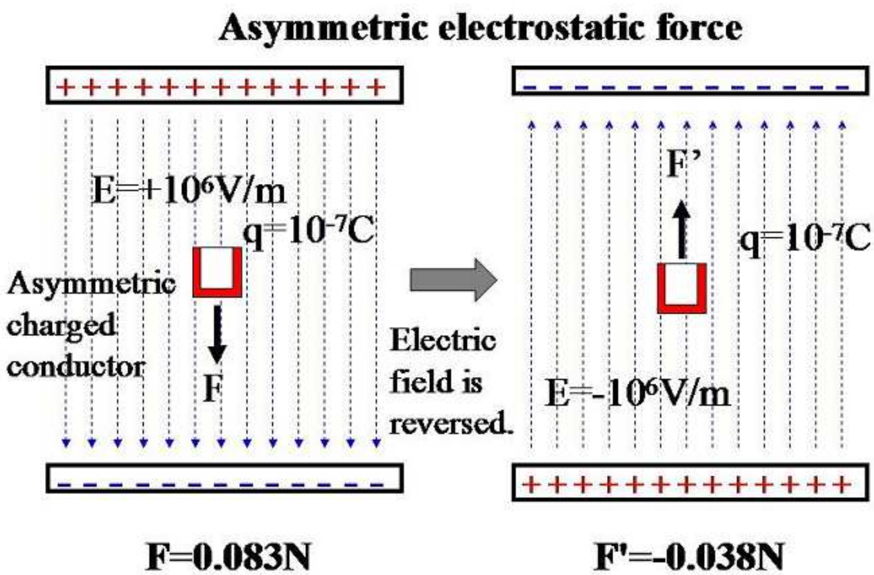

Fig. 2. Electrostatic force that acts on charged box conductor (Asymmetric electrostatic force)

And this changeable electrostatic force was named as Asymmetric electrostatic force unofficially.

And the left side electric field of figure 2 was named as a forward electric field and the right side electric field was named as a backward electric field. In the figure 2, the magnitude of the electrostatic force becomes less than half when the direction of the electric field is reversed. However, this is a simulation result. Actually, the change is not so large in real experiment as shown in figure 3 [4].

The blue lines mean the forward and back ward electrostatic force in the simulation and the red lines mean the forward and backward electrostatic force in the experiment. This experiment was done with a handmade instrument. Therefore, if this experiment would be done with a correct instrument made by a machine, the experiment result may agree with the simulation result. Unfortunately, the following experiment was done with the handmade instrument.

Nevertheless, the new electrostatic generator that is driven by Asymmetric force can be realized with this actual change.

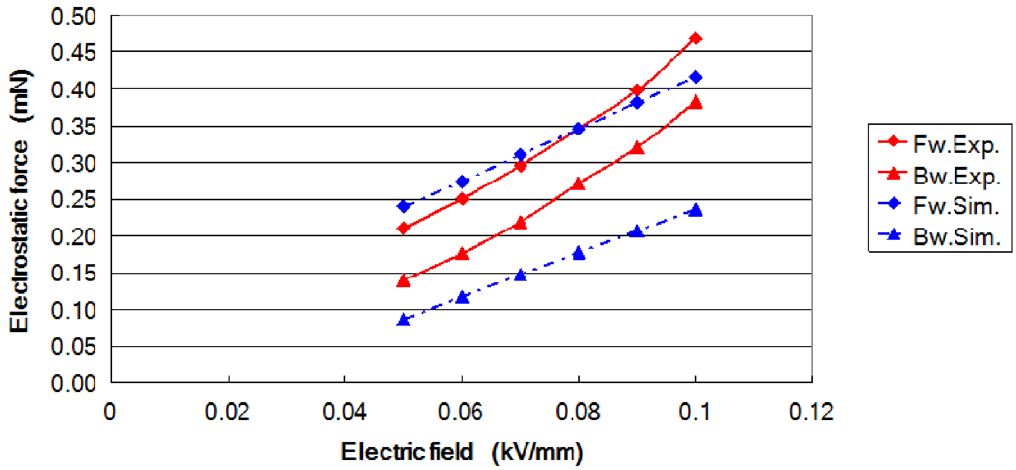

Fig. 3. Electrostatic force that acts on charged asymmetric shape conductor in the forward and the backward electric field (Simulation and experiment results).

B. Basic theory of the new electrostatic generator

The idea behind an electrostatic generator has been defined by lifting the charge to a high potential by 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. We call this body the charge carrier.

The most popular electrostatic generator is the Van de Graaff type electrostatic generator [5]. This was invented by Dr. Van de Graaff in 1931 in the USA. Today, it is used with a large voltage power supply. It can produce ten million volts. In this machine, an insulating belt is used as a charge carrier. Figure 4 shows an example of this generator.

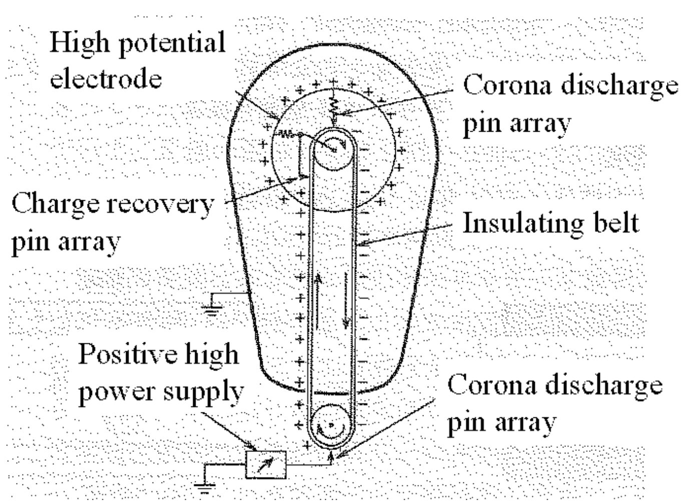

Fig. 4. Schematic layout of the Van de Graaff electrostatic generatorforce

The insulating belt is moved in the direction of the arrow by a motor. The bottom corona discharge pin array places positive ions on the insulating belt. The positive ions on the insulating belt are carried to the high voltage electrode sphere by the mechanical force of a motor. Corona discharge occurs between the negative charge on the recovery pin array and the positive ions on the insulating belt. As a result, the positive ions on the insulating belt are neutralized by the negative corona ions. Then, positive charges (holes) are added to the high voltage electrode sphere.

The principle of this electrostatic generator is shown schematically in Fig. 5.

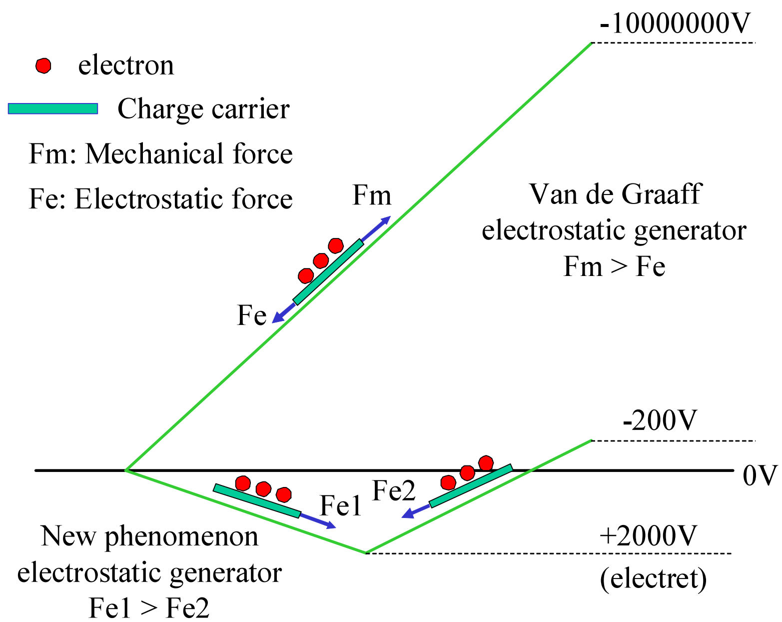

Fig. 5 Schematic explanation of the principles behind the two electrostatic generators.

In figure 5, the bold green line represents the potential, and the blue arrows represent the forces. The small red circles represent the electrons, and the sky blue plates represent the charge carriers. In the Van de Graaff electrostatic generator, the charge carrier is directly transported by a strong mechanical force, Fm, against the electrostatic force Fe.

In contrast, in the new electrostatic generator, the charge carrier is firstly moved in the forward electric field caused by electrets (the high voltage source) according to the electrostatic force Fe1. In this process, the charge carrier gains kinetic energy from the electric field. Then, the charge carrier is moved in the backward electric field, expending the given energy against electrostatic force Fe2.

The shape of this charge carrier is asymmetric. Therefore, Asymmetric electrostatic force acts on this charge carrier. Thus, the absolute value of Fe1 is larger than that of Fe2. As a result, the charge carrier can arrive at a potential that is higher (-200 V) than the initial potential (0 V).

A basic unit of the new electrostatic generator that is driven by Asymmetric electrostatic force is concretely shown in figure 6 .

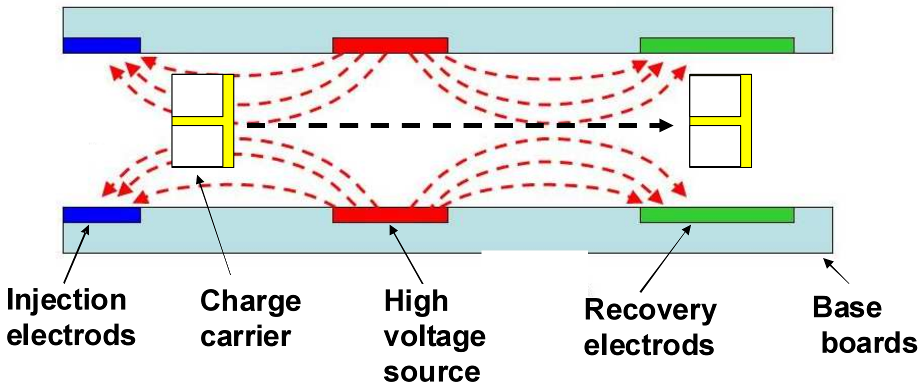

Fig. 6. Schematic layout of a basic unit of the new electrostatic generator.

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 6.

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 electric field and it produces a weak electrostatic force in the backward electric field. Therefore, the charge carrier gains large kinetic energy in the forward electric field. Then, it loses some of its kinetic energy in the backward electric 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.

This is the principle of the new electrostatic generator. This principle is a little different from that of the Van de Graaff electrostatic generator.

The new electrostatic generator cannot produce ten million volts, but it is low cost, safety, stable and producing no CO2. Furthermore, If the lifetime of the electret is infinite, the new electrostatic generator could generate electric energy forever without adding energy. Because, an electric field energy of an electret will not reduce even if the energy would be used to move a charge carrier [6].

Therefore, this new electrostatic generator will solve the CO_2 problem completely.

C. Development histry of the new electrostatic generator

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. If Asymmetric electrostatic force did not work, the charge carrier could not reach at the recovery electrode.

However, it is not yet confirmed that charges had been really carried from the injection electrode to the recovery electrode. If charges are recovered by the recovery electrode, its potential becomes higher.

In this step, a high voltage power supply was used as the high voltage source [7]. However, there was a few leak current from the high voltage power supply to the recovery electrode. As a result, the recovered charges were cancelled by this leak current. This was because they had the other charge polarity and the quantity of them was larger than the recovered charges.

Therefore, the next experiment used a friction charged Teflon sheet as a high voltage source [8]. Because, it does not produce a leak current. However, the result was not perfect because the high voltage of the friction charged teflon sheet quickly decayed.

Consequently, the next experiment must be done with an electret because it does not produce any leak current and its high voltage is kept for a long time.

II. EXPERIMENT INSTRUMENT

Figure 7 shows a photograph of the main part of the experiment equipment. Figure 8 shows the front view of the experiment equipment

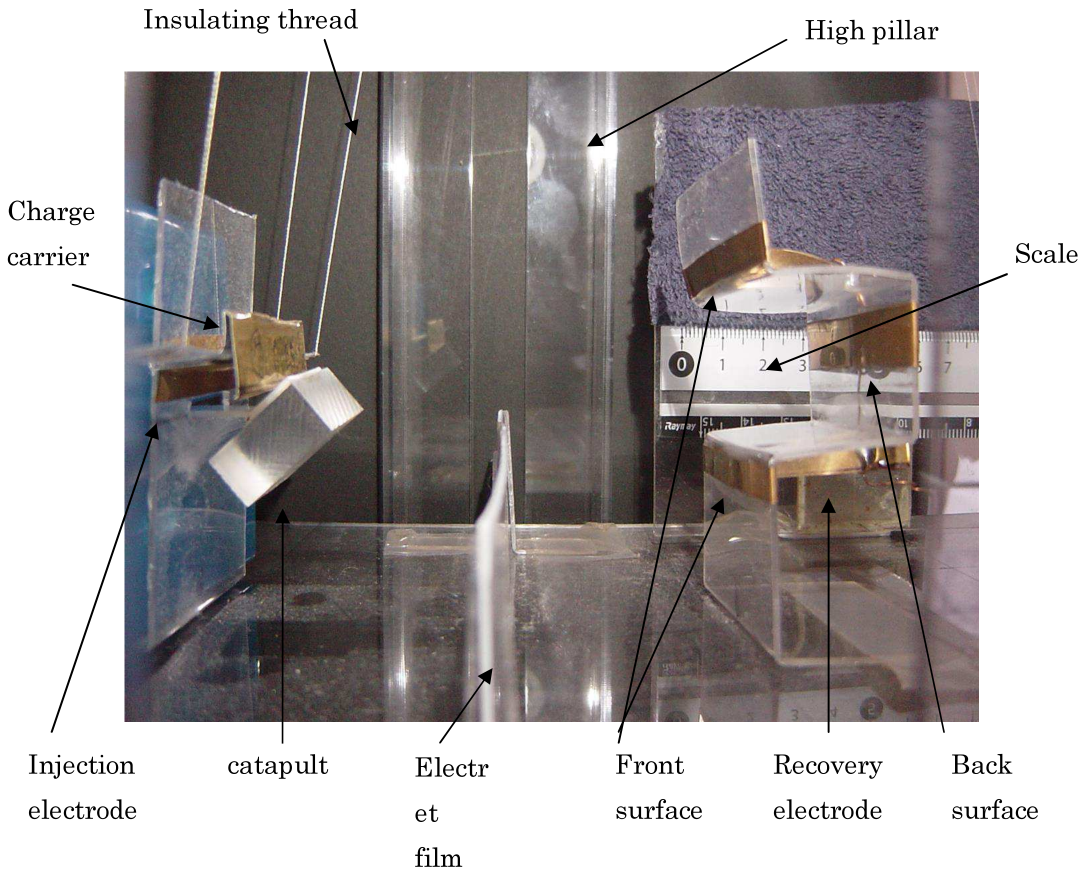

Fig. 7　A photograph of the main part of the experiment equipment of the new electrostatic generator

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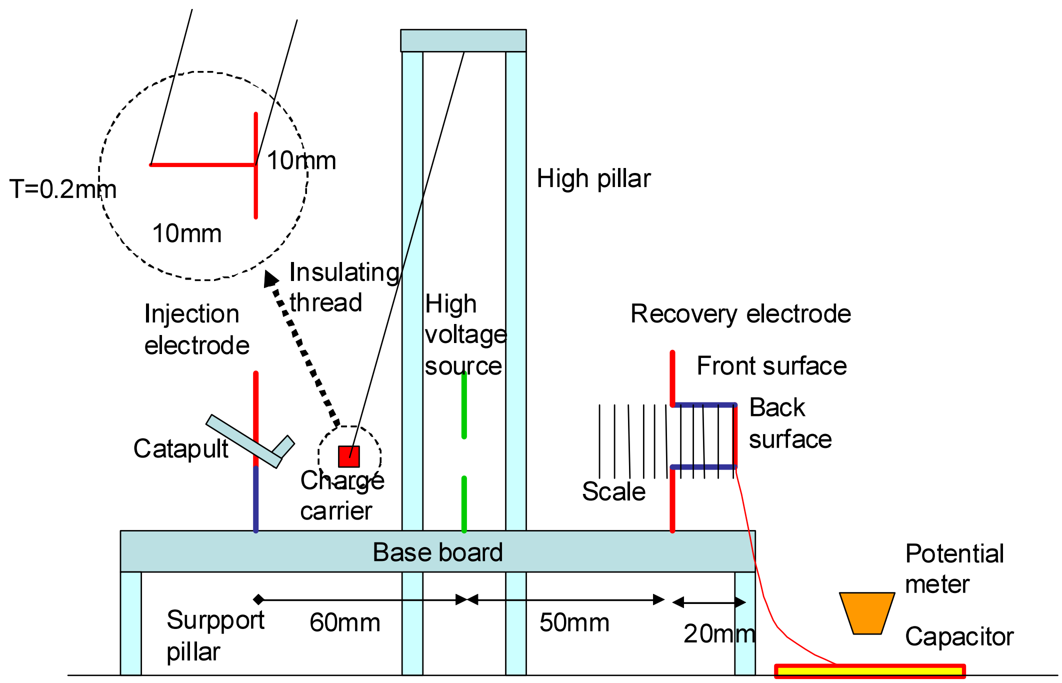

Fig. 8. Front view of the experiment instrument of the new electrostatic generator

This equipment mainly consists of a charge injection electrode, a high voltage source, a charge recovery electrode, and a charge carrier.

On the early stage of this experiment, upper and lower high voltage sources was used as shown in figure 8. However, only lower high voltage source was used as shown in figure 7 on the following experiment. Because just after the insulating threads passed near the upper high voltage source. the threads were strongly pulled back to left by electrostatic force between the thread and the upper high voltage source. Nevertheless, upper and lower two electret sheets will be used on the next remade instrument. Because the strength of the electric fields with two electrets is larger than that with one electret.

The main object of this experiment is to use an electret as high voltage source. However, a correct control of voltage of the electret is very difficult. Therefore, at first step, an electrode and a high voltage power supply was used as high voltage source in place of an electret. The used high voltage power supply was ELSL-30KIN, ELEMENT company, Japan.

The charge injection electrode has a catapult that releases the charge carrier from the charge injection electrode. The charge recovery electrode consists of two front surface electrodes and a back surface electrode. And it was connected to the capacitor. The potential of it was measured by the surface potential meter.

In figure 8, the inside of big circle on the left is an enlarged picture of the charge carrier. The injection and the recovery electrodes were made from one side gold gilding aluminium plates with 0.2mm thickness and the charge carrier was made from one side gold gilding aluminium plates with 1mm thicknesses. As a result, the electrostatic force always acts on the gold surface perpendicularly.

The injection electrode has a catapult at its center. The catapult holds the charge carrier temporary, and releases it automatically.

The charge recovery electrode had front surface electrodes and back surface electrode as shown in figure 8. As a result, the charge recovery electrode can perform semi-Faraday gauge. When the charge carrier touches the back surface of the charge recovery electrode, 90% charge on the charge carrier is transferred to the charge recovery electrode (simulation result).

The charge carrier was hung by the insulating thread at the center of this experiment instrument at first, then it was set on the catapult before an experiment start.

The insulating thread was made from raw silk that is used in Japanese kimono. A scale was placed on rear of the charge recovery electrode as shown in figure 8 for measuring the arriving position of the charge carrier.

The distance between the charge injection electrode and the center of this experiment instrument was 60mm. And the distance between the center of this experiment instrument and the front surface of the charge recovery electrode was 50mm.

The height of the high voltage source (an electrode or an electret) was 25mm. The heights of the lower part and the upper part of the front surface of the charge recovery electrode were 5mm each. The depth of the side part of the charge recovery electrode was 20mm. And the height of the back surface of the charge recovery electrode was 10mm.

The height and the width of the charge carrier were 10mm and 10mm respectively as shown in figure 8. The distance between the charge carrier and the high voltage electrode was 5mm when the charge carrier passes above the high voltage electrode. The height of high pillars and the support pillars were 500mm and 100mm respectively. The length of the threads were 365mm.

The charge carrier consists of a T character shape one side gold gilding aluminium and a PET resin sheet. The weight of the aluminium parts was 0.79g and the weight of the sheet was 0.42g. This sheet supported the aluminium parts and it was hung by the insulating thread. As a result, this charge carrier was always maintained as electrically floating condition.

The surface potential meter (SHISHIDO ELECTROSTATIC: STATIRON-DZ 3, Japan) required a large measurement area, namely 20cm*20cm. Therefore, the capacitor was made with the same area by hand. It was made with a bottom aluminium sheet, a PET film and a top aluminium sheet. The thickness of the film was 1.0mm and the Relative permittivity is 3.2. As a result, the electric capacitance of this capacitor becomes 1100pF.

In the second step of this experiment, an electret was used as a high voltage source. The electret was made from a Teflon film (SUKAIBUDO tape MSM100, CHUUKOU chemical industry, Japan). The thickness of the film is 0.05mm. This film was charged by 9 needles charger. The needles consist of insect pins. The height of the needles from the base plate is 30mm.

Ⅲ.Experiment results

A: The high voltage source was an high voltage power supply,

At the first experiment, the injection electrode and the high voltage electrode were grounded. And the recovery electrode was connected with the upper aluminium plate of the capacitor. The lower aluminium plate of the capacitor was grounded. In this situation, there was no electric field.

Then, the charge carrier was set on the catapult of the injection electrode. As a result, the left edge of the charge carrier touched into the injection electrode. Therefore, if there is an electric field, induction charge will be inputted to the charge carrier from the injection electrode.

At the first step without an electric field, the weight of the catapult of the charge injection electrode was picked up by hand.

As a result, the charge carrier was released from the catapult automatically. And It started to move to right direction by a tension of a thread against an air resistance. The charge carrier passed above the high voltage electrode that was grounded. And it passed through the upper and lower front surfaces of the charge recovery electrode. But, it never reached the back surface of the charge recovery electrode.

The distance between the center of this equipment and the charge injection electrode was 60mm and the distance between the center and the front surface of the charge recovery electrode was 50mm. Therefore, the charge carrier can pass through the front surfaces against an air resistance. The arriving position of the charge carrier was about 55mm from the center. This result means that, the lost distance by the air resistance was about 5mm.

However, the distance between the center and the back surface of the charge recovery electrode is 70mm. Accordingly, the remained distance to the back surface of the recovery electrode was 15mm. Therefore, Asymmetric electrostatic force must add an energy that can transport the charge carrier longer than15mm.

At the next steps with electric field, a high voltage was applied to the high voltage electrode from the high voltage power supply. As a result, the forward electric field was produced between the injection electrode and the high voltage electrode, and the backward electric field was produced between the high voltage electrode and the recovery electrode.

In this forward electric field, induction charges were injected from the grounded charge injection electrode to the charge carrier . An strong electrostatic force acts on this charge. Then, the charge carrier was released from the catapult and It started to move to right direction by this strong electrostatic force and the tension of the thread, against the air resistance force.

If there is strong electric field, the charge carrier will pass above the high voltage electrode, and hit the back surface of the charge recovery electrode.

When the charge carrier hit the back surface of the charge recovery electrode, charges that was carried by this charge carrier was almost recovered to this charge recovery electrode automatically.

After that, the charge carrier returned to the charge injection electrode automatically. Because the distance between the center and the back surface was 70mm and the distance between the center and the charge injection electrode was 60mm.

Then, the returned charge carrier will get a next injection charge and hit the recovery electrode again. This hitting and return movement will be repeated.

A capacitor that has 1100pf was connected between the charge recovery electrode and the ground. Therefore the surface potential of the capacitor changes from 0 volts to about +3 volts, when a +3nC charge (Simulation result) is recovered from the charge carrier to the charge recovery electrode by one hitting.

However, the minimum unit of this surface potential meter is 10 volts.

Therefore, the potential difference that is more than 10 volts is required to confirm the charge transfer from the grounded charge injection electrode to the charge recovery electrode.

Namely, the charge carrier must hit the back surface of the charge recovery electrode more than 4 times continuously.

At first, -8kV was applied to the high voltage electrode, but the charge carrier did not hit the recovery electrode. Next, -10kV, -12kV and -14kV were applied, but the charge carrier did not nit.

However, when -16kV was applied, the charge carrier strongly hited 67 times consecutively.

Therefore, the potential of the capacitor was expected to be positive. Because the charge carrier carried some positive charge from the injection electrode to the recovery electrode. Nevertheless, the potential of the capacitor was -0.65kV. The leak current from the high voltage electrode to the recovery electrode raises the potential of the capacitor from 0kV to -0.10kV on the same time. Therefore, this result means that -550nC was recovered from the charge carrier to the recovery electrode. As a result, the average charge quantity of the one hitting becomes -8.2nC.

This result was not expected. Because a simulation expected that +3nC will be injected from the injection electrode to the charge carrier. This unexpected result means that Corona discharge occurred between the positive charged charge carrier and the negative high voltage electrode when the charge carrier passed above the high voltage electrode.

The simulation expected that over 20kV is need to transport the charge carrier to the back surface of the recovery electrode. Therefore, this Corona discharge must be stopped when the applied voltage is lower than 20kV.

This Corona discharge voltage depends on the distance between the charge carrier and the high voltage electrode. Hence, the Corona discharge voltages were measured with different distances between the charge carrier and the high voltage electrode. Figure 9 shows this results.

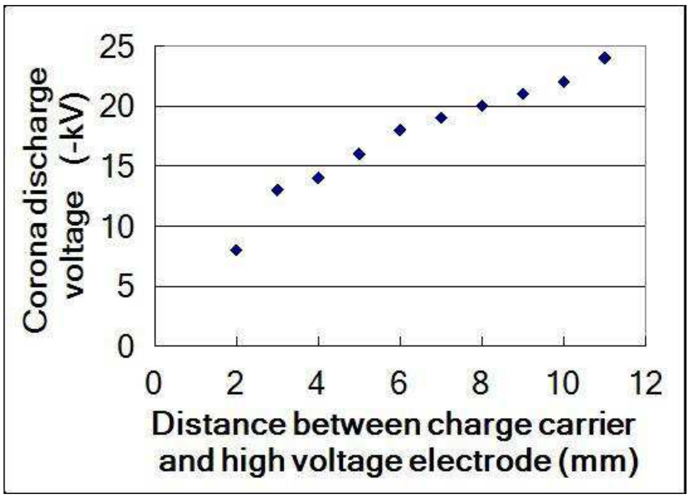

Fig. 9. Corona discharge voltage as a function of the distance between the charge carrier and the high voltage electrode.

The distance between the charge carrier and the high voltage electrode was selected to be 11mm from figure 9. Because the Corona discharge voltage of this distance is -24kV and the needed high voltage may be -21kV or -22kV.

The applied high voltage to the high voltage electrode was raised from -10kV to -24kV and the arriving point of the charge carrier was measured by movies. Figure 10 shows the results.

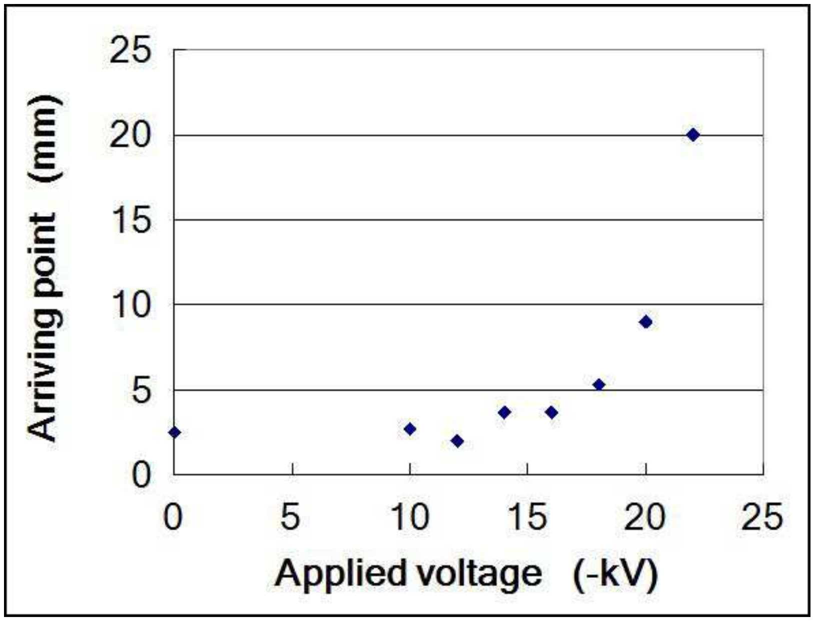

Fig. 10. The arriving point of the charge carrier as a function of the applied voltage of the high voltage electrode.

In figure 10, 0mm represents the front surface position of the recovery electrode, and 20mm represents the back surface position of the recovery electrode. When the applied voltage was -10kV or -12kV, the arriving point of the charge carrier is almost same to the arriving point on 0kV. And when the applied voltage was -14kv, -16kV and -18kV, the arriving point extended a little. Then when the applied voltage was -20kV, the arriving point extended remarkable. Finally when the applied voltage was -22kv, the arriving point extended to 20mm. Namely, the charge carrier hit the back surface of the recovery electrode. However, the consecutive hitting was only three times. Therefore, quantity of transported charge was not measured by the potential change of the capacitor. Nevertheless, the charge carrier weakly touched to the back surface of the recovery electrode. Therefore, this phenomenon must be the positive charge (+3nC) transporting. Because, when the applied voltage was -24kV, the charge carrier strongly hit the back surface of the recovery electrode consecutively. The quantity of the charge of this charge carrier was measured as -26nC at every hitting. Therefore, this result means that a Corona discharge occurred between the charge carrier and the high voltage electrode when -24kV was applied.

As a result, the needed high voltage of an electret was decided to be -22kV when the distance between the charge carrier and the high voltage source is 11mm.

B: The high voltage source was an electret,

The Teflon film was charged by the 9 needles Corona charger. The surface potential of this charged

Teflon film was measured by the surface potential meter. Figure 11 shows the result.

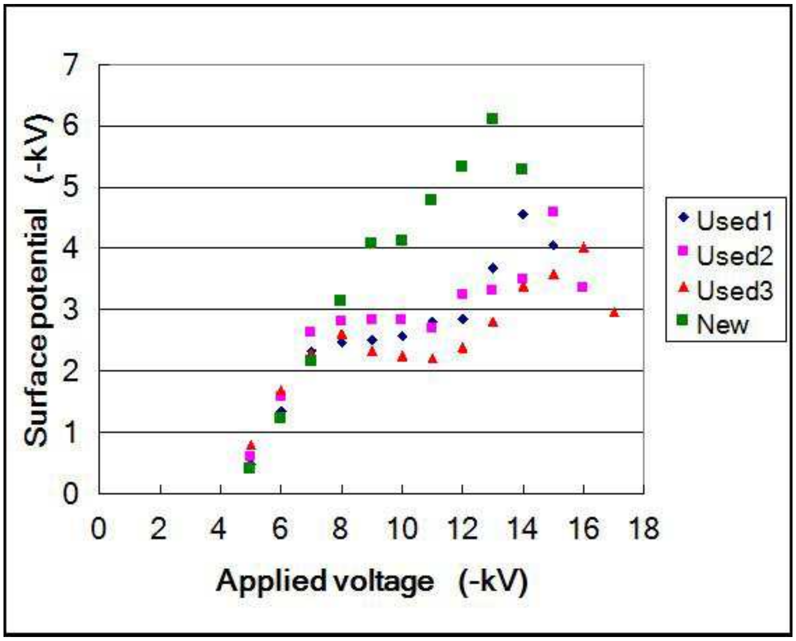

Fig. 11. The surface potential of the new and used Teflon films as a function of the applied voltage of the 9 needles Corona charger.

It is apparent from figure 11 that the surface potential of the Teflon film rises from 0kV to -6kV in proportion to the applied voltage of the charger. And it is apparent too that the surface potential of an used Teflon film can not rise over -5kV even if very high voltage was applied to the charger. Therefore, using the new film was decided. And -11kV was selected as a reasonable voltage of the charger. Because, -12kV and -13kV may destroy the film a little and -11kV can produce -5kV as a surface potential of the film.

It was expected that -22kV will be realized by four films piling up. Therefore, four films that were charged by -11kV were piled up one by one on the base aluminium plate. The surface potential of each charged films and the piled film were measured by the surface potential meter. Figure 12 shows the results.

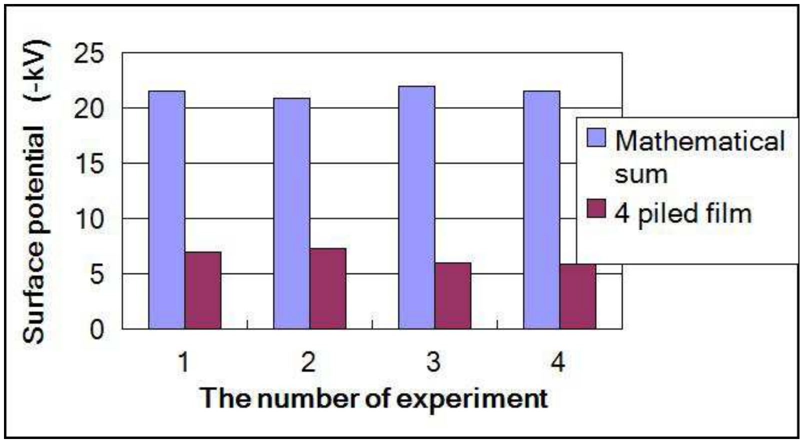

Fig. 12. The mathematical sum of the surface potential of the four charged films, and the measured surface potential of the four charged films that were piled one by one.

The mathematical sum of the surface potential of the four films were about -22kV at four times experiments each. Nevertheless, unfortunately the actual surface potential of the piled films was only -6kV or -7kV. Then, It will be expected that the surface potential of the piled five films is higher than the surface potential of the piled four films. But, actually the surface potential of the piled four films was not higher than the surface potential of the piled three films. Figure 13 shows the average result of six times experiments. Therefore, five film piling is meaningless.

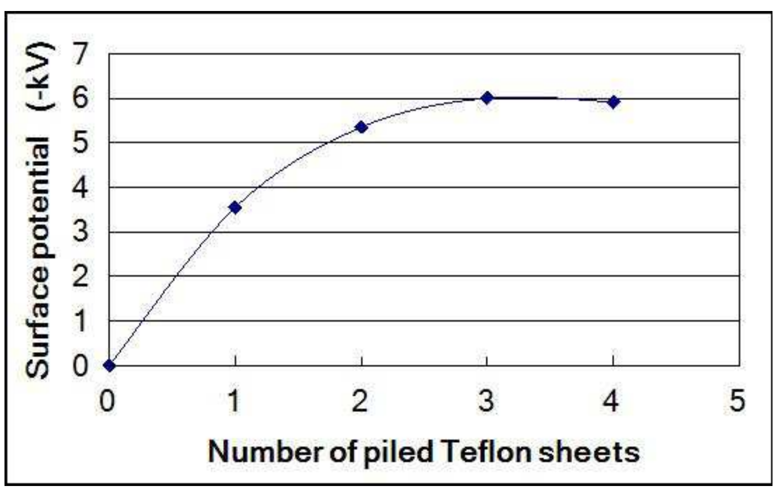

Fig. 13. The surface potential of the charged Teflon sheets as a function of the number of piled Teflon sheets.

Ⅳ。Cosideration

The -22kV electret was not realized with the Teflon sheet that has 0.05mm thickness, and the 9 needles charger that has 30mm height from the base plate. However, it may be realized with more thicker Teflon film, and more higher charger. Nevertheless, there was the other big problem when -22kV was applied to the high voltage electrode. Namely, The effect of Asymmetric electrostatic force reduced with a few experiment, but the effect automatically recovered on the next morning.

This phenomenon means that the PET base plate was polarized temporarily. Therefore, -22kV can not be used anyway. On the contrary, the commercial machine will be realized with -0.5kV electret. Because, the size of the one unit of this machine will be about 1mm. Unfortunantely, I can not make a 1mm size unit by my hand. Therefore, a 10mm size unit with -5kV electret will be reasonable selection.

Ⅴ。Conclusion

The improved instrument of the new electrostatic generator that is driven by Asymmetric electrostatic force needs -22kV for the potential of the high voltage source. A high voltage power supply can easily produce this potential, but the leak current from the high voltage electrode to the recover electrode is larger than the charges transported by the charge carrier.

As a result, this condition can not produce any electricity. Therefore, an electret that does not produce any leak current must be used as the high voltage source. But, one electret film can not produce this high potential. Therefore, four electret films were piled up.

The mathematical sum of the surface potential of each four films becomes -22kV, but unfortunately the actual surface potential of the four piled films was only -7kV.

Therefore, this experimental instrument must be perfectly remade to be used by -5kV electret.

REFERENCES

[1] David Halliday, Robert Resnick, Jearl Walker, Fundamentals of Physics. 6th edition Japanese version Chapter “Electric Charge“ question 1, Wiley & sons. Inc.

[2] K. Sakai, et al., Electrostatics: Theory and Applications, first ed. Nova Science Publish, New York, 2010 (Chapter 1)

[3] K. Sakai, Asymmetric Electrostatic Forces and a New Electrostatic Generator, first ed. Nova Science Publish, New York, 2010

[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] Handbook of electrostatic, Japan, (1998) 962

[6] K. Sakai, "The Electric Field Energy of an Electret", Global Journal of Science Frontier Research, A Volume 15 Issue 6

Version 1.0, 2015

[7] K. Sakai, “A first trial for the new electrostatic generator that will solve the CO_2 problem”, Proceedings of 2014 ESA annual Conference (2014) B3

[8] 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

Key words

Electrostatic Generator; Asymmetric Electrostatic Force; Corona discharge; Electret: Teflon