A simple experiment result that confirmed asymmetric electrostatic force.

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Abstract— **If shape of charged conductor is sphere, the magnitude of the electrostatic force that acts on this conductor does not change when the direction of the electric field is reversed. However, if the shape is not sphere, the magnitude changes due to shape.**

This is only a simulation result and not be confirmed by real experiment yet. Therefore, electrostatic forces that act on 19 different shapes charged conductors are measured by a simple experiment. The results agree well with simulation results.

I. INTRODUCTION

Electrostatic forces that act on 19 differently shaped charged conductors were simulated with the two-dimensional finite difference method [1]. And, the following very interesting phenomenon was found. Namely, if the shapes of conductors are asymmetric in the electric field direction, the magnitude of the force that acts on those conductors changes when the direction of the electric field is reversed.

The 19 differently shaped conductors were made from one simple conductive plate. The width of this plate is 10.5 mm, the length is 100.5 mm, and the thickness is 1.5 mm.

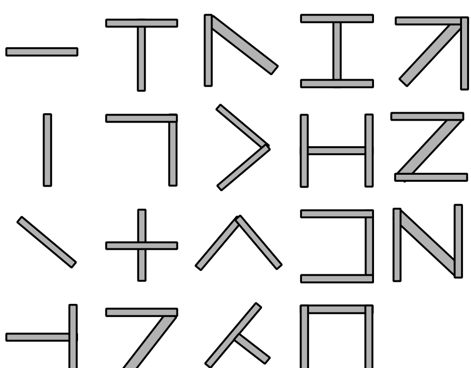

Fig. 1. Shapes of 19 different conductors.

Figure 1 shows the shapes of the 19 different conductors. They were placed in two uniform electric fields whose direction is opposite each other. And, electrostatic forces that act on those charged conductors were simulated one by one. Then, the ratio of the force of the reversed electric field to the force of the original electric field was calculated.

Figure 2 shows the calculated ratio.

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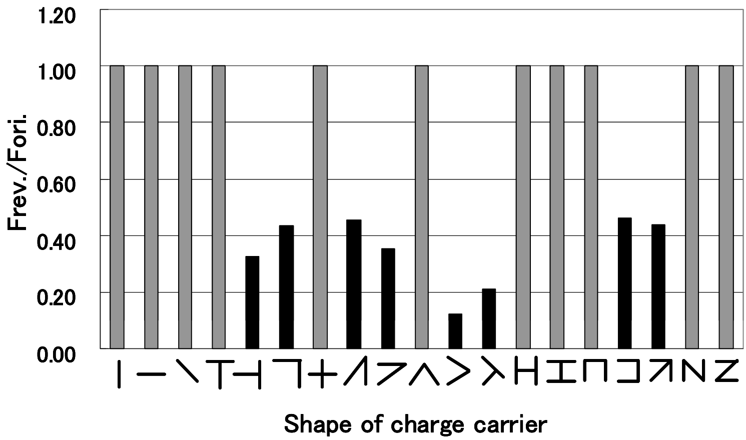

Fig. 2. The ratio of the force of reversed field to the force of original field. Both forces act on the 19 different shape charged conductors.

The magnitude of the force of 11 of the charged conductors (gray bars) did not change when the direction of the electric field was reversed. The shapes of those 11 charged conductors have common characteristics, namely, they are symmetric in the electric field direction.

On the contrary, the shapes of the other 8 conductors (black bars) are asymmetric in the electric field direction. Thus, the magnitude of the force that acts on those 8 conductors changes when the direction of the electric field is reversed.

The object of this paper is to confirm this phenomenon. If experimental result agree well with simulation result (figure 2), then it is apparent that this new phenomenon exist really.

II. EXPERIMENT

Experiments were performed in which the magnitude of the force that acts on 19 different shaped charged conductors in original and reversal fields was measured. The shape and size of the 19 conductors for this experiment were almost same with the shape and size of the 19 conductors that was used in the simulation without its thickness. The width, the height and the length of the conductor was about 10 mm, 10mm and 50mm respectively. The material of the conductors was aluminum, and the thickness was 0.2 mm

The thickness was changed from 1.5mm for simulation to 0.2mm for experiment, because the gravity force of 1.5mm thickness conductor is too heavy when it is compared with the electrostatic force that acts on this conductor.

Figure 3 shows the front view of the experimental instrument

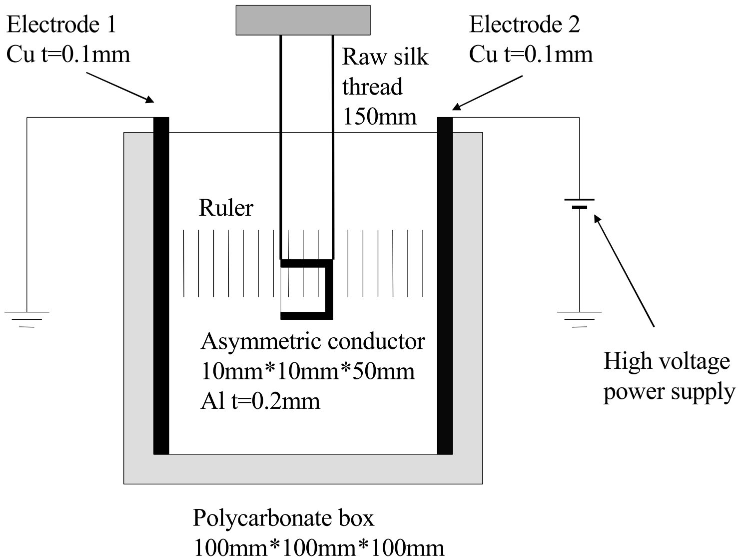

Fig. 3. The front view of the experimental instrument

This instrument consists of two parallel electrodes and a ruler. The distance between both electrodes was 100 mm. One of them was connected to a high voltage power supply, and the other was grounded. The different shape conductor was hung by an insulating raw silk threads at the center of the two electrodes. The position of the conductors was measured by a ruler.

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

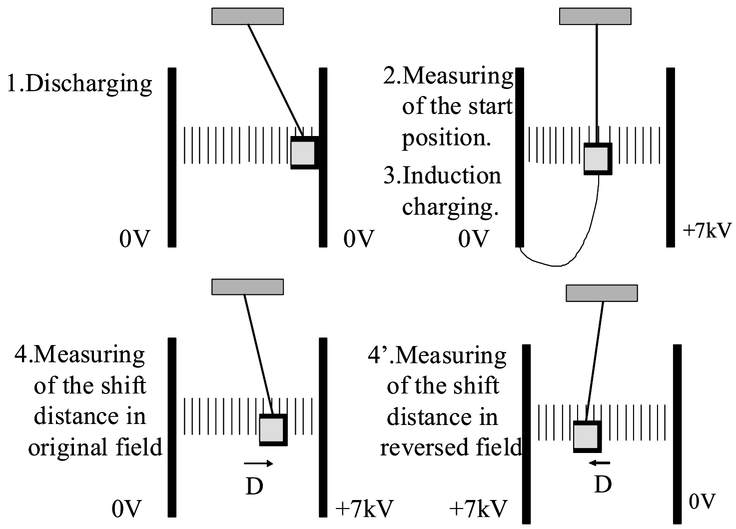

Fig. 4. A schematic of the experimental procedure

The experiment was performed using the following procedure:

① The left and right electrodes were grounded, and the conductor was touched to the grounded electrode for discharging.

② The non-charged conductor was centered between the electrodes, and the position of this conductor was measured using the ruler. This position was the start position.

③ The right electrode was charged to +7.0 kV and the left electrode was grounded, creating a original electric field, and the conductor was touched to the grounded wire for induction charging. The wire was then kept away from the conductor so that a negative charge was maintained on the conductor.

④ Then, the conductor was shifted toward the right side by the electrostatic force that acts on this conductor. This position of the conductor was measured using the ruler. This position was the end position. Difference between the start position and the end position was the shifted length D of the conductor.

④' Finally, the left electrode was charged to +7.0 kV and the right electrode was grounded, creating a reversed electric field, and the same experiment was performed again.

This experiment was repeated 4 times in two days and average value of the measured shifted distance D was used in the following calculation. Low humidity day was selected and the experiment was done with opened window. In those two days, the average temperature was 10 degree and the average humidity was 25%RH.

This shifted distance D is related with length L and height Y of the thread, as shown in Fig. 5.

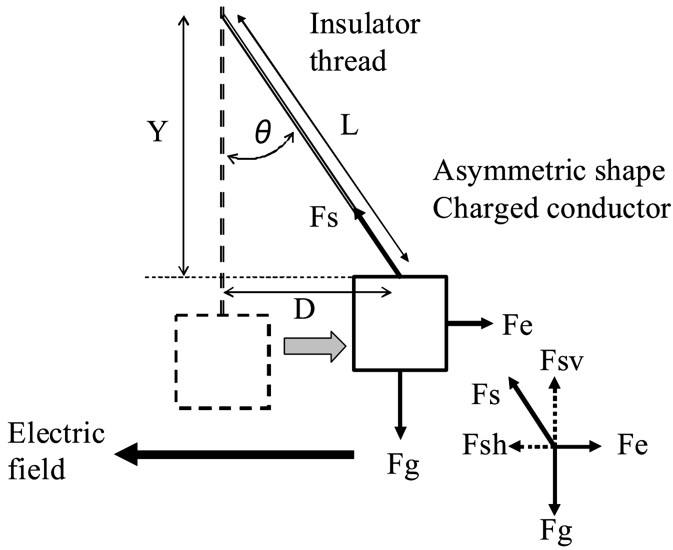

Fig. 5. Schematic diagram of the electrostatic force, the gravity force and the tensile force that act on the charged conductor in a high electric field.

The ratio of lengths L:D:Y is the same as the ratio of the tensile strength of the thread Fs: the electrostatic force Fe : the gravity force Fg. The horizontal component of the tensile force Fsh is equal to the electrostatic force Fe, and the vertical component of the tensile force Fsv is equal to the gravity force Fg. Therefore, the electrostatic force Fe was calculated from the shifted distance D, the thread length L and the gravity force Fg , using the following equation (1):

$$Fe = Fg \times \tan\theta = Fg \times \frac{D}{Y} = Fg \times \frac{D}{\sqrt{L^2 - D^2}} \qquad (1)$$

where L=150 mm and Fg=2.65 – 7.94mN, which was calculated from area of the conductor, which was 5 - 15cm^2, the thickness of the Al plate, which was 0.2mm, and the specific gravity of Al, which is 2.70.

Electrostatic force that acts on 19 different shape conductors in original and reversed electric fields were calculated using the equation, (1) Then, the ratio of the force of the reversed electric field to the force of the original electric field was calculated.

Figure 6 shows the result.

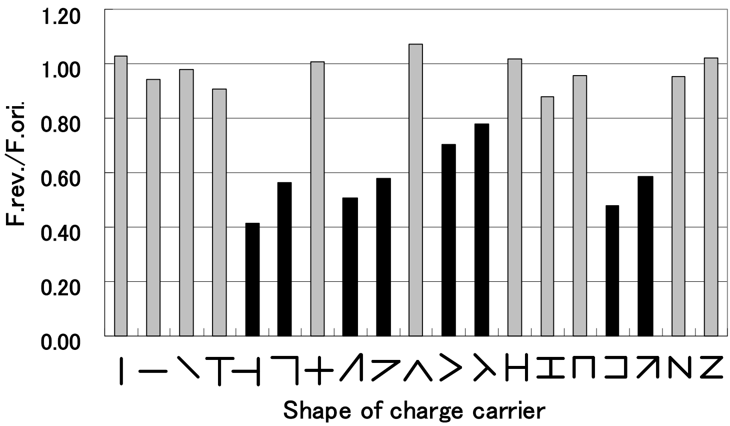

Fig. 6. The ratio of the force of reversed field to the force of original field that was calculated from experimental measured shift distance of the 19 different shape charged conductors.

It is apparent from figure 6 that the ratio of 11 symmetric shape conductors (gray bars) is about 1.0. On the contrary, the ratio of the other 8 asymmetric shape conductors (black bars) is less than 0.8. This experiment results agree with the simulation results (figure 2) as a general rule

III. Consideration

If the experiment results agree with the simulation results perfectly, difference between the ratio of the simulation and the ratio of the experiment becomes zero. Figure 7 shows absolute value of the difference.

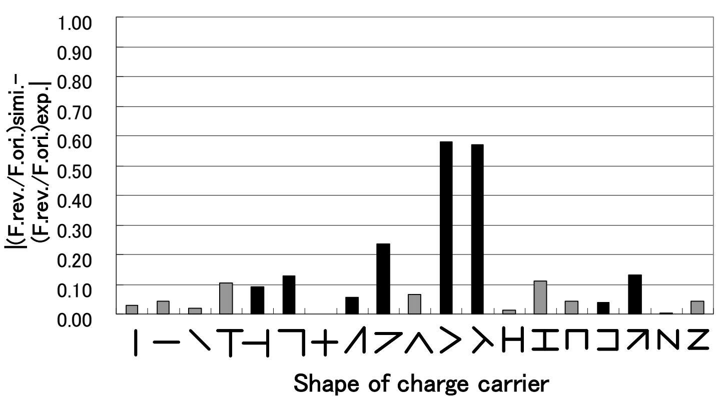

Fig. 7. Absolute value of the difference between the ratio of the simulation and the ratio of the experiment.

This is not precise experiment. Because, the position of the conductor that was measured by human eyes has a little error. Therefore, 0.1 difference is acceptable, but 0.6 difference is not acceptable. This result means that the simulation condition is not same with the experiment condition.

There are two big differences between both conditions. Namely, size of electric field and incline of hung conductors are different.

Figure 8 shows both size of electric field.

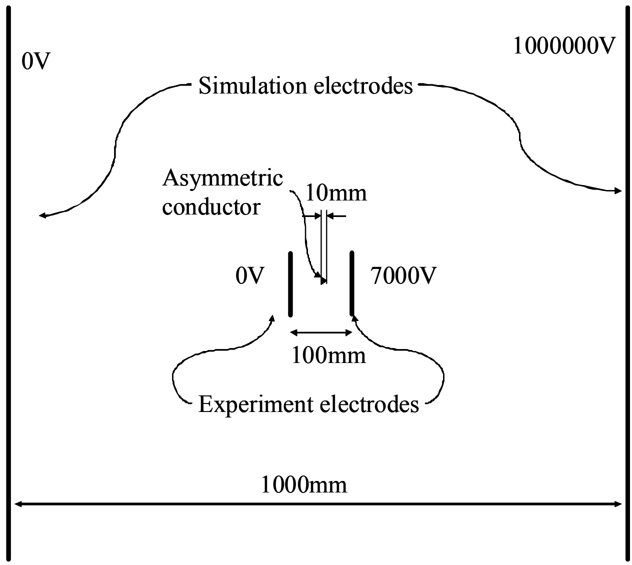

Fig. 8. Layout of electrodes of the simulation and the experiment.

Distance between right and left electrodes is 1000mm in the simulation and 100mm in the experiment. This big distance was selected to avoid image force, but this big instrument can not be made in actual experiment.

In the simulation, it was assumed that conductors shift laterally with same incline. But, its incline was changed when it was shifted. Figure 9 shows three positions and its inclines.

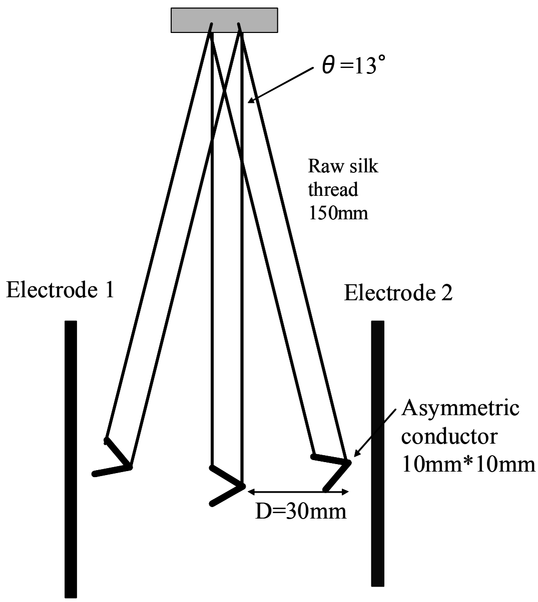

Fig. 9. Three positions and its inclines of an asymmetric conductor.

Figure 10 shows the ratio of the force of reversed field to the force of original field that was calculated from the improved simulation result.

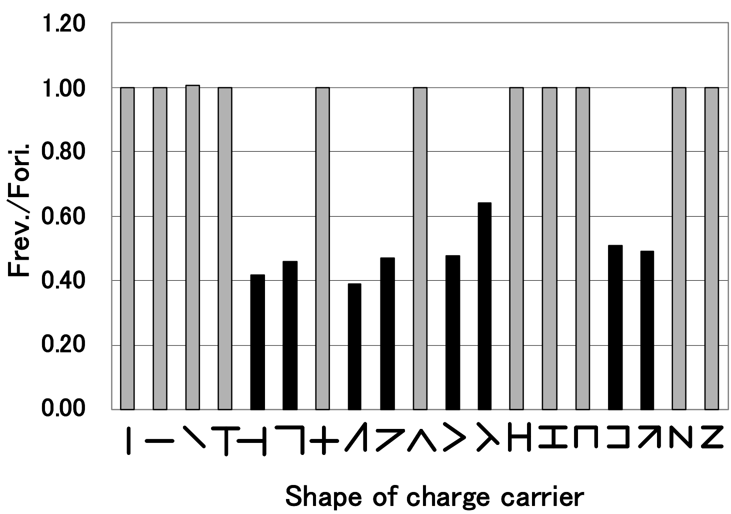

Fig. 10. The ratio of the force of reversed field to the force of original field that was calculated from the improved simulation result.

Then, Absolute value of the difference between the ratio of the improved simulation and the ratio of the experiment was calculated. Figure 11 shows the result.

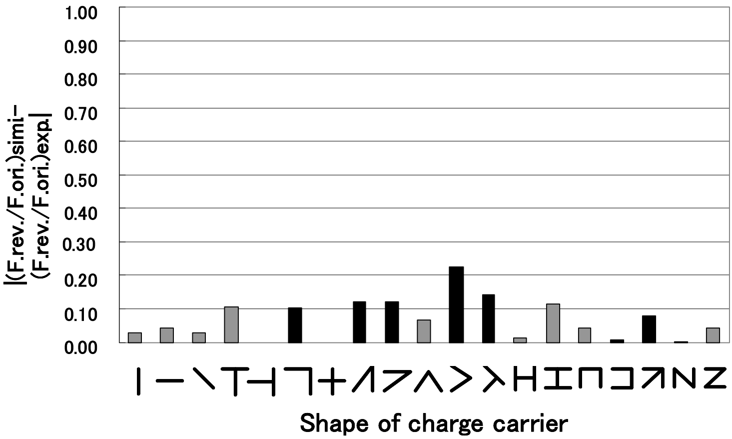

Fig. 11. Absolute value of the difference between the ratio of the improved simulation and the ratio of the experiment.

It is apparent from figure 11 that absolute value of the difference between the ratio of the improved simulation and the ratio of the experiment become less than 0.2. This means that this experimental result agree well with the improved simulation result

IV. Conclusion

As mentioned above, the experimental result agrees well with the improved simulation result, therefore existence of the new phenomenon has been confirmed now. The new phenomenon is that if the shapes of conductors are asymmetric in the electric field direction, the magnitude of the force that acts on those conductors changes when the direction of the electric field is reversed.

V. Postscript

A new electrostatic generator will be made with this new phenomenon in the near future. And, the environment problem and the energy crisis will be solved by this new electrostatic generator at the same time [2], [3].

References

[1] K. Sakai, "Electrostatic force that acts on non-sphere shape charged conductors", Proceedings of 2010 ESA annual Conference (2010) G4

[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