

Braking Force Suppression in Electrostatic Generators Using Counter-Electret

Katsuo Sakai

Electrostatic Generator Research Laboratory, Yokohama, Japan

Email: gy7a-ski@asahi-net.or.jp

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Abstract

To help address global warming, various power generation methods that do not release carbon dioxide have been established, including electrostatic power generation. A wide variety of electrostatic generators have been proposed for many centuries; however, the vibration-type electrostatic generator is currently the most commonly utilised. Electricity is generated via the movement of a charge carrier, which is charged by electrostatic induction in opposition to an injection electret (Hereafter, this will be abbreviated as IE.). The carrier is displaced from the electret using external energy forms such as waves, and the resultant generated charge is allowed to flow. As IE and charge carrier are charged with opposite polarities, a strong Coulomb force is generated between them, which acts as a braking force against the movement of the carrier. Therefore this paper present an improved method that revealed this braking force can be eliminated by placing a counter-electret (Hereafter, this will be abbreviated as CE.)—charged with the opposite polarity—adjacent to IE.

Keywords

Electrostatic Generator Injection Electret, Counter Electret, Braking Force, Accelerating Force

1. Introduction

Electrostatic generators have a long history and have been greatly studied in the 17th and 18th centuries; however, they have been almost forgotten because of the emergence of electromagnetic generators that have become very popular. Today, safe, pollution-free, all-time generators that use low-cost energy are strongly required. Therefore, there is a need to consider the use of electrostatic generators again.

The operation of electrostatic generators relies on elevating the charge carrier

from a low to high potential via mechanical forces that can counter the electric braking force acting on the charge carrier.

The Van de Graaff generator (ref. [1]) is a well-known electrostatic generator; however, it cannot be used to solve environmental problems. Because this generator uses an electric motor to transport a charge carrier belt, the motor of the generator needs much more electric energy than the output electric energy. Therefore, this generator has been used for high-voltage power supply and not as a generator.

In contrast, the vibration-powered electrostatic generator, as shown in **Figure 1** (ref. [2]), has recently gained significant popularity.

The electrode facing IE is the flat-type charge carrier, into which charge is injected via electrostatic induction. It is triggered to oscillate laterally owing to the mechanical vibrations of the waves; thereby, charge is collected and electricity is generated (see **Figure 1**).

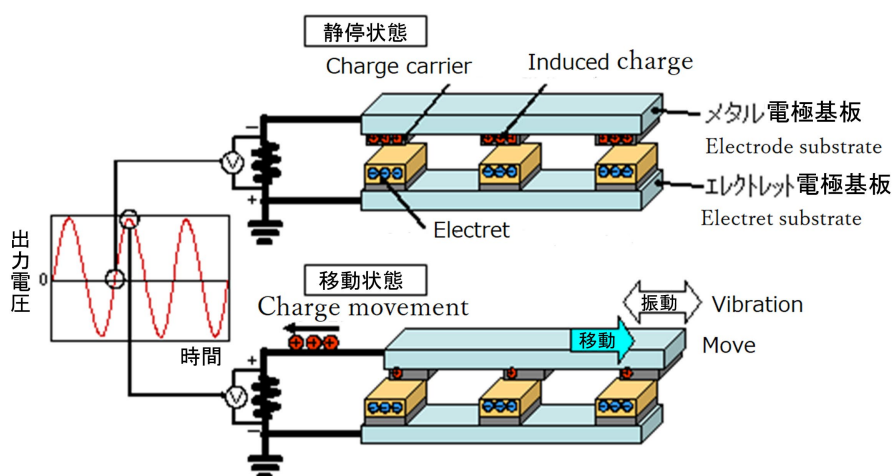


Figure 1. Vibration-powered electrostatic generator driven by mechanical wave-induced motion.

Currently, however, such electrostatic generators do nothing to address global warming and the related challenges.

This is because correctly the electrostatic generator was originally planned for use in communications due to its low output, but the cost of its control circuit ICs became unexpectedly high, and it is said to have fallen into disuse.

However, different electrostatic generator has been developed this century.

This new generator use Asymmetric electrostatic force invented by this author as a driving force of a charge carrier. After many mistakes, the bench model of this new generator succeeds to produce some electric power (ref. [3]-[9]).

In the near future, this Asymmetric electrostatic force electric generator will become commercial.

However, its cost must be high, because this generator needs a special shape (a horizontal gutter type.) charge carrier made by PCB manufacture method.

In contrast, a flat-type charge carrier used in the Vibration-powered electro-

static generator (see **Figure 1**) can be made by low cost.

Accordingly, the electrostatic generators that use a flat-type charge carrier must be developed again.

2. Braking Force Suppression via Placement of CE with Opposite Polarity Adjacent to IE

Figure 2 illustrates a typical basic electrostatic generator that use a flat-type charge carrier.

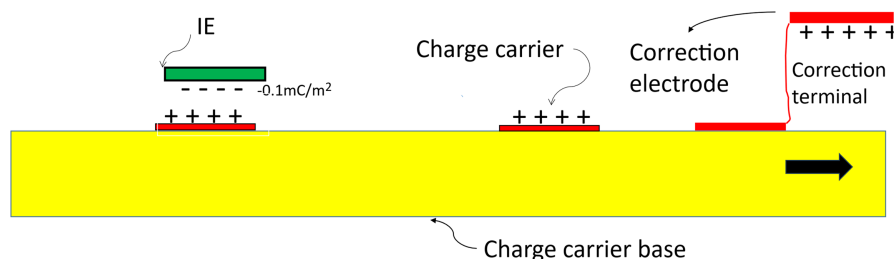


Figure 2. Basic unit of a typical electrostatic generator that use a flat-type charge carrier.

The unit primarily comprises a charge injection electrode, charge collection electrode, flat-type charge carrier, and charge collection terminal.

The surface of IE is negatively charged.

When the charge carrier moves beneath IE, positive charge is injected into the carrier via electrostatic induction.

These carriers retain their injected positive charge while being transported from IE up to the charge collection terminal.

When they come in contact with the charge collection terminal, some of the transported charges automatically flow into the charge collection electrode (Not shown in **Figure 2**), whereby electrostatic electricity generation occurs.

From, now the electrostatic force that acts on the charge injected charge carrier when it moves 19 mm from IE to the collection terminal is simulated by two dimensional finite difference method. This simulation has been done by Visual Basic.

Figure 3 illustrates basic Layout diagram of the charge carrier, IE and front CE. The front CE is added to **Figure 2** (see **Figure 4**).

This simulation program consists of 97 lines and 25 lows. The width of between lines is all 0.5 mm. The width of between first low and fifth low is 20 μm , fifth and 17th is 80 μm , 17th and 19th is 20 μm , 19th and 22th is 80 μm , 22th and 25th is 20 μm . The permittivity of the IE and CE base, and Charge carrier base is 2.0. All parts in this simulation have a length of 200 mm from the surface to the depth.

The thickness of charge carrier base is 240 μm thick, and It moves from left to right with the charge carrier, as depicted by the arrow in **Figure 3**. The system components—namely, the metallic flat-type charge carrier, IE and CE—are rectangular in shape, 40 μm thick, 3.0 mm wide, and 200 mm long. The distance between the electret surface and charge carrier surface is 0.98 mm, and the surface

charge density of the IE is -0.10 mC/m^2 and that of CE is $+0.10 \text{ mC/m}^2$. Therefore, using the well-known finite difference method, the amount of charge injected into the charge carriers was simulated and determined to be $+5.5 \text{ nC}$.

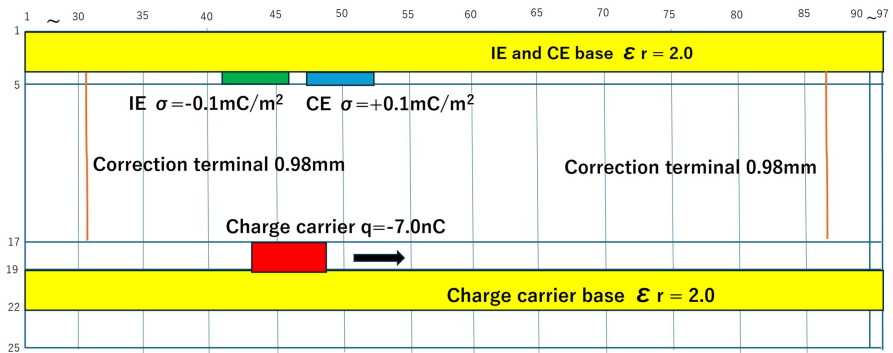


Figure 3. Illustrates basic Layout diagram of the charge carrier, IE and CE.

The collection terminal is string-shape and its height is 0.98 mm.

Notably, although the charge collection terminal is string shape, the two-dimensional (2D) simulation herein recognised it as a thin wall; resultantly, a stronger image force was simulated between the charged charge carrier and the earthed charge collection terminal. Therefore, the height of the collection terminal was corrected from 0.98 to 0.02 mm for more accurate simulations. Anyway, we can't simulate the correct force in real (3-dimension world) with using 2-dimension program.

The braking force is generated when the electric field produced in IE interacts with the charge of the charge carrier. Therefore, no braking forces are produced if the electric field lines are interrupted midway. Accordingly, CE was placed immediately adjacent to IE, as shown in **Figure 3**.

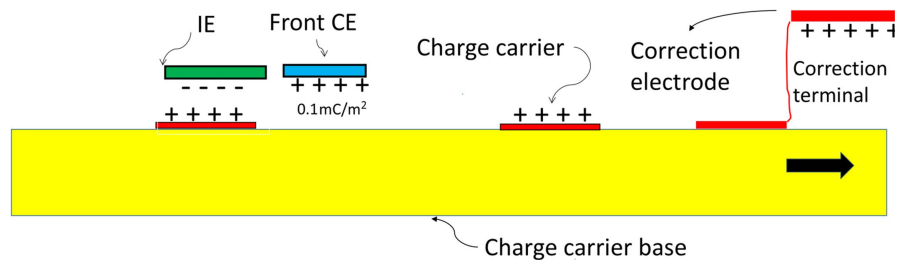


Figure 4. Placement of CE with opposite polarity adjacent to IE.

If the charge polarity of the CE is positive, and that of IE is negative (as shown in **Figure 3** and **Figure 4**), the number of electric field lines that can bridge from CE to the charge carrier is reduced.

Resultantly, only a weak braking force is generated. On the contrary, if the electric polarities of the CE and charge carriers are the same, and the CE is fixed, electrostatic repulsion forces are produced between them, accelerating the charge carrier movement toward the collection electrode.

The CE is shaped identically to IE, but they possess opposite charge polarities.

To confirm this prediction of electrostatic repulsion forces, the electrostatic force acting on the charge carriers was simulated with and without the CE via a 2D finite difference method, each time the charge carriers moved 1.0 mm to the right. The results are shown in **Figure 5**.

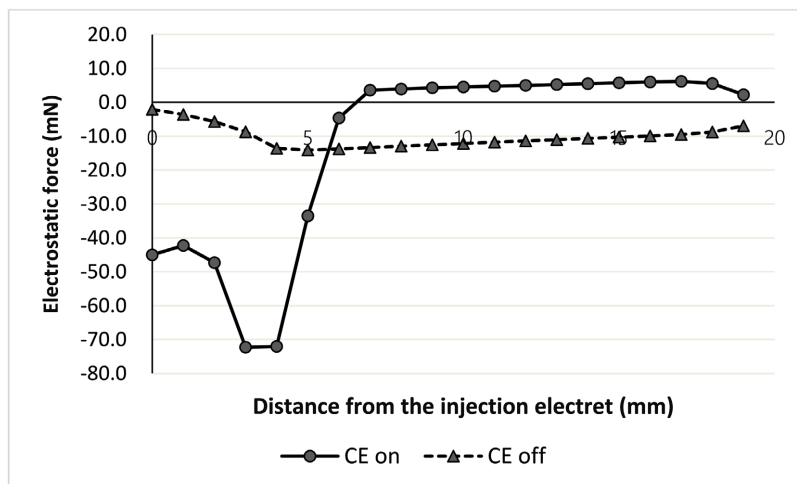


Figure 5. Position of charge carrier and electrostatic force acting on charge carriers, with and without CE.

From the graph in the figure, the electrostatic force acting on the charge carrier was at all points negative, *i.e.*, a braking force existed at all points (for a distance from 0 to 19 mm) without the CE. Consequently, an external force of 203 μJ was needed to move the charge carrier.

It is also clear that the electrostatic force acting on the charge carrier was positive, *i.e.*, an accelerating force, as predicted by theory, when the movement of the carrier after passing through the CE to the collecting terminal (for a distance from 8 to 19 mm).

This result implies that the braking force generated between the negative charge of IE and the positive charge of the charge carriers was eliminated by incorporating a CE before IE, as shown in **Figure 5**.

Conversely, incorporating a CE generated a negative force, *i.e.*, the braking force, when the charge carriers passed from beneath IE through the CE (for a distance between 0 and 7 mm).

However, this accelerating force was very weak, and the braking force was very strong, as shown in **Figure 5**.

Consequently, the external energy required to transport the charge carrier increased from 203 to 254 μJ . Such a result indicates that CE incorporation is ineffective and that even in this case, a strong external force is still required.

Therefore, this strong braking force needs to be eliminated or suppressed. To this end, the other CE was incorporated immediately behind IE as a rear CE, as shown in **Figure 6**.

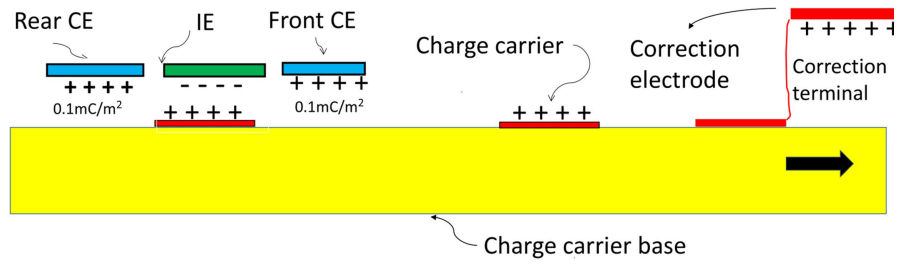


Figure 6. Incorporation of other CE behind the injection eletret.

The braking force was produced when the electric field lines emitted from IE reached the charged charge carrier. However, these electric field lines were then split in half by the front and rear CEs, such that only half of the electric field lines reached the charge carriers; additionally, the braking force was halved.

To confirm this prediction, the electrostatic force acting on this charge carrier was simulated in a similar manner.

The result is shown in **Figure 7**.

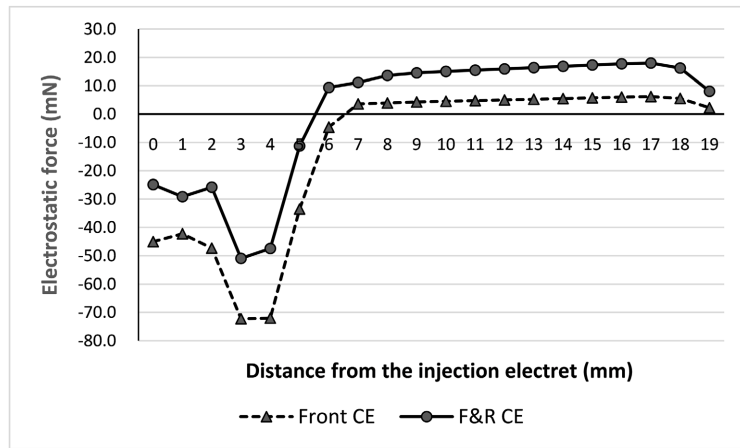


Figure 7. Position of charge carrier and electrostatic force acting on charge carriers with front CE, and front and rear CE.

As shown in **Figure 7**, the braking force is approximately halved, and the accelerating force is approximately tripled upon incorporating the rear CE. Consequently, the required external energy to transport the charge carriers was reduced from 254 μJ to zero; conversely, an internal energy of 18 μJ was generated, which could accelerate the charge carriers.

In any case, the layout described in **Figure 6** required a small electric motor for transportation of the charge carriers, as the accelerating force is very small.

The ultimate goal of this study is to transport charge carriers using only the electrostatic energy emitted from the eletret without any external force.

To this end, the surface charge density of the rear CE was increased by a factor of two, as shown in **Figure 8**. Resultantly, many electric field lines emitted from this rear CE could reach the charge carrier, resulting in even greater accelerating forces.

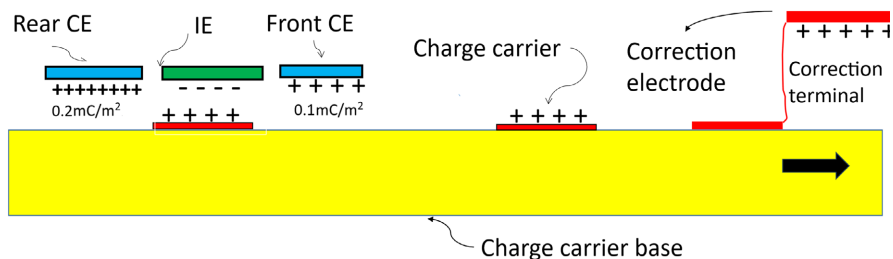


Figure 8. Doubling of surface charge density of rear CE.

To confirm this prediction, the electrostatic force acting on the charged charge carriers was simulated in a similar manner, and the results are shown in **Figure 9**.

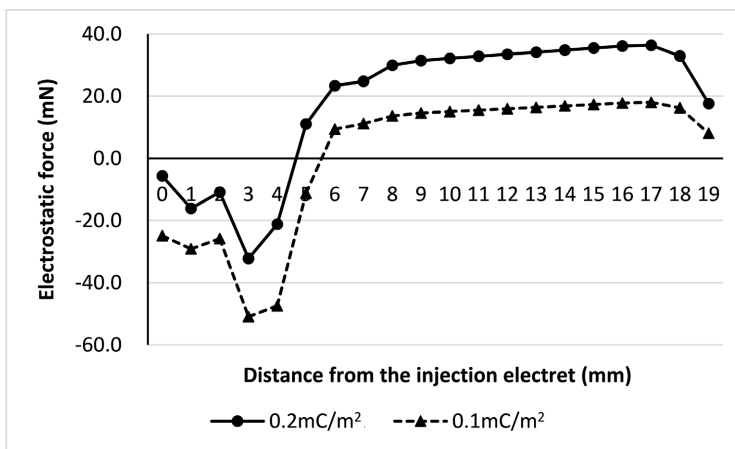


Figure 9. Position of charge carrier and electrostatic force acting on charge carriers when the surface charge density of rear CE was increased from 0.1 to 0.2 mC/m².

As shown in **Figure 9**, the braking force was approximately halved, and the accelerating force approximately doubled upon increasing the surface charge density from 0.1 to 0.2 mC/m².

Consequently, the internal energy emitted from the front and rear CEs, which accelerated the charge carriers, increased from +18 to +361 μJ.

The above simulation results are summarized in **Table 1**.

Table 1. CE place and charge vs. gained energy.

Layout	front CE	Rear CE	Energy (mJ)
no	non	non	-0.203
Front	+0.1 mC/m²	non	-0.254
Rear & Front	+0.1 mC/m²	-0.1 mC/m²	0.017
Rear *2 & Front	+0.1 mC/m²	-0.2 mC/m²	0.361

Then, the result of **Table 1** was graphed as **Figure 10**.

It is apparent from **Figure 10** that when CE is placed at front and rear of IE,

and the surface charge density of the Rear CE is double, the gained energy of the charge carrier becomes very high. However, this is not best result. The surface charge density of IE is -0.1 mC/m^2 used in this simulation, but, today, the maximum surface charge density of negative electret becomes -3.0 mC/m^2 . As a result, the gained energy can be 30 times.

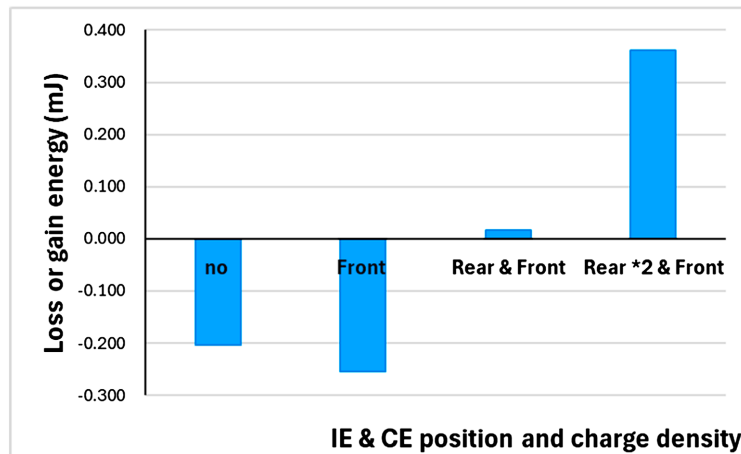


Figure 10. CE place and charge vs. gained energy.

The charge injection gap, namely distance between surface of the charge carrier and the surface of IE is $980 \mu\text{m}$ in this simulation, however, it can be reduced to $100 \mu\text{m}$ mechanically, As a result, the gained energy can be 10 times. The thickness of the charge carrier is $40 \mu\text{m}$ in this simulation,

However it can be $400 \mu\text{m}$ chemically, As a result, the gained energy can be 10 times. When, those three increasing methods are used together can trigger energy increases by factors of 10, 100, or 1000.

In such a situation, the endless charge carrier belt that has a lot of frat-type charge carrier on it can be transported only via this internal energy without external energy. And, the life time of electret is expected as 100 years. Therefore, this novel electret electrostatic generators comprising IE and CE, and charge carrier can produce electricity for extended durations (potentially 100 years).

3. Conclusion

In this study, 2D finite difference simulations confirmed that an opposing Coulomb braking force generated between a charged charge carrier and IE in an electret electrostatic generator can be suppressed by incorporating a CE, possessing charge of opposite polarity to that of IE, adjacent to IE.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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Appendix

Note

The electrostatic generating unit illustrated in **Figure 8** must be used in a vacuum or in space to prevent corona discharge.

Nevertheless, there is a new solution for this issue, which will be reported as a next paper.

This newly proposed electret electrostatic generator can initially be used in nuclear shelters, as such shelters are built underground and possess no external energy sources, such as sunlight, wind, or moving water (rivers).