

EHD and electrostatic propulsion device mounted with high voltage generator

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Abstract

Electro hydro dynamic (EHD) and electrostatic propulsion devices has no moving parts and, in the air, operates on electrical energy. It is expected to develop electric propulsion systems without future moving parts of airplanes and helicopters propellers in the future. One of the issues is below. The size and weight must be reduced to realize the drone because a high voltage generator with large weight is currently used at the experiments. In this time, the Tesla coil with a MHz high-frequency output was used. We had succeeded in reducing the size and weight of the high-voltage generator.

1.Introduction

It is expected to develop electric propulsion systems without future moving parts of airplanes and helicopters propellers in the future. The advantage of this propulsion system is that 1) there are no moving parts, easy to maintain and 2) the propulsion efficiency may exceed the conventional engine.

There is a report that the principle of ion craft considered as a part of a series of thrust generation experiment by Brown effect using high voltage is propulsion by the imbalance of electrostatic force, attraction by space charge. We also think so from many experimental results other than that paper. It is considered that the propulsion principle is determined not by the ion wind but by the external electric field (applied voltage) and the amount of electric charge accumulated in the electrode. Much research has been done on the principle of lifters. The current problem is that common high voltage devices have large weight. Driving EHD propulsion device requires a DC power supply or a low frequency pulse generator. As an example of the DC high voltage generation, a low frequency AC oscillator is used and the AC output was rectified to DC high voltage. For an example, rectifying a high voltage low frequency AC generated from a flyback transformer by connecting the output to a rectifier circuit are normally conducted. Here, the problem is composed of two. In common experiments, a very heavy power supply is used. A large-scale HV device to generate a higher high voltage always requires larger weight. There are two problems: 1) a transformer has a magnetic core to generate high-voltage and low-frequency alternating current of several 10kHz, and 2) a circuit that rectifies AC signal to obtain several times the output voltage. Heavy core materials such as iron and ferrite are used in the transformers. 2)Ceramic materials in rectifier circuits are commonly used. But, when we obtain the

higher the voltage, we use the ceramic capacitor with heavier weight.

Based on the above, the problems to be solved to realize a drone that can move freely in space include compactness of both the AC high voltage generator and the DC high voltage generator and weight reduction.

In order to realize drone, the levitation force needs to exceed the weight of the EHD device. Of course, the efficiency of thrust per unit weight (N/kg) and thrust per unit power consumption (N/W) are need to improve. Electrode multiplexing, utilization of polarization structures, and low voltage operation of ion sources, and generation of magnetic field by pulse operation are effective methods to improve them. However, even with these improvements, the levitation force cannot exceed the weight of the EHD device unless the above weight problem is solved.

In this time, we report here that the weight of the EHD device could be reduced by using of both an air-core tesla coil that operates as a transformer and the DC high voltage generator with light weight.

2. Experiment

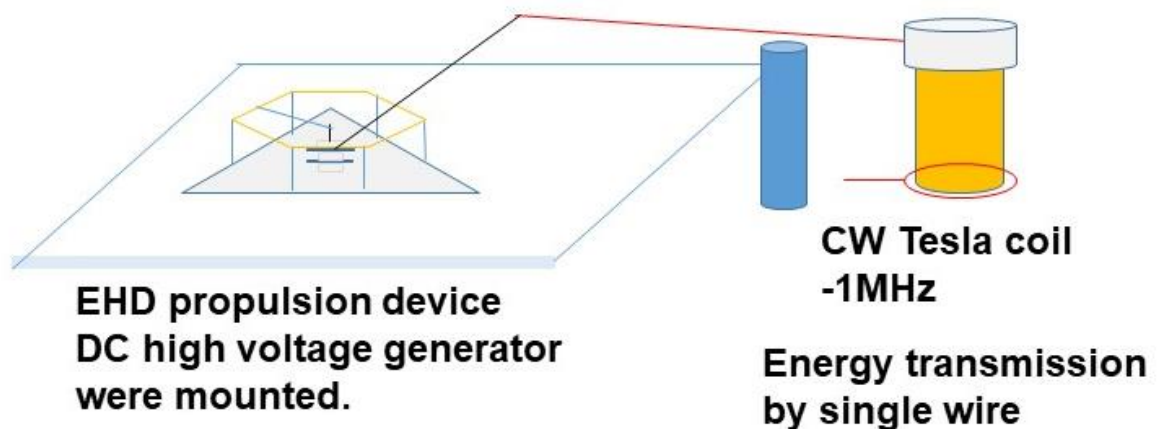


Fig.1. Experimental setup

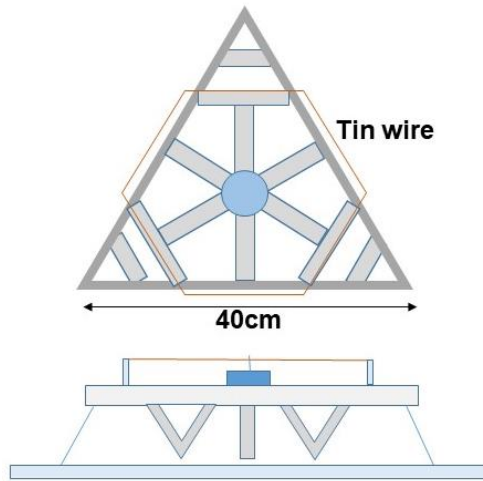


Fig.2. EHD propulsion device.

The entire experimental device of the EHD propulsion device is shown Fig.1. The used EHD propulsion device is shown Fig.2. The shape of the EHD propulsion device is a triangular shape as a whole. The device is made of Aluminum foil. The device weight was 2.0g. One side of the device was 40 cm. The height is 1 cm. The maximum output voltage of the DC rectified power supply was 30 kV. The gap was 3 cm and the payload that the device can carry was 3 g. The ultra-thin wire was connected to the + electrode, and the main body of the device was connected to the - electrode. The reason for using the ultra-thin wire is to enable low voltage operation. The EHD device floats at an input of 20 kV, can operate up to be 30 kV. The input voltage is limited by the discharge between the wire and the body.

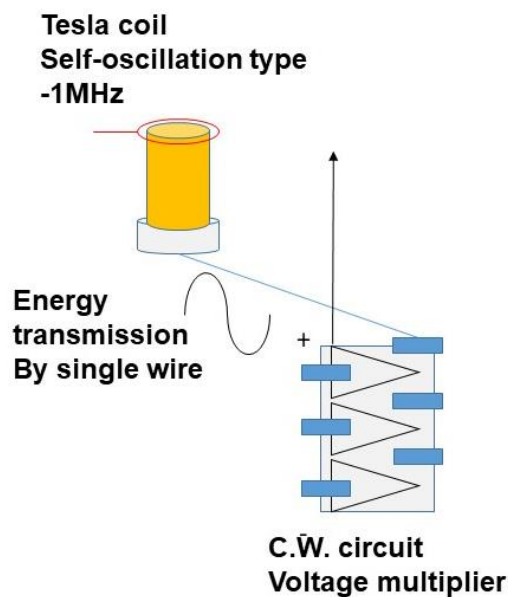


Fig.3. Concept of TC and DC HV generator.

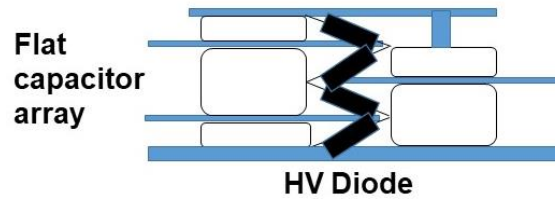


Fig.4. C.W. DC high voltage generator with light weight.

A concept of a Cockcroft-Walton rectifier driving by single output wire of TC is shown in Fig.3. The diameter of the Tesla coil winding was 0.1 mm, the main body was 3 cm in diameter, the number of turns was 250 turns, the weight of the coil only was 1.6 g, and the maximum input power was about 40 W. E-class zero cross switch self-oscillation using a single MOSFET was adopted to suppress the heat generation of the FET. It constitutes a self-oscillation circuit. We can rectify the output signal from TC by connecting only single wire.

A configuration example of a flat capacitor for rectification is shown in Fig.4. The figure shows a two-stage configuration for rectification, but it is possible to further increase the number of stages and generate high voltage. A thin film and Aluminum foil were used for the rectifying thin flat capacitor of the actual device. The weight was 0.3 g. Although it is the high voltage diode used this time, the recovery time of the reverse diode for rectifying the MHz signal is short enough. The withstand voltage of the diode was 12 kV. The total weight of the rectifier circuit was 1.5g.



Fig.5. EHD device floating in space at an experiment.

The photo at the actual experiment using the EHD propulsion device is shown in Fig.5. An acrylic plate was laid on the desk, and when it surfaced 5 cm from it. We succeeded in floating the device with vibrating at an extremely low frequency for a few ten seconds. Where, the minimum drive voltage for the EHD device was about DC 20kV.

Future issues to improve

At present, the equipment is still incomplete.

1) However, free movement with a single wire has become possible, and it has become possible to freely ascend and move in space than before.

2) There is still a considerable margin in the TC output power. First, the levitation force should be improved by increasing the size of the EHD device.

3) The issue is the decrease of TC output frequency. The Tesla coil can be miniaturized if the output frequency is high, but it seems that there is an optimum operating frequency of several hundred kHz due to the weight and the obtaining high voltage output. At high frequencies of 10 MHz, rectification is not possible because of silicon materials.

The circuit for self-excited oscillation drive has a weight of about 1 g because other driving circuit structures are simple. The weight of the TC coil is around 1 g. If 2) can be cleared, TC can be installed in the EHD device.

4) The heat generation in the diode is a problem. It is considered that the output is small, the input frequency is as high as MHz and the loss is large, and the capacitance of C is small, so that the voltage waveform is disturbed and the power loss is large. These will be improved in the future.

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