Operation of Electric Motors from the Atmospheric Electric Field

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An electret-type electric motor and a corona-type electric motor have been constructed for operation from the earth electric field. The power is delivered to the motors by means of simple earth-field antennas with radioactive or sharp-point collectors. Initial results on the operation of the motors are reported.

I. INTRODUCTION

It is a common knowledge that at the surface of the earth there exists an atmospheric electric field, or the earth electric field, as it is usually called. The average intensity of this field is about 120 V/m during fair-weather periods and can be much higher during electric storms. By using an appropriate earth-field antenna a few meters high one can obtain therefore a voltage of about 1000 V or more between the tip of the antenna and the ground. It is quite tempting to use this voltage for operating an electric device, an electric motor for example. However, since the electric conductivity of air is very small, the current that can be produced by means of an earth-field antenna is also very small. Thus only a motor requiring for its operation a fairly high voltage but an extremely small current, or an "extra high impedance" motor, can be powered in this fashion.

The currents obtainable with the earth-field antennas used for studying the earth electric field range from fractions of a microampere (antennas with α-source collectors during fair-weather periods) to perhaps a few milliamperes (antennas with sharp-point collectors during electric storms).[1] The voltages normally obtainable with these antennas range from several hundred to several thousand volts. Thus, if a motor is to be powered by means of such antennas, the motor should have an impedance of at least $10^5\ \Omega$.

An impedance of this magnitude is not practical with the usual electromagnetic motors, whose very nature demands the use of relatively high currents. But even a much higher impedance is attainable with electrostatic motors.[2] The impedance of the recently discussed "slot-effect electret motors," for example, is $10^9\ \Omega$ and higher.[3,4] Electrostatic motors with electrets and other similar motors should therefore be adaptable for operating from the earth electric field by means of the above-mentioned antennas.

II. EXPERIMENT

On the basis of the considerations just presented a slot-effect electret motor has been constructed requiring for its operation 100 V at 5×10^{-8} A and thus suitable for being powered by a conventional earth-field antenna. The active element of the motor is a stationary disk electret consisting of two oppositely polarized

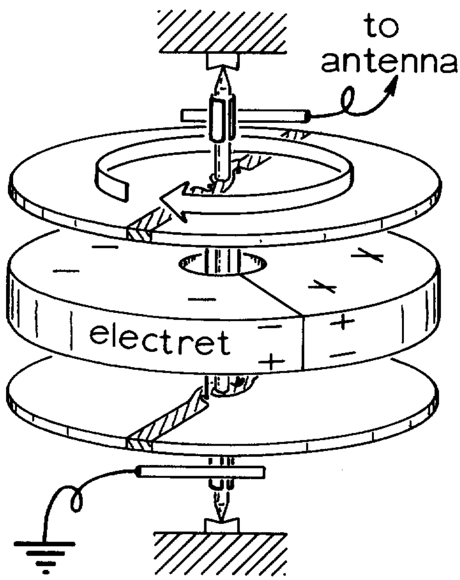

FIG. 1. Electret motor capable of operating from the atmospheric electric field.

half-disks (Fig. 1). The electret is positioned between two slotted disk-shaped rotor electrodes made of aluminum foil glued on two thin mica disks. The rotor electrodes are mounted on a Plexiglas axle having near its ends two "printed" commutators painted onto the axle with India ink. The commutators are connected with the rotor electrodes by means of narrow India ink lines drawn along the axle. The rotor assembly consisting of the two electrodes and the axle weighs 4 g. The brushes are made of two aluminum foil strips 0.5 mm wide. The diameter of the electret and rotor electrodes is 7.5 cm. The thickness of the electret is 1.3 cm. The electret is made of a mixture of carnauba wax, colophonium, and beeswax (45%, 45%, and 10%, respectively). The pulverized mixture was melted and heated for 1.5 h at 120°–125°C. The melt was then allowed to solidify while in a forming field of 7900 V/cm.[5] The effective surface charge density of the electret is approximately 2×10^{-6} Asec/m^2. Since the motor is designed for a very small power, the axle is supported by jewel bearings.

As expected, the motor operates very well when connected to an appropriate earth-field antenna. The method of operation is illustrated in Fig. 2. The motor was first tested with an antenna consisting of a 7-m wooden pole carrying an α source in a brass capsule at its top. Placed at the street level sufficiently far from tall buildings and trees this antenna produced, on an average, a voltage of 500 V and a current of 10^{-7} A. With this antenna the motor ran at a rate of about 60 rpm. Subsequently the motor has been powered by the same antenna placed on the roof of an isolated 11-story building (West Virginia University Engineering Building). On the roof the antenna normally produces a voltage of several thousand volts and a current of about one microampere, causing the motor to run at a rate of several hundred rpm. The motor operates equally well from a 7-m sharp-point antenna erected on the roof or from an airborne sharp-pointed antenna.

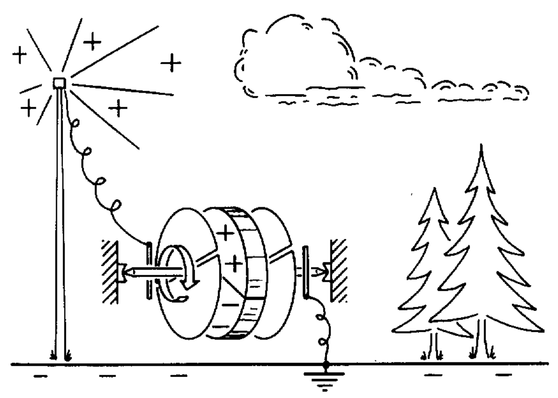

FIG. 2. Operation of the electret motor from the atmospheric electric field by means of an antenna with a radioactive collector.

Although various applications of low-power motors operating from the earth electric field are possible, it is interesting to explore whether the earth electric field can be used to operate motors of appreciable power. The maximum energy density in the earth electric field occurs during electric storms and may be assumed to be as large as 0.5 J/m^3 (corresponding to a field of $\approx 3\times10^5$ V/m).[6] Assuming furthermore that by means of appropriate antennas the energy contained in 1 m^3 of the earth field could be extracted from the field in 0.1 sec and that the field would replenish itself at the same rate, one would be able to deliver to a motor a maximum power of 5 W from each cubic meter of the field for as long as the assumed conditions would exist. It appears, therefore, that appreciable rates of energy extraction from the earth electric field should be possible, if only occasionally.

As far as the motors are concerned, of all presently known electrostatic motors the corona-type motors appear to be the most powerful ones.[2] It is therefore likely that motors of this type would be especially suitable for accepting significant amounts of power from the earth electric field.

In accordance with these considerations a fairly large corona motor has been constructed for investigating the possibility of operating this motor by means of antennas. The motor consists of a cylindrical Plexiglas rotor 10 cm in diameter and 10 cm long surrounded by 20 stationary knifelike brass electrodes, each two adjacent electrodes being of opposite polarity. The rotor is hollow and has an internal aluminum foil lining for enhancing the corona discharge from the electrodes onto the rotor. The rotor is mounted on a steel axle supported by ball bearings. The weight of the rotor with the axle is approximately 300 g. The motor is represented

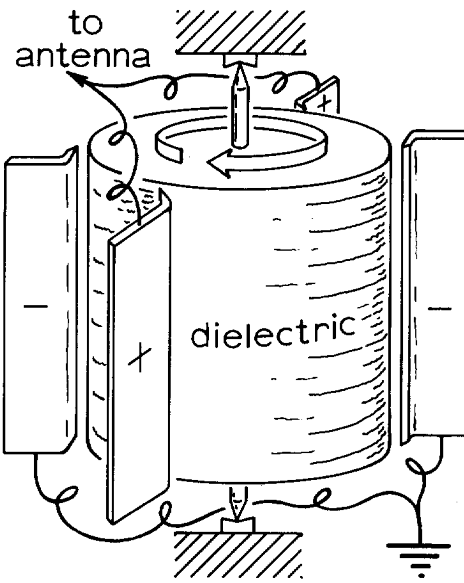

FIG. 3. Corona motor capable of operating from the atmospheric electric field.

schematically in Fig. 3, where only four electrodes are shown, for simplicity. This motor requires for its operation a minimum of 4000 V at 10^{-7} A and is capable of developing a maximum power of 70 W at about 10 000 rpm. In laboratory tests this motor has been found to perform very well from a small sharp-point antenna placed in the vicinity of a Van de Graaff generator. Connected to the roof-top sharp-point antenna the motor also operates but makes no more than 100 rpm (the slow rate is a result of the fact that the antenna normally produces just about the minimum voltage and current required for the operation of this motor).

III. DISCUSSION

The above experiments demonstrate that it is entirely possible to operate electric motors from the earth electric field. Low-power motors may be operated from the conventional earth-field antennas (those commonly used for the earth-field studies). In principle, motors of appreciable power can also be operated from the earth field. However, the conventional antennas are not well suited for this purpose since the currents which they produce are much too small. One will have to design therefore new types of antennas before motors developing a power of at least several watts can be conveniently operated from the earth electric field. For producing relatively large currents these antennas should have either multiple collectors or single collectors of large dimensions.

In conclusion it may be mentioned that the principles involved in the operation of electric motors from the earth electric field can be easily demonstrated in a classroom by means of the following very spectacular experiment. A small sharp-point antenna or, preferably, a candle-flame[1] antenna is placed in the vicinity of a Van de Graaff generator. The antenna is connected to a small electrostatic motor or, if such a motor is not available, to an "electric whirl" (electric reaction wheel). As soon as the generator is turned on, the motor (or the whirl) begins to turn although there is no direct connection between the motor and the generator. The power is delivered to the motor by the antenna located in the electric field of the generator. The antenna receives this power from the generator through the intervening air.

ACKNOWLEDGMENT

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[1] For a discussion of various collectors see J. A. Chalmers, *Atmospheric Electricity* (Pergamon, Oxford, Eng., 1967), pp. 122–134 and papers quoted therein.

[2] For a review of the various types of electrostatic motors and principles of their operation see O. Jefimenko and D. K. Walker, Phys. Teacher **9**, 121 (1971).

[3] O. Jefimenko, Proc. W. Va. Acad. Sci. **40**, 345 (1968).

[4] O. Jefimenko and D. K. Walker, in *Conference on Dielectric Materials, Measurements and Applications* (The Institution of Electrical Engineers, London, 1970), pp. 146–149.

[5] For details on fabrication of carnauba-wax electrets such as the one used here see O. Jefimenko and D. K. Walker, Appl. Phys. Letters **18**, 52 (1971) and papers quoted therein.

[6] Although the breakdown field as measured in a laboratory is $\approx 3\times10^6$ V/m, the maximum field occurring in the atmosphere appears to be no greater than $\approx 3\times10^5$ V/m (see Ref. 1, p. 330).