The Earth's Atmosphere As a Source for Electric Power

By William Aston

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Rain or shine, the air always contains positive electric charges that form an invisible blanket over the entire surface of the earth. Scientists call this 10-mile thick blanket the earth's electric field. Recently, the world's first motors powered by the earth's electric field were developed by a West Virginia University physicist, Dr. Oleg Jefimenko.

"Our experiments have proved that the energy of the earth's electric field can be converted into continuous mechanical motion," Dr. Jefimenko observed. "We also have demonstrated the unique properties of electro-static motors.

"The consequences of this development are difficult to predict. The components of our motors and their design can undoubtedly be improved. Our motors were made by us here in the lab under far from ideal conditions. And we made no effort to design efficient earth-field antennae."

If the technology can be developed to fully utilize Dr. Jefimenko's basic research, the earth's electric field could become a source of energy that would help avert the power shortage facing the Western world.

"There is no question that the earth's electric field can be used to generate power," Dr. Jefimenko explained. "The trouble is that, although very high voltages can be obtained from this field, only very small currents can be extracted from it by means of presently available techniques.

"Therefore, our main problem was to develop new motors that would run from relatively high voltages but that would consume only minute amounts of current," he said. "We solved the problem theoretically a long time ago; however, it took us some time to come up with practical designs."

On the night of Sept. 29, 1970, Dr. Jefimenko and David K. Walker, a WVU graduate student in physics from Monroeville, Pa., took one of their new motors to a large, empty parking lot in front of WVU's Engineering Sciences Building for the final test. They also had an earth-field antenna, which was simply a 24-foot wooden pole with a speck of radioactive material at one end and a wire attached to it.

Thus far the motor isn't very powerful (it produces less than a millionth of a horsepower), but it runs. This motor is of the electret electrostatic type and its design is extremely simple. The complete motor consists of a carnauba wax electret, several pieces of plastic and aluminum, two mica disks, two thin wires, an axle, and two jewel bearings.

The heart of the motor is the electret—a body with a permanent positive charge at one end or one side and a negative charge on the other.

"At first glance the idea of using the earth's electric field as a source of power looks like getting something for nothing—but in a sense all natural resources are free," Dr. Jefimenko observed.

Thus far Dr. Jefimenko and Mr. Walker have been working essentially on the theoretical aspects of this development. Last summer they presented a paper on electret motors and measuring devices at an international conference on dielectric (nonconducting) materials at the University of Lancaster in Great Britain.

The moderator who reviewed the paper, Professor T. J. Lewis of the University College of North Wales, observed: "The authors finally report on a multiple electret machine using 0.5 mm-thick mica electrets. This promises to be an almost 'wireless' motor and is made even more exciting by the proposal that an aerial suitably coupled to the elec-

Dr. Oleg Dimitri Jefimenko, professor of physics at West Virginia University, was born in Kharkov, USSR, and studied in Germany before coming to the United States in 1951. He then studied at Lewis and Clark College and the University of Oregon where he received his Ph.D. in physics in 1956. He joined the West Virginia University faculty in 1956. Besides his work in electro-statics, Dr. Jefimenko is known throughout the scientific community for his research on the production and absorption of light by colliding atoms and molecules. This work resulted in a new model of the atom.

tric field of the earth might be sufficient to power it. This surely is in the best traditions of Benjamin Franklin . . . " In July the motor hadn't been built but it now is on display at WVU.

Man's desire to heat things, move things and stop things is unending. He has tried just about everything imaginable in his quest for motive power. The wind, the sun, the moon and even his own strong back have been harnessed—either directly or indirectly—to satisfy man's desire for changing things.

The awesome power of atmospheric electricity—lightning and its thunder—is known to everyone. What is less known is that atmospheric electricity is always with us and that lightning is merely a manifestation of its abnormal concentration.

The earth's electric field changes from place to place and varies with atmospheric conditions. But if everything else is equal, the strength of the field varies with the distance above the earth. (In the Morgantown area, its strength increases by about 100 volts for every three-foot increase in height.)

Except for lightning, the earth's field normally makes its presence known by St. Elmo's fire—that bluish glow occasionally seen near sharp-pointed objects, such as airplane wing tips on stormy nights. Lightning and St. Elmo's fire are other manifestations of static electricity.

Lightning is the movement of static electricity (involving millions of volts) from one cloud to another and from clouds to the earth. Lightning usually comes in bolts or sheets and is like a spark—now you have it and now you don't.

St. Elmo's fire is more of a continuous nature and only involves several thousand volts. This form of static electricity moves from a sharp metal point to the air, or vice versa, in a steady flow. (The earth-field antenna of the new electret motor actually extracts electricity from the air by means of St. Elmo's fire.)

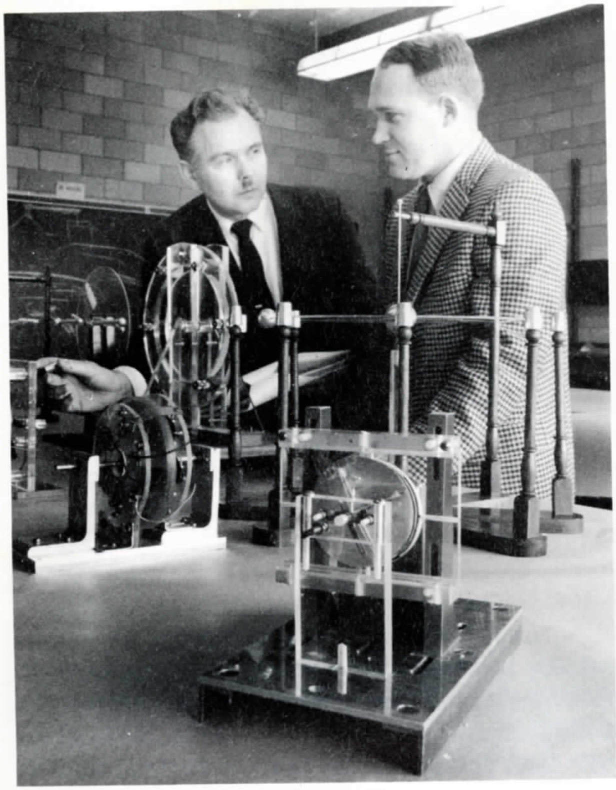
The Greek philosopher Thales of Miletus (circa 600 B.C.) is credited with first describing what we know today as static electricity. By rubbing amber—a fossil resin—with a piece of cloth it was found that the amber could pick up bits of lint, straw and other light objects. (The Greek word for amber is *elektron.*)

"Static electricity" is perhaps an unfortunate choice of words. It refers to a quantity of plus or minus electric charges that is stationary under certain conditions. Under other conditions, as when lightning strikes, the charges do move.

"Current electricity" refers to the movement of charges—as in the wiring system in a house or a car. Static electricity is usually associated with very high voltages and current electricity is usually associated with low voltages.

But whether moving or stationary, the charges are exactly the same—plus and minus. And the attractions and repulsions that these charges exert upon each other are the strongest non-nuclear forces presently known to exist in nature.

The cause of the earth's electric field isn't fully understood. According to one theory, the minute particles of dust in the air rub against the air molecules and become charged—just like rubbing amber with a cloth. Another theory suggests that the wind



Dr. Jefimenko and Graduate Student David K. Walker

breaks the small droplets of water in the air into parts that have an unequal distribution of plus and minus charges.

Still another theory attributes the field to radioactive substances within the earth. The sun appears to be responsible for at least part of the field.

On a clear day the air above one square mile of the earth's surface contains about 3,000 joules of electric energy—this is just about enough energy to light a 100-watt bulb for 30 seconds. During electric storms, the air above each square mile can contain up to a trillion joules of electric energy—enough to light 500 such bulbs for at least a year.

"But nobody yet knows what percentage of this energy can be converted into useful work and how fast the earth's field would replenish itself once part of the energy has been extracted from it," Dr. Jefimenko explained.

"At the present time this energy is simply wasted in the form of electric currents flowing from the air into the earth and from cloud to cloud. The power dissipated by these currents is estimated to be between one million kilowatts to one billion kilowatts. The latter figure exceeds the entire world's output of electric power," Dr. Jefimenko said.

Because of buildings, trees, power lines and so forth, the Earth's electric field isn't uniform near the surface. This is why Dr. Jefimenko and Mr. Walker used the parking lot, which is fairly clear of obstructions and is near the top of a hill, for their first experiment with the new electret motor.

However, because the voltage of the earth's field increases by about 30 volts for every foot change in height, it's possible—with a sufficiently long antenna—to generate the power needed to run an electrostatic motor.

The electric motors that are in common use today are based on the principles of electromagnetism. (They use electric currents but are moved by magnetic forces.) These principles were established by Michael Faraday in the early 1830s and he may have invented the first electromagnetic motor.

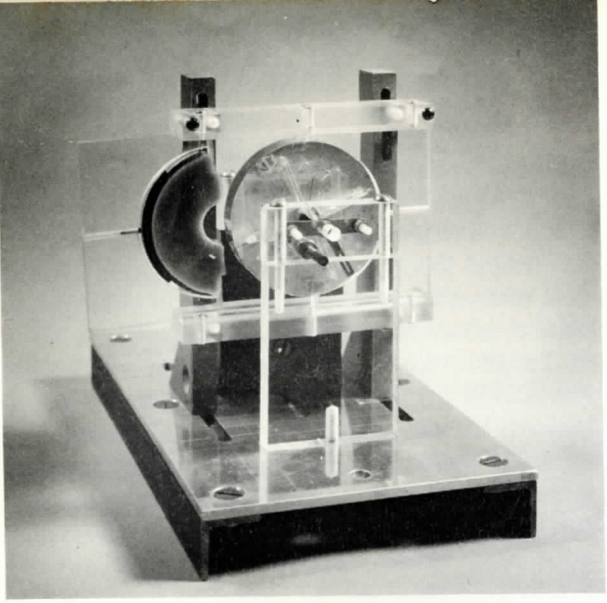
By 1873 Thomas Davenport, a New England blacksmith, used a battery-driven electromagnetic motor to operate a drill press. However, because of the efficiency of the steam engine and an apparently unlimited supply of wood and coal, Davenport's motor and similar devices developed during the following 30 years were looked upon as mere curiosities and not as useful mechanical inventions.

Electromagnetic motors require large currents and can't possibly use the earth's field as a direct source of power. Electrostatic motors, however, require only very small currents and can use relatively large voltages. They work on the principle that like charges repel each other and unlike charges attract each other.

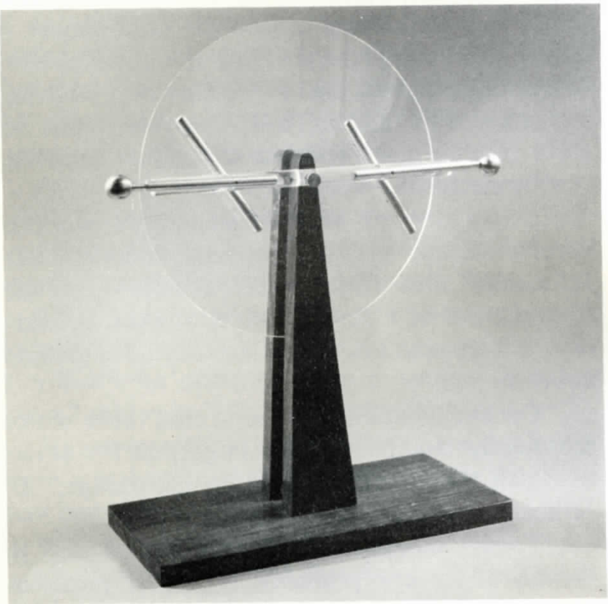
Electrostatic motors presently being studied at WVU are of three general types—spark, corona discharge and electret.

The first spark electrostatic motor—and the *first* electric motor—was made by Benjamin Franklin in the 1740s. It was powered from condensers (Leyden jars), which were in turn charged by mechanically turning a glass globe and rubbing it with a piece of bucksin.

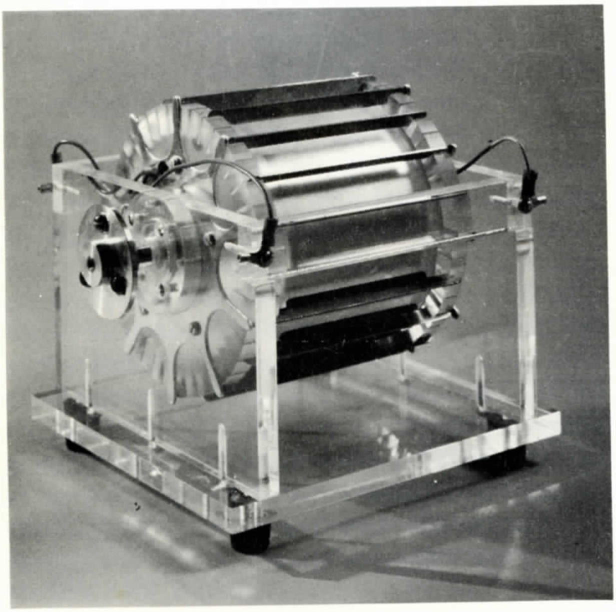
The simplest form of the motor consisted of a horizontal wooden disk fitted with narrow strips of glass with brass thimbles on the ends. The disk was placed between two oppositely-charged Leyden jars and, as each thimble approached the first jar, it received a spark. Since the thimble and the first jar now had the same charge, the thimble was repelled and caused the disk to turn. As that thimble approached the second jar, it was attracted and this force was added to turning the disk. Because the charge on the second jar was much greater than that on the thimble, a spark would again pass to the thimble. Now the thimble and the second jar would



This electret motor was the first ever operated from the earth's electric field. The event took place on the night of September 29, 1970, in the parking lot in front of the Engineering Sciences Building. The semi-circular disk at the left of the picture is half of the electret. In actual operation both halves of the electret are shielded by the rotors at the front and back.



A replica of the first corona motor built in the mid-1800s by the German physicist Poggendorff.



A modern version of the Poggendorff Corona motor utilizes a cylinder rotor instead of a disk. This particular motor was operated from charges of the earth's electric field. Dr. Jefimenko and Mr. Walker performed the experiment from the top of the Engineering Building using an antenna suspended from a balloon.

have the same charge and the thimble would be repelled again.

Spark electrostatic motors require thousands of volts to operate and aren't very powerful. A model of the Franklin motor made in the WVU physics laboratory generated less than one-thousandth of a horsepower.

According to Dr. Jefimenko, the first corona discharge electrostatic motor was made by the German physicist, Poggendorff, who described it in an article published in 1870. (Corona discharge is the same thing as St. Elmo's fire except that it is artificially produced with an electrostatic generator or a high voltage power supply while St. Elmo's fire is a natural phenomenon.)

The corona motor differs from the spark motor in that its rotor isn't fitted with electrodes (the thimbles in Franklin's motor). Both the inner tap and the body of a spark plug can be considered to be electrodes.

Poggendorff's motor consisted of a glass-plate rotor placed between two ebonite crosses that were fitted with sharp needles. The needles were connected to a manually driven electrostatic generator. The charges were sprayed onto the rotor, which in effect took the place of Franklin's thimbles, in a continuous manner by means of the corona discharge. The attraction and repulsion between the charges on the rotor and the needles acted in the same way as in the Franklin motor and caused the rotor to turn.

Corona motors are more powerful than spark motors and can operate on as little as 2,000 volts.

Although it has been 100 years since Poggendorff's work, a practical corona motor still isn't on the market. According to Dr. Jefimenko, one of the main reasons for this is that Poggendorff himself declared that neither his motor nor *any* other electric motor could ever develop enough power to be of practical significance.

Poggendorff's negative attitude about electricity as a motive power was shared by many physicists of his time.

By 1890 the idea that electric motors could be economically used had been disproved by a "mathematical proof." A textbook published in New York in that year stated:

"But, though an interesting application of the transformation of energy, these machines [electric motors] will never be practically applied in manufactures, for the expense of the acids and the zinc which they use [the materials of the batteries] very far exceeds that of the coal in steam engines of the same force. . . . A pound of coal yields 7,200 thermal units, and a pound of zinc only 1,200; and as zinc is ten times as dear as coal, engines worked by electricity, independently of any question as to the cost of construction, or of the cost of the acids, are sixty times as dear to work as steam engines."

In 1873 electricity was first transmitted over considerable distances by means of wires, but apparently the advantages of generating electricity at a central location and sending power throughout a large area—something that couldn't be done with a steam engine—hadn't been realized. In a textbook published in Boston in 1892 this idea was expressed. Although the author said that it would cost a hundred times as much to run an electric motor as a steam engine with the same power, he added: "But where the absolute amount of power is of less consequence than the facility of producing it instantaneously and at will, electromagnetic engines may be used with advantage, as in driving sewing machines."

It also appears that Poggendorff's work on corona motors is still practically unnoticed. Dr. Jefimenko cites three recent articles—one each from the Soviet Union, South Africa and Poland—in which the authors claim that they have invented novel motors.

"On examination it is found that these motors are merely modifications of Poggendorff's device, of which they obviously had no knowledge," Dr. Jefimenko said.

"Today electrostatic motors based on the corona effect are probably the most promising ones," according to Dr. Jefimenko. "Even in the simple form used by Poggendorff they were quite efficient. Furthermore, they are extremely lightweight in comparison to the horsepower they produce. Another advantage of corona motors is that theoretically there are no limits to the speeds that they can attain. (One of the corona motors built in Dr. Jefimenko's lab runs at about 10,000 rpm.)

It was originally thought that a specially designed antenna would be needed to run a corona motor from the earth's electric field. However, Dr. Jefimenko decided to try one of these motors with a makeshift arrangement attached to a balloon.

The helium-filled balloon was about two feet in diameter and the antenna was a 22-inch long piece of piano wire with one end filed to a very sharp point. No radioactive material was used with the antenna. A fine wire and a heavy string, which were about 100 yards long, connected the antenna to the motor.

The balloon was first flown from the roof of the WVU Engineering Sciences Building, which is about 11 stories above the ground, on December 10, 1970. The balloon didn't go much higher than the roof, but in such an arrangement the only problem is to get the antenna away from the building into a region where the earth's field isn't disturbed.

The corona motor ran much slower than it normally does in the lab when it is connected to a high voltage power supply, and it is estimated that the motor was producing one ten-thousandth of a horsepower. The rotor of this motor, which is of the multiple electrode type, weighs about one pound. (The rotor of the electret motor that was run from the earth's field weighs about one-eighth of an ounce.) When the electret motor was connected to the antenna on the balloon, it ran so fast that it had to be disconnected for fear of damaging the commutator. Voltages up to 6,000 volts were measured during this experiment.

According to Dr. Jefimenko, this experiment proves that large electrostatic motors can be operated from the earth's electric field provided that appropriate antennas are used to power them.

"But, despite all of their desirable properties, corona motors have a serious limitation—normally they can't be operated from a source less than about 2,000 volts," Dr. Jefimenko explained.

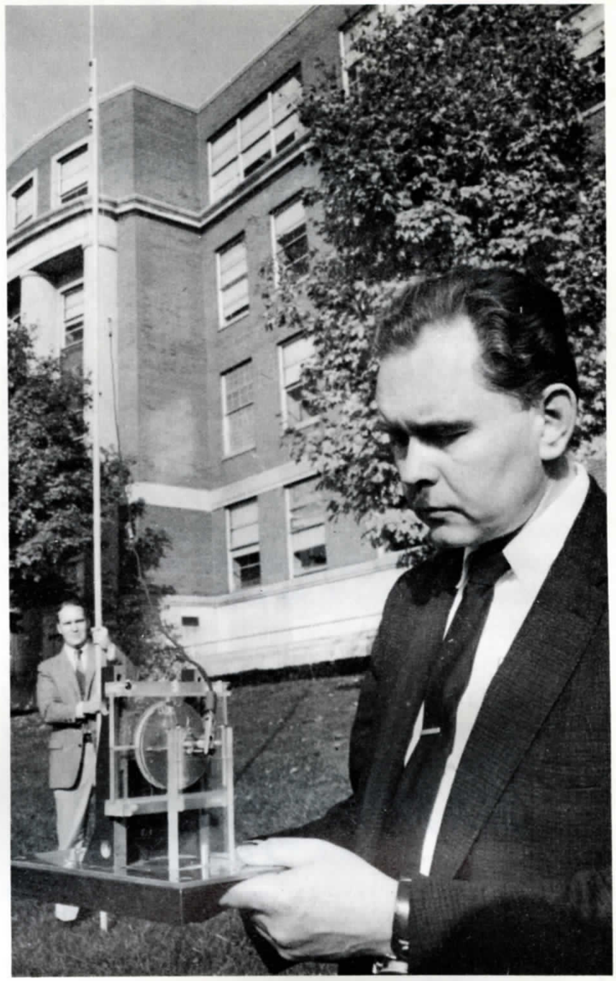
However, electret motors don't have this limitation—it is known that they can operate from less than one volt.

It's thought that the first electret electrostatic motor was built by the Russian physicist, A. N. Gubkin, in 1961. Like spark and corona motors, electret motors operate on the principle that like charges repel and unlike charges attract. (The first electret was made by the Japanese physicist, Motataro Eguchi, in 1919.)

The Russian motor had two wax electrets mounted on a shaft that was fitted with an axle. The electrets were alternately attracted and repelled by two sets of electrodes. The motor was powered by high voltage batteries.

Dr. Jefimenko has been able to improve the design of early electret motors by using what has been called the electret "slot effect."

The electret motor that was powered from the earth's electric field has a single carnauba-wax electret that is one-half inch thick and three inches in diameter. Besides being able to run from the earth's field, this motor can be powered by 60-volt dry cell batteries, A.C.-to-D.C. converters, condensers and electrostatic generators. Power for this motor—and for certain corona motors—also can be transmitted directly through the air without wires.


Electret motor operating from 20-foot pole antenna

"Present electrets have only moderately strong charges; thus electret motors can't compare with corona motors in regards to power. On the other hand, electret motors can operate at low voltages, so there should be many situations where they will be useful," Dr. Jefimenko said.

"A more important point is that the various types of electrostatic motors offer new and unique possibilities for use in numerous areas of science and technology. The absolute rule of electromagnetic motors, which has now lasted for some 100 years, may soon be ended.

"As to the significance of the earth's electric field as a source of power, a great deal of research will be needed before any certain statements can be made on the subject. At WVU we certainly intend to continue our work in this area."