CHARLES A. YOST

Electric field propulsion concepts from independent researchers

TWENTY-FOUR POSTER PAPERS WERE PRESENTED TO NASA AT THE BREAKTHROUGH PROPULSION PHYSICS WORKSHOP, AUGUST 12-14, 1997. ONE PAPER PRESENTED MATERIALS SUBMITTED BY VARIOUS *ESJ* NETWORKERS PERTAINING TO THE USE OF INTERACTIVE ELECTRODYNAMIC FIELDS FOR PROPULSION. ACCORDING TO ONE CONCEPT, PULSED ELECTROSTATIC POTENTIAL WAVES WOULD BE GENERATED AND TRANSMITTED IN LONGITUDINAL FORM FROM THE SURFACE OF ELECTRODES. INTENSE NON-LINEAR POLARIZING WAVES WOULD THEREBY EXTEND INTO THE SURROUNDING SPACE, AND IT IS POSSIBLE THAT A PRECISION SYSTEM COULD PULSE, PHASE AND DIRECT THEM TO DEVELOP REACTION FORCES ON SURROUNDING OBJECTS, MEDIA AND SPACE FIELDS.

CLASSIC EFFECTS

In the earlier publications of *ESJ*, much attention was devoted to investigating T.T. Brown's claims of a connection between electricity and gravity. Experiments conducted by T.T. Brown indicated that suspended capacitors underwent linear thrust when a voltage was applied. (See Fig. 1.) In other experiments, Brown showed that aluminum saucers, 1½-2' in diameter, suspended from tethers on opposite ends of a rotatable bar, would move rapidly when connected to a 50-150kv source. (See Fig. 2.) Brown and Bahnson did not establish an electrogravitics connection, and subsequent testing of Brown's devices, which tried to eliminate coulomb forces[1] and ion winds, have led to two definitive conclusions: (1) The coulomb forces and ion wind were all but impossible to negate, but when they were nearly eliminated, little or no force remained. (2) Transient discharge of the high voltage terminals resulted in increased thrust levels, indicative of an electrical phenomenon, and not the electrogravitics interaction that Brown and Bahnson had sought. Still, the action of intense electric pulsing continues to be of interest.

ELECTRICAL BEAMS

Schlieren imaging of the region between Wimshurst electrodes by Yost has shown how electrostatic forces alter the density of the surrounding air. Sparks produce cumuliform pressure bursts from both terminals. When the negative terminal is fitted with a point or a small ball, a coherent thread-like stream is emitted. (See Fig. 6.) A single thread could also be made to emanate from the positive terminal, but threads from the positive terminal were substantially weaker than threads with negative origins. The dual threads do not seem to interact with

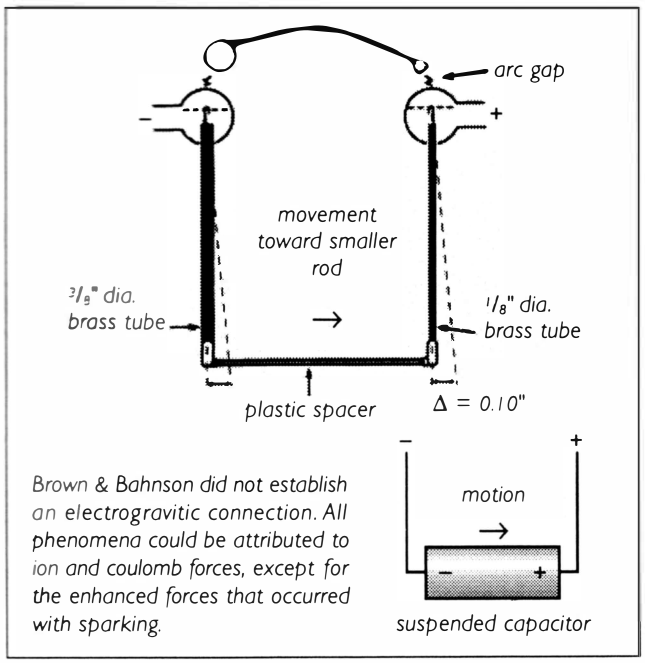


Fig. 1 *Arc pulsed pendulum enhances movement one order of magnitude.*

1 Coulomb forces have been shown to be capable of levitating small objects. (See Figs. 3-5.)

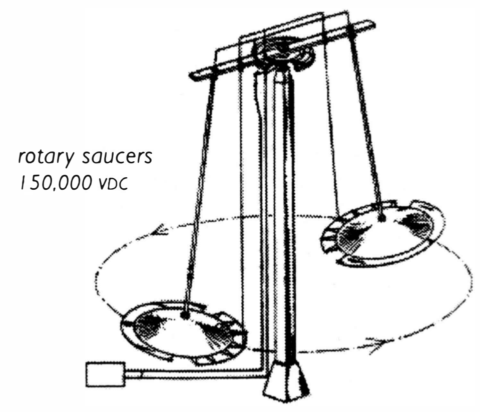


Fig. 2 T.T. Brown's Electrogravitic Thruster

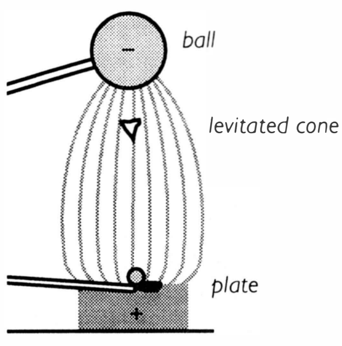


Fig. 3 Stationary Levitation

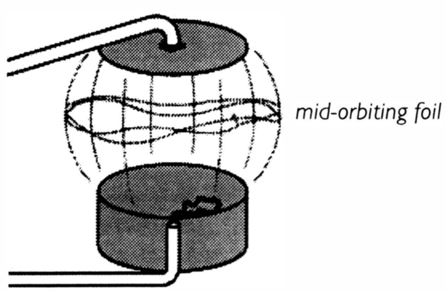
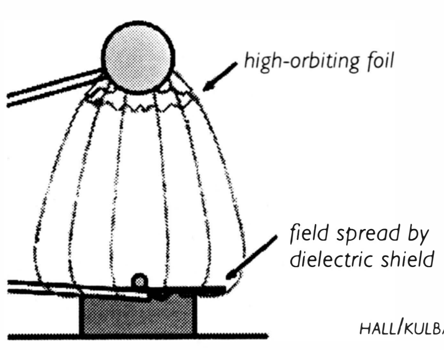


Fig. 4 Mid-orbiting Levitation



HALL/KULBA

Fig. 5 High-orbiting Levitation

each other. Subsequent experiments revealed that the movement of the thread was not influenced by the location or movement of the other electrode, ground, or a neodymium magnet moved in close proximity. A wire probe connected to a DC microammeter registered a current of 50 μA in the stream, and nothing immediately outside it. A mechanical wind vane, similarly, remained stationary except in positions intercepting the stream, where it would spin rapidly. While the stream had momentum and current, it seemed to be electrically neutral. It showed slight perturbations when a small steel ball placed near was suddenly whipped away.

Electrical beams with different properties have been generated by other means. Morton created a beam by placing a glass tube having a metal end plate on a charged Van de Graaff terminal. (See Fig. 7.) He observed that a spark jumped from the Van de Graaff to the end plate, which then emitted a beam. The beam charged a metal target at which it was aimed, as well as everything else in its path. Later, based on Morton's observations, Schlecht recreated the phenomenon with a more sophisticated device at the University Karlsruhe, Germany. (See Fig. 8.) This pulse device has generated energy beams which have been able to levitate talcum powder for brief instances. These beams were accompanied by electrostatic field effects and an obvious change in air pressure noted by experimenters at a distance of 4 m. This beam was not believed to be ion wind because a neon lamp was 25% ignited and test balls exhibited

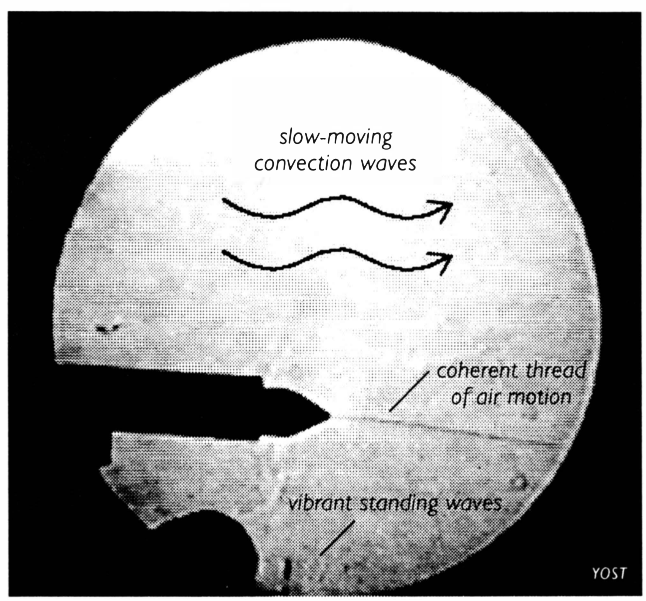


Fig. 6 A neutral coherent thread, 8"-12" long, emitted from electrode, made visible by schlieren optics

attraction-repulsion behavior when placed in its path, and its ignition spark was not of the characteristic color and form of conventional ion propulsion sparks. The Wardenclyffe Tower, constructed by Tesla (c. 1905) was designed to oscillate a high electrostatic charge on its dome-shaped electrode, which had a hole in its top for the projection of a beam toward the ionosphere. (See Fig. 9.) These experiments suggest possible new avenues for propulsion research.

ION LONGITUDINAL WAVE GENERATION AND TRANSMISSION

The concept of electrostatic waves (otherwise known as longitudinal, ionization, potential, or scalar waves) has been all but forgotten since Maxwellian transverse electromagnetic waves became the focus of electrical research. Although much experimentation is still required to understand the properties of these waves, a few fundamental notions have been established. The well-known electrostatic field that exists between separated charges exerts repulsion and attraction forces and polarizes neutral media and objects. It has no magnetic field associated with it. This field is referred to as a longitudinal field because variations in the intensity of an electrostatic field are transmitted longitudinally; that is, in the same direction as the disturbance. Longitudinal electrostatic waves can be created by any

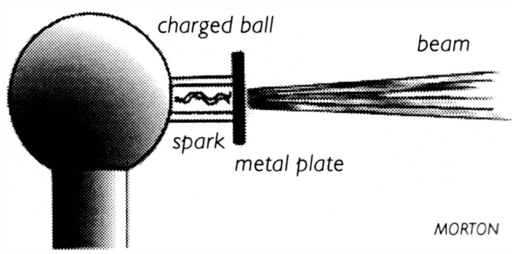


Fig. 7 Beam projection with pulsed electrostatic discharge

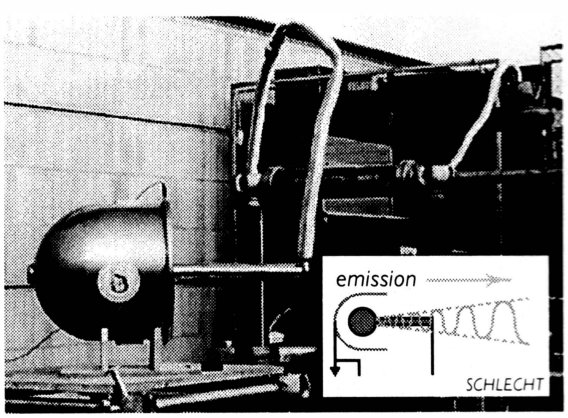


Fig. 8 Morton beam tested in Germany

variation in the electrostatic field. Variations may be caused by (1) oscillating an object holding a static charge, (2) periodically varying the amount of charge on an object, or (3) suddenly changing the charge on an object, as with a pulse or spark discharge. Longitudinal electrostatic waves transmit only electrostatic potential-difference, and are not, strictly speaking, physical ion or charge transfer mechanisms.

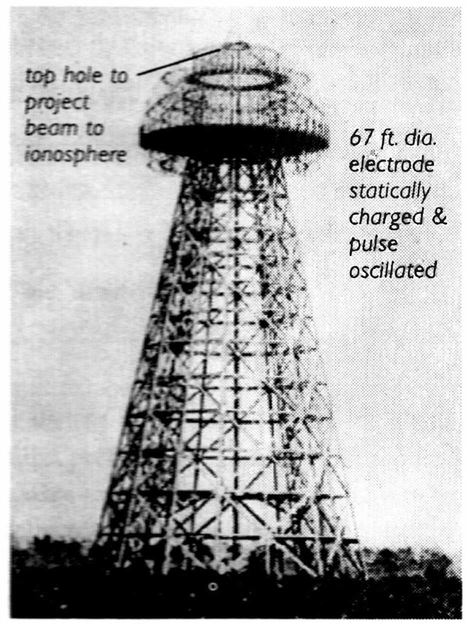


Fig. 9 Tesla Wardenclyffe Tower — Long Island

THE WIGGLE WAND

Yost and Hall have demonstrated the transmission of a potential wave by charging a plastic rod and moving it to and fro several feet from a ball antenna, which is connected directly to an oscilloscope. (See Fig. 10.) The variations in the electric field, caused by the motions of the charged rod, or wiggle wand, create an electrodynamic wave. When the wand is wiggled very near the antenna, large voltage fluctuations are induced; sixteen feet away, fluctuations of several millivolts are still detectable (the field strength falls off as $1/r^2$). The dynamic wave form on the oscilloscope corresponds with great fidelity to the motion of the rod.

Perhaps most interesting was the fact that oscillations of the electrostatically-charged wand could be picked up by an antenna sixteen feet away, on the other side of a closed, wooden door. When the door was opened, the signal reception was much weaker. It would seem that intervening solid dielectric objects transmit electrostatic force with less dispersion, just as metal conductors transmit current with very little loss. In air and vacuum, the electrostatic force falls off according to the inverse square law. In solid dielectrics, however, charges polarize, facilitating the transmission of electric fields, much like conducting materials have been presumed to conduct electric charge. Deavenport also showed that a light bulb would oscillate in response to an electrostatic field on the other side of either a ¼" thick Plexiglas™ plate, or a ⅛" thick glass dome.

These experiments support early claims made by Tesla that electrical energy can be transmitted by means of longitudinal electrostatic forces, the ground serving as the current conductor, and the air acting as a dielectric for the displacement current. The electrostatic field has the ability to polarize all atoms (metallic and dielectric). In the case of conductors, the polarization will cause a current to flow if the conductive material is in the form of a closed circuit. Thus, as Tesla suggested, potentials can be developed as standing waves on the earth, and power can be tapped by putting up a metal antenna.

Electrostatic longitudinal forces are believed to be analogous to acoustic longitudinal forces. Hartman showed how strumming the low E string on an amplified guitar, with approximately 25 watts of power, could cause a speaker, placed on the ground, to levitate for five seconds. (See Fig. 11.) Higher frequencies only vibrated the speaker, whereas distorted, lower frequencies could levitate the speaker as much as one centimeter above the ground.

Inspired by Hartman, Yost, in a similar experiment, demonstrated the acoustically-induced motion of a pendulum-suspended speaker. No motion was detected with a steady, intense 20-40 HZ signal. However, singular pulsing of the woofer caused it to swing, and the amplitude of the swinging could be increased by delivering the pulses at times coinciding with the swing period. In other experiments, Hartman floated a speaker in a tub of water and observed that certain tones would scoot it across the surface of the water, if it was initially tilted to make the force against the water asymmetric. Hartman reported that the speaker would either jump, sit still, spin, or scoot, depending on the frequency delivered. These experiments have led to speculations that electrostatic longitudinal forces might be modulated similarly. George Damm has advocated this possibility for quite some time.

HIGH-INTENSITY ELECTROSTATIC FIELD GENERATION

Tesla's insistence that the tower at his Colorado Springs laboratory was transmitting longitudinal electrostatic waves has not been well-accepted. Nevertheless, in a working analogue of Tesla's tower, created by Kovac, the partial conversion of the high-voltage output of a Tesla coil to static electricity was demonstrated. By sending high voltage RF from a Tesla coil secondary through a mercury vapor rectifier tube surrounded by a steel pipe, Kovac was able to accumulate an electrostatic charge on a ball electrode. (See Fig. 12.) This static

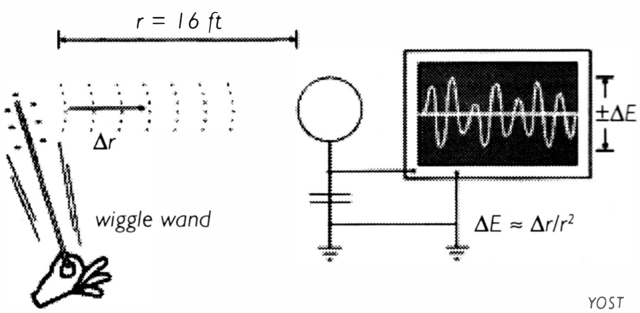


Fig. 10 Oscillations of charged plastic wand detected as field intensity variations.

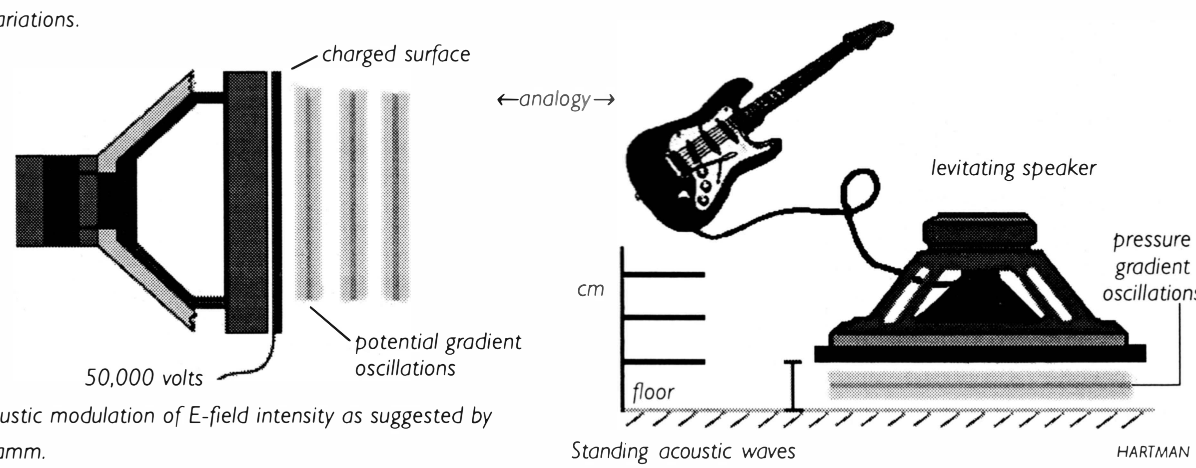


Fig. 11 Acoustic modulation of E-field intensity as suggested by George Damm.

field was, in turn, modulated into a waveform, representing the combination of an 8 HZ component and a 100 HZ component, by means of mechanical switches. The RF rectifier technique allows for higher power outputs from an electrostatic wave transmitter. This technique also permits the potential on an antenna to be modulated, indicating that it might be possible to set up resonant waves. Timing the electrostatic waves in a closed system, such as on the earth sphere, allows transmitted, longitudinal electrostatic polarizations to be reflected and to return to reinforce the excitation.

Research with Tesla coils has been a constant source of fascination for experimenters. Hall observed attractive and repulsive responses, for a variety of plastic and metallic objects suspended near a Tesla coil secondary, that led him to conclude that the objects were acquiring a static charge. (See Fig. 13.)

As early as 1991, Hull and his group, known as the Tesla Coil Builders of Richmond, noticed a buildup and retention of electrostatic charge on insulated coils and metallic objects located near an operating Tesla coil. Controlled experiments were therefore devised by Hull to quantify the charge buildup on a distant, insulated, conductive target. Charges of 20 kv were accumulated at distances up to nine feet away. (See Fig. 14.) Experiments set up with a fan positioned so as to blow the airborne charges toward, and then away from, the collector showed that charging was at least partially due to the flow of ions, but that perhaps another, faster charging mechanism was operating as well.

Hull repeated the experiments, replacing the Tesla coil with a Van de Graaff generator. The instant the Van de Graaff was turned on, a voltage of 15 kv appeared on the remote collector. But, it was discovered that in a steady static field, the collector barely picked up a charge. It was then supposed that a spark or other rapid field variation might be responsible for setting up a wave of charge transmission. Electrical waves propagating with speeds far in excess of those attainable by ionic motions have been researched in-depth. An experiment in 1930 (Lagarkov and Rutkevich-1993) revealed that a luminous wave, created by applying 180 kv across a long vacuum tube at 20 torr, moved with a speed of 5×10^9 cm/s. Because ions cannot move this rapidly, the high velocity was attributed to the propagation of an electric potential wave. A Russian patent application by Avramenko and Avramenko refers to the oscillations of free charges as the displacement current or longitudinal

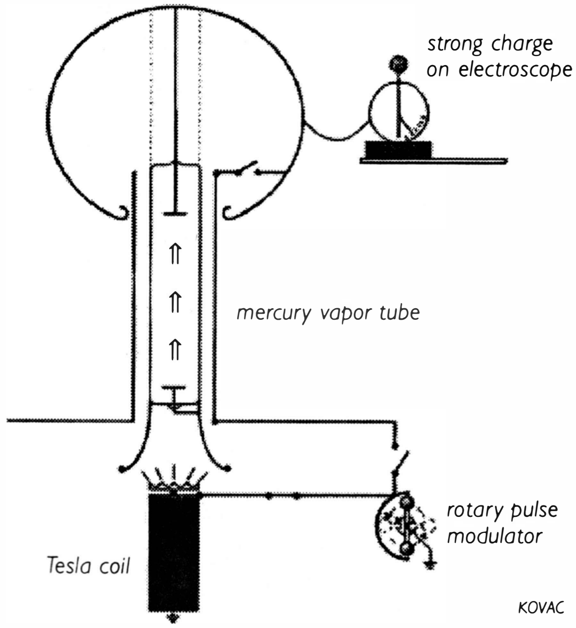


Fig. 12 Tesla coil RF rectified to static charge with mercury vapor tube

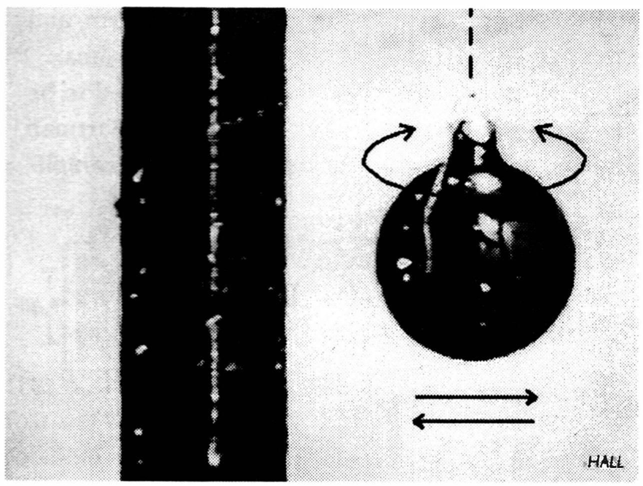


Fig. 13 Suspended ball swings and rotates near Tesla coil secondary

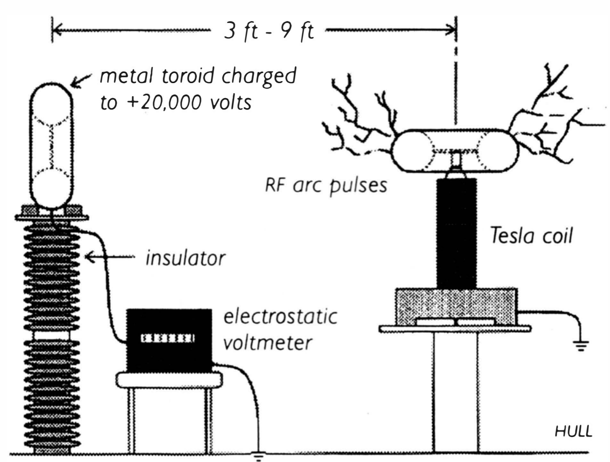


Fig. 14 RF arcs electrostatically charge distant conductor

electrical wave, capable of efficiently transmitting power. Jackson devotes only two sentences in his classic electrodynamics text to longitudinal electrostatic fields.

Damm has speculated that Tesla incorporated acoustic resonant criteria in the design and modulation of his tower at Shoreham, Long Island. The dimensions of the tower's components and their acoustic resonant frequencies are well-matched to the earth's electrical resonant frequencies. Tesla's notes mention that an electric pulse would traverse the earth's diameter and return with a period of 0.08484 seconds. He also claimed that lightning could resonate the earth electrically. In an investigation of multiple-stroke lightning, Yost discovered, as Tesla suggested, that the periods between flashes corresponded precisely to simple harmonics of the earth's diameter; ¼-, ½-, and ¾-diameter time periods being most prevalent. (See Fig. 15.) This suggests that the earth behaves as a giant dipole antenna, and that the electrostatic resonance of the earth was indeed a possibility. Tesla intended to transmit potential differences over the earth and build them up as resonant standing waves.

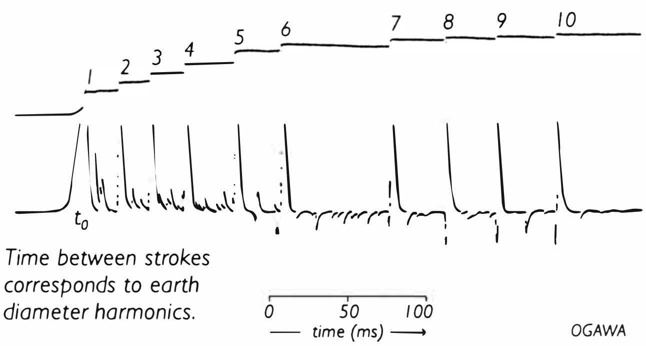


Fig. 15 *Earth Electrostatic Resonance — Lightning*

SPARK DISCHARGES

The spark discharge method of producing pulsed electrostatic waves is simple, most promising, and little understood. It is in this pulsed wave form that T.T. Brown's electrogravitic effects were thought to be enhanced. Recent developments with spark discharges have been made possible by engineering advancements with the Tesla magnifier made by Hull. (See Figs. 16 and 17.) The Tesla magnifier is a third coil, which Tesla used with some of his traditional coil setups. The magnifier serves as a free-resonance transformer for creating extremely high voltages at very low amperages. The magnifier coil is driven by the Tesla coil secondary. Very small magnifier coils, on the order of 4" in diameter by

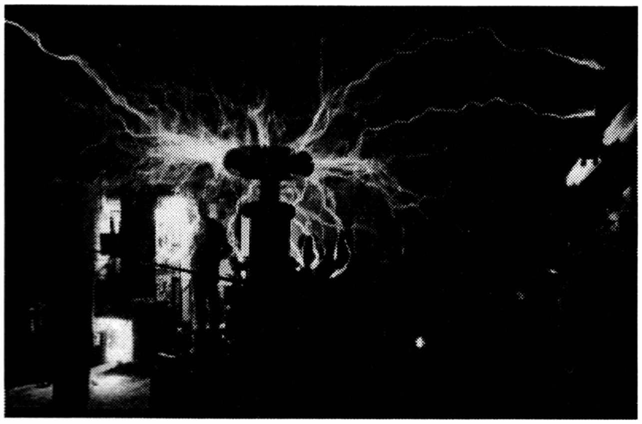


Fig. 16 *6000 watt Tesla magnifier* HULL

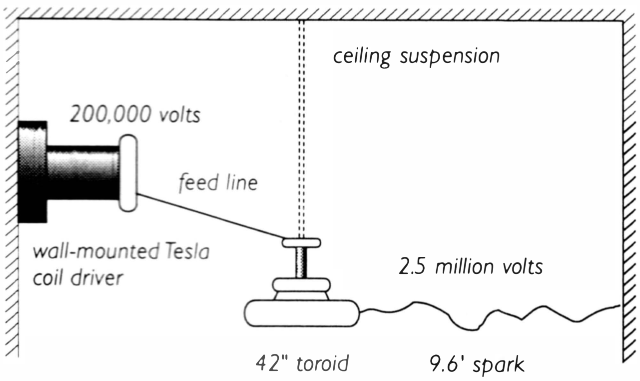


Fig. 17 *Power input to primary 20kV @ 6kW* HULL

12" long, are capable of producing 10-foot sparks, without heating or shorting, from a 6000 watt power source. Their output consists dominantly of an alternating electrostatic potential field.

Hull conducted a series of experiments involving the capacitive loading of Tesla coils. In one experiment, a coil was loaded until no sparking would occur. When the coil was turned on, a distant toroid used to collect electrostatic charge remained electrically neutral, while a neon tube at the same distance glowed intensely. When a thumbtack was placed on the terminal of the transmitting coil, sparks broke out, the collector toroid registered an immediate increase in charge, and the neon tube remained unlit. It became evident that spark discharges were necessary if the electrostatic transmission effects were to be observed. It is now believed that the Tesla coil can serve as a field emitter of pulsed potential to its surroundings. It is not difficult to produce by this means megavolts of potential and megawatts of impulse energy.

Further experiments by Hull with capacitive loadings suggested that capacitive coupling might be occurring. A coil system was set up so as not to spark. Nearby, a similarly-loaded, grounded coil, tuned to the frequency of the transmitting coil, was passively placed as a receiver and made to produce large sparks. Rotating the resonator through 90° resulted in no change in intensity, thereby demonstrating that the sparking was not due to electromagnetic induction. It was further noticed that the capacitive loading on the coils had a direct bearing on the degree of sparking. This indicated that tuned radio communication was not the sole means of energy transmission between the coils. In yet another experiment, two separated, ungrounded, passive, capacitively-loaded coils were conductively connected at their bases. (See Fig. 18.) When the active coil was operated nearby, sparking took place between the passive coils, which were acting as receivers, and an alternating current flowed through their connecting base wire. These phenomena demonstrate a potential for remote charging, which might be applicable to a craft and its immediate surroundings.

Experiments by Yost, designed to explore the nature of the combined fields of a Wimshurst generator and a Tesla coil, revealed that when the output from an electrostatic generator was sprayed onto the ball terminal of a Tesla coil, the electrostatic field surrounding the Tesla coil was greatly enhanced and extended.

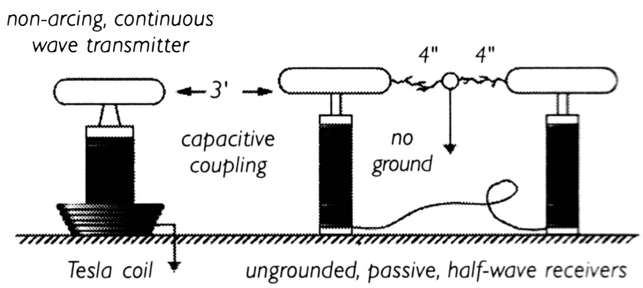


Fig. 18 Transmission by electrostatic coupling HULL

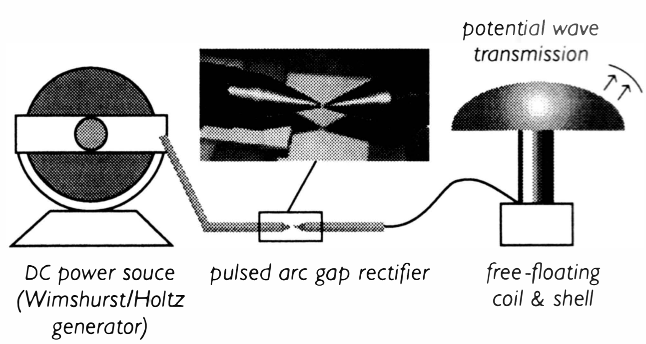


Fig. 19 Pulsed charge oscillation HULL/YOST

PULSED ELECTROSTATIC FIELDS

Over a year ago, Hull demonstrated an arc charge transfer technique suggested by Tesla. In later experiments, recreated by Hull and Yost at the *ESJ* lab, points were used to form a 0.01" spark gap. This gap joined the positive terminal of the Wimshurst generator to the base of an ungrounded coil which had a large metal bowl capacitor on top. (See Fig. 19.) When the system was operating, tiny sparks were observed to jump the gap. Four feet away, an antenna picked up strong signals from the bowl with high fidelity. Oscilloscope readings indicated that the antenna was pulse charging in less than 1 μs, with a positive charge that took 500 μs to decay. (See Figs. 20 a,b,c.) In other words, electrostatic potential was being impulsively transmitted to the isolated transmitter dome as Tesla claimed. Electrostatic oscillations of 600 kHz, generated by the LC circuit, were superimposed on the exponentially decaying potential. The bowl on top of the magnifier coil had an intense static charge, which it retained even after the power source was shut off.

Electrostatic field variations are caused by the projections of longitudinal electrostatic forces, and not electromagnetic waves. There are no currents transmitted, nor any need for conductors in order for such forces to transmit. However, displacement currents develop within each atom as it polarizes, and in the distant receivers.

Spark discharge experiments hint that it might be possible to design a craft that could be launched by generating positive or negative pulses, provided it can produce a repulsive force in its surroundings. The demonstrated techniques would need a high-power, polarized, phased wave to thrust a craft.

The electrostatic coulomb force is understood to fall off as the inverse square of distance. This relationship applies to the field around point static charges. The pulse discharging of large, dielectric surfaces seems to provide greater latitude for the development of coulomb forces which do not deteriorate according to an inverse square law. It is speculated that pulsed potentials carrying frequencies on the order of 100 MHz may allow electrodynamic longitudinal forces to be directed by a practical sized craft of 10 meters in diameter.

It is not possible to focus a static force field (analogous to a constant pressure field). However, as with sound waves, it is thought possible to be able to transmit and focus the variations in an electrostatic field. Means of intensifying, transmitting, and pulsing oscillating electro-

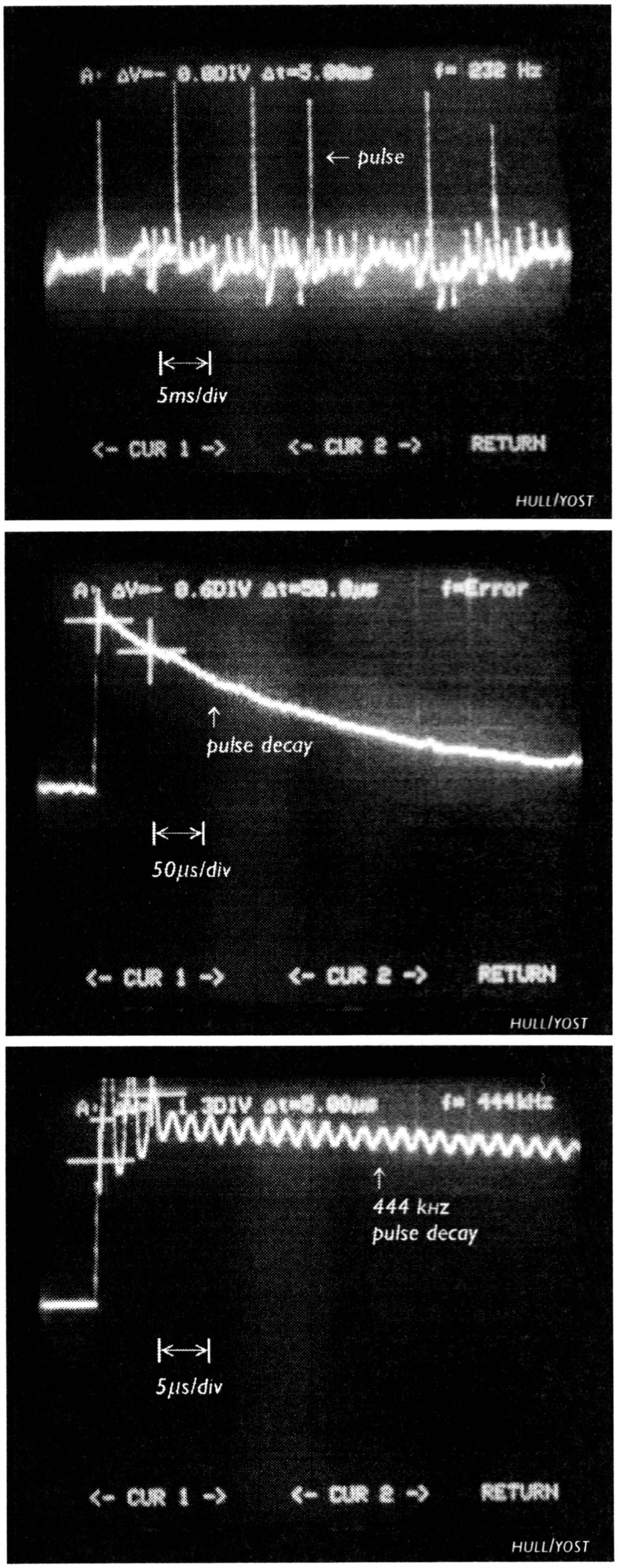


Fig.20a,b,c Each spark across the 0.01" gap generates a positive pulse with an exponentially-decaying, oscillating E-field

static field variations have been demonstrated. The successful electrostatic propulsion system will need to have the ability to set up an intense electrodynamic field around the craft. This field will need a sharp, transient electrostatic field gradient capable of being propagated. In some instances, the intense charging of remote objects might be used for action-reaction force. Thus, a method of pulsing, phasing, and directing electrostatic influence may be possible (See Figs. 21 and 22.); and it would not be necessary to force motion of the atmosphere at large, as is typical of ion propulsion. In any case, care must be taken to prevent voltage breakdown from shorting out and defeating the intense, oscillating field.

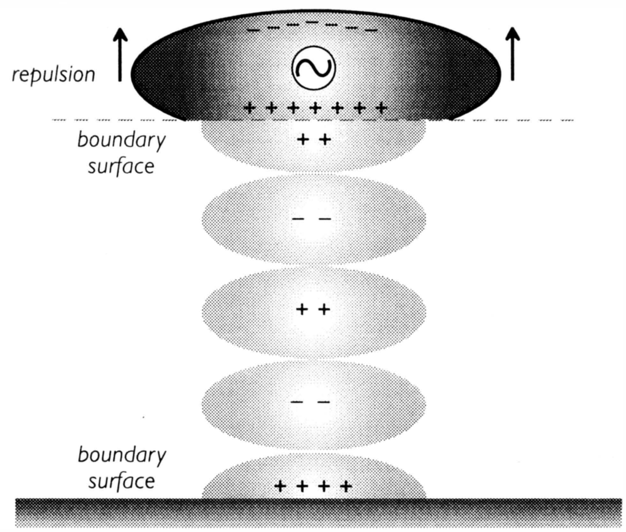


Fig.21 Alternating polarity to set up repulsion fields at boundary surfaces when phased at odd multiples of ¼ wavelength.

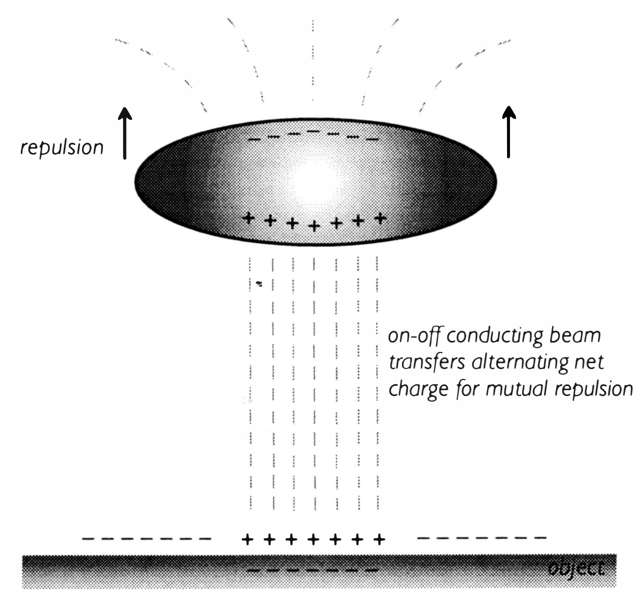


Fig.22 Conducted charge transfer to external object or medium

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Note: *A paper by F. Znidarsik was provided by NASA as a handout.*

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Electric Weather Forces

In spite of Earth's immense size, lightning signature data is shown to have voltage pulses at periods coincident with harmonics of Earth's diameter. This suggests that the earth behaves like a giant dipole antenna. Nikola Tesla concluded this from his studies of lightning electrical wave nodes at Colorado Springs in 1899.

Nikola Tesla proposed to transmit electrical power over the entire Earth without wires. This proposal was based on his belief that the entire Earth could be electrically resonated. The primary purpose of this report is to examine Tesla's concept of Earth electrical resonance, the ramifications of which would lead to an entirely new understanding of global weather forces.

BACKGROUND

When Nikola Tesla proposed that lightning was an earth resonance phenomenon, he also stated that the resonance would occur at wavelengths corresponding to ¼ and other odd quarter multiples of the earth's diameter, such as ¾, $^5/_4$, etc. This report presents the results of lightning signature data analysis designed to test these considerations. In addition, it draws attention to certain implications Earth electrical resonance may have for global weather.

The measurements of time intervals between the distinct flashes and pulse periods of lightning wave traces seem to indicate the presence of wavelengths corresponding to Earth electrical resonance. The evidence appears in both photographic and electrical measurements of time periods. Thus, some types of lightning appear to operate in accordance with resonance conditions associated with the earth's dimensions. The existence of multiple stroke lightning could therefore be explained by electric fields beyond the clouds themselves; fields of a global nature.

It is worth noting that the fundamental 0.08484 sec period, as quoted by Tesla, is the time it would take light to travel through the earth's diameter and reflect back. This clearly suggests that he thought electrical impulses could travel directly through the earth. This was and still is looked upon as rather incredible and unlikely; but certainly is a possibility.

If we assume, as shown in Figure 1, an electric pulse to expand radially in all directions, it would travel both the surface and the diameter distances in the same time. We see the surface distance to be $^{\pi}/_2$ times further. As a result, the surface velocity would appear to be $^{\pi}/_2$ times faster than the speed of light, or 471,240 km/sec, which is what Tesla said.

$$\frac{(\text{surface distance}/t)}{(2\times\text{diameter}/t)}=\frac{(\pi D/t)}{2D/t}=\frac{\pi}{2}$$

The natural condition of Earth electrical resonance caused by lightning would indicate that man-made Earth resonance could also be imposed using the techniques developed by Tesla. While the part electricity plays in forming our global weather has not been used in forecasting, its effect is becoming increasingly evident from the continued research results of many space scientists. One is led to consider the real possibilities of weather modification by the imposition of electrical forces.

Lightning is a common event, but still a mystery in the details of its production. In 1899 Tesla performed experiments to produce lightning effects of an earth scale and claimed to have succeeded. Even today, 100 years after Tesla's experimentation, there are skeptics who question his claim about Earth electrical resonance, mainly because of their focus on the predictions of Maxwell's electromagnetic wave theory. Electrostatic impulse, polarization waves and the properties of electrostatic/electrodynamic impulses raise questions not presently answered by Maxwellian theory.

TESLA'S PATENT #787,412

Tesla stated the basic requirement for Earth resonance in his Patent #787,412, filed May 16, 1900, and issued on April 18, 1905 (Tesla 1905). The patent states in part:

> ...The planet behaves like a perfectly smooth, polished conductor of inappreciable resistance with capacity and self-induction uniformly distributed along the axis of symmetry of wave propagation and transmitting slow electrical oscillations without sensible distortion and attenuation.
>
> ...Three requirements seem to be essential to the establishment of the resonating condition.
>
> First. The Earth's diameter passing through the pole should be an odd multiple of the quarter wavelength; that is, of the ratio between the velocity of light and four times the frequency of the currents.
>
> Second. It is necessary to employ oscillations in which the rate of radiation of energy into space in the form of hertzian or electromag-

netic waves is very small...I would say, that the frequency should be smaller than twenty thousand per second...

Third. The most essential requirement is, however, that irrespective of frequency, the wave or wave train should continue for a certain interval of time, which I have estimated to be not less than one-twelfth or probably 0.08484 of a second and which is taken in passing to and returning from the region diametrically opposite the pole over the earth's surface with a mean velocity of about four hundred and seventy-one thousand two hundred and forty (471,240) kilometers per second.

THE ELECTRIC WAVE

Little is said about properties of a purely electric wave. Nevertheless, some thoughts are herein entertained about the nature of the electric wave. Scientific nomenclature is often vague about making a distinction between electric waves, electrodynamic waves and electromagnetic waves. The waves we are considering are not electromagnetic, since such waves are not likely to travel through the earth, and do not transmit currents. Tesla was also definite about this point.

The electric wave would need to have predominantly longitudinal electrostatic properties, and is essentially a force and a polarization wave. An electrostatic field intensity can change with very little magnetic induction, since there is no associated current flow. Thus, as Tesla indicated, high potentials induce electrostatic effects. An electric wave might well dominate in the form of electrostatic dipole polarization among the atoms and propagate in longitudinal fashion as would an ordinary acoustic wave. Such propagation is permissible under various conditions in electrostatics and plasma physics.

The generation, by lightning, of strong magnetic fields is a result of real current flows in the stroke along its axis. At the same time, a strong electrostatic impulse from leading charges would be present to impel longitudinal wave propagation ahead of the axial current pulse (Jefimenko 1992). It seems that under such conditions, when an impulse of free electric charge is moving, an electrostatic field gradient would extend and co-exist as part of the radial wave front. (See Fig. 1.) As such, a surface wave is seen as part of an expanding wave front with a velocity at the surface that only appears to travel faster than the speed of light. The surface wave will always be connected to the diametric wave. The surface wave appears to travel as a concentric ring over the earth's surface, an electrostatic moving front ($\Delta q/\Delta s$). The transfer of charge over a distance ($\Delta q/\Delta s$) implies work against a potential difference or field intensity (E), but it might only be manifest as polarization if conductive breakdown does not occur.

An electric field meter under a charged cloud can sense the slow variations of electrostatic fields and thereby distinguish individual clouds as they pass. This dipole electric field is only in the vicinity of the cloud and cannot be detected far away. However, if lightning should flash between the cloud and the ground, a dynamic electric and magnetic transient is generated, which can be detected many miles away. The wave travels both through the air and through the ground. Through the air, the wave is electromagnetic in nature, but through the ground it is more likely to be a polarization wave.

A ball electrode can detect the dynamic electric fields produced by lightning. When the lightning bolt occurs, current flows to produce a powerful magnetic field around the discharge. The rate of change of this magnetic field (an accelerated charge flow) produces the dynamic electric wave, which is picked up by the ball electrode. The initial dynamic electric wave has features similar to any subsequent lightning discharges. The transient dipole field travels

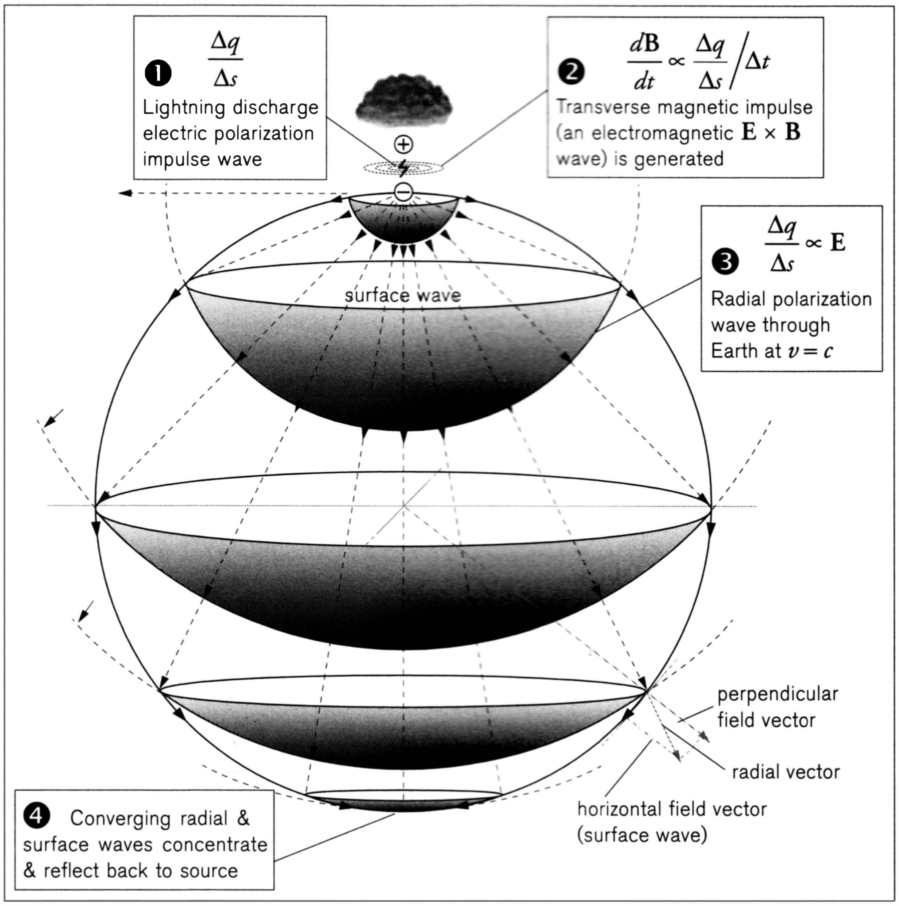


FIGURE 1 Surface and Diametric Waves

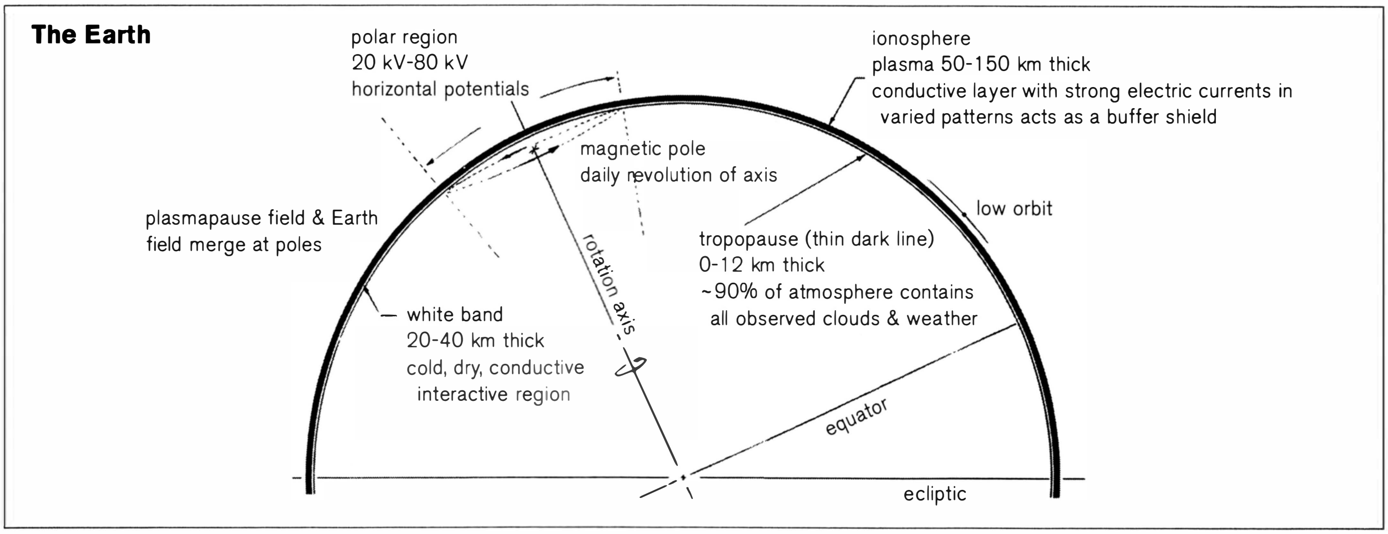


FIGURE 2 The Ionosphere and Tropopause

through all forms of media and is portrayed to be independent of the traveling electromagnetic field radiated.

Tesla indicated that these high potential waves would reflect from the anti-pole. Near perfect conductivity can be achieved by a polarization wave, whether it is carried by a dielectric or a metal conductor, since there is no current flow associated with polarization. This is like the "displacement current" of a capacitor as defined by Maxwell.

The polarization wave is a result of an electrostatic field intensity **E** (volts/meter) being suddenly imposed, varied or discharged. If no electric charge is transferred between atoms in the process, no current is generated between atoms. Nevertheless, an electric wave transient — a polarization wave — will propagate. This is particularly true of good insulators since the electrons will not transfer. On the other hand, polarization waves will even pass through metals, which shift electrons easily. An ungrounded metal will not stop polarization waves from passing through. A polarization wave will pass through anything...metals, insulators, air, plasma, wood — anything; but metals can be used to redirect the path of a polarization wave to ground. The concept of ground becomes less meaningful when talking about the whole Earth as the conductor, or an otherwise solitary electrical system.

Theoretically, the polarization wave can even pass through the earth's diameter. The polarization wave is confined to the earth body and projected radially from the E-field source. Thus, an electric field pulse intensity (**E**) will diminish as its front widens, and then begin to increase again as the front approaches the pole opposite its origin. If there were no losses, the E-field would return to its original source intensity, by reflection. Tesla said that it took 250 h.p. to overcome the losses while traveling the earth, which he attributed to water evaporation as the wave passed over the surface!

WAVE DETECTION

Two kinds of lightning data were obtained and analyzed in search of Earth electrical resonance.

1. Time-based photographs of multiple-stroke lightning flashes, and
2. Oscilloscope recordings of electrodynamic potential pulses generated by lightning.

If Earth resonance exists, it should show in photographs as specific time intervals between flashes; and it should show in voltage signatures as regular time intervals between sudden impulses on wave features. The time intervals sought would be determined by the dimensions of the earth and the speed at which potential waves travel. By hypothesis, we assume a wave to travel the surface of the earth and through the earth's diameter. The electrical wave is presumed to travel at the speed of light.

A signal propagated through the earth's diameter and back again to the point of the initial lightning would determine a fundamental radial wave period. For harmonics, this diametric wave could be divided into ¼, ½, ¾ or other time intervals. The times defined by the radial wave periods can then be compared to the measurements taken from lightning photographs and voltage signature data.

Tesla's objective at Colorado Springs was to verify that the earth could be electrically resonated. He did not strive to produce arcs of lightning. (Nonetheless, his experiments are remembered for their awesome lightning displays; and, ironically, the primary effort of most Tesla coil enthusiasts today is to see how big they can make the spark.) Tesla continued his Colorado Springs experiments in order to determine how to prevent the sparks since they represented a breakdown in the electric fields he was trying to control. He concluded his investigation with the impression that he had indeed learned how to control the wild spark.

Returning to New York, Tesla started to build his new design for Earth electrical resonance: the Wardenclyffe Tower on Long Island. It was different from any of his previous designs, and papers from the archives of Leland Anderson have only recently revealed some of his methods (*ESJ* 26: 5-10). Part of the reason I went to Belgrade in 1978 was to search for some answers about the specifics of the Wardenclyffe design. The Corum's have done likewise a number of times.

travel distance (diameter units)	travel time interval (sec)	reflection frequency (Hz)	travel distance (circumference units)	travel time interval (sec)	reflection frequency (Hz)
5 *D*	0.2125	4.71	4 *S*	0.5340	1.87
4 *D*	0.1700	5.88	3 *S*	0.4005	2.49
3 *D*	0.1275	7.84	2 *S*	0.2670	3.74
2 *D*	0.0850	11.76	1 *S*	0.1335	7.49
7/4 *D*	0.0744	13.44	7/8 *S*	0.1168	8.56
3/2 *D*	0.0637	15.70	3/4 *S*	0.1000	9.99
5/4 *D*	0.0531	18.83	5/8 *S*	0.0834	11.98
1 *D*	0.0425	23.53	1/2 *S*	0.0667	14.98
3/4 *D*	0.0319	31.35	3/8 *S*	0.0500	19.97
1/2 *D*	0.0212	47.17	1/4 *S*	0.0333	29.96
1/4 *D*	0.0106	94.34	1/8 *S*	0.0167	59.91
1/8 *D*	0.0053	188.68	1/16 *S*	0.0083	119.8
1/16 *D*	0.0026	384.61	1/32 *S*	0.0041	239.6

TABLE 1 The Light-Time Table

The half circle pictured in Figure 2 represents the earth. The line making this circle represents the atmosphere, but it is drawn three times too thick for the scale of the drawing. On this small scale, the storm clouds are buried in the hairline thickness of the atmosphere. As you can see, the earth's atmosphere is very thin, and it would be easily dominated by the electrical forces of space that surround it. Such electrical forces are naturally imposed by electrical charge emissions from the Sun and the earth's magnetic field which traps these charges in its magnetosphere. Electric forces surrounding the earth could be the cause of global atmospheric high and low pressure systems. But even today, pressure systems are only measured and reported to describe the weather. When the pressures change it is without any explanation!

LIGHT-TIME PERIODS

The time intervals that should exist for specific harmonics of the earth's diameter can be calculated. Measurements of the lightning waveform pulses should show distinct features at these calculated time intervals.

In the computation of a fundamental Earth electrical period:
1. The Earth's diameter is given as 12,742 km, and
2. The speed of light (*c*) is given as 299,792 km/sec.

The fundamental time interval for a wave to independently travel twice the earth's diameter at light speed *c* is:

$$t_D = \frac{2D}{c} = \frac{2\times 12{,}742 \text{ km}}{299{,}792 \text{ km/sec}} = 0.0850 \text{ sec (11.76 Hz)}.$$

This is very close to the 0.08484-second value suggested by Tesla, and represents nearly 1/12 of a second.

The fundamental time interval for an electric wave to independently travel via the earth's surface (*S*) to the anti-pole and return when moving at the speed of light is:

$$t_S = \frac{\pi D}{c} = \frac{\pi\times 12{,}742 \text{ km}}{299{,}792 \text{ km/sec}} = 0.1335 \text{ sec} = (7.49 \text{ Hz}).$$

The light-time table is a list of the fundamental and harmonic periods for electromagnetic radiation travelling the diameter and circumference of the earth. (See Table 1.) The time values are based on the average Earth diameter. The equivalent number of reflections per second (frequency) is listed next to each light-time period. Surface waves are notable in that there appears to be a near 60 cycle per second harmonic at ⅛*S*. Other integer harmonics appear likely at ¾*S* (10 Hz), ⅝*S* (12 Hz), ½*S* (15 Hz), ⅜*S* (20 Hz), ¼*S* (30 Hz), and 1/16*S* (120 Hz).

A comparison of diametric periods and circumferential periods does not show any exact matches. However, a few compared periods are close:

2*D* @ 0.0850 sec compares to ⅝*S* @ 0.0834 sec;
the difference is 0.0016 sec.

¾*D* @ 0.0319 sec compares to ¼*S* @ 0.0333 sec;
the difference is 0.0014 sec.

These time differences, while only differing by about one thousandth of a second, represent light travel distances of about 250 miles. Thus, it does not appear that independent circumference and diameter waves could reinforce each other. The possibility of some phase reinforcement exists within the 250-mile regions, though. Higher wave harmonics could make the time differences smaller.

Surface wave periods and harmonics did not correlate well with the data measured and are therefore not discussed further in this report.

DATA COLLECTION AND MEASUREMENT

Except for the literature references cited, the data used in this report comes from storms I recorded in the Asheville, North Carolina area (Yost 1985). The specific lab site and antenna are shown in Figure 3. Initially, in 1983, the antenna signals were recorded on an HP 1207A, and later on a Philips digital oscilloscope, Model PM 3350, having a 50 MHz band width.

The recording sensitivity used varied from 10 volts/div to 20 mV/div, in accordance with the lightning distance and signal strength. The 20mV sensitivity range picked up 60 Hz power line signals of approximately ±5 mV. The time base was typically 50 ms/div, and could easily be measured within ±0.0005 seconds using cross hair cursor settings and time expansion scales. Data was typically measured to within ±0.001 second. The subjective judgement of voltage pulse onset times contained more error than the instrument recording resolution.

The digital recording time base was selected in order to capture entire lightning signatures that lasted from ½ to 1 second. Typically, the storms being recorded were as distant as 20 miles, and as near as ½ mile.

I recorded and measured numerous lightning signatures in search of evidence that might support the theory of Earth electrical resonance outlined by Nikola Tesla in 1899 (Tesla 1905). Lightning signatures from other sources (Ogawa 1982; Volland 1982) were also analyzed. The time periods defined by Tesla were found to be significantly present in all cases.

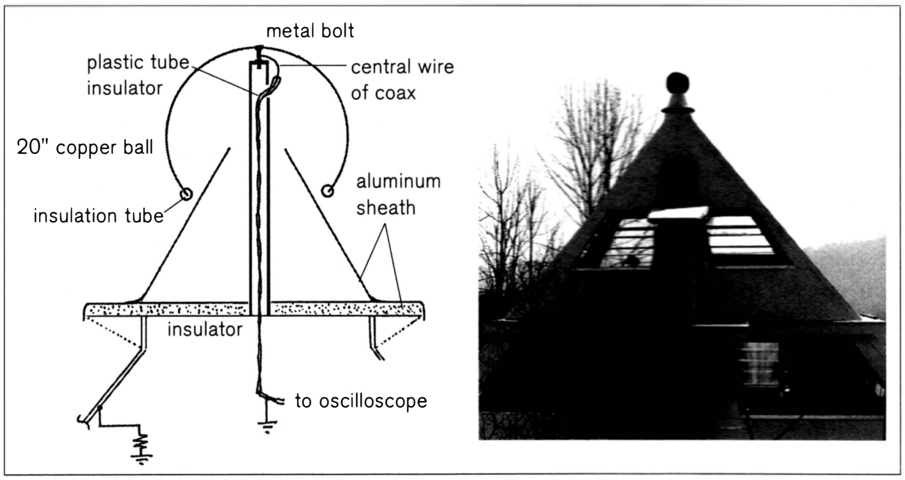
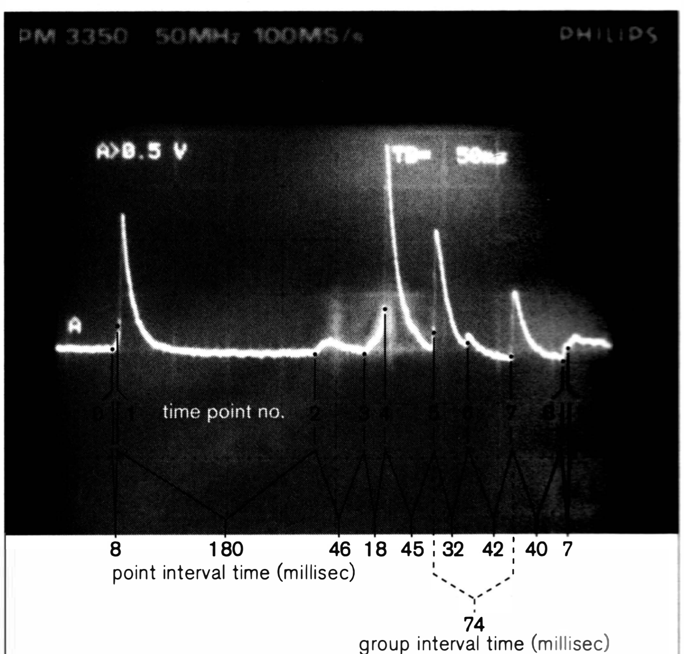


FIGURE 3 Antenna Setup: 50-foot long Belden #82221 RG-59/U, 80 ohm coax cable is extended from inside the 20-inch diameter copper ball antenna, 32 feet above ground.

My copper ball antenna was approximately 32 feet above the ground and connected to an oscilloscope at ground level by means of a coaxial cable. The central wire of the coax was attached to the ball, while the outer sheath was connected to ground at the oscilloscope. The objective was to isolate the ball from the earth so that the system could perform as an electrostatic dipole. The results obtained were clear and consistent. Lightning traces of a few millivolts were registered over a wide frequency range and for distances up to 40 miles.

The majority of the 1983 lightning data was collected using a Hewlett-Packard storage tube oscilloscope, Model 1207a, and with the elevated copper ball antenna to detect the lightning fields. Photographs were taken to record the traces from the face of the tube. When examining the early photographs, there was some question about what should be measured. A technique evolved based on periods of time between distinct pulse features in the waveforms. These pulse features were recorded and plotted as time intervals. The intervals were further examined for larger periods that may contain several of the smaller interval measurements.



1. Time points are marked at noticeable voltage increases.
2. Points associated with pulses are most accurate.
3. Time interval measurements are more accurate than elapsed time.

FIGURE 4 Measurement Technique

The most distinct and definitive time periods are measured between a series of sudden voltage pulses as they are clearly defined in an extended lightning signature. Here it was easy to see if the pulse periods (T) existed as simple harmonics of the earth's diameter (D). The lightning signatures were found to exhibit certain Earth-size harmonic periods far more often than any other time periods. One of many lightning traces is shown in Figure 4. In this particular sample, some of the stroke intervals are easily defined. The periods between the stroke onset points (5-6) and (6-7) are 0.032 and 0.042 seconds, respectively. These in turn compare very favorably with the ¾D and 1D harmonic periods of 0.0319 second and 0.0425 second.

The earth can have many harmonics, not only from its diametric size, but also from multiple storm harmonics and from internal cloud lightning activity. The premise in this study is that resonant periods are most likely to show as time intervals between distinct pulses on the trace.

It is evident from the compiled data that the most frequent resonant period is at ¼*D* with frequent periods also at ⅜*D*, ⅝*D*, ¾*D*, ⅞*D* and 1¼*D*. The great majority of time intervals fall within a one-Earth diameter period, with periods beyond 2*D* fairly well distributed at ¼*D* unit intervals. The extension of intervals beyond 2*D* that fall on ¼*D* unit intervals would support the idea of Earth resonance at odd multiples of the ¼ wavelength as Tesla suggested.

The data presented suggests that Earth electrical resonance is a function of its diameter. Some data scatter and the inability to clearly resolve 1/16*D* harmonics has prevented an examination of surface wave periods or possible combinations of surface wave and diameter wave beat periods.

All of the data in the original 1983 report is collected and presented in the Summary of Data chart shown in Figure 5. This chart shows a dot for each time interval measured from the voltage traces. The time intervals are scattered, but can be seen to predominate at Earth diameter harmonic periods. Since the data is displayed in terms of the earth diameter, contributions from other factors are not defined. Other factors that could scatter harmonics include ionospheric irregularities, induction effects or other storm system interactions.

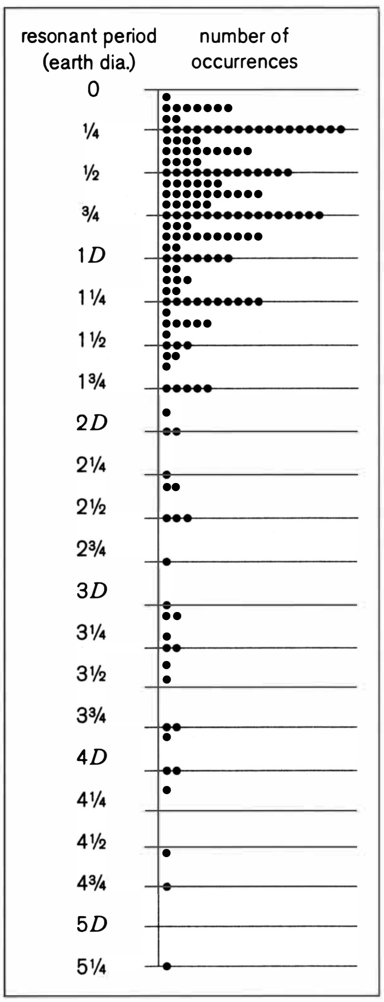


FIGURE 5 Summary of Data

OGAWA DATA

An independent lightning signature (Volland 1982, 181; Howener & Bradley 1964, 1155) provides data on a multiple-stroke flash recorded at frequencies of 5 kHz, 10 kHz, 45 kHz, and 11 MHz. Two strokes are clearly evident and separated by 0.074 seconds, which coincides with the 1¾ Earth diameter period. (A measurement error of perhaps ±0.001 seconds may exist in this case.)

Another excellent lightning signature from Ogawa (1982) was measured for time period data. This lightning signature was recorded with fast and slow antennas, and is illustrated in Figure 6.

The measurements of time intervals from this 10-stroke flash are shown in Table 2, and demonstrate frequent ½*D* and ¾*D* harmonic values. The data correlate very favorably with Earth diameter harmonics.

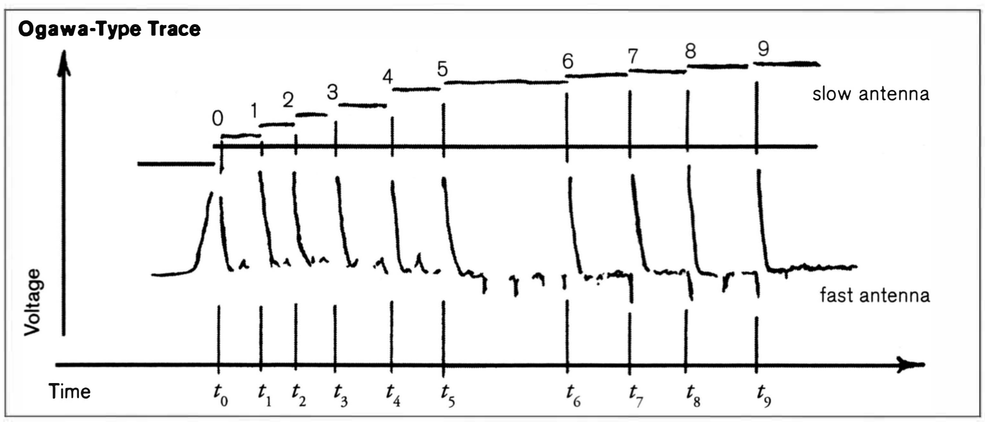


FIGURE 6 Ogawa Lightning Signature

point	t (sec)	Δt measured (sec)	diameter harmonic nD	diameter period $t = nD/c$	error (sec)	error (%)
t_0	0	——	——	——	——	–
t_1	0.022	0.022	½*D*	0.021	0.001	5
t_2	0.043	0.021	½*D*	0.021	0	0
t_3	0.064	0.021	½*D*	0.021	0	0
t_4	0.096	0.032	¾*D*	0.032	0	0
t_5	0.125	0.029	¾*D*	0.032	0.003	9
t_6	0.195	0.070	1¾*D*	0.074	0.004	5
t_7	0.230	0.035	¾*D*	0.032	0.003	9
t_8	0.263	0.033	¾*D*	0.032	0.001	3
t_9	0.301	0.038	¾ to 1*D*	0.032 to 0.042	-0.006 to 0.004	–

TABLE 2 Ogawa Signature Data

PHOTOGRAPHIC DATA

Additional lightning data came from analyzing photographs printed in *Lightning and Its Spectrum* (Salanave 1980). Only one set of photographs was analyzed for time interval data, although the book is filled with many excellent photographs of lightning. The photograph chosen was a 26-stroke discharge which lasted 2 seconds, with coverage by two separate but coordinated cameras. (See Fig. 7.) Other photographs were studied, analyzed and summarized in the original research report (Yost 1985).

The 26-flash data has the advantage of showing each lightning bolt as a distinct and separated visual object. There is then no question that the time interval represents a to-ground lightning flash. While voltage trace data is far more abundant and easy to collect, it suffers from the uncertainty of what the pulse time intervals represent. It is clear from the 26-flash data that $^1/_{16}D$ time intervals are real and manifest as distinctly separated flashes. A comparison of the 26-flash data and the voltage trace data reveals similar harmonics and scatter.

The data scatter and the lack of understanding of certain waveform features have prevented differentiating between diametric wave intervals, surface wave intervals, and their possible combinations. Despite the scatter, the information presented distinctly shows strong concentrations of data at time intervals associated only with harmonics of the earth's diameter.

The book *Lightning and Its Spectrum* has a section devoted to the tortuosity of lightning. In that section several photographs show the bizarre paths lightning can travel. Such paths would be hard to explain in terms of insulation breakdown. One photograph in particular shows the microscale structure of a lightning bolt clearly as a sinuous wave; however, in three dimensions it is in all probability a helical structure. This raises new speculations about the magnetic and electric conditions in a lightning bolt.

The detailed evaluation of this lightning bolt shows it could be a tight helix about 4 inches in outside diameter with a one-cycle turn in every 3 to 6 inches of length. The helical form of the lightning bolt and magnetic pinch effects could induce it to change direction radically and easily, if an electric field is produced along the length of the bolt. Such a condition is conducive to producing a trapped plasma and could propagate strong electrostatic waves along the axis of the lightning. What is not clear at this point is why the structure of the lightning should take a tight helical form. Perhaps its self-induced magnetic field interacts to pinch and twist the current flow.

A high voltage blip was commonly observed on the oscilloscope when storms were active in the area but still too distant to see or hear. The blips would occur when the voltages needed to produce full lightning waveforms were too weak because of distance. Measurements of the time intervals between blips indicate that they also predominate at Earth harmonic periods. The blips generally have a duration of 0.0002 to 0.002 seconds. An expansion of the blip shows it to be a highly damped wave oscillation of about 5,000 to 25,000 cycles per second. This wave damps out in just a few cycles. Blip events can be frequent after storms have passed and the sky is clear.

The blip oscillation frequency represents full wavelengths of 7½ to 37½ miles, so quarter wavelengths would range from about 2 to 9 miles. Such dimensions are roughly those of thundercloud size and atmospheric thickness. It may be that a ¼ wavelength size cloud would be influenced by full wavelength dimensions, which extend to the outer edges of the atmosphere and touch upon the ionosphere.

The lightning discharge is a complex of an electrostatic field, free charge motion, a current, and a plasma between the cloud and ground which is free to oscillate in accordance with the classic principles of electromagnetics and plasma physics. In addition, the induced electrostatic force field form becomes

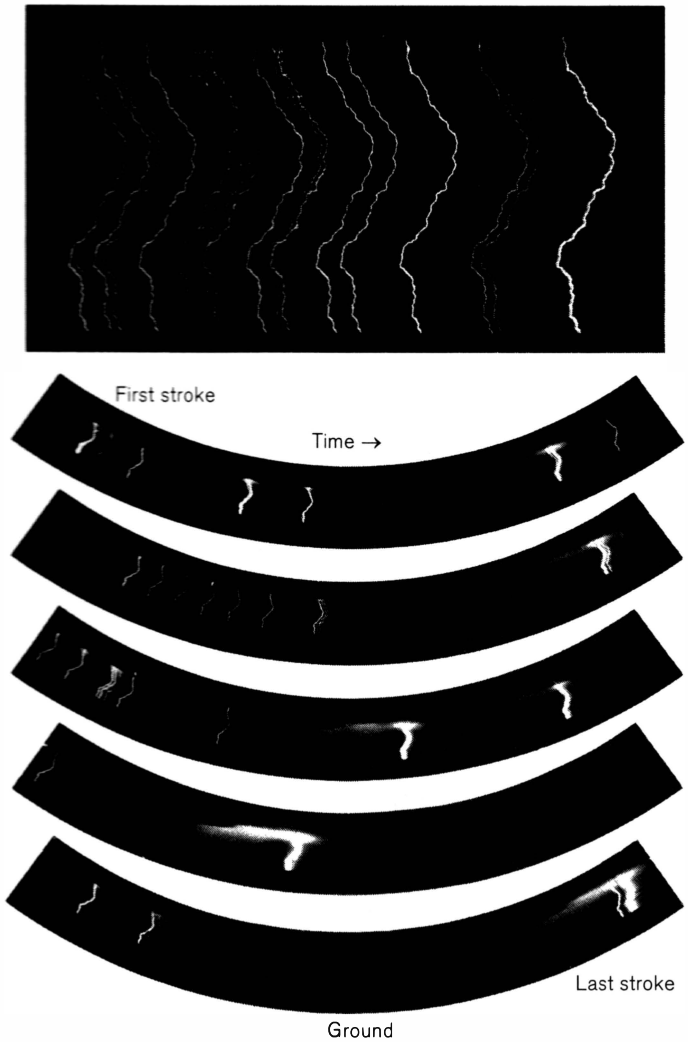


FIGURE 7 Twenty-six strokes in one flash. Photo courtesy of Langmuir Laboratory for Atmospheric Research, Socorro, NM.

very prominent (Jefimenko 1992). Some indication of the unique behavior of plasma can be gained from the book *Plasma: The Fourth State of Matter* (Frank-Kamenetskii 1972). The section of that text entitled "Electrostatic Plasma Oscillations and Plasma Oscillations in a Magnetic Field" can be particularly related to the phenomena of lightning. Frank-Kamenetskii relates that electrostatic plasma oscillations exist which are longitudinal (acoustic) and that these oscillations should not be confused with the transverse electric waves associated with the electromagnetic wave. Surface standing waves may occur should there be a resonant cavity relationship with the dimensions of the column that contains the plasma.

An electrostatic wave traveling through the earth's diameter at the speed of light may have an associated phase wave traveling faster than light at its intersection with the surface, as Tesla indicated. Since the test data indicates the predominance of lightning time intervals at Earth diameter harmonics and not circumferential or Schumann waves, a much closer study seems justified. Expanded study would explore the manner of possible wave propagation through the earth and the character of sharp electrostatic gradient waves.

ANOMALOUS PHENOMENA

While lightning signatures were the focus of the research, other phenomena were also recorded. Two incidents are worth mentioning, even though they were somewhat anomalous.

(1) May 5, 1992: (recorded with a Philips PM3350 scope mounted in my automobile. I was parked during a storm a few miles outside Champaign, Illinois.) A tornado was in the area. The scope was recording lightning signatures normally. During a quiet period, the scope suddenly traced a series of large-amplitude, undulating, irregularly shaped sine waves. These continued for several seconds before the scope trace returned to normal. The phenomenon happened briefly again a few minutes later. The irregular sine wave had a frequency of about 2 Hz.

(2) At 3:00 A.M., my North Carolina lab site recorded 15 Hz sine waves with a 2-second (amplitude modulated) beat frequency. The storm being monitored had passed and it became too distant to record lightning signatures.

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