Statitronics

Static Electricity and Free Energy Hype

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August, 2004

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Warning:

Electricity can kill you. This book is about electricity. Do not attempt to duplicate anything in this book unless you are skilled in the art or you may encounter fatal consequences!

This book is about two kinds of electricity; so-called "static" electricity, the stuff of which lightning is made and the more commonly available "current" electricity which surrounds us in our everyday lives.

This book describes certain investigations into the nature of static electricity and its conversion to current electricity.

By break this seal, the reader acknowledges notification that the apparatus and experimental equipment configurations described herein involve potentially lethal voltages and currents.

This book is intended to describe for the knowledgeable reader certain basic discoveries in the conversion of static electricity to current electricity in order to provide avenues of future research.

The author, his agents and heirs, specifically disavow any liability for danger to life, limb, or property from attempting to duplicate these results.

The author strongly urges that if you have an interest in pursuing further experiments on your own, or attempting to duplicate the equipment and set-ups contained in this book, that you begin with a good course in electronics at a local college or get involved with amateur radio. A good starting point is the American Radio Relay League's web site at www.arrl.org.

Once you understand a bit about current electricity, how AC radio waves propagate, and how insulators and conductors act, you'll be in a much better position to safely pursue your own investigations.

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Introduction

I've always been fascinated with electronics. Ever since I was a kid with an "All American five tube radio" which I retuned in order to hear tugboats chatting about their barges being shuttled around Elliott Bay in Seattle, I've always been able to find the pleasure of good company via electronics. Whether it was broadcasting, or amateur radio made little difference. There's something about talking to people in faraway places that verges on magical.

Still, there are limits to the hobby. After talking to some of the legendary ham radio operators of the 20th century, including Barry Goldwater and the King of Jordan, you might go looking for something else to do. And there's always been something else "out there". Ham radio today covers everything from painstakingly slow Morse Code to incredibly fast high speed data links that tie the ham radio system into the Internet.

It's a little known fact that every time a space shuttle goes into orbit, there's at least one ham radio operator aboard. Most of the Russian space probes carried ham radio operators, and the International Space Station (ISS) makes regular contacts with hams who volunteer time to bring equipment to schoolrooms and keep the magic of the hobby alive.

The purpose behind this book is to provide a basic set of data in an area that has received little attention, the notion of capturing electricity from the air. Most of the works that I've been able to locate so far seem to fall into one of three categories. Let's call them the "free energy", "academics", and "conspiracy theorists."

The first category was the "free energy" crowd. These are the folks who are on a quest to duplicate some of the experiments performed by Nicolas Tesla, who is the father of alternating current (AC) energy. While there's a lot of material available, much of it is either arcane (offering real something-for-nothing) devices or they were largely speculative in their offerings.

The second crowd was the university & academic group. These folks have developed all kinds of interesting applications for high energy and high voltage electricity, but the end applications seem more directed to development of beam weapons. A recent example was the new coverage given to a plan to develop a beam weapon which could be used by police to stop a car without injury to its occupants. The idea is fairly straightforward – simply shoot enough electricity toward a car, fry its sensitive electronics and the car will come to a halt being now brain-dead.

The difficulty with this second group is that so much of the material written is either tedious or beyond the comprehension of the casual reader.

Last, but not least, are the conspiracy theorists who argue that there is some kind of international conspiracy afoot designed to keep free energy out of the hands of the public. These people would have us believe that Tesla made breakthroughs of such importance that it was the U.S. government and other un-named entities that conspired to end his further experiments.

My research into the publications and offerings of all three groups left me quite unfulfilled. What I was looking for was a book that would explain in practical step-by-step terms, how to build a useful device to extract some useful work from static electricity and the electric fields that surround the earth. I wasn't able to find such a book. I wanted something that I could hand to my wife (a novice ham radio operator) or my brother-in-law (who placed antennas in trees during his Special Forces career) and convey enough understanding that they would be able to build something useful.

Oh sure, there were booklets, which for $15 would show me how to build a "free energy battery charger" and other such devices, but they lacked sufficient data for me to have high confidence that they'd work as advertised and would explain enough about electricity in passing that the subject would be demystified.

Because I have been involved in several electronics companies, not to mention a lot of time on the business end of a soldering gun, I developed an appreciation of the creative process in electronics. My friend, the late Don Stoner (W6TNS), provided an excellent role model when I worked with him at Microperipheral Corporation in Redmond, Washington. Don was the outfit's Chief Scientist and would spend hour after hour in the company lab with his test equipment dreaming up new circuits. From Don I learned that inventing something useful is just a matter of educated trial and error. Time, a can of pop and the right test gear, and an open mind have made thousands of advances in electronics.

Experience at two other electronics firms helped solidify my thinking. One was as head of sales and marketing for an HF radio manufacturing company. The good part of that ,experience was it ground into my head the notion that even in something as complicated as high frequency radio equipment, there is no such thing as "magic." Nothing happens except as decreed by the laws of physics. If something appeared to happen that wasn't in keeping with the laws of physics, then I was told it was because I didn't understand the laws of physics well enough.

The other formative experience was working for a company which made battery state-of-charge instrumentation. Cruising Equipment Corporation under Rick Proctor's leadership had probably the best patents to employee ratio of any small company I was aware of: three core (more with design) patents and a dozen employees. What made the company great was the almost religious fundamentalist belief that not only was there no magic, but that instrumentation was *everything* in a scientific endeavor.

So naturally, when I went looking for a book on how to build a "free energy" gizmo that could do something practical around our ranch here in East Texas, the resources I was able to locate came up short.

What I was specifically looking for in a book would include all of the following points:

1. What is static electricity and how is it different than current electricity? I had worked as an R&E mechanic for a major airline when I was young and had noticed the "static wicks" on the trailing edges of the DC-9's that I was working on, but had given it little thought. Still, a simple explanation of how static electricity worked was something that an ideal book ought to include.
2. What are the other forms of electricity that could be present and captured to be put to use? I had read a couple of accounts of Tesla putting "wires into the ground" and coming up with enough voltage to light an electric bulb. But where was the evidence from contemporary times? Where was the proof that it was anything but a showman putting on a show? What about all the radio frequency (RF) energy floating around. How much of it could be recaptured with a huge receiving antenna?
3. What are some block diagrams of various ways to convert captured energy into useful work?
4. When we get into the discussion of capturing such energy, what are the critical parameters and how do they interact? I like tables because they help me build a picture in my head of how things work.
5. What is the distribution of static electricity over time, height above ground, quality of insulator, quality of ground system, and even the relationship between the wire and compass bearings? Would I find, for example, that a wire oriented in a north-south direction would pick up different amounts of energy than the same wire oriented east-west? Is static charge greater between two straight wires, measured in the middle, or is it large when the wires are at 90 degree angles to one another?

As we head into the exploration, I am extremely lucky to be taking a bit of time off work in 2004 on a piece of property that is large enough (about 450 by 1200 feet) to allow me lots of room to put up all kinds of wires.

What’s the problem?

Science works best when presented with a problem. A well-defined problem is best. For our purposes, we will define the problem as:

> “Capture enough free energy not using solar, tidal, hydro, or wind power to provide useful work at my ranch in East Texas.”

Ideally, I would be able to generate enough “free energy” to power at least my office building adjacent to our home. Practically, however, any contribution to the energy budget would be useful and even a small amount of energy would be interesting. Perhaps enough to run the ham radio set once in a while would be an adequate payoff.

The standard practice when designing direct current (DC) power systems is to begin with a load sheet. A load sheet allows you to see how much energy you need to operate when you disconnect from the electrical grid – that’s the power provided by the local electric power company. When you disconnect from their wires you become an “off-grid” user.

The formulas involved are fairly simple, and I’ll try to keep the discussion non-technical wherever possible:

The Basic Power Formula

Voltage (E) times Current (I) in Amperes [Amps for short] equals Power (P) in Watts. This is easy to remember as P=IE.

> Example: A 115 Volt appliance draws 10 Amps while operating. How many Watts is it using at a particular moment in time?
>
> Answer: 115V times 10 A = 1,150 Watts
>
> Sample Appliance: Iron

Remember that P=IE is an *instantaneous* power level. Instant power levels are OK for some purposes such as specifying a component value in electronics, but it’s not a useful way of looking at energy consumption around the house, in your RV, or off cruising on your yacht. For this, you need to add the *time dimension* to your measurement.

Because we all operate on hours, minutes and seconds, engineers (and more rational people, too!) have adopted standard time intervals for energy consumption over time. Therefore, if you operate our hypothetical iron for 1 second, we will have consumed 1,150 watt-seconds. If we operate it for one minute, it would consume 1,150 watt-minutes and if we operated if for one hour, it would consume 1,150 watt-hours of electricity.

Power over Time

There's an important concept here involving power – that is, useful work. In electrical calculations, you get the same amount of work done whether you operate for a long time at a low current or a short time at a high current. In the case of our iron, the same amount of heat would be generated if you:

- Operate the iron for one second (1,150 watt seconds) Remember, this iron draws 10 Amps.
- Or if you plugged it into a 57.5 volt outlet (half the voltage of 115 volts) you would consume 575 watt-seconds of power, so you would need to plug it in for two seconds to get the same amount of work (heating) done.

This is a key concept which will come into play later in our investigation: Half the voltage means twice the time for the same amount of work. Or, half the voltage, half the work, all other things being equal.

Conversion to Kilowatt-hours

Watt-hours are nice, easy-to-use numbers if you're dealing with very small appliances and very small periods of time.

When you buy power from the local power company, you buy it based on kilowatt-hours (kwhrs). "Kilo" is the Greek prefix for "thousand".

To convert instantaneous watts into kilowatt-hours divide instantaneous power by 1,000.

A 1,150 watt appliance (10 Amps) will consume 1.15 kilowatt-hours of electricity from the local power company.

If you pay 12¢ per kilowatt-hour of electricity from the local power company, you will pay $0.12 X 1.15 kwhrs or about 13.8¢ to iron for an hour.

What's a Load Sheet?
Whether you are designing an electrical system for a house, building, an RV, or perhaps a sailboat, the starting point is always a "load sheet". This is simply a list of your appliances and collecting the number of watts they use over time.

Most appliances are not operated 24-hours a day, seven days a week, so the load sheet calculates how many hours

To develop your own load sheet, you may download the following spreadsheet from my web site at http://urbansurvival.com/statitronics/ (disabled in 2005)

Sample Load Sheet

Location: George's Office

Appliance	*Watts*	*Times Hrs/Day*	*Equals WHrs*	*÷1,000 equals KWhrs*	
Air Conditioner	900	16	14400	14.4	
Two meter radio chargers	7	24	168	0.168	
Ultrasonic bug repeller	3	24	72	0.072	
Computer	150	24	3600	3.6	
Computer Monitors (2)	130	14	1820	1.82	
TV/VCR	80	8	640	0.64	
Cordless phone	10	24	240	0.24	
Printer	7	24	168	0.168	
Wireless intercom	3	24	72	0.072	
Lights	80	1	80	0.08	
CPU Speakers	10	24	240	0.24	
Sony Stereo	70	3	210	0.21	
Icom SSB Ham Radio	200	2	400	0.4	
Subtotal	1650			22.11	
Times 30 days				663.3	kwhrs
Times local Electricity at		0.09	per kwhr	$ 59.70	

Sizing a Renewable Energy System

Let me point out a couple of numbers that fall out of this calculation. First, notice that right next to "subtotal" there is a peak Watts number (1,650 Watts to be exact). This is how much power would be consumed if everything in my home office was turned on at the same time.

To design a renewable energy system, I might generalize that I need a 1,500 watt inverter to turn my stored energy into useful 115 Volt AC current. If I were building a conventional off-grid system that's how much AC I would need to be able to produce. I would actually want to size the inverter a bit larger, say 2,000 watts, because the air conditioner has substantial inrush current. That means the air conditioner doesn't draw 900 watts all the time. Consumption might jump up to 1,200 watts – more than 10 Amps using our P=IE formula - when the compressor in the unit first kicks on. Might be much higher, though. Look up "locked rotor current" of motors when you have time.

Obviously, if you were living in more than one room, you'd need to do a load sheet for each room in the house and then add them up. However, remember when you are sizing sources that you will seldom, if ever, have everything turned on at precisely the same time.

Now that we know what our peak load is, we need to do some conversion work to figure out how big a battery bank would need to be in order to support this load.

Sizing the Battery Bank

Having figured out our monthly operating cost from the power company, about $59.70 per month, we could go ahead and do the calculations to see how big a battery bank (collection of batteries) we would need to build in order to support all of the equipment in my office for a single day.

One thing you need to know about batteries is that they should never be discharged more than 50% or their cycle life will be dramatically shortened. A cycle is defined differently by each battery manufacturer, but in general, if you remove 10% of the capacity of the battery bank, the manufacturer is likely to call that a "cycle".

The number of deep discharge "cycles" you can get from a battery varies by Depth of Discharge (DoD). For example, if you take 100% of the energy out of a battery 5 times, in most cases the battery will be done, finis, kaput. On the other hand, with a good quality deep cycle battery, you might be able to take 50 or 60% of its energy out and put it back in 500 times or more and still have a good battery.

It helps to know that there is a difference between deep cycle and regular automotive starting batteries along the way. The deep cycle battery has fewer battery plates, but the plates are thicker, holding the lead compound more firmly. The depth of the compound on the plate is a key manufacturing variable in determining how many times a battery may be deep cycled. A starting battery, on the other hand, has up to dozens of plates, each thin. But for delivering a quick start, what you want is high terminal voltage under load, and the way you get there is with lots of plate area.

Let's put another factor into our mix and that's energy conversion efficiency of our inverter. Although manufacturers make claims that such batteries are up to "95% efficient" the reality of most inverters is that over a wide range of loads they will typically run around 80% or so. The lost energy needs to be accounted for in our calculations.

We could perhaps use a lower design voltage than a nominal 12 volts, but if you observe the 50% Depth of Discharge rule, that's as good a starting point as any.

System Design Voltage

12 VDC

Appliance	Watts	Amps	Amp-Hours	80% Eff.
Air Conditioner	900	75.0	1200.0	1500.0
Two meter radio chargers	7	0.6	14.0	17.5
Ultrasonics bug repeller	3	0.3	6.0	7.5
Computer	150	12.5	300.0	375.0
Computer Monitors (2)	130	10.8	151.7	189.6
TV/VCR	80	6.7	53.3	66.7
Cordless phone	10	0.8	20.0	25.0
Printer	7	0.6	14.0	17.5
Wireless intercom	3	0.3	6.0	7.5
Lights	80	6.7	6.7	8.3
CPU Speakers	10	0.8	20.0	25.0
Sony Stereo	70	5.8	17.5	21.9
Icom Ham Radio	200	16.7	33.3	41.7
Subtotal	1650	137.5		2303.1

Note1: 100 Amp-hour batteries at 100% DoD	23
Note 2: Number of 100-amp-hour batteries at 50% Dod	46
Note 3: Cost of $60 Sam's Club golf cart batteries	$ 2,763.75

Ouch! $2,763.75 – before Texas sales tax – is a heck of a lot more than I was thinking about spending for running my office!

Comparing Source Costs

Putting energy into a battery bank and getting it back out again is not cheap. Remember the battery bank I've described here, and the accompanying inverter, only get me one days worth of energy should the power go out. Then I need some way to charge it back up right away because if you don't recharge right after discharge, the sulfuric acid that has crystallized onto the batteries plates will harden and the battery will lose efficiency.

I can buy a pretty good diesel generator for under $2-thousand and with enough snooping, I might get one that's electric start at that price. A bit of shopping around eBay should come up with something.

Solar panels are an attractive option, but they are also fairly expensive. To put up a solar array large enough to handle my peak load of 1,650 watts would require about 20 of the newer 85 watt panels. At the time of this writing, 85 watt panels are in a range from about $320 to $528.

There are some problems associated with solar power, not the least of which is that you can really only depend on a solar panel's output being anywhere near specs for about 8-

hours per day. Besides allowing for cloudy days, you need to consider that an 85-watt panel is not putting out that many amps.

In our design example here, we rearrange our P=IE formula so that it becomes

$$\frac{P}{E} = I$$

So 85 Watts divided by 12 volts is just a little over 7 Amps.

Knowing that our peak 12 volt demand is 137.5 amps, we can divide 137.5 Amps by 7 amps to come up with the number of panels necessary: 19.65 or rounded off, 20 panels.

Even if we purchased the panels for $320 each, this means we would be looking at $6,400 worth of panels.

But it gets worse. Solar panels cannot be connected directly to a battery bank. If you try that, the first sunny day when your battery bank is topped off, you'll find that the batteries are being seriously overcharged. This means several charge controllers to handle such a big array.

When a battery is overcharged, the electrolyte (the sulfuric acid solution) breaks down into hydro and oxygen that off gas. These gases are extremely flammable and many a DC power company has been hit with consumer claims from defective battery charging equipment that overcharges a battery and results in "gassing" which sometimes brings disastrous consequences.

There's one good thing about a small amount of overcharging and off-gassing. It tends to drive any hardened sulfur crystals on the battery's plates back into solution. This procedure, called "equalizing" is covered in other sources, but it bears mentioning here because deliberate overcharging is not necessarily a bad thing, done in moderation.

Conservation Impacts

One of my friends in the energy business, who last I heard was working for the Bonneville Power Administration, said "The cheapest Source of power is always conservation." And his point is well taken.

Let me show you how I could reconfigure my office to dramatically reduce the cost of operation:

1. The Air Conditioning goes to a low energy system. The reason that I bought the small window type unit for my office was that for $120 and little labor, I could get cool quickly and without much effort. However, I could have accomplished the same objective by building a maze of 4" PVC pipe buried 12 feet under the ground. At that elevation below grade, the temperature of the earth is about 55-degrees and maybe only getting up to 60 in the summertime. 100' of 4" PVC, a

small 4 Amp, 12 volt, DC fan from a marine parts house like West Marine, and I would be able to effectively cool the office with an energy budget of 49 watts
2. I could use my laptop computer and the second LCD display. I am not keen on that, but the flip side is always energy cost. The computer would consume about 65 watts while the second monitor would drop to less than 35 watts.
3. Although the lighting is fluorescent already, I could put in a downsized fixture, perhaps a single 40 watt light would do.

As you can see in our updated load sheet below, the monthly power bill would drop to under $14 from just under $60. This means a monthly saving of $46, but only in the summertime when air conditioning is almost a constant feature of Texas life.

Sample Load Sheet

Location: George's Office

Appliance	Watts	Hrs/Day	WHrs	KWhrs	
Air Conditioner	48	16	768	0.768	
Two meter radio chargers	7	24	168	0.168	
Ultrasonics bug repeller	3	24	72	0.072	
Computer	65	24	1560	1.56	
Computer Monitors (2)	35	14	490	0.49	
TV/VCR	80	8	640	0.64	
Cordless phone	10	24	240	0.24	
Printer	7	24	168	0.168	
Wireless intercom	3	24	72	0.072	
Lights	40	1	40	0.04	
CPU Speakers	10	24	240	0.24	
Sony Stereo	70	3	210	0.21	
Icom Ham Radio	200	2	400	0.4	
Subtotal	578			5.068	
Times 30 days				152.04	kwhrs
Times local Electricity at		0.09	per kwhr	$ 13.68	

Now we come to the reason why more people don't have big solar installations. The payback period, when you save maybe $200 a year, could be 5-years or longer. The majority of the improvement comes from the buried PVC pipe, but getting a 12-foot deep trench dug out and the pipe put in, and covered again is not a minor undertaking. I figure it would cost be perhaps $400 if I could talk a neighbor with a back-hoe into the project, or $1,500 if I had to pay for a Cat skinner to come out and do the job.

Still, if I was committed to a real off-grid renewable system, the place where the cost savings come back in spades is the lower cost of energy storage and off-grid generation as shown in the following table:

System Design Voltage 12 VDC				
Appliance	**Watts**	**Amps**	**Amp-Hours**	**80% Eff.**
Air Conditioner	48	4.0	64.0	80.0
Two meter radio chargers	7	0.6	14.0	17.5
Ultrasonics bug repeller	3	0.3	6.0	7.5
Computer	65	5.4	130.0	162.5
Computer Monitors (2)	35	2.9	40.8	51.0
TV/VCR	80	6.7	53.3	66.7
Cordless phone	10	0.8	20.0	25.0
Printer	7	0.6	14.0	17.5
Wireless intercom	3	0.3	6.0	7.5
Lights	40	3.3	3.3	4.2
CPU Speakers	10	0.8	20.0	25.0
Sony Stereo	70	5.8	17.5	21.9
Icom Ham Radio	200	16.7	33.3	41.7
Subtotal	578	48.2		527.9
Note1: 100 Amp-hour batteries at 100% DoD				5
Note 2: Number of 100-amp-hour batteries at 50% DoD				11
Note 3: Cost of $60 Sam's Club golf cart batteries				$ 633.50

DC System Cost Comparison

With the cheapskate version of air conditioning in place, we would save about $2,130 in battery costs and our solar panel investment would decrease to 8 panels or $2,560 from $6,400.

The bottom line is that conservation is always where one can begin because it has the largest payoff.

Is it practical to go looking for a *free* power source that will keep power-hungry offices like mine functioning? Maybe long-term, but by long, I expect that would mean a lifetime of focus on this one objective by many people. For me, it's too late. I'm well past 50, so I need to look for a scaled down project that just might be achievable. Sure I might get lucky – that's why men go fishing like this, because you *just never know*.

Project Design Goal

Let's name as our project goal keeping one of the small 2-meter ham radio transceivers charged up and ready for use.

There are several reasons for this selection.

- First, the radio is expendable. I am not in a hurry to get rid of it mind you, but if I blew up my main computer that would cost an arm and then some. But the ham radio set was under $100.
- Because the ham radio charger operates on 115 VAC, we can employ a small inverter. Such small inverters typically cost less than $1 per watt. A $30 unit would be more than enough.
- The ham radio charger draws 3 watts.
- All components could be easily located in a weatherproof enclosure outside away from humans. This is not important on a sunny day. I'm thinking more about days when lightning is about.

If you're inclined to try the same experimental path as the one I have chosen, you might find some small appliance that could serve as the load for your new energy system.

Next, we'll tackle the question of where will the energy come from?

Free Energy: What do we know?

One of the joys of the Internet is being able to quickly track down knowledge that has been committed to electronic network-accessible media. Today (mid-July 2004) when I put the search term "free energy" into www.google.com I am flooded with more than 700,000 results. This means there are nearly three-quarters of a million web pages dealing with "free energy."

Before we start getting really serious about our research, let's review…

Ben Franklin's Kite

Our first exposure to "free energy" as children came when in school we were taught about Benjamin Franklin's famous kite experiment. You may recall the sketches of Franklin's kite wire, with a key dangling from it, that was used to charge a Lyden Jar. Franklin's intent was to capture electricity so that he could transport it and presumably use it for other experiments.

If you consider yourself knowledgeable about electronics, you could skip this section, but some of the historical data is valuable and interesting. If you know about electricity and electronics, feel free to skip ahead to the section "Meantime, back at the kite."

Volts and Voltage

Franklin's adventure brings us the first two concepts that we need to thoroughly understand before venturing very far. The first is the concept of "Voltage". The term is named after Alessandro Voltage. Wikipedia tells us that he…

> "…was an Italian physicist known especially for the development of the electric battery. Late in life, he received the title of Count.
>
> Volta was born and educated in Como, Italy, where he became professor of physics at the Royal School in 1774. His passion had always been the study of electricity, and still a young student he had even written a poem in Latin on this fascinating new discovery. *De vi attractiva ignis electrici ac phaenomenis inde pendentibus* is his first scientific paper. In 1775 he devised the electrophorus, a device that produced a static electric charge. In 1776-77 he studied the chemistry of gases, discovered methane, and devised experiments such as the ignition of gases by an electric spark in a closed vessel.
>
> In 1779 he became professor of physics at the University of Pavia, a chair he occupied for 25 years. In 1794 Volta married Teresa Peregrini, daughter of Count Ludovico Peregrini; the couple had three sons.

> In 1800, as the result of a professional disagreement over the galvanic response advocated by Luigi Galvani, he developed the so-called voltaic pile, a forerunner of the electric battery, which produced a steady electric current. Volta had determined that the most effective pair of dissimilar metals to produce electricity was zinc and silver. Initially he experimented with individual cells in series, each cell being a wine goblet filled with brine into which the two dissimilar electrodes were dipped. The electric pile replaced the goblets with cardboard soaked in brine. (The number of cells, and thus the voltage it could produce, was limited by the pressure, exerted by the upper cells, that would squeeze all of the brine out of the cardboard of the bottom cell.)
>
> In honor of his work in the field of electricity, Napoleon made him a count in 1810; in 1815 the Emperor of Austria named him a professor of philosophy at Padua. Volta is buried in the city of Como in Italy; the Templo Voltiano near Lake Como is a museum devoted to explaining his work; his original instruments and papers are on display there. The building appeared, along with his portrait, on Italian currency before the introduction of the Euro.
>
> In 1881 an important electrical unit, the volt, was named in his honor. Volta is on 10000-Lira note."

Key Concept: When you are talking about electricity, voltage is *pressure* while current is the volume of electricity being moved. When we speak of electric wiring, we consider the voltage and current to be carried. A high voltage wire requires good insulation because the electricity is under high pressure. A high current wire must be large because there will be lots of electrons passing through it.

Static Electricity and Current Electricity

Let's start with this entry from Wikipedia:

> "Static electricity is an electric charge between two objects which have no conducting path between them, typically referring to charge with voltage of sufficient magnitude to produce a spark. It is a stored charge that does not flow in a current. The presence of charge means that the objects will exhibit attractive or repulsive forces. Static electricity can also be generated by touching two objects together and then separating them, because of contact electrification and the triboelectric effect. Friction between two objects generates a great amount of static electricity because of the many instances of contact and separation. Usually, substances that don't conduct electricity (insulators) are good at holding a surface charge. Some examples of these substances are rubber, plastic, glass, and pith. The charge that is transferred in static electricity is stored on the surface of each object."

We experience a buildup of static electricity when we walk across a wool carpet on a dry winter day wearing rubber sole shoes. The metal doorknob can become a shocking experience. But remember this oddity about static electricity: It is very high voltage but only very small currents.

The kind of electricity that we power home appliances with is called *current electricity* because although it operates at lower voltages (like 12 volts DC in the car and 115 volts AC in the house) there's a lot of current involved.

Resistance and Conductance

When more electrons are trying to get through a wire than its possible for the wire to carry, *resistance* or opposition to current flow, causes the wire to heat up.

> "Ohm's law (named after its discoverer Georg Ohm [1]) states that the ratio of the potential difference (or voltage drop) between the ends of a conductor (and resistor) to the current flowing through it is a constant, provided the temperature doesn't change"

E= I x R means that Voltage (E) is equal to the current (I) times the resistance (R)

If you know any two of the variables, you can calculate the third using Ohm's law.

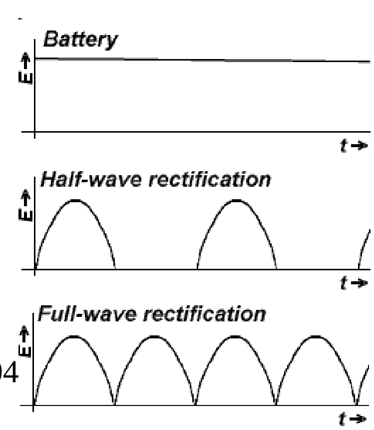
E/I = R or E/R= I are the two other forms of the law.

Conductance is the reciprocal of resistance and was originally called "mhos" (Ohms spelled backwards, get it?) It is 1 over R. It's more fashionable to call mhos of conductances "Siemens" and use the symbol SI to indicate conductance values. High conductance = low resistance. Low conductance – high resistance. But for our work, conductance will be of only limited value. About the only time we'll encounter it in our researches will be when we look at ground conductivity as it relates to certain kinds of electricity.

Two Kinds of Voltages: DC and AC

When you consider voltages, you need to look at the two types that underlie all electronics. One type is Direct Current (or DC) voltage. From Wikipedia:

> "Direct current (DC) is the continuous flow of electricity through a conductor such as a wire from high to low potential. In direct current, the electric charges flow always in the same direction, which distinguishes it from alternating current (AC). [in the following drawing, E is voltage and *t* is time…]



Types of direct currentDirect current was used originally for electric power transmission after the discovery by Thomas Edison of the generation of electricity in the late nineteenth century. It has mostly been abandoned for this purpose in favor of alternating current (discovered and promoted by Nikola Tesla, see War of Currents), which is much more suited to transmission over long distances. DC power transmission is still used to link AC power networks with different frequencies.

> DC is commonly found in many low-voltage applications, especially where these are powered by batteries, which can only produce DC. Most automotive applications use DC although the generator is an AC device which uses a rectifier to produce DC. Most electronic circuits require a DC power supply. Although DC stands for 'Direct Current', DC is generically used to refer to constant polarity voltages. Some forms of DC vary wildly in voltage, such as the raw output of a rectifier. Running them through an RC low-pass filter will produce more stable voltage.
>
> Direct current installations usually have different types of sockets, switches, and fixtures, mostly due to the very low voltages used, from those suitable for alternating current. It is usually extremely important with a direct current appliance to not reverse polarity unless the device has a diode bridge to correct for this. (Most battery-powered devices don't.) There is currently (2000) some interest in High Voltage Direct Current (HVDC) transmission systems. DC is also used in solar power systems that are supplied by solar cells."

Alternating Current, or AC is explained this way:

> "An alternating current (AC) is an electrical current, where electrical charge oscillates (i.e., moves back and forth), rather than flowing continuously in one direction as is the case with direct current. The desired waveform of the oscillation is generally that of a perfect sine wave, as this results in the most efficient transmission of energy."

Confusing Terms: Hertz

Back in the 1950's when I was busily teaching myself electronics, rather than studying much of anything else in junior and senior high school, alternating current's frequency was measured in "cycles per second". This was a really good term because you could envision a *wave* of alternating voltage. One cycle was the length of time it took for the forward peak voltage to decline from its peak to its negative peak, reverse and swing back up to its top.

Imagine for a moment that you are looking at waves on the ocean. The peak of the waves might be 7 to 10 seconds apart. If these waves were alternating current, we would say that a 10-second wave would have a frequency of 0.1 cycles per second. In other words, it took 10 seconds to complete one cycle.

I know it's not very politically correct to do so, but whenever you hear the word "Hertz", unless you're talking about Hertz the inventor, force yourself to hear "cycles per second." Alternating current makes much more sense this way.

Alternating current at different frequencies does different things.

- In the range of 20-20,000 Hertz (cycles per second!) you've got the audio range AC that is carried by speaker wires.
- The 60 Hertz (cycles per second) AC is what comes out of the wall.
- Once you get from 20,000 to 100,000 Hertz, you are into an area of electronics referred to as either ultrasonic if you use the energy with a speaker, or Extremely Low Frequency if you connect it to an antenna system and propagate waves.
- From about 100 kilohertz (a kilo-Hertz means 1,000 Hertz or kilocycles in the not-so-politically correct era) to 500 kHz was called the Low Frequency radio spectrum.
- From about 500 KhZ to 3 kHz was the medium frequency [MF] (AM broadcast band) frequencies.
- From 3 kHz to 30 mHz (Megahertz, [million Hertz] or megacycles in the old days) was the Hight Frequency (HF) radio spectrum.
- From 30 mHz to 300 mHz is the Very High Frequency (VHF bands) and from
- 300 mHz to 3 gigaHertz is the Ultra High Frequency (UHF) bands.

Antennas – a very short course

When you apply AC to a long enough piece of wire, it will radiate energy. A wire capable of sending or receiving useful AC voltages is called an antenna. The Antenna was a particular kind of spar on old sailing ships, and putting the wire up in the air some distance where it was found to work more effectively was akin to raising a sail from the *antenna*. The name stuck. However, in some countries, such as England, an antenna is still called an aerial – again, a reference to its height above ground.

The basic formula for a half wave length antenna is:

$468 \div f = \frac{1}{2}\lambda$ *length in feet* where:

f = the frequency of the AC voltage in Hertz (or cycles per second to keep it easy!) and λ is lambda, the engineering shorthand for "wavelength".

A little inspection of the formula and some test cases and we should be able to draw a few important touchstones for future use. Using experiments over the past century, the standard for most transmitting antennas is called a ½ λ dipole. This means that you would have a dipole (wire split in half) with a ¼ λ on each side. ¼ λ vertical antennas are commonly used by AM broadcasting stations.

Suppose we drove by the KIRO AM 710 kHz antenna tower on Vashon Island, Washington. We may calculate how high the antenna would be according to the formula:

$$468 \div .71 = \frac{1}{2}\lambda = \sim 659 \text{ Feet}$$

½ λ ÷ 2 (to get a quarter wavelength from the ½ wavelength) = 329.5 feet tall.

We can also calculate a ¼ λ CB whip antenna the same way:

468 ÷ 27.5 mHz = 17 feet for ½ λ

And this ½ λ ÷ 2 = 8.5 feet – sometimes called an 8' whip.

This super short course in antenna theory is designed to put into perspective this basic law about AC and antennas. The lower the frequency, the longer our antenna wires must be!

Now the important thing to realize about AC is that it may be "stepped up" in voltage (and down in current) by use of a…

Transformer

Again, from Wikipedia:

> "A transformer is an electrical device that transfers energy from one electrical circuit to another by magnetic coupling. It is often used to convert between high and low voltages and accordingly between low and high currents.
>
> A simple transformer consists of two electrical conductors called the primary coil and the secondary coil. The primary is fed with a varying (alternating or pulsed continuous) electric current which creates a varying magnetic field of voltage around the conductor. According to the principle of mutual inductance, which is a special case of electromagnetic induction applied to two coupled conductors, the secondary, which is placed in this varying magnetic field, will develop a potential difference called an electromotive force or EMF. If the ends of the secondary are connected together to form an electrical circuit, this EMF will cause a current to flow in the secondary. Thus, some of the electrical power fed into the primary is delivered to the secondary.
>
> **Electrical laws**
> Consider the following two electrical laws:
>
> According to the law of conservation of energy, the power delivered by a transformer cannot exceed the power fed into it.
>
> The power dissipated in a load at any instant is equal to the product of the voltage across it and the current passing through it.
>
> It follows from the above two laws that if the transformer is used to change power from one voltage to another, the magnitudes of the currents in the two windings must also be different, in inverse ratio to the voltages. The high-current low-voltage windings have fewer turns of thicker wire. The thicker wire helps carry

more current. The high-voltage, low-current windings have more turns of thinner wire. The thinner wire carries less current, but at a higher voltage.

Practical transformers
Transformers can be classified into three types according to the ratio of the numbers of turns in the coils:

Step-up
the secondary has more turns than the primary

Step-down
the secondary has fewer turns than the primary

Isolating
the two coils have equal numbers of turns

In most practical transformers, the primary and secondary conductors are coils of wire (usually copper), because a coil creates a denser magnetic field (higher magnetic flux) than a straight conductor. The EMF developed in the secondary is proportional to the ratio of the number of turns in the secondary coil to the number of turns in the primary coil. Hence, the Transformer Equation:

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

Where Vp is the voltage in the primary coil, Vs is the voltage in the secondary coil, Np is the number of turns of wire on the primary coil, and Ns is the number of turns of wire on the secondary coil. This leads to the commonest use of the transformer: to convert power at one voltage to power at a different voltage.

Losses
The difference between the power output and the power input is called the loss. An ideal transformer would have no loss, and would therefore be 100% efficient. In a practical transformer, there are losses due to:

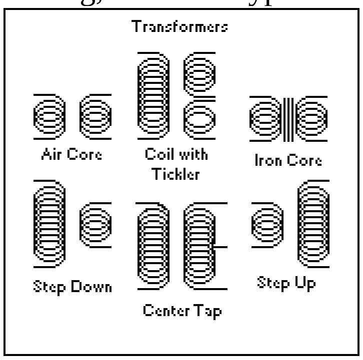
Eddy currents
Induced currents circulating in the core causing resistive heating of the core.

Winding resistance
The current flowing in the windings causes resistive heating of the conductors.

Stray magnetic coupling
Not all the magnetic field produced by the primary is intercepted by the secondary, the remainder being absorbed by other nearby objects and converted to heat.

Mechanical losses
The alternating magnetic field causes fluctuating electromagnetic forces between the coils of wire, the core and any nearby metalwork, causing vibrations which consume power.

Magnetostriction
A minor effect that causes periodic stresses, and therefore losses due to frictional heating, in certain types of core.



Key Point: You can't *transform* DC. Transformers work only with AC. High voltages mean many turns of wire. High current means large conductors. High power levels mean BIG transformers.

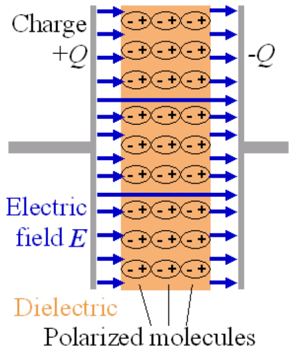
At low frequencies, up to perhaps 500 Hertz (cycles per second) AC works quite efficiently with iron core transformers. The iron core makes the transformer more efficient. When you get to high frequency alternating currents, you move into the *radio frequencies*. Here, you need to use a special kind of iron called "ferrite" which works well at higher frequencies.

Dielectrics and Insulators

If you're having trouble with the concept of "voltage" try thinking about electrons moving around in wires just like water moves around in hoses and pipes. Voltage may be usefully thought of as "water pressure" of electricity. Just like high pressure water will spring a leak at the weakest plumbing fitting, so too will electricity "burst" at the weakest point of a circuit as voltage is increased.

This pressure induced leakage of electricity comes because of a breakdown of something called the "dielectric" of the material surrounding the wire. Wikipedia tells us:

> "Most generally, a dielectric is an insulator, a substance that is highly resistant to flow of electric current. Layers of such substances are commonly inserted into capacitors to improve their performance, and the term dielectric refers specifically to this application.



The electrons in the molecules shift toward the positively charged left plate. The molecules then create a leftward electric field that partially annuls the field created by the plates. (The air gap is shown for clarity; in a real capacitor, the dielectric is in direct contact with the plates.)

The use of a dielectric in a capacitor presents several advantages. The simplest of these is that the conducting plates can be placed very close to one another without risk of contact. Also, if subjected to a very high electric field, any substance will ionize and become a conductor. Dielectrics are more resistant to ionization than air, so a capacitor containing a dielectric can be subjected to a higher voltage.

Also, dielectrics increase the capacitance of the capacitor. An electric field polarizes the molecules of the dielectric, producing concentrations of charge on its surfaces that create an electric field opposed (antiparallel) to that of the capacitor. Thus, a given amount of charge produces a weaker field between the plates than it would without the dielectric, which reduces the electric potential. Considered in reverse, this argument means that, with a dielectric, a given electric potential causes the capacitor to accumulate a larger charge.

The key point to remember is that as long as wire is surrounded by a good enough dielectric, the charge carried by the wire won't leak out. However, when the voltage goes high enough, even the dielectric of air may be breached resulting in a spark.

Sometimes, sparks are put to good use. Take the sparkplugs in your car. The way ignition systems work is that a brief high voltage is generated, perhaps in the area of 20,000 to 30,000 volts. This is enough to jump the air/fuel mixture dielectric inside the pistons of an automobile engine. The resulting explosions get your engine's crankshaft rotating.

Air is the most common dielectric and it has been assigned the "dielectric constant" of 1. As people learned to work with specific insulating materials, they began to notice that certain materials were better at insulating than plain air.

For example, if you look at the chart on the following page, you'll see that Dupont Mylar™ is about 7,500 times better than air when insulating things.

The chart also shows that not all plastics are created equal. Bakelite, one of the earliest insulators, has a dielectric constant of 5.4 to 4.4 – about the same insulating qualities as GE's Lexan™ (polycarbonate).

One of the problems with Mylar is that it's very flexible. That's why you will see Mylar used in applications like making capacitors (which we will cover in a few pages) while Dupont Teflon™ is commonly used in wiring.

Dielectric Constants Table

Material	Dielectric constant	Breakdown voltage volts per mil	Matter phase	Notes
Air	1	21	gas	
Bakelite	4.4 to 5.4	300	solid	
Cellulose acetate	3.3 to 3.9	250 to 600	solid	"cellophane"
Formica	4.6 to 4.9	450	solid	
Glass	7.6 to 8	200 to 250	solid	common/window
Mica	5.4	3800 to 5600	solid	
Mylar	3.2	7500	solid	
Paper	3.0	200	solid	no ink
Paraffin	2.1	?	solid	
Plexiglass	2.8	990	solid	
Polyethylene	2.3	1200	solid	
Polystyrene	2.6	500 to 700	solid	styrofoam
Porcelain	5.1 to 5.9	40 to 100	solid	
Quartz	3.8	1000	solid	
Rubber	2.8	?	solid	hard type
Teflon	2.1	1000 to 2000	solid	
Vacuum	1	?	n/a	
Vinyl	2.8 to 4.5	?	solid	
Water	76.5 to 80	?	liquid	distilled - bipolar

Capacitance and Capacitors

I won't try to write a clever story about capacitors because Wikipedia has it summarized very neatly:

> "A capacitor (historically known as a "condenser") is a device that stores energy in an electric field, by accumulating an internal imbalance of electric charge.
>
> Sometimes, other types of natural or man-made structures that store electric charge are also called capacitors. Examples include thunderclouds (separated from each other and from the earth by an air dielectric), and an automobile and the earth (separated by tires and air).
>
> Capacitors are most often used as electrostatic devices, but at high frequencies their inductive and electrodynamic properties also become significant."

The more complex explanation goes like this:

"**Energy**
The energy (in SI, measured in joules) stored in a capacitor is equal to the work done to charge it up. Consider a capacitor with capacitance C, holding a charge +q on one plate and -q on the other. Moving a small element of charge dq from one plate to the other against the potential difference V = q/C requires the work dW:

$$dW = \frac{q}{C}dq$$

We can find the energy stored in a capacitor by integrating this equation. Starting with an uncharged capacitor (q=0) and moving charge from one plate to the other until the plates have charge +Q and -Q requires the work W:

$$W_{charging} = \int_0^Q \frac{q}{C}dq = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}CV^2 = E_{stored}$$

The electrons in the molecules shift toward the positively charged left plate. The molecules then create a leftward electric field that partially annuls the field created by the plates. (The air gap is shown for clarity; in a real capacitor, the dielectric is in direct contact with the plates.)

In electric circuits
Electrons cannot directly pass across the dielectric from one plate of the capacitor to the other. When a voltage is applied to a capacitor through an external circuit, current flows to one plate, charging it, while flowing away from the other plate, charging it oppositely. In other words, when the voltage across a capacitor changes, the capacitor will be charged or discharged. The associated current is given by

$$I = \frac{dQ}{dt} = C\frac{dV}{dt}$$

where I is the current flowing in the conventional direction, and dV/dt is the time derivative of voltage.

In the case of a constant voltage (DC) soon an equilibrium is reached, where the charge of the plates corresponds with the applied voltage by the relation Q=CV, and no further current will flow in the circuit. Therefore direct current cannot pass. However, effectively alternating current (AC) can: every change of the voltage gives rise to a further charging or a discharging of the plates and therefore a current. The amount of "resistance" of a capacitor to AC is known as capacitive reactance, and varies depending on the AC frequency. Capacitive reactance is given by this formula:

$$X_C = \frac{1}{2\pi f C}$$

where:

XC = capacitive reactance, measured in ohms
f = frequency of AC in hertz
C = capacitance in farads
Thus the reactance is inversely proportional to the frequency. Since DC has a frequency of zero, the formula confirms that capacitors completely block direct current. For high-frequency alternating currents the reactance is small enough to be considered as zero in approximate analyses.

Reactance is so called because the capacitor doesn't dissipate power, but merely stores energy. In electrical circuits, as in mechanics, there are two types of load, resistive and reactive. Resistive loads (analogous to an object sliding on a rough surface) dissipate energy that enters them, ultimately by electromagnetic emission (see Black body radiation), while reactive loads (analogous to a spring or frictionless moving object) retain the energy.

The impedance of a capacitor is given by:

$$Z = \frac{-j}{2\pi f C}$$

where j is the imaginary number.

Hence, capacitive reactance is the negative imaginary component of impedance. The negative sign indicates that the current leads the voltage by 90° for a sinusoidal signal, as opposed to the inductor, where the current lags the voltage by 90°.

> Thus the reactance is inversely proportional to the frequency. Since DC has a frequency of zero, the formula confirms that capacitors completely block direct current. For high-frequency alternating currents the reactance is small enough to be considered as zero in approximate analyses."

Meantime, Back at the Kite

Armed with some understanding of voltages, currents, static electricity, conductors, and the like, we can now state in engineering terms what Franklin was trying to do: He was attempting to charge a high voltage capacitor (his Lyden jar) with high levels of static electricity which he captured using a wire (antenna) flow under windy stormy conditions.

Franklin was after Free Energy.

Franklin and the Fathers of Free Energy

Although a lot of credit for work in free energy goes to Nikola Tesla, who we'll get to in a few minutes, the first fellow that we heard about fiddling around with lightning was Ben Franklin. He was one of dozens of people who have set off to capture naturally occurring energy. Wikipedia picks up the story:

> "In 1748 he decided to retire from his printing business and created a partnership with his foreman, David Hill. The partnership provided Franklin with half of the shops profits for 18 years. This business arrangement provided leisure time for study, having now acquired comparative wealth; and in a few years he had made discoveries that gave him a reputation with the learned throughout Europe. These include his investigations of electricity. Franklin identified positive and negative electrical charges and also demonstrated that lightning was electrical.
>
> Franklin promoted this theory through the famous, though extremely dangerous, experiment of flying a kite during a lightning storm June 15th 1752. This experiment was not written up until Joseph Priestley's 1767 History and Present Status of Electricity; the evidence shows that Franklin was insulated (not in a conducting path, as he would have been electrocuted); unfortunately, other experimenters (such as Prof. Georg Richmann of St. Petersburg, Russia) were spectacularly electrocuted during the months following Franklin's famous experiment. Richmann, for example, was electrocuted by ball lightning to his forehead August 6th 1753. Franklin, in his writings, displays that he was cognizant of the dangers and alternative ways to demonstrate that lightning was electrical, as shown by his invention of the lightning rod, an application of the use of electrical ground. If Franklin did perform this experiment, he did not do it in the way that is often described (as it would have been dramatic but fatal (http://www.mos.org/sln/toe/kite.html)). See, for example, the 1805 painting by Benjamin West of Benjamin Franklin drawing electricity from the sky (http://www.frankelec.com/west_thumb_desc.htm).
>
> Franklin's inventions include the lightning rod, Franklin stove and bifocals. He was one of the best-known scientists of the 18th century. In recognition of his work with electricity, Franklin was elected a Fellow of the Royal Society and received its Copley Medal in 1753. The cgs unit of electric charge has been named after him: 1 franklin (Fr) is equal to 3.3356 x 10 -10 coulombs or 1 statcoulomb.
>
> Franklin established two major fields of physical science, electricity and meteorology. In his classic work (A History of The Theories of Electricity & Aether), Sir Edmund Whittaker (p. 46) refers to Franklin's inference that electric charge is not created by rubbing substances, but only transferred, so that "the total quantity in any insulated system is invariable. This assertion is known as the "principle of conservation of charge".

Franklin's Recollections

Franklin left a very readable autobiography that perhaps few people have taken the time to read. But his entries about electricity are particularly interesting:

> "In 1746, being at Boston, I met there with a Dr. Spence, who was lately arrived from Scotland, and show'd me some electric experiments. They were imperfectly perform'd, as he was not very expert; but, being on a subject quite new to me, they equally surpris'd and pleased me. Soon after my return to Philadelphia, our library company receiv'd from Mr. P. Collinson, Fellow of the Royal Society of London, a present of a glass tube, with some account of the use of it in making such experiments. I eagerly seized the opportunity of repeating what I had seen at Boston; and, by much practice, acquir'd great readiness in performing those, also, which we had an account of from England, adding a number of new ones. I say much practice, for my house was continually full, for some time, with people who came to see these new wonders.
>
> To divide a little this incumbrance among my friends, I caused a number of similar tubes to be blown at our glass-house, with which they furnish'd themselves, so that we had at length several performers. Among these, the principal was Mr. Kinnersley, an ingenious neighbor, who, being out of business, I encouraged to undertake showing the experiments for money, and drew up for him two lectures, in which the experiments were rang'd in such order, and accompanied with such explanations in such method, as that the foregoing should assist in comprehending the following. He procur'd an elegant apparatus for the purpose, in which all the little machines that I had roughly made for myself were nicely form'd by instrument-makers. His lectures were well attended, and gave great satisfaction; and after some time he went thro' the colonies, exhibiting them in every capital town, and pick'd up some money. In the West India islands, indeed, it was with difficulty the experiments could be made, from the general moisture of the air.
>
> Oblig'd as we were to Mr. Collinson for his present of the tube, etc., I thought it right he should be inform'd of our success in using it, and wrote him several letters containing accounts of our experiments. He got them read in the Royal Society, where they were not at first thought worth so much notice as to be printed in their Transactions. One paper, which I wrote for Mr. Kinnersley, on the sameness of lightning with electricity, I sent to Dr. Mitchel, an acquaintance of mine, and one of the members also of that society, who wrote me word that it had been read, but was laughed at by the connoisseurs. The papers, however, being shown to Dr. Fothergill, he thought them

of too much value to be stifled, and advis'd the printing of them. Mr. Collinson then gave them to Cave for publication in his Gentleman's Magazine; but he chose to print them separately in a pamphlet, and Dr. Fothergill wrote the preface. Cave, it seems, judged rightly for his profit, for by the additions that arrived afterward they swell'd to a quarto volume, which has had five editions, and cost him nothing for copy-money.

It was, however, some time before those papers were much taken notice of in England. A copy of them happening to fall into the hands of the Count de Buffon, a philosopher deservedly of great reputation in France, and, indeed, all over Europe, he prevailed with M. Dalibard to translate them into French, and they were printed at Paris. The publication offended the Abbe Nollet, preceptor in Natural Philosophy to the royal family, and an able experimenter, who had form'd and publish'd a theory of electricity, which then had the general vogue. He could not at first believe that such a work came from America, and said it must have been fabricated by his enemies at Paris, to decry his system. Afterwards, having been assur'd that there really existed such a person as Franklin at Philadelphia, which he had doubted, he wrote and published a volume of Letters, chiefly address'd to me, defending his theory, and denying the verity of my experiments, and of the positions deduc'd from them."

Franklin goes on a bit later to describe his accomplishements in a very modest way:

"What gave my book the more sudden and general celebrity, was the success of one of its proposed experiments, made by Messrs. Dalibard and De Lor at Marly, for drawing lightning from the clouds. This engag'd the public attention every where. M. de Lor, who had an apparatus for experimental philosophy, and lectur'd in that branch of science, undertook to repeat what he called the Philadelphia Experiments; and, after they were performed before the king and court, all the curious of Paris flocked to see them. I will not swell this narrative with an account of that capital experiment, nor of the infinite pleasure I receiv'd in the success of a similar one I made soon after with a kite at Philadelphia, as both are to be found in the histories of electricity.

Dr. Wright, an English physician, when at Paris, wrote to a friend, who was of the Royal Society, an account of the high esteem my experiments were in among the learned abroad, and of their wonder that my writings had been so little noticed in England. The society, on this, resum'd the consideration of the letters that had been read to them; and the celebrated Dr. Watson drew up a summary account of them, and of all I had afterwards sent to England on the subject, which be accompanied with some praise of the writer. This summary was then printed in their Transactions; and some members of the society in London, particularly the very ingenious Mr. Canton, having verified the experiment of procuring lightning from the clouds by a pointed rod, and acquainting them with the success, they soon made me more than amends for the slight with which they had before treated me. Without my having made any application for that honor, they chose me a member, and voted that I should be excus'd the customary payments, which would have amounted to twenty-five guineas; and ever since have given me their Transactions gratis. They also presented me with the gold medal of Sir Godfrey Copley for the year 1753, the delivery of which was accompanied by a very handsome speech of the president, Lord Macclesfield, wherein I was highly honoured."

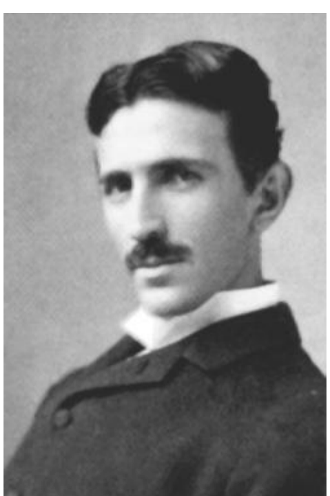
Ben Franklin's work holds a lot of promise for our present investigations as we shall see.

Tesla and his Coils

Wikipeadia's entry on Nikola Tesla is both long and interesting:

"Nikola Tesla (July 10, 1856 - January 7, 1943) (Baptism name: Николай; Nikolaj; Name in Cyrillic alphabet: Никола Тесла) was a Croatian - born Serb-American physicist, inventor, and electrical engineer. Tesla's most famous contribution was the theory of polyphase alternating current electricity, which he used to build the first induction motor in 1882, as well as developing the designs of numerous other electrical machines and related technology. His theory and many of his patents form the basis for the modern electric power system. Tesla is also noted for inventing the Tesla coil and a bladeless turbine (which functions on the principles of fluid viscosity and the boundary layer effect).

Life magazine, in a special double issue, listed Tesla in the "100 Most Important People in the Last 1000 Years". He occupied the 57th position, cited as "[one of] the most farsighted inventors of the electrical age". They state his work on the rotating magnetic field and alternating currents helped electrify the world. [1] (http://www.teslasociety.com/lifemag2.jpg)



The scientific compound derived SI unit measuring magnetic flux density or magnetic induction (commonly known as the magnetic field B), the tesla, was named in his honor (at the Conférence Générale des Poids et Mesures, Paris, 1960).

Tesla's Early years

Tesla on 100 Serbian Dinars in 2004Tesla was born "at the stroke of midnight" with lightning striking during a summer storm. He was born in Smiljani near Gospić, Lika, (the Krajina, a military district of Austro-Hungarian Empire, now in Croatia). The midwife commented, "He'll be a child of the storm," to which his mother replied, "No, of light." Tesla was baptised in the Old Slavonic Church rite. His Baptism Certificate reports that he was born on June 28 (Julian calendar; July 10 in the Gregorian calendar), and christened by the Serb orthodox priest, Toma Oklobd'ija.

His Serb father, the Rev. Milutin Tesla, was a priest in the Orthodox Metropolitanate of Karlovci which gathered to Serbs of the "Greek-rite" as they were legally referred to in Austria-Hungary at the time. His mother, Djuka Mandic, from a prominent Serb family of the Banija, made home craft tools. He was one of five children, having one brother and three sisters. His godfather, Jovan Drenovac, was a Captain in the Krajina army. His family moved to Gospić in 1862. Tesla went to school in Karlovac (Austria-Hungary), then studied electrical engineering at the Austria Politechnic in Graz, Austria (1875). While there, he studied the uses of alternating current. He also developed a telephone repeater (or amplifier).

In 1881 he moved to Budapest to work for the telegraph company, American Telephone Company. On the opening of the telephone exchange in Budapest, 1881, Tesla became the chief electrician to the telephone company, later engineer to the Yugoslav government and the country's first telephone system.

Tesla invented a precursor to modern wireless telephone, known as a telephone repeater (or sometimes a amplifier). The device could act as a audio speaker (not a audio transducer). The device had its resonance tuned to a particular frequency of other repeaters to communicate between each.

In 1916, Tesla described the prior developed audio transducers. According to Tesla, it was the "... [S]implest ways [to detect the radiant energy ...] the low frequency gave audible notes. [... in a field, there was] placed a conductor, a wire or a coil, and then Tesla would get a note [...] characteristics of the audible note". The audible sounds were of the quality of the telephones diaphragms of that period of time. The invention was never patented nor released publicly (till years later by Tesla himself). The device also contained the characteristics of modern wireless telephones.

For a while he stayed in Maribor. He was employed at his first job as an assistant engineer. Tesla suffered a nervous breakdown during this time. In 1882 he moved to Paris to work as an engineer for the Continental Edison Company. He worked designing improvements to electric equipment.

In the same year, Tesla conceived of the induction motor and began developing various devices that use rotating magnetic fields (for which he received patents in 1888). Tesla visualized the rotating fields and thereby designed the induction motor. Tesla hastened from Paris to his mother's side as she lay dying, arriving hours before her death in 1882. Her last words were to him were, "You've arrived, Nidzo, my pride." After her death, Tesla fell ill. He spent two to three weeks recuperating in Gospić and Tomingaj. All his life, Tesla kept a home-spun embroidered travel bag from his mother.

Middle years

In 1884, leaving the warfare of his birthplace behind, Tesla moved to the United States of America to accept a job with the Edison Company in New York City. He arrived in the US with 4 cents to his name, a book of poetry, and a letter of recommendation (from Charles Batchelor, his manager in his previous job).

Early employment

Tesla worked for Thomas Edison for a time. Edison offered him $50,000 for improvements in Edison's DC dynamos. Tesla worked nearly a year to redesign the inferior construction. Upon returning to Edison and inquiring about the $50,000, Edison replied, "Tesla, you don't understand our American humor." Tesla resigned. In 1886, Tesla formed his own company, Tesla Electric Light & Manufacturing. The initial financial investors disagreed with Tesla on his plan for an alternating current motor and eventually relieved Tesla of his duties at the company. Tesla was unemployed for a time.

Tesla worked on the streets of New York as a common laborer from 1886 to 1887 to raise capital to eat and for his next project. In 1887, he constructed the initial brushless alternate-current induction motor. He demonstrated the brushless two-phase one-fifth horsepower (150 W) induction motor to the American Institute of Electrical Engineers (now IEEE) in 1888. Also in 1888, he developed the principles of his Tesla coil. In the same period, he began working with Westinghouse, Westinghouse's Pittsburgh labs. Westinghouse listened to Tesla's ideas for polyphase systems. These systems would allow alternating current [AC] electricity to be transmitted over large distances.

X-rays and friendships

In April 1887, Tesla began investigating what would later be called X-rays using his own devices as well as Crookes tubes. He did this by experimenting with high voltages and vacuum tubes. His technical publications indicate that he invented and developed a special single-electrode X-ray tube. Tesla's tubes differed from other X-ray tubes in that they had no target electrode. He stated these facts in his 1897 X-ray lecture before the New York Academy of Sciences. The modern term for this is the bremsstrahlung process, in which a high-energy secondary X-ray emission is produced when charged particles (such as electrons) pass through matter.

In 1891, Tesla became a naturalized American citizen. Also in this year, Tesla established his Houston Street laboratory in New York. He lit vacuum tubes wirelessly in the lab, providing evidence for the potential of wireless power transmission. Around this time, Tesla developed a close and lasting friendship with author and humorist Mark Twain. They spent quite a bit of time together in Tesla's lab and other areas. Tesla's closest friends were writers and artists. Tesla's also befriended R. A. Jonson, who adapted several poems of the Serbian poet Jovan Jovanović Zmaj (and which were translated into English by Tesla).

When he was 36 years old, the first patents concerning the polyphase power system were granted. He continued researching rotating magnetic field principles and polyphase power distribution. By 1892, Tesla became aware of certain characteristics later identified by Wilhelm Conrad Röntgen as effects of X-rays. He performed several experiments (including taking photographs of the bones of his hand) but did not make his findings widely known. Much of his research was lost in the 1895 Houston Street lab fire. He did obtain pictures of the human body with X-rays and subsequently sent the images to Röntgen. His later X-ray experimentation by vacuum high field emissions led him to alert the scientific community first to the biological hazards associated with X-ray exposure.

Wireless and the AIEE

Tesla served as the Vice-President of AIEE, the American Institute of Electrical Engineers (now part of the IEEE) from 1892 to 1894. From 1893 to 1895, Tesla investigated high frequency alternating currents. He generated one million volts of alternating currents using a conical Tesla coil. He developed the skin effect in circuitry, designed tuned circuits, invented a machine for inducing sleep, cordless gas discharge lamps, and transmitted electromagnetic energy without wires, effectively building the first radio transmitter.

In St. Louis, Missouri, Tesla made the first public demonstration of radio communication in 1893. Addressing the Franklin Institute in Philadelphia, Pennsylvania and the National Electric Light Association, he described and demonstrated in detail the principles of radio communication. The apparatus he used contained all the elements that were incorporated into radio systems before the development of the vacuum tube.

World's Fair Exposition

At the 1893 World's Fair, the World Columbian Exposition, in Chicago, Illinois, celebrating the 400th anniversary of Christopher Columbus' first voyage to America, an international exposition was held, in which, for the first time, a building was devoted to electrical exhibits. It was a historic event and the beginning of a revolution as Tesla and Westinghouse introduced visitors to AC power by providing AC energy to illuminate the World Columbian Exposition. The public at large observed firsthand the qualities and abilities of AC power. All the exhibits were from commercial enterprises. Edison, Brush, Western Electric, and Westinghouse all had exhibits. General Electric Company (backed by Edison and J.P. Morgan) proposed to power the electric fair with direct current at the cost of one million dollars.

Westinghouse proposed, armed with Tesla's AC system, to illuminate the exposition for half as much. Tesla's high-frequency high-voltage lighting produced more efficient light with less heat. A two-phase induction motor was driven by current from the main generators to power the system. Edison tried to prevent the use of his light bulbs with Tesla's system. GE banned the use of Edison's lamps in Westinghouse's exhibits. Still, Westinghouse's proposal was chosen over the inferior DC system to power the fair.

Westinghouse displayed several polyphase systems. The exhibits included a switchboard, polyphase generators, step-up and step-down transformers, transmission line, commercial size induction motors, commercial size synchronous motors, and rotary direct current converters (one of which was operating a railway motor). The working-scale system allowed the public a view of a system of polyphase power which could transmit long distances. Meters and other auxiliary devices were also present.

Tesla displayed the first neon light tubes at the exposition, demonstrating his phosphorescent lighting powered without wires by high-frequency fields. Tesla's lighting inventions exposed to high-frequency currents would bring the gases to incandescence. Tesla displayed the first practical phosphorescent lamps (a precursor to fluorescent lamps). His innovations in this type of light emission were not regularly patented.

Also in the exhibits were Tesla's demonstrations, most notably the "Egg of Columbus". This device explains the principles of the rotating magnetic field and his induction motor. The Egg consisted of a polyphase field coil underneath a plate with a copper egg positioned over the top. When the sequence of the coils were energized, the magnetic field arrangement inductively created a rotation on the egg and made it stand up on end (appearing to resist gravity).

On August 25, Elisha Gray introduced Tesla for the delivery of a lecture on mechanical and electrical oscillators. Tesla explained his work for efficiently increasing the work at high frequency of reciprocation. As Electrical Congress members listened, Tesla delineated mechanisms which could produce oscillations of constant periods irrespective of the pressure applied and irrespective of frictional losses and loads. He explained the working means of producing constant period electric currents (not resorting to spark gaps or breaks) and how to produce these with reliable mechanisms.

The Exposition's illumination with electricity using Tesla's and Westinghouse's alternate current removed any doubt of the utility of the polyphase alternating current.

War of currents

During this time, direct current was the standard, and Edison was not disposed to lose all his patent royalties to a former employee. Adversaries due to Edison's promotion of DC for electric power distribution over the more efficient alternating current advocated by Tesla, Edison (or, reportedly, one of his employees) employed the tactics of misusing Tesla's patents to construct the first electric chair for the state of New York in order to promote the idea that alternating currents were deadly.

In his work with the rotary magnetic fields, Tesla devised the system for transmission of power over long distances. He partnered with George Westinghouse to commercialize this system. Westinghouse had previously bought the rights to Tesla's polyphase patents and other patents for AC transformers. Experts announced proposals to harness the Niagara Falls for generating electricity. Against General Electric and Edison's proposal, Tesla's AC system won the international Niagara Falls Commission contract. The commission was led by Lord Kelvin and backed by entrepreneurs (such as J.P. Morgan, Lord Rothschild, and John Jacob Astor). Work began in 1893 on the Niagara Falls generation project and Tesla's technology was applied to generate electromagnetic energy from the falls.

Some doubted that the system would generate enough electricity to power industry in Buffalo. Tesla was sure it would work, saying that Niagara Falls had the ability to power the entire eastern U.S. On November 16, 1896, the first transmission of electrical power between two cities was sent from Niagara Falls to industries in Buffalo from the first commercial two-phase power plants (known as hydroelectric generators) at the Edward Dean Adams Station.

The hydroelectric generators were built by Westinghouse Electric Corporation from Tesla's AC system patent designs. Tesla's system designs alleviated the limitations of the previous DC methods. The nameplates on the generators bear Tesla's name. He also set the 60 hertz standard for North America. It took five years to complete the whole facility.

With the financial backing of George Westinghouse, Tesla's AC replaced DC, enormously extending the range and improving the safety and efficiency of power distribution. Tesla's Niagara Falls system marked the end of Edison's roadmap for electrical transmission. Eventually, Edison's GE company converted to the AC system. Tesla's contributions to the modern world are widely regarded as more important and long-lasting, by some, than those of his nemesis and one-time employer, Thomas Edison.

Designs and Colorado

When Tesla was 41 years old, he filed the first basic radio patent (No. US645576). A year later, he demonstrated a remote controlled boat to the US military. Tesla believed that the military would want things such as radio-guided torpedoes. These devices had an innovative coherer and a series of logic gates. Mark Twain wrote Tesla over the demonstrations, though the military took little interest. Radio remote control remained a novelty until the Space Age. At the age of 42, Tesla devised an electric igniter for gasoline engines. His designs are nearly identical to ideas which deal with the same process which modern internal combustion engines use.

In 1899, Tesla traveled to Colorado Springs to continue his research into high-voltage, high frequency alternating current electricity. He was developing a system for wireless telegraphy, telephony and the transmission of power. He also conceived of a system for geophysical exploration--seismology--which he called telegeodynamics, based his reciprocating mechanical oscillator Tesla patented in 1894. He claimed that it could be used to identify underground ore deposits.

Colorado Springs and his diary

Colorado's geomagnetismIn 1899, Tesla decided to move and began conducting research in Colorado (near Colorado Springs), where he could have room for his high-voltage high-frequency experiments. After searching the country for a new location, Tesla chose Colorado Springs for his next series of experiments, primarily because of the frequent electrical storms and the thinness of the air (reducing its dielectric level), making it more conductive. Also, the property was free and electric power was available from the El Paso Power Company. Today electromagnetic intensity charts from the geological survey also show that the ground around his lab possesses a denser field than most of the surrounding area. Tesla reached Colorado Springs on May 17, 1899. Upon his arrival he told reporters that he was conducting experiments transmitting signals from Pikes Peak to Paris.

Tesla kept a diary of his experiments in the Colorado Springs lab where he spent nearly nine months. The diary consists of handwritten notes and date between June 1, 1899 and January 7, 1900. There are explanations (as seen in the photographs taken during this time) of his experimental work. It consists of 500 pages and nearly 200 drawings and is recorded chronologically as the work occurred. He experimented with high-voltage electricity and the possibility of transmitting and distributing large amounts of electrical energy over long distances without using wires. He also conceived the science of telegeodynamics, now known as seismology, and explained that a long sequence of small explosions could be used to find ore underground and could create earthquakes large enough to destroy the Earth. He did not experiment with this as he felt there would not be "a desirable outcome".

Laboratory construction

Tesla, a local contractor, and several assistants commenced the construction of the laboratory shortly after arriving in Colorado Springs. Tesla established his lab on Knob Hill in Colorado Springs, (east of the Colorado School for the Deaf and Blind and one mile east of downtown). The primary purpose of the laboratory was to experiment with high frequency electricity and other phenomena. The Colorado Springs lab's secondary purpose was to research wireless transmission of electrical power.

Tesla's design for the lab consisted of a building fifty feet by sixty feet with eighty-foot ceilings. A one-hundred-forty-two foot conducting aerial with a thirty-inch copper-foil-covered wooden ball was erected on the roof of the lab. The design also implemented a roof that rolled back to prevent fire from sparks and other dangerous effects from the experiments. The laboratory possessed sensitive instruments and equipment.

Magnifying transmitter

Double exposure publicity photo of Tesla sitting in his laboratory in Colorado Springs with his "magnifying transmitter" generating millions of volts of electricity. The arcs are about 22 feet long.The Colorado Springs lab possessed the largest Tesla Coil ever built, known as the "Magnifying Transmitter". This was not identical to the classic Tesla Coil. According to accounts, Tesla managed to transmit tens of thousands of watts of power without wires using the magnifier. Tesla posted a large fence around the coil with a sign, "Keep Out - Great Danger". Tesla's Magnifying Transmitter, at fifty-two feet in diameter, generated millions of volts of electricity and produced lightning bolts more than one-hundred feet long (30.5 metres). It was a three-coil magnifying system requiring alternative forms of analysis than lumped-constant coupled resonant coils presently described to most. The Magnifying Transmitter resonated at a natural quarter wavelength frequency. Tesla worked the magnifying transmitter in a continuous-wave mode and in a partially damped-wave resonant mode.

The Magnifying Transmitter produced thunder which was heard as far away as Cripple Creek. He became the first man to create electrical effects on the scale of lightning. People near the lab would observe sparks emitting from the ground to their feet and through their shoes. Some people observed electrical sparks from the fire hydrants (Tesla for a time grounded out to the plumbing of the city). The area around the laboratory would glow with a blue corona (similar to St. Elmo's Fire). One of Tesla's experiments with the Magnifying Transmitter destroyed Colorado Springs Electric Company's generator by backfeeding the city's power generators, and blacked out the city. The city had a backup generator and company officials denied Tesla further access to their feed if he did not repair the city's primary generator at his own expense. The generator was working again in a few days.

Tuned circuits

Tesla constructed many smaller resonance transformers in his lab and discovered the concept of tuned electrical circuits. Tesla also developed a number of coherers for separating and perceiving electromagnetic waves. In his Colorado experiments, he designed rotating coherers. These were used to detect the unique types of electromagnetic phenomenon observed by Tesla. Tesla's rotating coherer had a mechanism of geared wheels that were driven by a coiled spring-drive mechanism, which was used to rotate small glass cylinders. These experiments were the final stage of years of work related to synchronized electrical tuned circuits.

These transceivers were constructed to demonstrate how signals could be "tuned in". Tesla logged in the diary on July 3, 1899, that a separate resonance transformer tuned to the same high frequency as a larger high-voltage resonance transformer would transceive energy from the larger coil, acting as a transmitter of wireless energy. This data was used to confirm Tesla's patent for radio during later disputes in the courts. These air core high-frequency resonate coils were the predecessors of systems from radio to radar and medical magnetic resonance imaging devices.

Propagation and resonance

On July 3, 1899, Tesla discovered terrestrial stationary waves within the earth. He demonstrated that the Earth behaves as a smooth polished conductor and possesses electrical vibrations. He experimented with waves characterized by a lack of vibration at points, between which areas of maximum vibration occur periodically. These standing waves were produced by confining waves within constructed conductive boundaries. Tesla demonstrated that the Earth could respond at predescribed frequencies of electrical vibrations. At this time, Tesla realized that it was possible to transceive power around the globe.

Tesla conducted experiments contributing to the understanding of electromagnetic propagation and the Earth's resonance. It is well documented (from various photos from the time) that he lit hundreds of lamps wirelessly at a distance of up to twenty-five miles (forty kilometres). He transmitted signals several miles and lit neon tubes conducting through the ground. He researched ways to utilize the ionosphere to transmit energy wirelessly over long distances. He transmitted extremely low frequencies through the earth and portions of the ionosphere, called the Kennelly-Heaviside Layer, in his experiments. Tesla made mathematical calculations and computations based on his experiments and discovered that the resonant frequency of this area was approximately eight hertz. In the 1950s, researchers confirmed the resonant frequency was in this range.

Cosmic waves

In the Colorado Springs lab, Tesla recorded what he concluded were extraterrestrial radio signals and announced his findings in some of the scientific journals of the time. [2] (http://www.teslasociety.com/mars2.htm) His announcements and data were rejected by the scientific community who did not believe him. He notes measurements of repetitive signals from his receiver which are substantially different from the signals he had noted from storms and earth noise. Specifically, he later recalled that the signals appeared in groups of clicks 1, 2, 3, and 4 clicks together. He stated in the article "A Giant Eye to See Round the World", of Feburary 25, 1923, that:

"Twenty-two years ago, while experimenting in Colorado with a wireless power plant, I obtained extraordinary experimental evidence of the existence of life on Mars. I had perfected a wireless receiver of extraordinary sensitiveness, far beyond anything known, and I caught signals which I interpreted as meaning 1--2--3--4. I believe the Martians used numbers for communication because numbers are universal." Albany Telegram — February 25, 1923 [3] (http://www.tesla.hu/tesla/articles/19230225.doc)

Clearly, Tesla felt the signal groups originated on the planet Mars. In 1996 Corum and Corum published an analysis of Jovian plasma torus signals which indicate that there was a correspondence between the setting of Mars at Colorado Springs, and the cessation of signals from Jupiter in the summer of 1899 when Tesla was there. [4] (http://www.teslasociety.com/mars.pdf) Further, analysis by the Corums indicate that Tesla's transciever was sensitive in the 18 KHz gap in the Kennelly-Heaviside layer which would have allowed that reception from Jupiter. Therefore, there is evidence the signals Tesla noticed came from Jupiter, among other possible sources. Tesla spent the latter part of his life trying to signal Mars.

It is important to recognize that when he says he "recorded" these signals, it is meant that he wrote down the data and his impressions of what he had heard. He did release reports at the time. Tesla's inital announcement of the existence of extraterrestrial radio signals was in 1899. [5] (http://www.teslasociety.com/cosmos.htm)

In March of 1907, Tesla wrote about signaling to Mars in Harvard Magazine and how it was a problem of electrical engineering. [6] (http://www.teslasociety.com/signaltomars.htm) Additional descriptions come from remembrances twenty years later. All this was met with resistance and disbelief by his contemporaries.

Tesla left Colorado Springs on January 7, 1900. The lab was torn down, broken up, and its contents sold to pay debts. The Colorado experiments prepared Tesla for his next project, the establishment of a wireless power transmission facility that would be known as Wardenclyffe.

Wardenclyffe

In 1900, Tesla began planning the Wardenclyffe Tower facility. In 1901, the construction began on land near Long Island Sound. The architect Stanford White designed the Wardenclyffe facility main building. Tesla's project was funded by influential industrialists and other venture capitalists. In June 1902, Tesla's lab operations were moved to Wardenclyffe from Houston Street. In 1903, the tower structure neared completion, although it was not yet functional due to a design error. In Electrical World and Engineer (March 5, 1904), Tesla reportedly determined the mode of ball lightning formation and produced them artificially.

In 1904, the United States Patent Office awarded the patent for radio to Guglielmo Marconi, though his work is based on Tesla's widely-discussed demonstration years prior. In May 1905, some of Tesla's patents expired, stopping the royalty payments and causing severe reduction to the funding of the Wardenclyffe Tower. Tesla advertised services of the Wardenclyffe facility to find alternative funding to little success. Around 1910, Tesla designed the Tesla turbine at Wardenclyffe and produced Tesla coils for sale to various businesses to generate funding. He developed a 200 horsepower (150 kW) 16,000 revolutions-per-minute bladeless turbine. It was shown to an audience on his fiftieth birthday.

Of the 700-plus patents accumulated by Tesla, the most controversial today is his Wardenclyffe Tower. The tower was meant to be the start of a global system for wireless telecommunications and a national (and later global) system of towers broadcasting power to users as radio waves. A second plant was to be build in England. It was also intended as a demonstration of wireless electrical power distribution. Instead of supplying electricity through a current grid system, users would simply "receive" power through antennas on their roofs. At the time the power grid was quite limited in terms of who it reached and the proposed system represented a way of significantly reducing the cost of "electrifying" the countryside.

Though never completed successfully in Tesla's lifetime due to lack of funding, and finally dismantled for scrap during wartime, its principles are currently being implemented by a U.S. military project in Alaska, spanning several hundred acres. However, Project HAARP, as it is called, targets a different objective. While Tesla's tower was to be his supreme test of the applicability of transmitted power, HAARP is being used to study ionospheric effects on radio communication. Wardenclyffe also provides a basis for a current search for practical applications for focused wave and particle beams, such as the laser and maser.

In the financial panic of 1907, Tesla set Westinghouse free from payments on his patents over the induction motor for a nominal sum of money. Diminished in strength by the "War of the Currents," the Westinghouse Company survived due to Tesla's act of generosity. Between 1912 and 1915, Tesla's finances unraveled. Newspapers of the time labeled Wardenclyffe "Tesla's million-dollar folly."

Nobel rumors

Due to the fact that the Nobel Prize was awarded to Marconi for radio in 1909, it was believed that Tesla and Edison were to share the Nobel Prize of 1912 (or 1915; some accounts differ). Tesla's rumored nomination for the Nobel Prize in Physics was primarily for his experiments with tuned circuits using high-voltage high-frequency resonant transformers. It was possible that Tesla was told of the plans of the physics award committee and let it be known that he would not share the award with Edison.

Later years

Prior to the First World War, Tesla looked overseas for investors to fund his research. When the war started, Tesla lost funding he was receiving from his European patents. Wardenclyffe Tower was also demolished towards the end of WWI. Tesla had predicted the relevant issues of the post-World War I environment (a war which theoretically ended) in a printed article (December 20, 1914).

Tesla believed that the League of Nations was not a remedy for the times and issues. In 1915, Tesla filed a lawsuit against Marconi attempting, unsuccessfully, to obtain a court injunction against the claims of Marconi. Around 1916, Tesla filed for bankruptcy because he owed so much in back taxes. He was living in poverty.

Tesla started to exhibit pronounced symptoms of obsessive-compulsive disorder in the years following. He became obsessed with the number three. He often felt compelled to walk around a block three times before entering a building, demanded a stack of three folded cloth napkins beside his plate at every meal, etc. The nature of OCD was little understood at the time and no treatments were available, so his symptoms were considered by some to be evidence of partial insanity and this probably hurt what was left of his reputation. This obsessive-compulsive behavior may have originated from the observations over repeated polyphase systems in nature that Tesla researched.

At this time, he was staying at the Waldorf-Astoria, renting in an arrangement for deferred payments. In 1917, around the time that the Wardenclyffe Tower was demolished, Tesla received the highest and most significant honor the IEEE can award to any person who uses scientific knowledge to solve practical problem, the Edison Medal. The incongruities between what might have been and the situation at hand probably did not pass without notice by Tesla.

Radar

Tesla, in August 1917, first established principles regarding frequency and power level for the first primitive RADAR units in 1934. In the 1917 The Electrical Experimenter, Tesla stated the principles of modern military radar in detail. Tesla's study of high-voltage, high-frequency alternating current led to this development. Tesla had formed the concept of using radio waves to detect objects at a distance.

Tesla stated,

"For instance, by their [standing electromagnetic waves] use we may produce at will, from a sending station, an electrical effect in any particular region of the globe; [with which] we may determine the relative position or course of a moving object, such as a vessel at sea, the distance traversed by the same, or its speed." Tesla proposed to use electromagnetic waves to determine the relative position, speed, and course of a moving object and other modern concepts of radar. Tesla had proposed it may help find submarines (which it isn't well-suited for), though it was first applied successfully to find aircraft (after their later proliferation) and surface ships during World War II. Emil Girardeau, working with the first French radar systems, stated he was building radar systems "conceived according to the principles stated by Tesla".

By the twenties, Tesla reportedly negotiates with the United Kingdom's Prime Minister Chamberlin government over a ray system. Tesla also had stated efforts had been made to steal the "death ray" (though they had failed). The Chamberlin government was removed though before any final negotiations occurred. The incoming Baldwin government found no use of Tesla's suggestions and ended negotiations.

1930s

On Tesla's seventy-fifth birthday in 1931, Time magazine put Tesla on the cover. [7] (http://www.teslasociety.com/time.jpg) The cover caption noted his contribution to electrical power generation. In 1935, many of Marconi's patents relating to the radio were declared invalid by the United States Court of Claims. The Court of Claims decided that the prior work of Tesla (specifically US645576 and US649621) had anticipated Marconi's later works. Tesla got his last patent in 1928 on January 3, an apparatus for aerial transportation which was the first instance of VTOL aircraft. In 1934, Tesla wrote to consul Janković of his homeland. The letter contained the message of gratitude to Mihajlo Pupin who initiated a donation scheme by which American companies could support Tesla. Tesla refused the assistance. Tesla chose to live by a modest pension received from Yugoslavia and keep researching.

Dynamic theory of gravity

When he was eighty-one, Tesla challenged Albert Einstein's theory of relativity, announcing he was working on a dynamic theory of gravity and argued that a field of force was a better concept and did away with the curvature of space. Unfortunately the theory was never published, but Tesla may have been developing a theory about gravity waves. This theory provides a basis for plasma cosmology.

Death and afterwards

Tesla died alone in the hotel New Yorker of heart failure, some time between the evening of January 5 and the morning of January 8, 1943. Despite selling his AC electricity patents, Tesla was essentially destitute and died with significant debts.

At the time of his death, Tesla had been working on some form of teleforce weapon, or Death ray, the secrets of which he had offered to the United States War Department on the morning of January 5. It appears that his proposed death ray was related to his research into ball lightning and plasma. He was found dead 3 days later and, after the FBI was contacted by the War Department, his papers were declared to be top secret.

Immediately after his death became known, the Federal Bureau of Investigation instructed the Office of Alien Property to take possession of Tesla's papers and property, despite his US citizenship. All of Tesla's personal effects were seized on the advice of presidential advisors. J. Edgar Hoover declared the case "most secret," because of the nature of Tesla's inventions and patents. Tesla's Serbian-Orthodox family and the Yugoslav embassy struggled with American authorities to gain these items after Tesla's death due to the potential significance of some of Tesla's research. Eventually, Tesla's nephew, Sava Kosanovich, got possession of some of his personal effects (which are now housed in the Nikola Tesla Museum in Belgrade, Yugoslavia). Tesla's funeral took place on January 12, 1943 at the Cathedral of Saint John the Divine in Manhattan, New York City.

Tesla always disputed the claim that Marconi invented radio. An ongoing lawsuit regarding this was finally resolved in Tesla's favor after his death. This decision was based on the fact that there was prior work existing before the establishment of Marconi's patent. At the time, the United States Army was involved in a patent infringement lawsuit with Marconi regarding radio, leading some to posit that the government granted Tesla the patent in order to nullify any claims Marconi would have to compensation (as, some posit, the government's initial granting to Marconi the patent right in order to nullify any claims Tesla had for compensation).

In 1976, a bronze statue of Tesla was placed at Niagara Falls.

Perhaps because of Tesla's personal eccentricity and the dramatic nature of his demonstrations, conspiracy theories about applications of his work persist. The common Hollywood stereotype of the "mad scientist" mirrors Tesla's real-life persona, or at least a caricature of it—which may be no accident considering that many of the earliest such movies (including the first movie version of Mary Shelley's Frankenstein) were produced by Tesla's old rival, Thomas Edison. There are at least two films describing Tesla's life. In the first, arranged for TV, Tesla was portrayed by Rade Šerbedžija. In 1980, Orson Welles produced a Yugoslavian film named Tajna Nikole Tesle (The Secret of Nikola Tesla).

PBS has an excellent documentary, Tesla: Master of Lightning, which may be purchased from the PBS web site at http://www.pbs.org/tesla/boutiq/index.html

Edwin V. Gray

Born in 1925, died in 1989, Edwin Gray is an interesting fellow to be aware of because he purportedly developed a device to "split the positive". His followers believe that when an electrostatic discharge occurs, it is possible to "split the positive" and somehow come up with an over-unity device – one that will make more energy than it consumes.

Believers in Gray's work, which includes U.S. Patent 4,595,975, believe that he was able to power an 80-horsepower electric motor in a car with this system. However, in the patent itself, we find no claim of "over unity" – perhaps in part because the Patent Office is very skeptical of such claims. Here's what he actually claimed:

"Disclosed is an Electrical Driving and Recovery System for a High Frequency environment. The recovery system can be applied to drive present day direct-current or alternating-current loads for better efficiency. It has a low-voltage source coupled to a vibrator, a transformer and a bridge-type rectifier to provide a high voltage pulsating signal to a first capacitor. Where a high-voltage source is otherwise available, it may be coupled directly to a bridge-type rectifier, causing a pulsating signal to the first capacitor. The first capacitor in turn is coupled to a high voltage anode of an electrical conversion switching element tube. The switching element tube also includes a low voltage anode which is connected to a voltage source by a commutator and a switching element tube. Mounted around the high voltage anode is a charge receiving plate which is coupled to an inductive load to transmit a high voltage discharge from the switching element tube to the load. Also coupled to the load is a second capacitor for storing the back EMF created by the collapsing electrical field of the load when the current to the load is blocked. The second capacitor is coupled to the voltage source. When adapted to present day direct-current or alternating-current devices the load could be a battery or capacitor to enhance the productivity of electrical energy."

Gray goes on in his patent to describe a preferred embodiment – this is always a good place to look at an inventors work because it allows us to see more what they have in mind for their invention:

"DESCRIPTION OF THE PREFERRED EMBODIMENT

While the present invention is susceptible of various modifications and alternative constructions, an embodiment is shown in the drawings and will herein be described in detail. It should be understood however that it is not the intention to limit the invention to the particular form disclosed; but, on the contrary, the invention is to cover all modifications, equivalents and alternative constructions falling within the spirit and scope of the invention as expressed in the appended claims.

There is disclosed herein an electrical driving system which, on theory, will convert low voltage electric energy from a source such as an electric storage battery to a high potential, high current energy pulse that is capable of developing a working force at the inductive output of the device that is more efficient than that which is capable of being developed directly from the energy source. The improvement in efficiency is further enhanced by the capability of the device to return that portion of the initial energy developed, and not used by the inductive load in the production of mechanical energy, to the same or second energy reservoir or source for use elsewhere, or for storage.

This system accomplishes the results stated above by harnessing the "electrostatic" or "impulse" energy created by a high-intensity spark generated within a specially constructed electrical conversion switching element tube. This element utilizes a low-voltage anode, a high-voltage anode, and one or more "electrostatic" or charge receiving grids. These grids are of a physical size, and appropriately positioned, as to be compatible with the size of the tube, and therefore, directly related to the amount of energy to be anticipated when the device is operating.

The low-voltage anode may incorporate a resistive device to aid in controlling the amount of current drawn from the energy source. This low-voltage anode is connected to the energy source through a mechanical commutator or a solid-state pulser that controls the timing and duration of the energy spark within the element. The high-voltage anode is connected to a high-voltage potential developed by the associated circuits. An energy discharge occurs within the element when the external control circuits permit. This short duration, high-voltage, high-current energy pulse is captured by the "electrostatic" grids within the tube, stored momentarily, then transferred to the inductive output load.

The increase in efficiency anticipated in converting the electrical energy to mechanical energy within the inductive load is attributed to the utilization of the most optimum timing in introducing the electrical energy to the load device, for the optimum period of time.

Further enhancement of energy conservation is accomplished by capturing a significant portion of the energy generated by the inductive load when the useful energy field is collapsing. This energy is normally dissipated in load losses that are contrary to the desired energy utilization, and have heretofore been accepted because no suitable means had been developed to harness this energy and restore it to a suitable energy storage device.

The present invention is concerned with two concepts or characteristics. The first of these characteristics is observed with the introduction of an energizing current through the inductor. The inductor creates a contrary force (counter-electromotive force or CEMF) that opposes the energy introduced into the inductor. This CEMF increases throughout the time the introduced energy is increasing.

In normal applications of an alternating-current to an inductive load for mechanical applications, the useful work of the inductor is accomplished prior to terminating the application of energy. The excess energy applied is thereby wasted.

Previous attempts to provide energy inputs to an inductor of time durations limited to that period when the optimum transfer of inductive energy to mechanical energy is occuring, have been limited by the ability of any such device to handle the high current required to optimize the energy transfer.

The second characteristic is observed when the energizing current is removed from the inductor. As the current is decreased, the inductor generates an EMF that opposes the removal of current or, in other words, produces an energy source at the output of the inductor that simulates the original energy source, reduced by the actual energy removed from the circuit by the mechanical load. This "regenerated", or excess, energy has previously been lost due to a failure to provide a storage capability for this energy.

In this invention, a high-voltage, high-current, short duration energy pulse is applied to the inductive load by the conversion element. This element makes possible the use of certain of that energy impressed within an arc across a spark-gap, without the resultant deterioration of circuit elements normally associated with high energy electrical arcs.

This invention also provides for capture of a certain portion of the energy induced by the high inductive kick produced by the abrupt withdrawal of the introduced current. This abrupt withdrawal of current is attendant upon the termination of the stimulating arc. The voltage spike so created is imposed upon a capacitor that couples the attendant current to a secondary energy storage device.

A novel, but not essential, circuit arrangement provides for switching the energy source and the energy storage device. This switching may be so arranged as to actuate automatically at predetermined times. The switching may be at specified periods determined by experimentation with a particular device, or may be actuated by some control device that measures the relative energy content of the two energy reservoirs. "

Connecting Some Dots

While I could go on – almost without limits - on the character of the characters involved in the quest for free energy sources, that's not the goal of this book. Our objective, and one that's hard to remain focused on, is to come up with a reliable way to charge up a small two-meter ham radio transciever!

What we need to do is look at enough of the biographical documents and then to the technical documents to see if we can make some generalizations about what the particular inventors might have discovered.

The Franklin Lessons

The lesson from Franklin boils down to a couple of simple observations:

1. He was able to charge a Lyden jar (a big capacitor) by essentially running a long piece of wire into the air with a kite. He established that there is voltage available.
2. Franklin's voltage was very *high voltage,* but it was not transformed into real *work*. The size of his Lyden jar makes it likely that the capacitance involved was perhaps only 40-60 picofarads. That's not a lot of capacitance (plate area) but the purpose of a Lyden jar was to store high voltage. By contrast, a small Mylar electrolytic capacitor the size of your thumb might hold 1000 times the useful energy, but it would be at substantially lower voltage.

Franklin's work, not necessarily Tesla's, looks like a very good starting point.

Tesla Lessons

What I got out of reading Tesla was that:

3. The high voltages collected may be transformed from static into current electricity by means of transformers and spark gaps (or their equivalent).
4. There are at least three obvious types of electricity to be investigated in our quest to power the two-meter radio charger:
   - Static electricity which both Franklin and Tesla demonstrated.
   - Radio frequency energy that Tesla seems to have discovered, including possibly the first evidence of cosmic rays.
   - Ground electricity which we today call telluric currents.

Gray’s Lesson

Edwin Gray, Sr. and others who have come up to the boundaries of physics with over-unity push the envelope a bit farther than I’m prepared to go in a first serious encounter with the subject area. Call me a dyed-in-the-wool skeptic, but I think there are plenty of questions to be answered taking a conventional physics/electronics approach to the design problem without introducing the novelty of over-unity energy sources.

To be sure, Gray’s work deserves additional study, as does cold fusion, and other promising technologies. However, I’m just trying to charge a small battery for a start.

Static Electricity Experiment Design and Methodology

Regardless of whether we find adequate amounts of static electricity, or telluric currents, we will be faced with a fundamental problem common to electronics: power conversion.

The odds of us finding a free source of 115 Volt AC current is very limited, although it has been accomplished experimentally by running long wires under powerlines. The idea is that there is enough inductive coupling between the "receiving antenna wire" and the "transmitting antenna wire" (the powerline) that something can be extracted.

A natural power supply, on the other hand, would not go off when the power grid goes down, and thus would be more desireable.

What we come down to are two possibilities. We could run into a high voltage, low current static electricity source, or we could run into a high current, low voltage telluric (ground) current source.

Static Electricity Experiments to be performed

When we are dealing with static electricity, we have read in the literature that we should use well insulated wire because static will build up better on insulated wire than open wire. The thinking goes something like this: "If you have a bare wire, any static charge that builds up will be (relatively) quickly drained off by discharge to grounded objects by water in the air."

Research Experiment 1: I'm a great believer in seeing "what's out there" as a starting point for any project, whether it's a new web site, a piece of furniture, or just some off the wall project – like the search for Free Energy! The basis of the first experiment will be a to take a piece of public domain research, purchased off the web and see if it can be made to work as advertised.

Our first research project will attempt to duplicate the experiment described in an $8 booklet which offers a "free energy accumulator" which the author says may power small experiments, radios, " and so forth. This is quite appealing because it seems to alude to our goal of making a workable battery charger for our 2-meter ham radio.

The roof of my office building, a metal roof of 40 feet square with a 21 foot high vertical ham radio antenna plus radials will serve as the "antenna". We'll see how much energy can be accumulated.

Research Experiment 2: Because we're skeptical, one of our first experiments on the static electricity side of this project will be to conduct an actual measurement (side by side) of a solid conductor open to the air (we'll use a long length of #15 steel electric fence wire) and we'll use an equally long piece of insulated #22 wire. Both will be supported by clean 6" electric fence wire insulators.

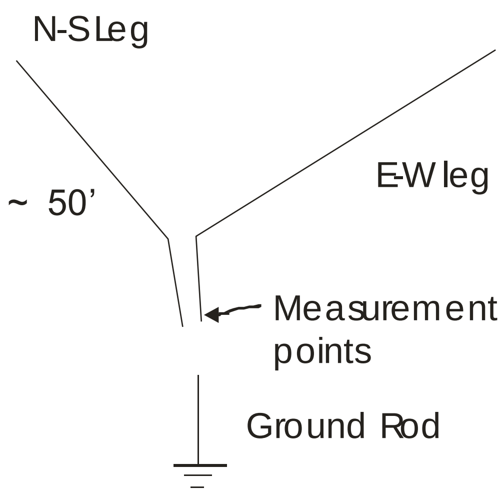
Both wires will be shorted to ground simultaneously and a charge allowed to accumulate over time. The results will be observed using a voltmeter and oscilloscope. Relative humidity will be noted as the experiment will be conducted in the early morning hours when RH is high and will be observed as RH drops as the temperature rises. The RH measurement is not essential to the outcome, as this experiment will really come down to a contest between the bare wire and the insulated over which will collect more energy.

Research Experiment 2: Once we establish which of the two conductors collects the greatest static charge, we will then investigate whether an East-West orientation or the wire, or a North-South orientation makes any difference in charge collected.

While conducting this portion of our investigations, we will construct relatively straight wire runs 10-feet off the ground using lengths of schedule 40 PVC water pipes which will be held upright by fishing line and run out equal lengths.

During the course of this experiment, we expect to switch measurements between the East-West wire and North-South wire within a few seconds of one another. Wind speed, temperature, and RH will be noted and again, the experiment will be conducted in early morning with multiple observtions as temperature increases and RH declines.

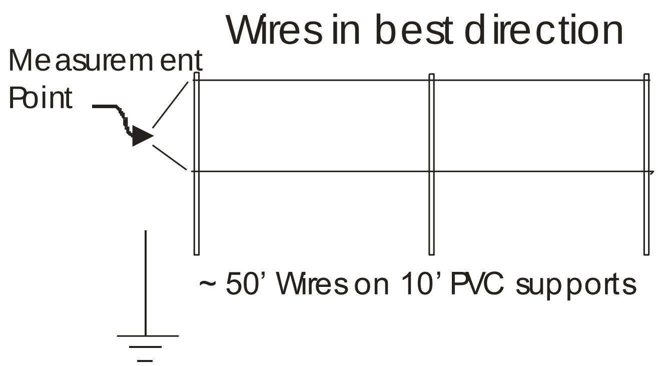
Schematically, I expect it will look something like this:



Research Experiment 4: If we determine that there is any significant difference in the static charge that builds up on this set-up, we will then move the lower leg in an arc around the initially higher reading wire in order to ascertain if there is one particular direction that generates more charge than another.

Research Experiment 5: Once (or if) a highest charge direction is determined, we will then conduct an experiment to determine to what extent the charge is dependent on height above ground.

The way we will accomplish this is to leave the highest charge line from Experiment 3 in place and run a similar length wire along the PVC insulator at the 5' level. Schematically, it will look like this:



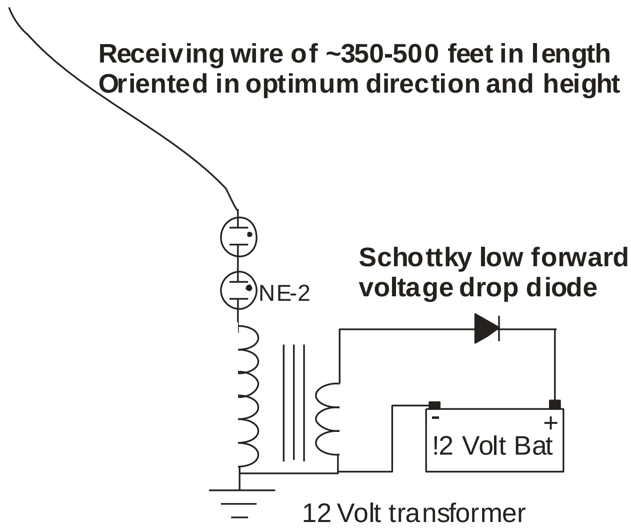
Research Experiment 6: A best direction, best height wire will be erected at a substantially greater length, perhaps 400' or longer. Depending on conditions, we anticipate that one of two methods of generating useful or at least measurable power will be achievable:

Low Voltage Energy Conversion

One of the experimental possibilities is that our research may identify relatively small amounts of static electricity at fairly low current. This approach would use 2 or 3 NE-2 neon bulbs connected between the receiving wire and ground. Neon bulbs are interesting and some experimental work has suggested that they are a bit sensitive to ambient light. The "trigger" voltage seems to decrease as the amount of ambient light increases. Experimentally, an NE-2 will fire at 60 volts or so in normal ambient room light, but that in a darkened room, that increases to about 62 volts. And, if you paint the bulb black to seal out ALL light, the trigger voltage increases to 68 volts or so.

Naturally, if we are able to generate low votage sufficient to fire a pair of NE-2's in series (such that they will fire at about 120 volts or so) we would be able to use a standard Radio Shack 12 volt power transformer to charge our battery.

In the following schematic, the round symbol with a dot in it represents the NE-2's while the odd looking triangle and bar is a diode. A diode is a basic electronic component which allows electricity to flow in only one direction. You may be interested to know that the old fashioned cat's whisker detectors used by crystal radio sets in the early 1900's were simply home made diodes.

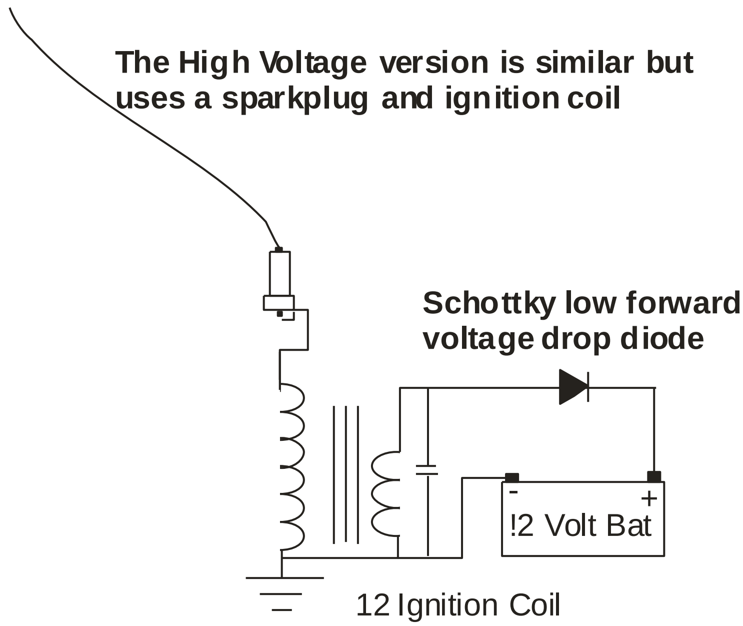


Theory of operation:

When a sufficient static charge has accumulated on the “receiving” antenna, the voltage drop across the NE-2 bulbs exceeds triggering voltage and the lights “fire”. This sends a pulse of energy down the primary winding of a 120 volt to 12 volt transformer. As this current passes through the primary, 12 volts is induced in the secondary. The 12 volt winding is connected to a special diode which has very low forward resistance (hence low energy loss). This allows positive voltage (+) to flow into the battery, but prevents the battery from discharging when a charging pulse is not present.

High Voltage Energy Conversion

The high voltage version of the battery charger is very similar to the low voltage version except that we have changed out the transformer to handle high voltages and we have installed a sparkplug (platinum no less) as the firing mechanism. We’ll be running the coil “backwards” in the sense that the static pulse will be applied to the big winding secondary and the low voltage will be extracted from the primary. Normally, in an automobile, the current flow is the other way around 12 volts on the primary.



You will also see that across the transformer I've installed a capacitor. What this is designed to do is "round off" the sharpness of the spike coming from the ignition coil. I suppose that it could be used on the low voltage version, too, but intuitively, it seems like the larger coil might have hotter transient voltage spikes.

Telluric Electricity Initial Research

Relatively less is written in the so-called "free energy" circles about Telluric currents. Wikipedia describes these as:

> "A **telluric current** (sometimes referred to as **Magnetotelluric**) is a extremely low-frequency electrical current that occurs naturally over large underground areas at or near the surface of the Earth. Magnetotelluric includes the magnetism component of the natural circuit.
>
> Telluric currents are influenced by the conductivity in the interior of the Earth. Telluric currents are induced by changes in Earth's magnetic field, which are usually caused by interactions between the solar wind and the ionosphere. Telluric currents can be measured and, after being normalized, provide information about current direction and the conductance.
>
> Both the telluric and magnetotelluric methods are used for exploring the structure beneath Earth's surface. For mineral exploration the target is conductive ore bodies. Other uses include exploration of geothermal fields, petroleum reservoirs, fault zones, ground water, magma chambers and plate tectonic boundaries.

> The Unites States Patent office has a division classification for geophysical electrical measuring devices of the telluric type (including magneto-telluric types)." http://en.wikipedia.org/wiki/Telluric_current

Our investigation of Telluric currents will be somewhat limited because as the oilfield service firm Schumberger notes on its web site, Telluric currents are "Extremely low-frequency telluric currents (with periods of days or months) provide information about conductivity in the deep interior of the Earth."

In free energy circles, there are occasional references to Telluric currents, such as this comment on the works of L.G.V. Rota circa 1939 referenced at http://www.keelynet.com/interact/Arc_1_98-7_98/00000607.htm

> "Rota discovered that the earth harboured currents. Towards the end of his life, he discovered some 191 different currents. He also stated that metals were formed by these currents. Copper for instance was a mixture of four different currents. Rota buried huge (as he called them) `blocs' in the earth, consisting of amalgams of different metals, sometimes even a hundred different metals or so. With these, he claimed to be able to use these earth currents for the production of energies!"

The purpose of our investigations we're doggedly focused on powering that 3-watt charger and we need to be careful to differentiate between Telluric currents such as naturally occur and so-called "earth batteries".

The evidence of Telluric currents being real comes from a large number of sources, primarily geologists, but particularly those experienced with pipeline construction.

For example, we find some tantalizing table of contents entries in a report "Telluric and Ocean Current Effects on Buried Pipelines and Their Cathodic Protection Systems" prepared for the Pipeline Corrosion Supervisory Committee of Pipeline Research International, Inc.

We find, for example that reference is made to Telluric currents on the Alaska Pipeline project. This might be a particularly interesting area for further study because high latitude Telluric currents might be difficult to distinguish from other electrical phenomena such as Borealis discharge and the like, and the index references to work specufically done on Aurora currents.

Not surprisingly, there appear to be induced Telluric currents of appreciable size generated by the movement of water in places like the Bay of Fundy, known for its tidal extremes.

The Pipeline Research Council's book, which is more than likely worth buying if you are serious about large-scale development. Ask for "Telluric and Ocean Current Effects on Buried Pipeline and their Cathodic Protection Systems (eBook) Corrosion and Inspection

PR-262-0030 CORRENG Consulting Service, Inc. L51909e" and it will only set you back $395 [more than our entire research budget for this book!].

Telluric Current or Earth Battery?

We need to be quite precise when looking for Telluric current because it may be easily confused with "earth battery" effects.

Although both Telluric current and earth batteries get you "energy from the ground", the energy involved is different. The Telluric current is many times a North-South affair, where current flows south toward the equator in the day, and flows northward toward the pole at night. Telluric current is also very low frequency AC – which might appear as DC if you were to take an instantaneous measurement. This means sensitive DC instrumentation could detect a Telluric current because of its long wave period.

The electrical mechanism of an "earth battery" is much different. It's a straight DC matter. It was first discovered when two pieces of dissimilar metal were buried in the ground – useful energy could be extracted.

Because of Telluric currents, most metal pipelines laid in the earth (or underway) are coated to prevent electrical connection to the earth from being made. As a result, a standard method for discovering when coating defects have arisen over time in a pipeline is to perform DC voltage gradient surveys in the vicinity of a pipeline. Depending on the ground conductivity, small amounts of DC may be found putting wire probes into the ground just a few feet from one another.

We find from an investigation into Auroras and Telluric currents that the amount of energy has been sizeable when the Borealis was extrmely active. This is particularly pertinent today as the Sun seems to have altered from its "normal" 11-year solar cycles. From the web site http://aurora.fmi.fi we read about some early electrical disruptions

On February 4, 1872 we read that "The telluric currents attained an extraordinary development during the aurora which was one of the most extensive known. The disturbances in telegraphic communication were not less extensive. In Germany all the lines were affected, and communication was for a long time impossible between Cologne and London. Telluric currents were also observed in England, France, Austria, Switzerland, Italy and Turkey. Transmission of messages was also prevented on submarine cables, especially on the line from Lisbon to Gibraltar, on the line from Suez to Aden, and from Aden to Bombay, and on the transatlantic cable from Brest to Duxbury (Angot, 1897; see also Arrhenius, 1903)."

More important, there is evidence in the research that allows us to make some power calculations. In 1891 the website reports "Electromotive force of 768 volts was recorded on the Western Union lines between New York and Buffalo, the circuits varying from 450 to 480 miles in length. On several occasions the strength of the earth current reached nearly 300 mA, compared to normal working currents that did not excced 35 mA (Finn, 1903)." This grabs our attention because we know (from earlier) that 768 volts times 300 ma (or 0.3 amps) is 230.4 watts. A couple of 100-watt (incandescent) lights is an impressive amount of power. Successive runs of wire (for a larger "capture" (or in antenna terms *aperture*)) would presumably multiply the effects, If one or two wires can nab 230 watts, 10 such wires under these unusual conditions would be able to power my office! (Downer now: How long were those wires, *each*? (gulp!)

Now, we don't know what was going on along the length of the 450-mile circuit, but we can't rule out the possibility that one, or more, telegraph repeaters was involved in the long distance circuit. If so, and depending on the wiring and power scheme, the power levels which we will calculate could be wrong by a factor of (1+ *n*) where *n* is the number of telegraphic repeaters.

This means that if one of the new (1875) quadruplex telegraph repeaters was installed somewhere around the midpoint of the circuit, the power levels on a per mile basis and watts per mile basis would be multiplied times 2. If there were three such repeaters, the power levels would be multiplied times 4, and so on.

Our first calculation will be volts per mile. The calculation would be voltage (768) divided by miles (let's use 450). This would be 1.7 volts per mile. Old D cell batteries kind of levels. Yawn.

Now for power levels: Under normal conditions, the current seemed to be about 35 milliamps or 0.035 amps. Remember P = I E? Watts per mile is 1.7 * .035 for 0.0595 watts. Call it about a 16^{th} of a watt.
Under the extraordinary circumstances of 350 milliamps however, the power was 10-times greater or something over ½ watt. Now this begins to look like a useful power level.

As the TV commercials blare, "But wait! There's more!" If there were telegraph repeaters involved, its possible that the power levels would be much higher. Unfortunately, it's not possible to know if the relatively high traffic telegraph lines between New York and Buffalo had been equipped with repeaters – or how many – by 1891, so we'll pursue our own measurements.

Research Experiment #1

Background:

The purpose of this experiment is to attempt to replicate a free energy accumulator, for which construction information is offered on the Internet for $8 from a fellow free energy explorer in British Columbia.

The gist of his notion is that:

- Free energy is real
- It may be extracted with realtively low cost apparatus.
- It will not produce a *lot* of power.
- It will produce substantial voltage (e.g. >20 volts) over time.

When I read the report this fellow had put together what it lacked, and the reason I am writing this book to further the discussion of *recoverable* free energy is it lacked the sophistication that I'm used to dealing with after working shoulder-to-shoulder with some of the best energy engineers in the world.

Set Up

The booklet that I received from the Internet advertising was not what I expected. It was a lot of history and heresay about various inventors, but didn't have the kind of details that I expect because my functions (to say it once again) is to come up with a way to power a battery charger that consumes 2-3 watts. If I can't get that from any so-called "free energy" device, then my interest level goes to zero. Think of it as trying to date the best looking person of the opposite sex in high school. There may be a certain thrill of the pursuit, but it you aren't going to "catch it" in the end, why waste your time? I think you can see why I was considered a "nerd" even before computers with this kind of attitude.

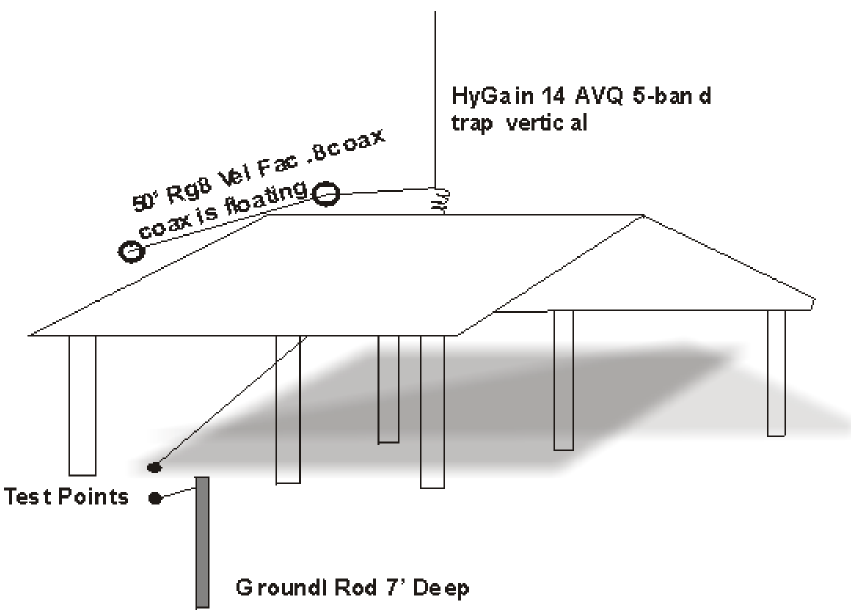
The major failing of the Internet booklet was that it didn't talk about the length of antenna, whether it was insulated or bare wire, what its orientation was, or any of those hundred and one details that, at least in the area of competitive ham radio antenna design, make the difference between being an HF guru and a low signal loser in the hobby. I'm a guru, thanks.

The author of the booklet says "antenna" and it operates against a "ground" described as a ground rod driven into the earth 6-7 feet.

Let me show you the "antenna" we'll be using for this first experiment. It's the metal roof of my office building/ shop on my ranch in East Texas. It looks suspiciously like this:

Experiment 1, Figure 1: Roof as "antenna"

As you will see from a quick inspection of the above picture, what I can an "antenna' may be simply envisioned as a 40' square peaked roof poll building with a vertical antenna of 21 feet mounted near its middle at the peak and which is grounded (to static charge) via a small RF choke to ground. Schematically, it looks like this:



(2024 note: Please notice that for the initial experiments, I failed to disconnect the coaxial cable which was left dangling. Only later, while thinking back on things did I remember thbe coax offers a capacitance of about 30 pico Farads per foot, There was about 50 feet of coax, so 1,500 pF of capacitance which would skew results.)

Experiment 1, Figure 2: Roof Antenna Schematically

I don't have any particular pride in the building, but the lodge pole construction has withstood many a good wind down in these parts and if I were estimating the amount of insulation between the roof surface and the ground, I would honestly have to tell you that it is highly dependent on the nature of our humidity here in Texas which can run on the high side from 90% or so, down into the 50-60% range, depending on temperature generally. In winter down to 5 percent RH during cold dry spells.. Our highest relative humidities around found on summer mornings when it's cool but there is a hot day coming. It's not uncommon under these conditions to find that humidity is up around 85-95%. On a cool evening, when the high during the day has only hit the mid 70's, on the other hand, the humidity doesn't drop much, perhaps to 80% or so.

The humidity notwithstanding, the DC resistance from the roof of the building to ground is several megohms (millions of Ohms of resistance).

Herein lies one of the problems of "free energy". A lot of what is in the literature regarding voltage build-up is not related directly to relative humidity. This is a serious shortcoming in research as it doesn't do me any good as a researcher in Texas to look at a circuit diagram which is predicated on relative humidity (RH) under 30%. That won't happen until about Christmas.

Here's a chart from www.est-static.com that shows how static charge building is directly related to humidity:

Table I - Typical Electrostatic Voltage

	Electrostatic Voltages	
Means of Static Generation	10-20 percent Relative Humidity	65-90 percent Relative Humidity
Walking across carpet	35,000	1,500
Walking over vinyl floor	12,000	250
Worker at bench	6,000	100
Vinyl envelopes for work instructions	7,000	600
Common poly bag picked up from bench	20,000	1,200

The factor is on the order of 15-20 times the energy. Thus, if static electricity is to be a viable source of energy in lower latitudes, we need to consider the implications of high humidity on static build up. Kinetic, or generated electricity seems to work well under all humidity conditions, right up to the point of insulation breakdown or surface path conductivity.

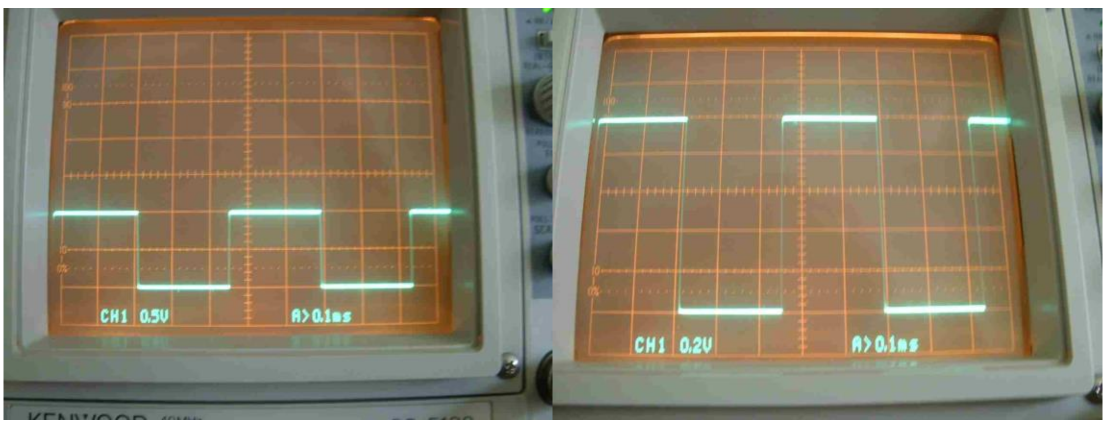
We will attempt in this experiment to measure voltages (and frequencies) using the following devices:

- A “direct” measurement between the antenna and ground (Case A)
- A “half wave rectifier” between the antenna and ground (Case B)
- A “voltage doubler” configuration (Case C) (After George Wiseman’s work[1])

Each of the rectifier configurations will be used to charge a large electrolytic capacitor (rated 4700 uF at 35 WVDC). Rectifiers in all cases will be 1N914 type small signal diodes (Radio Shack 276-1620 or equivalent).

Measurement Equipment:

By way of introduction, because we haven’t discussed it previously, our instrument of choice for this kind of measurement is an oscilloscope. The choice is dictated because it allows us to take pictures of our results more reliably than a meter, plus it allows us to look at specific waveforms and frequencies – both darned hard to do with a conventional voltmeter. Oscilloscopes (“scopes” as they are commonly called) have two other great features. First, they do not appreciably load down the circuit being measured and they have exceptionally good small signal measuring capabilities. If you plan to do real research in so-called “free energy”, a good used oscilloscope – preferrably dual channel, with built in calibration facility and a frequency response of at least 20 MHz.



Above, we can see the internal calibration of the 1 volt peak-to-peak 1 KHz reference. On the left, we see two divisions of the 0.5 Volt scale while on the right we see five divisions of the 0.2 Volt scale. In pictures you’ll see as we progress through this research, you’ll see a small horizontal grid. The particular ‘scope I’m using, (in 2004-g) a Kenwood CS-5130 dual trace, 40 MHz scope, has voltage and time cursors that allow you to set the bottom of a trace and measure to the top. It saves time trying to interpolate between divisions on the scale especially as we will be making some fairly rapid measurements about one each 15 seconds. That doesn’t leave much time for interpolation!

Inductance

We need to define a few terms of basic electronics to go much further, but I will make this as quick, and painless as possible.

Our first experiment involves measurement of the “raw” voltage available on the antenna. Remember that the antenna in this case is a 40 foot square, peaked roof metal roof with no particular attention to electrical bonding, and a 21 foot high ham radio antenna mounted near the center. The vertical antenna is DC grounded via an RF choke of about 2.5 mH. That “mH” means “millihenries” a measurement of how much “inductance” is created by a coil. So let’s talk about coils.

Hint: “Milli” means one-thousandth and “micro” means one-millionth. So when we are talking about “millihenries” we are talking about 2.5 thousandths of one Henry. A Henry is a measurement of inductance.

Inductance? Yes – like coils. Coils are neat and very useful electronic components. They allow DC (direct current) to pass unobstructed, but they oppose the passage of AC. In other words, if you have a big enough inductor (coils are called inductors) you could plug it into a wall socket and not get an AC shock. On the other hand, no matter how big an inductor you put in a circuit, you will still be able to get DC through it, up to the current carrying capacity of the wire. No, don’t try this at home…you won’t have a big enough coil!

The characteristics of the inductor change based on a who slew of factors:

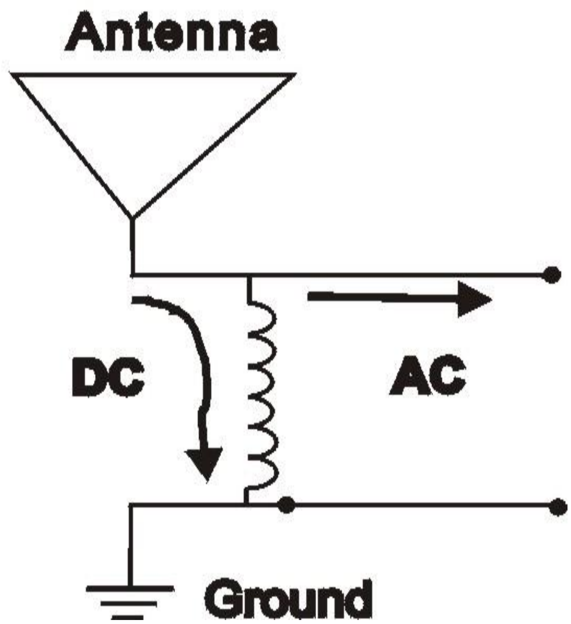
- How many turns of wire
- The diameter of the coil
- The distance the turns are spread over (e.g. coil length)
- Dielectric factors if not air wound
- Permeability of the core if wound on a ferrous core

To give you an idea how the calculations work out, five turns of wire on an air core of 1.5 inches diameter spread out over 4 inches. Pretend you put 5 turns of wire on a toilet paper roll form. Probably 50% of all ham radio operators have done this at some point, using a toilet paper roll as a form. That coil would give you about 0.3 microhenries. That’s not very much inductance.

Here’s the fun part. Doubling the windings gives *four times* the inductance. So, 10 turns of wire on the same form would get you about 1.23 microhenries.
So, how many turns on a toilet paper roll form would the 2.5 millihenry RF choke in the ham radio antenna take? If I’ve done the math right (it’s been a while, OK?) it would take 452 turns or so.

How to Coral AC or DC

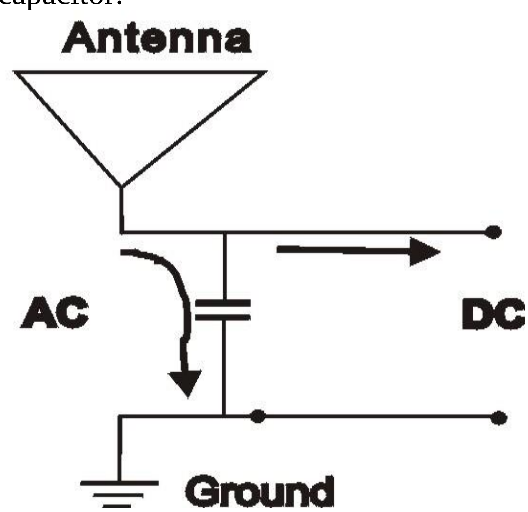
The reason I’m going through all of this is so you can see a simple fact of electronics. If you don’t want to capture DC, you can simply put a properly sized inductance to ground and the DC will be shorted to ground while the AC energy is held above ground. This way, you can insure that pesky DC is not fouling up your measurements. However, if the coil is not large enough (in Henries, the measurement of inductance) some AC may be lost to ground. If you are planning to be scientific, you need to look a bit deeper into electronics than this book will go. Still, here's the idea:



If a coil is of a fixed size, the higher the frequency of the AC, the better pseudo-insulation the coil provides.

Suppose now that we want to get rid of the AC component and look only at the DC. How would we do that?

Simply replace the inductor (coil) in the above diagram with a sufficiently large capacitor:

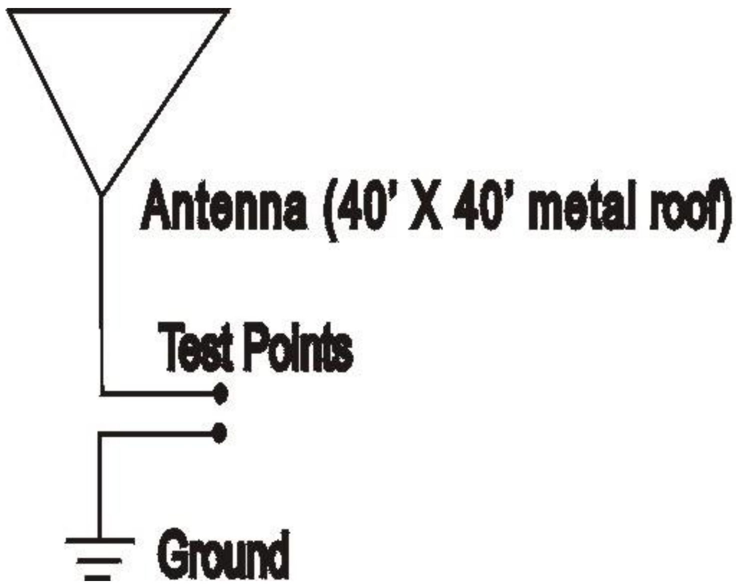


The same caution applies here: If the capacitor is too small, not all of the AC will be shunted to ground and might interfere with your measurements if you are using a conventional voltmeter.

We don't need to worry about this because our oscilloscope let's us look at complex signals – part AC and part DC should we desire.

Experiment 1 Findings

Case A

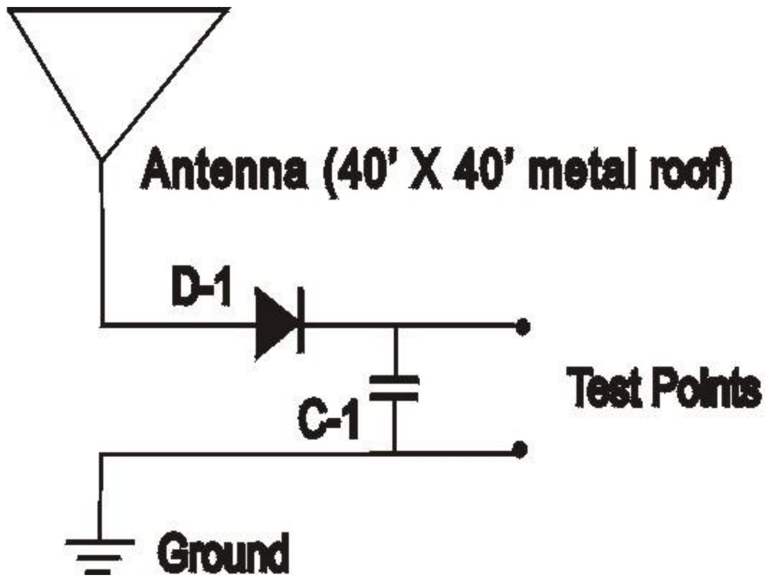


We measured both the DC and AC components on a number of occasions over a two day period. In all cases, we noted a fairly consistent 19.5 volts (all AC voltages are peak-to-peak unless otherwise noted) but at no appreciable current.

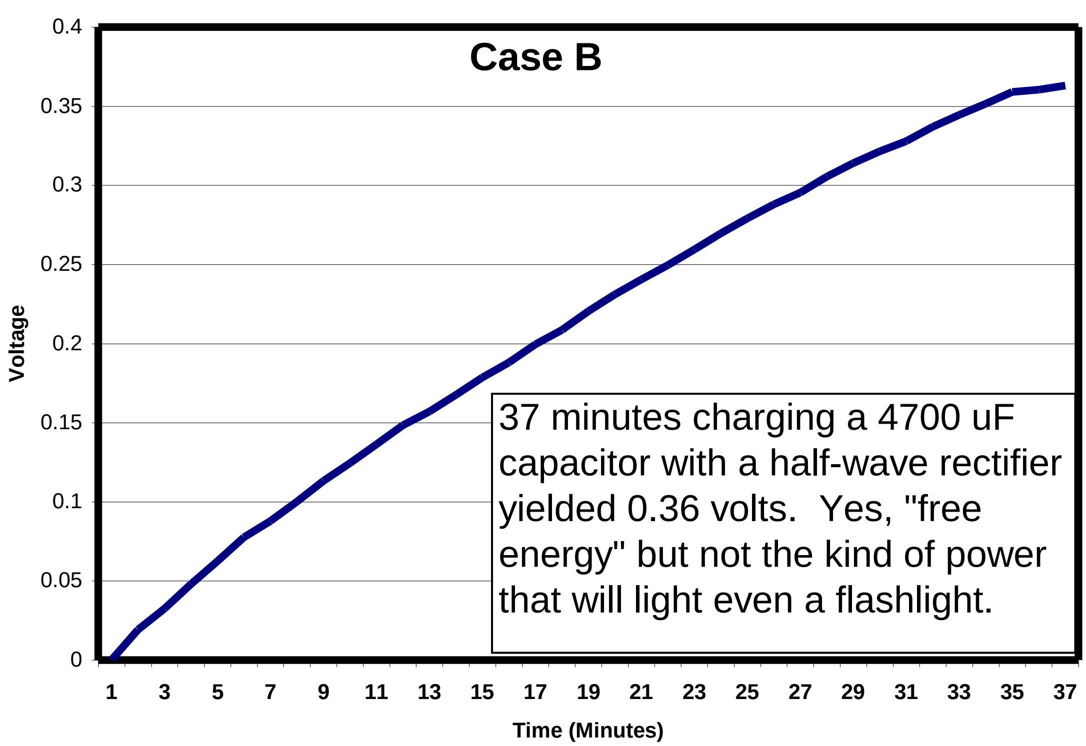
Simply adding the small load presented by the half-wave rectifier (See Case B schematic) dropped the AC to 6.25 volts.

There did appear to be some voltage at frequencies higher than 60 Hz AC, which we expect was predominantly coupling from AC wiring which runs under the sheet metal roof and throughout the building. However, isolated visually, it appeared that such voltages were perhaps 100 microvolts (millionths of a volt) which one would expect in an area that is some distance away from the nearest AM radio station (15 air miles or so).

Case B



You'll recall that Case B is the simple half-wave rectifier input. We would have expected to see this be a very simple charging as some incredibly slow pace of the load capacitor. This expectation is based on the observatioin that the 19.5 volts AC was of no appreciable current, but *something* would be expected to accumulate over time.



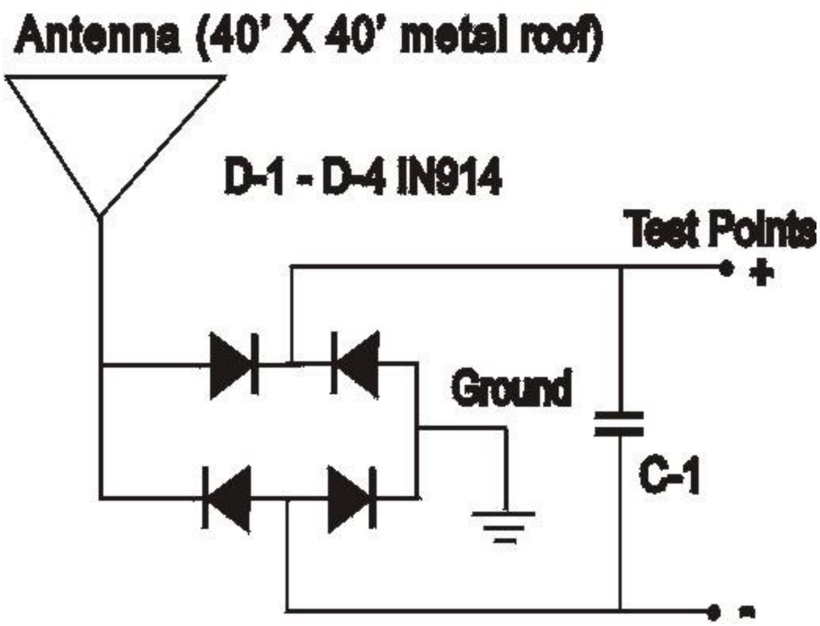
As it turns out, this is our "problem child" experiment. When we began making measurements, we noticed a very slow rise to about 3.10 volts DC across the capacitor. On our first run, charging took from approximately 4:30 PM till 8:30 PM – a total of four hours. That's not much energy.

When I returned to the experiment setup in the office the next morning, I noted that the voltage had *fallen* to 2.85 volts. As the day wore on, the voltage declined until it declined to hold at 1.55 volts DC about 20-hours after the experiment had started..

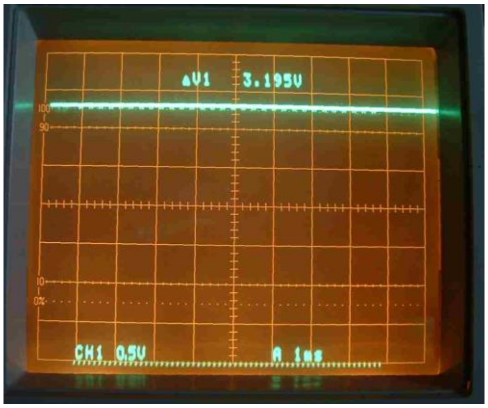
What makes this problematic is that the DC voltage should not rise *and then fall* in this manner. When the voltage was high (2.85 V) this morning, the temperature was 68 degrees and relative humidity was 92%. As the charge has declined to 1.55 volts at 3:00 PM, the temperature has climbed to 48% relative humidity and a temperature of 86 degrees. (2024 ponder: Is there an ultra low frequency wave going on here? Several more days and some searching for polarity change would be interesting…)

I expect that the variance in the results may have something to do with plate forming of a new electrolytic capacitor. Electrolytics are curious in that once charged, their plates tend to want to return to a former state of charge. This would explain the error.

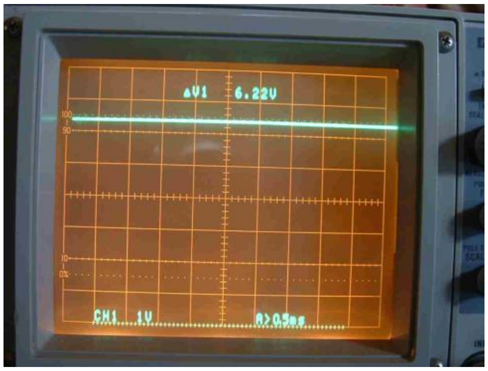
Case C



We noted in Case C that there was actually a slow accumulation of energy using the bridge rectifier, but as the scope shows, this static electricity level is more related to something other than "free energy", although just what is not clear. At its peak, the voltage climbed to about 6.22 volts (see picture 2 below) and at its ebb, usually around 8 AM, perhaps corresponding to the higher relative humidity around dawn, which one would expect to dissipate static charge, the level dropped (due likely to internal losses of the capacitor or leakage due to the minute small load of the scope probe). Let me show you the first picture – a 24 hour run dropping to about 3.2 volts (negligible current) at 8 AM local time in East Texas with a reletive humidity of about 80% and ambient air temp of 75 degree F.



The next picture is a 4-hour run from 6 PM shown at 10 PM with RH 40% and ambient air temp of 65%: 6.22 volts.



What we observed again was that the current was negligible. Voltage accumulated over time, but was not sufficient to do useful work.

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[1] George Wiseman, www.eagle-research.com "Free Energy Accumulator" Page 6.