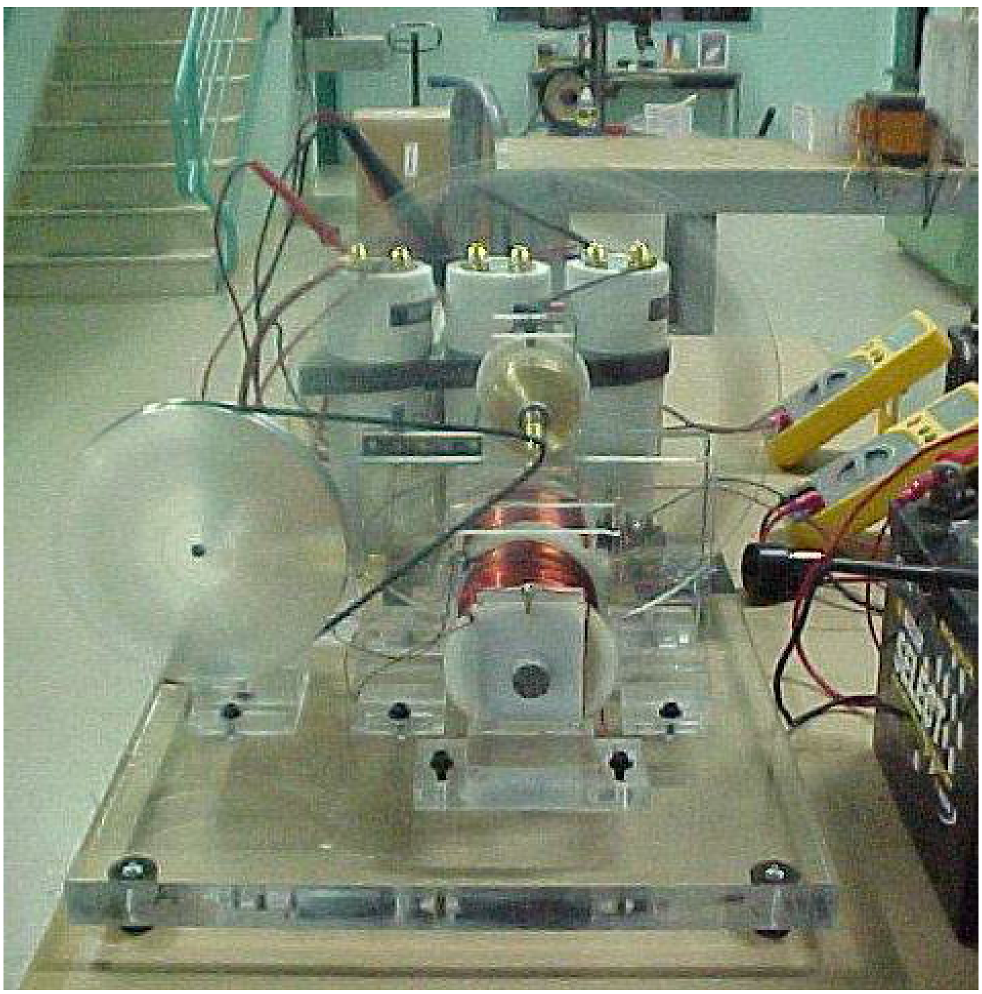
Bedini SG

The Complete Intermediate Handbook

Understanding Circuit Optimization and Capacitor Discharge



Written by
Peter Lindemann, D.Sc. and Aaron Murakami, BSNH

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Published by
A&P Electronic Media
Liberty Lake, Washington

Cover Layout: Peter Lindemann
A&P Electronic Media
Liberty Lake, Washington

Front Cover Image: John Bedini
Interior Images by: John Bedini, Peter Lindemann and Aaron Murakami

Digital Edition Published by: A&P Electronic Media
PO Box 713
Liberty Lake, WA 99019
http://www.emediapress.com/

First Edition:
First Printing: March 2013
Digital Format: PDF File
50,000 authorized Downloads

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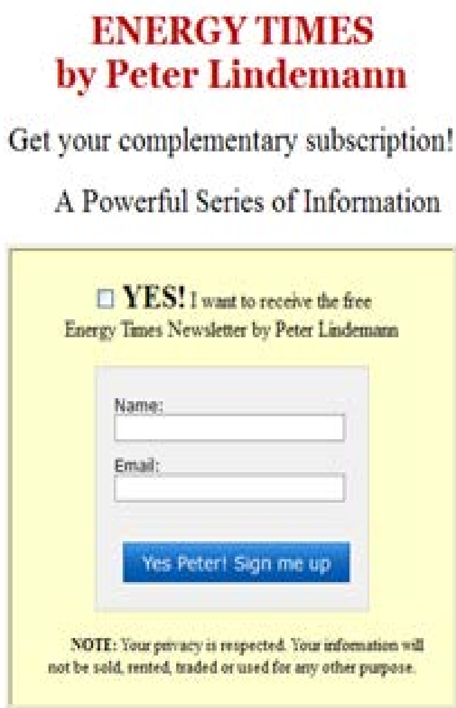

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Foreword

This book is the second in the series of Bedini SG Handbooks. The full instructions on how to build the Bedini SG Energizer are in the first book of the series titled **Bedini SG, the Complete Beginner's Handbook**. If you are not familiar with the Bedini SG project, then you can learn more HERE.

This book does not review any material from the first book. It simply picks up the instructions at the Intermediate Level. For instance, the first book assumed the reader did not know anything about electronic parts or circuits. This book, on the other hand, assumes the reader does have a working knowledge of electronics and circuit functions.

Since the release of the first book, **Bedini SG, the Complete Beginner's Handbook**, the entire Bedini SG world has been taken to the next level. It includes the most detailed instructions on how to build the machine, coupled with a comprehensive explanation of the theory of operation. It also introduces the "attraction mode" of operation for best performance.

This book picks up where the Beginner's Handbook leaves off. It starts with methods to "fine tune" the oscillator, how to charge capacitors and discharge them into the batteries, and other related concepts. It also includes more advanced theoretical discussions about Tesla's methods for creating a "power gain" in a circuit and the difference between energy conservation and energy recycling.

After learning this material, you should be able to raise the efficiency of your Bedini SG project to levels that you may not have thought possible.

Peter Lindemann (March 2013)

Introduction

"There are only two ways to live your life. One is as though nothing is a miracle. The other is as though everything is a miracle."
Albert Einstein

The first time I asked John Bedini how the energizer worked, he looked me straight in the eye and said "it's a trick." This was not the answer I wanted. It made me really mad! For me, the idea of a "trick" meant that it was not real, or that I was being fooled in some way. Luckily, this is not what John meant. But what he did mean took me years to understand.

The machine does NOT break any Laws of Nature. It does, however, take advantage of a number of narrow "windows of opportunity" which mainstream science has not spent much time exploring. When measured directly, the over-all efficiency of the machine is always under 100%. However, when built properly, the battery being charged by the system always charges faster than the battery being drained by the system.

This apparent paradox is the "trick" that John was referring to. Electrically, the machine does not produce a "net energy gain." The machine does not produce more electricity than it uses. It does, however, produce an unusual set of conditions that the batteries translate into an accelerated charging rate. The end result is an energy gain that can be accessed from the batteries over time.

This Intermediate Handbook is the next step in the unraveling of some of John's "tricks", what they are, why they work, and how you can do it to.

Peter Lindemann, D.Sc.
Aaron Murakami, BSNH

Chapter One

Fine Tuning the SG Energizer

Introduction:

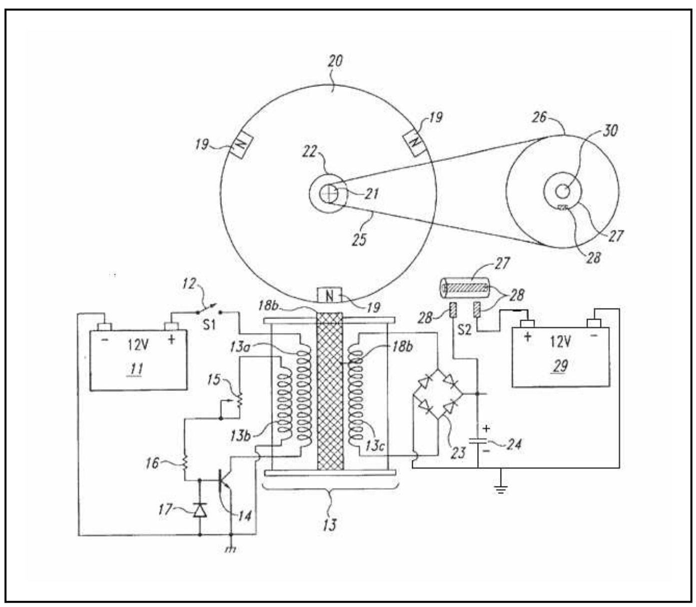
It is assumed that, if you are reading this, you own a copy of the first book in the series, **Bedini SG, the Complete Beginner's Handbook**, and that you have a working model of an SG Energizer in your possession.

The purpose of this chapter is to guide you, step-by-step, to make a number of minor modifications to the machine so that it draws less energy from the run battery, delivers more energy to the charging battery, and at the same time, produces more mechanical energy on the wheel.

If you built your model based on the instructions in the Beginner's Handbook, it is probably running pretty well already. But guess what? It can run better! So, let's get started.

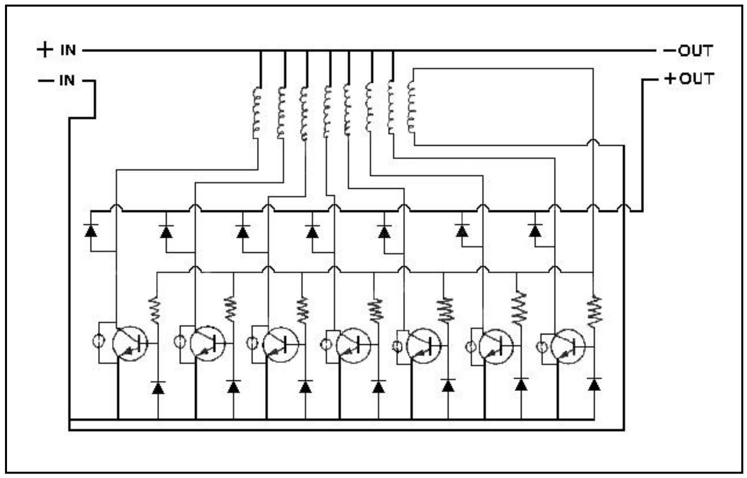
Basic Tuning:

If you have done your research, you know that the Bedini SG Energizer is based on John Bedini's US Patent #6,545,444. Here is a copy of the diagram from that patent. You can see that the circuit includes a "variable resistor" in the section that connects the trigger coil to the base of the transistor (component #15).

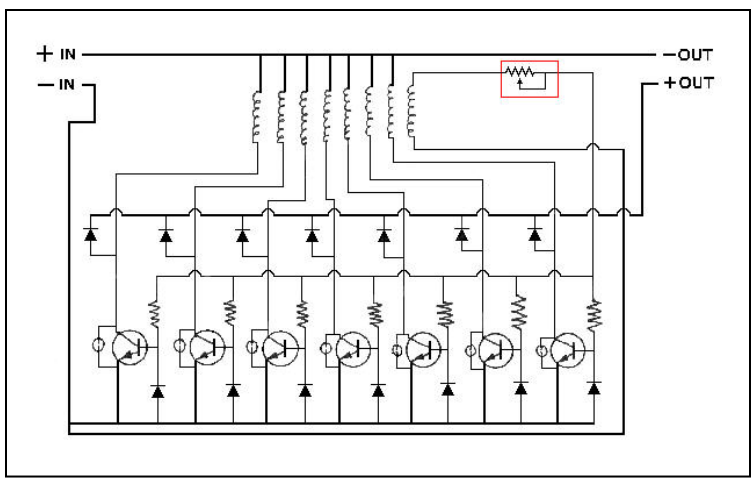


It also includes a capacitor (component #24) and a means to discharge the capacitor periodically into the second battery (components #27 and 28).

If you have looked on the internet or into some of the discussion forums for the SG or Monopole, you have probably heard of a simple method of "fine tuning" the SG Energizer. When there is only one power coil, this process is quite simple. But when there are multiple power windings, as in your Beginner's model, the process has a few more details associated with it.



The simple method involves replacing the 470 Ohm base resistors on each transistor with a 100 Ohm resistor and then inserting a 1 watt 1k Ohm variable resistor (potentiometer) in series, as shown in the second drawing. (Red box)



To "tune" the unit, simply start it up and find the place on the potentiometer where the wheel is turning the fastest while the circuit is drawing the least current from the run battery. Obviously, you would need an amp meter on the run battery and a tachometer on the wheel to determine these conditions.

Some experimenters thought this information should have been included in the Beginner's Handbook. While it was being written, I specifically asked John about this, and he said that he wanted beginners to build the basic model and get it running first, so the 470 Ohm fixed resistors were specified on the base of each transistor in that book.

That said, while the method of placing a 1k Ohm potentiometer in series with the 100 Ohm resistors does give a reasonable measure of variability, it does NOT really set up the conditions for "fine tuning" the system. This is especially true of coils that have multiple strands of wire on them and multiple transistors.

Fine Tuning:

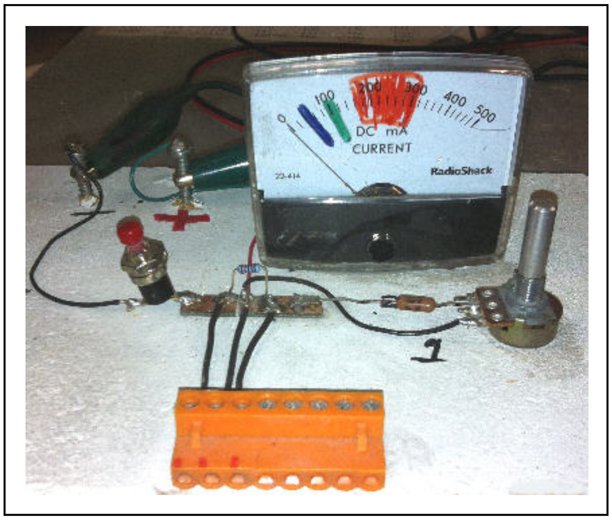
To understand why this is true, we have to look closely at the timing of the transistor switching, down at the micro-second level. "Fine tuning" is about optimizing the operations of the oscillator. If you have a dual-trace oscilloscope, you can watch the switching of any two of the transistors simultaneously. If you watch enough sets, with the time base short enough, you will start to see that they can switch one or two micro-seconds apart.

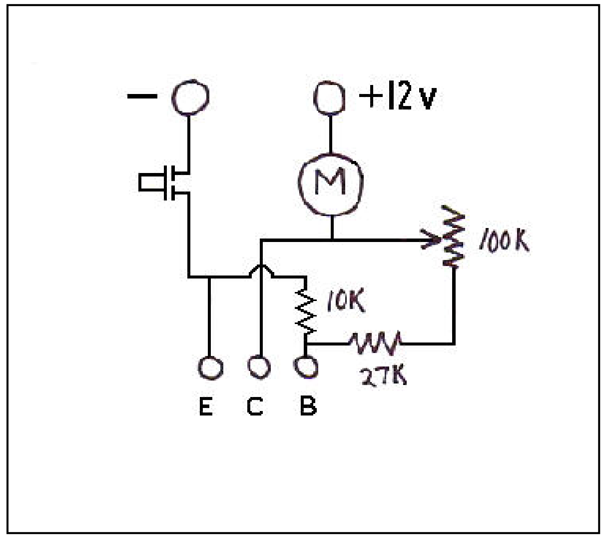
This is especially important when the transistors are turning OFF because that is when they are trying to discharge their energy into the recovery circuit. If a few transistors are turning OFF while the rest are staying ON, even for a few micro-seconds, this can blunt the inductive kickback of the system. You quickly realize that what you want is for all of the transistors to turn ON and turn OFF at *exactly* the same time, so the energy can flow through the machine perfectly smoothly.

The reason the transistors may not be perfectly synchronized at this point is that you are using electronic components that are mass-produced. That means that they each may have slightly different operating specifications. While they are all "very close" and "within acceptable tolerances", they are not all exactly the same. So, to get them all to behave the same in the circuit, we have to find the ones whose performance specifications match.

In order to do that, we actually have to measure the performance characteristics of the transistors BEFORE we put them in the circuit of the SG oscillator. Here is a photo and a schematic of the simple circuit that John developed to perform this test.

Essentially, it measures the current passing through the transistor, also called the "collector current" or the "gain" of the transistors.





The tester consists of a 12 volt power supply, a 500ma meter, a place to temporarily connect the transistor, a variable potentiometer to adjust the base current, a momentary switch to activate the test, and two other resistors. In this example, John has taken the front off the meter and added some marks on it so the test is easier to interpret. Regardless of these extra markings, the test results will be on a scale of 0 to 500 milliamps.

From the schematic, you can see that the circuit simply passes current through the transistor to operate the meter. What you are looking for are 7 transistors that pass the same amount of current to the collector when they are activated by the same amount of current to the base.

It order to do this, you may need to look through (purchase) between 30 and 40 transistors. For hobbyists on a budget, this may be prohibitively expensive. But for serious students who really want to understand how well their SG model can perform, it’s a small price to pay. Also, since it is probable that more than one set of matched transistors could come out of a group of 40 transistors tested, experimenters could make group purchases and share the results.

The Transistor Matching Test:

The test is run like this. Once you have the circuit built and the group of transistors you want to test ready, get out a note pad and start testing. Put the first transistor in the tester, push the button to start the test, and adjust the potentiometer to read "mid-scale." The first time through, you are simply looking for the transistor that has the LOWEST gain, meaning the lowest reading on the meter. (You may have to raise or lower the potentiometer in order to find the right range to get the meter to read for all of the transistors.) When you find the transistor with the lowest reading, mark it "Calibration 100". After you have done that, then put that transistor back in the tester and turn the potentiometer so that the meter READS 100. The circuit is now "calibrated" and ready to test your other transistors.

Test each transistor again, but this time, write the meter reading on the transistor in pencil. When you are done testing all of the transistors you have, find all of the ones that have the same number, or numbers that are relatively close to each other. These will become the "matched sets."

If you test 40 transistors, you may be able to put together 2 or 3 matched sets of 7 transistors, with various ranges of gain. The best set will be the 7 transistors that have the highest value with the same gain.

[From now on, leave the calibration transistor with the test circuit. It is part of the test set-up now. This tester is specific for testing MOSFET or NPN Bi-polar Transistors, but you can test any model number within those types. All you have to do is create a specific calibration unit for each different transistor type. This allows you to test a wide variety of transistors and always go back to the settings that are best for each model of transistor.]

Further Refinements:

You may have noticed that we have now discovered which transistors have the same gain <u>when activated by the same base current</u>. After we calibrated the test circuit, each transistor was activated by the same current coming through the potentiometer. In order to get those identical gains to appear in our SG Energizer when it is operating, we need to duplicate that condition, as well.

What that means is, to finish the "fine tuning" process, we still have to find seven base resistors that have identical values. If you absolutely want to max out your fine tuning, you will want to use the single 1K potentiometer and the seven 100 Ohm resistors, one on each transistor base connection, as described in the "basic tuning" section described on pages 8 and 9. If you just want to use fixed resistors, then you want to just use the 470 Ohm resistors that were specified originally.

Luckily, most resistors are inexpensive and come in bags of 200. This gives us plenty of candidates to test. All you'll need for this test is an Ohm Meter (usually part of any digital multi-meter) that can read Ohms down to tenths of an Ohm. When measuring each resistor, standardize the contact method using alligator clips, and write down each resistance. When you have found 7 resistors with the same resistance, you can stop testing.

After you have found 7 matched transistors and 7 matched resistors, you may install them in your model. Your Bedini SG is now "fine tuned."

What is the Most Important?

That depends on your level of interest. If saving money is most important, then just install the 1K potentiometer and any 100 Ohm resistors. This will give you a benefit at a low cost. If you want to see how far the science will go and are willing and able to afford the time and parts, this chapter fully outlines how to optimize the SG oscillator efficiency.

You may be wondering whether using matched sets or faster diodes on the output circuits are necessary? After extensive testing, John has never seen a significant benefit there, but you are always welcome to experiment.

Other Adjustments:

OK, we have tuned the SG Energizer from the electrical stand-point. The last thing to do is tune it from a mechanical stand-point.

The main issues here are maximizing balance and minimizing friction. Right now, the wheel and fan should be fairly well balanced, but you could check that and make any minor adjustments to improve it, if you wish.

The other issue is friction. Since the wheel has an open architecture, there is not a lot of air resistance. The only other friction issue would be in the bearings. If you believe the bearings are stiff because they are either too old or too new, you can take them out of the SG and soak them in kerosene to remove all of the grease. Once they are clean and dry, you can apply a small amount of a light weight oil to them. This should give you a very low friction, free-running bearing.

The last thing you can look at is the height of the magnets above the coil. On page 56 of the Beginner's Handbook, we specified a magnet to coil clearance of 1/8th of an inch. After you have optimized the circuit timing for maximum wheel speed at the lowest current draw from the run battery and are satisfied with the free running of your bearings, you can see if adjusting the height of the wheel above the coil can give you any final improvements. It is the last thing to look at.

Adjusting the wheel height above the coil may have to be done in extremely small increments. For this, a series of shims or spacers is the best method to use. Even if very little benefit is to be expected, you may want to run the experiment just to see the result.

Now that your Bedini SG Energizer is "fine tuned", let's start looking at some advanced theory.

Chapter Two

Energy Conservation vs Energy Recycling

The Bedini SG Energizer is a machine that demonstrates an "energy gain" while it runs. This "energy gain" is supposed to be impossible according to the First Law of Thermodynamics and the idea of "Energy Conservation." The First Law of Thermodynamics is usually expressed with the idea that "Energy can be converted from one form to another, but it can not be created or destroyed."

This idea was initially derived from a paper titled ***On the Conservation of Force***, published in 1847, by Hermann von Helmholtz. But this is a significant departure from what he really said. His original statement was "Nature as a whole possesses a store of energy which cannot in any wise be added to or subtracted from", to which I would simply add "by us".

But I would go farther. I would also say that "Nature as a whole possesses the entire store of energy by which any of our machines may be activated, regardless of how well they may convert that energy into a useful form."

We have never said that the Bedini SG Energizer "creates" energy. We have said, however, that it operates in an "open relationship" with the immediate environment. This allows the machine to gather energy from the environment at a rate that more than makes up for any energy that may be dissipated back into the environment at the same time.

Energy Conservation states that "energy cannot be created or destroyed." This, however, does not preclude the idea that this same indestructible energy may be able to be recycled or reused! The general interpretation presumes that this cannot be done, but, in fact, it can.

Nikola Tesla was one of the first significant scientists to turn his back on the Laws of Thermodynamics and publicly state his disbelief in these ideas. He openly proposed "heat engines" that derived all of their energy from the ambient heat of the air while producing cold air as a by-product. His replication of Heinrich Hertz' experiments concerning the propagation of electromagnetic waves in air caused him to denounce the entire "discovery" as completely false. He even referred to the mathematical work of James Clerk-Maxwell as "poetical concepts." By 1900, Tesla had run enough experiments that he was certain that electrical phenomena did not follow the same laws as heat in almost every situation.

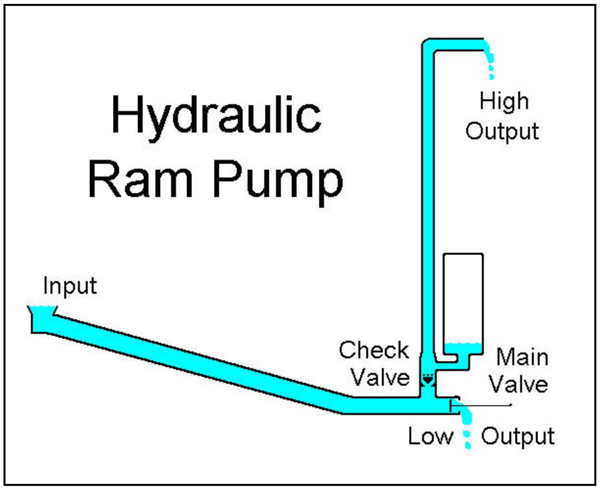
Tesla saw no reason to associate thermodynamics with electrodynamics at all. In fact, he thought electrodynamics was much more related to fluid dynamics. In his June 1900 article titled ***The Problems of Increasing Human Energy***, Tesla states "Whatever electricity may be, it is a fact that it behaves like an incompressible fluid and the earth may be looked upon as an immense reservoir of electricity."

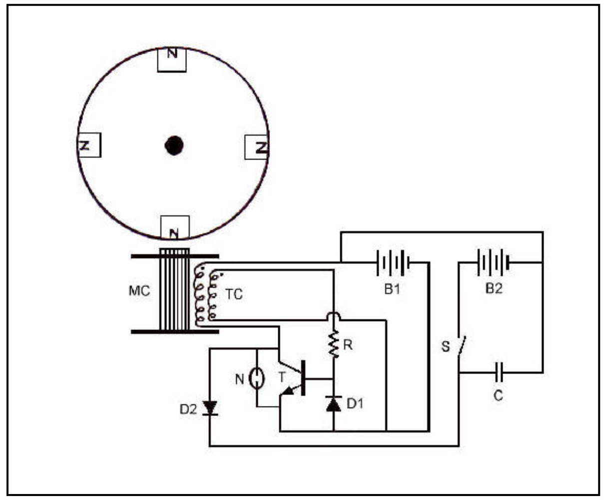
While Helmholtz was brilliant, and we owe a great debt of gratitude to him for his discoveries, his philosophical attempt to unify all forms of energy into a single set of behavioral laws in 1847 was premature, and ultimately, incorrect.

So, what is really going on? What methods allow us to use electricity, recaptured it, recycled it, and use it again? Its really quite simple. Since electricity becomes useful when a potential difference is present, the "trick" to recycling it is to get electricity to raise it's own potential!

In thermodynamics, it is difficult to get heat to raise it's own temperature, but in fluid dynamics, it is quite easy to get a low potential flow of water to pump itself to a higher level by taking advantage of it's inertia. The best known method to do this involves the use of a device called a hydraulic ram pump.

The following illustrations highlight a number of similarities between the hydraulic ram pump and the Bedini SG oscillator.





The hydraulic ram pump is a simple device that allows the inertia of a FLOW of water to pump some of that water to a higher level. Here's how it works. Water flows from the Input to the Low Output through the Main Valve. This flow builds up a momentum in the mass of the water. So, when the main Valve is suddenly shut, the water has nowhere to go but past the Check Valve, up the Rise Pipe, and out the High Output. When the pressure and momentum of the water flow is exhausted, the Check Valve closes, the Main Valve opens, and the cycle begins again.

The Bedini SG oscillator is remarkably similar. Battery B1 establishes a flow of electricity through the Main Coil MC when transistor T is conducting. This builds up an inertial momentum in the circuit that establishes itself as the magnetic field in Main Coil MC. When the transistor T suddenly stops conducting, the magnetic field established by the current flow wants to keep that current flowing. This represents an inertial property of electricity, like stored momentum. Since the current continues to flow, but cannot flow in the loop with battery B1, it is forced out through diode D2 and will raise it's potential as high as it needs to to fully exhaust the momentum.

So, the gravity fed water flow from Input to Low Output in the ram pump is like the Input to the oscillator from battery B1. The inertial properties of the water flow are like the magnetic field in Main Coil MC. The Main Valve in the ram pump is like the transistor T in the SG oscillator. The Check Valve in the ram pump is like diode D2 in the oscillator. The High Output of the ram pump is like battery B2 being charged to levels above battery B1 in the SG circuit.

This illustrates how a hydraulic ram pump is almost a perfect analogy for the Bedini SG circuit. Tesla was right. The behavior of electricity closely follows the model of fluid dynamics, not Thermodynamics. In addition to this, the method to get electricity to "raise it's own potential" by eliciting its inertial properties has been known for over 100 years!

If you question these ideas or someone else questions you about this, don't be intimidated. The Bedini SG Energizer does NOT follow thermodynamic models and its behavior is not limited by modern interpretations of these rules. The SG does use and recapture much of the energy it is running on, and then goes on to recycle it again for future use in the second battery.

Tesla discovered these processes while trying to replicate Hertz's supposed findings of electromagnetic waves. He first reported on these discoveries in a lecture titled ***On Light and Other High Frequency Phenomena*** in February of 1893. (120 years ago!) This lecture outlines what Tesla spent the rest of his life working on. It is also the first public disclosure of his discovery of a new way to use electricity.

This process he called his "Method of Conversion."

Chapter Three

Tesla's "Method of Conversion"

On May 1, 1888, Nikola Tesla was granted seven US Patents. These patents covered his single phase and multi-phase electric motors, generators, transformers, and the methods to transmit electric power over long distances with minimal losses. Five other US Patents were issued to him that year that helped round out the new way to use poly-phase, alternating current (AC) electricity at an industrial scale.

In 1896, these inventions and methods became the basis for the first large-scale hydro-electric power station to be built at Niagara Falls with the power used to light up Buffalo, New York, and eventually, New York City, over 400 miles away. Most inventors would be proud of such an accomplishment, but for Tesla, there was a problem. Between 1888 and 1896, he had developed a better way to use and transmit electric power!

He first publicly described these new methods of energy production and energy transmission in a lecture titled ***On Light and Other High Frequency Phenomena***, delivered twice, first in February 1983 in Philadelphia, and second, in March in St. Louis. In this lecture, he openly declared that he had discovered a whole new way to use electricity and a way to "convert" ordinary electricity into this new type.

These discoveries proved to Tesla that static electricity was more powerful than electro-magnetic force; that interrupted direct currents were more important than alternating currents; that electric current could be propagated down a single wire with no return; and that loads could be operated at the end of a transmission line that reflected little or no energy consumption effects back to the generator.

This was definitely a better way to use electricity! The process to produce these effects from ordinary electricity he simply called his….

"Method of Conversion."

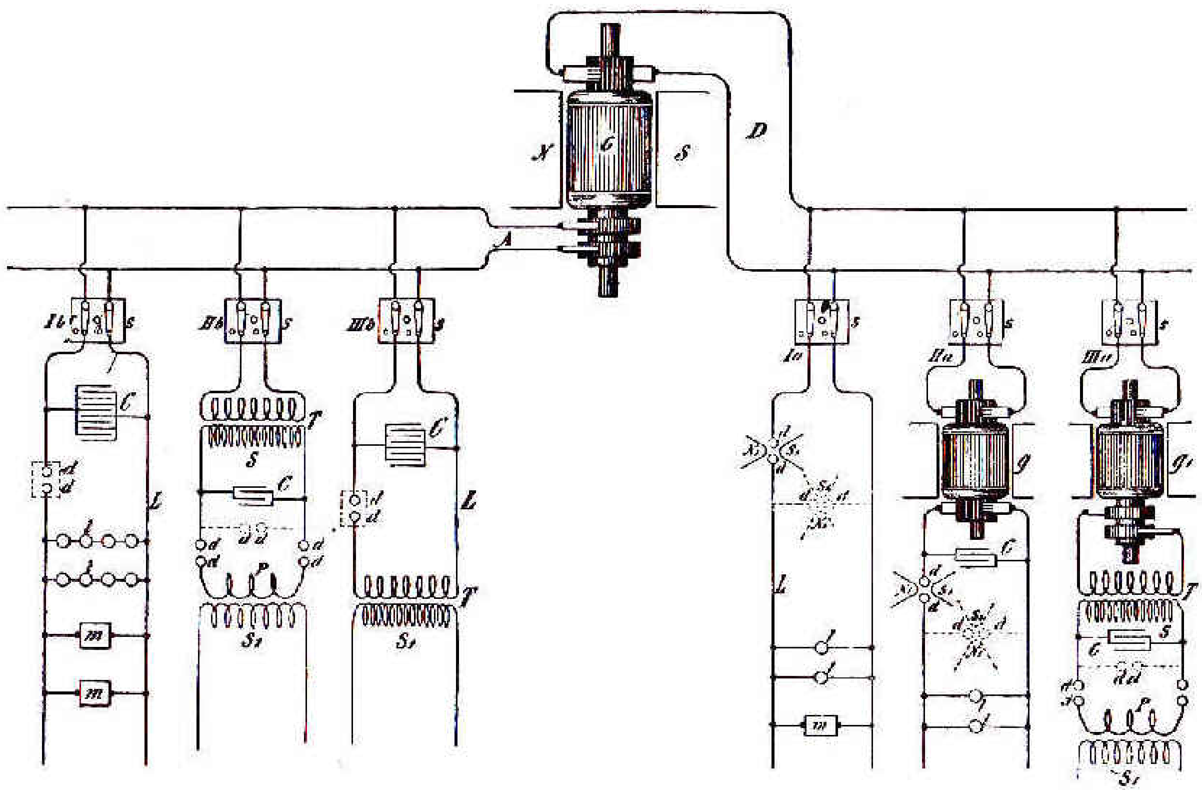
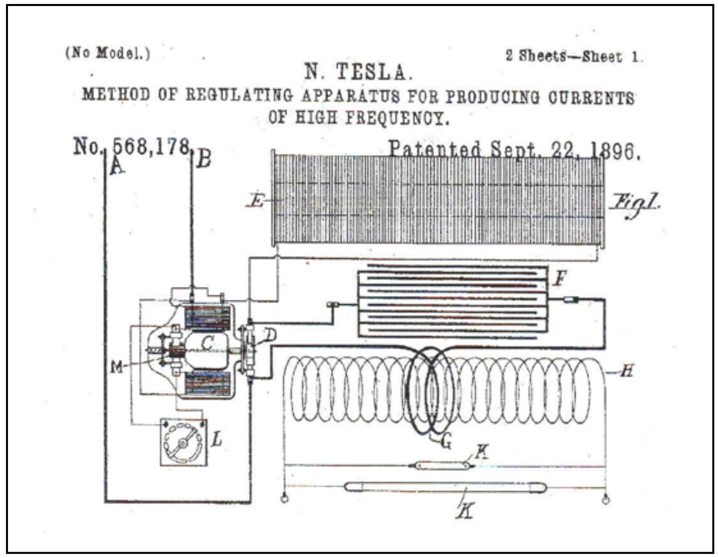


Fig. 165.

This diagram, taken from Tesla's lecture, shows the six most effective ways to produce the effects he discovered. He clearly shows that the effects can be produced whether he started with AC (3 examples on the left) or DC (3 examples on the right). [Mind you, these are circuits for the methods that worked the best in 1893. Modern circuits open up new possibilities.]

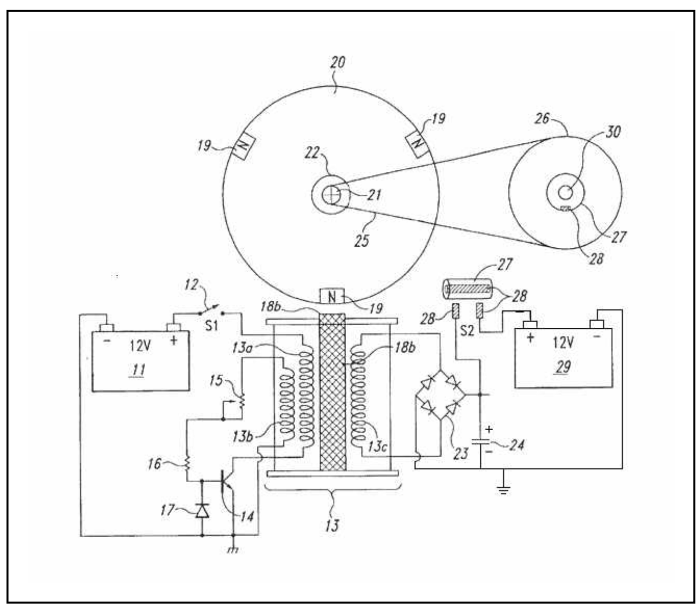
He also developed solid-state methods to produce these effects. The best example of this type of circuit is found in US Patent #568,178 issued in September of 1896. The circuit charges an inductor with interrupted DC currents, then discharges the inductor to charge a capacitor, which in turn discharges into a low impedance circuit to produce the effects he wanted.

The patent states: "The energy of the direct current supply is periodically directed into and stored in a circuit of relatively high self-induction, and in such form is employed to charge a condenser or circuit of capacity, which in turn, is caused to discharge through a circuit of low self-induction .. for producing any desired effect." Tesla used this circuit to step the voltage up from the capacitor discharge to power special lights designed to run on these currents, as shown in the image above.



This illustration also shows a small electric motor operating a rotating switch to control the capacitor discharges.

Here, again, is the illustration of the SG circuit from John's US Patent. The circuit charges an inductor (coil) from an interrupted DC source, discharges the coil into a capacitor, which in turn is discharged periodically into a low impedance load (battery).



The similarities are obvious. The SG circuitry looks like a modern version of Tesla's Method of Conversion. It is simply designed to operate on lower voltages and with modern components. Besides that, it performs many of the same circuit functions and provides many of the same benefits.

What does the Circuit Do?

The output of Tesla's circuits operated the loads on a rapid series of capacitor discharges. These were bursts of voltage and current, all propagating in the same direction, separated by intervals of no activity. Tesla said that running circuits on this type of power "..enables me to produce many effects which are not producible with an unvarying force."

What he is saying is that a staccato of uni-directional impulses can accomplish things that pure DC (direct current) cannot. So, let's look at this situation and analyze what is happening.

A relatively low voltage, low current source of DC can be used to charge the inductor (coil) in the first step. When the coil discharges into the capacitor, depending on its capacitance, the voltage may rise to many times the voltage of the original source. So, in step two, the voltage rises, which for Tesla represents the "electrostatic force." Voltage is the equivalent of pressure in a fluid, so in step two, the electrical pressure has been raised.

Now, when the capacitor is discharged into a circuit of low impedance, all of the energy can discharge very quickly. This means that for a very short time, there is a very high flow of current. So, the total effect of the circuit is to take a moderate but continuous flow of voltage and current and convert it into a series of short impulses of high voltage at high current.

What are the Benefits?

In order to get a clear idea of the benefits of this conversion, I offer this illustration. Imagine, if you will, a wall made of a typical wooden frame covered by sheet rock (plaster board). My goal is to tear down the wall, but all I have is the energy equivalent of "one pound of force" distributed over "one square foot" of the wall. I can provide this amount of energy continuously, but applied to the wall directly in its present form, I cannot move the wall or even scratch the paint. How can I use this amount of energy to destroy the wall?

Tesla's Method of Conversion is the way. So, in the first step, I need to raise the pressure of the energy manifestation. I can do that by taking the one pound of force distributed over the one square foot (144 square inches) and apply that force across a smaller area. Let's say I cut the area down to ¼ the size. So now I am applying my force across an area that is 6 inches by 6 inches, or 36 square inches. For the amount of energy to be the same, I am now applying 4 pounds of force across 36 square inches of the wall.

This is great, but it's not enough, so I cut the area down by ¼ again. Now I am down to an area that is 3 inches by 3 inches with a force of 16 pounds applied to it. So, I have raised the pressure (force) in the situation by 16 times by applying the energy to a smaller cross-section of the wall. But this is only step one in Tesla's Method.

Step two is to make the force intermittent. OK, I currently have 16 pounds of force continuously applied to 9 square inches of the wall. What happens if I apply all of that force in 1/10th the time? Now I can hit the wall with 160 pounds of force for a 10th of a second. Now that is going to start smashing the plaster board. Mind you, we are still talking about exactly the same amount of energy as we started with.

Step three of Tesla's Method allows us to create a series of these large impulses, second after second. So, we can hit the wall with one 160 pound impulse for a 10th of a second, once a second. Alternately, we can hit the wall with 160 pounds for a 100th of a second, ten times a second, or for 1000th of a second 100 times a second. As I can continue to do this, second after second, the wall is rapidly demolished.

So, what has changed? Think about it. It's important that you understand this. The total amount of energy expended has not increased. There is NO energy gain here. But what we have done is to concentrate that energy and change the density and time constant of its expression.

Energy is defined as the ability to do "work" and the rate at which work is delivered over time is called "power." So, one of the things Tesla's Method of Conversion produces is a "power gain." It can convert a source of low voltage and low current electricity into a series of uni-directional electrical impulses of high voltage and high current. Tesla stated that this process was able to produce effects that could not be replicated any other way.

Even alternating currents of high voltage and high current could not do what the uni-directional impulses could. Upon careful analysis, the reason is clear. Alternating currents do not transfer any net inertial effects since all momentum produced in one direction is negated by the next reversal. Thus, the inertial properties of electricity cannot be expressed using alternating currents or continuous direct currents. Only intermittent direct current impulses allow the expression of electrical inertia to build up in a system; like a hidden flywheel storing momentum. This is another added advantage of the process.

Yet another advantage of the process has to do with the electrical characteristics of capacitors designed for rapid discharge. The property is called a "low ESR", or equivalent series resistance. The capacitor offers almost no resistance to the discharge of high currents. In AC systems, this is referred to as "low impedance."

Many of you may know, when the source impedance of a power supply is lower than the connected load, the rate of power transfer can be very high. John Bedini found this to be especially useful when applied to battery charging. The inertial effects of the electrical impulses would build up in the battery, and even continue to charge the battery after the charger was disconnected! John eventually referred to this process as "over-potentializing the electrolyte."

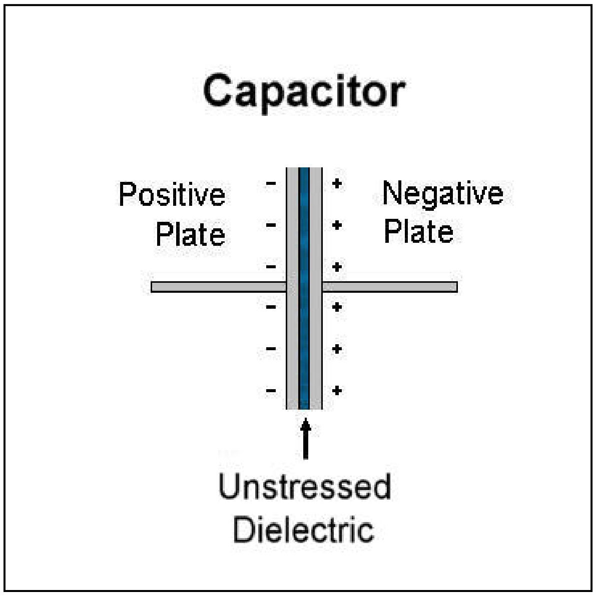
There are even more advantages that show up when Tesla's Method of Conversion" is fully explored. To do this, let's look closer at the capacitor and see what happens when it is charged by a collapsing inductor.

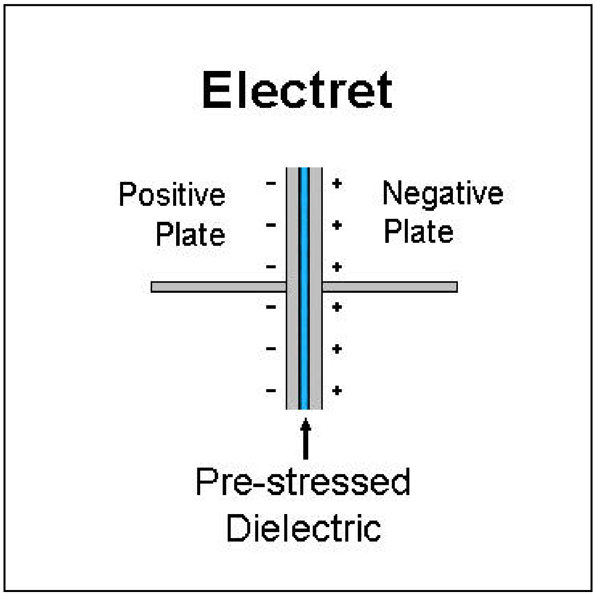
Chapter Four

Capacitors and Electrets

Capacitors are electrical devices that can "store" electricity. This is the general understanding. The specific issues concerning "how capacitors work" and "how electricity is stored in them" are extremely complex. Questions of whether that charge is stored as electrons on the plates or as a stress in the dielectric separator are still being debated in professional circles.

But before we explore that, we need to understand the function of another electrical device called an electret. An electret is similar in construction to a capacitor in that it has two electrically conductive plates separate by a dielectric material. But in the case of an electret, the dielectric material is permanently polarized, so it spontaneously produces a charge separation. An electret is like the static electricity analog of the permanent magnet. A permanent magnet constantly produces a polarized magnetic field around itself, and an electret constantly produces a polarized electric field within itself.





The simplest way to make an electret is to pour hot, molten wax in between two metal plates and establish a high voltage gradient across the plates. As the wax cools and hardens, its crystal structure forms in the stress of the electric field. After the wax cools down to room temperature, the two metal plates will always have a voltage potential between them. The best kinds of wax for making electrets are bees wax and carnauba wax.

What is interesting about this is that Nikola Tesla routinely used paper impregnated with bees wax as the dielectric separators in his capacitors. This arrangement always made his oscillators produce higher outputs.

John Bedini has used commercially available "electrolytic" capacitors in his oscillator circuits, but has found corresponding gains, even at much lower voltages and much lower frequencies than Tesla employed. It has taken considerable work to figure this all out, but what seems to be happening is this.

Temporary Electrets:

When an appropriate dielectric material is used in a capacitor that is charged from the energy of an inductive collapse, the electrostatic component of this type of electricity produces a "temporary electret effect" in the capacitor. Exactly how well this effect is established and how long it persists depends on the material used as the dielectric.

Here is what it looks like. Normally, if you charge a DC capacitor from a battery or from a rectified power supply, the capacitor will charge to the applied voltage. After the supply is removed, the capacitor can be discharged once and drawn down to 0.00 volts. After the load is removed, the voltage on the capacitor may rise above 0.00 volts by a few millivolts. The standard behavior of a capacitor involves very little voltage recovery.

If, however, that same capacitor is charged by an inductive collapse event and subsequently discharged to 0.00 volts, as soon as the load is removed the voltage may rise back to as much as one VOLT! This behavior of ordinary electrolytic capacitors has been witnessed thousands of times. As this process is repeated during operation of the SG oscillator, the effect eventually reaches a maximum level. Whatever that benefit level is, this is the second method employed by John in the SG Energizer to get electricity to "raise it's own potential."

What this means is that every time we discharge the capacitor into the battery to charge it, the capacitor is refilled, partially from the coil discharges, and partially from the "temporary electret effect" in the capacitor itself. This phenomena is definitely an energy gain in the system and the appearance of electricity that did not come from the run battery in any way that can be measured on today's meters.

This clearly establishes the theoretical basis for the observed performance of the machine. The second battery charges better and faster when the capacitor charge and discharge section is added to the circuit, in spite of the measurable losses associated with the switching process.

All of the charge rebound that the capacitor provides on its own is completely free, as it is not provided by the first battery in any known way. This gives an immediate and obvious advantage over charging the battery directly with the coil discharges.

So, in spite of the energy losses that are measurable in the switches, and even the charge losses caused by capacitor "leakage", the "temporary electret effect" seems to be able to more than off-set these losses with an even larger gain in charge.

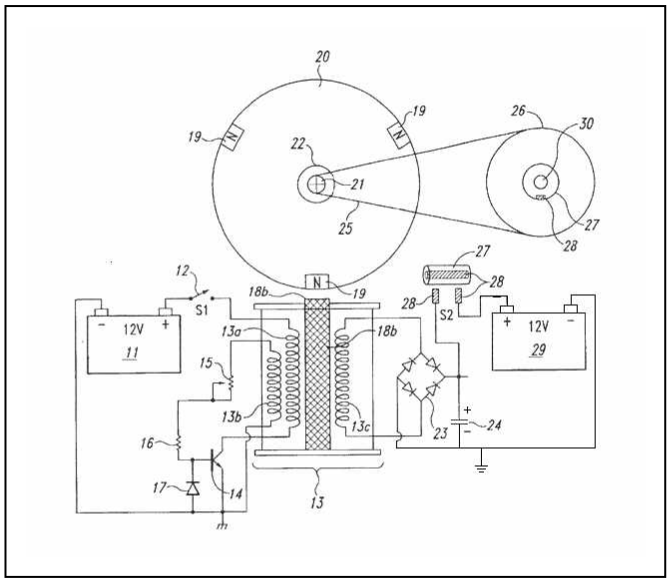
OK, let's look at this process more closely.

Chapter Five

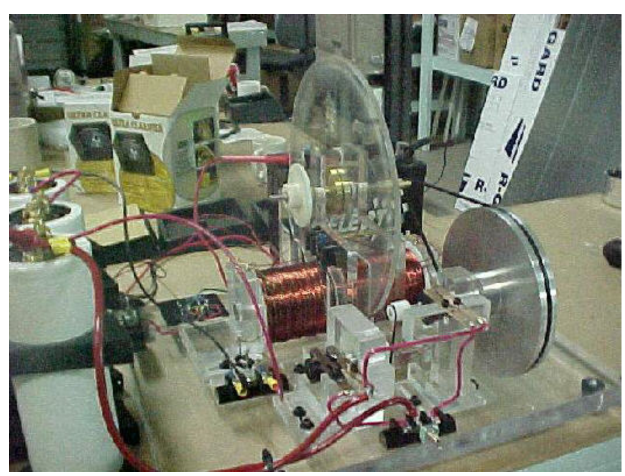
Capacitor Charge and Discharge Methods

Over the last 8 years, a great deal of information about capacitor discharge methods for the SG circuits have been discussed on the Internet. In order to remove as much confusion as possible from this presentation of the material, a brief review of these ideas will be helpful.

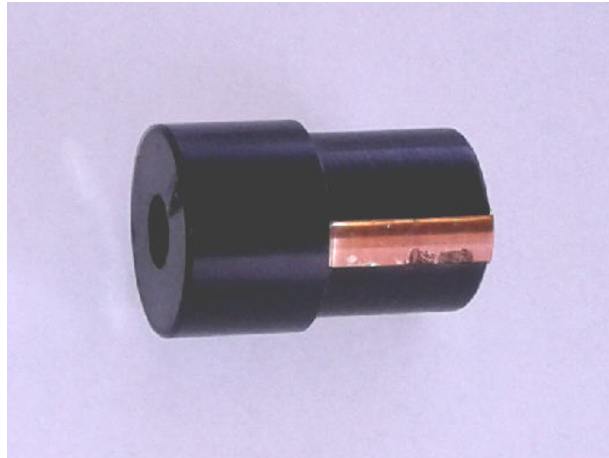
The Beginning:

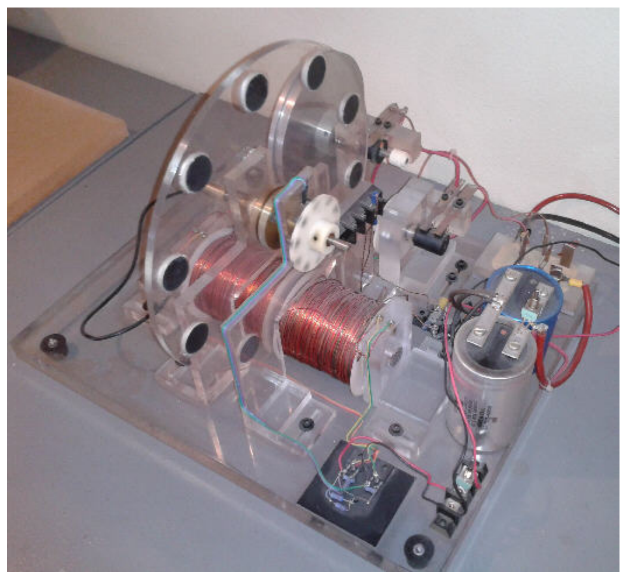


All methods of capacitor charging and discharging stem from John's original patent diagram, shown here. It shows a capacitor (#24) being charged by an isolated output winding (#13c) through a full-wave bridge rectifier (#23). The capacitor is then discharged through a rotating commutator and brush mechanism that makes and breaks the POSITIVE wire connection between the capacitor and the battery.



One variation of this machine ran continuously for over 10 weeks straight during the winter of 2002. The capacitor was 330,000uf charged to 3 volts above the battery and discharged about once per second. The brushes had silver contacts and the commutator wheel consisted of a section of copper rod inserted into a Delrin wheel, with the wheel machined down to expose the copper, as shown here in this close-up photo. The Delrin made the brush friction very low, and the silver/copper combination made the contact resistance very low. The wire in the capacitor discharge path was 8 gauge, also to keep the electrical resistance low.





The SG wheel was turned in the "forced repulsion mode" operated by the "Bedini-Cole Switch" on the black heat sink in the lower foreground. Even though I explained in the first book that the "self-triggered" system operating in the "attraction mode" is more efficient, this early unit was still able to "self run" for more than 10 weeks by trading front and back batteries about once every 12 hours.

The point is this. There are multiple ways to make this work, but every system I have seen "self run" had a capacitor discharge circuit charging the batteries.

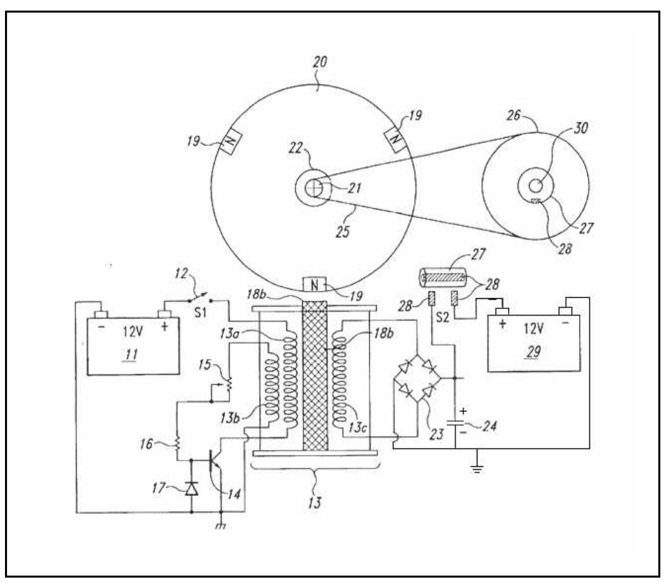
So, let's recap this design. It has an isolated winding in the output. It has a full-wave bridge rectifier between the coil and the capacitor. The discharge circuit makes and breaks the positive line between the capacitor and the battery. Contact for the discharge is made with a rotating commutator and brush mechanism. Large diameter wire is used in the discharge path to keep electrical resistance down. The capacitor is relatively large (330,000uf) and the discharge rate is about once per second.

This example clearly defines the five major components needed for charging and discharging the capacitor. They are:

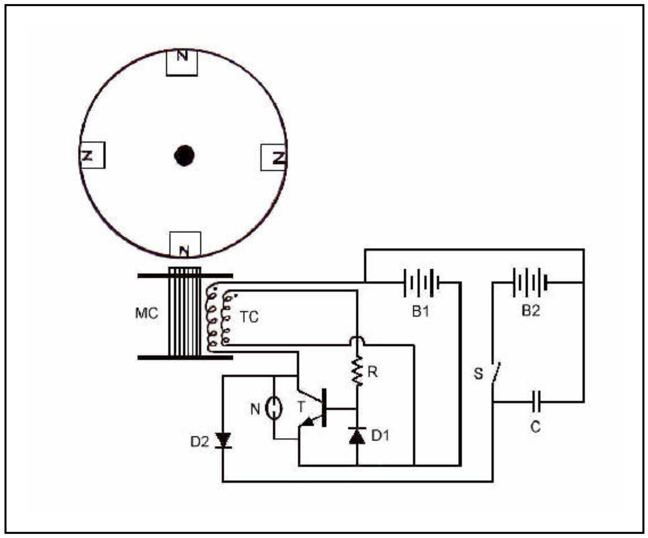
1. The circuit used to take the energy out of the coil and transfer it to the capacitor.
2. The circuit used to take the energy out of the capacitor and transfer it to the battery.
3. The method of switching used to discharge the capacitor.
4. The method of timing used to trigger the switching mechanism.
5. The size of the capacitor and the frequency of its discharge.

John has tried at least 300 variations on all of these parameters and has come to a set of specifications he uses regularly now. Over the years, many people in the forums experimented with dozens of these ideas, so it is difficult to find the best way to do this from that source. To clarify the best way to accomplish each of these, I'd like to expand on them a little bit.

Circuits for Charging the Capacitor:



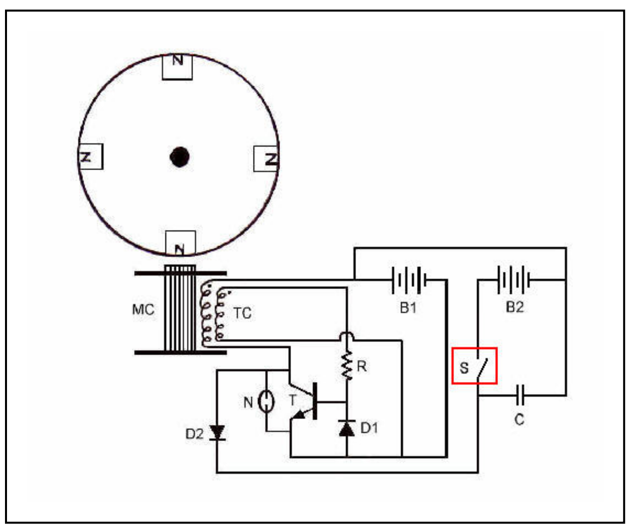
The drawing to the right shows the circuit that charges the capacitor (#24) from an isolated output winding (#13c) through a full-wave bridge rectifier (#23). From an electrical efficiency point of view, this is the least efficient method. The full-wave bridge requires the output pulse to travel through two diodes that each have a voltage drop of about .6 volts. Second, having the output pulse produced on a coil winding that is different than the winding the pulse came into the coil on, also produces about a 2% loss by induction.



So, it seems clear that collecting the output pulse from the main coil winding (MC) and using a single diode (D2) to direct that impulse to the capacitor (C) is more efficient.

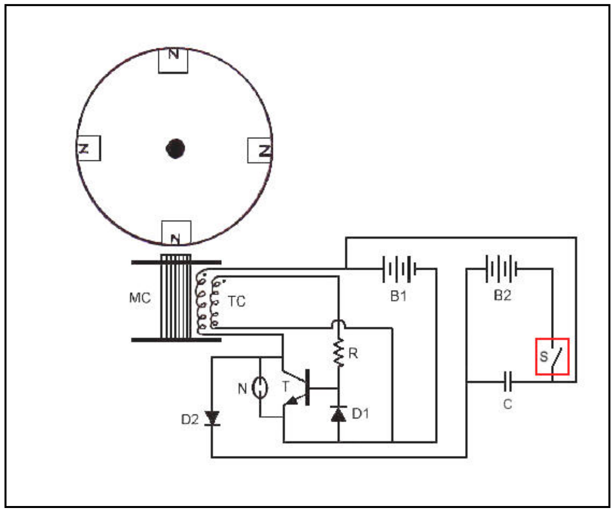
If the goal is to charge the capacitor and discharge it into a second battery, as shown, there are very few reasons not to use the second method. If your goal is to recover this energy and make it available to off-set the drain from the first battery, then collecting it off of an isolated winding makes this task much easier. (Sample circuit not shown) But since the output pulse is inherently DC in nature, there is rarely a need to use the full-wave bridge at anytime, since a single diode is sufficient to isolate the pulse and store it in the capacitor.

Circuits for Discharging the Capacitor:



From the very early diagrams to the drawings used in the Beginner's Handbook, we have always shown the capacitor discharge circuit with the switch on the POSITIVE line. Classical electric circuit theory usually leaves the negative or ground lines connected throughout the circuit, and this is where John began his experiments, as well.

However, when John started to seriously explore the capacitor discharge effects on the battery, he found that leaving the positive lines connected and switching the NEGATIVE line also had merit. After extensive testing, John now switches the NEGATIVE line almost all of the time.



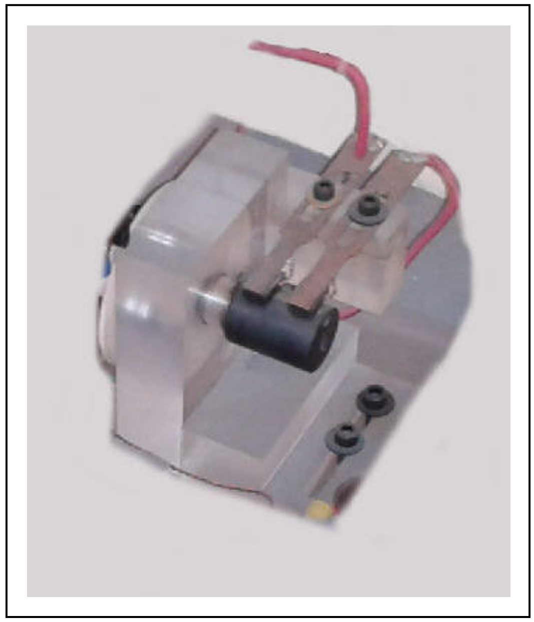
The new theory that supports this thinking suggests that allowing the high voltage pulses coming from the coil to build up on the capacitor, but also letting them act on the positive terminal of the battery, produces a better result. The theory is that this circuit allows the positive plate of the battery to become "pre-potentialized" even before the current surge released by the switch acts on the chemistry.

Switching both the Positive and the Negative connections between the capacitor and the battery at the same time may also have merit, but this option has not been extensively explored yet. This would provide complete isolation between the capacitor and the battery and may have uses under special conditions.

Methods of Switching:

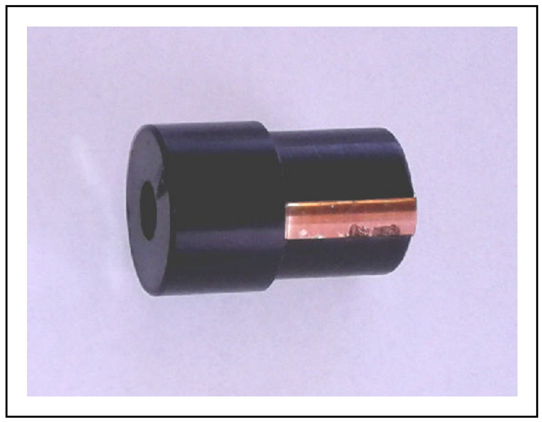
We have discussed the capacitor discharge circuits. Now we are going to discuss the various ways that are available to make and break the circuit. In general, there are three basic ways to do this. They include mechanical methods, electronic methods, and hybrid methods that use features of both.

The mechanical methods generally use a brush style commutator like the ones shown previously, or a cam actuated mechanical switch. The electronic methods generally use either bi-polar transistors, MOSFETs, or SCRs. The hybrid methods may use a cam actuated switch to trigger a transistor or other device. You can see, there are lots of options here. So let's look at each of these in more detail.

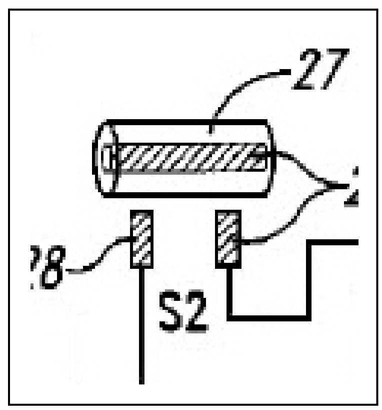


Mechanical Methods:

So, again, here is a picture of the basic mechanical switch used by John in many of the early models. The black wheel is turned at a mechanically reduced rate from the main Energizer Wheel. It is made of Delrin with a copper bar inserted into it. Then both are turned down in a Lathe to expose a small section of the copper.



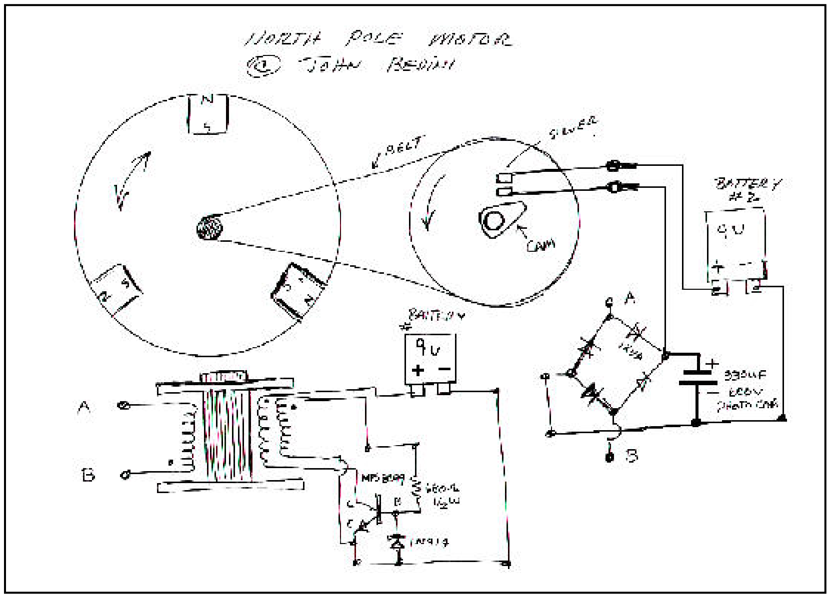
Both brushes contact the surface of the Delrin and when the copper section comes around, a contact is made between the brushes. This creates an electrical connection between the capacitor and the battery, and so the energy charge in the capacitor discharges into the battery.



There are advantages and disadvantages to this method. The main benefit is that it is mechanical, so it can be built with no knowledge of complex electronic circuits. It does require some special tools, like a lathe, but industrious individuals can probably figure out how to built a rotating switch similar to this with basic tools.

One disadvantage can be seen in the middle photo. You should be able to see that the copper is "pitted" along the lower edge. This represents the first edge to contact the brushes where the initial current surges from the capacitor discharges are melting away the copper. So, there is some physical degradation of the switch and a maintenance issue over time.

The other main disadvantage is that the brushes make contact with the switch for a much longer time than is required to discharge the capacitor down to the voltage of the battery, since the capacitor cannot begin to charge up again until the switch disengages.



The other method to discharge the capacitor with a mechanical switch uses a small "cam" mechanism on the shaft of a geared down wheel, and the cam is used to actuate a stationary, enclosed momentary contact switch.

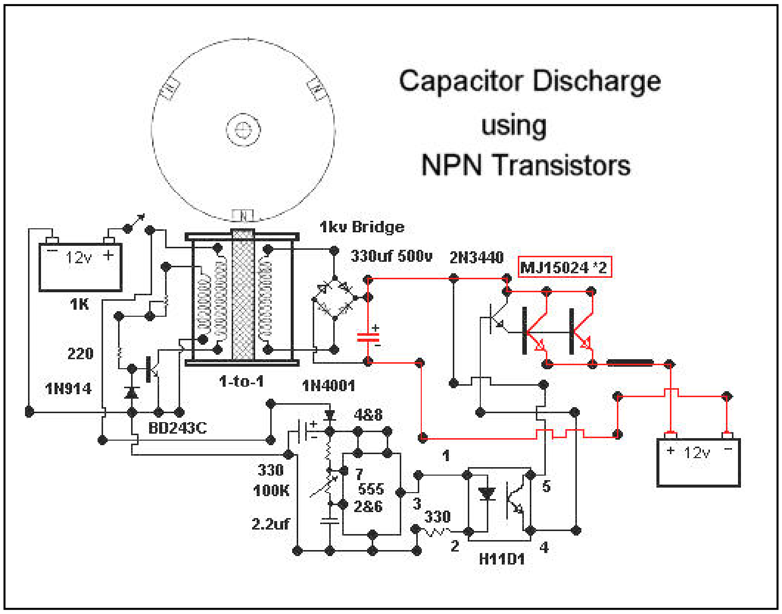
This type of switch, pictured here, is readily available from many commercial outlets. Many of them come with their own "roller" attached to the actuator arm that is also spring loaded to turn itself OFF again after the cam passes.

This method can be easily built by beginners who do not have access to machine tools, such as lathes or milling machines.

Electronic Methods:

The electronic methods to discharge the capacitors are much more complicated. Most of them use similar circuitry to control the device that actually does the switching.

Here is an example of a circuit that has been posted on the discussion threads for many years. I have highlighted in RED that part of the circuit that actually allows the discharge from the capacitor to the battery.

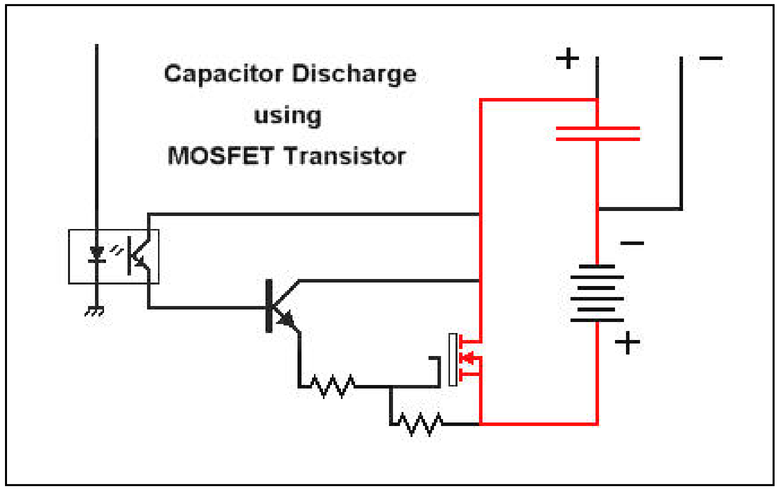


You can see that the circuit also includes a timer chip (555), as well as an opto-isolator chip (H11D1) and a smaller NPN transistor (2N3440) to turn ON the main transistors (MJ15024).

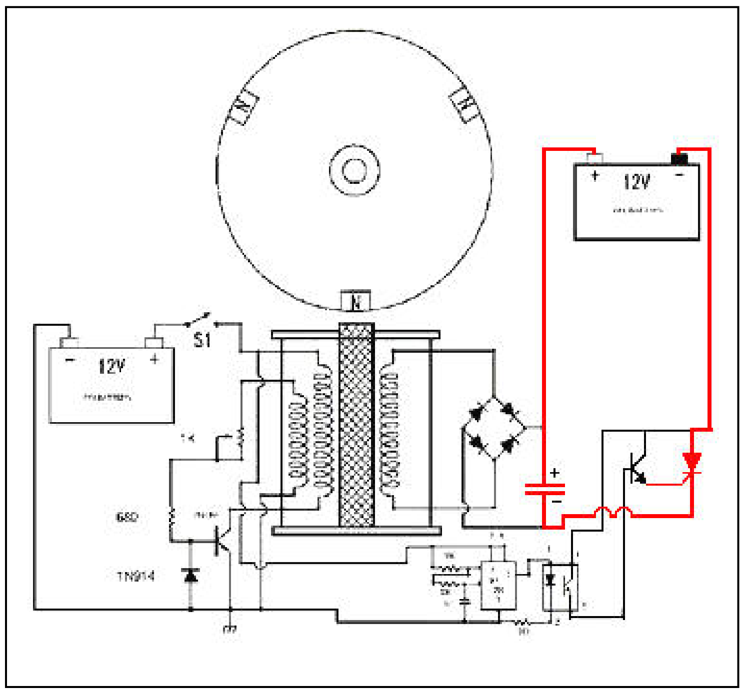
This is very close to the circuit used in the small unit pictured here called "The Real McCoy". The small yellow capacitors, with a total of 6.6uf, were charged to about 100 volts and discharged about once a second. It could charge any type of battery from 2 volts to 24 volts.

Since the unit was completely enclosed in this old bulk CD case, it had to "self-start" when connected to power. For this reason, it used the forced repulsion drive mode and the "Bedini-Cole switch" to control the oscillator.

Here is an example of a circuit to discharge the capacitor using a MOSFET transistor. The discharge circuit path is traced in RED. The section of the circuit that charges the capacitor comes from the (+) and (-) terminals in the upper right corner. The signal that controls the discharge timing comes from the upper left corner, also not shown. These features could be the same as shown in the diagram illustrating the NPN Transistor circuit on the previous page.



Finally, here is an example of a capacitor discharge circuit using an SCR. The discharge circuit path is traced in RED. Again, John has used a 555 timer chip, an opto-isolator, and another small transistor to trigger the SCR, like he used for the MOSFET and the power NPN Transistor.

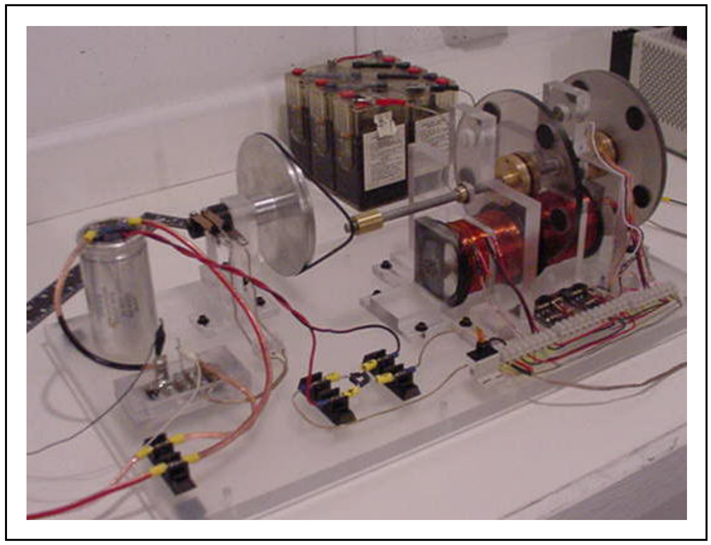


The first two transistor circuits show the Positive line being switched while the third one, the SCR circuit, shows the Negative line being switched. The point is, the methods to switch either line are very similar.

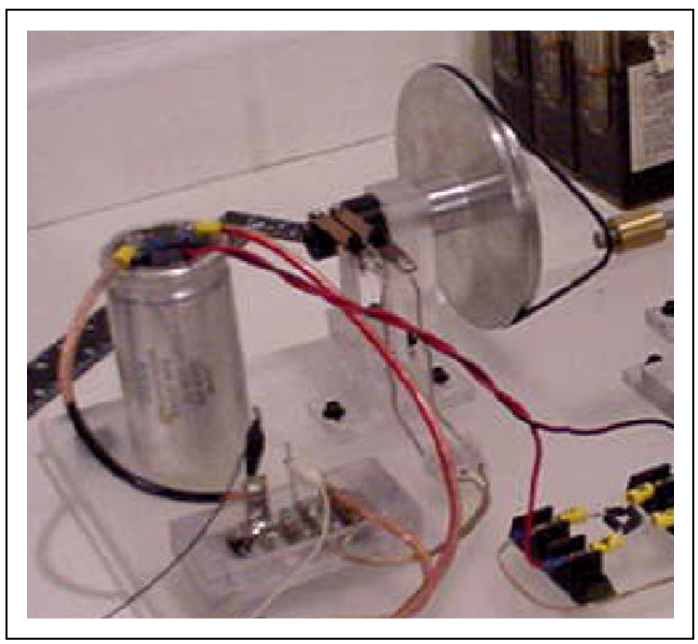
The pros and cons of each of these devices are as follows. The NPN transistor has the highest voltage drop across it's junction, so it is better in systems where the capacitor is charged to higher voltages. The SCR has the lowest voltage drop across it's junction, but once activated, it will not turn

OFF until the voltages equalize between the capacitor and the battery. The MOSFET has a middle value voltage drop across it's junction, about half way between the NPN and the SCR. But it can be turned ON and OFF at will, like the NPN. For these reasons, the MOSFET is usually the device chosen for these systems, as long as the voltages in the capacitor are in the moderate range, which means less than 20 volts above the battery.

Hybrid Methods:



These methods of discharging the capacitor use features of both mechanical switching and electronic switching together. In this picture, you can see the belt driven speed reduction feature, similar to the one shown on page 28.



That is operating the rotating brush switch, which in turn triggers the transistors shown in the plastic box in the lower center of the second picture. The switching of the transistor then discharges the capacitor to charge the battery.

So, this illustrates the three main ways to discharge the capacitor into the battery. As you can see, many dozens of different methods have been devised and tested over the years. Working closely with John during this period of development, I was constantly confronted with "John's Method".

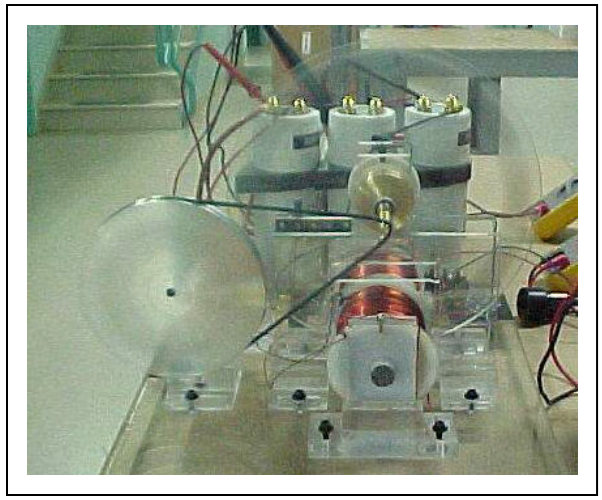
That is, he was never satisfied when an experiment worked, even if it worked extremely well. He was always looking beyond the moment, to see what was still possible. And….he never guessed! He would always built it, and run the test!

At one point, John was testing different control circuits to trigger the discharge and he built and tested over 30 variations of a circuit in about two weeks. This photo shows a sample of some of those test circuits, still in the box and stored on a shelf in his shop. He also never threw anything away, and never scavenged one experiment to build a newer one. Everyone of the circuit boards in this box still works!

For John, it was always about the learning and the path of discovery. It was never about getting a "self-running machine", primarily because he had done that in 1984 and many other times since then. He was looking for specific, incremental gains that he could add to his already vast knowledge base.

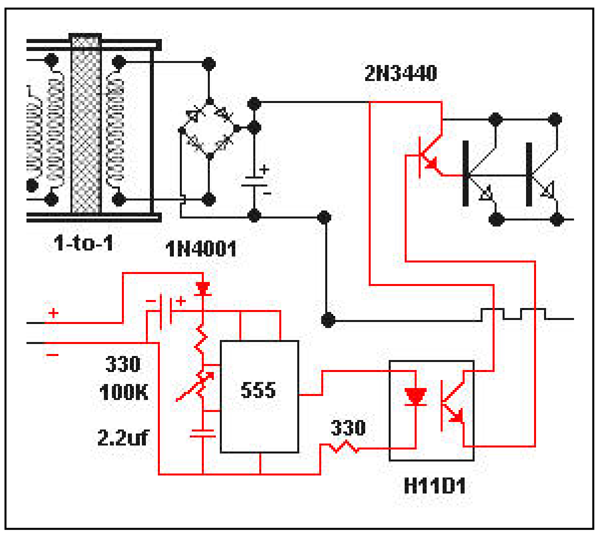
Back in his 20's, John worked for TRW, a manufacturer of semi-conductor devices. There he learned that any kind of device, like a MOSFET or an SCR, can be operated outside of it's normally considered specifications, if you know how to safely push it there. Because of this, John can get circuits to do things that other electronic circuit designers cannot. So, for instance, when John refers to using "inverted circuits", he is generally referring to using one or more components in the circuit in a way that is either different or even completely opposite of the standard method of use.

As an example, John has devised ways to turn SCRs ON and OFF at will, even when the voltages across the junctions never equalize. In standard practice, this cannot be done, and most circuit designers do not know how to accomplish this. But John knows how and has used this method in a wide variety of circuits.



Methods of Timing:

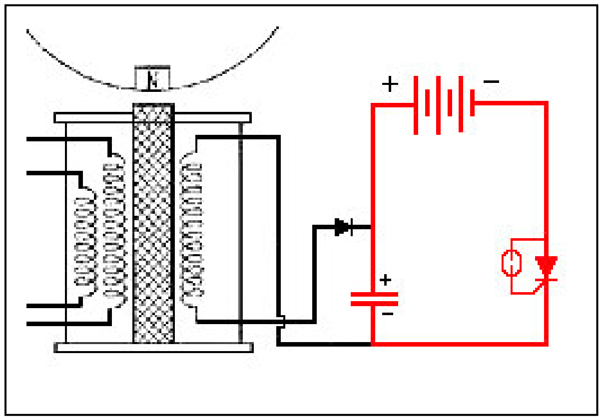
The simplest timing methods are the mechanical ones. Here we see an end view of one of the early units. The "gear reduction" ratio on this belt drive is at least 20-to-1, so the main rotor turns 20 revolutions for every time the timing wheel turns once. With 10 magnets on the wheel, it means that 200 pulses charge the capacitor before the brush mechanism discharges it into the battery.



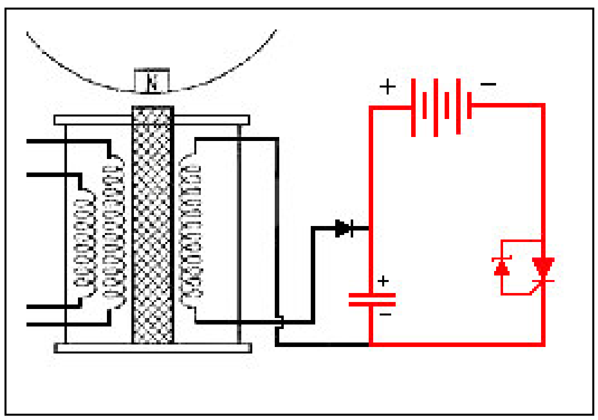
The next method to control the timing is the purely electronic method. Here is a blow-up of the Timing Section of the circuit from the diagram on page 35. It shows power (12 volts) coming in from the Run Battery on the left (+ and -). This powers a 555 timer chip configured to produce an impulse between .2 and 20 times per second, selectable on the 100K trim pot. The output of the 555 powers the LED section of the H11D1 Opto-Isolator chip. This chip allows the timer, which is powered by the input battery, to control the discharge of the capacitor, which has no connection to the input battery. The output of the H11D1 chip then controls the triggering of the 2N3440 transistor, which in turn, controls the primary device used to discharge the capacitor.

Again, the kinds of devices that can be used to discharge the capacitor can include NPN transistors, PNP transistors, MOSFETs, SCRs or even Triacs.

The third method of controlling the timing of the capacitor discharge uses a circuit that can sense (measure) the voltage building up in the capacitor, and discharge it when that voltage reaches a predetermined level. These "automatic" methods of triggering the capacitor discharge range from simple to complex. One simple method is illustrated here, where a neon bulb is used to trigger an SCR when the voltage in the capacitor rises to about 100 volts. This method works really well for about 20 hours, after which the neon bulb "polarizes" and stops firing. This was the first method John experimented with in 2003.



Other simple methods involve using an SCR triggered by a Zener diode or a Zener diode triggering a small transistor which triggers the SCR. The value of the Zener diode will determine how high the voltage in the capacitor will rise above the battery before it discharges.



These SCR circuits only work when the capacitor is charged by periodic pulses, like the output of the Bedini SG, as the SCR may never latch closed again if the capacitor is charged by a continuous current method.

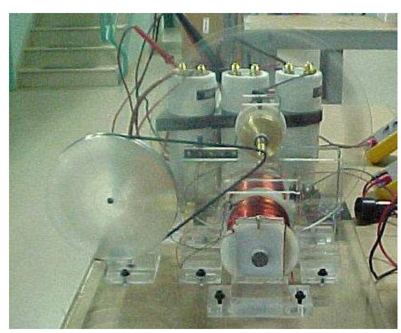
Other, more sophisticated circuits can use a combination of Zener diodes, OP-AMP chips, and voltage regulators to monitor the voltage of the capacitor and automatically regulate its discharge. John has developed excellent circuits that work on this principle. You may wish to purchase one of his "ready built" capacitor discharge circuits for the SG Energizer Kits, or develop your own. These kinds of circuits are great because they can automatically adjust to a faster discharge rate as you increase the charge rate of the capacitor.

Capacitor Characteristics:

Capacitors are one of the most varied electronic components available today. They can be used for dozens of purposes, including filtering high frequency noise, storing charge for later use, creating phase shifts in AC circuits, helping to start AC electric motors, producing resonant oscillations, as well as facilitating the production of instantaneous transients.

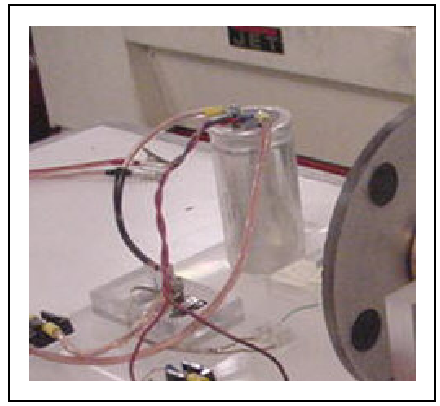
In the Bedini SG circuitry, capacitors are used to store charges coming from the coil and discharging them into the batteries. For model builders, the question is, what kind of capacitor works the best? Luckily, just about every kind of capacitor that can be considered appropriate for this application has been tried!

In this picture, you see three 20 volt, "1 Farad" capacitors connected in series to produce a 60 volt, 330,000uf capacitor. This capacitor set-up was charged to about 3 volts above the batteries and discharged about once a second through a rotating brush contactor.

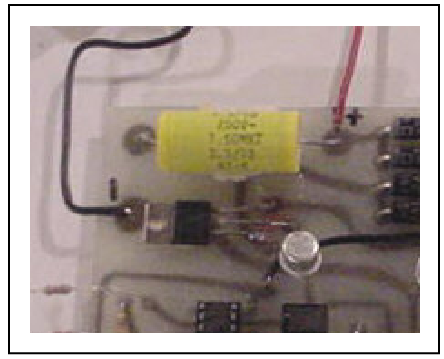


This machine was one of the "self-runners" that John demonstrated in 2002. It ran for over 6 weeks straight, just rotating the batteries from front to back. So, very large capacitors discharging relatively high current, low voltage impulses is certainly a method that works.

In this picture, a capacitor rated at about 18,000uf @ 40 volts is tested on one of the many "test stands" built between 2002 and 2006. This particular arrangement was never tested for "self-running", but it illustrates that capacitors in this range were explored. This type of capacitor was originally designed as a power supply, filter capacitor.



And, of course, these small, yellow capacitors that are rated at 3.3uf @ 250 volts, originally used in Bedini Audio Amplifiers, have been extensively tested. The end result of years of work and hundreds of individual tests have lead to the following recommendations.



The best type of capacitor for the application of being charged by an SG oscillator and then discharged into a battery is a "Photo Flash" type of electrolytic capacitor. They are designed specifically for rapid discharge, so they produce a very low impedance "source" for the battery. They also seem to produce the "temporary electret effect" very well. These two characteristics seem to be the most important.

Here is an example of this type of capacitor, rated at 15,000uf @ 80 volts. They come in a variety of sizes and voltages, so experimenting with different scale machines is possible.

Completeness and Frequency of Discharge:

OK, we have discussed the various types of capacitors that have been used. We have discussed the methods to discharge the capacitor using mechanical contacts, transistors, MOSFETs, and SCRs. We have discussed the various ways to trigger the discharge using mechanical timing, electronic timing and even voltage sensing. Now, we are going to look at how various systems come together, what their circuit characteristics are, and how that effects the energy being transferred to the battery.

The two most important circuit characteristics are:

1. how much resistance is introduced into the circuit by the switching method
2. how precisely can the discharge be controlled by the switching method and the timing method

Let's, once again, review the methods we have discussed before with these two criteria in mind.

1) Mechanical Switching with Mechanical Timing

The mechanical contactors that John used in his experiments worked extremely well. The ones that used silver brushes and copper conducting strips in the Delrin wheels worked the best, with an effective resistance near zero. Experiments that used brass or bronze strips in the Delrin wheels did not work as well. No "self-running" systems were ever demonstrated using brass or bronze in the conducting strip. This lowering of the effectiveness of the system was due to the increased electrical resistance in the brass or bronze members.

The precise timing of the discharge was not very good with the mechanical brush. Typically, the capacitor was connected to the battery far longer than it took to fully discharge, so vital "recharge time" was lost before the next discharge. Also, if the voltage difference between the capacitor and the battery was too high, the arcing at the brush tended to degrade the front lip of the copper bar (as seen on page 33), which also lowered the over-all effectiveness of the method.

2) Transistor Switching with Electronic Timing

Of all of the switching methods discussed in this book, the NPN Bi-polar Power Transistor introduces the highest resistance into the switching circuit. The .6 volt drop across the semi-conductor junction adds a significant resistance barrier to the otherwise high frequency, low impedance connection between the capacitor and the battery. This arrangement was only used when the batteries were small, and the capacitor voltages were at least 30 or 40 volts above the battery, to minimize the percentage of loss.

In spite of the fact that electronic timing methods could be used to optimize the contact time, I never saw an SG system attain the "self-running" mode using bi-polar transistors to switch the capacitor discharge.

3) SCR Switching with Electronic or Automatic Timing

Of all of the electronic devices used to effect the discharge of the capacitor, the SCR has the lowest resistance. It introduces no voltage drop across the semi-conductor junction (0.00 volts) and when triggered, it begins conducting quickly at full power. It requires very little energy to trigger and shuts off automatically when the voltage between the capacitor and the battery equalize. In many ways, it seems like the ideal device for this application.

Remarkably, I have never seen a "self-running" system use an SCR to discharge the capacitor into the battery, although I do believe that such a system could be developed. The primary weakness of the SCR switching method is that it requires the capacitor to discharge all the way down to the battery level and remain there until the current transfer stops. Under most circumstances, it is not possible to get the SCR to re-set until this happens. For systems in the low to medium voltage range, this can really "flatten out" the benefit otherwise available from the "temporary electret effect" and it's spontaneous recharging of the capacitor.

4) MOSFET Switching with Electronic or Automatic Timing

As we start to approach the understanding of the "sweet spot" for this phenomena, we see that the SCR's weakness is that it cannot be turned OFF when we want it to be. The MOSFET switch appears to be the best device because it has the lowest resistance for any device that allows us total control of the timing.

It has a .3 volt drop across its semi-conductor junction, which puts it about halfway between the SCR and the Bi-polar Transistor. However, the device can be turned On and OFF very rapidly, if necessary. This gives us a whole new opportunity to explore, and that is, to turn the capacitor discharge off BEFORE the capacitor is completely discharged.

The MOSFET Switch gives us the ability to partially discharge the capacitor. By doing so, we can deliver a short, sharp (high voltage, high current) impulse to the battery while taking best advantage of two other benefits. These are:

1. the time interval to the next "full charge" state is shortened
2. the "temporary electret effect" is allowed to provide the largest percentage of the voltage recovery in the capacitor per cycle

This gets us directly back to Tesla's "Method of Conversion" where, with the least energy input, we can deliver the highest number of high energy impacts to the battery in the shortest amount of time.

In order for you to understand the importance of this, I quote from page 80 in the Beginner's Handbook: "The first thing you must know is that the 'state of charge' in the battery is a CHEMICAL condition, not an ENERGY condition" and "**<u>Anything</u> that restores this chemical condition in the battery is contributing to the charging process.**"

Optimum Discharge Circuits:

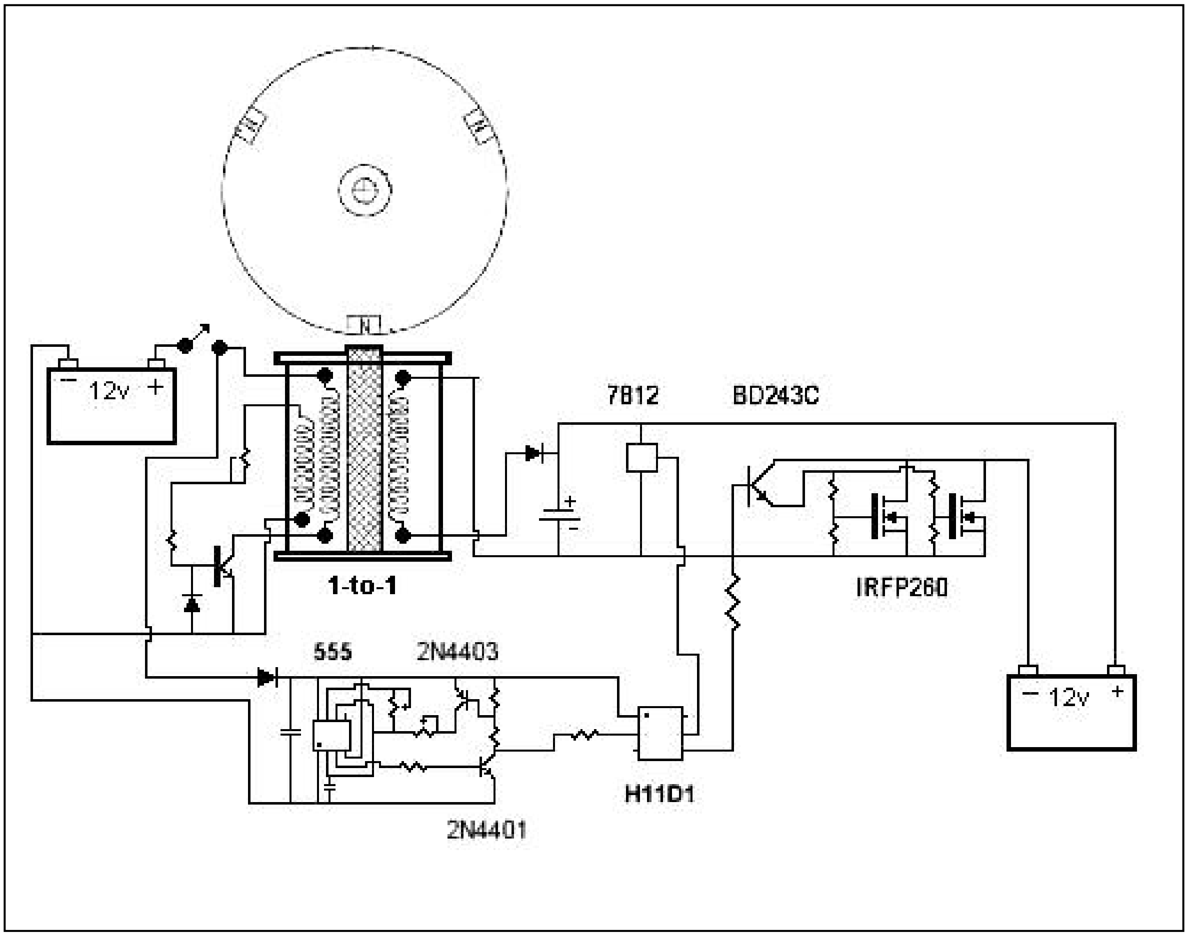
John has developed an automatic discharge circuit that optimizes the capacitor discharge and the battery charging process. It has repeatedly produced the highest COPs for any SG Energizer that I have ever heard of. That number is a COP > 1.25.

Of course, these capacitor discharge circuits are for sale, and for the time being at least, remain the proprietary property of John's company. The circuits come potted, to prevent tampering, so I can't tell you exactly how it works. What I can tell you is what you would see if you put this circuit on your SG Energizer between the output and the battery and measured everything that was happening to the capacitor.

The capacitor section of the circuit can plainly be seen to consist of 4 of the 80 volt, 15,000uf photo flash capacitors I show on page 42. This makes the value of the capacitor to be 60,000uf @80 volts. This capacitor is charged to approximately twice the battery voltage, so for a 12 volt system, the cap is charged to around 24 volts. The capacitor is discharged by an automatic circuit that senses the voltage and the discharge is interrupted when the voltage in the capacitor drops to about 5 volts above the battery.

The question is, is there a way to simulate this circuit behavior using an electronic timer? The answer is YES! All we need to do is build a 555 timer where we have independent control of the ON time and the OFF time of the timing cycle. Then, the ON time control will let us select the exact amount of time that the capacitor is discharging, and the OFF time control will let us select the exact amount of time that the capacitor is charging. As long as the system is running in a stable window, the results will be quite good!

The circuit diagram is shown on the next page. It includes two IRFP260 MOSFETs switching the negative line between the capacitor and the battery. The main discharge capacitor should be of the Photo Flash type with a value in the range of 60,000uf @ 80 volts or whatever you choose.



The NPN transistor turning the MOSFETs on is the BD243C or any suitable replacement. Since the capacitor is varying in voltage, the voltage to the control section is managed by a voltage regulator 7812 or any suitable replacement. Resistors on the MOSFET gates are 1K or suitable variant.

On the timer side, the main timer chip is any version of the 555 timer, such as the TS555CN or equivalent. The diode on the positive rail feeding the timer can be a 1N914 or a 1N4148. The small capacitor just before the 555 can be 100uf @ 25 volts electrolytic. The timing cap between pin 2 and ground is about .80uf @ 25 volts. Both potentiometers are 1 megohm. The resistor between pin 3 and the base of the 2N4401 can be anything between 2k and 10k. The two resistors between the positive rail and the collector of the 2N4401 are 2K and 1K with the 1K resistor connected to the collector. The resistor feeding into the H11D1 is 330 ohm. The resistor feeding to the base of the BD243C is 2K or suitable variant.

This circuit will allow you to completely control the charge and discharge timing of the capacitor. The 1 megohm pot coming off of the collector of the 2N4403 controls the "on time" of the timer and the "discharge time" of the capacitor. The other 1 megohm pot controls the "off time" of the timer and the "charge time" of the capacitor. Increasing the resistance of the pots increases the time duration for these functions. You can also add a 1K resistor in series with each of these 1Meg Pots so the value of the resistance cannot drop to zero.

So, you can manually set the discharge time to a very short interval that only partially discharges the capacitor, and likewise set the charge time so the capacitor charges to whatever voltage you want.

By watching the voltage of the capacitor on an oscilloscope, you can easily see what the potentiometers do and set them according to your own needs.

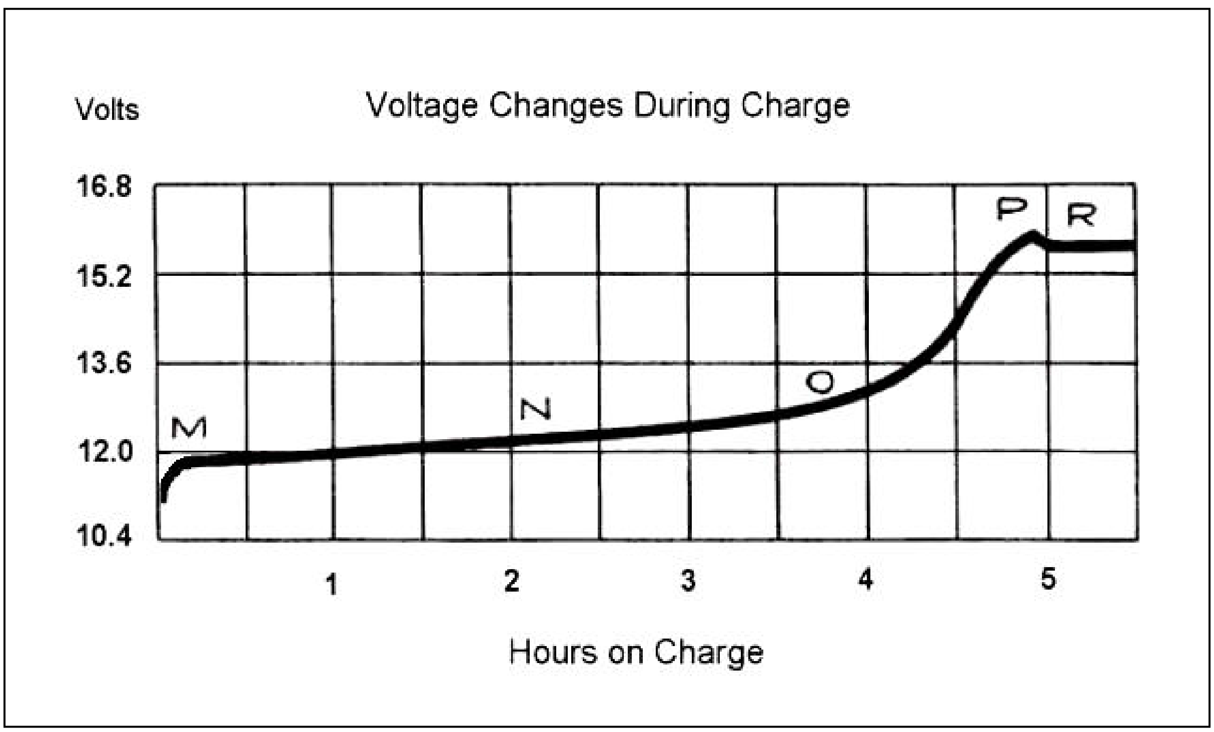
Variations on this circuit include using more than two IRFP260 devices to discharge larger capacitors. Don't forget to put them on a heat sink! There are also other 555 circuits that can provide the same control features for the process. Use this one if you like, or any other one you prefer.

Battery Charging Benefits

There are three separate and distinct benefits to charging batteries this way over standard charging methods. The first benefit is caused by Tesla's "Method of Conversion", which gives us a "power gain" in the system, and allows us to apply electricity to the battery in high density impulses.

The second benefit is caused by the "temporary electret effect" in the capacitors, which gives us a true "energy gain" due to the voltage recovery in the capacitor produced by the unmeterable electrostatic component of the inductive discharges from the coil.

The third benefit relates to the "charge finishing time" and has never been discussed in the public forms. In some ways, this is the biggest gain of all.



Here is the illustration from page 78 in the Beginner's Handbook. It shows the voltage profile of a battery as it charges and what happens at the end of the charge as the chemistry "finishes." To review this process briefly, the voltage rises slowly from point M to point O, then rises more quickly from point O to point P. Point P represents the point at which there are no more sulfate ions in the plates and the voltage has risen to its highest value. Any further applications of electricity to the battery beyond this point can only produce electrolysis, since the chemical charging process is "finished."

This is all interesting and theoretical, but what does it look like in real life? To find out, John and I started graphing charge cycles on a computer in 2004, during the development of the first Golf Cart battery charger produced by Energenx, Inc.

In order to appreciate what you are about to see, you need a little bit of background. The charger under development was being modified every couple of weeks. In this phase, the general type of changes being made were increases in the power level. To produce significant data in the charge graphs, a standardized discharge protocol was instituted.

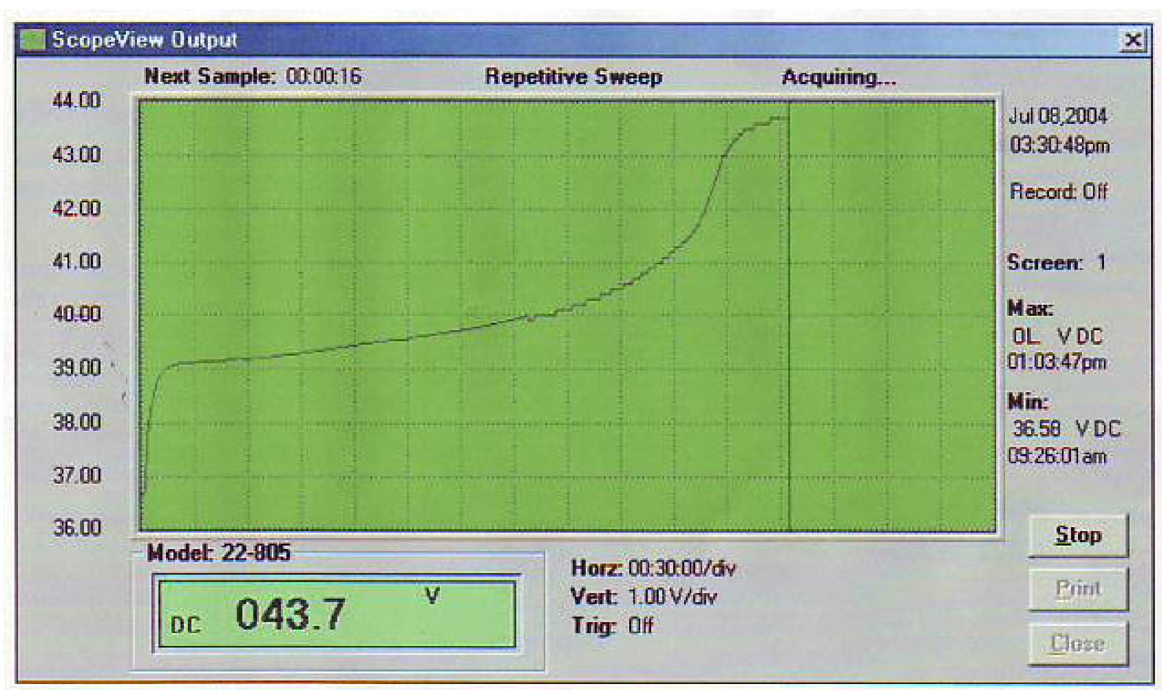
During this period, the Golf Cart was driven 6 miles each day, first thing in the morning, and then put on the charger to charge all day, so we could observe the process. The batteries would sit over night, fully charged, and the golf cart was taken out again the next morning. This rest period was typically 16 hours between the end of the charge cycle in the afternoon and the beginning of the next discharge cycle early the next morning. Over the weekends, the batteries would rest about 64 hours before the next discharge. Three day weekends provided an 88 hour rest for the batteries, but they were always left fully charged.

John has always told people if they wanted to see the system work at its best, they need to "condition the batteries" and just let the system run. Before the data collected from the Golf Cart test runs, we knew this was necessary, but we didn't know exactly why it worked. After these tests, we knew we had found the reason.

The charging chart on page 49 suggests that about 2/3^{rds} of the charge time is spent on the "charge plateau" (between points M and O) and about the last 1/3rd of the charge time is spent in the "finishing phase" (between points O and P). What we found is that this is not always true.

The following four images illustrate what we discovered. These graphs have never been shown to the public before, and remain the copy righted, proprietary property of Energenx, Inc. In each case, the power level of the charger was the same, and the discharge before the charge that is graphed is also the same, representing driving the Golf Cart for 6 miles.

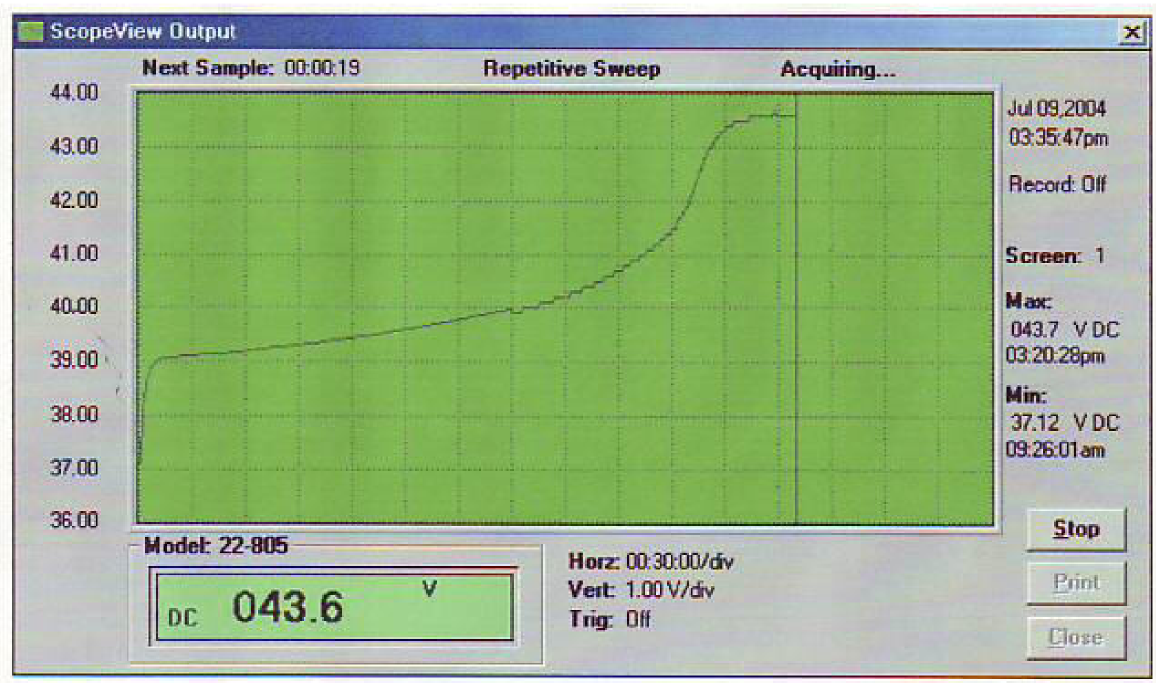
So, here is the first image, taken of the finished charging graph on Thursday, July 8, 2004. The major horizontal grid (left to right) shows time elapsed in 30 minutes per division. The major vertical grid (down to up) shows battery voltage as 1 volt per division, indicated on the left column.



Golf Cart Driven 6 miles and put on Charger.
Charge Profile on Thursday, July 8, 2004. Voltage Tops in just about 6 hours.

Point M is established in about 10 minutes. Point O occurs at about 4 hours. Point P happens at about 6 hours. So this graph generally follows the rule.

The next example is the graph produced from the test run on Friday, July 9, 2004. Again, point M is established in about 10 minutes. Point O occurs at about 4 hours, and point P happens at 5 hours and 45 minutes.

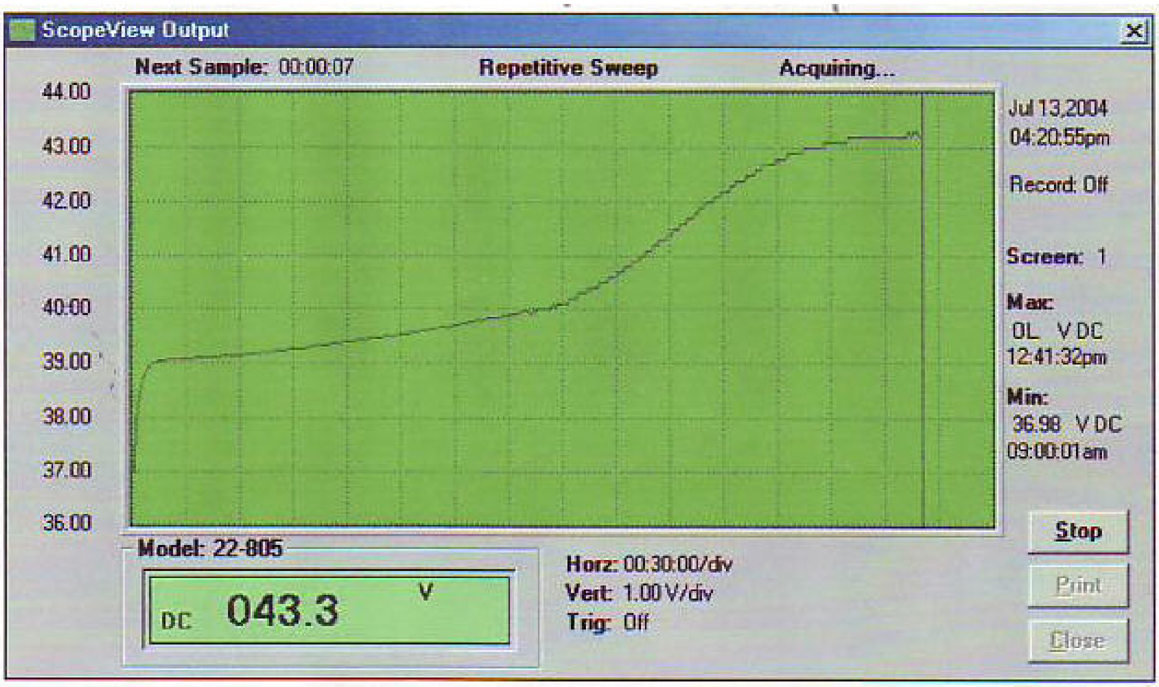


Golf Cart Driven 6 miles and put on Charger.
Charge Profile on Friday, July 9, 2004. Voltage Tops in a little under 6 hours.

These two graphs look very similar, and are, in fact, showing a slight increase in the efficiency of the battery. Mind you, the batteries in this Golf Cart were 13 years old, having been purchased in 1991. They had been considered "dead" twice before these tests, but were obviously responding quite well to these experiments.

You may also have noticed that the vertical rise of the voltage near the end of the charge is much steeper than the graph on page 49 indicates. Up to this time, we had noticed some variation in the "finishing time" of the charge, but since we were also changing the power level of the charger under development, we had not yet considered these different charge characteristics significant. Right at this time, we were presented with a 3 day weekend. So, on Tuesday, July 13, 2004, we drove the Golf Cart 6 miles in the morning and put it on the charger for the rest of the day.

Here is the graph that was generated that day.



Golf Cart Driven 6 miles and put on Charger. Charge Profile on Tuesday, July 13, 2004, after a three day weekend. Voltage takes 7 hours and 15 minutes to Top.

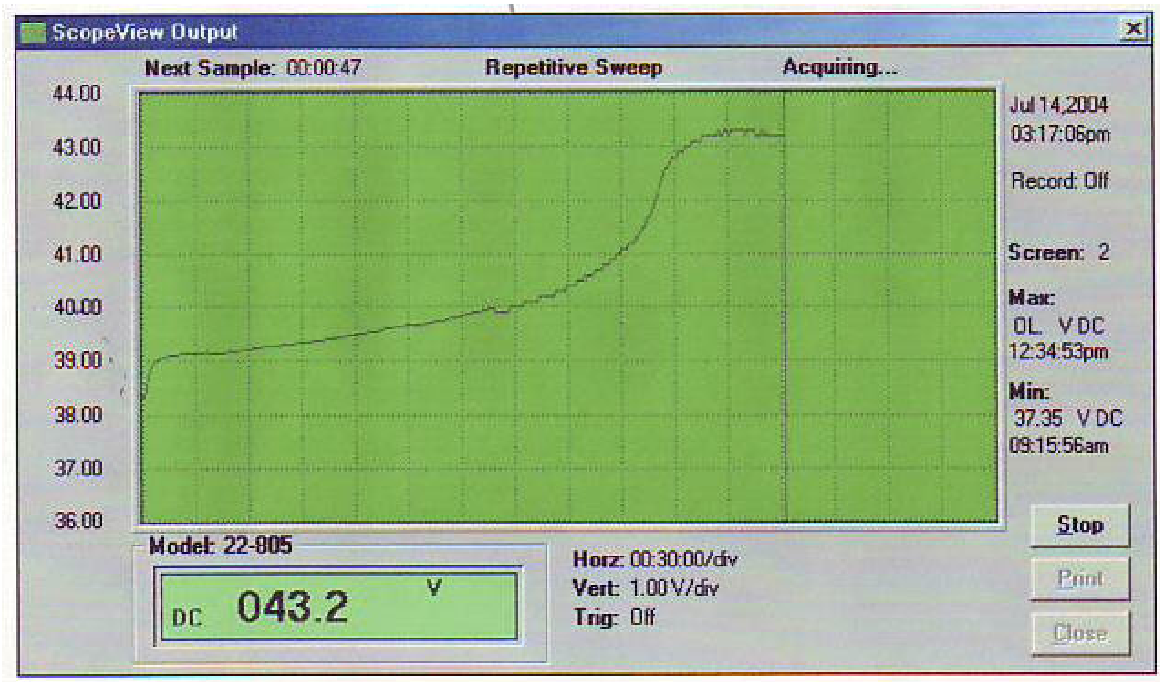
Point M is established in about 10 minutes. Point O occurs at about 4 hours. But now the "finishing phase" of the charge has changed! Point P does not happen until about 7 hours and 15 minutes into the charge cycle.

Neither the discharge amount nor the charge rate of the charger have changed from the two previous cycles. But clearly, something has changed in the battery requiring it to take another hour and 15 minutes to finish charging. The question is….WHAT has changed?

In the two previous cycles, it looked like the battery was recovering, and actually charging in less time, so this graph looked like something "bad" had happened. On Tuesday evening, we were confused, not really knowing what we were looking at.

So, on Wednesday, July 14, 2004, we repeated the experiment again. We drove the Golf Cart for 6 miles and put it on the charger all day.

Here is the graph that was generated that day.



Golf Cart Driven 6 miles and put on Charger.
Charge Profile on Wednesday, July 14, 2004. Voltage Tops in about 5½ hours.

Point M is established in about 10 minutes. Point O occurs at about 3 hours and 45 minutes. Point P happens at 5 hours and 30 minutes. So, the long "finishing phase" has disappeared again, and it is back to looking like the battery continues to recover and is charging in less time. The battery is also topping at a lower voltage, suggesting a drop in impedance (a good thing).

Over the course of the summer, this pattern repeated itself consistently. When the battery was charged and used the next day (about 16 hours rest) the finishing phase was shortest. When there was one day off in-between the charge and the next discharge (40 hours), the finishing phase started becoming longer. With two days off (64 hours) the finishing phase grew longer still. With 3 days off (88 hours) the finishing phase was like the graph on page 53. With 4 days off (over 100 hours) the time it took to finish a charge cycle maxed out. Any further delays in using the battery did NOT increase the charge time required to finish the charge. Whatever allowed the battery to finish its charge early seemed to dissipate in about 100 hours.

The questions remained. What were we looking at? What caused the finishing time to vary? Up to this time, I had been a vocal proponent for the "chemical explanation" of what was going on in the battery. But this phenomena seemed to defy logic. There seemed to be no reasonable chemical explanation that made any sense.

First of all, this finishing time variation did not occur when the battery was charged using conventional methods. At least, we had never seen it. We had also never seen it reported in the literature. We had to ask ourselves whether we were looking at a new battery behavior elicited by the charging method we were experimenting with? At that point, we didn't know.

Here is what we do know now:

1. This phenomena shows up when batteries are charged with either capacitive or inductive discharges.
2. This phenomena does not show up when batteries are charged by rectified transformer outputs or by DC power supplies.
3. This is the nature of the "conditioning" that is required to maximize the over-all efficiency of an SG Energizer.
4. This "conditioning" is temporary, as it dissipates within 100 hours.
5. It demonstrates why the machines that are cycled continuously outperform the ones that are tested or worked on "once in a while".

The bottom line is this. If you take the total time the battery took to reach its "topping voltage" in the last two graphs (pages 53 and 54) the battery took 24.2% less time to charge on July 14th than it did on July 13th. This is a huge difference in the amount of electrical energy applied to the battery, especially considering that the end result of the chemical state of charge is identical in both cases.

In chapters two and three of this book, I have discussed the idea that electricity can exhibit "inertial properties" under certain circumstances. John and I were confronted with the possibility that this was another "unmeterable" presentation of these effects. We didn't know, but there was one more phenomena that routinely showed up that helped shed some light on this.

Before we learned about how the charge in a battery "finished" and topped out at a maximum voltage, John had seen another phenomena. It first showed up in his experiments with the "G-field generator" developed by Raymond Kromrey. Later, the same phenomena was strongly apparent from the SG Energizers.

During the last phase of charging, after the voltage had risen to 13.5 and above, a strange thing happened. If the battery was disconnected from the charger, the voltage did NOT drop very quickly. I have personally seen batteries take over 90 minutes to drop from 14 volts down to the normal resting voltage of 12.6. When charged by a conventional charger, the excess voltage of the battery will drop down to 12.6 volts in a few minutes.

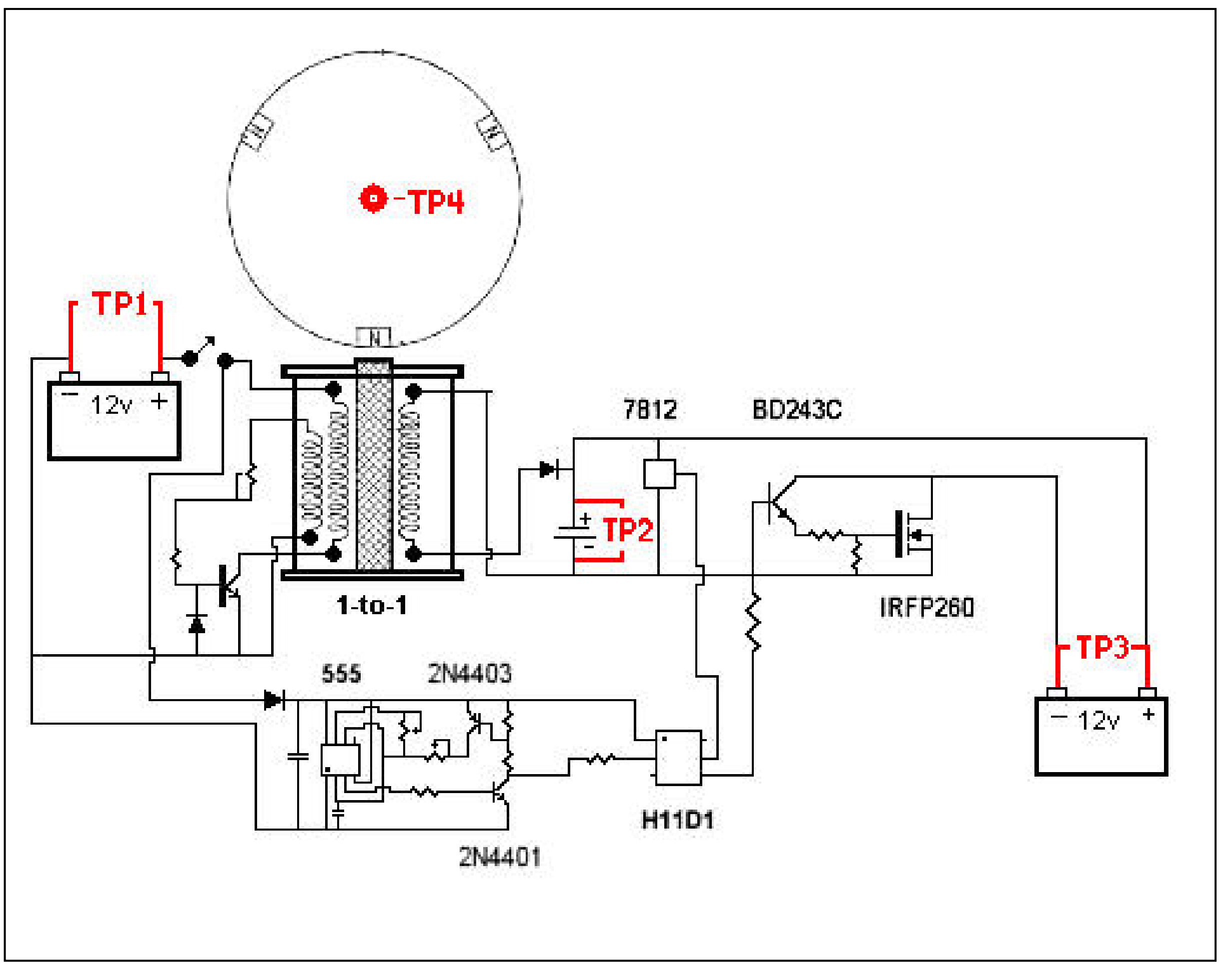
This tendency for the voltage of the battery to sustain itself, well above the normal resting voltage, lead us to believe that the battery continued to charge ITSELF even after it was disconnected from the charger. This idea was also supported by the fact that the cells continued to "off-gas" (produce hydrogen) during this period! John coined the term "over-potentializing the electrolyte" in an attempt to explain this process.

There was no "chemical" explanation for any of this! We were seeing significant, unmeterable benefits in the battery charging process that no standard chemical or electrical theory could explain. Currently, we believe that this "self-charging" process is the pre-cursor to the shorter "finishing phase" of the charge illustrated on pages 51, 52, and 54.

This only shows up when the batteries are charged in ways that release the inertial properties of electricity. This can be called "Radiant Energy", phi-dot current, electrostatic potential, longitudinal waves, or a host of other names. What it is called is not important. What is important is that this phenomena is REAL, and that it provides a number of battery charging benefits that cannot be quantified by standard methods or meters.

Measuring Input vs Output

Now that you are able to minimize the energy going into your Bedini SG Energizer and maximize the energy coming out of it, the time has come to seriously look at ***MEASURING*** these values. The various places in the circuit where power gains and energy gains show up have already been explained to you. So this is how John measures the energy functions of the machine to arrive at a reasonable COP rating.



The image above shows four "test points", labeled 1, 2, 3, and 4.

These are the locations where meaningful data can be gathered in your attempt to understand the **REAL** energy economy of your Bedini SG Energizer. These locations are:

1. The Input Battery
2. The Output Capacitor
3. The Output Battery
4. The Output Shaft of the Wheel

Measuring Inputs:

The energy Input to the machine is the easiest to measure and understand. Test Point #1 represents the idea of measuring all electricity that leaves the "run battery" during operation of the SG Energizer. It can be as simple as an:

1. Analog Volt Meter across the battery terminals, and an
2. Analog Amp Meter located where the "ON/OFF switch is shown

For basic measurements, these devices work quite well and are usually about 98% accurate. Even though the Amp Meter is measuring intermittent current in pulses, analog meters do a respectable job of "averaging" these values and giving a continuous reading of that average.

For more accurate readings, a dual trace oscilloscope can be used with one channel monitoring the voltage across the battery and the second channel monitoring the voltage drop across a calibrated resistor, placed where the ON/OFF switch is. A second option for current measurement is to use a calibrated "current probe" plugged into channel two of the scope.

Which ever method you use, it will measure "all electrical inputs" including all of the electricity used by the SG oscillator as well as all of the electricity used by the 555 timer circuit. This represents 100% of the energy you are required to put into the machine in order for it to operate. Nothing else is required EXCEPT the small amount of mechanical energy needed to start the wheel spinning. This small mechanical input is usually disregarded in the over-all calculations, but is mentioned here, to be accurate.

Measuring Outputs:

There are two basic outputs from operating the SG oscillator. Both are consequences of the current moving in the Main Coil. The first output is produced when the magnetic field is present, and that is the mechanical energy that turns the Wheel. The second output is produced when that magnetic field collapses and is the high voltage spike that charges the capacitor. So, let's look at the electrical output first. We'll get back to the mechanical energy a little later.

The nature of the inductive collapse is quite controversial and measuring its precise energy quantity is difficult, even with extremely high speed oscilloscopes. So, the first place in the circuit where the energy quantity can be seen and measured is at Test Point #2, which is at the capacitor.

Test Point #2:

The energy in a capacitor can be measured in Joules and is equal to one half of the capacitance, rated in Farads, times the voltage squared. The formula looks like this:

$$E = \tfrac{1}{2}\, C\, V^2$$

If you place an oscilloscope across the capacitor, you can watch the voltage rising and dropping as it charges and discharges. Two calculations can be made for the energy stored in the capacitor. One for how much energy is in the capacitor when its voltage is lowest, and one for when its voltage is highest. The difference is how much energy it is delivering to the battery during each discharge. The last piece of significant information is: how many times is the capacitor discharging into the battery per second?

So, one Joule is equal to one Watt-second. The first calculation will tell you how many Joules are delivered to the battery in one capacitor discharge, and the second calculation will tell you how many discharges per second. When these are multiplied together, you get how many Joules per second the system is delivering to the battery.

So, this first Output measurement is measured in Joules per second, or Watt-seconds per second. The seconds cancel out, and so the numerical value of the calculation is in the units of Watts.

The Input was measured in volts times amps equals watts, and now our first Output measurement is also measured in watt-seconds per second equals watts. So this gives us our first, reasonable comparison point.

Efficiency is usually defined as the ratio of the Output divided by the Input producing a decimal fraction. When this decimal is multiplied by 100, the efficiency can be presented in it's usual percentage form.

$$\frac{\textbf{OUTPUT in Watts}}{\textbf{INPUT in Watts}} \mathbf{\times 100 = 50\%} \text{ (or whatever)}$$

When the SG Energizer is operated in the Attraction Mode and the capacitor has low leakage, a 50% measurement here is quite good. When the SG Energizer is operated in the Repulsion Mode and the capacitor has low leakage, a 35% measurement is more typical.

There is one point here that should not be forgotten. Any voltage reading taken at the capacitor can NOT determine how much of that voltage charge is coming from the coil and how much is coming from the "temporary electret effect" in the capacitor. So, in spite of our attempts to quantify the electrical energy being recovered directly from the magnetic field collapse, we still don't know, exactly. No matter how carefully we measure these voltages and calculate these energy movements, there is a factor here that we cannot quantify without a much more complicated procedure.

Test Point #3:

The end of the circuit is the Output Battery. This is the battery being charged by the circuit, and its "state of charge" is the last and most important indicator of the "efficiency" of the machine. From the last step, we have a fairly "accurate" measurement of how much electrical energy we are delivering to the Output Battery. The voltage reading on the Output Battery is Test Point #3. However, during the charging process, the moment to moment voltage reading is not enough information to determine the instantaneous "state of charge" of the battery. There is actually only ONE PLACE where we really know the "state of charge" of the battery, and that is at the END of the charge, when the voltage tops out indicating that the chemistry is "finished".

All other measurement points on the battery are relative. That includes:

1. the resting voltage
2. the specific gravity of the electrolyte
3. the temperature, and
4. the internal impedance

Only when the voltage tops out does the battery "tell us" that there is nothing else we can do to increase its charge. This is the only reliable and <u>absolute indicator</u> of the "state of charge" of the battery.

And again….(harp, harp)….. the fully charged state in the battery is a CHEMICAL STATE where the negative plate is composed entirely of sponge lead, the positive plate is composed entirely of lead-peroxide, and the electrolyte is composed entirely of water and sulfuric acid (H_2SO_4).

The ***IDEA*** that it takes a specific quantity of electricity to create this chemical state in the battery goes back to the published work of Michael Faraday in 1840. While this published work was monumental in its day, the ordinary behavior of your Bedini SG Energizer clearly demonstrates that Faraday's methods and conclusions <u>**did not define all there is to know about this phenomena**</u>. Chapter Six of this book shows some of the strongest evidence ever published that there are here-to-fore unreported qualities in electricity that can greatly modify Faraday's results.

From an electrical point of view, there is nothing you can do to estimate "how well" the battery is charging during the process. All you can do, is determine exactly when the charge process is finished!

Test Point #4:

The only other Output from the machine is the mechanical energy that turns the wheel. This mechanical energy must be measured mechanically using a dynamometer. Complete directions on how to build a small, fractional horse-power dynamometer are given on this educational film:

http://www.youtube.com/watch?v=Zox7EnafQmE

For Bedini SG Energizers running on the Repulsion Mode, mechanical energy production is about 28% of electrical input. For models running on the Attraction Mode, mechanical energy production can be closer to 35%. This is at least true for the models with the bicycle wheel, ceramic #8 magnets and a multi-winding coil, like the design specified in the Beginner's Handbook.

In the next part of this series, **Bedini SG, The Complete Advanced Handbook**, we will explore the methods to convert this mechanical energy back into more electricity, to charge the back battery even more. But for this stage of the work, quantifying the energy on the wheel with a dynamometer is as far as we go.

Other Factors:

OK, we have discussed the most logical Test Points on the machine. One other set of conditions that are easy to identify are the places in the circuit where there are obvious losses of energy back to the environment. Technically, these are all Outputs that can be measured and added to the final efficiency calculations. They include:

1. heat at the main switching transistors
2. heat at the capacitor discharge MOSFETS
3. heat generated anywhere else in any other circuit components
4. I^2R losses, hysteresis in the coil core material, noise
5. air moved by the fan and the wheel spokes

Each of these represent energy produced by the system that cannot be recycled and reused. So, any gain seen in the operation of the Energizer is more than making up for these outputs (losses), as well.

Measurement Realities:

As you can see, it is possible to measure a number of energy movements through the machine. Remarkably, none of the Output measurements give any real clue about how quickly the second battery is charging. Most "self-respecting scientists" taking measurements on your Bedini SG Energizer at the Input (Test Point #1) and at the Output (Test Point #3) would easily determine the efficiency at 50% or less, and quickly dismiss any rumors of COP>1 operation as existing somewhere in the realm between "mistaken" and "delusional."

The bottom line is this. None of us who have been involved with John's invention for a long time know how to measure the efficiency of the complete system when the measurements are taken <u>on the machine</u>. All the simple measurements of the Input and Output, that we know how to take and calculate correctly, lead to erroneous conclusions about the real energy economy of the system.

John has always said that it is the machine's effect on the Battery that leads to the understanding of the energy gain in the system. The only thing we know for sure is how to cycle the batteries and recognize when the battery being charged is finished. All other anomalies lead to the recognition that we still do not know "what electricity is" and therefore do not presume to understand all of its behaviors.

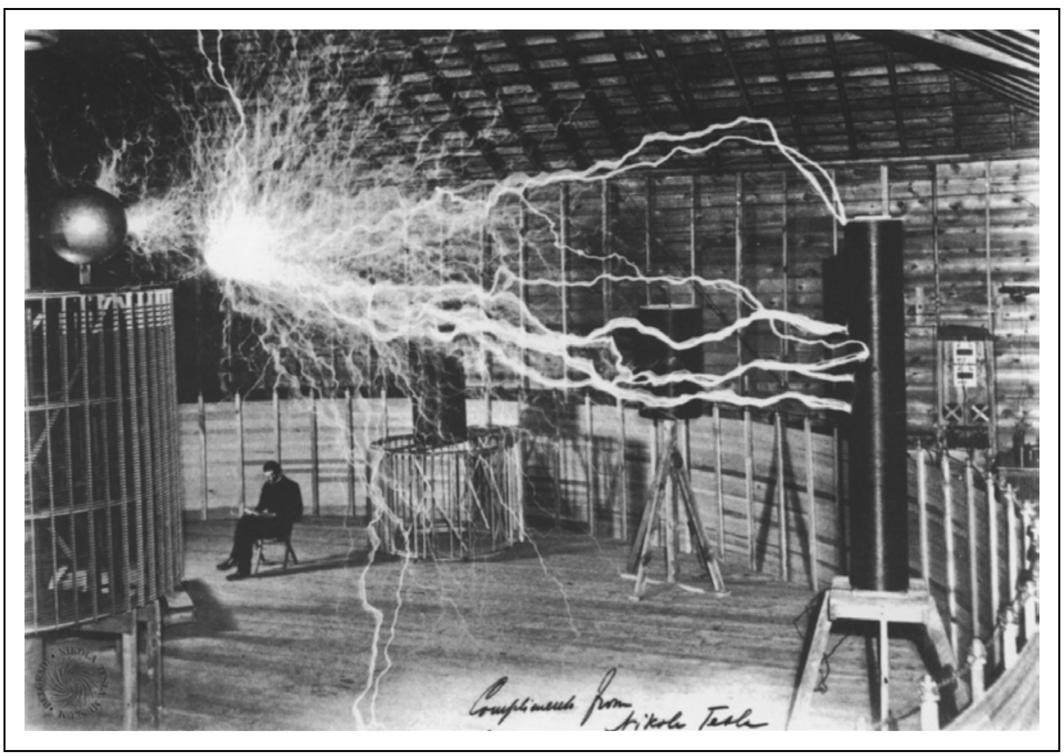
It is still a good exercise to do learn how to do all of these measurements, so when the next "expert" shows up and tells you you're crazy, you can show him he's right!

Chapter Eight

Summary and Conclusions

"The day when we shall know exactly what 'electricity' is, will chronicle an event probably greater, more important than any other recorded in the history of the human race."

Nikola Tesla wrote those words in 1893 and spent the better part of his life exploring the nature of electrical phenomena. During this period of discovery, he found a way to transform a relatively low voltage, low current, high impedance supply of electricity into a relatively high voltage, high current, low impedance source of rapidly repeating impulses. With this new "Method of Conversion" Tesla could expend modest amounts of electrical energy to produce some of the most colossal displays of electrical phenomena ever achieved.



Using only coils, capacitors, spark disrupters and high speed rotating contactors, Tesla was able to demonstrate behaviors in electricity that very few people know anything about today. And because he was limited to these relatively primitive circuit control mechanisms, he was also limited to demonstrating these effects at relatively high voltage.

Even so, he did identify a number of significant combinations of components that produce their "magic" at almost any voltage levels, high or low. This simple combination of electrical components includes a coil of wire that is operated on an intermittent supply of direct current (DC) so that the coil is magnetized and de-magnetized in a rapid sequence. The electrical energy returning to the circuit from the de-magnetization of the coil is then directed to charge a capacitor.

This capacitor is built in such a way as to be susceptible to the particular qualities inherent in the energy coming from the coil. In particular, I refer to his use of Bees Wax in the dielectric of the capacitor, which tends to be able to store electrostatic stress and partially recharge itself after discharge.

Once charged, the capacitor is then discharged into a circuit of low impedance, so that its entire charge may be expended in an extremely short period of time. As this process is repeated with only short intervals in-between, it produces a longitudinal wave-front of electric energy that can propagate down a single wire with no return, like sound waves traveling through the air from their source to the next listener. By 1899, he had proved that he could use the earth itself as that "single wire" and propagate electricity to any location he wanted to by a method he called "wireless."

By 1900, he still didn't possess a complete understanding of electricity, but he did feel confident to say this in a published article:

"Whatever electricity may be, it is a fact that it behaves like an incompressible fluid and the earth may be looked upon as an immense reservoir of electricity."

By the time he proved that high levels of electrical energy could be distributed to any location on the earth, with no means of ever being metered, he was black listed by the industrial bankers and his work was never financed again. We will never know what else this great genius could have accomplished if his work had been allowed to continue.

Summary:

In the last 35 years, through a process of exhaustive experimental research, John Bedini rediscovered most of Tesla's anomalous findings about the true nature of electricity. But this time, these electrical properties were being demonstrated at very low voltages and with table top devices.

John also made two significant additional discoveries to Tesla's primary methodology. John found that when the coil was being magnetized, it could also attract a magnet, producing mechanical energy. He also discovered that if the low impedance load the capacitor was discharged into was a battery, that a whole new set of electrical behaviors appeared.

The Bedini SG Energizer is a miniature model of Tesla's Method of Conversion with an added mechanical output and enhanced battery charging capabilities. Tesla was interested in industrial scale effects, so he never tried to use his methods for these applications. This is why John was granted a patent on the Mono-pole Motor, because no one had ever done it before!

In the guise of a simple toy, the Bedini SG Energizer boldly demonstrates that electricity has properties that are generally unrecognized by today's scientific community. By running thousands of experiments over decades of time, by keeping impeccable lab notes in bound volumes, by building one anomalous effect after another, John has given us the fruit of his labors.

The Bedini SG Energizer accomplishes the following. It takes a small amount of electricity from the first battery and uses it to magnetize a coil of wire. As the coil magnetizes, it attracts a magnet on a wheel, and produces a manifestation of mechanical energy. Then, the electricity coming from the battery is interrupted. This event ends the energy input to the machine.

The magnetic field in the coil then collapses and discharges a form of electricity into the capacitor that has a number of different ***qualities*** than the form of electricity that came from the battery. This form of electricity has a very high value of "voltage potential" and is sometimes referred to here as having a component of "static electricity". This is the so-called "mass free" charge, radiant energy, Phi-Dot current, or whatever else you want to call it. It is a product of the unrestricted magnetic field collapse.

When THIS type of electricity is used to charge a capacitor, it has the added ability to build up a temporary stress in the dielectric material that has a certain time-constant. We have referred to this as the "temporary electret effect." This ***quality*** in the electricity is not recognized by today's scientific standards and therefore passes to the capacitor unseen, unmeasured, and unacknowledged. Properly configured capacitors can store this quality in the electricity to partially re-establish their own voltage charge after discharge, but also pass this quality along with the rest of the electricity to the load operating on the discharges.

When this quality in the electricity is transferred to the battery, it also helps the battery raise its own potential. This is seen as the battery continuing to charge after the system is disconnected, as well as the battery moving through its "finishing phase" of the charge in much less time than normal.

So, as John would say: "That's the trick!" What really makes the system work with a COP>1 is not measurable, which is exactly what John has said all along. There has never been any attempt to mislead you or to hide the process. Gathering the evidence and developing the language to convey these ideas has, in some ways, been more difficult than developing the technology itself.

John, Aaron and Peter really hope you can appreciate this.

Conclusion:

When you have applied all of this information to your Bedini SG Energizer model, you will have a machine whose performance will rival any model that John has built for himself. You will also understand the technology at a level that far exceeds what you could have learned by studying the information on the Internet discussion forums or from any other website.

If you actually build the machine, run it and test it, and learn what it is teaching you, you will rapidly be approaching the "inner circle" of those "in the know" concerning this astonishing technology.

Thank you for wanting to learn this material. By doing so, you are helping to build a better future.

Part 3 of this series, **Bedini SG, The Complete Advanced Handbook**, will finish the project of documenting this technology. It will cover the methods of converting the mechanical energy of the wheel into more electricity to maximize the electric energy gain of the system.

Projected publishing date is late 2013.

Chapter Nine

Modifications Checklist

Here is a quick list of the modifications to your Bedini SG Energizer suggested in this book.

Minimizing Energy Input:

Basic Tuning:

- Replace 470 ohm base resistors with 100 ohm base resistors
- Add 1K, 1 watt potentiometer
- Tune operation for lowest current draw for highest wheel speed

Fine Tuning:

- Build Transistor Testing Circuit
- Test Transistors
- Find Matching Set of 7 Transistors
- Test 100 ohm Resistors
- Find Matching Set of 7 100 ohm Resistors
- Make sure that all wires in the coil have the identical length
- Install new Transistors and Base Resistors in your SG circuit
- Install 1K, 1 watt potentiometer in the Trigger loop
- Tune operation for lowest current draw for highest wheel speed

Reducing Mechanical Losses

- Re-align and re-balance wheel, if necessary
- Clean bearings and re-lubricate with light oil
- Re-adjust distance between magnets and top of coil, if needed

Build and Install Capacitor Discharge Circuit

- Make complete list of parts needed (with extras of major parts)
- Purchase all parts needed
- Assemble Timer Section
- Test Timer Section for Proper Function
- Assemble Capacitor Section
- Test MOSFETs with Transistor Tester
- Find as many Matching MOSFETs as your Circuit Needs
- Assemble Capacitor Discharge Section of Circuit
- Don't forget Heat Sinks on the MOSFETs
- Install Capacitor Discharge Circuit between SG output and battery
- Test Completed Capacitor Discharge Circuit

Other Issues

- Measure all Inputs and Outputs (for your own edification)
- Keep Good Notes on both Energizer and Battery performance
- Always Use Good Batteries and Run Continuously for Best Results

Study Tesla's Method of Conversion

- On Light and other High Frequency Phenomena
- US Patent #462,418 (included in the Appendices)
- US Patent #568,178 (included in the Appendices)
- Dr. Lindemann's Lecture "Tesla's Radiant Energy" now available at: http://teslasradiantenergy.com (Highly recommended)

Appendices

United States Patents issued to Nikola Tesla:

United States Patent issued to Raymond Kromrey:

Article:

On Light and Other High Frequency Phenomena
Link: Tesla's Article

Other Resources:

Electronic Parts

Mouser Electronics http://www.mouser.com
Radio Shack http://www.radioshack.com

A&P Electronic Media

Home of the Best Collection of Information Products on the Planet! http://www.emediapress.com

Tesla Chargers

Home of "ready to use" battery chargers designed by John Bedini http://teslachargers.com

(No Model.)

N. TESLA.

METHOD OF AND APPARATUS FOR ELECTRICAL CONVERSION AND DISTRIBUTION.

No. 462,418. Patented Nov. 3, 1891.

Fig. 1

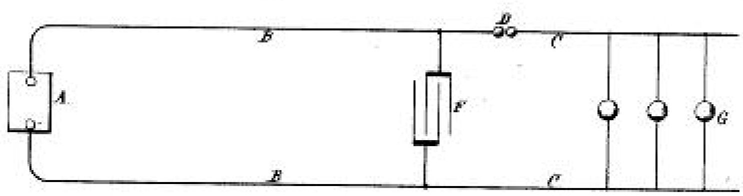
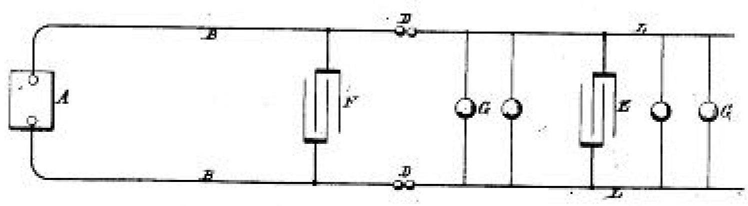


Fig. 2



Witnesses:
Raphael Netter
Frank B. Murphy

Inventor
Nikola Tesla
by Duncan & Page.
Attorneys.

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

METHOD OF AND APPARATUS FOR ELECTRICAL CONVERSION AND DISTRIBUTION.

SPECIFICATION forming part of Letters Patent No. 462,418, dated November 3, 1891.

Application filed February 4, 1891. Serial No. 380,182. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a subject of the Emperor of Austria, from Smiljan, Lika, border country of Austria-Hungary, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Methods of and Apparatus for Electrical Conversion and Distribution, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

This invention is an improvement in methods of and apparatus for electrical conversion, designed for the better and more economical distribution and application of electrical energy for general useful purposes.

My invention is based on certain electrical phenomena which have been observed by eminent scientists and recognized as due to laws which have been in a measure demonstrated, but which, so far as I am aware, have not hitherto been utilized or applied with any practically useful results. Stated briefly, these phenomena are as follows: First, if a condenser or conductor possessing capacity be charged from a suitable generator and discharged through a circuit, the discharge under certain conditions will be of an intermittent or oscillatory character; second, if two points in an electric circuit through which a current rapidly rising and falling in strength is made to flow be connected with the plates or armatures of a condenser, a variation in the current's strength in the entire circuit or in a portion of the same only may be produced; third, the amount or character of such variation in the current's strength is dependent upon the condenser capacity, the self-induction and resistance of the circuit or its sections, and the period or time rate of change of the current. It may be observed, however, that these several factors—the capacity, the self-induction, resistance, and period—are all related in a manner well understood by electricians; but to render such conversion as may be effected by condensers practically available and useful it is desirable, chiefly on account of the increased output and efficiency and reduced cost of the apparatus, to produce current-impulses succeeding each other with very great rapidity, or, in other words, to render the duration of each impulse, alternation, or oscillation of the current extremely small. To the many difficulties in the way of effecting this mechanically, as by means of rotating switches or interrupters, is perhaps due the failure to realize practically, at least to any marked degree, the advantages of which such a system is capable. To obviate these difficulties, I have in my present invention taken advantage of the fact above referred to, and which has been long recognized, that if a condenser or a conductor possessing capacity be charged from a suitable source and be discharged through a circuit the discharge under certain conditions, dependent on the capacity of the condenser or conductor, the self-induction and resistance of the discharging circuit, and the rate of supply and decay of the electrical energy, may be effected intermittently or in the form of oscillations of extremely small period.

Briefly stated in general terms, the plan which I pursue in carrying out my invention is as follows:

I employ a generator, preferably, of very high tension and capable of yielding either direct or alternating currents. This generator I connect up with a condenser or conductor of some capacity and discharge the accumulated electrical energy disruptively through an air-space or otherwise into a working circuit containing translating devices and, when required, condensers. These discharges may be of the same direction or alternating and intermittent, succeeding each other more or less rapidly or oscillating to and fro with extreme rapidity. In the working circuit, by reason of the condenser action, the current impulses or discharges of high tension and small volume are converted into currents of lower tension and greater volume. The production and application of a current of such rapid oscillations or alternations (the number may be many millions per second) secures, among others, the following exceptional advantages: First, the capacity of the condensers for a given output is much diminished; second, the efficiency of the condensers is increased and the tendency to become heated reduced, and, third, the range of conversion is enlarged. I have thus succeeded in producing a system or method of conversion radically different from what has been done heretofore—first, with respect to the number of impulses, alternations, or oscillations of current per unit of time, and, second, with respect to the manner in which the impulses are obtained. To express this result, I define the working current as one of an excessively small period or of an excessively large number of impulses or alternations or oscillations per unit of time, by which I mean not a thousand or even twenty or thirty thousand per second, but many times that number, and one which is made intermittent, alternating, or oscillating of itself without the employment of mechanical devices.

I now proceed to an explanation somewhat more in detail of the nature of my invention, referring to the accompanying drawings.

The two figures are diagrams, each representing a generating-circuit, a working circuit, means for producing an intermittent or oscillating discharge, and condensers arranged or combined as contemplated by my invention.

In Figure 1, A represents a generator of high tension; B B, the conductors which lead out from the same. To these conductors are connected the conductors C of a working circuit containing translating devices, such as incandescent lamps or motors G. In one or both conductors B is a break D, the two ends being separated by an air-space or a film of insulation, through which a disruptive discharge takes place. F is a condenser, the plates of which are connected to the generating-circuit. If this circuit possess itself sufficient capacity, the condenser F may be dispensed with.

In Fig. 2 the generating-circuit B B contains a condenser F and discharges through the air-gaps D into the working circuit C, to any two points of which is connected a condenser E. The condenser E is used to modify the current in any part of the working circuit, such as L.

It may conduce to a better understanding of the invention to consider more in detail the conditions existing in such a system as is illustrated in Fig. 1. Let it be assumed, therefore, that in the system there shown the rate of supply of the electrical energy, the capacity, self-induction, and the resistance of the circuits are so related that a disruptive, intermittent, or oscillating discharge occurs at D. Assume that the first-named takes place. This will evidently occur when the rate of supply from the generator is not adequate to the capacity of the generator, conductors B B, and condenser F. Each time the condenser F is charged to such an extent that the potential or accumulated charge overcomes the dielectric strength of the insulating-space at D the condenser is discharged. It is then recharged from the generator A, and this process is repeated in more or less rapid succession. The discharges will follow each other the more rapidly the more nearly the rate of supply from the generator equals the rate at which the circuit including the generator is capable of taking up and getting rid of the energy. Since the resistance and self-induction of the working circuit C and the rapidity of the successive discharges may be varied at will, the current strength in the working and generating circuit may bear to one another any desired relation.

To understand the action of the local condenser E in Fig. 2, let a single discharge be first considered. This discharge has two paths offered—one to the condenser E, the other through the part L of the working circuit C. The part L, however, by virtue of its self-induction, offers a strong opposition to such a sudden discharge, while the condenser, on the other hand, offers no such opposition. The result is that practically no current passes at first through the branch L, but presumably opposite electricities rush to the condenser-coatings, this storing for the moment electrical energy in the condenser. Time is gained by this means, and the condenser then discharges through the branch L, this process being repeated for each discharge occurring at D. The amount of electrical energy stored in the condenser at each charge is dependent upon the capacity of the condenser and the potential of its plates. It is evident, therefore, that the quicker the discharges succeed each other the smaller for a given output need be the capacity of the condenser and the greater is also the efficiency of the condenser. This is confirmed by practical results.

The discharges occurring at D, as stated, may be of the same direction or may be alternating, and in the former case the devices contained in the working circuit may be traversed by currents of the same or alternately-opposite direction. It may be observed, however, that each intermittent discharge occurring at D may consist of a number of oscillations in the working circuit or branch L.

A periodically-oscillating discharge will occur at D in Fig. 1 when the quantities concerned bear a certain relation expressed in well-known formulæ and ascertained by simple experiment. In this case it is demonstrated in theory and practice that the ratio of the strength of the current in the working to that in the generating circuits is the greater the greater the self-induction, and the smaller the resistance of the working circuit the smaller the period of oscillation.

I do not limit myself to the use of any specific forms of the apparatus described in connection with this invention nor to the precise arrangement of the system with respect to its details herein shown. In the drawings return-wires are shown in the circuit; but it will be understood that in any case the ground may be conveniently used in lieu of the return-wire.

What I claim is—

1. The method of electrical conversion herein described, which consists in charging a con-

denser or conductor possessing capacity and maintaining a succession of intermittent or oscillating disruptive discharges of said conductor into a working circuit containing translating devices.

2. In a system of electrical conversion, the combination of a generator or source of electricity and a line or generating circuit containing a condenser or possessing capacity, and a working circuit operatively connected with the generating-circuit through one or more air-gaps or breaks in the conducting medium, the electrical conditions being so adjusted that an intermittent or oscillating disruptive discharge from the generating into the working circuit will be maintained, as set forth.

NIKOLA TESLA.

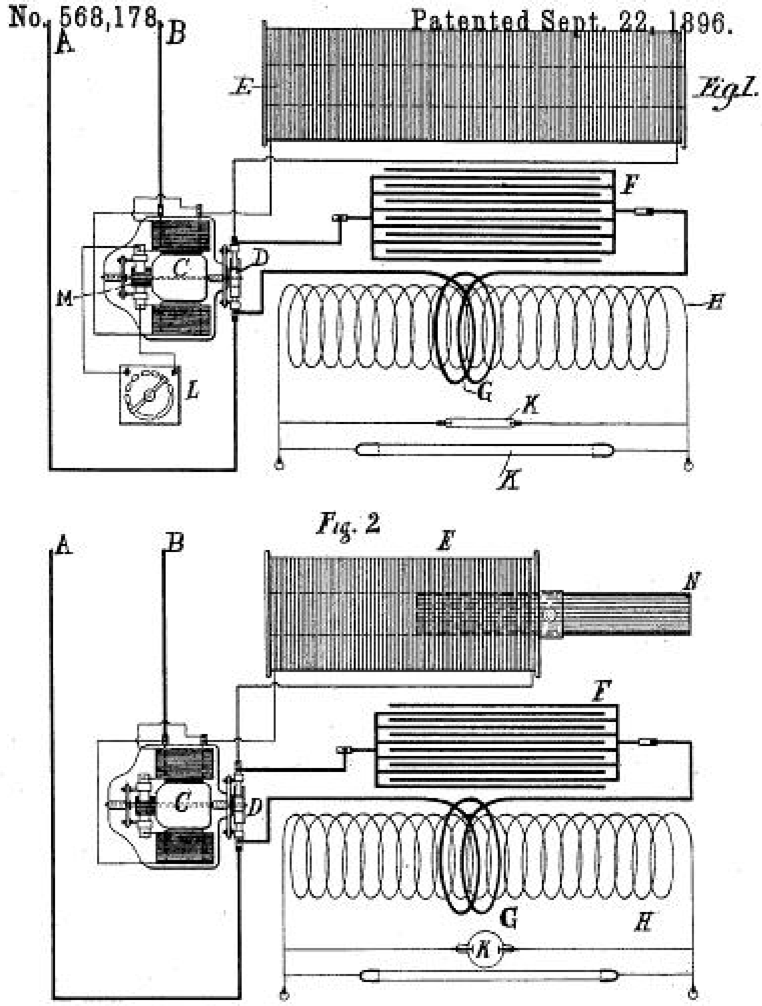
Witnesses:
ROBT. F. GAYLORD,
PARKER W. PAGE.

(No Model.) 2 Sheets—Sheet 1.

N. TESLA.

METHOD OF REGULATING APPARATUS FOR PRODUCING CURRENTS OF HIGH FREQUENCY.

No. 568,178. Patented Sept. 22, 1896.



WITNESSES

Edwin B. Hopkinson
M. Lawson Dyer.

INVENTOR

Nikola Tesla

BY

Kerr, Curtis & Page

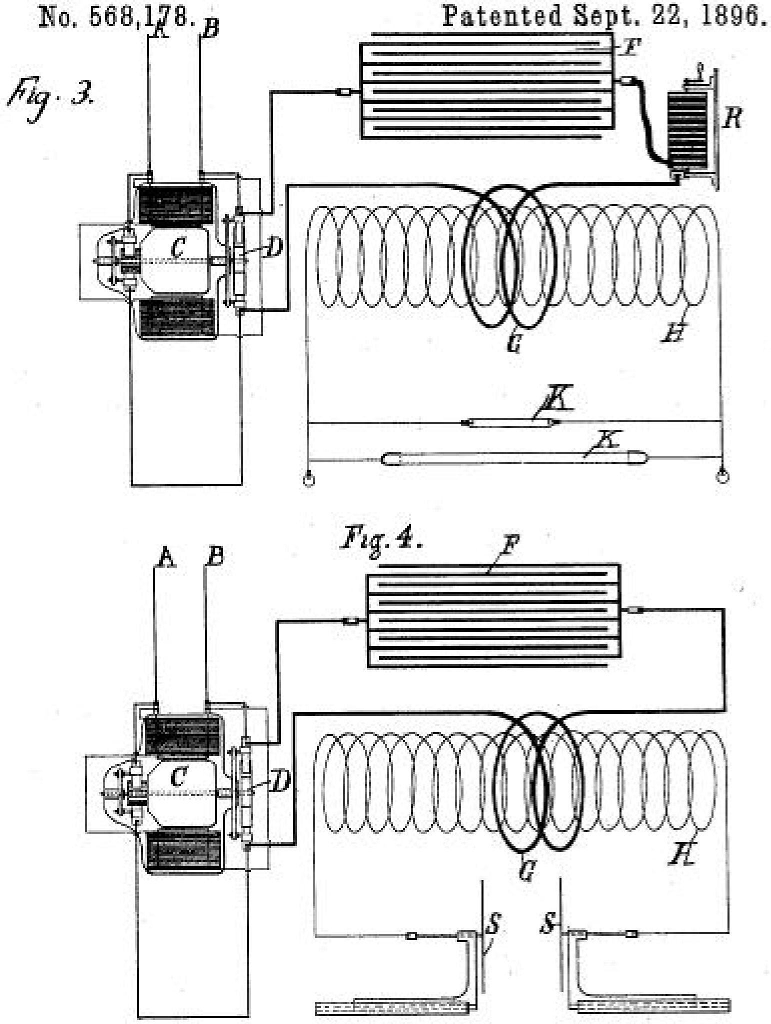
ATTORNEYS

(No Model.) 2 Sheets—Sheet 2.

N. TESLA.

METHOD OF REGULATING APPARATUS FOR PRODUCING CURRENTS OF HIGH FREQUENCY.

No. 568,178. Patented Sept. 22, 1896.



WITNESSES
Edwin B. Hopkinson,
M. Lawson Dyer.

INVENTOR
Nikola Tesla
BY
Kerr, Curtis & Page
ATTORNEYS

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

METHOD OF REGULATING APPARATUS FOR PRODUCING CURRENTS OF HIGH FREQUENCY.

SPECIFICATION forming part of Letters Patent No. 568,178, dated September 22, 1896.

Application filed June 20, 1896. Serial No. 596,262. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Methods of Regulating Apparatus for Producing Currents of High Frequency, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

In previous patents and applications I have shown and described a method of and apparatus for generating electric currents of high frequency suitable for the production of various novel phenomena, such as illumination by means of vacuum-tubes, the production of ozone, Roentgen shadows, and other purposes. The special apparatus of this character which I have devised for use with circuits carrying currents in the nature of those classed as direct, or such as are generally obtainable from the ordinary circuits used in municipal systems of incandescent lighting, is based upon the following principles:

The energy of the direct-current supply is periodically directed into and stored in a circuit of relatively high self-induction, and in such form is employed to charge a condenser or circuit of capacity, which, in turn, is caused to discharge through a circuit of low self-induction containing means whereby the intermittent current of discharge is raised to the potential necessary for producing any desired effect.

Considering the conditions necessary for the attainment of these results, there will be found, as the essential elements of the system, the supply-circuit, from which the periodic impulses are obtained, and what may be regarded as the local circuits, comprising the circuit of high self-induction for charging the condenser and the circuit of low self-induction into which the condenser discharges and which itself may constitute the working circuit, or that containing the devices for utilizing the current, or may be inductively related to a secondary circuit which constitutes the working circuit proper. These several circuits, it will be understood, may be more or less interconnected; but for purposes of illustration they may be regarded as practically distinct, with a circuit-controller for alternately connecting the condenser with the circuit by which it is charged and with that into which it discharges, and with a primary of a transformer in the latter circuit having its secondary in that which contains the devices operated by the current.

To this system or combination the invention, subject of my present application, pertains, and has for its object to provide a proper and economical means of regulation therefor.

It is well known that every electric circuit, provided its ohmic resistance does not exceed certain definite limits, has a period of vibration of its own analogous to the period of vibration of a weighted spring. In order to alternately charge a given circuit of this character by periodic impulses impressed upon it and to discharge it most effectively, the frequency of the impressed impulses should bear a definite relation to the frequency of vibration possessed by the circuit itself. Moreover, for like reasons the period or vibration of the discharge-circuit should bear a similar relation to the impressed impulses or the period of the charging-circuit. When the conditions are such that the general law of harmonic vibrations is followed, the circuits are said to be in resonance or in electromagnetic synchronism, and this condition I have found in my system to be highly advantageous. Hence in practice I adjust the electrical constants of the circuits so that in normal operation this condition of resonance is approximately attained. To accomplish this, the number of impulses of current directed into the charging-circuit per unit time is made equal to the period of the charging-circuit itself, or, generally, to a harmonic thereof, and the same relations are maintained between the charging and discharge circuit. Any departure from this condition will result in a decreased output, and this fact I take advantage of in regulating such output by varying the frequencies of the impulses or vibrations in the several circuits.

Inasmuch as the period of any given circuit depends upon the relations of its resistance, self-induction, and capacity, a variation of any one or more of these may result in a variation in its period. There are therefore various ways in which the frequencies of vibration of the several circuits in the system referred to may be varied, but the most practicable and efficient ways of accomplishing the desired result are the following: (*a*) varying the rate of the impressed impulses of current, or those which are directed from the source of supply into the charging-circuit, as by varying the speed of the commutator or other circuit-controller; (*b*) varying the self-induction of the charging-circuit; (*c*) varying the self-induction or capacity of the discharge-circuit.

To regulate the output of a single circuit which has no vibration of its own by merely varying its period would evidently require, for any extended range of regulation, a very wide range of variation of period; but in the system described a very wide range of regulation of the output may be obtained by a very slight change of the frequency of one of the circuits when the above-mentioned rules are observed.

In illustration of my invention I have shown by diagrams in the accompanying drawings some of the more practicable means for carrying out the same. The figures, as stated, are diagrammatic illustrations of the system in its typical form provided with regulating devices of different specific character. These diagrams will be described in detail in their order.

In each of the figures, A B designate the conductors of a supply-circuit of continuous current; C, a motor connected therewith in any of the usual ways and driving a current-controller D, which serves to alternately close the supply-circuit through the motor or through a self-induction coil E and to connect such motor-circuit with a condenser F, the circuit of which contains a primary coil G, in proximity to which is a secondary coil H, serving as the source of supply to the working circuit, or that in which are connected up the devices K K for utilizing the current.

The circuit-controller, it may be stated, is any device which will permit of a periodic charging of the condenser F by the energy of the supply-circuit and its discharging into a circuit of low self-induction supplying directly or indirectly the translating devices. Inasmuch as the source of supply is generally of low potential, it is undesirable to charge the condenser directly therefrom, as a condenser of large capacity will in such cases be required. I therefore employ a motor of high self-induction, or in place of or in addition to such motor a choking or self-induction coil E, to store up the energy of the supply-current directed into it and to deliver it in the form of a high-potential discharge when its circuit is interrupted and connected to the terminals of the condenser.

In order to secure the greatest efficiency in a system of this kind, it is essential, as I have before stated, that the circuits, which, mainly as a matter of convenience, I have designated as the "charging" and the "discharge" circuits, should be approximately in resonance or electromagnetic synchronism. Moreover, in order to obtain the greatest output from a given apparatus of this kind, it is desirable to maintain as high a frequency as possible.

The electrical conditions, which are now well understood, having been adjusted to secure, as far as practical considerations will permit, these results, I effect the regulation of the system by adjusting its elements so as to depart in a greater or less degree from the above conditions with a corresponding variation of output. For example, as in Figure 1, I may vary the speed of the motor, and consequently of the controller, in any suitable manner, as by means of a rheostat L in a shunt to such motor or by shifting the position of the brushes on the main commutator M of the motor or otherwise. A very slight variation in this respect, by disturbing the relations between the rate of impressed impulses and the vibration of the circuit of high self-induction into which they are directed, causes a marked departure from the condition of resonance and a corresponding reduction in the amount of energy delivered by the impressed impulses to the apparatus.

A similar result may be secured by modifying any of the constants of the local circuits, as above indicated. For example, in Fig. 2 the choking-coil E is shown as provided with an adjustable core N, by the movement of which into and out of the coil the self-induction, and consequently the period of the circuit containing such coil, may be varied.

As an example of the way in which the discharge-circuit, or that into which the condenser discharges, may be modified to produce the same result I have shown in Fig. 3 an adjustable self-induction coil R in the circuit with the condenser, by the adjustment of which the period of vibration of such circuit may be changed.

The same result would be secured by varying the capacity of the condenser; but if the condenser were of relatively large capacity this might be an objectionable plan, and a more practicable method is to employ a variable condenser in the secondary or working circuit, as shown in Fig. 4. As the potential in this circuit is raised to a high degree, a condenser of very small capacity may be employed, and if the two circuits, primary and secondary, are very intimately and closely connected the variation of capacity in the secondary is similar in its effects to the variation of the capacity of the condenser in the primary. I have illustrated as a means well adapted for this purpose two metallic plates S S, adjustable to and from each other and constituting the two armatures of the condenser.

I have confined the description herein to a source of supply of direct current, as to such the invention more particularly applies, but it will be understood that if the system be supplied by periodic impulses from any source which will effect the same results the regulation of the system may be effected by the method herein described, and this my claims are intended to include.

What I claim is—

1. The method of regulating the energy delivered by a system for the production of high-frequency currents and comprising a supply-circuit, a condenser, a circuit through which the same discharges and means for controlling the charging of the condenser by the supply-circuit and the discharging of the same, the said method consisting in varying the relations of the frequencies of the impulses in the circuits comprising the system, as set forth.

2. The method of regulating the energy delivered by a system for the production of high-frequency currents comprising a supply-circuit of direct currents, a condenser adapted to be charged by the supply-circuit and to discharge through another circuit, the said method consisting in varying the frequency of the impulses of current from the supply-circuit, as set forth.

3. The method of producing and regulating electric currents of high frequency which consists in directing impulses from a supply-circuit into a charging-circuit of high self-induction, charging a condenser by the accumulated energy of such charging-circuit, discharging the condenser through a circuit of low self-induction, raising the potential of the condenser discharge and varying the relations of the frequencies of the electrical impulses in the said circuits, as herein set forth.

NIKOLA TESLA.

Witnesses:
M. LAWSON DYER,
DRURY W. COOPER.

March 19, 1968 R. KROMREY 3,374,376

ELECTRIC GENERATOR

Filed Jan. 3, 1964 5 Sheets-Sheet 1

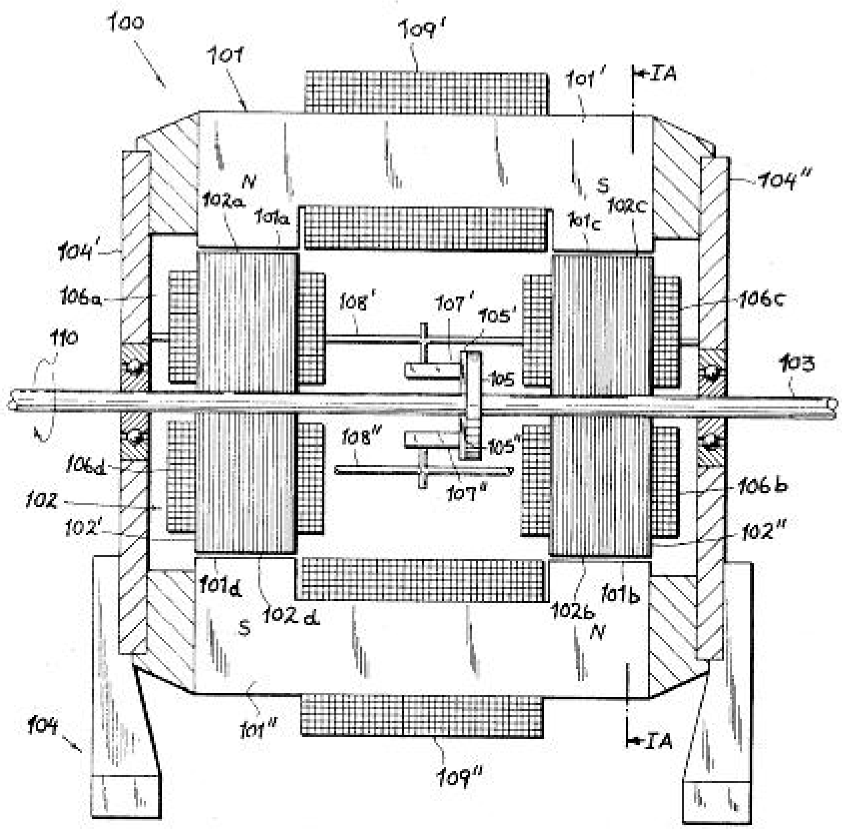


Fig.1

RAYMOND KROMREY
INVENTOR.

BY Karl G. Ross
AGENT

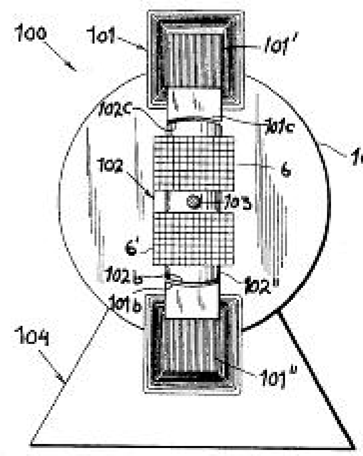


Fig.1A

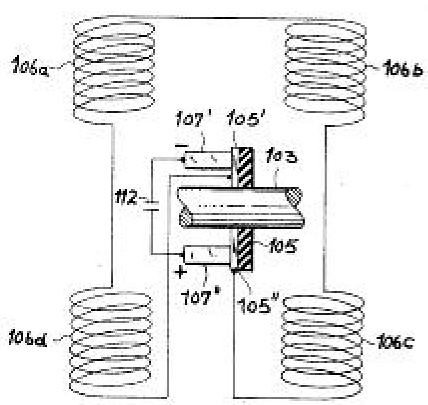


Fig.4

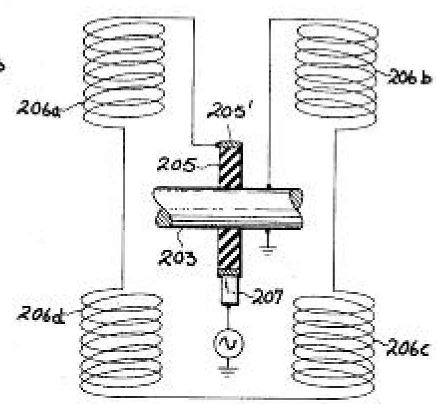


Fig.5

INVENTOR.
RAYMOND KROMREY

BY

AGENT

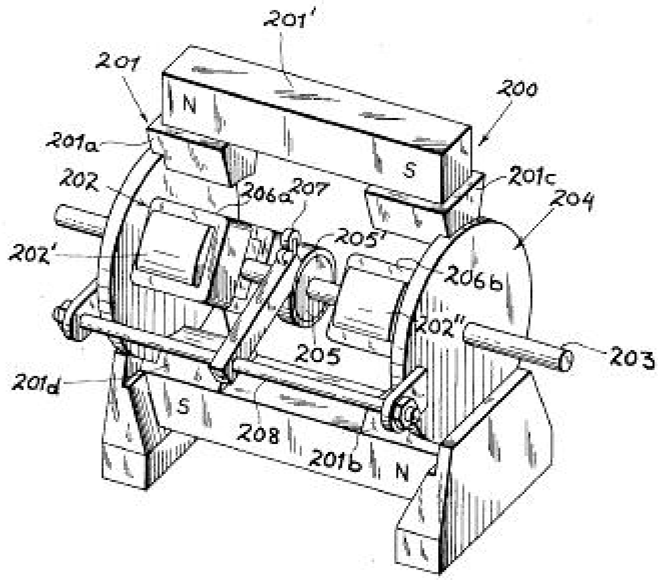


Fig.2

RAYMOND KROMREY
INVENTOR.

BY Karl G. Ross
AGENT

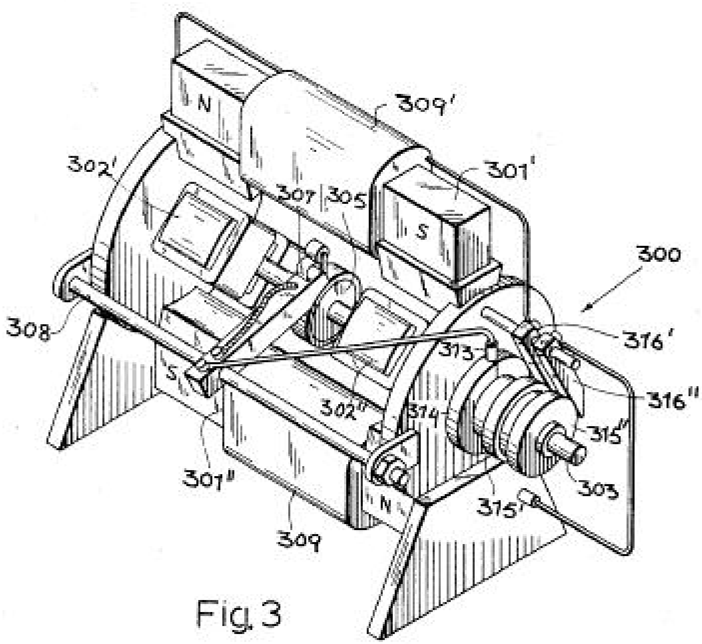


Fig. 3

RAYMOND KROMREY
INVENTOR.

BY Karl G. Ross
AGENT

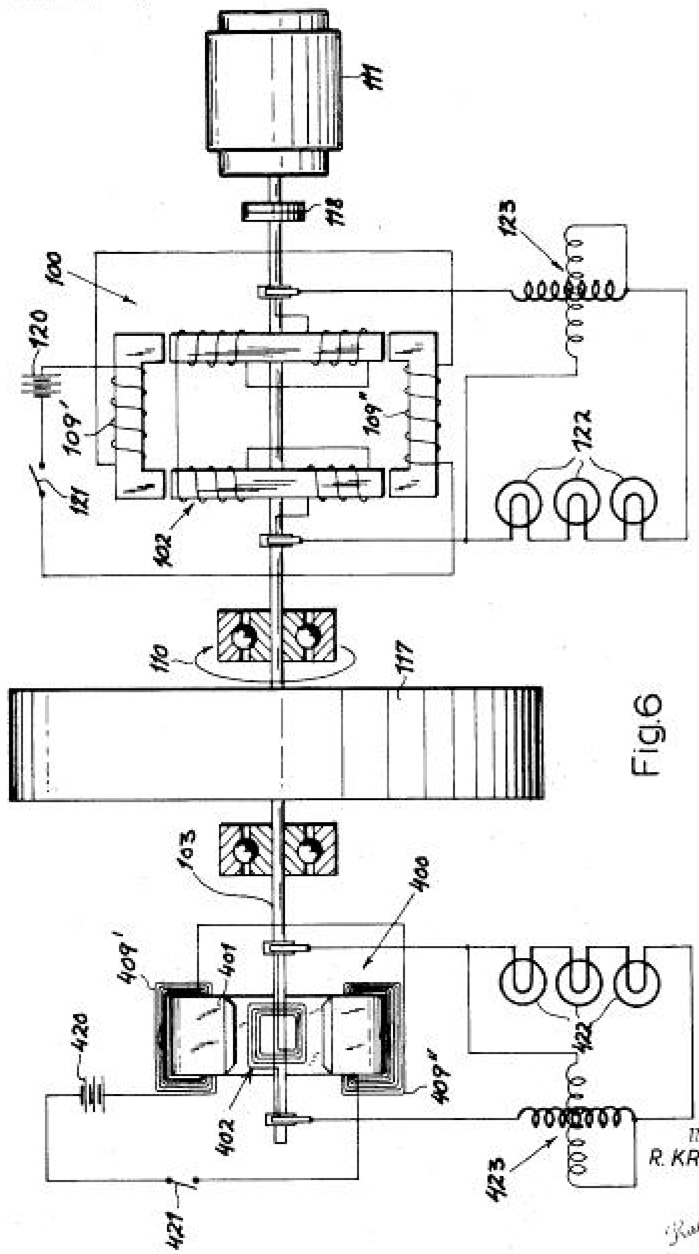


Fig.6

INVENTOR.
R. KROMREY
Karl G. Ross
AGENT

United States Patent Office

3,374,376
Patented Mar. 19, 1968

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3,374,376
ELECTRIC GENERATOR
Raymond Kromrey, 15 Rue du Mt. Blanc,
Geneva, Switzerland
Filed Jan. 9, 1964, Ser. No. 336,769
1 Claim. (Cl. 310—112)

My present invention relates to an electric generator serving to convert magnetic force into electric energy with the aid of two relatively rotatable members, i.e. a stator and a rotor, one of these members being provided with electromagnetic or permanent-magnetic means adapted to induce a voltage in a winding forming part of an output circuit on the other member.

Conventional generators of this type utilize a winding whose conductors form loops in different axial planes whereby, upon relative rotation of the two members, diametrically opposite portions of each loop pass twice per revolution through the field of each pole pair of the magnetic inductor member (usually the stator). If the loops are open-circuited, no current flows in the winding and no reaction torque is developed so that the rotor will be free to turn at the maximum speed of its driving unit. As soon as the output circuit including the winding is short-circuited or connected across a load, the resulting current flow tends to retard the motion of the rotor to an extent dependent upon the magnitude of the current, it being therefore necessary to provide compensating speed-regulating devices if it is desired to maintain a substantially constant terminal voltage. Moreover, the variable reaction torque subjects the rotor and its transmission to considerable mechanical stresses which, in the case of widely fluctuating load currents, may lead to objectionable strains.

It is, therefore, the general object of my present and new invention to provide an electric generator which obviates the aforedescribed disadvantages.

A more particular object of my invention is to provide a generator of such construction that its reaction torque and, therefore, its rotor speed in response to a given driving torque varies but little upon changeover from open circuit to current delivery or vice versa.

It is also an object of this invention to provide an electric generator whose terminal voltage varies at a considerably lesser rate than its rotor speed so as to be less affected than conventional generators by fluctuations of its driving rate.

I have found, in accordance with this invention, that the foregoing objects can be realized by the relative rotation of an elongated ferromagnetic element, such as a bar-shaped soft-iron armature, and a pair of pole pieces defining an air gap wherein a magnetic field is set up under the influence of a suitable source of coercive force. The armature carries a winding, advantageously in the form of two series-connected coils embracing opposite extremities thereof, which is included in an output circuit adapted to be connected to a load. As the armature rotates within the stationary air gap (or, conversely, the pole pieces swing about the stationary armature), the magnetic circuit is intermittently completed and the armature experiences periodic remagnetizations with successive reversals of polarity.

When the output circuit is open, the mechanical energy applied to the driven rotor member is converted, to the extent that it is not needed to overcome frictional resistance, into work of magnetization which in turn is dissipated as heat; in actual practice, however, the resultant rise in the temperature of the armature will be hardly noticeable, particularly if the armature is part of the continuously air-cooled rotor assembly. When the output circuit is closed, part of this work is translated into electrical

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energy as the current flow through the winding opposes the magnetizing action of the field and increases the apparent magnetic reluctance of the armature. This explains why, in a system embodying my invention, the speed of the generator remains substantially unchanged when the output circuit is either opened or closed.

As the armature approaches its position of alignment with the gap, the constant magnetic field existing thereacross tends to accelerate the rotation of the armature relative to the pole pieces, thereby aiding the applied driving torque; the opposite action, i.e. a retarding effect, occurs after the armature passes through its aligned position. As the rotor attains a certain speed, however, the flywheel effect of its mass overcomes these fluctuations in the total applied torque so that a smooth rotation ensues.

In a practical embodiment, according to a more specific feature of my invention, the magnetic-flux path includes two axially spaced magnetic fields traversing the rotor axis substantially at right angles, these fields being generated by respective pole pairs co-operating with two axially spaced armatures of the character described. It will generally be convenient to arrange the two armatures in a common axial plane, the two field-producing pole pairs being similarly coplanar. The armatures are preferably of the laminated type to minimize the flow of eddy currents therein; thus, they may consist in essence of highly permeable (e.g. soft-iron) foils whose principal dimension is perpendicular to the rotor axis, the foils being held together by rivets or other suitable fastening means.

If the ferromagnetic elements are part of the rotor, the output circuit will include the usual current-collecting means, such as slip rings or commutator segments, according to whether alternating or direct current is desired. The source of coercive force in the stator includes, advantageously, a pair of oppositely disposed yoke-shaped magnets, of the permanent or the electrically energized type, whose extremities constitute the aforementioned pole pieces. If electromagnets are used in the magnetic circuit, they may be energized by an external source or by direct current from the output circuit of the generator itself.

I have found that the terminal voltage of the output circuit of a generator according to the invention does not vary proportionately to the rotor speed, as might be expected, but drops at a considerably slower rate with decreasing speed of rotation; thus, in a particular unit tested, this voltage fell only to about half its original value upon a cutting of the rotor speed to one-third. This nonlinear relationship between terminal voltage and driving rate enables the maintenance of a substantially constant load current and, therefore, electric output over a wide speed range, at least under certain load conditions, inasmuch as the inductive reactance of the winding is proportional to frequency (and consequently to rotor speed) so as to drop off more rapidly than the terminal voltage, in the event of a speed reduction, with a resulting improvement in the power factor of the load circuit.

If the magnetic circuit includes but a single pole pair per air gap, the flux induced in the relatively rotating armature will change its direction twice per revolution so that each revolution produces one complete cycle of 360 electrical degrees. In general, the number of electrical degrees per revolution will equal 360 times the number of pole pairs, it being apparent that this number ought to be odd since with even numbers it would not be possible to have poles alternating in polarity along the path of the armature and also to have the north and south poles of each pair at diametrically opposite locations. In any case it is important to dimension the confronting arcuate faces of the pole pairs in such manner as to avoid bridging of adjoining poles by the armature, hence it behooves to make the sum of the arcs spanned by these faces (in the plane of rotation) equal to considerably less than 360° electrical.

The invention will be described hereinafter with greater detail, reference being made to the accompanying drawing in which:

FIGS. 1 and 1A illustrate a first embodiment of my invention in axial section and in a cross-sectional view taken on line 1A—1A of FIG. 1, respectively;

FIGS. 2 and 3 are perspective views illustrating two further embodiments;

FIGS. 4 and 5 diagrammatically illustrate two output circuits for a generator according to the invention, designed respectively for direct and alternating current; and

FIG. 6 is a somewhat diagrammatic illustration of an arrangement for comparing the outputs of a conventional generator and a generator according to the invention.

The generator **100** shown in FIGS. 1 and 1A comprises a stator member **101** and a rotor member **102**, the latter comprising a pair of laminated armatures **102'**, **102''** carried on a shaft **103** which is rotatably journaled in end plates **104'**, **104''** of a generator housing **104** of nonmagnetic material (e.g. aluminum) rigid with the stator. Shaft **103** is coupled with a source of driving power indicated diagrammatically by an arrow **110**.

The stator **101** includes a pair of yoke-shaped laminated electromagnets **101'**, **101''** whose extremities form two pairs of coplanar pole pieces respectively designated **101*a***, **101*b*** (north) and **101*c***, **101*d*** (south). The pole pieces have concave faces confronting complementarily convex faces **102*a***, **102*d*** of armature **102'** and **102*b***, **102*c*** of armature **102''**. These faces, whose concavities are all centered on the axis of shaft **103**, extend over arcs of approximately 20 to 25° each in the plane of rotation (FIG. 1A) so that the sum of these arcs adds up to about 90° geometrical and electrical.

The magnets **101'**, **101''** of the stator are surrounded by respective energizing windings **109'**, **109''** which are connected across a suitable source of constant direct current, not shown. Similar windings, each composed of two series-connected coils **106*a***, **106*d*** and **106*b***, **106*c***, surround the rotor armatures **102'** and **102''**, respectively. These coils form part of an output circuit which further includes a pair of brushes **107'**, **107''** that are carried by arms **108'**, **108''** on housing **104** with mutual insulation; brushes **107'**, **107''** co-operate with a pair of commutator segments **105'**, **105''** (see also FIG. 4) which are supported by a disk **105** of insulating material on shaft **103**. By virtue of the series connection of coils **106*a*–106*d*** between the segments **105'** and **105''**, as illustrated in FIG. 4, the alternating voltage induced in these coils gives rise to a rectified output voltage at brushes **107'** and **107''**; the unidirectional current delivered by these brushes to a load (not shown) may be smoothed, in a manner known per se, by conventional filter means represented diagrammatically by a condenser **112** in FIG. 4.

In FIG. 2 I have shown a modified generator **200** whose housing **204** supports a stator **201** consisting essentially of two permanent bar magnets **201'** and **201''** extending parallel to the drive shaft **203** on opposite sides thereof, each of these magnets being rigid with a respective pair of pole shoes **201*a***, **201*c*** and **201*b***, **201*d***. Rotor **202** comprises a pair of laminated armatures **202'**, **202''**, similar to those of the preceding embodiment, whose output coils **206*a***, **206*b***, **206*c***, **206*d*** are serially connected between a slip ring **205'**, supported on shaft **203** through the intermediary of an insulating disk **205**, and another terminal here represented by the grounded shaft **203** itself. Slip ring **205'** is contacted by a brush **207** on a holder **208**, the output of this brush being an alternating current of a frequency determined by the rotor speed.

In FIG. 3 I have shown a generator **300** basically similar to generator **100** of FIGS. 1 and 1A, its shaft

303 carrying a pair of laminated soft-iron armatures **302'**, **302''** rotatable in the air gaps of a pair of electromagnets **301'**, **301''** bearing energizing windings **309'** and **309''**. The commutator **305** again co-operates with a pair of brushes of which only one, designated **307**, is visible in the figure. This brush, carried on an arm **308**, is electrically connected to a brush **313** engaging a slip ring **314** on an extremity of shaft **303** which also carries two further slip rings **315'**, **315''** in conductive contact with ring **314** but insulated from the shaft. Two further brushes **316'**, **316''** contact the rings **315'**, **315''** and are respectively connected to windings **309'** and **309''**, respectively, the other ends of these windings being connected to an analogous system of brushes and slip rings on the opposite shaft extremity whereby the two commutator brushes are effectively bridged across the windings **309'** and **309''** in parallel. In this embodiment, therefore, the stator magnets are energized from the generator output itself, it being understood that the magnets **301'** and **301''** (made, for example, of steel rather than soft iron) will have a residual coercive force sufficient to induce an intial output voltage as is known per se. Naturally, the circuits leading from the brushes **307** to the windings **309'**, **309''** may include filter means as described in connection with FIG. 4.

In FIG. 6 I have shown a test circuit designed to compare the outputs of a generator according to the invention, such as the unit **100** of FIGS. 1 and 1A, with a conventional generator **400** of the type having a looped armature **402** rotatable in a gap of a stator magnet **401** with energizing winding **409'**, **409''**. The two generators are interconnected by a common shaft **103** carrying a flywheel **117**, this shaft being coupled via a clutch **118** to a drive motor **111** whereby the rotors **402** and **102** of both generators are rotatable in unison as indicated by arrow **110**. Two batteries **120** and **420**, in series with switches **121** and **421**, are representative of means for supplying direct current to the stator windings **109'**, **109''** and **409'**, **409''** of the two generators.

The rectified output of generator **100** is delivered to a load **122**, here shown as three series-connected incandescent lamps with a combined consumption of 500 watts, generator **400** working into an identical load **422**. Two wattmeters **123** and **423** have their voltage and current windings respectively connected in shunt and in series with the associated loads **122** and **422** to measure the electric power delivered by each generator.

Upon engagement of the clutch **118**, shaft **103** with its flywheel **117** is brought to an initial driving speed of 1200 r.p.m. whereupon the switch **421** in the energizing circuit of conventional generator **400** is closed. The lamps **422** light immediately and the corresponding wattmeter **423** shows an initial output of 500 watts; this output, however, drops instantly as the flywheel **117** is decelerated by the braking effect of the magnetic field upon armature **402**.

Next, the procedure is repeated but with switch **421** open and switch **121** closed to energize the generator **100**. The lamps **122** light up and the wattmeter **123** shows an output of 500 watts which remains constant for an indefinite period, there being no appreciable deceleration of flywheel **117**. When the clutch **118** is released and the rotor speed gradually decreases, the output of generator **100** is still substantially 500 watts at a speed of 900 r.p.m. and remains as high as 360 watts when the speed drops further to 600 r.p.m.

In a similar test with a generator of the permanent-magnet type, such as the one shown at **200** in FIG. 2, a substantially constant output was observed over a range of 1600 to 640 r.p.m.

Modifications of the specific arrangements described and illustrated will, of course, be apparent to persons skilled in the art and are deemed to be embraced in the spirit and scope of my invention as defined in the appended claim.

I claim:

1. An electric generator comprising a fixed stator and a rotor coaxial with said stator; drive means for rotating said rotor about its axis, said stator being provided with a pair of elongated bar magnets extending parallel to said axis on opposite sides thereof and terminating in transverse extremities, oppositely poled extremities of said magnets confronting each other and defining magnet means having two axially spaced pole pairs disposed in a common axial plane and forming a pair of diametrically extending air gaps for establishing a magnetic-flux path including two axially spaced parallel magnetic fields across said air gaps traversing said axis substantially at right angles, said rotor being provided with two axially spaced parallel elongated ferromagnetic elements slightly shorter than the spacing of said confronting extremities and extending perpendicularly to said axis at locations coplanar with said pole pairs for concurrent periodic alignment of said elements with said fields in said air gaps upon rotation of said rotor; and an output circuit on said rotor including winding means on each of said elements and collector means in series with said winding means, each of said pole pairs and the corresponding elements having confronting arcuate faces centered on said axis, the sum of the arcs spanned by said faces being substantially equal to 90° in the plane of rotation.

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MILTON O. HIRSHFIELD, *Primary Examiner.*

J. W. GIBBS, D. G. DUGGAN, *Assistant Examiners.*

Bedini SG, The Complete Intermediate Handbook

by Peter Lindemann and Aaron Murakami

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