Ignition Secrets by Aaron Murakami
2014 Energy Science & Technology Conference
http://ignitionsecrets.com

4 GENERAL IGNITION SYSTEMS

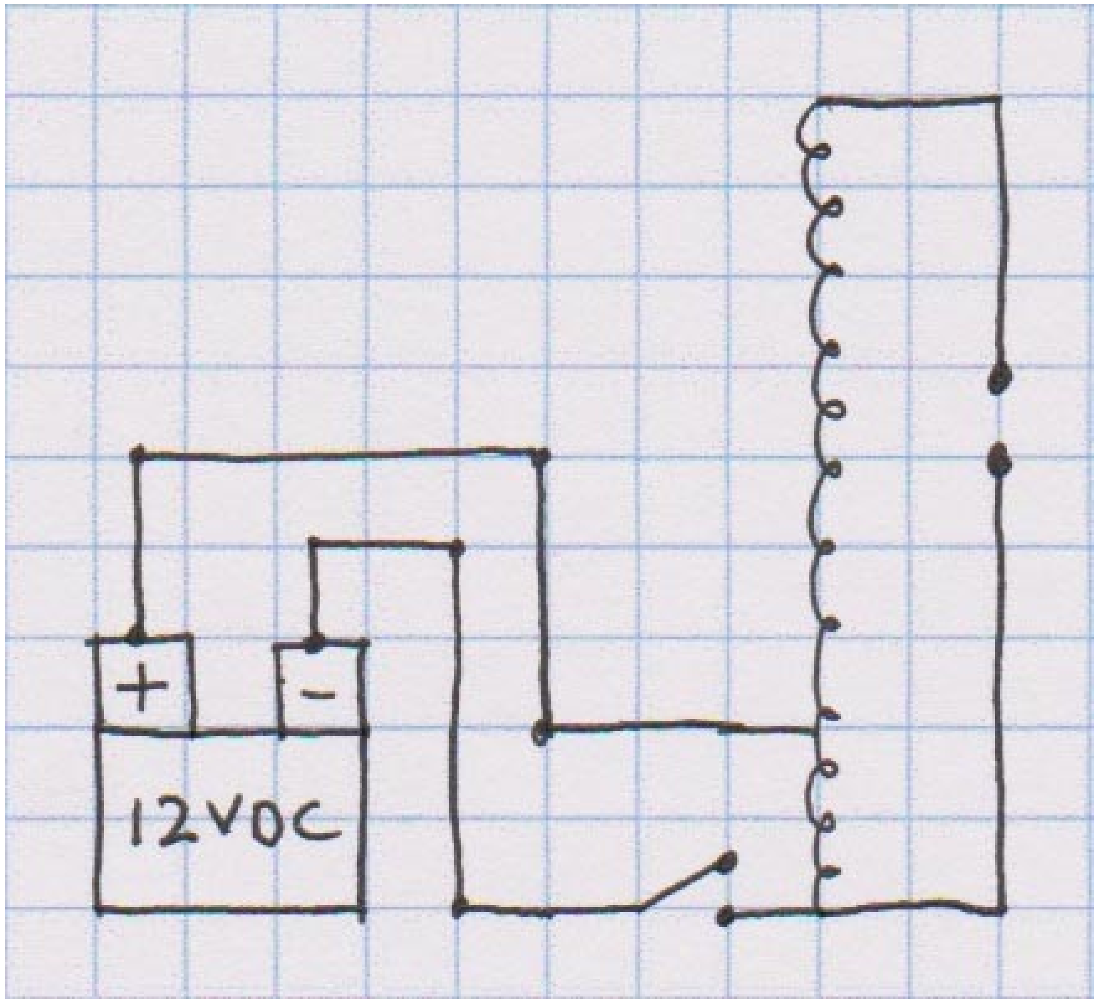
Kettering Spark Ignition

Peaking Capacitor

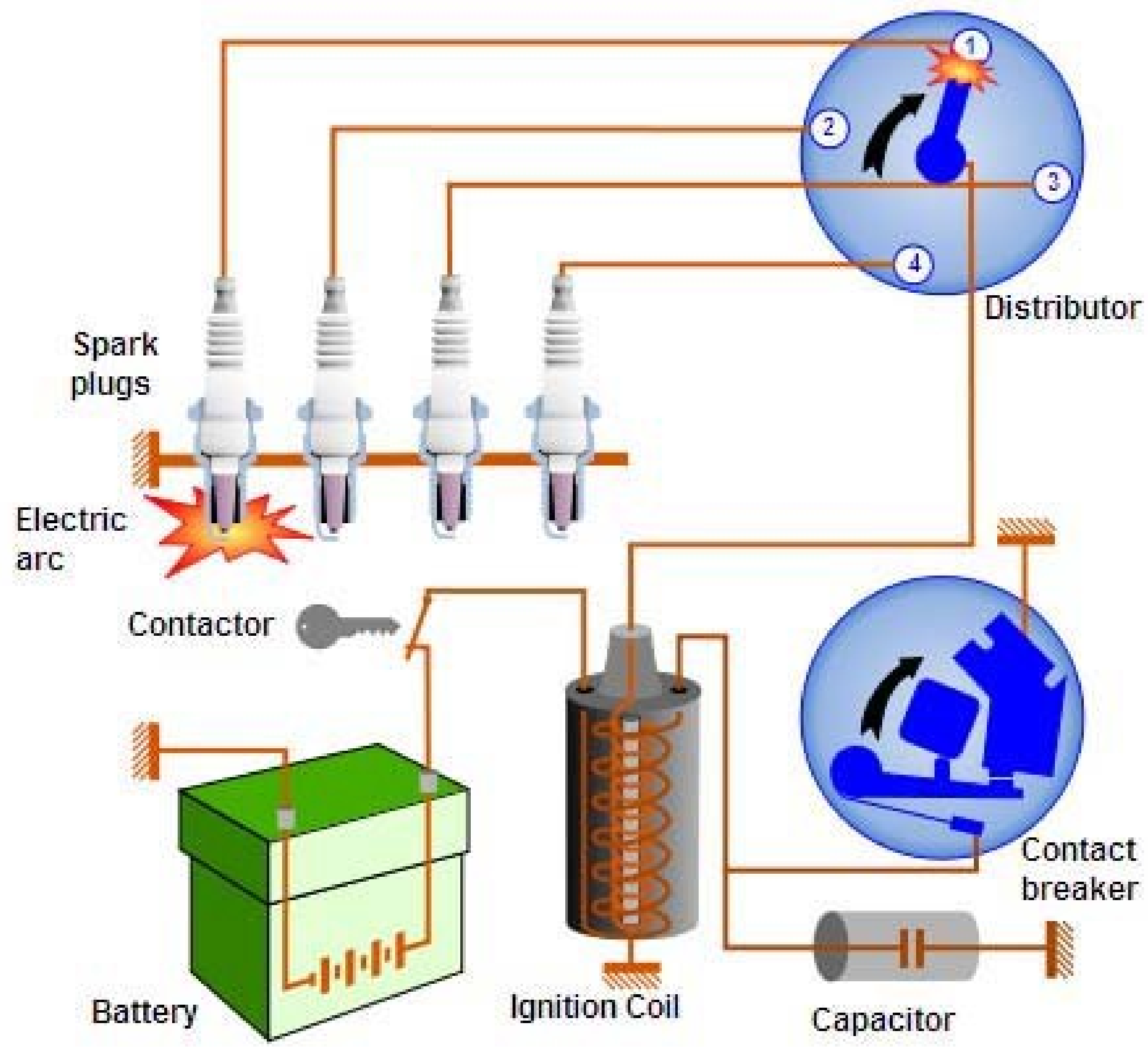
Capacitive Discharge Ignition

Plasma Jet Ignition

KETTERING SPARK IGNITION

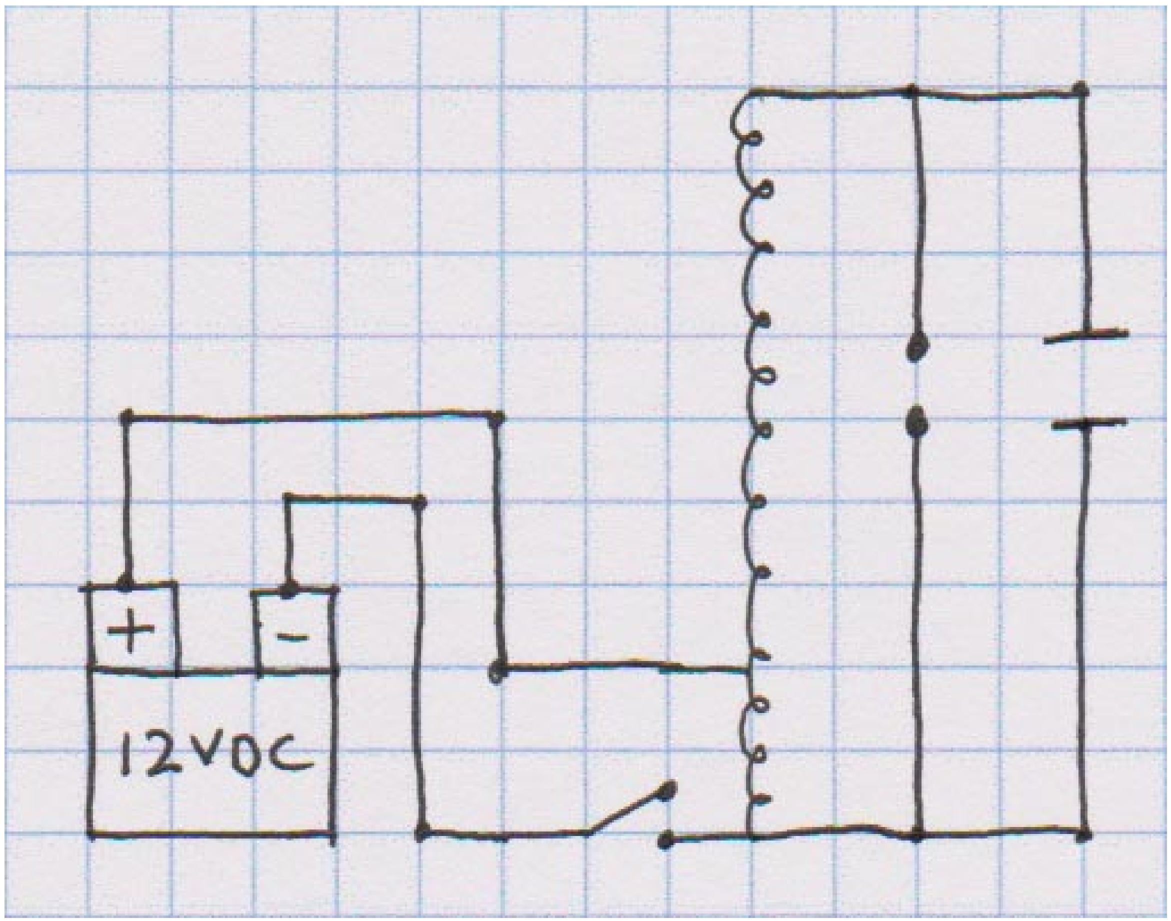


KETTERING SPARK IGNITION

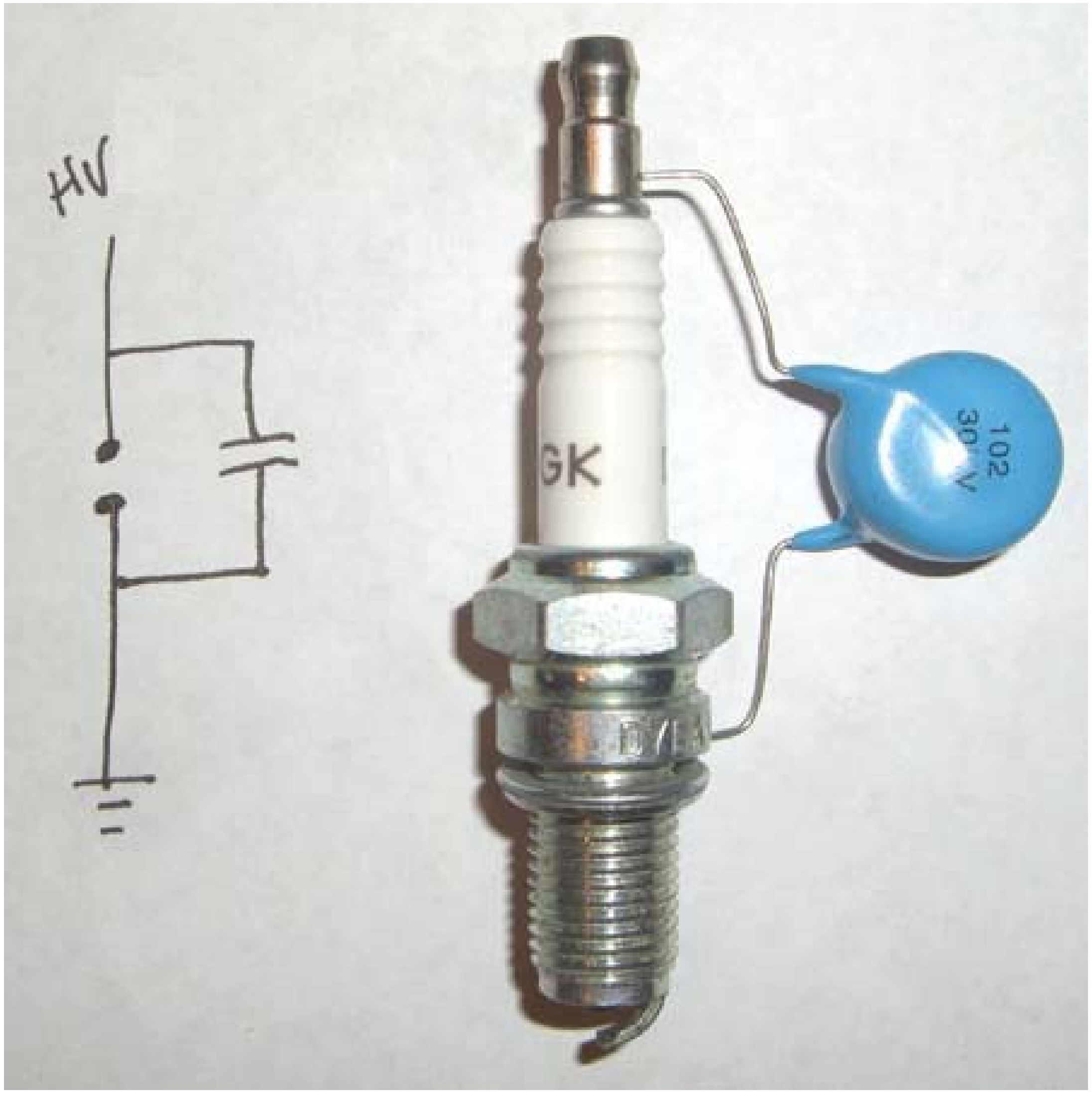


KETTERING SPARK IGNITION

PEAKING CAPACITORS



PEAKING CAPACITORS



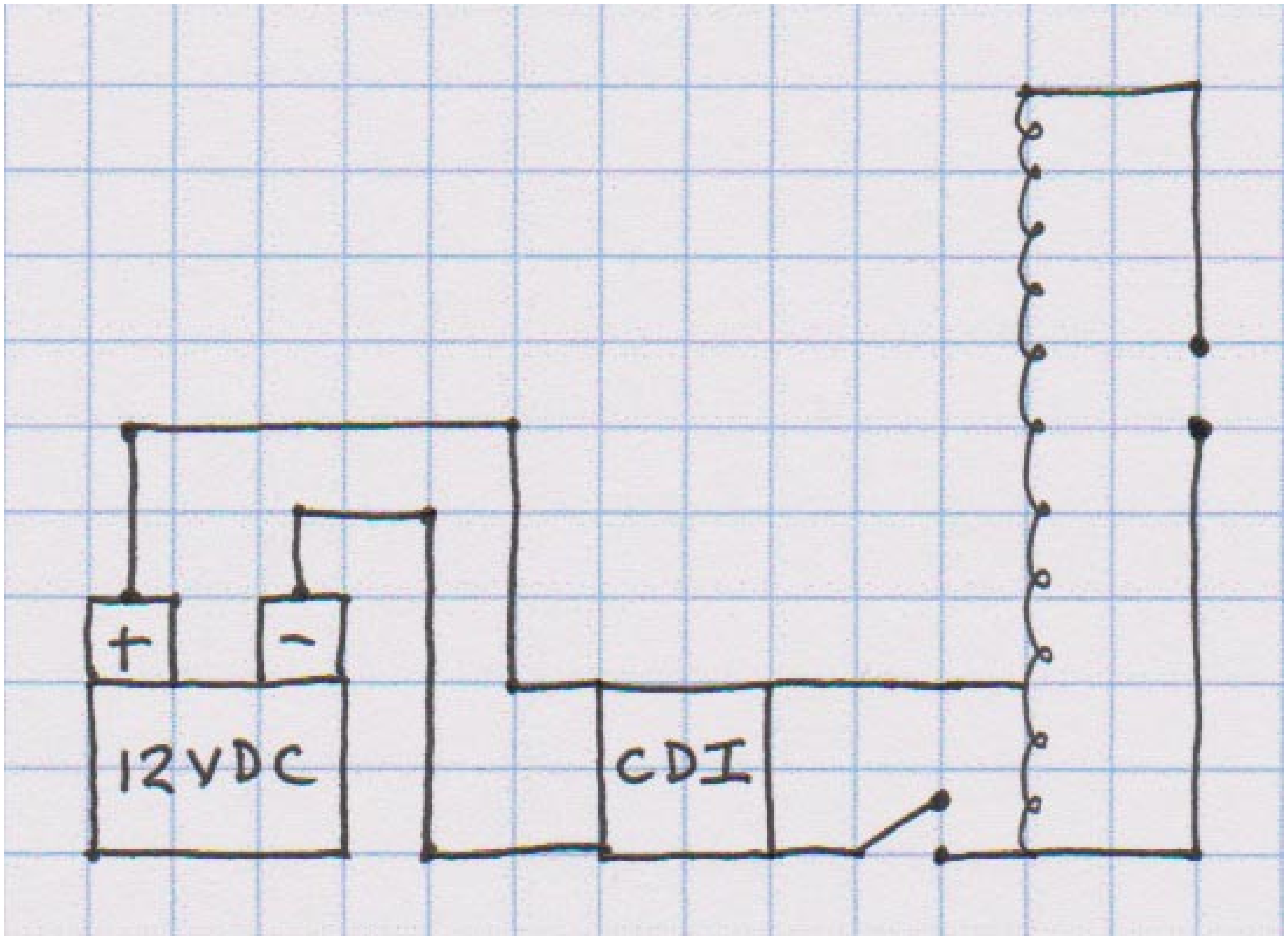
PEAKING CAPACITORS

PEAKING CAPACITORS

KETTERING SPARK IGNITION

PEAKING CAPACITORS

CAPACITIVE DISCHARGE IGNITION



CAPACITIVE DISCHARGE IGNITION

CAPACITIVE DISCHARGE IGNITION

KETTERING SPARK IGNITION

PEAKING CAPACITORS

CAPACITIVE DISCHARGE IGNITION

MURAKAMI PLASMA IGNITION

MURAKAMI PLASMA IGNITION

KETTERING SPARK IGNITION

PEAKING CAPACITORS

CAPACITIVE DISCHARGE IGNITION

MURAKAMI PLASMA IGNITION

IONIZATION BY COLLISION

John Sealy Edward Townsend

THE THEORY OF IONIZATION OF GASES BY COLLISION

CHAPTER I

IONIZATION BY NEGATIVE IONS

1. Variation of current with electric force.

The process of ionization by collision between ions and molecules of a gas may be examined by investigating

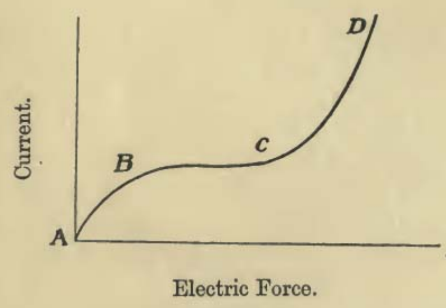
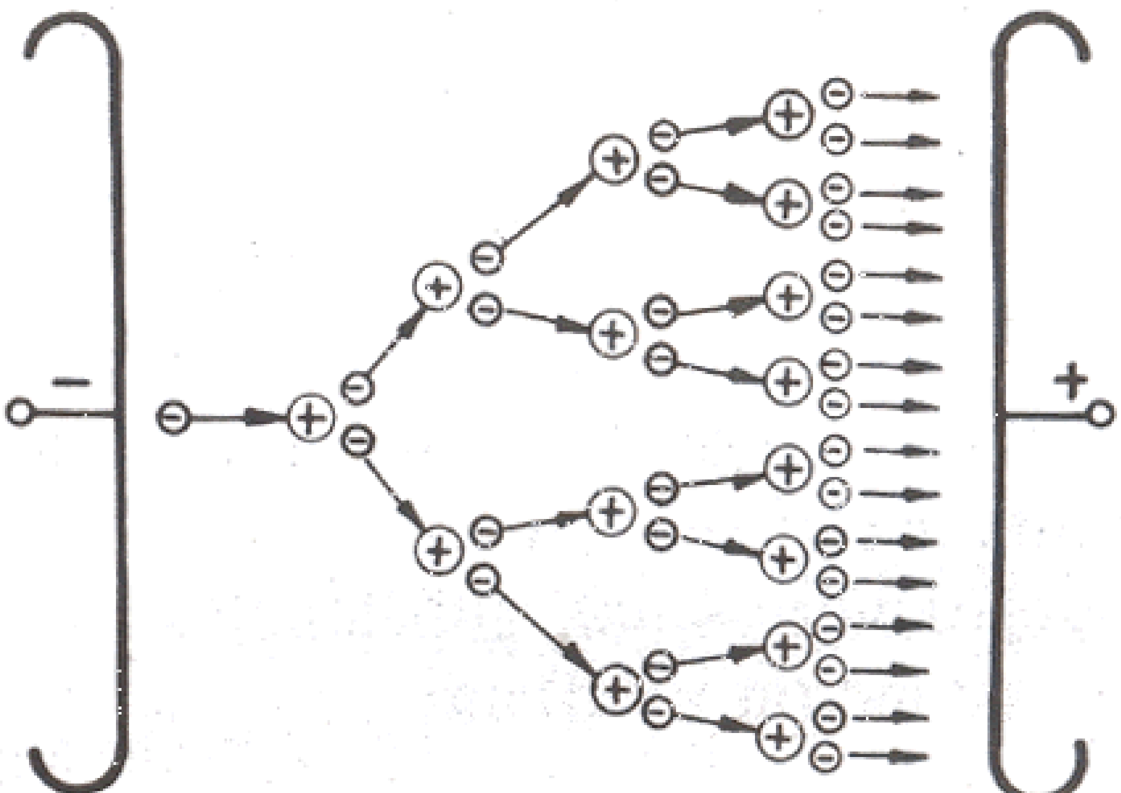


Figure 1.

the currents between parallel plate electrodes when ultra-violet light falls on the negative electrode or when the gas is ionized by Röntgen rays. If the gas is at a high pressure, the current increases with the electric force and

IONIZATION BY COLLISION
“Townsend Discharge” Avalanche



BREAKDOWN VOLTAGE

- **Electrical breakdown** or **dielectric breakdown** refers to a rapid reduction in the resistance of an electrical insulator when the voltage applied across it exceeds the breakdown voltage. This results in a portion of the insulator becoming electrically conductive. Electrical breakdown may be a momentary event (as in an electrostatic discharge), or may lead to a continuous arc discharge if protective devices fail to interrupt the current in a high power circuit.

- Under sufficient electrical stress, electrical breakdown can occur within solids, liquids, gases or vacuum. However, the specific breakdown mechanisms are significantly different for each, particularly in different kinds of dielectric medium.

BREAKDOWN VOLTAGE

If it takes about 5000 volts to jump a 1mm gap, is it possible to get a capacitor of only 400 volts to jump over the same gap?

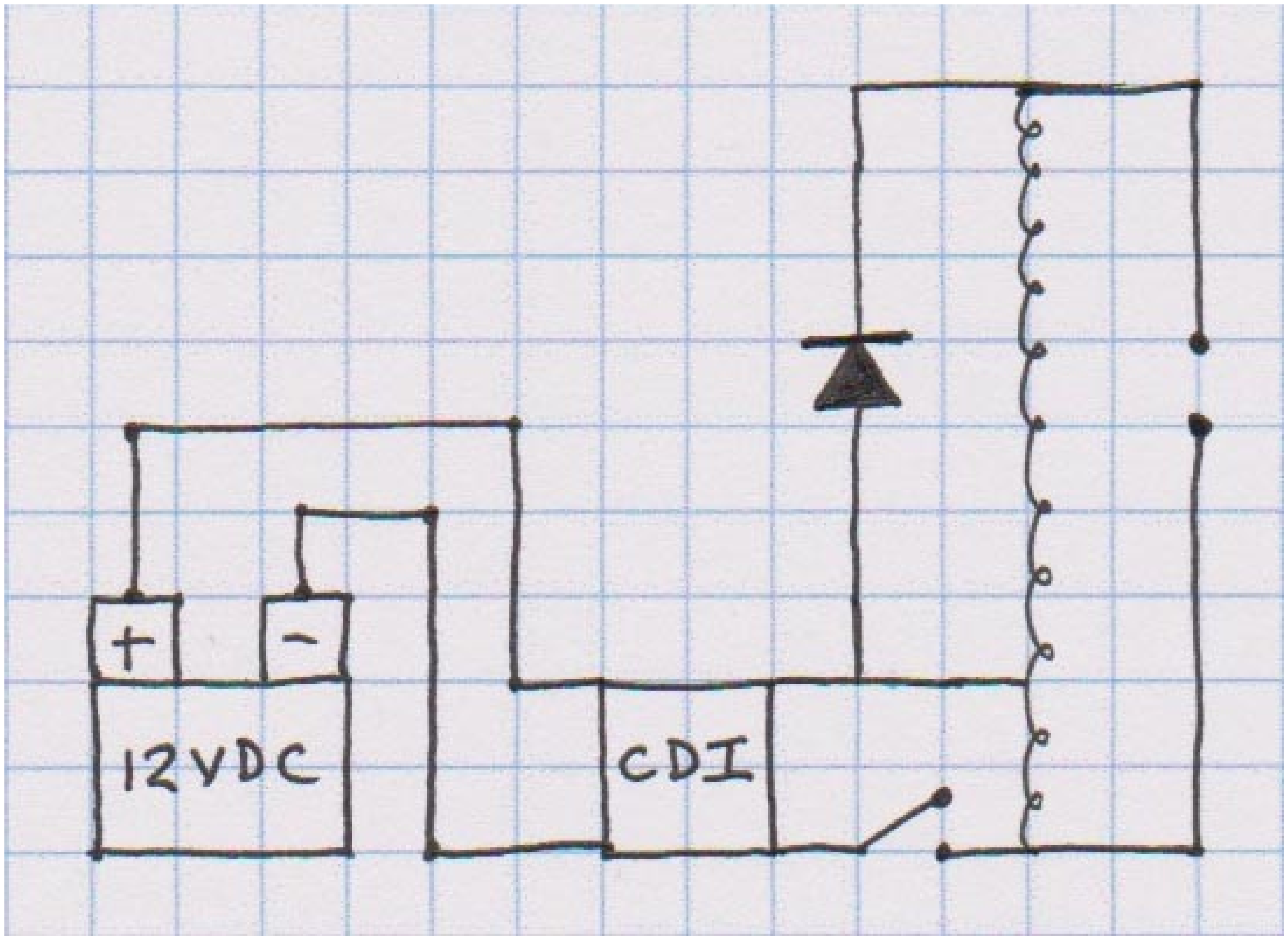
BREAKDOWN VOLTAGE

As the gap conductivity increases, the dielectric breakdown voltage decreases for the current state of the insulator at the gap.

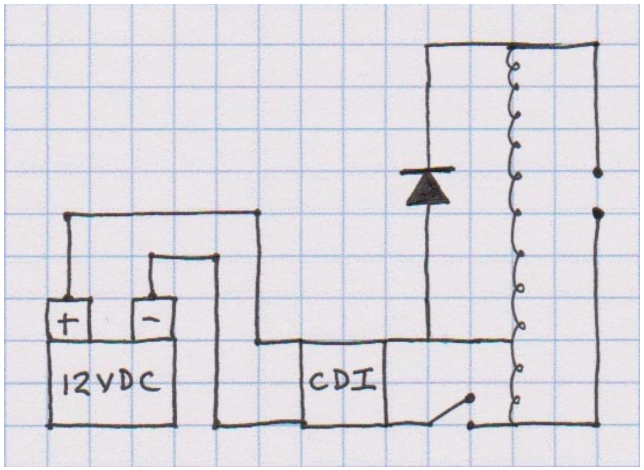
As the High Voltage breaks down the dielectric resistance of the gap, the gap becomes ionized (positively charged) and very conductive to negatively charged current.

When the gap becomes conductive enough, a capacitor at only a few hundred volts can now jump the gap when it normally wouldn't be possible!

MURAKAMI PLASMA IGNITION



MURAKAMI PLASMA IGNITION



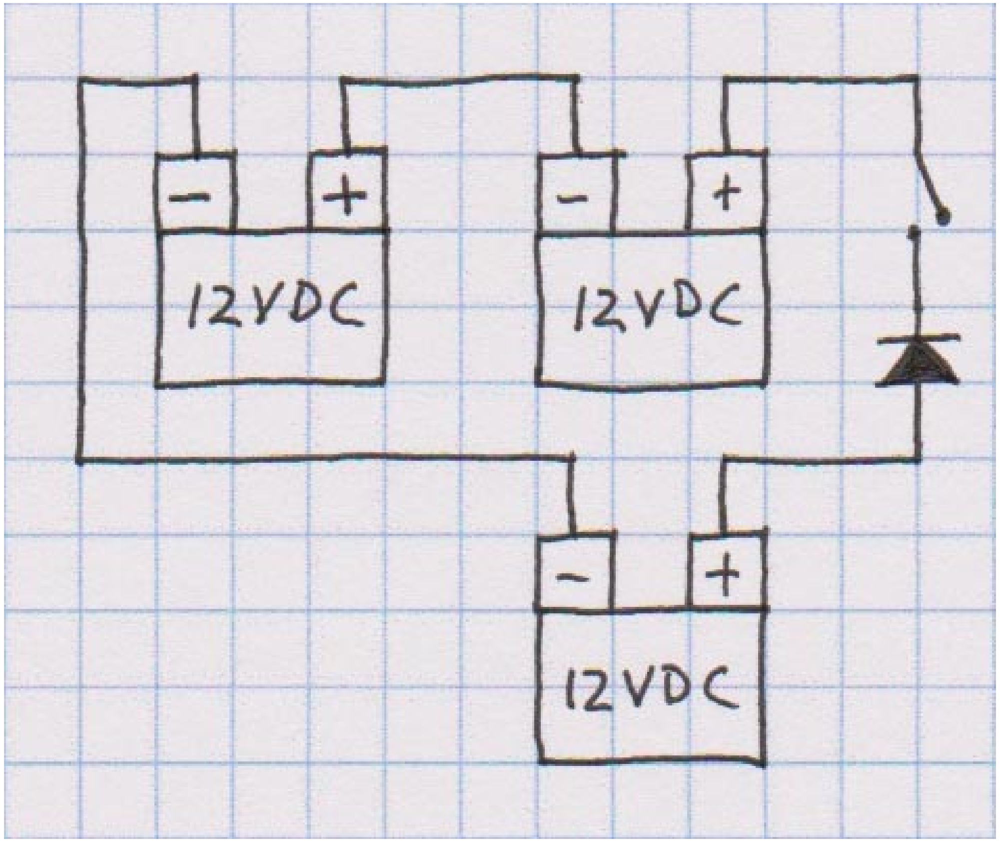
HIGH VOLTAGE DIODES

The diodes need to be rated so that the voltage is above the high voltage coil voltage. The HV output of the ignition coil has TWO paths to ground. One is over the gap and the other is through the diode to the capacitor back to ground.

The diode is NOT automatically a “blocking diode” when it opposes a higher voltage from another source. The HV diode or HV diode string does NOT stop the HV from the coil from moving towards the capacitor until AFTER the voltage on the cathode is higher than the anode. THEN, the diode will turn into a blocking diode. UNTIL that point, the diode is a wide open path to ground!

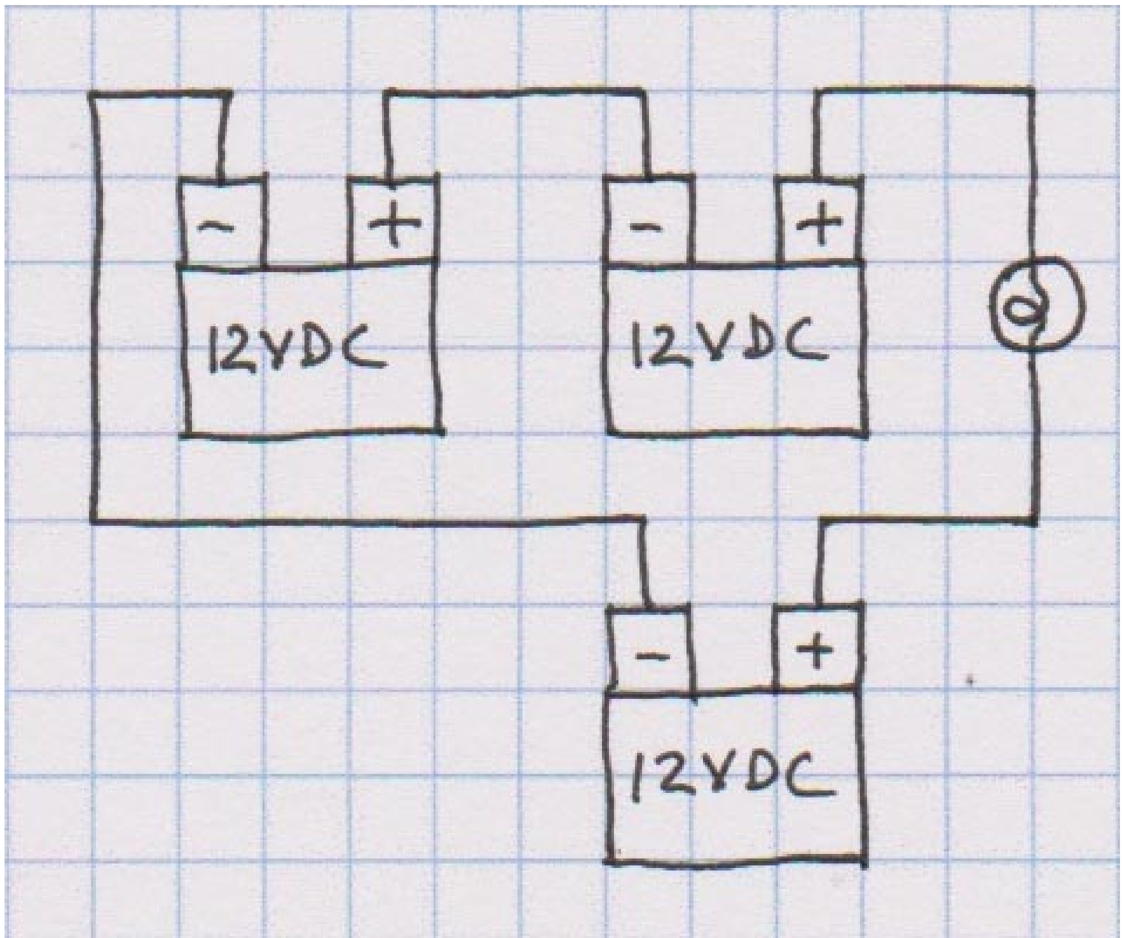
DIODES

A higher voltage positive will jump to a lower voltage positive with a common ground. The polarity is irrelevant. <u>It is the potential difference, which counts.</u>

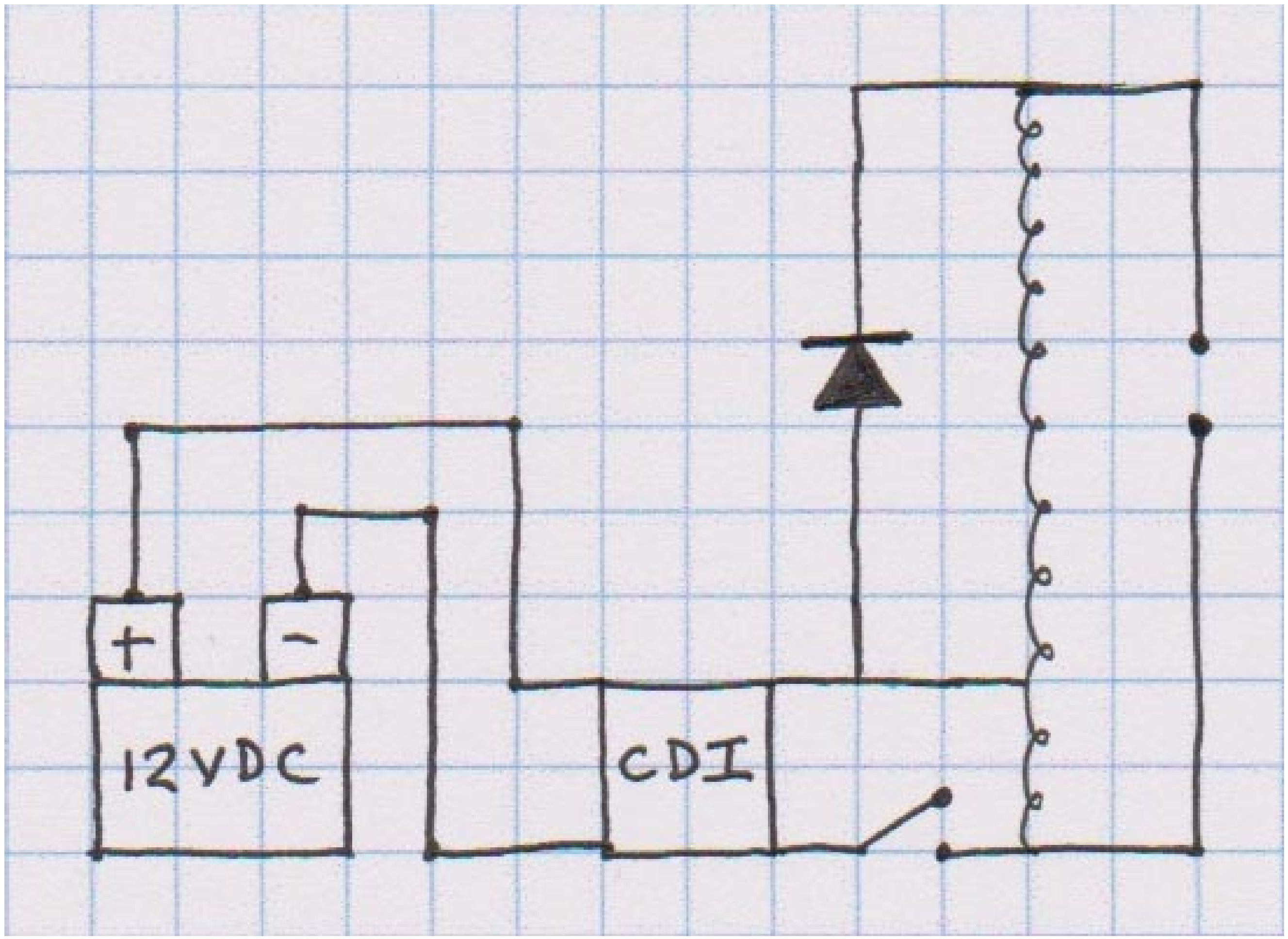


SPLITTING THE POSITIVE

With 24 VDC and an opposing 12 VDC, there is 12 VDC potential difference between the positive terminals. A 12 VDC load will run.



MURAKAMI PLASMA IGNITION



TYPICAL PLASMA IGNITION

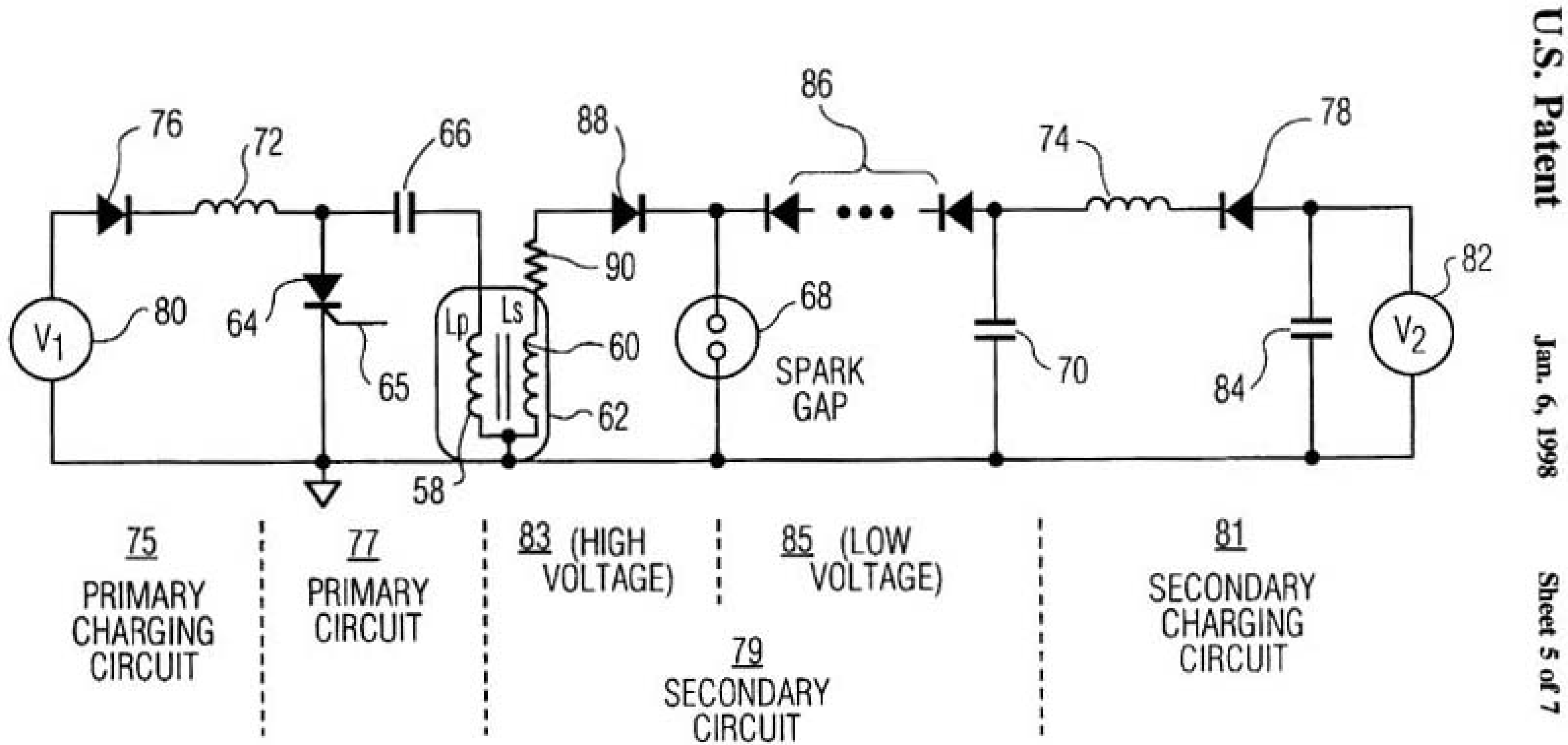


FIG. 7

WHY DOES THIS HAPPEN WHEN DISCHARGING A HIGH VOLTAGE LOW CURRENT IGNITION COIL OVER A GAP AND THEN GETTING A LOW VOLTAGE HIGH CURRENT CAPACITOR TO DISCHARGE OVER THE SAME GAP?

(BOTH START WITH THE SAME POTENTIAL ENERGY IN A SINGLE CAP)

CAPACITIVE DISCHARGE IGNITION

MURAKAMI PLASMA IGNITION

First, let’s talk about IMPULSE

KNOCK ON THE WINDOW

If we knock on the window with 10 units of energy and knock 10 times, that is 100 units of energy expended over the time it takes to knock 10 times.

We can repeat this all day long and nothing happens to the window.

KNOCK ON THE WINDOW

If we use all 100 units of energy but use it within 1 single knock, we will shatter the glass into countless pieces.

KNOCK ON THE WINDOW

In both examples, we used the SAME amount of energy.

But it was the duration of TIME this energy was used that gave completely different results.

IMPULSE

When we use a certain amount of energy in a small blip of time instead of a longer period of time, we are using "IMPULSE" technology.

POWER vs WORK (ENERGY)

1 volt x 1 amp = 1 watt

1 watt x 1 second = 1 watt second

1 watt = POWER

1 watt second = WORK

POWER vs WORK (ENERGY)

1 joule / 1 second = 1 watt

1 joule / 0.5 seconds = 2 watts

1 joule / 1/100th second = 100 watts

1 joule / 1/1000000th second = 1 MEGAWATT

SAME ENERGY but DIFFERENT POWER

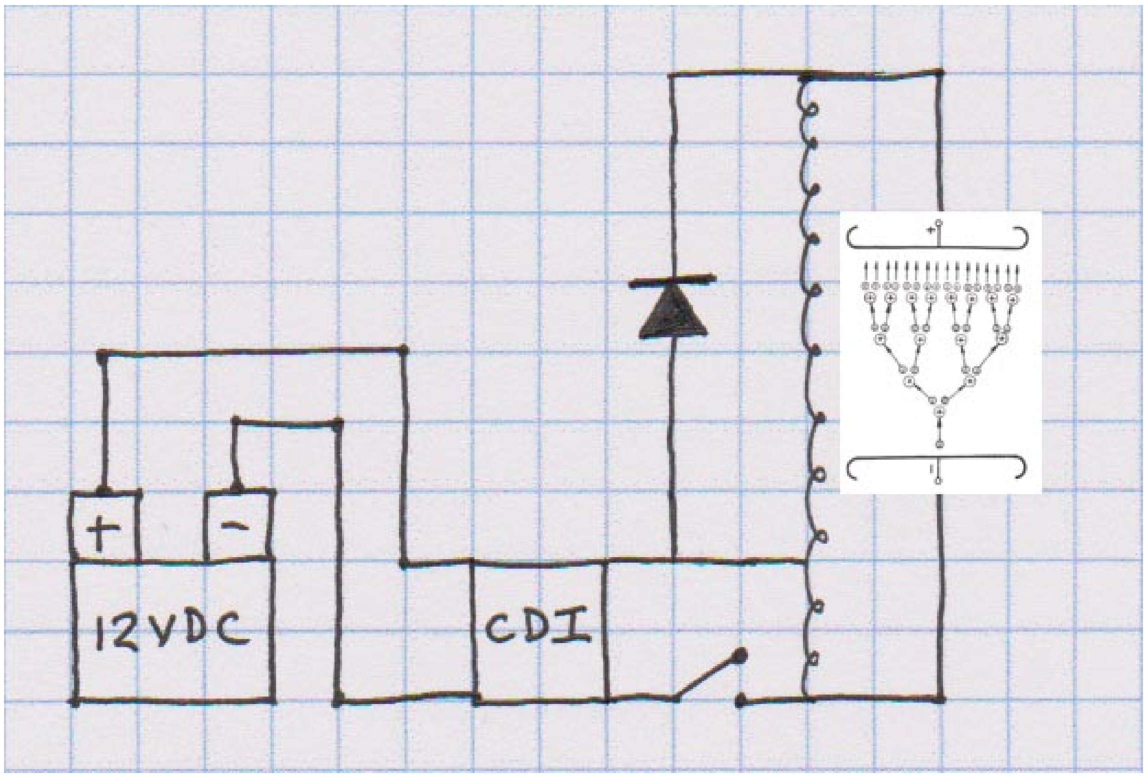
Because of the TIME Compression

IMPULSE

NEGATIVE RESISTOR

The gap is a NEGATIVE RESISTOR because the current (electrons) moving across the gap accelerates, which is the opposite of moving into a positive resistance and more electrons are freed than we supplied.

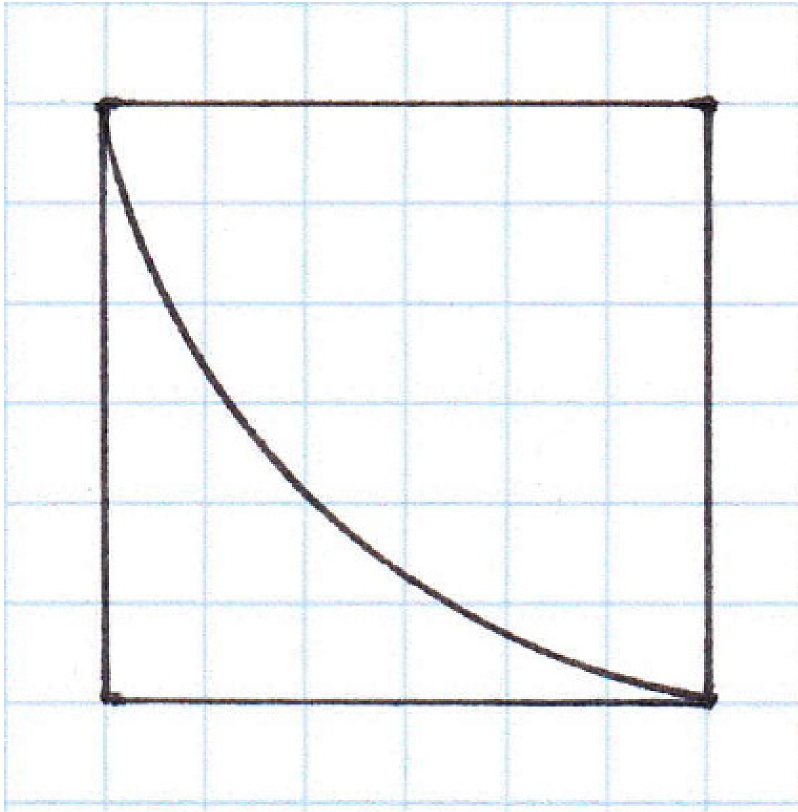
NEGATIVE RESISTOR



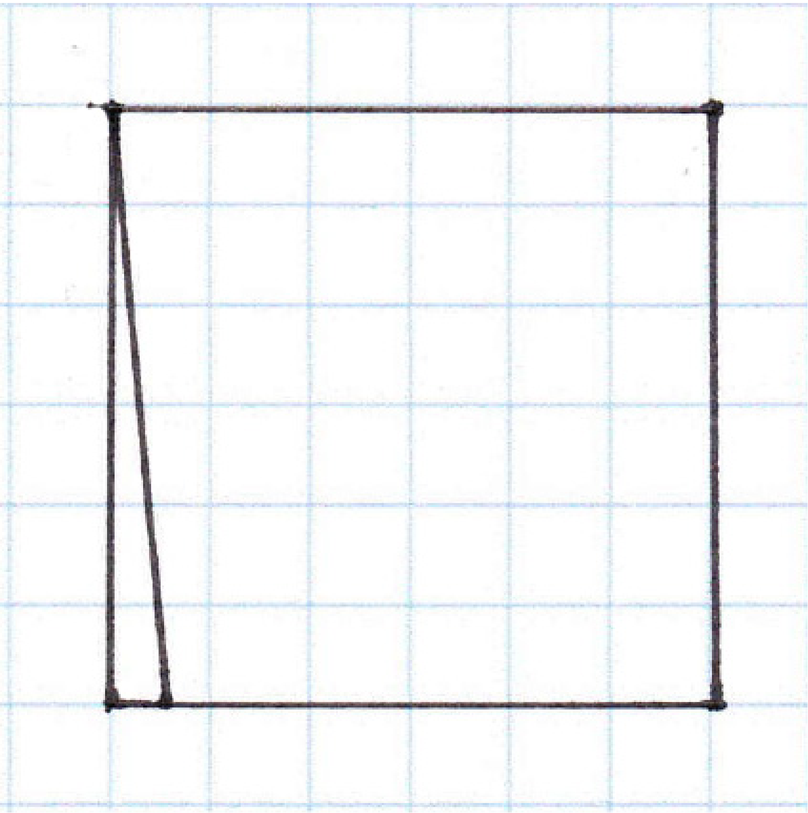
High Voltage Ignition Spark has Low Current

Low Voltage Capacitor Has High Current

NEGATIVE RESISTOR

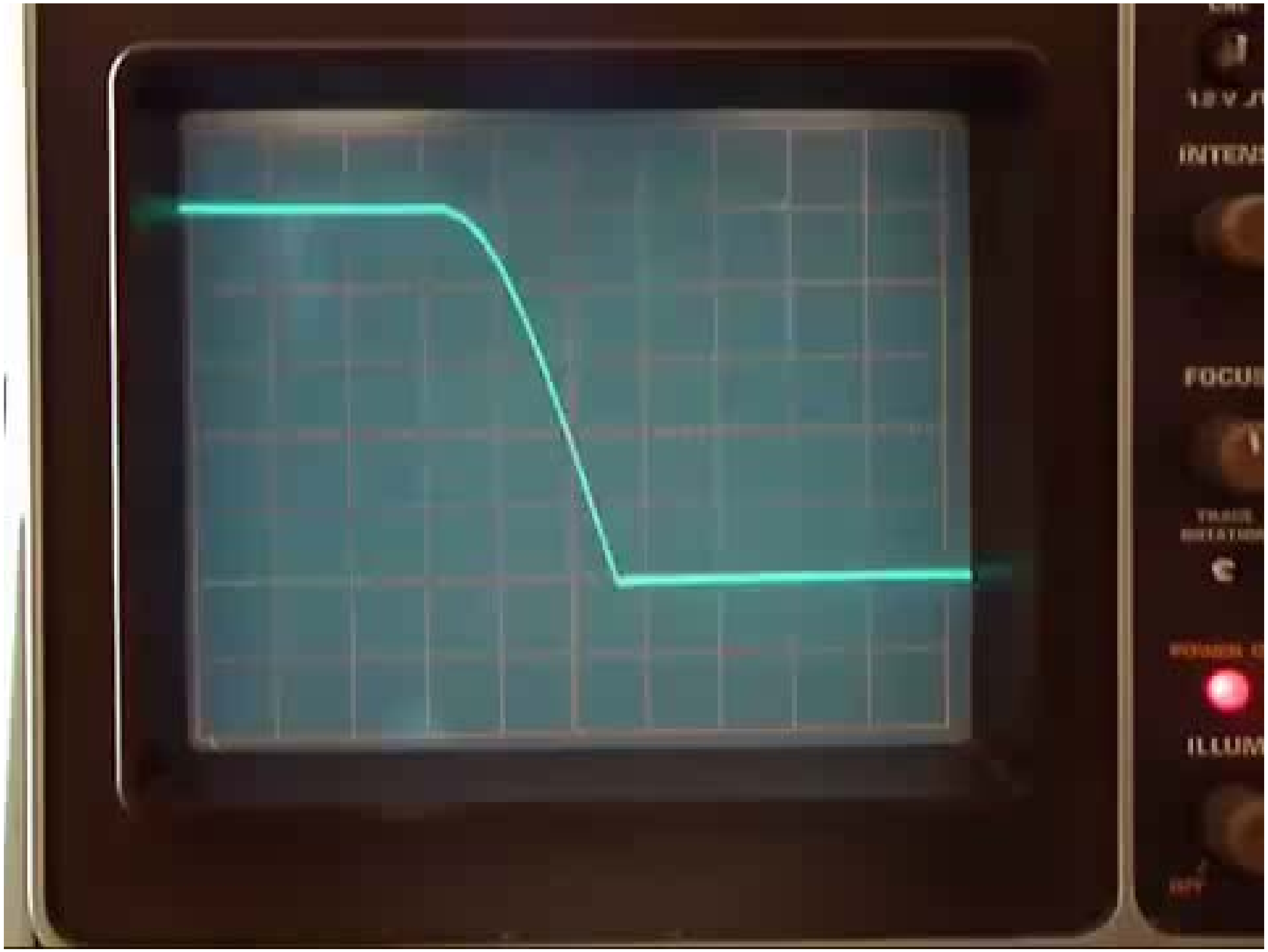


NORMAL CAP DISCHARGE



ACCELERATED DISCHARGE

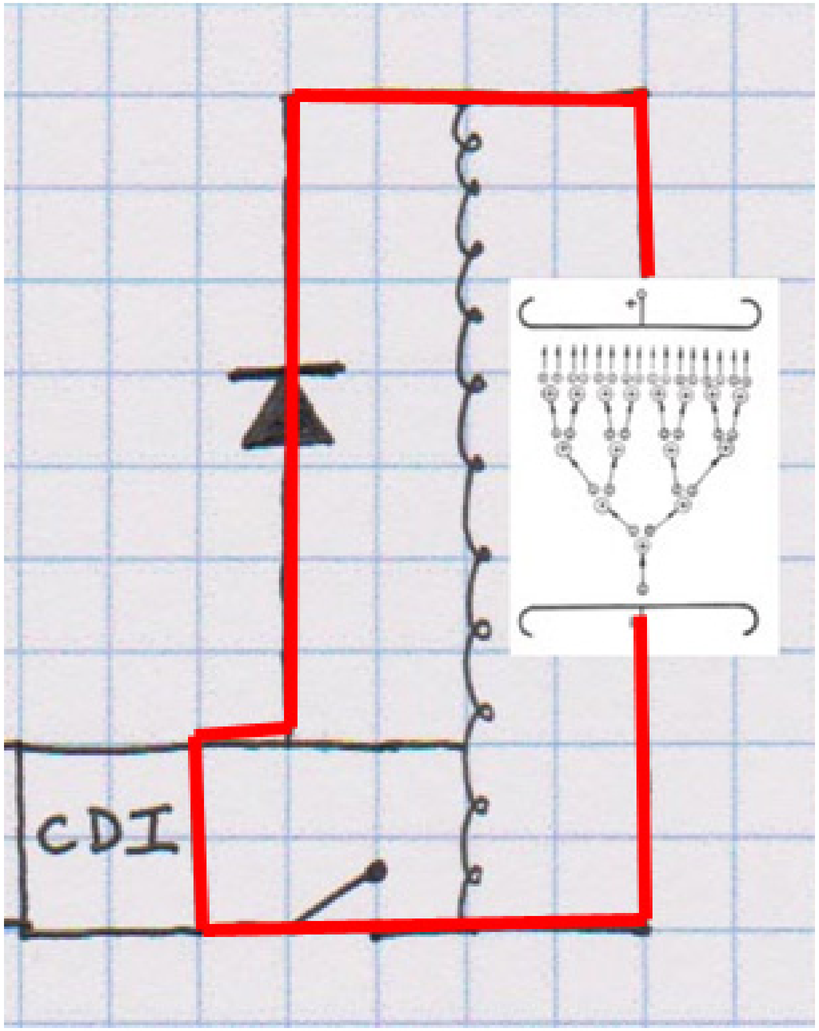
NEGATIVE RESISTOR



Video by: smw1998a

NEGATIVE RESISTOR

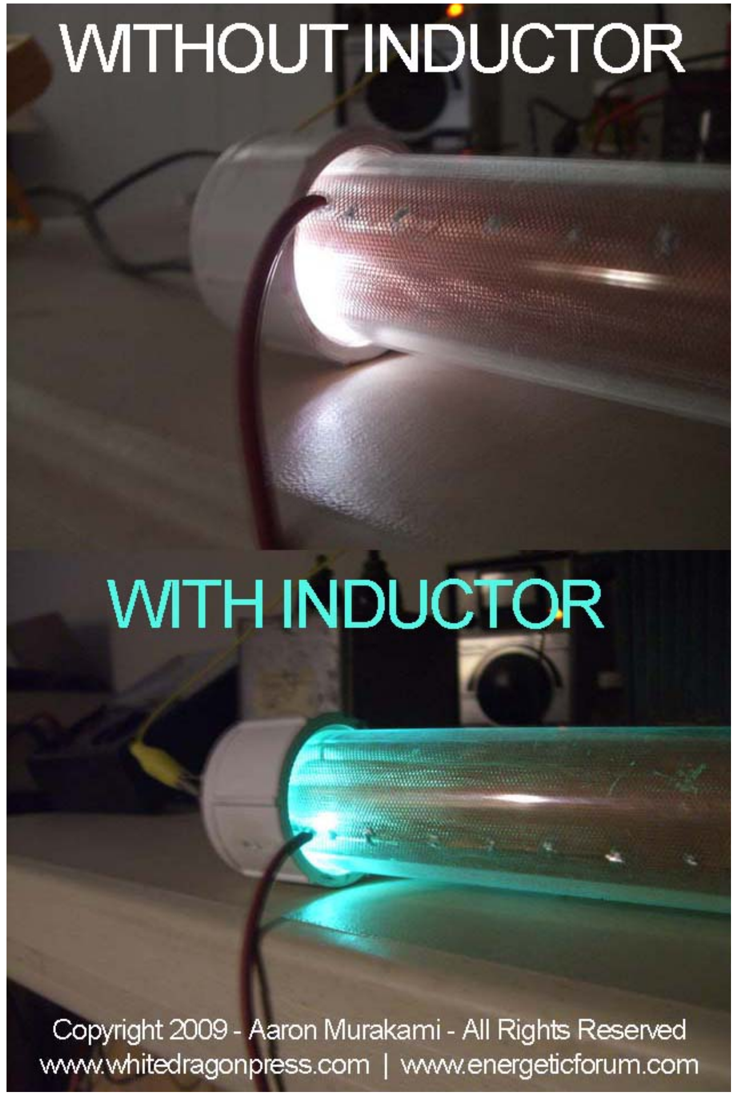
Because the capacitor discharges at an ACCELERATED rate, the negative resistance is NOT just at the gap, it is in the entire loop!



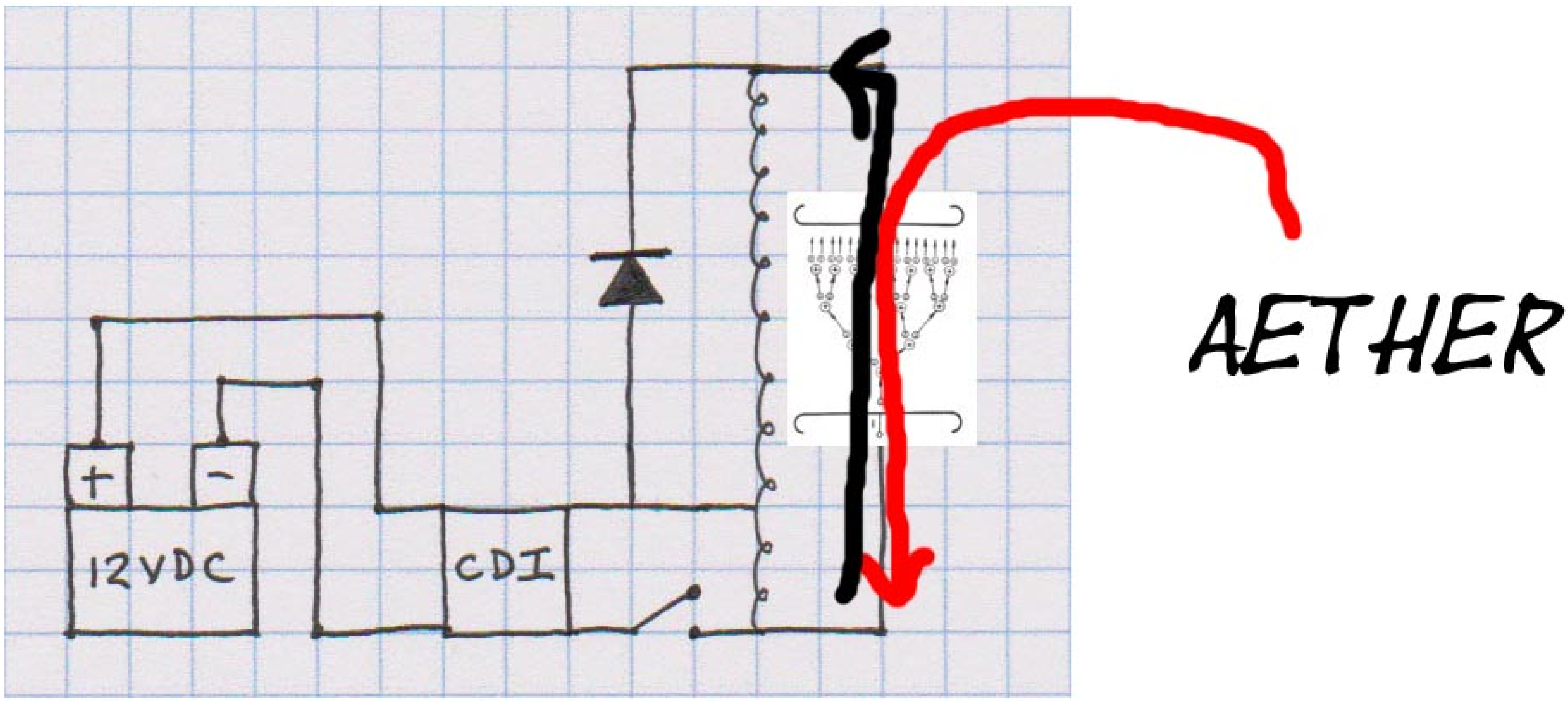
NEGATIVE RESISTOR

If the resistance of the entire capacitor circuit has been removed or reduced substantially, could we remove the resistances/impedances of an inductor if we put one in that loop?

PLASMA WITH INDUCTOR



GAIN MECHANISM?



HISTORY OF THE PLASMA IGNITION

Instead of putting the history first in this presentation, you now have the "schema" or context that it all fits in so the history will make more sense.

HISTORY OF THE PLASMA IGNITION

The goal was to make a water powered engine. This was a goal of some open source researchers in the forums.

This probably was not the goal of NASA, Princeton, auto manufacturers or spark plug companies.

HISTORY OF THE PLASMA IGNITION

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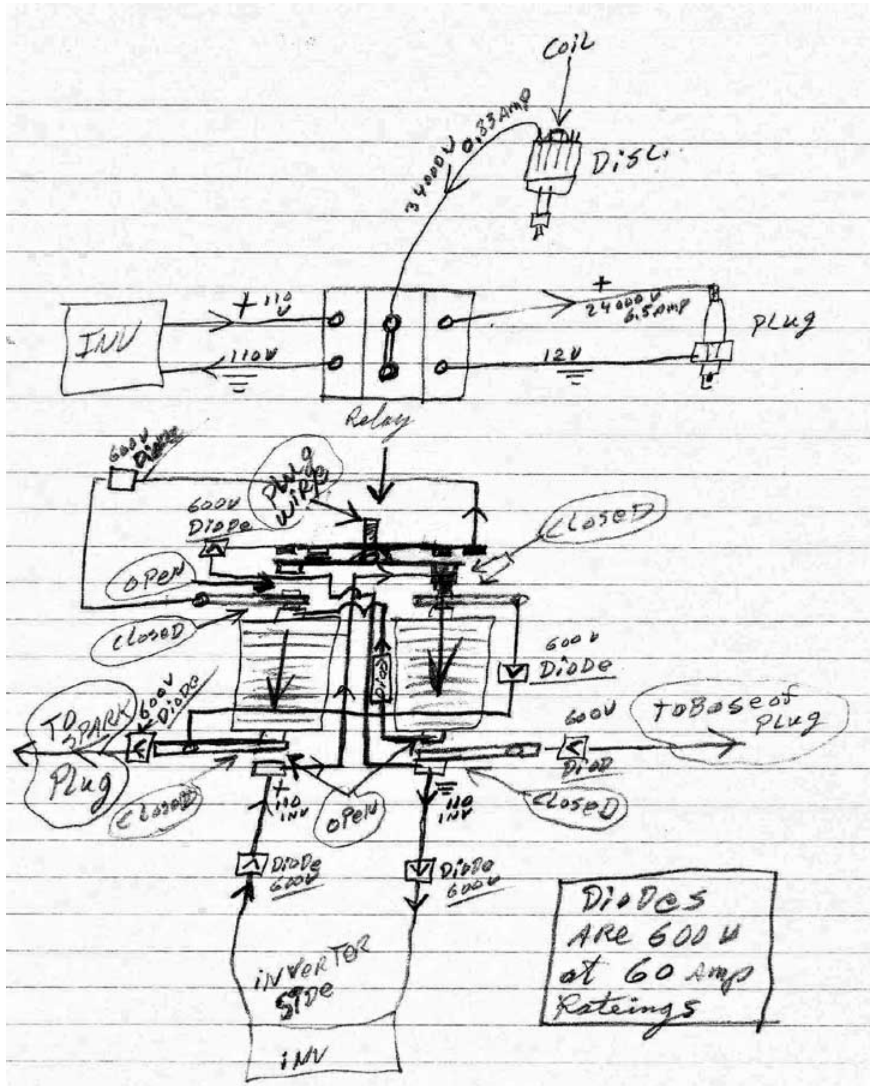

HISTORY OF THE PLASMA IGNITION
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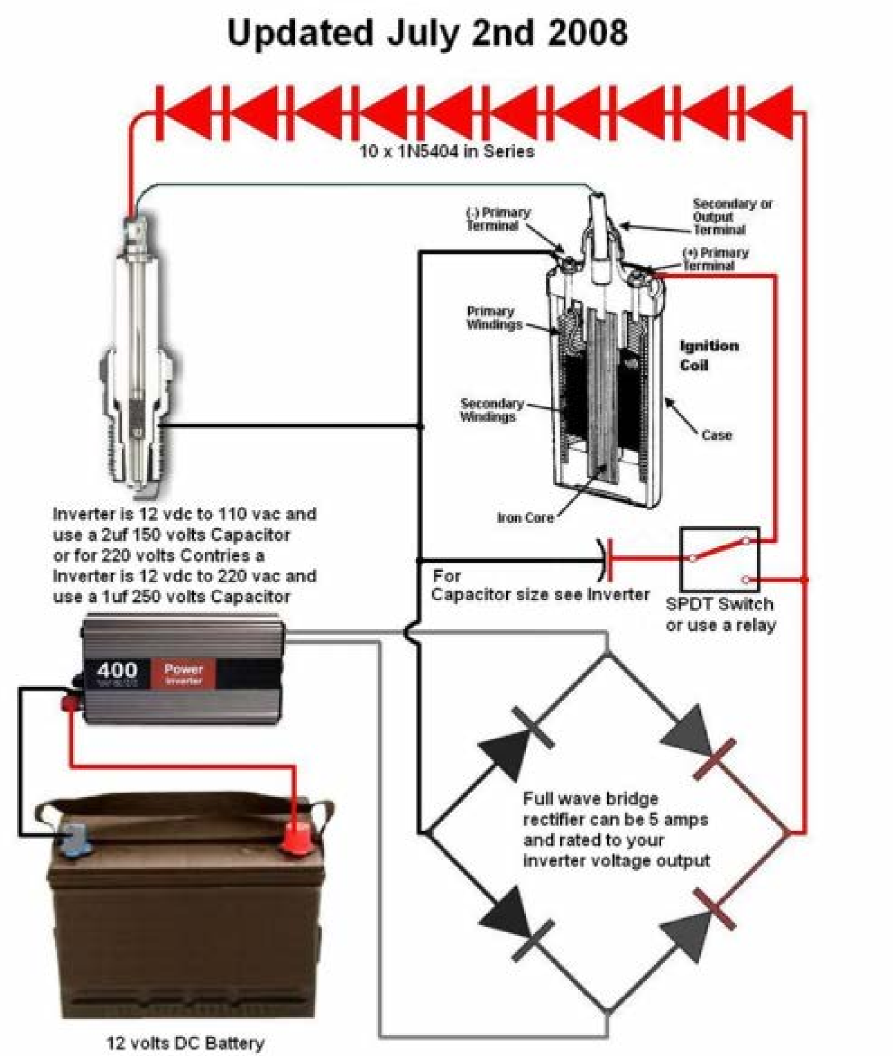
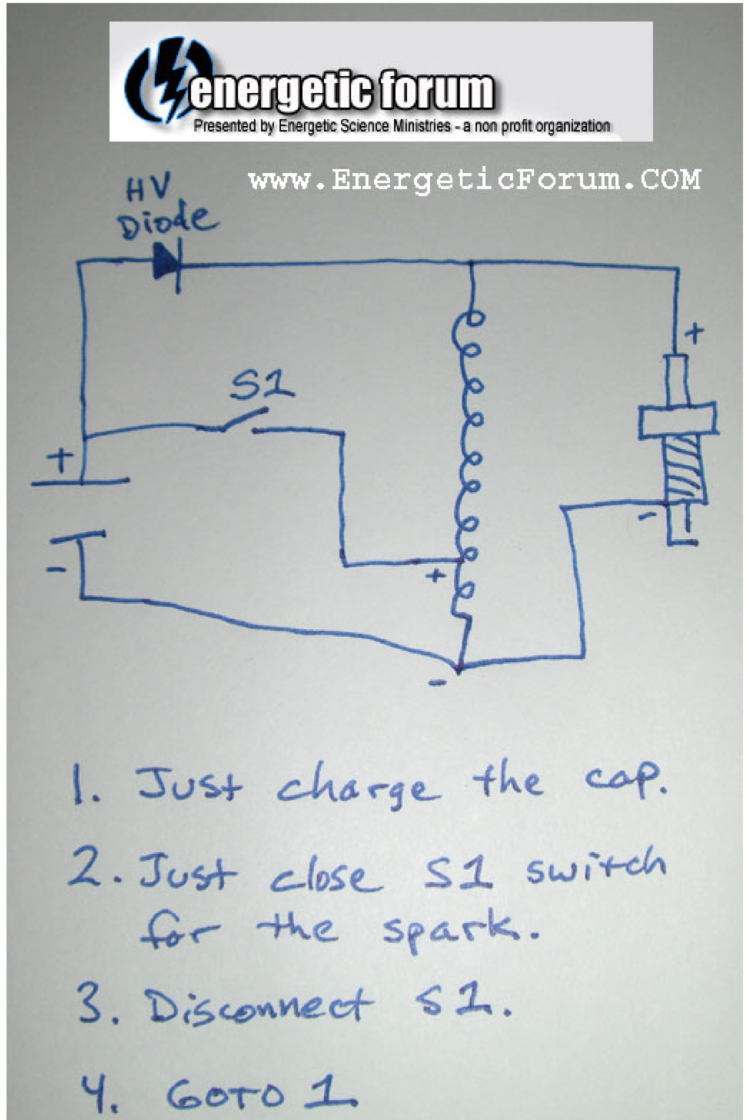


HISTORY OF THE PLASMA IGNITION

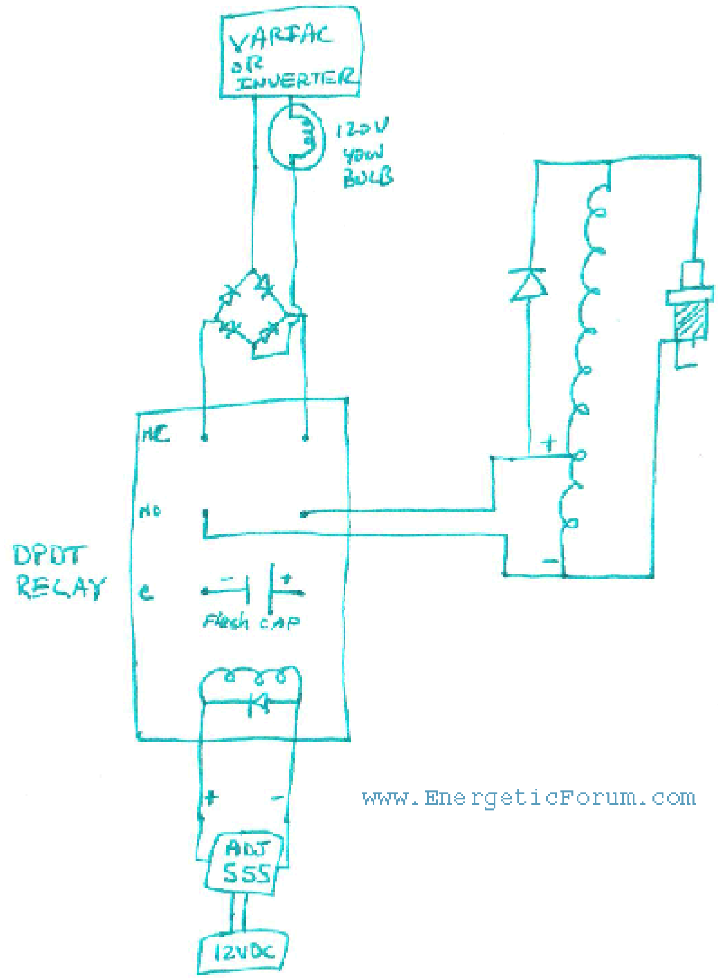


HISTORY OF THE PLASMA IGNITION

ISOLATED CAPACITOR PROOF

HISTORY OF THE PLASMA IGNITION

ISOLATED CAPACITOR PROOF



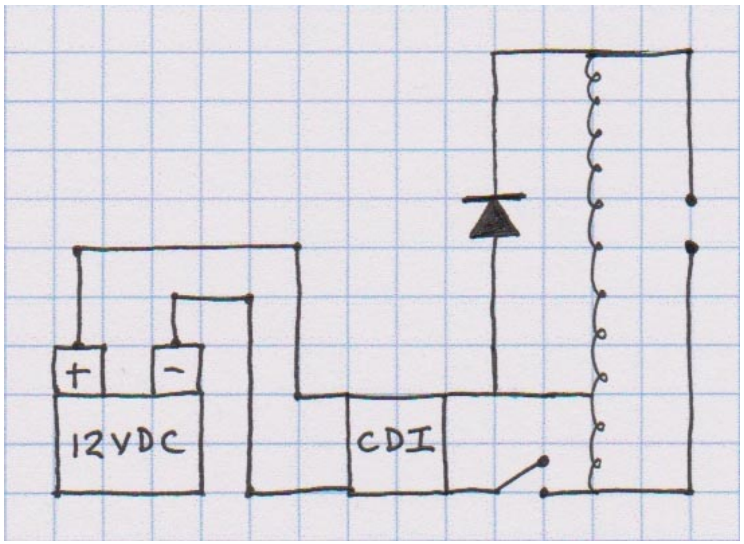
HISTORY OF THE PLASMA IGNITION

“BOOSTER CAPS”

HISTORY OF THE PLASMA IGNITION
"BOOSTER CAPS"

It is NOT necessary to use large plasma bursts in an engine because unlike conventional sparks that get snuffed out with compression, air, etc… the plasma actually **GROWS** under those conditions.

PLASMA IGNITION COMPARISON



vs

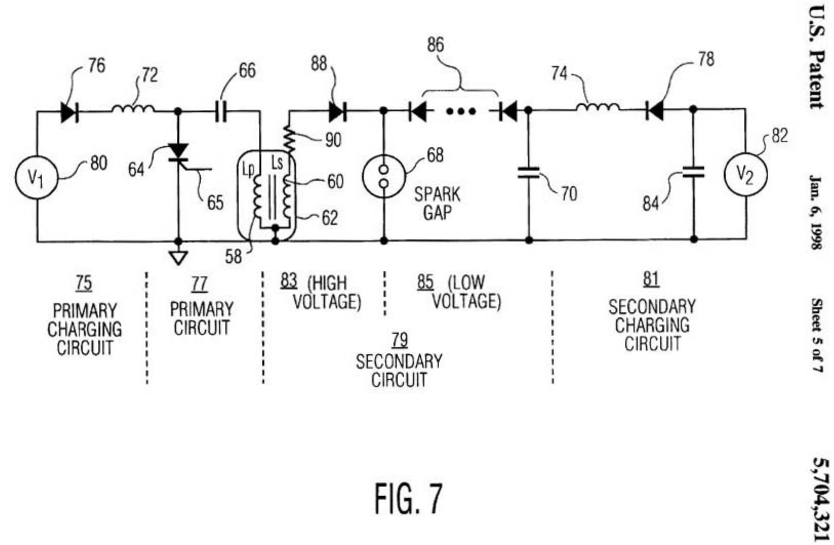
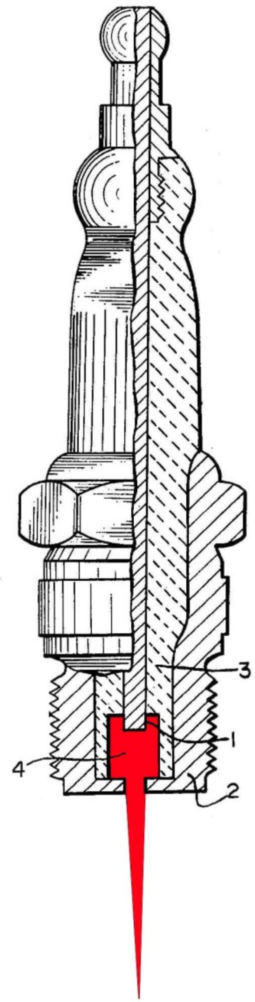


FIG. 7

1 Power Supply
Higher Initiating Voltage
More Reliable in High Compression Ranges
Lower Cost

2 Power Supplies
Lower Initiating Voltage
More Prone to Fail in High Compression
Higher Cost

WHAT IS PLASMA "JET" IGNITION?



PLASMA JET IGNITION REFERENCES

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Plasma Jet Ignition of Lean Mixtures

Paper #: **750349** Published: 1975-02-01

DOI: 10.4271/750349

Citation: Wyczalek, F., Frank, D., and Neuman, J., "Plasma Jet Ignition of Lean Mixtures," SAE Technical Paper 750349, 1975, doi:10.4271/750349.

Author(s): Floyd A. Wyczalek Daniel L. Frank John G. Neuman

Affiliated: General Motors Corp.

Abstract: The development of a plasma jet ignition system is described on a 4-cyl, 140 in$_3$ engine. Performance was evaluated on the basis of combustion flame photographs in a single-cylinder engine at 20/1 A/F dynamometer tests on a modified 4-cyl engine, and cold start emissions, fuel economy, and drivability in a vehicle at 19/1 air fuel ratio.
In addition to adjustable engine variables such as air-fuel ratio and spark advance, system electrical and mechanical parameters were varied to improve combustion of lean mixtures. As examples, the air-fuel ratio range was 16-22/1, secondary ignition current was varied from 40 to 6000 mA, and plasma jet cavity and electrode geometry were optimized.

It is shown that the plasma jet produces an ignition source which penetrates the mixture ahead of the initial flame front and reduces oxides of nitrogen emission, in comparison to a conventional production combustion chamber. The reduction in oxides of nitrogen is attributed to decreased gas residence time at high temperatures and a lower gas temperature history.

PLASMA JET IGNITION REFERENCES

Operational Characteristics of a Lean Burn SI-Engine: Comparison Between Plasma-Jet and Conventional Ignition System

Paper #: **870608** Published: 1987-02-01

DOI: 10.4271/870608

Citation: Kupe, J., Wilhelmi, H., and Adams, W., "Operational Characteristics of a Lean Burn SI-Engine: Comparison Between Plasma-Jet and Conventional Ignition System," SAE Technical Paper 870608, 1987, doi:10.4271/870608.

Author(s): J. Kupe H. Wilhelmi W. Adams

Affiliated: institut für industrieofenbau und Wärmetechnik, RWTH

FEV Motorentechnik

Abstract: Besides the specific demands on mixture formation the main problem of lean-mixture SI engines is to assure the ignition of the air-fuel mixture even if very lean and at all operational conditions.

In the scope of extensive research work an analysis was made of the operational behavior of a 4-stroke SI-engine with a newly developed plasma-jet ignition and a conventional transistorized ignition system, respectively. The investigations on the engine were completed by tests in a combustion chamber with methane-air mixture.

With plasma-jet ignition the combustion delay and the combustion duration are clearly shorter. The engine tests also revealed a clearly extended lean misfire limit and a reduction of cyclic variations. The NO_x-emissions are only slightly higher than with the transistorized ignition system although a considerable improvement of the brake efficiency can be obtained. In the case of plasma-jet ignition the analysis of the combustion process shows an essential reduction of the losses due to real combustion, while heat losses increase less distinctly.

PLASMA JET IGNITION REFERENCES

DOE/NASA/0131-1
NASA CR-168139

Experimental and Theoretical Study of Combustion Jet Ignition

(NASA-CR-168139) EXPERIMENTAL AND THEORETICAL STUDY OF COMBUSTION JET IGNITION Final Report (California Univ.) 138 p HC A07/MF A01 CSCL 21E N84-10054
Unclas G3/07 42339

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2.1.5 Plasma Jet Ignition Method

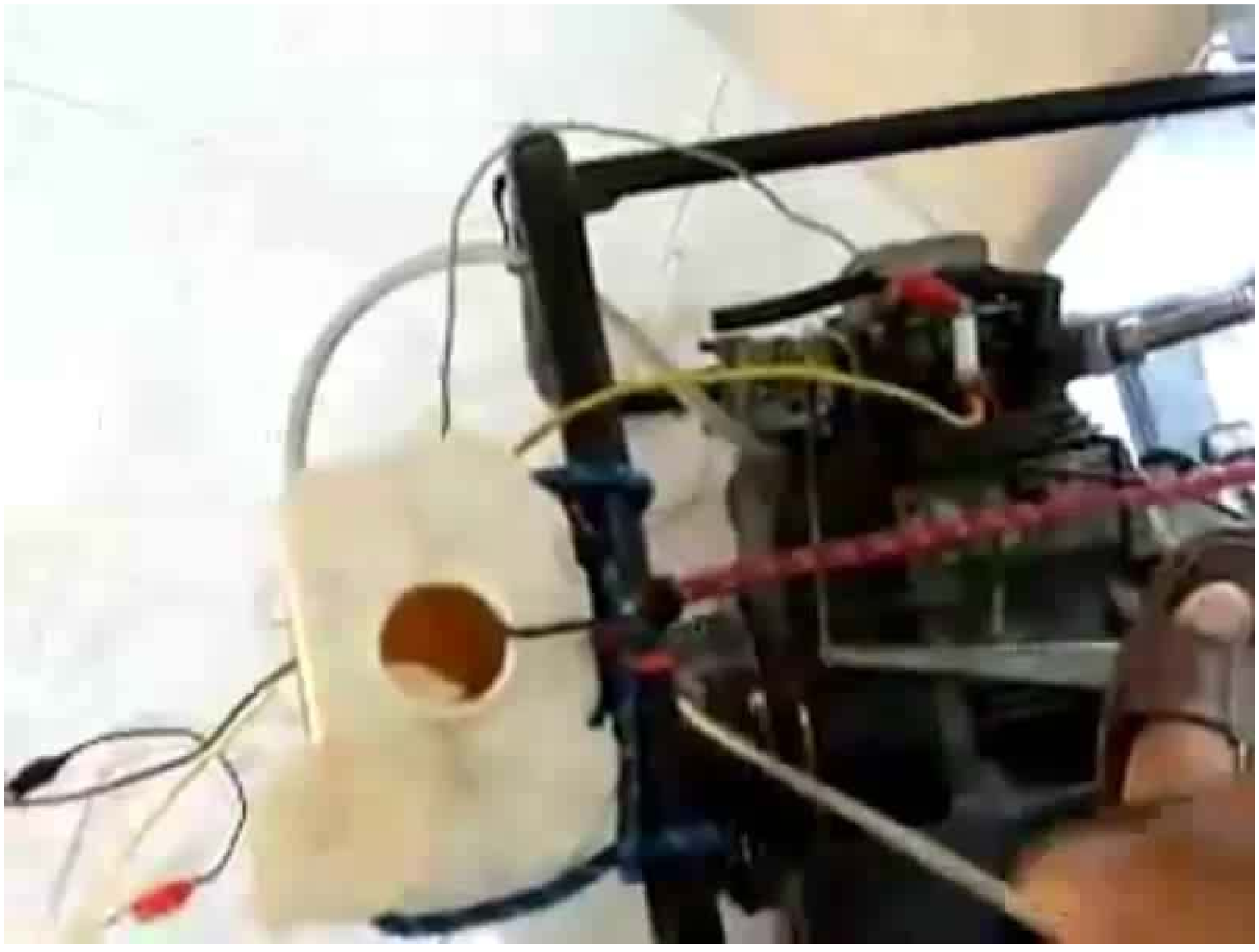
The plasma jet ignition method produces a high temperature plasma in a confined, recessed cavity provided with an orifice. The high temperature plasma is generated so rapidly that the cavity is pressurized, causing a jet of plasma to be discharged through the orifice into the combustible medium as an ignition source. The electric power supply for plasma jet ignition system discharges at a relatively low voltage and high current through the spark which is generated in a conventional manner by a high voltage, low current ignition system.

Considerable research work[33-41] has been done on the studies of plasma jets and their ignition characteristics. Some observations were obtained as listed in the following:

1. Plasma jets enter the main chamber in the form of a turbulent plume which is imbedded in a blast wave headed by a hemispherical shock wave.
2. The blast wave effects are dissipated by the time combustion starts. After a delay typically of an order of 1 msec, ignition takes place in the turbulent zone of the plume.
3. The depth of penetration of the jets is a function of their initial velocity.
4. The burning speed is initially quite high and decreases monotonically as the flame kernel expands.
5. With provisions made to fill the cavity with different feedstocks, the most effective for ignition were hydrocarbons, among which those initially in liquid state were particularly effective.

6. Plasma jets can ignite gaseous mixtures below the normal flammability limit.
7. A plasma jet ignition system requires relatively high electric power, *e.g.* 1 J.
8. The HC and NO emissions are increased and the CO emission is slightly decreased.

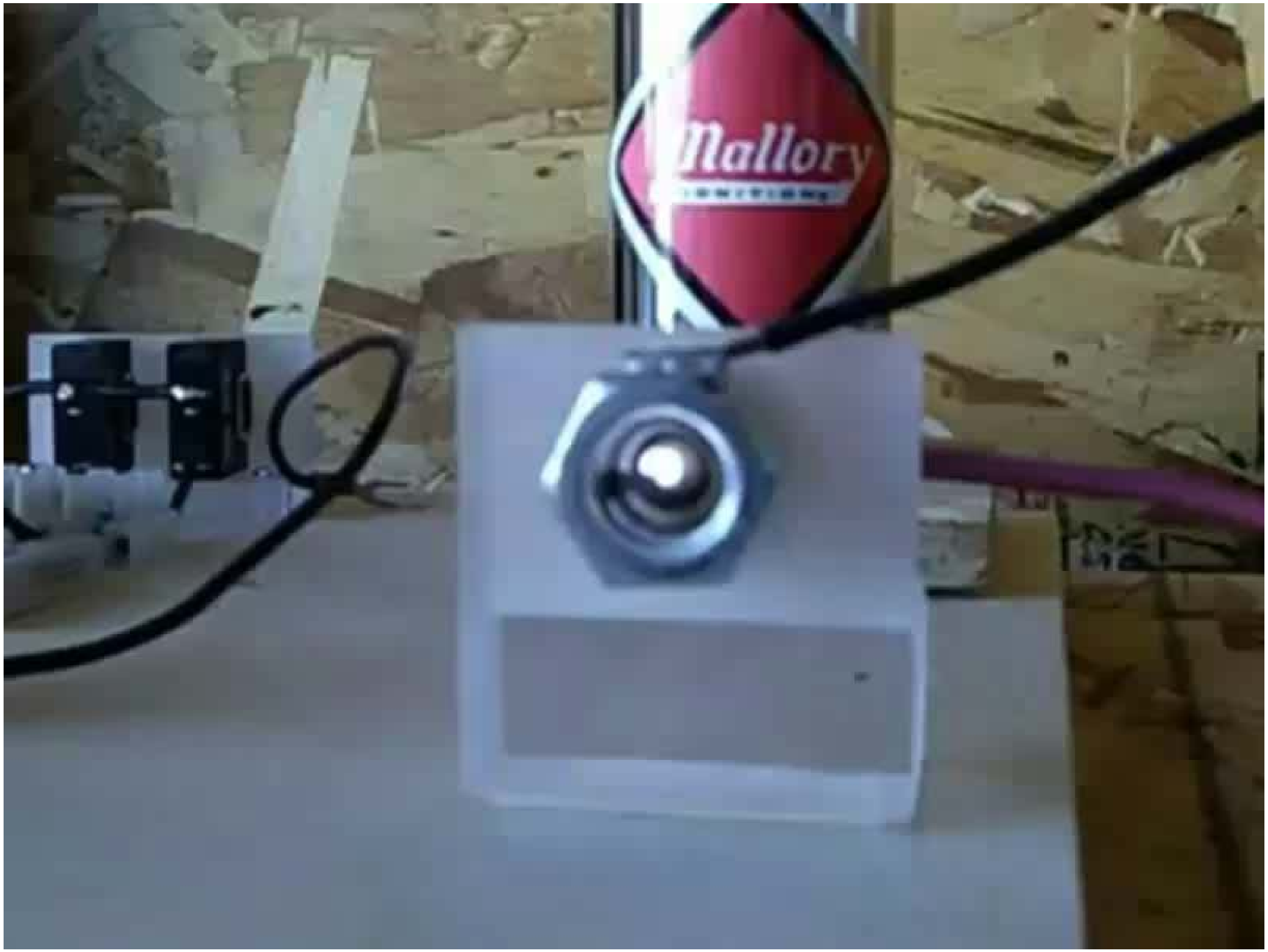
PLASMA JET IGNITION VIDEOS PLASMA SO STRONG, IT RUNS A GASOLINE ENGINE ON DIESEL!

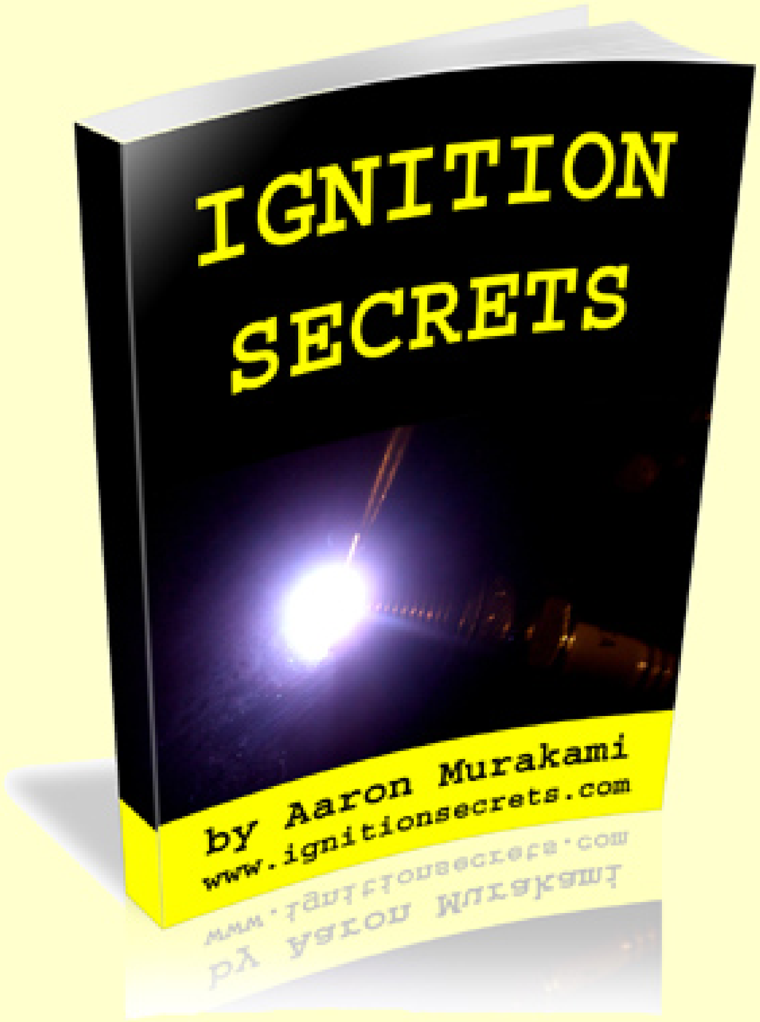


PLASMA JET IGNITION VIDEOS
H & O RECOMBINE TO FORM WATER AND SHRINKS IN VOLUME (IMPLOSION)

PLASMA JET IGNITION VIDEOS LAWNMOWER GAS JET CLOSED ALL THE WAY – RUNS ONLY ON IDLE JET FULL RPM

PLASMA JET IGNITION VIDEOS
50Hz CDI DEMONSTRATION





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